Advanced Astronomy in Bhagavata Purana: 
the Role of the Sun and a Tale from 108

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Abstract

Starting from the interpretation of Bhu-mandala (the level of material universe including Earth as mentioned in Puranic tradition) as a description of the solar system, already present in the literature, further effort is devoted in finding additional correlations with current astronomical knowledge, with regard to the following points: (i) the length of the solar chariot axle; (ii) the height of the solar chariot axle on Bhu-mandala plane; (iii) the relevance of 108 in Puranic tradition. The width of Bhu-mandala regions, represented as a circle surrounded by a series of concentric circular coronae, is expressed via simple formulae which, for inner zones, are variants of the empirical Titius-Bode law. Further connection with the solar system, in addition to current results, is found with regard to bounding circumferences between contiguous regions. The location of the solar globe on the solar chariot axle is related to apogee locus of Sun geocentric orbit, instead of mean Earth-Sun distance. The height of the solar globe on Bhu-mandala plane is related to solar diameter. Assuming planet orbital parameters underwent only statistical fluctuations via gravitational interactions and collisions from large asteroids, and taking into consideration solar diameter growth due to stellar evolution, a past epoch is inferred where the ratio of mean (or

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aphelion) Earth-Sun distance to solar diameter was 108. Finally, an inspection of solar evolution, regardless of Puranic tradition, discloses a new era is coming into the world.

**Keywords:** Puranic cosmology; solar system; sun: evolution.

1 Introduction

Traditional books of wisdom cannot escape from being analysed in the light of formal logic, to find some connection with present scientific knowledge. But it does not imply traditional books of wisdom were written in the light of formal logic instead of different kinds of logic. More specifically, contradictions could arise from the standpoint of formal logic, but could not from the standpoint of different kinds of logic. Then related investigations should be performed with due respect, better yet with due devotion, regardless of conclusions that could be attained.

The current study is focused on the description of material universe appearing in Bhagavata Purana (canto V, part II), a collection of twelve cantoes where creations and activities of the Supreme Being, Krsna, are described. In particular, the level of material universe containing the Earth is named Bhu-mandala. Four different but coexistent interpretations of the text have been proposed, involving the following descriptions [22]: (a) local geography of India and neighbouring regions; (b) global geography of Earth via stereographic projection onto a plane tangent on the north pole, starting from the south pole; (c) solar system on the ecliptic plane up to Uranus orbit; (d) the realm of the Demigods. Further considerations shall be restricted to point (c) above.

Accordingly, Bhu-mandala can be interpreted as a description of the solar system extending up to Uranus, which is invisible to naked eye [21][22]. More specifically, Bhu-mandala is made of a central continent surrounded by oceans alternated with continents, bounded by concentric circumferences. The seventh ocean is surrounded by the last eighth continent, subdivided into three lands, extending up to the boundary of material universe, along the plane of Bhu-mandala.

A comparison between the above mentioned bounding circumferences and perigee or apogee loci of planet and Sun geocentric orbits, yields nine correlations with the addition of two related to median circumferences i.e. equally distant from the internal and external boundary [21][22].

In reviewing the interpretation of Bhu-mandala as a description of the solar system, further effort shall be devoted to the following points: (i) the length of solar chariot axle; (ii) the height of the solar chariot axle on Bhu-mandala plane; (iii) the relevance of 108 in Puranic tradition.
The above mentioned points are investigated in Sections 2, 3, 4, respectively. The discussion is performed in Section 5. The conclusion is drawn in Section 6. Further details are shown in the Appendix.

The current paper is an English translation of an earlier Italian version [4].

2 Bhu-mandala related to the solar system

Historical and geodesical considerations disclose two different standard lengths were used in ancient India, both named yojana, equivalent to \((1/15)^\circ \text{Lt}_e\) and \((1/8)^\circ \text{Lt}_e\), respectively [20][22] 4.5, where \(\text{Lt}_e\) denotes latitude at the equator. Lengths reported in Bhu-mandala description [2] are related to the last one which, for this reason, shall be quoted in the following as “celestial yojana” and denoted as \(y_c\). The remaining one shall be quoted in the following as “terrestrial yojana” and denoted as \(y_t\).

A submultiple of yojana is hasta, which also has a different formulation in different cases, as [20][22] 4.5.2:

\[
\begin{align*}
1 y_t &= 16000 h_t = 16000 \cdot 460.7 \text{ mm} = 7.3712 \text{ km} = (1/15)^\circ \text{Lt}_e; \\
1 y_c &= 32000 h_c = 32000 \cdot 431.9 \text{ mm} = 13.8208 \text{ km} = (1/8)^\circ \text{Lt}_e;
\end{align*}
\]

where, by definition, \(h_t\) and \(h_c\) denote terrestrial hasta and celestial hasta, respectively. For convenience, the unit length used in Bhu-mandala description shall be chosen as celestial kiloyojana \((1 \text{ ky}_c = 1000 y_c)\).

A beautiful expression of number 360, which is the measure of the round angle in degrees, and a correlation with number 108, is shown in Appendix A.

The material universe is represented in Puranic cosmology as the intersection of a sphere with a series of parallele planes, structured in different levels. The bottom of the sphere is filled by the primordial ocean [2] 23, 9 (explanation), above which different world levels are located between contiguous planes, from hellish to heavenly planets. The diameter of the sphere equals 500000 \(\text{ky}_c\) [2] 23, 9 (explanation). Terrestrial planets are located in the middle i.e. above hellish planets and below heavenly planets [19]. Outside the sphere, along the equatorial plane, are all who want to get free from chains of material universe [2] 20, 42.

According to the description [2] 20, 1-4 [21][22] 2, Bhu-mandala is made of a series of eight continents alternated with seven oceans, bounded by sixteen concentric circumferences, where the inner reduces to the common centre and the outer marks the end of material universe along Bhu-mandala plane. Special relevance is devoted to three elevations: Sumeru mons, placed on Bhu-mandala centre; Manasottara mountain chain, placed on the median circumference with respect to the seventh continent; Lokaloka mountain chain, placed on the median circumference with respect of Bhu-mandala, within the eight continent.
Table 1: Identity code, UN, internal radius, $R_{\text{int}}$, external radius, $R_{\text{ext}}$, radial width, $\Delta R = R_{\text{ext}} - R_{\text{int}}$, name, and meaning, of different Bhu-mandala regions, as described in Bhagavata Purana. Identity code caption: U = C (continent), O (ocean), L (land); N = 1, 2, 3, ..., going from inwards to outwards. Distances are expressed in thousands of celestial yojana, or celestial kiloyojana, $10^3 y_c = 1 k y_c = 13820.8 \text{ km}$. Meaning has to be related to continent, ocean, or land, according to identity code caption. See text for further details.

