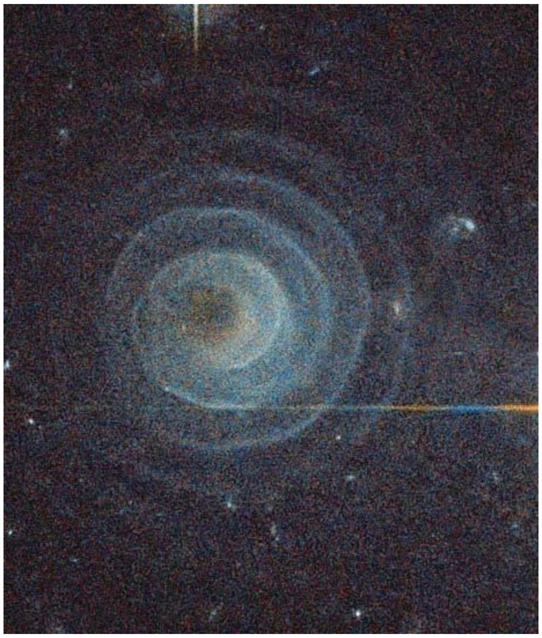
Courtesy Advanced Camera/ HST (2010)

This remarkable picture captures the formation of an unusual spiral nebula around the star LL Pegasi located 3,000 light years from the sun in the constellation of Pegasus (the Winged Horse). The spiral is made the same way that an 'arc' of water is produced by a revolving water sprinkler on your lawn.

The picture shows a thin spiral pattern winding around the star, which is itself hidden behind a cloud of thick dust at the center. The spiral is thought to arise because LL Pegasi is a binary system, with the star that is losing material and a companion star orbiting each other. The spacing between layers in the spiral is equal to the 800-year orbit period of the binary.

**Problem 1** – If the expansion speed is 50,000 km/hour, how far does the gas travel every year?

**Problem 2** - Draw a line from the center of the spiral to the edge of the picture in any direction. How far apart will the successive 'shells' of gas be along this axis?

**Problem 3** - Find a direction where the number of shells is a maximum. How many years did it take for the gas to reach the farthest shell you can see?

**Problem 4** - Suppose that the brightness of each shell decreases according to the function $B = 128\ N^{-3/2}$ where N is the shell number. If the sky has a brightness of B=2 in these units, what is the maximum number of shells that you could count in a picture?

**Problem 5** - About how long ago was the last detectable shell in Problem 4 emitted by the binary system?

**Problem 1** – If the expansion speed is 50,000 km/hour, how far does the gas travel every year?

Answer: 50,000 km/hour x (24 hours / 1 day) x (365 days / 1 year) = **438 million km**.

**Problem 2** - Draw a line from the center of the spiral to the edge of the picture in any direction. How far apart will the successive 'shells' of gas be along this axis?

Answer; the gas travels 438 million km/yr x 800 yrs = **350 billion kilometers**.

**Problem 3** - Find a direction where the number of shells is a maximum. How many years did it take for the gas to reach the farthest shell you can see?

Answer; If students count 6 shells, then 6 x 800 years = **4800 years**.

**Problem 4** - Suppose that the brightness of each shell decreases according to the function $B = 128\ N^{-3/2}$ where N is the shell number. If the sky has a brightness of B=2 in these units, what is the maximum number of shells that you could count in a picture?

Answer $N^{3/2} = 128/2$ so $N^{3/2} = 2^{6}$ and $N = (2^{6})^{2/3}$ so **N = 16**

**Problem 5** - About how long ago was the last detectable shell in Problem 4 emitted by the binary system?

Answer: 800 years x (16) = **12,800 years ago**!