A tale of two Cygnuses: Are they black holes?

. . . Cygnus X-1: Possible identification

Shortly after Einstein published his theory of general relativity, Karl Schwarzschild derived from it a prediction that a body of certain size might undergo collapse due to the mutual gravitational attraction of its parts. If the body were large enough—several times the mass of the sun—its collapse would run away and bring it to a state where neither matter nor radiation could escape from it. Such a body was called a black hole, and for about half a century it existed only in theory.

Now, however, some astrophysicists are beginning to think they see one. The suspect lies in the constellation Cygnus. There, in a small space of sky are a binary star system in which one partner is seen and the other dark, an X-ray source called Cygnus X-1 and a radio source. Assuming that all these emanations come from the same system one can begin to ask the nature of the dark companion. "Black hole" was heard more and more in conversation. Now the X-ray astronomers of American Science and Engineering have put it into print (H. Tananbaum, H. Gursky, E. Kellogg and R. Giacconi with C. Jones of Harvard in the Oct. 1 ASTROPHYSICAL JOURNAL LETTERS). This group recorded simultaneous changes in X-ray and radio signals from Cygnus X-1. From this they conclude that the radio and X-ray sources are the same object and identify them with the binary star. Calculation of the probable mass of the unseen companion leads them to write: "By elimination, we are then left with the possible identification of Cyg X-1 as a black hole."

But, says Jerome Kristian of the Hale Observatories, "It is not a very clear situation observationally." He points out that a lot of assumptions are involved, the most crucial being that the three sources are the same system and that the visible member is a supergiant of the B0-Ib class. To estimate the mass of the unseen companion, which must be several times the mass of the sun to be a black hole, one needs to know the mass of the visible one. If one is certain of the spectral class, one knows the mass within certain limits.

Granting the fact that assumptions are necessary, Tananbaum still puts a confidence of more than 90 percent on each point in the chain of reasoning. Thomas Bolton of the University of Toronto's David Dunlap Observatory cites recent unpublished results of his own that would indicate about 7.5 solar masses for the dark companion, "well outside the upper limit" for anything but a black hole, and there is a preprint of a Russian paper floating around that calculates the dark body at 20 or 30 solar masses.

It is "a bit premature" to make any final judgments, says Kip Thorne of California Institute of Technology. Observations are still in progress, and they have a month or so more to run while Cyg X-1 remains above the horizon for northern observers. When these observations have been digested, Thorne hopes it will be possible to say something definite. Nevertheless he describes himself as about 60 percent confident of a black hole.

. . . Cygnus X-3: Odds are favorable

"Odds are now that Cygnus X-3 will turn out to be the same phenomenon as Cygnus X-1," says Robert Hjellming of the U.S. National Radio Astronomy Observatory at Green Bank, W. Va. His conclusions are based on the observations and work of about 80 scientists who have contributed 24 articles to NATURE on the Cygnus X-3 event (SN: 9/23/72, p. 197). Three introductory articles appear in the Oct. 20 issue, followed by a special issue of NATURE PHYSICAL SCIENCES, Oct. 23, devoted exclusively to reporting the data from Cygnus X-3.

The X-ray source became the object of international study shortly after the radio outburst of Sept. 2 (SN: 9/9/72, p. 164) in which the flux density increased overnight from about 0.1 to 22 flux units.

One of the more important discoveries was made by E. E. Becklin, J. Kristian, Garry Neugebauer and C. G. Wynn-Williams of the Hale Observatories. They identified an infrared source with the radio source. The star has about the same intrinsic optical luminosity as the star in Cygnus X-1.

Other data indicate that the system may contain a black hole. Cygnus X-3 was first studied as an X-ray source. A group at American Science and Engineering in Cambridge, Mass., found no intensity change in the X-ray emissions coincident with the radio flare, but they did find, upon examination of earlier data, that the X-ray source had a 4.8-hour periodicity. This might eventually turn out to be the revolution period of the binary system.

The typical size scales suggested for the object a few days after the radio outburst are less than about one to two light-days. The source is thought to be at a distance between 8 and 11 kiloparsecs.

Evidence from Moscow on gravity waves

It is now more than three years since Joseph Weber of the University of Maryland announced he had detected gravitational waves. Gravitational waves are one of the predictions of Einstein's general relativity theory: Just as there are electromagnetic waves (light and radio) that involve oscillating electric and magnetic forces and carry energy from place to place, so there should be gravitational waves that involve oscillating gravitational forces and carry energy from place to place.

For a long time Weber was the only one looking for gravity waves. Few believed that they could be found. Since Weber's announcement experimenters around the world have gotten into the search to try to confirm his findings (SN: 7/8/72, p. 30). A first report is now in from another group in another place, the first published results of observations with detectors similar to Weber's. The place is Moscow, and the observers are Vladimir, B. Braginskii, A. B. Manukin, E. I. Popov, V. N. Rudenko and A. A. Khorev of Moscow State University and the Space Research Institute of the Academy of Sciences of the U.S.S.R. The report is in JETP LETTERS (Vol. 16, No. 3).

Weber's original antennas for gravitational waves were large aluminum cylinders. According to his calculations, gravitational waves should excite very small vibrations in the cylinders. So small are the vibrations that great care must be taken to isolate the cylinders from all other sources of vibration.

Braginskii and his collaborators used cylinders of the same size as Weber's. One was set up at MSU and the other at the ISR, which is 20 kilometers from Moscow. The idea was to find, if possible, simultaneous pulses on the two cylinders, a further precaution against vibrations that might still be picked up from the surroundings.

Although the cylinders are well isolated, as long as they have some temperature above absolute zero they will have a background of thermal vibrations. The trick is to measure bursts of

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