Vertical Dimension and Size of the Puranic Universe:

EXISTING INTERPRETATIONS AND NEW INSIGHTS

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"Srimad-Bhagavatam *is as great as Krsna, the Supreme Lord and shelter of everything. In each and every verse of* Srimad-Bhagavatam *and in each and every syllable, there are various meanings.*"[1]

1. INTRODUCTION

In this investigation, we are considering some questions related to the measurements of the vertical dimension of the Puranic universe. The work is based on Bhaktivedanta Swami Prabhupada's purports on the Fifth Canto of the *Srimad-Bhagavatam,*[2] *Vaishnava Acaryas' Commentaries on the Fifth Canto*[3] by Danavir Goswami, cosmology books by Dr. Richard L. Thompson (Sadaputa),[4,5] and the work of Bhaktisvarupa Damodara Goswami.[6]

The object of investigation in the Fifth Canto is the "Brahmanda," which is in some way related to the modern notion of the "universe." The *Bhagavatam* describes innumerable Brahmandas, each one with its own spherical shell containing an earth disk, called Bhu-mandala. Bhu-mandala divides the universe in half, forming an upper, heavenly region and a subterranean region filled with water. As shown in Figure 1, the Brahmanda is surrounded by 8 layers of material elements (earth, water, fire, air, ether, mind, intelligence, and ego) with each successive layer being 10 times thicker than the previous one.

The diameter of our Brahmanda, as given in the *Srimad-Bhagavatam*[7], is 500,000,000 *yojanas* (~6.5 billion km or 4 billion mi). Thus, the radius of Bhu-mandala, the main component of the universe's horizontal structure, is 250,000,000 *yojanas* (~3.25 billion km or 2 billion mi), which is comparable to the distance to Uranus (~2.9 billion km or 1.8 billion mi). Bhu-mandala can be interpreted in

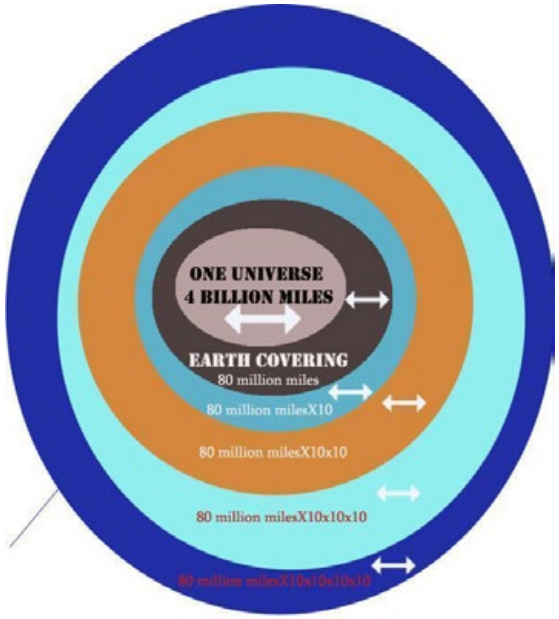

Figure 1. Brahmanda surrounded by coverings (not to actual scale).

many different ways, four of which are found in *Mysteries of the Sacred Universe* (*MSU*) by Sadaputa Prabhu.[8]

The "vertical" dimension of the Brahmanda, however, is more difficult to account for than the horizontal dimension. The vertical features of the Puranic universe are mainly discussed in Chapters 22-24 of the Fifth Canto and are said to consist of 14 layers spread out over its 500,000,000-*yojana* diameter. These dimensions are confirmed in other *Puranas* and in the *Caitanya-caritamrta*.[9] This size of the

Brahmanda is relatively small in comparison with the modern estimation of the observable universe[10] (even if we take into account the coverings of the Brahmanda). The corresponding data are given in Table 1.

Table 1. The sizes of the Brahmanda, Milky Way, and observable universe.

Object	Diameter in light years
Brahmanda	0.0007 (6 light hours)
Brahmanda + 3 coverings	0.8
Brahmanda + 7 coverings	7620
Brahmanda + 8 coverings	76,208
Milky Way	~100,000
Observable universe as per modern estimation	~93 billion

Even more problematic than the size of the universe are the *heights* of the planets given in *Srimad-Bhagavatam*. As shown in Table 2, this distances differ significantly from modern mean distances to these planets.[11] We used a value of 13.667 km (8.489 mi) for the *yojana,* as suggested by Sadaputa.[12]

Table 2. Puranic heights and mean distances to the planets.

