Analysis of readings of underground acoustic installation on 23 February 1987

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There is a statistically significant increase above the background in acoustic signals detected in an underground shaft in the Carpathian Mountains between 6 and 9 h UT on 23 February 1987. These signals were not associated with seismic processes or human activities. Since a supernova explosion (SN 1987A) was detected in the Large Magellanic Cloud at 10.40 UT (IAU Circ., 1987, No. 4316), it is possible that these signals were associated with SN 1987A.

A method for continuous geoacoustic monitoring of the stress-strain state of rock formations for geodynamic and seismic prediction problems is described in Ref. 2. This method enjoys a high sensitivity because the useful signal which is detected consists of parametric and nonlinear effects which arise during the propagation of elastic waves through deformable rock. The apparatus is installed at a depth of 20 m in a gallery near the city of Beregovo in Zakarpatskaya Oblast in the Ukraine. Transmitting and receiving piezoelastic transducers are mounted ~1 m apart on the walls of recesses in the gallery. The measurements were carried out over the frequency range 2–20 kHz.

According to Ref. 2, the amplitude of the harmonics which are multiples of the fundamental frequency and which arise during the propagation of a sinusoidal sound wave through a fissured medium is more sensitive than the amplitude at the fundamental frequency to changes in the microscopic fissuring and the stress-strain state of rock.

Figure 1 shows the time evolution of the fluctuations in the second-harmonic amplitude of the elastic wave, A_2, from 22 to 25 February 1987.

It can be seen from this figure that in the Universal Time intervals 6–7 h and 8–9 h on 23 February there are some clearly defined peaks in the time evolution of A_2, against the background of ordinary fluctuations, in particular, fluctuations associated with tidal deformations of the earth's lithosphere. The statistical reliability of the first peak (in the interval 6–7 h) is $\sim 4.5\sigma$, and that of the second $\sim 3\sigma$, where σ is the mean square deviation of A_2 from the average background.

A thorough analysis of data on regional seismic activity, meterological processes, and anthropogenic sources of noise and also of the operating parameters of the apparatus which were monitored has revealed no association with the nature of the peaks.

As we know, a gravitational antenna in Rome operated near 2 h 52 min UT (Ref. 3), and this operation was accompanied by the detection of a rare event (five interaction events which were detected in the LSD detector under Mont Blanc in an interval

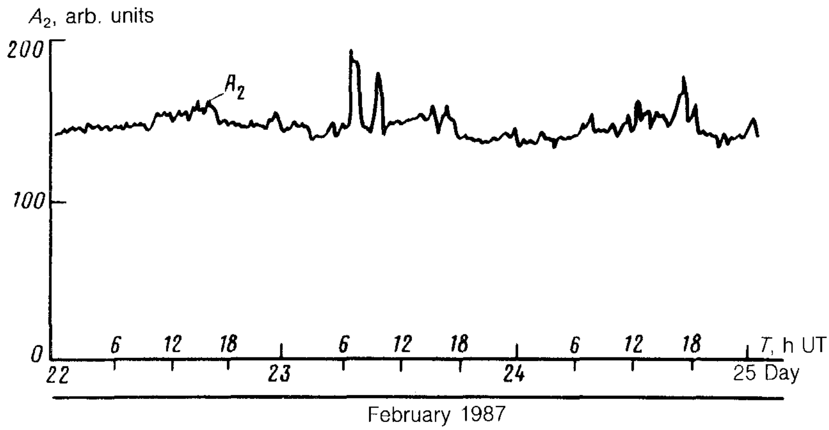

FIG. 1. Variations in the amplitude (A_2) of the second harmonic of the elastic wave in rock versus the universal time (UT) on 22–25 February 1987.

of 7 s; Ref. 4). Near 7 h 36 min UT, several detectors (JMB, Kamiokande II, and the Baksan Underground Neutrino Telescope)[5–7] detected bursts of respectively 8, 11, and 5 pulses, which were possibly due to an interaction of neutrinos with matter.

As we see, the acoustic signals do not coincide in time with the operation of the gravitational antenna or with the operation of the underground neutrino detectors. However, there are grounds for suggesting that the events which have been detected are of a macroscopic nature, because contradictions arise in attempts to explain the events[8] detected in the underground neutrino detectors as resulting from interactions of neutrinos: The number of events detected by each of the underground installations (LSD, JMB, Baksan, and Kamiokande II) is not proportional to the mass of the detector, and the angular distributions do not correspond to the isotropic distribution which would be characteristic of the most likely reaction, $\nu + p \rightarrow e^+ + n$ (Ref. (9)). It is possible that these events are associated with changes caused in geophysical fields and the medium by a gravitational wave, high-energy gravitons, or some other macroscopic mechanism.[10]

In this situation it is worthwhile, in an analysis of the reasons for the operation of the various detectors on 23 February 1987 and of their correlations with the explosion of SN 1987A in the Large Magellanic Cloud, to compare the information from these detectors with the acoustic data in Fig. 1.

It is no less important to carry out an independent analysis of all the seismic data (from the worldwide and regional networks, experimental installations with frequency-selective reception, etc.), measurements concerning the fluid-dynamic regime and the chemical composition of the gases, and the entire complex of parameters of the earth's electromagnetic field.

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[1]IAU Circ., 1987, No. 4316.
[2]T. Z. Verbitskiĭ, in: Seismic Sounding of Focus Zones in Earthquake Prediction and Geodynamics, Nauka, Moscow, 1979, p. 216.
[3]E. Amaldi *et al.*, Europhys. Lett. **3**, 1325 (1987).
[4]V. L. Dadykin *et al.*, Pis'ma Zh. Eksp. Teor. Fiz. **45**, 464 (1987) [JETP Lett. **45**, 593 (1987)].
[5]R. M. Bionta *et al.*, Phys. Rev. Lett. **58**, 1494 (1987).
[6]K. Hirata *et al.*, Phys. Rev. Lett. **58**, 1490 (1987).
[7]E. N. Alekseev *et al.*, Pis'ma Zh. Eksp. Teor. Fiz. **45**, 461 (1987) [JETP Lett. **45**, 589 (1987)].
[8]V. L. Dadykin, Usp. Fiz. Nauk **158**, 139 (1989) [Sov. Phys. Usp. **32**, 459 (1989)].
[9]V. V. Kolpachev, Pis'ma Zh. Eksp. Teor. Fiz. **49**, 644 (1989) [JETP Lett. **49**, 738 (1989)].
[10]O. G. Ryazhskaya and V. G. Ryasnyĭ, Pis'ma Zh. Eksp. Teor. Fiz. **47**, 236 (1988) [JETP Lett. **47**, 283 (1988)].

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