

ARCHAEOASTRONOMY AT BHUBANESWAR : A POLYGONAL AND MATHEMATICAL MODEL — *TĀRAKĀ*

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(Received 21 May 2003; revised 22 September 2005)

Location and design of the ancient temples of Bhubaneswar have been guided by astronomical insight. Apart from temples, an inland river dock has been identified in accordance with the location of distinct, bright stars and constellations. Individual monuments have corresponding stars and as groups correspond with constellations both in shape and location. Layout plan is radial and is traceable also as a giant star. The star-temple correlation is centered around the star Betelgeuse and Paraśurāmeśwar temple. A nine pointed star is also traceable with constellation Orion as the hub. Orion is reproduced on ground in its entirety. A polygonal method, alongwith a mathematical route for dating of archaeology in light of Astronomy is presented.

Key words: Archaeoastronomy, Betelgeuse, Bhubaneswar, Constellation, East – West line, Ekamra, Mathematical, Nakṣatra, Orion, Paraśurāmeśwar, Polygonal, Radial pattern, Rudra, Siddhānta, Śiva, *Tārakā* (inter-star), Vedic concepts.

INTRODUCTION

There are scientific reports on astronomical connections of historical monuments in Egypt, UK, Central America, Peru, Polynesia and S E Asia¹⁻⁵. But none have been reported from the Indian subcontinent. India is the very geographical zone in which Hindu alias *Sanātana*⁶, *Jaina* and *Buddhist* religions, with all their abundant astronomical fascinations, flourished. Starting with the Vedic period, celestial observation in India had culminated into a systematic science in the *siddhānta* age from 5th AD onwards. Authorities like

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Āryabhaṭa⁷, Varāhamihira⁸, Brahmagupta⁹, Bhāskarācārya¹⁰, Śātānanda & Sāmanta Candra Śekhara¹¹, have left invaluable contributions, including observations, calculations and instruments^{12, 13}.

Having such perspective in mind the *R̥gveda*¹⁴ on closer examination appears to us as an ode to the cosmos, in limited diction and in present-continuous grammar. It is an abstract, and about abstracts. Besides, a strong tradition of immense influence of astronomy on society by way of elaborate prescription of ideal dates and time for observance of religious and social functions, including for birth, marriage and demise is noted in the Hindu society, as a common unifying element.

Ancient Orissa has a rich maritime history¹⁵ conjuncted with a long historical period of building activity, predominance of *Pās'upats*¹⁶ and *Kālāmukh Śaivas*, who have been held as *Siddhāntins*¹⁷ and concurrency of Vedic astronomical traditions¹⁸, begs the following three questions as no related archaeology (material evidence) has so far been reported:

- Q No.1 - Whether the Hindu archaeology at Bhubaneswar indicates any astronomical concepts or astro association?
- Q No.2 - If yes, details thereof including identity of such celestial bodies and their corresponding sites?
- Q No.3- Do they indicate any inter-civilisation reciprocity?

LOCATION AND HISTORICAL CONTEXT

Bhubaneswar is located on 85°.82, 20°.5 (longitude, latitude), on the eastern sea board of India¹⁹. It is the present administrative capital of Orissa province. It is globally well connected. The modern city covers around approximately 100 sq. kms. Extant archaeological sites of various size and antiquity number more than 100, which cover the entire city's span. Whereas, a cluster is noted covering an area of 10 sq km in the SE quadrant, termed as 'Core Area' in Indian National Trust for Art & Cultural Heritage (INTACH), *Ekamra Kṣetra* Heritage Zone Conservation Plan²⁰ of 1989. Religious literatures mention *Ekamra* as the name of Bhubaneswar²¹. Historical period of such archaeology covers two millennia, datable between BC 300 and 1700

AD. Such territory was better known as Kalinga. The archaeological members (AM) include Jaina, Buddhist and Hindu sites²². All temples i.e. heritage sites are termed as the archaeological members (AM). 28 heritage sites have been taken in this study [see Table I]. Few among the heritage sites are poly membered . In such cases the principal AM has been taken . The *Vedas* are said to name 28 *nakṣatras*²³.

MOTIVATION

(i) The Radial pattern : Tārakā

In early 1997 , while working on a locational and site map (Fig. 1) of the heritage sites at Bhubaneswar, co-author 1 noted, that Paraśurāmeśwar temple seemed to lay at the center , while all others lay around it . On the site map and as well on the ground , the monuments could be joined by radial lines to this temple i.e. Paraśurāmeśwar temple appeared to be the central member. As a case study, few important temples were connected radially to Paraśurāmeśwar temple . This creates a starry pattern, hereinafter, referred to as the Terrestrial Tārakā (TT) . It is given the code Tārakā - A for the following reasons.

Thiruvachagam and *Koyil pūrāṇa*²⁴ mentions the “Forest of Tārakā”, wherein Lord Śiva , in his *Naṭarāj* form (dance lord) is said to have appeared first, only to be followed by a second appearance at Cidāmbaram. It also states that in the said forest of Tārakā lived heretics who practiced *Mimāṃsā*. *Cidambaram Mahātmya* indicates such place as “center of universe”²⁵. There is a river by name Tārakā in Karnataka. The term Tārakā also means falling star²⁶. In view of such mythology, pre-existing reference and nomenclature we call our radial pattern as “Tārakā”.

17 number of AMs including AM-19 ** are symbolically indicated on the Survey of India map²⁷. 16 AMs could easily be connected radially with AM-19 . This also yields a radial pattern (Fig. 2) , which is given the code Tārakā – B .

(ii) Key Star – Temple Correlation

The key point in our attempt to investigate the possibility of astronomical traditions in Kalingān belt heritage (archaeology) was the identification of

* The INTACH heritage map is a schematic representation of roads and lanes that lead to heritage sites. It is designed for popular information and pilgrim guidance. It is not to scale .

** The identification numbers of the AMs and CMs are from Table I, which in term corresponds to Fig. 4 and section 4.1 .



Fig. 1: Black circles & Black lines with Red center represents *Tārakā* - A, centered on AM-19; Orange radial pattern in *Tārakā* - C centered at TP (as in Fig. 4)

Note: On this map the TP is shown slightly to the right of its actual location to avoid clutter.

