The first black hole image: A gravitomagnetic monopole as an alternative explanation

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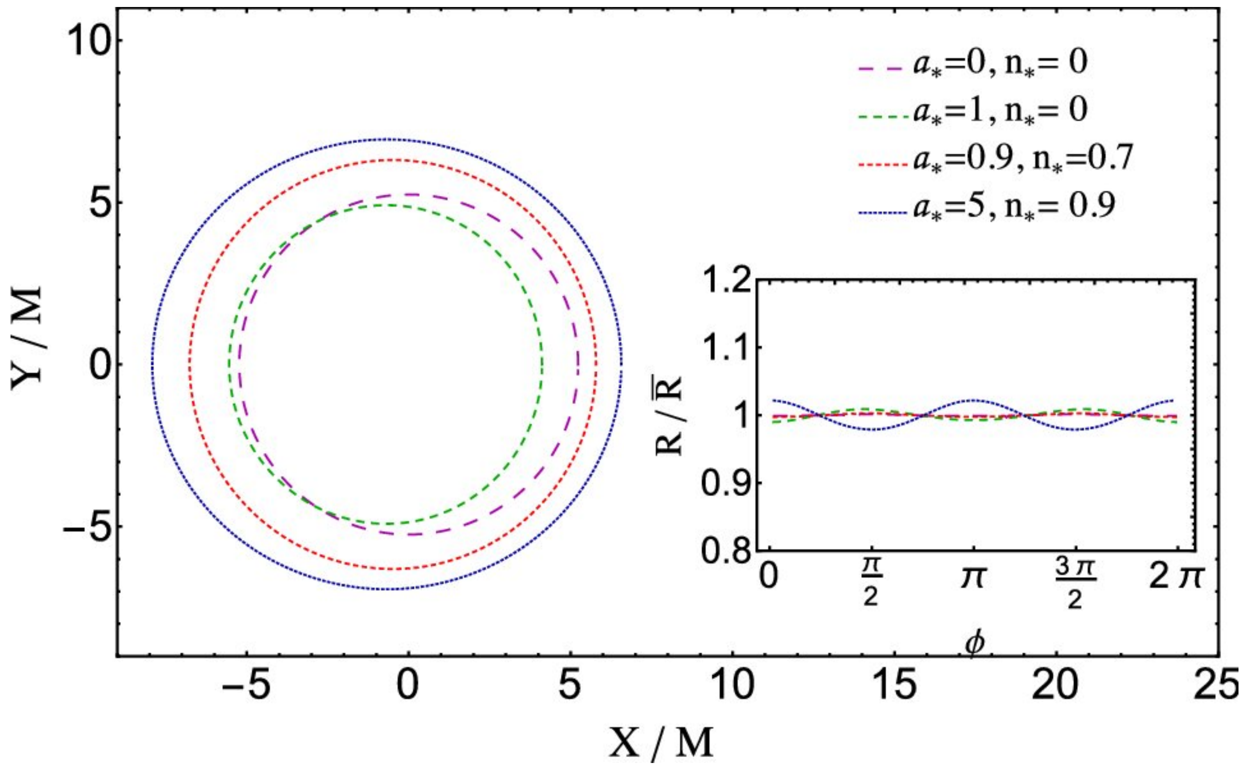

Shadow shapes resulting from the four different settings on the spin (a_*) and the NUT parameter (n_*), i.e., (a_*,n_*)=(0,0) (Schwarzschild metric), (1, 0) (extremely rotating Kerr metric), (0.9, 0.7) (KTN BH), and (5, 0.9) (KTN NS), respectively, for i=17◦. This Figure illustrates that the shadow shapes resulting from different KTN parameter settings are all nearly circular but the shadow sizes can be significantly different from each other. In the inset, although we display that the resulting deviation from circularity is only within 5% for these particular settings of parameters, it can be, in fact, higher for the different settings of a_* and n_*.

Credit: DOI: 10.1140/epjc/s10052-021-09696-3

The Event Horizon Telescope (EHT) has recently mapped the central compact object of the galaxy M87 with an unprecedented angular resolution. Though the remarkable breakthrough has been interpreted based on theory that M87 contains a rotating or "Kerr" black hole. New research published in *EPJ C* by Chandrachur Chakraborty and Qingjuan Yu at the Kavli Institute for Astronomy and Astrophysics, Peking University (KIAA-PKU), Masoumeh Ghasemi-Nodehi and Youjun Lu, at the National Astronomical Observatories of China, looks at possible alternative explanations for the image.

"The EHT collaboration has tried to show that the observed image is overall consistent with the expectations for the shadow of a Kerr black hole," Chakraborty says. "As the alternatives to the Kerr BH have not been ruled out, we have investigated whether the EHT data is also consistent or not with alternative models for the central object of M87."

Chakraborty goes on to explain that he and his co-authors had one primary purpose to show how a gravitomagnetic monopole — or an NUT parameter — affects the shadow size and shape, and whether its existence can be ruled out or not in M87*. "To show this, we use the observational parameter values of the first image of M87* and found that a non-zero gravitomagnetic monopole is still compatible with the current EHT observations," Chakraborty says.

Chakraborty goes on to explain what a gravitomagnetic monopole is: "In nature, north and south magnetic poles always go hand in hand. Cutting a bar magnet in half just creates two magnets, each of which still has two poles, rather than creating separate north and south poles on each half. Yet their electrostatic cousins, positive and negative charges, exist independently."

The researcher adds that in theoretical physics, gravity and electromagnetism have analogous features. "Mass is considered as the analogous to electric charge. Therefore, we call mass the gravitoelectric charge," Chakraborty says. "The next question is, does gravitomagnetic charge or the so-called gravitomagnetic monopole exist in nature?"

In the paper, the authors propose that M87* may contain a gravitomagnetic monopole, and, therefore, could be described as a more general Kerr-Taub-NUT spacetime, with Kerr spacetime a special case of the Kerr-Taub-NUT spacetime with vanishing gravitomagnetic monopole.

"In that sense, no models are incorrect, and this basically put a strong constraint on the spacetime structure of the central compact radio source in M87," Chakraborty concludes, adding how competing theories could be tested. "Essentially, accurate measurements of both the shadow size and asymmetry could put strong constraints on Kerr parameter and NUT parameter, and break the degeneracies between the Kerr and Kerr-Taub-NUT spacetimes, including those between the black holes and naked singularities."

More information: M. Ghasemi-Nodehi et al, Investigating the existence of gravitomagnetic monopole in M87*, *The European Physical Journal C* (2021). DOI: 10.1140/epjc/s10052-021-09696-3

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