Spectral Energy Distribution of a Body in Hydrostatic Equilibrium

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Abstract

The Spectral Energy Distribution (SED) measurements of Sunlight indicate that the Sun's SED is approximately that of a black body at a temperature of $\sim 5777\,\mathrm{K}$. This fact has been known for quite some time now. What is surprising is that this fact has not been interpreted correctly to mean that the Sun's temperature is constant throughout its profile *i.e.* the temperature of the core right up to the Surface must be the same *i.e.* if $\mathcal{T}_{\odot}(r)$ the temperature of the Sun at any radial point r, then $\mathcal{T}_{\odot}(r) \simeq 5777\,\mathrm{K}$. From the fundamental principles of statistical thermodynamics, a blackbody is a body whose constituents are all at a constant temperature and such a body will exhibit a Planckian SED. For a body that has a nearly blackbody SED like the Sun (and the stars), this means the constituents of this body must, at a reasonable degree of approximation, be at the same temperature *i.e.* its temperature must be constant throughout. If the Sun is approximately a blackbody as experience indicates, then, the Standard Solar Model (SSM) can not be a correct description of physical and natural reality for the one simple reason, that the Solar core must be at same temperature as the Solar surface. Simple, the Sun is not hot enough to ignite thermonuclear fission at its nimbus. If this is the case, then how does the Sun (and the stars) generate its luminosity. A suggestion to this problem is made in a future reading that is at an advanced stage of preparation; therein, it is proposed that the Sun is in a state of thermodynamic equilibrium – *i.e.*, in a state of uniform temperature and further a proposal (hypothesis or conjecture) is set-forth that the Sun may very well be powered by the $104.17\,\mu\mathrm{Hz}$ gravitational oscillations first detected by Brookes et al. (1976), Severny et al. (1976). Herein, we verily prove that the SED of a body in hydrostatic equilibrium can not, in general be Planckian in nature, thus ruling out the SSM in its current constitution. Only in the case were the density index is $\alpha_{\varrho} = 2$ (which implies a zero temperature index *i.e.* $\alpha_T = 0$), will the SED of such a body be Planckian.

1 Introduction

In elementary physics, that is, at the first level of one's bachelor's degree, one learns that a blackbody exhibits a Planck-type function in its Spectral Energy Distribution (SED). The Planckian SED arises when an object reaches true thermodynamic equilibrium. True thermodynamic equilibrium is attained *when and only when* the constituents of the body in question are all at the same constant temperature throughout the body in question. This means, if one were to measure the SED of an object and this SED is Planckian in nature, this body must surely be in thermodynamic equilibrium, *i.e.*, its temperature profile must have a constant, uniform temperature throughout.

Surprisingly, the Solar SED has been known to be Planckian yet, the widely accepted Standard Solar Model (SSM) holds that the Sun is in a state of hydrostatic equilibrium with its temperature varying across the entire Solar profile. This SSM posits that the Sun is held-up against the "tyranny" of gravitation by the resisting thermonuclear forces generated at its core which is presumed to be at a temperature of about $\mathcal{T}^{\odot}_{\mathrm{core}} = 15.2 \times 10^{6}\,\mathrm{K}$ while its surface is at a moderate temperature of $\mathcal{T}^{\odot}_{\mathrm{surf}} = 5777\,\mathrm{K}$. Given this kind of scenario were the body has such temperature variations, how does one go on to explain the observed Planckian SED of the Sun? To answer this question constitutes the main theme of this reading.

To that end, in §(2), we give an exposition of the Planck SED by deriving it from the fundamental principles of statistical thermodynamics. This exposition can be found in most good books of physics. We present this exposition here for later and instructive purposes. We demonstrate in this section that, only a body at a constant temperature is the one that is going to exhibit a Planck SED.

Further, in §(3), we briefly study a simple Solar hydrostatic equilibrium model. We show that this model lead us to conduct that the Sun can not be a simple hydrostatic equilibrium but perhaps in magneto-hydrostatic equilibrium. This study is not meant to be an involved one but a brief study to highlight a point.

Furthermore, having all the above, finally, we proceed in §(4) to derive the SED of a body in hydrostatic equilibrium. It is seen that the SED of such a body can not be Planckian in nature. If this proof is correct (as we believe it to be) and is at the same time acceptable, then, we are left with no choice but to accept that the SSM can not be correct description of physical and natural reality. In §(5), we give a general discussion and conclusions drawn thereof.

