Macroscopic interpretation of neutrino events from SN1987A

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The neutrino signal from four detectors on 23 February 1987 is interpreted as an internal effect in the detectors, caused by a gravitational wave.

The major difficulties in interpreting the signals detected on 23 February 1987 from four neutrino detectors are the absence of a proportionality between the number of events detected and the mass of the detector, the difference in the energies of the events, and the increased anisotropy in the angular distribution.[1,2] A fact which has gone unexplained is the coincidence of a signal from the gravitational antenna in Rome with the signal in the LSD neutrino detector under Mont Blanc.[3]

The set of experimental facts suggests that the signals in these detectors were not caused by neutrinos from SN1987A and were instead a consequence of an internal effect in the detectors themselves, caused by the same factor as gave rise to the signal from the gravitational antenna (we assume below that this factor was a gravitational wave).

The Geograv antenna is a 2300-kg rod with a resonant frequency of 858 Hz, which is held at room temperature.[3] The number of measurements with energies above ΔE for this antenna is described by

$$N(\geqslant \Delta E) = N_0 \exp(-\Delta E/E_0),$$

where $E_0 = kT_0$ is the equilibrium energy, $T_0 = 30$ K, and N_0 is the total number of measurements. The signal obtained from the antenna agrees well, after the background is subtracted, with the signal from the LSD detector in terms of both arrival time and time evolution.

Figure 1 shows the number of neutrino events per hydrogen atom in the effective volume as a function of the total energy of the events for four detectors: LSD (Italy, USSR), $n = 5$, $N_H = 8.4\times 10^{30}$; Baksan (USSR), $n = 5$, $N_H = 1.87\times 10^{31}$; KII (Japan), $n = 11$, $N_H = 1.42\times 10^{32}$; and IMB (US), $n = 8$, $N_H = 4.52\times 10^{32}$. The points are correlated with a coefficient $R = 0.9997$; this behavior would seem overly regular for random events with such statistics. The functional dependence here is described by

$$n/N_H = K_0 \exp(-\Delta E/E_0), \tag{1}$$

where $K_0 = 1.0\times 10^{-30}$ and $E_0 = 66.4 \pm 3.0$ MeV. It follows directly from (1) that 1) at a fixed N_H (i.e., for one detector) the number of events detected falls off exponentially with the energy, rather than increasing in accordance with the cross section, and 2) the specific number of events decreases with increasing mass of the detector.

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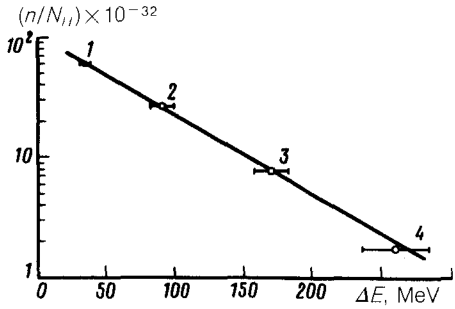

FIG. 1. Number of events per hydrogen atom versus the total energy. 1—LSD; 2—Baksan; 3—KII; 4—IMB.

One gets the impression that the factor which caused the responses of the detectors acted on each detector as a whole (this circumstance would be natural for a gravitational wave); i.e., this factor was distributed among the bonds between particles (because of the low wave frequency, $\lesssim 1$ kHz, free protons dominate the situation). The greater the number of bonds (protons), the lower the wave energy per bond and thus the lower the probability for the rupture of the bond. For this reason, a greater specific number of events is observed in detectors with a smaller mass.

During the passage of the gravitational wave, there thus exists an equilibrium system of hydrogen atoms with a state energy $E_0 = 66.4$ MeV. The signals are thus caused by processes of the type

$$\begin{aligned} & e^- + p \to n + \nu, \\ & \nu + e \to e + \nu, \end{aligned} \tag{2}$$

which, incidentally, preserve information about the direction to the source.

Note, however, that the only particles which were detected were an electron and a neutron, so it may be that the role of the neutrinos in (2) is being played by some virtual system of particles in a coherent motion which implements conservation laws. The neutrino may thus be regarded as a system which is decaying, and an antineutrino as a system which is being created. The different types of neutrinos differ in the number of particles which are participating coherently in the process. The nucleon is a proton or a neutron, depending on the particular system to which it belongs. Nucleons bound in nuclei are not part of the coherent motion common to the entire volume (their contribution depends on the frequency of the gravitational wave). Processes (2) apparently play out in a corresponding way in nuclei, but fewer particles are involved. The parameter K_0 is thus related to the number of particles that form the neutrino effect (i.e., to the probability for the process), and E_0 may characterize the mass of this neutrino.

A point which remains unclear is the separation in time, of nearly 5 h, of the signals from the LSD detector and the three other detectors. Apparently there were two factors causing the responses of the detectors, but they were of the same nature, as follows from Fig. 1 and expression (1). The second factor might have been, say, a scattered gravitational wave.

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[2]O. G. Ryazhskaya and V. G. Ryasnyĭ, Pis'ma Zh. Eksp. Teor. Fiz. **47**, 236 (1988) [JETP Lett. **47**, 283 (1988)].
[3]E. Amaldi *et al*, Europhys. Lett. **3**, 1325 (1987).

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