Object	Puranic height (x1000 yojanas)	Modern mean distance (x1000 yojanas)
Sun	100	10951
Moon	200	28
Stars	400	2.94×10^9 (nearest, 4.24 light years)
Venus	600	10959
Mercury	800	10951
Mars	1000	16679
Jupiter	1200	56957
Saturn	1400	104488

What do these heights and the size of the universe mean? In the following section, we consider several existing explanations and then propose two new ones.

2. PREVIOUS WORK

2.1 Variations on the Length of a Yojana

A commonly assumed value for the *yojana* is approximately 13 km (8-8.5 mi). Nonetheless, we may not understand the distances "as they are" correctly. For example, it is not clear how to adjust the Brahmanda's diameter of 500,000,000 *yojanas* given in the *Bhagavatam* with its circumference of 18,712,069,200,000,000 *yojanas* as given by Srila Bhaktisiddhanta Sarasvati, and included by Srila Prabhupada in His purport for *Caitanya-caritamrta.*[13] The idea that the latter value is for the total diameter of the universe with its coverings is supported neither by Sadaputa, nor by the interpretation suggested in the abovementioned purport.

There are different estimations of the size of the *yojana* (e.g. Sadaputa in *Vedic Cosmography and Astronomy*[14]). A value of ~12.9 km (8 mi) per *yojana*, however, is generally accepted within ISKCON because of Srila Prabhupada's endorsement. Sadaputa fine-tuned this value to 13.6 km (8.49 mi) per *yojana* because this value produced a striking closeness-of-fit between the modern geocentric orbits of the planets and the rings of Bhu-mandala. Still, the issue with planetary heights suggests that the term *yojana* may imply different values under various circumstances.

2.2 Alternative Understandings of Distance

To resolve these types of discrepancies, some researchers suggest that the distances described in the *Bhagavatam* are the distances experienced by the yogis, *rsis* and other higher beings. If the *Srimad-Bhagavatam* explains "unearthly" philosophy, it is logical that the Puranic structure of the universe is also presented from the viewpoint of entities who have a higher level of consciousness. This point is additionally substantiated by Srila Prabhupada's words "time and space are correlative terms."[15] If time is perceived in a different way at the different levels of the universe, the same could be true with the perception of distances. Figure 2 shows how the seven upper worlds and the polar

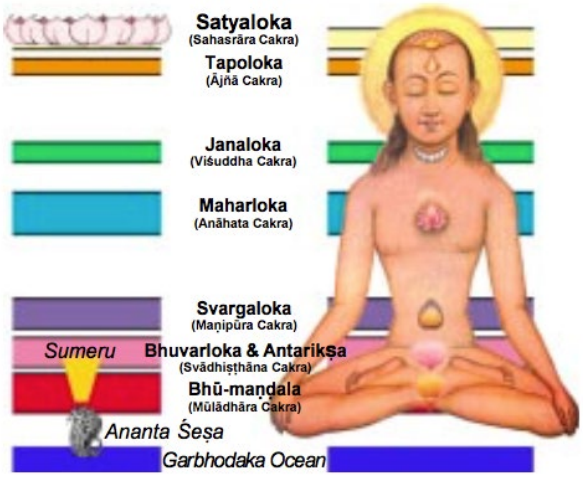

Figure 2. Graphical representation of Puranic heights and heights above the ecliptic.

axis (aligned along Mount Meru) are compared with the seven spinal *cakras* and the spinal column of the yogi.

