physical sciences

Gathered last week at the Third International Conference on High-Energy Physics and Nuclear Structure in New York

MESONS

Looking for another force

Physicists sometimes wonder if they know all the different kinds of forces that exist in nature. So far they are aware of four: gravitational, electromagnetic, strong nuclear and weak nuclear.

There are persistent suggestions that others may exist, usually to explain certain strange experimental results.

A group from the Joint Institute for Nuclear Research at Dubna in the U.S.S.R., Drs. S. M. Korenchenko, B. F. Kostin, A. G. Morozov, G. V. Micelmacher and K. G. Nekrasov decided to look for a particular radioactive decay of the pi meson that would be governed by one of these proposed forces of so-called exotic interactions.

They searched among 5.9 billion pi mesons and took 80,000 photographs to see if the pi meson ever decayed into two electrons, a positron and a neutrino. They found no single event that they could interpret as the decay mode they sought.

They conlcuded therefore that the ratio of this kind of event to the most common mode of pi meson decay is no more than one in 100 million, if it is not exactly zero. The experiment thus gives no evidence for the existence of any fifth class of force.

THERMAL NEUTRONS

Deuterium formation puzzle

The experimentally measured probability cross section that a proton will capture a so-called thermal neutron to form the nucleus of deuterium is 334.5 plus or minus 0.5 millibarns. The theoretical prediction, however, is 302.5 plus or minus 3.99 millibarns.

Several attempts to rework the theory to do away with the discrepancy have proved unsatisfactory, say Drs. Ronald J. Adler of Virginia Polytechnic Institute and Benson T. Chertok and Henry C. Miller of American University. They, therefore, made a recalculation on the assumption that the neutron and proton exchange a pi meson as they approach each other. This raises the theoretical cross section by two or three percent, but still leaves a discrepancy of seven percent.

Of all the possible additions to the theory that might account for the remaining discrepancy, they conclude that the most likely one is to suppose that the neutron and proton are energetically excited when the deuterium nucleus is formed.

NUCLEAR STRUCTURE

Magnetism in the nucleus

Electric and magnetic effects of atomic nuclei will cause a so-called hyperfine splitting of the light and X-ray spectral lines emitted by the atoms. The X-ray spectra emitted by atoms in which a mu meson has replaced an electron are especially sensitive indicators of nuclear electricity and magnetism.

Drs. Won Yong Lee, S. S. Bernow, M. Y. Chen, S. C. Cheng, David Hitlin, J. W. Kast, E. R. Macagno, A. M. Rushton and C. S. Wu of Columbia University and Burton Budick of New York University studied indium 115, cesium 133 and praseodymium 141 in which there were muons. They find that magnetism that arises from orbital motions in the nucleus is concentrated closer to the center, while magnetism caused by the spin of individual nuclear particles is tied to their positions and thus more evenly distributed over the volume of the nucleus. The results, they say, tend to favor nuclear models in which the magnetism is concentrated closer to the surface and is mainly spin magnetism.

MESONIC ATOMS

Resonance explains emission

When a mu meson replaces an electron in an atom of iodine 127, it betrays its presence by the emission of characteristic X-rays as it moves from one energy state to another. A problem in the study of muonic iodine 127 has been that the ratio between the brightnesses of two frequencies generated by transition from the energy level labeled 2P has been much smaller than the theoretically calculated figure of 1.95.

Theoreticians have suggested that the discrepancy might be due to a resonance between the energy states of the mu meson and those of the nucleus. A group at Columbia University led by Dr. Won Yong Lee investigated the X-ray spectrum of muonic iodine 127 to see whether this could be so.

From their observations they calculate a theoretical spectrum for the atom and have determined that the resonance exists, and is between the 2P level of the mu meson and the ground and first excited energy states of the nucleus.

HIGH-ENERGY COLLISIONS

Real nuclei as targets

"One does sense a revival of interest in the role of real nuclei as opposed to protons as targets in high-energy collisions," says Dr. R. J. Glauber of Harvard.

Experiments using nuclei as targets have usually been done at energies in the range of millions of electron volts. Now they are beginning to be done at billion electron volts, and in this Dr. Glauber sees the possibility of learning a good deal about nuclear structure.

"Nuclear physics at GeV (billion-electron-volt) energies becomes a much simpler subject than it is at lower energies," he says. This is because at these energies the incoming particle tends to find the gentlest way it can through the nucleus. It collides with the particles in the nucleus one by one; the other particles in the nucleus become only bystanders.

This, says Dr. Glauber, leads to a diffraction theory, one analogous to that of the bending of a light beam by a piece of glass; the analogy may show a way to learn more about the internal structure of the nucleus.