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Observations, Mathematical Modeling and Purported Facts: Standard Solar Models as a Case Study

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ABSTRACT

The subject work has provenance as originating as an example that was considered, by the subject author, for inclusion in a different work, which was focused primarily upon a philosophical context. A portion of the latter serves as introductory for this work. Specifically, a position of metaphysical and ontological realism is coupled with a position of epistemic humility. This is applied to science, as an ideal episteme, characterized by a method for which Popperian falsification is a key component. Korzybski's cartographic analogy and Box's characterization of models are coupled to the perspective that every symbolic system, whether it be natural language, formal logic or mathematics, involves assumptions, stated or otherwise, in regards to that which is or is not considered as being within the domain of reality. Hawking's claims regarding the (premature) death of philosophy and the role of scientists as the (purported) torch bearers in the quest for knowledge is evaluated in the general context of astrophysics and cosmology, and specifically in regards to the use of standard solar models (SSMs). Key to this evaluation are the modeling assumptions that are typically made not only in regards to equations of state and process relationships but also in regards to observations. Rather than finding facts, one finds models that are rendered to be unfalsifiable secondary to the use of tunable parameters, claims that fail to meet a reduced standard of verification, model based circularity and observations that are heavily model-laden in regards to their filtering.

Keywords: Mathematical modeling, abstraction, model filtered observations, Standard Solar Models

INTRODUCTION

The provenance of the subject work traces to an origin of being an example in a different work (Singh, 2026), in regards to content, focus and topical coverage, developed by the subject author and submitted for contemporaneous publication with the subject work. Because of this derivative contextualization, as well as salience, a number of conclusions in regards to the incipient work are presented here in conclusory form. The first statement is the adoption of a metaphysical and ontological position of realism, which is characterized by a modification of Jesson's (2007, pp. 79-121) critique of Bergmann, and stated here as whatever exists does so and has the properties and relations it does, independently of deriving its existence or nature from being thought of, experienced, or solely by virtue of linguistic mediation. The second statement is the adoption of the position of epistemic humility and with a basis thereof being ensconced within the Münchausen trilemma (Popper, 1935/2005, pg. 87; Albert, 1968/1995, pg. 18). The third statement is the view of science, as an ideal episteme, which is different than science as a practice or the sociology of science. The key aspects of science, as an ideal episteme, as adopted by the subject author, are the following components typically found in extant constructions of the scientific method (Dewey, 1910, pp. 145-157). The first component is hypotheses that can be subjected to falsification. The second is the independent repeatability of claimed results. This adoption is made with full awareness that Popperian (1935/2005, pg. 19) falsification, as a restrictive (far more so than verification) criterion, well postdates periods of scientific development (e.g. such as the Scientific Revolution). The corollary to the third statement is the rejection, subject to epistemic humility, of the contention of science as metaphysics or ontology. This rejection is informed by the following: (a) the conception of science as an episteme (even more so for the case of the practice of science or the sociology of science) is an entirely human derived conjecture and thus is subject to the biological and cognitive limitations that are inherent with such a limiting condition, (b) Korzybski's (1931/1994, pg. 58; 1933/1994, pp. 747-761) apt observation that the map is not the territory and

(c) a modification of Box's (1976; 1979, pg. 202) statement that all models are "wrong" (modified by the subject author to "incomplete") but some models are useful. The second and third components of this listing, within the context of fallacy (of informal logic), are encapsulated by reification when the term is applied to the false equivalence between an objectivistic (here not used as a synonym for objective but rather used as an adjective for factual actuality) phenomenon under study and the model of the phenomenon.

Secondary to adopting a position of epistemic humility, one can preface or caveat, as grammatically appropriate, most, if not all, the subsequent sentences as having the content thereof being subject to epistemic humility. Doing so, however, becomes repetitive and tedious. An alternative approach, which shifts the responsibility for applying the delimiting phrase from the subject author to the reader, is to make the statement, as one has done through the incipient sentence of this paragraph, and state the domain of applicability. A position of epistemic humility does not render one subject to accepting all claims, statements, proclamations, hypotheses, etc. as having equivalent validity. It is not a mere veneer of pragmatic tautology to differentiate between that which might be plausible versus that which is possible. The latter, in its usage, by the subject author, for the purpose of the subject work, refers to the relaxation or removal, in hypothetical abstraction, irrespective of the feasibility of such relaxation or removal in any other context, of the appropriate delimiters. One also notes that the position taken in regards to epistemology doesn't preclude and is not inconsistent with strongly worded, as per the subject author's interpretation, rejection of various claims and positions (with the caveat that one remains amenable to revising one's position in the face of novel evidence).

As an example, one rejects the claim, as insipid nonsense, that the meaning ascribed to words within any human symbolic language, as having any bearing upon objectivistic factual actuality (redundancy intended) solely by virtue of linguistic mediation. Some semblance of commonality of meaning, noting that meaning remains vague in the case when one only has other symbolic words to serve as referents, can be reached through commonality of usage, thereby making it a social phenomenon, and yet even in such a case provide no constraint when it comes to any number of individuals ascribing a different meaning. Logically, as a derivative of this view, one rejects "strong" forms of social constructivism as insipid nonsense. One also rejects the claim, for the most part, that reality is socially constructed (the acceptance of such a claim en toto would be entirely inconsistent with the metaphysical and ontological position taken by the subject author in regards to this work; a more accurate statement is that certain aspects of reality are socially described). One is reminded, here, of the following statement articulated by Sokol (1996) and with the subject author's comments indicated by brackets: "Not our theories of physical reality, mind you, but the reality itself [the claim being that the latter is socially constructed]. Fair enough. Anyone who believes that the laws of physics are mere social conventions is invited to try transgressing those conventions from the windows of my apartment (I live on the twenty-first floor)." The subject author notes, perhaps somewhat sardonically, that it does not appear that even a single social constructionist that articulated the view that reality is a social construct availed himself or herself of the opportunity offered by Sokol. One does note, and not merely in passing, that one disagrees with the wording used by Sokol. The laws of physics are a social construction. The portion of factual actuality to which they are partially isomorphic are not (the physical phenomena are independent of the labels ascribed to them).

Linguistic conventions, constructivism and Sokol's commentary provide a slightly circuitous but well worth the traversal (in the subject author's view) segue that returns the discussion to the topics of the terrain, maps and models. Here, one rejects, as one must, in order to retain logical consistency with one's stated metaphysical and ontological position, one's construction of Bartlett's (2021, pp. 87-398) metalogic of reference. This rejection, detailed to a greater degree in the subject author's originating work, is that to use Bartlett's metalogical rules in a consistent manner collapses the frame of reference concept to that of the unitary individual. Furthermore, one would have no basis to suggest that other systems of reference (i.e. people) actually exist or that they function in a manner similar to one. Any claim regarding humans (generic singular) in regards to neurology instantiates humans in a broader biological context, which if one follows the metalogical rules articulated by Bartlett (in the subject author's construction), represents a performative contradiction, as such as transcendental projection would be logically meaningless. This rejection is manifested in the form of placing humans in a broader external reality (one that is characterized as per the metaphysical and ontological position that one has articulated). This is salient when one considers the complexity of the territory (i.e. factual actuality) to certain, relevant, characteristics of the humans that are within a portion of the territory.

The following is stated in declarative fashion and involves a number of foundational presumptions. Furthermore, the words used are not used as references to the words themselves but rather to the phenomena that they represent, irrespective of the word or words used for making such a reference (this statement is a metalinguistic statement). One aspect of the normative (one uses this term without apology and those choosing to take offense at the usage of such a term are left to their own recourse) human biological system is a set of domain and bandwidth limited sensory organs that transduct certain physical phenomenon (e.g. photons, pressure waves, chemical bonds) into a uniform language characterized by electrochemical spikes. As an example, the photopic spectral sensitivity of the human (generic singular) eye, mediated by specialized cells such as rod and cone cells, ranges from 360 to 400 nanometers (nm) as a lower limit and from 760 to 830 nm as an upper limit, but can extend from 310 nm to 1100 nm for specific individuals and under the correct conditions (Sliney, 2016). The normative photopic spectral sensitivity spans the portion of the electromagnetic spectrum that conforms with visible light. This leaves the vast majority of electromagnetic radiation external to the domain limits of human visual sensitivity. While not done here, one can readily make a similar argument for bandwidth limits for the other organs of the normative human (generic singular) biological system (as well as the information that exists but is external to the bandwidth limits). One has avoided the use of the term perception, thus far, in that environmental stimulation of the appropriate sensory organ followed by electrochemical excitation of an afferent pathway, carrying sensory information to the central nervous system, is antecedent to and different than perception.

One need not turn to miasma theory, advanced by Hippocrates in the 5th century BCE (Jouanna, 2005, pp. 13-17), which became and remained the “consensus” view until nearly the terminus of the 19th century CE, as an example for the proposition that the complexity of factual actuality exceeds that of the limited domain and limited bandwidth of normative human sensory organ capability. That one rejects, as insipid nonsense, the claim that “consensus” has any bearing on factual actuality, solely by its own virtue, is consistent with the metaphysical and ontological position that one has taken. Furthermore, the historical record of the failure of so-called “consensus” as a valid epistemology is patent to such an extent that relegation as detritus to the proverbial midden heap as a falsified hypothesis would have represented a logical outcome of following the scientific method. Setting such issues aside, for the time being, the process of perception, as already distinguished from the process of sensation, involves the sensemaking system, which is ensconced in the biology of the human central nervous system. Based upon mathematical modeling, which represents the contextual area that one is working towards presenting, the estimated rate of normative sensory system data acquisition is on the order of 10^9 bits per second while the rate of conscious information processing is a mere 10 bits per second (Zheng and Meister, 2025). If these numbers are accurate, one is looking at a 10^8 fold difference in sensory data acquisition, even under the domain and bandwidth limits of the sensory organs, and the rate at which information is processed consciously. This statement is not substantively altered when considering other model derived estimates such as 40 to 60 bits per second for auditory speech and visual reading (Reed and Durlach, 1998). Using a lower rate of sensory information transmission of $1.1 \cdot 10^7$ bits per second reduces the order of the difference but without changing the substantive discrepancy. On a percentage basis, the estimated amount of information from sight represents about 80 percent of the total sensory input, followed by hearing (about ten percent) and with the remaining ten percent being divided between the senses of smell, touch and taste (note that this excludes equilibrioception and proprioception) (Man and Olchawa, 2018). These percentages differ from those that can be calculated based upon the information bitrate as can be found in the informal literature (Nørretranders, 1998, pp. 125-126). The numbers provided, without a reference basis, are at least 10^7 bits per second for the visual sensory information, 10^6 bits per second for tactile sensory information, 10^5 bits per second for auditory as well as olfactory (individually) sensory information and 10^3 bits per second for gustatory sensory information. Sauerbrei and Pruszynski (2025) articulate the view that 10 bits per second is a lower limit in regards to a maximum estimate of information processing in the brain. While a numerical value is not provided, it is indicated that it appeared likely that most of the neurons in the central nervous system contribute to subconscious sensorimotor processing for feedback control.

The relevance of the content of the previous paragraph, in regards to the subject work, is multifold. The first point of relevance is that human sensory systems, in the normative case, only have the capability for undergoing excitation by an exceedingly small fraction of physical phenomena that are extant within the externality in which one instantiates humans (generic singular). The natural conclusion that arises from this statement is that the complexity of factual actuality exceeds (either in term of entire modalities or in terms of bandwidth) the sensing capacity of the organs of the human sensory system. The second point of relevance, one which is stated here in declarative form, is that sensemaking is predicated on the processing of information through an extant mental framework. Here, one has foregone presenting the entire chain (both in terms of theory and the supportive evidence) starting from the fusion of two haploid gametes into a single diploid cell and extending through the developmental periods during which such frameworks are established. One does note that one rejects the specific form of Locke's tabula rasa argument as well as the specific form of Descartes' innate ideas argument. Furthermore, one rejects, nature versus nurture, as a false dichotomy. Declaratively, (i.e. forgoing the presentation of the basis and evidence), one states that the sensory systems in question and the mental processes involved as they relate to the preferential processing of certain categories of sensory information are both resultants of traits that were selected for (or in the very least not selected against) during human evolutionary development. Setting such issues aside, the resultant of the first two points is that the human mind, at a very basic level, generates models used to create maps that map to the territory of factual actuality but clearly not with a one-to-one scale of isomorphism. The analogy of the human mind as a central processing unit and the sensory organs as peripheral sensors (i.e. instrumentation) holds in both a symbolic and literal sense.

The issue of the extent of complexity of physical actuality is of particular relevance. One has already adopted the position that such complexity, in terms of information, exceeds the extent of information that can be obtained by the limited human sensory organs. While one tends to opt for the position that the extent of such complexity is exceedingly large, perhaps approaching infinity in the limit, one has to reign in such a supposition secondary to the capacity of the human mind when it comes to abstraction. This term requires further clarification. While all usages of relevance involve mental processes, a certain subset of usages specifically involve physical referents. The contexts range from using objects in the broader external environment to mediate a perceived goal oriented action to contemplation regarding a physical referent. In the former case, the term perceived is apt when the context involves an external observer (much more can be said in this regard as it relates to the anthropomorphic fallacy that arises due to projection onto non-human animals and the insipidity of purported empathy as having access to the qualia of other individuals; Husserl's phenomenology collapses into solipsism without the fallacy of Einfühlung). In the latter case, one takes care to distinguish the mental encoding of the contemplation (i.e. thoughts encoded in symbolic language) and the linguistic label of the physical referent, from the referent itself.

The form of abstraction to which one was referring was the capacity for contemplation regarding that which has no physical referent. Symbolic language, itself, is an excellent example of such abstraction. Logic (both formal and informal) and mathematics are also excellent examples. A feature of human language and logic is that humans can use both in a recursive manner. This can readily be seen, in the linguistic context, by means of embedding of prepositional phrases. Because such can be done ad infinitum, language, itself, does not provide a constraint on being used in a manner that results in an infinite metalinguistic regression (there are other, somewhat obvious constraints). Both language and logic can be used to create categories of categories, again with no limit provided solely by virtue of either language or logic (e.g. linguistic, metalinguistic, metametalinguistic, etc.). In the language of this work, a semantically equivalent statement is the ad infinitum creation of maps of maps. It is because of this facet, which is a characteristic, of the form of abstraction of interest, that care must be taken when it comes to assignment of complexity, perhaps in a context delimited manner, to factual actuality versus the human capacity for abstraction. Clearly, however, it would be a mistake to equate the human capacity for infinite abstraction to having infinite knowledge of factual actuality. Having mentioned formal logic, it is relevant to consider a simple case secondary to the relationship between the same and mathematics. The Aristotelian syllogism (a form of a categorical syllogism) consists of a major premise, a minor premise and a consequent. For example: All birds can fly; penguins are birds; therefore penguins can fly. This statement is logically valid. Both the major and minor premises are taken as being axiomatic (assumed to be "true") and the consequent follows directly therefrom. While the logical argument may be valid, it is also unsound. It is unsound because the axiomatic major premise is a false map to the territory of factual actuality. It should not be a surprise that the expressions of formal logic can be expressed in mathematical form. Nor should it be a surprise that every established branch of mathematics has certain tenets that are taken as axiomatic. This is often encoded in the definitional stage (e.g. a vector space over a field being a non-empty set together with a binary operation and a binary function that satisfies certain axioms).

Mathematics is not science even though mathematics often provides the model for hypothesis testing (i.e. statistical hypothesis testing). One often sees the use and misuse of linear regression for hypothesis testing (all problems look like nails when a hammer is the only tool that one has). There are a minimum of four assumptions that are axiomatic for such usage: the relationship between the dependent and independent variable is actually linear, errors are normally distributed, homoscedasticity of errors and that the observations are independent. Mathematics plays another, important, role when it comes to science and that is providing a language for encoding relationships between variables. In theory, the territory may contain an infinite number of variables. Variables that are independent of each other are referred to as degrees of freedom. Because a one-to-one isomorphic map to the territory is the territory itself, the reduction of the degrees of freedom, based (in theory) upon salience, is requisite for tractability. It is worth noting, again, that the map that is generated via mathematical modeling, is not the territory itself. It is worth noting, again, that a model is not evidence for the phenomenon under study. One may attempt to use one or more models to "validate" another model, but such "validation" changes nothing in regards to the models not being the territory. Here, one would be remiss to not mention that the concept of using a model to filter "observations" and then using the results as a "test" for the "validity" of the model represents a perverse circularity. As a simple example, consider a model whose statement is that there are no numbers greater than five and a set of "raw observations," {1, 3, 6, 9, 11, 13}. Filtering the latter using the former results in the "observations" of {1, 3}. The conclusion that the "observations" validate, prove, support, etc. the model is insipid nonsense. Another issue that is worth noting at this juncture is that any phenomenon can be modeled by an infinite number of mathematical models. As an example consider the univariate model, shown in (1), where x is the independent variable, y(x) is the dependent variable and the terms a_j $\{j: j \in \mathbb{Z}^{0+}\}$ are constant valued coefficients. This equation is simply a polynomial function in the variable x.

$$y(x)=a_0x^0+a_1x^1+a_2x^2+\cdots=\sum_{j=0}^{\infty}a_jx^j \tag{1}$$

Truncation of this expansion to the first two terms (noting that $x^0 = 1$ and $x^1 = x$) yields the standard slope-intercept form of a straight line. If one considers the model shown in (1) as the first two terms plus the summation starting at j = 2 (rather than at j = 0), how would one distinguish between the cases of a model consisting of just the first two terms (with the resultant of the summation being zero) versus the case where the summation is approximately zero to the extent of precision or within a particular domain of x? One can ask the same question, ad infinitum, for any number of terms that are explicitly removed from the summation (coupled with changing the lower limit on the summation). One can also ask the same type of question in regards to any coefficient term, beyond a certain number, being small or any subset of additive terms being approximately zero. Even with this simple example, it is readily apparent that one is dealing with an infinite number of options. One approach to resolving this problem is to assume parsimony (i.e. using the simplest model that "fits" the evidence; Occam's razor). However, factual actuality is under no constraint to be subject to such an assumption.

One final point is worthy of mention (in the introductory sense) prior to presenting the immediate basis that precipitated the subject work. One has already noted that information obtained by the sense organs undergoes mental model processing in order to generate maps. The view of the sense organs as instruments was also noted. Information obtained by the use of instruments external to anatomical sensory systems also involves modeling, both in regards to the design of the instruments, information filtering (as apt) and the interpretation of collected information. Consider the relatively simple case of using a mercury-in-glass thermometer to take a temperature reading. The instrument is not measuring temperature directly, but rather is measuring a proxy, here the expansion of a liquid, from which one can infer the temperature based upon the modeling assumption that the physical properties in question change predictably with heat (for liquids, for a fixed value of pressure and amount of liquid, the coefficient of expansion, b, is given as $(1/V)(\partial V/\partial T)$, where V is the volume, T is the temperature and ∂ denotes a partial derivative). A reading that doesn't change with time leads to the inference that thermal equilibrium has been reached between the thermometer and the substrate. Finally, calibration must be considered in regards to the fixed points over which the instrument provides "accurate" values, in regards to standards (e.g. setting the freezing and boiling points of water at 0^o C and 100^o C respectively, which are conventions used as an attempt for ensuring consistency across different instruments) and in regards to the temperature scale. The calibration process can be more involved for different types of instrumentation (e.g. accelerometers, load cells, opacimeters, etc.). The determination of the portion of information obtained from an instrument that is the measurement of relevance (the signal) versus that which is extraneous (the noise), while of limited import in this simple example, becomes one of significant import when one is working with electronics based instrumentation (the actual observation being a change in voltage or current) or in cases in which the ratio of signal to noise is low. Filtering of the actual observations requires additional mathematics, which in turn, involves additional assumptions. While one has used the term, infer, as well as its grammatically appropriate analogs, care must be taken not to equate the term with validity (just as for the case where the word guess would not be equated with invalidity). The view taken by the subject author, in regards to this work, is that no inference is taken as axiomatic such that it is unquestionable. The corollary to this statement is that no inference is invalid simply due to it being questioned.

An encapsulation of the position taken by the subject author in regards to this work is the following: "No symbolic system (be it math or language) is free of assumptions. It rests on a set of philosophical concepts and presuppositions about reality (Gaspard and Pili, 2022)." The following quote, from an earlier work of Stephen Hawking (2001, pg. 31) is one that mostly comports with the position taken by the subject author in regards to this work.

'Any sound scientific theory… should in my opinion be based on the most workable philosophy of science: the positivist approach put forward by Karl Popper and others. According to this way of thinking, a scientific theory is a mathematical model that describes and codifies the observations we make. A good theory will describe a large range of phenomena on the basis of a few simple postulates and will make definite predictions that can be tested. If the predictions agree with the observations, the theory survives that test, though it can never be proved to be correct. On the other hand, if the observations disagree with the predictions, one has to discard or modify the theory. (At least, that is what is supposed to happen. In practice, people often question the accuracy of the observations and the reliability and moral character of those making the observations).'

This can be contrasted against another quote taken from a later work by Hawking (1942-2018) and where the subject author's comments are denoted, within the quote, by braces. "Traditionally these [metaphysical, ontological and epistemological] are questions for philosophy, but philosophy is dead. Philosophy has not kept up with modern developments in science, particularly physics. Scientists have become the bearers of the torch of discovery in our quest for knowledge (Hawking and Mlodinow, 2010, pg. 5)." The attribution of this view to Hawking, rather than Mlodinow, either solely or in conjunction, is based upon a subsequent interview in which Hawking reiterated the view articulated in the quote (ZeitgeistMinds, 2011, 0:34). In the subject author's interpretation, the content of the quote is paradoxical and reminiscent of the liar's paradox (i.e. assume that "this sentence is false," is true, which results in a contradiction). Secondly, the statement falls within the classification of a category error in that philosophy, being an abstraction, has no capacity for being dead or alive. Thirdly, at least in the subject author's construction, there is a substantial difference in the articulated view regarding those, that at least in theory, practice "science." In the first quote, Hawking aptly describes science, as an episteme (for the cases in which mathematical modeling is salient), and via the parenthetical aptly describes what the subject author terms the response of those defending an orthodox position. While it is beyond the scope of the subject work, the view, in extant time, of "science" as being unquestionable (the irony is duly noted when considering that the ideal episteme requires questioning) and "scientists" as (a) possessors of sacred knowledge and (b) being above the requirements, motivations and limitations inherent in other humans (generic singular) is not a novel paradigm but is rather a manifestation of a long established paradigm, which the subject author relates to how some (perhaps most) humans (generic singular) manage the uncertainty that is inherent with temporary existence in a larger factual actuality. It is exactly this view that one sees in one's interpretation of Hawking's later quote. Scientists, rather than being practitioners of an ideal episteme (when doing science) are elevated to the status of torchbearers of discovery in the quest for knowledge.