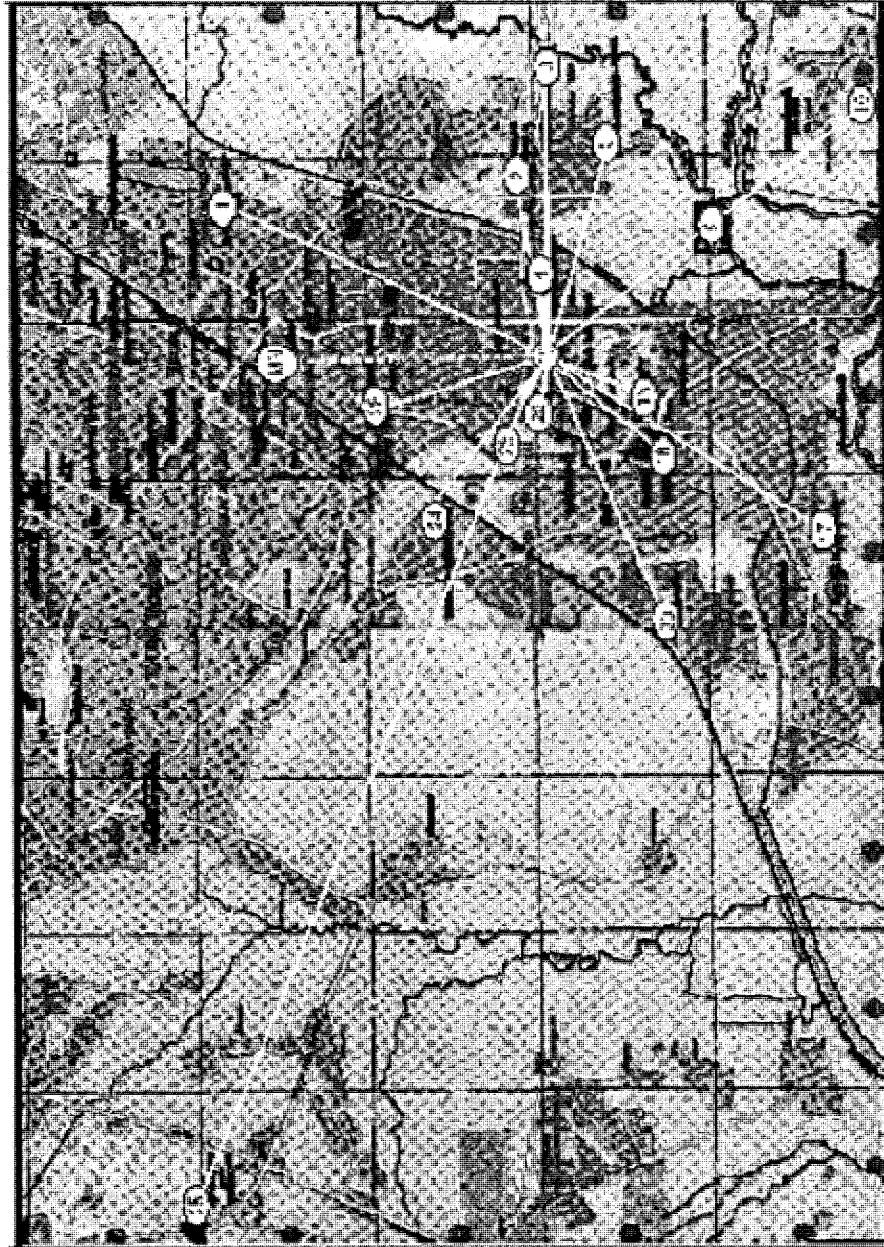


Fig. 2: Tārakā - B. [Ref. No. 26]

reference stars and corresponding sites on the ground. Few inter-corroborating clues were hit upon easily.

α *Orionis* is the ageing red giant, a variable star of magnitude 1. It is the largest star in the constellation Orion. It is known as *Rudra* and has been sung vociferously in the *R̥gveda*. Paraśurāmeśwar represents the Hindu deity Śiva's *rudra* (violent) aspect. The temple's *citra bhāśā* (art dialect) presents the terrific aspects of *Rudra Siva* and also depicts battle and war themes. It also has traces of red paint (*vajra lepa*), which may signify such "red-hot" aspect of the star. The α *Orionis* therefore, corresponds in many ways with Paraśurāmeśwar temple (AM 19).

β -*Orionis* (Rigel), is identified with a bow and arrow held by a hunter or a warrior, in both *siddhāntic*²⁸ and in western star-lore²⁹. The star's puranic name, *Bāṇā Rājā*, means "king with arrow"³⁰. It is the brightest star in the constellation Orion. The spire of the Liṅgarāj temple (AM-18) sports the *Pināka* (Lord Śiva's bow and arrow). Rising to a height of 54.5 mts AM-18 is also the tallest monument. It dominates the sky line. AM – 18 possibly indicates the celestial magnitude of star Rigel. As a tall member, AM-18 acted as a reference and facilitated initial comparative angular study among the AMs of the TT. If we identify AM-22 with γ *Ori.* and AM -15 with χ *Ori.* we get the prominent four cornered constellation of the Orion on the ground.

On a star map³¹, constellation Orion is located relatively central in the sky, as part of it spans either hemispheres (Fig. 3). It is also the most spectacular constellation and has been visible over all major river valley civilisations for last few thousand years. The α *Ori.* can be joined with imaginary radiating lines to various other stars also forming another starry pattern, hereinafter referred to as the Celestial *Tārakā* (C T). The stars of the CT are referred to as the celestial members (CM).

CMs viz. α - *Ori.*, α - *Tauri*, β - *Ori.* form a triangle. α - *Ori.* and α - *Can Minor* form a slightly inclined straight line on a E - W axis in relation to true north (TN) line. Similarly, *Canopus* and β *Auriga* form a slightly inclined bisecting line along the N – S axis in relation to the TN line. This imaginary N– S line passes by to the east of α - *Ori.* on a star chart and bisects the E – W line (formed by α - *Ori.* and α - *Can Minor*) close to the east of α *Ori.* (Fig. 7).

