PHOTOMETRIC OBSERVATIONS OF THE OCCULTATIONS OF STARS BY THE MOON

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1. Introduction

The idea of finding the radius of a star from the distortion of the Fresnel pattern caused by diffraction at the edge of the Moon during an occultation, was first proposed by Williams in 1938. In subsequent years this idea was again taken up by a number of investigators: Whitford (1938, 1946,) Diercks and Hunger (1952), Evans *et al.* (1953), Cousins and Guelke (1953), Rakos (1964, 1967), Nather and Evans (1970). The greatest difficulty in carrying out such measures was the lack of a light detector of sufficiently high quantum efficiency and recording equipment of sufficiently short time constant. Modern advances in electronics have overcome these difficulties to such an extent that it now appears feasible to determine the apparent diameters of many stars with a minimum expenditure of observing time and equipment.

Aside from the Sun and certain double stars, there are only a very few stars whose diameters have been directly measured. It is well known that calculation of a stellar radius from the star's luminosity and mass by means of the theory of stellar structures is not entirely free of certain assumptions. (See the failure to detect the predicted flux of neutrinos from the Sun.) Accumulation of a larger number of such measurements will lead to improved knowledge concerning stellar radii, center-to-limb darkening, effective temperature, bolometric correction, interstellar absorption, the statistics of close double stars and their orbital elements. The fact that it will be possible to study several stars of the Hyades cluster by this method appears to be of particularly great interest. The distance of this cluster from the Sun is a quantity of fundamental importance for establishing the galactic distance scale.

The measurement of the accurate time of occultations can be used to derive other important data:

(a) Corrections to orbital elements of the lunar theory.
(b) Corrections to the ephemeris time relative to the atomic time scale.
(c) Corrections to individual star positions and proper motions.
(d) Establishment of a dynamical coordinate system on the celestial sphere.

2. The Measuring Technique

The observations discussed here were carried out with the 21, 42 and 72 in. (Perkins) reflectors of the Lowell Observatory, Flagstaff, Arizona and 27 in. refractor of the

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Vienna University Observatory. The author wishes to acknowledge the generous help of the Lowell Obs. staff and to express his gratitude to O. G. Franz for help on the telescope. A circular aperture of 10 arc sec diam. at the focal plane of the telescopes has usually been used. Behind this aperture is a semitransparent mirror, (only 10% of light is reflected and lost) so that the star within the aperture can be seen all the time during the observations by means of a microscope.

It follows from the sidereal period of the Moon that the latter moves at a rate of about 0.55 arc sec/s relative to the stars. An occultation is therefore an event that takes place very rapidly. Only very rarely, in the case of a grazing occultation, will it last longer than 0.1 sec. As previously shown (Rakos, 1967), the longest reasonable time of integration for one measuring point during an occultation, considering the required time resolution and accuracy, is about one millisecond. Similarly, it was shown that the optimum circular telescope aperture for such measures is of the order of 100 cm. These two parameters allow us to estimate how bright the stars to be observed must be in order to provide the necessary accuracy.

The accuracy of photoelectric observations is limited by many different factors. The most important are the statistical fluctuations in the effective number of stellar photons and in the electron emission from the photocathode. For this reason a two-channel photometer is used, equipped with light detectors having as high a quantum efficiency as possible. A dichroic filter, Bausch and Lomb No. 45-2-600 and Schott

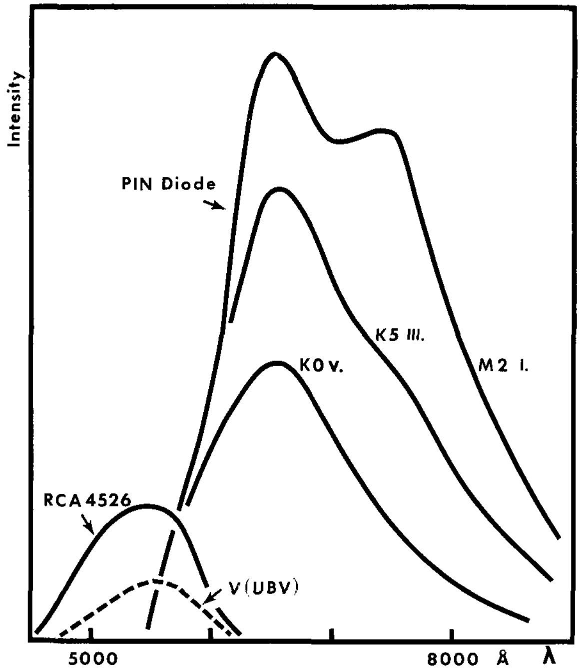


Fig. 1. The intensity of the primary photocurrent (number of photoelectrons) for a star of constant visual magnitude but different spectral types for both photometer channels and the *V* region of the UBV system.

