An irresistible attraction

There is something fascinating about Black holes. Perhaps it is their strong gravitational pull and elusiveness

Jonathan Freundlich

Black holes are among the most fascinating objects in the Universe. How would a journey towards a black hole look like?

The escape velocity

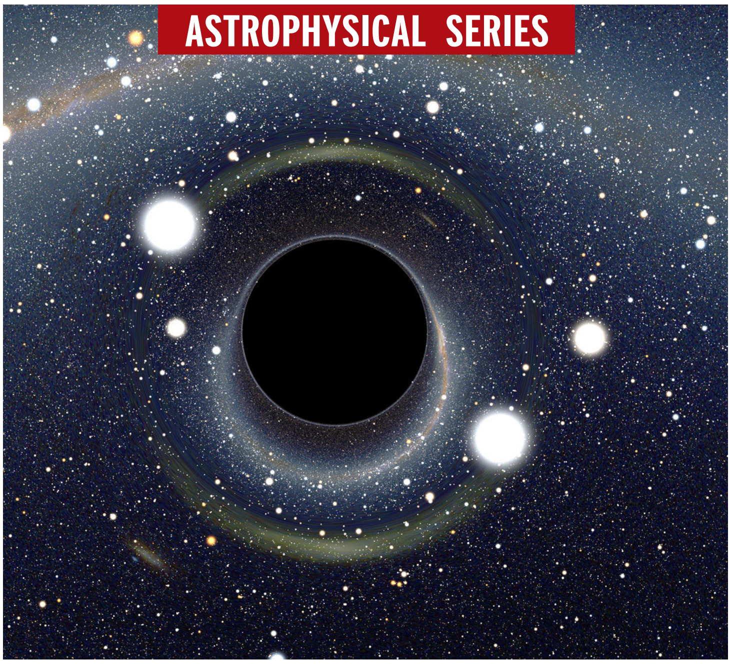
When you throw a ball up in the air, it always falls back down to the ground because of the Earth's gravitational attraction. If you throw the ball harder, it will get higher but will still fall down afterwards. The ball can't easily escape the Earth's gravity!

If you could throw the ball at an extremely high speed though, it would escape the Earth's gravitational attraction and continue its journey into outer space. The velocity required for that is called the escape velocity, and it is about 11 kilometers per second at the surface of the Earth. This is the speed space rockets have to reach in order to **liberate** themselves from the Earth's gravitational influence, and it requires a lot of energy. Have you ever seen how impressive rocket launches look?

If the Earth was more massive, its gravitational attraction would be stronger, your ball wouldn't go as high as usual, and it would require more energy to send something into outer space: the escape velocity would be higher and hence more difficult to reach. For extremely massive objects, the escape velocity could even be impossible to reach!

A black hole is an object which is so massive and so compact that its escape velocity is greater than the speed of light: as nothing can move faster than the speed of light, nothing can get out of a black hole. Even light. Any light emitted inside the black hole is dragged back by its strong gravitational attraction and thus never reaches observers situated outside. A black hole looks black because there is simply no light coming out of it.

ASTROPHYSICAL SERIES



IN THE DARK *A computer generated image of a black hole showing the visual distortions it would cause if you were to approach it.* CREDIT: ALAIN RIAZUELO, IAP/UPMC/CNRS.

- The contracting core of a very big star can become a black hole during its explosion as a supernova, but our Sun will never turn into a black hole because it is far from massive enough.
- Gravity around a black hole is so strong it would stretch you and tear you apart as you get closer.
- A black hole disrupts the structure of space-time itself, which would cause unusual visual distortions when you approach it.
- Time flows differently near the event horizon of a black hole: you would age much slower there than on Earth, and a few minutes spent there could mean years on Earth if you come back.

A journey into a black hole

A black hole is like a huge maelstrom that attracts the surrounding matter, so moving towards it would be a bit like swimming towards a huge waterfall. Gravity would pull you towards the black hole as the water flow would towards the fall. If you are far away, you can still swim back and get away. But as you get nearer, the current gets faster and faster, up to a point where there is no turning back anymore: you are **doomed** to fall with the flow. For a black hole, this point of no return is called the event horizon and this is where the escape velocity is equal to the speed of light. But although crossing the event horizon of a black hole would mark a turning point in your life, as you wouldn't be able to travel back anymore nor communicate with the outside world, you wouldn't necessarily notice anything special on the moment as you would still seem to fall towards an endless black pit.

But what is exactly inside a black hole? There are many **speculations** about it, but no decisive answers yet: as no light ever comes out, we can't see anything beyond the event horizon. Are black holes gateways to different places or even different universes? Is all their mass concentrated in a single point in space? Or are they just extreme astrophysical objects denser than neutron stars? All of these are open questions, as we still lack a unified model to describe the inside of black holes.

Nevertheless, it is possible to observe how gravity affects stars and gas around them, and this is how we know they do exist. There is notably a supermassive black hole at the center of our Milky Way, as in most other galaxies. It is named Sagittarius A* (to be pronounced *"Sagittarius A-star"*) and should weigh as much as four million suns. As in a whirlpool, stars orbit extremely fast around it, in an **irresistible** cosmic dance!

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