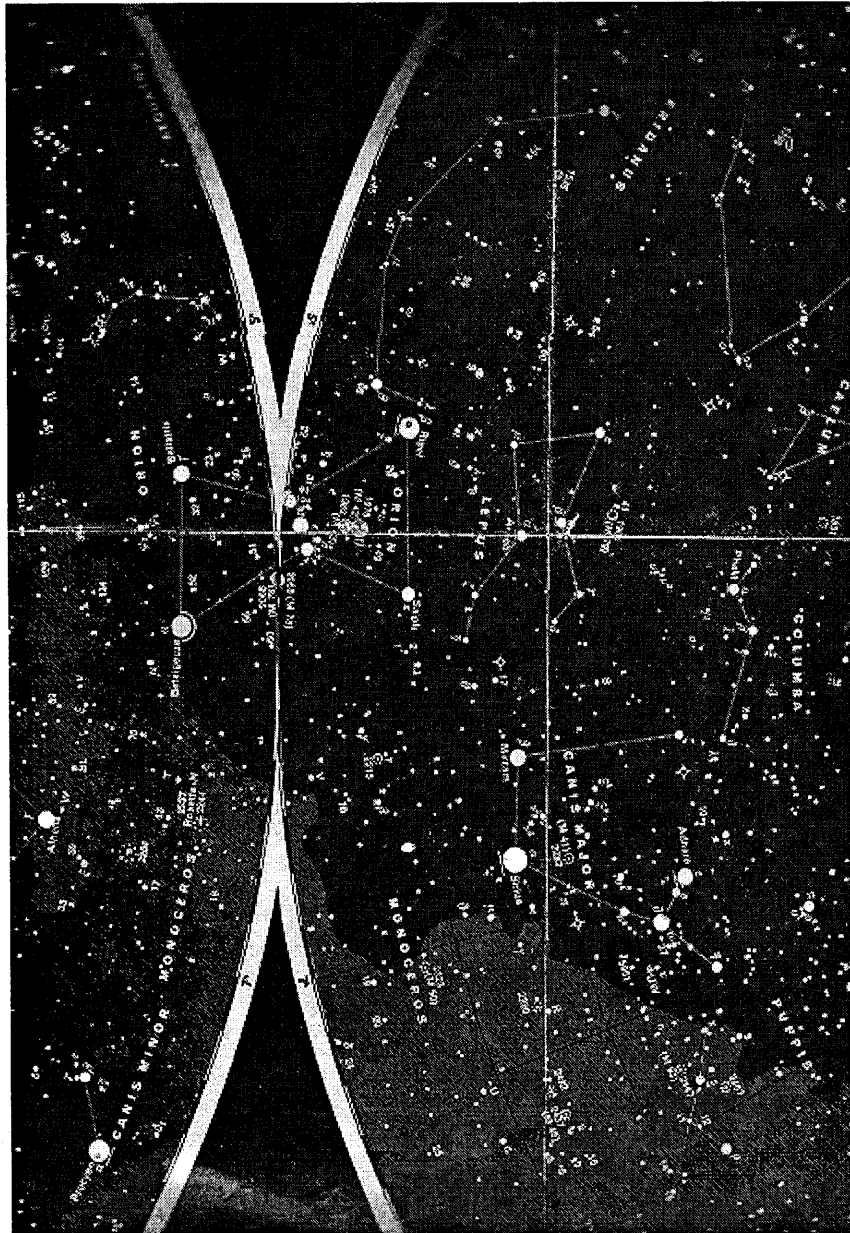


Fig. 3: Star map showing central position of Orion [Ref. No. 30].

Such celestial polygonal format was physically compared on the ground between the designate AMs as given in Table I. A corresponding embryonic terrestrial polygonal format emerged. Study of angular positions also grossly matched. It became abundantly clear that a one-to-one correspondence might be feasible between all the CMs and the AMs. Therefore, the matter was considered appropriate enough for further investigation. Verifiable and repeatable experiments were designed to establish the validity of such correlation.

MATERIALS AND METHOD

Extensive field study was conducted covering all the archaeological sites in the *Ekamra* Heritage Zone. Ecclesiastical practices; *citrā bhāṣā* (art); architecture; engineering concepts; associated mythic lore; historical background etc. as is associated with each AM were noted and compared with the *siddhānta* lore. We term these as, multi mode correlation.

Theodolite Survey: A theodolite survey was conducted for providing better directional accuracy of the locations of all the AMs. Metro Mansion, a tall multistoried building was selected as the base for theodolite readings, as its roof offered a clear view of most of the AMs, moreover, it was only around 150mts. to the NE of the central member No-19. Theodolite³², was calibrated and aligned to magnetic north (MN) with pearl India needle compass. It was positioned on the south-east corner of the roof. Angles between AMs were measured using the theodolite's cross hair coinciding with the *ayudha* as on each temple's top. Readings were taken in clockwise order from the MN line. The first monument recorded (to the east of the MN) was designated as AM-1. The angular separation between (i) two AMs and (ii) the gross offset from MN was recorded (Table I, Fig. 4). Due to obstruction of field of view by a water tank between angles 240° and 350° along the western horizon, the theodolite was repositioned on the NW corner of the building, it was reset and re-calibrated with the standard reference and the NS baseline. Due to these adjustments, both the positions of the theodolite are taken as one, hereinafter referred to as TP [Fig. 1 & 4]. Interestingly, no monuments were found in line with the magnetic north or south, which is also corroborated by the CT. In contrast, the E-W line is prominently represented in both the terrestrial and in