<table>
<thead>
<tr>
<th>UN</th>
<th>$R_{\text{int}}$</th>
<th>$R_{\text{ext}}$</th>
<th>$\Delta R$</th>
<th>name</th>
<th>meaning</th>
</tr>
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<tbody>
<tr>
<td>C1</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>Jambudvipa</td>
<td>apple-tree</td>
</tr>
<tr>
<td>O1</td>
<td>50</td>
<td>150</td>
<td>100</td>
<td>Lavanoda</td>
<td>salty water</td>
</tr>
<tr>
<td>C2</td>
<td>150</td>
<td>350</td>
<td>200</td>
<td>Plaksadvipa</td>
<td>shining tree</td>
</tr>
<tr>
<td>O2</td>
<td>350</td>
<td>550</td>
<td>200</td>
<td>Iksura</td>
<td>sugar cane juice</td>
</tr>
<tr>
<td>C3</td>
<td>550</td>
<td>950</td>
<td>400</td>
<td>Salmalidvipa</td>
<td>bird tree</td>
</tr>
<tr>
<td>O3</td>
<td>950</td>
<td>1350</td>
<td>400</td>
<td>Suroda</td>
<td>liquor</td>
</tr>
<tr>
<td>C4</td>
<td>1350</td>
<td>2150</td>
<td>800</td>
<td>Kusadvipa</td>
<td>will-o-the-wisp</td>
</tr>
<tr>
<td>O4</td>
<td>2150</td>
<td>2950</td>
<td>800</td>
<td>Ghrtoda</td>
<td>drawn butter</td>
</tr>
<tr>
<td>C5</td>
<td>2950</td>
<td>4550</td>
<td>1600</td>
<td>Krauncadvipa</td>
<td>large mountain</td>
</tr>
<tr>
<td>O5</td>
<td>4550</td>
<td>6150</td>
<td>1600</td>
<td>Ksiroda</td>
<td>milk</td>
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<td>6150</td>
<td>9350</td>
<td>3200</td>
<td>Sakadvipa</td>
<td>scented tree</td>
</tr>
<tr>
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<td>9350</td>
<td>12550</td>
<td>3200</td>
<td>Dadhyoda</td>
<td>yogurt</td>
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<tr>
<td>C7</td>
<td>12550</td>
<td>18950</td>
<td>6400</td>
<td>Puskaradvipa</td>
<td>lotus flower</td>
</tr>
<tr>
<td>O7</td>
<td>18950</td>
<td>25350</td>
<td>6400</td>
<td>Svadudaka</td>
<td>fresh water</td>
</tr>
<tr>
<td>L1</td>
<td>25350</td>
<td>41100</td>
<td>15750</td>
<td>Loka-varsra</td>
<td>inhabited land</td>
</tr>
<tr>
<td>L2</td>
<td>41100</td>
<td>125000</td>
<td>83900</td>
<td>Kancanibhumi</td>
<td>golden land</td>
</tr>
<tr>
<td>L3</td>
<td>125000</td>
<td>250000</td>
<td>125000</td>
<td>Aloka-varsra</td>
<td>uninhabited land</td>
</tr>
</tbody>
</table>

Radial dimensions of Bhu-mandala regions, together with name, identity code (to be used, for convenience, instead of name) and meaning, are listed in Table 1. With regard to C8, lands L1 and L2 are named according to the literal translation of the original text, which mentions an anonymous abitable land (Loka-varsra) after O7, followed by a golden, mirror-reflecting land, for this reason uninhabited, followed in turn by an uninhabited dark land [2] 20, 36-38, 42.

The following lengths relate to the above mentioned elevations. Sumeru mons, on the centre of C1, has height (from bottom to top basis) equal to $100 k y_c$, of which 84 $k y_c$ are above earth level and 16 $k y_c$ are below; bottom and top basis are 16 $k y_c$ and 32 $k y_c$ large, respectively [2] 5, 7. Accordingly, it can be inferred Sumeru mons is shaped as a reversed truncated cone [21][22].
Manasottara mountain chain subdivides C7 in two parts of equal width which implies, conformly to data listed in Table 1, it is placed at a distance from Bhu-mandala symmetry axis equal to \( R_M = \frac{(12550 + 18950)}{2} \) ky\(_c\) = 15750 ky\(_c\); in addition, both width and height equal 10 ky\(_c\). Lokaloka mountain chain subdivides Bhu-mandala in two parts of equal width which implies, conformly to data listed in Table 1, it is placed at a distance from Bhu-mandala symmetry axis equal to \( R_L = 125000 \) ky\(_c\). Lokaloka height exceeds Polaris height above earth \( \pm 20, 37, 42 \) hence light from Sun, Moon, stars, cannot reach L3. Then it can safely be assumed Lokaloka height exceeds 2500 ky\(_c\) and, by analogy with Manasottara, Lokaloka width exceeds 2500 ky\(_c\). In particular, Lokaloka height and width can safely be assumed as equal to C5 internal radius, that is 2950 ky\(_c\) as shown in Table 1. Related implications will be seen below.

Concerning Bhu-mandala region width, an inspection of Table 1 discloses the following.

1) C1 diameter equals O1 width \( \pm 22, 2.1 \).

2) C2 and O2 width doubles O1 one and so on, up to C7 and O7 width which doubles C6 and O6 one \( \pm 22, 2.1 \).

3) Doubling O7 width turns 6400 ky\(_c\) into 12800 ky\(_c\), and the addition of 2950 ky\(_c\) (O4 external radius) yields 15750 ky\(_c\) (L1 width).

4) Increasing tenfold O7 width turns 6400 ky\(_c\) into 64000 ky\(_c\), the addition of 18950 ky\(_c\) (O7 internal radius) yields 82950 ky\(_c\), and the addition of 950 ky\(_c\) (O3 internal radius) yields 83900 ky\(_c\) (L2 width).

5) L3 width equals the whole inner region (C1 + O1 + ... + C7 + O7 + L1 + L2), that is L3 internal radius.

The above results may be expressed as:

\[
\Delta R(O1) = 2\Delta R(C1) \quad ; \\
\Delta R(Ok) = \Delta R(Ck) \quad ; \quad 2 \leq k \leq 7 \quad ; \\
\Delta R[(O(k+1)] = 2\Delta R(Ok) \quad ; \quad 1 \leq k \leq 6 \quad ; \\
\Delta R(L1) = 2\Delta R(O7) + \left[ 2 \sum_{k=2}^{4} \Delta R(Ok) + \frac{3}{2} \Delta R(O1) \right] \quad ; \\
\Delta R(L2) = 10\Delta R(O7) + \left[ \Delta R(O7) + 2 \sum_{k=2}^{6} \Delta R(Ok) + \frac{3}{2} \Delta R(O1) \right] \\
+ \left[ \Delta R(O3) + 2\Delta R(O2) + \frac{3}{2} \Delta R(O1) \right]
\]
\[ = 11\Delta R(O7) + 2 \sum_{k=4}^{6} \Delta R(Ok) + 4 \sum_{k=2}^{3} \Delta R(Ok) + 3\Delta R(O1) \] ; \hspace{1em} (7) \\
\[ \Delta R(L3) = \Delta R(L2) + \Delta R(L1) + 2 \sum_{k=2}^{7} \Delta R(Ok) + \frac{3}{2}\Delta R(O1) \] ; \hspace{1em} (8)

where the right-hand sides can be rewritten in terms of ocean internal and external radii. Accordingly, Bhu-mandala region dimensions can readily be determined using simple formulation, starting from Sumeru mons height (from bottom to top basis), which equals C1 diameter. It is worth noticing Sumeru mons, Manasottara mountain chain, and Lokaloka mountain chain, exhibit features more closely related to artificial buildings than natural formations.

With regard to Sumeru mons, a remarkable connection is shown between bottom (16 ky\(c\)) and top (32 ky\(c\)) basis diameter vs. terrestrial and celestial yojana expression in terms of related hasta submultiple, 1 ky\(t\) = 16000 h\(t\) and 1 ky\(c\) = 32000 h\(c\), respectively \[20\][22].

