COLOURS OF LUNAR ECLIPSES ACCORDING TO INDIAN TRADITION*

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(*Received August 12, 1968*)

Eclipses occur when the sun or the moon at the time of a syzygy passes through a nodal point of the lunar orbit. Hindu astronomers treat these points like planets: *Rāhu* and *Ketu*. According to their Indian and Tibetan synonyms a solar eclipse was 'black', but the eclipsed moon considered as dark-red, variegated, or smoky. The dark-red colour is mentioned in the old Hebrew and Armenian literature, too. The classical Sanskrit books on astronomy show a fair knowledge of the colours of lunar eclipses and their dependence on the degree of totality. This fact was well known to al-Biruni and is corroborated by modern observational evidence. In later Western tradition, however, another—schematic and intentionally photometric—sequence of six colours prevailed until 1540 C.E.

Eclipses of the sun and the moon are, besides large bright comets, the most spectacular phenomena which interrupt the regular course of events on the sky. In the mythological view of the early man it was obvious that superhuman beings—gods or demons—were responsible for them. The terms 'dragon's head' and 'dragon's tail' for the nodes of the lunar orbit go back to such conception. In India, these nodes (or what was considered their equivalent in producing the eclipses) are called Rāhu and Ketu and play an important role. In mythology, Rāhu was considered a demon who devours sun and moon. His dark (*tamomaya*) chariot is pulled by eight black horses. Ketu, his abdomen which had been cut off from his body by a revenging stroke of Viṣṇu's sword, figures as a separate individuum. His chariot is pulled by eight horses too; but these horses are brindled and glow in the colour of smouldering straw (*palāladhūmavarṇabha*).[1]

The 'dragon points' are by definition opposite to each other by 180° and fulfil in a period of 18,61 years one retrograde revolution in the ecliptic. Therefore it is possible to treat them in simple astronomical calculations like a couple of planets of the same period and no deviation in latitude. This is done by Hindu astronomers. Of course, the 'pseudoplanets' (W. Hartner)

* Dedicated to Prof. Helmuth Gericke on the occasion of his sixtieth birthday, 1969, May 7.

are not directly observable. But when, at the time of a syzygy (full or new moon), the moon happens to pass through one of his orbital nodes, then an eclipse occurs: at full moon a lunar and at new moon a solar eclipse. Sometimes two different eclipses follow each other at half a month's interval.

It is interesting to see which basic phenomena are involved in Indian tradition on Rāhu and Ketu. The word *rāhu* may have had the original meaning of 'he who grasps or seizes', from the root *rabh-*[2]. Ketu (root: cit-?) means any conspicuous appearance of luminosity, be it a torch or be it a shooting star. *Ketugraha* is the 'planet Ketu' whereas *ketutārā*, 'Ketu-star', is a comet. More evidence to this point is to be found in the Tibetan *Kālacakra* literature.[3] The *Vaiḍūrya-dkarpo* contains lists of synonyms for the planets—mostly translated or derived from the Sanskrit and of either mythological or descriptive character. Here are the synonym names for the three (!) pseudoplanets:

bsod nams ldan pa mun pa čan / mt'o ris snaṅ byed gza'i rnal /
mgo zlum lam nag zla ba'i dgra / seṅ ge mo'i bu zla ba 'joms /
ñe bar 'p' ar 'gro ša za daṅ / sprin las rnam rgyal bra ñe skyes /
k'ams gsum rnam rgyal sgra gčan miṅ //

mig sman mdog čan ñi zla za / dus kyi me daṅ sbyaṅ kyi dan /
sna c'ogs mdog čan la sogs pa / mǰug ma'i miṅ du mk'as pas bšad //
p'od čan daṅ ni mǰug pod čan / gcug p'ud čan daṅ sbrul čan daṅ /
skag las skyes daṅ skra gñis pa / du ba mǰug riṅ miṅ du grags //

Some of Rāhu's names here are: enemy of the moon, subduer of the moon, the dark one, black path (?), meat-devourer; others are: son of a lioness, owner of religious merit, victor over the tripartite (*k'ams gsum* = *triloka*) world, brightener of the heavenly paradise, and offspring of the *Bharaṇī* (a lunar mansion in Aries, but also = vulva).

