Hints of TeV-Scale Black Holes

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By application of the 10D/4D correspondence, the radii of nearby stars have been shown to map onto the masses of stable atomic nuclei. The correspondence is now used to calculate the mass m and radius r of the subatomic object that corresponds to a typical 1.4 solar mass neutron star. The mass m is found to be 4.0 TeV. Using natural units, r/m is precisely 2.

The 10D/4D correspondence [1], found in an analysis of dark energy as vacuum energy, relates subatomic scales to cosmological and astrophysical scales. The correspondence is a generalisation of the precise equation

$$2\mathrm{a_0}^5 = \mathrm{r_{ou}}^2 \tag{1}$$

where $\mathrm{a_0}$ is the Bohr radius, 0.529×10^{-10} m and $\mathrm{r_{ou}}$ is the radius, 14,300Mpc [2], of the observable universe; the use of natural units (ħ = c = G = 1), in (1) and throughout the paper, explains the apparent unbalanced dimensions. The 10D/4D correspondence relates sub-Planckian mass and length scales derived from the locations of boundaries in (ten-dimensional) $AdS_5 \times S^5$ spacetime to cosmological and astrophysical length and mass scales, respectively, in four-dimensional spacetime:

$$2\mathrm{m_{10}}^{-5} = l_4{}^2 \tag{2}$$

$$2l_{10}{}^{-5} = \mathrm{m_4}^2 \tag{3}$$

Equations (2) and (3) have been used to show that the sub-Planckian scales (m_{10} and l_{10}) corresponding to the radii (l_4) and masses ($\mathrm{m_4}$) of astrophysical bodies lie on levels of mass and length scale that descend in geometric progression from Planck scale [3, 4]: $1.220910(29) \times 10^{19}$ GeV and $1.616229(38) \times 10^{-35}$ m [5].

The values of mass scale m_{10} calculated from the confidently-known radii of prominent nearby stars (and Pollux, the nearest giant star) and gaseous planets not only lie on the levels of the Planck sequences[1] but also tend to coincide with the masses of stable atomic nuclei [4], as shown in Figure 1. In the calculations, binary stars are represented in radius (l_4) by the geometric mean of the two stellar radii. The stellar radii and masses used are shown in Table 1. Solar and planetary data are from the NASA Space Science Data Coordinated Archive [6].

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[1] Sequence 1 is of common ratio 1/π, Sequence 2 is of common ratio 2/π and Sequence 3 is of common ratio 1/e. Levels in the three sequences are numbered $\mathrm{n_1}$, $\mathrm{n_2}$ and $\mathrm{n_3}$ from Planck scale (n = 0), and may take fractional values. In the two-dimensional graphs presented, the mass and length scales lie on a straight line since $\mathrm{n_1}$, $\mathrm{n_2}$ and $\mathrm{n_3}$ are in constant ratio.

Star	Radius in solar radii	Mass in solar masses
Proxima Centauri	0.141(7) [7]	0.123(6) [7]
Alpha Centauri A	1.227(5) [8]	1.100(6) [9]
Alpha Centauri B	0.865(6) [8]	0.907 (6) [9]
Sirius A	1.711(13) [10]	2.02(3) [11]
Sirius B	0.00840(25) [12]	1.02(2) [11]
Pollux	8.8(1) [13]	2.04(4) [14]

Table 1: Radii and masses of the stars investigated

(a)

(b)

