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reactions, they further selected only those in which the η^0 then decayed into π^+, π^- and π^0. After background events had been thrown out, 1441 remained.

Asymmetry found. To look for a possible asymmetry, they calculated $N+$, the number of events for which π^+ is more energetic than π^-, and $N-$, the number of events for which π^- is more energetic than π^+. They found the asymmetry $A = (N+ - N-)/(N+ + N-)$ was 0.072 ± 0.028. That is, on the average, π^+'s have more energy 7% more often than π^-'s do.

Other groups have also seen indications of asymmetry, but with less certainty. A compilation of 1300 events (to be published) measured at Columbia, Berkeley, Purdue, Wisconsin and Yale, shows $A = 0.058 \pm 0.034$. Earle Fowler of Duke, at the April American Physical Society meeting, reported 355 events with $A = 0.087 \pm 0.053$.

Before these experiments were over, Lee, working with Jeremy Bernstein (New York University) and Gerald Feinberg (Columbia) (*Phys. Rev.* **139**, B1650, 1965) undertook a careful examination of experimental evidence for each of the particle symmetries in each of the interactions. Surprisingly, for some symmetries taken for granted over the years, there was almost no evidence. For electromagnetic interactions of strongly interacting particles, there was absolutely no evidence that either C or T is invariant (unlike electromagnetic interactions of leptons, which are C invariant to at least the fifth or sixth decimal place). They explained the K_2^0 decay as a violation of C (or T) in the electromagnetic interaction. Then the decay would occur in three steps—the first two caused by an electromagnetic interaction (emitting and absorbing a photon), and the third by the weak interaction. Saul Barshay of Rutgers (*Phys. Letters* **17**, 78, 1965) also proposed that C (or T) is violated in the electromagnetic interaction.

To find out if the η^0 asymmetry is caused by an electromagnetic force, rather than a new intermediate force, one should look at a decay that yields a photon. Since the Columbia-Stony Brook group has plenty of bubble-chamber photographs showing η^0 decaying into π^+, π^- and γ, they are now analyzing these events, and hope to learn if the C-invariance violation is indeed produced by an electromagnetic force. Other groups are also looking at the same decay.

Lee, in talking about particle symmetries, now carefully distinguishes between C, P and T for each kind of interaction. So, for example, he discusses C_{st}, C_γ, C_{wk}. Then he can ask whether C_{st} is equal to C_γ, instead of asking whether the electromagnetic interaction obeys C invariance (where plain C, without subscripts, denotes the customary particle-antiparticle conjugation operator).

The implications of asymmetry in eta decay are many. The question of which particle symmetries are good for what kind of interaction does not have a complete answer yet. And even when theorists and experimentalists alike finally feel they do know the answer, as the development of physics has shown in the past, the feeling is likely to be temporary.

Beyond its significance for particle physics, this violation of matter-antimatter symmetry has also excited physcists interested in space exploration. As Fowler remarked in his APS talk, "Since the asymmetry corresponds to observing the kinetic energy of charged particles, it can be used by observers remote from one another in the universe to tell whether or not their local regions are composed of matter and antimatter. Let us suppose that we are in communication with an observer at the other 'end' of the universe. We lead him to the point where he can observe well enough to perceive that pions of one charge have more kinetic energy than those of opposite charge. It is then suggested that he compare this charge with the charge of his nuclei. If they are the same, then we can plan to visit him."—GBL

Protostars

Recent observations have placed a very narrow bound on the extent of the celestial x-ray source in the constellation Scorpio (hereinafter designated "Sco X-1") and provoked a suggestion that it may represent a hitherto unseen class of objects, protostars. The observation, which placed a bound of 20 sec of arc on the angular diameter of Sco X-1, was made on 8 March with a rocket-borne experiment by Herbert Gursky, Riccardo Giacconi, Paul Gorenstein, John R. Waters of American Science and Engineering Corp.; Minoru Oda, Hale Bradt, Gordon Garmire and B. V. Sreekantan of MIT. It was published in the June issue of *The Astrophysical Journal* (**144**, 1249, 1966). The suggestion that Sco X-1 is a protostar is by Oscar P. Manley of American Science and Engineering and appeared in the same issue of *The Astrophysical Journal* as a companion letter to that of Gursky and his associates.

The new size determination for Sco X-1 represents a significant advance in the resolution and discrimination of celestial x-ray sources. "X ray" in this context signifies primarily electromagnetic radiation in the wavelength range 0.1 to 1 nanometer (1 to 10 keV energy). Since the earth's atmosphere is opaque to radiation in in this range, observations have customarily been made from rockets with accompanying difficulties of stabilization, orientation and duration. Nevertheless in one case lunar occultation has been used for a determination of the size of the x-ray source in the Crab Nebula, an operation that requires extremely precise timing of rocket flights not to mention other experimental parameters.

