A black hole unmasked

November 29 2011

An optical image of the sky showing the location of the black hole, Cygnus X-1. (Right) An artist's conception of the black hole system, showing the black hole drawing material towards it from a massive, blue companion star. This material forms a disk and jets that emit radiation. Credit: Optical: DSS; Illustration: NASA/CXC/M.Weiss

Black holes are among the most amazing and bizarre predictions of Einstein's theory of gravity. A black hole is thought to be point-like in dimension, but it is surrounded by an imaginary surface, or "edge," of finite size (its "event horizon") within which anything that ventures becomes lost forever to the rest of the universe.

Despite their reputation as implacable sinks for matter and energy, the regions around black holes are often sources of powerful emission. They can be ringed by a disk of matter, for example contributed by gas from

an orbiting companion star; when infalling material interacts with that disk, radiation and matter can be ejected.

A black hole is so simple that it can be completely described by only three parameters: its mass, its spin, and its electric charge, but measuring these values is far from simple. The charge is usually considered to be negligibly small, leaving only two parameters. The mass can be found when the black hole has an orbiting companion, since the periodic orbital motions of the pair are precisely determined by their masses and the orbit's size. Infalling material provides a source of radiation to measure the period, but ascertaining the size of the orbit requires knowing the distance to the source.

All these difficulties have been overcome in a set of three papers appearing together this month. CfA astronomers Mark Reid, Jeff McClintock, Ramesh Narayan, Lijun Gou, James Steiner, and Jingen Xiang, together with their colleagues, used radio wavelength parallax techniques to measure the precise distance to the first discovered black hole, Cygnus X-1: it is 6060 light-years away, with an uncertainty of about 6%. The firm distance estimate enabled the scientists to infer the mass of the black hole: 14.8 solar masses with about the same uncertainty, 7%. Not least, the sole remaining parameter of a black hole -- its spin -- could now also be determined. The team calculated that the black hole is rotating at about 95% of the maximum rotation permitted in Einstein's theory, corresponding to its event horizon whirling around about 800 times per second. While these objects are still just as amazing and bizarre, these new papers are a dramatic step forward in our understanding of their basic properties.

Provided by Harvard-Smithsonian Center for Astrophysics

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