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Connecting scientists in the era of Solar Orbiter

The first post-launch science meeting dedicated to the ESA/NASA Solar Orbiter spacecraft met in-person in Belfast nearly two and a half years into the mission, focusing on building new collaborations and rekindling old friendships.

Attendees of the 8th Solar Orbiter Workshop. The workshop was held at the Assembly Building in Belfast, Northern Ireland on 12–16 September 2022.

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Despite its role in creating and sustaining life on Earth as our source of light, heat and energy, the connection between the Sun and the Earth, and indeed the Sun's connection with its heliosphere, remain something of a conundrum. Models predict, and observations seem to confirm, that the solar magnetic field is created and driven by plasma flows deep within the interior of the Sun. These field lines then burst through the visible solar surface as sunspots and active regions, before extending out into the heliosphere where they can interact with planetary magnetospheres and guide energetic particles and solar plasma eruptions. However, solar missions have traditionally been limited to observing the Sun from within the ecliptic plane, with the result that we have no observations of how the solar magnetic field evolves near the poles. Existing solar observatories have also tended to observe the Sun from one astronomical unit, (that is, the orbit of the Earth), so that observations of eruptions on the Sun are connected with in situ measurements of the resulting plasma after the plasma has been mixed up by propagation through the turbulent heliosphere.

The 8th Solar Orbiter workshop, held at the Assembly Buildings in Belfast on 12–16 September 2022, represented the first time since the launch of the Solar Orbiter mission (and since the start of the COVID-19 pandemic) that scientists from the different instrument teams had met in person to present and discuss initial results. Solar Orbiter, a joint collaborative effort between the European Space Agency (ESA) and NASA (the National Aeronautics and Space Administration), is the first mission in ESA's Cosmic Vision 2015–2025 programme, and two of its goals are understanding the origin of the Sun's magnetic field, and connecting what happens on the Sun with what is detected in situ prior to any mixing of the erupted plasma. Solar Orbiter launched from Cape Canaveral in Florida in February 2020, just prior to the onset of the COVID-19 pandemic, with the pandemic forcing commissioning of the spacecraft and instruments to be done remotely from bedrooms and playrooms by the different instrument teams (for example, www.esa.int/Science_Exploration/Space_Science/Solar_Orbiter/Solar_Orbiter_ready_for_science_despite_COVID-19_setbacks).

With the broad variety of instruments onboard Solar Orbiter, and given the reduced opportunities for younger scientists to present their work during the pandemic, a conscious decision was made to invite early-career researchers to present reviews centred around the different instruments. Each of these review presentations offered unique insights into the strengths and opportunities provided by the Solar Orbiter instruments, with the presenters also taking the opportunity to pose questions that will guide upcoming observing campaigns.

Although still a new mission, with the science phase having begun at the end of 2021 and one perihelion with science-quality data completed by the start of the workshop, a wide variety of observations and results could already be presented. The high temporal and spatial resolution observations of the low solar corona at a temperature of approximately 1 million degrees provided by the Extreme Ultraviolet Imager were shown to be ideal for identifying oscillating coronal loops and small-scale energy release (the so-called campfires). The co-alignment of the different high-resolution remote-sensing instruments has also enabled spectroscopic observations of these campfires using the Spectral Imaging of the Coronal Environment instrument, as well as a probing of their magnetic environment using the Polarimetric and Helioseismic Imager. The orbit of Solar Orbiter has taken it far from Earth around the far side of the Sun, with the Spectrometer/Telescope for Imaging X-rays and Metis Coronagraph vital for providing observations of solar flares and coronal mass ejections away from the Sun–Earth line.

Solar Orbiter's scientific payload is unique in its combination of both remote-sensing and in situ instruments, which enable eruptions to be observed on the Sun and then measured as they pass over the spacecraft. As this requires an accurate estimation of where the spacecraft is magnetically connected to the Sun, one of the key components of the mission prior to launch was the development of a suite of models designed to predict this magnetic

connectivity. These models are used both in advance of observing campaigns to predict where best to point the different instruments, and afterwards to determine the origin of material detected at the spacecraft. The vital role of these models in connecting the Sun with the spacecraft is already being seen, with many of the in situ particle and magnetic field detections being related to different eruptions and phenomena observed on the Sun. As the mission continues and these models mature, we will surely gain new insight into the connections between the Sun and its heliosphere.

As a new mission, one of the goals of this workshop was to encourage the use of Solar Orbiter data and observations by the wider community outside those already involved in the different instruments. To do this, we organized a data analysis day, with each of the 10 instrument teams presenting a brief introduction to their respective instruments, having prepared a Jupyter notebook in advance, which provided an introduction into accessing, preparing and handling the data for their instruments. As well as enabling researchers outside the instrument teams to access and work with data, this also provided an opportunity for team members to use data from other instruments, which can only encourage further collaboration and connected science. In addition, all of the material prepared and presented by the different instrument teams will remain available online via GitHub (https://github.com/SolarOrbiterWorkshop/solo8_tutorials), with the goal of providing an access point for new (and old) members of the community to Solar Orbiter data.

The 8th Solar Orbiter workshop was a great success, both as the first in-person science meeting following the launch of the mission, but also as an opportunity for the development of new collaborations and the rekindling of old networks. Despite the restrictions imposed by the global pandemic, the spacecraft is operating well and making new and exciting observations, which are being fully exploited by all members of the community. Long may it continue!

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Competing interests
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