Gamma ray source that 'isn't there'

Astronomy remains the science of surprises. Astronomers repeatedly find objects in the sky that behave in unusual ways, and then the scramble is on to figure out what they are. Gamma ray astronomy, the newest specialty in the science, is now providing such an object of concern, the source known as Geminga.

Geminga is the brightest in the catalog of gamma ray sources measured by the satellite Cos B that has not been identified with some already known object. The name comes from the constellation Gemini, where the thing is located, and its being a *ga*mma ray source. Astronomers usually pronounce it with both g's hard. G. F. Bignami and P. A. Caraveo of the Istituto di Fisica Cosmica of the Italian National Research Council in Milan say that this is because, pronounced that way, it means "does not exist" or "not there" in the Milanese dialect.

Geminga is catalogued as 2CG 195+04. Within its error box (that is, the margin for error in detecting its location) lies an X-ray source catalogued as 1E 0630+178. Caraveo discussed this object at last week's meeting in Las Vegas, Nev., of the American Astronomical Society. It has, she says, a set of characteristics unique among known X-ray sources. These are: a pointlike appearance, no radio counterpart, and a very soft X-ray spectrum, most of the photons having less than 100,000 electron-volts energy. That makes it a good candidate for identification as the X-ray counterpart of Geminga, and so it was put on the agenda of both of the currently operating X-ray observing satellites, the Japanese TENMA and the European EXOSAT. EXOSAT observed Geminga for 27,500 seconds (10 hours) on Sept. 9, 1983, recording in that time 400 photons. (Bignami says these are the first EXOSAT data across the Atlantic.) The data give a hint of variability of the X-ray output on a scale of hours, but, Caraveo says, the observation was too short to tell whether the variation is periodic.

Bignami discussed a visible object with "a clear stellarlike nature" that is found just within Geminga's error box and so is a candidate for Geminga's optical counterpart. The object looks bluish, but is probably not intrinsically blue, he says, just less reddened by interstellar absorption than others of its kind, and so the nearest of them. The low interstellar absorption suggests a distance of 100 parsecs (about 400 light-years). On that basis the object's X-ray emission is 10^{30} ergs per second, its gamma ray output 10^{33} ergs per second. Its visual magnitude is +16. The calculated ratio of X-ray to visible output (200) and the soft X-ray spectrum lead to the suggestion that Geminga is a pulsar, but one with no radio output. (Most pulsars have radio output). As Bignami, Caraveo and Richard C. Lamb of Iowa State University in Ames pointed out in Astrophysical Journal Letters (Vol. 272, p. L9) there are difficulties in calling something a pulsar from which no pulses have been seen, but there is no better candidate. (They don't exclude a "peculiar" object.)

The "pulsar" option is also supported by Jules P. Halpern of California Institute of Technology and Jonathan E. Grindlay of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., who did spectroscopic studies of the visible object using the 200-inch Hale telescope on Palomar Mountain. Halpern told the meeting that no emission or absorption features were found in the spectrum. The object is bluish for its magnitude, and that rules out stars of spectral classes earlier than K. To look like that they would have to be 15,000 parsecs away. The object lies in the direction opposite to the center of the galaxy, and that also makes K and M and earlier classes unlikely. The only normal class of star it could be is G, but the featureless spectrum tends to support the pulsar suggestion. *—D. E. Thomsen*

The thermonuclear jets of SS433

One of the greatest astronomical surprises of recent years is the object known as SS433. This is apparently a binary star system that is shooting out revolving jets of matter. Furthermore it is embedded in the remnant of an old supernova (which is manifested by its radio emission). How a binary system could go through a supernova explosion and not be blown apart is difficult to figure. Now, to make SS433 even more peculiar, recently discovered gamma ray emissions indicate that thermonuclear fusion processes are going on in the jets. Richard C. Lamb of Iowa State University in Ames, who directed the work, calls the finding "bizarre."

SS433 first came to attention because its visible spectrum showed patterns of resonance lines that moved up and down in wavelength in a cyclic way. This was interpreted as a cyclic motion of the matter that is emitting them, and led to the model of a rotating object emitting jets of matter. The emitter precesses as it rotates, and that leads to a corkscrew pattern in the jets. The motion of the matter in the jets is complex, Lamb told last week's meeting in Las Vegas, Nev., of the American Astronomical Society. The matter comes out in blobs, each of which has a particular velocity; its characteristic emissions will persist for days. Thus there is a good deal of jitter in the data due to small variations in velocity and aiming of the blobs.

Nevertheless observers in six or seven years of watching have been able to calculate a minimum age for the jets of 1,500 years based on an average velocity of 26 percent of the speed of light and the length of the jets as derived from radio observations. The data also yield an orbital period for the binary system of 13.1 days, a precession period of 164 days and a distance of 5,100 parsecs (about 20,000 light years).

For 18 days in October 1979, SS433 was in view of the satellite HEAO 3. This happened to be a period that coincided with one of the flares that SS433 occasionally throws. Lamb and co-workers observed it with the Jet Propulsion Laboratory high energy resolution gamma ray spectrometer aboard the spacecraft. They found in SS433's gamma ray spectrum a resonance emission line corresponding to an energy of 1.5 million electron-volts (1.5 MeV).

Gamma ray resonances are produced by various processes in atomic nuclei and among subnuclear particles. No known resonance yields 1.5 MeV, so the observers had to assume that the line was shifted from its normal rest value, either by motion or by SS433's gravitational field. There were two possibilities for gravitational redshift. One would have given SS433's central object a mass of 0.7 times that of the sun, the other would give it 1.9 times the sun's mass, making it almost a black hole.

But it is most likely a blueshift, which has to be a Doppler shift due to motion. The observers made this choice because they also had slight evidence for a line at 1.2 MeV, which could be the redshifted counterpart of the one at 1.5 MeV. This would mean that the strong 1.5 MeV line comes from the jet pointing more toward the earth; the weak 1.2 MeV emission from the one pointing more away from the earth. The rest energy of the line lies between at 1.37 MeV.

For this rest energy there is a choice of two possibilities: deexcitation of an energetic nucleus of magnesium 24 or deexcitation of a nucleus of oxygen 15 that has just formed as a nitrogen 14 nucleus collided and fused with a proton. For various reasons the latter seems most likely to Lamb and co-workers. This oxygen deexcitation is part of the carbon-nitrogen-oxygen (CNO) thermonuclear burning cycle that fuels certain kinds of old stars. The next step in the process yields a line, which, shifted appropriately, comes to 6.7 MeV. Most recently they have found that in the data. They are now convinced that CNO burning is going on in SS433's jets and is possibly closely connected to the flares—a tremendous astrophysical surprise.

—D. E. Thomsen