Concerning vertical distances, what is needed (for reasons which will be clarified below) is the height of the solar globe on Bhu-mandala plane. As an end of the solar chariot axle is hinged on Sumeru mons symmetry axis, the above mentioned height cannot be exceeded by Sumeru mons height on earth level, equal to 84 ky\(c\) \[2\]16, 7. The solar globe is placed on the axle of the solar chariot \[2\]20, 30, which implies a height above earth level equal to solar chariot one, leaving aside negligible corrections due to axle and platform (on which the solar globe presumably lies) finite thickness \[21\][22].

On the other hand, Earth-Sun distance is mentioned equal to 100 ky\(c\) \[2\]23, 9 (explanation) \[22\] 3,4, hence two non mutually exclusive possibilities can be taken into consideration. If Sumeru mons is located on highlands, it could safely be assumed the underground fraction, 16/100 \[2\] 16, 7, extends down to sea level: accordingly, the height (from bottom to top basis) of Sumeru mons would be equal to the height of solar chariot axle on sea level. In addition, Sumeru mons top basis is inhabited by celestial beings \[2\] 16, 28, which implies the hinge on Sumeru mons symmetry axis, where solar chariot axle is fixed, should be placed well above the top basis to avoid collisions against natural formations and artificial buildings, unless the top basis rotates as a whole together with the solar chariot axle. In fact, people therein suffer from warm as at noon: this is why Sun always moves above their heads \[2\] 21, 8-9. Nonetheless, the height of solar chariot axle on the sea level could equal 100 ky\(c\), according to the above quoted value, which shall be assumed in the following, regardless of the interpretation.

An inspection of Table 1 discloses Bhu-mandala could be conceived as a description of the solar system, which is essentially flat, instead of the Earth as a planet. In this view, a nontrivial question is if Bhu-mandala regions exhibit some intrinsic feature. More specifically, a connection between circumferences
separating contiguous regions and perigee or apogee loci of planet geocentric orbits, can be investigated [21][22] 4.4.

To this aim, modern data expressed in km must be converted into ky$_c$ using a best fit procedure for minimizing the sum of square discrepancies with respect to Bhu-mandala description [2] 20 [22] 4.4. The result is 1 ky$_c$ = 13797 km [21][22], fully consistent with its counterpart inferred from historical and geodesical considerations, 1 ky$_c$ = 13820.8 km [20][22] 4.4, which is used in the current paper. Related values are listed in Table 2, where the identity code of Bhu-mandala regions is as in Table 1 together with the external radius, $R_{\text{ext}}$, while perigee (P) or apogee (A) locus of planet or Sun (p) geocentric orbit is denoted by a radius, $R_{\text{pgo}}$. Also listed is the percent error, $\delta R = 1 - R_{\text{pgo}}/R_{\text{ext}}$.

An inspection of Table 2 discloses both O6 and C7 are subdivided into an internal (i) and external (e) subregions of equal width, for comparison with loci 3A (Sun apogee) and 1A (Mercury apogee), respectively. In addition, land L1 appears on two lines for comparison with loci 5A (Ceres apogee) and 6P (Jupiter perigee), respectively. Lengths are expressed in ky$_c$, 1 ky$_c$ = 13820.8 km [20][22]. It is apparent Bhu-mandala regions surrounding C4 exhibit at least one bounding or median circumference, which fits to a perigee or apogee locus of planet or Sun geocentric orbit. Related percent error is less than 11% (Mars), 9% (Uranus), 6% (Mercury and Jupiter), 4% (Ceres, Venus, Saturn, Sun). In particular, no geocentric orbit lies inside O4 external radius, $R_{\text{ext}}$(O4) = 2950 ky$_c$. If Lokaloka mountain chain height and width equal 2950 ky$_c$, a connection with the radius of perigee locus of Venus geocentric orbit could be interpreted in the above specified sense.

Radii of Bhu-mandala bounding circumferences, $R_{\text{ext}}$, and perigee and/or apogee loci of planet or Sun geocentric orbit, $R_{\text{pgo}}$, are translated into logarithmic scale in Figure 1, where lengths are expressed in km. Bhu-mandala continents and oceans are plotted as full and dotted horizontal segments, respectively, from C1 on the left (extending up to negative infinite) to C8 on the right. Vertical bars from the left to the right represent O6 and C7 median circumferences with the addition of L1-L2 and L2-L3 bounding circumferences, respectively, marking Manasottara (C7) and Lokaloka (L2-L3) mountain chains. Perigee and apogee loci of planet and Sun geocentric orbits are plotted as vertical dotted lines with the following identity code: Mercury - 1; Venus - 2; Sun - 3; Mars - 4; Ceres - 5; Jupiter - 6; Saturn - 7; Uranus - 8. If a planet appears twice, the left and right line relate to perigee and apogee, respectively. If otherwise, only apogee locus is represented with the exception of Jupiter, where perigee locus appears.

A further correlation has been proposed [21][22] 4.7 between planet heights above Earth [2] 22, 8-16 and maximum planet height above the ecliptic plane. In author's opinion, related comparison [21][22] yields no acceptable concordance (i.e. percent error less than 10%) with the exception of Venus, which
Table 2: Code, UN, external radius, $R_{\text{ext}}$, of different Bhu-mandala regions, as described in Bhagavata Purana; radius, $R_{\text{pgo}}$, of perigee (pE = pP) or apogee (pE = pA) locus of planet geocentric orbit, and percent error, $\delta R = 1 - R_{\text{pgo}}/R_{\text{ext}}$. Code caption: U = C (continent), O (ocean), L (land); N = 1, 2, 3, ..., going from inwards to outwards. Planet caption (p): Mercury - 1; Venus - 2; Sun - 3; Mars - 4; Ceres - 5; Jupiter - 6; Saturn - 7; Uranus - 8. Both O6 and C7 are subdivided into an internal (i) and external (e) subregion of equal radial width for fitting to 3A and 1A, respectively. Land L1 is repeated for fitting to 5A and 6P, respectively. Distances are expressed in thousands of celestial yojana, or celestial kiloyojana, $10^3 y_c = 1 ky_c = 13820.8$ km. See text for further details.

<table>
<thead>
<tr>
<th>UN</th>
<th>$R_{\text{ext}}$</th>
<th>$R_{\text{pgo}}$</th>
<th>pE</th>
<th>$\delta R$</th>
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<td>C1</td>
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<tr>
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<td>C2</td>
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<td>7A</td>
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</tr>
<tr>
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<td>250000</td>
<td>229415.3</td>
<td>8A</td>
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exhibits the lower minimum distance from the Earth. In this view, the above mentioned comparison discloses the following.

1. Planet heights on Bhu-mandala and ecliptic plane are correlated in trend i.e. both are increasing or decreasing.

2. Planet heights on ecliptic plane are far closer to planet heights on Bhu-mandala plane with respect to Earth-planet mean distances. For the Sun, the above mentioned values coincide by definition of ecliptic, after normalization to Sun height above Bhu-mandala plane equal to 100 ky_c.


In conclusion, a concordance of the kind considered appears (in author’s opinion) not sufficiently motivated, unless by reversing planet motion an epoch is attained, where the fit is largely improved. On the other hand, heights of celestial bodies above Bhu-mandala could be interpreted as placed on a planisphere map of the Earth [22] 3.4.

Further inspection of Table 2 provides major insight on the position of Manasottara and Lokaloka circular mountain chains. The former is placed near the apogee locus of Mercury geocentric orbit, that is the boundary between the region filled by no and one or more complete geocentric orbit, respectively. It is worth remembering Manasottara is the way of the solar wheel [2] 20, 30. The latter is placed near the apogee locus of Saturn geocentric orbit, that is the boundary between the region filled by visible (to naked eye leaving aside Ceres) and invisible planet geocentric orbits, respectively. In addition, the circumference between lands L1-L2 is placed near the apogee locus of Ceres and the perigee locus of Jupiter geocentric orbit, respectively, that is the boundary between the region filled by internal (including Ceres) and external planet geocentric orbit, respectively. It is worth remembering the circumference between lands L1-L2 marks the boundary between Bhu-mandala inhabited and uninhabited region, respectively [2] 20, 35.

