CHAPTER I
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ANCIENT INDIAN SPACE PROGRAMME

The beauty and regularity of the heavenly bodies have fascinated mankind from time immemorial. Perceptions of space and celestial bodies in ancient India derive from mainly two sources, which often overlap, namely mythological/religions explanations of the origins of the universe and the contributions of ancient scholars to astronomy. Given the vastness and richness of the Vedic and other related literature and the works of astronomy and astrology, what is attempted here is merely a bird's eye view of the perceptions of space during ancient times. This chapter sketches the contributions of ancient Indian astronomers to the Indian space programme and the role of ancient literature – secular or religious – in the field of astronomy. While ancient Indians were involved in finding the hidden secrets of the universe, there were others across the globe trying to explore the universe. It is interesting to note that almost all the observers of heavenly bodies concluded one of the three bodies – the Earth, the Sun – as the centre of the universe. While the discussion on the centre of the universe revolves around the three bodies, these observers are split on other propositions, such as the path of the moving objects. This chapter attempts to present the various theories proposed by ancient astronomers. The chapter begins with explaining the concept of cosmos and its
existence, and the role of Egypt, Babylonia, Greek and Rome in astronomical explorations.

Cosmology

Cosmology is the study of the universe as a whole, including structure and history of the universe. It tries to explain how the universe was formed, what happened to it in the past, and what might happen to it in the future.¹ The word cosmology derives from the Greek word kosmos, for the order that is revealed in the beauty of the sky.² Cosmology is different from cosmogony, which is concerned with the origin and evolution of individual objects in the universe, such as stars and galaxies.³ The study of the cosmos dates back to ancient times; however, modern scientific cosmology may be said to have begun as recently as 1917, when Albert Einstein applied his general theory of relativity to the structure of the universe as a whole.

Ancient Cosmologies

Primitive people had no conception of the true nature of the Sun, the Moon, the planets or “wandering stars”, and the so-called fixed star. Unable to understand

the cosmos that they observed, primitive men associated its mysteries with their religious beliefs.

Mesopotamia: The first real attempt to study the cosmos is found among the civilizations that inhabited the plains of Mesopotamia as long ago as 4000 BC. Their cosmological ideas – a mixture of astrology and astronomy – were based essentially on the notion that the earth is the most important heavenly body and the centre of motion for all other bodies. Thus, they assume that the vault of the sky does not rotate and that the sun, the moon, and the stars move above the earth in well-defined orbits; their ideas about the shape and position of the earth itself were very primitive and fantastic.4

Egyptian and Hebrew Concepts: The astronomy of ancient Egypt was no more advanced than that of the Mesopotamian civilization, and very few of its concepts can be separated from astrological notions. The Egyptian universe was substantially similar to the Babylonian universe; it was pictured as a rectangular box with a north-south orientation and with a slightly concave surface, with Egypt in the centre.5

A good idea of the similarly primitive state of Hebrew astronomy can be gained from Biblical writings, such as the Genesis creation story and the various

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5 Ibid.
psalms that extol the firmament, the stars, the sun, and the earth. The Hebrews saw the earth as an almost flat surface consisting of a solid and a liquid part, and the sky as the realms of light in which heavenly bodies move. The earth rested on cornerstones and could not be moved except by Jehovah (as in an earthquake). According to the Hebrews, the sun and the moon were only at a short distance from one another.

**Greece:** The first significant efforts to determine the actual structure of the universe were made in ancient Greece. Greece was the mother of European science and modern ideas. The scientific spirit developed by the Greek 2500 years ago laid the foundation for the future European civilization. Greek philosophers made very remarkable contributions about the universe. Pythagoras, a renowned mathematician who lived in the sixth century BC, and his followers held the view that everything in nature is controlled by numerical relationships, as in the regularity of celestial motions and the harmony among musical sounds. The Pythagoreans saw the Earth as a spherical body at the centre of the universe, around which other heavenly bodies circle. The fifth-century philosopher Philolaus, a member of the Pythagorean school, suggested that the earth and the other bodies circled around a central fire.

