NOTES FOR THE OBSERVER

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1. Occultations

An occultation is a total or a partial cut-off of the light of a celestial body due to its passage behind another body. The finest example of an occultation is the solar eclipse. Strictly speaking, it is not an eclipse, but a lunar occultation of the sun. An eclipse occurs when a celestial body passes into the shadow of another. The lunar eclipse and the eclipses of satellites by their parent planets are examples of eclipses in the solar system. The occultations of planets by one another are extremely rare, but the occultations of the stars by the solar system objects occur quite often. These occultations are of great interest to an astronomer since they yield information on the occulting object as also on the star being occulted.

The occultation of SAO 158687 by Uranus on 1977 March 10 led to the discovery of the rings of Uranus. We will shortly be witnessing another occultation by Uranus. This time it is a 9.5 magnitude star BD $-19°4222$ which will be occulted by Uranus on the night of April 26. The star will pass behind the disk of Uranus at 0115 IST (i.e. early on April 27) and reappear around 0151 IST. The most prominent ring, termed ϵ, will occult the star at 0051 IST and again at 0204 IST.

The position of Uranus on the night of this occultation is $\alpha = 15^h\ 47^m\ 21^s$ and $\delta = -19°\ 42'$. It will be about 1° west and 0.5° north of a fifth magnitude star λ Librae. Uranus is 5.8 mag bright and therefore easy to spot. The star to be occulted is easily observable with a 6-inch telescope. It should not be difficult to spot even through a 3-inch telescope.

The planetary occultations also yield information on the atmospheres of planets which cannot easily be obtained otherwise. The layered structure of Jupiter's atmosphere was discovered, for example, during the occultation of β Scorpii on 1971 May 13. A still rarer event is an occultation by one of the satellites of a planet. An eighth magnitude star SAO 186800 was occulted by Jupiter's third satellite Ganymede on 1972 June 7. The first proof that Ganymede may have a thin atmosphere came from the Kavalur records of this occultation. Occasionally a star may be occulted by a minor planet too. The accurate timing observations of the disappearance and the reappearance of the occulted star is the only direct method available for measuring the diameter of a minor planet. The first proof of the absence of atmosphere on the moon was also obtained through occultation observations. In 1834 Bessel established from lunar occultations of stars that the lunar atmosphere must be less than one part in 2000 of the earth's atmosphere. Current astronomical interest in lunar occultations has centred on the measurement of stellar diameters and the separation between double stars which are too close to be resolved otherwise. The accuracy one can attain in both the kinds of measurements is of the order of a milliarcsec, a value that cannot be reached photographically by any ground based telescope because of the limitations imposed by earth's atmosphere.

Accurate timings of lunar occultations provide rigorous checks on the computations of celestial mechanics. Lunar occultation observations have thus been useful in geodetic measurements, studies of lunar ephemerides, lunar limb profile and a number of other problems of the earth-moon system. Amateurs working with a small telescope have made valuable contribution to this aspect of astronomical research. Each timing observation of lunar occultation is unique. The greater the number of observers with a good spread in their locations, the better is the value derived for the position of the moon in the sky at a given instant. Each observer should know his accurate geographical coordinates for his observation to be physically meaningful. He should send the details of his observations and location to established astronomical centres for further analysis.

The lunar occultations may be divided into two types: disappearance of the star behind the lunar disk and its subsequent reappearance. Since the moon advances eastward in its orbit by an amount equal to its own diameter in one hour, the maximum possible duration of an occultation is of the same order. This maximum duration depends also on the declination of the moon. The actual duration is shorter if the star is not centrally occulted but traverses a chord of the lunar disk. The disappearances are easier to observe since the star can be conveniently followed before the occultation occurs. Once the disappearance has been observed one may wait for its appearance by following the opposite limb of the moon at the same declination. It is much easier if the telescope has a drive that can track stars accurately over this period of time; then one need only wait for the lunar disk to cross the star.

Because of the lack of any atmosphere on the moon, a star disappears instantaneously behind its disk without any flickering and fading. While this element of surprise adds to the excitement of the observations of lunar occultations, it also facilitates an accurate timing of the event. One can with a little experience easily reach an accuracy of 0.2–0.1 s using a stop watch.

How faint a star can be easily observed while it is getting occulted by the moon depends on the phase of the moon. Even a 3-inch telescope can show a seventh magnitude star near a crescent moon. If one points the same telescope towards a full moon, even a fifth magnitude star may be lost in the moon's glare. It is hence advisable to use an eye-piece of moderate to high power in order to reduce the glare of the moon. The occultations occurring at the bright limb of the moon are also more difficult to observe. These disappearances occur after the full moon and therefore at a later part of the night. The most convenient period for observing lunar occultations is when the moon is young. The eastern limb of the moon is dark during this time. Since the moon advances eastward with respect to the stars the disappearances always occur at the eastern limb.

