Beauty and (or) a Beast

Prediction of Arrival time of Coronal Mass Ejections

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Why do we study *Coronal Mass Ejections*?

Coronal mass ejections (CMEs) are large-scale eruptions of plasma and magnetic field from the Sun. These play an important role in controlling space weather, which can generate intensive geomagnetic disturbances on the Earth [1]. They are known to produce beautiful auroras, as well as, cause major power disruptions (Carrington event, 1859 [2]) during intense geomagnetic storm.

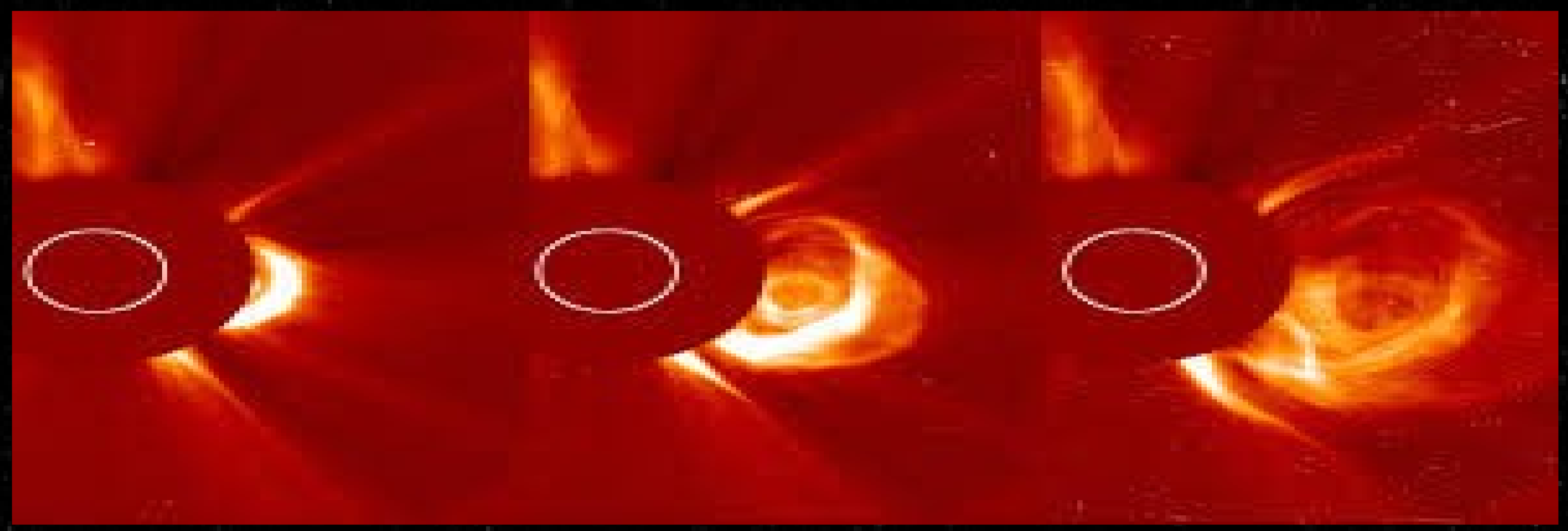


Figure1: Evolution of a CME seen by *SOlar and Heliospheric Observatory* (SOHO). Credit: SOHO NASA.

