**HUNTING FOR BLACK HOLES**

**Student’s activity guide**

**MATERIALS**

Part 1: Marbles (heavy and light weight), stretchy sheet, wash bowl, elastic string.

Part 2: Wooden skewer, small square cardboard (with drawing of orange spirals).

Part 3: Large cardboard, ball bearing, chalk.

Part 4: Wine glass, candle + plastic cup, paper plate, color tape.

**FULL ACTIVITY DESCRIPTION**

**Part 1: Black hole has powerful gravity**

1. Cover a stretchy sheet over a large round bowl. The surface of the sheet is like a small portion of space in 2 dimensions (remember that space is 3-dimensional and surrounds us everywhere in all directions).

2. Some black holes can be more massive than a billion Suns so use the heaviest marble to represent a black hole. Place the heavy marble on the sheet. Observe there’s a dip (curvature) due to the mass of the marble.

3. Roll a lighter marble on the sheet (instead of dropping it to fall straight to the medium marble). Do you see that the light marble moves toward the heavier one and rolls around it?

4. Remove everything. Now place the light marble in the center of the stretchy sheet. Compare the dip with that created by the heavy marble before.

5. Roll the heavy marble on the sheet. Observe the movement of the lighter marble with respect to the heavier one.

6. What causes the light marble to move and interact with the heavy marble?

→ Any object has mass can distort space like the marble does to the stretchy sheet, causing objects to be attracted to each other. So this effect is called **gravity, which is the bending of space.**

7. Which marble shows the strongest gravity? Relate this activity to explain why a black hole causes other objects to fall into it.

**Part 2: Observation of a fed black hole**

1. The center of the spiral is a black hole and the dots are infalling materials outside the event horizon of the black hole. Put a skewer through the center hole of the cardboard.
2. Spin the cardboard as fast as possible.
3. Observe the dots and the spirals as the board spins. Do you see that the spirals and the dots have formed into a brighter, more clearly seen disc of color? How do you relate this model to the accretion disc created by a black hole?

**Part 3: Observation of a resting black hole**

1. With the cardboard and ball bearing, locate the area of a hidden cluster of magnets within this cardboard.
2. Once you know where the magnet is, use chalk to trace the area that you feel magnet’s attraction.
3. Relate this activity with the effect of black hole on a nearby star. What is the magnet attraction presenting? What is the ball bearing presenting?
4. Because of black hole’s gravity, nearby stars (but not too close to the event horizon) are attracted to orbit around an apparently empty space, but in fact they are orbiting around a black hole. So, although resting black holes are invisible, the effect of their gravity on nearby stars allows their observation.

**Part 4: Gravitational lensing (15 min)**

1. Scientists can indirectly observe black hole as its gravity bends light. Use a tape and create a straight line on a table surface. This represents light, which travels straight in space.
2. Use a paper plate to represent the curvature of space. Partly remove and lift up one end of the tape and move the plastic plate (upside down) to where the tape was previously.
3. Put down the tape, pasting it onto the surface that is in its path (i.e. the plate and the table).
4. To paste the tape smoothly on the plate surface and on the table, it has to be bent and cannot be pasted in a straight line as before.
5. This is similar to how black hole bends light that passes nearby. The plate is like the curved space around the black hole (due to its gravity), so that light now travels on this curved space, appearing to be bent by the black hole’s gravity.
6. Light being bent by gravity is a phenomenon called gravitational lensing. You can see something similar to this phenomenon created by black hole by looking at a candle light through the base of a wine glass. Follow teacher’s instruction.
7. Observe the candle light that is distorted and form a ring or arc of light. The distorted images mimic the gravitational lensing phenomenon observed by telescope.

*Note: The glass base is not really creating gravity. It just represents the effect of something “invisible”, like a black hole, in front of the distant light source, distorting the path of the light before reaches us.*