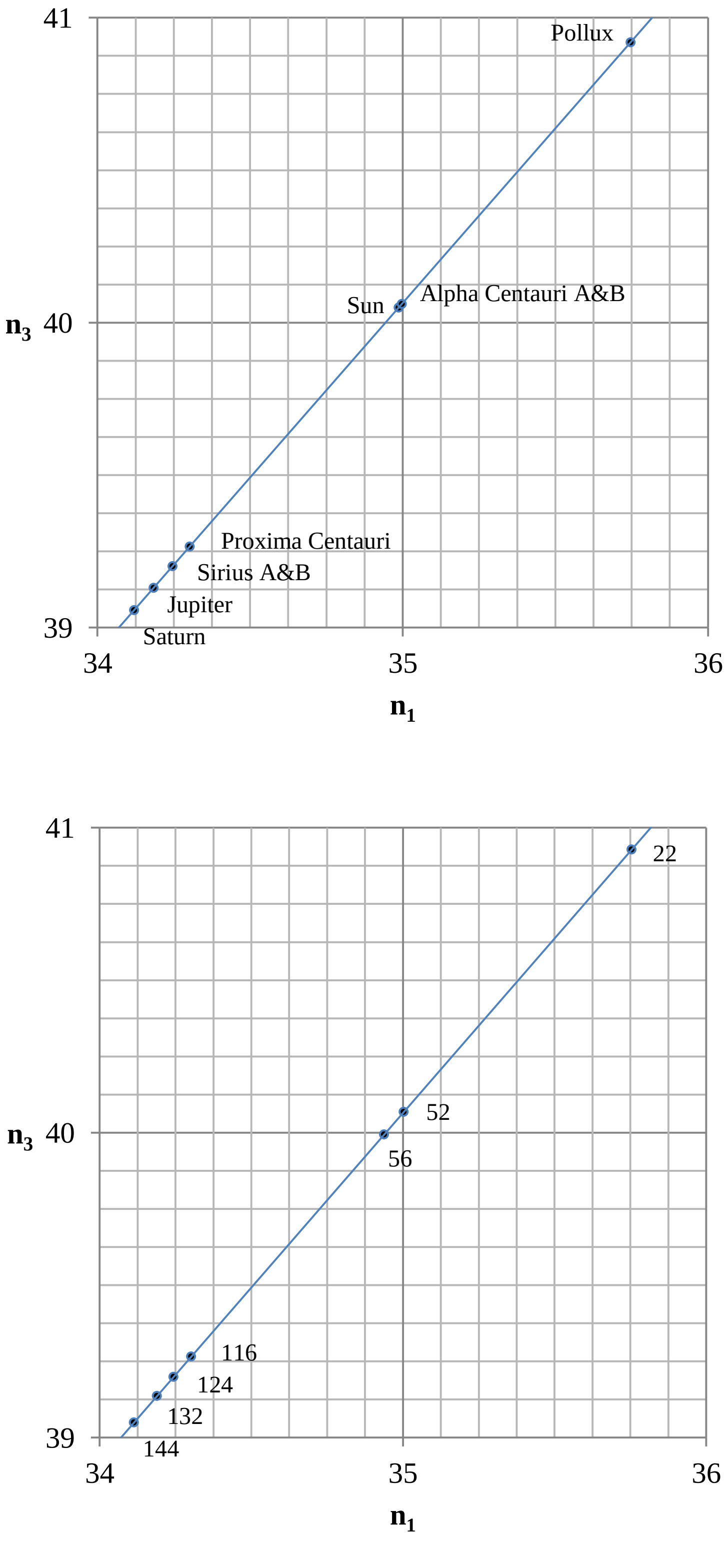

Figure 1: The occupation of mass levels, numbered n_1 and n_3, in Planck Sequences 1 (common ratio 1/π) and 3 (common ratio 1/e) by
(a) mass scales m_{10} calculated from the radii of stars and gaseous planets according to (2)
(b) atomic nuclei with the mass numbers (A) shown
Not shown, values of m_{10} calculated from the nearly equal radii of Uranus and Neptune lie close to and either side of the mass of a nucleus for which the mass number A = 200.

Values of m_{10} calculated for the Sun and Alpha Centauri A & B – all dwarf stars, central in the Main Sequence – lie close to Level 35 in Sequence 1, on the near-coincidence (35, 40) in Sequences 1 and 3. In the Planck Model [15], near-coincident mass levels whose numbers are multiples of 5 are important locations for physics. The highly stable ^{56}Fe nucleus occupies mass level 40 in Sequence 3, on the near-coincidence (35, 40) in Sequences 1 and 3, as shown in Figure 1. As doublets, the quarks occupy the near-coincidences (110, 50), (100, 45) and (90, 40) in Sequences 2 and 3, as shown in Figure 2. Each quark doublet is represented in mass by the geometric mean of the two quark masses. Particle Data Group quark mass evaluations [16] have been used in the calculations.