Similar to the dilation of time from the perspective of the demigods, it is also possible that space itself takes on different proportions in different parts of the universe. The idea that physical laws may be different in various points of time-space is suggested by the general theory of relativity and elaborated upon by Sadaputa in *Mysteries of the Sacred Universe.*[16]

Another option is that these distances relate to an unknown dimension outside of the purview of traditional 4D space-time. This explanation is often used by Sadaputa. The multidimensional approach to the universe is currently being developed by string theorists. Additionally, the theory of branes also suggests that some dimensions of the universe may be quite small.[17] Still, nothing is known about the origin or nature of these alternative dimensions. The physical reality that we observe could be the projection of a more voluminous reality, one with many more dimensions, onto our limited senses. Just as a city map is not a city, the universe we see is a map of a different, more voluminous reality, presented as a three-dimensional projection. As Sadaputa writes, "… the Puranic Brahmanda can be seen as a system of *higher-dimensional* heavenly worlds, combined with an astronomically reasonable model of the solar system."[18]

The *Puranas* also describe special "routes" in the universe (e.g. the descent of the Ganges, travels of Durvasa and Siva, *Susumna* ray, etc.). In the purport by Vijajadhvaja Tirtha to the *Srimad-Bhagavatam*, Canto 5, Chapter 20, Verse 35,[19] distance is associated with the degrees of happiness. Ashish Dalela (Rsiraja), in his 2016 book *Mystic Universe,*[20] takes a similar kind of semantic approach by suggesting at least four different ways to redefine "distance" according to different contexts. These definitions of distance include (a) the linear distance between two objects, (b) the amount of effort it takes to transform an object into another (c) the time it takes to send information from one to another, and (d) the length of the *path* it would take for an observer to *become* that object.

2.3 The Astrolabe Model

The uniform spacing of 200,000 *yojanas* for celestial bodies (Table 1) could be a hint that these are not factual distances, but may simply refer to layers in astrolabe-like models. An exploded diagram of an astrolabe is shown in Figure 3. This is another

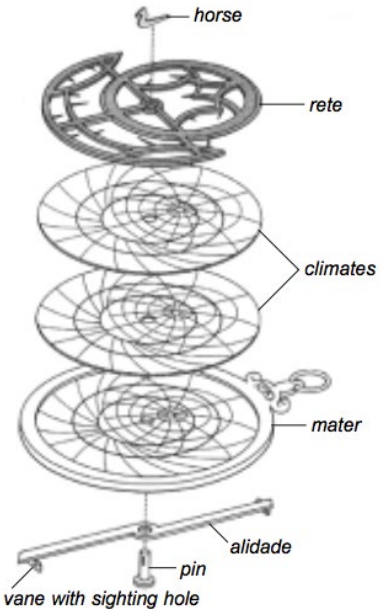

Figure 3. Exploded picture of an astrolabe, showing plates representing the earth (mater) and the ecliptic and star positions (rete).

interpretation suggested by Sadaputa in *Mysteries of the Sacred Universe.*[21]

2.4 Heights above the ecliptic plane

In both in both *Vedic Cosmography and Astronomy*[22] and *Mysteries of the Sacred Universe*[23], Sadaputa Prabhu interpreted the heights of the planets to be the maximum distance a planet assumes above and below the ecliptic plane due to its orbital inclination, shifted by 100,000 *yojanas*. A schematic diagram of this concept is shown in Figure 4. The following transformation formula can be applied to express this value in *yojanas*:

$$H = \frac{h}{8.489 \times 1.61} + 100000$$

where H is the height above Bhu-mandala in *yojanas*, and h is the maximum distance of a planet from the ecliptic plane in kilometers, using the conversion factors of 8.489

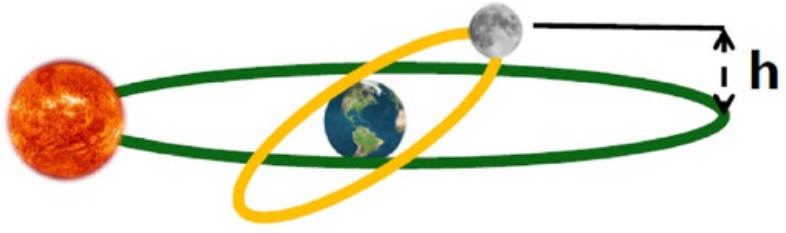

Figure 4. Interpretation of planetary heights as given in MSU

miles per *yojanas* and 1.61 kilometers per mile. The corresponding data are presented in Table 3.

