Eclipses in ancient cultures

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Abstract
We discuss the different approaches to the observation of eclipses by ancient cultures with a particular emphasis on the astronomical myths in the Indian culture. We show that all cultures begin by assuming that during eclipses Sun and Moon are being devoured by some creature and that it is a bad omen. Only a few cultures take it as a good omen. In India this myth of the creature makes for a complex narrative in the form of Rahu and Ketu. As the culture evolves and the true cause of eclipse become apparent, in most cultures, the earlier stories are forgotten. In India Rahu and Ketu are transformed into the ascending and descending nodes of the plane of interaction of the Ecliptic with the Equator and their position with respect to the Sun and the Moon are used to predict eclipses.

Introduction
Humans have been fascinated and afraid of eclipses that seem to hurt the two principal celestial sources that are central to their life, the Sun and the Moon. Every culture has reacted differently to the occurrence of eclipses. Most cultures have elaborate stories on the reasons for occurrence of eclipses and methods to help Sun and Moon during eclipses. Comparing these myths provides valuable insights into the thinking of different civilisations.

Ancient eclipses are a very valuable resource for historians. They allow historical events to be dated precisely and ancient calendars cab be calibrated by this method. They provide insight on the complexity of the Earth-Moon system over a period of hundreds of years (see e.g. Tanikawa and Soma, 2004, Tanikawa, Yamamoto and Soma, 2010, Soma and Tanikawa, 2010, Vahia et al., 2013, Espank, 2011). Recent solar eclipses have also proven to be valuable tool for understanding the interaction between the Sun's corona and the Interplanetary medium. More recently eclipses have been used to confirm the theory of relativity.

Eclipses occur when, as seen from Earth, the disk of the Sun gets obstructed or the disk of the Moon goes dark. It is a result of the location where the shadows of Earth and Moon fall. In principle of course, the Earth and the Moon cast their shadows all the time. However, we record it as an eclipse when the Moon's shadow falls on Earth (Solar Eclipse) or Earth's shadow falls on Moon (lunar eclipse). Since the Earth – Moon – Sun system is not perfectly synchronised, it is not easy to predict eclipses. The angle between the orbital plane of the Sun and Moon around the Earth is off by about 5^{o} and hence the shadows tend to miss the Earth or Moon as the case may be. For an eclipse to occur, it is important that both the objects are on the point of intersection of the two orbits. If the Sun and Moon are on opposing intersection points, we get a Lunar Eclipse which is visible over a whole hemisphere of the Earth. If both are on the same side of the Earth however, the Moon shadow will be visible in some specific part of the Earth only.

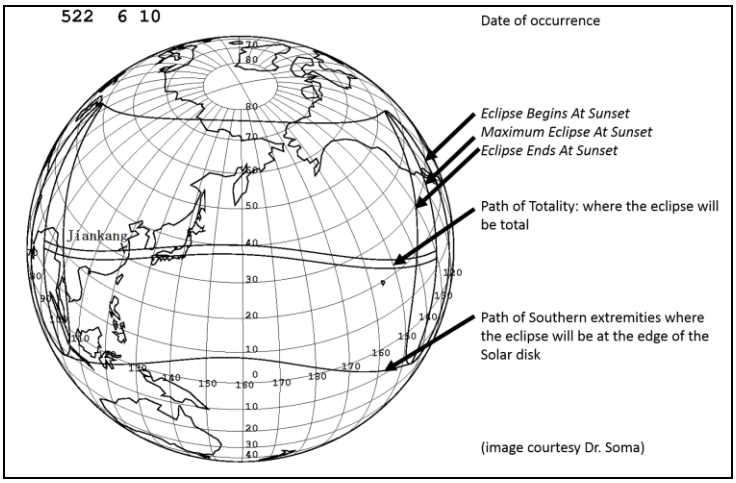

Figure 1: Path of a solar eclipse. The image is courtesy Dr. Soma.

