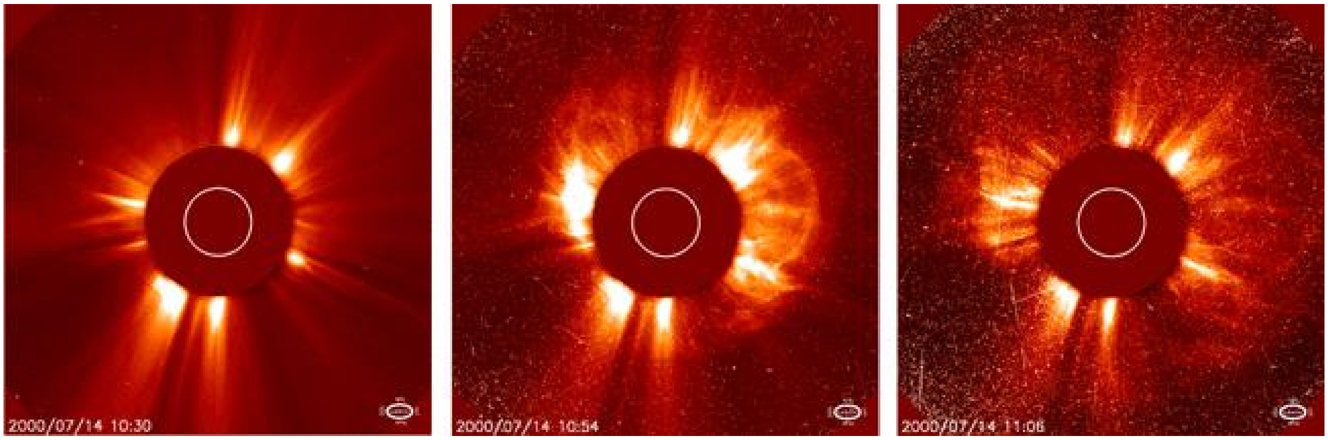
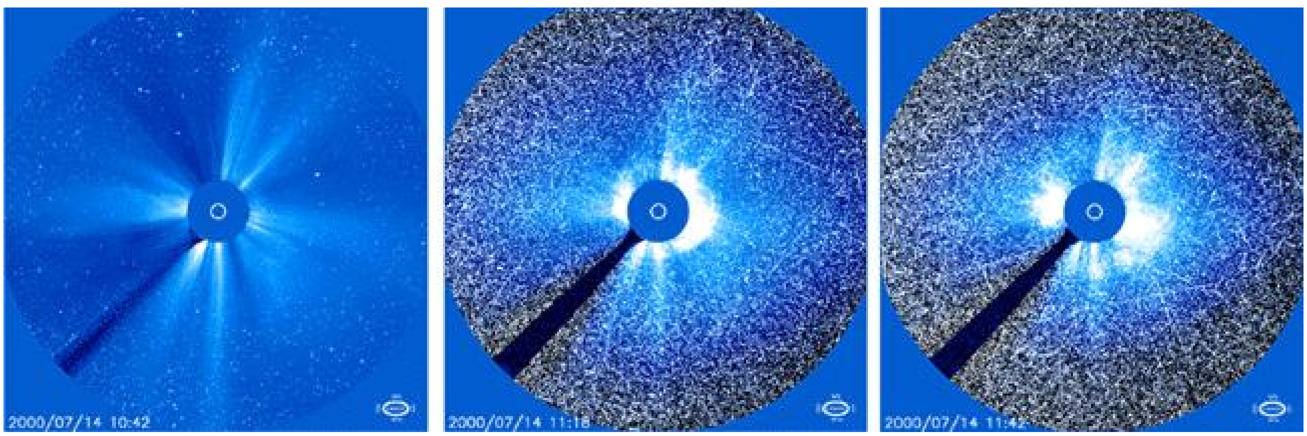
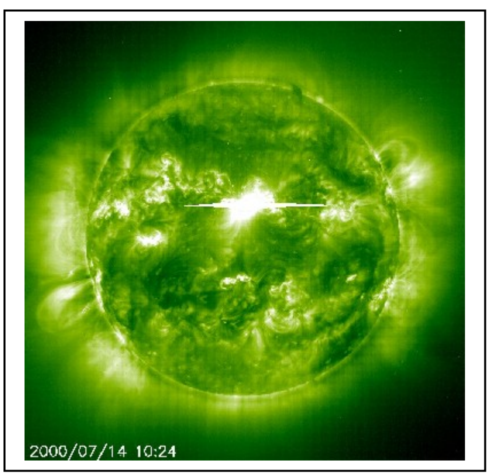
Data Corruption by High-Energy Particles







Solar flares can severely affect sensitive instruments in space and corrupt the data that they produce. On July 14, 2000 the sun produced a powerful X-class flare, which was captured by instruments onboard the Solar and Heliospheric Observatory (SOHO). The EIT imager operating at a wavelength of 195 Angstroms, showed a brilliant flash of light (left image). When these particles arrived at the SOHO satellite some time later, they caused the imaging equipment to develop 'snow' as the individual particles streaked through the sensitive electronic equipment. The above images taken by the SOHO LASCO c2 and c3 imagers show what happened to that instrument when this shower of particles arrived. The date and time information (hr : min) is given in the lower left corner of each image, and give the approximate times of the events.

Problem 1: At about what time did the solar flare first erupt on the sun?
Problem 2: At about what time did the LASCO imagers begin to show significant signs of the particles having arrived?
Problem 3: If the SOHO satellite was located 147 million kilometers from the sun, about what was the speed of the arriving particles?
Problem 4: If the speed of light is 300,000 km/sec, what percentage of light-speed were the particles traveling?

Answer Key:

Problem 1: At about what time did the solar flare first erupt on the sun?

Answer: The EIT image time says 10:24 or 10 hours and 24 minutes Universal Time The reason this is not an exact time is because the images were taken at set times, and not at the exact times of the start or end of the events. To within the 24-minute interval between successive EIT images, we will assume that 10:24 UT is the closest time.

Problem 2: At about what time did the LASCO imagers begin to show significant signs of the particles having arrived?

Answer: The top sequence shows that the 'snow began to fall' at 10:54 UT. The second sequence suggests a later time near 11:18. However, the 11:18 time is later than the 10:54 time. The time interval between exposures is 24 minutes, but the top series started at 10:30 and ended at 10:54 UT, while the lower series started at 10:42 and ended at 11:18. That means, comparing the exposures between the two series, the snow arrived between 10:42 and 10:54 UT. We can split the difference and assume that the snow began around 10:48 UT.

Problem 3: If the SOHO satellite was located 147 million kilometers from the sun, about what was the speed of the arriving particles?

Answer: The elapsed time between the sighting of the flare by EIT (10:24 UT) and the beginning of the snow seen by LASCO (10:48 UT) is 10:48 UT – 10:24 UT = 24 minutes. The speed of the particles was about 147 million km/24 minutes or 6.1 million km/minute.

Problem 4: If the speed of light is 300,000 km/sec, what percentage of light-speed were the particles traveling?

Answer: Converting 6.1 million km/minute into km/sec we get 6,100,000 km/sec x (1 min /60 sec) or 102,000 kilometers/sec. Comparing this to the speed of light we see that the particles traveled at (102,000/300,000)x100% = 34% the speed of light!

Note: Because these damaging high-speed particles can arrive only a half-hour after the x-ray flash is first seen on the sun, it can be very difficult to protect sensitive equipment from these storms of particles if you wait for the first sighting of the solar flare flash. In some cases, science research satellites have actually been permanently damaged by these particle storms.