Table - 1

AM Name No.	AM	Hist. Dt.	Religio	Angle	CM	Indian
			Status			
	Magnetic North			00°		
1	Cintamaniswar	11 AD	H	NV	α U Maj	Kratu
2	Bhaskareswar	4 AD	H/B	80°	α Leo	Maghā
3	Megheswar	13 AD	H	85°	β Leo	Fālgunī
4	Rajarani	11 AD	H	90°	α Gem	Purnarvas
5	Bramheswar	11 AD	H	105°	α CaMi	Parswn
6	Cakreswar	11 AD	H	125°	β Gem	Punarvasu
7	Gokarneswar	15 AD	H	140°	α Hyd	NK
8	Madhyameswar	NK	H/B	NV	ϵ CaMa	NK
9	Vela	4 BC	H	145°	λ Vel	Velāka
10	Sisupalgarh	4 BC	H	145°	α Cra	Pakhīrāj
11	Dhauri	3 BC	H/B	175°	α Curcis	Triśanku
12	Sukhameswar	15 AD	H	NV	β Vel	NK
13	Mukteswar	10 AD	H	190°	γ Gem	NK
14	Gauri	9 AD	H	190°	α CaMa	Lubdhaka
15	D. Bivisana	4 AD	H/B	205°	ξ Ori	Kartavīrya
16	Vaidyanath	NK	H	NV	α Can	Agastya
17	Kapileswar	13 AD	H/B	NV	α Eri	Matsyamukha
18	Linhstsj	10 AD	H	225°	β Ori	BānRājā
19	Parasuram	7 AD	H	240°	α Ori	Rudra
20	Bhimeswar	15 AD	H	NV	α Poa	Nadī mukha
21	Dhundevis Khala	NK	H	268°	β Tau	Hrutabhuk
22	Uttareswar	11 AD	H/B	270°	γ Ori	Kārtikeya
23	Gosahasreswar	11 AD	H	281°	α Tau	Rohinī
24	Kukuteswar	15 AD	H	NV	β Pers	Agni/Pretaśara
25	Udaygiri	2 or 1st BC	J/H	NV	β Cetu	NK
26	Baranesw/Barangagada	11 AD	H	NV	α Pega	Uttara Bhadrāpāda
27	Nageswar	11 AD	H	324°	β Aur	Brahmāgnī
28	Rameswar	11 AD	H/B	336°	α Cass	Kāśyapa
--	Magnetic North	---		360°	---	----

Index : H = Hindu; H/B = Buddhist site Converted to Hindu; J/H = Jaina-Hindu composite site; NK = Not Known; NV = Not Visible.

Note: The above 28 stars cover the entire span of the present night sky. These 28 CMs do not represent the 28 *Nakṣatras* listed in the *Yajurveda*.

the celestial schemes. This radial pattern [Fig. 4] was given the code *Tāarakā*-C. CMs were given identical number code to pair them with AMs [see Table I].

Map Superposition: *Tāarakā* – B was superposed on *Tāarakā* – C. The radial pattern was apparent in either and the angles offered rough correspondence. It also confirmed that Survey of India map bears the signature of the radial pattern. *Tāarakā* – C was superposed on *Tāarakā* – A [Fig 1]. All variations of enquiry confirmed the radial lay-out of the AMs when Paraśurāmeśwar temple is considered as the fulcrum.

Computer Simulation: Using solid modeling package³³ IRON-CAD - Version 3, a three-dimensional model of the celestial hemisphere was generated on the scale of a Japanese, Marco's, star globe of 12 cm dia. module. Angles were

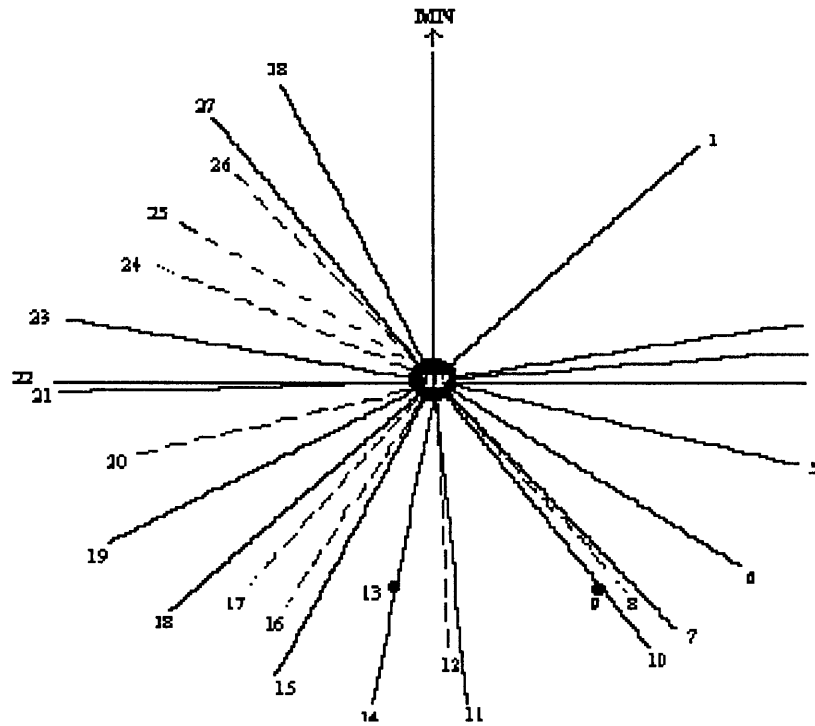


Fig. 4: *Tāarakā* - C, MN = Magnetic North; TP = Theodolite position; Dotted lines point to AMs that were 'Not Visible' from position TP.

measured from center in reference to vertical and the horizontal. Each CM's position (declination & longitude) was then determined. The locations determined in such manner helped in placing the CMs on the crust of the celestial dome (CD). TN and the celestial equator (CE) were marked. CMs on either sides of the CE were given separate colours. The point on the CD which marked the position of αOri was then taken as the top center of the dome. This provided zenithal position for αOri . The corresponding CM was given red colour in conformity with αOri . The CD was bisected below the point of $\alpha Crucis$, which had maximum declination. The TN and the CE were rechecked. CD was then given transparency effect with appropriate command which enabled viewing of the entire span from all possible angles. The CMs were also visible from inside and from outside the CD. Such method allowed researchers to take real time and real place view of the span in relation to local lat. with αOri at zenith. The projected CM's were represented as mini spheres having a dimension of 5mm dia. The span matched the view as on $+20^\circ$. $\alpha Crucis$ which is only seasonally visible, was projected beyond the horizontal bisector of CD. As $\alpha Crucis$ is beyond 90° horizon on $+20^\circ$ Lat., it had to be adjusted onto CD surface by shortening the projection length and bisection of CD was done below the 180° horizontal to incorporate all the 28 CMs.

A representative 3D horizontal plane (RHP) of 2mm thickness and 12 cm diameter was generated below the CD. TN in consonance with TN of CD was marked on the RHP; both were then inter-locked. CMs were then reflected onto RHP by vertical cascade animation method. The point of touch down of each star was marked by small coloured spheres. Symbolic AMs were then placed on the opposite face of RHP by pierce through method. All were connected radially to the central CM and to the central AM respectively for comparison. Radial patterns evolved as shown in Fig 5a, and 5b which are similar to *Tārakā* B & C. The CD and the RHP could be rotated about any axis to offer virtual reality viewing of the celestial and the terrestrial patterns simultaneously.

