“Black holes with hair”

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The influential XXth century physicist John Wheeler, created the mantra “black holes have no hair”, to stress the remarkable simplicity of these objects. Indeed, according to general relativity, the most general astrophysically interesting black hole has only 2 degrees of freedom: its total mass M and angular momentum J, and is described by an elegant solution of the Einstein equations, called the Kerr metric. This simplicity contrasts with what is known for ordinary stars – or any other known object – which, for the same M, J, may differ considerably, as M, J may be differently distributed throughout the star.

The “no-hair idea” idea is anchored on rigorous mathematical theorems, dubbed uniqueness black hole theorems, which have been proven in the 1970s for gravitational collapse in the presence of specific matter sources. But it extrapolates from these theorems by assuming that a similar statement holds for any matter source, a fact that has only partial mathematical support. Hence it is a conjecture.

In a paper published in Physical Review Letters (PRL 112(2014)221101), a team from the University of Aveiro has explicitly constructed a family of black hole solutions with 'hair' by exploiting a loophole in previous no-hair theorems. For these new 'Kerr black holes with scalar hair', the hair is provided by scalar matter, that can stay in equilibrium with the black hole due to a new mechanism unveiled in this work, which can, moreover, allow other more general types of matter to linger around black holes, thus setting the stage for constructing more generic 'hairy' examples.

The Aveiro team provided preliminary evidence for astrophysical signatures of these models, which could work as smoking guns for hair, and could arise by observing: black hole shadows, currently being measured by the Event Horizon Telescope; properties of accretion disks; or gravitational wave emission from perturbed black holes that will be measured by ground based interferometers such as Advanced LIGO.

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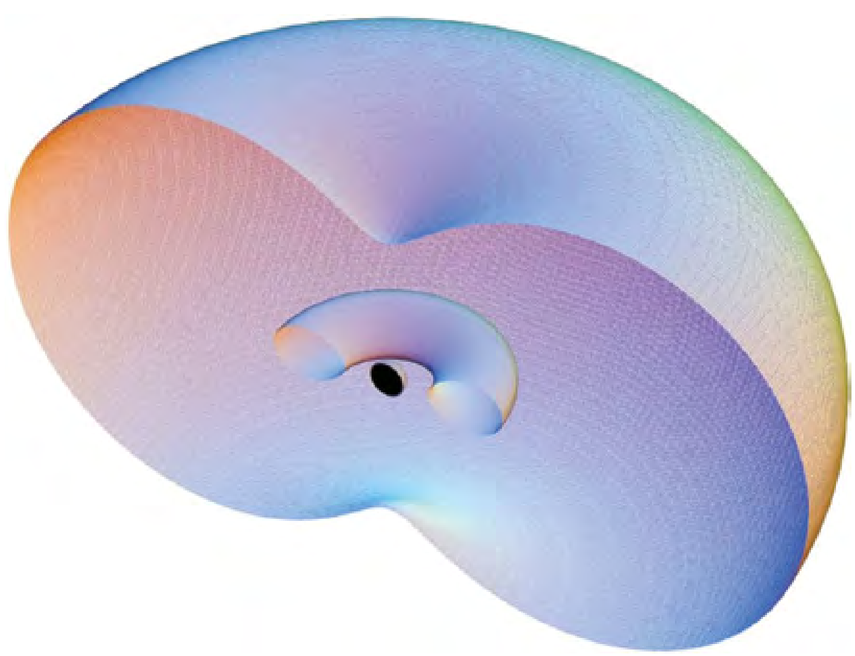

FIGURE 1
The horizon of a Kerr black hole with scalar hair (small central sphere with black top) surrounded by surfaces of constant energy density of the scalar matter, which are topologically tori near the black hole (due to the rotation) and become topologically spherical asymptotically.