As shown in Table 3, there is a good correlation between Puranic heights (column 2) and transformed heights above the ecliptic (column 4), except for the moon and Saturn. For a deeper statistical analysis, however, we propose using correlation coefficients (also known as the Pearson correlation coefficient[10]), which is defined for two vectors, $x = (x_1, x_2, x_3, \ldots x_n)$ and $y = (y_1, y_2, y_3, \ldots y_n)$ as follows:

$$K_c(\mathbf{x},\mathbf{y}) = \frac{\sum_{k=1}^{n}(x_k-\bar{x})(y_k-\bar{y})}{\sqrt{\sum_{k=1}^{n}(x_k-\bar{x})^2}\sqrt{\sum_{k=1}^{n}(y_k-\bar{y})^2}} \quad (1)$$

where

$$\bar{x} = \frac{1}{n}\sum_{k=1}^{n} x_k ,$$

and

$$\bar{y} = \frac{1}{n}\sum_{k=1}^{n} y_k$$

are mean (average) values of vectors x and y respectively.

The values of a correlation coefficient lie in the interval [0,1]. The value of the correlation coefficient represents the probability that the variance observed in the dataset is not random.

The values for the correlation coefficients $K_c(H_p,h)$ (between Puranic heights and heights above the ecliptic) and $K_c(H_p, H)$ (between Puranic heights and transformed heights) are both equal to 0.76 (the last row of table 3). Note that $K_c(H_p,h) = K_c(H_p, H)$ because the correlation coefficient is not affected by a linear vector transformation. The correlation coefficient being equal to 0.76 reveals a *moderate* linear dependence between Puranic heights and heights above the ecliptic, though the small amount of data (i.e. just seven elements) does not allow us to make definitive conclusions.

If we graph Puranic heights vs heights above the ecliptic on a coordinate plane (Figure 5), we see that they are quite scattered in relation to the line which shows the *optimal linear prediction* of Puranic heights based on heights above the ecliptic. This confirms that Puranic heights and heights above the ecliptic have only a slight linear dependence.

Table 3. Puranic heights along with their estimations, based on the heights of the planets above the ecliptic.

Planet	Puranic height (H_p, in thousands of yojanas)	Height above ecliptic (*h*, in millions of kilometers)	Transformed height (*H*, in thousands of yojanas)
Sun	100	0	100
Moon	200	0.03	102
Venus	600	6.34	564
Mercury	800	6.33	563
Mars	1000	8.09	692
Jupiter	1200	19.72	1543
Saturn	1400	65.70	4907
Correlation		0.76	0.76

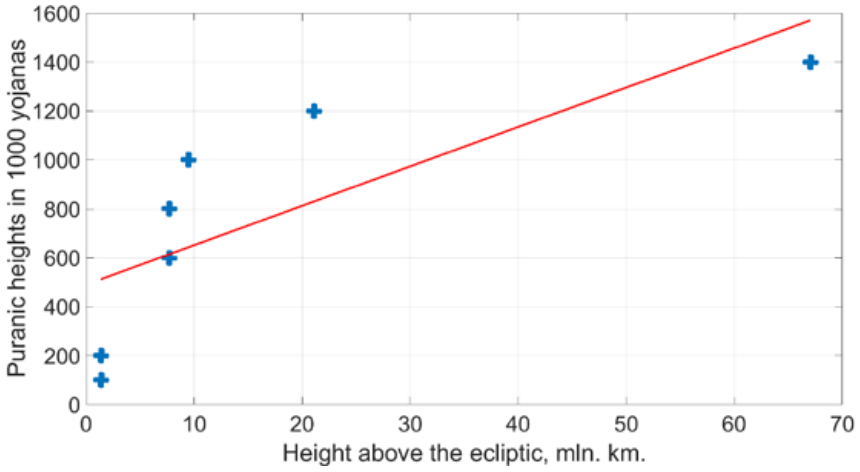

Figure 5. Graphical representation of Puranic heights and heights above the ecliptic

3. NEW PERSPECTIVES

3.1 Correlation with Modern Distances to the Planets

As explained by Sadaputa, from the point of view of someone on earth, the planets orbit in epicycles (see for example, the geocentric orbit Mercury shown in Figure 6). Thus, for the geocentric orbit of each planet we can find the following values:

a. minimum distance from the Earth, d_{min}
b. maximum distance from the Earth, d_{max}

