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THE PHOTOMETRY OF THE TOTAL SOLAR ECLIPSE ON AUGUST 11, 1999

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Abstract. The relative brightness of the sky was measured during the total solar eclipse on August 11, 1999, and from that the absolute brightness was derived. The obtained results were compared with some simple eclipse models based on the Schwarzschild - Schuster and Eddington approximations for the limb darkening of the solar disc.

1. INTRODUCTION

The intensity of extraterrestrial radiation changes due to variations in the Earth - Sun distance and in solar activity, ranging from 1307 to 1393 W/m2. The solar radiation spectrum before entering the Earth's atmosphere is in 0.015-1000 mm wavelength range. As the solar radiation passes through the Earth's atmosphere, 25-50% of energy is lost.

During a total solar eclipse the brightness of the sky changes rapidly. The roughest physical model assumes that the brightness depends only on the area of the visible portion of the solar disc, which could be calculated by using the coordinates of the Sun and the Moon, as well as their apparent diameters in certain eclipse phases. That model could be somewhat improved by taking into consideration the darkening toward the limb of the solar disc.

According to the Schwarzschild - Schuster model of darkening toward the limb, the intensity of radiation of unit area of the Sun is given by:

$$I(\theta) = F(\frac{1}{2} + \cos\theta) \qquad 1$$

where I stands for the intensity of radiation coming from the observed point on the Sun's surface, q is the angular distance of the observed point from the center of the Solar disc, and and F is the intensity in the center of the Sun.

According to the Eddington model the radiation intensity coming from a certain point on the Sun's surface is:

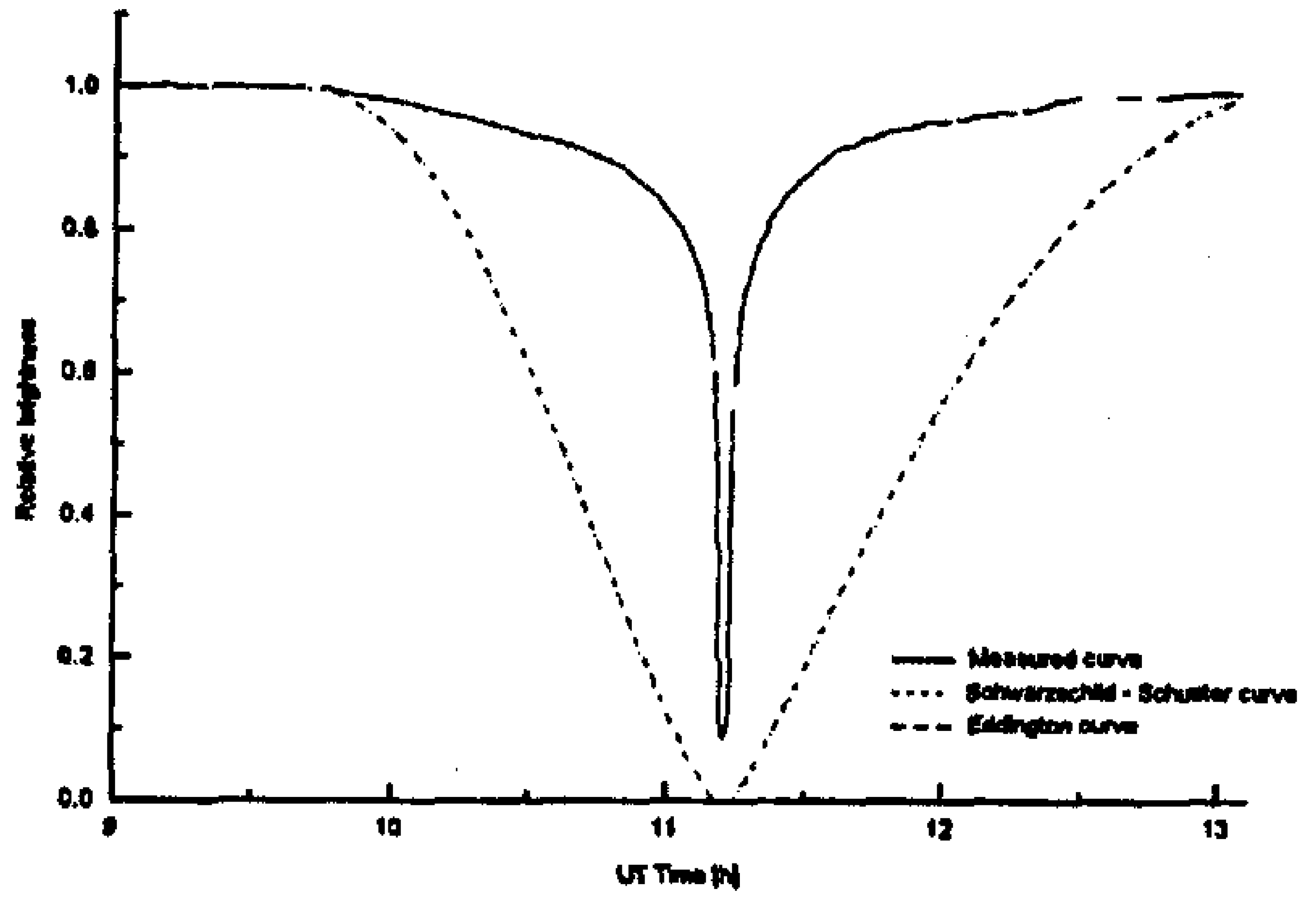

Fig. 2. The relative brightness as a function of time. The solid curve was measured, and the broken curves represent physical models based on the Schwarzschild - Schuster and Eddington approximations. The symmetry of all three curves is disturbed by true motion of the Sun and the Moon with respect to the Earth.

The intervals between the measurements were being changed from 5 to 2, 1 and 0.5 minutes according to the approaching of the totality. The test measurements were being done in 5 - minute intervals.

The results obtained from the August 10, and August 11 measurements are shown on in Fig. 1. The relative brightness during the eclipse was simulated according to equations 1 and 2. It is shown in Fig. 2, together with the actual relative brightness measured.

	Time UT h	Absolute Brightness W/m^2
1st contact	09.770722222	900±20
2nd contact	11.184638889	220±20
3rd contact	11.220666667	210±20
4th contact	12.556555556	800±40
Maximum eclipse	11.202666667	80±5

Table 1. The contact times and absolute brightness.

For getting the absolute brightness it was necessary to calibrate the photodiode. The calibration was done with a piranometer in The Rebublic Hydrometeorological Institute - Meteorological Laboratory Belgrade. The piranometer was calibrated with respect to the national measured unit - pirheliometer, so the piranometer was used as the second measured unit. The acquisition of the data shown by piranometer was done using a program SOLAR. Mr. Slobodan Hadživuković had written the algorithm for the program. The absolute brightness was shown in Fig. 3, and its values in the points of contact are given in Table 1.

$$I(\theta) = F(\frac{1}{2} + \frac{3}{4}\cos\theta) \qquad 2$$

When the influence of the Earth's atmosphere is ignored, the total intensity of solar radiation is proportional to the total amount of radiation coming to the Earth's unit area (brightness).

2. MEASUREMENT

Silicon photodiode of type FD5N was used as a base for the photometric equipment. During the observations it was pointed toward the zenith.