This path is difficult to predict since the orbits are not perfectly circular and the distance between the Earth and Moon and Earth and Sun is not constant. This makes prediction of Eclipses, especially Solar Eclipses very tricky. Ancient Indian astronomers used the concept of 'Vyatipata', when the Sun and the Moon were close to the point of intersection of the orbits of Sun's orbit and Moon's orbit (called Rahu and Ketu). At Vyatipata, an eclipse, visible somewhere on the Earth was sure to occur but it may or may be visible from a specific location, especially in the case of Solar Eclipse (Balachandra Rao and Venugopal, 2008, see also Shylaja in this volume). It is suggested that at Stonehenge in UK, as early as 3000 BC, stone markings were used to keep track of the proximity of the Sun and Moon to predict eclipses (Hoyle, 1977).

Belief systems

Different cultures respond to eclipse in different manners (Rana, 2000). In ancient Egypt, the King who was a representative of Sun went around the city to reassure people. Babylonians, Greeks and Romans considered it an omen and the month in which the eclipse was recorded was considered important. Batammaliba people in Togo and Benin believe that Sun and Moon are fighting during an eclipse. The people encourage the sun and the moon to stop fighting. Armenians thought that Sun was invaded by a black planet at eclipse.

West Africans believed that the shadow of the Sun fell on the moon at lunar Eclipses and they gathered in open spaces to urge the shadow to leave the Sun alone. American Indians believed that during Eclipse the Sun lost some of its power and help rekindle it by sending burning arrows in the direction of the Sun. Japanese lit fires or displayed shiny jewels to compensate for the dulling of the Sun or the moon. Maoris of Assam believed that lunar eclipse announced an imminent victory over their enemies. Eskimos turned their utensils upside down to prevent bad influences from falling into their cooking (Rana, 2000). Kolams, a small tribe in Central India have an interesting myth about Eclipses. They consider solar eclipse as the time when debt collectors come to collect the dues from Sun. (Vahia et al., 2014).

In China, India, Peru and South East Asia there were beliefs that dragons or demons

attack the Sun during eclipses. The ancient Egyptian myth of the snake Apep that attacks the boat of the Sun god is believed now to refer to solar eclipses. The Chinese and the Incas tried to frighten these monsters away but the Indians made a different attempt by immersing themselves in water. They performed this religious ritual to help the Sun struggle against the demon. Even today, in some countries, it is still traditional to bang pots, chant or shoot into the air when an eclipse happens.

Eclipses and major civilisations

Major civilisations had a more complex and evolved approach to eclipses. We summarise this below (See also, Zhentao et al. (1989), Steele (1998) and Stephenson (1997) along with the web references).

Ancient China

In ancient China, the solar and lunar eclipses were considered to be omens that foretell the future of the Emperor. It was therefore important to predict eclipses. The ancient Chinese believed that solar eclipses occur when a celestial dragon devours the Sun. They also believed that the same dragon attacks the Moon during lunar eclipses. It was a tradition in ancient China to bang drums and pots and make loud noise during eclipses to frighten that dragon away. Even more recently, in the nineteenth century, the Chinese navy fired its cannons during a lunar eclipse to scare the dragon that was eating the Moon.

Chinese traditions of astronomical observations can be dated to Li Shu in 2650 BC and they had sophisticated observatory buildings by 2300 BC. Observing total solar eclipses was a major element of forecasting the future health and successes of the Emperor. The astrologers worked hard to predict eclipses. In at least one recorded case, Chinese Emperor Zhong Kang of China supposedly beheaded two astronomers, Hsi and Ho, who failed to predict an eclipse in 2300 BC. Systematic Chinese records of eclipses begin at around 720 BC. The 4th century BC astronomer Shi Shen described the prediction of eclipses by using the relative positions of the Moon and Sun. The "radiating influence" theory (i.e., the Moon's light was light reflected from the Sun) was existent in Chinese thought from about the sixth century BC (in the *Zhi Ran* of Zhi Ni Zi). Records from ancient China show that by about 20 BC Chinese astrologers understood the true cause of eclipses, and by 8 BC some predictions of total solar eclipse were made using the 135-month recurrence period. By CE 206, Chinese astronomers were able to predict solar eclipses by analysing the motion of the Moon.

