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Astrophysics

Black holes with magnetic field 'hair' shed it in hot plasma

Leah Crane

BLACK holes with "hair" will quickly go bald. A key theoretical prediction about black holes called the no-hair theorem states that an isolated black hole can be described by just three numbers – its mass, spin and charge – and any other properties, or "hair", are irrelevant. Now, a set of detailed simulations has shown how black holes can shed a magnetic field to comply with the no-hair theorem.

When a black hole forms from a magnetised star, it is born with a magnetic field. How long that magnetic field sticks around is an open question, and some previous work has suggested that the plasma surrounding black holes may keep the magnetic field around for longer than expected, which would be a violation of the no-hair theorem. Ashley Bransgrove at Columbia University in New York and his colleagues used a set of detailed computer simulations to solve this problem.

"In the magnetic domain, this is the most realistic test of the no-hair theorem to date," says Kyle Parfrey at Trinity College Dublin, Ireland.

The researchers simulated a rotating black hole surrounded by magnetised plasma. They found that the lines of the magnetic field converged at the black hole's equator and turned into closed loops in a process called magnetic reconnection.

These magnetic loops filled with plasma dissipated the magnetic field that had previously permeated the black hole, freeing up space at the equator for more field lines to converge.

"Field lines keep flowing in and making these loops, and that just keeps happening until they're all gone," says Bransgrove. "Some of these loops fly away into space, and some fall into the black hole."

This process happened relatively quickly, allowing the black hole to follow the no-hair theorem.

"The original no-hair theorem is for a black hole in a vacuum, but we're trying to move that into something more realistic," says Bransgrove.

For now, it seems that the theorem works even for black holes that are surrounded by plasma, as many are in the real world (*Physical Review Letters*, doi.org/gmcptn).

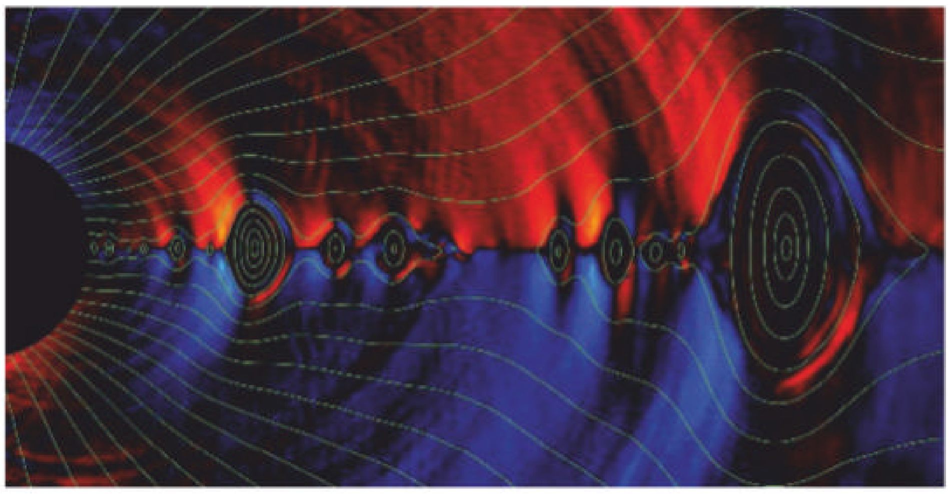
This result isn't particularly surprising, says Vitor Cardoso at the University of Lisbon in Portugal. "We had predictions for practically everything that was reported now – but those predictions were back-of-the-envelope estimates, and we all know that the devil hides in the details," he says. "Now, this work worked out the details, [and] there was no devil, which is reassuring!"

However, it does help us understand the magnetic behaviour of black holes, he says. Comprehending this process of shedding magnetic fields could help researchers find and identify newly formed black holes.

"We can't say for sure yet whether we see this in observations, but there are hints," says Bransgrove. Some huge black holes send out powerful flares of X-rays that may be powered by magnetic reconnection, but astronomers haven't yet spotted the magnetic loops full of plasma that these simulations suggest.

Observing the X-rays coming from the hot plasma surrounding the biggest black holes may allow us to confirm that this process is taking place, moving the no-hair theorem one step closer to describing the real world. ▮

A simulation of magnetic field lines reconnecting outside a black hole



BRANSGROVE A.,ET AL./AMERICAN PHYSICAL SOCIETY

Fibre optics

Tiny bendy camera can produce three-dimensional images

A FIBRE-OPTIC cable the thickness of a human hair can transmit accurate 3D images in real time, creating a tiny, flexible camera.

Miles Padgett at the University of Glasgow, UK, and his colleagues have developed a system several orders of magnitude smaller than pre-existing cameras based on fibre-optic cable. The system uses a cable that is 40 centimetres long and 50 micrometres in diameter. It can take 3D pictures of objects up to 2.5 metres away.

The camera works similarly to a lidar scanner, which gauges distance by sending out pulses of light and measuring how long they take to bounce back.

Light sent down the fibre-optic cable does much the same in miniature, determining the size and shape of an object to an accuracy of a millimetre. The camera makes more than 23,000 of these measurements every second to build up a 3D image (arxiv.org/abs/2107.11450).

"It's easy to say it has medical applications, but I think it also has applications in industrial inspection, and potentially surveillance," says Jurgen Schmoll at Durham University, UK.

Padgett is currently working on threading the fibre through a needle as a way of deploying the cable, which could allow it to penetrate human tissue.

"The camera works similarly to a lidar scanner, which gauges distance through pulses of light"

He also wants to extend the length of the fibre to 2 metres or more, although that would require using a different type of fibre that would give higher resolution in the middle of the image and lower resolution at the edges.

"That might not be a bad thing," says Padgett. "That's what the [human] eye does." ▮

Chris Stokel-Walker