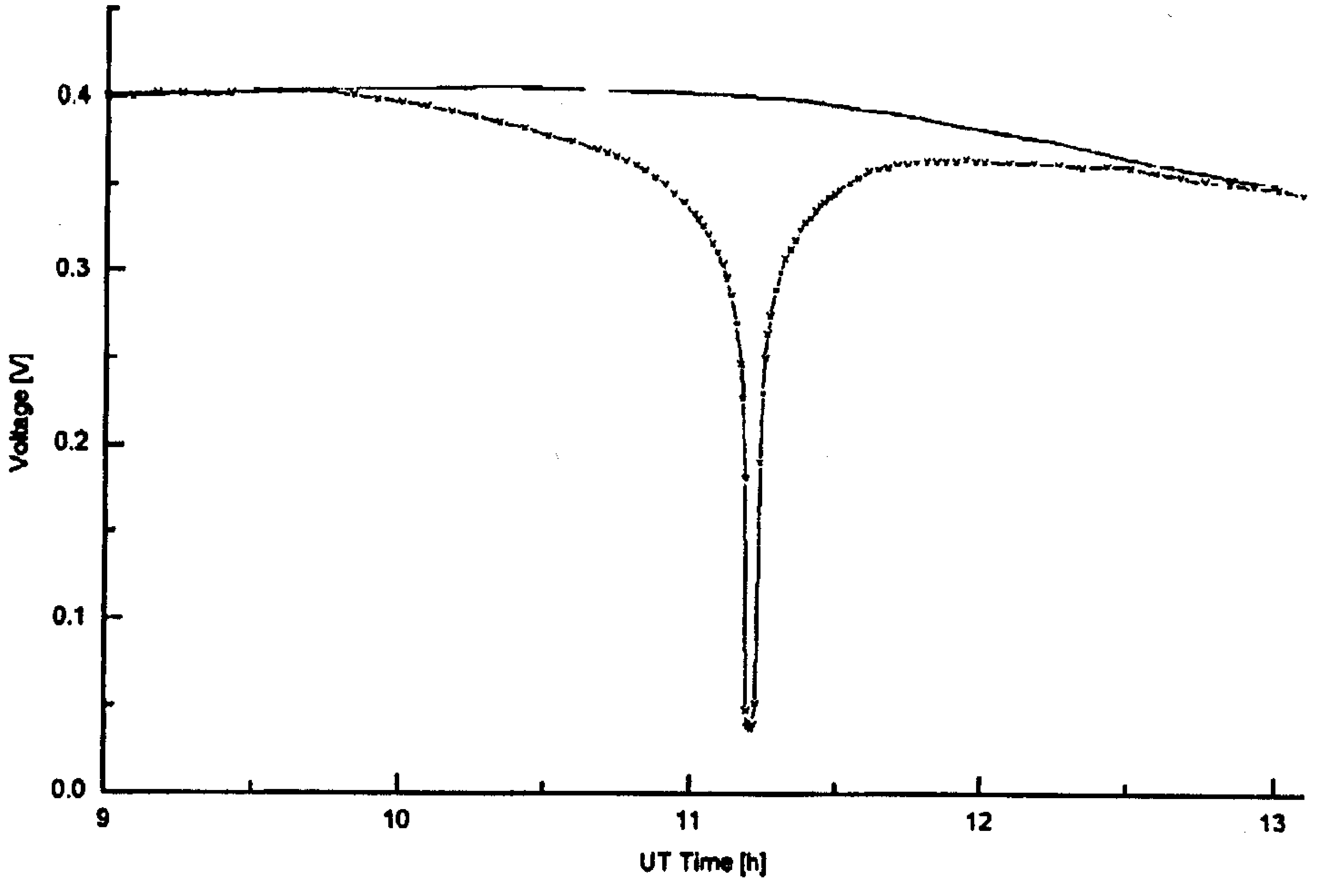

Fig. 1. Dependence of voltage at the photodiode on time, measured the day before the eclipse on August 10, 1999 (the curve above), and during the eclipse on August 11, 1999 (the curve below). The local noon was at 10.13245667 h UT.

The photometric observations of the total solar eclipse were made in Kamen Bryag, Bulgaria (l=28°33′15" E, j=43°27′32" N) on August 11, 1999. The observing site was chosen because of the high probability of clear skies and because the central line of the eclipse was close to the observing site. The test measurements were done on August 10, and August 12. However, the August 12 results were useless because of the bad weather. The brightness of the sky measured during the eclipse and the test measurement were done from 9.00am until 1.00pm UT. The times of contacts and the maximum eclipse time in UT system are given in Table 1.

