Monster Black Holes Soon to Collide?

Imagine a binary system consisting of two monstrous black holes locked in a tight orbital embrace. One of the beasts contains an astonishing 100 million times the mass of our Sun, outweighing the Milky Way's central black hole by a factor of 25. But compared to its master, it's a pipsqueak — a pathetic excuse for a black hole. The primary black hole contains 17 or 18 *billion* solar masses, making it the heaviest single object known to science.

An international team led by Mauri J. Valtonen (University of Turku, Finland) not only claims that such a system exists, but that the team has measured a decay in the period of the binary's 12-year, highly elongated orbit. As Valtonen and his colleagues reported at last week's American Astronomical Society meeting in Austin, Texas, the two black holes are drawing slowly but inexorably nearer during each orbital passage as they radiate gravitational waves, ripples in the fabric of space-time predicted by Einstein's general theory of relativity.

If their analysis is correct, the system, located in the active galaxy OJ 287, contains one of the most massive black holes in the universe and is the most extreme binary system ever discovered. Moreover, OJ 287 presents scientists with an extraordinary opportunity to test Einstein's greatest theory in the strongest gravitational fields the universe has to offer.

"I'd like it to be true, since it would be a tremendously exciting discovery," says Cole Miller (University of Maryland). "But there are observational and theoretical reasons to be skeptical."

Valtonen and his colleagues are hinging their conclusion on a series of optical outbursts, or pulses, that seem to repeat every 12 years, but with a shrinking time interval between each outburst. These pulses, argues the team, occur when the smaller black hole plunges into a gaseous disk that feeds the larger black hole. Last year the team predicted that OJ 287's next outburst would occur within one or two days of September 13, 2007. Valtonen organized an observing campaign among 30 professional and amateur astronomers in 10 nations. The group saw OJ 287 flare exactly on cue.

"The size of the outburst was predicted theoretically, as well as its 4-day length," says Valtonen. He adds that the polarization of the light also disappeared, as his group's model predicts. If the orbit were not shrinking due to gravitational waves, the outburst would have occurred about 20 days later. "It would be a huge coincidence to have all of these observations fit our model by chance," says Valtonen. "There is no other explanation except for Einstein's theory. The timing of the outbursts shows that Einstein's theory is correct to the 10% level."

OJ 287, located 3 billion light-years from Earth in Cancer, has been monitored since the 1890s. The observations show sporadic outbursts, but their frequency doesn't match up perfectly with a 12-year orbit. "The time separation increased from the 1970s to the 80s and 90s," says Tod Strohmayer (NASA/Goddard Space Flight Center). "That appears to me to be opposite to what one would expect if the orbit were shrinking, in which case the period should show a regular decrease. In order to explain these variations," says Strohmayer, "they need very fast precession of the orbit, and the only way to explain that in the context of their model is to invoke a problematically high black hole mass. I think they are over-interpreting the data."

Miller adds that OJ 287 belongs to a class of active galaxies known as blazars, which are highly variable in their light output. "OJ 287 shows a plethora of other brightness peaks not related to these 12-year cycles," says Miller. "Some of these peaks are higher than the ones from this recent cycle."

Miller also notes that as two supermassive black holes orbit each other in a binary, the orbit should slowly circularize itself. But the orbit in Valtonen's model is highly elongated. Only a third supermassive black hole, lurking somewhere nearby, could gravitationally perturb the system enough to explain the elongated orbit. Such a black hole cannot be ruled out, but at present there is no evidence for it.

If future observations confirm Valtonen's model, however, astronomers have struck gold. The two black holes will collide and merge within 10,000 years — a cosmic blink of an eye. The collision will release powerful gravitational waves that will convulse the fabric of space-time, releasing more total energy for several minutes than all the stars in the visible universe combined.

The binary black hole is already releasing gravitational waves, but not at a frequency that can be detected by current gravitational-wave observatories such as the Laser Interferometer Gravitational-Wave Observatory (LIGO) or future space missions such as the Laser Interferometer Space Antenna (LISA). But the existence of a relatively nearby supermassive black hole binary so close to coalescence would demonstrate unequivocally that such remarkable systems exist, bolstering the already impressive science case for developing LISA, which would catch their final inspiral, merger, and ringdown.

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