INVESTIGATING A CME WHODUNIT IN PREPARATION FOR SOLAR ORBITER

B. IRURETA-GOYENA[1], F. CARCABOSO[2], G. GRAHAM[3], A. JAMES[3], N. JANITZEK[3]

1 The University of Manchester

2 Universidad de Alcalá

3 European Space Agency

3 solar orbiter

MINISTERIO DE ECONOMÍA, INDUSTRIA Y COMPETITIVIDAD

Unión Europea
Fondo Europeo de Desarrollo Regional

INTRODUCTION

Coronal mass ejections (CMEs) are large eruptions of magnetised plasma from the Sun's corona. Interplanetary CMEs (ICMEs) can have significant effects on the Earth, such as geomagnetic storms. ICMEs with smoothly rotating magnetic-field direction can be said to contain a "flux rope" structure.

In this work, we extend previous studies by other authors[4] on two specific ICMEs that occurred in 2011. These studies attempted to identify their solar origins, with contradictory results.

THE CASE

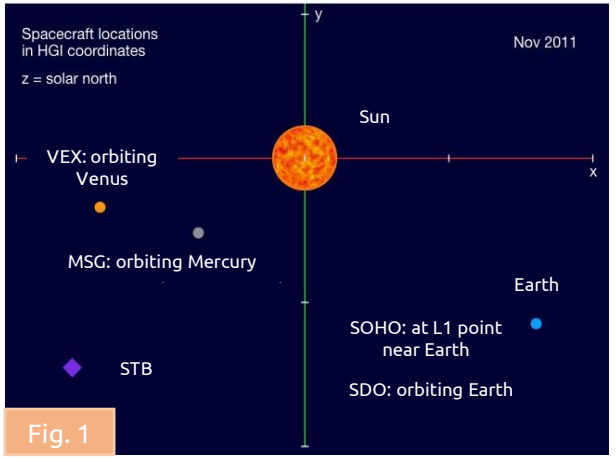

Fig. 1

On the 5 and 6 November 2011, different ICME signatures were detected at MESSENGER (MSG), *Venus Express* (VEX) and STEREO-B (STB).

As shown in Figure 1, the three spacecraft had a separation of less than 30°.

[4] S. W. Good et al (2015), T.M Salman, R.M Winslow and N. Lugaz (2019) and Gómez-Herrero et al (2015).

THE SUSPECTS

In the days before the detections in situ, two CMEs erupted from the Sun: CME A, from a small region near the eastern limb seen by STB, and CME B, from a larger region west of the CME A source (see Figure 2, taken with SDO HMI magnetogram).

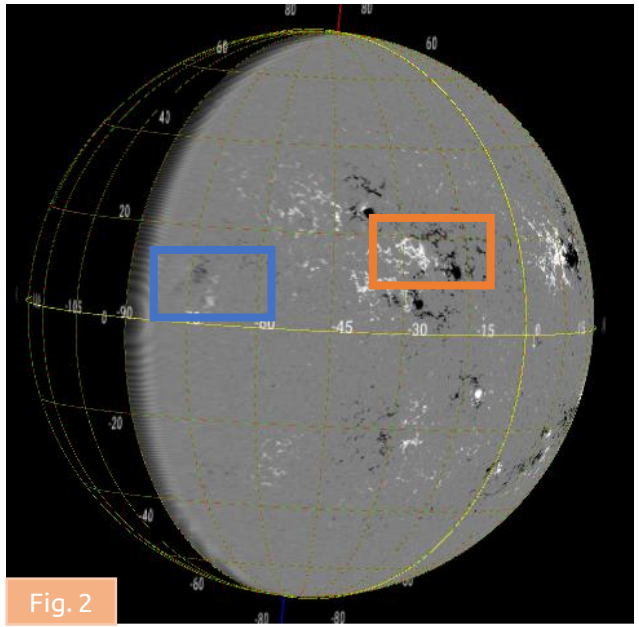

Fig. 2

Using observational proxies (magnetic tongues[5] and J-shaped EUV flare ribbons[6]), we inferred that the magnetic flux ropes that erupted in CMEs A and B had right-handed and left-handed magnetic twist, respectively.