^2 Throughout the text, internal (rocky) planets are intended as lying between Sun and asteroid belt, including Ceres. In a different context, internal planets are intended as lying inside Earth orbit i.e. Mercury and Venus.

^3 Throughout the text, external (gaseous) planets are intended as lying between asteroid and Kuiper belt, including Pluto, where gas is in solid state. In a different context, external planets are intended as lying outside Earth orbit i.e. Mars, Ceres, Jupiter, Saturn, Uranus, Neptune, and Pluto.
3 Role of the Sun in Bhu-mandala

In Puranic tradition [2] three different terms are used for referring to the Sun, namely (i) the Sun; (ii) the God of the Sun; (iii) the solar globe. It may safely be assumed the Sun and the solar globe are synonymous, keeping in mind lunar globe is also mentioned [2] 24, 2, and the God of the Sun is the God who carries the Sun, for this reason driving the solar chariot [2] 21, 15. The axle of the solar chariot, on one hand, hosts the solar wheel and, on the other end, is hinged to Sumeru mons symmetry axis [2] 21, 13. Then the solar chariot axle length equals $15750 \text{ky}_c$, as can be inferred from Table 1 keeping in mind the solar wheel leans on Manasottara mountain chain.

The Sun lies on the equatorial plane of the material universe, near the centre [2] 20, 43, which implies the centre of the material universe is placed on Sumeru mons symmetry axis where the solar chariot axle is hinged, with a negligible correction due to the thickness of the solar chariot axle, the solar globe, and the platform where it is placed.

The length of the circumference described by the solar globe equals $95100 \text{ky}_c$ [2] 21, 7, which implies the distance between the solar globe and Sumeru mons symmetry axis is:

$$R_{\text{sun}} = \frac{95100}{(2\pi)} \text{ky}_c = 15135.635088 \text{ky}_c ;$$

(9)

cursively the approximation, $\pi \approx \frac{22}{7}$, known in ancient times, yields:

$$R_{\text{sun}} = \frac{95100 \cdot 7}{44} \text{ky}_c = 15129.54 ;$$

(10)

which is an acceptable fit to the exact result.

The solar chariot is $3600 \text{ky}_c$ long and $900 \text{ky}_c$ large where, to a yoke of equal width, seven horses are attached [2] 21, 15. The above mentioned dimensions are consistent with Manasottara mountain chain, which is $10 \text{ky}_c$ large [2] 10, 30, where the solar wheel runs. The God of the Sun is safely placed on the solar chariot centre, where one side is close to the solar wheel. Accordingly, the distance between the centre of the solar chariot and Sumeru mons symmetry axis is:

$$R_c = (15750 - 900/2) \text{ky}_c = 15300 \text{ky}_c ;$$

(11)

consistent with (10), to be intended as related to the God of the Sun or the solar chariot. On the other hand the solar globe, whose diameter equals $10 \text{ky}_c$ [2] 24, 2, could be placed everywhere on the solar chariot axle, in particular distant $10950 \text{ky}_c$ from Sumeru mons symmetry axis for fitting to the apogee locus of Sun geocentric orbit, as assumed above.

The speed of solar chariot equals $3400.8 \text{ky}_c / \text{mubarta}$ [2] 21, 12, and keeping in mind $1 \text{mubarta} = 48 \text{m} = 2880 \text{s}$, the above value translates into $16320.061\overline{3} \text{km/s}$,
which is slightly larger than $1/20$ the speed of light and estimates the equatorial velocity of a millisecond pulsar whose radius and period equals $10\text{ km}$ and $3.85 \cdot 10^{-3}\text{ s}$, respectively. The above mentioned values have no connection with astronomy in the solar system, unless they are related to something else via a particular symbolic interpretation.

From this point on the working hypothesis shall be accepted, that the solar globe is placed at a distance of $10950\text{ ky}_c$ from Sumeru mons symmetry axis, and its height on Blu-mandala plane equals $100\text{ ky}_c$ [21][22]. If the former represents Earth-Sun distance at aphelion, $d_a$, and the latter solar diameter, $2R_\odot$, the following relation holds:

$$\frac{d_a}{2R_\odot} = \frac{10950}{100} = 109.50 ;$$

(12)

where $R_\odot$ is the solar photospheric radius [8]. On the other hand, using modern data yields:

$$\frac{d_a}{2R_\odot} = 109.319689 ; \quad \frac{d_p}{2R_\odot} = 105.726010 ;$$

$$\frac{\text{AU}}{2R_\odot} = 107.522569 ;$$

(13)

where $d_p$ is the Earth-Sun distance at perihelion, AU the mean Earth-Sun distance (astronomic unit), and numerical values are reported in Appendix B.

4 A tale from 108

Planet orbital parameters undergo statistical fluctuations via gravitational interactions and collisions from large asteroids. For instance, it has been speculated Earth orbit could be enlarged up to Mars by changing a large asteroid orbit, with aphelium outside Saturn orbit, to make angular momentum transfer via periodic close encounters [10]. Owing to the above mentioned statistical fluctuations, it has been preferred a conversion value from $y_c$ to km inferred from historical and geodesical considerations [20][22] instead of astronomical and statistical algorithms [21][22] even if the difference is small.

Conversely, solar diameter systematically grows via stellar evolution where, according to a recent model, there is a nearly linear increase until today, followed by a larger rate [17]. The present value of solar diameter, inferred from the solar radius, is:

$$2R_\odot = 13.91316 \cdot 10^5\text{ km} ; \quad R_\odot = R_\odot(t_a) ; \quad t_a = 4.58\text{ Gyr} ;$$

(15)

where $t_a$ is the current solar age (starting from the ZAMS) inferred from the model [17]. The special value of solar diameter:

$$2R_\odot^* = \frac{\text{AU}}{108} = 13.851655 \cdot 10^5\text{ km} ; \quad R_\odot^* = R_\odot(t^*) ;$$

(16)
Table 3: Fractional solar radius, \( F_\odot(t) = R_\odot(t)/R_\odot \), inferred from a recent solar evolution model \[17\], for the following special points of MS evolution: entrance (ZAMS), current solar age (CSAG), maximum effective temperature (METE), exit (MSEX). Time is expressed in Gyr.

<table>
<thead>
<tr>
<th>state</th>
<th>( t/Gyr )</th>
<th>( F_\odot(t) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZAMS</td>
<td>0.00</td>
<td>0.89</td>
</tr>
<tr>
<td>CSAG</td>
<td>4.58</td>
<td>1.00</td>
</tr>
<tr>
<td>METE</td>
<td>7.13</td>
<td>1.11</td>
</tr>
<tr>
<td>MSEX</td>
<td>10.00</td>
<td>1.37</td>
</tr>
</tbody>
</table>

belongs to the past in that the ratio:

\[
\frac{R^*_\odot}{R_\odot} = 0.99557934 ; \tag{17}
\]

is less than unity, provided variations of Earth-Sun distance are negligible as due to statistical fluctuations. The special age, \( t^* \), can be inferred from the knowledge of fractional solar radius evolution, \( R_\odot(t)/R_\odot \). To this respect, interpolation is performed on four special points of MS evolution, namely zero age mean sequence (ZAMS), current solar age (CSAG), maximum effective temperature (METE), and main sequence exit (MSEX), as listed in Table 3 \[17\]. The above mentioned points are plotted as diamonds in Figure 2.

