#### History of Science in South Asia



## The Core of the Non-Universe in Jaina Cosmology as a Cube of Eight Space-Points

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According to Jaina cosmology, the non-universe is a hollow sphere beyond and exists all round the universe, whose middle region is the horizontal universe resting on a circular disc. The Bhagavatī Sūtra and the Sthānāṅga Sūtra each mention that there is the core of the horizontal universe where a cube of eight space-points is and from those eight space-points ten directions originate. This paper presents a conjectural explanation for understanding that cube. The core of the non-universe is the core of a core-sphere when the core-sphere is formed using n core-circle south that they are stacked up and down in the same order from the nth core-circle to the first core-circle. The upper four points of the cube of eight points form the core of the horizontal universe and the cube of eight points is the core of the non-universe. The nth core-circle becomes the horizontal universe when n is innumerable and the nth core-sphere forms the non-universe when n approaches infinity. This paper also shows that the intermediate and cardinal directions are linear and planar respectively while the zenith and nadir ones are three-dimensional.

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### The Core of the Non-Universe in Jaina Cosmology as a Cube of Eight Space-Points

#### Dipak Jadhav

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#### 1 INTRODUCTION

This paper is not intended as a strong assertion about the history of Jaina thought; rather, it presents a conjectural explanation for understanding the core of the non-universe as a cube of eight space-points and invites further discussion and debate.

According to Jaina cosmology, there is the core of the horizontal universe where a cube of eight space-points is and ten directions originate from those eight space-points. Such a concept is not found outside India.

Walther Schubring wrote that,

there are 8 centremost units, which, ... are supposed to exist in the centre of the upper regions of the world, called the *Ruyaga*, in Rayana-ppabhā, ....<sup>1</sup>

J. C. Sikdar wrote that,

in the Jambūdvīpa island, just in the middle part of the Mandāramountain [i.e., Mandara-mountain] ..., here is located the centre of the horizontal region called *Rucaka*, having eight parts [i.e., points], because from this [i.e., these] point[s] flow the ten directions – East, East-South, etc.<sup>2</sup>

and Rayanappabhā (Skt. Ratnaprabhā). 2 Sikdar 1964: 521. Glossary is as follows. Region (universe).

<sup>1</sup> Schubring 1962: 130. Glossary according to Schubring is as follows. Centremost units (*majjha-paesa*). Glossary is as follows. World (universe), *ruyaga* (Skt. *rucaka*, cube),

Jozef Deleu wrote that, "the centre of the central, or horizontal, world is the socalled Cube of Eight Space-units …"<sup>3</sup> M. R. Gelra referred to the cube of eight space-points as the eight-point centre of the universe.<sup>4</sup> Samani Chaitanya Pragya wrote that, "in reference to the central point of the universe, the concept of *Rucaka* is really astonishing and noticeable." She also called it "the centre of the middle section."<sup>5</sup>

These scholars have been largely successful in bringing this important concept of the cube of eight space-points to scholarly attention, on the basis of the texts of the *Ţhāṇa* (Skt. *Sthānāṅga* [*Sūtra*]) and the *Bhagavaī* (Skt. *Bhagavatī* [*Sūtra*], "The Venerable"). Despite this, it is yet to be understood how there is the core of the horizontal universe where a cube of eight space-points is.

The *Sthānāṅga Sūtra* and the *Bhagavatī Sūtra* are the third and fifth of the twelve books of the Śvetāmbara Jaina canon respectively.<sup>6</sup> Both of them are composed in Arddha-Māgadhī Prakrit. Each of them is an encyclopaedic work. On the basis of mathematical ideas<sup>7</sup> contained in them, they belong to the canonical class of the Jaina school of Indian mathematics.<sup>8</sup>

The *Sthānānga Sūtra* is subdivided into ten chapters.<sup>9</sup> The old genuine name of the *Bhagavatī Sūtra* is the *Viyāhapaṇṇatti* (Skt. *Vyākhyāprajñapti,* "Excellent Knowledge about the Explanations" or "Suggestion on the Explanations").<sup>10</sup> *Bhagavaī* (Skt. *Bhagavatī*) is only an epithet which was originally added to the *Viyāhapaṇṇatti* but the former has later on superseded the latter.<sup>11</sup> It is divided into forty-one chapters. Each chapter has sub-divisions called lessons.<sup>12</sup> For a detailed description of the *Jambūdvīpa* Island, the *Bhagavatī Sūtra* refers to the fifth auxiliary canonical book *Jaṃbuddivapaṇṇattī* (Skt. *Jambūdvīpa Prajñapti [Sūtra*]).<sup>13</sup>

5 Pragya 2005: 24–25, especially see p. 24. Glossary is as follows. Middle section (horizontal universe).

lows. Chapter (thāṇa, Skt. sthāna).

10 At some places it is also written *Viyāha*pannatti or *Vivāhapannatti* or *Viāhapanṇattī*. For *Viyāhapannatti* and *Vivāhapannatti*, see Deleu 1970: 17. For *Viāhapaṇṇattī*, see *BhaSū*,: i, iii.

11 Deleu 1970: 17

12 Glossary is as follows. Chapter (*saya*, Skt. *śataka*), and lesson (*uddeso*, Skt. *ud-deśaka*). Here the term *saya* (Skt. *śataka*) has no relevance with the number hundred. It can be said to indicate a great number of different teachings gathered in each chapter. See Schubring 1962: 88.