The second pseudoplanet is *mǰug ma* = tail. It is also called: devourer of sun and moon, coloured, variegated, and fire of destruction (*dus me* = *kālāgni*). As a third pseudoplanet is listed separately *du ba mǰug riṅ* (long smoke-tail). It is snakelike, wears a mane or a hair-tuff and (or) two braids.

Obviously, the two first beings are responsible for eclipses of both kinds and, moreover, are considered as cosmical forces in a more general way. This latter conception is typical for the cosmosophic attitude of the *Kālacakra* proper. Very remarkable is the name 'wolf' (*spyaṅ kyi*) of the second pseudoplanet. This reminds us of the eclipse-wolves in the old nordic mythology. Those are two of them: a black wolf who causes the solar eclipses and a red one who causes the lunar eclipses.[4]

Black and red are, indeed, the basic colours of the respective phenomena. In a solar eclipse, the shadow of the moon appears deep black. In lunar eclipses, the shadow of the earth has a rim of changing colours, and the moon,

when totally eclipsed, appears mostly dark red. When we read of Rāhu (or his horses) being black and of Ketu (or his horses) being coloured, it is an attempt to separate the roles of the two dragon points—probably caused by the well-known effect that lunar and solar eclipses alternate at half a month's (corresponding to 180° of the moon's orbit—the angular distance of the nodes) interval. But, since the ascending and the descending nodes are perfectly equivalent as regards the constellation of an eclipse, such attempts to systematize could not give any reliable results.

In antiquity and medieval times much has been written on the shape of the so-called 'lunar face'. Best known is Plutarch's monography on this subject. As soon as the moon was known to be a cold celestial body like the earth, discussions arose on possible life there. But the colour phenomena of his eclipses have been widely neglected by ancient scientists. An intrinsic difficulty is that the appearance of the earth-shadow changes individually from eclipse to eclipse. Eye-witness reports are therefore oftentimes rather contradictory. Since Aristotle through to the end of the middle ages, there have been speculations on a faint luminosity of the lunar surface. In Ptolemy's 'Optics' we read: *Luna vero habet proprium colorem qui apparet in eclipsi sine lumine et non apparet in ceteris temporibus*[5] = the moon has a colour of its own which is apparent in the eclipse without light and which is not apparent at other times.

This citation shows, by the way, the problem of interdependence between light and colour, which studied in particular Ibn al-Haytham. He came finally to the concept of what we call the phenomenon of diffuse reflexion. At the end of his book 'On the Light of the Moon', Ibn al-Haytham writes that the colour of the moon is made luminous by the action of the sun upon its substance.[6] This conclusion is likely to strike us as an anticipation of the finding of modern astrophysics that some parts of the lunar surface show luminescence caused by solar activity.

But ancient reports on the colours of lunar eclipses are rare and have been neglected by most modern historians of science. In general, we should distinguish between naive speculations on the red colour of the totally eclipsed moon and scientific attempts to put the various colours showing during the partial phases in a sequence. On this subject, Indian astronomers have given very remarkable details which well deserve to be known and discussed in our days. Before entering this topic, some remarks may be allowed on a theistic interpretation of the colour of the eclipsed moon.

The first chapter of the Bible tells that sun and moon have been created by God as lamps (Hebrew: me'or) to enlighten day and night respectively.[7] For the early Christian fathers therefore it was a matter of course that the moon must be self-luminous. Eznik of Kolb, an Armenian theologist (Sec. V, C.E.), after summing up the (correct) teachings of 'the wise men of outside'

(*artak'in imastunk'* = heathen philosophers) on the formation of lunar eclipses (§ 290),[8] opposes strongly against the implication that the moon should not have its own light (§ 312). Eznik wants the eclipses to be understood as signs made by God to demonstrate the nonsense of worshipping the sun and the moon (§ 315). He cites from the Old Testament the prophecy, Joel 3, 4: 'The sun will be turned into darkness and the moon into blood'.