GG14 yellow filter, splits the starlight into two spectral regions. The reflected part is detected by the special red sensitive RCA 4526 photomultiplier. The effective wavelength corresponds roughly to the visual magnitude of the UBV system. For all stars between G and M this photomultiplier-filter combination yields almost 3 times the number of photo-electrons in the V magnitude as does the standard UBV photometer (see Figure 1).

Ideally, such observations should be carried out in monochromatic light, as the distances between maxima and minima of the diffraction patterns are wavelength dependent. However, the use of very narrow wavelength bands would necessitate the use of telescopes of the largest existing apertures, which, in turn, would cause considerable smearing of the observed diffraction patterns. A telescope of aperture $D=100$ cm produces an effect equal to that of a star whose apparent diameter is about 0.0005 sec of arc. If, however, one balances the errors produced by use of a wider wavelength band against those introduced by the size of the telescope and the length of the integration times, one finds an effective bandwidth of about 800 Å for $\lambda_{\text{eff}}=4000$ Å ($\Delta\lambda/\lambda=0.2$) to be a suitable compromise.

The transmitted part of the light-beam behind the dichroic filter passes through a KG 1 Schott filter and is detected by a Hewlet Packard 4204 PIN photodiode. Figure 1 shows the difference in the total number of photoelectrons (all filters are included) for a given star of constant visual magnitude but different spectral types between both channels and the V region of the UBV system. Because of its high sensitivity over a wide spectral range in the near infrared region, unprecedented speed of response, unrivaled low noise performance, – the signal to noise ratio for a constant light input of the diode is 100 times better than for a S 1 photocathode, – the HP 4204 is the most useful light detector for this purpose (Fisher, 1968).

The additional amplification of the photoelectric current at the output of RCA 4526 photomultiplier and HP 4204 PIN photodiode is made by means of field effect transistor input operational amplifiers similar to Fairchild μA 740 or μA 725 or EG and G Inc. HA-100. The General Radio amplifier commonly used in the conventional direct current photometer is not suitable for this purpose. It becomes increasingly non-linear for frequencies over 30 Hz. In connection with the photomultiplier, pulse counting technique was also used. This is not very convenient for bright star observations.

The amplified signals are fed into two voltage-to-frequency converters and from there to a four channel instrumentation magnetic tape recorder. In addition to the diffraction patterns, the time signal and the observer's comments are recorded simultaneously. For each star undergoing occultation, the epoch of the event will thus be determined to an accuracy of 0.01 sec.

3. The Observational Material

The first source of observational error – the statistical fluctuations in the effective number of stellar photons and in the electron emission in the photodetector – was mentioned earlier. The brightness of the sky background is the second and last significant source of observational error. It is generally produced by the brightness of the dark limb of the Moon and by the moonlight scattered by the Earth's atmosphere and by the optics of the telescope. These two contributions both change with the phase of the moon. The observations presented here were obtained with a diaphragm of 10 arc sec diameter at the focus of the different telescopes, and show that these quantities can be neglected as long as one observes stars brighter than magnitude 7. Only for fainter stars does the sky brightness become noticeably disturbing. Such faint stars, however, cannot be considered for these observations, since their apparent diameters generally lie below 0.0005 arc sec (see Figure 2).

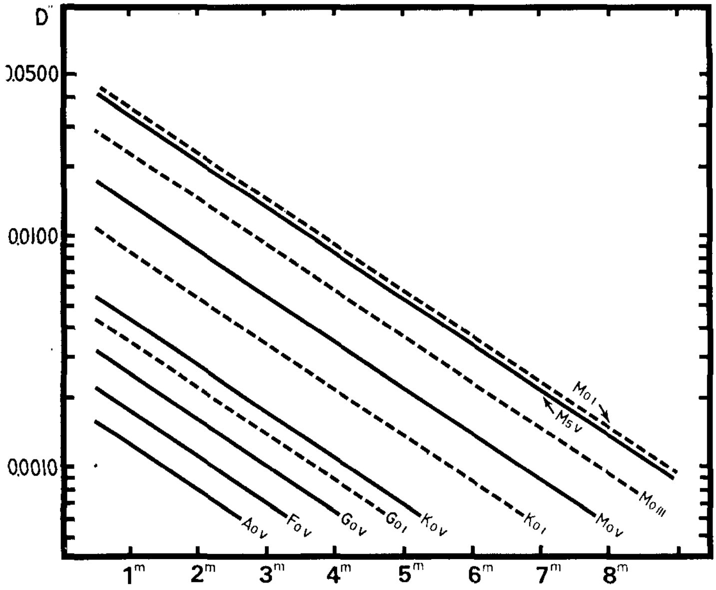


Fig. 2. The apparent diameter of stars as a function of visual magnitude and spectrum type.