Keeping in mind interpolation is only aimed to see the past, it can be performed by joining either the first two points via a straight line, or all the four points via a cubic. In any case, an equation can be written for each interpolation point and the related system can be solved by use of Kramer method. The result is:

\[
y = a_1x + a_2 ; \tag{18a}
\]

\[
a_1 = 0.0240175 ; \quad a_2 = 0.89 \tag{18b}
\]

with regard to the straight line, and:

\[
y = a_1x^3 + a_2x^2 + a_3x + a_4 ; \tag{19a}
\]

\[
a_1 = 6.07395 \cdot 10^{-4} ; \quad a_2 = -4.43100 \cdot 10^{-3} ; \tag{19b}
\]

\[
a_3 = 3.15705 \cdot 10^{-2} ; \quad a_4 = 0.89 \tag{19c}
\]

with regard to the cubic, where \( x = t/Gyr \) and \( y = R_\odot(t)/R_\odot(t_a) \). The straight line (dotted) and the cubic (full) are plotted in Figure 2: it is apparent both interpolations hold to a comparable extent within the range of
interest, $0 \leq t / \text{Gyr} \leq 4.58$, where the straight line and the cubic are virtually indistinguishable.

With regard to a fixed value, $y^* = y(t^*) = R_\odot(t^*) / R_\odot(t_a)$, related solar age can be inferred by replacing $y$ with $y^*$ in Equation (18) or (19), and solving the first or third degree equation, respectively. The result is:

\begin{align*}
t_1^* &= 4.39594 \text{ Gyr} ; \\
t_3^* &= 4.42551 \text{ Gyr} ;
\end{align*}

where subscripts, 1 and 3, relate to first and third degree equation, that is straight line and cubic, respectively. Related points are plotted as crosses in Figure 2.

If the oral tradition, from which Bhu-mandala description [2] took origin, started since an epoch between 150 and 200 million years ago, in the light of the current interpretation and selected solar evolution model, the solar diameter at that time reads:

\begin{equation}
2R_\odot^* = 100 \text{ky}_c = 13.8208 \cdot 10^5 \text{km} ;
\end{equation}

which is consistent with Equation (16), where the difference could ascribed to Earth-Sun distance variations via statistical fluctuations due to gravitational interactions and collisions from large asteroids.

If the mean Earth-Sun distance at the epoch, $t = t^*$, reads:

\begin{equation}
\text{AU}^* = 108 \cdot 100 \text{ky}_c = 108 \cdot 1382080 \text{ km} = 1.49264640 \cdot 10^8 \text{ km} ;
\end{equation}

or, in other words, equals 108 solar diameters, then celestial yojana is defined as:

\begin{equation}
\text{yc} = (1/8)^9 \text{Ltc} = \text{AU}^*/(108 \cdot 10^5) = 10^{-5} \cdot 2R_\odot^* ;
\end{equation}

which would explain the relevance of 108 in Puranic tradition.

Following a similar procedure with regard to Earth-Sun distance at aphe- lion, $d_a$, instead of mean distance, AU, and defining $R_\odot^t = R_\odot(t^t)$ at the special age, $t^t$, where $2R_\odot^t = 109.50 \text{ky}_c$, and supposing $d_a$ is left unchanged leaving aside statistical fluctuations, the counterpart of Equation (17) is:

\begin{equation}
\frac{R_\odot^t}{R_\odot} = \frac{109.318689}{109.50} = 0.99834419 ;
\end{equation}

and the counterpart of Equations (20)-(21) is:

\begin{align*}
t_1^t &= 4.511438 \text{ Gyr} ; \\
t_3^t &= 4.523189 \text{ Gyr} ;
\end{align*}
which relates to an epoch between 50 and 70 million years ago.

Moon (29°56′-33°29′) and Sun (31°29′-32°33′) angular diameter are similar, which implies similar distance-to-diameter ratios. Using modern values, the counterparts of Eqs.(13)-(14) read:

\[
\frac{d_a'}{2R_\odot} = 116.713464 \ ; \quad \frac{d_p'}{2R_\odot} = 104.460299 \ ;
\]

\[
\frac{d'}{2R_\odot} = 110.586881 \ ;
\]

where \(d_a', d_p', d'\), is the Earth-Moon distance at apogee, perigee, averaged, respectively, \(R_\odot\) is the lunar radius, and related values are reported in Appendix B.

Unlike Sun-Earth system, where solar diameter is increasing in time and Sun-Earth distance may be considered constant to a first extent, Earth-Moon system exhibits constant lunar diameter and Earth-Moon distance increasing in time mainly owing to the tidal action from Moon on oceans. Accordingly, a similar method can be used for determining the epoch where the distance-to-diameter ratio equals 108 [5].

5 Discussion

As pointed out in earlier investigations [20][21][22], elements of advanced astronomy are present in Bhagavata Purana [2]. To this respect, it is worth noticing a real connection exists between e.g., Bhu-mandala regions and planet or Sun geocentric orbits, on one hand, but no connection exists between e.g., Sun or Moon diameter and modern data, on the other hand. Discrepancies of the kind considered arise in consequence of analysing Bhagavata Purana from the standpoint of formal logic, which is necessary to test the scientific validity of data therein. The above mentioned discrepancies could disappear if the text is analysed from the standpoint of different kinds of logic involving symbolic interpretation. Furthermore, it cannot be excluded Bhagavata Purana is a collection of oral traditions from different epochs, among which only a part exhibits scientific relevance.

To this respect, a working hypothesis could be the existence of an antediluvian science [22] 4.4.1, 9.4, whose memory would be fossilised into traditional books of wisdom. Earth history is characterized by a series of mass extinctions [13][15], presumably due to catastrophic events of terrestrial and/or celestial origin, among which one would have destroyed technology necessary for surviving science. In other words, the possibility of falsifying theories would have been lost and only texts would have been left, the content of which would have been accepted as an act of faith, that is from thinking to believing. In
conclusion, science would have been turned into myth. In this picture, it is natural texts were written somewhat hermetically, to be accessible only to a small amount of initiates after having passed a number of trials. Turning to Puranic cosmology, Bhu-mandala description [2] could be interpreted as a message from some antediluvian science, the memory of which would have survived into myths and legends. With regard to region width, data can easily be remembered: the starting point is C1 whose effective width has to be taken equal to the diameter, that is \(100 \text{ ky}_c\), which, in turn, coincides with O1 width. From here up to C7 and O7, the width doubles time over time, conformally to Equations (3)-(4), or:

\[
\Delta R(C_k) = \Delta R(O_k) = 2^{k-1} \cdot 100 \text{ ky}_c ; \quad 1 \leq k \leq 7 ; \quad (30)
\]

where \(\Delta R(C1)\) has to be intended as effective width in the above specified sense. Keeping in mind \(\Delta R(C1)\) equals C1 diameter, which is equivalent to Sumeru mons height (from bottom to top basis), the internal and external radius of each continent or ocean can readily be evaluated. The determination of land width within C8 is more complicated, but can be performed using Equations (6)-(8).

