BLACK HOLE CONSTANT MAKES UNEXPECTED APPEARANCE

Find may be a coincidence or something more interesting

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If you were orbiting a rotating black hole, you might be in for a wild ride of dizzying and seemingly unpredictable gyrations. Yet more than 40 years ago, a physicist found a mathematical constant that revealed regularity in that ride. Now a similar constant has been discovered in a mild-mannered Newtonian system, reports a paper in the Feb. 13 *Physical Review Letters*.

The findings could be mere coincidence, nothing more than a mathematical curiosity, comments astrophysicist Saul Teukolsky of Cornell University. But, he says, they could shed light on the mysterious conditions of rotating black holes, which are predicted to exist by Einstein’s general relativity equations.

Rotating black holes are thought to be the end point in the evolution of massive stars that collapse under their own gravity when their nuclear fuel is exhausted. For black holes with no electrical charge, the gravitational field depends on only mass and spin (hence the saying that “black holes have no hair”). Strangely, this simplicity holds true even though a rotating black hole doesn’t have perfect symmetry. Like any rotating object, a black hole becomes slightly flattened because of centrifugal forces (like Earth, which bulges at the equator).

That loss of symmetry in a massive rotating black hole should suggest that anything orbiting it, such as a neutron star, would behave erratically. Such orbits do *appear* chaotic, says physicist Clifford Will of Washington University in St. Louis, author of the new paper.

“The orbits go wild — they gyrate and spin, they’re incredibly complex. It’s
But in 1968, physicist Brandon Carter discovered a mathematical constant that showed the orbits are predictable.

"Black holes have this extra constant that restores the regularity of the orbits," Teukolsky says. "It's a mystery. Every other situation where we have these extra constants, we have symmetry. But there's no symmetry for an orbiting black hole — that's why it is regarded as a miracle."

There's no obvious reason why the Carter constant should emerge in the general-relativity description of spinning black holes, says Teukolsky. By looking for it in other places, scientists might learn more of the specialness of the conditions surrounding such black holes.

Now Will has found a Carter-like constant in a Newtonian system. The equations describing a third body orbiting two masses that are arranged just right yield a similar constant.

"I still don't completely understand what it is telling us," says Will, who says he was amazed at the appearance of the constant.

Other physicists also aren't sure what specialness leads to the constant in both systems.

"I have no idea — to me this is a mystery," says Teukolsky, who worked on similar questions as part of his Ph.D. thesis in the 1970s. "I'm still baffled."

Will is still pushing the pencil, adding higher-order terms to the equations. He says that the constant disappears when he adds the mathematical terms for frame-dragging, the ability of a rotating body to drag spacetime around it, akin to the swirling exhibited around a spoon stirring a bowl of molasses. However, adding the next order of terms brings the constant back, Will says.

"It's mathematically intriguing," says E. Sterl Phinney of the California Institute of Technology in Pasadena. Similar work was published in 2003 by English astrophysicist Donald Lynden-Bell, Phinney says. "I don't know what it means, or that it has deep meaning."