CME A

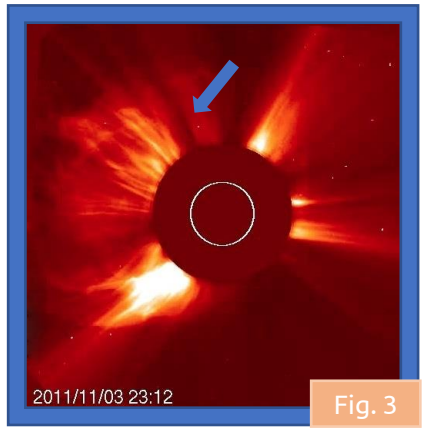

Fig. 3

Viewed along the Earth-Sun line, CME A was first seen in the field of view of the SOHO LASCO C2 at 23:12 UT on 3 November 2011. The CME speed in the plane-of-sky was 991 km/s[7].

CME B

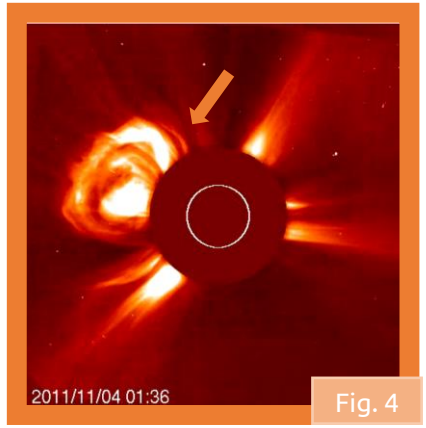

Fig. 4

CME B was first seen in the field of view of the SOHO LASCO C2 at 01:25 UT on 4 November 2011. It had a plane-of-sky speed of 756 km/s[7].

[5] López Fuentes et al (2000).
[6] Démoulin et al (1996b).
[7] SOHO LASCO CME Catalog

THE EVIDENCE

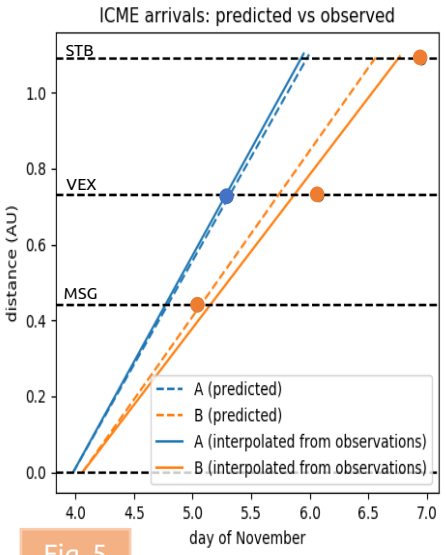

Fig. 5

We compared the measured arrival times of the ICMEs (coloured circles in Figure 5) at MSG, VEX and STB spacecraft to predicted arrival times based on the onset times and speeds of the CMEs.

The ICME signatures at MSG and VEX are shown in Figures 6, 7 (magnetic-field data) and 8 (proton data of VEX).