13 *BhaSū*<sub>3</sub>: 9.1.3, p. 307. Glossary is as follows. Auxiliary canonical book (*uvāmga*, Skt. *upānga*).

<sup>3</sup> Deleu 1970: 194–195. Glossary according to Deleu is as follows. Horizontal world (*tiriya-loga*), and cube of eight space-units (*attha-paesiya ruyaga*).

<sup>4</sup> Gelra 1999: 121–130.

<sup>6</sup> Glossary is as follows. Twelve books  $(dv\bar{a}das\bar{a}ng\bar{a})$ . Each book (anga) is called a *sutta* (Skt. *sūtra*). According some scholars, there are eleven books because the twelfth book *Ditthivada* (Skt. *Dṛṣțivāda*) did not survive. See Wiles 2006:62.

<sup>7</sup> Rajgopal 1991: 1–6; Shah 2008: 3–24; Jadhav 2009: 35–53; 2022: 87–102.

<sup>8</sup> Jadhav 2017: 321–322.

<sup>9</sup> Krümpelmann 2006: 1. Glossary is as fol-

These books have come down to us in their present form through three stages of their development. They were first derived from the initial core of the teachings which are attributed to Lord Mahāvīra (599–527 все), the twenty-fourth and last *Tīrthaṅkara* in the history of ecclesiastic Jainism, and then given a shape of book by the subsequent individuals. In the second stage, they were collected and fixed in the first synod of monks. According to the *Āvassaya-cuṇṇi* (Skt. *Āvaśyaka-cūrṇi*), generally dated between 593 cE and 693 cE, this synod was held at Pāṭaliputra. According to Hemacandra's *Pariśiṣṭaparvan*, written between 1159 cE and 1172 cE, it was held after 160 years after Lord Mahāvīra. In the third and last stage, they were redacted in the synod of monks held at Valabhī after 980 or 993 years after Lord Mahāvīra or in the fifth century cE.<sup>14</sup>

Geometrical forms are considered in chapter twenty-five of the *Bhagavatī*  $S\bar{u}tra$  by way of points. The least significant number of points required to construct them are referred to in it. Distinction has been drawn between even and odd number of points. In my paper published in 2009,<sup>15</sup> I showed how those least even and odd numbers were arrived at and identified them as figurate numbers. Those forms with their even and odd number of points are line (2, 3), isosceles triangle (6, 3), square (4, 9), rectangle (6, 15), circle (12, 5), outer-lying circular-annulus (20), pyramid of isosceles triangular base (4, 35), cube (8, 27), cuboid (12, 45), sphere (32, 7), and outer-lying circular-cylinder (40)<sup>16</sup> That paper is highly relevant here. Since how there is the core of the horizontal universe where a cube of eight space-points is is not expressed in the above sources, an explanation is needed to understand it. Therefore, the purpose of this paper is mainly to suggest an explanation to understand it. The concept of the cube is important in that it has a mathematical basis, which I will show in this paper. Based on the information given in the Bhagavatī Sūtra and using the concepts of core-circle and core-sphere, I will show how there is the core of the horizontal universe where the cube of eight space-points is. Beyond this, I will explain those ten directions in mathematical terms and discuss other issues related to all these.

This paper is an extension to that paper of mine in the sense that it is only after that paper that I find myself in a position to suggest the aforesaid explanation in this paper and is a partial addendum to that paper in the sense that I will suggest expressions in this paper for the total number of points required to construct the  $n^{th}$  core-circle and  $n^{th}$  core-sphere, which I could not suggest in that paper.

15 Jadhav 2009.
16 BhaSū<sub>9</sub>: 25.3.726, pp. 405–407; Jadhav 2009: 38, 42–51.

<sup>14</sup> Wiles 2006: 61–63, 75–76; Sikdar 1964: 34; S. K. Jain 1975: 33. Etymologically, *"Tīrthaṅkara"* means "Builder of a ford [across an ocean of suffering]."

#### 2 MENTION OF THE CUBE OF EIGHT SPACE-POINTS IN THE BHAGAVATĪ SŪTRA AND STHĀNĀŅGA SŪTRA

**T**N A REPLY TO THE QUESTION as to where the core of the horizontal universe is, the *Bhagavatī*  $S\bar{u}tra$  states the following:<sup>17</sup>

जंबुद्दीवे दीवे मंदरस्स पव्वयस्स बहुमज्झहदेसभाए इमीसे रयणप्पभाए पुढवीए उवरिमहेट्ठिल्लेसु खुड्डगपयरेसु एत्थ णं तिरियलोगस्स मज्झे अट्ठपएसिए रुयए पण्णत्ते, जओ णं इमाओ दस दिसाओ पवहंति, तं जहा— पुरच्छिमा पुरच्छिम—दाहिणा एवं जहा दसमसए णामधेज्ञं ति।<sup>18</sup>

"[Amid] the upper and nether thin planes situated in [the top of] this Rayaṇappabhā hell, in the very core [in the centre of the bottomsurface] of Mount Mandara of Jaṃbuddīva Island, is the core of the horizontal-universe; that is where a [cube, namely,] *ruyae* of eight space-points is. From this cube originate the ten directions, namely, east, east-south, etc. Their names can be known from the [first lesson of the] tenth chapter [of the *Bhagavatī Sūtra*]."<sup>19</sup>

Commenting on this passage, Abhayadeva Sūri (eleventh century CE) wrote that at the core of the horizontal universe is a cube of eight space-points contained in two thin planes; one plane is upper and the other is lower.<sup>20</sup> Almost the same passage is given in the *Sthānānga Sūtra*.<sup>21</sup> Commenting on that passage, Abhayadeva compared each of the upper and lower sets of the four space-points of this cube of eight space-points with the four teats of a cow's udder, which are one above the other and facing each other.<sup>22</sup>

(*dasamasae*, Skt. *daśama-śataka*). For "that is where the cube of eight space-points is," especially see  $BhaS\bar{u}_7$ : 130.