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Plato described a cosmological outlook similar to that of the Pythagoreans. He stated that the universe was created in a spherical form because the sphere is the most perfect of all shapes.\(^9\)

Aristarchus of Samos in the first half of the third century BC together with Heraclides Ponticus in the late fourth century BC were one of the first to advance the opinion that the Earth rotates daily on its axis and that the sun stands motionless in the centre of the universe as the earth moves around it. However, it was eclipsed by Ptolemy in the second century AD.\(^10\)

**Ptolemaic System.** Ptolemy was a Greek astronomer and mathematician who set forth a geocentric (earth-centric) view of the universe, which dominated astronomy until the advent of the heliocentric system (sun-centric) of Copernicus in the sixteenth century. According to him the planets were very much nearer to the Earth than were the stars, but that they were far from the moon. Because he had no way to determine their distances, he simply placed Mars, Jupiter and Saturn in increasing distances beyond the sun and located Venus and Mercury between the Sun and the moon. By means of deferments and epicycles, however, he was able to explain the

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\(^10\) Robert S. Phillips, (ed.), *Loc.cit.*, 
motions of the heavenly bodies about the earth in a more satisfactory way than did his predecessors.\(^{11}\)

**Ancient Indian Cosmology**

Indian astronomers too tried to explore the space and documented their finding in various works. However, these views were based on religious belief and superstition. In short, science and religion were inextricably intertwined. Early Indian cosmology is generally based upon squares and cubes. A work entitled *Ancient Astronomy and Cosmology* written by C.P.S. Menon states:

> There is first of all the earth based on a square, with a corner towards the south, and shaped like a pyramid, with a number of successive homocentric square terraces rising up to a point (or rather, to a small square): on the top of this is the mount Meru, a pyramid widening out as it rises, at a small angle to the vertical; round this lie the orbits of the sun forming homologous squares on horizontal plane; above the sun's plane is that of the moon with similar orbits. We may imagine above this were the planes of the different planets at increasing heights, as described in the Vishnu Purana (of the Hindus); if these were also originally square orbits, we should have the original

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conception of the orbits of the planets as forming the successive terraces of a pyramid representing the heavens.\textsuperscript{12}

Associated with this early Meru cosmology was a series of numbers, 4, 12, 28, 60, obtained through sub-division of the square, or a rectangle. The system was dictated by mathematical rather than by astronomical requirements. Later, Meru cosmology, which is to be found in the Jaina texts, adopted the circle as the basic form. Some of the Buddhist literatures such as \textit{Sara Sangha}, \textit{Visuddhi Magga}, \textit{Satta Suryagamana Suttanta}, and \textit{Jinalan Kara} described Maha Meru, or Sineru, which, it was believed, occupied the central position of the universe.\textsuperscript{13}

However, the first exclusive treaty of Astronomy entitled \textit{Jyotisha Vedanga}, which dates back to fifth century AD, deals with moon, \textit{nakshatras} (stars), \textit{ayanas} which fall in cycles of five years each of 366 days and solar years.\textsuperscript{14}

As mentioned earlier man has through the ages attributed divinity to all things humanly incomprehensible, for instance the concept of \textit{vismroopa} found in the \textit{Gita} and other religious texts. It reminds one that every animated or inanimated thing

\textsuperscript{13} A.L. Basham, \textit{A Cultural History of India}, (Delhi: Oxford University Press, 1997), pp.143-144.
\textsuperscript{14} \textit{Ibid}, p.143.
issues from, is enveloped by, and ends in, the divine power, which itself has no beginning, not subject to the wheel of time, and no end.\textsuperscript{15} As Arjuna says in the \textit{Gita}:

\begin{quote}
This space between heaven and earth is Perused by Thee alone; also all the quarters (directions of the sky). O, Exalted One, when this wondrous terrible form of Thine [i.e. the \textit{Vishnuroopa}] is seen, the three worlds tremble.\textsuperscript{16}
\end{quote}

