SN IN HIGH SCHOOLS Dec. 24, 2016 & Jan. 7, 2017

Making Waves

Wave Generation Activity: Student Guide

1. Fill a shallow clear tank about half full with water.
2. Listen to your teacher for instructions on how you should illuminate the water so that you are able to see ripples on its surface.
3. Add a small object that floats on the water or breaks the surface of the water.
4. Define spacetime. In what ways is this a good model for spacetime?
5. What aspects of spacetime does this system not model accurately?
6. Does a stationary object generate water ripples? Does a stationary black hole create gravitational waves?
7. Describe the waves produced by a sudden event, such as a marble dropping into the water or a star exploding in space.
8. If you have a cellphone, you might use it to record video of the waves and play back the video in slow motion.
9. How do ripples affect the relative positions of two corks or Ping-Pong balls floating on the water? Compare and contrast the affect from water waves with the affect from gravitational waves in spacetime.
10. Tape three pencils together side-by-side, such that the two outer pencils stick up by the same amount and higher than the pencil in the middle. Your pencil contraption should look like a two-pronged fork.
11. Hold your pencil contraption vertically so that the outer two pencils stick down into the water and the middle pencil is not in the water. Rotate the contraption so that the outer two pencils circle each other in the water, like an eggbeater or like the two orbiting black holes in the video. Find a method that gives good rotary motion while minimizing side-to-side motion in the water. (The two outer pencil "black holes" should just orbit each other, not drift off or jitter around.)
12. Describe the waves produced by the two outer pencil "black holes" as they orbit each other at various speeds.
13. If you have a tuning fork, bang the two prongs against a table edge, or hit them with a pencil. What do the two prongs do?
14. Bang the tuning fork's prongs and stick just the tips of the prongs in the water. Describe the waves produced.

15. Do the waves from one tuning fork prong interfere with the waves from the other prong?
16. How is that similar to or different from the interference between two light waves in a laser interferometer gravitational-wave detector?
17. Lay a ruler on the end of the water tank such that half the ruler sticks out over the water like a diving board or pirate plank. Now give the end of the ruler two "snake fangs" that stick down into the water. Two small binder clips work well, with both clipped to the end of the ruler and one metal arm of each binder clip sticking down into the water. Alternatively, you could bend two large regular paper clips and attach or tape them to the end of the ruler.
18. Hold the ruler on the edge of the water tank like a diving board, gently lift the end over the water with your finger (don't poke yourself with a paper clip), and let the ruler oscillate.
19. Describe the waves produced by the ruler with two "fangs."
20. Describe the waves produced by the ruler if it only has one "fang."
21. When the ruler has two fangs, do the waves from one fang interfere with the waves from the other fang?
22. What have you learned about gravitational waves from this experiment?
23. What have you learned about interferometers from this experiment?