Table 1 contains some of the easily observable lunar occultations between the months of April and June this year. The first two columns of the Table list the date and time of the event. The time of the occultations have been computed for the location of the Kavalur Observatory. The timings at the other locations would differ because of the finite parallax of the moon. The third column indicates the nature of the event disappearance (D) or reappearance (R). The next five columns list the name of the star to be occulted, its magnitude, spectral type and the coordinates. The altitude of moon at the time of the event is listed in the ninth column and the lunar phase in the tenth. The phase is given as the percentage of lunar disk

Table 1. Lunar occultations between 1981 April-June

Date	Time (IST)	Type	Star	Mag	SpT	Right ascension	Declination	Moon's altitude	Percentage illumination
						h m s	° ′ ″		
15 April	23 47 25	D	HR 4358	5.9	K0	11 13 03.6	08 09 47	61°	89+
8 May	20 44 47	D	56 Gem	5.2	G8	7 20 49.1	20 28 45	29	26+
	21 41 54	R						15	
18 May	03 02 24	D	13 Lib	5.8	K0	14 53 22.4	—11 49 20	31	99+
18 May	21 47 22	D	38 Lib	4.0	K0	15 34 29.3	—14 43 22	47	100+
	23 23 02	R						61	
22 May	04 34 35	D	13 μ Sgr	4.0	B8p	18 12 39.1	—21 03 48	44	92—
	04 48 05	R						42	
22 May	21 46 42	D	37 Sgr	3.6	K0	18 56 37.2	—21 07 51	4	87—
	22 30 38	R						14	
23 May	02 44 19	D	39 ο Sgr	3.9	K0	19 03 34.3	—21 46 06	55	87—
	02 59 29	R						55	
5 June	19 47 45	D	85 Gem	5.4	A0	07 54 45.4	19 56 03	24	13+
	20 37 26	R						13	
24 June	01 48 29	D	91 Aqr	4.5	K0	23 14 54.1	—09 11 21	33	64—
	02 54 38	R						47	
24 June	02 49 55	D	92 Aqr	4.6	B5	23 16 55.9	—09 10 17	46	64—
	04 02 58	R						60	

illuminated. A positive sign indicates that the moon is waxing and a negative sign that it is waning.

The easiest among the occultations listed in the Table are the occultation of 56 Geminorum on May 8 and of 85 Geminorum on June 5. The moon will be crescent at these times and the event occurs in a convenient time of the night. The occulations of HR 4358 on April 15 and ξ^1 Librae on May 18 are difficult since the moon is very bright. They may be used to check the limit of one's equipment. The occultation of γ Librae is not a difficult target though the moon is almost full. This occultation occurs at the dark edge of the moon which is only 2 arcsec away from the terminator. If a sunlit peak is present near the part of the edge that occults the star,the star may touch this peak before disappearing, and a timing observation may be difficult.

A number of occultations of very bright star occurs during this period, but mostly at the bright edge of the moon. The disappearances are still possible to observe but the timing observations may not be easy.

The reappearances are more difficult to observe than the disappearances. If the telescope can track the stars well one can lock it on to the star before it is occulted and observe both the disappearance and the reappearance as the moon's disk covers and uncovers the star. If the tracking facility is not available one would follow the opposite limb of the moon at the particular declination of the star. Accurate time of reappearance is needed at the observer's location so that one is well prepared to catch the event.

A note of caution : It is harmful to the eye to keep watching a bright moon continuously with an eye-piece of low power even through a small telescope.

2. Planetary phenomena

Jupiter and Saturn are a good sight in the constellations of Virgo. They are little over a degree apart. They will be in opposition by the end of March, and are visible all through the night. Both these planets are in retrograde motion. They move westward till June, receding from the interesting visual binary γ Virginis and approach the spectroscopic binary η Virginis. Moon will appear close to them on the nights of March 21, April 17, May 14 and June 10. One can catch the eight-day old moon on the evening of June 10 hovering barely 2 deg. away from these planets.

Mercury can be seen in March with difficulty and just before sunrise. It will be in superior conjunction with the sun on April 27 while Venus will be in superior conjunction on April 7. Both these planets will appear in the west after sunset, Mercury by the middle of May and Venus by the end of May. They can be observed below Castor and Pollux in the evening sky. The greatest elongation of Mercury (23°) is on May 26. We lose this planet again by the end of June when it is in inferior conjunction. Venus, Castor, Pollux, Jupiter, Saturn, Regulus and Spica make a striking configuration in the evening sky of late June.

Mars is at conjunction on April 2. It becomes conspicuous in the morning sky of June, passing between the Hyades and the Pleiades around June 10, and 6° north of Aldebaran on June 19. Uranus is a 5.8 mag object in Libra. It is northeast of λ Librae in April and moves in retrograde motion towards κ Librae till June. It passes two minutes north of 41 Librae on June 25.

Neptune has a magnitude of 7.7. It is in the constellation of Ophiucus, between 58 Ophiuchi and ξ Ophiuchi. Pluto will be in opposition on April 13, but at a magnitude of 13.7 it is a difficult target even for moderate sized telescopes.