Solar eclipses, were considered important enough to be recorded in chronicles and on "oracle" bones – pieces of animal bones and tortoise shells which were probably used for divinations. Oracle bones hail from the Shang dynasty (c. 1600 - 1050 BC) and make many references to solar eclipses. The eclipse records are often incomplete, however, and the dating of the bones is not reliable. Records of eclipse can be found from the Chou dynasty and Warring States period (c. 1050-221 BC), and onward. They have been precisely dated, and it appears that some astronomers recognized eclipses as naturally occurring phenomena. From the Chou dynasty, 36 solar eclipse observations are recorded in the Ch'un-ch'iu beginning around 720 BC. The Piao and the Shih-chi documents refer to nine solar eclipses from the Warring States period.

For example it is noted that Jul 17, 709 BC: "Duke Huan, 3rd year, 7th month, day jen-ch'en, the first day, the Sun was eclipsed and it was total." (Ch'un-ch'iu). In another instance, it is noted that on Oct 24 444 BC: "Duke Li (of the Ch'in dynasty), 34th year. The Sun was eclipsed. It became dark in the daytime and stars were seen." (Shih-chi, chp. 15).

Ancient Egypt

Our understanding of ancient Egyptian civilisation's knowledge of astronomy comes to us from tomb paintings, temple inscriptions, and a few of papyrus documents. The oldest example of a sundial is Egyptian from about 1500 BC. The fabulous astrological ceiling of Senmut painted around 1460 BC, includes celestial objects such as Sirius, Orion, and four planets Mercury, Venus, Jupiter, and Saturn. The oldest known copies of an almanac are dated to 1220 BC at the time of Ramses the Great. In 1100 BC Amenhope wrote "Catalogue of the Universe" which identifies the major known constellations. The Vienna papyrus that describe lunar and solar eclipses and their portent was probably copied in late second century AD, and presents knowledge of astronomy that is regarded as Babylonian in nature.

The Egyptian astronomer Ibn Yunus (950-1009), regarded as one of the greatest observational astronomers of his time, made detailed observations of lunar and solar eclipses in Cairo.

Babylon and Sumeria

Astronomy flourished in Mesopotamia (present day Iraq, Kuwait, Syria, Jordan and Israel) lying in the plain between the rivers Tigris and Euphrates, around 4^{th} millennium BC. The Babylonian astronomers observed the motions of the Sun, Moon and planets carefully and kept records of the celestial events. They are also credited with remarkable contributions to ancient astronomy. Three important solar eclipses were recorded in Mesopotamia. The first one was that of the eclipse of 3 May 1375 BCE, which was visible in the city of Ugarit (located in present Syrian Arab Republic). Another total eclipse "that turned day into night" was found to be the eclipse of 31 July 1036 BCE. The third is an Assyrian record of the solar eclipse of 15 June 763 BCE that was observed in the city of Nineva.

Babylonian astronomers are credited with having discovered the 223-month period for lunar eclipses, most probably using the Lunar Eclipse records. "If the sun at its rising is like a crescent and wears a crown like the moon: the king will capture his enemy's land: evil will leave the land, and (the land) will experience good." Refers to a solar eclipse of 27 May 669 BC. Rasil the Older, Babylonian Scribe to the King.

Ancient Greece

The ancient Greek astronomers also kept records of the eclipses. Aristarchus (ca. 320-250 BCE) made a rough estimate of the lunar diameter and proposed the first known heliocentric model of the Universe. In this model, the Sun, not the Earth, is at the centre of the Universe. Hipparchus (190-120 BCE) compiled the first star catalogue. The ancient Greek astronomers had also great knowledge of eclipses. A fragment of a lost poem by the Greek poet Archilochus (ca. 680–645 BCE), suggest observation of a total solar eclipse. “Nothing there is beyond hope,

nothing that can be sworn impossible, nothing wonderful, since Zeus, father of the Olympians, made night from mid-day, hiding the light of the shining Sun, and sore fear came upon men.".

Herodotus, (5th century BC), as cited by the Greek philosopher Thales (ca. 624-547 BCE), predicted the solar eclipse of 28 May 585 BCE. It put an end to the conflict between the Lydians and the Medes. Herodotus wrote:"… day was all of sudden changed into night. This event had been foretold by Thales, the Milesian, who forewarned the Ionians of it, fixing for it the very year in which it took place. The Medes and the Lydians when they observed the change, ceased fighting, and were alike anxious to have terms of peace agreed on".