Finally, one other source of error should be mentioned, namely the fluctuation of the extinction in the earth's atmosphere. It is of course dependent on the zenith distance of the star under observation. Because of the size of the telescope aperture, rapid fluctuations in extinction remain generally very small compared to the other errors already mentioned. Only slower changes of extinction with periods of about 1 sec and longer could sensibly disturb the observations of those occultations which last longer than 0.1 sec. Such long-lasting events, however, are very rare. The effects of positional scintillation upon the accuracy are negligible because of the use of a sufficiently large diaphragm at the focus of the telescope.

We can now estimate how bright stars will have to be in order to yield intensity measures with an accuracy of 1% for integration time of 0.001 sec. For the necessary numbers of photoelectrons per millisecond in the yellow region of the photometric system, using a 27 in. telescope, and with a sky background brightness of 7 mag., we obtain a lower limit of 6 mag. Considering the use of PIN diode in near infrared region and the spectral distribution of energy for stars of later types, a gain of more than two magnitudes can be attained, see Figure 1. Also the sky background is suppressed in this spectral region by at least one magnitude. Therein lies the great advantage of the use of a two-channel photometer. We thus find from Figure 2 that all stars with apparent diameter larger than 0.001 sec arc can be observed with an accuracy of one percent for a single reading (each millisecond). Finally, this means that the practical limit for radius determinations by the occultation method is set by small scale irregularities on the portion of the lunar surface involved in the occultation. Recent photographs of the Moon surface show very few rocks larger than 50 cm.

The following frequency distribution of the apparent diameters for the stars in the Zodiacal Catalog can be expected:

No. of stars	Apparent diameter (sec arc)
38	$D > 0.008$
269	$0.008 > D > 0.001$
976	$0.001 > D > 0.0005$

Since most of these stars are brighter than mag. 8, their brightness change during occultation, as has been shown earlier, should be measurable with an accuracy of $\pm 1\%$ or better.

The orbital plane of the Moon shifts along the ecliptic with a period of 18.6 yr. Within this time interval the possibility exists that the occultation of these stars can be observed. These observations will therefore yield apparent diameters for about 40 stars a year. Some of these will be occulted more than once during the single year, thus providing an opportunity to evaluate the external accuracy of radius determinations. The numbers of observable events will, of course, be reduced by the weather conditions at any observing site. Experience has shown that at Flagstaff about half of all events might actually be observable.

4. Results of Observations

During the exploratory observations carried out in 1964 and 1967/68 at the Lowell Observatory the occultations of about 100 stars were measured. The accurate time of disappearance or reappearance was recorded for 75 stars, see Table I. Figure 3 shows, for example, the disappearance of BD$-9°$6142, $m_v = 8.6$; F8. Two consecutive second pulses of the WWV time signal are visible too. Figure 4 is the registration of HD 75974 ($m_v = 6.8$; F8), a previously binary. Binary star observations require a pair of occultations from different positions on the lunar limb in order to obtain a separation of the components.