Thereupon Eznik speaks of heathenly attempts to make the moon come down to the earth's surface by incantations. He writes that sorcerers (or witches) 'at a time where by order of God the moon (I prefer the reading *lusnoyn*—moon—to the editors' conjecture *lusoyn*—light—because it is given by the manuscript and fits better to Joel) has become blood-coloured (*aryunagoyn*), compare its appearance to that of a demon (*div*)' (§ 316). Obviously, that particular time is the time of a total lunar eclipse! Elsewhere (§ 266) Eznik says that red colour of the rising sun announces rain on account of the underlying atmospheric humidity; but the only meteorological effect he mentions concerning the moon is the halo (*bak*). This implies that the temporal blood-colour of the moon is considered a pure astronomical phenomenon.

To sum up: Pre-scientific observations distinguished clearly between the red or blood-red colour of a (total) lunar eclipse and the blackness of the eclipsed sun. Moreover, the Indian mythology speaks of variegated and smoky colours. This is a strong argument for genuine Indian offspring of the data on the colours of lunar eclipses during the partial phase to which we will turn now our attention.

The *Sūryasiddhānta* explains the fact that partial solar eclipses are being observed only at a rather late phase, in contradistinction to partial eclipses of the moon, quite correctly as a physiological effect caused by the dazzling glare of the sun:

svacchatvāddvādaśāṃśo'pi grastaścandrasya dṛśyate |
liptātrayamapi grastaṃ tīkṣṇatvānna vivasvataḥ || 6, 13 ||

E. Burgess translates: 'Owing to her clearness, even the twelfth part of the moon, when eclipsed, is observable; but, owing to his piercing brilliancy, even three minutes of the sun, when eclipsed, are not observable.'[9] I cannot find any negation in this verse which sets lower limits to the phase where an eclipse is observable. 'Three minutes' is to be understood as 'three-sixteenths of diameter' (*liptā* taken in the sense of *kalā*). This comes close to *Āryabhaṭīya*, Gola, 47:

sūryenduparidhiyoge 'rkāṣṭamabhāgo bhavatyanādeśyaḥ |
bhānorbhāsurabhāvāt svacchatanutvācca śaśiparidheḥ ||

'At the conjunction of the disks (*paridhi*) of sun and moon, the eighth part of the sun is not discernible (as eclipsed), owing to the brilliant nature of

the sun and the clearness and minuteness of the moon's disk.' Instead of three-sixteenths as in the *Sūryasiddhānta*, here the less value of one-eighth is given as phase limit to the observability of a solar eclipse. The 'minuteness' (*tanutva*) occurs again in what al-Biruni ascribes to the learned men supported by God (*al-'ulamā' al-mu'ayyadūn min 'inda allāh*)[10]: 'Because that which covers the moon is large, her light wanes when only one-half of it is eclipsed; and because that which covers the sun is not large, the rays are powerful notwithstanding the eclipse.'[11]

At the end of Chapter 59 'On the Eclipses of the Sun and the Moon', where the just cited sentence is taken from, al-Biruni criticizes what al-Khwārizmī tells about the colours (Sachau incorrectly translates: 'different kinds'; but the Hyderabad edition reads *alwān*) of eclipses as discordant with observations, though nicely arrayed in words. Then al-Biruni continues:

'More correct is a similar view of the Hindus, viz. that the eclipse has the colour of smoke if it covers less than half the body of the moon; that it is coal-black if it completely covers one-half of her; that it has a colour between black and red if the eclipse covers more than half of her body; and, lastly, that it is yellow-brown if it covers the whole body of the moon.'[12] Literally, the two last colours are: 'its dark-black is mixing with red' and 'yellow with reddish colour (*śuqra*) in it'. As already Sachau knew, these data virtually coincide with what the *Sūryasiddhānta* says:

ardhādūne sadhūmraṃ syāt kṛṣṇamardhādhike bhavet /
vimuñcataḥ kṛṣṇatāmraṃ kapilaṃ sakalagrahe // 6, 23 //

'When half (of the moon's disk) has been taken away, (the colour) may be smoky; when more than a half, it is likely to grow black; when released (*vimuñcataḥ*, translated by Burgess: 'when emerging', refers to phases close to totality, between—say—0, 8 and 095; this interpretation is supported by the Sanskrit commentaries, too) dark-red; when the eclipse is total, brown (or reddish: *kapila*).'

The *Āryabhaṭīya* omits the intermediate *kṛṣṇatāmra* (which al-Biruni describes as 'dark-black mixing with red', at a phase between 0,5 and 1,0) and transfers this colour to a phase beyond 1, 0, i.e. mid-totality:

pragrahaṇānte dhūmraḥ khaṇḍagrahaṇe śaśī bhavati kṛṣṇaḥ /
sarvagrāse kapilassa kṛṣṇatāmrastamomadhye // Gola, 46 //

'At the end of the eclipse (*anta* 'border, hem' means both limits: the first and the fourth contact) smoky, the moon is black when partly eclipsed; brown at totality, and dark-red in the midst of darkness.'

Bhāskara in his *Grahagaṇita* gives some colour synonyms for the same phenomena:

svalpe channe dhūmravarṇaḥ sudhāṃśorardhe kṛṣṇaḥ
kṛṣṇarakto'dhike'rdhāt |
sarvacchanne varṇa uktaḥ piśāṅgo
bhānoścchanne sarvadā kṛṣṇa eva || Vol. 2, v. 36 ||

'When very little is covered, smoke-coloured; when half of the moon, black; black-red when more than a half; when totally covered, the colour is called reddish brown. At a solar eclipse always black.'

Varāha Mihira, in Chapter 6 ('according to the *Pauliśa Siddhānta*') of his well-known *Pañcasiddhāntikā*, goes less into detail:

sarvagrāse pītaṃ varṇaviśeṣam vadenniśānāthe |
udayāstagrāsadhūmraṃ khaṇḍagrahaṇe ca salilābham || 9 ||

'At eclipse totality, the distinctive colour of the Ruler of the Night may be called saffron-yellow; smoky (is the colour of) the beginning and the end; and inconstant when the eclipse is partial.' The translation of Thibaut and Dvivedi[13] is not quite correct. *Udaya* and *asta* have nothing to do here with 'rising or setting of the moon'; and 'waterish' is based upon the special meaning of *salila*, but here, too, the original sense of the word fits better.

Taken altogether, the Indian astronomers had a good knowledge of the colours of lunar eclipses. Differences concern mainly the limits of the 'black' phase. The smoke-colour may refer to the penumbra. M. Dubois describes the appearance of the moon just before the first contact with the full umbra of the earth as 'enfumée'.[14] On the other hand, the exterior parts of the umbra itself show an almost neutral 'colour', because Rayleigh extinction is still minor in the higher layers of the earth's atmosphere (which the pertinent rays of the sun have to pass).

M. Waldmeier describes the colour sequence of a lunar eclipse as follows: 'At the beginning of totality, that part which is closest to the shadow-border appears lemon-yellow; towards the shadow-centre follow the colours: yellow, yellow-brown, brown-red. The well-known dark-red colour does not yet occur. At mid-totality, the exterior limb of the moon appears copper-red, and the centre of the umbra appears dark-red with a strong tinge of brown and violet.'[15] This dark-red reminds us of Āryabhaṭa's 'dark-red in the midst of darkness'!