Before 450 BC, Meton realized that a single period of 235 lunar months (19 years) would cause the popular lunar calendar to return to synchrony with the solar, seasonal calendar. At this time, the same lunar phase would be recorded at the same time of the solar calendar year. This period also gives a rough guide to when a lunar eclipse will recur at the same geographic location.

Claudius Ptolemy (ca. 87-150 CE) wrote about eclipses in Almagest. His writings show that he studied the lunar orbit carefully and had a complex scheme for predicting both solar and lunar eclipses. Ptolemy noted that the Sun must be within 20 degrees 41' of the node point, and that up to two solar eclipses could occur within seven months in the same part of the world.

The Mayans

While Chinese, Babylonian, and Greek astronomers dominated the knowledge of old world astronomy, half way across the globe, Mayan observers were working on calendars and recording celestial observations. The Dresden Codex records several tables thought to be lunar eclipse tables. As in previous civilizations in other parts of the world, the Mayas used records of historical lunar eclipses to calculate how often they occurred over a 405-month period. There is no mention of recorded total solar eclipses, or discussions in the Codex for how to predict these events. After the Spanish Conquistadores, came the missionaries in the 1600s who intentionally destroyed nearly all native written records. Little survives to tell us whether the Mayas, Incas, or Aztecs achieved a deeper understanding of solar eclipses and their forecasting.

The Islamic World

Islamic astronomy became the western world's powerhouse of scientific research during the 9th and 10th centuries AD, while the Dark Ages engulfed much of the western world. The works by Ptolemy, Plato, and Aristotle were translated, amplified upon and spread throughout the Muslim world.

Arabic astronomy played one important historical role. An annular solar eclipse of 27 January 632 was visible in Medina during the lifetime of Prophet Mohammad (Peace Be Upon Him (PBUH)). It coincided with the death of his little son Ibrahim. The Prophet stated explicitly and definitely that the eclipses of the Sun and the Moon are not bad omens, but are cosmic spectacles that demonstrate the might and knowledge of Allah the Great.

Ancient India

Some of the most elaborate myths regarding Eclipses can be found in India. In the ancient Indian religious structure, the universe exists on the basis of tripartite agreement between Gods, Ancestors and Humans. Each must curry favour from the other by giving gifts etc. Because at the time of eclipse the Sun God is in trouble, humans must donate generously to help gods fight off the threat from the Asuras. This practice continues even today. Eclipses are therefore the time for donations and these donations are recorded.

The oldest reference of Eclipse in India is in the Rig Veda (around 1200 to 1500 BC) (see Subarayappa and Sarma, 1985). In its 5th book on verse 40, the lines 5 to 9 describe the effect of eclipse. It describes how the great sage Atri saved the Sun when the demon *Svarbhanu* tried to destroy him. Rig Veda Book V Verse XL states that

> Oh Sun, Svarbhanu pierced you through and through with darkness,
> All creatures looked like one who is bewildered,
> who knows not the place where he is standing
> What time were you struck by Svarbhanu's magic that spread itself beneath the sky, O Indra?
> By his sacred prayer, Atri discovered Surya Concealed in gloom that stayed his function.
> "Let not the oppressor with this dread, through anger swallow me up, for I am yours O Atri .."
> The Brahman Atri, as he set the press-stones, serving Gods with adorations.
> Atri found the Sun again, him whom Svarbhanu of the brood,
> this none besides (Atri) had the power to do.

In Pancavimsa-Brahmana (900 – 600 BC), there is a description of the eclipse. `The demoniac Svarbhanu struck the Sun with darkness; the gods did not discern it (the Sun, hidden as it was in darkness): they resorted to Atri; Atri repelled its darkness by the *bhasa?*

> *The part of the darkness he:*
> *first repelled* became a black sheep;
> what (he repelled) the second time (became) a silvery (sheep);
> what (he repelled) the third time (became) a reddish one;
> and with what (arrow) he set free its original appearance (colour), that was a white sheep.'