TABLE I

Occultations

No.	Star No.	Observed Time (UT)	Telescope	Remarks
1	BD − 20°06266	13 Oct. 1967 $3^h38^m17^s.40$	Perkins	Entry
2	BD − 09°06156	15 Oct. 1967 $4^h43^m37^s.33$	Perkins	Entry
3	BD − 10°06086	15 Oct. 1967 $3^h05^m59^s.85$	Perkins	Entry
4	CD − 26°15036	8 Nov. 1967 no occultation	Perkins	
5	CD − 25°14840	8 Nov. 1967 $2^h40^m25^s.20$	Perkins	Entry
6	CD − 25°14845	8 Nov. 1967 $2^h55^m56^s.52$	Perkins	Entry
7	CD − 25°14851	8 Nov. 1967 $3^h15^m50^s.87$	Perkins	Entry
8	CD − 25°14854	8 Nov. 1967 $3^h34^m06^s.36$	Perkins	Entry
9	CD − 25°14869	8 Nov. 1967 $4^h11^m41^s.04$	Perkins	Entry
10	BD − 21°06016	9 Nov. 1967 $3^h14^m20^s.45$	21 in.	Entry
11	BD − 16°06057	10 Nov. 1967 $4^h23^m00^s.42$	21 in.	Entry
12	BD + 04°00190	14 Nov. 1967 $1^h14^m32^s.92$	Perkins	Entry
13	BD + 04°00195	14 Nov. 1967 $1^h32^m41^s.04$	Perkins	Entry
14	BD + 06°00181	14 Nov. 1967 $6^h59^m39^s.10$	Perkins	Entry
15	BD + 11°00261	15 Nov. 1967 $7^h33^m06^s.87$	Perkins	Entry
16	CD − 23°16675	6 Dec. 1967 $2^h06^m24^s.50$	Perkins	Entry[a]
17	CD − 22°15166	6 Dec. 1967 $2^h14^m58^s.55$	Perkins	Entry
18	CD − 22°15182	6 Dec. 1967 $2^h19^m25^s.18$	Perkins	Entry
19	BD − 18°06037	7 Dec. 1967 $1^h55^m06^s.19$	21 in.	Entry
20	BD − 18°06042	7 Dec. 1967 $2^h57^m44^s.46$	21 in.	Entry[a]
21	BD − 17°06142	7 Dec. 1967 $4^h01^m04^s.51$	21 in.	Entry[a]
22	BD − 18°06052	7 Dec. 1967 $4^h15^m29^s.28$	21 in.	Entry
23	BD − 07°06037	9 Dec. 1967 $3^h23^m48^s.51$	21 in.	Entry[a]
24	BD − 07°06046	9 Dec. 1967 $4^h28^m54^s.72$	21 in.	Entry
25	BD + 09°00194	12 Dec. 1967 $1^h25^m36^s.96$	21 in.	Entry[b]
26	BD + 09°00194	12 Dec. 1967 $1^h25^m37^s.08$	21 in.	Exit[b]
27	BD + 09°00206	12 Dec. 1967 $4^h36^m55^s.23$	21 in.	Entry
28	BD − 14°06283	4 Jan. 1968 $2^h51^m39^s.18$	21 in.	Entry[a]
29	BD − 09°06142	5 Jan. 1968 $1^h09^m36^s.30$	21 in.	Entry
30	BD − 09°06146	5 Jan. 1968 $2^h12^m00^s.03$	21 in.	Entry
31	BD − 09°06147	5 Jan. 1968 $2^h26^m16^s.75$	21 in.	Entry[a]
32	BD − 09°06149	5 Jan. 1968 $2^h52^m25^s.73$	21 in.	Entry
33	BD − 09°06151	5 Jan. 1968 $3^h20^m19^s.48$	21 in.	Entry
34	BD − 03°03360	21 Jan. 1968 $8^h59^m01^s.97$	Perkins	Exit
35	BD + 00°00054/	3 Febr. 1968 $3^h35^m33^s.52$	Perkins	Entry
36	BD + 05°00146	4 Febr. 1968 $1^h43^m21^s.96$	21 in.	Entry
37	BD + 11°00245	5 Febr. 1968 $3^h23^m27^s.66$	21 in.	Entry
38	BD + 11°00249	5 Febr. 1968 $4^h27^m01^s.06$	21 in.	Entry
39	BD + 11°00248	5 Febr. 1968 $4^h34^m35^s.63$	21 in.	Entry
40	BD + 11°00251	5 Febr. 1968 $5^h09^m12^s.56$	21 in.	Entry
41	BD + 14°00383	4 March 1968 $3^h38^m50^s.48$	21 in.	Entry
42	BD + 15°00331	4 March 1968 $4^h00^m01^s.08$	21 in.	Entry
43	BD + 19°00468	5 March 1968 $4^h22^m59^s.42$	21 in.	Entry
44	BD + 19°00475	5 March 1968 $5^h23^m16^s.00$	21 in.	Entry
45	BD + 19°00476	5 March 1968 $5^h24^m38^s.25$	21 in.	Entry[b]
46	BD + 23°00584	6 March 1968 $2^h01^m27^s.34$	21 in.	Entry
47	BD + 23°00586	6 March 1968 $2^h17^m39^s.96$	21 in.	Entry
48	BD + 23°00594	6 March 1968 $4^h08^m56^s.83$	21 in.	Entry
49	BD + 23°00597	6 March 1968 $4^h11^m39^s.72$	21 in.	Entry
50	BD + 23°00598	6 March 1968 $4^h14^m18^s.32$	21 in.	Entry
51	BD + 24°01950	11 March 1968 $3^h52^m42^s.32$	Perkins	Entry[b]

Table 1 (continued)

