EXPERIMENT WITH PARACONIC PENDULUMS DURING THE NOVEMBER 3, 1994 SOLAR ECLIPSE IN BRAZIL

L. A. Savrov

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The present article is the concluding article in a series discussing the results of the author's experiments with paraconic pendulums during solar eclipses from 1990 to 1994. During an eclipse, it is found that the rate of rotation of the pendulum's plane of oscillation increases in the same direction as the Foucault effect by a magnitude equal to that of the Foucault effect. However, all abnormal effects in the behavior of instruments during an eclipse are found to be at the level of instrument and measurement errors and computational errors.

Analysis of the results of an experiment with a paraconic pendulum during the total solar eclipse of July 11, 1991 in Mexico demonstrates [1] that, first, the instrument must function in the continuous mode at the observation point as long as possible, and, second, that several identical instruments are needed. Thus, in anticipation of the total solar eclipse of November 3, 1994 in southern Brazil, two identical instruments that were of the same type as those that had been used in Mexico in 1991, were manufactured by the division of gravity measurements of the Shternberg State Astronomical Institute.

Site and Equipment. From October 27 to November 10, a joint international expedition, which included scientists from Belgium, Italy, Russia, and France, was lodged at the Federal College of Technical Education (26°12' S, 52°41' W, Pato-Branco, state of Parana, Brazil).

The eclipse commenced on November 3 at 9:36:54 local time and concluded at 12:11:59. The total phase began at 10:48:28 (with the Sun 56° above the horizon) and concluded at 10:51:34 (local time).

The equipment was placed in two isolated laboratories with cement floors. The first compartment was intended for a G-783 relative geodynamic gravimeter, an LC&G-402 Lacoste-Romberg tidal gravimeter, and a Philips two-component static vertical pendulum. Paraconic pendulums supplied with recording units were placed in the second compartment.

Agate cones with hemispheres at their ends were used as the suspensions of the two paraconic pendulums, which were entirely identical in terms of dimension, configuration, and mass (mass 1320 g, length 31 cm). The diameters of the contact hemispheres measured 3 mm in the case of the first pendulum and 4 mm in the case of the second pendulum. Agate slabs were used as the slides. Both pendulums were placed in thermostatically controlled chambers. The system for automatic initiation, stop, and computer-aided data collection and control was the same one used in the observations of the solar eclipse of July 11, 1991 in Mexico.

Observations and Data Collection. In preparing the experiment, both devices were, of course, subjected to laboratory testing with complete run-through of the observation technique. The tests demonstrated that the movement of both pendulums was highly stable, and that the data recording system, a description of which may be found in [2], functioned in stable fashion.

On October 27 the expedition arrived at the observation site. The equipment was taken out, tested, and gotten ready for a continuous, round-the-clock mode of observation. At 9:30 on November 1 local time, the experiment commenced. Both pendulums were started in the north–south meridian plane. Every 2 h 45 min, the pendulums were halted and, 15 rain later, restarted in the plane of the same meridian, thus completing a single running cycle. The length of each series was selected so as to encompass the duration of the eclipse, which at the observation site amounted to 2 h 35 min.

Every 15 seconds data on the path of the pendulums' travel was taken down by the recording system and transmitted to the memory of a IBM 386 computer, thus forming a data bank. In the course of the experiment, which concluded November 5 at 20:30, the database consisted of a total of 183,504 files of information. A total of 36 series of continuous, round-the-clock observations was obtained for the first pendulum. The agate cone of the second pendulum experienced a microstrain, and so
General Considerations. The obtained data are in the form of coordinates $x$, $y$ of the elliptical trajectories of the motion of the two pendulums. The azimuths of the major semiaxes of the pendulums' oscillation ellipses were computed using the standard method of least squares. The computation technique and graphical representation of the dependence of azimuth on time was the same as were used in processing the data of the earlier experiment in Mexico [1].

Figure 1 shows comparative graphs representing the dependence of the azimuth of the first pendulum's oscillation plane on time. Three series were taken, first, during the eclipse (middle graph), second, during the 24 h preceding the eclipse (bottom graph), and third, in the course of the 48 h following the eclipse (upper graph); all three series were begun at 9:30 and concluded at 12:15 local time. The horizontal axis expresses time, counted off in min (scale division 2.5 min), and the vertical axis, the azimuth, expressed in degrees (scale division $2^\circ$). The digits above the horizontal axis next to the vertical lines denote the starting time of the experiment, the full phase period, and the time at which the eclipse concluded (hour:minute:second), respectively.

In comparing these graphs with the similar graphs for the previous experiment in Mexico (see Fig. 2 in [2]), the following are the principal features that may be noted: (a) the characteristic movement of the pendulum's oscillation plane is

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**Fig. 1.** Azimuth of oscillation plane as a function of time for the first pendulum.

**Fig. 2.** Azimuth of oscillation plane as a function of time for the second pendulum.

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was replaced by a back-up pendulum. Continuous observations of the latter pendulum began November 2 at 21:30. Thus, 24 series of observations were performed with this pendulum. Clearly, there were a total of 60 series performed with the two pendulums, nearly ten times as many as had been performed using the same device on July 10 and 11, 1991 in Mexico (a total of eight series were performed in Mexico).