Discussion: *Tārakā*-A is drawn on a popular road-lane map. It is a rough estimation for easy guidance of pilgrims and visitors to negotiate the lanes and the streets to reach various heritage sites. It is not to scale. *Tārakā* - B is a Survey of India map. The location of the TP in *Tārakā* - C is not identical with that

of the location of AM-19 as in *Tāarakā* – A or in *Tāarakā* - B. Hence, angular homology between each of the radial patterns is not met with. Angular mis-match is also noted in the polygonal correlation study between the TT (Fig. 4) and the CT (Fig. 5a) as the CT relies on TN while the TT relies on the MN. Additionally, it is also due to the fact, that the star map is based on polar view zenithal projection, while the Survey of India map is based on zenithal equal area projection type which is based on chain and tape survey of the field. The known historical position that various AMs were built in various historical periods may also explain the apparent aberration i.e. the *Tāarakā* scheme is the result of a continuous practice. Relative distances also indicate mis-match. This is because the builders have reduced the span to within a limited area of 10 sq km. They have visualised an angular cascade. Whereas this study uses a vertical cascade method (4.3). Therefore, distances have not been taken into consideration in this study. However, the radial pattern withstands in every form of enquiry.

Findings: Experiments confirms: [i] the radial pattern of *Tāarakā*, [ii] polygonal study as a valid method in archaeoastronomy, [iii] scope for astro-mathematic as a valid route, [iv] that the ancient temple builders & the faithful conceived of a cascade pattern for CMs to locate AMs, [v] the ancients reduced the entire night span on to a ground area of 10 sq km and located the AMs with a one-to-one correspondence with designate CMs, of which, we have selected 28 pairs in this study, [vi] *Tāarakā* encompasses the entire night span, [vii] Computer Simulation experiment suggests that a visual alignment of $\alpha Ori.$ and the ecliptic with $+ 20^\circ$ lat. may have been the cause of inspiration, [viii] the Orion has been copied entirely on the ground, and [ix] the Orion forms the hub of the *Tāarakā*.

UNIQUENESS OF AM – 19

(i) The radial patterns as noted in Fig. 1, 2, 4, 5a & 5b are also drawable using AM-22 or any of the constituent of the ground Orion. AM-19 offers close call with the *Rudra* aspect and its location is also vetted by the intersection point between the TN and the EW lines. It is also the best preserved and the most ancient Hindu monument at Ekamra. It also does not have any historical or archaeological connection with any pre-existing

