



On July 15, 2001 a solar storm was tracked from the Sun to Earth by a number of research satellites and observatories. This activity lets you perform time and day arithmetic to figure out how long various events lasted. This is a very basic process that scientists go through to study an astronomical phenomenon. The image to the left was taken by the TRACE satellite and shows the x-ray flare on the Sun. The 'slinky' shape is caused by magnetic fields.

Photo courtesy SOHO/NASA

The Story: On July 14, 2000, NASA's TRACE satellite spotted a major X5.7-class solar flare erupting at 09:41 from Active Region 9077. The flare continued to release energy until 12:31. At 10:18:27, radio astronomers using the Nancay radio telescope detected the start of a radio-frequency Type-I noise storm. This storm strengthened, and at 10:27:27, four moving radio sources appeared. Meanwhile, the satellite, GOES-10 detected the maximum of the x-ray light from this flare at 10:23. The SOHO satellite, located 92 million miles from the Sun, and 1 million miles from Earth, recorded a radiation storm from fast-moving particles, that caused data corruption at 10:41. The SOHO satellite's LASCO imager also detected the launch of a coronal mass ejection (CME) at 10:54. The CME arrived at the satellite at 14:17 on July 15. Then at 14:37 on July 15, the CME shock wave arrived at Earth and compressed Earth's magnetic field. The IMAGE satellite recorded the brightening of the auroral oval starting at 14:25. Aurora were at their brightest at 14:58. The aurora expanded to the lowest latitude at 17:35. By 20:00, Earth's magnetic field has slightly decreased in strength in the equatorial regions. By 16:47 on July 16, the IMAGE satellite recorded the recovery of Earth's magnetosphere to normal conditions. On January 12, 2001, the CME was detected by the Voyager I satellite located 63 AU from the Sun.

Problem 1 - From this information, create a time line of the events mentioned.

Problem 2 – How long did it take for the CME to reach Earth?

Inquiry: What other questions can you explore using this timing information?

Problem 1

July 14,

- 09:41 - X5.7-class solar flare
- 10:19 - Radio astronomers detect Type-I radio storm.
- 10:23 - GOES-10 detected the maximum of the x-ray light from this flare
- 10:27 - Four moving radio sources appeared on sun.
- 10:41 - SOHO satellite radiation storm and data corruption.
- 10:54 - SOHO sees launch of CME

July 15,

- 14:17 - CME shock wave arrived at Earth
- 14:25 - IMAGE satellite sees brightening of the auroral oval
- 14:58 - Aurora at brightest
- 17:35 - Aurora expand to lowest latitudes
- 20:00 - Earth's magnetic field has slightly decreased in strength

July 16

- 16:47 - IMAGE satellite recorded the recovery of Earth's magnetosphere

January 12, 2001, CME detected by Voyager I satellite 63 AU from the Sun.

Problem 2 - The CME was launched on July 14 at 10:54 and arrived at Earth on July 15 at 14:17. The elapsed time is 1 full day (24 hours) and the difference between 10:54 and 14:17 which is $14:17 - 10:54 = 13:77 - 10:54 = 3\text{hours and } 77-54 = 23\text{ minutes}$. The total elapsed time is then $24\text{h} + 3\text{h } 23\text{m} = 27\text{hours } 23\text{minutes}$.

Inquiry – There are many possibilities, for example, how long did it take for the CME to reach Voyager in days? Hours? What was the speed of the CME as it traveled to Earth? How long after the flare did SOHO experience a radiation storm?