2 Blackbody Radiation Spectrum

We derive here the formula for the SED of a blackbody. As is well known, this formula was first derived by the great and pre-eminent German scientist, Max Karl Ernst Ludwig Planck (1858 – 1947) in 1900. We are not going to go through Planck's original derivation but that advanced latter in 1907 by another great German-Swiss-American scientist and philosopher, Albert Einstein (1879 – 1955). The reason for reproducing this derivation is for latter instructive purposes, *i.e.* in §(4), this exposition is vital for the derivation of the SED of a body in hydrostatic equilibrium presented therein; and also it is vital for demonstrating the important fact that this formula applies to bodies that are at uniform constant temperature. What this then means is that, if the SED of a particular body were to be measured and found to be that of (or approximately that of) a blackbody, this body must be at a constant uniform temperature.

Planck arrived at his formula after a difficult struggle, his quest was to arrive at a formula that fits the experimental data and to do this, he had to give up the long held idea of the continuum and introduce the then seemingly spurious quanta. The vibrating atoms that emit the blackbody radiation could no-longer have arbitrary energies, but they vibrated with energies that were a multiple of a fundamental energy unit ($\epsilon_1 = h\nu$), where ν the fundamental frequency of vibration and $h = 6.63 \times 10^{-34}$ Js is Planck's fundamental constant. That is, the energy of an oscillator is now given by ($\epsilon_n = nh\nu$) where ($n = 0, 1, 2, 3,$ *etc*). To arrive at the same formula as Planck, Einstein (1907) simply applied Boltzmann's counting procedure to these oscillators and the energy they emit.

He (Einstein) assumed that the emitted radiation by any oscillator occurred spontaneously and randomly, and more importantly, this energy is quantised in integral units of a fundamental energy unit ($\epsilon_1 = h\nu$). If ϵ_n is the energy of the emitted quanta, then, according to Boltzmann's counting procedure, for an oscillator at temperature $\mathcal{T}$, the probability $p(\mathcal{T})$ that this oscillator will radiate a quanta of energy ϵ_n is $p(\mathcal{T}) \propto e^{-\epsilon_n/k_\mathrm{B}\mathcal{T}}$. If N_0 is the number of oscillators in the ground state emitting quanta of energy $\epsilon_0 = 0$ *i.e.* no quanta emission, then, the number of oscillators in the state ($n = 2$) emitting quanta of energy ϵ_2 is $N_0 e^{-2\epsilon_n/k_\mathrm{B}\mathcal{T}}$; and the number of oscillators in the state ($n = 3$) emitting quanta of energy ϵ_3, is $N_0 e^{-3\epsilon_n/k_\mathrm{B}\mathcal{T}}$, *etc.* For such a setting, the mean energy $\bar{E}$ radiated by these oscillators is:

$$\bar{E} = \frac{\sum_{n=0}^{N} \epsilon_n N_0 e^{-\epsilon_n/k_\mathrm{B}\mathcal{T}}}{\sum_{n=0}^{N} N_0 e^{-\epsilon_n/k_\mathrm{B}\mathcal{T}}} = \frac{\epsilon_1 e^{-\epsilon_1/k_\mathrm{B}\mathcal{T}}}{1 - e^{-\epsilon_1/k_\mathrm{B}\mathcal{T}}}, \tag{1}$$

and this can be rewritten as:

$$\bar{E} = \frac{h\nu}{e^{h\nu/k_\mathrm{B}\mathcal{T}} - 1}, \tag{2}$$

see *e.g.* Longair (2003, pp. 354-355). This kind of mean energy of the radiation emitted, leads directly to a Planckian distribution of energy. To see this, we have to go to Planck (1899)'s energy distribution function. Planck showed that the energy density per unit frequency is given by:

$$u(h\nu)d(h\nu) = \left(\frac{8\pi h^2\nu^2}{h^3c^3}\right)\bar{E}d(h\nu). \tag{3}$$

