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BOOK REVIEW

Bernett, Hogendijk, Plofker and Yano (Eds), ***Studies in the History of the Exact Sciences in Honour of David Pingree***, Published by Brill, Leiden, The Netherlands, 2004 (Price not mentioned)

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This volume is a collection of essays brought out in honour of Professor David Pingree, Brown University, USA. The late Prof. Pingree's prolific contribution to the history of exact sciences as also his monumental *CESS* (*Census of the Exact Sciences in Sanskrit*) volumes are exemplary of highest professionalism.

The book under review has in all 29 articles distributed into four major sections, highlighting the studies in the history of the exact sciences in Mesopotamia (5 articles), Classical and Medieval Europe (5 articles), India and Iran (11 articles) and Islam (8 articles).

In the article, "*Constellation into planet*", Erica Reiner deals with the philological problems with the terms used in astral omens to describe the ominous phenomena, both the astronomical and the atmospheric ones. Reiner and Pingree jointly authored *Babylonian Planetary Omens* (in 3 parts) over an interval of 23 years, from 1975 to 1998. The author points out that among the words used to describe the appearance of denoting a celestial body the terms demotic brightness span the scale from dim or faint to various degrees of brightness, using a vocabulary the nuances of which cannot be established.

Herman Hunger, in the article "*Stars, Cities and Predictions*", investigates the contents of tablet, BM 47494, which is a part of the 81-11-3 collection of the British Museum (BM). The author guesses that the said tablet must have come from Babylon. The author translates the contents of the tablet which is damaged. Many planetary omens and their predictions are mentioned. There are references to various cities some of which are difficult to identify according to the author. The tablet contains a first part about the correlation of constellations with geographical units (mostly cities) and then several sections concerning the use of constellations for purposes of prediction.

In his paper, "*An Early Observation Text for Mars: HSM 1899.2.112*", John Britton discusses in detail the contents of the tablet, acquired by Harvard in 1899 and probably from Babylon. In this tablet the observations and calculated phenomena of Mars are recorded for each year from around the beginning of the reign of Esarhaddon (-679) till the end of the reign of Nebuchadnezzar (-561). The author presents a detailed analysis of the recorded positions and phenomena of Mars. The text of the tablet, under discussion, represents a systematic compilation of observations of Mars's synodic phenomena. At the outset and still by the end of the first column (-656) only appearances (*igi*) and disappearances (*ŝù*) are recorded. It would seem that at least occasional observations of Mars's appearances and disappearances began to be recorded around the commencement of Easarhaddon's reign (-679). The author points out that during about six decades (-633 to -569) systematic observations of the stations and oppositions were introduced. The positions of the distinctive synodic phenomena (i.e. excepting oppositions) began to be recorded as measured intervals from Normal (reference) Stars in two coordinates. These innovations were accompanied by an increase of accuracy of the dates of recorded phenomena, which by the end of the text reflected average errors of roughly 1 day and maximal errors of less than 3 days. John Britton rightly points out that positional measurements, recorded with a precision of half a cubit, seem to have had a general accuracy consistent with that precision, suggesting an ongoing program of careful, systematic observations. A deep study of valuable astronomical data recorded in such ancient tablets goes a long way in understanding the extent and depth of knowledge of the science in ancient times.

In the article, "*A Babylonian Rising-Times Scheme in Non-Tabular Astronomical Texts,*" Francesca Rochberg discusses at length the Babylonian scheme of rising of the twelve signs (each of 30^0 extent) of the zodiac. The author uses five sources for the analysis. These are A 3427, LBAT 1499 rev. 10ff; LBAT 1503, U 196 and BM 77242 designated respectively as texts A to E. In this group of non-tabular late Babylonian astronomical texts, the rising times of 12 micro-zodiac 'portions' (HA.LA = Zittu), each representing $2\frac{1}{2}^0$ of the ecliptic are given, as are totals (PAP) for the sign as a whole in a number of instances. The author clarifies the discrepancy between the rising-times scheme underlying System A and that of the 'micro-zodiac' texts. It is pointed out that the micro-zodiac texts attest to an awareness of the problem of the oblique ascensions of the zodiacal signs in that a determination, however crude, of values for the rising timer is developed. Of further interest is the implication of the micro-zodiac rising times scheme for the understanding of the variation in daylight as a function of the position of the sun in the ecliptic, with simpler parameters than in the manner of late Babylonian mathematical astronomy. The author concludes that, regardless of the data of its invention, the hybrid daylight scheme that follows from the rising times values in Texts A to C certainly adds a new dimension to our picture of late Babylonian non-tabular astronomical texts.

Lis Brach-Bernsen and John Steele discuss aspects of mathematics, astronomy and astrology combined in the contents of two tablets they have chosen in their article, "*Babylonian Mathemagics. . . .*". The two tablets, published here, are BM 96258 (1902-4-12, 370) and BM 96293 (1902-4-12, 405) from the purchased collection at the British Museum. The tablets are of dimensions 4 cm × 4.5 cm and 4 cm × 5.25 cm respectively. The *Kalendertext* and *Dodekatemoria* schemes for different months are analyzed. A glance of Table 1 (page 106) shows that all the possible degree numbers from 1 to 30 occur during the 30 days of a month and also that all the twelve zodiacal signs are represented. Thus the *Kalendertext* scheme for the whole ideal year (Table 2, page 109) gives a one-to-one correspondence between the 360 days of the ideal year and the 360 degrees of the zodiac. Table 7 (page 117) is obtained by swapping dates and positions in the *Kalendertext* scheme (Table 2). For any given position (degrees) the table provides the date on which the moon was at that position according to the *Dodekatemoria* scheme. This latter scheme has an astronomical significance – it represents the ideal year of 360 days. The authors conclude that the schemes, studied in the paper, show an interest and belief on the part of Babylonian astrologers in increasing the astrological potential of a date or position in the zodiac by mathematical manipulation – a procedure which the authors of this article call "mathemagics." Is it not truly distressing that even millennia after the age of such astrological "mathe-magics," sizable portion of the world's populace still persistently believes in mathematically manipulating stars' and planets' positions to its advantage?