In this framework, perfect agreement with modern data cannot be expected, still the concordance is surprising, as shown in Table 2. In fact, it can be seen Equation (30) is a variant of the empirical Titius-Bode law [3][11], which can be expressed as:

\[
\frac{R_i}{\text{AU}} = \frac{R_{i+1}}{\text{AU}} - \frac{3}{1000} \frac{\Delta R_i}{\text{ky}_c} ; \quad (31)
\]

where \(R_i\) is the mean \(i\)th planet-Sun distance (in AU), \(\Delta R_i\) is \(O_i\) width (in \(\text{ky}_c\)) in Bhu-mandala, and \(i\) is the Titius-Bode index: \(i = -\infty, 1, 2, ..., 6\), from Mercury to Uranus, where observations are fitted to an acceptable extent. The correspondence with Bhu-mandala oceans reads \(i = k - 1\), where \(i = -\infty\) relates to C1 instead of O0 (not existing), whose effective width is \(\Delta R_{-\infty} = \Delta R(C1) = 100 \text{ ky}_c\), while \(\Delta R_i = \Delta R(Ok), k = i + 1\), in the remaining cases. In fact, some bounding circumferences between Bhu-mandala regions can be related to perigee or apogee locus of planet geocentric orbit from Mercury to Uranus. For further details, an interested reader is addressed to Appendix C.

It is worth mentioning the capital of mithic Atlantis, according to Plato [14], is structured similarly to inner three Bhu-mandala continents (C1-O3), for which no astronomical correspondence appears [22] 3.1, as shown in Table 2. A difference is found in the proportions of terrain and water belt widths, equal to 5:1:2:2:3:3 (Atlantis) instead of 1:1:2:2:4:4 (Bhu-mandala) and, in addition, the external water belt is surrounded by the remaining of the isle (irregular in shape) which, in turn, is bounded by the ocean.
The current interpretation of Bhu-mandala description, as related to the solar system, exhibits two main differences with respect to earlier investigations [21][22]. First, the unit of length is taken to be the celestial yojana inferred from historical and geodesical considerations [20][22] 4.5, instead of its counterpart inferred from statistic methods involving astronomical data [21][22] 4.4. This choice is due to the fact that Earth surface is far less modified, with respect to planet orbits, via gravitational interactions and collisions from large asteroids. Anyway, the difference between yojana values in the above mentioned alternatives is comfortably small. Second, apogee locus of Sun geocentric orbit is preferred with respect to Earth-Sun mean distance locus for the following reasons: (a) perigee or apogee locus of planet geocentric orbit is also considered, and (b) the median O6 circumference fits slightly better to apogee locus of Sun geocentric orbit, with respect to Earth-Sun mean distance locus.

Circular mountain chains in Bhu-mandala disclose special meaning: (the inner) Manasottara fits to apogee locus of Mercury geocentric orbit, then marks the boundary between regions where incomplete and (at least one) complete geocentric orbits are located; (the outer) Lokaloka fits to apogee locus of Saturn geocentric orbit, then marks the boundary between regions where visible (to a naked eye) and invisible planet geocentric orbits are located. In addition, the bounding circumference between L1-L2 lands fit to both apogee and perigee locus of Ceres and Jupiter geocentric orbit, respectively, then marks the boundary between regions where internal (including Ceres) and external planet geocentric orbits are located. Interestingly, L2 land is mentioned as uninhabited [2] 20, 35, as well as L3 land completely in darkness [2] 20, 36-37. No name is assigned to L1 land, mentioned as an inhabited region (Loka-varsa) followed by a golden mirror-reflecting region, for this reason abandoned by any beings [2] 20, 35.

The interpretation of planet height above Bhu-mandala plane as maximum height above ecliptic plane accessible to planets [21][22] 4.7 is, in author’s opinion, poorly supported to be taken into consideration. Keeping in mind no discrepancy exists for the Sun, by definition of ecliptic, after normalization to the Sun height above Bhu-mandala plane, an acceptable fit is provided only by Venus, which exhibits the lower minimum distance from Earth, while for the remaining planets the percent error exceeds about 30%, as inferred by comparison with modern data [21][22] 4.7. If the source of Bhu-mandala description [2] is sufficiently back in the past, it could not be excluded an initial connection between planet height above Bhu-mandala plane and maximum planet height accessible above ecliptic plane was erased via statistical fluctuations due to gravitational interactions and collisions from large asteroids. This is why planet heights above the ecliptic plane are intrinsically small and could be significantly changed by occurring statistical fluctuations.
Sun position (in vertical projection) on Bhu-mandala is not explicitly mentioned in Bhagavata Purana and must be inferred from the text. First, a distinction has to be made between the God of the Sun, who drives the solar chariot, and the solar globe placed on a platform on the solar chariot axle [21][22]. The position of the solar globe can be constrained by the correspondence between median O6 circumference and apogee locus of Sun geocentric orbit, which implies a distance of the solar globe from Sumeru mons symmetry axis, $R_{\text{sun}} = 10950\, \text{ky}_c$. Then the ratio of $R_{\text{sun}}$ to the solar chariot axle length, $R_{\text{axle}}$, reads:

$$\frac{R_{\text{sun}}}{R_{\text{axle}}} = \frac{10950}{15750} = \frac{73}{105} = \frac{70}{105} + \frac{3}{105} = \frac{2}{3} + \frac{1}{35} ; \quad (32)$$

where it is worth of note the ratio, $2/3$, appears in the definition of photospheric radius, with regard to the optical depth [8].

The interpretation of Sun height on Bhu-mandala as related to solar diameter is introduced as a working hypothesis, but a tenuous connection could be recognized in the original text, where Sun and Moon are mentioned to be $10\, \text{ky}_c$ and $20\, \text{ky}_c$ large, and related height on Bhu-mandala $100\, \text{ky}_c$ and $200\, \text{ky}_c$, respectively [2][22][8]. Regardless of wrong values with respect to modern data, direct proportionality is shown between diameter and height on Bhu-mandala.

The above mentioned solar diameter could be thought of as related to the solar core (where hydrogen burning occurs) but, if it is the case, the core fractional radius would be $10/100 = 0.1$ instead of 0.2 according to solar evolution models. A perfect agreement could be attained provided solar globe radius, instead of diameter, amounts to $10\, \text{ky}_c$ in length: in fact, it can be seen the oral tradition, source of ancient Indian books of wisdom, implies knowledge of (visible to naked eye) planet dimensions even if, in two cases, text corruption made confusion between radius and diameter values [22][A10].

Though the ratio of mean Earth-Sun distance to solar diameter is known to be close to $108$, as well as the ratio of mean Earth-Moon distance to lunar diameter [9][22][8][5], still the possibility of exact values at some past epoch (to the knowledge of the author) has never been considered. The working hypothesis of a past ratio of mean Earth-Sun distance to solar diameter equal to 108, and the determination of related epoch, rely on the assumption planet orbits, in particular Earth orbit, are stable leaving aside statistical fluctuations due to gravitational interactions and collisions from large asteroids. Conversely, a gradual growth of solar diameter follows from stellar evolution, which allows an estimate of the above mentioned epoch. To this respect, different error sources could exist, owing to current uncertainties on solar parameters (e.g., composition) on one hand, and still open problems on the theory of stellar evolution, on the other hand. Accordingly, related results are not quantitatively reliable but the method is valid and can be applied when improved data and/or models are available.
For this reason, a slight discrepancy has been left, due to a difference between the current solar radius value [8] used for calculations as listed in Table 4, and its counterpart within the solar evolution model [17] also used for calculations, from which a value, \( R_\odot = 6.9665778 \cdot 10^5 \text{ km} \) has been inferred. With regard to the former value, the model predicts a current solar age, \( t_a = 4.5364 \text{ Gyr} \), instead of \( t_a = 4.58 \text{ Gyr} \) [17], while the remaining is left unaltered. Related changes on ages, expressed by Equations (20)-(21) and (26)-(27), do not exceed a few percent, which is expected to be comparable to its counterpart from other error sources.

