Secrets of the Sun

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When measured in Planck units the vital parameters of the sun take particular values.

Radius

The solar radius $R_\odot = 6.957 \times 10^{8}$ m [1]. In Planck units, $R_\odot = 4.304 \times 10^{43} = e^{100.47}$. That is,

$$\boxed{R_\odot \sim e^{100}\, l_P} \qquad (1)$$

where $l_P = 1.616229 \times 10^{-35}$ m is the Planck Length [2].

Rotation Period

The (sidereal Carrington) rotation period $P_\odot$ of the sun is 25.38 days [1].

In Planck units, $P_\odot = 4.067 \times 10^{49} = \pi^{99.79}$. That is,

$$\boxed{P_\odot \sim \pi^{100}\, t_P} \qquad (2)$$

where $t_P = 5.39116 \times 10^{-44}$ s is the Planck Time [2].

Mass

The mass $M_\odot = 1.9885 \times 10^{30}$ kg [1] of the sun, its radius $R_\odot$ and rotation period $P_\odot$ are related in size. Using Planck units,

$$\boxed{P_\odot = \frac{2{R_\odot}^2}{M_\odot}} \qquad (3)$$

The use of Planck units explains the apparently unbalanced dimensions in (3). Calculating $P_\odot$ by (3) from the measured values of $R_\odot$ and $M_\odot$, one finds that $P_\odot$ = 25.31 days, which is very close to the Carrington rotation period of 25.38 days. Since the surface gravity $g_\odot = M_\odot/{R_\odot}^2$ using Planck units, one may write:

$$\boxed{g_\odot = \frac{2}{P_\odot}} \qquad (4)$$

From (4), with $P_\odot$ = 25.38 days, $g_\odot = 273.4$ ms^{-2}.

Moment of Inertia

The sun's moment of inertia $I_{\odot}$ = solar moment of inertia factor × $M_{\odot}R_{\odot}^2$. With the solar moment of inertia factor equal to 0.070 [1], $I_{\odot}$ = 6.737 × 10^{46} kg.m^2. In Planck units, $I_{\odot}$ = 1.185 × 10^{124} = $\pi^{249.57}$. That is,

$$\boxed{I_{\odot} \sim \pi^{250}\, I_{\mathrm{P}}} \qquad (5)$$

where I_{P} is the Planck Moment of Inertia.

Spin Angular Momentum

The sun's spin angular momentum $S_{\odot} = 2\pi I_{\odot}/P_{\odot}$ = 1.930 × 10^{41} kg.m^2.s^{-1}.
In Planck units, $S_{\odot}$ = 1.831 × 10^{75} = $2^{250.02}$. That is,

$$\boxed{S_{\odot} = 2^{250}\, \hbar} \qquad (6)$$

where ħ = 1.054571800 × 10^{-34} J.s (or kg.m^2.s^{-1}) is the Planck unit of angular momentum [2]. For stars in general the spin angular momentum $S_* = 2^N\, \hbar$, where N is an integer [3].

Temperature

The temperature $T_{\odot,\mathrm{C}}$ at the centre of the sun is ~1.57 × 10^7 K [1].
In Planck units, $T_{\odot,\mathrm{C}}$ = 1.108 × 10^{-25} = $\pi^{-50.20}$. That is,

$$\boxed{T_{\odot,\mathrm{C}} \sim \pi^{-50}\, T_{\mathrm{P}}} \qquad (7)$$

where T_{P} = 1.416808 × 10^{32} K is the Planck Temperature [2].

Luminosity

The luminosity $L_{\odot}$ = 3.828 × 10^{26} W [1] of the sun, the solar radius $R_{\odot}$ and the surface temperature $T_{\odot,\mathrm{S}}$ ~ 5800 K of the sun are related by the Stefan-Boltzmann Law. For a star, $L_* \propto R_*^2 T_*^4$. When Planck units are used the luminosity of the sun is given by

$$\boxed{L_{\odot} \sim 2 R_{\odot}^2 T_{\odot,\mathrm{S}}^4} \qquad (8)$$

Calculating $L_{\odot}$ by (8) from the measured values of $R_{\odot}$ and $T_{\odot,\mathrm{S}}$, one finds that $L_{\odot}$ = 3.8 × 10^{26} W.

Discussion

The sun has formed and developed in such a way that its vital parameters have taken what appear to be preferred and consequently average values, placing the sun in the middle of the Main Sequence.

That the parameters considered here are related to Planck scale through particular exponential factors suggests that phenomena at stellar scales emerge from physics at Planck scale. Hints of that physics are given by equations (3), (4) and (8), which relate parameters elegantly.

References

1. Sun Fact Sheet, https://nssdc.gsfc.nasa.gov/planetary/factsheet/sunfact.html
2. 2014 CODATA recommended values
3. B. F. Riley, viXra:1811.0232, The quantised angular momenta of astronomical bodies