# Observation of 1990 solar eclipse by a torsion pendulum

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(Received 12 December 1990)

During the solar eclipse of 22 July 1990 in the city of Bielomorsk of the U.S.S.R., we repeated the torsion pendulum experiment of Saxl and Allen, who reported an anomalous period increase during the solar eclipse of 7 March 1970. The relative change in the pendulum's period associated with the eclipse was found to be less than $5.2\times10^{-5}$ (90% confidence).

During the solar eclipse of 7 March 1970, Saxl and Allen [1] observed the part periods of a torsion pendulum to have relatively increased by about $2.7\times10^{-4}$. This anomalous phenomenon cannot be explained on the basis of classical gravitational theories. Neither has it been reported again in the subsequent two decades. To examine the validity of this anomalous phenomenon, we designed a torsion pendulum and took part in the international scientific expedition, organized by Moscow State University, to the region of Bielomorsk city in North Karelia, to observe the eclipse on 22 July 1990. Our experiment is not a simple repeat of the Saxl and Allen one, but has some advantages compared with their earlier work. We can obtain much more information from the measurement of each consecutive half-period of a torsion pendulum by a special time-delay counter. From the data, we can decide whether the full periods have changed and whether the equilibrium point of the torsion pendulum has drifted during the solar eclipse.

The torsion pendulum and its recording system were made at the Huazhong University of Science and Technology (China). The disk of the torsion pendulum with which the subsequent half-period observations were made is about 70 g and made from high-purity aluminum (99.9%). It is suspended from an isoelastic tungsten wire of diameter 25 $\mu$m and length about 130 mm. The pendulum is installed in an aluminum chamber which is supported by three adjustable bars. A mirror is attached to the mounting of the disk. When a laser beam goes through a glass window of the chamber and is reflected by the mirror, it scans across a photoelectric diode, recording both in its clockwise motion and counterclockwise return. One half-period of the torsion pendulum was timed by photoelectrically gating the output of a crystal oscillator (4 MHz) as the disk rotated to a midpoint where its speed approached the maximum value. By means of a 25-sec time delay, we can write down the data shown on a display (see Fig. 1).

During the day of the solar eclipse in Bielomorsk, the pendulum was started at 4:00 a.m. about 1 h before the beginning of the solar eclipse. We recorded the periods of the pendulum from 4:10 a.m. to 7:00 a.m., which is shown in Fig. 2 by points represented by circles. The beginning of the eclipse at 5:02 a.m. the full eclipse from 5:53 a.m. to 5:55 a.m., and its end at 6:49 a.m. are also indicated on this graph. As compared with the result of a comparison experment on 21 July (1 day before the eclipse), which is shown in Fig. 2 as points shown as triangles, we can find that the two curves are completely similar, except for a steady difference of about 10 ms. This difference in periods is due to the difference in magnitude of the initial angular amplitudes. If the amplitude of the torsion pendulum were used as the abscissa instead of the observation number in Fig. 2, it would be very evident that the two curves almost coincide. It means that

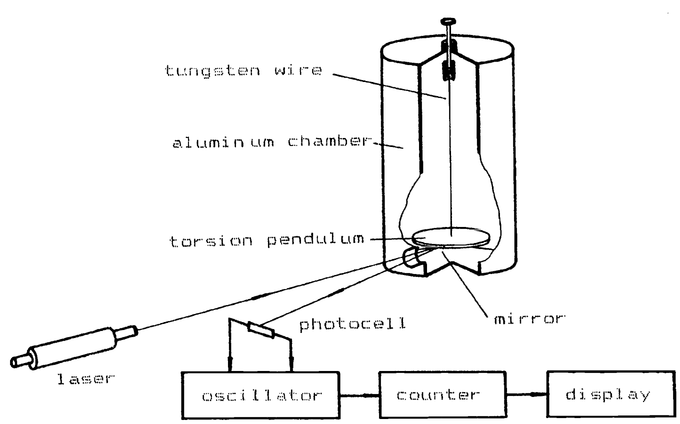


FIG. 1. Schematic of the experimental apparatus including the optical and time-recording systems.

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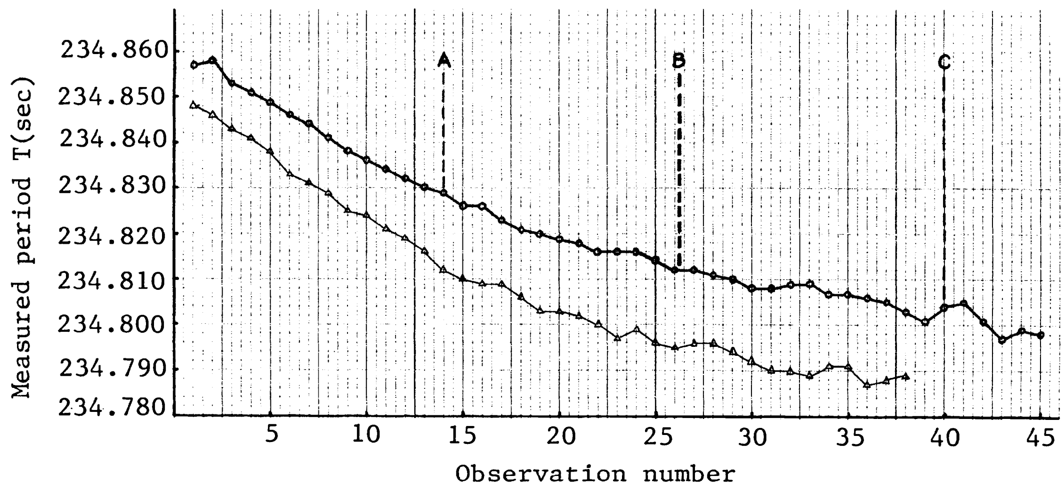


FIG. 2. Period versus observation number. *A*, *B*, and *C* represent the onset, midpoint, and end point of the eclipse, respectively.