20 BhaS $\bar{u}_8$ : 562. Glossary is as follows. The core of the horizontal universe (*tirya-glokamadhya*), cube (*rucaka*), eight spacepoints (*aṣṭapradeśa*), two planes (*pratarad-vaya*), thin (*kṣullaka*), upper (*uparima*), and lower (*adhastana*).

21 जंबुद्दीवे दीवे मंदरस्स पव्वतस्स बहुमज्झदेसभागे इमीसे रयणप्पभाते पुढवीते उवरिमहेट्ठिल्लेसु खुड्डगपतरेसु एत्थ णमट्टपतेसिते रुयगे पण्णत्ते जओ णमिइमातो दस दिसातो पवहंति, तंजहा— पुरत्थिमा, पुरत्थिमदाहिणा, दाहिणा, दाहिणपच्चत्थिमा, पच्चत्थिमा, पच्चत्थिमुत्तरा, उत्तरा, उत्तरपुरत्थिमा, उड्ढा, अधा। SthāSū<sub>1</sub>: ch. 10, sūtra 720, p. 823. Also see SthāSū<sub>2</sub>: ch. 10, sūtra 30, p. 484.

22 *SthāSū*<sub>1</sub>: ch. 10 commentary, p. 826, Glossary is as follows. Teats of a cow's udder (*gostana*).

<sup>17</sup> *BhaSū*<sub>6</sub>: 13.4.13 (question), p. 45. Glossary is as follows. Core ( $\bar{a}y\bar{a}mamajjha$ , Skt.  $\bar{a}y\bar{a}mamadhya$ ), and horizontal universe (*tiriyaloga*, Skt. *tiryakloka*).

<sup>18</sup> *BhaSū*<sub>6</sub>: 13.4.13 (reply), p. 45.

<sup>19</sup> Glossary is as follows. Upper (*uvarima*, Skt. uparitana), nether (hetthilla, Skt. adhastana), thin (khuddaga, Skt. ksullaka, with no thickness), planes (payaras, Skt. prataras), Rayanappabhā (Skt. Ratnaprabhā, Gem-hued), hell (pudhavi, Skt. prthavī), very core (bahu-majjha-desa-bhāe, Skt. bahu-maddhya-deśa-bhāga), Mount Mandara (Mamdara pavvaya, Skt. Meru parvata), Jambuddīva Island (Jambuddīva dīva, Skt. Jambūdvīpa dvīpa), core (majjha, Skt. madhya), cube (ruyae or ruyaga, Skt. rucaka), eight space-points (attha-paesas Skt. asta-pradeśas), east (puracchimā, Skt. east-south (puracchima-dāhiņā, pūrva), Skt. *pūrva-daksiņa*), and tenth chapter

#### 3 RESULTS AND DISCUSSION

A CCORDING TO THE BHAGAVATĪ SŪTRA, aether, anti-aether, space, soul, and matter are five realities or fundamental entities. Time too, in addition to these five realities, appears as a reality in it.<sup>23</sup>

#### THE UNIVERSE-SPACE AND NON-UNIVERSE-SPACE AND THEIR SHAPES

Space, the third reality, is responsible to provide accommodation. An indivisible part of space is called space-point.<sup>24</sup> We can simply call it point. Space is comprised of infinite such points. It establishes the receptacles of living and nonliving substances.<sup>25</sup> It is not entirely occupied by the other realities. Instead, it is partly occupied and partly unoccupied even though it is a homogeneous continuum, ubiquitous, and all-pervading.<sup>26</sup> The part of space which is pervaded by the other realities is called the universe-space and the rest of the space, which is empty, is called the non-universe-space.<sup>27</sup>

The non-universe is all pure infinite space beyond and exists all round the universe. It equals the whole space minus its infinite part, i.e., minus the universe-space.<sup>28</sup> At its central part, there exists the universe. The non-universe has the shape of a hollow sphere.<sup>29</sup>

The universe is limited.<sup>30</sup> The number of space-points in it is innumerable.<sup>31</sup> The universe is described using metaphors. It is like a firmly standing formation. It is wide at the base with a gradual taper ending with the shape of an upright drum. It is divided into three regions, namely, the lower universe, the horizontal

28 *BhaSū*<sub>1</sub>, 2.10.12, p. 334.

29 BhaS $\overline{u}_4$ , 11.10.11, p.142; Schubring 1962: 204. Glossary is as follows. Hollow (*jhusira*, Skt. *susira*), and sphere (*gola*).

30 *BhaSū*<sub>1</sub>: 2.1.24, p. 247. Glossary is as follows. Limited ( $sa^amta$ , Skt. santa).

31 *BhaSū*<sub>3</sub>: 8.10.29, p. 289. The canonical class of the Jaina school of Indian mathematics divides positive integers into three main divisions: numerable (*sańkhyāta*), innumerable (*sańkhyāta*), and infinite (*ananta*). The lowest numerable number is 2 while the first innumerable number is the highest numerable number plus one and the first infinite number is the highest innumerable number glus one. This is the number-measure system of the Jainas. For its preliminary information, see Datta 1929: 140–142. And for unity not being a number, see Jadhav 2021b: 209–227.