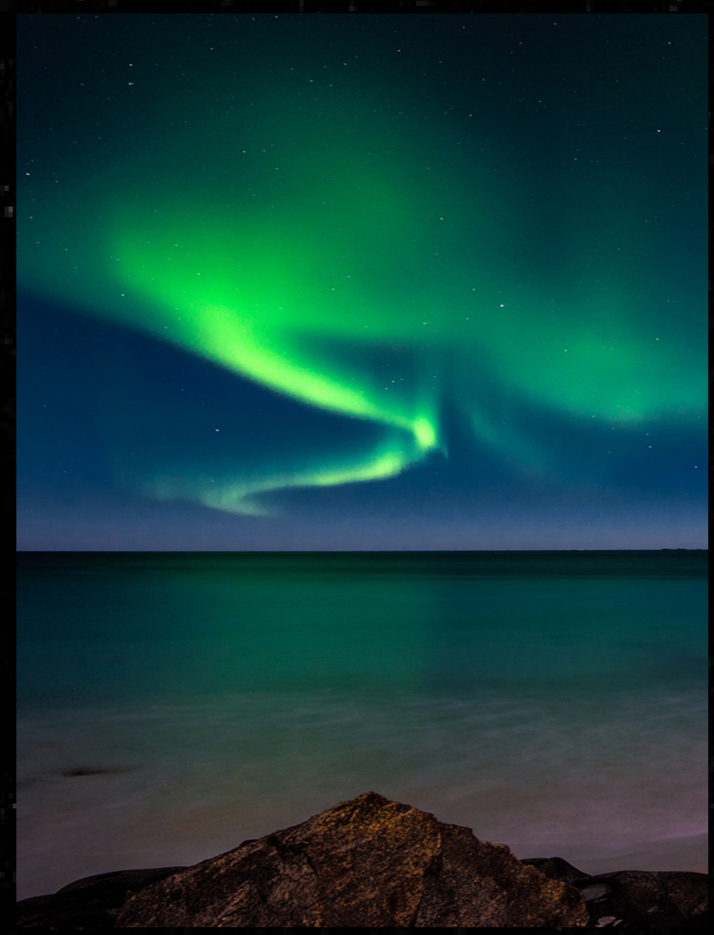


Figure2: Auroras or Northern lights. Credit: Alpha coder.

VS

Figure 3: Illustration of power breakdown during powerful geomagnetic storm. Credit: Chet Richards.

Results

1) Our approach of using maximum velocity of the CME to predict Transit Time (TT) offers reduced errors compared to previous studies.

2) STEREO offers a wider field of view (1.5 solar radii – upto Earth), whereas, SOHO observes at (1.1 – 30 solar radii). Hence, STEREO data is much more helpful to study CMEs.

3) The new approach has radically reduced the maximum TT estimation errors to 29 hours. Previous studies determined the TT using average velocities with a maximum error equal to 50 hours.

Data: SOHO or STEREO?

Both! The data from both the NASA missions were used to do comparative studies; spacecrafts have been dedicated to study the Sun since 1995 and 2006, respectively. The coronographs onboard image the Sun in white light.

