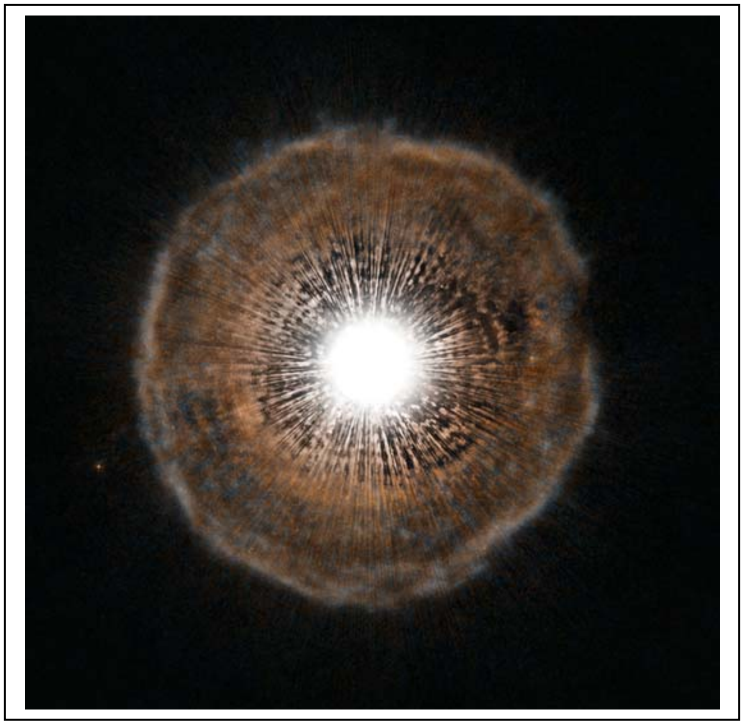
The Expanding Gas Shell of U Camelopardalis



This dramatic image, taken by the Hubble Space Telescope, reveals details in the shell of gas ejected by the star thousands of years ago.

Located 1,400 light years from our sun, the shell is expanding at a speed of about 25 km/sec, and its outer edge is about 500 billion km from the central star (greatly overexposed in this image).

Although it looks impressive, the amount of mass in this shell is actually quite small. It is only about 1/10 the mass of our own Earth!

Problem 1 – The radius of the shell is 500 billion km, and the estimated expansion speed is about 25 km/sec. How many years did it take for the expanding shell to reach its current size if 1 year = 31 million seconds?

Problem 2 - The mass of Earth is 6.0×10^{24} kilograms. The mass of a hydrogen atom is 1.6×10^{-27} kilograms. If the entire mass of the shell were evenly spread throughout a sphere with a radius of 500 billion km, how many hydrogen atoms would you expect to find in a cubic meter of this shell?

Problem 1 – The radius of the shell is 500 billion km, and the estimated expansion speed is about 25 km/sec. How many years did it take for the expanding shell to reach its current size if 1 year = 31 million seconds?

Answer: Time = distance/speed so
Time = 500 billion km/25 km
= 20 billion seconds.

Since 1 year = 31 million seconds,
Time = 20 billion x (1 year / 31 million)
= **645 years**.

Problem 2 = The mass of Earth is 6.0 x 10^{24} kilograms. The mass of a hydrogen atom is 1.6 x 10^{-27} kilograms. If the entire mass of the shell were evenly spread throughout a sphere with a radius of 500 billion km, how many hydrogen atoms would you expect to find in a cubic meter of this shell?

Answer: Convert lengths into meters. 5.0×10^{11} km x 1000 meters/1 km = 5.0×10^{14} meters.

Volume = 4/3 π R^3 so V = 1.333 x 3.141 x $(5.0\times10^{14})^3$ and so V = 5.2×10^{44} $meters^3$

The mass of the shell is **1/10 that of Earth** so M = 0.1 x 6.0×10^{24} kg = 6.0×10^{23} kg.

Density = mass/volume, so
D = 6.0×10^{23} kg / 5.2 x 10^{44} $meters^3$, and so
D = 1.1×10^{-21} kg/m^3

Since 1 proton = 2.0×10^{-27} kg, the number of protons in 1 cubic meter of the nebula is
N = 1.1×10^{-21} x (1 atom/2.0×10^{-27}) = 576,923 atoms, or rounded to 2 significant figures, **580,000 atoms**.