Alexandar Jones, in his paper "*An 'Almagest' Before Ptolemy's*?" identifies and discusses some papyri from Egypt containing astronomy of the Greco-Roman period. He observes that in these papyri truly theoretical writings are far outnumbered by tables and instructional texts. In fact, most of the roughly two hundred published astronomical papyri are either included in A. Jones' "*Astronomical Payri from Oxyrhynchus*" (1999) or listed in its bibliography. The author attempts to investigate whether there existed books comparable to the *Almagest* before Ptolemy. As for the contributions of the astronomers who lived during the three centuries between Hipparchus and himself, Ptolemy makes only a brief and disparaging comment (*Almagest* 9.2) about unnamed authors. Their performances, he writes, were faulty and 'lacked proofs'. The author concludes that the hypothetical text, preceding the *Almagest*, had much less of mathematical analyses. He further recalls his earlier argument [A. Jones, 1999] that Ptolemy probably saw this treatise and "plundered" it for observation reports.

In his article, "*Ptolemy's Harmonics and the 'Tones of the Universe'* in the Canobic Inscription*,"* the author, N.M. Swerdlow, expresses the 'modest' purpose of his article: "To set out an explanation . . . of the astronomical chapters of the *Harmonics* . . . with a selective exposition of the music theory required to understand them and to investigate the relation between the list of tones in the Canobic Inscription and the Harmonics." He points out that *Harmonics* 1.1-2 and some other parts of it contain Ptolemy's most detailed account of what he (Ptolemy) considers proper method in the applied mathematical sciences. According to Swerdlow, Ptolemy's method is 'rigorously mathematical and rigorously empirical,' that he has followed in his other book *Almagest.* In comparison the astronomical and astrological parts of the *Harmonics* are not on Ptolemy's highest level, however his statements of method and exposition is enough to make the *Harmonics*, perhaps Ptolemy's earliest work of lasting importance to the history of the mathematical sciences. N.M.Swerdlow alludes to one of the oldest ideas of a relation of art and science in nature that the heavens are formed according to the principles of music – now usually called the 'music of the spheres', which is criticised by Aristotle (*De caelo* 2.9) who dismisses the whole idea as elegant and ingenious nonsense!

In the interesting article, "*Neither Observation nor Astronomical Tables*: ….", David Juste points out that before the age of Arabic-Latin translations of scientific texts in the 12^{th} century, planetary astronomy (excepting lunar and solar cycles) was in the Western world mainly restricted to information found in ancient encyclopaedias. The author quotes a passage from a treatise of computation method by Rabanus Maurus (820 AD) giving on the positions of the sun, the moon, Saturn and Jupiter as on 9^{th} July, 820, and adds further that Venus and Mercury were not visible at that moment since these planets were close to the sun in daylight. The given positions of planets were possibly based not merely on computations but also on actual observations. He further identifies two types of works of the medieval period and calls them 'System A' and 'System B'. The System A refers to the method of *IQSVM* (*In quo signo versetur Mars*?), a short text, without title, opening with the words, "*In quo. . .*" (hence the name *IQSVM*!). The System B refers to a variant of that method. In 1936 this text was noted by André Van de Vyver who identified it as a source of the *Liber Alchandrei* and gave a list of manuscripts in which it occurs. These *IQSVM* texts consist of five chapters describing a handy method for computing the position of each of the five planets. The method is based on empirical combination of the three elements: (1) the positions of the planets at the 'creation' of the world, (2) the zodiacal periods of the planets and (3) the time elapsed since the creation of the world. David Juste points out that such *IQSVM* occurs among astronomical material in nine manuscripts from the ninth to the twelfth century. The 'System B' ultimately derives from the Greek tradition. The author concludes that the method of the 'years of the world' appears to have been the standard way of computing the planetary longitudes in the early Western Middle Ages. The text books, potentially available during that period, such as the *Astronomica* of Manilius and the *Mathesis* Fermicus Maternus, were useless because of the lack of any means for determining the planetary longitudes and the rising sign for a given date and time.

Charles Burnett, in the article, '*Arabic and Latin Astrology Compared . . .*', argues that while the Arabic astrological texts were translated into Latin, the native Latin astrological tradition was not consigned to oblivion. He points out that the principal Latin textbook on astrology, the fourth-century *Mathesis* of Fermicus Maternus actually had a resurgence of popularity in the eleventh and twelfth centuries precisely when new texts were being introduced from the Arabic. In this context, the present reviewer would like to point out that a serious and objective critique of medieval Hindu astrology vis-à-vis Arabic and European astrological texts is much in order. This fresh and critical approach is notwithstanding the tentative findings of the late Prof. David Pingree.

Antonio Panaino, in the article *On the Dimension of the Astral Bodies*, observes that although Pahlavi Zoroastrian literature preserves only a few remnants of a larger astrological and astronomical production, we can still find therein some scattered information and a lot of traditional astral beliefs. The author notices that the Sasanian astral culture reflects the ambiguous and contradictory attempts of a priestly class trying to make use of Greek and Indian astronomical and astrological sciences without any radical refusal of standard theological doctrines. As an example, patern of contradictions between past and present 'doctrines' attested in Pahlavi texts is the one concerning the dimensions of the astral bodies. The author takes this opportunity to trace and compare different and concurrent traditions. The author concludes that the Iranian astral culture seems to have – independently and in a very primitive form - foreseen a real astronomical problem by distinguishing the brightness of stars in three groups of different size.

