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1. New measurements of the gravitational constant

New experiments intended to measure the gravitational constant G were carried out at three laboratories. Their results differed greatly from one another and from the value accepted at present: $G_0 = 6.6726 \times 10^{-8}$ cm^3 g^{-1} s^{-2}, accurate to within 0.01%. At the German Bureau of Standards the value obtained exceeded G_0 by 0.6% (60 standard deviations). The results obtained at the New Zealand Laboratory for Measurement Standards and at the Wuppertal University in Germany were smaller than G_0 by, respectively, 0.07% – 0.08% (7 – 8 standard deviations) and 0.07% (7 standard deviations). All three groups investigated the gravitational field of massive cylinders. This disagreement between the measurements may be solved by the experiments planned at present at Los Alamos, where the aim is to reach a precision 5 times greater than that attainable at present.

The value of G is known less accurately than any other fundamental constant. It is difficult to measure directly, in particular because of the weakness of the gravitational interaction and because of gravitational interference by adjacent objects. However, the exact value of G is important in many celestial mechanics and cosmology problems. One cannot exclude the hypothetical possibility that G varies with time. If $|\dot{G}|/G \lesssim 10^{-10}$ per year, then the change in G should affect the evolution of cosmic objects. At present an experimental estimate of this quantity is close to $|\dot{G}|/G \lesssim 10^{-10}$ per year.

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2. Neutrino oscillations

The problem of the neutrino mass is one of the most important in the physics of elementary particles. In the standard model of electroweak interactions the neutrino is regarded as having zero mass, but the majority of the Grand Unification Theories require that the neutrino should have a mass. Convincing proof of zero or finite neutrino mass is still lacking. Only the upper limits have been established experimentally. For example, an investigation of the β-decay spectrum of tritium has given $m_{\nu_e} < 50$ eV. Observations of the CH 1987A supernova show that $m_{\nu_e} < 16$ eV. If the mass of at least one kind of neutrino were to be $m_\nu \gtrsim 10$ eV, this would be of enormous importance in cosmology. The neutrino could then be part of dark matter, responsible for the dark-matter mass of the Universe, and could influence the formation of the large-scale structure of the Universe. Cosmology, however, provides evidence that none of the neutrino forms can have a mass in excess of 80 eV.

One of the most interesting consequences of the finite neutrino mass could be neutrino oscillations representing the transformation of ν_e into other kinds of neutrino (ν_μ and ν_τ) and vice versa. This effect could take place if what are known as the flavour states ν_e, ν_μ, and ν_τ were to differ from the mass eigenstates. Neutrino oscillations occur because of the change with time in the relative phases of the various components of the neutrino wave function.

Neutrino oscillations could solve the problem of solar neutrinos. The problem is that the flux of ν_e proceeding from the Sun and observed on the Earth is almost 4 times less than the theoretically predicted value. However, if neutrino oscillations do take place, then the bulk of ν_e created inside the Sun could have been transformed into ν_μ and ν_τ while crossing the Sun and the result would not be detectable experimentally.

In view of the great importance of the problem of neutrino oscillations in physics, experimental attempts have been made to observe such oscillations. Recently, a group of experimentalists at Los Alamos, working with the LAMPF accelerator, reported possible observations of neutrino oscillations. Their experiments suggested possible transformations of the muon antineutrino into the electron antineutrino. The source of neutrinos was the decay of pions and muons. Neutrinos were recorded with the aid of a liquid scintillation neutrino detector (LSND) on the basis of the Cherenkov radiation emitted by positrons formed as a result of the interaction of neutrinos with the detector material (mineral oil). Nine events were recorded, whereas the theoretically expected number of events was 2.1 ± 0.3. However, the final judgment about these results can be made only if they are repeated independently.

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3. Gravitational field and superconductors

Interesting experiments were carried out in 1982 by E Podkletnov and his colleagues. In these experiments they measured the weight of a test body levitating above a superconducting disk. This disk was cooled with liquid helium and levitated in a magnetic field because of the Meisner effect. The experiments gave an unexpected result: the weight of the test body decreased by 0.05% from its

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initial value. When the disk was rotated by an alternating magnetic field, the reduction in the weight reached 0.3%. Further experiments showed that the maximum reduction in the weight (2%) was observed at the moment when the disk was stopped.

These experiments were carefully analysed and the only explanation of the observed effect (if it is regarded as reliably established) is the influence of a superconductor on the gravitational force of the Earth between the disk and the test body. If this explanation is correct, then we are dealing with a laboratory investigation of the quantum gravitation effects. An important feature is the fact that a superconductor has a macroscopic wave function which describes the Bose condensate of the Cooper pairs. The gradient of this function has a strong effect when the disk is decelerated. G Modanese (Max Planck Institute) in his analysis concluded that among all the proposed theories of quantum gravitation the one that could fit is non-renormalisable quantum gravitation on a lattice. At this stage these conclusions are very tentative and further experiments are needed to make the picture clearer.

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