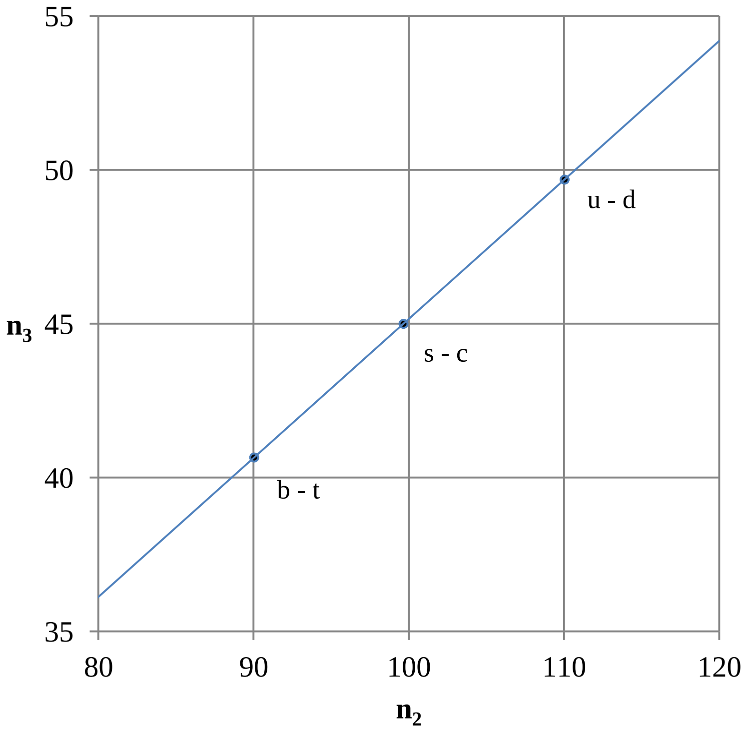

Figure 2: The occupation of mass levels, numbered n_2 and n_3, in Planck Sequences 2 (common ratio $2/\pi$) and 3 (common ratio 1/e) by the quarks, as doublets. These quark masses have been used to calculate the doublet masses: 2.2 MeV, 4.7 MeV, 96 MeV, 1.27 GeV, 4.18 GeV and 173.21 GeV [16].

A key length scale in the Planck Model, the Bohr radius lies on Level 125 in Sequence 2 [15], on the near-coincidence (50, 125) in Sequences 1 and 2.

The electron and up quark (2.2 MeV) occupy levels whose numbers are multiples of 5, as shown in Figure 3.

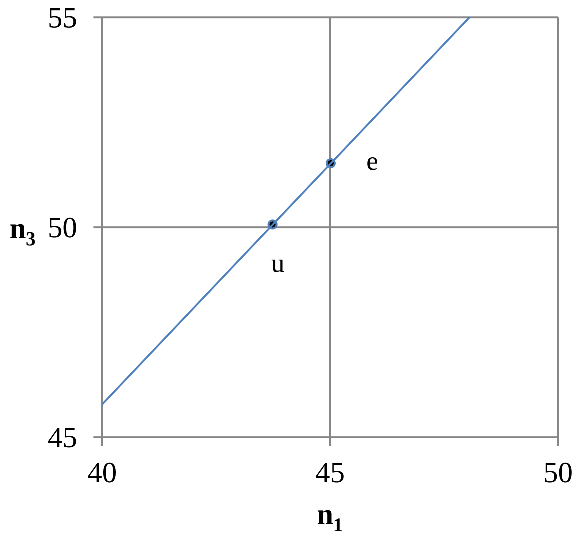

Figure 3: The occupation of mass levels, numbered n_1 and n_3, in Planck Sequences 1 (common ratio $1/\pi$) and 3 (common ratio $1/e$) by the electron and the up quark (2.2 MeV [16]).

Values of sub-Planckian length scale l_{10} calculated from the masses of the stars and planets of Figure 1 are shown on the levels and sublevels of the Planck sequences in Figures 4 and 5.

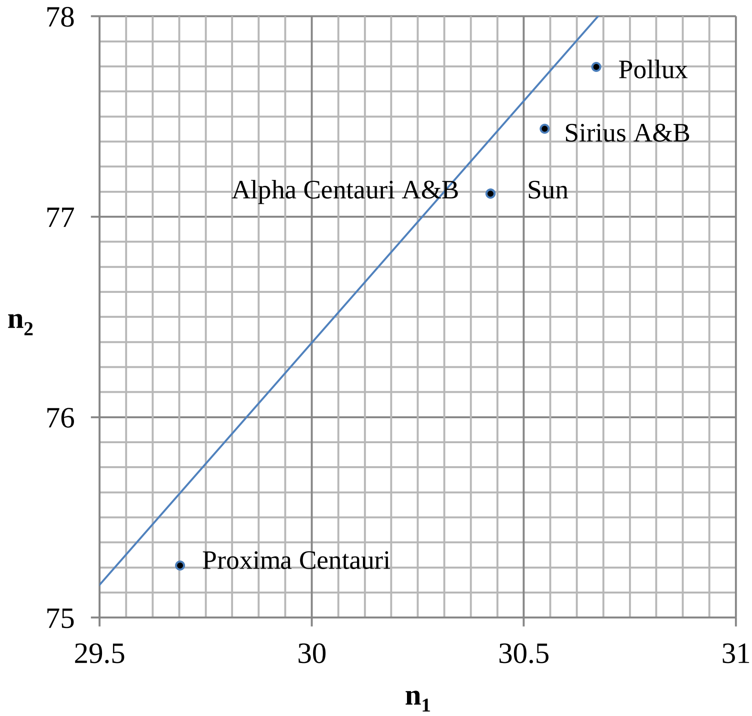

Figure 4: The occupation of levels of sub-Planckian length scale, numbered n_1 and n_2, in Planck Sequences 1 (common ratio $1/\pi$) and 2 (common ratio $2/\pi$) by length scales l_{10} calculated from the masses of stars according to (3).