Hawking was a theoretical astrophysicist and cosmologist. In considering these two fields as well as astronomy, which in the very least provides "observations" for use in the indicated fields, one finds a veritable plethora (rather than paucity) of claims, articulated as "facts" and that involve not only reification of models and modeled results but also the granting of ontological and metaphysical status to residual errors. A comprehensive detailing of these issues, even with peripheral coverage of each instantiation, even on a preliminary attempt extended to a book length treatise (coupled with peripheral coverage being unsatisfying). Thusly, for the subject work, the author decided upon a single topic, standard solar models (SSMs), which at least are honestly labeled as models, but the results of which are often presented as "facts." Because the various iterations of the modeling paradigm share the same underlying structure and assumptions, the singular, standard solar model (SSM) is used in this work to refer to any such model for which the modeling paradigm is apt. While this model is for the sun, the model is treated as being "valid" for all population I stars (stars that are modeled as being "younger" and with higher metallicity; in context, all elements except for hydrogen and helium are called metals; Baade, 1944). In that all symbolic systems are based on certain assumptions, the objective of the author, through the subject work, is a determination of the assumptions involved in the SSM.

METHODS

Because the SSM is an extant model, one aspect of the methodology used in regards to this work clearly involves a review of the model. While one could have separated this review from the evaluation of the assumptions involved, such an approach appeared somewhat disjoint and duplicative. Thusly, from the perspective of methodology, an in situ approach was used instead. A characterization of the methodology as qualitative is not necessarily incorrect in the sense that the work did not involve novel data collection or the reduction of existing data (beyond a few nominal cases). The work does, however, involve the presentation of equations used for mathematical modeling. While the subject author has attempted to explain, using natural language, the mathematical relationships that are presented, a mathematical background including univariate and multivariate calculus is beneficial. While certain equations are derived, others are not secondary to the extent of background material that would be required and with such background, in the subject author's estimation, being beyond the realm of what is considered reasonable for a typical reader. Thusly, the subject work is characterized by the author as being closer to the informal node on a qualitative spectrum of formality.

In the following, the International System of Units (SI) is used, unless stated otherwise. The following abbreviations are employed: centimeter (cm), meter (m), kilometer (km), gram (gm), kilogram (kg), seconds (sec), kelvin (K), joules (J), pascals (Pa), watts (W) and electronvolts (eV). As already indicated by the abbreviation for kilometer, the preceding k refers to 10^3. A preceding M (i.e. MeV) refers to 10^6. Cases in which a preceding k or M are not a reference to scale should be readily apparent by the context in which such occurrences occur. Abbreviations for other units are defined and shown as per first usage.

This study provides a strict epistemological critique of modeling frameworks, distinct from sociopolitical critical theory. The analytical arguments presented herein assume a baseline of scientific objectivity and academic rigor; consequently, specific conclusions are articulated with deliberate emphasis to underscore systemic modeling discrepancies.

Standard Solar Model

Preliminaries

Having placed a boundary on the scope of the subject endeavor, it is useful to consider the following, prior to detailing the SSM. The Artemis II lunar flyby mission is a topic that is current with respect to the time of the writing of this work. In such regards, it has been noted that the crew of the mission set a new record for human distance from the Earth by traveling 406,771 km away. If the upper range for the estimates of the geocorona (100 Earth radii and with the moon located at a distance of approximately 60 Earth radii away) are correct (Baliukin et al., 2019), this new record would still fall within the exosphere of the planet (this sounds quite different than claims of the crew having gone into deep space). This number is still approximately two orders of magnitude less than the statutory definition of one astronomical unit (i.e. approximately, here, due to rounding, of $1.496 \cdot 10^{11}$ m; 1 AU). The current (as of the time of the drafting of this work) estimated distance between the Earth and the Voyager 1 spacecraft is $25.4 \cdot 10^{12}$ m. Had the spacecraft been directed towards the Alpha Centauri star system (including the closest known star to the sun), located a mere 4.37 light years away, it would take between 74,000 and 77,000 years for the spacecraft to cover that distance (traveling at its estimated current velocity of 17 km/sec). These number define (a) the maximum extent of distance away that humans have traveled from the planet and (b) the maximum extent of distance away that a human created object has traveled from the planet.

The portion of the physical universe to which humans (generic singular) have actually reached or that spacecraft have reached represents a rounding error with respect to the hypothesized extent of the universe. The assignment of an excessive amount of importance upon being able to be physically present, either directly or through instrumentation such as spacecraft, is dubious in the same manner as is excessive importance upon the limited information that can be obtained by the sensory organs. Certain claims or contentions, however, have to be evaluated with a certain degree of clarity. The information that is available in regards to distant cosmological objects, as well as the phenomena occurring within their proximity, is limited. Claims such as human (generic singular) created "laws" of physics are the same everywhere in the visible universe are speculative and assumptive. The "observations" typically proffered in support of such claims are heavily filtered through the very models for which they are offered as evidence (as noted before, this is perverse circularity). While even direct "observations" involve maps and models, there is a clear difference between having direct access to the contents of the wallet of a person versus seeing a quasi-rectangular topological rise in one of the rear pockets of a pair of pants worn by an individual when it comes to the task of ascertaining how much currency is present in said wallet. In the second case, the observable surface phenomenon does not even map to the singular case of the phenomenon being created by a wallet. A claim that one could "infer" that the object in question was a wallet and further determine the amount of currency present is more aptly labeled as a guess.

For the sun, the deepest layer for which one has access when it comes to making direct observations is the surface (the photosphere). Thusly, one is limited to an estimated depth of between 100 to 500 km radially inward from the visible solar disc and extends outward to contain the chromosphere (estimated at 3 to 5 thousand km) and the corona (estimated at 7 to 14 million km from the photosphere). Hypothetically, if one was presented, as a statement of fact, that the temperature at the core of the Sun was X degrees or even 50 thousand km below the photosphere was Y degrees or that some structure or phenomenon Z was present at some interior location within the sun, one might have a reasonable expectation that such statements of fact were based on direct measurement. Yet, as one noted previously, no human has journeyed one astronomical unit away from the planet and the closest that a spacecraft has gone to the sun (the Parker Solar Probe) failed to even "pierce" the surface (closest approach being $6.1 \cdot 10^6$ km away). Thusly, the idea of a human or a spacecraft placing an instrument (e.g. a thermometer) at a radial depth of 50 thousand or 5 thousand km into the photosphere is a non-starter. This also holds for an instrument that could "pierce" the veil of the photosphere and obtain measurements of temperature, density, pressure, etc. or direct "observations" of the processes at play (one addresses neutrino "measurements" and helioseismology in short order).

The purported "facts"

Based upon the subject author's informal survey, the textbook presentation (over the last five decades at a minimum) of solar structure has been consistent in regards to radial separability and with the first four radial layers consisting of a core, a radiative zone, a convective zone and the photosphere (e.g. Chaisson and McMillian, 2014, pg. 390). Accurate presentations will note that the first three of these layers are modeled layers and not determinations based upon direct observation. Inaccurate presentations will simply claim that the various layers below the photosphere are "facts." The pervasive epistemic issue, in regards to claims made by authors within a contemporary educational setting, with respect to structural reification of computational simulations extends well beyond hypothesized, unobservable solar zones. Unobservable internal parameters are frequently stated as absolute physical realities rather than mathematical deductions (this statement applies even if the wording is otherwise within a given text). As examples, Chaisson and McMillan (2014, pg. 413) and Bennett et al. (2020, pg. 423) declare that the solar core temperature is approximately 15 million K as part of an uncritical but factually articulated narrative (in the view of the subject author) that is divorced from the foundational hydrostatic assumption and parameter tunings inherent to the model from which such values derive. The set of quantitative "facts" that are articulated in this manner, subject to same disparity in regards to indicating model based results versus direct observation are the following: the mass of the sun (M) is $1.988 \cdot 10^{30}$ kg, the radius of the sun (R) is $6.957 \cdot 10^8$ m, the central temperature (T_c) of the sun is $15.7 \cdot 10^6$ K, the central pressure of the sun is $2.3 \cdot 10^{16}$ Pa, the central density of the sun is $1.52 \cdot 10^5$ kg/m^3 (i.e. 150 gm/cm^3), the age of the sun is 4.54 $\cdot 10^9$ years and the "current" solar luminosity is $3.828 \cdot 10^{26}$ W.

While one may not have direct access to the hypothesized layers of the sun that are below the photosphere, one should in theory, at least have, as a basis for claims that certain phenomena are present when material of a presumed composition exists at a certain state (i.e. at a certain temperature, pressure and density), laboratory based verification. The highest modeled temperature at CERN's Large Hadron Collider (LHC) has been claimed to be between 5.0 and 5.5 trillion K. The modeled pressure for diamond anvil cells ranges from 4.05 to 6.08 · 10^{11} Pa. The modeled pressure, temperature and density of 3.04 · 10^{16} Pa, 100 to 180 · 10^{6} K and 1000 g/cm^3 respectively, reported in regards to the laser-based inertial confinement fusion research facility known as the National Ignition Facility (NIF) are in excess of the modeled solar core parameters. Testing conducted by the appropriate individuals with NIF affiliation has been interpreted as the creation of "burning plasma" (i.e. where nuclear fusion is the primary heat source). This should be sufficient to replicate the modeled conditions within the solar core and show, at least in the laboratory, that the processes that are claimed to be working within these parameter bounds are actually working in accordance with theory. Not surprisingly, such is not the case. These reactions are engendered by asymmetric implosion and exist for a modeled time that is within the picoseconds. This differs substantively, as detailed below, from the modeled case in which the solar core environment is treated as a stable (over a multi-billion year time period) system that exists in a state of gravitational equilibrium. The inability to verify that the modeled phenomena attributed to the modeled core, by means of macroscopic scale laboratory replication of the thermodynamic state that is at issue, even with the previously indicated statement that verification is insufficient for scientific hypothesis adjudication, is not limited to the core. It also holds for the hypothesized radiative zone and convective zone. In regards to the photosphere, specific physical conditions for specific elemental compositions, in a certain state, have been reproducible, but not as a unified, macroscopic, system that naturally stabilizes and maintains the salient properties of the photosphere. In regards to the solar corona, laboratory scale replication of solar flares and coronal magnetic loops has been achieved (Zhang et al., 2023).

Basis for the solar mass

The basis for the solar mass, which is modeled, can be explained externally to the SSM. To do so, one first starts with the mathematical abstraction of a point, which is an exact position in physical space but with zero dimension. In $\mathbb{R}^3$ this is represented by an ordered triplet (this can be extended to an ordered tuplet of n terms, where n is the dimension of the space under consideration). When mass is assigned to a point (i.e. a point mass) one has the case of infinite density secondary to r = m/V, where m is the mass and V = 0 is the volume. The point mass approximation, however, has wide usage in Newtonian mechanics. Newton's law of "universal" gravitation, in the condensed restatement that comports with extant presentations, indicates that for a two point mass system, where m_1 is the mass of the first body and m_2 is the mass of the second body, that the gravitational force vector applied on the second body (exerted by the first body), $\mathbf{F}_{21}$, is along the unit vector from the first body to the second body, $\hat{\mathbf{r}}_{21}$ and is proportional to the inverse of the square of the distance between the bodies.

$$\mathbf{F}_{21} = -\frac{Gm_1m_2}{|\mathbf{r}_{21}|^2}\hat{\mathbf{r}}_{21} \xrightarrow{\hat{\mathbf{r}}_{21} \equiv \frac{\mathbf{r}_2-\mathbf{r}_1}{|\mathbf{r}_2-\mathbf{r}_1|}} -\frac{Gm_1m_2}{|\mathbf{r}_{21}|^3}\mathbf{r}_{21} \xrightarrow{|\mathbf{F}|=\frac{Gm_1m_2}{|\mathbf{r}_{21}|^2}} -|\mathbf{F}_{21}|\hat{\mathbf{r}}_{21} = -|\mathbf{F}_{21}|\left(\frac{\mathbf{r}_2-\mathbf{r}_1}{|\mathbf{r}_2-\mathbf{r}_1|}\right) \quad (2)$$

In (2), | · | denotes the magnitude and G is the Newtonian "constant" of gravitation (6.674 · 10^{-11} m^{3}kg^{-1}sec^{-2}). By Newton's third law of motion, $\mathbf{F}_{12} = -\mathbf{F}_{21}$. In Newton's 1687 *Principia*, G was not specifically used and instead proportionality was mentioned (G was first "measured" by Cavendish approximately a century later in 1797). Newton, via his theory ensconced in (2), was able to mathematically derive Kepler's laws of planetary motion, which, in turn, were based upon Kepler's analysis of Tycho Brahe's observations of the orbit of the planet Mars (i.e. that the orbit was elliptical). From the perspective of orbital mechanics, the inverse square law shown in (2) allows for planar orbits that are conic sections (i.e. circle, ellipse, parabola or hyperbola). A circular orbit requires that the orbital velocity be exactly tuned to the gravitational pull on the object (i.e. the magnitude of the centripetal acceleration has to equal the magnitude of the gravitational acceleration). Any deviation from this exact tuning results in an elliptical orbit. One should also note that an analytic closed form solution exists for the two body system (two point masses). If one adds even one additional point mass (the three body problem), the trajectories not only no longer are perfect ellipses but also can no longer be determined in regards to an analytic closed form solution.

One would be remiss to not note, here, that the "science," "fact" and "consensus" for approximately 1400 years, starting with Ptolemy's *Almagest* (ca. 150 CE), with respect to Copernicus' 1543 CE publication, was of a geocentric universe in which the known planets of the Solar system, the sun and the moon orbited a stationary Earth. The heliocentrism proposed by Copernicus was merely ultra-radical and far-extreme in that it retained circular orbits, epicycles and uniform orbital velocity. Brahe's 1588 CE work involved a system in which the sun and moon revolved around the Earth and other five (as of the time), known, planets revolved around the sun. It was not until after the 1609 CE publication of Kepler's *Astronomia Nova* that there were suddenly new "facts" that were subsequently supported as the "science" and became the new "consensus." Newton's law of "universal" gravitation, which provided the mathematical basis for Kepler's extrapolation (Kepler extrapolated the finding of an elliptical orbit of the planet Mars to all orbits), became the universal law and remained unchallenged as "consensus" "science" and "fact" for over 200 years. With the passage of time, an increase in the accuracy of observations of the planet Mercury resulted in the conclusion, that the planet, at perihelion, was shifting forward by approximately 43 arcseconds per century. This conclusion was in contradiction to the elliptical orbit predicated by Newton's law of "universal" gravitation. The solution to this problem, at least initially, was not questioning whether or not Newton's theory was accurate, but rather was the paradigmatic replay of what had earlier been manifested by adding epicycles. This instantiation was yet another case of confusing the model mediated map for the territory, leading to reification of the model as well as the conversion of ignorance (an apt term) into a form with ontological status, in 1859, which was manifested in name by the (fictive) planet, Vulcan. This convenient fiction was the creation of Urban Le Verrier, who had ironically accurately predicted the existence of the planet Neptune. It was not until 76 years later, when Albert Einstein (1915/1997a, pp. 112-116) published the third of his papers, in that year, regarding his theory of general relativity, providing a mathematical formulation that explained the wobble in the orbit of Mercury that Vulcan was quietly forgotten and with nothing learned in regards to maps not being the territory.

While a review of the Einstein field equations is beyond the scope of the subject work, it is worth noting that these equations of general relativity are simultaneously simplified and yet far too complex while not being beyond the scope of being a mathematical model, which does not alter the statement that the map is not the terrain. In regards to the claim of simplified, the model is based upon the assumption of continuity, but only allows for curvature of a spacetime manifold without allowing for torsion or non-metricity. The complexity arises from the fact that the six equations (expressed in compact form as a single, indexed, tensor equation) are coupled, nonlinear, partial differential equations. If one were to write out any one of these equations, with all of the terms that can be written out in terms of the metric tensor and its derivatives, the resulting expansion would involve thousands of terms. It should not come as a surprise that there are only a small handful of analytic closed form solutions to Einstein's field equations. Each such solution involves making assumptions that lead to substantial simplification. In the subject author's construction of Einstein's work pertaining to explaining the orbit of Mercury, the following simplifications were made: the sun was treated as a perfectly spherical, non-rotating, stationary point mass; the vacuum assumption regarding the space around the sun was used (i.e. the stress-energy-momentum tensor, T_{mn}, was set equal to zero); the problem was reduced to the two body case (i.e. the sun and Mercury); a static gravitational field was used; the local geometry of spacetime in the vicinity of the sun was assumed to be isotropic; the weak field and small velocity limits were used. This work, interestingly enough, preceded Einstein's publication, later in the same year, of his field equations of gravitation (Einstein, 1915/1997b, pp. 117-120).

The brief presentation of the material contained in the previous two paragraphs was neither digressive nor tangential. Given that one has established that even a slight perturbation will turn a circular orbit into an elliptical orbit and that Newtonian mechanics fails to provide a modeled prediction that matches the orbit of Mercury, it should come as somewhat of a surprise that one returns to both a circular orbit and Newtonian mechanics for determining the mass of the sun. Furthermore, one removes from consideration any other bodies, from consideration, outside of the point masses representing the sun and the Earth. Starting with (2), and relabeling (for ease of presentation), $|\mathbf{F}_{21}|$ as F_g, m_1 as M (mass of the sun), m_2 as m (mass of the Earth) and $|\mathbf{r}_{21}|$ as r, one obtains the following:

$$F_g = \frac{GM\,m}{r^2} \tag{3}$$

An orbit is perfectly circular, for the two body case, when the gravitational force is matched by the centripetal force. Denoting the magnitude of the orbital velocity as v, the centripetal force magnitude is:

$$F_c = \frac{m v^2}{r} \tag{4}$$

The orbital velocity is equal to the distance traveled in one revolution divided by the time taken for the same (i.e. the orbital period, p). For a circular orbit (with a radius, r), the distance traveled is equal to the circumference of the circle (i.e. 2pr). Thusly, v = 2pr/p. Substitution of this result into (4), followed by setting (3) equal to the resultant (one can readily approach this problem by retaining the vector formalism rather than implicitly accounting for the same but using scalar magnitudes) and algebraically rearranging leads to the following solution:

$$M = \frac{4\pi^2 r^3}{Gp^2} \tag{5}$$

To make this equation "work" for an elliptical orbit, the sleight-of-hand of replacing the radius, r, with the length of the semi-major axis of an ellipse (obtained from parallax and denoted as a) is used. Without this sleight-of-hand, the mass of the sun would appear to fluctuate as the Earth moved from perihelion to aphelion.

$$M = \frac{4\pi^2 a^3}{Gp^2} \tag{6}$$

Substitution for the two variables on the right of the equality (i.e. for a and p) results in the aforementioned "fact" of the mass of the sun as being $1.988 \cdot 10^{30}$ kg.

The one-dimensional onion

The SSM, spatially, is a one-dimensional (1D) model and with that dimension being the radial direction. Assumed in regards to the model is radial symmetry (in three dimensions, i.e. 3D, this maps to spherical symmetry, staticity (i.e. the model is spatially static which means no rotation, translation or volumetric change) and a lack of magnetic fields (the last condition may vary depending on the model). The model is colloquially referred to as an onion or the onion model secondary to the appearance that results from the 1D "shells" (of constant temperature) that are generated for the stepwise changes in radial position (i.e., the radius, r, moving from r = 0 to r = R in steps of Dr). For each radial step, there are four equations at issue: (a) mass balance, (b) hydrostatic equilibrium, (c) energy generation and (d) energy transport. Based upon certain values for the state variables, corresponding to purported boundaries between the presumed (and aforementioned) layers of the solar structure, certain equations are either turned on or off or changed in form. The model starts at a value of time equal to the negative of current estimated age of the sun and "evolved" forward in time. Additional assumptions in this evolution are that there has been zero mass loss or gain during the temporal period under consideration (thereby excluding mass loss from conversion to energy and mass loss through the solar wind), a presumed elemental composition with homogenous distribution and a presumption that the majority of the luminosity is attributable to nuclear fusion. One addresses the basis for the claimed age and presumed elemental composition shortly. The estimated earliest human civilizations is approximately ten thousand BCE. Adding an additional two thousand years (approximately) results in $1.2 \cdot 10^4$ years. When compared to the mean of the estimated age of the sun (i.e. $4.54 \cdot 10^9$ years), the former is approximately $2.64 \cdot 10^{-4}$ percent of the latter and thusly any time to which the model can be evolved forward for where one has "observations" to evaluate the modeled results effectively maps to a "now" in which the civilizational time scale fails to equate to even a rounding error (i.e. $5 \cdot 10^6$ years) on the estimated solar time scale. At the terminus point of the modeling procedure, the model based radius and luminosity are compared to the model based and filtered "observations" of the same.

