

## 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 Thomas Bolton of the University of Toronto's David Dunlap Observatory cites recent unpublished results of his own that would indicate about 7.5 solar masses for the dark companion, "well outside the upper limit" for anything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

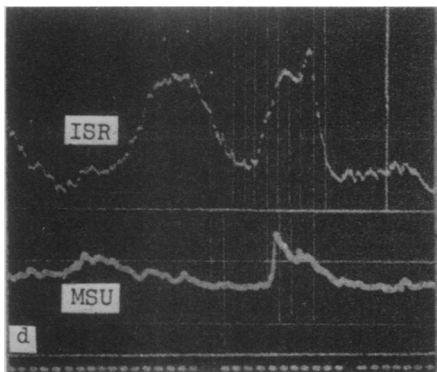
believed that they could be found. Since Weber's announcement experimenters around the world have gotten into the search to try to confirm his findings (SN: 7/8/72, p. 30). A first report is now in from another group in another place, the first published results of observations with detectors similar 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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*Coincident bursts, different shapes.*

vibration that rise above this background. Braginskii and co-workers say that they have: "In both antennas we observed relatively rare bursts of oscillations of patently nonthermal origin (exceeding in frequency the statistical predictions)." They do not say flat out that these are gravitational waves—the paper is very cautiously worded—but the implication is that it would be hard for them to be anything else. As far as coincidences are concerned, the Moscow group recorded a number of events that came at the same time on both antennas, but the shape of the waves was so different from one antenna to another that the observers cannot say that they are coincident pulses from the same extraterrestrial source.

Although the paper is not a flat-out confirmation of Weber's work, it is the first non-Weberian evidence from an experiment similar to his, and it points in a positive direction. Observations, of course, continue. □

## Mariner 9 shut down

Mariner 9 ran out of gas Oct. 27 during its 698th orbit of the planet Mars. The spacecraft, which went into orbit Nov. 13, 1971, transmitted to earth 7,329 pictures of Mars and its moons and acted upon nearly 46,000 commands from earth.

Mariner 9 completed its primary mission in February and since then has been on an eight-month extended mission. The flexibility of the spacecraft programming allowed scientists to work around the dust storm that completely shrouded the planet for the first two months. Ground controllers at the Jet Propulsion Laboratory in Pasadena, Calif., were maneuvering the spacecraft's antenna toward earth for transmission of 15 more pictures last week when its attitude-control gas was depleted. They then sent a command to turn off Mariner 9's radio transmitter. The spacecraft will remain in Martian orbit for 50 to 100 years, after which time it will crash onto the surface of the planet. □

## Bills on ocean dumping, mammals, noise, coasts

President Nixon has a mixed record on the environment, partly because there appears to be little unanimity within the Administration itself about how high a priority environmental measures should get. Two weeks ago, the President vetoed the Clean Water Bill passed by Congress; Congress in its closing days, however, turned right around and overrode the veto (SN: 10/21/72, p. 262).

Last week, the President may partly have redeemed himself in the eyes of environmentalists by signing several bills generally regarded as favorable to the environment. Of course, until the next Administration budget is released, there will be no certainty about what the bill signings really mean; most of the bills are enabling or authorizing measures and do not carry a price tag.

Among the new bills signed into law are ones to control ocean dumping, control coastal zone management, protect marine mammals, control noise and establish "Gateway Recreation Areas" in and near New York City and San Francisco. All except the noise bill are regarded as potentially effective. The main problem with the noise bill, which is aimed primarily at controlling the noise level of certain products, is that it says little about actual enforcement of ambient noise standards in given locations.

The ocean dumping bill bans the dumping of certain hazardous substances and regulates the dumping of other, less hazardous, ones; the bill also provides for research and monitoring programs and for establishment of marine sanctuaries. The Environmental Protection Agency and the National Oceanic and Atmospheric Administration will implement the bill. NOAA will designate the marine sanctuaries. These sanctuaries, says a Wilderness Society spokesman, may be somewhat like terrestrial wilderness areas.

The coastal zone management bill is essentially a land use bill which provides for states to make individual coastal land use decisions with the guidance of the Commerce Department. The marine mammals bill requires specific permits before marine mammals may be taken or imported; it also aims at encouraging other nations to adopt similar measures.

The Gateway Recreation Areas bill "came out in fine shape," says the Wilderness Society spokesman. The bill will establish the first urban national recreation areas in the nation. The bill, incidentally, is virtually the only Nixon Administration environmental proposal that came out of Congress almost ex-

actly as it was originally proposed.

In other action, the President vetoed the public works authorization bill, an action about which environmental interests had mixed feelings. Although usually public works proposals are for massive construction projects built by such traditional foes of the environmentalists as the Army Corps of Engineers, times are changing. This year's bill, for instance, would have authorized National River status for parts of the Cumberland River in Kentucky and Tennessee. Although this would have involved considerable construction by the Corps, it was of a kind environmentalists wanted: bank stabilization and preservation rather than dam building. The bill would also have authorized Corps activities to preserve parts of the flood plain of the South Platte River in Colorado, another project favored by environmentalists. On the other hand, the bill would have delayed implementation of new Water Resources Council guidelines which are expected to restrict the kinds of construction environmentalists *do not* like.

The bills signed last week represent only a small portion of environmental legislation introduced, or even passed, during the Nixon Administration, and most environmentalists are of two minds about the long-term environmental record of the Administration. Although EPA Administrator William D. Ruckelshaus, a Nixon appointee, is regarded as a dedicated environmentalist, environmentalists say the Administration has sometimes taken away with one hand what Ruckelshaus had given with the other. Former Commerce Secretary Maurice Stans, for instance, was accused of thwarting Ruckelshaus at every opportunity.

And ENVIRONMENTAL QUALITY magazine in its November issue tabulates the Nixon record on environmental legislation. In the long haul, the President has opposed more measures that EQ regards as environmentally sound than he has supported. □

## Aging: Inability of cells to reproduce?

There are several explanations for aging that are backed by some experimental evidence. One is that DNA (genes) no longer function or repair themselves normally. Another is that proteins make errors in self-replication. Another is that the hypothalamus of the brain fails to regulate the body's hormones. A fourth one is that unstable, highly reactive molecular fragments known as free radicals can destroy body substances. Now two investigators at the Medical College of Georgia—Seymour Gelfant and J. Graham Smith