The \textit{History of the Dharma Sastra}, authored by Professor Pandurang Vaman Kane (1880–1972) and published in five volumes, is an encyclopaedia of ancient social laws and customs. It indicates that the word \textquote{antariksham}, used at least a hundred times in the \textit{Rig Veda}, seems to bear two meanings: first the whole intermediate region between the heaven and the earth, and second the region of dust, mists and clouds.\textsuperscript{17} The heaven, the place of gods, was indeed unreachable for mortals. Hence the \textit{Rig Vedic} prohibition that \textquote{no one dare soar up to the third step of Vishnu (i.e. the heaven), not even the birds flying on their wings." There is also a reference to the ethereal regions created by the power of prayers by the sage Vishwamitra to fulfill the desire of King Trishanku of entering the Heaven with his physical body, who was not

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allowed to do so by Indra, the Lord of the Heaven. One is of course not sure whether this *trishanku stuungam* would form part of *antariksham* in its expansive sense.\(^\text{18}\)

**Mythological Theories of the Origin of Universe**

Various ancient Hindu texts express different mythological theories of origin of the universe. Although they differ in tracing the origin of the universe to a feminine divine power (*Devi* or *Shakti*), Shiva, or Vishnu, they all agree that the ultimate cause was and continued to be a divine power that created the universe and all the living and non-living things therein, and laid down the laws of nature according to which birth, life and death of the living beings, transformation of non-living things and movements of starts and planets take place.\(^\text{19}\) Yet, a majority of the texts tend to identify Vishnu, perhaps in the form of Krishna, as the ultimate cause, the *Parabrahmam*. Indeed when Krishna advises Arjuna, he represents the cream of all things in the universe:

> Great Brahma (Prakrit, i.e. Nature) is my work in that I cast the seed and from it is the birth of all beings, O Bharatha (Arjuna).\(^\text{20}\)

Tracing the origin of the universe to the Brahman,Parampurusha or Paramatma, the *Rig Veda* describes Him thus:

\(^{18}\) V.S. Mani, (ed.), *Loc.cit.*


A thousand (i.e. innumerable) heads hath pursa, a thousand eyes, a thousand feet. On every side perving the earth (the universe), he fills space ten fingers wide.21

According to Saptapatha Brahmana (the word Brahmanas refer to the interpretations of the Vedic texts), in the beginning there was only water. The water desired to procreate. As it toiled and prayed the parabrahman, it became overly hot and a golden egg materialised. It floated for as long as a ‘year’ (although Time, i.e. Kala, had not born yet). Then, a man named Prajapati endeavoured to speak, he produced the sound of bhub, and the earth was born; for bhuuah, the antarikham; and for suuh, the sky or the heaven.22

According to Manusmriti, in the beginning it was all darkness. Then the Lord appeared. He decided to launch upon the task of creation. He first created water and cast his seeds that became enveloped by a golden egg (hiranyagarbham) and stayed afloat (hence the name Narayana). Prajapathi, the Purusa himself, issued out of the egg. He broke the egg into two parts. The golden part formed the heaven, and the silver part, the earth; in the middle, the sky and the light regions and a perpetual place for water (antariksham) all materialised.23 Below the surface of the earth, the Patalas appeared, and became the abode of the demons. On the earth were born the animals, plants, and the humans. The heaven was the reserved domain of gods, the deus.

\textit{antariksham}, the mid-region, was allotted to the pitrus, the Gandharvas, the Kinnars etc.

