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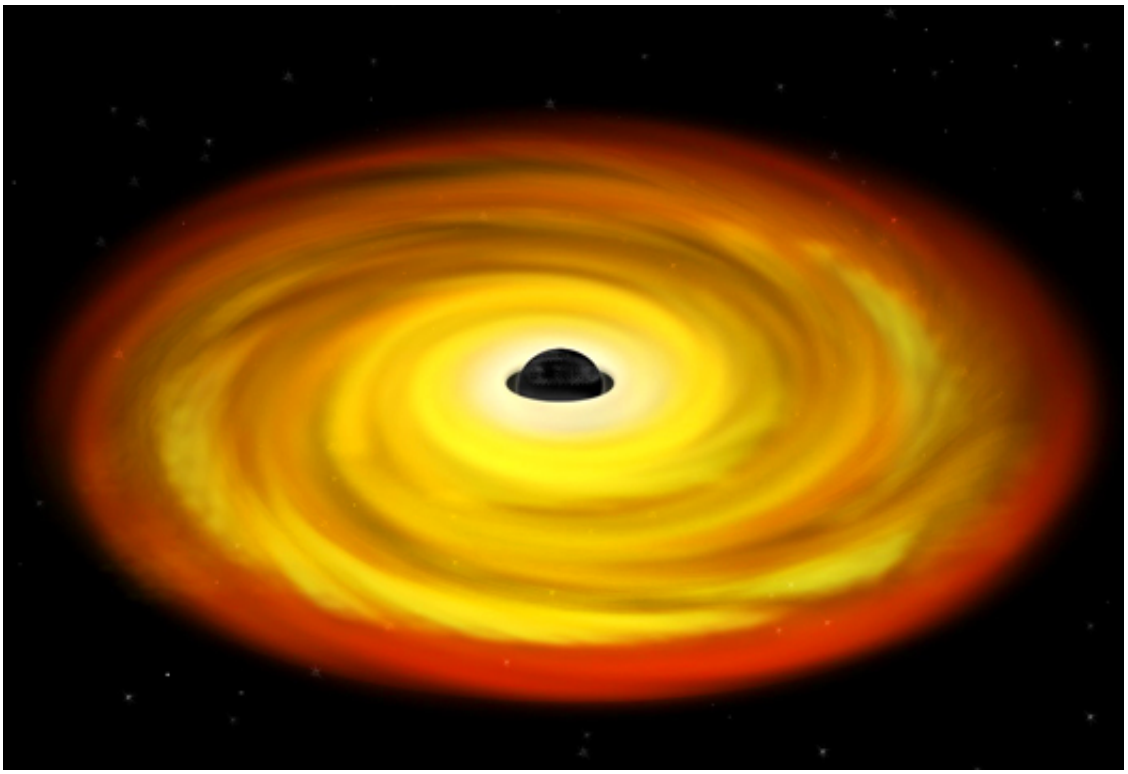
Math team may put 'wrinkle' in general relativity



General relativity predicts that gravity waves are produced, for example, by the collision of massive objects like black holes, but no one has observed them in nature. Shockwaves passing within stars could also form regularity singularities, the researchers theorize. (Credit: NASA/CXC/M. Weiss)

UC DAVIS (US) — Mathematicians have devised a new way to crinkle up the fabric of space-time—at least in theory.

"We show that space-time cannot be locally flat at a point where two shock waves collide," says Blake

Temple, professor of mathematics at University of California, Davis. "This is a new kind of singularity in general relativity."

Straight from the Source

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1471-2946

The results are reported in two papers by Temple with graduate students Moritz Reintjes and Zeke Vogler, respectively, both published in the journal *Proceedings of the Royal Society A*.

Einstein's theory of general relativity explains gravity as a curvature in space-time. But the theory starts from the assumption that any local patch of space-time looks flat, Temple says.

A singularity is a patch of space-time that cannot be made to look flat in any coordinate system, Temple says. One example of a singularity is inside a black hole, where the curvature of space becomes extreme.

Temple and his collaborators study the mathematics of how shockwaves in a perfect fluid can affect the curvature of space-time in general relativity. In earlier work, Temple and collaborator Joel Smoller, professor of mathematics at the University of Michigan, produced a model for the biggest shockwave of all, created from the Big Bang when the universe burst into existence.

A shockwave creates an abrupt change, or discontinuity, in the pressure and density of a fluid, and this creates a jump in the curvature. But it has been known since the 1960s that the jump in curvature created by a single shock wave is not enough to rule out the locally flat nature of space-time.


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Vogler's doctoral work used mathematics to simulate two shockwaves colliding, while Reintjes followed up with an analysis of the equations that describe what happens when shockwaves cross. He found this created a new type of singularity, which he dubbed a "regularity singularity."

What is surprising is that something as mild as interacting waves could create something as extreme as a space-time singularity, Temple says.

Temple and his colleagues are investigating whether the steep gradients in the space-time fabric at a regularity singularity could create any effects that are measurable in the real world. For example, they wonder whether they might produce gravity waves, Temple says.

General relativity predicts that these are produced, for example, by the collision of massive objects like black holes, but they have not yet been observed in nature. Regularity singularities could also be formed within stars as shockwaves pass within them, the researchers theorize.

Reintjes, now a postdoctoral scholar at the University of

Regensburg, Germany, presented the work at the International Congress on Hyperbolic Problems in Padua, in June.

The National Science Foundation funded the study.

Source: University of California, Davis

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Tags: general relativity, mathematics, space-time, University of California at Davis

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