A Quick Introduction to Black Holes

By
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If one throws a ball straight up, it will rise to a certain height (determined by its initial velocity) and then it will fall back to earth. As the velocity at which the ball is thrown increases, the ball will rise higher and higher. If the velocity is sufficiently large, then ball will slow down as it rises but it will never stop rising. This velocity at which the ball continues to rise is called escape velocity and, for the earth, is about 27 thousand miles per hour. As the mass of an object increases (or its radius decreases), its escape velocity also increases. For the sun, escape velocity is about 1.5 MILLION miles per hour.

As the mass of an object keeps increasing (and/or the size keeps decreasing), one will finally find that the escape velocity for that object exceeds the speed of light (approximately 1 BILLION miles per hour). For objects with larger masses (or smaller radii), light itself cannot escape. These objects are called black holes since nothing (including light) can escape from them. If all of the mass of the sun were squeezed down into an object with a radius of less than 2 miles, then that mass would form a black hole. On the other hand, if the mass is that of a billion suns, then the size of the black hole would be around the size of Saturn's orbit.

Stellar mass black holes (i.e., those with masses up to around 10 times that of the sun) form when a large star (greater than about 8 solar masses) blows up in a supernova. This occurs when a star can no longer sustain thermonuclear reactions in its center (this was discussed in a previous version of this column). These thermonuclear reactions counterbalance gravity but when the chemistry of a star changes sufficiently so that the reactions cannot continue, gravity will take over and crush the large star into a black hole. Once a black hole is formed, it can continue to grow by absorbing matter that gets near it (e.g., clouds of gas, whole stars, or even other black holes). Very massive black holes are found near the center of several galaxies (including our Milky Way galaxy) and they have likely gotten as large as they have by this growth process.

Black holes cannot be seen in a normal sense. However, as dust and gas spirals around and falls into the black hole, it heats up considerably. And, as it gets hotter, it stars emitting radiation of differing frequencies. These hot clouds CAN be seen with different types of devices and this gives evidence of the black hole. One of the black holes nearest to the earth is found in the constellation Cygnus. Cygnus X-1 is a well-known X-ray source where a high mass star orbits a black hole at a distance that would lie inside the orbit of the planet Mercury. The gas from the star is being drawn off and into the black hole and emitting copious amounts of X-rays as is does so. While we can't show you a black hole at the observatory, we can show you the companion and show you where a black hole is located.

In addition to this short introduction, there is a lot of information available about black holes on the internet. Wikipedia has an extensive (and fairly deep) discussion. NASA has also put some easily approachable information on this topic and this can be found at:

http://hubblesite.org/explore_astronomy/black_holes/

Please join us at the Community Observatory, a gift of the Cameron Park Rotary Club, some weekend night this summer and let us show you all of the different conditions of stars that are currently visible. The docents will be happy to explain what you are seeing and discuss how and why the nebulae and clusters look the way they do.