physical sciences

From our reporter at the annual meeting of the American Physical Society in New York

Possibly superfluid helium 3

Until now the only known superfluid has been helium 4. At temperatures within a few degrees of absolute zero, helium 4 loses its viscosity. Currents can flow without resistance, and other bizarre properties appear. The fluid, for instance, may climb the wall of its container or rise in fountains seemingly against gravity.

Superfluidity is similar in many ways to superconductivity, a property of certain metals by which electrical resistance is lost. The theory developed to explain superconductivity, the Bardeen-Cooper-Schrieffer theory, led to suggestions that helium 3 might be a superfluid. Superconductivity arises from the pairing of conduction electrons. The spins of the members of the pair point in opposite directions. Similarly in helium 3 the spins of atoms would be paired and the pairing would bring about superfluid properties.

At the meeting a group of seven physicists from Cornell University reported evidence for a transition to such a paired state in helium 3. The discovery was first made by Douglas Osheroff, a graduate student, and Profs. Robert Richardson and David Lee. The apparent pairing transition occurs at 0.003 degrees K. So far no direct measurement of the superconducting properties has been possible, because the helium samples in the experiments contain both solid and liquid, and the two cannot be separated.

Mass of the antiproton

Atoms can be made in which an antiproton takes the place of an electron. Study of the radiation emitted by such an antiprotonic atom can yield important information about the structure of its nucleus and about the antiproton. Use of such a technique resulted in a measurement of the antiproton's magnetic moment (SN: 8/5/72, p. 88). Roger B. Sutton of Carnegie-Mellon University in Pittsburgh now reports data on the antiproton's mass.

Theory says the antiproton should have the same properties as the proton except that some of them (electric charge, for instance) have reversed polarity. The magnetic moment came out properly, equal to the proton's and oppositely directed. The mass comes out on the average 938.22 million electron-volts. This compares well with the proton's average of 938.2582 million electron-volts.

The moon's magnetism

Rocks brought back from the moon show evidence of magnetism (SN: 5/27/72, p. 346) yet the moon does not now have a global magnetic field and there are formidable difficulties in the way of believing that it ever did have. As Roman Smoluchowski of Princeton University points out, a global magnetic field requires a molten core. If the moon had had one, it would have had difficulty maintaining its highly nonspherical shape, Smoluchowski says, and even if it had had such a core, chances are there would not have been enough heat produced by radioactivity to start the motion required for a global field.

Smoluchowski brings in another piece of evidence: that there was widespread melting on the surface of the moon. This would have created seas of magma, and in these seas the earth would have raised great tides. According to Smoluchowski, calculation shows that the electrical conductivity of the liquid and the velocity of the tides would be enough to produce local magnetic fields. These would be strongest near the lunar equator, and that, in fact, is what the results of an Explorer orbiting spacecraft indicated.

Containment of cosmic rays

The cosmic rays arrive at the earth in equal strength from all directions. This isotropy indicates that whatever their sources, the cosmic rays have been traveling through space long enough and have suffered enough changes of direction to be thoroughly mixed up.

One of the interesting cosmic-ray questions is: How large is the space in which these mixings take place? Many astronomers had supposed that cosmic rays were confined to the disk of the Milky Way galaxy. Some time ago V. L. Ginzburg of the Lebedev Institute in Moscow, suggested that the galactic halo, the sphere of tenuous matter that surrounds the galactic disk, might be included.

Some idea of what the containment space might be can be obtained from measurements of the travel time. This can be determined by comparing the abundances of the radioactive nuclei of known lifetime that appear among the cosmic rays. Maurice M. Shapiro of the Naval Research Laboratory reports that the time appears to average around a million years. This would exclude the galactic halo as part of the containment space for the cosmic rays.

Forces between excited nucleons

Excited nucleons are neutrons and protons that possess more internal energy than they normally need. By convention, excited nucleon states are designated by different names, usually Greek letters such as delta, sigma, lambda, and often regarded as separate kinds of particles. The excited states are unstable and decay radioactively along various paths until they become neutrons and protons.

For the time that they exist, however, the excited states may be of use in nuclear physics and astrophysics. If it is possible to form nuclei made up of excited states, the result might give information both about the excited-state particles and about the properties of massive astrophysical bodies like neutron stars. The excited states are so short lived that forming aggregates of more than one at a time is very difficult. G. F. Chapline Jr. and M. S. Weiss of the Lawrence Livermore Laboratory suggest that it might be done in the nucleus-nucleus collisions of a heavy-ion accelerator. Calculation of the forces that would exist between excited nucleons indicates that the nuclei would be nearly bound and could therefore be studied as nuclei for as long as the excited states continued to exist.