In his admirable compendium of astronomy called '*al-Qānūn al-Mas'ūdī*', al-Biruni dwells extensively upon the colours of lunar eclipses.[16] Here too, he praises the Indian astronomers for their correctness. He disagrees with those *munaǧǧimūn* (hellenistic astronomers/astrologers) who pretend that the darkness of a lunar eclipse be thoroughly correlated to its phase. They give a

sequence of colours which is apparently intended to be a photometric one and advances in six steps according to the moon's latitude, from 10′ to 10′. It goes like this: deep-black, greenish, reddish, yellowish, dusty, 'similar to dusty' (*šibha bilġubra*; I would prefer to read: *šuhba* 'gray'; on the following page of the Hyderabad edition occurs: *bilšuhba waġlubra*). Thereupon al-Biruni continues:

'But the findings of perception disagree with that, and they agree with (read *mā* instead of *min* or *man*?) the opinion of the Indians in it.'

Al-Biruni was even well aware of the differentiation of colours during totality, and he ascribes this knowledge to the Indians: 'They (the Indians) say: thereafter, when (the eclipse) is total or stays after it (sc. the setting in of totality), its black colour mixes with yellowness.'

This advanced knowledge seems to have been lost in the later Western tradition, whereas the sextuple scale of colours is still to be found in Petrus Apianus' *Astronomicum Caesareum*.[17] There it goes: nigerrima / nigra habens in se viredinem / nigra cum rubedine / nigra cum pallore / pallida grisea / grisea cum albedine //. These steps are co-ordinated, firstly, to the moon's latitude, and, secondly, to its angular distance from perigee. The result, of course, is declared to be a *mixtura* of colours. Apainus maintains that in performing this mixing by evaluation of his two scales, the true colour of any eclipse will be found. The only type of colour in those sequences which was not already noted by the Indian astronomers was the green. It appears occasionally at the shadow-line during partiality and is caused by ozone in the earth's atmosphere.[18]

References

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[3] Petri, W., *Tibetan Astronomy*. Oxford—New York, 1968. In: *Vistas in Astronomy*, 9. The following paragraphs have been adapted from a larger study on *Kālacakra Astronomy* by the present author, prepared for printing.

[4] Reuter, O. S., *Germanische Himmelskunde*. München, 1934, p. 291.

[5] Ptolemy, *Optics*, ed. Lejeune. Louvain, 1956, p. 59 = II 93.

[6] Schramm, M., *Ibn al-Haythams Weg zur Physik*. Wiesbaden, 1963, p. 83.

[7] Genesis 1 : 14–16.

[8] Eznik de Kolb, De Deo. *Édition critique et traduction française par L. Mariès et Ch.* Mercier, Paris, 1959.

[9] Burgess, E., *Translation of the Sūrya-Siddhānta*. Repr., Calcutta, 1935.

[10] Al-Biruni, *India*, Chapter 59. Arabic text, Hyderabad, 1958, p. 433.

[11] ——— Translated by E. Sachau. Repr., Delhi-Lucknow-Bombay, 1964. Vol. 2, p. 109.

[12] ———, *Ibid.*, p. 114.

[13] Varāha Mihira, *The Panchasiddhāntikā*. Edited and translated by G. Thibaut and M. S. Dvivedī. Repr., Lahore, 1930, p. 54.

[14] Dubois, M., *Obs. Bordeaux*, Série A, No. 7. Bordeaux, 1954.

[15] Waldmeier, M., *Himmelswelt*, 52. Berlin, 1942, p. 90 (translated by W. P.).

[16] Al-Biruni, *Canon Masudicus*. Hyderabad, 1955, Vol. II, p. 927 sqq. *See also* E. Wiedemann, *Über die verschiedenen, bei der Mondfinsternis auftretenden Farben nach Bīrūnī*. Halle, 1913. In: *Jahrbuch für Photographie . . . für das Jahr* 1914.

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[18] Modern monographs (with ample references) are:

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