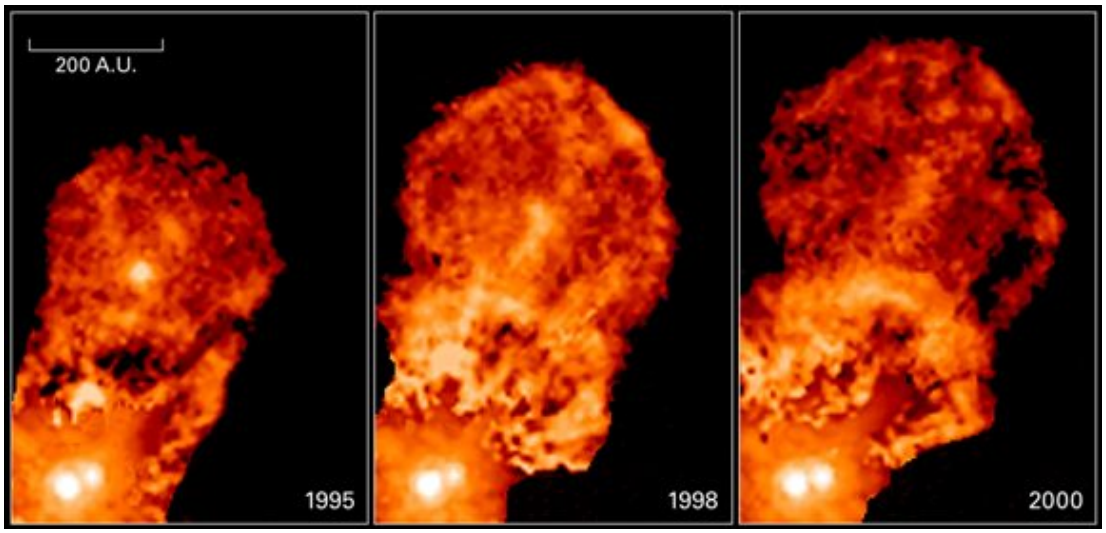
XZ Tauri and the Super CME!



These pictures were taken by the Hubble Space Telescope between 1995 and 2000. They show a time sequence that captures the explosion of matter from the star XZ Tauri in the constellation Taurus. The star is located 450 light years from the sun. This star is less than one million years old, and is probably similar to what our own sun was like at the same age.

Today, our sun still ejects gas in events called Coronal Mass Ejections (CMEs) but involve far less matter ejected into space.

Problem 1 - Using a millimeter ruler, and the fact that 1 A.U. = 147 million kilometers what is the scale of these images in kilometers per millimeter?

Problem 2 - A) How many millimeters did the XZ Tauri cloud travel between 1995 and 2000? B) How many kilometers did it travel?

Problem 3 - What was the average speed of the cloud between 1995 - 2000 in; A) kilometers per day; B) kilometers per hour? C) kilometers per second?

Extra for Experts:

Problem 4 - The estimated total mass of this 'round' cloud was 1.1×10^{25} grams. Assuming it filled a spherical volume with a volume $V = 4/3\ \pi\ R^3$ A) What was the volume of this cloud in 1998 in cubic centimeters? B) What was the density of this cloud in grams per cubic centimeter? C) If one hydrogen atom has a mass of 1.6×10^{-24} grams, how many hydrogen atoms per cubic centimeter were present in the star's interplanetary space?

Answer Key:

Problem 1 - Using a millimeter ruler, and the fact that 1 A.U. = 147 million kilometers what is the scale of these images in kilometers per millimeter?

Answer - The 200 AU image scale is 17.5 millimeters long. 200 AU = 200 x 147 million kilometers, so the scale is 200 x 147 million km/17.5 mm = 1,680 million km/mm

Problem 2 - A) How many millimeters did the XZ Tauri cloud travel between 1995 and 2000? B) How many kilometers did it travel?

Answer A) Depending on how you measure, the cloud traveled about 12 millimeters. B) 12 millimeters x 1,680 million km/mm = 20,160 million kilometers.

Problem 3 - What was the average speed of the cloud between 1995 - 2000 in; A) kilometers per day; B) kilometers per hour? C) kilometers per second?

Answer: A) 2000-1995=Five years = 365 x 5 = 1825 days, so it traveled 20,160 million km/1825 days = 11.0 million km/day. B) 11.0 million km / 24 hours = 458,000 km/hour. C) 458,000 km/3600 seconds = 127 kilometers/second.

Extra for Experts:

Problem 4 - The estimated total mass of this 'round' cloud was 1.1×10^{25} grams. Assuming it filled a spherical volume

A) What was the volume of this cloud in 1998 in cubic centimeters?

Answer - The diameter of the cloud in the middle image is 38 mm or 38 x 1,680 million km = 63,840 million km. The radius is 31,920 million km. This equals a radius of $31,920 \times 10^{6}$ km x 1.0×10^{5} cm/km = 3.2×10^{15} cm. The volume of a sphere is $V = 4/3\ \pi\ R^{3}$, so the volume of the cloud is $4/3\ \pi\ (3.2 \times 10^{15}\ \text{cm})^{3} = 1.4 \times 10^{47}$ cubic centimeters.

B) What was the density of this cloud in grams per cubic centimeter?
Answer: Density = Mass / volume = 1.1×10^{25} grams / 1.4×10^{47} cubic centimeters = 7.8×10^{-23} grams/cc

C) If one hydrogen atom has a mass of 1.6×10^{-24} grams, how many hydrogen atoms per cubic centimeter were present in the star's interplanetary space?
Answer = 7.8×10^{-23} grams/cc / (1.6×10^{-24} grams) = 50 hydrogen atoms/cc.