Since we already know the mean energy of the radiation emitted by these oscillators, it follows that the energy distribution function of the emitted radiation will be given by:

$$u(\nu)d(h\nu) = \left(\frac{8\pi}{h^3c^3}\right)\frac{(h\nu)^3 d(h\nu)}{e^{h\nu/k_\mathrm{B}\mathcal{T}} - 1}. \tag{4}$$

This is the usual Planck function (Planck 1900) that explains very well the energy spectra of the Sun and the stars. Notice that in this derivation there is a crucial assumption without which one can not obtain the Planckian SED, that is, all the oscillators are assumed to be at a constant uniform temperature $\mathcal{T}$. What this means is that any body (such as the Sun and the stars) that exhibits a Planckian SED must be at a constant uniform temperature. As will be seen in §(4), any temperature variations will lead to a none-Planckian SED.

3 Hydrostatic Equilibrium

Assuming that particles in the interior of a star are not significantly affected by the magnetic field of the star, then, only two forces are worthy considering, that is, the gravitational and thermal forces. Let us consider an arbitrary particle located at a point $\boldsymbol{r} = r\hat{\boldsymbol{r}}$ from the Solar (star's) center. Let this particle be of mass m. The Sun (star) is considered to be comprised of identical particles each of mass m – this assumptions is a valid statistical assumption and holds good, it is the same assumption used in the SSM. Now, the equation of motion of a particle at an arbitrary position r is given by:

$$m\frac{d^2\boldsymbol{r}}{dt^2} = \boldsymbol{F}_{\text{grav}} - \boldsymbol{F}_{\text{th}}, \tag{5}$$

where $\boldsymbol{F}_{\text{grav}}$ is the gravitational force on the particle of mass m and $\boldsymbol{F}_{\text{th}}$ is the thermal force acting on this particle. For hydrostatic equilibrium, we will have: $\boldsymbol{F}_{\text{grav}} = \boldsymbol{F}_{\text{th}}$ at all r; *i.e.* $d^2\boldsymbol{r}/dt^2 = 0$.

For our study, we assume that Newtonian spherical gravitation is adequate for the present analysis. Thus for the gravitational force acting a particle in the Solar (star's) interior of constant density density profile is represented by the function $\varrho_{\text{star}}(r)$, we have:

$$\boldsymbol{F}_{\text{grav}} = -\frac{G\mathcal{M}(r)m}{r^3}\boldsymbol{r} = -\frac{4\pi G\varrho_{\text{star}}(r)m}{3}\boldsymbol{r}, \tag{6}$$

and for the thermal force we have:

$$\boldsymbol{F}_{\text{th}} = \left(\frac{k_{\text{B}}\mathcal{T}_{\text{star}}(r)}{r^2}\right)\boldsymbol{r}, \tag{7}$$

where $\boldsymbol{r} = r\hat{\boldsymbol{r}}$ is the radial unit vector. This is how one arrives at (7). We know that that force (F) is equal to pressure (P) times the area (A) *i.e.* $F = PA$. The force per unit mass is $F/\mathcal{M}(r)$ where $\mathcal{M}(r)$ is the total mass encased in the sphere of radius r from the Solar (star's) center. For material enclosed inside the sphere of radius r, we have $P_{\text{tot}} = \varrho(r)k_{\text{B}}\mathcal{T}_{\text{star}}/\mu_m m_H$ where P_{tot} is the pressure due to all the particles encased in the sphere of radius r; where $m = \mu_m m_H$, and μ_m is the mean number of particles per average molecule making up the Sun (star). The pressure due to a single particle $P = \mu_m m_H P_{tot}/\mathcal{M}(r)$, so that the thermal force acting on a single particle is $F_{\text{th}} = 4\pi\mu_m m_H r^2 P_{tot}/\mathcal{M}(r)$ and from this, equation (7) flows.

