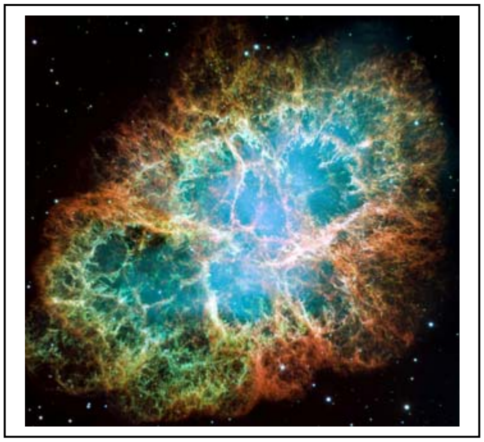
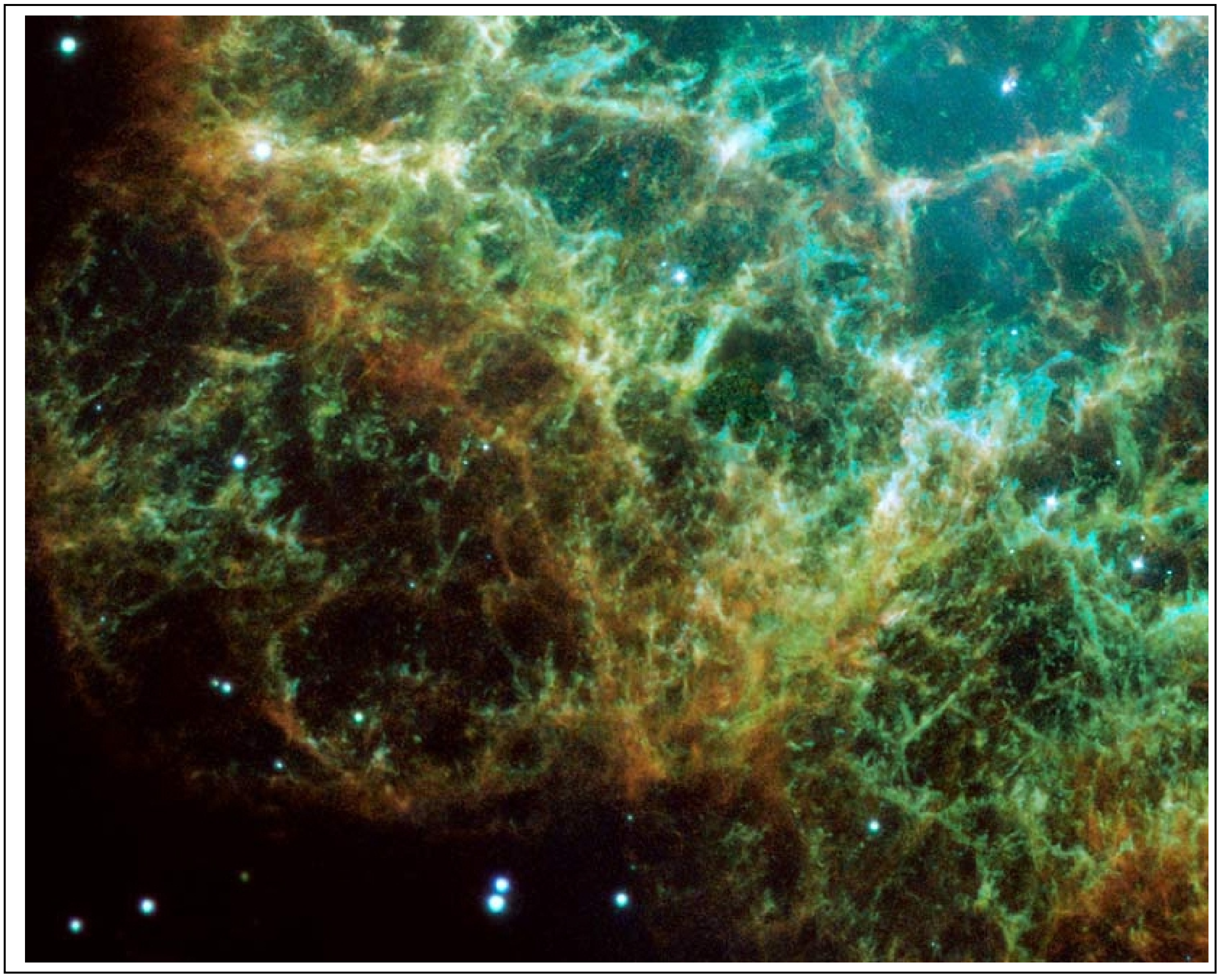
Details from an exploding star



These dramatic images of the Crab Nebula were taken in 2005 by the Hubble Space Telescope. The image on the left has a scale of 0.2 light years/millimeter. The enlargement below has a scale of 0.025 light years/millimeter.

The star that produced this nebula exploded as a supernova in the year 1054 AD, and the expanding gas has been traveling outwards ever since.



Problem 1 – From the information given, what is the average speed of the expanding gas cloud in kilometers/hour? (Note that 1 light year = 62,000 Astronomical Units, and 1 Astronomical Unit = 150 million kilometers, also 1 year = 8760 hours).

Problem 2 – How large are the smallest clumps of the gas in the expanding cloud?

Problem 3 – Draw a sketch, to scale, of the diameter of the solar system (80 Astronomical Units) compared to the size of two or three of the smallest gas clumps.

Answer Key

Problem 1 – From the information given, what is the average speed of the expanding gas cloud in kilometers/hour? (Note that 1 light year = 62,000 Astronomical Units, and 1 Astronomical Unit = 150 million kilometers, also 1 year = 8760 hours).

Answer: The fastest gas will have traveled the farthest distance in the picture, so we will measure the longest dimension of the nebula. From the upper image, the largest diameter of the nebula is about 66 millimeters, so the radius is 33 millimeters. At a scale of 0.2 light years/mm, this equals 33 x 0.2 = 6.5 light years. From the conversion information, this equals 6.5 x (62,000 AU/ly) x (150 million km/AU) = 60 trillion kilometers. The time taken to travel this distance is the number of years between 1054 and 2005, which is 951 years. This equals 951 years x (8760 hours/yr) = 8,331,000 hours. The speed average is then 60 trillion km/8,331,000 hours = 7,300,000 kilometers/hour.

Problem 2 – How large are the smallest clumps of the gas in the expanding cloud?
Answer: In the larger image, students will find filaments and condensations that are about 0.2 millimeters across, which corresponds to 0.2 x 0.025 light years/mm = 0.005 light years across. In terms of Astronomical Units, this equals 0.005 Light years x 62,000 AU/ly) = 310 AU.

Problem 3 – Draw a sketch, to scale, of the diameter of the solar system (80 Astronomical Units) compared to the size of two or three of the smallest gas clumps.
Answer: Creating a scaled image is a bit of a challenge. You want the scale to accommodate 1) enough resolution that you can comfortably draw the smallest object you want to represent, and 2) include a full rendition of the largest object you want to represent. For common 8.5 x 11-inch paper, a scale of 5 AU per millimeter would cover the entire solar system (Diameter of 16 millimeters) and a Crab nebula globule (Diameter of 310 AU = 62 millimeters). Students may color the image with a range of colors suggested by the Hubble photo and include several globules and filaments of the proper scale in the field.