In yet another version, the \textit{Brahmadaranyaka Upanishad} says that in the beginning there was \textit{Atman} (the soul) in the form of \textit{Pumsa}. Being alone, he found no pleasure, and so he desired to have a companion. He made his \textit{Atman} fall aside in two parts to become husband and wife from whom were born the humankind. He produced other animals. He made the universe unfold and develop. \textit{Atman} entered all creations up to their fingertips, “just as a razor remains hidden in the sheath or just as all supporting (fire) is not seen in wood”\textsuperscript{24}

Varied indeed are the ancient Indian theories of the origin of universe.\textsuperscript{25} Yet they appear to have been weighed by the “higher thought that insisted that the highest truth (\textit{Paramarthika sathyu}) is that \textit{Brahman} is one, that everything in the world (man, animals, inorganic matter) is \textit{Brahman}.”\textsuperscript{26} In this sense, the functions of creation (\textit{srishti}) and destruction (\textit{pralaya}) are the same as the establishment of the identity of the \textit{Atman}.

\textit{Agni Purana} attempts to deal with the various components of the universe. According to it, there are seven nether regions (\textit{patalas}) beneath the surface of the earth, namely \textit{atala, ritala, nitala, ghastimut, mokshya, suta}la and \textit{suya}. These are

\textsuperscript{25} \textit{Ibid.}, pp.1515-1522.
\textsuperscript{26} \textit{Ibid.}, pp.1498-1499.
made up of sand, stone and gold, of black, brown and reddish colour, fit for only
demons to live in. Beneath is the primordial serpent, *Adisesha*, who balances the earth
on its hundred hoods.  

According to these texts, nearest to the earth are the sun and the moon, and
then a belt of fixed stars. The distance between any two of these celestial bodies was
thought to be 800,000 *yojanas* (1 *yojana* = 3 miles). The farthest constellation is
*Saptarishi* (Ursa Major) and the Saturn is 100,000 *yojanas* from this constellation.  

The authors of the ancient texts were well aware of the immensity of the
universal space and hence the reference in *Atharvaa Veda* to the distance between
the earth and the heaven to be “a thousand days’ journey for horse,” perhaps a
poetic expression meaning “thousands of days”, a description of *Pumsa.*

The universe is known as the *brahmandam* i.e. the egg of the Brahman. The
ancient Indian scholars were aware that the Brahman had laid thousands of such eggs
and spread them out! Thence the statement in the *Agni Purana*:

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This Nature is inconceivable and battles all measurements and comprehension. Innumerable are the eggs of such worlds and systems which are constantly hatched into their fiery existence under the wings of the Divine Mother.  

The ancient Indian mind, therefore, should not have been surprised at the recent ‘discoveries’ of universes, galaxies, and celestial bodies whose existence was hitherto unknown to us, small insignificant earthlings.

Planets and Stars

Ancient Hindu texts including Vedas had knowledge of planets and nakshatras (stars), though they were not proved scientifically. However, it is highly remarkable how ancient Indian society observed the sky, the planets and nakshatras. Kane refers to Rig Veda, which makes specific mention of Brahaspati along with other planets: “Brahaspath (Jupiter) when first appearing, rose in front of Tisya (Pursya) constellation.” Kane would deem Vena to be Venus. To him, Rig Veda, Chapter X, Verses 123, 1 and 5 contains a “fine description of Venus rising in the east at dawn”.

The ancient texts have seriously discussed nakshatras. The word nakshatra has three meanings: (1) stars in general, (2) 27 equal parts of the zodiac, and (3) esterisms

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30 Ibid., p.74.
in the zodiacal belt (which may each consist of one or more stars). The first and the third are the meanings frequently employed in these texts, according to Kane. These texts enumerate twenty-seven or twenty-eight asterisms (there is a difference of opinion on recognising abhijit to be an asterism). A similar argument was put forward by A.L. Basham.