Now, for hydrostatic equilibrium ($|\boldsymbol{F}_{\text{grav}}| = |\boldsymbol{F}_{\text{th}}|$) to hold, it follows that:

$$\mathcal{T}_{\text{star}}(r) = \left(\frac{4\pi\mu_m G m_H \mathcal{R}^2_{\text{star}}}{3k_{\text{B}}}\right)\left(\frac{\mathcal{R}_{\text{star}}}{r}\right)^{-2}\varrho_{\text{star}}(r). \tag{8}$$

In this state of hydrostatic equilibrium, the Solar (star's) interior will exhibit a density profile of the form $\varrho_{\text{star}}(r) \propto r^{-\alpha_\varrho}$. From (8), it follows that a temperature profile of the form $\mathcal{T}_{\text{star}}(r) \propto r^{-\alpha_T}$ will accompany the density profile. From this, it follows the density (α_ϱ) and temperature (α_T) indices will be related by:

$$\alpha_\varrho = 2 + \alpha_T, \tag{9}$$

for balance between the gravitational and thermal force to occur. The density profile can be normalised and written as:

$$\varrho_{\text{star}}(r) = \varrho^{av}_{\text{star}} \left(\frac{\mathcal{R}_{\text{star}}}{r}\right)^{\alpha_\varrho}. \tag{10}$$

where $\varrho^{av}_{\text{star}} = 3\mathcal{M}_{\text{star}}/4\pi\mathcal{R}^3_{\text{star}}$ is the average density of the star. In the same fashion, the temperate profile can be normalised and written as:

$$\mathcal{T}(r) = \mathcal{T}_{\text{surf}} \left(\frac{\mathcal{R}_{\text{star}}}{r}\right)^{\alpha_T}, \qquad \text{for} \quad r \geq \mathcal{R}_{\text{core}}, \tag{11}$$

where $\mathcal{T}_{\text{surf}}$ is the surface temperature of the star and $\mathcal{R}_{\text{core}}$ is the radius of the core of the star. Now, if the condition $\mathcal{T}(\mathcal{R}_{\text{core}}) = \mathcal{T}_{\text{core}}$, is imposed, then, the temperature index is going to become a dependent variable governed by the equation:

$$\alpha_T = \frac{\ln\left(\mathcal{T}_{\text{core}}/\mathcal{T}_{\text{surf}}\right)}{\ln\left(\mathcal{R}_{\text{star}}/\mathcal{R}_{\text{core}}\right)}, \tag{12}$$

thus if $\mathcal{T}_{\text{core}}, \mathcal{T}_{\text{surf}}, \mathcal{R}_{\text{star}}$ and $\mathcal{R}_{\text{core}}$ are known, the temperature index will be known. Given that the core of the Sun is considered to extend from the center to about $20-25\%$ of the Solar radius (García et al. 2007) with the temperature being close to $15.7 \times 10^6\,\text{K}$ and the Solar surface being at a temperature of $\sim 5777\,\text{K}$, it follows from (12), that $\alpha_T = 5.30 \pm 0.40$. In Nyambuya (2010), it has been argued that the density index α_ϱ can only take values in the range $(0 \leq \alpha_\varrho \leq 3)$. Since $\alpha_\varrho = 2 + \alpha_T$, this means $(-2 \leq \alpha_T \leq 1)$, but since $(\alpha_\varrho \geq 0)$, it therefore follows that $(0 \leq \alpha_T \leq 1)$, thus the value $\alpha_T = 5.30 \pm 0.40$, is according to Nyambuya (2010), unphysical.

Now, from (8) and (11), it follows that the surface temperature $\mathcal{T}_{\text{surf}}$ is going to be given by:

$$\mathcal{T}_{\text{surf}} = \frac{4\pi\mu_m G m_H \varrho^{av}_{\text{star}}\mathcal{R}^2_{\text{star}}}{3k_{\text{B}}} = \left(\frac{\mu_m G m_H}{k_{\text{B}}}\right)\frac{\mathcal{M}_{\text{star}}}{\mathcal{R}_{\text{star}}}. \tag{13}$$

If one were to substitute the relevant Solar values into (13), they would obtain the value $\mathcal{T}_{\text{surf}} = 31.0 \times 10^6\,\text{K}$. This value is certainly not correct. Off cause, one can argue that since the is Sun assumed[1] to be comprised of plasma, we have not considered the magnetic forces, the magnetic field will certainly play an important role in the attainment of equilibrium, the meaning of which is that, the Sun may not only be in hydrostatic equilibrium but in magneto-hydrostatic equilibrium.