The presumed age of the sun is based upon an unverifiable genetic assumption of presumed provenance. In the first, it is assumed that the materials that are present in the solar system, en toto, have a foundational basis in a singular protoplanetary disc. This genetic assumption of presumed provenance extends to rocky objects. Radiometric dating, itself involving modeling assumptions, of the "oldest" meteorites serves as the basis for the estimated age of the sun (Guenther, 1989). This genetic assumption is also evident in regards to one component of the presumed initial, homogenously mixed as a perfect fluid, composition of the sun. These components, of which the first befits the previous statement, are: a) metal content taken from assumed "pristine" C1 chondrites (a specific kind of meteorite) which are scaled to the silicon content of the same followed by using the modeled solar photospheric silicon to force scale the entire metal content of the Sun to match that of the meteorite, (b) volatiles based upon solar spectroscopic models and (c) noble gasses based upon models of the solar wind or solar corona. In theory, one could at least validate the genetic assumption and presumed provenance, not in regards to the sun, but in regards to protostar formation, T Tauri star development, lack of any substantive material incursion from sources external to the protoplanetary disc and the relationship between the radiometric age of intrasystem rocky material and the directly observed age of the system simply by traveling to the nearest candidate, waiting and collecting samples as required. It is then that one remembers that humans (generic singular) have yet to make it out of the Earth's geocorona, falling laughably short of the estimated (a discussion on the rickety cosmic distance ladder is beyond the scope of this work) 1267 light year distance to the Orion nebula (the closest currently known region of star formation) and that have lifespans (generic singular) that are irrelevant and yet again not even within the realm of a rounding error when it comes to the estimated times for protostar formation and T Tauri star gas accretion. Even the far simpler task of sampling a sufficient quantity of rocky material, with appropriate spatial distribution, from within the solar system, is a task that is most likely beyond the ken of current human capacity, irrespective of the specific individual humans involved.

Because of the repeated use of the assumption of hydrostatic equilibrium as well as conservation of mass relationship, it is useful to first derive both for the 1D radial model.

Hydrostatic equilibrium and conservation of mass

Here one assumes that the reader is familiar with the mathematical abstraction of integration of a univariate function over a closed interval (i.e. a definite integral). A few examples are given in (7). The first equation is the "area under the curve" interpretation for the polynomial function $f(x) = ax^n$ where $a \in \mathbb{R}$, $n \in \mathbb{Z}$ and the closed interval is $\{x: x_a \leq x \leq x_b\}$. The second equation is the area of a circle based on circumference. The third is the volume of a sphere based upon the surface area of the same.

$$\int_{x_a}^{x_b} ax^n dx = \frac{a}{n+1}\left(x_b^{\,n+1} - x_a^{\,n+1}\right) \quad \int_0^R 2\pi r dr = \pi R^2 \quad \int_0^R 4\pi r^2 dr = \frac{4}{3}\pi R^3 \tag{7}$$

One starts by considering a variational or virtual mass element, dm, with a radial dimension of dr and a surface area (orthogonal to r) of ds. The mass element can be expressed as a function of density, r(r), where the parenthetical denotes a function of the radius, by the following:

$$\delta m = \rho(r)\delta r\delta s \tag{8}$$

In (8), drds is the virtual volume (dV), which leads to the definition of density as mass per unit volume. If there is a radially outward pressure, P(r), acting on the mass element, then the radially outward force is simply P(r)ds. If there is a radially inward force acting on the mass element, one can additively decompose the force into the sum of the force exerted by material radially external to the mass element, P(r + dr)ds and the force due to gravity secondary to the matter contained within the radius, $Gm(r)r^{-2}dm$, where m(r) denotes the functional dependence of the mass on the radius (i.e. mass as a function of radial position). The sum of these two forces gives the total radial inward directed force (the functional dependence of m on r is not shown for purposes of clarity of presentation but remains patent and should not be forgotten).

$$P(r+\delta r)\delta s + Gm\, r^{-2}\delta m \tag{9}$$

Substitution for dm, in (9), based upon the definition in (8), leads to the following (the functional dependence of r on r is not shown for purposes of clarity of presentation but remains patent and should not be forgotten).

$$P(r+\delta r)\delta s + Gm\, r^{-2}\rho\delta r\delta s \tag{10}$$

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For the mass element to be in hydrostatic equilibrium, the radially outward force, P(r)ds, must be equal to the total radially inward force, given by (10). Setting the two equal, dividing both sides of the equality by the common factor ds and algebraically rearranging the result leads to the following.

$$P(r+\delta r)-P(r)=-Gm\,r^{-2}\rho\delta r \tag{11}$$

Dividing both sides of the equality in (11) by dr leads to the following:

$$\frac{P(r+\delta r)-P(r)}{\delta r}=-Gm\,r^{-2}\rho \tag{12}$$

In the limit, as dr goes to zero, the term on the left of the equality, by the limit definition of the derivative, becomes the derivative of P(r) with respect to r. Therefore (and reinserting the functional dependence on the radius for the mass and density), one has the following:

$$\frac{dP(r)}{dr}=-\frac{Gm(r)\rho(r)}{r^2} \tag{13}$$

The relationship given by (13) is the 1D equation for hydrostatic equilibrium, which relates the change in hydrostatic pressure to the change in radial position, to the change in mass and density (both also a function of radial position). For mass conservation, consider a thin shell of material with inner radius r and outer radius r + dr. The mass of the shell, dm, is obtained by the density and the volume, which in turn is obtained by multiplying the surface area, as per the integrand of the third equation in (7), by the variation in radial position, dr.

$$\delta m=\rho(r)\delta V=4\pi r^2\rho(r)\delta r \tag{14}$$

The mass variation is also defined as the difference in the mass contained within the outer radius, m(r + dr), and the mass within the inner radius, m(r).

$$\delta m=m(r+\delta r)-m(r) \tag{15}$$

Setting equations (14) and (15) equal to each other and dividing both sides of the equality by dr leads to the following:

$$\frac{m(r+\delta r)-m(r)}{\delta r}=4\pi r^2\rho(r) \tag{16}$$

Following the same argument made for the case of hydrostatic equilibrium, using the limit definition of the derivative by taking the limit of the left side of the equality as dr goes to zero, leads to the following:

$$\frac{dm(r)}{dr}=4\pi r^2\rho(r) \tag{17}$$

Equation (17) is the mathematical expression for the conservation of mass for the subject 1D case.

A worthy divergence

An equation of state is a thermodynamic relationship that relates aggregate properties (e.g. temperature, pressure, volume, etc.) of a system in a macroscopic sense. Here, one starts with a polytrope model for the equation of state (one that conveniently leaves out having to model the complexities of actual heat, radiation or nuclear fusion). The equation takes the form of a power law function which relates pressure to density (K is a constant and n is the polytropic index).

$$P = K\rho^{1+n^{-1}} \tag{18}$$

Within the context of solar (more generally stellar) modeling, are the assumptions that (18) holds from the center of the core to the surface, that the movement or deformation of any control volume of gas doesn't result in any heat exchange with the surroundings (the adiabatic assumption), spherical symmetry, no rotation and hydrostatic balance (gravity and pressure are the only components). Starting with (13), again not showing the explicit dependence on r (for the purpose of clarity of presentation), dividing both sides by the density, r, and differentiating with respect to the radius yields the following:

$$\frac{d}{dr}\left(\frac{1}{\rho}\frac{dP}{dr}\right) = \frac{d}{dr}\left(-\frac{Gm}{r^2}\right) = \frac{2Gm}{r^3} - \frac{G}{r^2}\frac{dm}{dr} \tag{19}$$

The form on the right of the final equality in (19) has two terms. This arises because mass is treated as having a functional dependence on the radius (again, not showing the functional dependence does not remove that such a dependence is mathematically present). The differentiation with respect to r, thusly, requires the use of the product rule of differentiation. Substitution for the mass gradient in (19), from (17), and rewriting the first term using (13) leads to the following:

$$\frac{d}{dr}\left(\frac{1}{\rho}\frac{dP}{dr}\right) = -\frac{2}{\rho r}\frac{dP}{dr} - 4\pi G\rho \tag{20}$$

Multiplying both sides of (20) by r^2 followed by algebraic rearrangement:

$$r^2\frac{d}{dr}\left(\frac{1}{\rho}\frac{dP}{dr}\right) + \frac{2r}{\rho}\frac{dP}{dr} = -4\pi G r^2\rho \tag{21}$$

The two terms on the left of the equality in (21) can readily be seen to be the product rule of differentiation expansion of the following:

$$\frac{d}{dr}\left(\frac{r^2}{\rho}\frac{dP}{dr}\right) = \frac{d}{dr}\left(\left(r^2\right)\left(\frac{1}{\rho}\frac{dP}{dr}\right)\right) = r^2\frac{d}{dr}\left(\frac{1}{\rho}\frac{dP}{dr}\right) + \frac{2r}{\rho}\frac{dP}{dr} \tag{22}$$

Using the result shown in (22), the relationship in (21) can be rewritten as (where both sides have been divided by r^2 following the substitution):

$$\frac{1}{r^2}\frac{d}{dr}\left(\frac{r^2}{\rho}\frac{dP}{dr}\right) = -4\pi G\rho \tag{23}$$

If one now defines x as a dimensionless variable representing the radius and q as a dimensionless variable representing the density, one can write the density as $r = r_c q^n$, where r_c is the central density. One also defines g as $g = (n+1)/n = 1 + n^{-1}$. The polytropic equation of state can be written as the following:

$$P = K\rho^{\gamma} = K\rho_c^{\gamma}\theta^{\gamma n} = K\rho_c^{1+n^{-1}}\theta^{n+1} \tag{24}$$

Substitution of the density relationship ($r = r_c q^n$) and (24) into (23) leads to the following:

$$\frac{1}{r^2}\frac{d}{dr}\left(\frac{r^2}{\rho}\frac{dP}{dr}\right) = -4\pi G\rho \rightarrow \frac{1}{r^2}\frac{d}{dr}\left(\frac{r^2}{\rho_c\theta^n}\frac{d}{dr}\left(K\rho_c^{\gamma}\theta^{n+1}\right)\right) = -4\pi G\rho_c\theta^n \tag{25}$$

Evaluating the form to the right of the arrow:

$$\frac{K\rho_c^{\gamma}}{\rho_c}\frac{1}{r^2}\frac{d}{dr}\left(\frac{r^2}{\theta^n}\frac{d\theta^{n+1}}{dr}\right)=-4\pi G\rho_c\theta^n$$

$$\left(\frac{K\rho_c^{\gamma}}{4\pi G\rho_c^{2}}\right)\frac{1}{r^2}\frac{d}{dr}\left(\frac{r^2}{\theta^n}(n+1)\theta^n\frac{d\theta}{dr}\right)=-\theta^n$$

$$\left(\frac{K\rho_c^{\gamma}(n+1)}{4\pi G\rho_c^{2}}\right)\frac{1}{r^2}\frac{d}{dr}\left(r^2\frac{d\theta}{dr}\right)=-\theta^n$$

The pressure, for the polytropic model, is related to the central pressure, P_c, by $P = P_c q^{n+1} = P_c q^{gn}$. Comparing this to (24), yields $P_c = K r_c^{g}$. Substitution of this result into the unnumbered derivation above results in the following:

$$\left(\frac{P_c(n+1)}{4\pi G\rho_c^{2}}\right)\frac{1}{r^2}\frac{d}{dr}\left(r^2\frac{d\theta}{dr}\right)=-\theta^n \tag{26}$$

Setting a^2 equal to the terms contained within the first parenthetical in (26), yields the following form:

$$\frac{\alpha^2}{r^2}\frac{d}{dr}\left(r^2\frac{d\theta}{dr}\right)=-\theta^n \tag{27}$$

Letting $r = ax$, where a is a scaling factor that relates the dimensionless parameter, x, to the radius, and substituting the result in (27) results in the following:

$$\frac{1}{\xi^2}\frac{d}{d\xi}\left(\xi^2\frac{d\theta}{d\xi}\right)=-\theta^n \tag{28}$$

Equation (28) is the Lane-Emden equation and is the Poisson equation in dimensionless variables. The initial conditions, at $x = 0$, are of $q = 1$ and $dq/dx = 0$. At $r = R$, the density is zero-valued. Thusly $R = ax_1$ is where $q(x)$ first reaches zero. One can rewrite (17) in integral form, which is then equal to the mass.

$$m=\int_0^R 4\pi r^2\rho\, dr \tag{29}$$

Using $r = ax$, $r = r_c q^n$ and $R = ax_1$, (29) can be written as:

$$m=4\pi\alpha^3\rho_c\int_0^{\xi_1}\xi^2\theta^n d\xi \tag{30}$$

Algebraic rearrangement of (28) yields the following:

$$\xi^2\theta^n=-\frac{d}{d\xi}\left(\xi^2\frac{d\theta}{d\xi}\right) \tag{31}$$

Substitution of this solution into the integrand in (30) results in the following solution:

$$m=-4\pi\alpha^3\rho_c\xi_1^{2}\left.\frac{d\theta}{d\xi}\right|_{\xi-\xi_1} \tag{32}$$

One can rewrite a, by substituting for the central pressure in terms of the central density and K (noting that g – 2 = (n + 1)/n – 2n/n = (1 – n)/n).

$$\alpha = \left(\frac{P_c (n+1)}{4\pi G \rho_c^{\;2}} \right)^{0.5} = \left(\frac{K\rho_c^{\;\gamma} (n+1)}{4\pi G \rho_c^{\;2}} \right)^{0.5} = \left(\frac{K\rho_c^{\;n^{-1}-1} (n+1)}{4\pi G} \right)^{0.5} \tag{33}$$

Substitution of (33) into (32) followed by simplification leads to the following result:

$$m = -\frac{(n+1)^{1.5}}{(4\pi)^{0.5}} \left(\frac{K}{G} \right)^{1.5} \left(\rho_c^{\frac{3-n}{2n}} \right) \xi_1^{\;2} \left. \frac{d\theta}{d\xi} \right|_{\xi=\xi_1} \tag{34}$$

From this relationship, when n is equal to three, the mass becomes independent of the central density (because $r_c^0 = 1$). One can define the average density as the ratio of the mass to the spherical volume.

$$\bar{\rho} = \frac{3m}{4\pi R^3} \tag{35}$$

The ratio of the central density to the average density is denoted as D_n, which can be written as the following (after the appropriate substitutions and simplifications).

$$D_n \equiv \frac{\rho_c}{\rho} = -\left(\frac{3}{\xi_1} \left. \frac{d\theta}{d\xi} \right|_{\xi_1} \right)^{-1} \tag{36}$$

Another commonly employed assumption is that the ideal gas law holds (N_A is Avogadro's constant = $6.02214076 \cdot 10^{23}$ mol^{-1}, k is Boltzmann's constant = $1.380649 \cdot 10^{-23}$ J/K and m is the mean molecular weight):

$$P = \frac{N_A k}{\mu} \rho T \tag{37}$$

For the polytropic model, T as a function of radius, T(r) = T_cq, where q is again, a function of radius. Substitution of this relationship and the relationships for pressure and density in terms of their central values into (37), followed by algebraic rearrangement, results in the following:

$$T_c = \frac{\mu K}{N_A k} \rho_c^{\;n^{-1}} \tag{38}$$

Analytic closed form solutions are only present for three specific values of n: for n equals zero (only if one does not use the pressure-density relation explicitly secondary to P = $Kr^{(n+1)/n}$ becoming divergent as n → 0), for n equals one and for n equals five. There are no solutions for n > 5 (x_1 becomes infinite and thusly predicts an infinite radius). For the general case of $0 \leq n \leq 5$, one must employ an approximate numerical method (i.e. numerical integration) in order to obtain a solution. Before briefly presenting the solution approach, one first notes that once a value for n has been chosen (e.g. n = 3), one can either calculate or use precalculated (i.e. tabular) data for certain parameters. For n set to three, x_1 = 6.8969, $-x_1^2(dq/dx)|x_1$ = 2.01824 and D_3 = 54.1825 (Hansen et al., 2004, pg. 340; Pols, 2011, pg. 47). One needs to specify m and K (typically) or m and R. Returning to the problem of the general case (for n), one starts be rewriting (28) by evaluating the derivative.

$$\frac{1}{\xi^2} \frac{d}{d\xi} \left(\xi^2 \frac{d\theta}{d\xi} \right) = \frac{2}{\xi} \frac{d\theta}{d\xi} + \frac{d}{d\xi} \frac{d\theta}{d\xi} = -\theta^n \tag{39}$$

This equation is a nonlinear differential equation and can be rewritten as a system of two first order differential equations by setting x = x, y = q, z = (dq/dx) = (dy/dx), which results in (39) being rewritten as (2/x)z + (d/dx)(dy/dx) = - y^n. The system of two first order differential equations is:

$$\frac{dy}{dx} = z$$
$$\frac{dz}{dx} = \frac{d}{dx}\left(\frac{dy}{dx}\right) = -y^n - \frac{2}{x}z \qquad (40)$$

The system given by (40), starting with initial values for x, y and z can then be numerically integrated (e.g. using fourth order Runge-Kutta numerical integration) to solve for the values of x, y and z at the next increment (i.e. for a step size, h, solve for y_{i+1} and z_{i+1} at $x_{i+1} = x_i + h$). An issue, which can readily be ascertained by cursory examination of (39) is that the relationship fails mathematically when x = 0. This also holds for the second equation (x = x) under (40). Surmounting this issue involves yet another approximation. For a function f(l), that is infinitely differentiable with respect to l, the Taylor series expansion about l = l_a is the power series defined by the following:

$$f(\lambda) = f(\lambda_a) + \frac{f'(\lambda_a)}{1!}(\lambda - \lambda_a) + \frac{f''(\lambda_a)}{2!}(\lambda - \lambda_a)^2 + \cdots = \sum_{k=0}^{\infty} \frac{f^{(k)}(\lambda_a)}{k!}(\lambda - \lambda_a)^k \qquad (41)$$

Where k! denotes the factorial of k, $f^{(k)}(l_a)$ denotes the k^{th} derivative of f(l) evaluated at l_a. The zeroth order derivative of f(l) is defined as the function f(l) and $(l – l_a)^0$ and 0! are both defined to be unity. This expansion is commonly used in mathematics, physics and engineering (e.g. numerical methods such as the finite difference method). Because the summation is infinite, however, dropping higher order terms results in truncation error. The form of the Taylor series expansion, as shown above, fits that of a univariate power series expansion.

$$\sum_{k=0}^{\infty} a_k(\lambda - \lambda_a)^k = a_0 + a_1(\lambda - \lambda_a) + a_2(\lambda - \lambda_a)^2 + \cdots \qquad (42)$$

When l_a is equal to zero in (42), the power series expansion is also known as the Maclaurin series. For the subject case, the Maclaurin series expansion of q(x) is (Hansen et al., 2004, pg. 339):

$$\theta(\xi) = 1 - \frac{1}{6}\xi^2 + \frac{n}{120}\xi^4 - \frac{n(8n-5)}{15120}\xi^6 + \cdots \qquad (43)$$

This results in the following expansion for the first derivative:

$$\frac{d\theta(\xi)}{d\xi} = -\frac{1}{3}\xi + \frac{n}{30}\xi^3 - \frac{n(8n-5)}{2520}\xi^5 + \cdots \qquad (44)$$

Thusly, when x = 0, q(x) ≈ 1 and the first derivative is approximately equal to -x/3, which is equal to zero. An alternative approach is to start the numerical integration at $0 < x \ll 1$. The numerical integration concludes when q = y crosses a zero value. Solving for the central density (r_c), central pressure (P_c) and central temperature (T_c) results in respective values of $7.65 \cdot 10^4$ kg/m^3, $1.25 \cdot 10^{16}$ Pa and $1.18 \cdot 10^7$ K. How well do these values comport with the values that were previously presented as purported “facts?” The calculated central density is approximately 50.3 percent of the “factual” value. The calculated central pressure is approximately 54.3 percent of the “factual” value. The calculated central temperature is approximately 75.2 percent of the “factual” value.

If one’s reaction to the numbers presented above is along the lines of the polytropic model being a known, simple model that obviously underpredicts the “fact’ based “reality” of modernity then there is clearly a failure, which is reasonably expected, when it comes to the myopia of the extant. For the cases of failure of so-called “consensus,” in regards to “facts,” that have already been presented, the myopia of the extent was clearly apt in

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regards to each case, within its own timeframe. The evaluation of this statement starts with William Thomson (i.e. 1st Baron Kelvin or Lord Kelvin). Thomson (1862) articulated the view that sun was "an incandescent liquid not losing heat" and for which "some form of the meteoric theory is certainly the true and complete explanation of solar heat [that] can scarcely be doubted…" This was preceded by "the form of meteoric theory which now seems most probable, and which was first discussed on true thermodynamic principles by Helmholtz consists in supposing the sun and his heat to have originated in a coalition of smaller bodies, falling together by mutual gravitation, and generating, as they must do according to the great law demonstrated by Joule, an exact equivalent of heat for the motion lost in collision." This description, the Kelvin-Helmholtz mechanism, in the subject author's construction, is of surface cooling, causing a reduction in internal pressure, causing contraction, which then results in an increase in internal temperature. Finally, it was noted that there was "no difficulty" in accounting for a solar age of 20 million years, that the lowest estimate was 10 million years (but with 50 or 100 million years "as possible") and that "on the whole most probable" that the "sun has not illuminated the Earth" for 100 million years (and "almost certain" that it had not done so for 500 million years). In regards to the future: "… we may say, with equal certainty, that inhabitants of the earth can not continue to enjoy the light and heat essential to their life for many million years longer unless sources now unknown to us are prepared in the great storehouse of creation." Presented in the same year, but not published until two years later, Thomson (1864) provided an estimate for the age of the Earth as being between 24 million and 400 million years, with 100 million years being the most likely. This estimate was based upon the use of Fourier's heat flow equations and the modeling of the Earth as a formerly molten sphere that had been cooling over time. In a subsequent publication (Thomson, 1899), a significant portion of which involved the context of attempting to refute estimates made by various geologists and biologists that proffered views on much longer age, a reduced age of 20 to 40 million years was articulated.

