Method to study the "traces" of coronal mass ejections

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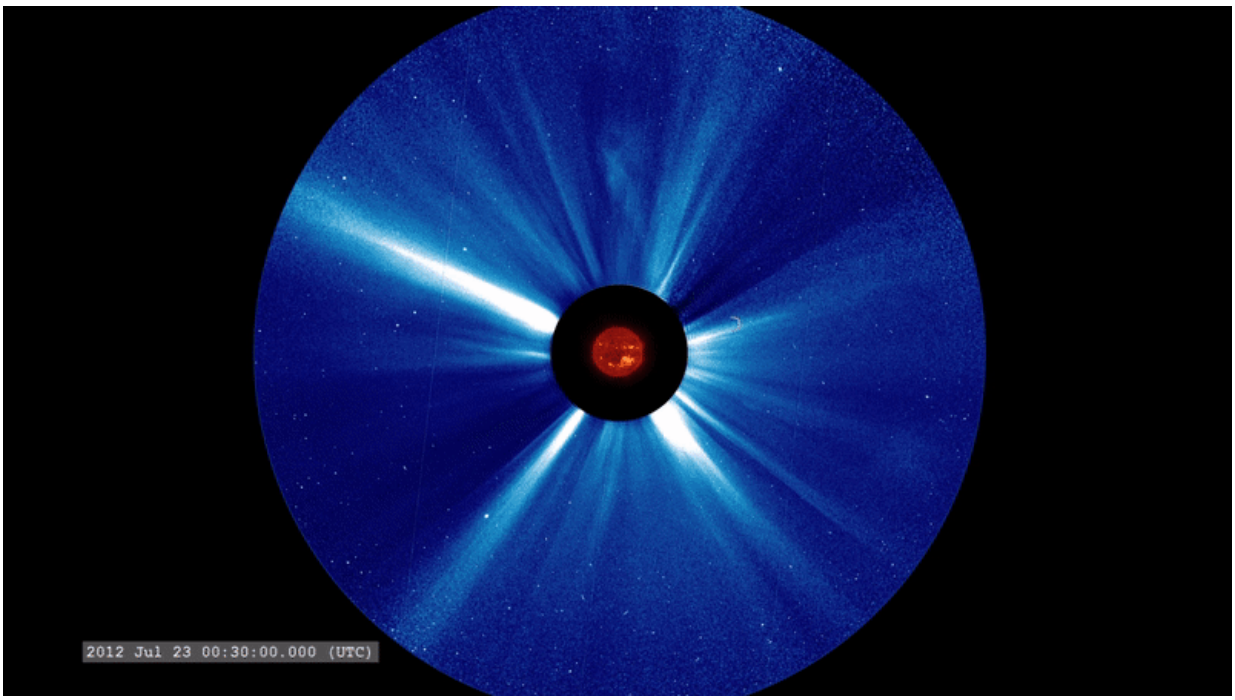


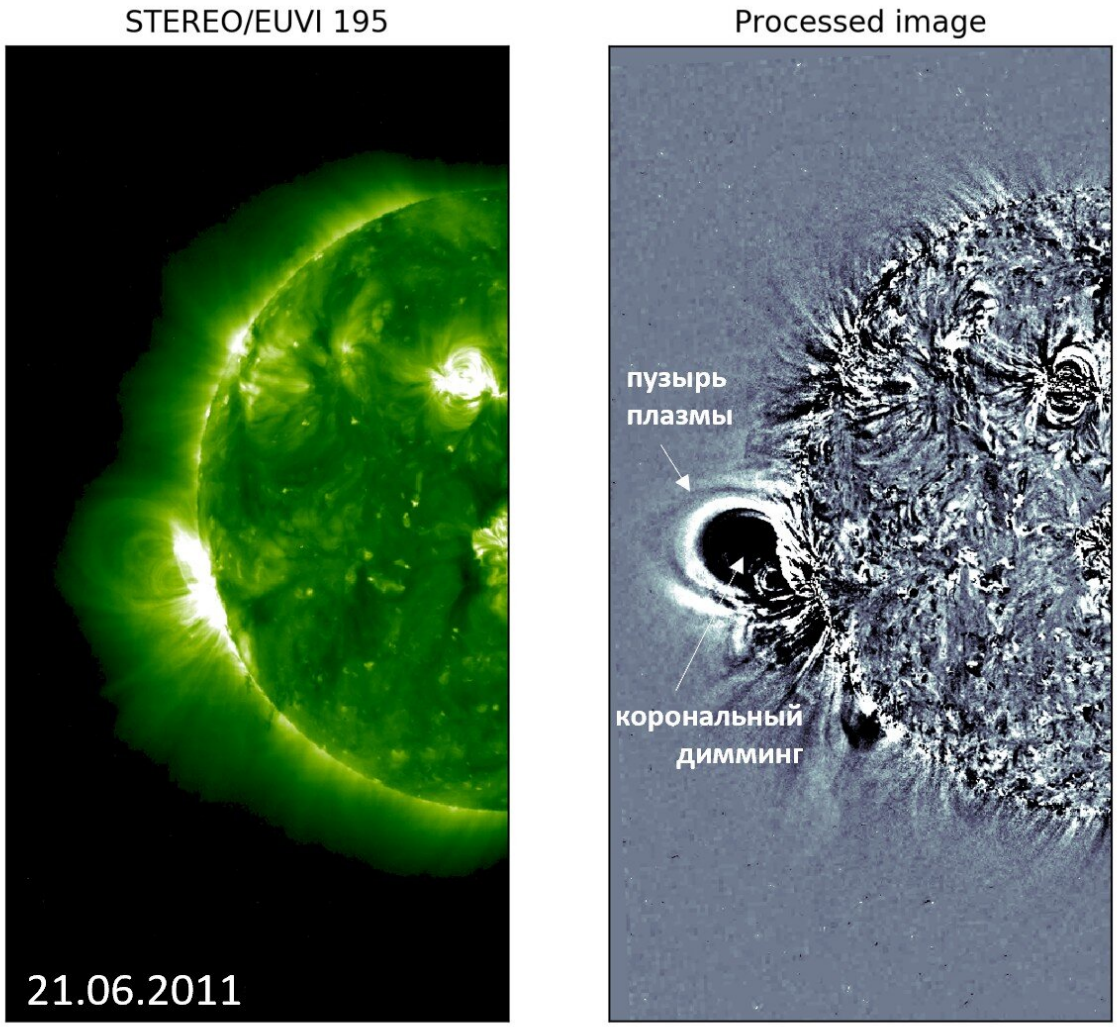
A composite view of the coronal mass ejection via STEREO-A instruments: EUVI imager and coronagraph COR2. Credit: STEREO-A/EUVI + COR2