In the interesting article, '*Jambudvîpa: Apples or Plums*', Dominik Wujastyk, starts with the fact that one of the common Sanskrit names for India is '*Jambudvîpa'*. This phrase, a combination of two words *jambu* and *dvîpa,* literally means 'the continent (or island) of the rose-apple trees.' The botanical name of the fruit (formerly *Eugenia jambolana*) is *Syzygium jambos*. Very interestingly, this article is offered "with respect and affection" to David Pingree "who has done so much to reveal . . . about *Jambudvîpa*." The author concludes that India (the *Jambu-dvîpa*) is not the 'Land of the Rose Apple Tree.' It is more correctly the 'Isle of the Jambul' or 'Black Plum Island."

Sreeramula Rajeswara Sarma traces the development of the use of the water clock of the sinking bowl type (*Ghaṭikâ*- or *Ghaṭî - yantra*) as the chief device in India for measuring time. The device consists of a hemispherical bowl with a minute perforation at the bottom. When the bowl is placed on the surface of water in a larger vessel or basin (*kuṇḍa, kuṇḍikâ, kuṇḍî*), water slowly percolates into the bowl through the perforation. When the bowl is full, it sinks to the bottom of the vessel with an audible thud. The weight and the size of the perforation are so adjusted that the bowl sinks sixty times in nychthemèron (*ahorâtra*). Thus the time taken to fill the bowl fully once was the standard unit of time called *ghaṭikâ* or *ghaṭî* (equal to 24 minutes). At the end of each *ghaṭikâ,* it was customary to announce it with blast on a conch-shell or strokes on a drum. In the early medieval period the conch and drum were replaced by the gong which was designated as *ghaḍiyâla* (from *ghaṭikâlaya,* 'water clock-house'). S.R. Sarma makes translation and critical assessment of the passages on bowl of the water clock as given by Âryabhaṭa I (b. AD 476) in his *Âryabhaṭa-siddhânta*, Lalla's *Śiṣyadhîvṛddhida* (*Yantrâdhikâra*), and Bhâskara II, *Siddhânta úiromaṇi* (*Golâdhyâya, Yantrâdhyâya*, 8) and his auto commentary *Vâsanâbhâṣya*, which criticized earlier author's remarks regarding the dimension of the parforations and its change when the weight and the size of the bowl differs. According to Sarma in spite of theoretical confusion in the texts, countless specimens of this water clock were produced throughout the centuries and that these kept reasonably correct time of one *ghaṭikâ* of 24 minutes. The author refers to (i) the Chinese traveller I-T sing (c. 675-685 AD in India) giving a detailed description of the time keeping establishment at the famous Buddhist monastery at Nalanda and (ii) al-Bîrûnî's (early 11th century) description of the time-keeping establishement at Purshor (modern Peshawar) and adds, 'Pious people have bequeathed for these clepsydrae (i.e. water clocks) and for their administration, legacies and fixed incomes.'

The most interesting and valuable part of S.R.Sarma's article is where he describes the installation of the water clock in common households on special occasions like marriages in order to know precisely the 'the astrologically auspicious moment' (*úubha muhûrta* or *lagna*). He refers to passages from four texts with translation, although corrupt, from an unpublished manuscript entitled *Ghaṭâ-yantra-ghaṭanâ-vidhi* which cites Nârada as the authority for the ritual, Govinda Daivajña's *Pîyuṣadhâra* commentary (1603 AD) on his uncle Râma Daivajña's *Muhûrta cintâmaṇi* (1600 AD) and Kâúînâtha Upâdhâye's *Dharmasindhu* (1790-91 AD). On the whole S.R.Sarma's article is a detailed study of *ghaṭikâ yantra*, its composition and the related rituals.

Michio Yano in the article '*Planet Worship in Ancient India,'* explains the development of the concept of *graha* as a planet in ancient India and then looks at the rite of planet worship (*grahayajña*) in the group of ritual texts (*gṛhyasûtras*) and makes clear the historical position of the section called *Grahaúânti* (appeasement of *grahas*) in the *Yâjñavalkya smṛti,* one of the most influential texts on *dharmaúâstra*. Yano starts with the eclipse demon called Svarbhânu, referred to in the *Ṛgveda* (*RV* 5.40.5, 5.40.9), and conjectures, 'and probably, *graha* (from the Sanskrit root *grah)* means "to seize".' The demon got the name Râhu and, somewhat later, the tail of the truncated Râhu was called Ketu. The author holds the view that the five planets were regarded as *graham* 'because they possess man and do him harm.' Later, the sun and the moon joined the five *grahas* and along with Râhu and Ketu these were considered as the nine *grahas*. The week-day order of the seven *grahas* (from the Sun to Saturn) was established. However, the author points out that the quoted passage from the *Ṛgveda* is the only reference to Svarbhânu in that text and that there is no evidence that this demon was identified as *graha*. In the two epics, the *Ramâyaṇa* and the *Mahâbhârata*, Svarbhânu is explicitly called *graha*. The author quotes from the *Râmâyaṇa* the line which refers to *Svarbhânu* as holding (or seizing) the Sun in a solar eclipse: '*jagrâhaisûryaṃsvarbhânur aparvaṇi mahâgrahaḥ.*' Yano refers to the sixteenth century commentator Sâyana and comments, "…Sâyana had no qualms about interpreting *grahas* as 'the planets beginning with Mars' but I see no strong reason to support him." Besides the *Atharvaveda*, perhaps the oldest text where *graha* appears together with Râhu, the author quotes the *Chândogya-Upaniṣad* and the *Maitrâyaṇî-Upaniṣad* which refer either only to Râhu or to Râhu and Ketu along with Saturn (*úani*). The *Chândogya Upaniṣad* says, 'Just, like the Moon who was released from Râhu's mouth…' (*candra iva râhor mukhât pramucya…*).

