Frequently asked questions (FAQ) about black holes

Quick non-technical answers to frequently asked questions about black holes (in particular spinning black holes).

Why is there a maximal limit for the rotation rates (the spin) of black holes?

This is a prediction from Einstein's general theory of relativity. If a black hole could be made to rotate faster than the maximal spin it would be destroyed! As Kip Thorne puts it: "if the hole were to spin extremely rapidly, centrifugal forces would tear its horizon apart much like they flixig water out of a bucket when the bucket spins extremely rapidly."

What is the rotation speed that corresponds to this maximal spin of black holes?

Let's consider the case of black hole with a mass equal to the mass of the Sun rotating at the maximal possible spin. Its radius would be approximately 1.5 km. For contrast the radius of a stationary (non-rotating) black hole would be about 3 km. Such a spinning black hole would rotate about 16000 times each second!

We can estimate the rotation speed of the black hole using the following simple formula:

$$\text{rotation speed} = \frac{\text{circunference of the black hole}}{\text{period of rotation}}.$$

Due to the weird properties of the curved spacetime around the rotating black hole, the circunference around the equator is not simply calculated as

$$2\pi \times \text{radius} = 2\pi \times 1.5 \text{ km}$$

as in the Euclidean geometry. Instead, the circunference is given by $4\pi \times 1.5$ km (and does not depend on the spin). The rotation speed of the black hole at its equator is then given by

$$\text{rotation speed} = \frac{\text{circunference of the black hole}}{\text{period of rotation}} = \frac{4\pi \times 1.5 \text{ km}}{1/16000 \text{ s}} \approx c,$$

where c is the speed of light (approximately 300000 km/s). We can conclude that the maximal spin corresponds to the case where the black hole is rotating at the speed of light, as one would expect. Keep in mind that rotation causes the black hole to bulge out at its equator. The shape of a rotating black hole is similar to that of a football ball, while the shape of a stationary (non-rotating) black hole is similar to that of soccer ball.

Is it possible to spin up a black hole above the maximal spin rate and therefore destroy it?

No. Again Dr. Thorne explains it well and succintly: "if one tries to make the hole spin faster than its

maximum by any method at all, one will always fail. For example, if one tries to speed up a maximally spinning hole by throwing fast-spinning matter into it, centrifugal forces will prevent the fast-spinning matter from reaching the horizon and entering the hole."

About how far away from Earth are these black holes?

The black holes that I studied have typically a mass of one billion (1 followed by nine zeros!) Sun masses. Such kind of very massive black holes are called supermassive black holes and are pretty far away from us, located in the central regions of galaxies. In the particular case of the objects I studied, they are at a distance between about thirty million light-years (three followed by seven zeros) and three hundred million light-years from us. So do not worry, they are pretty far away from us!

About how far do these black holes' gravitational fields reach?

The distance that the gravitational field of a supermassive black hole may reach is determined by the mass of the black hole and the distribution of mass of the galaxy hosting the black hole. The total mass of a galaxy including interstellar gas, stars and dark matter may be more than one thousand times bigger than the mass of the central black hole. If you were in a spaceship outside a galaxy like our own Milky Way, the strength of the gravitational field of the black hole would be negligible compared to the collective gravitational field from the stars, gas etc in the galaxy.

Inside the galaxy, if you get closer than a certain distance from the central black hole (inside the "sphere of influence") its gravitational field would become more important than the collective field of the galaxy and you would start to be "pushed" towards the black hole. In the case of our own galaxy, which harbors a central black hole with a mass of approximately one million solar masses, the size of the "sphere of influence" of the black hole is about one light-year. For bigger galaxies hosting more massive black holes, the size of the "sphere of influence" may be as big as one hundred light-years.

Suggested reading for further information

For a lively non-technical description of the physics and astrophysics of black holes you can refer to the book Black holes & time warps by Kip Thorne.

For technical details about the physics of black holes involving the use of Einstein's theory of general relativity, I suggest the books Gravity: an introduction to Einstein's general relativity by James Hartle, Exploring black holes: an introduction to general relativity by Edwin F. Taylor and John A. Wheeler, and Gravitation by Charles Misner et al.

The Scientific American Special Edition "Reality bending black holes" (entirely dedicated to black holes) contains several articles describing recent developments on the research of black holes, both in the astronomical and theoretical fronts.

A compilation of several links about black holes can be found here.

Updated: Feb. 8 2008.

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