No.	Star No.	Observed Time (UT)		Telescope	Remarks
52	BD + 19°02226	12 March 1968	$6^h58^m16^s.52$	Perkins	Entry
53	BD + 21°01973	8 April 1968	$5^h11^m11^s.86$	21 in.	Entry
54	BD + 21°01974	8 April 1968	$5^h33^m15^s.56$	21 in.	Entry
55	BD + 21°01982	8 April 1968	$6^h30^m05^s.12$	21 in.	Entry
56	BD + 21°01987	8 April 1968	$7^h41^m09^s.46$	21 in.	Entry
57	BD + 21°01988	8 April 1968	$7^h57^m17^s.44$	21 in.	Entry
58	BD + 22°01998	5 May 1968	$5^h05^m32^s.20$	21 in.	Entry
59	BD + 22°01997	5 May 1968	$5^h09^m10^s.52$	21 in.	Entry
60	BD + 22°02004	5 May 1968	$6^h05^m38^s.44$	21 in.	Entry[b]
61	BD + 13°02274	7 May 1968	$6^h35^m51^s.12$	21 in.	Entry[b]
62	BD + 12°02229	7 May 1968	$7^h01^m05^s.12$	21 in.	Entry[b]
63	BD + 26°01616	31 May 1968	$3^h39^m38^s.04$	21 in.	Entry[b]
64	BD + 26°01625	31 May 1968	$4^h36^m04^s.98$	21 in.	Entry
65	BD + 20°02315	2 June 1968	$3^h41^m20^s.15$	21 in.	Entry
66	BD + 19°02212	2 June 1968	$5^h01^m51^s.61$	21 in.	Entry
67	BD + 19°02215	2 June 1968	$5^h06^m04^s.08$	21 in.	Entry
68	BD + 08°02451	4 June 1968	$4^h36^m37^s.83$	21 in.	Entry
69	BD + 08°02453	4 June 1968	$4^h54^m28^s.74$	21 in.	Entry
70	BD + 01°02628	5 June 1968	$7^h12^m43^s.20$	21 in.	Entry
71	BD – 10°03699	7 June 1968	$3^h24^m30^s.99$	21 in.	Entry[b]
72	BD – 10°03705	7 June 1968	$4^h40^m59^s.11$	21 in.	Entry
73	CD – 23°12372	9 June 1968	$6^h06^m37^s.16$	21 in.	Entry[b]
74	CD – 29°14894	9 July 1968	$5^h25^m58^s.66$	21 in.	Entry[b]
75	CD – 28°14648	9 July 1968	$9^h06^m46^s.00$	21 in.	Entry[b]

[a] Observed through the clouds.
[b] The data might have lower accuracy.

The apparent diameters of seven observed stars exceed 0.001 arc sec. The diffraction patterns may be analysed either by fitting the data with theoretical curves or by deconvolution methods. Figure 5 shows an occultation of BD +24° 1946, $m_v = 6.4$; K0. The magnetic tape record of the occultation was read out by means of a frequency to voltage converter and the oscilloscope. Also a similar read-out can be obtained using a fast multichannel oscillograph. A multichannel analyser and associated paper tape punch may be used to read the magnetic tape and record the observed diffraction patterns in machine readable form. Figure 6 is a comparison between the diffraction patterns of 80 Virginis, ν Virginis and Antares. The time scale for Antares should be multiplied by a factor of two.

The results of the preliminary analysis are in very good agreement with the theoretical values derived from stellar models. For example the observations of ν Vir were evaluated by fitting the data with theoretical curves. For three different values of the diameter, namely

$$D_1 = 5.09 \times 10^{-3} \text{ sec of arc}$$
$$D_2 = 5.50 \times 10^{-3} \text{ sec of arc}$$
$$D_3 = 5.91 \times 10^{-3} \text{ sec of arc}$$

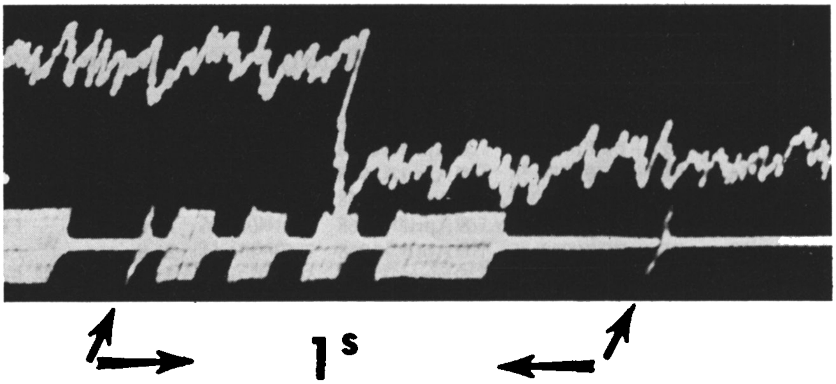


Fig. 3. Oscilloscope record of the disappearance of BD $-9^{0}6141$, $m_v = 8.6$; F8. Two consecutive second pulses of the WWV time singal are visible too.