**<sup>23</sup>** *BhaSū*<sub>6</sub>: 13.4.17, p. 47; *BhaSū*<sub>7</sub>: 13.4.55, p. 132; Sikdar 1964: 559. Glossary is as follows. Aether (*dhamma*, Skt. *dharma*, medium of motion), anti-aether (*ahamma*, Skt. *adharma*, medium of rest), space ( $\bar{a}g\bar{a}sa$ , Skt.  $\bar{a}k\bar{a}sa$ ), soul ( $j\bar{v}a$ ), matter (*poggala*, Skt. *pudgala*), and time ( $k\bar{a}la$ ).

<sup>24</sup> Deleu 1970: 94. Glossary is as follows. Accommodation (*avagāhaņā*, Skt. *avagāhanā*), and space-point (*paesa*, Skt. *pradeśa*).

**<sup>25</sup>** *BhaSū*<sub>6</sub>: 13.4.20, p. 48. Glossary is as follows. Receptacle (*bhāyaṇa*, Skt. *bhājana*), living (*jīva*), non-living (*ajīva*), and substances (*davvas*, Skt. *dravyas*).

<sup>26</sup> Kumar 2010: 118.

**<sup>27</sup>** *BhaSū*<sub>1</sub>: 2.10.10, p. 332. Glossary is as follows. Universe-space (loyāgāsa, Skt. lokā-kāśa), and non-universe-space (aloyāgāsa, Skt. alokākāśa).

universe, and the upper universe. The horizontal universe is in the shape of a round disc such as a kind of cymbal. The upper universe has the shape of an upright drum. It is divided into fifteen regions. Out of them, the first region is Sohammakappa and the fifteenth and uppermost region is Īsipabbhāra. The lower universe is divided into seven hells. Rayaṇappabhā is the first and uppermost hell, while the seventh and lower most hell is Ahesattamā.<sup>32</sup> The lower universe has the shape of a *tappa*.<sup>33</sup> *"Tappa* might be," writes Deleu, *"talpa."* The latter means bed in Sanskrit. The basis on which he writes so is that the universe is also described as having a bedstead-like shape in its lower part.<sup>34</sup> But Abhayadeva Sūri takes *tappa* as *tapra*. He also gives *udupaka*, which means boat in Sanskrit, as a synonym for *tapra*. He further explains that the lower universe is *"shaped like an earthen bowl turned upside down."* 

The horizontal universe rests on a disc the thickness of which is zero.<sup>36</sup> According to the *Bhagavatī Sūtra*, it is a flat plane divided into an innumerable number of concentric annuli which are alternatively islands and seas. The innermost region is known as the Jambuddīva Island. Being the first annulus, it is a circular disc. The last annulus is the Sayam-bhū-ramaņa Sea.<sup>37</sup> At the very middle of the Jambuddīva Island of diameter of 10<sup>5</sup> *yojana* is Mandara Mountain. It is 99 × 10<sup>3</sup> *yojana* high and 10<sup>3</sup> *yojana* deep. Its diameter at the foundation is 10090 $\frac{10}{11}$  *yojana*, at the surface is 10<sup>4</sup> *yojana* and at the top is 10<sup>3</sup> *yojana*.<sup>38</sup>

On the basis of these features it is very difficult to determine whether the universe as propounded in the *Bhagavatī Sūtra* is to be visualized as model 1a, 1b or 1c in Figure 1. The dimensions shown in each of the three figures are in *rajjus* where *rajju* is a linear measure. As far as the total volume of the universe is concerned, both the Śvetāmbara and Digambara Jaina thinkers have accepted that it is 343 cubic *rajjus* but their views on the exact shape of the universe differ.<sup>39</sup> According to the Digambara thinkers including Yativṛṣabha<sup>40</sup> (some date

32 BhaSū<sub>2</sub>: 7.1.5, p. 328; BhaSū<sub>4</sub>: 11.10.3–4 and 11.10.6–10, pp. 139–142; Deleu 1970: 176. Glossary is as follows. Firmly standing formation (supa^iṭṭhaga saṇṭhāṇa, Skt. supratiṣṭhika saṇṣthāna), lower universe (aholoya, Skt. adholoka), horizontal universe (tiriyaloya, Skt. tiryagloka), upper universe (uḍḍhloya, Skt. tiryagloka), upper universe (uḍḍhloya, Skt. tirdhvaloka), cymbal (jhallari, Skt. jhallaka), upright drum (uḍḍhamuiṃga, Skt. ūrdhvamṛdaṅga), Sohammakappa (Skt. Saudharmakalpa), Īsipabbhāra (Skt. Īṣatprāgbhāra), and Ahesattamā (Skt. Adhaḥsaptamā).

33 *BhaSū*<sub>4</sub>: 11.10.7, p. 141.

34 Deleu 1970: 177; *BhaSū*<sub>2</sub>: 5.9.14, p. 160. Glossary is as follows. Bedstead (*paliyaņika*,

Skt. palyańka).

35 BhaSū<sub>8</sub>: 395; also see Deleu 1970: 177. Glossary is as follows. Shaped like an earthen bowl turned upside down (adhomukha-śarāvākāra-saṃsthāna). 36 Schubring 1962: 216. 37 BhaS $\bar{u}_{4}$ : 11.10.5, p. 140. Glossary is as follows. Innumerable (asamkhejja, Skt. asankhyeya), and Sayam-bhū-ramana svayam-bhū-ramaņa, "Self-born (Skt. merriment"). 38 JaDvīPraSū: 4.132, pp. 361-362.