Scientists at Skolkovo Institute of Science and Technology (skoltech), together with colleagues from the Karl-Franzens University of Graz and the Kanzelhoehe Observatory (Austria), have developed an automatic method for detecting coronal dimmings, or traces of coronal mass ejections from the sun; they have also proved that these are reliable

indicators of the early diagnosis of powerful emissions of energy from the atmosphere of the sun traveling to Earth at great speed. The results of the study are published in the *Astrophysical Journal*.

Coronal mass ejections are among the most striking manifestations of solar activity. Huge plasma clouds pierced by magnetic lines are ejected from the atmosphere of the sun into the surrounding space at speeds of 100 to 3500 km/s. If a stream of charged particles reaches the Earth, auroras and magnetic storms arise in its atmosphere. This can lead to serious problems in the operation of electrical equipment and signal loss, and spacecraft and astronauts in orbit are most exposed to danger.

Coronal mass ejections occur in the atmosphere of the sun, the solar corona, which is very sparse and does not shine as brightly as the solar disk. Therefore, the evolution of these ejections can be observed only with the help of special tools—coronagraphs, which create an artificial solar eclipse by blocking the bright sun with a dark disk. Earth-based coronagraphs do not provide accurate results due to the bright glow of the sky. Therefore, they are usually installed on spacecraft. To date, there are only two coronagraphs in space, those aboard the STEREO-A and SOHO satellites. New missions are expected no earlier than a few years from now. However, coronagraph observations have a significant drawback: Blocking the solar disk by several radii makes it impossible to discern the early evolution of the ejection, but only its shape at a developed stage.



STEREO/EUVI, Coronal dimming and the associated coronal mass ejection. Credit: Skolkovo Institute of Science and Technology

But one solution to this problem is studying the coronal dimmings directly on the surface of the sun, rather than the coronal ejection itself. By observing the solar corona in the ultraviolet, the gaps in the intensity become apparent as dark spots that are associated with the loss of material in the corona during the ejection of plasma. Due to the unique

position of the STEREO-A, STEREO-B and SDO satellites, it is now possible to compare the size and brightness of coronal dimming from different observation points. The results confirm the earlier work of the co-authors of the study from the University of Graz, where the same dimmings were studied on the solar disk using SDO satellite images.

"We showed that by observing dimmings on the sun, it is possible to estimate the mass and speed of the coronal mass ejection at early stages—key parameters that allow us to predict the scale of the event and the time of its expected consequences on Earth. This is of great applied importance for the development of operational space weather services, as well as for future space missions to the Lagrange point L5. Spacecraft will be located in orbit, always retaining the same position with respect to the Earth. This will make it possible to detect traces of coronal mass ejections directly on the sun, as well as to predict the parameters of powerful ejections before they are seen from Earth," says Galina Chikunova, a graduate student at the Skoltech Space Center and the first author of the study.

"Humanity is entering a new era in the exploration of outer space, the creation of new space technologies that are gradually moving into our daily lives. At present, it is very important to study the nature of explosions on the sun to develop methods for their early forecasting in order to protect our society and technologies from the dangers of space weather, to turn off equipment in satellites in time, to move astronauts to a protected area, to cancel satellite maneuvers, air travel through the polar regions and report possible navigation problems," says Tatyana Podladchikova, professor at the Skoltech Space Center, and study co-author.

More information: Galina Chikunova et al. Coronal Dimmings Associated with Coronal Mass Ejections on the Solar Limb, *The Astrophysical Journal* (2020). DOI: 10.3847/1538-4357/ab9105