According to Yano there is no strong evidence in Sanskrit literature of the Vedic period which shows the identification of *grahas* as planets. They might have watched those stars whose behavior was different from those of the fixed stars, but they failed to classify them as a group of *grahas* or planets. It is only after the period of Greek settlement in Bactria (third century BC) that explicit references to planets are attested in Sanskrit texts.' Even as regards Kauṭilya *Arthaúâstra's* reference to Jupiter and Venus by names Bṛhaspati and Śukra respectively in the context of weather prognostics, he supports Pingree who regards such prognostics as of Babylonian origin. Yano is however silent about references to Bṛhaspati as early as in the *Ṛgveda* (*RV*) and the *Taittirîya samhitâ (TS).* The *mantra* in *RV* states: *Bṛhaspatiḥ* *prathmaṃ jâyamâno maho jyotiṣaḥ parame vyoman. . .*(‘*Bṛhaspati*, when being born in the highest heaven of supreme light, …’ – *RV.* IV. 50.4). The *Taittirîya Saṃhitâ* is still more explicit in referring to a conjunction of Bṛhaspati with star *Tiṣya* (*Puṣya*, δ Cancri). The text reads, ‘*Bṛhaspatiḥ - prathamaṃ - jâyamânas tiṣyam nakṣatraṃ abhisambabhûva*’ – *Taitt. Sam.* 3.1.5. (*Bṛhaspati*, when first appearing, rose in front of the *Tiṣya* asterism).

So is the reference by traditional Indian scholars that the name *vena* mentioned in the *Ṛgveda* refers to planet Venus. The text says metaphorically:

‘*apsarâ . . . . bibharti parame vyoman |*

carati . . . . sa venaḥ || (*RV*. X. 123. 5)

(The young lady (*uṣas*) approaching . . . . moves about in the places of *vena . . .*).

Yano records *Gârgya jyotiṣa* (somewhere near the start of the current era) which arranges the nine *grahas* in the following strange order: the Moon, Râhu, Jupiter, . . ., the Sun; and in the great epic *Mahâbhârata* the week-day order attested’. The question is: where does the *Mahâbhârata* refer to week-days named after the *grahas*? The author puts on record that the oldest Indian inscription which gives a date with the week-day is that of Ā ṣâḍha, the 12th day of the bright half-month (*úukla pakṣa*), Thursday (*sura-guru*) corresponding to 21 July, 484 AD. Further, Yano quotes the *Āryabhaṭîya* as the first astronomical text which defines the week-day. The author quotes extensively from the *grahayajña* section of the *Gṛhyasûtras* and from the *grahaúânti* section of the *Yâjñavalkya Smṛti* (*YS*), and holds the view that the section of *YS* which deals with the planets, with their order specified, was composed not before the beginning of the fourth century AD. In Table 2 of his article, he finds the *Purâṇic* parallels of the *grahaúânti* section of *YS* from the *Agni-purâṇa* (*AP*), the *Garuḍa Purâṇa* (*GP*) and some verses in the *Matsya-purâṇa* (MP), the *Bhavisya purâṇa* (*BPU*) and the *Viṣṇudharmottara purâṇa* (*VD*). It is shown how *YS* set a model of planet worship for some later texts (viz., the above mentioned *purâṇas*).

In the article, ‘*Competing Cosmologies in Early Modern Indian Astronomy*,’ Christopher Minkowski refers to David Pingree’s article, ‘The Purâṇas and Jyotiḥsâstra’ which sketched the history of the cosmological account found in the Sanskrit astronomical *siddhântas* taking shape in relation to the standard cosmology of the Sanskrit Purâṇas. Lallâcârya (early 9th century) formulated Indian astronomers' viewpoint, that came to be accepted as standard, and his solution preserved the features of the astronomers' model, necessary for supporting their calculations, and rejected those parts of the Purâṇic model that contradicted them. On this background, the author focuses his attention on comparatively modern works and referred to it as the "*virodha* problem". Two works, *Saura-paurâṇika-mata-samarthana* of Nîlakaṇṭha Caturdhara and *Bhâgavata-jyotiṣayoḥ Bhûgola-khagola-virodha-parihâraḥ* of Kevalarâma Jyotiṣâcârya were taken into account where he details the stand of the astronomers of Pârthapura: Jñânarâja and his sons, Cintâmaṇi and Sûryadâsa (born 1508). He continueed to elaborate on the approach by later Indian astronomers like Nṛsimha Daivajña (born 1586) and Munîúvara Viúvarûpa (born 1603), even refers to the text, *Mataikyacandra* of Harideva Bhaṭṭa with a question, 'If the science was practically useful (which it was, in enabling a confident timing of ritual practices and casting horoscopes), would that not be enough to guarantee the creation of a niche within the ecosphere of canonical literature?' In order to resolve the "*virodha* problem", the author concludes his essay with the remark, "The 'levels of truth' appeal could be interpreted as the basis for a modernizing intellectual adjustment . . . . An accommodation between science and religion of this kind is sometimes claimed to be the trademark of the arrival of modernity in the contemporary cosmological debates in Florence and Rome".