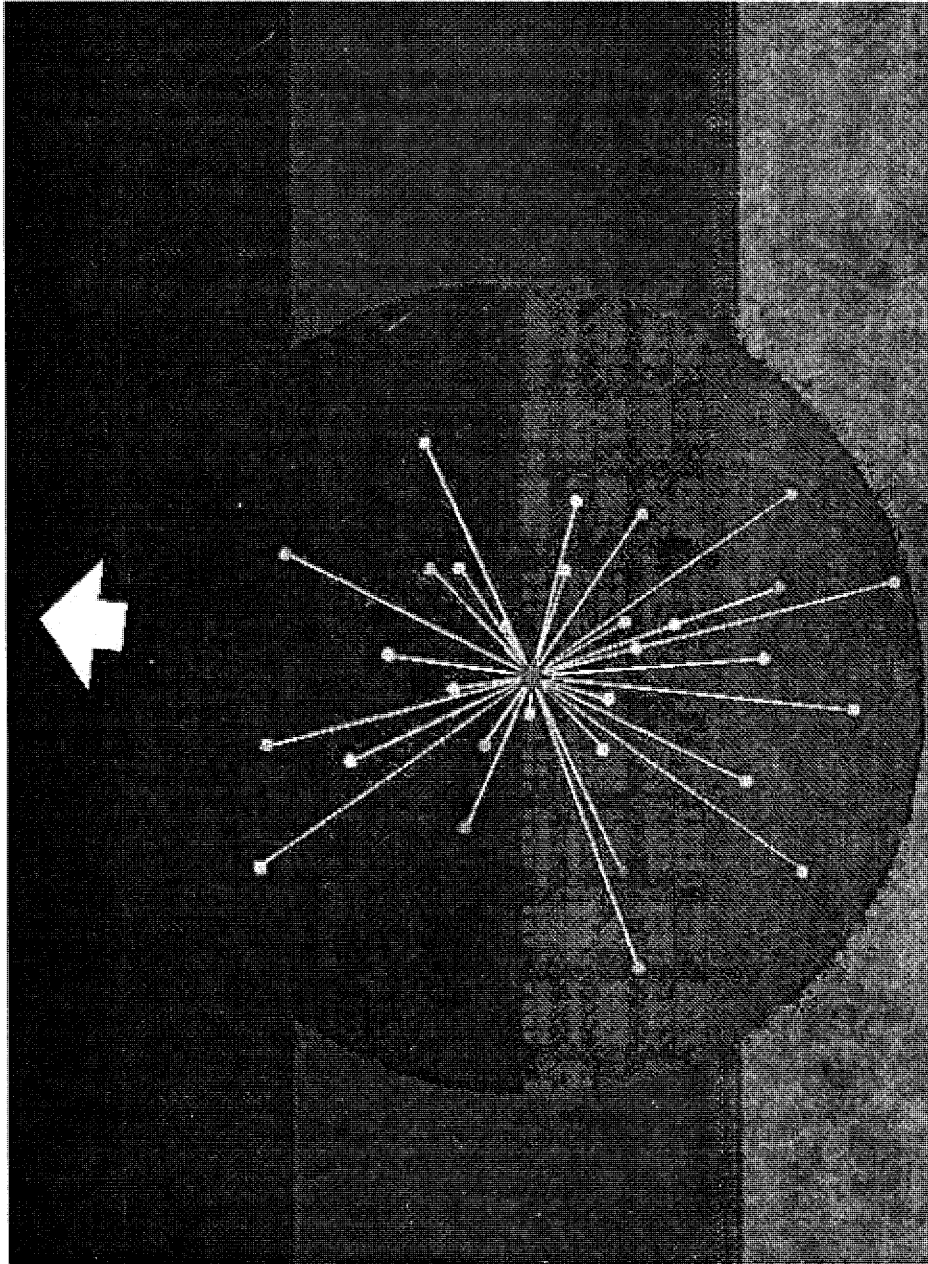


Fig. 5a: Small coloured spheres represent the CMs

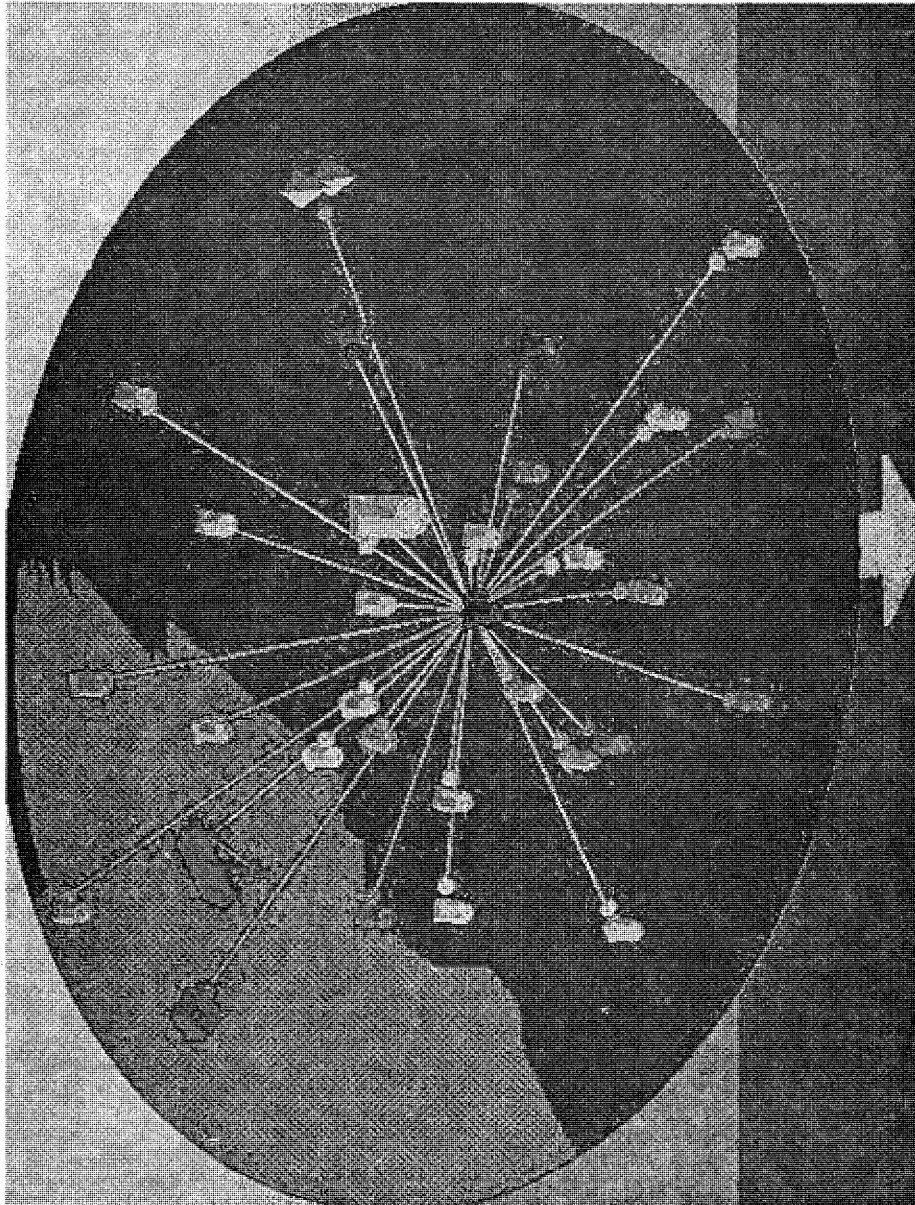


Fig. 5b: AMs have been figuratively represented

non Hindu archaeology. The concept of the *Tārakā* radial pattern compels us to exclude any other AM as the central member, because a corresponding inter-star pattern cannot be generated using any other CM other than Betelgeuse alias *Rudra* of the *siddhānta*. Because the angular separation between the CMs in the CT and the angular separations between the AMs in the TT indicate best homology when AM-19 is taken as the hub of the TT, AM – 19 emerges as the unique candidate.

(ii) Historians are unanimous that archaeology at Bhubaneswar started with the Buddhist period dated to 3rd BC ³⁴. Bhubaneswar has a number of mauryan & non mauryan Buddhist sites. We have used AM 22, which is a ex-Buddhist site. It is a constituent member of the ground Orion and is the nearest site to AM-19. It connects all the known ex-Buddhist sites that are within the *Tārakā* zone (Fig. 6). We see, that, they form only a partial *Tārakā* . Therefore, AM-19 qualifies as the sole candidate.

NAKṢATRA (THE NINE POINTED STAR)

A nine pointed star alias *nakṣatra* is also traceable on the ground by

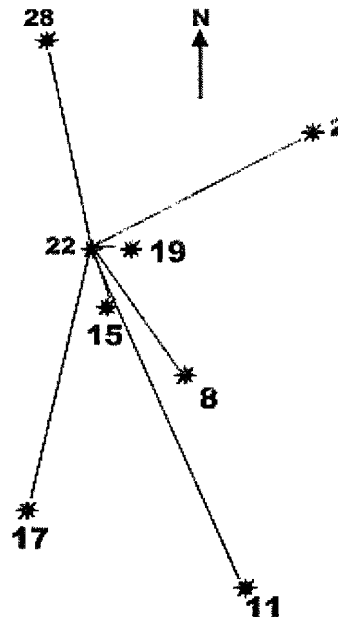


Fig. 6: Ex-Buddhist in sites in *Tārakā* zone

using the peripheral AMs of the *Tārakā* Fig. 7. The *Kālapuruṣa* (Orion) as we can see, is also the hub of such *nakṣatra*, while α Ori. is only a constituent member of the hub. Table IIa gives the star-temple correlation of the *Kālapuruṣa*, which is traceable in the sky and on the ground. The *Kālapuruṣa*, is a *vedic cum siddhānta* term. The *nakṣatra* is also traceable on star charts and on universe modules as well using the corresponding CMs. Members of the *nakṣatra* are given in Table II b. The term *nakṣatra* also has Vedic genesis, where its use denotes star. We have used the term *nakṣatra* to denote 9 zones, since 9

