# physical sciences

## Shklovskii on Her X-1 and Sco X-1

Determining the nature of the variable celestial X-ray sources is one of the great current problems of astrophysics. Two of them, Hercules X-1 and Scorpius X-1, are especially intriguing, Her X-1 because it has a strange 35-day cycle in which it is on 12 days and off 23, Sco X-1 because of an irregular flaring pattern in its X-ray emissions. In the September-October SOVIET ASTRONOMY, I. S. Shklovskii, one of the foremost Soviet astrophysicists, concludes that Her X-1 is neutron star and Sco X-1 is a black hole.

Her X-1 has been identified with the star XZ Herculis, and it is generally believed that the actual X-ray source is a compact dark companion bound in a binary system with XZ Herculis. It is usually supposed that such compact bodies are the remnant of a star that exploded. The closeness of the binary system sets limits on how big an explosion could have occurred without disrupting the system. This consideration leads Shklovskii to an estimate of the mass of the star that exploded, and that tells him the residual body should be a neutron star. He explains the 35-day on-and-off period by proposing that the X-rays are emitted from a region of the neutron star with a "knife-edge" profile that is carried in and out of the line of sight by a precession of the star's motion.

No optical identification has yet been made for Sco X-1, but Shklovskii nevertheless suggests that it is part of a binary system. Its companion would be a dwarf star of the UV Ceti type, and would be of low luminosity and rather far from the X-ray source, thus accounting for its non-observation so far. The greater distance between components in this case allows a bigger explosion, and Shklovskii calculates his way to the conclusion that this X-ray source is a black hole. The X-rays would be produced by matter falling into the black hole. Most of this matter comes from the companion star. UV Ceti stars are subject to irregular outbursts in which they throw off large quantities of gas. When these surges arrive at the black hole, they cause the X-ray flares.

## Deuterium at nearly 1 million atmospheres

Hydrogen in its various isotopes is an important constituent of the major planets (Jupiter, Saturn, Uranus). One of the important questions regarding their structure concerns the point at which hydrogen shifts from the molecular to the metallic state. The outer regions of these planets are supposed to be molecular hydrogen, the inner parts metallic.

Metallic hydrogen can exist only under high pressure, and the question is what are the conditions at the point where the transition takes place. They have been experimentally investigated by a group of eight physicists led by Mathias van Thiel of the Lawrence Livermore Laboratory. They took samples of liquid deuterium originally at a temperature of 21 degrees K. and compressed them by means of shock waves first to a pressure of 200,000 atmospheres and a temperature of 4,500 degrees K. and then to 900,000 atmospheres and 7,000 degrees K.

As a result of the experiment they were able to derive a theory of the force between deuterium and hydrogen molecules under pressure, and they report in the Oct. 15 PHYSICAL REVIEW LETTERS that this leads to a prediction of a transition to metal at a pressure of 4.2 million atmospheres for molecular hydrogen and 4.8 million atmospheres for deuterium. The hydrogen would have a density more than twice as great as water; the deuterium, more than four times as great.

## K-zero-long to two-mu sweepstakes

An important recent case in particle physics is the question of whether the meson called K-zero-long does once in a very long while decay into two muons. The importance of the question lies in the law of conservation of matter and energy. Theory demands that the two-mu decay of the K-zero-long exist or else the conservation law, one of the most basic in physics, is violated.

A first experiment to look for such decay failed to find it and caused consternation among physicists. Then there was a report that the decay had been found. Most recently (SN: 7/7/73, p. 9) we reported that a team led by W. C. Carrithers of Brookhaven National Laboratory had also found the decay, putting the score at two to one. In the Oct. 15 PHYSICAL REVIEW LETTERS the score becomes three to one. Carrithers and a new group have repeated the experiment with some modifications and again found the two-muon decay. The new result shows it happening about 12 times in a billion K-zero-long decays, in excellent agreement with theory, according to the experimenters. This will be our last bulletin on the subject.

## Gamma rays from interstellar clouds

When cosmic rays interact with hydrogen nuclei in dense interstellar clouds, gamma rays may be produced. The interaction of a high-energy cosmic-ray proton with the proton of a hydrogen nucleus produces pi mesons. Some of these are neutral pi mesons, which proceed to decay into pairs of gamma-ray photons. In the Oct. 1 ASTROPHYSICAL JOURNAL LETTERS John H. Black of Harvard University and G. G. Fazio of the Smithsonian Astrophysical Observatory and Harvard College Observatory propose that this mechanism may be at work in some observed gamma-ray sources.

Black and Fazio identify one gamma-ray source with a dust cloud south of the star Rho Ophiuchi. Another gamma-ray source, denoted Sagittarius gamma-one, is associated, they say, with the dark cloud in Corona Austrina (the two constellations are neighbors, and there is a certain indefiniteness about the exact location of gamma-ray sources). Furthermore they suggest that dark clouds near the center of the galaxy could be contributing to gamma rays coming from there.

The intensity of the gamma-ray flux can be used to compute the mass of the cloud. For the Rho Ophiuchi cloud, Black and Fazio get 300,000 times the sun's mass and for the Corona Austrina cloud 260,000 solar masses.

## Radio telescope on Morningside Heights

The first radio telescope to be built in the metropolitan New York area, and perhaps the first ever erected in the middle of a large city, will be built on the roof of the Pupin Physics Laboratories on the Columbia University campus on Morningside Heights in upper Manhattan. It will be a four-foot dish antenna designed for studies in the millimeter-wavelength range. It was designed by Patrick Thaddeus and his students, and its purpose is to study the distributions of molecules in interstellar space.

The world has very few installations for millimeter-wave astronomy (most of it is done at Kitt Peak, Ariz., or the McDonald Observatory in Texas) so the Columbia astrophysicists expect their instrument to make an important contribution. Though the city environment is full of radio noise at longer wavelengths, it is quiet at millimeter waves, and this makes the location feasible.