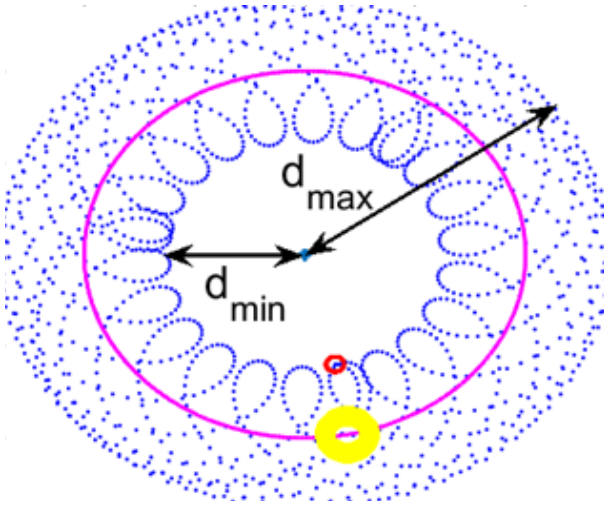

Figure 6. Example of the epicycle trajectory of Mercury around the earth (blue dot in the center). The sun is represented by the yellow disk.

c. mean distance from the Earth, $0.5(d_{min} + d_{max})$
d. difference between maximum and minimum distances, $(d_{max} - d_{min})$

Table 4 presents the data for mean, minimum, and maximum distances to the planets along with the corresponding correlations with Puranic heights. The correlation values for these distances (0.73, 0.84, 0.80) are comparable to the correlation for the heights above the ecliptic in Table 3 (0.76). Yet, if we consider the correlation of Puranic heights with the *difference between maximum and minimum distances to the planets* (column 5), the value of the correlation coefficient is much higher, namely, 0.96, which implies a strong linear dependence between Puranic heights and the values for $(d_{max} - d_{min})$.

This dependence between Puranic heights and "max-min differences" is illustrated in Figure 7. The line shows the optimal linear prediction of Puranic heights based on "max-min differences." It is interesting to note that this line passes almost exactly through the points corresponding to the moon and Saturn. The corresponding linear predictions for Puranic heights based on "max-min differences" are given in Table 5 (column 4), along with Puranic heights (column 2) and approximations based on heights above the ecliptic (column 3) for the purpose of comparison.

Besides the correlation coefficients that were given earlier in Tables 3 and 4, we also provide the mean

Table 4. The parameters of planetary orbits (in 1000 yojanas) as given in *MSU*[24], along with their respective correlation coefficients.

Planet	Minimum distance (d_{min})	Maximum distance (d_{max})	Mean distance (d_{mean})	Difference of max-min distances
Sun	10761	11140	10951	379
Moon	26.9	29.6	28	3
Venus	2903	19014	10959	16111
Mercury	6019	15883	10951	9864
Mars	4075	29282	16679	25207
Jupiter	43315	70599	56957	27284
Saturn	87237	121739	104488	34502
Correlation	0.73	0.84	0.80	0.96

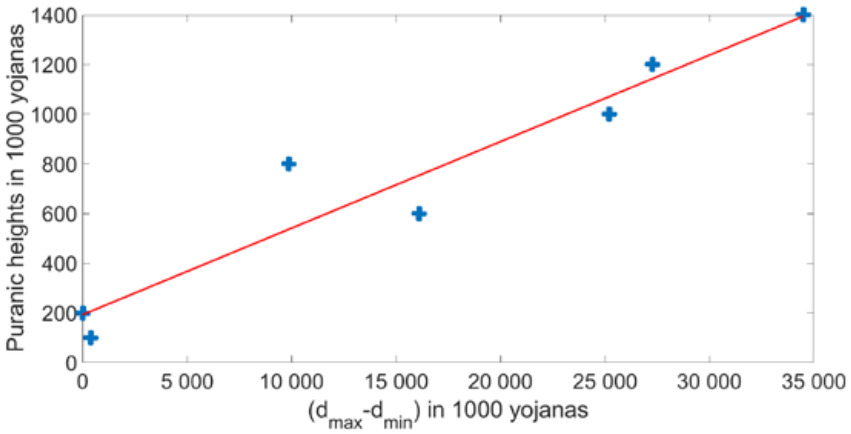

Figure 7. Graphical representation of Puranic heights and "max-min differences"