The influence of Thomson and his views were substantial. As stated by Dalrymple (2022, pg. 38), "in spite of the questionable assumptions and the high degree of uncertainty in the data, Kelvin's calculations of the ages of the sun and the Earth were, at the time, considered highly authoritative. For three decades they stood as the best that physics could offer on the subject." While Thomson's assumptions, in hindsight, are presented as questionable, such assumptions, as they related to Thomson's modeling approaching via thermodynamics, were stated as the very basis for the validity of the conclusions that he articulated and as a counter, in regards to what was being ignored, by various geologists of the time in regards to their conclusions of a virtually infinite age for the Earth (see, again, Thomson, 1864). The "consensus" based upon the "authoritative" stature of Thomson, was predicated upon a 1D (radial) conduction model, for which it was assumed that the Earth was a solid, homogenous block. There is an extant narrative that it was the subsequent "discovery" of radioactivity, a phenomenon unaccounted for by Thomson in the cited writings that predated the "discovery," that altered the "consensus." This narrative may be an apt statement, but is incorrect in regards to whether or not Thomson's modeling assumptions were challengeable and challenged at an earlier point in time. Thomson's former assistant, John Perry, proposed a model in which the Earth's interior was fluid (highly viscous), which in turn would result in heat transfer via convection rather than just conduction. A model of a convective mantle overlayed by a thin, conductive crust, matched the surface heat gradients that Thomson articulated as a basis for his age estimates and yet allowed for a planetary age that was in the billions of years (Perry, 1895). One should not view the geologists as the oppressed that were subjugated under the tyrannical heal of "consensus" engendered by the "authoritative" Lord Kelvin. Fixism, that being the claim that Earth's continents and oceans were immovable (in contrast to plate tectonics and continental drift), was the "consensus" view in the field for over 50 years (ca. 1912 – 1965). Again, it was merely a manifestation of the same underlying paradigm.

Returning, now, to the Lane-Emden model, Lane (1870), articulated the view, in the subject author's construction that challenged the condensed matter "consensus" (as exemplified by the articulated position of Thomson, as discussed above). This involved using hydrostatic equilibrium, again a modeling assumption, for predicting central solar conditions for a sun comprised of gas. Embden (1907) published the definitive solutions for various polytropic indices. Eddington (1926), while introducing radiative transport, still utilized the n = 3 polytrope formulation (the resultant being the Eddington "Standard Model"). Using 1870 as an albeit early estimate and the late 1920s/early 1930s as a terminus estimate, the "consensus" "facts" regarding the sun were of those given by the equations (and assumptions) of polytropic gas spheres. Yet another "consensus" "fact" is of relevance here.

One has already noted the assumed state of matter, as per Thomson, in regards to the sun, but one has yet to discuss the assumed composition. While Wollaston (1802) was the first to publish on the appearance of dark features of the solar spectrum, it is Fraunhofer (1814-1815, 193-226), whose name is attached to the set of spectral absorption lines seen in the solar optical spectrum. Kirchhoff (1859a, 662-665; 1859b; 1860) and Kirchoff and Bunsen (1860) articulated the view that a number of Fraunhofer lines were coincidental to emission lines that could be identified in the spectra of heated chemical elements. The conclusion reached was that the dark lines in the solar spectrum were caused by specific chemical elements in the solar atmosphere. In Kirchhoff's (1861, 63-951; 1862, 227-240) subsequent publications, it was articulated that approximately 60 iron emission lines corresponded to Fraunhofer lines, followed by the conclusion that the sun was an iron "liquid fireball" with an atmosphere comprised of iron vapor. Iron, as the primary solar compositional element, did not change once the condensed matter "consensus" was abandoned for the gaseous "consensus" following the work of Lane. Rowland's (1896) mapping of 20,000 lines in the solar spectrum attributable to iron, with a reference to his spectral analysis first being announced in 1886 and published in serial format between 1895 and 1897, only served to further cement the "consensus" that had been in place for over five decades. It was Rowland (1891), who stated that "were the whole Earth heated to the temperature of the Sun, its spectrum would probably resemble that of the Sun very closely." Henry Norris Russell, whose name the reader might recognize in regards to the Hertzsprung-Russell diagram, articulated the following in a paper published in 1914: "Upon comparing the lists of Rowland and Clarke, we meet at once the fact – one of the commonplaces of astrophysics – that the non-metallic elements, with the exception of carbon and silicon, are scarcely if at all represented in the solar spectrum." That such a "fact" would mean that hydrogen and helium would be scarcely, if at all, represented in the solar spectrum. In the same work, Russell articulated the view that, "in spite of these exceptions, the agreement of the solar and terrestrial lists is such as to confirm very strongly Rowland's opinion that, if the Earth's crust should be raised to the temperature of the sun's atmosphere, it would give a very similar absorption spectrum." An aspect of the "consensus" was that the number and intensity of solar spectral lines carried a direct relationship to elemental abundance. The consequence of this "fact" was yet another "fact" and that being one of 66 percent of the sun being composed of iron. Russell served as a reviewer for the doctoral dissertation of Cecilia Payne. Using Meghnad Saha's ionization theory, Payne concluded that (a) the variation in solar absorption lines was due to differing quantities of ionization at different temperatures (rather than the elemental abundance) and (b) that hydrogen and helium were vastly more abundant than in the terrestrial composition. The statement in Payne's dissertation regarding her findings as almost certainly not real, should not come as a surprise. In 1929, however, Russell himself reached the same conclusion as Payne, provided a brief acknowledgement to the latter, and was generally credited for the conclusions that became the new "consensus."

The SSM solar core

Returning to the 1D SSM, one starts with the presumed and modeled deepest solar region. As noted previously, there are four relationships that are considered for each region. The equation for hydrostatic equilibrium was given by (13). The equation for conservation of mass was given by (17). This leaves the equations for energy generation and energy transfer. For the former, the variational mass of a thin shell was given by (14). Denoting the energy production per unit mass as e(r), the energy production in a 1D shell of variational mass dm is given as:

$$4\pi r^2 \rho(r)\varepsilon(r)\delta r \tag{45}$$

From conservation of energy, the energy flow (L), which is also known as the luminosity, at r + dr, is equal to the sum of the energy flow at r plus the energy generated by the material contained in the 1D shell between r and r + dr.

$$L(r+\delta r) = L(r) + 4\pi r^2 \rho(r)\varepsilon(r)\delta r \tag{46}$$

Rearranging (46) leads to the following:

$$\frac{L(r+\delta r) - L(r)}{\delta r} = 4\pi r^2 \rho(r)\varepsilon(r) \tag{47}$$

Taking the limit as dr goes to zero, just as was done for the derivation of the hydrostatic equilibrium relationship and the conservation of mass relationship, leads to the following:

$$\frac{dL}{dr} = 4\pi r^2 \rho(r)\varepsilon(r) \tag{48}$$

One can readily find alternative forms of (48), that have a higher level of complexity secondary to the inclusion of additional modeling terms, such as entropy per unit mass (s), given by (49) (see equation 1 of Turck-Chièze, 2016), or internal energy per unit volume (e), given by (50) (see equation 3 of Christensen-Dalsgaard, 2021).

$$\frac{dL(r)}{dr} = 4\pi r^2 \rho(r)\left(\varepsilon(r) - T(r)\frac{\partial S(r)}{\partial t}\right) \tag{49}$$

$$\frac{dL}{dr} = 4\pi r^2\left(\rho(r)\varepsilon(r) - \rho(r)\frac{d}{dt}\left(\frac{e(r)}{\rho(r)}\right) + \frac{P(r)}{\rho(r)}\frac{d\rho(r)}{dt}\right) \tag{50}$$

In this work, one will be working with the simplest form, that given by (48), secondary to the actual fact that increasing mathematical complexity, in the context of this work, requires the presentation of additional mathematics, which does not alter the model based contextual presentation, which can be done so with the simpler modeling case. One does note, however, that when (49) is used, the time rate of change of entropy ($\partial S/\partial t$) is a rare case in which an explicit dependence on time is present (this can also be seen in (50) in regards to the second term in the parenthetical). The evaluation of the energy production per unit mass, e(r), regardless of which equation between the three options, between (48) through (50) that one chooses to use, requires further elucidation.

Harkins and Wilson (1915a, 1915b), using Einstein's mass-energy equivalence relationship, were the first to propose that four hydrogen atoms fused into one helium would release enough energy to power the sun (secondary to the 0.77 percent mass loss). Perrin (1919) reached similar conclusions but without referencing Harkins and Wilson. Eddington (1920), who in a later work credited Perrin (a later work rather than the work cited in the previous sentence), while omitting reference to Harkins and Wilson but referencing Aston (1920) in regards to experimental work pertaining to the mass of hydrogen and helium, articulated the following: "The position may be summarized in these terms: the atoms of all elements are built of hydrogen atoms bound together, and presumably have at one time been formed from hydrogen; the interior of a star seems as likely a place as any for the evolution to have occurred…" It is of passing interest to note that the hypothesis of the fusion of hydrogen as the source of solar energy generation was first indicated in the literature almost fifteen years prior to the terminus of the iron "consensus." Bethe (1939), writing nearly a decade after the terminus of the same "consensus," opined the following: The energy production of stars is then due entirely to the combination of four protons and two electrons into an a particle. This simplifies the discussion of stellar evolution inasmuch as the amount of heavy matter, and therefore the opacity, does not change with time." A simplifying assumption, in the subject author's construction of this work, is that any element heavier than helium had to be present at formation and could not be built up, to any significant extent, after formation. This, then allows for the use of such "at birth" metals to act as catalysts for the carbon-nitrogen-oxygen (CNO) cycle. Indicated in the first sentence of the abstract is the following: "It is shown that the most important source of energy in ordinary stars is the reactions of carbon and nitrogen with protons. These reactions form a cycle…" In the subject author's construction of Bethe's work, the fusion of two helium-3 nuclei is missing from the description of the proton-proton (pp) chain, a core temperature of 18 to 20 million K was used to justify the proposed rates of nuclear reactions, mathematical extrapolation was used to downscale laboratory test results (high energies) to the predicted low energies of the core and the omission of neutrinos from the energy balance equations. Care should be taken when claims are made in current textbooks in regards to Bethe having "proved" how the Sun generates energy. Setting aside claims of proof, Bethe's articulated view, as constructed by the subject author, is of dominance of the CNO cycle, which is adverse to current theory, and yet is often glossed over when it comes to presentations that just happen to leave out the historical actualities and result in a narrative of continuous and uncontested "discovery."

The reader is again reminded that there is no supportive evidence for the claim that any human (generic singular) or human created system has access to the hypothesized solar core as it relates to obtaining direct measurements. There is substantial evidence to the contrary. Both are stated with epistemic humility. One has already noted that the placement of excessive weight on the domain and bandwidth limited information accessible by human organic sensory systems is a dubious proposition. Conversely, however, care should be taken when it comes to claims that individual atoms have been "observed" by using scanning tunneling microscopy, atomic force microscopy or their variants. These are not relatively simple visual microscopy based determinations. Rather, they are heavily model dependent in regards to the processing of raw signals through layers of theoretical assumptions and mathematical reconstruction. This also holds when it comes to subatomic particles. Claims of "observations" of novel subatomic particles during LHC experiments are again not the direct visualization of subatomic particles. Electrical impulses generated by silicon trackers are algorithmically processed, again heavily model-laden, for "inferring" particle paths. The interpretation of data from calorimeters is also heavily model-laden (geometric algorithms for energy clustering, algorithms such as the Anti-Kt algorithm for jet identification, Monte Carlo simulation for detector calibration, machine learning algorithms for particle identification and leakage correction algorithms for how much energy should have escaped when a shower is poorly contained). The standard model is then used to "observe" particles by their missing transverse energy (i.e. using a model to calculate "something" in order for conservation of momentum to hold). As noted by Zheng (2025): "This explanatory paradigm requires complex assumptions including 17 elementary particles, four fundamental interactions, and mechanisms like the Higgs mechanism. It also indirectly characterizes the mass of particles by converting it into energy units (eV) through theoretical models." Another issue, specifically involving the LHC, is that "… LHC experiments use real-time data analysis, known as "triggering," in order to select roughly between 0.001% and 0.01% of the most interesting data collected by the detectors for further analysis and permanently discard the rest (Gligorov, 2015)." The most interesting data, not surprisingly, is data that has been deemed so based on a priori model based filtering.

Returning to the issue of how e(r) is modeled, one first notes that it is assumed that (a) the ideal gas law holds and (b) that the ideal gas in the modeled core is fully ionized. The second assumption is predicated upon the assumed central temperature, which results in $kT \approx 1.3$ keV. This is compared to the modeled "observation" of 13.6 eV as the binding energy of an electron to a proton (^1H consists of one proton and one electron), the binding energies for the first (24.6 eV) and second (54.5 eV) electrons of helium and the binding energies for most but not all electrons of iron (as an example of a metal, with 26 electrons, the K-shell electrons require between 7 to 9 keV for removal). Each binding energy value is a modeled observation based upon applying quantum electrodynamics and the Schrödinger equation to spectral data (the Lyman limit, followed by the Rydberg formula followed by a number of theoretical corrections). Of course, these binding energies are based upon spectroscopy conducted under "vacuum" (i.e. low pressure) conditions in Earth based laboratories. At the modeled central pressure of the Sun, the modeled response is of pressure ionization (overlapping of electrical fields between neighboring protons and electrons). The continuum lowering of binding energy at such pressures is modeled (guessed at) by the use of the Debye-Hückel model (Rosseland, 1924).

Under this assumption of full ionization, in which electrons no longer move between atomic orbits, as in the bound case, the deflection of freely moving electrons, by protons, results in energy loss for the former, which is manifested by photon emission (braking radiation or bremsstrahlung). Because such a deflection "can" be any amount, the emitted photon "can" be of any wavelength. This is coupled with an assumption of infinite optical depth ($t \rightarrow \infty$). In natural language, the assumption is that the "core" is so dense that photons cannot move freely (an assumed mean free path of 0.01 centimeters) and are almost immediately, following emission, reprocessed by the plasma. This results in an ideal perfect trap in which the photons and the plasma reach the same energy state. This, in turn, "justifies" the use of the Planck function which provides a modeled result of a smooth curve of all wavelengths where the only independent variable is temperature. A third assumption is that for every photon emitted, an identical photon is absorbed nearby. This assumption removes the "identity" of photons (i.e. the specific nuclear reaction or elements involved in the generation of the photons) and renders all photons in the "core" as being isotropic and anonymous. Of course, magnetic field effects (Zeeman effect or synchrotron radiation) and non-thermal effects are excluded. The assumption that sits on top of these assumptions is that for the core, the source function (S_v) is equivalent to the idealized Planck function (B_v) across all frequencies (from zero to infinity) of the electromagnetic spectrum. The claims of the time taken for a photon to "escape" the core being, on average of 170,000 years, are based entirely on this set of modeling assumptions (the answer is negative

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in regards to there being observational evidence of tracking a photon for this time period, from its "birth" in the core until its "escape" from the core).

Conversely, when it comes to protons, the modeled space between nuclei is 10^{-11} m while the modeled size of a proton is on the scale of 10^{-15} m. There is, however, a problem and that is that, in theory, a temperature of 15.7 million K is insufficient to generate the energies needed to overcome the Coulomb barrier (the modeled force that is repulsive between two point charges of the same charge; here, overcoming proton-proton repulsion, approximately 1000 keV). The claimed "fix" to this issue is quantum tunneling. While this is a modeled observation for alpha particles and is used in the design of tunnel diodes, the claim that it applies to the modeled conditions of the "core" is pure assumption and scale-invariant extrapolation. In theory, the validity of this claim should be readily testable. All one would need to do is create a sufficient volume of plasma at the modeled temperature, pressure and density values and… Here, one has to remind oneself that such a laboratory scale creation is one that has thus far proven to be beyond the ken of any human. This also applies when it comes to creating a plasma that is simultaneously opaque enough to be a perfect blackbody and yet transparent enough to allow for sustained proton-proton fusion. The following notation is used for presenting the proton-proton chain: proton (p or ^{1}H), deuteron or heavy hydrogen (d or ^{2}H), helium (^{3}He or ^{4}He depending on isotope), lithium (^{7}Li), beryllium (^{7}Be, ^{8}Be or $^{8}Be^{*}$ depending on isotope and where the * in the right superscript indicates an excited state), boron (^{8}B), lithium (^{7}Li), electron (e^{-}), positron (e^{+}), gamma ray (g) and electron neutrino (n_e). There are four branches for the pp chain, with the first three typically denoted as pp I, pp II and pp III. The fourth branch is typically denoted as pep (proton-electron-proton). The reaction sequence for the pp I branch is:

$$\begin{gathered} p^{+}+p^{+}\rightarrow {}^{2}H+e^{+}+\nu_{e} \\ {}^{2}H+p^{+}\rightarrow {}^{3}He+\gamma \\ {}^{3}He+{}^{3}He\rightarrow {}^{4}He+2p^{+} \end{gathered} \tag{51}$$

The pp II branch starts with the first two reactions shown under (51).

$$\begin{gathered} {}^{3}He+{}^{4}He\rightarrow {}^{7}Be+\gamma \\ {}^{7}Be+e^{-}\rightarrow {}^{7}Li+\nu_{e} \\ {}^{7}Li+p^{+}\rightarrow {}^{4}He+{}^{4}He \end{gathered} \tag{52}$$

The pp III branch starts with the first two reactions shown under (51) and the third reaction shown under (52).

$$\begin{gathered} {}^{7}Be+p^{+}\rightarrow {}^{8}B+\gamma \\ {}^{8}B\rightarrow {}^{8}B^{*}+e^{+}+\nu_{e} \\ {}^{8}B^{*}\rightarrow {}^{4}He+{}^{4}He \end{gathered} \tag{53}$$

Finally, the fourth branch (i.e. the pep reaction) is:

$$p^{+}+e^{-}+p^{+}\rightarrow {}^{2}H+\nu_{e} \tag{54}$$

The percentage contribution to the second reaction of the pp I branch is 99.77 percent from the first reaction of the same branch and 0.23 percent from the pep reaction. The second reaction of the pp I branch can lead to the third reaction in the same branch (84.92 percent), the first reaction of the pp II branch (15.08 percent) or to what is referred to as the hep (helium-proton) reaction (10^{-5} percent).

$${}^{3}He+p^{+}\rightarrow {}^{4}He+e^{+}+\nu_{e} \tag{55}$$

The first step of the pp II branch proceeding along the same branch is 99.9 percent and with a 0.01 percent proceeding to the PP III branch. The CNO cycle is either presented as a single cycle or as a bi-cycle when one incudes side reactions. The former is shown here, where the following additional notation is used: carbon (^{12}C or ^{13}C depending upon isotope), nitrogen (^{13}N or ^{14}N depending on isotope) and oxygen (^{15}O).

$$\begin{aligned}
&^{12}C+p^{+} \rightarrow {}^{13}N+\gamma \\
&^{13}N \rightarrow {}^{13}C+e^{+}+\nu_{e} \\
&^{13}C+p^{+} \rightarrow {}^{14}N+\gamma \\
&^{14}N+p^{+} \rightarrow {}^{15}O+\gamma \\
&^{15}O \rightarrow {}^{15}N+e^{+}+\nu_{e} \\
&^{15}N+p^{+} \rightarrow {}^{12}C+{}^{4}He
\end{aligned} \tag{56}$$

Adelberger et al. (2011) state the following: "Two reactions discussed in this review, p + p → d + e^{+} + n_e and ^{3}He + p → ^{4}He + e^{+} + n_e, are presently beyond the reach of experiment." In the subject author's construction of this statement, the very first step in the pp I branch and the hep reaction have zero laboratory verification. Since the empirical support is zero, the entire basis for the reactions is effective field theory (and for the Sun, the assumption is stretched to the weak interaction behaving exactly as modeled by current particle physics theories, at the modeled densities). A reason for the convoluted nature of the pp cycle is secondary to the mass-5 and mass-8 barriers. In theory, one could take a ^{4}He nucleus and a proton and produce ^{5}Li. Yet, there are no known stable nuclides with a mass number of five. One could also take two ^{4}He nuclei and fuse them to create ^{8}Be. Neither ^{5}Li nor ^{8}Be has been created, in the laboratory setting, to determine the result of what happens when either is impacted by another particle or subatomic particle. Numerical values for the half-life of each (^{5}Li decaying into one p^{+} and one ^{4}He in ~ 10^{-22} sec and ^{8}Be decaying into two ^{4}He in ~ 10^{-16} sec) is either entirely based on theory or based on modeling (e.g. the case of ^{8}Be in regards to taking the "observed" resonance from particle accelerator testing and dividing by the reduced Planck constant) or outright extrapolation. How these mass barriers actually function in the solar interior is entirely based upon quantum mechanical simulations and extrapolation of particle accelerator data. One would be remiss to not note that the percentage values provided for the pp chain, in regards to reaction occurrence, are not measured. Rather, they are what is required for the SSM to produce a modeled luminosity that is equal to the modeled "observed" luminosity. In regards to the CNO cycle, none of the reactions have been reproduced, in a laboratory setting, under the conditions that purportedly exist in the solar core.