The twenty-eighth nakshatra was Abhijit, which was placed between Uttarasadha and Snruma. It will be seen from this list that the ancient Indian system of constellations differed widely from that of the West. However, in the year 1973 an article was published in the journal Annales Academiae Scientiarum Fennicae, from Helsinki it described that the nakshatras are of Harappan origin, as also are the later Dravidian names of the five planets related to their colours (e.g. Mars, the ‘red star’). Should this

be substantiated, it would locate the origin of the nakshatras, traditionally associated with the Hindus within the earlier Indus Valley culture.\textsuperscript{33}

The ancient texts are also familiar with the planets (graha), minor planets or satellites (upagraha), meteors (dhoomi), the polar star (jyotirath) and comets (dhoomakeetu). According to them there are seven planets: the Sun, the Moon, the Mars (Mangai), the Mercury (Budha), the Jupiter (Brahaspati), the Venus (Sukra), and the Saturn (Sani); to these Planets (grahas) were added Rahu and Ketu. While the Sun is both a nakshatra and planet, Rahu and Ketu are upagrahas. The legend has it that at the time when the premordial pcean was churned and the nectar materialized, a demon named saihikeya sought to steal it from Vishnu who beheaded the demon. The severed head became Rahu and the body, Ketu. According to Hindu Metrology, the solar eclipse takes place when Rahu swallows the Sun, and the lunar eclipse, when Ketu swallows the moon.\textsuperscript{34} Yet, there is evidence of rationalism found in Brhat-Samhitas that the real cause of eclipse was known to Indian astronomers several centuries before Varahamihira (sixth century AD). It is interesting to note that the enumeration of the planets closely follows the names of the days of week.

Ancient Indian Scholars

There was considerable overlapping between astrology, astronomy and mathematics in ancient India. Vedanga Jyotisa in fact does not distinguish between

\textsuperscript{33} A.L. Basham, \textit{A Cultural History of India}, p. 161.
\textsuperscript{34} A.L. Basham, \textit{The Wonder that was India}, p. 491.
them. Thus as seen already, while astrology attributed eclipses of Rahu and Ketu, there was awareness among rationalists that they were caused by the movements of the moon and the earth in relation to the sun. By AD 500 scholarly treatises in astronomy materialized involving a systematic study of matters and methods hitherto unknown. These were called the *siddhantas*, and the prominent among them were the *Paitamaha Siddhanta*, the *Vasishtha Siddhanta*, the *Paulisa Siddhanta*, the *Romaka Siddhanta*, and the *Surya Siddhanta*. In this connection ancient scholars contributed remarkably.

*Aryabhatta*

Aryabhatta is also known as Aryabhatta-I to distinguish him from the later mathematician of the same name who lived about four hundred years later. He was born in AD 476 at Kusumapura near Patna. At the age of twenty-three, he authored *Aryabhatiya* composed in AD 499.\(^5\) *Aryabhatiya* speaks about mathematics and astronomy, the mathematical part covering arithmetic, algebra, plane trigonometry and spherical trigonometry. Aryabhatta gives the radius of the planetary orbits in terms of the radius of the earth/sun orbit as essentially their period of rotation around the sun. He believes that the moon and planets shine by the light reflected from the sun; incredibly he believes that the orbits of the planets are ellipses. He

correctly explains the causes of eclipses of the sun and the moon. The Indian belief up to that time was that eclipses were caused by a demon called Rahu.

Aryabhata has been credited with the view that stars did not revolve around the Earth, but the earth rotated on its own axis and “gave the illustration of a person in a vessel, while moving forward,” says Aryabhata, “sees an immovable object moving backward, in the same manner do the stars, though immovable seem to move daily”. This is what popularly known as heliocentric theory as already proposed by some of the Greek scholars – for example, Aristarchus of ancient Greece (270 B.C.). It is very unfortunate that this theory was not popularised by the contemporary scholars and their successors. As the result, the entire world waited around thousand years for this theory to be properly addressed by Copernicus in the fifteenth century AD. Government of India, in memory of Aryabhatta’s contribution, named after him India’s first satellite.

