

Black holes gain new powers when they spin fast enough

December 11 2020, by Brian Koberlein



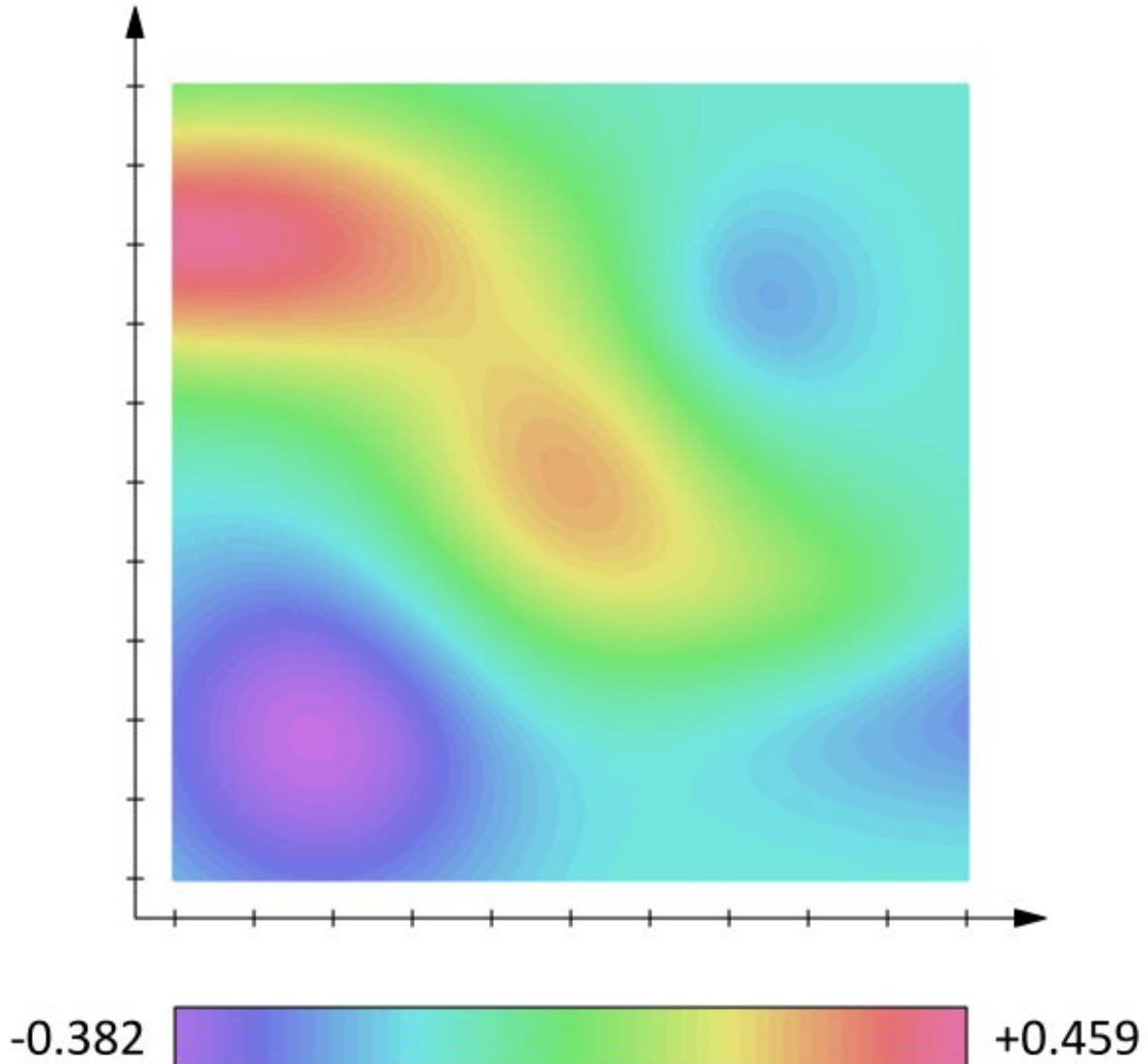
The conflict between relativity and quantum theory leads to the firewall paradox.
Credit: Jeremy Perkins / Unsplash

General relativity is a profoundly complex mathematical theory, but its

description of black holes is amazingly simple. A stable black hole can be described by just three properties: its mass, its electric charge and its rotation or spin. Since black holes aren't likely to have much charge, it really takes just two properties. If you know a black hole's mass and spin, you know all there is to know about the black hole.

This property is often summarized as the no-hair theorem. Specifically, the theorem asserts that once matter falls into a black hole, the only characteristic that remains is mass. You could make a black hole out of a sun's worth of hydrogen, chairs or those old copies of *National Geographic* from Grandma's attic, and there would be no difference. Mass is mass as far as general [relativity](#) is concerned. In every case, the event horizon of a black hole is perfectly smooth, with no extra features. As Jacob Bekenstein said, "black holes have no hair."

But with all its predictive power, general relativity has a problem with quantum [theory](#). This is particularly true with black holes. If the no-hair theorem is correct, the information within an object is destroyed when it crosses the event horizon. Quantum theory says that information can never be destroyed. So the valid theory of gravity is contradicted by the valid theory of the quanta. This leads to problems such as the firewall paradox, which can't decide whether an event horizon should be hot or cold.



The temperature within a room is an example of a scalar field. Credit: Lucas Vieira

Several theories have been proposed to solve this contradiction, often involving extensions to relativity. The difference between standard relativity and these modified theories can only be seen in extreme

situations, making them difficult to study observationally. But a new paper in *Physical Review Letters* shows how they might be studied through the spin of a black hole.

Many modified relativity theories have an extra parameter not seen in the standard theory. Known as a massless scalar field, it allows Einstein's model to connect with [quantum theory](#) in a way that isn't contradictory. In this new work, the team looked at how such a scalar field connects to the rotation of a black hole. They found that at low spins, a modified black hole is indistinguishable from the standard model, but at high rotations, the scalar field allows a black hole to have extra features. In other words, in these alternative models, rapidly rotating black holes can have hair.

The hairy aspects of rotating black holes would only be seen near the event horizon itself, but they would also affect merging black holes. As the authors point out, future gravitational wave observatories should be able to use rapidly rotating [black holes](#) to determine whether an alternative to general relativity is valid.

Einstein's theory of [general relativity](#) has passed every observational challenge so far, but it will likely break down in the most extreme environments of the universe. Studies such as this show how we might be able to discover the theory that comes next.

More information: Alexandru Dima et al. Spin-Induced Black Hole Spontaneous Scalarization, *Physical Review Letters* (2020). [DOI: 10.1103/PhysRevLett.125.231101](https://doi.org/10.1103/PhysRevLett.125.231101)

Provided by Universe Today

Citation: Black holes gain new powers when they spin fast enough (2020, December 11)
retrieved 26 March 2023 from <https://phys.org/news/2020-12-black-holes-gain-powers-fast.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.