- 39 Kumar 2010: 144–145.
- 40 *TiLoPa*: vv. 1.136–138, pp. 32–33 and vv. 148–149, pp. 37–38.



Figure 1: Three possible models of the universe.

between 176 CE and 609 CE), Vīrasena<sup>41</sup> (c. 816 CE), and Nemicandra<sup>42</sup> (c. 981 CE), the universe is in the form of three trapezoidal prisms piled one upon another as shown in Figure 1 as model 1c. Model 1b suggests that the universe is in the form of three truncated cones placed one upon another. But Vīrasena refers to that it is not the shape of the universe as its volume comes to be nearly 161 cubic *rajjus*, which is less than half of the accepted volume of the universe.<sup>43</sup> The shape of the universe as propounded in the *Bhagavatī Sūtra* might be model 1a as Muni Mahendra Kumar claims to have reached it while retaining all the fundamental beliefs and dimensions intact.<sup>44</sup> But the dimension and shape of the horizontal universe appears to fit model 1b. This is because the Sayam-bhū-ramana Sea is the last circular annulus on the horizontal universe.

#### ILLUSTRATION OF THE POSITION OF THE CUBE OF EIGHT SPACE-POINTS

Based on the above details we are able to illustrate where the cube of eight spacepoints is, although it is an issue which of the models in Figure 1 is the model of the universe according to the *Bhagavatī Sūtra*. The lower four points of the cube lie in the nether plane and its upper four points lie in the upper plane. These two planes are adjacent. See Figure 2a.<sup>45</sup> Those eight points are interlinked in such a way that each point is adjacent to the other seven points; to the three points

43 *ṢaKhaĀ*: 1.3.2, vv. 6–7, pp. 11 and 13.

45 For plain drawing of the cube of eight space-points, see  $BhaS\bar{u}_8$ : 562. For the figure drawn by Trilok Sharma to illustrate it, see page just after p. 4 in  $BhaS\bar{u}_4$ .

<sup>41</sup> *ṢaKhaĀ*: 1.3.2, pp. 19–22.

<sup>42</sup> *TriLoSā*: v. 113, p. 110.

<sup>44</sup> Kumar 2010: 155–159, 388–402.



(b) Close-up view.

Figure 2: The cube of eight points.

forming the edges of the cube, to the three points forming the diagonals of the surfaces of the cube, and to one point forming the diagonal of the cube. This is why they form the smallest cube. The adjacency of those eight points can be better understood through Figure 2b.



Figure 3: System of points as described in the *Bhagavatī Sūtra*.

#### SYSTEM OF POINTS IN THE BHAGAVATĪ SŪTRA

In chapter twenty-five of the *Bhagavatī* Sūtra, the term used for line is *sedhi*. While commenting on the term, Abhayadeva Sūri writes that sedhi means a long row and here it is acceptable as a row of space-points.<sup>46</sup> It is further stated in the same chapter that lines in general are infinite in substance whether they run from east to west or from south to north or from zenith to nadir. This is also the case with the lines in the non-universe. But the lines in the universe are innumerable. This is, Abhayadeva says, because there are innumerable points in the universe. As in substance, lines usually are infinite in length in whatever direction they run. In the universe, the horizontal lines, i.e., the lines running from east to west and from north to south are numerable or innumerable in length while the vertical lines are innumerable in length. In the non-universe, the horizontal lines are infinite in length while the vertical lines, i.e., the lines running from nadir to zenith are infinite, innumerable or numerable in length. Lines as a whole have no beginning and no end in whatever direction they run. All lines in the universe have a beginning and an end. In the non-universe, the vertical lines may have a beginning and an end and both the vertical and horizontal lines may have neither of these or one of these.<sup>47</sup>

infinite (*aṇamta*, Skt. *ananta*), east to west (*pāīṇapadīṇa*, Skt. *pūroa-paścima*), south to north (*dāhiṇuttara*, Skt. *dakṣiṇauttara*), zenith to nadir (*uddhamaha*, Skt. *ūrdhva-adhaḥ*), lines in the non-universe

<sup>46</sup> *BhaSū*<sub>9</sub>: 25.3, pp. 414–415. Glossary is as follows. *Sedhi* (Skt. *śreņī*), row (*pańkti*), and space-points (*ākāśapradeśas*).

<sup>47</sup>  $BhaS\bar{u}_9$ : 25.3, pp. 414–419; Deleu 1970: 273. Glossary is as follows. Substance (i.e., number, *davva*, Skt. *dravya*),



Figure 4: Constructing a core-circle and a core-sphere.

Based on the above, we can say that in the *Bhagavatī Sūtra* such a system of points is considered that the points lie in a plane in a rectangular system of their horizontal rows as shown in Figure 3a and they are located in space in a rectangular system of their horizontal and vertical rows as shown in Figure 3b.<sup>48</sup> This interpretation will serve as a basic framework for us to understand the figurate numbers given in it. The above characteristics of the lines in the non-universe confirm that the non-universe is spherical in shape. Every line whether it is horizontal or vertical is a chord of the circular cross-section of the spherical non-universe.