Takao Hayashi in the longish article of 111 pages, 'Two Banares Manuscripts of Nârâyaṇa Paṇḍita's *Bîjagaṇitâvataṃsa*,' presents an edition of Part II of the *Bîjagaṇitâvataṃsa* together with an English translation with a mathematical commentary, based on two Benaras manuscripts including the one newly discovered by Prof. Pingree. Nârâyaṇa (often qualified with suffix Paṇḍita), son of Nṛsimha, composed a book each in the two major fields of Indian mathematics : *Gaṇitakaumudî* in *pâṭî-gaṇita* and *Bîjagaṇitâvataṃsa* in *bîja-gaṇita* . He flourished in the middle of the 14th century. Nârâyaṇa, in the colophonic verse of his *Gaṇitakaumudî,* declares the date of the completition of the text, which corresponds to November 10, 1356. From the distribution of available manuscripts of his two texts, it is inferred that Nârâyaṇa's sphere of activity was somewhere in North India. The *Bîjagaṇitâvataṃsa* is a work on algebra modelled on the *Bîjagaṇitam* (1150 A.D.) of Bhâskara II. It is divided into two major parts. Part I deals with operations involving positive and negative numbers, zero, unknown quantities, surds and the pulverizer (*kuṭṭaka*) and the square-nature (*varga prakṛti*). Four types of equations, for which the contents of part I are necessary, form the subject matter of Part II. Takao Hayashi, in his well-edited work, provides the actual text in Roman script (with variant words in the footnote) in section 2, translation in section 3 and commentary in section 4. Hayashi richly deserves encomia for bringing out, with translation and learned comments, this important text of Nârâyaṇa Paṇḍita.

Takanori Kusuba, in his article *"Indian Rules for the Decomposition of Fractions"* summarizes the rules for the decomposition of fractions discussed by Datta and Singh with examples from Mahâvîra's *Gaṇita-sâra-saṇgraha* and compares the corresponding rules as given in Nârâyaṇa Paṇḍita's *Gaṇita-kaumudî.* The author discusses at length some eight rules of Nârâyaṇa and concludes that his survey attests to a remarkable continuity of computational tradition from Mahâvîra to Nârâyaṇa despite the five centuries for which "we know of no representatives of that tradition." But it is not clear why Kusuba ignores Bhâskara II (b. 1114 AD) who flourished almost during the middle of that five centuries stretch. Kusuba further concludes that some of Nârâyaṇa's rules are equivalent to or can be deduced from Mahâvîras's. He remarks that the use of indeterminate equations seems to be characteristic of Nârâyaṇa.

R.C.Gupta in his article, "*Area of a Bow-Figure in India*," discusses the various expressions, given by Indian and other ancient civilizations, for the area of a segment of a circle i.e. the region bounded by an arc of a circle and the corresponding chord (joining the ends of the arc). If *c* is the chord (*jyâ* of *jîvâ*, "bow-string") and *h* the segment's height (joining the midpoints of the chord and the smaller arc), then the exact relation between *c* and *h* is

$$c \equiv \sqrt{4h(d-h)}$$

where *d* is the diameter of the circle. Gupta points out that an explicit verbal statement of the above expression is found in the *Bhâṣya* on the Jain text, *Tattvârthâdigama sūtra* of Umâsvâti. Gupta refers to the expression for the arc of a circular segment given by Nîlakaṇtha Somasutvan (ca. 1500 AD):

$$s \equiv \sqrt{c^2 + kh^2}$$

where k = 16/3. The earlier Indian mathematicians had chosen k = 5 (with π=3) and k=6 (with $\pi = \sqrt{10}$). Gupta also cites an altogether different formula

$$s = \sqrt{10\left(\frac{c}{4}+\frac{h}{2}\right)^2}$$

quoted by Bhâskara I in his commentary (629 AD) on the *Āryabhaṭîya* of Ā ryabhaṭa I (b. 476 A.D.).

The author discusses at some length the expressions for the area of a circular segment given in other ancient civilizations like the Babylonia, Hellenistic Egypt and China.

Gupta points out that the classical rule for the area

is given by the Jain mathematician, *Mahâvîra* (ca. 850 AD) in his popular text, *Gaṇita sâra saṅgraha* as also by Nemicandra (10th century). Both these authors use the rough approximation 3 for π. The improvements by Nârâyaṇa Paṇḍita (1356) in his *Gaṇita kaumudî*, Úrîdhara (ca. 750 AD) in his *Triúataka* and *Āryabhaṭa* II in his *Mahâsiddhânta* are given. The author concludes his write-up with expressions given in Karavinda's commentary on the *Āpastamba úulvasūtra*.

Setsuro Ikeyama analyses very systematically the procedures for true daily motions of the heavenly bodies in his article*, "A Survey of Rules for Computing the True Daily Motion of the planets in India."* Types of procedures are used. In Type 1, the geocentric distance (*karṇa* H) is used. The rule is often referred to as *karṇabhukti.* In Type 2, the difference between the true and mean daily motion is calculated first and then added algebraically to the mean daily motion. Starting with Varâhamihira's (505 AD) *Pañcasiddhântikâ* (*PS*), the author considers various succeeding texts and discusses the procedures described in them for obtaining the true daily motion. Texts used for the purpose, besides *PS,* are *Laghu*- and *Mahâ- Bhâskarîyams* of Bhâskara I, Brahmagupta's *Khaṇḍakhâdyaka*, Lalla's *Úṣyadhîvṛddhida*, *Sūryasiddhânta, Vaṭeśvara siddhânta,* Mañjula's (or *Muñjala's*) *Laghumânasa,* *Siddhântaúekhara* of Úrîpati, Āryabhaṭa IIs *Mahâsiddhânta, Siddhântaúiromaṇi* of Bhâskara II, *Somasiddhânta* and Citrabhânu's *Karaṇâmṛta.* While discussing the expression provided by the *Laghumânasa*, the author remarks that he has not found a satisfactory explanation for the formula:

$$v = (v_s - \tilde{v}) . \frac{vy\hat{a}sa - \acute{u}\hat{\imath}ghraaphala / 12}{\acute{u}\hat{\imath}ghra\ divisor}$$

where the *'úîghra divisors'* are calculated in the *Laghumânasa* from the formula *úîghra* divisor = $d_m \cdot \frac{r_m}{r_s} + \frac{\sin\tilde{\alpha}}{3} \pm \cos\tilde{\alpha}$. The author stops short of arriving at any conclusion about the extents of accuracy of the different texts or comparing them for veracity with the related modern expressions.

