Exotic physics finds black holes could be most 'perfect,' low-viscosity fluid

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In three spatial dimensions, it is a close relative of the quark-gluon plasma, the super-hot state of matter that hasn't existed since the tiniest fraction of a second after the big bang that started the universe. When viewed in 10 dimensions, the minimum number prescribed by what physicists call "string theory," it is a black hole.
No matter what you call it, though, that substance and others similar to it could be the most-perfect fluids in existence because they have ultra-low viscosity, or resistance to flow, said Dam Thanh Son, an associate physics professor in the Institute for Nuclear Theory at the University of Washington.

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Son and two colleagues used a string theory method called the gauge/gravity duality to determine that a black hole in 10 dimensions – or the holographic image of a black hole, a quark-gluon plasma, in three spatial dimensions – behaves as if it has a viscosity near zero, the lowest yet measured.

It is easy to see the difference in viscosity between a jar of honey or molasses at room temperature and a glass of water. The honey is much thicker and more viscous, and it pours very slowly compared with the water.

Using string theory as a measuring tool, Son and colleagues Pavlo Kovtun of the University of California, Santa Barbara, and Andrei Starinets of the Perimeter Institute for Theoretical Physics in Waterloo, Ontario, have found that water is 400 times more viscous than black hole fluid having the same number of particles per cubic inch.

"One can 'stir up' the black hole, and it will wiggle for some time," Son said. "After awhile it comes back to rest in exactly the same way as when you have stirred a cup of water – the water moves for awhile and then slows and stops. Viscosity is a reason why water stops. Similarly, one can associate viscosity with a black hole, and the viscosity is the reason it eventually stops moving after having been stirred."

A paper describing the use of string theory to compute black hole viscosity is scheduled for publication in the March 25 edition of Physical Review Letters, a journal of the American Physical Society. The work is supported by grants from the U.S. Department of Energy, the National Science Foundation and the Alfred P. Sloan Foundation.

Physicists for years have used string theory to unify forces of nature – gravity and electromagnetism, for example – when observations involving one force cannot be reconciled with those involving another force.

In string theory, elementary particles are described as small one-dimensional objects called strings, rather than simple points that do not occupy a dimension. But string theory requires at least six dimensions beyond the four in which humans traditionally think and function – three spatial dimensions plus time, often referred to as space-time. Most of those extra dimensions are thought to be very tiny, yet they can have measurable effects on the other dimensions.

To be comparable to the quark-gluon plasma, a black hole's temperature should be about 2 trillion degrees Celsius. At such extreme heat, it is not surprising that it might evaporate like other liquids. That is exactly what happens to black holes in three spatial dimensions, according to a well-accepted theory of particle radiation from black holes by physicist Stephen Hawking.

But in the 10 dimensions of string theory, the fluid of a black hole isn't like other fluids. Space-time is considered to be flat in our perception, Son said, and five of the extra dimensions are compacted into a small, finite sphere. In the remaining dimension, however, space is curved. Evaporation doesn't occur in this dimension, he said, because as particles radiate from the fluid they strike the curved edge of the dimension and are sent bouncing back into the black hole.

While a black hole's extreme temperature, among other things, would make it a decidedly inhospitable place for humans, its extremely low viscosity would make swimming in it a breeze. But Son noted that the smaller an organism is, the more viscous a fluid would appear to be.

"For bacteria, swimming in water must be like humans trying to swim in honey," he said.

Source: University of Washington

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