#### CORE-CIRCLE AND CORE-SPHERE

In the *Bhagavatī* Sūtra, the circle is constructed by means of points in two ways. In way one the centre of a circle is determined by a single point and in way two it is determined by the core of the four points forming a square. For this reason I used the terms centered-circle and core-circle. Similar is the case with sphere. The number of points required to construct a centered-circle and a centered-sphere is always odd.<sup>49</sup> On the other hand, the number of points required to construct a core-circle and a core-circle and a core-sphere is always even. Here, it is relevant to see how the Jainas arrived at these even numbers. The way must have been as follows.<sup>50</sup>

We first set four points on the plane as a core forming a square. From then on, keeping the same distance in each of the two consecutive circles, we draw

(alogāgāsasedhīs, Skt. aloka-ākāśa-śreņis), lines in the universe (logāgāsasedhīs, Skt. loka-ākāśa-śreņis), length (i.e., region, paesa, Skt. pradeśa), numerable (saņikhejja, Skt. saṅkhyeya), beginning (sāiya), no beginning (aṇāiya), end (sapajjavasiya, Skt. saparyavasita, i.e., sānta), and no end (apajjavasiya, Skt. aparyavasita, i.e., ananta).

48 I suggested Figure 3a and Figure 3b for the first time in my paper published in 2009.
See Jadhav 2009: 40.
49 Jadhav 2009: 46–48.

50 Jadhav 2009: 48–50.

con-core-circles. The circumference of each such circle goes through eight points. This means that 12 points are required to form the foremost core-circle including its disc. We are able to see the core-circles up to the fourth one in Figure 4a.

The expression for the total number of points required to construct the  $n^{th}$  core-circle, say C(n), can, if we apply inductive reasoning, be given by,<sup>51</sup>

$$C(n) = \begin{cases} 4 & \text{when } n = 1\\ (2n)^2 - 4 & \text{when } n \ge 2. \end{cases}$$

The number of points required to construct the core-circles are

when n = 1, 2, 3, ... respectively.

Looking at this series, we are able to point out some of its salient features. The first term, i.e., the four points, does not form a core-circle. In fact, they form the core of the four points forming a square. But by convention this square is the first core-circle. The number of points required to construct a core-circle is always even. Since the first term of the series does not form a core-circle, the least even number of points required to construct a core-circle is 12.

If the least core of a core-circle is a square of four points, then that of a coresphere will be a cube of eight points.<sup>52</sup> The upper four points of the cube are located in the first upper plane and its lower four points are located in the first lower plane. By convention, this cube will be the first core-sphere. It is very interesting to note that this cube will always remain the least core of any bigger core-sphere, no matter how big the core-sphere is. The second sphere is comprised of the points located in the four planes. It contains the second core-circle two times, one being in the first upper plane and the other being in the first lower plane and the first core-circle two times, one being in the second upper plane and the other being in the second lower plane. See Figure 4b. The third core-sphere is formed by placing the upper hemispherical part of the second core-sphere atop one third core-circle located in the first upper plane and the lower hemispherical part of the second core-sphere below the other third core-circle located in the first lower plane; this way the third core-sphere occupies its points in the six planes.

tracted it from the information given in the *Bhagavatī Sūtra* that the minimum even number of points required to form corecircle and core-sphere are 12 and 32 respectively. See Jadhav 2009: 50.

<sup>51</sup> I did not suggest any expression in my paper published in 2009 for the total number of points required to construct the  $n^{th}$  core-circle. See Jadhav 2009: 48. In this paper I suggest it.

<sup>52</sup> This reasoning is not mine. I have ex-

Using inductive reasoning the expression for the total points required to construct the  $n^{th}$  core-sphere, say S(n), can be given by,<sup>53</sup>

$$S(n) = \frac{4}{3} \left( 2n^3 + 3n^2 - 5n + 6 \right)$$

The number of points required to construct the core-spheres are

when n = 1, 2, 3, ... respectively.

Looking at this series, we are able to point out that the first term, i.e., the eight points, does not form a core-sphere. In fact, they form the core of eight points forming a cube. But by convention, this cube is the first core-sphere. The number of points required to construct a core-sphere is always even. Since the first term of the series does not form a core-sphere, the least even number of points required to construct a core-sphere is 32.

#### UNDERSTANDING THE CUBE OF EIGHT POINTS

Now we are able to understand how the cube of eight points relates to the horizontal universe and the non-universe. The upper and nether thin planes of the Rayaṇappabhā hell are adjacent. The upper thin plane is the horizontal universe. It expands into the non-universe and becomes the first upper plane of the non-universe. The same is the case with the nether thin plane, which expands into the non-universe and becomes the first lower plane of the non-universe. Since the non-universe is a hollow sphere, these two planes must be its biggest equal and parallel core-circles, say C(n) where n approaches infinity. Since the horizontal universe is a core-circle, the upper four points of the cube of eight points, forming a square, are its core in a true mathematical sense. See Figures 2a and 4b to visualize this. Since the non-universe is a sphere, the cube of eight points is its core.