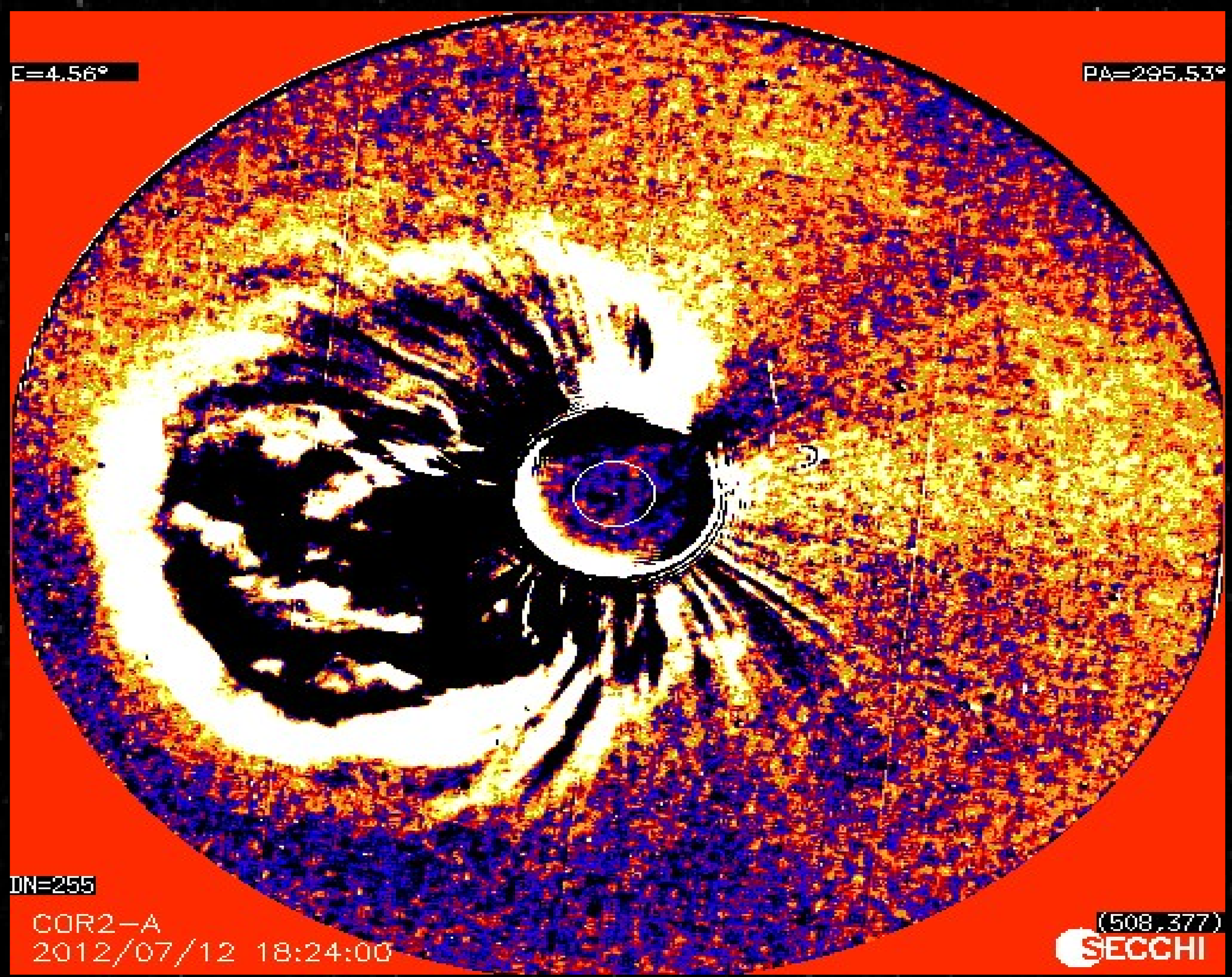


Figure4: *Solar TErrestrial RElations Observatory (STEREO)* Coronograph image of CME eruption on 12 July, 2012. This is a good example of Earth-directed (Halo) CME. Credit: STEREO NASA.

What is *NEW* in our research?

1) The quadrature position of STEREO's twin spacecraft during 2009-2013 offers a vantage point to observe Earth-directed (Halo) CMEs accurately, where as, SOHO's observations contain projection effects for Halo CMEs.

2) We use the maximum speed that the CME achieves during the expansion into the interplanetary medium for determination of their arrival time. This approach offers better correlation than average speed used in previous speed.