With regard to current solar radius value, assuming a pre-sequence solar evolution ranging on 0.04 Gyr [7][16] yields the following global (pre-sequence + main sequence up today) current solar age:

\[
\begin{align*}
    t_\odot &= t_p + t_a = (0.04 + 4.5364) \text{ Gyr} \\
    &= 4.5764 \text{ Gyr} ;
\end{align*}
\]

which is within the range, \( 4.55 < t/\text{Gyr} < 4.59 \), consistent with meteoritic age [1][16].

6 Conclusion

Aiming to see if Puranic cosmology [2] exhibits additional features of advanced astronomy with respect to earlier investigations [21][22], a translation of the original text has been analysed in the light of formal logic. It does not exclude Bhagavata Purana can be analysed in the light of different kinds of logic, and contradictions appearing from the standpoint of formal logic could disappear from the standpoint of different kinds of logic.

The results of the current paper, not mentioned in earlier investigations [21][22], can be summarized as follows.

1. The width of Bhu-mandala regions can be determined using a simple formulation, which can be partially related to a variant of the Titius-Bode empirical law, starting from Sumeru mons height (from bottom to top basis) that is equal to the diameter of C1 continent.

2. The median circumference of O6 ocean better relates to apogee locus of Sun geocentric orbit with respect to mean Earth-Sun distance.

3. The bounding circumference between continent and ocean C4-O4, as related to perigee locus of Venus geocentric orbit, marks the separation between regions filled by no and at least part of planet geocentric orbits.

4. The bounding circumference between ocean and continent O6-C7, as related to apogee locus of Mercury geocentric orbit, marks the separation between regions filled by incomplete and (one at least) complete planet geocentric orbits.
(5) The bounding circumference between lands L1-L2, as related to both apogee locus of Ceres and perigee locus of Jupiter geocentric orbit, marks the separation between regions filled by internal (including Ceres) and external planet geocentric orbits.

(6) The location of solar globe, above the median circumference of ocean O6, implies a distance from Sumeru mons symmetry axis equal to \((2/3 + 1/35)\) the length of solar chariot axle.

(7) The height of solar globe on Bhu-mandala plane relates to solar diameter.

(8) If the source of oral tradition, from which Puranic cosmology [2] arose, relates to a ratio of mean (or aphelium) Earth-Sun distance to solar diameter equal to 108, the corresponding epoch dates from 150 to 200 (or 50 to 70) million years ago, provided Earth orbit underwent no relevant variation from that time until today.

Finally, regardless of Puranic cosmology but concerning the four human ages (e.g., gold, silver, heroes, iron) mentioned in mythology [6][18], the current departure of fractional solar radius evolution from the linear trend, shown in Figure 2, discloses that the fifth age (e.g., fire) is going to come into the world or, in other terms, the scarlet rose is going to blossom in the heavens.

**Acknowledgements**

Thanks are due to K.-P. Schröder and R.C. Smith for making available unpublished detailed outputs of their computer code describing solar evolution [17]. The author is deeply grateful to T. Valentinuzzi for suggesting the presence of advanced astronomy in Puranic cosmology, making related publications [20][21][22] available, fruitful discussions and useful explanations on the subject.

**References**


Advanced astronomy in Bhagavata Purana


Appendix

A 108 and 360: an elegant formulation

An elegant formulation of 108 and 360, from a purely numerical standpoint i.e. with no connection with physics, astronomy, geometry, reads:

\[
108 = 1^1 \cdot 2^2 \cdot 3^3 ; \quad (34)
\]

\[
360 = 1^5 \cdot 2^3 \cdot 3^2 \cdot 5^1 = 2^3 \cdot 3^2 \cdot (2 + 3) ; \quad (35)
\]

the ratio of which is:

\[
\frac{108}{360} = \frac{3}{10} ; \quad (36)
\]

involving both 3 and 10, highly relevant in ancient books of wisdom.

B Length values

Length values used for calculations are listed in Table 4 together with related symbol and meaning. Lengths are expressed in km. Solar radius value reconciles results from different methods [8].
Table 4: Length values (expressed in km) used for calculations.

<table>
<thead>
<tr>
<th>symbol</th>
<th>value (km)</th>
<th>meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>(d_p)</td>
<td>1.47098290</td>
<td>Earth-Sun distance at perihelion</td>
</tr>
<tr>
<td>(d_a)</td>
<td>1.52098232</td>
<td>Earth-Sun distance at aphelion</td>
</tr>
<tr>
<td>AU</td>
<td>1.49597870700</td>
<td>Earth-Sun distance (mean)</td>
</tr>
<tr>
<td>(R_\odot)</td>
<td>6.95658</td>
<td>current solar radius</td>
</tr>
<tr>
<td>(^\circ L_t)</td>
<td>1.105664</td>
<td>degree of latitude from equator</td>
</tr>
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<td>Earth-Moon distance at perigee</td>
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<tr>
<td>(d')</td>
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<td>(R_l)</td>
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<td>lunar radius</td>
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</table>

C Titius-Bode law in Bhu-mandala

Titius-Bode (TB) law is an empirical law from which planet-Sun distances can be inferred. Predicted values reproduce data from observations to an acceptable extent, for planets (including Ceres) up to Uranus, while the discrepancy is exceedingly large for Neptune. The validity of TB law has been extended to planets hosted by the pulsar PSR B1257+12 [12].

TB law can be expressed as:

\[
\frac{R_i(TB)}{AU} = \frac{4 + 3 \cdot 2^i}{10} ; \quad i = -\infty, 0, 1, 2, ... ; \quad (37)
\]

where \(R_i\) is the mean \(i\)th planet-Sun distance, \(i\) is the TB index, the notation, \(i = -\infty\), is purely symbolic and used for convenience in place of the mathematical notation, \(i \rightarrow -\infty\). Values of \(i\), \(2^i\), \(R_i(TB)\), and its counterpart, \(R_i\), inferred from observations, are listed in Table 5 for planets up to Uranus, where distances are expressed in AU.

With regard to circular orbits where the radius equals the predicted mean planet-Sun distance, the width of the circular corona defined by contiguous orbits, \(\Delta R_i(TB)\), is:

\[
\Delta R_i(TB) = R_{i+1}(TB) - R_i(TB) = \frac{3 \cdot 2^i}{10} AU ; \quad i \geq 0 ; \quad (38a)
\]

\[
\Delta R_{-\infty}(TB) = R_0(TB) - R_{-\infty}(TB) = (0.7 - 0.4) AU = 0.3 AU ; \quad (38b)
\]

and comparison with its counterpart inferred from observations is shown in Table 5. The discrepancy exhibited by Uranus is owing to mean Neptune-Sun distance, which is badly predicted by TB law.
Table 5: TB index, $i$; power, $2^i$; mean predicted by TB law, $R_i(TB)$, and inferred from observations, $R_i$, planet-Sun distance; width of the circular corona bounded by contiguous orbits, predicted by TB law, $\Delta R_i(TB) = R_{i+1}(TB) - R_i(TB)$, and inferred from observations, $\Delta R_i = R_{i+1} - R_i$; for planets from Mercury to Uranus with the addition of Bhu-mandala regions, UN, and related width, $\Delta R_i(BH) = R_{\text{ext}} - R_{\text{int}}$, where the effective width, equal to the diameter, is considered for C1. The conversion from astronomic unit to celestial kiloyojana is taken as $1 \text{ AU} = 10833.9897826 \text{ ky}_c$. See text for further details.