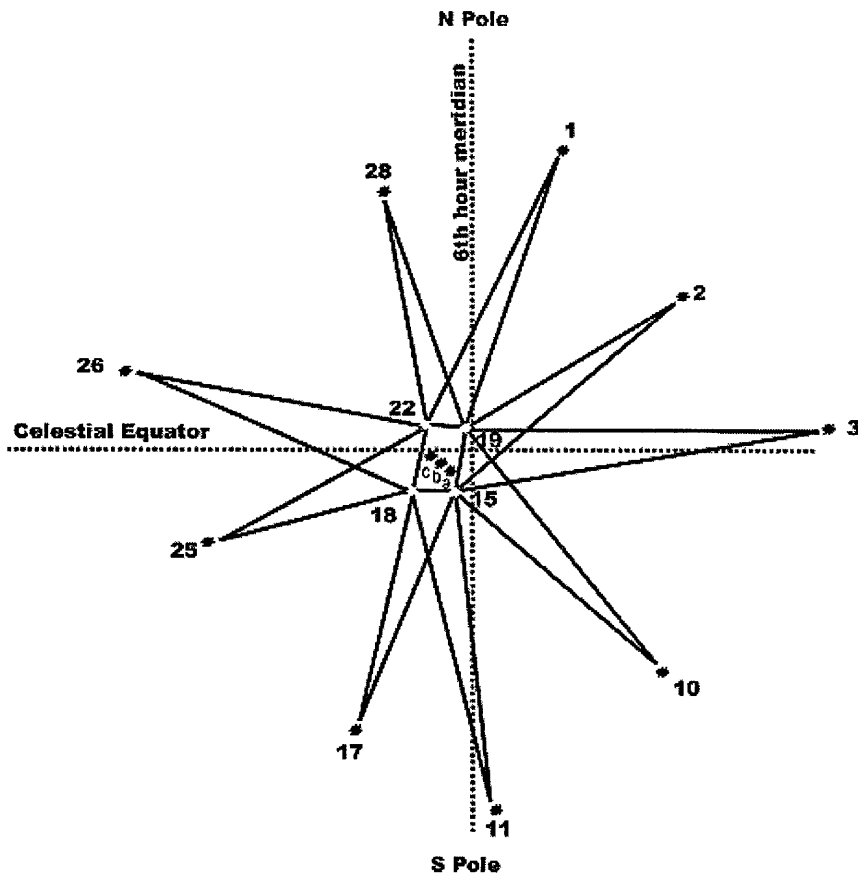


Fig. 7: [Nakṣatra with Orion as Hub] Dotted line between the celestial N & S poles denote the 06UTC meridian

Table - II a : Members of hub [Orion]

MN	CM Western Name	CM Hindu Name
15	Saiph (χ Ori.)	<i>Kartavīrya</i>
18	Rigel (β Ori.)	<i>Bāṇa-Rāja</i>
19	Betelgeuse (α Ori.)	<i>Rudra</i>
22	Bellatrix (γ Ori.)	<i>Kārtikeya</i>
a	NK (ξ Ori.)	<i>Uṣa</i>
b	NK (ϵ Ori.)	<i>Aniruddha</i>
c	NK (δ Ori.)	<i>Citrlekha</i>

MN – Member Number ; NK - Not Known .

Table - II b : Members of the *Nakṣatra*

Monument Number	CM Western Name	CM Hindu Name
1	Dhube (α U Maj)	<i>Kratu</i>
2	Regulus (α Leo)	<i>Maghā</i>
3	13AD (β Leo)	<i>Fālgunī</i>
10	P. Square (α peg)	<i>Pākhīrāj</i>
11	S. Crux (α Curcis)	<i>Trīśanku</i>
17	Fomalhaut (α Eri)	<i>Matsyamukha</i>
25	Cetus (β Cetu)	NK
26	Alpheratz (α Andromeda)	<i>U.Bhadrapāda</i>
28	Cassiopeia (α Cass)	<i>Kāśyapa</i>

important AMs are marked out on the ground in 9 different directions in consonance with the CMs in the sky . The *Tāarakā* with a inlaid *nakṣatra* which has the *Kālapuruṣa* (Orion) as its hub is a additional component which withstands scrutiny from polygonal and astronomical angle.

DATE OF ORION'S ALIGNMENT WITH BHUBANESWAR

All these necessitates a mathematical co-relation to find out , if at all the core of *Tāarakā* i.e. Orion as a whole or any of its member star was ever aligned over +20°.15 lat (Bhubaneswar). αOri - the northern most member of the trapezium attains a maximum declination of +7°.5³⁵. That as on 2006 αOri is only approximately 60-100 yrs away from +7°.5 lat (calculated on red shift basis). Naked eye observation (the only tool of yester years) from +20° lat. indicates αOri to be almost on zenith during capricornian solstice on its diurnal passage in the current epoch.

But location on passage on apparent diurnal motion and astronomical alignment do not mean the same. According to us , astro-alignment occurs when the longitude of the star is such that the corresponding point on the ecliptic attains the declination equal to the latitude of a given station i.e. it reaches the zenith of the place , we term that as Z ecliptic . The longitude demarcation on the ecliptic and its declination are related through inclination of the ecliptic by the formula³⁶,

$$\text{Sin}\lambda = \frac{\text{Sin}\delta}{\text{Sin}\epsilon}$$

where λ is the longitude; δ is declination and ϵ is inclination of the ecliptic to the equator .

It is well known that $\epsilon = 23^\circ.5$; $\delta = 20^\circ.15$ & λ turns out to be $59^\circ.75$. This is in the *sāyana* system , i.e. with respect to the equinoctial point. The correct *nirayana* longitude (with respect to fixed star *Revatī* alias $\zeta Pisicum$) of αOri . as on 1869 AD is $65^\circ 19' = 65^\circ.3166$. Adding the *ayānamśa* as on that date (1869), which is $22^\circ 51.75'$ ³⁷, the *sāyana* longitude works out to be $87^\circ 20' 51.75'' = 87^\circ.3477$. So the difference in longitude is $\lambda = 27^\circ.5877$. For this the time difference in precession of equinox @ $50.23''/\text{yr} = 1977$ years. Therefore 1869 AD - 1977 yrs = BC 108 or 2nd century BC. At that

time $\alpha Ori.$ had a δ of 4.1° i.e. 16° south of zenith . Also right ascension (denoted by α) for these objects for the above locations turns out to be $\alpha(\alpha Ori.) = 61^\circ.6$ and $\alpha(Z \text{ ecliptic}) = 58^\circ.6$. So $\alpha Ori.$ transits about 12 minutes after Z ecliptic and therefore appear as aligned to the naked eye.

