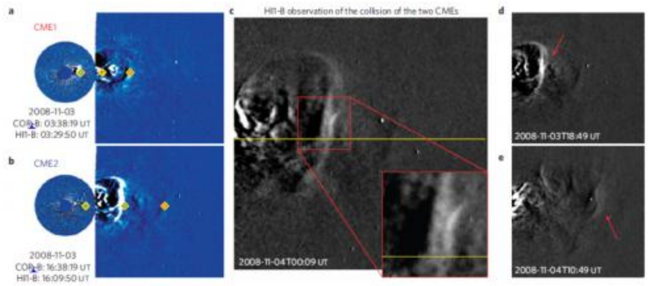
NRL's SECCHI captures super-elastic collision of coronal mass ejections

11 January 2013



The STEREO/SECCHI images of the two CMEs and their collision in the heliosphere. (a,b) Running-difference images showing CME1 and CME2. The red diamond and plus symbols mark the front and rear edges of CME1, respectively, and the blue symbols are for CME2. (c) The running-difference image of HI1-B showing the collision of the two CMEs. (d,e) The beginning and end of the collision; the red arrows indicate the collision region. Credit: U.S. Naval Research Laboratory

(Phys.org)—Scientists at the Naval Research Laboratory and the University of Science and Technology in Hefei, China have captured the super-elastic collision of two coronal mass ejections in the heliosphere. They recorded the surprising event, which occurred in November 2008, using the Space Science Division (SSD)-led Sun-Earth Connection Coronal and Heliospheric Investigation (SECCHI) suite onboard NASA's twin Solar Terrestrial Relations Observatory (STEREO). NRL Space Science Division's Dr. Angelos Vourlidas, the SECCHI project scientist and co-author of this study, reported this research in the journal *Nature Physics* on October 7, 2012. The research contributes to improving scientists' ability to understand and forecast Sun-Earth System space weather that can affect military and civilian space and communication systems.

Sometimes, collisions between solid objects lead to an increase of the kinetic energy of the system. This unusual process, called super-elastic collision, can occur between coronal mass ejections (CMEs), the largest magnetized plasmoids ejected from the Sun. The super-elastic collision that NRL researchers captured using SECCHI was in the heliosphere with clear imaging observations during November 2-8, 2008.

The two CMEs were ejected on November 2nd at about 00:35 UT and 22:35 UT, respectively, when the STEREO-A and B spacecraft were located at around 40° to the west and east of the Sun-Earth line, respectively. Being fast, the second CME (called CME2) caught up and collided with the first CME (called CME1). The apparent collision of the two CMEs began at approximately 18:49 UT on November 3rd and lasted for about 16 hours.

During this time interval, the researchers saw an arc structure deforming, with a brightening caused by the compression of the CMEs - the result of a soft object colliding with a hard object. CME1's kinetic evolution cannot be explained only by solar wind acceleration. The research team analyzed the collision of the two CMEs and determined that there was a 73% likelihood of this being a super-elastic collision.

Vourlidas explains that when the (CME) plasmoids collide, the process is similar to that of elastic balls, which include a pre-collision phase, a compression phase, a restitution phase and a post-collision phase. After the collision, CME2 was deflected eastwards (towards the Sun-Earth line) while CME1 was deflected westwards and accelerated slightly, as expected in a super-elastic collision.

Only CME1 was detected by the in-situ instruments on STEREO-A as predicted by the imaging analysis. The collision led to a 6.6% increase in the kinetic energy of the system, thereby significantly influencing its dynamics. The net kinetic energy increase of 6.6% could be easily provided by the internal CME thermal and magnetic energy.

Experiments and simulations with granular materials and nanoclusters show that super-elastic collisions require sufficient interaction time and surface area for momentum exchange and energy conversion. In this case, the long duration and large size of the collision area may explain the super-elastic nature of the collision.

The study has important implications for plasma physics; for example, the dynamical interaction between large-scale magnetized plasmoids can be described simply in terms of solid-body interactions. The study also has impact regarding space weather, for example, CME-CME collisions can alter the propagation path of CMEs thereby increasing—or reducing—the probability of an Earth encounter.

Provided by Naval Research Laboratory