One now returns to (48), the simplest of the models for energy generation, and evaluates the energy generation per unit mass term, e(r), in greater detail. The modeled reaction rate between two nuclei, r_{12}, is (Burbidge et al., 1957):

$$r_{12} = \frac{n_1 n_2}{1+\delta_{12}} \langle \sigma v \rangle_{12} \tag{57}$$

In (57), n_1 and n_2 denote the number densities of the nuclei (type 1 having atomic number Z_1 and mass number A_1 and type 2 having atomic number Z_2 and mass number A_2), d_{12} denotes the Kronecker delta and $<sv>_{12}$ denotes the product of the reaction cross section (s) and the relative velocity (v) of the interacting nuclei. If the two particles are different(e.g. a proton and a carbon-12 nucleus), d_{12} is zero. If the two particles are the same (e.g. two protons), d_{12} is one. The brackets on sv are mathematically symbolic for averaging over the entire range of modeled possible particle velocities within the core. Thusly:

$$\langle \sigma v \rangle_{12} = \int_0^{\infty} \sigma(v)\Phi(v) v\,dv \tag{58}$$

The presumed conditions of the solar interior precipitates the use of the Maxwell-Boltzmann distribution for the relative velocity. This is clearly not only the case of circular reasoning in which the assumptive requirement of one model, rather than direct observation, drive the choice of yet another model, thereby rendering what one would otherwise be attempting to prove into what is instead assuming. The Maxwell-Boltzmann distribution for the relative velocity is:

$$\Phi(v) = 4\pi v^2 \left(\frac{\mu}{2\pi kT}\right)^{1.5} \exp\left(-\frac{\mu v^2}{2kT}\right) \tag{59}$$

In (59), m denotes the reduced mass, which is the multiple of the masses of the collision partners divided by the sum of the masses of the collision partners. The relative kinetic energy, E, in the center of mass reference frame is given by the following, which can be rearranged to solve for the relative velocity.

$$E=\frac{1}{2}\mu v^2 \rightarrow v=\left(\frac{2E}{\mu}\right)^{0.5} \tag{60}$$

Differentiating both sides of (60) followed by algebraic rearrangement allows one to determine the differential dv in terms of the differential dE.

$$dE=\mu v dv \rightarrow dv=\frac{dE}{\mu v}=\frac{dE}{\mu\left(2E\mu^{-1}\right)^{0.5}}=\frac{dE}{\left(2E\mu\right)^{0.5}} \tag{61}$$

Substitution of (59) into (58) followed by substitution for v using (60) and dv using (61) and simplifying the resultant leads to the following:

$$\langle \sigma v \rangle=\sqrt{\frac{8}{\pi\mu}}\left(kT\right)^{-1.5}\int_0^\infty \sigma\left(E\right)E\exp\left(-\frac{E}{kT}\right)dE \tag{62}$$

The cross-section, s(E), not surprisingly, is also modeled.

$$\sigma\left(E\right)=\frac{S\left(E\right)}{E}\exp\left(-2\pi\eta\left(E\right)\right) \tag{63}$$

In (63) h(E) is the Sommerfeld parameter, which in turn, is calculated as:

$$\eta\left(E\right)=\frac{Z_1 Z_2 e^2}{\hbar v} \tag{64}$$

Where Z_1 and Z_2 are the respective proton number (as noted before), for the reacting nuclei, e (ignoring any other usage of the symbol as a variable) is the elementary charge, $\hbar$ is the reduce Planck constant and v, again, is the relative velocity. Thusly, the Sommerfeld parameter represents the ratio of the electrical repulsion (Coulomb potential) to the relative velocity of the particles. The Gamow factor represents the electrical repulsion, while S(E), the astrophysical S-factor, is a "tunable knob" that represents the nuclear portion of the reaction. S(E) is extrapolated (Adelberger et al., 2011) and not interpolated. Using the relationship between the relative velocity and relative kinetic energy, as per (60), one can rewrite (64).

$$\eta\left(E\right)=\frac{Z_1 Z_2 e^2}{\hbar\left(2E\mu^{-1}\right)^{0.5}} \tag{65}$$

Multiplying both sides of the equality in (65) by 2p, secondary to the presence of 2ph(E) in the operand of the exponential function in (63), one can group all of the constant into a single term, b, where b = 2ph(E)$^{0.5}$ = paZ_1Z_2(2mc^2), where a is the fine-structure constant and c is the speed of light in an ideal vacuum. As a result, the cross-section can be written as:

$$\sigma\left(E\right)=\frac{S\left(E\right)}{E}\exp\left(-\frac{b}{E^{0.5}}\right) \tag{66}$$

In looking at the reaction rate integral, as per the definition of <sv>, one has a multiplication between the Maxwell-Boltzmann distribution (~ exp(-E/(kT)) and the quantum tunneling probability(~ exp(-b/(E)$^{0.5}$). To find the window where fusion occurs, one finds the energy, E, where the product of the two exponentials is at a maximum. This maximum, or peak, energy is $E_0 = (bkT/2)^{2/3}$. For the proton-proton chain, this works out to approximately 6 keV. Thusly, the modeled fusion doesn't occur at the "average" energy of the solar core. Only a small fraction of the protons in the solar core (much less than one percent) are modeled as having sufficient energy to enter the very narrow Gamow window. There is, of course, an issue with a peak energy of 6 keV. Earth based laboratory experiments operate in the range of 100 to 1000 keV (the reaction rates at 6 keV are nearly zero under laboratory achievable conditions). This is of import in regards to the astrophysical S-factor. The Taylor series expansion, discussed previously as per (41), is again employed.

$$S(E) \approx S(0) + S^{(1)}(0)E + \frac{1}{2}S^{(2)}(0)E^2 \tag{67}$$

In (67), the values of S(0) and its derivatives are extrapolated down (i.e. guessed at) from higher energy laboratory testing (this assumes that S is a continuously smooth function of E through the second derivative). If this extrapolation doesn't scale downward or if there are changes (resonances such as spikes) in the reaction probability, the modeled changes in regards to S(0) and its derivatives (collectively, the set of "tunable knobs" here) would be modeling artifacts. Once r_{12} has been determined, the energy production per unit mass, e(r), is determined by:

$$\varepsilon(r) = \frac{Q\, r_{12}}{\rho(r)} \tag{68}$$

In (68), Q is the energy produced in a single event (e.g. 26.7 MeV for the full pp chain). One also sees the energy generation relationship approximated as follows:

$$\varepsilon \approx \varepsilon_0 \rho X_1 X_2 T^{\eta} \tag{69}$$

The relationship shown in (69) is a simple power law approximation (h ≈ 4 for the modeled pp chain and approximately 17 for the modeled CNO cycle). The luminosity "check" for a model is given by comparing the modeled "observed" luminosity to the calculated SSM based luminosity. When they match, the following holds:

$$L_{\odot} = \int_0^R 4\pi r^2 \varepsilon(r)\rho(r)\,dr \tag{70}$$

Energy transfer in the core is assumed to be radiative. One has already mentioned the assumption regarding the mean free path of 0.01 centimeters. Because of this assumption, in relationship to the solar radius, radiation is modeled as a diffusion process. Another assumption, again not verifiable, is that in each shell in the modeled core, the radiation and plasma have the same temperature. This is known as local thermodynamic equilibrium (LTE). The derivation of the energy transfer relationship starts with the thermodynamics relationship between pressure and temperature for a photon gas.

$$P = \frac{1}{3}aT^4 \tag{71}$$

In (71), the parameter, a, is the radiation constant. For radially outward energy transfer, there must be a pressure gradient. This can obtained by differentiating the pressure with respect to the radius (note that the temperature is also a function of the radius).

$$\frac{dP}{dr} = \frac{4}{3}aT^3\frac{dT}{dr} \tag{72}$$

The pressure gradient can then be mathematically related to the radiative flux, F, which is the amount of energy passing through a unit area. This is the radiative diffusion equation.

$$\frac{dP}{dr} = -\frac{\kappa\rho(r)}{c}F \tag{73}$$

Where k is the opacity. The radiative flux can be written in terms of the luminosity, here as function of r, and under the assumption of spherical symmetry, as $L(r) = 4pr^2F$. Inverting this relationship and substituting the result in (73) results in the following:

$$\frac{dP}{dr} = -\frac{\kappa\rho(r)L(r)}{4\pi cr^2} \tag{74}$$

Because both (72) and (74) define the same pressure gradient, they must be equal. Setting the two equations equal to each other and solving for the temperature gradient yields the following:

$$\frac{dT}{dr} = -\frac{3}{16\pi ac}\frac{\kappa\rho(r)L(r)}{r^2T^3} \tag{75}$$

An alternative form of (75) can be obtained by the thermodynamic relationship between the radiation constant and the speed of light (i.e. $a = 4sc^{-1}$). Here, barring all prior usage, s refers to the Stefan-Boltzmann constant. Substitution of this relationship into (75) results in the following form:

$$\frac{dT}{dr} = -\frac{3}{64\pi\sigma}\frac{\kappa\rho(r)L(r)}{r^2T^3} \tag{76}$$

The "tunable knob" for the radiative energy transport is hidden in the opacity, which is calculated to be a an averaged (smoothed) single number (the Rosseland mean). Starting with the LTE assumption, the LTE temperature is plugged into the Saha-Boltzmann equations ((returning the "fact," as noted above, that the temperature is so high that all electrons are free). This modeled result is then used to justify the claim that the core is an all wavelength source. The assumption of LTE and "fact" of the core being a perfect blackbody source are used to calculate a single opacity value for the sea of free electrons. This modeled result then results in yet another modeled result of the random walk, leading to the modeled result of light being "perfectly" trapped, which then "proves: that LTE must be true. The Saha-Boltzmann equations, which will not be presented in detail here, requires a partition function, which is the sum of all possible states that an atom can be in, which in theory is infinity (a value that destroys the mathematics) and thus subject to arbitrary cutoffs using "occupancy probability" and "pressure ionization." One rarely calculates the Rosseland mean opacity value by hand. Rather, one uses precalculated lookup tables, which are built on millions of modeled atomic transitions (again, relying on laboratory scale physics), such as OPacity at Lawrence Livermore National Laboratory (OPAL) and OPacity LIBrary (OPLIB, also known as the Los Alamos OPLIB database), which provides a single value, k, for an assumed elemental mixture, temperature and density (or the variable r/T_6^3 where T_6 is the temperature in millions of Kelvin). The justifications, as noted above, are circular in nature given that one is "proving" that which one has assumed in order to utilize the equations. A parameter of importance to the calculation of opacity is the mean molecular weight. Iron, as an example of a metal, adds an iron nucleus and 24 free electrons (out of 26) at the modeled energy of the solar core. On a per atom basis, metals contribute more free electrons, on a per atom basis, than either hydrogen or helium. Thusly, the calculations for opacity are highly dependent upon the assumed elemental constituents. When discrepancies arise between modeled results and new model filtered observations, opacity is often adjusted to remove the discrepancy and preserve the model.

The transition between the modeled core and the modeled radiative zone, as expected, is entirely modeled (and not directly observable). The criteria used to set the boundary radius is the radius where the cumulative luminosity equals 99 percent of the "observed" luminosity. Depending upon the model, this occurs at between 20 to 25 percent of the "observed" solar radius. For a SSM, with increasing time, the mean molecular weight in the modeled core should be increasing secondary to the modeled fusion of hydrogen into helium. On the radiative zone side of the boundary, however, the elemental composition is modeled as being static and unmixed.

The SSM radiative zone

For the radiative zone, hydrostatic equilibrium as per (13) and conservation of mass as per (17) are taken as being valid. The energy generation for this zone is set to zero (i.e. no new energy generation). Energy transfer is again assumed to be radiative and follows the form of (75). While the chemical composition within the radiative zone is static, the modeled opacity is not. The modeled temperature near the inner boundary is typically around $7 \cdot 10^6$ K while the modeled temperature near the outer boundary is typically around $2 \cdot 10^6$ K. While the details are not presented here, yet another mathematical model, Kramer's opacity "law," leads to the following proportionality: $k \propto rT^{-3.5}$. While one might expect the opacity to increase with decreasing radius (i.e. closer towards the center of the spherically modeled sun) secondary to increasing density, the temperature increase is far steeper resulting in the $T^{-3.5}$ term dominating the modeled opacity. Thusly, moving from the outer aspect of the modeled radiative zone to the inner aspect results in a decrease in the modeled opacity. The total opacity is taken as the sum of four distinct, heavily modeled, atomic interactions (free-free and free-bound electron scattering and bound-bound and bound-free transitions), the details of which are beyond the scope of the subject work but which can readily be found elsewhere (Shu, 1991). As noted above and just as for the modeled solar core, interpolated opacity tables are used for the radiative zone.

The transition from the radiative zone to the convective zone is based on the Schwarzschild (1958, pp. 37-51) criterion. This criterion is based on comparing two modeled temperature gradients, the radiative and the adiabatic, both of which share the same dimensionless form:

$$\nabla \equiv \frac{d\ln T}{d\ln P} \tag{77}$$

The radiative temperature gradient defines the temperature profile that would be present if photons were the sole mechanism by which energy was transported through the modeled shell under consideration. This derives directly from (75).

$$\nabla_{rad} = \left(\frac{d\ln T}{d\ln P}\right)_{rad} = \frac{3}{16\pi acG} \frac{\kappa P L(r)}{m(r) T^4} \tag{78}$$

The luminosity, L(r), and the mass, m(r), refer to the enclosed values. The adiabatic temperature gradient, by definition, refers to temperature change as a result of pressure change and under the assumption that there is no heat exchange with the surrounding environment. For a monoatomic ideal gas, the adiabatic temperature gradient is a thermodynamic constant.

$$\nabla_{ad} = \left(\frac{d\ln T}{d\ln P}\right)_{ad} = \frac{\gamma - 1}{\gamma} \tag{79}$$

In (79), g is the specific heat, which for fully ionized monoatomic gas is equal to 5/3. Substitution of this value into (79) leads to the solution of $\nabla_{ad} = 0.40$. For each shell in the radiative zone, the radiative temperature gradient is calculated and compared to the constant adiabatic temperature gradient. A shell is within the radiative zone if $\nabla_{ead} < 0.40$. In theory, the radius at which $\nabla_{ead} = 0.40$ should be variable depending on the values used for the various model parameters. However, $\nabla_{ead} = 0.40$ is mapped to occur at exactly $r = 0.713R_{\odot}$. A fixed value of the modeled solar radius is used in an attempt to avoid mathematical instability in the coupled differential equations. More importantly, showing yet another case of circularity, is that the specific value of 0.713 times the modeled solar radius is required because of helioseismic inversion models (the claim that such models "validate" the SSM can readily be seen to be dubious secondary to such circularity). Forcing the radiative temperature gradient to exactly equal 0.40 at the location of 0.713 times the modeled solar radius is mediated through the opacity "tuning knobs" by altering the presumed metal composition and electron-capture models. The modeled and unobservable transition between the modeled radiative zone and modeled convective zone is called the tachocline. A zero thickness radially invariant transition zone, which while required for a 1D model that does not involve the calculation of 3D fluid shear (yet again, more modeling), has certain issues in regards to the very helioseismic inversion models used to justify its existence. The conclusion that the external equatorial regions of the sun rotated at a faster rate than the polar regions (latitudinal differential rotation) was based upon direct observation in the early 1600s CE. In regards to the unobservable regions of the sun, pre-helioseismology modeling, based on conservation of angular momentum, led to the conclusion that the solar core and radiative zone should have a higher rate of rotation than the surface. Based upon helioseismic inversion models, the radiative zone is treated as rotating in a manner similar to a solid billiard ball while the convective zone is treated as having differential rotation. The expectation that the boundary between the zones would be aptly describable as a highly turbulent fluid shear layer is not an unjustifiable expectation. The resultant conclusion that a claim that either a zero thickness mathematical artifact or that a less than 0.05 modeled solar radius thickness (using other models; see Table 2 of Howe, 2009) remains intact against the modeled massive turbulence that surrounds it is dubious. To keep this layer intact, additional "tuning knobs," external to the SSM, such as viscosity and magnetic braking are invoked and with questionable assigned values used coupled with the claim of magnetic tension. There are also ad-hoc parameters based upon a hypothesized internal magnetic field, locked into the radiative zone, which acts as a rigid skeleton to force the entire zone to rotate at a single angular velocity (Goode and Dziembowski, 1991). For details regarding hydrodynamic models of the tachocline, see part II of Hughes et al. (2007).

While the SSM does not account for magnetic effects, the tachocline serves as a modeled physical location for anchoring the model filtered observation of the solar magnetic cycle (i.e. the 11 year sunspot cycle). The presentation of the tachocline as the origin of solar magnetism as a "fact" is not based upon fact but rather based upon mathematical modeling. There are zero direct measurements, model filtered or otherwise, for the magnetic field strength at the depth of the modeled tachocline. Another somewhat obvious issue is that if the convective zone, a modeled region of boiling plasma, is apt, then one has a problem with explaining the mechanism by which the momentum of such plasma magically stops at a zero thickness or very thin boundary. The attempts to patch over this issue, the issue of convective overshoot, are also ad-hoc. When included, this is modeled by means of the overshoot length equation.

$$d_{ov} = \alpha_{ov} H_p \tag{80}$$

In (80), d_{ov} is the overshoot distance (i.e. the distance that the modeled plasma of the modeled convective layer is allowed to enter into the modeled radiative zone), H_p is the pressure scale height at the boundary (i.e. the radial distance over which the modeled solar pressure changes by a given factor; this is approximately $5 \cdot 10^4$ km for a radial value of 71.3 percent of the solar radius) and a_{OV} is yet another "tuning knob" (typically between 0.1 and 0.3) which has no derivational basis in any fundamental physics equation. The overshoot distance is related to d_{ov}, modeled dimensionless value that provides the measure for superadiabatic deviation within the modeled overshoot layer. It represents the extent to which the modeled temperature gradient drops below the modeled ideal adiabatic gradient of $\nabla_{ad} = 0.40$.

$$\delta_{ov} \equiv \nabla_{ad} - \nabla \tag{81}$$

The value of d_{ov} is not treated as a constant. Rather it is treated as having a functional dependency on the depth radially inward from the convective boundary (the depth, z, at the boundary being zero). Thusly, $d_{ov}(z) = 0$ for $z \geq d_{ov}$ (at a distance of d_{ov} below the convective boundary, the thermal deviation must vanish and the temperature gradient must match the modeled radiative gradient). The shape of $d_{ov}(z)$ across the overshoot distance involves yet more mathematical modeling (non-local convection modeling such as the Shaviv-Salpeter or Zahn framework). The kinetic energy flux (F_{kin}) of parcels of plasma entering the overshoot zone is related to the deceleration of the parcels, over the distance d_{ov}, balanced by the thermal work done against buoyancy, which is governed by d_{ov}.

$$\int_0^{d_{ov}} \delta_{ov}(z) \cdot \left(\frac{g \rho c_p}{H_p} \right) dz = F_{kin}(0) \tag{82}$$

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In (82), $F_{kin}(0)$ is the kinetic energy flux of the plasma parcels entering from the convective zone, g, r and c_p, respectively, are the local gravity, density and specific heat capacity of the plasma within the shell. In practice, (82) is not solved directly. Instead, a polynomial or exponential damping model is used.

$$\delta_{ov}\left(z\right)=\delta_0\left(1-\frac{z}{d_{ov}}\right)^n \tag{83}$$

The overshoot distance controls the slope at which the temperature gradient is rewritten. As the a_{ov} "tuning knob" is increased, d_{ov} increases, which increases the denominator in (83), thereby increasing the distance over which d_{ov} operates, which results in a more gradual blending of the temperature profile. In the Aarhus Stellar Evolution Code (ASTEC) codebase, n is set equal to zero, with a_{ov} being set to between 0.10 and 0.25. This creates a discontinuity at d_{ov}, where the temperature gradient jumps to 0.40 to the local radiative value (this is smoothed using artificial numerical diffusion). In the Modules for Experiments in Stellar Astrophysics (MESA) codebase, a diffusion coefficient (D_{ov}) and an exponential thermal gradient decay is used.

$$D_{ov}\left(z\right)=D_0\exp\left(-\frac{2z}{f_{ov}H_p}\right) \tag{84}$$

In (84), d_{ov} is not used and is replaced by another "tuning knob," f_{ov}, the Herwig parameter, which is typically set to between 0.014 and 0.020. The exponential thermal gradient decay model (Herwig, 2000) was chosen to match the results of yet another mathematical model (3D hydrodynamic simulations). The relevance of convective overshoot to the lithium depletion problem is presented slightly later in this work.