Fig. 4. Occultation of a previously unknown binary. The separation of the components projected onto the direction of the Moon orbit is 0.02 arc sec.

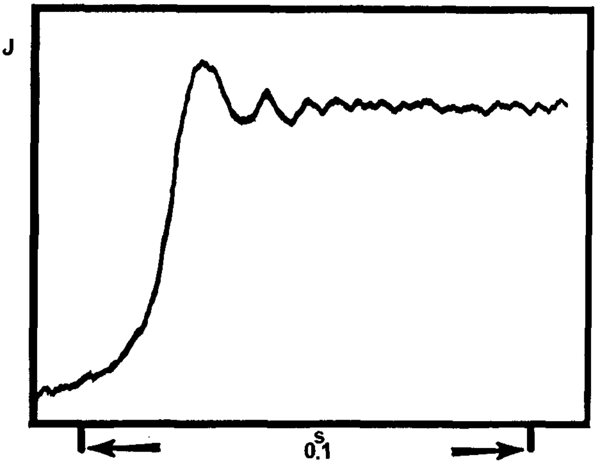


Fig. 5. The diffraction pattern of the star $24^{0}1946$, $m_v = 6.4$; KO.

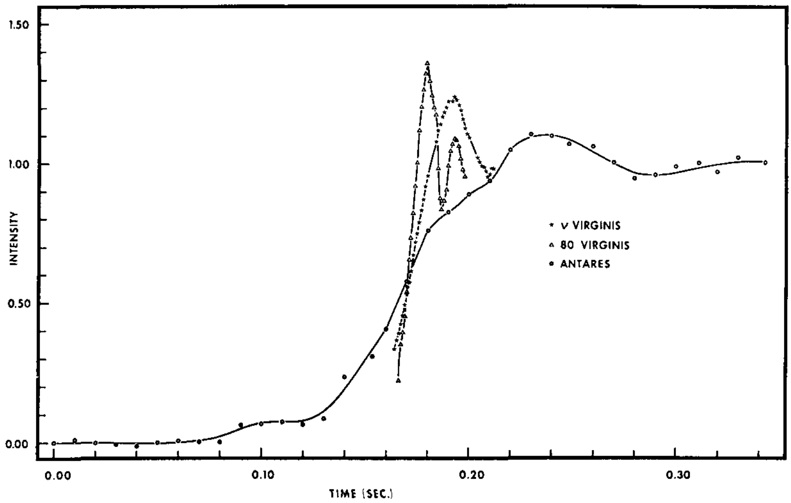


Fig. 6. A comparison between the diffraction patterns of 80 Virginis, ν Virginis and Antares. The time scale for Antares should be multiplied by two.

the values of the theoretical diffraction patterns (assuming a linear law of limb darkening) were calculated by numerical integration and then compared with the observed values. Interpolation led to a value of the apparent diameter of

$$D = 0''.005\,65 \pm 0''.000\,01 \text{ p.e.}$$

The value for the probable error was derived from the scatter of the measures. Since, however, the oscilloscope used in these observations permits an accuracy of only 1%, the systematic accuracy of the result is certainly not better than 1%. A digital recording

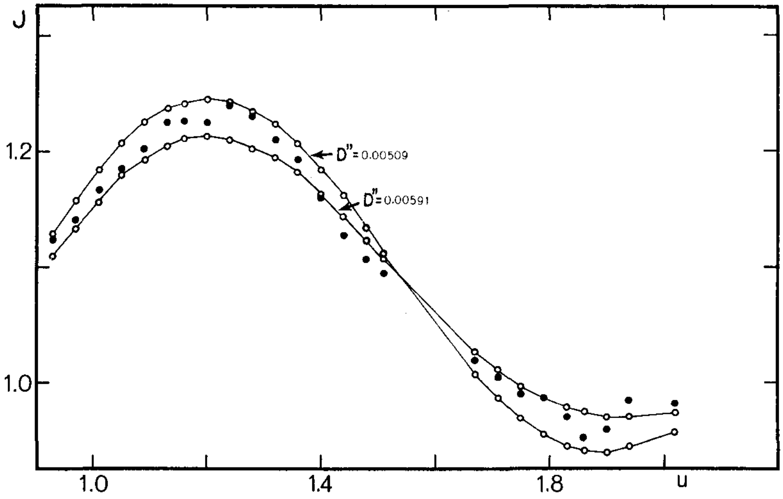


Fig. 7. First maximum and first minimum of the diffraction pattern of ν Vir (filled circles) lie almost always between the computed diffraction figures for diameters of 0″.00509 and 0″.00591 (open circles).

system of the photocurrent will therefore, permit even higher accuracy. Figure 7 shows clearly that the measured points (filled circles) fall almost always between the computed curves (open circles) for D_1 and D_3. The measured points were derived only for those portions of the curve that are best suited for diameter determination.