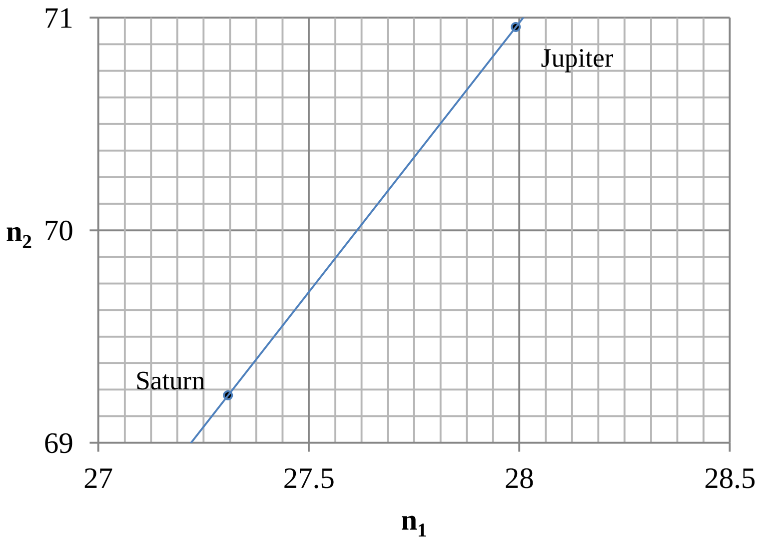

Figure 5: The occupation of levels of sub-Planckian length scale, numbered n_1 and n_2, in Planck Sequences 1 (common ratio 1/π) and 2 (common ratio 2/π) by length scales l_{10} calculated from the masses of Jupiter and Saturn according to (3).

We see that the values of l_{10} calculated for stars and gaseous planets lie on the levels and sublevels of the Planck sequences.

Values of m_{10} and l_{10} for the Sun and Tau Ceti[2] as a pair of twins, as suggested in [5] – the stars being represented by the geometric mean of the two radii and by the geometric mean of the two masses – would occupy 'principal levels': mass level 40.00 in Sequence 3, which is associated with the ^{56}Fe nucleus, and length-scale level 77.01(1) in Sequence 2. The notable location of the pair within the Planck sequences perhaps reflects the positions of the two stars at the centre of the Main Sequence.

Equations (2) and (3) will now be applied to a neutron star. Steiner, Lattimer and Brown [18] have determined that the radius of a typical 1.4 solar mass neutron star lies between 10.4 km and 12.9 km, independent of assumptions about the composition of the core. With m_4 = 1.4 solar masses and l_4 = 11.7 km, the mid-range value of radius in Steiner et al's analysis, the application of (2) and (3) results in l_{10} = 6.5682(2) × 10^{-16} l_{Planck} and m_{10} = 3.2835(2) × 10^{-16} m_{Planck} = 4.01 TeV. We see that l_{10}/m_{10} = 2.000. So, for the subatomic object, of mass m and radius r, corresponding to a typical neutron star, we find that r/m = 2, precisely.

For a classical black hole, $\mathrm{r_S/m}$ = 2, where $\mathrm{r_S}$ is the Schwarzschild radius. Perhaps our subatomic object is a micro black hole. Since stellar radii tend to map onto the masses of stable nuclei, or at least

[2] Tau Ceti: radius 0.793(4) solar radii, mass 0.783(12) solar masses [17]

nuclei with even numbers – often multiples of 4 – of nucleons, the micro black hole may similarly be stable.

The value of l_{10} calculated from a typical neutron star mass of 1.4 solar masses is found to lie adjacent to the very nearly coincident levels 77.5 in Sequence 2 and 35 in Sequence 3, as shown in Figure 6. Such a near-coincidence of a superlevel – a level whose number is a multiple of 5 – with a half-superlevel is a highly important location for physics in the Planck Model. The value of l_{10} calculated from a neutron star mass of 1.55 solar masses would lie on the coincident levels. The corresponding micro black hole would be of mass 3.85 TeV. The range of micro black hole mass corresponding to neutron star masses in the range 1.0 – 2.0 solar masses would be 3.5 – 4.6 TeV.