Kim Plofker is known for her specialization in the *asakṛt* or iterative procedure used often in Indian astronomical texts. In her article, *"The Problem of the Sun's Corner Altitude and Convergence of Fixed-point Iterations in Medieval Indian Astronomy,"* Plofker examines quite elaborately the mathematical behaviour of the fixed-point iterations and reconstructs how some of their users apparently recognized and attempted to deal with the problems inherent in them. The author points out that the problem of finding the sun's altitude above the horizon, given its declination δ, corner direction *d* and the terrestrial latitude ϕ is almost entirely peculiar to Indian astronomy. The first known solution is provided in the *Tripraúnâdhikâra* of Brahmagupta's *Brâhmasphuṭasiddhânta* (628 AD). Plofker explains the mathematical implications of the fixed-point iterative procedure resulting in (a) oscillating swift convergence, (b) oscillating slow convergence, (c) divergence to cycle, (d) divergence to undefined value, (e) monotonic convergence at d_{max} and (f) oscillating at f_{max} by considering the orbits of a function g(sinα) for various ϕ and δ. According to her, Lalla's method for the corner altitude is somewhat simpler than Brahmagupta's rule. The convergence problems with the *koṇaúaṅku* rule were in fact noticed and that partially successful methods were developed and quotes Bhâskara II (1150 AD) in this context. A different and more constructive modification of Lalla's original rule is shown appearing in Mallikârjuna Sūri (c. 1178) who must have worked at a place of latitude around 18^0N. Parameúvara's new iterative method for *koṇaúaṅku* and generalization of them is also discussed elaborately. She feels that all the serious convergence problems with the original *koṇaúaṅku* iteration and its variants are at this point successfully resolved, some seven centuries after its initial appearance in Lalla's text.

S.M.R.Ansari in his article, "Sanskrit Scientific Texts in Indo-Persian Sources, with special emphasis on siddhântas and karaṇas" refers to the pioneering work of Prof. David Pingree and mentions particularly *Āryabhaṭâsiddhânta* of Āryabhaṭa I (b. 476 AD) and perhaps *Mahâsiddhânta*, based on *Brâhmasphuṭasiddhânta* (628 AD) which were translated from Sanskrit to Arabic and started the tradition of "*Sind-hind"* texts. Sanskrit astronomical "handbooks" (*karaṇa* genre), included Brahmagupta's *Khaṇḍakhâdyaka* (epoch 665) which appeared as *Zîj al-Arkand*, the Arabic translation of Vijayânanda's *Karaṇatilaka* (compiled in 966 AD), carried out by al-Bîrunî (973-1048), available in the private collection of Dargâh Pîr Muḥammad Shâh in Ahmedabad (India). The Arabic text with a facsimile of the manuscript has been published by N.A.Baloch and an English translation by F.M.Quraishi. As to the reverse trend of transmission of knowledge of astronomy – Naṣîruddîn al-Ṭûsî's Marâgha school of Islamic theoretical astronomy and *Zijes* played important role in India during the pre-Mughal and Mughal periods. Among them, a commentary on Ulugh Beg's Tables (*ZUB*), *Tashîl Zîj-i Ulugh Beg*, was translated into Sanskrit, by Akbar's order (reigned 1556-1605). A copy of the Sanskrit translation is available in the City Palace Museum of Jaipur (India). *Zîj-i Shâhjahânî*, dedicated to emperor Shâh Jahân (reigned 1628-58) was translated into Sanskrit by Nityânanda, the emperor's Hindu court astronomer. Copies of the manuscripts are available at Jaipur. The most important *Zîj-i Muḥammad Shâhî* (*ZMS*) compiled by Mirzâ Khayrullâh Muhandis (d. 1747) for Maharaja Sawai Jai Singh (1686-1743) replaced much of the earlier *Zîjes* including even the standard *Zîj-i Ulugh Beg*. Ansari does not mention if *ZMS* is based on the French tables of de la Hire.

Ansari provides a very useful list of Persian translation of Sanskrit scientific texts e.g. Bhâskara II's *Lîlâvatî* by Abu'l Fayḍ Fayḍî (1587) at the instance of Emperor Akbar, *Bîjagaṇitam* by 'Atâ'ullâh Rushdî (or son of the architect of the Taj Mahal) and dedicated to emperor Shâh Jahan in the year 1634-35, later it was translated into English in 1813 (London) by E. Strachey;

Varâhamihira's *Bṛhat Samhitâ* (VBS), *Kitâb Bârâhî Sanghtâ* by 'Abdul 'Azîz Shams Thanesarî were also rendered into Persian translation under the order of Sul-ân Fîrûz Shâh Tughlaq and so on.

Persian translations of *Karaṇas* (astronomical handbooks) includes *Karaṇkatû(û)hal* available at Punjab University Library (Lahore) may be a Persian translation of Bhâskara II's *Karaṇakutûhala* (epoch: February 24, 1183 AD, Thursday); *Sharā Frankûhal* (or *Frankûhal*) a commentary on the *Karaṇakutûhala* (composed around 1752 AD) is also available at the Punjab Public Library and so on. He also reported that complete anonymous manuscript copy of the Persian translation of the *Karaṇakutûhala* lies in Raza Library (Rampur). It refers to a lunar eclipse of 1434 A.D. and a solar eclipse of 1441 AD observed by the Persian author in Delhi. Ansari promises that he intends to publish its detailed study shortly. It would be rewarding if the parameters of the above-cited Persian translation are compared with those of the original Sanskrit *karaṇa* and checked if the Persian authors incorporated innovations based on their observations.