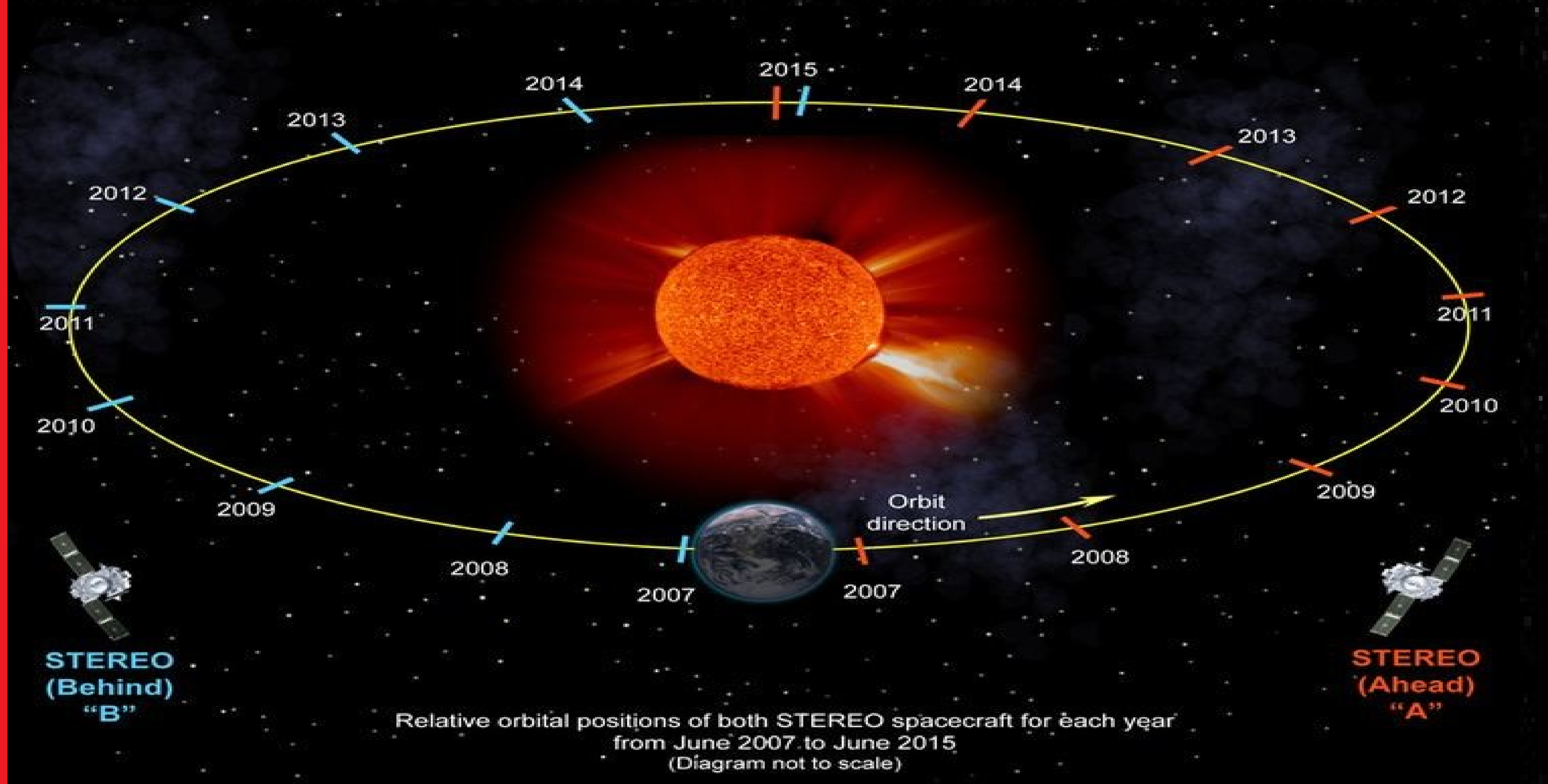


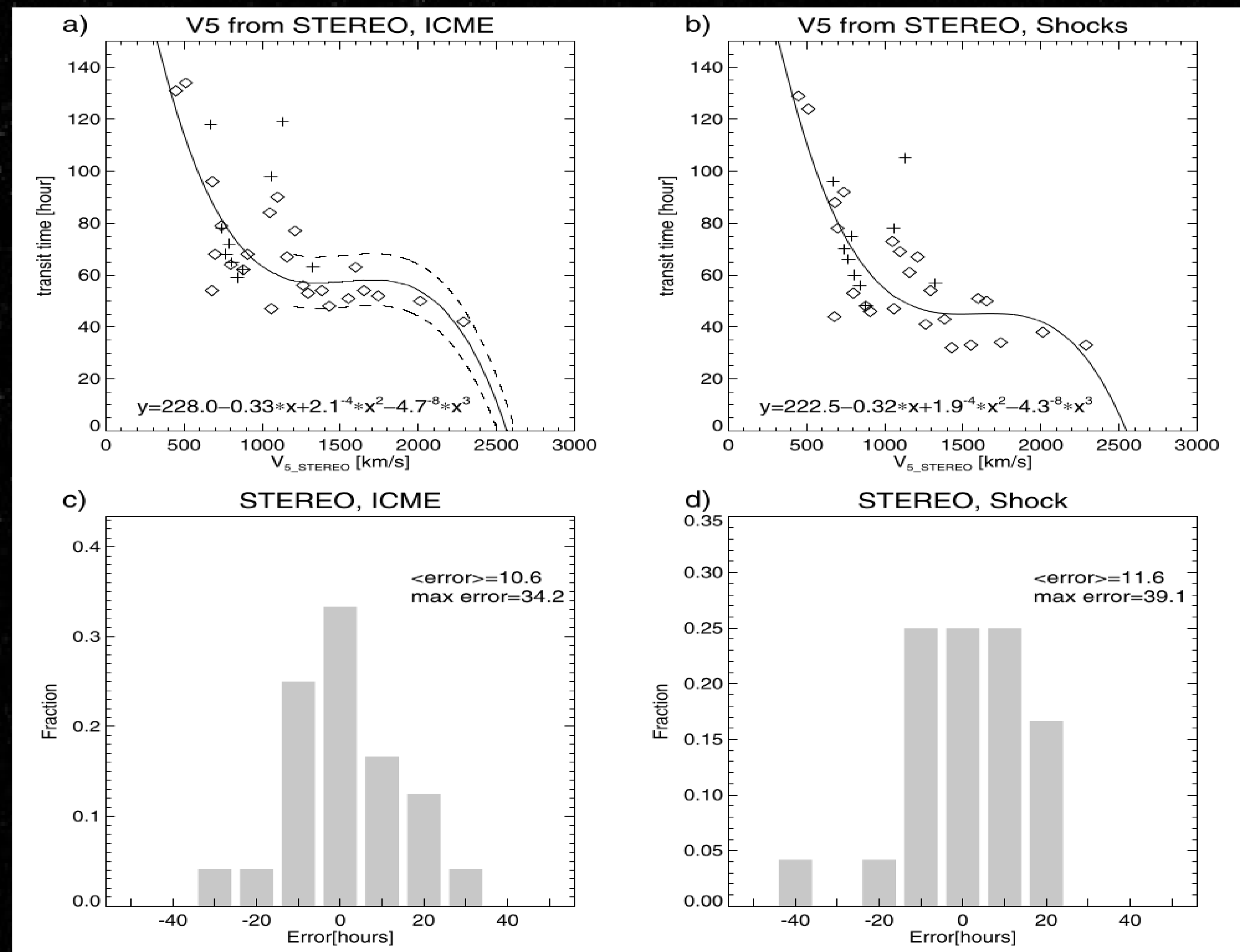
Figure5: The orbit of STEREO A and B spacecrafts around Sun. The quadrature position during 2009-2013 offers best results for Earth-directed CMEs. Credit: STEREO NASA.

Do we have a better model?

1) Yes! The model presented below can be used universally.

2) Strong CMEs are fast and reach Earth in few hours, ≤ 40 hours. These are potential threats that cause power breakdown due to intense geomagnetic storms. The slower CMEs can cause beautiful auroras.

Hence, accurate prediction of these CMEs can prepare us to know if we would face a threat or a beautiful marvel, sooner or later.



Acknowledgement

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References

[1] Gopalswamy, N et al. (2001). J. Geophys. Res. 106, 29207.

[2] R. C. Carrington, (1859). MNRAS, Volume 20, Issue 1.

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