UPDATED FAQS   **BLACK HOLES**   hrs

[A lot of what follows was written using as references: *Gravitation*, by Charles Misner, Kip Thorne, and John Wheeler. i.e., MTW, and *The Elegant Universe*, by Brian Greene]

What are black holes?

A "black hole" is an unfortunate name for a region of space where gravity is so intense that light cannot escape (now that the name exists, we are stuck with it). Gravity intensity is related to density. For stars about twice as massive as our sun, the stuff making up the black hole must be squeezed inside a volume only a few miles across as viewed from a long distance away. Only a few processes (like a supernova explosion) are energetic enough to do this.

What would happen if I fell into a black hole?

First of all, you would be ripped apart by the difference in the strength of gravity between your feet and head long before you got to the hole. However, let's assume for a moment that you were able to survive the gravity effects. Looking up away from the hole, you see a distorted view of the universe. As you keep on moving into the hole, the world outside speeds up and turns brighter and bluer. You don't know when you pass the "edge" of the hole as seen from the outside world but it is sometime near when the universe seems to go off like a flashbulb. When you do pass the edge, you have only about 0.00001 seconds to live before you are crunched at the center (for a solar mass black hole).

What do people on the outside see?

Oddly enough, as viewed from far outside they don't see you pass the edge of the hole. They see you move toward it, turn redder, flatter, and then dimmer, whereupon it seems you freeze into place and finally get too dim to see.

Why don't they see you fall into the hole?

Because time passes at a much different rate in the hole compared to the outside. The edge of a hole, from our point of view, is an edge of the Universe. Like I said in another section, edges of the Universe are in time, not space.

What if I dropped a camera in the hole and had it radio me the view?

Won't work. Radio is similar to light.

What if I suspended a rope from a spaceship into the hole. Could I pull it out?

First of all, you can't really hang a rope into the hole. From your point of view it goes only to slightly above the hole's edge, gets compressed, very stubby and dim, and gets too dark to see. But if you were to tug it back, there would always be a place where the rope would be broken. The only rope you would get back would always be much shorter than it would have to be to have been at the edge of the hole. Gravity is so strong that this thing resembles a ball of super-glue!

Is there really much evidence for black holes?

For black holes of a few sun masses, evidence is thin. It's not that we think they're not there, just that they are so rare and they are so hard to tell from neutron stars. There are a few excellent cases in binary x-ray sources, however. There is a lot of evidence for gigantic black holes in the center of galaxies, where they form radio galaxies or quasars. Indeed, they may be the seeds around which galaxies form.

Will black holes eventually pull everything inside of them?

No. Outside of a black hole the gravity is normal. Once you get beyond the distance where tidal forces are strong, you wouldn't notice the difference between a black hole and an ordinary massive object.

Are the movie depictions of worm holes and black holes (i.e., tunnels and funnels) accurate?

No. The funnel analogy comes from what is called an "imbedding diagram," which does resemble a funnel. It is a fundamental property of curved coordinate systems that they can be rendered into a non-curved (called Euclidean) space in a higher number of dimensions. In this case, the distorted structure of spacetime has been redrawn as a surface in eight Euclidean dimensions, and then the less interesting dimensions have been suppressed. The resultant funnel is a plot that includes the geometric implications of the stretching of time. It is not meant to indicate the here-and-now structure of a hole. Any non- or slow-rotating hole would look from every side like a black cue ball (rotating ones are ellipsoidal). Stars and other objects behind it would peek out from behind the edge distorted as if their light had passed through a bad lens. Any matter falling into the hole would be stretched by angular momentum into a disk and speed up as it approaches the black hole; from a distance such accretion disks look a lot like a hurricane. In that sense, one sees something very like a drain at the center, but the hole itself doesn't appear like a funnel pointed one way or the other.

A wormhole is something else again. It is best understood by means of the Kruskal-Szekeres diagram (833 and following, MTW). These coordinates show that the black hole has, in theory, another side. This wormhole to elsewhere is called an Einstein-Rosen bridge (837 and following, MTW). The wormhole of a non-rotating black hole can be successfully threaded only by a photon that is started at just the right angle and time. All other photons and all heavy matter eventually encounters the "jaws" of the hole. In the Kerr-Newman metric for rotating, charged, black holes, the bridge region is expanded somewhat and is easier to aim at. However, there would be no *Star Trek: The Motion Picture* or *Contact*-like movement along a literal tunnel. Wormholes, if such things could be made at the macroscopic scale, would more resemble the fictional *Star Trek* transporter. First you are *here* and then, suddenly, you are *there*.

There must be an inverted hole on the other side. It is highly unlikely that such hole would open up just as you need it. There really isn't a mechanism that supports a macroscopic "white" hole. Wormholes are defined in a "multiply-connected universe." There is no evidence that our universe is multiply-connected on the large scale, but then again, there is no evidence that it is not.

All this is very exciting. It seems that these science-fictional concepts are real!

It is even more exciting than that. There are a set of theoretical physicists who are working right now on a theory of quantum gravity. They have found the most fruitful research direction in constructing a ten-dimensional universe, where six of the dimensions are rolled up into tiny twisted topological forms and all the different sub-atomic particles are different vibrational modes of something called a string in the twisted dimensions. The trouble is that they don't know all the particles or which of thousands of acceptable small-dimension forms to choose. Some of the mathematics needed to handle such problems has not even been invented yet. We are like people needing to invent calculus and we still use Roman numerals. Some of the suggested solutions allow our universe to be stretched like a membrane over other universes or distant folds of our own. I don't pretend to understand it, but it is a very exciting time in which hyperspace may be discovered to be a fact. However, whether we can use it for travel is unknown.