#### UNDERSTANDING THE TEN DIRECTIONS IN MATHEMATICAL TERMS

In chapter ten of the *Bhagavatī*  $S\bar{u}tra$  it is stated that east, west, south, north, up, and down are the six main directions. It is further stated that there are actually ten directions. With their proper names they are:<sup>54</sup>

write that S(n) = C(1) + C(2) + ... + C(n-1) + C(n) + C(n) + C(n-1) + ... + C(2) + C(1).54  $BhaS\bar{u}_5$ : 10.1.2–5, pp. 477–479;  $BhaS\bar{u}_4$ : 10.1.2–6, pp. 2–4. Glossary is as follows. East ( $p\bar{a}\bar{n}q\bar{a}$ , Skt.  $prac\bar{n}n\bar{a}$ ), east

<sup>53</sup> I did not suggest any expression in my paper published in 2009 for the total number of points required to form the  $n^{th}$  coresphere. See Jadhav 2009: 50. In this paper I suggest it. For the sake of explanation, I

i	east – Imdā,	vi	west-north – Vāyavvā
ii	east-south – <i>Aggeyī</i> ,	vii	north – <i>Somā</i> ,
iii	south – Jammā,	viii	north-east – <i>Īsāņī,</i>
iv	south-west – Neraī,	ix	zenith – <i>Vimalā</i> , and
v	west – Vārunī,	x	nadir – <i>Tamā</i> .

In section two of this paper, we have noticed from the passage of the *Bhagavatī*  $S\bar{u}tra$  that the above ten directions originated from the cube of eight points. The same is given in chapter ten of the *Sthānānga Sūtra*.<sup>55</sup>

It is further stated in the *Bhagavatī* Sūtra that the east direction starts with two points. It increases by two points at each further step. It is shaped like a drum in the universe and like the part of a carriage in the non-universe. Similar is the case with the other three cardinal directions, namely, south, west, and north. The east-south direction starts with one point. It extends by adding another point to each further step without any increase. It is shaped like a broken string of pearls. Similar is the case with the other three intermediate directions, namely, south-west, west-north, and north-east. The zenith direction starts with four points. It extends by adding another four points to each subsequent step without increment. It is in the shape of a cuboidal column. Similar is the case with the nadir direction. Every direction whether cardinal or intermediate or up or down has its origination and flow from the cube of eight points and occupies innumerable points in the universe and infinite points in the non-universe and has a beginning and an end in the universe and a beginning but not an end in the non-universe.<sup>56</sup>

On the basis of the above features, these ten directions can be better understood through Figure 5, which shows how they start from the cube. It can be deduced that the intermediate directions are linear while the cardinal directions

v. 153, p. 823.

56 BhaSū<sub>6</sub>: 13.4.14–16, pp. 45–46. Also see Deleu 1970: 195. Glossary is as follows. Drum (*muraja*), part (*uddhi*), carriage (*sagaḍa*, Skt. *śakaṭa*), cardinal directions (*disās*, Skt. *diśās*), "broken string of pearls" (*chiṇṇamuttāvalī*, Skt. *chinnamuktāvali*), intermediate directions (*vidisās*, Skt. *vidišās*), and cuboidal (*ruyaga*, Skt. *rucaka*). 'Broken string of pearls' has been a motif in Indian poetry and mathematics. It is also known as 'broken string and scattered pearls.' For details on the motif, see Sarma 2004: 463–476. Also see Jadhav 2021*a*: 104–109.

<sup>(</sup>puratthimā, Skt. paurastyā), west (padīņā, Skt. praticīnā), west (paccatthimā, Skt. pāścātyā), south (dāhiņā, Skt. dakṣinā), north (udīņā, Skt. udīcīnā), north (uttarā), up (uddhā, Skt. urdhvā), down (aho, Skt. adhaḥ), Imdā (Skt. Indrā), east-south (puratthimdāhiņā, Skt. paurastyadakṣiņā), Aggeyī (Skt. Āgneyī), Jammā (Skt. Yāmyā), south-west (dāhinpaccatthimā, Skt. dakṣiṇapāścātyā), Neraī (Skt. Nerrīī), west-north (paccatthimuttarā, Skt. pāścātyottarā), Vāyavvā (Skt. Vāyavyā), Somā (Skt. Saumyā), north-east (uttarapuratthimā, Skt. uttarapaurastyā), and Īsāņī (Skt. Ēśānī).

<sup>55</sup> *SthāSū*<sub>1</sub>: chapter 10, under sūtra 720,



Figure 5: The ten directions.

are planar and the up and down directions are three dimensional.<sup>57</sup> We have noticed above that the cardinal direction is shaped in the universe like a drum and in the non-universe like the part of a carriage. The part of a carriage, according to Deleu's interpretation, is its seat.<sup>58</sup> It seems to me to be the full seat of an old-fashioned bullock cart. In fact, both the drum-shaped cardinal direction in the universe and the carriage-seat-shaped cardinal direction in the non-universe

does not read so at all. See two pages between pp. 4 and 5 in  $BhaS\bar{u}_4$ . 58 Deleu 1970: 195.

<sup>57</sup> A figure drawn by Trilok Sharma to illustrate the ten directions shows that both the cardinal and intermediate directions are three dimensional, although its description

are isosceles trapezia. The smaller parallel side of the drum-shaped cardinal direction consists of two points while that of the carriage-seat-shaped cardinal direction innumerable points.

#### 4 CONCLUDING REMARKS

**I**N THIS PAPER, by exploring the mathematical approach on which the cube of eight points in Jain cosmology was based, we suggest the following as a plausible explanation to understand it. The core of the non-universe is the core of a core-sphere when the core-sphere is formed using n core-circles such that they are stacked up and down in the same order from the  $n^{th}$  core-circle to the first core-circle. The upper four points of the cube of eight points form the core of the horizontal universe and the cube of eight points is the core of the non-universe. An  $n^{th}$  core-circle becomes the horizontal universe when n is innumerable and an  $n^{th}$  core-sphere forms the non-universe when n approaches infinity.