Virendra N. Sharma (*IJHS*, 42.1 (2006)), revising his earlier stand (*IJHS*, 25.1-4 (1990)), concludes that "indeed a strong case can be built that *ZMS* tables are based on the *Tabulae Astronomicae* of de La Hire".

In the last section of the volume there are eight articles highlighting the Islamic contribution. Berggren and Hogendijk have thrown light on 'The Fragments of Abû Sahl al-Kûhî's Lost Geometrical Works in the writings of al-Sijzî'. Abû Sahl Wîjan ibn Rustam al-Kûhî, a mathematician from Tabaristan, flourished in the latter half of the tenth century under the patronage of the Buyid Dynasty. Geometers Ibrâhîm (909-946) and al-Sijzî (fl. 970) were his contemporarious and directly connected with the work of al-Kûhî. Al-Ṣaghânî and al-Bûzjânî worked with al-Kûhî on solar observations during the reign of Sharaf al-Daula in 988. In their paper the authors preserve a small part of the lost work of al-Kûhî, and observe that six of the first seven problems are closely related to the works of Apollonius and bear directly on matters discussed in his *Conics, Cutting-off of a Ratio, Plane Loci* and *Determinate Section*. Variety of geometrical problems considered by al-Kûhî are available in fragements in the writings of al-Sijzî. The original Arabic passages of these fragments are reproduced by the authors at the end of the article.

David King in his long article "*A Hellenistic Astrological Table ...* ", discusses at length the Arabic tradition of Vettius Valens' Auxiliary Function for finding an individual's longevity (called *âyurdâya* in Sanskrit). The late-second-century astrologer Vettius Valens, of Antioch and later of Alexandria, contributed a scheme of tables of longevity against the rising point of the ecliptic in the eastern horizon, called *horoscopus* (Ascendant, *Lagna* in Sanskrit) at the time of an individual's birth. The *Anthology* of Vettius Valens was very popular, published by Wilhelm Kroll in 1908 and a more authorative text by David Pingree in 1986. A Persian commentary on the *Anthology* was prepared in the sixth century by the Sasanid minister Buzurjmihr. This commentary, now lost, was translated into Arabic as *Kitâb al-Bizîdhaj*, but it is no longer exant in the original form either. The material of Vettius Valens on longevity is found at the end of Book VIII of the *Anthology* in the form of two tables. The first table has been discussed by Otto Neugebauer in *Greek Horoscopes*. He has shown that the tabulated function is defined by $L(\lambda_H) = \zeta(\lambda_H) / 60 \times 2D(\lambda_H)$ were 2D is the length of daylight corresponding to a solar longitude equal to λ_H The equinox was taken at Aries 8° as in Babylonian system *B* solar theory. The length of daylight in the surviving Greek table was computed using a linear zigzag function having the traditional extremal values 210^0 and 150^0 (ratio 7 : 5), a standard scheme for Alexandria. In the published tables, the latitude of only Alexandria is used. The author David King provides a modified description of the function ζ, which differs but slightly from Neugebauer's, takes into consideration Vettius Valens' second table also. A rationale for the formation is provided based on a possible solution suggested by José Chabas.

David King describes at length the procedures for determining the *horoscopus* (ascendant) at the time of birth and the time of conception. The author cites the 'thumb rule' : the positions of the moon and the horoscopus at the time of conception get interchanged at the time of the birth. This is the basis of what is pompously called "pre-natal epoch theory" in western astrology. The mathematics and astronomical procedures involved in this theory are indeed impressive. But the question remains finally whether a child's longevity is pre-determined and whether it really obliges the beautifully evolved mathematical algorithm. The author does not seem to address this problem. It may be pointed out here that Varâhamihira (fl. 505 A.D.) in his astrological magnum-opus, *Bṛhajjâtaka* devoted an entire chapter to the determination of one's longevity (*âyurdâya*). According to his calculations the maximum longevity of man is 120 years and 5 days!

Jacques Sesiano in his article, "*Magic Squares for Daily Life*" describes the development of the science of magic squares in the Islamic civilization. It appeared in the ninth century, developed over the tenth and eleventh, and began to decline in the thirteenth. The magic squares (called *wafq al-a'dâd*) were being put to "magical purposes" as amulets or talismans – producing good results to oneself and bad to the enemies. The users needed no knowledge of the construction of such magic squares. Europe seems to have acquired the knowledge of magic squares through Latin translations of the Islamic works. An example of such an adaptation occurs in MS Vienna, copied in the fourteenth century. An excellent reproduction of the text is found in *K*. Nowotony's reprint of Cornelius Agrippa's *De occulta philosophia*. This text is transcribed and translated in Jacques Sesiano's article. The article contains the Latin text as well as its English translation. A typical passage in the text reads like this : "You are to know that in these seven figures the ancient philosophers and scholars have hidden the seven names of God, the reason being that nobody might pronounce them unworthily; for many ignorant persons may do much harm with them . . ." The nature of the contents of this text is best exemplified by the following: "The figure of Saturn is square, three by three, with 15 on each side.

2	9	4
7	5	3
6	1	8

The importance of this article under review lies in that the author explains the methods of construction of the *odd* and *even* ordered magic squares adopted in the text.