Considering the stellar model for ν Vir, the theoretical value of apparent diameter can be computed as follows: From 'Revised Harvard Photometry' we find $m_{\text{vis}} = 4.20$ and Spectral Type MO. If one assumes the star to belong to luminosity class III, then one finds for the diameter the value:

$$\log D'' = 5.14 + \frac{\text{BC}}{5} - \frac{m_v}{5} - 2 \log T_e$$

BC = bolometric correction; T_e = effective temperature, i.e.

$$D'' = 5.25 \times 10^{-3}.$$

Complete agreement between this value and that found from observations can be obtained by decreasing the effective temperature of the star by merely 110 K. For this star, more recent photometric data and spectral classification are available. 'Photoelectric Photometry of Bright Stars', (*Uppsala Meddelande* **155**, 1966) gives: $V = 4.06$; M 1 III. These values lead to a diameter of 6.25×10^{-3} sec of arc, a value considerably larger than the measured one, which is rather unlikely. Irregularities on the lunar surface may cause a stellar radius to be measured too large, but never too small. It is obvious that any or all of the quantities, V, T_e, BC, must be incorrect. For instance a change of merely 150 K in the effective temperature would remove this discrepancy.

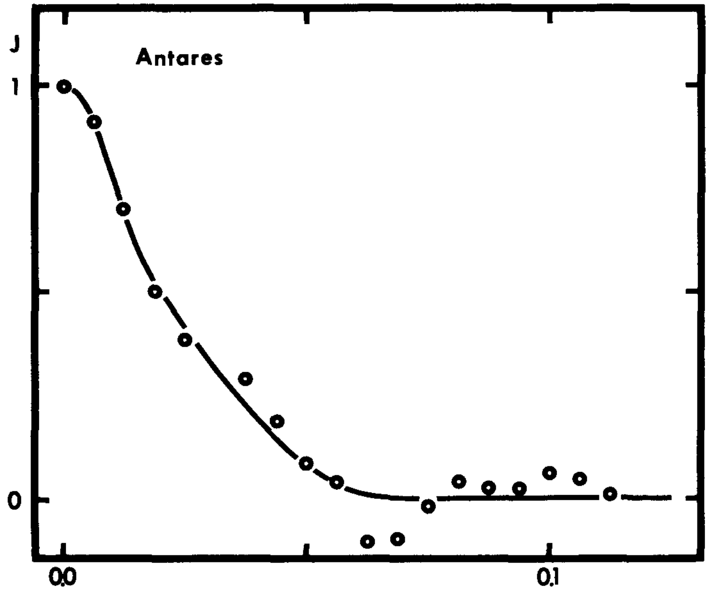


Fig. 8. The brightness distribution over the disc of Antares. The abscissa, starting from the disc center, is given in arc sec.

Accurate photometric and spectroscopic data will, in conjunction with occultation measures of a larger number of stars, provide valuable help in fixing the temperature scale and the bolometric corrections, especially for stars of late spectral types. It is important to note that the 'Stellar Intensity Interferometer' can be successfully applied only to the brightest stars of early spectral types.

The observation of Antares, see Figure 6, was made under very unusual conditions. The disappearance on the bright Moon limb during the day time (solar altitude 32 and stellar altitude only 12 deg) was measured in the near infrared region, $\lambda_{\text{eff}} = 7300$ Å; $\Delta\lambda = 600$ Å. Figure 8 shows the brightness distribution over the disc of Antares. The abscissa, starting from the disc center, is given in arc sec. The preliminary data have been analysed by convolving with a suitable restoring function. It is identical to the one used by the NRAO occultation program. I wish to express my thanks to Dr Joseph H. Taylor, Jr. of Harvard College Observatory for running this program for me at Harvard.