#### HISTORICAL IMPORTANCE

Many interpretations including cosmographical and mathematical ones, can be drawn from the above results and discussion. From the very beginning I have confined myself to their mathematical interpretation and would like to extend it to the history of figurate numbers. It is of great mathematical interest and historical importance to us that the models of both the horizontal universe and the non-universe were originally developed by the Jaina thinkers with the involvement of the concept of figurate numbers. Otherwise, they would not have referred to that there is the core of the horizontal universe where a cube of eight points is and ten directions originate from those eight points.

The Greek mathematicians such as Pythagoras (572–510 BCE), Philolaus (480–385 BCE), Nicomachus (c. 100 CE), and Theon of Smyrna (c. 125 CE) paid great attention to the development of figurate numbers. They counted figurate numbers by arranging dots or pebbles in the shapes of different geometrical forms. On the other hand, the figurate numbers in the *Bhagavatī Sūtra* were counted, before or certainly during the period from the fourth century BCE to the fifth century CE, by joining the points located in a plane or space in a rectangular system. The Greeks discussed plane numbers such as triangular numbers, square numbers, oblong numbers, pentagonal numbers, hexagonal numbers, etc., and solid numbers such as cube numbers, pyramidal numbers, etc.<sup>59</sup> We do not have any report which reads that circle numbers (i.e., centered-circle numbers and core-circle numbers), spherical numbers (i.e., centered-spherical

<sup>59</sup> Heath 1921: 76-84; Hollingdale 1989: 15-

Eves 1969: 56–57; Katz 2009: 37–38, 173–175.

<sup>16;</sup> Boyer 1968: 59-60; Smith 1958: 24-25;

numbers and core-spherical numbers), outer-lying-circular-annulus numbers, and outer-lying cylindrical numbers were included in their discussion or not except that David Eugene Smith refers to that Nicomachus included spherical numbers in his discussion. Smith gives us this information from the Boetti de *institutione arithmetica libri duo* of Boethius (died 524 cE).<sup>60</sup> Not only core-circle numbers and core-spherical numbers relate to the Jaina models of the horizontal universe and the non-universe but also outer-lying-circular-annulus numbers and outer-lying-cylindrical numbers pertain to them. If every number of the series of core-circle numbers is subtracted from its succeeding term starting from 12, we get the series of core-circular-annulus numbers, i.e., 8, 20, 28, 36, ... Since the first term of this series forms the circumference of the first core-circle, in fact, of the second core-circle if the core is considered to be the first core-circle, the least even number of points required to construct outer-lyingcircular-annulus is 20, which is given in the Bhagavatī Sūtra.<sup>61</sup> Every term of the series of outer-lying-circular-annulus numbers forms its own series of outerlying-circular-cylindrical numbers when the corresponding outer-lying-circular annulus is stacked on itself. The first few outer-lying-cylindrical numbers are 16, 24, 32, 40, ...; 40, 60, 80, 100, ...; 56, 84, 112, 140, ...; ... Since the points in the first series form no more than the curved surfaces of every first circular cylinder, the least number of points required to construct an outer-lying-circular-cylinder is 40, which is given in the *Bhagavatī*  $S\bar{u}tra.^{62}$  In Figure 2a, we are able to see the outer-lying-circular annuli in the horizontal universe and to visualize the outer-lying-circular cylinders formed in the parallel planes starting downward from the horizontal universe.<sup>63</sup>

The systems of points, both two dimensional (Figure 3a) and three dimensional (Figure 3b), culled from the *Bhagavatī Sūtra* is significant in the sense that by way of them the formations of isosceles triangle, pyramid of isosceles triangular base, square, cube, rectangle, line, cuboid, circle, sphere, outer-lying circular annulus, outer-lying circular cylinder, the core of the non-universe as a cube of eight points, and the ten directions with their shapes and patterns of points were conceived in India by the Jaina thinkers. As a result, their details were recorded in the *Bhagavatī Sūtra* with reference to the minimum points.

#### TRANSMISSION

If the period of the *Bhagavatī* Sūtra is compared with that of Pythagoras and Philolaus, it may be suspected that the ideas of figurate numbers, especially of line, isosceles triangle, square, rectangle, pyramid of isosceles triangular base,

62  $BhaS\bar{u}_9$ : 25.3.726, p. 407; Jadhav 2009: 51. 63 For exact illustrations, see Jadhav 2009: 51.

<sup>60</sup> Smith 1958: 25; *BDIALD*: 104 and 121.
61 *BhaSū*<sub>9</sub>: 25.3.726, p. 407; Jadhav 2009: 50–51.

cube, and cuboid, might have been transmitted from Greece to India and those of the rest were developed by the Jaina thinkers in accordance with their requirements. But the lack of concrete evidence of transmission such as Greek loanwords related to figurate numbers in any Prakrit (or Sanskrit) treatise must surely lead us to conclude that such transmission did not occur and that the ideas of figurate numbers arose independently in the Greek and Jaina cultures.

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#### ABBREVIATIONS AND NOTATION

- HU Horizontal universe.
- LU Lower universe.
- Skt. Sanskrit. The term(s) added by me after this abbreviation are intended to aid the reader to understand Prakrit terms through their Sanskrit equivalents.
- UU Upper universe.
- [...] A pair of square brackets, wherever used, contains a paraphrase inserted by me to achieve comprehensiveness together with clarity. It does not mean that the original expressions are incomplete or corrupted.

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