The point we want to drive home here is that a simple hydrodynamic model of the Sun (stars) is inconsistent with physical and natural reality. Additionally, this exercise that we have conducted here is necessary for the derivation that we shall carry-out in the next section. Furthermore, what is important is not whether or not the Sun (stars) is (are) in hydrostatic equilibrium or not, but whether or not it is in thermodynamic equilibrium. Whatever mechanism that generates the Sun's (star's) luminosity, it must explain the Solar's near blackbody SED. That is what is important. Any mechanism that leads to a Solar temperature profile with a none

[1] Actually, it is taken as fact that the Sun is comprised of Plasma. We would like to relax this assumption because of the findings we have made in the upcoming reading where we propose new Solar model powered by the 160-min g-mode oscillation first observed by Brookes et al. (1976), Severny et al. (1976).

constant and none uniform temperature across the Solar profile – however feasible it may be; this mechanism will successfully fail to explain the Solar SED, hence it has no correspondence with natural and physical reality.

4 Spectrum of Body in Hydrostatic Equilibrium

To compute the SED of a body in hydrostatic equilibrium, let us consider a star in hydrostatic equilibrium. For this star, let us consider a small element shell of thickness dr. Because of the smallness of the shells, their temperature is – to first order approximation; constant, the meaning of which is that they must be in a state of thermodynamic equilibrium. What we need to do is to compute the mean energy of a particle for the entire star. This we will do by the method of integration but before that, we need to compute the mean energy of the shell and find a way to add up the mean energies of the many different shells.

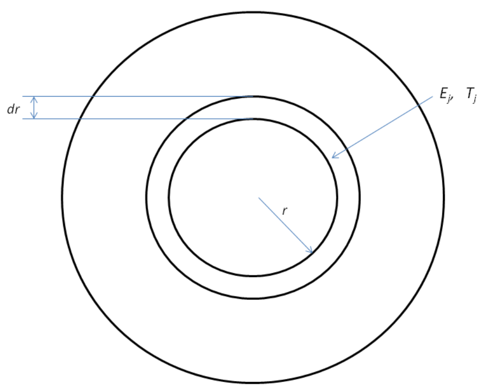

Figure (1): *Hydrostatic core held in equilibrium by thermal forces. An element shell of thickness dr can be considered to be in thermodynamic equilibrium. This shell has temperature $\mathcal{T}_j$ and the mean energy of the particles in this shell is $\bar{E}_j$.*

Since, at the end of the day, we shall consider many element shells, let the current shell element be the j^{th} element shell. Because this shell is in thermodynamic dynamic equilibrium, the mean energy of particles in this shell is:

$$\bar{E}^j_{\text{shell}} = \frac{h\nu}{e^{h\nu/k_{\text{B}}\mathcal{T}_j} - 1}, \qquad (14)$$

where $\mathcal{T}_j$ is the temperature of this shell. Now, let the number of particles in this shells be dn_j. If the star is divided into m shells, each of these will have mean energy $\bar{E}_j$. Because the temperature of the shells $\mathcal{T}_j$ is different, the mean energy $\bar{E}_j$ of these shells will be different. Now, the mean energy of the entire star is given by:

$$\bar{E}_{\text{star}} = \frac{\sum_{j=1}^{m} \bar{E}^j_{\text{shell}} dn_j}{\sum_{j=1}^{m} n_j} = \frac{1}{N}\left(\sum_{j=1}^{m} \bar{E}^j_{\text{shell}} dn_j\right), \qquad (15)$$

where N is the total number of particles making up the star. If we make the shells to be infinitesimally small, then the summation sign transforms to an integral sign *i.e.* $\sum \longmapsto \int$, this means:

$$\bar{E}_{\text{star}} = \int \bar{E}_{\text{shell}} dn. \qquad (16)$$

Now, we need to compute dn in terms of the temperature $\mathcal{T}$ of the shells. To do this, we have to resort to the Mass Distribution Function (MDF), that is:

$$\mathcal{M}_{\text{star}}(r) = \mathcal{M}_{\text{star}} \left(\frac{\mathcal{R}_{\text{star}}}{r} \right)^{\alpha_m}, \tag{17}$$

where $\mathcal{M}_{\text{star}}(r)$ is the mass enclosed inside the sphere of radius r [see Nyambuya (2010), for an explanation of this MDF]. Dividing this expression by $\mu_m m_H$, and making use of (11), we obtain:

$$n_{\text{star}}(r) = \frac{\mathcal{M}_{\text{star}}}{\mu_m m_H} \left(\frac{\mathcal{R}_{\text{star}}}{r} \right)^{\alpha_m} = N \left(\frac{\mathcal{R}_{\text{star}}}{r} \right)^{\alpha_m} = N \left(\frac{\mathcal{T}}{\mathcal{T}_{\text{surf}}} \right)^{\frac{\alpha_m}{\alpha_T}}, \tag{18}$$

where $n_{\text{star}}(r)$ is the total number of particles enclosed in sphere of radius r. Differentiating the above, one is led to:

$$dn = -\alpha_m N \left(\frac{\mathcal{R}_{\text{star}}}{r} \right)^{\alpha_m} \frac{dr}{r} = -\alpha_m n \frac{dr}{r} = -\alpha_m N \left(\frac{\mathcal{T}}{\mathcal{T}_{\text{surf}}} \right)^{\frac{\alpha_m}{\alpha_T}} \frac{dr}{r}. \tag{19}$$

To compute dr/r, we differentiate (11) and then re-arrange, so doing, one is led to:

$$\frac{dr}{r} = -\frac{1}{\alpha_T} \frac{d\mathcal{T}}{\mathcal{T}}. \tag{20}$$

Substituting this into (19), we obtain:

$$dn = N \left(\frac{\alpha_m}{\alpha_T} \right) \left(\frac{\mathcal{T}}{\mathcal{T}_{\text{surf}}} \right)^{\frac{\alpha_m}{\alpha_T} - 1} d \left(\frac{\mathcal{T}}{\mathcal{T}_{\text{surf}}} \right). \tag{21}$$

Substituting this into (16), finally, we obtain the expression for the mean energy of the entire star, *i.e.*:

$$\bar{E}_{\text{star}} = \mathcal{T}_{\text{surf}}^{-\frac{\alpha_m}{\alpha_T}} \left(\frac{\alpha_m}{\alpha_T} \right) \int_{\mathcal{T}_{\text{surf}}}^{\mathcal{T}_{\text{core}}} \left(\frac{(h\nu) \mathcal{T}^{\frac{\alpha_m}{\alpha_T} - 1}}{e^{h\nu / k_{\text{B}} \mathcal{T}} - 1} \right) d\mathcal{T}. \tag{22}$$

Now, substituting this into (3), we are led to our sought for and final expression of the SED of body in hydrostatic equilibrium, *i.e.*:

$$u(h\nu) d(h\nu) = \mathcal{T}_{\text{surf}}^{-\frac{\alpha_m}{\alpha_T}} \left(\frac{\alpha_m}{\alpha_T} \right) \left(\frac{8\pi}{h^3 c^3} \right) \int_{\mathcal{T}_{\text{surf}}}^{\mathcal{T}_{\text{core}}} \left(\frac{(h\nu)^3 \mathcal{T}^{\frac{\alpha_m}{\alpha_T} - 1}}{e^{h\nu / k_{\text{B}} \mathcal{T}} - 1} \right) d\mathcal{T} d(h\nu). \tag{23}$$

This formula, or the SED function of a body in hydrostatic equilibrium is different from that of a blackbody. To evaluate this formula would require numerical integration. We are not going to conduct this exercise here, what is clear is that the resultant curve emerging from this formula is different from that of a blackbody. With a core at $15.2 \times 10^6\,\text{K}$ and a surface temperature of $5777\,\text{K}$ and a core radius of $0.20\mathcal{R}_{\odot}$, the average Solar temperature gradient is $0.03\,\text{Km}^{-1}$, certainly, there will be significant temperature variations. From this, we conclude that the Sun can not have temperature variations in its interior if one were to successfully explain the near blackbody Solar SED that is observed. Actually, it can only be at a constant temperature of $5777\,\text{K}$ for this to be so. Interestingly, this temperature falls far short of the $\sim 10^7\,\text{K}$

required for the proton-proton chain reaction that is presumed to power the Sun. In the discussion section, we shall touch on the new idea that we are currently working on to solve this problem of "*What then causes the Sun and the stars to shine?*".

