Let's Make A Supernova!

Using balls, this activity illustrates what happens when a star explodes.

About the Activity

Participants imagine themselves inside a large star at the end of its life, just as it is about to go supernova. Learn what happens in the core of a star when it runs out of fuel. This is a very active, engaging activity that your audience will remember.

Topics Covered

Why supernovae happen and what happens when they do.

Materials Needed

- Tennis Balls
- Ping-pong balls
- Uncooked Salad Macaroni (Optional)

Location and Timing

This activity can be used indoors or outdoors, before a star party, in a classroom, or at a club meeting. It takes about 2 to 5 minutes. *Note: This must be done on a hard surface, like a bare floor or in a parking lot. Heavily carpeted floors or grass lawns don't work as well.*

Participants

Activities are appropriate for families with children over the age of 9, the general public, and school groups in ages 10 and up. Any number of visitors may participate.

Background Information

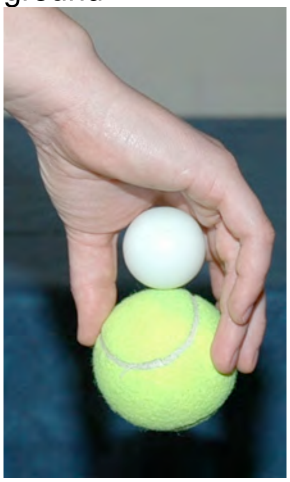
These websites explain the physics behind the "Let's Make a Supernova" activity with the tennis ball and ping-pong ball:
http://chandra.harvard.edu/edu/formal/demos/ejection.html
http://www.bu.edu/gk12/kelly/momentum%20demo.htm

Let's Make a Supernova!

Leader's Role	**Participants' Role (Anticipated)**
Materials: Tennis balls and ping-pong balls. *Optional:* Wooden spools (or uncooked salad macaroni) representing gamma-rays. Salad macaroni is preferred in this activity since you might lose the wooden gamma-ray models in an outdoor or cluttered environment. *NOTE:* This must be done on a hard surface, like a bare floor or in a parking lot. Heavily carpeted floors or grass lawns don't work as well.	
Objective: Allow visitors to understand what happens during a supernova**.**	
To do: Hand out one tennis ball and one ping-pong ball to each person. *To say:* Each of these large balls represents a small part of the core of the star – where all the fusion is taking place. The small ball represents the outer layers of the atmosphere of the star. Let's imagine we are all inside of a massive star, holding a part of the core [indicate the tennis ball] and a part of the outer layers [indicate the ping-pong ball]. *To do:* Start tossing one of the balls up in the air and catching it when it comes back down. *To say:* Everyone toss up one of the balls [this is easier with the tennis ball]. As long as you keep pushing a ball up, it will stay in the air. What happens if you stop pushing?  *To do:* Allow ball to drop.	Oh! These are hot! (tosses balls) It falls.

Leader's Role	Participants' Role (Anticipated)
To say: You are using energy to push the ball up. What's making the ball come back down? *To do:* Continue tossing. *To say:* Same kind of thing happens inside a star. The heat generated by fusion in the core creates pressure which pushes out on the rest of the star. What happens if the core stops generating heat? *To say:* Right! Let's imagine we're all standing inside of a massive star. In its core the star continues to fuse atoms into heavier and heavier elements – hydrogen to helium to carbon to silicon – generating lots of heat until we get to … iron. Because the fusion process stops at iron, the core stops generating heat. Then the core collapses under its own weight. And the outer layers start falling in and then . . . let's see what happens! Ready to make a supernova?	 Gravity! Gravity takes over. YEAH!

Group counting down, ready to drop the balls and "make a supernova."

<table>
<tr><th>Leader's Role</th><th>Participants' Role (Anticipated)</th></tr>
<tr><td>
<u>To do:</u>
Hold the small ball on top of large ball about 2 to 3 feet above the ground

One-handed hold
(Leave a little space between your hand and the ping-pong ball so it doesn't stick to your palm.)