Varahamihira

Aryabhata’s successor, Varahamihira was born at Avanthi, the capital of Ujjayini, in the sixth century AD. He has given us no less than six works on all the

three branches in his *Jyotish Sastra*: Tantra (astronomy and mathematics), *Hora* (horoscope), and *sambita* (astrology). His astronomical work *Panhashidhdantika* has five older siddhantas: Paulisa, Romaka, Vasishta, Saura, and Paitamaha.\(^{39}\) The first of these belonged to the pre-scientific period, and the other four show a more advanced stage of thought and spirit. His work *Brihat Sambita*, edited by Dr. Korn, consists of no less than 106 chapters, dealing with various subjects. The first thirty-nine chapters of the work related to the sun, moon, earth, and planets.\(^{40}\) Varahamihira rejected the Aryabhata's view that the earth was a sphere and rotated on its axis and that the eclipses were not the work of Rahu but caused by the shadow of the earth falling on the moon. Varahamihira claimed that the moon rotates around the sun. He utilised several Greek words to explain the movements of the planets and some other astronomical problems. Although the Greek knowledge influenced Indian astronomy, the Indians, doubtlessly, pursued the subject further and made use of it in their observations of the planets.

*Bhaskara I and II*

Bhaskara I (b. AD 629) authored *Mahabhaskariya* and *Laghubhaskariya* and a Bhaya on *Aryabhatiya*. Bhaskara II (b. AD 1114) wrote *Siddhanta Sironani* in AD 1150. The latter explained the motions of the sun, the moon and the planets with the help of some models and astronomical instruments. He wrote a manual for easy

calculations of astronomic events and an accurate calendar was evolved with the help of this.\textsuperscript{41} The preliminary portions of this work are the \textit{Vijaganita} (algebra) and the \textit{Lilavati} (arithmetic) and have been translated by Colebrooks; the \textit{Goladhyaya} portion on spherical trigonometry has been translated by Wilkinson and revised by the renowned mathematician, Pundit Bapudeva Sastri.\textsuperscript{42}

Though evidence exist to suggest that the ancient Indians had a vast knowledge of the celestial bodies, still doubts prevail about the originality of the concepts and construction of these knowledge. Influence of Westerners, particularly Greeks, is believed to be substantial.

Romila Thapar pointed out that “contact with the Hellenistic would have introduced a variety of new systems, some of which were incorporated into Indian astronomy.” Further, she argues, “Varahamihira’s \textit{Pancharatnaka} discussed the five currently known schools of astronomy, of which two reflected a close knowledge of Hellenistic astronomy. The exploration of all these systems had not been carried out in isolation. An increasing dialogue existed between Indian and Arab astronomers and mathematicians, similar to the earlier one between Hellenistic and Indian astronomers. Indian works on mathematics, astronomy and medicine in particular were much praised in the scholarly centers that arose under the caliphate at Baghdad.

and where Indian scholars were resident. It seems to be the interchange of ideas was a characteristic of these systems of knowledge, even though some of the breakthroughs came from Indian thinkers.

These interests and involvement in sciences in general, and space science in particular, did not develop as one may expect. Instead the following period saw the waning of interest and activities in space science. Various reasons can be attributed to this.

There are many aspects to the concept of interior and exterior space in Islam. The best way to start is, as always, to go back to the Koran, where the so-called Throne-verse (Sura 2/256) says:

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\text{rasic'a kuniyshbu's-samkada wu'l-and wa la ya'uddubu bijnubuna wa hima'l-all al-azim}
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It means God’s Throne encompasses the heavens and the earth, and it is not difficult for Him to preserve them. That means that God’s throne is the all-comprehensive entity in which everything else is integrated.