Historically, such date coincides with the wane of imperial Magadha and state sponsored Buddhism from Kalinga. To us it indicates that around such period re-establishment of *Śiva-liṅga* shrines may have re-gained currency. Above deduction indicates a possible date either for the present grand edifice or for its fore runner. However, this does not mean that earlier datable Hindu shrines did not exist or any other view point nor do we propose a revisionist theory.

It also means that in relation to the afore quoted southern texts [Ref. No. 24 & 25] which state *Śiva (Naṭarāja)* appeared first in the forest of *Tārakā* (2nd appearance being at Cidāmbaram) does not hold good in the current epoch. It means that such reported first appearance refers to some other previous precession cycle.

Orion's present location covering a span of $+7^\circ$ to -8° gives it a central placement. While *nakṣatra* covers $+60^\circ$ to -60° of the span . Orion is the hub of the *nakṣatra* Fig.7, while *nakṣatra* is inlaid within *Tārakā*. Orion therefore, appears as centrally located when viewed from either hemisphere i.e. from any point of the *nakṣatra* zone. Orion being identified as *Śiva* by the Hindus, such *Orion-nakṣatra* combination makes it spectacular enough to influence the faithful's mind.

From $+7^\circ \alpha Orionis$ precesses unto $-24 \text{ deg. } 32 \text{ arc min}^{38}$. This means as the star precesses (south) past the celestial equator Orion can no more act as the hub of the *nakṣatra*, neither can a *nakṣatra* be traced using CMs as in Table I. Orion's central location is lost and *Tārakā* gets infracted. Therefore, it may be construed that the 1st appearances of *Naṭarāja* alludes to $\alpha Ori.$'s visual alignment with $+20^\circ$ (Prāci delta / Ekamra) in 25,908 BC. Even at that time $\lambda(\alpha Ori.) = 25^\circ$, and $\lambda(Z \text{ ecliptic}) = +7^\circ$, there thus was a difference of 22° , with a corresponding difference in their right ascension which works out to $1\frac{1}{2}$ hours between their transit over Cidāmbaram ($+11^\circ \text{ lat}$). In other words, other than naked eye visual alignment

no astronomical alignment had ever occurred either with Bhubaneswar or with Cidāmbaram.

DISCUSSION AND CONCLUSIONS

We have demonstrated that the archeological sites at Bhubaneswar (Ekamra Kṣetra) are positioned according to the arrangement of stars as has been visible in the sky since 108 BC when α *Orionis* transited 12 minutes after zenith point on the ecliptic. So the answer to question No. 1 gets as yes indicating that Hindu archaeology at Bhubaneswar is based on astronomical concepts. Numerous stars are mentioned in the *R̥gveda*. The Vedas mention *Kālapuruṣa* as the regulator of time. The Cosmos, we know regulates time. The *Kālapuruṣa* as per *siddhānta* is Orion and Orion straddles across the mid belt of the cosmos. In *Śvetaśvatara Upaniṣad* the *Kālapuruṣa* is indicated as a synonym of *Maheśvara*, *Mahādeva*, *Śiva* & *Rudra*³⁹. α *Ori.* is known as *Rudra* and *Rudra* is the hub of the *Tārākā*. In relation to our question No. 2 our findings prove that *Śiva* alias *Rudra* and his aksic forms have been related with stars in the sky, while the constituent AMs of the *Tārākā* at Bhubaneswar are dedicated exclusively to such aksic forms. Archaeoastronomy is also noted in the Nile valley, SE Asia & Polynesia. The *Kaliṅgāns* have a rich maritime tradition. The *Kaliṅgas* are also known to have established royal dynasties in *Suvarṇadvīpa* i.e S E Asian archipelago. This answers the question No. 3 in implied affirmative. Finally, it would be appropriate to comment that the procedure adopted by us in identifying the archaeological sites with astronomical entities along with congruence of star and terrestrial sites is a valid tool of archaeoastronomy. The unique aspect being that the ancient *Kaliṅgas* have copied the entire night span, a pattern so far not reported from any other civilisation. That it was a Ori. centric. Lexicon indicates that the term *Kaliṅga* means clever and cunning⁴⁰.

ACKNOWLEDGEMENT

Inter-phasing and inter-acting the celestial span with the terrestrial zone may not have been possible for virtual realisation but for the gracious and skillful Er. J.P. Mahanto of m/s *Mantra Udyog*, who computed the data and generated a near virtual imagery on three dimension platform for extensive experimentation. We are thankful to Dr. R Kron, Scientific Spokesman, Uni. of

Chicago, Dept. of Astronomy & Astrophysics ; Dr. J. F. Hemboldt & Dr. R. Walterbros of Dept. of Astronomy , New Mexico state University; Dr. M. Geoff Chester , USNO , Public affairs office & Dr. Patrick So , lecturer – Astronomy , Griffith laboratory for their private communications. We are also thankful to Dr. S. Maiti , Superintendent and Mr. P. K. Mahapatra of the Chemical branch A S I, for assisting in conducting close physical study of AM- 19 . Dr. P.K. Kar, H.O.D. Geography, Utkal University for lending the theodolite ; Dr. Dilip. Behera, Sr. Scientist for lending magnetic compass & for participating in theodolite exercises alongwith Mr. P. K. Dikshit Asst. Archaeologist of A.S.I. Excavation Division ; Dr. Bhagwan Panda, Secretary, Kedarnath Gabesana Pratisthan for assisting with Lexicons, *Purāṇa* references & Sanskrit translations ; Mr. Debaraj Pradhan, Secretary, Maritime and SE Asian studies ; Sri Manmath Samal, Librarian Orissa State Museum for valuable references ; Mr. Graham Hancock and Mr. Sharif Shakar for having presented us with references on archaeoastronomy ; Mr. T.B. Sahoo, for helping with computer graphics ; to the learned referee for his very constructive and valuable comments. Our special gratitude goes to temple *sebayats* (servitors) namely, Mr. Manoj Batu, Mr. D. Samantaraya, Mr. Bipin Batu and others for physical help and in taking repeat measurements. Mrs. Mamata Bhattacharya financed this work .

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