5. Future Work

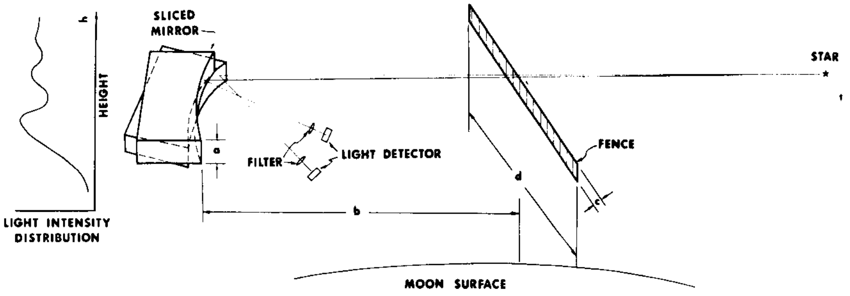
The experiences, reported here, have overcome all observational difficulties to such an extent that successful observations of this type can now be carried out on a routine basis. The 27 in. refractor of the University Observatory in Vienna is currently being used for this purpose. Part of the photoelectric photometer is a gift on an indefinite loan basis from the Naval Observatory in Washington. Also the Nautical Almanac Office has kindly agreed to provide occultation predictions. The Vienna University Observatory and myself wish to express our thanks to the Scientific Director of the Naval Observatory, Dr K. Aa. Strand, the Director of the Nautical Almanac Office, Dr R. L. Duncombe, and the Director of the Time Service Division, Dr G. M. R. Winkler, for this very effective cooperation.

We are planning to extend the observations at Kanzelhöhe Observatory, but at the moment we do not have a suitable telescope there. Also we will cooperate with the Hamburger Sternwarte exchanging the data and equipment.

There is yet another reason for dealing with this observational technique at the present time: Once an astronomical observatory has been established on the lunar surface, one would think that interferometric measures of one kind or another for determining stellar radii would almost certainly be part of its observing program. It can easily be shown that a diffracting edge mounted almost parallel with the Moon's horizon and at a distance of about one dozen kilometers from the observatory on the lunar surface, used in conjunction with a telescope of special design, would provide the possibility of making repeated observations of the same star. The following suppositions for the design can be adopted:

(1) Accuracy of measures: Our aim is to measure the distortion of the diffraction pattern produced by stars of apparent diameters as small as 0.001 arc sec.

(2) Telescope: The full aperture of the telescope is 50 × 50 cm; see Figure 9. The mirror consists 50 cylindrical polished sections. These are oriented with respect to one another in such a way that the images of a star under observation are contained



MEASUREMENT OF STELLAR DIAMETERS FROM THE MOON'S SURFACE

Fig. 9. Moon telescope of special design for occultation program in space. $a = 1$ cm; $b = 10$ km; $c = 2.5$ cm; $d = 2$ km.

in the 2×2 cm area of a SEC TV camera tube. The minimum resolution of the mirror in the direction of the cylinder axis shall be 0.05 mm. The integration time of the SEC tube should be about 1 sec and transmission of data should be in accordance with standard TV techniques.

(3) Telescope controls: In order to find and set up on a star, the telescope is to be movable through 20 deg in the horizontal direction. In order to achieve the necessary integration time of 1 sec, the mirror shall be movable parallel to itself through about 5 cm in the vertical direction. The accuracy of the horizontal motion should be ± 1 arc min, the vertical motion should be uniform to ± 0.03 mm.

(4) Spectral regions: For measurements of stellar diameters and of double stars three different interference filters of at most 50 Å band widths should be available for placement in front of the cathode of the SEC tube. For photometry of stars additional filters should be available, particularly for observations in the UV.

(5) The diffracting edge: A band, 1 in. wide, should be placed a distance of 10 km to serve as the diffracting edge (fence). The minimum height above the lunar surface should be 1 m and the length should correspond to 20 deg as seen from the telescope. The band can be laid out in sections. It must be parallel with the sections of the mirror to within ± 5 deg. Even a considerably shorter length of the fence, for example 5 deg instead of 20 deg, would not seriously decrease the number of observable stars, since the orbital plane of the moon shifts along the ecliptic with a period of 18.6 yr; in this case, however, one would have to operate the instrument on the lunar surface for a much longer time to obtain the same coverage of objects as can be obtained with the longer fence.

A check of the 'Bright Star Catalogue' shows that within the band of declination $-10°$ to $+10°$ there are about 400 stars to $V = 6\overset{\mathrm{m}}{.}5$ (limiting magnitude of the catalogue) whose diameters exceed 0.001 arc sec. However, since stars of spectral type *M* down to $V = 8.5$ generally have angular diameters larger than 0.002 arc sec, one can in reality expect to be able to measure the diameters of about 1000 stars. During the course of one year the diameter determination of any given star could be repeated at least five times. Should the equipment remain functional for a longer period of time, then at least 500 more stars could be added to the observing list because of the gradual shift of the plane of the lunar orbit relative to the ecliptic.

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