Bernard Goldstein in the article, "*A Prognostication Based on the Conjunction of Saturn and Jupiter in 1166 (561 AH)*", traces the theory of astrological history based on conjunctions of Saturn and Jupiter. The author points out that the same was already described in the past by Mâshâ'allâh (d.ca.815) and that its roots lie in the Sasanian period. This theory was applied by a number of Hebrew authors like Abraham Bar Hiyya (d. ca. 1135) and Levi ben Gerson (d. 1344). In the standard theory, a "small conjunction" (of Saturn and Jupiter) takes place every 20 years indicating a change in the ruler; a "middle conjunction takes place every 240 years (when the conjunction moves from one triplicity to another) indicating a change in dynasty. A "great conjunction" takes place every 960 years when a cycle is completed and the conjunction returns to Aries 0^0. The conjunction discussed in this article is a "small conjunction." It contains also "prognostciation" (*ha-davar*) made in the year 1153-54 concerning a forthcoming conjunction of Saturn and Jupiter to have taken place on July 31, 1166. It says : "This (conjunction) indicates a consolidation (*tiqqun*) of the affairs of kings . . . the strength of the conspirators of will diminish, their kingdom will fall and perish . . ."; it goes on like this. In the section entitled, *Astronomical and Astrological Commentary*, the author throws some light on the mean and true positions, as also the retrograde motion of Jupiter and Saturn for the assigned dates of conjunctions of these two planets.

George Saliba in his article, *"Reform of Ptolemaic Astronomy at the Court of Ulugh Beg*", reviews the results already published in the third issue of the *Arabic Sciences and Philosophy*. His continued interest in non-Ptolemaic astronomy helped him to examine the model for the motion of Mercury developed by Qushji (somewhere between 1420 and 1449) and al-Urḍî (d. 1266) of Damascus. While Qushji did not change the direction of motions, unlike what al-Urḍî did, he added two small epicycles functioning just like the small epicycle of al-Urḍî used in his own model for the upper planets. The author points out that Qushji's model did satisfy the axiomatic requirements of uniform motion and accounted for all the observations which were recorded by Ptolemy without any variations at all. Saliba makes an assessment of Qushji's model in the light of what is already known about the development of planetary theories in Arabic. The author points out that political patrons were usually interested in astrology, and thus restricted themselves to patronizing *zîjes* for astrological computations. He remarks that at least this was the case for the production of the *Ilkhânî Zîj* at Marâgha, for which the observatory was built in the first place. All the other non-Ptolemaic astronomical texts produced at that observatory came as an additional bonus. George Saliba produces new evidence of interest in non-Ptolemaic astronomy at the court of Ulugh Beg. In a text by al-Shirwânî (d. ca. 1486), a commentary on al-Qûsi's "*al-Tadhkira fî al-Hay'a*", it is said that Ulugh Beg used to visit the school he had built at Samarqand on a regular basis and would attend the classes of al-Rūmî. The classes were in Arabic, for the sole text that was read in astronomy was apparently the commentary of al-Nîsâbûrî (c. 1311) on the *Tadhkira* of Qûsî, which was also in Arabic. The author goes on giving details to confirm that the texts used, were all in Arabic and Sultan Ulugh Beg himself encouraged them and participated personally in their propagation.

Benno Van Dalen discusses the *Zîj-i Nâṣirî* of Maṣmûd ibn 'Umar in the article. This text is the earliest known Islamic astronomical handbook with tables that was written in India. Charles Ambrose Storey was the first western scholar to mention *Zîj-i Nâṣirî* in the astronomical section of his *Persian Literature: a Bio-Bibliographical Survey* (1958). Dalen records that Catalogue of the Mar'ashî Library in Qum (Vol. 23, 1994) provides a one-page description of the Persian manuscript 9176 (165 folios) which contains a complete copy of the *Nâṣirî Zîj.* Due to the efforts of Mohammad Bagheri (Tehran, Iran) and S. M. R. Ansari (Aligarh) that a photocopy of the whole manuscript was obtained. Benno Van Dalen proceeds to provide some preliminary results concentrating on the tables for calculating planetary longitudes. The author shows that nearly all of these tables derive directly or indirectly from '*Alâ'î Zîj,* the latest of the six *zîjes* written by the Caucasian astronomer al-Fahhâd (ca. 1180). In the course of his investigation Dalen shows that it is plausible that Chioniade's version of the '*Alâ'î Zij* contains the original planetary tables of al-Fahhâd. The *Nâṣiri Zîj* consists of two divisions (*rukn*), the first one on "details" in 66 chapters (121 folios) and the second on "general principles" (*kulliyât*) in 60 chapters (44 folios). The author provides a clear picture of the mean daily motions of the planets in *Nâṣirî zîj* by comparing those from the Byzantine version of the '*Alâ'î Zîj* with (1) the actual mean motion tables in that same work, (2) the estimates derived from the *Nâṣirî Zîj* and (3) the complete list of parameters in the *Sanjufînî Zîj*. He points out that each of the latter three sets of data can be derived from the basic set of '*Alâ'î* parameters listed in the Byzantine version. As far as the origin of the mean motion parameters in the '*Alâ'î Zîj* is concerned, it appears that not all of them were based on new observations.

In Table 2 of the article under review the author lists the epochal positions of the sun, the moon and the planets, their apogees, centrums and anomalies for Delhi. The solar equation (of centre) in the *Nâṣirî Zîj* assumes a maximum value of 1°59′ and the author points out that this value corresponds to a solar eccentricity of 2; 4,35,30 units which goes back to the Mumtaḥan observations. Table 3 gives the maximum equations of centrum for the five planets. These are close to the values given in Ptolemy's *Handy Tables.* The maximum value of planetary equations of anomaly are given in Table 4. Again, the maximum values and hence the related eccentricities and epicyclic radii are all Ptolemaic. Benno Van Dalen has successsfully established the dependence of *Nâṣirî Zîj* by Maḥmūd ibn 'Umar on the '*Alâ'î Zîj* by al-Fahhâd. Further it is shown that Maḥmūd computed accurate mean motion tables on the basis of the daily mean motions listed in the Byzantine version of the '*Alâ'î Zîj* by Gregory Chioniades and further unrelated *Sanjufînî Zîj*.

On the whole this volume is a very befitting felicitation in honour of Professor David Pingree. The learned articles, on topics dear to his heart, are woven verily into a garland of obeisance to Prof Pingree.