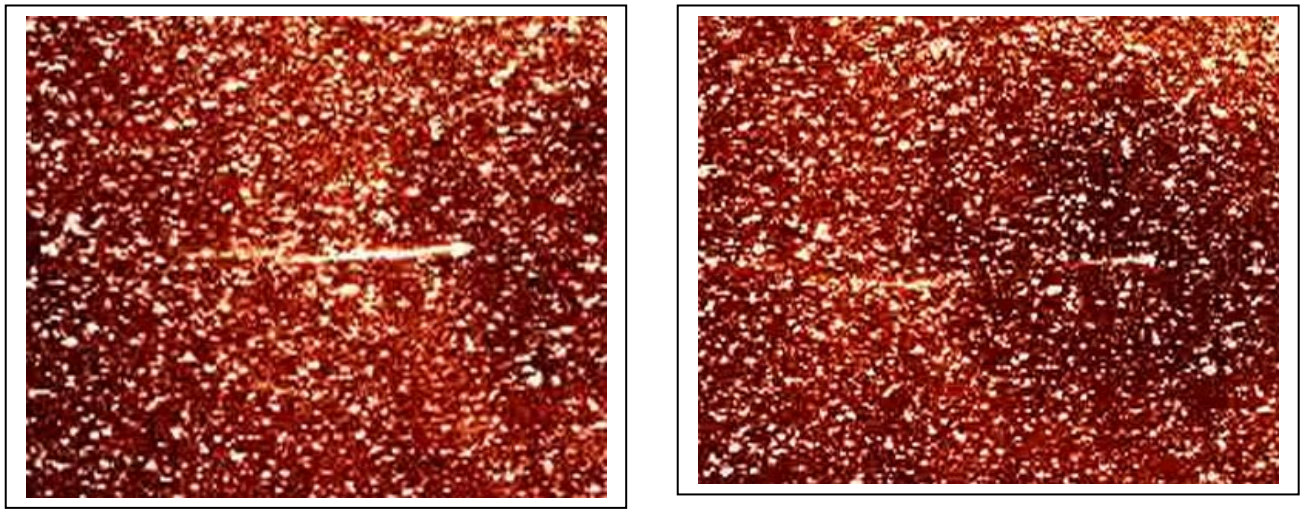
The Comet Encke Tail Disruption Event

On April 20, 2007, NASA's STEREO satellite witnessed a rare solar system event. The Comet Encke had just passed inside the orbit of Venus and was at a distance of 114 million kilometers from STEREO-A ,when a Coronal Mass Ejection occurred on the sun. The cloud of magnetized gas passed over the comet's tail at 18:50 UT, and moments later caused the tail of the comet to break into two. The two images below show two images from the tail breakup sequence. The left image was taken at 18:10 UT and the right image was taken at 20:50 UT. At the distance of the comet, each image subtends an angular size of 6.4 degrees x 5.3 degrees. For comparison, the Full Moon would correspond to a circle with a diameter of 0.5 degrees.



Problem 1 - What is the scale of the images in arcminutes per millimeter? (1 degree=60 arcminutes)

Problem 2 - How many seconds elapsed between the time the two images were taken by the STEREO-A satellite?

Problem 3 - The left image shows the comet with an intact tail. The right image shows the tail separated from the head of the comet (the right-most bright feature along the comets horizontal axis which we will call Point A), and flowing to the left. Meanwhile, you can see that the comet has already begun to reform a new tail. Carefully examine the right-hand image and identify the right-most end of the ejected tail (Call it Point B). Note that star images do not move, and are more nearly point-like than the tail gases. How far, in millimeters, is Point B from Point A?

Problem 4 - From the image scale, convert your answer to Problem 3 into arcminutes.

Problem 5 - The distance of the comet was 114 million kilometers, and at that distance, one arcminute of angular separation corresponds to 33,000 kilometers. How far did the tail fragment travel between the times of the two images?

Problem 6 - What was the speed of the tail fragment?

Problem 7 - If the comet's speed was about 40 km/sec and the CME speed was at least several hundred times faster, based on your answer to Problem 6, was the comet fragment 'left behind' or did the CME carry it off?

Answer Key:

Problem 1 - What is the scale of the images in arcminutes per millimeter? (1 degree=60 arcminutes)

Answer: horizontally, the image span 6.4 degrees x 60 minutes/degree = 384 arcminutes. The length is 77 millimeters, so the scale is 384/77 = **5.0 arcminutes/mm**

Problem 2 - How many seconds elapsed between the time the two images were taken by the STEREO-A satellite?

Answer: 20:50 - 18:10 = 2 hours and 40 minutes = 160 minutes or **9600 seconds.**

Problem 3 - The left image shows the comet with an intact tail. The right image shows the tail separated from the head of the comet (the right-most bright feature along the comets horizontal axis which we will call Point A), and flowing to the left. Meanwhile, you can see that the comet has already begun to reform a new tail. Carefully examine the right-hand image and identify the right-most end of the ejected tail (Call it Point B). Note that star images do not move, and are more nearly point-like than the tail gases. How far, in millimeters, is Point B from Point A?

Answer: An answer near **17 millimeters** is acceptable, but students may measure from 15 to 20 millimeters as reasonable answers.

Problem 4 - From the image scale, convert your answer to Problem 3 into arcminutes.

Answer: 17 millimeters x 5 arcminutes/mm = **85 arcminutes**.

Problem 5 - The distance of the comet was 114 million kilometers, and at that distance, one arcminute of angular separation corresponds to 33,000 kilometers. How far did the tail fragment travel between the times of the two images?

Answer: 85 arcminutes x 33,000 kilometers/arcminute = **2.8 million kilometers.**

Problem 6 - What was the speed of the tail fragment?

Answer: 2.8 million kilometers/9600 seconds = **292 kilometers/second.**

Problem 7 - If the comet's speed was about 40 km/sec and the CME speed was at least several hundred times faster, based on your answer to Problem 6, was the comet fragment 'left behind' or did the CME carry it off?
Answer: The speed in Problem 6 is much closer to the CME speed than the comet speed, so the fragment was carried off by the CME and not ejected by the comet.

This collision was studied in detail by Dr. Angelos Vourlidas and his colleagues at the Naval Research laboratory in Washington, D.C and the Rutherford Laboratory in England. They deduced from a more careful analysis that the CME speed was about 500 km/sec and the solar wind speed was about 420 km/sec. The tail fragment was carried off by the CME. Details can be found in The Astrophysical Journal (Letters), vol. 668, pp L79-L82 which was published on October 10, 2007. A movie of the encounter may be seen at the STEREO web site (http://stereo.gsfc.nasa.gov) in their movie gallery.