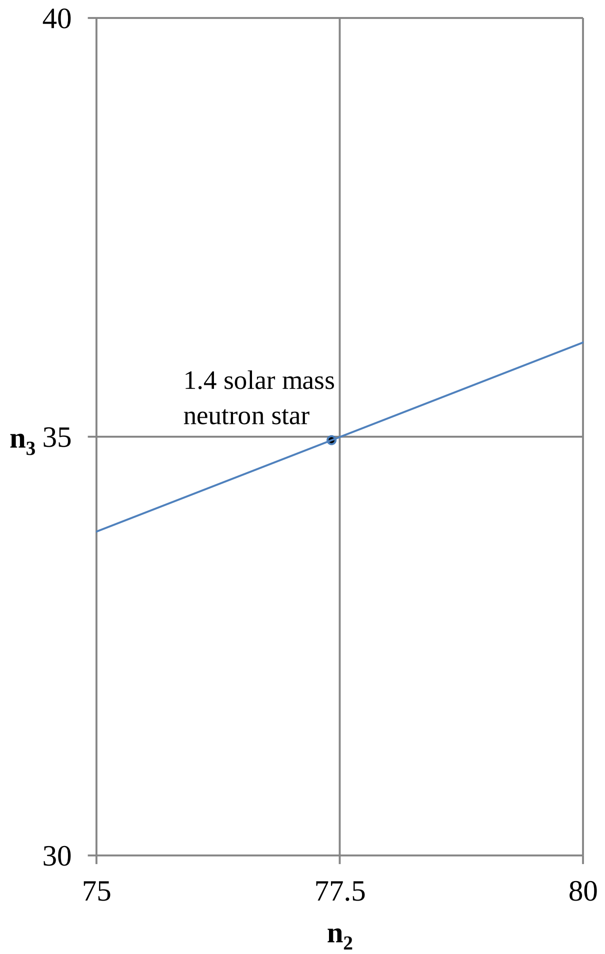

Figure 6: The occupation of levels of sub-Planckian length scale, numbered n_2 and n_3, in Planck Sequences 2 (common ratio 2/π) and 3 (common ratio 1/e) by length scales l_{10} calculated from the mass of a 1.4 solar mass neutron star.

References

1. B. F. Riley, 10D/4D correspondence and the Big Bang, viXra:1503.0104
2. J. R. Gott III et al, A map of the universe, arXiv:astro-ph/0310571; Astrophys. J. 624:463, 2005
3. B. F. Riley, Planets and their moons as trans-Planckian bodies, viXra:1508.0167
4. B. F. Riley, The correlation between stellar radii and the masses of stable atomic nuclei, viXra:1704.0049
5. CODATA 2014
6. NASA Space Science Data Coordinated Archive, Lunar and Planetary Science, nssdc.gsfc.nasa.gov/planetary/
7. B.-O. Demory et al, Mass-radius relation of low and very low-mass stars revisited with the VLTI, arXiv:0906.0602
8. P. Kervella et al, The diameters of Alpha Centauri A and B – A comparison of the asteroseismic and VINCI/VLTI views, arXiv:astro-ph/0303634; Astron.Astrophys.404:1087-1098, 2003
9. F. Thevenin et al, Asteroseismology and calibration of alpha Cen binary system, arXiv:astro-ph/0206283; Astron.Astrophys.392:L9, 2002
10. P. Kervella et al, The interferometric diameter and internal structure of Sirius A, arXiv:astro-ph/0306604; Astron.Astrophys.408:681-688, 2003
11. J. Liebert et al, The age and progenitor mass of Sirius B, arXiv:astro-ph/0507523; Astrophys.J.630:L69, 2005
12. J. B. Holberg et al, Sirius B: A new, more accurate view, Astrophys.J.497, Issue 2, 935-942, 1998
13. A. P. Hatzes et al, Confirmation of the planet hypothesis for the long-period radial velocity variations of Beta Geminorum, arXiv:astro-ph/0606517; Astron.Astrophys.457:335-341, 2006
14. A. P. Hatzes and M. Zechmeister, The discovery of stellar oscillations in planet hosting giant star Beta Geminorum, arXiv:0709.1406; Astrophys. J. Letters 670, No.1, 2007
15. B. F. Riley, The Planck Model, viXra:1311.0053
16. C. Patrignani, (Particle Data Group), Chin. Phys. C, **40**, 100001 (2016)
17. T. C. Teixeira et al, Solar-like oscillations in the G8 V star tau Ceti, arXiv:0811.3989; Astron.Astrophys.494 1 237-242, 2009
18. A. W. Steiner, J. M. Lattimer and E. F. Brown, The neutron star mass-radius relation and the equation of state of dense matter, arXiv:1205.6871