According to the more common story, Gods and Asuras wish to attain immortality by consuming a nectar that is available under the sea. In order to extract this, the Gods and Asuras join hands and churn the seas. However, when eventually the nectar does come out, the Gods send a beautiful woman – Mohini to distract the Asuras. She largely succeeds but Rahu realises what is going on. He therefore takes the form of one of the Gods and tries to get some of the nectar. Just as he is about to consume it, the Sun and the Moon realise what is going on, and they try to stop him by cutting off his head. But it is too late. The angry, disembodied Rahu, for ever tries to take revenge on the Sun and the Moon and hence the eclipses arise.

According to other references, a demon Svarbhanu attempts to pierce the Sun with his magic. In later literature Svarbhanu is called Rahu, a more common name today. Rahu is an Asura (an alien but not a demon). Swarbhanu is the son of the Rakhasi Singhika (or Samhika) (Sister of Dhruva and grandson of Hiranyalashyap) who worshipped Bramha and asked for the boon of having the same status as the planets in the heavens. After the churning, the severed head was taken by the mother of Asura Swarbhanu and nursed patiently. Over a period of time, the head was named Rahu. On the other hand, a Brahmin named Mini took the severed body and he brought it up as his own son. Lord Vishnu granted a serpent's head to this body named Ketu, who in due course of time became a revered seer. Rahu is further classified as Nitya and Parva Rahu. As Nitya, Rahu keeps tugging at the Moon causing it to wax and wane, while the Parva Rahu swallows the moon causing the lunar eclipse. Ketu causes the Solar Eclipse. However, in the modern version, Rahu causes the eclipses and Ketu is associated with comets.

In later literature, Comets are called *Dhum*ketu (or Ketu with a smoke). While the literature has lots of discussions on the kinds of comets, there are no explicit citing records that can be dated. Like all ancient astronomies, Indian astronomy begins with 7 'planets' – Sun, Moon, Mercury, Venus, Mars, Jupiter and Saturn that make up the 7 days of the week. However, to calculate Eclipses, it is good to keep track of the Rahu and Ketu. Hence, in later mythology, there are 9 'planets' and Rahu and Ketu are called dark planets.

By about 499 AD, Indian astronomy becomes more mathematical. The great scholar Aryabhata states that: "the Moon eclipses the Sun, and the great shadow of the Earth eclipses the Moon". "When at (New Moon) the Moon lying near its node "enters the Sun" or at Full Moon it enters the Earth's shadow it is more or less the middle of an eclipse" i.e. solar eclipse in the former case, and lunar eclipse in the latter case. At this stage Rahu and Ketu are redefined as the ascending and descending nodes of the points of contact between the Ecliptic and the Equator. When both Sun and Moon approach this point, we get an eclipse.

Since then several hundred eclipses have been recorded in ancient Indian records (Shylaja, 1997, Vahia and Subbarayappa, 2011, see also Subbarayappa in this volume). The method employed by them will be discussed by Ramasubramanian and Shylaja in this volume.

Summary

In general therefore, all cultures begin by assuming that the Sun and the Moon become dark during eclipses because something happens to them. In most cases they assume that some form of demons are attempting to devour the Sun. The most common approach to the problem is to scare away the offending entity by making noises or firing arrows etc. In rare cases it is assumed that the Sun has been dulled by illness or some other cause. In that case, the approach is to attempt to support the Sun with other shining objects. However, most cultures seem to attach some omen to the eclipses. In most cases the eclipse is considered a bad omen and only rarely is it considered a good omen.

In India a continuous evolution of the myth provides an interesting perspective. Beginning with the classical belief in a demon (Rahu) eating up the Sun, a more elaborate story of its intentions is created and the life history of the demon is integrated into other prevalent stories. With the realisation of the true reason for the eclipses the story is then modified to use the same names of demons for astronomically important points whose location is calculated to predict eclipses. The astronomers of India often recorded eclipses which were not visible at their locations. However, the most important source of eclipse records in India is the inscriptions that record the donations made at the time of eclipses, supposedly to assist the Sun at the time when it is being troubled by the demon.

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