Radiation in the range considered can be measured by counting equipment as in the Gursky experiment where wire-grid collimators were used to pass 1–20-keV x rays (with an angular resolution of 40 sec of arc) or by reflecting equipment such as Giacconi and Bruno Rossi have proposed (*J. Geophys. Research*, **66**, 173, 1960). Such reflectors differ from radio and optical reflectors by employing grazing incidence instead of the near-normal incidence employed in the optical and radio cases. Grazing reflection is the only way to collect radiation of this range since at these wavelengths the natural vibration frequencies of electrons in the reflecting solid are smaller than the radiation frequency, and x rays entering a solid from air speed up in phase rather than slowing down (as visible light does). In general, for most materials, reflection takes place at angles less than a degree.

As a result x-ray telescopes need extremely long focal lengths. A simple paraboloid similar to a truncated cone of narrow vertex angle will serve, but it suffers from severe astigmatism unless corrected by subsequent reflection from a hyperboloid. A telescope of this configuration (9-cm diameter, 64-cm focal length) has been built by a group at American Science and Engineering Corp. and the NASA Goddard Space Flight Center and successfully flown on an aerobee rocket to photograph the sun. Giacconi has high hopes for the future of x-ray reflectors. According to him a telescope of about 30 meters focal length could observe sources a million times weaker than the one in the Crab Nebula. (The Crab yields 3 counts/cm^2/sec between 0.1 and 1.5 nanometers.) The telescopes, however, are a very new thing; earlier observations were done with counters.

Earlier observations are themselves very recent. Although x-ray emission from the sun has been known since 1949, discrete sources elsewhere were not seen until 1962. Since then about a dozen have been seen, most of them standing quite apart from known optical or radio objects. These discoveries were something of a surprise since known objects radiating x rays by the solar mechanism would have produced a flux too weak to be recorded at the earth. Various new mechanisms were suggested, including synchrotron radiation from nebulae and neutron stars.

Now Manley suggests that Sco X-1 (which he also calls an "extar" to distinguish it from other classes of objects) is a protostar engaged in shedding its magnetic field. To reach this conclusion he first calculates the distance of Sco X-1 from its apparent size and energy loss (assuming synchrotron radiation); then he calculates an actual size and an energy density that comes out considerably greater than that for a supernova remnant.

According to Manley, his suggestion would solve a difficulty of current theories of stellar evolution, namely the lack of a rapid mechanism for dissipating the primordial magnetic field trapped in a mass of protostellar material. The magnetic energy would transform to x rays by synchrotron processes, and in astronomical terms it would go very fast ("more than 30 years" is Manley's figure for the lifetime).

If one assumes that the stellar population of our galaxy is in an approximately steady state, new stars must appear to offset the formation of white dwarfs. The rate at which stars turn into white dwarfs is estimated at about 10^{-12} per cubic parsec per year. If the rate of extar appearance balances this, then at any given time there are about 20 extars in our galaxy. (There are at present about a dozen known x-ray sources not identified with supernovae.)

The observable consequences of this model are that new extars radiating x rays will appear from time to time as new stars begin to form and that older extars, as they evolve, will cease to radiate x rays and eventually appear in the visible as young stars.

—DET

NRAO equipment available

The radio telescopes and other equipment of the National Radio Astronomy Observatory are available for use by qualified scientists and graduate students from any institution. Observing time is allocated solely on the basis of the scientific merit of the proposed program and the suitability of the program for the telescope requested. More than 60% of the telescope time on major instruments is allocated to nonstaff observers from all over the country. There is no charge for telescope time or for the supplies and services ordinarily required for a program.

The major instruments of the NRAO, located at Green Bank, West Virginia, include a 300-foot diameter transit telescope, a 140-foot diameter fully steerable telescope, and a variable baseline interferometer consisting of two fully steerable 85-foot diameter telescopes. Radiometers, feeds, and associated equipment, for frequencies ranging from 200 MHz to 30 000 MHz, are available, or an observer may provide all or part of his own equipment. A 36-foot diameter telescope, for observations at millimeter wavelengths, is under construction in Arizona. Library, laboratory, shop and computer facilities, and technical assistance are provided at Green Bank and at the NRAO office in Charlottesville, Virginia.

Further information and technical data on telescopes and equipment can be obtained from the Director, National Radio Astronomy Observatory, Edgemont Dairy Road, Charlottesville, Virginia 22901. NRAO is operated by Associated Universities, Inc., under contract with the National Science Foundation. □