Table 5. Comparison of Puranic heights with their approximations based on heights above the ecliptic and "max-min differences" (in 1000 *yojanas*)

Planet	Puranic height (H_p)	Transformed height (*H*)	Transformed "max-min difference"
Sun	100	100	206
Moon	200	102	193
Venus	600	564	754
Mercury	800	563	537
Mars	1000	692	1071
Jupiter	1200	1543	1143
Saturn	1400	4907	1395
Correlation		0.76	0.96
Error		647.0	94.8
Normalized error		0.56	0.25

error, which is defined for two vectors $x = (x_1, x_2, x_3, \ldots x_n)$, $y = (y_1, y_2, y_3, \ldots y_n)$, as follows:

$$E(\mathbf{x},\mathbf{y}) = \frac{1}{n}\sum_{k=1}^{n} | x_k - y_k |$$

and average error

$$E_{norm}(\mathbf{x},\mathbf{y}) = \frac{1}{n}\sum_{k=1}^{n} \frac{| x_k - y_k |}{x_k}$$

Note that the normalized error is similar to the one used by Sadaputa in *MSU* for the correlation of geocentric planetary orbits with Bhu-mandala features[25]).

Table 5 shows that the linear approximation based on transformed "max-min differences" not only provides a higher correlation coefficient but also provides lower values of error and average error (6.8 and 2.2 times, respectively) compared to the approximation based on the heights above the ecliptic.

In this subsection, we have shown the connection of Puranic heights to the differences between the maximum and minimum distances to the planets in a geocentric orbit. The approximation of Puranic heights by this approach was shown to be more exact than the comparison based on the heights above the ecliptic, both in terms of correlation coefficients and mean errors. The values for the planetary heights given in the *Bhagavatam,* however, have the same order of magnitude as their respective maximum distances from the ecliptic plane. This is not the case when correlating the heights to the distance from the plane of the ecliptic. But that approach does not explain such issues as the Puranic height of the moon and the size of the Brahmanda.

3.2 Correlation of Puranic heights with log-distances

We also calculated the correlation coefficients between Puranic planetary heights and the logarithms of mean distances to the planets as given in Table 4, column 4. The corresponding logarithms of mean distances are given in Table 6, column 3. The log-distances along with Puranic heights are represented in Figure 8. Although we see from Fig. 8 that the data are quite scattered, which is confirmed by the relatively small correlation coefficient (0.71), it can also be seen that points for the last four planets (i.e. starting from Mercury) lie approximately on the same line (with correlation coefficient 0.98). The line in Fig. 8 shows the optimal linear prediction of Puranic heights based on the logarithmic mean distances for the last four planets. The equation of this line is:

$$y = p_1 \log(d_{mean}) + p_2 \,, \quad (2)$$

where p_1 = 241780 and p_2 = -3712600.

Since astronomical distances are often expressed in light years, let us introduce the corresponding value:

Table 6. Puranic heights along with logarithms of mean distances to the planets.

	Puranic height (in 1000 yojanas)	Log-mean distance (in kilometers)
Sun	100	18.8
Moon	200	12.9
Venus	600	18.8
Mercury	800	18.8
Mars	1000	19.2
Jupiter	1200	20.5
Saturn	1400	21.1
Correlation		0.71
Correlation for the last 4 planets		0.98

