SOLAR BLAST

Scientists attempt to track an ejected piece of the sun.

By JONATHAN EBERHART

Scientists participating in a complex experiment involving two aging satellites have barely two months to carry off an unprecedented study of a coronal mass ejection — a hot, gaseous blob of plasma shot out by the sun. If their plans work, the Earth-orbiting Solar Maximum Mission satellite will spot such an ejection rushing away from the sun. Two or three days and 93 million miles later, the solar-orbiting International Sun-Earth Explorer (ISEE-3) will take measurements of the same blob.

In fact, it may already have happened. Solar Max photographed a blob on March 18; two days later ISEE-3's magnetometer detected a pronounced shock-wave possibly associated with a CME or a solar flare. The sun was producing record amounts of X-rays and flares at the time (SN: 4/8/89, p.212). But Edward J. Smith and Daniel Winterhalter of NASA's Jet Propulsion Laboratory in Pasadena, Calif., note that ISEE-3's magnetometer should be able to distinguish between the magnetic characteristics of a solar flare and those of a passing CME. Another clue may lie in the passing phenomenon's density and composition. The analysis will take time, says Keith Ogilvie of the NASA Goddard Space Flight Center in Greenbelt, Md., but unless another suitable ejection happens soon, the March ISEE-3 observation may end up as the only one of its kind linked with a specific CME.

If it is not a CME at all, the effort's success will depend on whether the "Solar Max" satellite avoids its anticipated fiery plunge toward Earth long enough to do its part. Even now, a group of scientists is about to publish results of the "CME Onset Program," describing in detail the varied blobs seen by Solar Max from September 1985 to December 1987.

Coronal mass ejections, or CMEs, come in different sizes and leave the sun at widely different speeds. They range in mass from about 10 billion to 100 billion tons and explode from the sun's corona at speeds of 22,000 to more than 2 million mph, according to researchers on the project.

The onset program, headed by Richard A. Harrison of the Rutherford Appleton Laboratory in Didcot, England, covered 16 CMEs photographed with Solar Max's coronagraph and monitored with its X-ray polychromator. Those blobs traveled at speeds from 100,000 to nearly 1.8 million mph, and coronagraph pictures reveal that their widths varied in solar latitude from 9° to 95°.

Yet major questions remain unanswered. The researchers conclude, for example, that many if not all CME "launches" are accompanied by significant X-ray emissions from the sun, but their study provides more statistics than answers. The CMEs studied appeared before the first brightening associated with X-ray events in eight of 13 cases, and before the X-ray intensity reached its maximum rate of increase in nine of 13.

Once they leave the sun, their behavior becomes even more mysterious. "The 'signature' of CMEs in the interplanetary medium is entirely unknown," says David G. Sime of the National Center for Atmospheric Research (NCAR) in Boulder, Colo., referring to how a CME's journey through space affects its temperature, magnetic field, density and composition. In fact, Sime adds, identifying a CME's "interplanetary signature" is the planned experiment's central goal.

What drives the blobs out from the sun in the first place? Although the mechanisms remain unknown, Sime says, "the initial theories which suggested that CMEs were the coronal response to impulsive events such as flares now appear to be wrong." Instead, he says, the relative timing, sizes and locations on the sun of CMEs and solar flares suggest the blobs "cannot be in response to flares, but rather precede them."

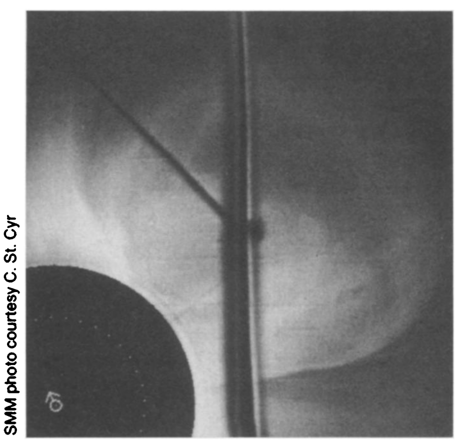
Arthur J. Hundhausen of NCAR and others suggest a flare is the release of energy from a spatially small magnetic-field disturbance, while a CME is the release of energy from a large-scale disturbance. According to Christopher St. Cyr of NASA Goddard, this idea represents "a real revelation in turning around all the flare physicists."

The International Sun-Earth Explorer, due to be immersed in one of the blobs, is a small satellite perhaps best known for being the first human-made object to fly through the tail of a comet (SN: 9/21/85, p.180). It is now stationed off the west limb of the sun, about the same distance out as the Earth. A passing blob is unlikely to incinerate the satellite. Although CMEs leave the sun with temperatures of tens of thousands to millions of degrees centigrade, they spread out as they travel, becoming so diffuse they probably wouldn't warm your spacesuit if you went spacewalking in their way. By the time a typical CME moves into the view of the coronagraph (an "occulting disk" blocks out most of the sun itself), it may have expanded to several times the nearly 900,000-mile radius of the sun itself, Sime says.

To repeat the experiment, however, time is short. The sun is now approaching the most active part of its 11-year cycle, when its ultraviolet radiation causes Earth's atmosphere to heat and expand. NASA officials expect the increased atmospheric drag on Solar Max to make the craft uncontrollable by early August and doom it to a fiery reentry a few months later.

ISEE-3 poses difficulties of another kind. For one, it has no camera; its specialties are measuring ions, neutral atoms and magnetic fields. More to the point, it lacks a tape recorder, so its data are available only when they can be received "live" by the ground stations of NASA's Deep Space Network. And even if Solar Max is still working in August, the stations probably won't be available for ISEE-3, since they will be busy with Voyager 2's Aug. 24 flight past Neptune.

The experiment is supposed to begin when Solar Max's coronagraph takes two or more photos of a single CME. This enables St. Cyr to estimate its speed and its arrival time at ISEE-3. He passes this information on to the ISEE-3 team (both satellites are controlled from Goddard), which in turn calls the Deep Space Network to ask whether tracking can be available when the blob reaches ISEE-3 — on as little as two days' notice. □



SMM photo courtesy C. St. Cyr

Solar Max photographed this blob leaving the sun's corona at about 700,000 m.p.h. on March 18, heading toward ISEE-3.