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NewScientist

New Scientist

June 12, 2004

SECTION: News; This Week; Pg. 8

LENGTH: 525 words

HEADLINE: Black holes drive speedy particles to new highs

BYLINE: Marcus Chown

BODY:
BLACK holes, among the strangest objects in the universe, have once again surprised astronomers. It turns out that they generate strange tidal forces that affect high-speed particles in an entirely different way to low-speed ones. The unanticipated effect means that **black holes** in our galaxy could be the source of rare high-energy cosmic ray particles that astronomers have spotted slamming into the Earth's atmosphere with inexplicable violence.

Tidal forces are a result of the way gravity diminishes with increasing distance from an object. For example, two particles at different distances from a black hole should experience different forces, so one accelerates with respect to the other. At least, that's the way physicists understand tides using Newtonian physics.

But Bahram Mashhoon and Carmen Chicone of the University of Missouri in Columbia stumbled onto the unexpected property of black holes while investigating the effect of Einstein's theory of gravity on fast-moving subatomic particles.

Astronomers know that conditions in the swirling, magnetised plasmas around black holes create an abundance of high-speed particles, and Mashhoon and Chicone were calculating how these particles would behave in the black hole's gravitational field. They discovered that tidal forces affect low-speed particles just as Newton would have expected. "However, it is absolutely not what we discovered when we considered particles moving close to the speed of light," says Mashhoon.

Particles travelling faster than about 70 per cent of the speed of light behave in a way that depends on the direction they are travelling. Fast particles moving along a black hole's axis of spin are decelerated with respect to slow particles, while fast particles travelling perpendicular to the axis of spin are accelerated to extraordinary energies (www.arxiv.org/abs/astro-ph/0406005).

The work could explain some curious observations about black holes. Astronomers can see jets of particles streaming away from the poles of microquasars, which are thought to hide black holes. But particles within these jets appear to be decelerating, something that has puzzled astronomers. "We think this explains why astronomers report clumps of particles decelerating in the jets," says Mashhoon.

Meanwhile the new work indicates that even more exciting events may be occurring unseen in all other directions, where fast-moving particles are being accelerated rather than decelerated. According to the team’s calculations, the tidal deceleration occurs only within 55 degrees of a hole’s spin axis. High-speed particles elsewhere undergo huge levels of acceleration. "Einstein predicts they should approach the speed of light itself," says Mashhoon.

If Mashhoon and Chicone are right, black holes across the galaxy are spraying out particles -- most probably protons -- with energies in excess of the 1020 electronvolts that high energy cosmic rays can have when they reach Earth. They suggest that astronomers could test the idea by looking for correlations between the arrival direction of ultra-high-energy cosmic rays and the locations of microquasars.

LOAD-DATE: June 14, 2004