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There is still another aspect of the concept of space in Islam, a concept which probably would come to mind at the very outset. That is architecture. In the structure of mausoleums the high dome may be understood as representing the heavenly sphere, although one should beware of an oversimplified “mystical” interpretation of architecture.45

In India, during the Medieval period, when the Muslim monarchs ruling India, the main purpose of astronomy was one of working out a calendar, fixing the dates of seasons, festivals and for administrative requirements, use in navigation, calculation of time and casting of horoscopes.46

There are number of technologies and industries existed in medieval India. Even while keeping in mind that it may be hard to distinguish between science and technology prior to the Industrial Revolution, medieval Indian society exhibited a fair degree of development in science. The development of scientific thinking was especially evident in the field of astronomy. Due to extensive patronage extended by a number of Mughal rulers, medieval Indian society offered an advantageous climate for the development of the indigenous as well as central and west Asian astronomical traditions.47

45 Ibid., p.177.
A number of factors contributed to the patronage of astronomy by the Mughal rulers. Significant aspects of the lives of people were partly influenced by astrological considerations, which themselves depended on an accurate knowledge and understanding of the trajectories of planets and stars, most of the medieval rulers and elites were well versed in and aware of the different astronomical traditions. For example, the first Mughal ruler, Babar, was cognizant of some of the practical uses of astronomical tables. In his discussion of the astronomical work of one of his ancestors, Mirza Ulugh Beg of Samarkand, Babar described a “fine building [which] is an observatory, that is, an instrument for writing Astronomical Tables. . . . [B]y its means the Mirza worked out the Kurkani Tables, now used all over the world”.

Another passage indicates that Babar was aware of other distinctive traditions of observational astronomy: "Not more than seven or eight observatories seem to have been constructed in the world. Mamum Khalifa made one with which the Mamumi Tables were written. Batalmus [Ptolemy] constructed another. Another was made, in Hindustan, in the time of Raja Vikramaditya Hindu in Ujjain and Dhar. The Hindus of Hindustan use the Tables of this Observatory". Astronomical observation and the calendars compiled as a result of such observations were useful in the sphere of religion as well as in the administration of the empire. For example, in the construction of mosques in South Asia particular care had to be taken to ensure that they were built in such a way that people praying faced Mecca. In Babar's time,

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49 Ibid.
astronomical observation was being utilised to achieve accuracy in delineating the ritually specified directional orientation of the Muslim places of worship. In 1498 A.D. Babar recorded in his diary that “there is great discrepancy between the qibla of this mosque and that of the College; that of the mosque seems to have been fixed by astronomical observation”.

Babar’s son and successor, Humayun (1530-1536), was also keenly interested in and patronized astronomy. In Jahangir’s memoirs, a reference is made to a handwritten manuscript by Humayun that contained “an introduction to the science of astronomy, and other marvelous things, most of which he had studied and carried into practice”. Abul Fazl records that shortly before his death, Humayun was planning to construct a large astronomical observatory and had even acquired a number of astronomical instruments. During the reign of his son, Akbar, (1536-1605), patronage of astronomy and astrology continued. Abul Fazl in his Akbar Nama mentions “Maulana Chand, the astrologer, who possessed great acuteness and thorough dexterity in the science of the astrolabe, in the scrutinizing of astronomical tables, the construction of almanacs and the interpretations of the stars”.

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50 Ibid.
This reference from Abul Fazl's account of Akbar's reign explicitly establishes a symbiotic relationship between astrology and observational astronomy. Maulana Chand compiled a set of astronomical tables known as *Tahsilat-i-Akbar Shahi*, which was referred to by the astronomer-statesman, Raja Jai Singh, almost two hundred years later. Finally, astronomy was explicitly patronized during the reign of Akbar's son, Jahangir (1605-1627), who was an accomplished naturalist himself. His memoirs, the *Tuzuk-i-Jahangiri*, contain extensive accounts of the flora and fauna of medieval India. The following extract from Jahangir's memoirs illustrates his own keen interest in astronomical knowledge and provides evidence of the presence of astronomers in that period.53

It is evident that due to a number of factors, astronomy attracted considerable patronage in medieval India. One of the factors that indirectly stimulated interest in astronomical observation was the widespread use of astrology for determining the auspicious as well as accurate timing for significant undertakings. Astronomy and astrology were not clearly demarcated from each other in the medieval or the ancient period, and the memoirs of the various Mughal rulers are replete with references that establish the significance accorded to the effect of the positions of the stars and constellations on human affairs.54