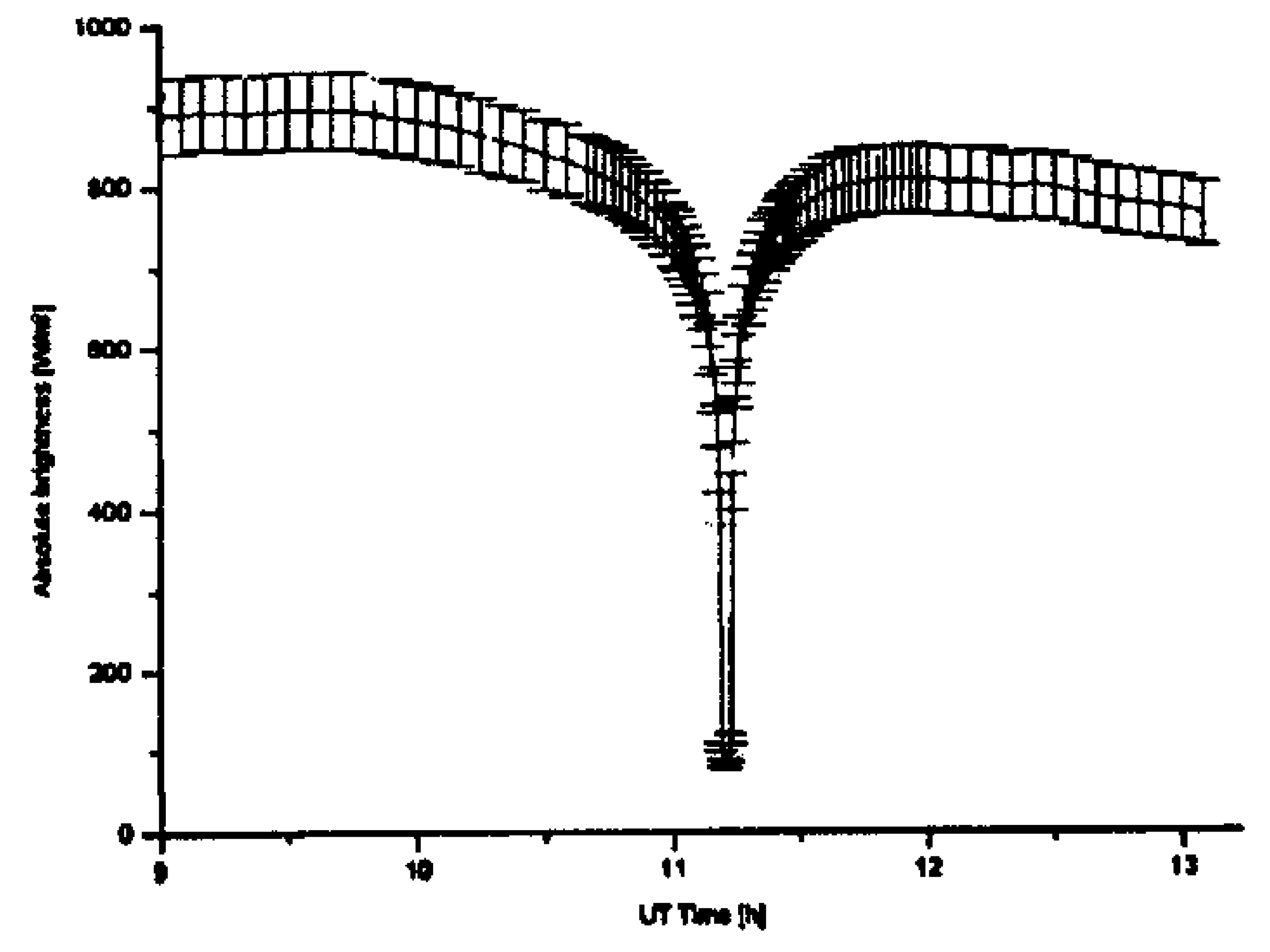

Fig. 3. The absolute brightness as a function of time during the eclipse in Kamen Bryag, Bulgaria, on August 11, 1999.

3. CONCLUSION

By comparing the observational results with the two physical models, as shown in Fig. 2, a great difference in relative brightness can be seen. The curves obtained from Schwarzschild - Schuster and Eddington approximations differ only slightly. As the time of the eclipse totality approaches, those curves have neither rapid declining nor growing.

The measured brightness curve rapidly turns downward immediately before, and it starts to turning rapidly immediately after the eclipse totality.

An even better eclipse model would have to include influences of the atmosphere, the ground, and the duration of the totality.

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