Nov, 86

MARK OF THE QUARK STARS

By Marcia Bartusiak

More than 30,000 light-years from Earth, in the direction of the constellation Cygnus the Swan, lies one of the most powerful X-ray sources in our galaxy: Cygnus X-3. Astronomers have long assumed that Cygnus X-3's energetic radiations are the product of a neutron star—an ultradense, ten-mile-wide ball left in the aftermath of a supernova explosion—drawing matter from a normal stellar companion. The two complete an orbit around each other, say theorists, every 4.8 hours.

The traditional interpretation of the star's composition is being challenged by a group of audacious physicists who offer as evidence some curious subatomic particles picked up by their proton-decay detectors. The evidence now suggests that the star is a compact globe of more basic subatomic particles—quarks. (Quarks are the building blocks of protons and neutrons.) If this is so, astronomers could be forced to revise their theories of astrophysics.

The saga of Cygnus X-3 began in 1982. Physicists from the University of Minnesota and the Argonne National Laboratory were studying the decay of protons registered by their detector, which was installed in an old Minnesota iron mine. They were mystified when their detector recorded intermittent showers of muons (heavy, electronlike particles). "We puzzled over this and found there was an order in the madness," says Minnesota physicist Marvin Marshak. The showers appeared to be coming from the general direction of Cygnus X-3.

In 1984 another proton-decay group, working in a salt mine near Cleveland, found their muon signal waxed and waned every 4.8 hours. "It was as if a lighthouse were flashing," says Marshak. The Cleveland group hypothesized that Cygnus X-3 was influencing the particle flow and that more particles were received when Cygnus X-3 was in full sight and fewer when it was eclipsed by its companion.

Cygnus X-3 goes through sporadic outbursts of energy that few other objects in the sky display. Its violent episodes have been detected with radio and infrared instruments as well as with space-based X-ray telescopes. Now with its activity detected by underground proton-decay detectors, theorists are surmising that the enigmatic X-ray source is releasing not only electromagnetic energy during its rages but streams of exotic particles, too.

Because muons are too short-lived to survive the journey from Cygnus X-3 to Earth, it was then concluded that the muons were produced by a stream of unknown particles from Cygnus colliding with either the earth or its atmosphere.

Theorists went through their list of subatomic suspects. The particles couldn't be neutrinos: Since neutrinos are capable of whizzing right through the earth, their effect would register all the time, not just when the star was in sight. The Minnesota physicists spotted a wave of muons with their proton-decay detector at the same time astronomers detected bursts of X rays and radio waves coming from the star. Whatever the particles were, they seemed to travel at virtually the speed of light. But high-energy photons can't be subatomic light particles.

Cygnus X-3: superquark or quack?

Given these constraints, some physicists have suggested that these particles are lumps of quarks ejected from the star. According to traditional theories, when a star explodes, the matter at its core is compressed into a mass of neutrons. But under the tremendous pressure of a supernova explosion, a star's core of protons and electrons may be broken into smaller elements. The result is not a neutron star but a quark star.

Matter drawn off from its stellar companion knocks some quark nuggets off the quark star (each clump of quarks is about the size of an atomic nucleus). The nuggets are thrown out into space at near light-speed by the quark star's intense magnetic field. Eventually some of the cygnets, as the unknown particles have come to be known, hit the earth's atmosphere and crust, setting off a cascade of particles.

That's the theory. The evidence, however, is inconclusive. Theoretical physicist Edward Farhi of the Massachusetts Institute of Technology is not yet convinced Cygnus X-3 qualifies as a quark star. Given the proposed properties of quark stars, he believes such an object would have a thin crust of ordinary stellar material, which would prevent any quark lumps from escaping.

Also, proton-decay groups in Europe and Japan declare they have seen nothing at all with their instruments. After months of viewing, Marshak's team was able to trace only a few thousand muons to a broad region around Cygnus. Of these only a small percentage could definitely be correlated with Cygnus X-3's 4.8-hour orbital period. Marshak himself admits that the evidence remains sparse.

Even so, the idea of the quark star is still very much alive. "People don't like this business because it doesn't make sense in terms of the physics that we know," says Marshak. "But we're operating at the very edge of detectability here, where things are not nearly as clear-cut as they appear in textbooks."

Marcia Bartusiak's book Thursday's Universe *will be published this month by Times Books.*