The SSM convective zone

For the modeled convective zone, hydrostatic equilibrium and mass conservation remain as before, energy generation remains off and energy transfer is replaced with yet another mathematical model. The convective temperature gradient is modeled as being between the adiabatic and radiative limits.

$$\nabla_{conv}=\nabla_{ad}+\left(\nabla_{rad}-\nabla_{ad}\right)\left(1-\Gamma\right) \tag{85}$$

In (85), the term G {G: 0 ≤ G ≤ 1} is the convective efficiency. Near the boundary with the modeled radiative zone, G → 1, which forces the convective temperature gradient to match the adiabatic limit. Near the photosphere, G → 0, which forces the convective temperature gradient to match the modeled radiative temperature gradient of the photosphere. The superadiabatic excess (discussed in the previous subsection), here denoted as x, is defined as:

$$\xi=\nabla_{conv}-\nabla_{ad}=\left(\nabla_{rad}-\nabla_{ad}\right)\left(1-\Gamma\right) \tag{86}$$

The convective velocity equation, which is for the average radial speed at which convective plumes are assumed to move through a shell within the zone is given by the following:

$$v_{conv}=c_{conv}\alpha_{MLT}\left(\frac{gQH_p}{8}\right)^{0.5}\left(\nabla-\nabla_e\right)^{0.5} \tag{87}$$

In (87), c_{conv} is the geometric dissipation parameter (fixed at ½ or 1/3), ∇_e is the temperature gradient of the convective gas parcel, ∇ is the ambient temperature gradient of the surrounding solar shell, H_p (as before) is the local pressure scale height, g is the local gravitational acceleration and a_{MLT} is the mixing length ratio (the primary "tunable knob"). Q is the dimensionless expansion coefficient for the plasma at constant pressure.

$$Q\equiv-\left(\frac{\partial\ln\rho}{\partial\ln T}\right)_P=-\frac{T}{\rho}\left(\frac{\partial\rho}{\partial T}\right)_P \tag{88}$$

For a standard monoatomic ideal gas, Q = 1. This is the value used in the modeled lower convective zone. In the upper convective zone, however, the value of Q can spike to over 4.0 or 5.0 (for partial ionization). The values for Q are not calculated within the SSM, but rather are obtained, for each step, from pre-computed equation of state tables (e.g. OPAL-EOS). The validity of any value for Q is highly dependent upon the assumed mass fractions of the assumed elemental composition. The tables are based on two stabilized variables, which as axes in a coordinate system are, the T_6 axis (i.e. $\log_{10}(T/10^6$ K), where 10^6 K = one million Kelvin) and the "natural" density gradient of a self-gravitating sphere axis (i.e. $r/(T^6)^3$ where r is a function of radial position). The software used for implementing the equation of state tables performs a 3D spline interpolation across the two axes and the assumed mass fraction to determine the pressure response to temperature at a fixed density (c_T) and the pressure response to density at a fixed temperature (c_r).

$$\chi_T = \left(\frac{\partial \ln P}{\partial \ln T}\right)_\rho \quad \chi_\rho = \left(\frac{\partial \ln P}{\partial \ln \rho}\right)_T \tag{89}$$

Once these parameters are interpolated, the value for Q is obtained using the thermodynamic chain rule.

$$Q \equiv -\left(\frac{\partial \ln \rho}{\partial \ln T}\right)_P = \frac{\chi_T}{\chi_\rho} \tag{90}$$

Mixing length theory (Böhm-Vitense, 1958) is based upon the assumption of symmetric up-and-down buoyancy. The assumption is manifest in regards to the following: for each parcel of plasma rising upward (radially outward) at velocity $+v_{conv}$, an identical parcel of plasma is sinking downward (radially inward) at velocity $-v_{conv}$. This is how conservation of mass is enforced within a 1D shell for this modeled zone. The velocity given by (87) is thusly not a velocity but is rather the scalar speed (i.e. the absolute speed of the idealized dual traffic). The direction of travel is dictated by the difference of gradient term. This modeling assumption comports poorly when compared to 3D hydrodynamic models and simulations, the results of which are interpreted to indicate a deep asymmetry in the directional velocity of the presumed convective flow (broad and slow at the center of solar granules and narrow and supersonic downward frictional plumes in the intergranular lanes). With this duly noted, the mixing length is defined as $l = a_{MLT}H_p$. The local pressure scale height is defined as the distance over which the pressure changes by a factor of e (i.e. ~ 2.718). In other words, $H_p = -dr/d(\ln P) = P/(rg)$, where the local gravitational acceleration, g, is defined as $Gm(r)/r^2$. Thusly, H_p can be written as $Pr^2/(Gmr)$. The convective heat flux is given by the following:

$$F_{conv} = a\rho c_p v_{conv} \Delta T \tag{91}$$

In (91), a is yet another "tunable knob," and represents a numerical value for the shape parameter for convective gas parcel (typically set to ½ or 9/4). The temperature difference, DT, is based upon the modeling assumption that a convective gas parcel starts with the same temperature as that of its ambient solar shell. As it moves through a mixing length, l, a temperature difference is developed.

$$\Delta T = T_e - T = T\frac{\lambda}{H_p}(\nabla - \nabla_e) = T\alpha_{MLT}(\nabla - \nabla_e) \tag{92}$$

Substitution of (92) and (87) into (91) followed by algebraic simplification leads to the following result.

$$F_{conv} = (ac_{conv})\rho c_p T\left(\frac{gQH_p}{8}\right)^{0.5} \alpha_{MLT}{}^2 (\nabla - \nabla_e)^{1.5} \tag{93}$$

To achieve a cubic power law model such that $F_{conv} \propto a_{MLT}{}^3$, the following is assumed:

$$(\nabla - \nabla_e) \propto \alpha_{MLT}(\nabla_{rad} - \nabla_{ad}) \tag{94}$$

The relationship between a_{MLT} and the convective efficiency, G, for mixing length theory, is obtained as follows. First, G is defined as the ratio of heat transported to the heat lost (by radiation) by a parcel of plasma during its characteristic lifetime (t*). The heat transported is defined as:

$$q_t = \rho c_p \Delta T \tag{95}$$

The rate of heat loss per unit volume is modeled as a function of the local radiative conductivity (c_{rad}), the temperature difference and the diameter of the plasma parcel (d).

$$\frac{\chi_{rad}\Delta T}{d^2} \tag{96}$$

The local radiative conductivity is defined as:

$$\chi_{rad} = \frac{4 a_{rad} c T^3}{3\kappa\rho} \tag{97}$$

The radiation constant, a_{rad}, in (97) is defined as the following and has a fixed value of $7.5657 \cdot 10^{-16}$ $Jm^{-3}K^{-4}$.

$$a_{rad} = \frac{8\pi^5 k^4}{15 c^3 h^3} \tag{98}$$

The characteristic lifetime, t*, is defined as the mixing length divided by the convective velocity. The total heat radiated per unit volume during the characteristic lifetime is defined as the rate of heat loss per unit volume times the characteristic lifetime.

$$\frac{\chi_{rad}\Delta T}{d^2}\tau^* = \left(\frac{\chi_{rad}\Delta T}{d^2}\right)\left(\frac{\lambda}{v_{conv}}\right) \tag{99}$$

From the definition of G as per the text preceding (95):

$$\Gamma = \frac{\rho c_p \Delta T}{\left(\frac{\chi_{rad}\Delta T}{d^2}\right)\left(\frac{\lambda}{v_{conv}}\right)} = \frac{\rho c_p d^2}{\chi_{rad}\lambda} v_{conv} \tag{100}$$

Because the model is 1D rather than 3D, the ratio of the square of the diameter squared to the mixing length is taken as being (2/3) a, where a is the "tunable knob" defined after (91). A second "tunable knob," b (also shown as n) is the energy loss parameter for dissipation due to friction (typically set to 4 or 8). Equation (100), accounting for these knobs, becomes:

$$\Gamma = \frac{2a\rho c_p}{3b\chi_{rad}} v_{conv} \tag{101}$$

The total energy flux passing through any given shell is the sum of the radiative and convective flux and is matched by the luminosity constraint.

$$F_{rad} + F_{conv} = \frac{L(r)}{4\pi r^2} \tag{102}$$

The ratio of the difference between the temperature gradients $\nabla - \nabla_e$ to the difference between the radiative and adiabatic temperature gradients, $\nabla_{rad} - \nabla_{ad}$, is defined as:

$$\frac{\nabla-\nabla_e}{\nabla_{rad}-\nabla_{ad}}=\frac{\Gamma}{\Gamma+1}\rightarrow\nabla-\nabla_e=\left(\nabla_{rad}-\nabla_{ad}\right)\frac{\Gamma}{\Gamma+1} \tag{103}$$

Substitution from (103) into (93) results in the following:

$$F_{conv}=\left(ac_{conv}\right)\rho c_p T\left(\frac{gQH_p}{8}\right)^{0.5}\alpha_{MLT}{}^2\left(\nabla_{rad}-\nabla_{ad}\right)^{1.5}\left(\frac{\Gamma}{\Gamma+1}\right)^{1.5} \tag{104}$$

The solution from (104) is set equal to the difference between the luminosity constraint and the radiative flux, as per (102). Rearrangement of the resultant leads to the following cubic constraint equation.

$$\frac{\Gamma^3}{\left(\Gamma+1\right)^2}=\frac{4ac_{conv}{}^2}{b^2}\left(\frac{\rho^2 c_p{}^2\kappa H_p{}^2\left(gQH_p\right)^{0.5}}{a_{rad}cT^3}\right)^2\alpha_{MLT}{}^4\left(\nabla_{rad}-\nabla_{ad}\right) \tag{105}$$

The three "tuning knobs" in the lead term on the right of the equality form a fixed scaling factor while the main "tuning knob," a_{MLT}, scales to the fourth power. A simplified solution procedure consists of solving for ∇_{rad} and ∇_{ad} from the local mass and pressure; substitution for the values used in the lead "tuning knobs," the main "tuning knob" and constants, solving for G and using it to determine ∇_{conv} for the shell. Additional details can be found in Paxton, et al. (2010). In regards to mixing length theory and specifically the "tuning knob" of a_{MLT}, Joyce and Tayar (2023) noted the following: "Mixing length theory requires a number of naïve – and in some cases, outright incorrect – physical assumptions." Another issue, as one had mentioned earlier, that being the lithium depletion problem (Straus et al., 1976), is addressed here. Because the purported convective zone is modeled as a closed, self-contained, plasma loop, SSMs predict that the surface lithium content should match the "pristine" meteoric lithium abundances. This is in contrast to modeled observations in the form of spectroscopy, which is interpreted as showing a loss of more than 99 percent of the presumed initial lithium abundance. One approach to resolving this issue was convective overshoot, which is treated as a mechanism for transporting surface plasma into the radiative zone. This, however, creates another issue. Matching the modeled sound-speed profile to modeled helioseismic data at the purported tachocline requires that f_{ov} be set to approximately 0.016. When this value is used, however, the resultant model prediction of the surface abundance of lithium is near zero (versus the "observed" value of 1.05). The overshoot parameter has to be reduced to approximately 0.005 to produce a modeled result that matches the "observed" lithium abundance, but in doing so, fails to match the helioseismic modeled data (Schlattl and Weiss, 1999). Attempt patches to rescue the 1D uniform shell assumption, including but not limited to rotation mixing, early mass loss and magnetic fields, are entirely post hoc in character and involve the introduction of yet additional unobservable parameters.

The SSM photosphere

For the photosphere, the convective model is turned off and a radiative model, here dropping the perfect blackbody assumption, is used. This atmospheric model is based on the assumptions of being plane-parallel (i.e. the surface being a flat 1D radial column rather than even the simplification of a perfect sphere), LTE and the gas within being grey (the same opacity for all wavelengths). The optical depth function, t(r), where t(R) = 0, is defined as the following:

$$\tau\left(r\right)=\int_r^{\infty}\kappa\rho dr \tag{106}$$

The model filtered observation is that the main source of opacity in the photosphere is the H^- ion (hydrogen atom with an extra electron). How is the opacity determined? It isn't determined based upon laboratory measurements under modeled solar conditions. Rather it is modeled based upon the above-discussed simulation based modeling. The model based determination of the radius is t(R) = 2/3 and with the lower limit of integration in (106) being r = R. Why 2/3, one might ask? The temperature at different depths of the photosphere is modeled using the Milne-Eddington relation.

$$T^4(\tau) = \frac{3}{4} T_{eff}{}^4 \left(\tau + \frac{2}{3} \right) \tag{107}$$

In (107), T_{eff} is the model filtered "observed" temperature of the "surface" of the Sun (5778 K). The value at t = 2/3 is $T^4(2/3) = (3/4)T_{eff}{}^4(4/3)$,which reduces to $T(2/3) = T_{eff}$. The choice of 2/3 is "50/50" modeled definition as the point where a photon has a modeled 50 percent change of escaping (i.e. 1- exp(-2/3), which is approximately 48.7 percent). Of course, there is no observational support based upon tracking individual photons to see if approximately half escape at the modeled radius of $6.957 \cdot 10^8$ m.

The "fact" of the solar constant

What about the "fact" of the "solar constant" (i.e. total solar irradiance)? To evaluate this "fact," one starts with the electrical substitution radiometer (ESR) which is a bolometric detector that compares the temperature change of absorbed optical radiation with that of electrical power heating (Kopp, 2025). There are, of course, a number of assumptions and layers of mathematical modeling involved (as an example, see Richard et al., 2020). The first of these is responsivity mapping, which arises due to the fact that such sensors have a differential response to different wavelengths of incident light. The mapping involves using calibration lamps with their own assumed properties for the purposes of creating a spectral response function. The second modeling assumption is that of equivalence. The third assumption is the equivalence principle as it relates to losses (e.g. heat leakage or absorption by the sensor housing). Spatial inhomogeneity, here being incident radiation striking the bottom of the bolometer but with the electrical heater (usually) being on the sides, and heat leakage from the wires (lead-wire error) involve thermal modeling for "correcting" the differences. The fifth model based filtering is geometrical modeling of the aperture, which is subject to changes due to heat related expansion and contraction, using thermal-structural modeling. Accounting for potential light scattering away from the detector at the edges of the aperture involves Fourier-based modeling for diffraction correction. Monte Carlo ray-tracing simulations are used to estimate how much of a signal is secondary to "straight light." The resulting point spread function is then used to model the background noise, which is then subtracted from the raw voltage.

The Total Irradiance Monitor (TIM) and Spectral Irradiance Monitor (SIM), the two instruments of the International Space Station (ISS) based Total and Spectral Solar Irradiance Sensor (TSIS-1) as well as similar instruments on the Solar Radiation and Climate Experiment (SORCE) satellite, are in environments subject to high-energy solar ultraviolet radiation and undergo degradation. The impact of this degradation is mathematically modeled. Thusly, the "observation," which is a voltage value, undergoes multiple layers of model based filtering even prior to being passed through yet more models to generate a value of flux per unit area (in units of W/m^2). Subsequent to the aforementioned model based filtering, the resultant is normalized to 1 AU. This is required because the "solar constant" is defined at exactly 1 AU. The problem is that the Earth is never at exactly 1 AU secondary to the modeled orbit being elliptical. This is then coupled with the assumption that the Sun is a single, uniform, point-source of light. Earth orbiting satellites observe the solar disc from one angle and there are no ESR equipped satellites stationed "behind" the Sun or at the solar poles. However, as expected, the Sun is modeled as an isotropic radiator, radiating equally in all directions. Until approximately 2011, the "consensus" "fact," based upon the modeled data obtained via the variability of solar irradiance and gravity oscillations (VIRGO) investigation on the Solar and Heliospheric Observatory (SOHO) spacecraft (Fröhlich et al., 1995), was that the "solar constant" was 1366 W/m^2. The modeled value, as of 2005, of 1361 W/m^2 was generated based upon the TIM instrument. While a 5 W/m^2 (0.35 percent) difference might seem trivial, the value far exceeded the stated uncertainty of either instrument (Butler et al., 2008). Oddly enough, the "problem" of scattered light, associated with the VIRGO instrumentation, which had not been a problem for years, became manifest in a post hoc manner and the change in the "solar constant" had nothing to do with a change in the Sun, but rather was due to a change in the structural and scattering models used to interpret instrumentation voltage.

The "new," value for the "solar constant," not surprisingly, created an issue in regards to the decades of antecedent data, which consisted of the VIRGO and Active Cavity Radiometer Irradiance Monitor (ACRIM) datasets. This bears particular relevance to the total solar irradiance (TSI) composite, which is a Frankenstein stitching of over four decades of disjoint satellite measurements that is often passed off a single, continuous, "fact." There are, of course, a whole host of assumptions involved, extending beyond the assumptions noted above, in making the Frankenstein creation. The first of these is the assumption that the degradation of one instrument can be perfectly corrected by comparing it to a second instrument. The reality is that both instruments, since they are on satellite-based platforms, are subject to degradation. As analogy, one is using a broken ruler to calibrate a crooked stick. The second assumption is present in regards to the bridge or patch used for the years of 1989 through 1991. This gap is present secondary to the time lapse between the "death" of the ACRIM-I satellite and the launch of the ACRIM-II satellite. The ACRIM patch is based upon unaltered data from lower precision satellites (e.g. Nimbus-7/ERB) as a bridge. The result of this patch is that solar output has increased since 1980. The Physikalisch-Meteorologisches Observatorium Davos (PMOD) patch is based upon altered data from lower precision satellites, such that the alteration matches proxy models based upon sunspot counts. The result of this patch is that solar out has decreased. Thusly, the "fact" of the trend is entirely based upon the mathematical patch that one uses. The third assumption involves the fact that each instrument has a different "absolute scale." The "solution" to this issue is to assume that one instrument is a reference followed by shifting all other historical data. Again, the 5 W/m^2 change had nothing to do with any change in the Sun, but was solely due to a shifting baseline. The fourth assumption, specifically in regards to Bayesian hierarchical models and machine learning for "data fusion," is that the noise follows a predictable Gaussian distribution. Statistical probability serves a basis for determining what the Sun did during the gaps over which data is lacking. The totality, therefore, is that a TSI composite, presented as a continuous "fact," hides the fact of laundering instrumentation errors through cross-calibration, subjective scaling and proxy based "correcting."

The "fact" of the Sun as a blackbody source

What of the "fact" of the Sun as a perfect (or near-perfect) 5778 K blackbody source? Once again, the actual measurement is voltage and the aforementioned instrumentation related model based filtering also applies here (even when the instrument incorporates photodiodes). For ground based "observations," additional filtering, again model based, to subtract atmospheric losses to dust, gas and water vapor absorption effects is used. Any resultant is scaled up using the inverse square law (yet again with a circular orbit at 1 AU assumption). The perfect (or near perfect) claim is a statistical fit and is not an "observation" of a single temperature source. The effective temperature is a mathematical back-calculation based upon taking the total energy measured across all wavelengths (i.e. the area under the curve) and then finding a single temperature of a theoretical blackbody that would produce the same total energy. Reference spectra, such as the American Society for Testing and Materials (ASTM) standard G173, are synthetic, based upon averaging across multiple missions (and thusly over time). Even with model based filtering, as it relates to instrumentation, the light from the Sun comes from different depths, even when such is limited to the photosphere and above, and at different temperatures. The deviation from the theoretical curve of a 5778 K blackbody is most apparent as one considers wavelengths outside of the visible peak. In theory, a blackbody at the effective temperature should exhibit a precipitous drop in energy in the extreme ultraviolet and x-ray bands. Radiation in these bands appears to derive from the corona (at a modeled temperature of one million K), is modeled as being driven by magnetic heating and highly ionized atoms such as neon or iron (rather than simple thermal equilibrium), is dominated by emission lines (often smoothed over in an incorrect continuum narrative) and can be on the order of 10^3 in excess in energy when compared to the theoretical predictions (Juzeniene et al., 2011). There are also issues in the radio portion of the spectrum (especially in regards to the S-band and longer decameter wavelengths). During sunspot activity, model filtered measurements of radio emissions can increase by orders of magnitude, completely abandoning any resemblance to a blackbody. Even in the infrared portion of the spectrum, a window between 20 and 250 microns provides a better modeled match to 4000 K rather than the effective temperature.

The "fact" of helioseismology

What of the "facts" of helioseismology? This is often presented under the rubric of an "ultrasound" of the Sun, but is by no means an equivalent to the direct measurement of reflected sound waves. The theory of helioseismology traces to the pioneering work of Leighton et al. (1962). Not surprisingly, a number of assumptions in regards to instrumentation and theory were used to arrive at the conclusions of five minute solar oscillations and supergranulation. In the subject author's construction, the original authors relied on a dual exposure technique using the Mount Wilson Observatory spectroheliograph. Two monochromatic images of the sun, slightly off-center on opposing aspects of a spectral line, were obtained followed by physical superimposition of the photographic negative of one image onto the positive of the other. The assumptions in this approach were (a) perfect cancellation of photospheric brightness (granulation) in the compositive image, leaving behind only a Doppler plate in which grey tones mapped linearly to vertical velocity and (b) linearity in the photographic emulsion across the entire plate. Analytically, an assumption was made of local turbulent convection in which the "observed" five minute periodic oscillations were modeled as secondary and superficial effects of convective solar granules moving to the solar surface. The periodic oscillations were later interpreted as being surface manifestations of global acoustic p-modes (Ulrich, 1970; Leibacher and Stein, 1971). The solar atmosphere was modeled as a vertically progressive plane wave traveling through a perfectly isothermal (i.e. constant temperature) gas. To account for the discrepancy between the data, interpreted as showing a decreasing oscillatory period with increasing height, versus the isothermal model, which predicted an increasing oscillatory period with increasing height, an assumed cooling factor (radiative relaxation time) was used to force the "observations" to match the model. In regards to mapping supergranulation cells, the authors assumed that solar plasma possessed almost infinite electrical conductivity. This allowed for the use of Alfvén's theorem (frozen-in flux theorem), which in ideal magnetohydrodynamics, constrains the movement of electrically conducting fluids (inclusive of plasma) and embedded magnetic fields. The manifestation was in the form of a claim that horizontal plasma currents were physically placing magnetic field lines into tension, which was then used to explain the network structure of the chromosphere (without any measurement of the local magnetic field).

The dubious but almost ubiquitous assumption of the line-of-sight "velocity" (one should not confuse the use of the term "radial" as actually being so) as having a specific orientation with respect to the source, observer or both is a glaring and patent issue with much of the "foundational" structure of astrophysics and cosmology. The presentation of such an issue, however, extends well beyond the scope of the subject work (given its ubiquity).

In more recent times, the instruments for helioseismology are the Michelson Doppler Imager (MDI), which was on the SOHO satellite (Duvall et al., 1997), the Helioseismic and Magnetic Imager (HMI), onboard the Solar Dynamics Observatory (SDO) satellite (Scherrer et al., 2012) and ground based platforms such as the Solar Tower Telescope at the Mt. Wilson Observatory and a network of six, identical, Earth based telescopes, collectively referred to as the Global Oscillation Network Group (GONG) Project (Harvey et al., 1996). The instrumentation in question are digital imagers (pixel detectors) and thusly the raw data, again, consists of voltage (i.e. voltage generated at a specific pixel on a charge-coupled device (CCD)). For the satellite based platforms, the instrument obtains multiple images across the "width" of a specific spectral line followed by the use of a line profile model (Gaussian or Lorentzian fitting) to model the "center" of the line (e.g. the filtergram for the HMI involves taking six discrete images through narrow filters at different points along the absorption line followed by using a weighted average of those points, via a MDI-like algorithm, to determine the "center" of the line). The "reference" value for this spectral line is based upon layers of mathematical modeling that include, but are not limited to, the modeled velocity of the spacecraft platform with respect to the Sun, an internal laser reference (i.e. a stabilized laser diode and a series of Michelson interferometers for estimating instrumental drift) for the HMI instrument, a disk average model (i.e. the assumption that the "velocity" across all pixels around the solar disc, when averaged, should equate the platform's orbital velocity; once subtracted, any residual is labeled as instrumental bias or convective blueshift and removed by detrending) and the use of a look-up table based upon a pre-flight model of spectral line shape (a static, perfect, profile) to map signal intensity to "velocity." Ground based platforms typically have a different target spectral line (nickel rather than iron) and, as noted previously, use model based filtering in an attempt to remove noise attributed to the atmosphere. For the GONG Project, each "identical" telescope is located at a different site and has its own individual operational characteristics. Statistical modeling is used to determine which data, on a telescope basis, is the most reliable, at any given point in time, as the data used in the stitched, single, timeline. Unlike the filtergram approach of the HMI, the ground based observations are filtered using a Fourier tachometer approach in which incident light is split, thereby creating an interference pattern (i.e. fringes) and with intensity measurements taken at different phases of the fringe. For the ground based observation one has either (a) the assumption that the center of the solar disc is the zero velocity point (resting on the assumption that all large-scale horizontal motions are orthogonal to the line of site, at the exact center of the solar disc, thereby making the net velocity zero), which is a flawed assumption

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secondary to offsets created by magnetic fields and convective blueshifts (Ulrich, 2010; Waidele et al., 2023) or (b) by means of a synthetic signal (Cacciani et al., 1993; Samuell et al., 2017) that is based upon a modeled spectral line. Another issue with the disc center assumption is the introduction of systematic error via the center-to-limb effect (Kitiashvili, 2026). After the gamut of filtering, approximately 99 percent of the purported Solar surface motion is removed.

