physical sciences

GRAVITATION

Limit on variation of the constant

The gravitational constant is a number that relates the strength of a gravitational force to the masses of the bodies producing it. Isaac Newton, who introduced it into physics, based his theory of gravitation on the assumption that it is in fact constant.

Among modern theories Newton's view of the constant is represented by Albert Einstein's general relativity. However the rival theory of Carl H. Brans and Robert H. Dicke (SN: 11/21, p. 395) assumes that the constant varies with time.

An experiment that could show such variation would be a comparison of gravitational time—the orbital period of a planet—against an atomic clock. This has been done by Drs. Irwin I. Shapiro, William B. Smith, Michael B. Ash, Richard P. Ingalls and Gordon H. Pettengill of the Massachusetts Institute of Technology by timing radar determinations of Mercury's position against an atomic clock.

They report in the Jan. 4 PHYSICAL REVIEW LETTERS that the variation of the constant can be no more than 4 parts in 10 billion per year. Continuation of the experiment, they say, could bring the limit down to 3 parts in 100 billion.

QUANTUM MECHANICS

Electron standing waves

A standing wave is a wave that has been reflected back on itself in such a way that incoming and reflected waves interfere constructively. That means that their high and low points coincide and reinforce each other. Such a thing can happen to a wave confined in a box, for example.

One of the bases of modern physics is the principle that material particles are also waves. There is plenty of experimental evidence for various kinds of wave-like behavior by particles, especially electrons. Yet another form of wave-like behavior, the formation of standing electron waves, is reported in the Jan. 11 PHYSICAL REVIEW LETTERS by Drs. R. C. Jaklevic, John Lambe, Mati Mikkor and W. C. Vassell of the Ford Motor Co.

Since electron wavelengths are exceedingly small, a box with microscopically smooth sides would be needed to form standing waves. The Ford researchers found an out, however, in the fact that electrons are particles whose behavior is quantized, and the wavelengths they can have form a series of discrete values.

A box with rough walls, where the roughness was in discrete steps, would work, they found, and this is provided by a film of crystalline lead. Standing waves were observed as peaks in the conductivity of the lead.

PARTICLES

Muons are like electrons

The muon or mu meson is sometimes called the heavy electron since it has all the characteristics of an electron except that it is about 200 times as heavy. Experimenters have been trying to find some further difference between muons and electrons in the hope of explaining why the heavier particle exists.

One possible difference, a group of experimenters thought, might lie in the sort of statistics the muon obeys. The term statistics refers to the mathematical expression describing how many particles with the same amount of energy, momentum, spin and other properties can be in the same neighborhood at the same time. Some forms of statistics allow any number, but the Fermi statistics obeyed by electrons permit only one electron with a given set of properties (or quantum numbers as they are called) in a given neighborhood.

To find out what statistics the muon obeys, it is necessary to devise an experiment that produces two muons with identical quantum numbers and see how they behave. Drs. J. J. Russell, R. C. Sah and M. J. Tannenbaum of Harvard University, W. E. Cleland of the University of Massachusetts, and D. G. Ryan and D. G. Stairs of McGill University have performed such an experiment at Brookhaven National Laboratory. They bombarded lead nuclei with muons in such a way that after each hit, three muons were present, two of them identical. Muons obey Fermi statistics, they report in PHYSICAL REVIEW LETTERS for Jan. 4, which is another similarity with electrons.

SPECIAL RELATIVITY

Rest mass of the photon

According to the special theory of relativity a photon, or light particle, has a rest mass exactly equal to zero. Among the consequences of this statement are that photons can exist only in motion, that their speed is a universal speed limit and that electrical and magnetic fields extend an infinite distance from their sources.

If a photon has a rest mass, none of those statements is true. An experiment to look for a photon rest mass is reported by Drs. P. A. Franken and G. W. Ampulski of the University of Michigan in the Jan. 11 PHYSICAL REVIEW LETTERS. They attempted to measure a deviation in the relationship between resonant electric circuits that would be caused by any change in the velocity of light due to the existence of a finite mass for the photon.

The photon mass can be no more than 10^{-49} grams, they find, but they are a little uncertain of the result; dielectric elements in the circuits may have affected it.

X-RAY ASTRONOMY

Anomalous soft background

A background flux of soft X-rays that is brighter than that expected by extrapolating the known spectrum of harder X-rays has been observed in the direction of the north galactic pole. The observation was made with an Aerobee rocket flown on March 13, 1969. Dr. Richard C. Henry of the Johns Hopkins University and Drs. Gilbert Fritz, John F. Meekins, Talbot Chubb and Herbert Friedman of the Naval Research Laboratory report in the Jan. 15 ASTROPHYSICAL JOURNAL LETTERS.

The X-rays in question are of 18 angstroms wavelength (energies of 0.68 kiloelectron-volts). The flux observed is several times what would have been expected by extrapolating the spectrum that has been determined for the range 2 to 10 kiloelectron-volts. The observers suggest that thermal emission from a dense intergalactic gas may be the source.