Solar transient events like ICMEs can make the prediction of space weather uncertain

Scientists tracing interplanetary coronal mass ejections (ICMEs) that move out of the solar atmosphere have observationally verified for the first time that ICMEs are initially circular but flatten significantly during their propagation in the solar wind, due to high compression caused by the fast solar wind. Such a deformed morphological feature not only alters the prediction of the arrival time of these astronomical events, which have a lot of impact on space weather, and also has significant implications in solar-terrestrial physics.

Interplanetary coronal mass ejections (ICMEs) are the counterpart of coronal mass ejections (CMEs) and can induce strong geomagnetic storms when they interact with the Earth's atmosphere. In the last few decades, researchers around the globe have studied different aspects of the ICMEs; however, there are significant gaps in our understanding of their underlying physical mechanisms. It is known that the initial circular cross-section of ICME flattens significantly during their propagation in the solar wind, and this is referred to as 'pancaking'. However, an observational verification of this phenomenon had been pending and could eventually be the primary concern of several morphological models.

Scientists of Indian Institute of Geomagnetism (IIG), an autonomous institute of the Department of Science and Technology (DST), investigated phenomena like dynamic and morphological change of ICMEs as also regions of ICMEs that actually contribute to temporal decrease or recovery of cosmic rays intensity/storm. They reported the first unambiguous observational evidence of extreme flattening of the cross-section of ICMEs, similar to pancaking, based on *in situ* measurements of ICMEs.

They used sophisticated and comprehensive data analysis from several spacecraft missions like Advanced Composition Explorer (ACE), Wind, Operating Missions as a Node on the Internet (OMNI), Parker Solar Probe (PSP), Magnetospheric Multiscale (MMS), and so on as well as data available from NASA and the worldwide neutron monitor database (NMDB), to study the dynamics, evolution, and properties of 420 ICMEs from 1998 to 2017 using *in-situ* data at 1 astronomical unit (AU, equivalent to 149,597,870.7 km) location.

On the basis of their observations, the scientists have proposed that the cross-section of ICME transformed into a quasi-two-dimensional planar magnetic structure (PMS) (named a planar ICME) due to high compression caused by the fast solar wind or ICME-ICME interaction. Such a deformed morphological feature not only alters the prediction of their arrival time but also has significant implications in solar-terrestrial physics. The researchers also noted in the paper published in Monthly Notices of the Royal Astronomical Society (MNRAS) and The Astrophysical Journal (ApJ) that the plasma properties of such planar ICMEs are significantly high and are more favourable to immense disturbances in Earth's magnetic field.

The research work by Dr. Zubair Shaikh will help to understand dynamics and effects of these solar eruptions on planetary bodies, spacecraft instruments, navigation systems, ionospheric variability, energetic charged particle variation, cosmic ray modulation, radiation belt dynamics, geomagnetic storm, magnetospheric dynamics, and so on. The study advances the knowledge of solar eruptions, which will be very important for upcoming India's first interplanetary mission, "Aditya L1 mission" as well as planning of future space missions of humanity.

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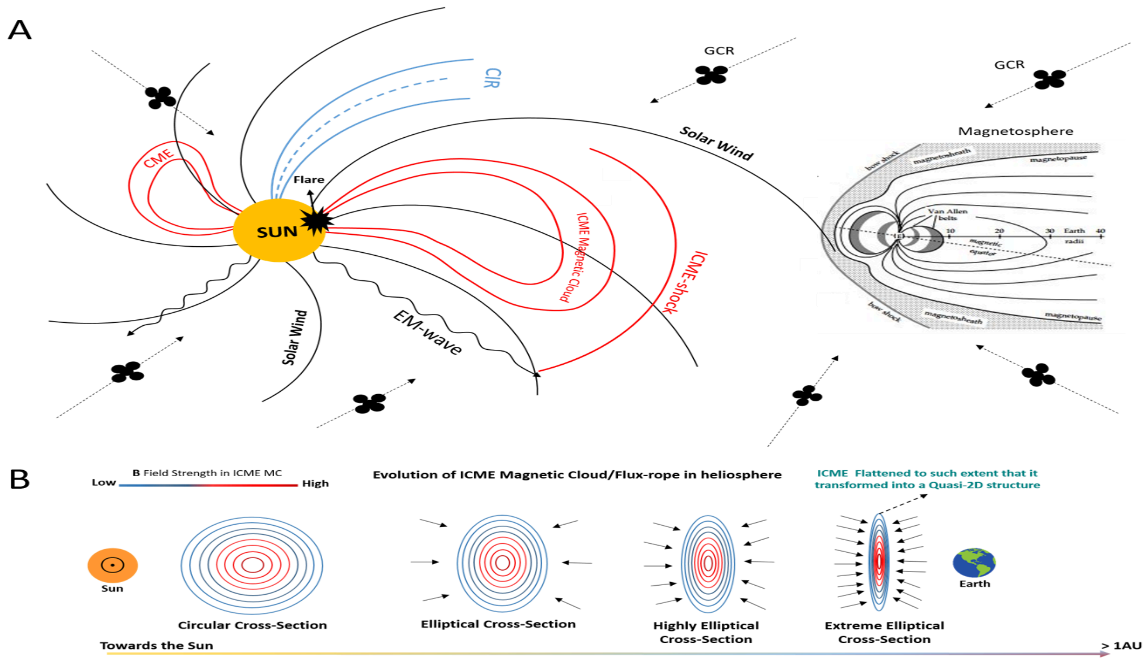

Figure 1: A) Schematic diagram of solar transient events CME, CIR, Flare, Etc., and its interaction with the Earth's magnetosphere and galactic cosmic rays (GCR). B) Schematic of ICME magnetic cloud (MC) dynamics and evolution from the Sun to toward the Earth. MC can be transformed from 3D into a quasi-2D magnetic structure under high compression.

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