Claims in the literature that helioseismology either "validates" or "verifies" the SSM is outright insipid nonsense. Mathematically, the use of (model filtered) finite surface data points to map the interior of a continuous volume maps to an infinite number of theoretical interior velocity profiles that can mathematically yield the exact same surface observations. In greater detail, one starts with heavily model-filtered "Doppler velocities" that are surface level only (i.e. the photosphere). The claim that these modeled surface phenomena provide insight into the deeper structure of the Sun first starts with yet another (familiar) modeling assumption: for the global oscillation model, the Sun is modeled as a perfect fluid sphere. The p-modes and g-modes are entirely theoretical harmonics that such a mathematical model should have. The determination of spherical harmonics requires a further assumption. That being that the Sun is sufficiently symmetric in order to allow for orthogonal mode decomposition. The next step, that of inversion, shows that claims regarding the interior are not observations. In other words, one has heavily model filtered and model assumption based surface "frequencies" and one wishes to calculate an internal density. The latter cannot be uniquely obtained from the former.

This does not change if one is using a different model, such as 3D magnetohydrodynamic software to build computer-simulated patches, using different physical frameworks (for different helioseismic approaches) or using regularization approaches (e.g. regularized least squares or subtractive optimally localized averaging) that prioritize the smoothest fluid profiles (for a review, see Kosovichev, 1999). Every regularization technique introduces a user defined hyperparameter (i.e. the trade-off parameter, l). A value for l that is too high smooths the data to an extent where physical features are mathematically erased. A value for l that is too low causes the inversion to fail. An "optimal" value is chosen by the user, using tools, such as the L-curve criterion to balance smoothness against data fitting. This choice is a mathematical compromise and is not an empirical discovery. Thusly, any 3D velocity profile based upon helioseismology is not a depiction of the actual solar interior but rather is a possible, smooth, interior that is entirely a model-dependent representation. When inversions are linearized around a reference model and when that reference is the SSM, the results are inherently biased on the reference. Such cases are obvious instantiations of circularity. Even when the SSM is not stated as being a reference, certain assumptions such as a core comprised of fully ionized gas, are required in order to calculate the theoretical, modeled, vibrations at the surface. One then uses the "tuning knobs" to engender a match between one model (e.g. the SSM) and another model (e.g. the modeled surface "Doppler velocities"). This approach, by no means, provides an "observation" of any of the layers below the photosphere, but instead provides a model to model correlation. Another claim typically propounded in regards to helioseismology is that the speed of sound is being measured. This is incorrect. The actual model filtered measurement is the travel time. To turn this into a temperature or ionization state, one must assume an equation of state. Again, if the SSM is used, one has a model to model, circular, relationship.

When it comes to claims of "accuracy" in regards to the SSM, the claims are almost never validated against physical actuality but rather are based upon the reduction in numerical differences between differing mathematical formulations. This is readily apparent when one considers the sound-speed profile discrepancy (dc/c). This metric is a linearized integral equation, for which the primary formula is the following:

$$\frac{\delta v_i}{v_i} = \int_0^{R_{\square}} K^{i}_{c_s^2,\rho}(r)\frac{\delta c_s^2}{c_s^2}(r)dr + \int_0^{R_{\square}} K^{i}_{\rho,c_s^2}(r)\frac{\delta\rho}{\rho}(r)dr + \frac{F_{surf}(v_i)}{Q_i} \quad (108)$$

In (108), the term on the left of the equality is the relative frequency difference between the model filtered surface oscillation frequency (for the i^{th} oscillation) and the corresponding frequency predicted by a reference model. The two K terms, each separately as a portion of an integrand, on the right side of the equality, are the inversion kernels. Each term is calculated entirely using the wave functions of the reference model and define the sensitivity of a given wave frequency to shifts in sound speed (c_s) and density (r) at a specific radius. The final term on the right side of the equality is an ad-hoc mathematical "surface correction" function. The sound speed profile, $(dc_s^2/c_s^2)(r)$ cannot be directly calculated from data. The kernels depend upon the reference model and changing the reference model changes the sound speed profile. Thusly, the "accuracy" is an internal mathematical consistency check that evaluates the consistency between the linearized perturbations of the reference model to the frequency eigenvalues of the exact same reference model.

The "fact" of solar neutrinos

What of the "facts" of Solar neutrino detection? Here, yet again, one sees "observations" so heavily processed by layers of mathematical and theoretical assumptions that one is left with a case of confirmation bias for the SSM rather than an independent discovery. Beta decay is a form of radioactive decay in which an atomic nucleus emits a beta particle (an energetic electron or positron), thereby transforming into an isobar of the nuclide. Becquerel (1896ab) is generally credited with the discovery of radiation (from uranium salts). The Curies (1898ab) isolated radium and coined the spontaneous emission from the element as radioactivity. Rutherford (1899) indicated that two forms of radiation existed, which he termed alpha and beta and Villard (1900) discovered a third form, which Rutherford later called gamma radiation. Beta decay, secondary to conservation of momentum, should have a fixed energy. Ellis and Wooster (1927), with preceding work by others (such as Meitner, Hahn and Chadwick), concluded that the electron spectrum was continuous rather than fixed. Pauli (1930) proposed a solution and is credited with first having proposed the idea of an electrically neutral particle that should have mass of the same order as that of an electron but not greater than one percent of the mass of a proton. Fermi (1933) utilized Pauli's proposed particle, which Pauli referred to as a "neutron," renaming it as the neutrino, in his theory of beta decay. The responsibility for the claim of the massless neutrino cannot accurately be attributed to Fermi (in the subject author's construction), secondary to Fermi having left the mass issue open. Fermi did note that the energy spectrum for Bismuth-210 matched the zero mass calculation to a much better extent than when the cases in which significant mass was assigned to the neutrino. The former also simplified the calculations. The zero mass neutrino was at least a convenient assumption, if not a "consensus fact" for the next four decades. This "consensus fact" became a part of the standard model of particle physics from the mid-1970s until 1998. Taking a few steps back and admittedly skipping certain seminal contributions, Pontecorvo (1946) proposed a method using chlorine to argon transformation, for which large volumes of cheaply obtainable reactant in the form of dry cleaning fluids such as tetrachloroethylene (C_2Cl_4) or carbon tetrachloride (CCl_4) could be procured, for detecting neutrinos. Sakata and Inoue (1946) proposed a decay scheme, $p \rightarrow m + n_m$, where the primary particle (p, the pion), decayed into a daughter particle (m, the muon) and a second type of neutrino (n_m, the muon neutrino). The muon neutrino was indicated to be distinct from Pauli's electron neutrino (n_e). Model filtered observational data by Conversi et al. (1947) and Lattes et al. (1947ab) has been indicated as "confirmation" of this decay scheme. Cowan et al. (1956) claimed the discovery of physically detectable neutrinos, based upon inverse beta decay and subject to heavy filtering and mathematical modeling. Goldhaber et al. (1958), based upon experimental data subject to mathematical model based filtering, proposed that neutrino spin was anti-parallel to neutrino motion (i.e. left-handed). Bahcall (1964) published a theoretical framework for detecting solar neutrinos based upon SSM predictions of core temperatures and fusion rates. Davis (1964), based upon Bahcall's theoretical framework and consistent with Pontecorvo's proposal regarding chlorine, developed an experimental protocol involving a tank containing 10^5 gallons of perchloroethylene (C_2Cl_4) for capturing neutrinos. The Homestake experiment arose from building such a detector at a depth of 4850 feet below the surface of the Earth. The model filtered results of the experiment were interpreted as indicating a detection of only 1/3 of the neutrino count that was predicted. This resulted in a decades long 'solar neutrino crisis.' One returns to this issue, shortly, after a brief discussion of neutrino detectors.

All neutrino detectors are Earth based and usually built underground in order to isolate the detector from cosmic rays and other background radiation. Early designs consisted of large volumes of chlorine or gallium that were checked periodically for reaction products that were presumably generated by neutrino interactions with the original substrate. Others consisted of liquid or solid scintillators coupled with photoelectric detectors. Newer designs, such as Super Kamiokande and the Sudbury Neutrino Observatory (SNO), consist of large volume of water or heavy water coupled with photoelectric detectors. Two facts should be abundantly clear from this description. The first is that there is no detection of a subatomic particle occurring. Rather one is detecting the resultant of a purported interaction (e.g. Cherenkov radiation). The second is that there are no intermediary sensors or detectors between a purported source and the aforementioned detectors. Thusly, the concept of tracking a neutrino or group of neutrinos from "birth" up until detection occurs at an Earth based detector is a non-starter. From the first fact, the claimed detection of a neutrino requires the modeling and removal of false positive signals (i.e. noise). To create a flux from detection counts, one needs the interaction cross-section (i.e. the area of the target atom in regards to neutrino interaction). This is not and cannot be measured in the laboratory but rather is based entirely on theoretical calculations using the standard model of particle physics. Thusly, the neutrino flux is entirely dependent upon the prevailing mathematical model for the weak nuclear force.

The "solution" for the solar neutrino crisis initiated in the late 1970s with the theoretical development of the "see-saw mechanism," which revived the claim of neutrinos having non-zero mass. Such was required because, theoretically, a massless particle traveling at the speed of light would experience no passage of time and therefore "flavor shifting" would be an impossibility. Based upon the work of Wolfenstein (1978), Mikheyev and Smirnov (1985) proposed a mechanism (subsequently labeled the MSW effect, with the acronym based upon the surnames of the three authors) that "solved" the solar neutrino crisis. According to this patch, electron neutrinos passing through the solar core experience an extra forward scattering potential secondary to the interaction with the dense sea of electrons present, via W-boson exchange (charged current). This does not occur for muon or tau neutrinos. The interaction modifies the effective mass of the electron neutrinos (i.e. mass is no longer a fixed intrinsic trait but rather becomes a dynamic variable that changes depending on the local electron density). Before these neutrinos reach the "vacuum" of space, they pass through a critical "resonance density," at which the mass shift forces the mixing angle to become maximal (45^o). The resultant is an adiabatic flavor conversion that flips almost all of the high-energy solar neutrinos into muon or tau flavors. Of course, there has been no direct measurement of neutrino mass or direct observation of such a matter-induced resonance flip under controlled conditions. Claims made in regards to the Long-Baseline Accelerator Experiments do not provide validation of the latter. Such testing involves firing a beam of muon neutrinos through the Earth's crust. A near detector is located at the source site and a far detector is located at the destination. That the Earth's crust is a poor substitute when it comes to the modeled density of the solar core should go without saying (one also sets aside the issue of the "refraction" defense when considering the neutrino interactions with matter versus the claim that neutrinos have little to no interaction with matter). When an asymmetry is reported, at the far detector, in regards to the electron neutrino count versus the electron antineutrino count, such is claimed as "validation" that the matter of the Earth's crust is modifying the quantum wave function via the MSW mechanism. That such an asymmetry is not a result that is causally unique to the MSW mechanism should not be a surprising finding. The standard model, itself, has another "tuning knob" called the CP-violating phase (d_{CP}), from which one obtains an intrinsic and fundamental asymmetry between matter and antimatter (irrespective of the Earth's crust). Because the testing in question is not vacuum control testing, both the MSW mechanism and CP-violation become entangled in the software algorithms used for data processing. This becomes manifest in the form of guessing the value of d_{CP} coupled with using a simulated density profile for the Earth's crust. Monte Carlo simulation is then used to produce a "best fit." Once again, one is dealing with layers of model filtered and model based abstraction.

The "consensus fact" that neutrinos were massless became the "consensus fact" that neutrinos had mass with the presentation, in June of 1998, of results from the Super-Kamiokande collaboration. Again, this did not involve any direct measurement of mass. Rather, muon neutrinos, generated (purportedly) by cosmic rays hitting the Earth's upper atmosphere, disappearing as they traveled through the planet, matched the mathematical frequency profile of a quantum flavor shift. The creation of neutrino mass was necessary to justify flavor change, which in turn, was required to explain why the Homestake experiment resulted in "observations" that were only 1/3 of the predicted value and why detectors such as GALLEX and SAGE, which utilized gallium (gallium trichloride-hydrochloric acid with the reaction being $n_e + {}^{71}Ga \rightarrow {}^{71}Ge + e^-$) as the reactant detecting only ½ to 3/5 of the predicted neutrino count. The final component of the narrative, as it stands, comes from the interpretation of data collected at SNO. According to the researchers, SNO measured ^8B neutrinos through the following three reactions (Ahmad et al., 2001).

$$\begin{gathered} \nu_e + d \rightarrow p + p + e^- \\ \nu_x + d \rightarrow p + n + \nu_x \\ \nu_x + e^- \rightarrow \nu_x + e^- \end{gathered} \tag{109}$$

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The first reaction was indicated to be the charged current (CC) reaction, which was sensitive to electron neutrinos only. The second reaction was indicated to be the neutral current (NC) reaction, which was sensitive to all neutrino flavors (x = e, m, t). The third reaction was indicated to be sensitive to all flavors of neutrinos but with reduced sensitivity for n_m and n_t neutrinos. The first reaction, that being of an electron neutrino striking a deuterium nucleus, resulting in a neutron turning into a proton and the release of a high energy electron, resulted in the release of a distinct cone-shaped light response (i.e. Cherenkov radiation). The second reaction, that being of a neutrino of any flavor striking a deuterium nucleus, causing it to split into a proton and a neutron, with the eventual capture of the liberated neutron by another nucleus resulted in the release of a gamma ray (the light response being more isotropic in nature and different from the sharp cone of the CC reaction). The third reaction (electron scattering), that being of a neutrino striking an electron in a glancing manner, was used to determine incident directionality (i.e. electrons being detected in the direction away from the Sun meaning that the incident neutrinos came from the Sun). Additional testing was done to “tune” the sensitivity of the detector to the neutral current. The reference to boron eight neutrinos is not extraneous. The modeled energies for ^8B neutrinos are up to approximately 15 MeV. Depending upon the data collection iteration, the analysis threshold for SNO data was between 5.0 to 5.5 MeV. Thusly, neutrinos modeled as arising from the pp chain (0 to 0.4 MeV), the pep reaction and ^7Be reaction (both in the range of 0.8 to 1.4 MeV), the totality of which represented approximately 99 percent of the modeled solar neutrino output, were excluded from capture. This threshold was used in an attempt to avoid false positive detections from the background. Even with purification of the deuterium, traces of uranium 238 and thorium 232 decay chains, producing gamma rays and beta particles with maximum energies within the range of 3.5 to 4.0 MeV, remained present. One does note that there is no laboratory based verification of how pure muon or tau neutrinos, at modeled solar energies, should break apart deuterium nuclei.

For the 5.0 to 10.0 MeV energy levels, the angular resolution of the reconstructed electrons was between 25 and 30 degrees. For comparison, the (modeled) angular diameter of the Sun is approximately 0.5 degrees. The presentation, in the previous paragraph, of the signals generated by the three hypothesized reactions, as being inherently distinct belies the actuality. The poor angular resolution (i.e. 25 to 30 degrees v. 0.5 degrees) required substantial filtering and angular modeling in order to support the claim that the “observations” were related to the Sun. Letting q be the angle between the reconstructed electron direction and the calculated position of the Sun in the sky, the use of nuclear theory leads to the conclusion that the CC reaction would result in electrons emitted with a weak backward asymmetry, approximately following a smooth 1- 0.33cos(q) distribution. This created a sloping, nearly flat curve across the entire sky. The NC reaction does not involve any retention of q and thusly produces a horizontal line in regards to an angular mathematical profile. The ES reaction, in theory, should produce a spiked angular mathematical profile, but due to the issue of angular resolution, instead, produced an angular mathematical profile that was broad and centered around cos(q) = 1. A consequence of the angular resolution issue was that the “observations” did not neatly separate, on the basis of angle, into three discrete bins. Rather, for any given angle, the “observation” consisted of components from all three reactions. The separation of “observations” into the three reactions required substantial statistical filtering and modeling. Mathematical templates were for fixed expected angular shapes for the three reactions combined with a modeled detector resolution. An extended maximum likelihood fit algorithm was employed to adjust the sizes of the three templates until the mathematical sum of the three matched the histogram of the “observations.” The Super Kamiokande neutrino detector has the same angular resolution for neutrinos within the 5 to 15 MeV range. IceCube, a deep ice neutrino detector, and KM3NeT/ANTARES, an undersea neutrino detector, can achieve angular resolutions of 0.1 to 0.4 degrees, but only for neutrinos with energies in the tera or peta eV range (well beyond the modeled 0.015 giga eV upper limit for solar neutrinos). “Verifying” the size of the solar core, without relying on software averaging templates, in theory, requires a much larger detector and extended operational times measured in decades (Davis, 2016).

While one can readily find claims that the results generated from SNO are independent of the SSM, such a claim is not accurate. While the modeled neutrino energies are independent of the SSM, the estimated neutrino flux is directly dependent on the modeled core temperature. For the former, the masses of the boron nucleus, beryllium nucleus and electron neutrinos (while model based) are fixed. Because of mass-energy conservation, the maximum energy of the neutrino is 15.8 MeV. The rate of production of ^8B via the reaction of $^7Be + p \rightarrow {}^8B +$ g, however, is temperature dependent. This temperature dependency, in the SSM, is a T^{24} dependency. Thusly, 1 one percent increase in the modeled core temperature results in a 27 percent increase in the predicted rate of ^8B. Do the neutrino results “verify” the SSM? The answer again, as it was for the case of helioseismology, is no. The savior that prevented falsification of the SSM was the invention of the mass patch (i.e. neutrino mass and flavor oscillation). The mixing parameters of the mass patch were calculated by assuming that the SSM's total neutrino output was already correct. To then use the neutrino results to claim that the SSM was "verified" is circular. The aforementioned extreme temperature volatility is a second reason. The temperature of the actual solar core belies direct measurement and thusly the "match" between the neutrino data and theory is one of parameter tuning and not that of empirical verification of a stable solar core. A third reason is that limitations arising from terrestrial radioactive noise place a limit on information that is recorded as data, prior to any subsequent filtering and modeling, which removes over 99 percent of the modeled neutrinos (in terms of energy) that have a purported solar source. Being blind to over 99 percent of the output of a system belies any claim of holistic verification of the any model for that system. The final reason (at least of those proffered here), is because of severe angular blurring. An angular resolution of 25 to 30 degrees for a target that is 0.5 degrees makes it so that the "observations" are not of a clear, discrete neutrino flow from the solar core (an even smaller angular target based upon the modeled size of the core). The cleaned "observation" of the neutrino emissions from the solar core (in the subject author's view, this appears as a smear), is heavily filtered via the extended maximum likelihood fit algorithm and preprogrammed software templates and is not an unmediated physical reality.

The crises of modeling

The lithium depletion crisis and the solar neutrino crisis are not the only crises in which the SSM results fail to match either "observations" or predictions from other mathematical frameworks. The solar abundance crisis (i.e. the solar metallicity problem) is another example. For decades, the SSM was tuned to match a specific metallicity mixture based upon "observations" from the solar atmosphere. When newer 3D hydrodynamic simulations were utilized to read solar spectral lines, the results indicated a reduction by, 25 to 35 percent, in heavy elements than had been assumed for tuning the SSM. Use of the newer chemical abundances in the SSM resulted in substantive drop in radiative opacity, causing the convective zone depth, surface helium abundance and internal sound-speed profile to wildly diverge from the helioseismic data. A similar issue is present in regards to helium abundance (Dziembowski, 1998). In the SSM, the initial helium abundance is a "tunable knob" that is adjusted such that the modeled solar evolution results in the current "observed" (modeled) luminosity. Helioseismic inversion, however, can be used to estimate the helium content at the base of the convective zone (through changes in the adiabatic exponent of the solar plasma). The results from such an analysis do not match the tuned value(s) used for the SSM. The latter requires a much higher initial helium fraction to sustain the luminosity equations than what is supported by helioseismology. The core rotation paradox, yet another issue, was discussed above. The beryllium-7 issue, yet another problem, mimics the previously mentioned lithium depletion crisis.

DISCUSSION

In 2004, Freeman Dyson published an essay that detailed a 1953 meeting that he had with Enrico Fermi. The meeting focused on pseudoscalar meson theory, which the former and his students were employing to study meson-proton interaction. When Freeman was queried about the number of arbitrary parameters that were used in the model, his response was four. Fermi's response was a reference to John von Neumann, whom he quoted as saying "with four parameters I can fit an elephant, and with five I can make him wiggle his trunk." As an anecdote, rather than as a literal mathematical formulation, a typical interpretation of this statement is as a warning against overfitting of data, in parametric modeling, through the use of arbitrary adjustable parameters that while allowing for interpolation result in a model that lacks predictive power. Popper (1935/2005, pp. 59-60), in his commentary on "conventionalism," indicated (the subject author's commentary are in braces) that a conventionalist "… will explain away the inconsistencies which may have arisen [when those ascribing to an extant system view that system as being threatened by the results of new experiments that may be interpreted as falsifications]; perhaps by blaming our inadequate mastery of the system. Or he will eliminate them by suggesting ad hoc the adoption of certain auxiliary hypotheses, or perhaps of certain corrections to our measuring systems." Furthermore, in regards to auxiliary hypotheses, Popper stated that "… we propose to lay down the rule that only those [auxiliary hypotheses] that are acceptable whose introduction does not diminish the degree of falsifiability or testability of the system in question, but on the contrary, increases it (Popper, 1935/2005, pg. 62)." In another work, Popper (1963/2002, pg. 48) indicated that "a theory which is not refutable by any conceivable event is non-scientific. Irrefutability is not a virtue of a theory (as people often think) but a vice." Also stated (Popper, 1963/2002, pg. 48) is the following: "Some genuinely testable theories, when found to be false, are still upheld by their admirers – for example by introducing ad hoc some auxiliary assumption, or by reinterpreting the theory ad hoc in such a way that it escapes refutation. Such a procedure is always possible, but it rescues the theory from refutation only at the price of destroying, or at least lowering, its scientific status."

