Black Holes

Activity #2: A Scale Model of a Black Hole

The radius of the event horizon of a black hole with the mass of the Sun would be about 3 kilometers, about the same size as your city, town or village. If the Earth could be compressed into a black hole, the radius of its event horizon would be 1/330,000 of this, because the mass of the Earth is 1/330,000 times the mass of the Sun. Have your students calculate the radius of its event horizon [about 1 centimeter] and suggest a common object which could be used to represent it in this full-sized model [a golf ball]. It can also be instructive to construct a scale model of the Cygnus X- 1 binary system, in order to appreciate the relative size of the normal star and the black hole. The scale of this model is 1 cm to 100,000 km.

Object	**Actual Diameter (kilometers)**	**Scale Diameter (centimeters)**
Blue supergiant HDE 226868	30,000,000	300
Accretion disk in Cygnus X-1	20,000,000	200
Bulge in accretion disk	700,000	7
X-Ray emitting region	20,000	0.2
Black hole event horizon	60	0.0006
Sun	1,400,000	14

On a larger scale in which the black hole is the size of a penny, the Sun would be the size of your schoolyard, and the blue supergiant HDE 226868 would be the size of a city.

Black hole myths

MYTH: All stars collapse to become black holes upon their death.
TRUTH: Only rare, massive stars (one in millions!) end up this way.

MYTH: A black hole in space would devour everything in our galaxy.
TRUTH: There is so much space between the stars that a black hole would not affect any objects except those very close to it.

MYTH: The black hole in the Cygnus X-1 system is devouring the blue supergiant.
TRUTH: Less than a thousandth of the mass of the blue supergiant will fall into the black hole before it too dies, a million or so years from now.

MYTH: Matter which falls into a black hole reappears somewhere else in the universe.
TRUTH: The matter remains in the black hole; in fact, it is the matter in a black hole which causes the gravitational force which allows us to discover these objects.

MYTH: The gravity of a black hole is different from the gravity of a normal object.
TRUTH: If the Sun were to suddenly turn into a black hole (which it won't, by the way, because its gravity is too weak for it to completely collapse in on itself, the Earth and planets would continue to move in the normal way. However, the Earth would have lost its source of heat and light!

MYTH: Black holes are very dense.
TRUTH: Small and medium black holes are very dense, but a supermassive black hole with a 100 million solar masses, for example would have a density the same as water. [You can work this out from the mass of the black hole and the radius of its event horizon; this assumes that all of the matter is distributed within the entire event horizon, not just in the singularity.]

For Further Reading About Black Holes

- *Black Holes,* an information packet prepared by the A.S.P., containing reprints of articles, and a reading list.
- Kaufmann, W.: *Black Holes and Warped Spacetime.* 1979, W.H. Freeman & Sons. A brief, non-technical overview.
- Parker, B.: "In and Around Black Holes'' in *Astronomy,* Oct. 1986, p. 6. A non-technical article describing the fascinating properties of black holes.
- Shipman, H.: *Black Holes, Quasars and the Universe,* 1980, Houghton Mifflin. A somewhat more advanced book, giving an excellent account of how modern astronomical research is done.
- Thorne, K.: "The Search for Black Holes'' in *Scientific American,* Dec. 1974, p 32. A superb, classic semi-technical article.

Science Fiction With Interesting and Accurate Treatment of Black Holes:

- Niven, L.: *A Hole in Space,* 1974 Ballantine
- Niven, L.: *Neutron Star,* 1968 Ballantine
- Pournelle, J.: *Anthology of Black Holes,* 1978 Fawcett