Light bending by a black hole may offer proof of extra dimensions

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(PhysOrg.com) -- Researchers at the University of Pennsylvania report that a new test for measuring the ability of gravity to bend light seen from distant stars around large objects like black holes may offer proof of the existence of extra dimensions in the universe.

Most of the work by astrophysicists studying the effects of gravitational lensing, or light bending, relates to galaxies and galaxy clusters. New research from Penn makes use of the supermassive black hole believed to exist at the center of the Milky Way galaxy.

The analysis was carried out by Amitai Y. Bin-Nun, a theoretical astrophysics and cosmology graduate student at Penn, with guidance from Justin Khoury, assistant professor, and Ravi K. Sheth, professor, both in the Physics and Astronomy Department in Penn's School of Arts and Sciences. The article appears in the journal *Physical Review D*.

"We found that, if our universe is described by a theory incorporating extra dimensions, light near the black hole at the center of our galaxy may appear brighter than it would if we live in a universe without extra dimensions," Bin-Nun said. "Detecting images at the brighter intensity would represent evidence of extra dimensions and would be an incredibly important development."

Bin-Nun studied the effect of gravitational lensing on the stars orbiting Sagittarius A*, or Sgr A*, a radio source in the center of the Milky Way. Sgr A* was chosen because it hosts the supermassive black hole hypothesized to exist at the center of the Milky Way. The strong gravitational pull of the black hole distorts the light from Sgr A* before it reaches Earth, creating the illusion of multiple images of the same star.

Bin-Nun simulated the orbits of stars near the black hole and treated each star as a source lensed by the black hole, solving for the location and brightness of the “secondary” image which appears near the black hole. For each individual star, Bin-Nun found that the brightness of the secondary image would change over time and would peak in brightness when the star is nearly aligned with Sgr A*.

Next, he repeated the lensing analysis assuming the black hole was described by a metric coming from the theoretical Randall-Sundrum II braneworld scenario, which prescribes an extra fifth dimension. If that description of the black hole is correct, then the seconday image of the star S2 will be up to 44 percent brighter in early 2018 when it reaches its peak brightness, providing evidence for the presence of a fifth dimension where gravity is severely diluted. If not, then the four dimensional description of the black hole should be seen as more accurate.

Even if the exact universe is not five dimensional, or this analysis breaks down at other points, “we have shown alternative gravity theories have the possibility of creating a large gravitational lensing effect and we should look into lensing as a test for gravity theories,” Bin-Nun said.

The findings come with several caveats.

Certain assumptions on the form of the black hole were made as the shape of space around a five dimensional black hole is not known. Researchers did not take into account the spin of the black hole, which confounds the analysis. It’s also highly probable that, because the image is so close to the black hole and resolution of available ground-based telescopes are limited, the light from larger, nearby objects could obscure the image of the star, meaning observers won't be able to isolate the effects of this particular iamge.

"These findings illustrate how the opportunities provided by the Penn physics Ph.D. program and its new Center for Particle Cosmology allow its students to make important contributions at the cutting edge of discovery," Sheth said.

Provided by University of Pennsylvania

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