When one considers the SSM, depending upon iteration, one finds approximately 20 "tunable knobs." Three of these come from the global boundary conditions consisting of the presumed age, the modeled solar luminosity and the modeled solar radius. Seven or eight, depending upon model iteration, come in the form of the reaction cross-sections (i.e. the astrophysical S-factors). Another eight to ten, again depending upon model iteration, come in the form of the assumed initial elemental metallicity abundances. These directly impact the radiative opacity. The final two "tunable knobs" appear in the form of the initial helium abundance (adjusted such that the model predicts exactly the "observed" solar luminosity at the presumed current age of the Sun) and the mixing length parameter. The consequences of such an approach, as it relates to falsifiability, given that each underlying relationship can readily be recast in the form of a hypothesis, is somewhat complex. The claims that solar age and initial elemental metallicity abundances are based upon "inference" is apt if "inference" is little more than guesswork involving assumptions for which there is no known capacity for verification (much less falsification). There is no known mechanism for traveling 4.54 billion years into the past and making a direct observation as to whether or not the Sun was present and if it was present, to make a determination of its initial elemental metallicity abundances. There is no mechanism by which one can verify, much less falsify, the genetic assumption in regards to whether or not the "pristine" meteorites originated from the material that formed the stellar protostar and its protoplanetary disc or if the start of modeled stellar core nuclear fusion was contemporaneous with the meteorite formation. There is also no mechanism to determine if the initial elemental metallicity abundances, whatever they might have been, were altered during the billions of years of the modeled evolution of the sun prior to sustained observation by humans. Furthermore, the entire modeled structure in regards to the core, radiative zone, convective zone, etc. are beyond the reach of current capacity for direct observation. One can extend this statement even further by noting that the predicted state of matter, at the modeled temperatures, pressures and densities, in a macroscopic volumetric sense, is beyond the capacity of laboratory verification. With these points noted, in theory, failure of the SSM, at various points in time, as different crises arose between, at the time, extant "facts" of the model, and either new (model-filtered) "observations" or even the results of other more "accurate" models, the SSM could have been considered falsified. The historical approach, however, has been quite different. In this regard, the large number of "tuning knobs" have been key given that the "facts" are simply changed to new and different "facts" as needed and in order to avoid falsification.

The SSM is a modeling approach that can be viewed as either simple or complicated or simultaneously both and with such a characterization being applied en toto or with different characterizations for different aspects. Of the 109 equations presented in this work, 108 were directly involved in the SSM. The subject author readily states that the equation count could have been greatly expanded if the totality of the mathematical framework had been presented. Such a presentation, however, would have only strengthened the conclusions that have been reached. This point is relevant in that the various "tunable knobs" of the SSM allow for sufficient complexity, within the context of a sufficiently segregated (by process) model, as to allow for compartmentalized changes by those that defend the model, against attempts at falsification. Segregation and compartmentalization are on equal footing with complexity, in this regard. A complex model in which a single step is key to the extent that the falsification of the step causes the entire model to fail is a slightly different construction than the SSM. Thusly, model complexity, in and of itself, does not lead to the singular conclusion of unfalsifiability. Interestingly enough, the model of orbital mechanics based upon epicycles revolving upon a fixed deferent, while far simpler in its mathematical construction, has the following characteristic: "There is no bilaterally-symmetrical nor eccentrically-periodic curve used in any branch of astrophysics or observational astronomy today which could not be smoothly plotted as the resultant motion of a point turning within a constellation of epicycles, finite in number, revolving upon a fixed deferent (Hanson, 1960)."

While one finds the approach taken to the SSM as being consistent with Popper's description of conventionalism, the issue of unfalsifiability via "tuning knobs" equating to unscientific is not a singular conclusion. If one accepts falsifiability as a strict requirement for the ideal episteme of science, then the lack of falsifiability, logically, and irrespective of design or choice, leads to the conclusion that the claims being made are unscientific. The label of "scientist" on those that are engaged in the underlying endeavor or as a purported defense is entirely immaterial. The content of the work either stands or fails on its own merits or lack thereof. Popper is not the only individual that has commented upon the issues at hand. Underdetermination of scientific theory, by evidence, has been an area explored by others. Duhem (1954/1988, pg. 261), writing with physics as the specifics context, articulated the following: "A physicist decides to demonstrate the inaccuracy of a proposition… he does not confine himself to making use of the proposition in question; he makes use also of a whole group of theories accepted by him as beyond dispute… if the predicted phenomenon is not produce, not only is the proposition questioned at fault, but so is the whole theoretical scaffolding used by the physicist. The only thing the experiment teaches us is that among the propositions used to predict the phenomenon and to establish whether it would be produced, there is at least one error; but where the error lies is just what it does not tell us." The contextual restriction of the issues raised to physics is a restriction that the subject author disagrees with. Rather, one finds a much broader applicability of this perspective as per the author's construction of the work of Quine (1951/1988, pg. 296). In the subject author's construction of the (translated) quote, the contention being articulated is that the testing of a (singular) hypothesis does not involve just the hypothesis but also involves the supportive framework for that hypothesis. A potential conclusion, based upon this view (one that the subject author does not agree with), is that no hypothesis is actually testable secondary to involving any number of actual or entirely fictive accessory hypotheses. From a slightly different perspective, one can readily see how auxiliary hypotheses are used to shield the primary hypotheses from falsification. The failure of the Homestake experiment did not result in questioning of the underlying modeling assumptions of the SSM. Instead, the auxiliary hypotheses of the previously massless neutrino was abrogated and the addition of the MSW effect was created, resulted in the core the SSM remaining unchallenged.

While the sociology of science or science as a social process has not been the focus of the subject work, the foray into the same has been unavoidable. This goes beyond the relatively superficial (and in the view of the subject author, somewhat obvious) context of the subject work involving content that was generated within the scope of science as a social process. It is within this social context that one finds (one's construction) of Kuhn's (1962) observations to be apropos. In the subject author's reading, the salient observations consist of the vast majority of scientific practice consisting not of model falsification but instead of "normal science," which is explicitly defined as "puzzle solving." Here, the SSM would represent a dominant paradigm that serves the role of mechanism for everyday "puzzle solving." However, this is just one role. As a dominant paradigm, the SSM is used to determine which queries are made, which instrumentation is made, which research is funded and what data is considered legitimate. Anomalies that develop, such as the various crises noted, are not considered as refutations but are rather treated as "unsolved puzzles." Contradictory facts, alone, are insufficient to engender a paradigm shift. This arises because the very paradigm in question is used to define the "facts." Here, as an example, the sensitivity kernels used in helioseismology are predicated upon the assumption of the correctness of the SSM. At a more fundamental level, secondary to the actual fact that paradigms, institutions, etc. have no capacity for agency, one is dealing with humans. The claim that scientists are above the concerns as well as "foibles" of mere, "common" humans is insipid nonsense. Beyond the subjective attachment that one might have to one's theory or theories, the issues of funding and social standing are directly germane as to why an extant paradigm is defended and promulgated. Having to admit that one was wrong might carry substantial repercussions.

Here, one would be remiss to not discuss Lakatos' (1973/1988, pp. 23-26) conceptualization of competing research program. In the subject author's construction of this work, there is a difference between the theory in isolation, attributed to Popper, and the "irrational" psychological paradigm shift, attributed to Kuhn. Lakatos' articulation of a research program, the competition between competing forms being the mechanism by which perspectives changes in science, consists of two structural zones. The first is the hard core, which in the subject author's wording is treated as unshakeable or as sacred dogma. The second is the protective belt, which in the subject author's wording is treated as sacrificial should the need arise. For the SSM, the hard core consists of the basic 1D stellar physics (i.e. the Sun is a perfect sphere in hydrostatic static equilibrium with energy generation being solely by nuclear fusion in the "core" and with energy transport being strictly by radiative diffusion and convection). The negative heuristic insulates the hard core from criticism. The protective belt for the SSM consists of the sprawling moat comprised of auxiliary hypotheses, data filtering algorithm and adjustable parameters. Neutrino mass, the MSW effect, initial metallicity abundances and artificial opacity adjustments, all of which represent instantiations of sacrificing previous theoretical formulations or values, are all examples of usage of the protective belt (in the form of mathematical patches). In the subject author's construction, Lakatos' articulation of the research program concept doesn't exclude the use of a protective belt, but instead involves constraints on the use of the same. Auxiliary hypotheses are to be content-increasing (not a simple retroactive removal of what is considered an error but also predictive) and allow for empirical progression (the predictions, at least in part, must have physically observable outcomes). When auxiliary hypotheses are entirely ad hoc, the research program is considered degenerate. The mathematical patches, in such cases, only serve to follow the presentation of embarrassing anomalies, without every leading to successful novel predictions. In the subject author's view, the solar abundance crisis firmly places the SSM into a degenerating phase. An astute observation, articulated by Lakatos, is that an established research program, irrespective of its degeneracy, will not be abandoned until a rival research program that can be used to explain the previous successes of the degenerate program and that can naturally account for the anomalies without needing the patches, emerges.

In the subject work, the author has taken a certain degree of care to point out certain instantiations where so-called "consensus" failed when it came to determining facts in regards to the portions of the territory for which an incomplete map (redundancy intended) was present. While one remains open to the possibility that factual actuality can simply come to be or have properties and relations solely by virtue by "consensus," the evidence available points to the conclusion that "consensus," as an episteme, is insipid nonsense. Were there no planetary orbits prior to the time that the first "consensus" was reached among the salient mass of humans? Did the known planets obtain their orbits, characterized by and by sole virtue of whatever the "consensus" might have been at that time? If this "consensus" differed from epicycles about a fixed deferent, did the planets change their orbits solely due to the salient humans having reached a "consensus?" Did the planets again change their orbits solely due to the salient humans having reached a "consensus" in regards to elliptical orbits? Was the Sun actually being carried by Ra on his solar barque, fending off the violent attempts of Apophis, in relation to carrying out his divine duty when such was the "consensus" among the salient humans in 24 century BCE Egypt (one can insert any or even all similar historical anthropomorphized "facts" for this question)? Did the Sun change into a sphere comprised of molten iron and rock and with loss of divine status or attendant solely due to the changed "consensus" among the salient humans? Was the actual age of the Earth and Sun 20 to 40 million years solely due to the "consensus" reached and driven by the "authoritative" status of Lord Kelvin? Was an entire new past created as "fact" for both the Earth and Sun solely due to the new "consensus" in which more than 4.5 billion years of prior existence was created? Perhaps the solar composition, as a matter of factual actuality, changed in composition when the "consensus" changed from a primary composition of iron to hydrogen. While it might be sacrilegious, the subject author would suggest that "consensus" is entirely irrelevant to the factual actuality of orbital geometry, solar age, solar composition and solar energy production. That one presented a number of other contextually relevant cases (e.g. the "facts" based on the polytropic model) for which one could have readily asked the same questions, which are not entirely rhetorical, is somewhat telling. That one could have readily presented many more cases, both context specific and also within the broader purview of "science," is also telling.

Galileo Galilei (1623/1960, pg. 300), in translation, is indicated to have stated that, "I say that even in conclusions of which one may attain a knowledge only by reasoning, the testimony of many men is worth little more that of a few, it being certain that the number of those who reason well in difficult matters is much smaller than the number of those who reason badly." One often sees another quote attributed to Galileo, one that bears the same gist as the cited quote, but one which does not appear to be a direct quote: "In questions of science, the authority of a thousand is not worth the humble reasoning of a single individual." Crichton (2003) was perhaps slightly more pointed in his critique: "I regard consensus science as an extremely pernicious development that ought to be stopped cold in its tracks. Historically, the claim of consensus has been the first refuge of scoundrels; it is a way to avoid debate by claiming that the matter is already settled… Let's be clear: the work of science has nothing whatever to do with consensus. Consensus is the business of politics. Science, on the contrary, requires only one investigator who happens to be right, which means that he or she has results that are verifiable by reference to the real world. In science consensus is irrelevant. What is relevant is reproducible results. The greatest scientists in history are great precisely because they broke with the consensus. There is no such thing as consensus science. If it's consensus, it isn't science. If it's science, it isn't consensus. Period." One finds that the positions taken in regards to metaphysics, ontology and epistemology are generally consistent with these quotes. Factual actuality is not created by "consensus" but rather is partially mapped when the map is partially isomorphic and irrespective of "consensus." That retrospective views of major advancements in science are attributed to specific individuals and not a nebulous collective is not a surprising finding. Within the subject context, given the repeated failures of the episteme of "consensus," the fact that repetition of rather than divestiture from the same is quite telling. One would suggest that a portion of the reasoning for this was already discussed above in regards to science as a social endeavor. While the topic is not the specific focus of this work, one would also suggest that there is a certain hubris of extancy, a certitude in the "facts" at any given point in history, that is also an operative paradigm.

An aspect of the "consensus" that is, in the view of the subject author, little discussed and with such potentially being due to its ready predictability is the following. The generation of material, typically in the written form (typewritten or otherwise) but not solely limited to the written form, by individuals engaged in the practice of science, and with such material being consistent with an operative paradigm, represents a somewhat recent norm (with recent being referenced to the civilizational timeline). Irrespective of any other motivations that might apply as the basis for "publishing," as it relates to context established in the previous sentence, one would take the position that the motivation of having later audiences view such works as exemplary of historical anachronism is a least or less likely case. Informally, looking at the corpus generated under the "iron Sun" paradigm, one finds a number of textbooks and a few hundred (at most) other written works that typically fall under a broad journal article classification. When it comes to the SSM, however, the number of salient texts runs into the hundreds and the number of journal articles runs into the thousands (again, informally and taking a broad view of the categorical areas involved). When an entire corpus is rendered as obsolete or incorrect, in view at least, and if discussed, typically involves some degree of hedging that functions to mitigate or soften the unvarnished "waste" (if the goal of the endeavor(s) is correctly ascertaining some aspect of factual actuality) of time, resources and effort. A less salient but sufficiently important point, specifically related to this work, is that even an informal review of the subject type, could readily be expanded to book or multi-book length and with the reference count befitting such an expansion.

While the subject author has been critical of the vast majority of that which is presented as "fact" when in fact that which is presented is extrapolation, speculation, unverifiable, and/or a confusion between the map and territory, one has been very careful to avoid making the claim that any of that which has been discussed is "wrong." This approach has been taken to avoid a performative contradiction in regards to the epistemic approach that one has taken in regards to the subject work. Recalling the utility aspect of Box's statement regarding models, Newton's law of "universal" gravitation was not usable for accurately predicting the orbit of Mercury, but is still used, to this very day, when it comes to the planning of satellite orbits as well as their placement. Point mass modeling approximations still suffice for modeling terrestrially constrained object kinetics and kinematics (inclusive of collisions). It would be somewhat dubious, however, to confuse or conflate an abstract point mass with the object that is being modeled as such.

The topical content upon which those in the fields of astrophysics or cosmology expound upon is a proverbial double edged sword. The analogous sword is the inability to make direct observations. One form of this, as exemplified by the inability to produce finite volumes of material at the modeled temperature, pressure and density of the modeled solar core. It would certainly be an interesting irony if it turned out that the reality of the solar core was one of condensed matter (Robitaille, 2013) rather than a fully ionized plasma. This inability to reproduce states of matter that exist only as theoretical constructs extends to more exotic forms of matter such as electron degenerate matter hypothesized to be present in white dwarfs and neutron degenerate matter hypothesized to be present in neutron stars. Yet another form of the sword is the patent inability to verify and validate claims that are made about distant (and even not so distant) locations across the observed universe. The problem of claims of "facts" based upon a grossly limited capacity for making direct observations, model filtered "observations" and tortuous circularity only increase as one considers locales that are more distant than the Sun. As an example, there is a vast difference between being able to test the claim that the laws of physics are the same everywhere by virtue of traveling to any location falling under the scope of the description "everywhere" and performing tests at that location (this is still model based and model filtered but it removes entire layers of modeling) versus being limited to using layer upon layer of model filtered guesses (i.e. "inferences").

Spectrographic measurements, even disregarding the layers of modeling assumptions involved in making the "observations," of distant objects such as quasars, when used to calculate the fine-structure constant require an assumption that the standard model of particle physics holds across the entire path from origin to destination and requires that a stripped of mathematical complexity model, that launders the label of general relativity, is accurate. The claims that Type 1a supernovae and baryon acoustic oscillations independently "verify" or "validate" the aforementioned is simply incorrect. The entire rickety structure of the cosmic distance ladder, while beyond the scope of this work, is subject to the same form of critique used in the subject work when it comes to the claims of "standard candles." The "standard rulers" in regards to baryonic acoustic oscillations is predicated upon the lambda cold dark matter (LCDM) model. The LCDM model is the crowning achievement of laundering when it comes to the label of general relativity. The model strips away, via the assumptions of universal homogeneity and isotropy, the mathematical complexity of general relativity, strips away relativity by reintroducing a preferred frame of reference (the co-moving frame of reference) and reestablishes absolute time. That the model is derivable from Newtonian theory (McCrea and Milne, 1934) with slight modification (i.e. post-Newtonian approximation) belies claims that are made in regards to a basis of general relativity. It is only somewhat of an exaggeration to state that this is akin to taking Einstein's field equations, multiplying both sides by zero, adding one to both sides and then claiming that general relativity was used to show that one equals one. The "evidence" that purportedly supports this model involves shifting goalposts (e.g. the distances over which the universe is purportedly isotropic and homogenous), highly dubious claims of Doppler redshift as the single factor cause when it comes to claims of 1D modeled "radial velocity" showing "expansion" (often, this claim is made as Hubble "proving" that the universe was expanding; the irony is that Hubble consistently articulated an opposition to expansion), dubious claims that "observations" "proving" that boundary region stars are orbiting galactic centers faster than they "should" be (in addition to the redshift issue one is again dealing with the layers of modeling and assumptions that go into estimates of galactic stellar populations, galactic mass, relative orientation between the observer and the observed and the "should" being in regards to perfectly circular orbits; claims of "spherical halos" are indicative of a modeled result) and claims that the cosmic microwave background radiation (CMB; this is one of the most heavily model filtered, in a circular manner, "observations," that one can find; the CMB is also predicted by other models) "proves" the model. In any number of other contexts, a division by zero result is viewed as either an error or a case in which the model breaks down. Here, it is viewed as the cosmological origin in the form of a singularity with infinite density, pressure and temperature. The residual between the orbit of Mercury and the model of Newton's law of "universal" gravitation was merely a planet sized conjecture that was granted ontological status. The residual in current cosmology has swelled to accounting for the vast majority of the universe in the form of "dark matter" and "dark energy." The former differs substantively from Zwicky's hypothesized "dunkle materie." That the evidence that contradicts the modeling assumptions, even after being heavily filtered by the modeling assumptions in question, being referred to as instrumentation anomalies, is merely an expected par for the course. Factual actuality has no requirement to conform to any modeling assumption or simplification that any human employs. This also holds in regards to time, resource and cost considerations when it comes to using models such as the SSM, which can readily be used on a typical personal computer, versus more complex models (e.g. those utilizing non-LTE assumptions, 3D magnetohydrodynamic codes or numerical methods for general relativity).

The other edge of the proverbial sword, as per the analogy, is that those making context specific proclamations of model based and model filtered results as "facts" can rest somewhat assured that the claims, based on current limitations, cannot be subject to falsification by direct observation. Traveling through the solar photosphere and into the non-superficial portions of the Sun, via manned or unmanned spacecraft, surviving the journey and reporting on any direct observations made, remains an untenable goal based upon current limitations. While noted earlier, it is worth restating that claims of model accuracy are not in regards to the relationship between model and factual actuality but rather are in regards to model to model comparison (often involving tortuous circularity, the same set of underlying assumptions, or both).

CONCLUSION

It is unclear, at least for the subject author, as to what changed for Hawking in regards to the views articulated by the same in 2001 versus those articulated in 2010. The former, in the subject author's construction, is interpretable as showing a distinction between the territory and the map, consistent with epistemic humility and consistent with Popper's philosophical views. The latter, in the subject author's construction, is interpretable as the lionization of those engaged in a certain vocation and with disregard for the previously articulated perspectives regarding science as an episteme and science as a practice. In this work, the subject author has focused on evaluating the "facts" of one particular instantiation, the SSM, that falls into the categories of astrophysics and cosmology. The analysis, rather than showing "torch bearers" in the quest for knowledge, reveals yet another instantiation of the paradigms of conflation of the map with the territory, the treatment of model based "observations" as "facts" and the social process of model preservation and avoidance of falsification. While one remains epistemically humble to the possibility that mere "consensus" dictates factual actuality, the context limited case provides multiple instantiations of where "consensus" as an episteme represented insipid nonsense. It takes very little specialized training, education or background to ask simple questions in regards to the assumptions being made, models being used, etc. and to make the simple request for the actual evidence to be shown when it comes to any claim that is purportedly scientific. The claims that any science is "settled," that scientists are not subject to the same foibles as any other human or that the practice of science is free of unscientific practices are patently incorrect. In the broader sense, especially in light of recent history involving a lack of longitudinal or cross-sectional data in regards to efficacy or safety (U.S. Food and Drug Administration, 2020), magical single valued "safe spaces" based not on data or science but rather conjectured from speculation (U.S. House of Representatives, Committee on Oversight and Accountability [House Committee on Oversight], 2024), outlandish nonsense in which being questioned equated to an attack on "science" (DeMarche, 2021) and what appears (at least in the opinion taken herein by the subject author) as self-serving collusion rather than science (U.S. House of Representatives, Committee on Oversight and Accountability [House Committee on Oversight], 2023), the approaches of the fallacy of false appeal to false authority and "consensus" are not theoretically or evidentially defensible substitutes for science as an ideal episteme.

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