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Astrophysics

Einstein's black hole idea was right

Observations of matter plunging into a black hole show his predictions were correct

Leah Crane

A STRANGE area around black holes called the "plunging region" has been spotted for the first time. This area, where matter stops circling a black hole and instead falls straight in, was predicted by Albert Einstein's general theory of relativity, but it has never been observed before. Studying plunging regions could teach us how black holes form and evolve, as well as reveal new information about the nature of space-time.

When matter gets too close to a black hole, it rips apart and forms an orbiting ring around it called an accretion disc. General relativity predicts there should be an inner boundary to the accretion disc past which nothing can orbit the black hole – instead, it should plunge straight in, rapidly accelerating to near the speed of light as it falls.

"It's like a river turning into a waterfall, and until now we've only been looking at the river," says Andrew Mummery at the University of Oxford. "If Einstein was wrong, then it would be stable all the way down – there would only be a river." Now we have had our first peek at the waterfall, suggesting Einstein was correct.

BURADAKI/ALAMY

We have glimpsed the waterfall of matter entering a black hole

Mummery and his colleagues spotted evidence of the plunging region around a black hole in a binary system called MAXI J1820+070, which is about 10,000 light years from Earth. They used data from the Nuclear Spectroscopic Telescope Array (NuSTAR), a space-based X-ray telescope, to build models of the light from the black hole's accretion disc.

They found the models only fit the data when they included the light emitted by matter in the plunging region in addition to light from the accretion disc (*Monthly Notices of the Royal Astronomical Society*, doi.org/mwmm). "Before, we sort of thought that anything that crosses this boundary would have no time to really radiate appreciably before it plunges into the black hole," so researchers wouldn't see anything, says Greg Salvesen at Los Alamos National Laboratory in New Mexico, who wasn't involved with this work. "But it turns out that this plunging region gives you extra light that you wouldn't have expected."

This extra light could solve a long-standing problem in X-ray astronomy, in which black holes appear to spin faster than theory predicts. The spin of a black hole and the brightness of the area around it are connected, so adding some extra light could bring the spins back in line with predictions. "Black hole spins tell us about all kinds of things, so if we could measure it better, we could answer loads of questions," says Salvesen.

That includes questions about the nature of gravity and space-time itself, because plunging regions are some of the most extreme regions of space we can observe. The plunging region is just outside the event horizon, beyond which the gravitational forces are so strong, no matter or even light can escape.

"It's like a river turning into a waterfall, and until now we've only been looking at the river"

"Technically, if the matter had a rocket it could escape the plunging region, but it's doomed – its orbit has become unstable and it's rapidly accelerating toward the speed of light," says Mummery. "This stuff has about as much chance of coming back as water off the edge of a waterfall." ▮

Archaeology

Nomads thrived in Greece after collapse of the Roman Empire

AN ANALYSIS of pollen from Lake Volvi in Greece has unexpectedly revealed that nomads thrived in this region for centuries after the collapse of the Roman Empire.

Adam Izdebski at the Max Planck Institute of Geoanthropology in Germany and his colleagues have been studying sediment cores from the lake. Changes in the abundance of the kinds of pollen in sediment layers can record how the nearby vegetation changed over time.

In some other places around the Mediterranean, the team has found signs of reforestation after the collapse of the Western Roman Empire around AD 476. But at Lake Volvi, from around AD 540, the team found less tree pollen but more pollen from plants associated with nomadic livestock herders. These nomads were returning to the same areas seasonally, so they planted some crops, such as barley.

"We have this moment when the Roman agriculture disappears… but you don't get reforestation – you actually get less forest very quickly," says Izdebski. "The landscape was dominated by pasture animals even in the high mountain areas. This was a complete shift from how the Romans farmed the lowlands."

ONLY FRANCE/ALAMY

Pollen records reveal a Grecian landscape that was dominated by pasture

This means those earlier farmers moved away, died or adopted a nomadic lifestyle, he says.

Greece was nominally under the control of the Eastern Roman, or Byzantine, Empire at the time of this shift. It is known that the region was raided by Bulgar nomads around AD 540, but it wasn't known that nomads lived there. The findings also correlate with an account of a Byzantine emperor being ambushed by nomads around AD 700.

"It seems that there was a local society that didn't want any emperor to be around," says Izdebski, who presented the findings at the meeting of the European Geosciences Union in Vienna, Austria, last month. ▮

Michael Le Page