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54 Henry Beveridges, (trans.), *The Akbar Nama of Abu-l-Fazl, Loc.cit.*, 
In 1584, during the reign of Akbar, Fathullah Shiraz reinterpreted the astronomical data from the tables of the central Asian astronomer Ulugh Beg. As a result, a new and reformed solar Ilahi-era calendar was introduced and adopted as the official calendar of the Mughal Empire for nearly seventy-five years. During Aurangzeb's reign in 1659, this solar calendar was replaced by the lunar Hejira calendar, which, in turn, was rejected after his death in 1707. Efforts at compiling a reformed solar calendar based on empirical observation of the trajectory of the sun led to the construction of the giant astronomical observatories by Jai Singh in early eighteenth-century India.55

The main observatories continued to be at Ujjain, Benares, Mathura and Delhi. The former two were the old observatories, the one at Delhi was first organised by Humayun at Sher Mandal, though a few observational posts were erected at the time of Firoze Tughlaq, and finally by Raja Jai Singh II of Jaipur in the reign of Muhammad Shah. There was an observatory at Daulatabad established by Firoze Shah Bahmani under Hakim Ali Mohsin and Saiyyad Muhammad Kazimi. Shah Jahan had also proposed to build an observatory for Mulla Mahmud at Jaunpur, but it could not materialise for lack of funds.56

The finest and the best chain of observatories were, however, erected by Raja Jai Singh II of Jaipur. The synthesis of these diverse astronomical traditions found its

most spectacular expression in the five gigantic observatories designed by Raja Jai Singh II, and completed between 1722 and 1739. Delhi and Jaipur observatories were started in 1718 and completed in 1734. The observatories constructed at Ujjain, Mathura and Benares no longer existed. The chief features of these were the masonry instruments which he had erected in preference to small metallic ones to increase the accuracy of measurements. On the basis of the observations carried out at these observatories, Zij-i-Jadid Muhammad Shabi was compiled by Raja Jai Singh II and is by far the most outstanding book of the period.

Jai Singh was a Rajput ruler who exercised control over a semi-autonomous territory in present-day Rajasthan. Although Jai Singh had control over this vast territory, he also owed nominal fealty to Muhammad Shah in Delhi, the emperor of a rapidly declining Mughal empire. Raja Jai Singh was a statesman-scholar who was well versed in astronomy, and patronized a large number of indigenous astronomers of his time. Patronage was a significant factor, as without the wealth from Jai Singh’s treasury, neither the construction of these giant observatories nor the support for different schools of indigenous astronomers would have been possible in the late medieval period.

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The chief instrument for astronomical observation was the astrolabe. This reached its zenith in the 17th century in India; of that period about 40 astrolabes are still extant. Lahore seems to have been the major centre for the industry where about 29 were made. Of the astrolabe makers we have an account of one family from the time of Humayun to Aurangzeb. Besides the astrolabe the other instruments used were the various types of quadrants and armillary spheres.  

However, the general belief about earth varied from flat to a solid sphere, its rotation though discussed was refuted, and geocentric theory was generally accepted. The phenomenon of seasons was explained on the basis of revolution of the sun in general, the Ptolemaic scheme was in vogue.  

Overall, regardless of the changing socio-historical context, astrology and astronomy were patronized by successive rulers. In fact, the changing socio-historical conditions were conducive to a partial synthesis of indigenous, central and west Asian astronomical traditions.  

In any case, the decline or “collapse” of the Mughal Empire, precipitated by internal structural contradictions and accelerated by the growth of trade by the East India Company, led to the decline and eventual disappearance of patronage for scientific activity or large-scale public works projects, which had encouraged technical  

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innovation. However, it is ironical that the arrival of the first British ship in India coincided with the invention of the telescope in Europe.

The seeds of science which scattered from the Middle East sprawled to various parts of the world and grew which laid the foundation for the development of science in the Europe during early modern age. Anyhow, the modern science; as concept and practice came to India only from the Europe.

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