<table>
<thead>
<tr>
<th>planet</th>
<th>$i$</th>
<th>$2^i$</th>
<th>$\frac{R_i(TB)}{\text{AU}}$</th>
<th>$\frac{R_i}{\text{AU}}$</th>
<th>$\frac{\Delta R_i(TB)}{\text{AU}}$</th>
<th>$\frac{\Delta R_i}{\text{AU}}$</th>
<th>UN</th>
<th>$\frac{\Delta R_i(BH)}{\text{ky}_c}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>$-\infty$</td>
<td>0</td>
<td>0.4</td>
<td>0.39</td>
<td>0.3</td>
<td>0.33</td>
<td>C1</td>
<td>100</td>
</tr>
<tr>
<td>Venus</td>
<td>0</td>
<td>1</td>
<td>0.7</td>
<td>0.72</td>
<td>0.3</td>
<td>0.28</td>
<td>O1</td>
<td>100</td>
</tr>
<tr>
<td>Earth</td>
<td>1</td>
<td>2</td>
<td>1.0</td>
<td>1.00</td>
<td>0.6</td>
<td>0.52</td>
<td>O2</td>
<td>200</td>
</tr>
<tr>
<td>Mars</td>
<td>2</td>
<td>4</td>
<td>1.6</td>
<td>1.52</td>
<td>1.2</td>
<td>1.25</td>
<td>O3</td>
<td>400</td>
</tr>
<tr>
<td>Ceres</td>
<td>3</td>
<td>8</td>
<td>2.8</td>
<td>2.77</td>
<td>2.4</td>
<td>2.43</td>
<td>O4</td>
<td>800</td>
</tr>
<tr>
<td>Jupiter</td>
<td>4</td>
<td>16</td>
<td>5.2</td>
<td>5.20</td>
<td>4.8</td>
<td>4.34</td>
<td>O5</td>
<td>1600</td>
</tr>
<tr>
<td>Saturn</td>
<td>5</td>
<td>32</td>
<td>10.0</td>
<td>9.54</td>
<td>9.6</td>
<td>9.66</td>
<td>O6</td>
<td>3200</td>
</tr>
<tr>
<td>Uranus</td>
<td>6</td>
<td>64</td>
<td>19.6</td>
<td>19.18</td>
<td>19.2</td>
<td>10.88</td>
<td>O7</td>
<td>6400</td>
</tr>
</tbody>
</table>

Table 5: TB index, $i$; power, $2^i$; mean predicted by TB law, $R_i(TB)$, and inferred from observations, $R_i$, planet-Sun distance; width of the circular corona bounded by contiguous orbits, predicted by TB law, $\Delta R_i(TB) = R_{i+1}(TB) - R_i(TB)$, and inferred from observations, $\Delta R_i = R_{i+1} - R_i$; for planets from Mercury to Uranus with the addition of Bhu-mandala regions, UN, and related width, $\Delta R_i(BH) = R_{\text{ext}} - R_{\text{int}}$, where the effective width, equal to the diameter, is considered for C1. The conversion from astronomic unit to celestial kiloyojana is taken as $1 \text{ AU} = 10833.9897826 \text{ ky}_c$. See text for further details.

Aiming to find a connection with Bhu-mandala regions, as listed in Table 1, let $i$th planet, $0 \leq i \leq 6$, relate to O$(i+1)$ ocean, and let Mercury, $i = -\infty$, relate to C1, where the effective width, equal to the diameter, is considered. Values are also listed in Table 5, where lengths are in $\text{ky}_c$. In this view, Equation (30) takes the form:

$$\Delta R_i(BH) = 2^i \cdot 100 \text{ ky}_c ; \quad i \geq 0$$

$$\Delta R_{-\infty}(BH) = \Delta R(C1) = 100 \text{ ky}_c ; \quad i = -\infty ;$$

where the conversion factor, $\kappa$, for turning (39) into (38), is inferred from $\Delta R_i(TB) = \kappa \Delta R_i(BH)$, as:

$$\kappa = \frac{\Delta R_i(TB)}{\Delta R_i(BH)} = \frac{3 \cdot 2^i}{10} \cdot \frac{1}{2^i \cdot 100 \text{ ky}_c} = \frac{3 \text{ AU}}{1000 \text{ ky}_c} ;$$

and using the relation:

$$R_i(TB) = R_{i+1}(TB) - [R_{i+1}(TB) - R_i(TB)] = R_{i+1}(TB) - \Delta R_i(TB) = R_{i+1}(TB) - \kappa \Delta R_i(BH) ;$$

TB law can be expressed as:

$$R_i(TB) = R_{i+1}(TB) - 0.3 \cdot 2^i \text{ AU} ; \quad i \geq 0 ;$$

$$R_{-\infty}(TB) = R_0(TB) - 0.3 \text{ AU} ; \quad i = -\infty ;$$
where mean planet-Sun distances can be inferred starting from mean Earth-
Sun distance, \( R_1(\text{TB}) = 1 \text{ AU} \).

On the other hand, the external radius of Bhu-mandala continents and oceans can be inferred from data listed in Table 1, as:

\[
R_i(\text{BH}) = \left[ 50 + 300 \sum_{k=0}^{i} 2^k \right] k \gamma_c \quad ;
\]

(43)

for continents, and:

\[
R_i(\text{BH}) = \left[ 150 + 400 \sum_{k=0}^{i} 2^k \right] k \gamma_c \quad ;
\]

(44)

for oceans, where \( i \) is the TB index and summations are null for \( i = -\infty \). It is apparent TB law is followed with regard to Bhu-mandala region width instead of continent or ocean external radius, where \( C1 \) relates to Mercury and \( O(i + 1) \) relates to \( i \)th planet, \( 0 \leq i \leq 6 \).

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Figure 1: Different Bhu-mandala regions, according to Bhagavata Purana, represented in logarithmic scale as full (continents) and dotted (oceans) horizontal segments, from the left (C1) to the right (C8). The continent, C1, extends on the left up to negative infinite. The median circle of the ocean, O6, and the continent, C7; the bounding circle between lands, L1-L2 and L2-L3; are denoted as vertical bars from the left to the right, respectively. The locus of planet (including Sun) perigee or apogee geocentric orbit, is denoted as a vertical dotted segment on the left (perigee) and on the right (apogee). Single occurrences relate to apogees with the exception of Jupiter, where perigee is involved. Planet caption (on the box top): Mercury - 1; Venus - 2; Sun - 3; Mars - 4; Ceres - 5; Jupiter - 6; Saturn - 7; Uranus - 8. Distances are expressed in kilometers. See text for further details.
Figure 2: Fractional solar radius, $R_\odot(t)/R_\odot(t_a)$, as a function of the solar age, $t$, via interpolation of four computed values (diamonds) from a recent model of solar evolution [17]: $(0.00, 0.89)$, $(4.58, 1.00)$, $(7.13, 1.11)$, $(10.00, 1.37)$. The second point from the left represents the sun at the current age, $t_a = 4.58$ Gyr, which can safely be assumed as the beginning of nonlinear phase. The dotted line connects the first two points from the left. The interpolation curve is a cubic. Points related to solar radius inferred from Bhagavata-Purana, $R_\odot^* = R_\odot(t^*) = AU/216$, are marked as crosses for both the straight line (left) and the cubic (right). See text for further details.