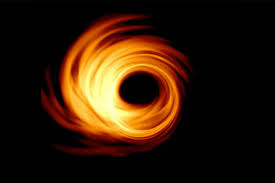
Black hole

A black hole is a region of [spacetime](https://en.wikipedia.org/wiki/Spacetime) where [gravity](https://en.wikipedia.org/wiki/Gravitation) is so strong that nothing—no [particles](https://en.wikipedia.org/wiki/Particle) or even [electromagnetic radiation](https://en.wikipedia.org/wiki/Electromagnetic_radiation) such as [light](https://en.wikipedia.org/wiki/Light)—can escape from it. The theory of [general relativity](https://en.wikipedia.org/wiki/General_relativity) predicts that a sufficiently compact [mass](https://en.wikipedia.org/wiki/Mass) can deform spacetime to form a black hole. The boundary of the region from which no escape is possible is called the [event horizon](https://en.wikipedia.org/wiki/Event_horizon). Although the event horizon has an enormous effect on the fate and circumstances of an object crossing it, it has no locally detectable features. In many ways, a black hole acts like an ideal [black body](https://en.wikipedia.org/wiki/Black_body), as it reflects no light. Moreover, [quantum field theory in curved spacetime](https://en.wikipedia.org/wiki/Quantum_field_theory_in_curved_spacetime) predicts that event horizons emit [Hawking radiation](https://en.wikipedia.org/wiki/Hawking_radiation), with [the same spectrum](https://en.wikipedia.org/wiki/Thermal_radiation) as a black body of a temperature inversely proportional to its mass. This temperature is on the order of billionths of a [kelvin](https://en.wikipedia.org/wiki/Kelvin) for [black holes of stellar mass](https://en.wikipedia.org/wiki/Stellar_black_hole), making it essentially impossible to observe.

Black holes of stellar mass are expected to form when very massive stars collapse at the end of their life cycle. After a black hole has formed, it can continue to grow by absorbing mass from its surroundings. By absorbing other stars and merging with other black holes, [supermassive black holes](https://en.wikipedia.org/wiki/Supermassive_black_hole) of millions of [solar masses](https://en.wikipedia.org/wiki/Solar_mass) (M☉) may form. There is consensus that supermassive black holes exist in the centres of most [galaxies](https://en.wikipedia.org/wiki/Galaxy).



Properties and structure

The [no-hair conjecture](https://en.wikipedia.org/wiki/No-hair_theorem) postulates that, once it achieves a stable condition after formation, a black hole has only three independent physical properties: [mass](https://en.wikipedia.org/wiki/Mass), [charge](https://en.wikipedia.org/wiki/Electric_charge), and [angular momentum](https://en.wikipedia.org/wiki/Angular_momentum); the black hole is otherwise featureless. If the conjecture is true, any two black holes that share the same values for these properties, or parameters, are indistinguishable from one another. The degree to which the conjecture is true for real black holes under the laws of modern physics, is currently an unsolved problem.

These properties are special because they are visible from outside a black hole. For example, a charged black hole repels other like charges just like any other charged object. Similarly, the total mass inside a sphere containing a black hole can be found by using the gravitational analog of [Gauss's law](https://en.wikipedia.org/wiki/Gauss%27s_law), the [ADM mass](https://en.wikipedia.org/wiki/ADM_mass), far away from the black hole. Likewise, the angular momentum can be measured from far away using [frame dragging](https://en.wikipedia.org/wiki/Frame_dragging) by the [gravitomagnetic field](https://en.wikipedia.org/wiki/Gravitomagnetism).

## Formation and evolution

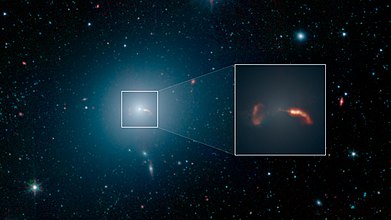
Given the bizarre character of black holes, it was long questioned whether such objects could actually exist in nature or whether they were merely pathological solutions to Einstein's equations. Einstein himself wrongly thought black holes would not form, because he held that the angular momentum of collapsing particles would stabilize their motion at some radius. This led the general relativity community to dismiss all results to the contrary for many years. However, a minority of relativists continued to contend that black holes were physical objects, and by the end of the 1960s, they had persuaded the majority of researchers in the field that there is no obstacle to the formation of an event horizon.



Simulation of two black holes colliding

Penrose demonstrated that once an event horizon forms, general relativity without quantum mechanics requires that a singularity will form within. Shortly afterwards, Hawking showed that many cosmological solutions that describe the [Big Bang](https://en.wikipedia.org/wiki/Big_Bang) have singularities without [scalar fields](https://en.wikipedia.org/wiki/Scalar_field) or other [exotic matter](https://en.wikipedia.org/wiki/Exotic_matter) (see "[Penrose–Hawking singularity theorems](https://en.wikipedia.org/wiki/Penrose%E2%80%93Hawking_singularity_theorems)"). The [Kerr solution](https://en.wikipedia.org/wiki/Kerr_solution), the [no-hair theorem](https://en.wikipedia.org/wiki/No-hair_theorem), and the laws of [black hole thermodynamics](https://en.wikipedia.org/wiki/Black_hole_thermodynamics) showed that the physical properties of black holes were simple and comprehensible, making them respectable subjects for research. Conventional black holes are formed by [gravitational collapse](https://en.wikipedia.org/wiki/Gravitational_collapse) of heavy objects such as stars, but they can also in theory be formed by other processes.

## Observational evidence



By nature, black holes do not themselves emit any electromagnetic radiation other than the hypothetical [Hawking radiation](https://en.wikipedia.org/wiki/Hawking_radiation), so astrophysicists searching for black holes must generally rely on indirect observations. For example, a black hole's existence can sometimes be inferred by observing its gravitational influence upon its surroundings.

On 10 April 2019 an image was released of a black hole, which is seen in magnified fashion because the light paths near the event horizon are highly bent. The dark shadow in the middle results from light paths absorbed by the black hole. The image is in [false color](https://en.wikipedia.org/wiki/False_color), as the detected light halo in this image is not in the visible spectrum, but radio waves.

The brightening of this material in the 'bottom' half of the processed EHT image is thought to be caused by [Doppler beaming](https://en.wikipedia.org/wiki/Relativistic_beaming), whereby material approaching the viewer at relativistic speeds is perceived as brighter than material moving away. In the case of a black hole this phenomenon implies that the visible material is rotating at relativistic speeds (>1,000 km/s), the only speeds at which it is possible to centrifugally balance the immense gravitational attraction of the singularity, and thereby remain in orbit above the event horizon. This configuration of bright material implies that the EHT observed [M87\*](https://en.wikipedia.org/wiki/M87*) from a perspective catching the black hole's accretion disc nearly edge-on, as the whole system rotated clockwise. However, the extreme [gravitational lensing](https://en.wikipedia.org/wiki/Gravitational_lens) associated with black holes produces the illusion of a perspective that sees the accretion disc from above. In reality, most of the ring in the EHT image was created when the light emitted by the far side of the accretion disc bent around the black hole's gravity well and escaped such that most of the possible perspectives on M87\* can see the entire disc, even that directly behind the "shadow".

Prior to this, in 2015, the EHT detected magnetic fields just outside the event horizon of Sagittarius A\*, and even discerned some of their properties. The field lines that pass through the accretion disc were found to be a complex mixture of ordered and tangled. The existence of magnetic fields had been predicted by theoretical studies of black holes.