Solar Storm Propagation from Sun to Earth: A General Picture Revealed

True beauty lies in the sky or in space scientists' eyes, in the vast and mysterious space with its order, extent and darkness. They explode with immense power in the solar atmosphere and are hurled out from the Sun at millions of kilometers per hour. They light up brilliant auroras in the mid-latitude skies upon impacting the Earth. Breathtakingly beautiful and yet catastrophically dangerous, they bear a name unfamiliar to the public: coronal mass ejections (CMEs).

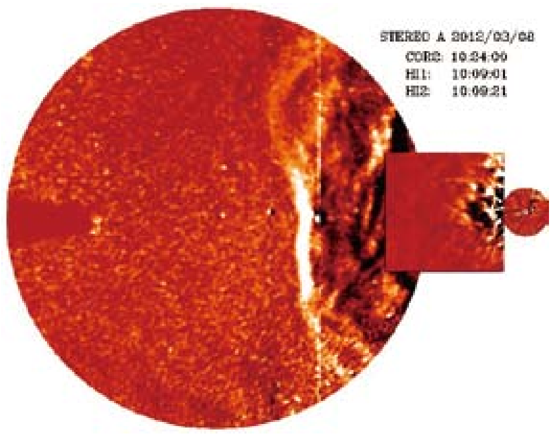
CMEs are large-scale expulsions of ionized gas and magnetic field from the solar corona, often associated with forms of enhanced solar activity, most noticeably solar flares. They originate, in most cases, from active regions on Sun's surface known as sunspots.

CMEs are of great danger to the life and technology on the Earth and in space, producing a form of solar cosmic rays which are hazardous to spacecraft, satellites and astronauts, and disrupting power grids, satellite navigation and mobile phone networks on the Earth. These phenomena are now known as "space weather", which are largely induced by CMEs propagating from the Sun into interplanetary space.

Will our planet be hit by such large-scale ejections of the Sun? Can we forecast them so that the damages can be avoided or reduced? These are among the top concerns of space physicists. "How CMEs propagate through the space between the Sun and Earth is the key to answering these questions," said Dr. LIU Ying, a space scientist from the National Space Science Center (NSSC), Chinese Academy of Sciences.

With data from NASA's twin spacecraft, STEREO, Dr. LIU and his colleagues from the US and Europe developed a novel technique called "geometric triangulation" to determine the trajectory and velocity of CMEs continuously when they travel in interplanetary space. Triangulation literally means use of two separated points to observe a third, as used in fields like surveying and navigation. STEREO for the first time gave us those needed two "eyes" off the Sun-Earth line.

The unique capability of the geometric triangulation technique enabled a detailed study of how CMEs propagate through the vast Sun-Earth space. It can also predict when a CME will reach the Earth and at what velocity. With its assistance Dr. LIU and his coworkers discovered a scenario that seems to generalize the whole Sun-to-Earth propagation of those fast and dangerous ones: first an impulsive acceleration, then a rapid deceleration, and finally a nearly constant speed propagation or gradual deceleration.



An image from STEREO observations shows how a gigantic solar storm blows through interplanetary space. The spot with a vertical streak is the image of the Earth.

While this general picture of the Sun-to-Earth propagation of CMEs is crucial to space weather forecasting, it also has its importance in the understanding of solar storms and their interplanetary consequences, as Dr. LIU envisioned. "The quick deceleration of CMEs is a surprising finding, and may change our understanding of how the energy carried by CMEs dissipates into interplanetary space," he pointed out.

Based on their triangulation concept, Dr. LIU and his colleagues further proposed an audacious yet practical strategy for space weather forecasting, which places dedicated spacecraft at L4 and L5 for routine observations. L4 and L5, where the Sun/Earth's gravity cancels and a spacecraft can be stationary, co-move with the Earth around the Sun but lie at 60 degrees ahead and behind. "We cannot predict when and where a CME will happen on the Sun, but once a CME has occurred, we will be able to track it continuously and determine its path and velocity with the triangulation measurements, in much the same way the terrestrial weather forecast works," Dr. LIU said.