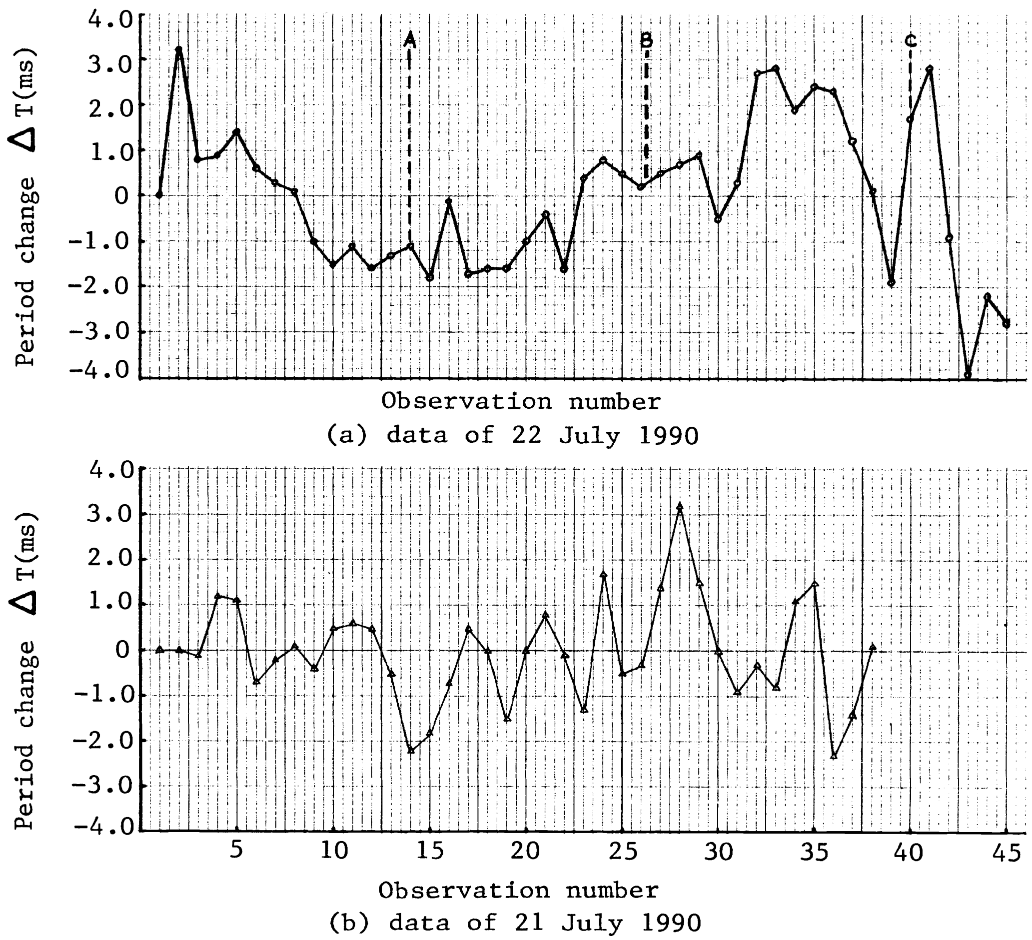


FIG. 3. Period deviations after correcting systematic errors. (a) Data of 22 July 1990 and (b) data of 21 July 1990.

the period of the torsion pendulum has no anomalous increases during the eclipse.

It is also to be noted that the period curves drift with the decay of the angular amplitude of pendulum. This effect can be explained as the variation in damping torque acting on the pendulum with its angular speed. This effect has been examined in detail both in experiments and in a theoretical analysis [2]. After removing the systematic errors from the recordings of period, we can obtain the deviation of each measured period from the theoretical value as shown in Fig. 3. The rms deviations of the period changes as shown in Fig. 3(a) and 3(b) are 1.5 and 1.2 ms, respectively. With the $t$ test, which has been applied to establish the significance of the difference between the observed and calculated values of the periods in two experiments, we found that the relative change in the pendulum's period associated with the eclipse was less than $5.2\times10^{-5}$ (90% confidence).

Examination of the half periods of the torsion pendulum also shows that the equilibrium point has no anomalous drift.

We cannot say what possible systematic error or errors would account for the results of Saxl and Allen, but to the limit of our experimental sensitivity, there is no observed anomalous period increases of the torsion pendulum during the solar eclipse at a level much smaller than the effect they reported.

International travel support came from the National Natural Science Foundation of China. We thank our friends of Lumumba University and Sternberg Astronomical Institute for their kind cooperation. We also thank Professor V. De Sabbata, F. Pedrielli, G. Bertault, V. Rudenko, V. Milyukov, V. Melnikov, and L. Savrov for their advice and helpful discussions.

[1] E. Saxl and M. Allen, Phys. Rev. D **3**, 823 (1971).

[2] Luo Jun and Li Jianguo, J. Huazhong Univ. Sci. Technol. **17**, 135 (1989).