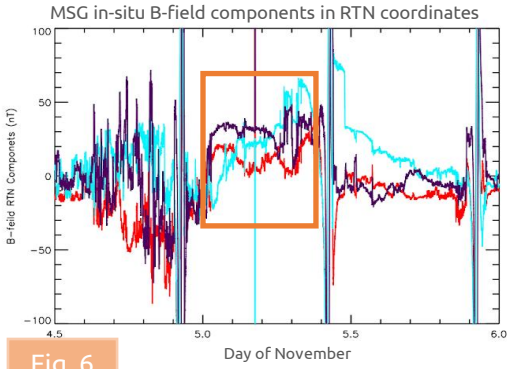

Fig. 6

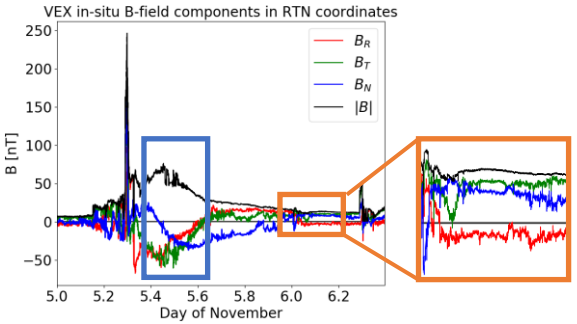

Fig. 7

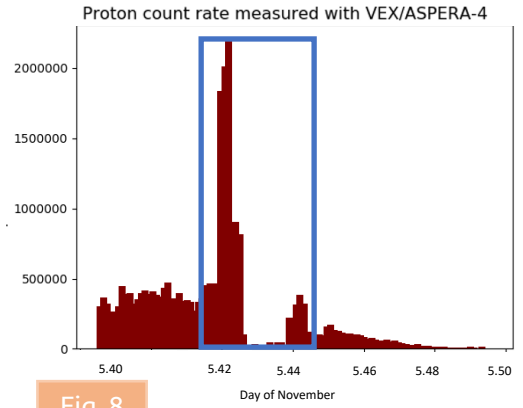

Fig. 8

Since the handedness of the flux rope of a CME remains invariant throughout its whole interplanetary journey, we used a catalogue[8] to verify the handedness of the ICME at MSG (left-handed) and the two at VEX (one right-handed, one left-handed). For STB, we fitted the Hidalgo flux-rope model to the magnetic-field data to determine the handedness of the ICME (left-handed) (cf. Figure 9).

This further suggests CME A was detected at VEX on 5/11 and CME B was detected at MSG on 4/11, VEX on 6/11, and STB on 6/11.

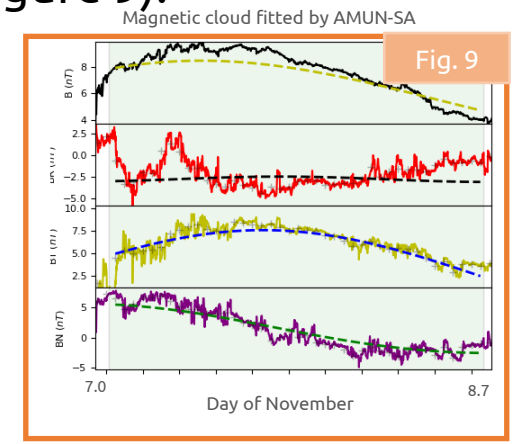

Fig. 9

[8] S. W. Good and R.J Forsyth (2016).

SUMMATION

Two CMEs were released from two different active regions of the Sun, close enough in time and space to interact in the interplanetary medium. There has been disagreement over their subsequent journey.

Using remote-sensing observations, we analysed the properties of the two CMEs and compared them to those measured in situ. By studying the arrival times of the ICMEs and the magnetic-field and proton data, we concluded that a possible reconstruction of the event is that shown in Figure 10.

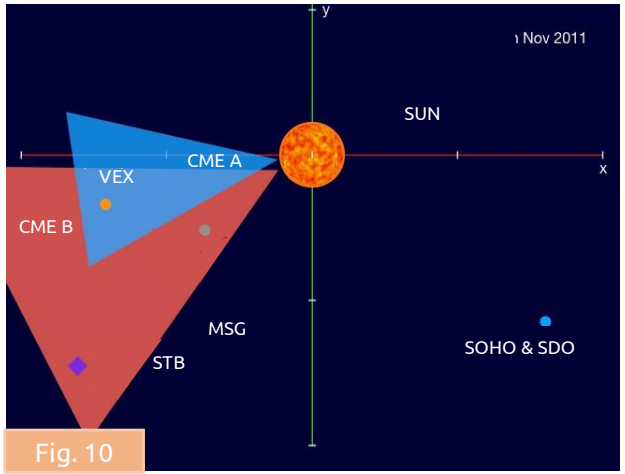

Fig. 10

FUTURE INVESTIGATION

In the ongoing study, we will use the proton data of VEX to derive solar wind speed, temperature and α-particle / proton ratio to analyse a possible interaction between ICMEs.

Similar studies of CME evolution in the inner heliosphere are planned from 2021 on with Solar Orbiter based on the spacecraft's in-situ and remote sensing instrument suite.

ACKNOWLEDGMENTS

We acknowledge the instrument teams of the missions MESSENGER, *Venus Express*, STEREO, SOHO and SDO for their data and open policy. We acknowledge the financial support by the Spanish MINECO-FPI-2016 predoctoral grant with FSE and research fellowships from the ESA.