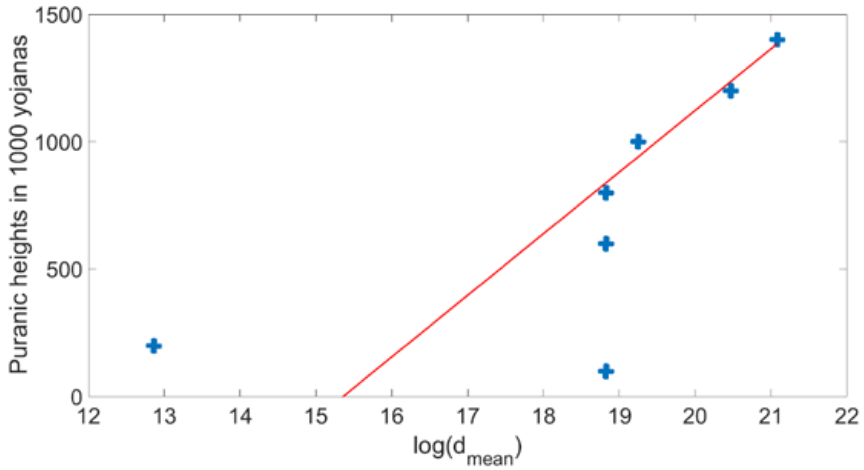

Figure 8. Graphical representation of Puranic heights and logarithmic mean distances to the planets.

$$d_{mean}^{LY} = \frac{d_{mean}}{c \times 365 \times 24 \times 3600},$$

Where $c = 3*10^5$ km/s is the speed of light.

Hence, formula (2) can be rewritten as

$$y = p_1 \log(d_{mean}^{LY}) + p_2', \quad (3)$$

where $p'_2 = 3511213$

We can also use this approximate linear dependence to estimate, for example, the Puranic height of Dhruvaloka (the Pole Star, currently Polaris), the distance to which is estimated today as 433 light years. According to formula (3), the predicted value is 4,980,000 *yojanas*, which has the same order of magnitude as the value of 3,900,000 *yojanas*, the height given for Dhruvaloka.[26] Similarly, if we the take the radius of the *observable universe* estimated as 93 x 10^9 light years,[10] we obtain an approximate estimate of 9,600,000 *yojanas,* which has the same order of magnitude as the height of Maharloka (about 30% less), given as 13,900,000 *yojanas.*[26]

4. CONCLUSION

In this essay we have unpacked some possible meanings for the concept of "heights above Bhu-mandala" as described in the 5th Canto of the *Srimad-Bhagavatam*, to see how they may relate to the world we experience. First, we examined various ways this has been understood within ISKCON. Those who understand the distances "as they are" encounter inexplicable conflicts with simple observations and generally invoke *acintya-bhedabheda-tattva* to justify this position. Taking a more indirect approach, we explored several interesting analyses given in terms of higher dimensionality, space dilation, and levels of consciousness. We touched upon the astrolabe model suggested by Richard L. Thompson in *Mysteries of the Sacred Universe,* and examined in more depth the correlation between planetary heights and orbital inclinations that he investigates first in *Vedic Astronomy and Cosmography* and then develops further in *Mysteries of the Sacred Universe.* Asish Dalela, in his book *Mystic Universe,* proposes several novel ways to understand concepts such as "distance" from a Vedic viewpoint that help to broaden our understanding.

Finally, noting that the *yojana* assumes different values under various circumstances, we researched correlations between Puranic planetary heights and distances from earth as currently understood by modern astronomy. By using Pearson correlation coefficients, we showed a strong linear dependence between Puranic heights and the values for the max-min differences of the planetary orbits around the Earth. The correlation was significantly greater than the linear correlation with orbital inclinations above the ecliptic. We also show a correlation with the logarithms of mean distances to the planets.

Although in this essay we establish significant parallels between the *Srimad-Bhagavatam's* description of the Brahmanda and the universe of our experience, there is clearly no simple one-to-one mapping between the two. This is to be expected, for as Sukadeva Goswami explains to Maharaja Pariksit as he begins his description of Jambudvipa:

> *My dear King, there is no limit to the expansion of the Supreme Personality of Godhead's material energy. This material world is a transformation of the material qualities [sattva-guna, rajo-guna and tamo-guna], yet no one could possibly explain it perfectly, even in a lifetime as long as that of Brahma. No one in the material world is perfect, and an imperfect person could not describe this material universe accurately, even after continued speculation. O King, I shall nevertheless try to explain to you the principal regions, such as Bhuloka, with their names, forms, measurements and various symptoms.*[27]

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[27]A.C. Bhaktivedanta Swami Prabhupada, *Srimad-Bhagavatam*, Canto 5, Chapter 16, Text 4 (Los Angeles, CA: The Bhaktivedanta Book Trust, 1988), p. 557.

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