physical sciences

From our reporter at the meeting of the American Physical Society in Washington

Solar neutrinos: Curioser and curioser

For several years a group of observers from Brookhaven National Laboratory have been using a large tank of perchlorethylene in a mine in Lead, S.D., to look for a flux of neutrinos from the sun (SN: 9/25/71, p. 210). Theory predicts that there should be such a flux and how much it should be.

The experiment has not found the flux, and in a progress report Raymond Davis Jr. told the meeting that data accumulated so far indicate that if there are any solar neutrinos, they are fewer than one-tenth what theory predicts.

The discrepancy is inexplicable on grounds of conventional physical theory, so more exotic suggestions are being made.

Toroidal and bubble nuclei

Nuclear physicists have generally thought that atomic nuclei were solid shapes as tightly packed as physical conditions would allow: spheres or ellipsoids. Cheuk-Yin Wong of Oak Ridge National Laboratory now presents an argument to show that toroidal and bubble-shaped nuclei, hollow in the middle, might in some cases be stable.

The idea of hollow nuclei goes back to some speculations by John Wheeler of Princeton University in 1948. Because of their supposed close packing, nuclei have been treated theoretically as analogous to drops of electrically charged liquid. Wheeler showed that classically toroids or bubbles of such liquid would be unstable.

But the liquid-drop model is not exact. There are quantum effects to take into consideration, particularly the wave nature of neutrons and protons. The orbit of each nucleon within the nucleus must be a standing wave —it must fit an exactly integral number of periods of the particle's associated wave.

Taking this into consideration Wong found that toroidal nuclei with particular combinations of neutrons and protons may be stable or metastable. The predicted combinations are: 80 to 100 protons and 100 to 130 neutrons for toroids; 80 protons and 120 neutrons, 70 and 104 and 104 and 146 for bubble shapes.

The two faces of lithium 6

In an atomic nucleus that has a large number of neutrons and protons, physicists suppose that the nucleons may associate in substructures. In such substructures a few protons and neutrons are tightly bound to each other and interact with the rest of the nucleus more or less as a whole.

Lithium 6, which consists of three protons and three neutrons, is one of the simplest nuclei in which alternate substructure possibilities can be studied. Particularly interesting are the two possibilities designated d plus alpha and t plus He-3. In the one case the substructures are a deuteron (neutron and proton) and an alpha particle (two of each). The other case is a triton (proton and two neutrons) and a helium 3 nucleus (two protons and a neutron). The d plus alpha model has been successful in explaining some properties of lithium 6, and Michael F. Werby and Steve Edwards of Florida State University set out to discover whether that excluded the other model.

They bombarded lithium 6 with protons. If the Li-6 was structured as d plus alpha a proton would pick up the d and form helium 3, which would come off in the same direction as the protons were going. If it was structured as t plus He-3, a proton would pick up the t and form an alpha particle. Meanwhile the law of conservation of momentum would send the remaining He-3 in the backward direction.

Welby and Edwards thought that the predominant direction of the emerging He-3 would tell which model was favored. They found equal numbers in both directions, and conclude that the lithium 6 nucleus is two-faced. Each structure is present about half the time.

Polarized X-rays from the Crab

The polarization of X-rays from the Crab nebula has been measured by a group from Columbia University, Richard F. Berthelsdorf, Richard A. Linke, Robert Novick, Martin C. Weisskopf and Richard S. Wolff.

The work was done with an Aerobee-350 sounding rocket that flew 100 miles above the earth's surface on Feb. 21, 1971. It is, the Columbia group says, the first measurement of polarization of X-rays from an astronomical source.

The X-ray polarization comes out to be the same as the polarization of visible light from the Crab, indicating that the light and X-rays come from the same area and are produced by the same process: synchrotron emission.

Synchrotron emission occurs when electrically charged particles proceeding at relativistic speeds are deflected into circular paths by magnetic fields. The Columbia group takes it as evidence that pulsars are sources of cosmic rays. They suggest that the Crab pulsar accelerates the particles characteristic of cosmic rays, and on their way out of the nebula its magnetic field induces them to produce the synchrotron emission.

A new transient X-ray source

A flaring X-ray source, a kind of X-ray nova, has been found in the constellation Lupus by the X-ray observing satellite Uhuru. The report was by T. A. Matilsky, Riccardo Giacconi, Herbert Gursky, E. M. Kellogg and H. D. Tannanbaum of American Science and Engineering.

Optical novas, in which a star jumps from relative obscurity to sudden brightness and then dies down, are a well-known phenomenon. They are explained by supposing that a star explosively sheds some of its outer layers of gas. X-ray novas seem to be different. This one did not cool down in the way an expanding shell of gas should. Furthermore no visible light could be seen from it. If it is the same basic phenomenon as an ordinary nova, this means it must be more than 30,000 light-years away because the visible light from a nova should be seen up to that distance. But then the observed strength of its X-ray emission is hard to explain. Possibly it is a white dwarf star, the discoverers suggest.