Two-handed hold

<u>To say:</u>
Hold the parts of the star together – your part of the outer layers above your piece of the core [the small ball on top of the bigger ball]. I'll count down and we'll all let go of both balls at once and shout "SUPERNOVA!"
Ready? 3, 2, 1 …

<u>To do:</u>
Drop both balls at once.

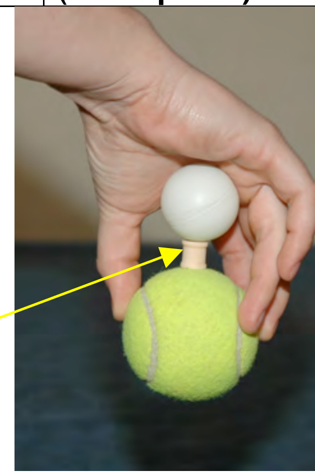
<u>To say:</u>
SUPERNOVA! What happened?

Yes! An explosive shock wave and the energy generated from the core collapse starts moving outward, heating the surrounding layers of the star, and BOOM. Most of the star is blasted into space in a supernova explosion.

Would you like to see stars in the sky that are likely to go supernova at the end of their lives?
</td><td>
SUPERNOVA!
Balls drop,

The ping-pong balls went flying.

YES!
</td></tr>
</table>

Leader's Role	Participants' Role (Anticipated)
Alternate Presentation: To include the idea of the gamma-rays (and other radiation) generated by the tremendous heat of the supernova explosion, place one of the short spools (or salad macaroni) representing a gamma-ray in between the tennis ball and the ping-pong ball, then let go of all three at once. **Spool representing gamma-ray**  The spools are in the "Models for Cosmic Radiation" bag. See the activity "Protecting Earth from Cosmic Radiation."	

Presentation Notes:

During core collapse, the core of the star (assuming that it is not massive enough to continue the collapse all the way to form a black hole) changes from a diameter of about 10,000 km (6,000 miles) to about 20 km (12 miles) – there is no longer any energy being generated to hold it up. Both the core and the outer layers of the star fall inward. During core collapse, the electrons and protons in the core of the star become so tightly packed that they interact to form neutrons (this is why, in this case, the remaining core of the star after the explosion is called a neutron star). Neutrinos are released from this process.

The core collapse stops when the neutrons can't be packed any more tightly. In this demonstration, the floor represents the point at which this happens. When the collapse stops, all the material falling in will bounce back out. There's a momentum transfer from the denser material of the core (represented by the tennis balls) to the lighter material of the outer layers (represented by the ping-pong balls).

After your visitors make the supernova once (or twice) you might also have them imagine everyone on earth doing it, to get across the idea that the explosion is spherical.

Actually, nature is a bit more complicated and the exact mechanism that causes the star to expel its outer layers violently is not completely understood. It is thought that some fraction of the copious neutrinos that are produced during core collapse are absorbed by the infalling outer layers, heating it and blasting the star's outer parts into space. The details of this mechanism are still uncertain however.

Leader's Role	Participants' Role (Anticipated)
To imagine the dimensions of the star and its core: The star has become a red supergiant star prior to going supernova. Imagine Betelgeuse, which is roughly 900 million km in diameter, shrunk down so it would fit in the Pacific Ocean. The diameter of this red supergiant compared to the size of its core (before collapse) is about 100,000 to 1. Betelgeuse's core would fit inside a football stadium. During core collapse, its core would shrink to be 500 times smaller. So its core would collapse from the size of a football stadium to about the size of a basketball. And then: SUPERNOVA!	

There go the outer layers of the star! The core collapse of the star stops when the neutrons can't be packed any more tightly. In this demonstration, the sidewalk represents the point at which this happens. When the collapse stopped (when the tennis balls hit the sidewalk), all the material falling in (the ping-pong balls) bounced back out. There's a momentum transfer from the denser material of the core (represented by the tennis balls) to the lighter material of the outer layers (represented by the ping-pong balls).