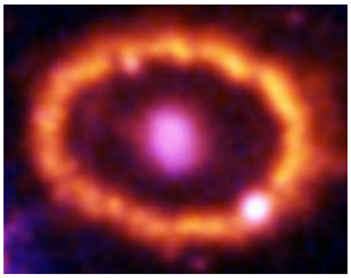
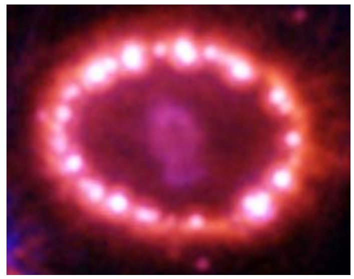
Objects in space move. To figure out how fast they move, astronomers use many different techniques depending on what they are investigating. In this activity, you will measure the speed of astronomical phenomena using the scaling clues and the time intervals between photographs of three phenomena: A supernova explosion, a coronal mass ejection, and a solar flare shock wave.



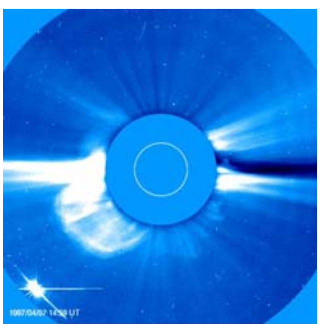


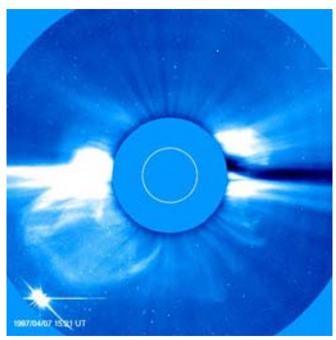
Measure the change in longest dimension of the inner blob of light. The outer ring is about one light-year in diameter. The left-hand image was taken by the Hubble Space Telescope in March, 1995. The right-hand image was taken in November, 2003. Note 1 light-year = 9.2 trillion km.

Problem 1: Supernova 1987A was photographed 7.7 years apart to study its expanding shell of gas. What is the speed of this material shown in the photographs in:

A) light-years per year?
B) kilometers per second?

For more information, visit: http://hubblesite.org/newscenter/newsdesk/archive/releases/2004/



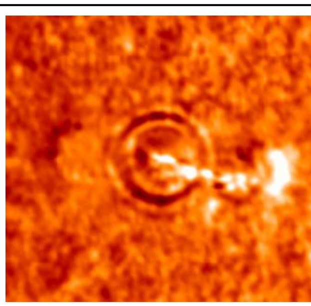


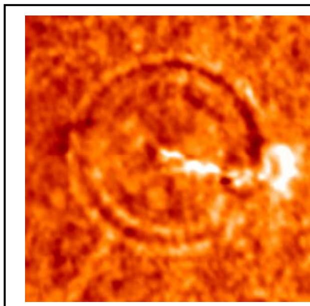
The white circle is the diameter of the sun (1.4 million km). Images taken at 14:59 UT (left) and 15:21 UT (right).

Problem 2: Closer to Earth, solar storms provide another example of violent motion. How fast did this coronal mass ejection travel in:

A) kilometers per second?
B) kilometers per day?

CME observed by the SOHO satellite on April 7, 1997.





Each picture is 150 million meters on a side. The difference in time between the images is one hour.

Problem 3 – A solar flare on July 9, 1996 caused a phenomenon called a Morton Wave to travel across the sun's surface. What was its speed in:

A) kilometers per hour?
B) kilometers per second?

More information: http://www.solarviews.com/eng/sohopr3.htm

Problem 1: Supernova 1987A was photographed 7.7 years apart to study its expanding shell of gas. What is the speed of this material shown in the photographs in: A) light-years (LY) per year? B) kilometers per second?

Answer: Using a millimeter ruler and the stated size of the image, the scale is about 30mm = 1 LY. The central 'blob' which is the supernova shell has an initial diameter of 5mm and a final largest diameter of 10mm, so its **radius** has increased by 2.5mm which equals (2.5mm/30mm)x 1LY = 0.085 LY. The difference in time between the images is 7.7 years so A) 0.085 LY/7.7 yrs = 0.010 Light-years/year, and for 3.1 x 10^7 seconds in a year, B) 9.2 x 10^{12} x 0.010/3.1x 10^7 = 3,100 km/sec.

Problem 2: Closer to Earth, solar storms provide another example of violent motion. How fast did this coronal mass ejection travel in: A) kilometers per second? B) kilometers per day?

Answer: The scale of the prints is about 7 mm = 1.4 million km. If you measure the distance from the center of the sun circle to the outer edge of the CME in the lower left corner of each picture, you get about 13.5 mm and 19 mm respectively. This equals a **change** in distance of (5.5mm/7mm) x 1.4 million km = 1.1 million km. The difference in time between the two images is 22 minutes or 1320 seconds, so A) the speed is about 1.1 million km/1320 sec = 833 km/sec. There are 24x60x60 = 86400 seconds in a day, so B) is about 833 x 86400 = 72 million km/day.

Problem 3 – A solar flare on July 9, 1996 caused a phenomenon called a Morton Wave to travel across the sun's surface. What was its speed in: A) kilometers per second? B) kilometers per hour?

Answer: The image scale is 37 mm = 150 million meters. The circles represent the shock wave, and the outer ring radius has increased from 7mm to 12mm in one hour. This is a distance change of (5mm/37mm)x 150 million meters = 20 million meters or 20,000 kilometers. A) 20,000 kilometers/hour. B) There are 3600 seconds in an hour so 20,000/3600 = 5.6 km/sec.