5 Discussion and Conclusion

Given the fact that it is well known that the SED of the Sun is approximately that of a blackbody, it is surprising that the SSM has survived this long. This blackbody Solar SED invariably tells us that the Sun is – to a reasonable degree of approximation; in thermodynamic equilibrium, the meaning of which is that its temperature is constant throughout its entire profile *i.e.* from its nimbus right up to its surface. Stated simpler, the Solar core must be at the same temperature as the Solar surface, otherwise its SED would not be approximately that of a blackbody. This state of affairs must be true for other stars as-well.

What this means is that the SSM can not be a correct description of physical and natural reality as we know it because the SSM has as its central tenant the assumption that the Solar core and surface at different temperatures. Not only are these temperatures different, there is a very significant difference in the two temperatures, the meaning of which is that the Sun's SED should not be anything approximating a blackbody.

In order to demonstrate our point, we have derived the correct SED of a body in hydrostatic equilibrium were the density and temperature profiles are described by the usual inverse distance power laws thought to govern not only stellar interior, but molecular clouds, and their cores. The resulting formula tells us that the SED of a body in hydrostatic equilibrium is different from that of blackbody. What this means at the end of the day, is that any model that purports to describe the Solar (stellar) interiors and takes as its central tenant that the Sun (stars) are in a state of hydrostatic equilibrium, these models can not be correct description of natural and physical reality. Such models must explain how it comes about that a very hot core will heat up the rest of the star at a constant temperature.

Other than the SSM, there are some seemingly credible ideas about how the Sun generates its luminosity. Retired NASA scientist, Emeritus Professor, Oliver K. Manual is the leader of the Iron Sun Model (ISM) (see *e.g.* Manuel et al. 2002,3, Manuel *&* Katragada 2004, Manuel et al. 2005). Professor Manual's team holds that there encased a Neutron star at the center of the Sun and this Neutron star is what generates the luminosity of the Sun *via* energy released from Neutron repulsion (Manuel 2011). This model may or may not be correct, but one thing that these researchers will have to do, is make sure that their model can explain the Planckian SED of the Sun, otherwise this model will suffer the same fate as the SSM. If it is feasible, *they must* adopt the assumption that the material encasing the hypothetical Neutron star at the Solar nimbus must be at a constant temperature. That is, the hypothetical central Neutron star must heat-up this envelope (encasing material) and maintain it at a constant temperature. How this can be achieved, we leave it to the proponents of the model. The sure thing is that they should be able to explain the approximately Planckian SED observed for the Sun.

In a future reading that is at an advanced stage of preparation, we propose a new model of how the Sun (and the stars) generate its luminosity. This model seizes on the controversial observations of Brookes et al. (1976), Severny et al. (1976). These researchers (Brookes et al. 1976, Severny et al. 1976) where the first to observe a the 160-minute oscillation of the Sun. However, in a paper by Elsworth et al. (1989), this signal was dismissed as an artefact cause by the Earth's atmosphere. This is the view taken by a significant number of researchers (*e.g.* Howe 2009, Pallé et al. 1998) but there is also a number that believe this signal is real. We take the approach that this signal is real (*e.g.* Kotov et al. 2000, 1997, Kotov & Kotov 1997, Kotov & Lutyi 1992, Kotov et al. 1991, Kotov & Tsap 1990).

To explain its origins, we propose that the Sun (and stars) has a constant uniform density through their profile *i.e.* if $\varrho_{\rm star}(r)$ is the density of material enclosed inside radius r, then for the Sun we assume $\varrho_{\rm star}(\mathrm{r}) = \mathrm{constant}$.. For the temperature profile, we make the same assumption *i.e.* if $\mathcal{T}_{\rm star}(r)$ is the average temperature of the material enclosed inside radius r, then, we assume $\mathcal{T}_{\rm star}(r) = \mathrm{constant}$. With these assumptions, it is seen that the Sun (star) is going to have a core that is held against collapse by thermal forces in hydrostatic equilibrium and the encasing material is going to execute gravitational simple harmonic motion with oscillations whose period is 167-minutes. If the material making up the encasement is to be made of Neutrons (and not Plasma), and knowing that Neutrons have a permanent electric dipole moment, and applying the laws of electromagnetism together with the laws of statistical thermodynamics, it is seen that one can not only explain the luminosity of the Sun (stars) but the SED as-well.

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