Shining light on solar energetic particles and jets

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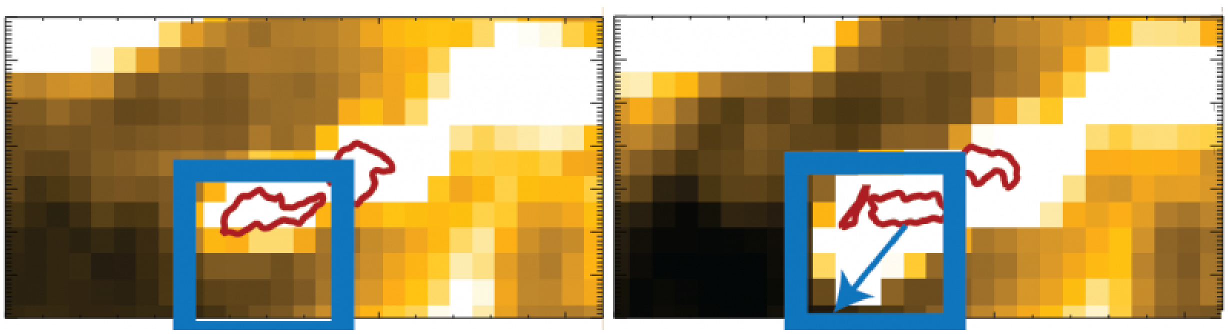

Image of the jet (blue arrow) emerging from the observed footpoint (red contour). The structures also agreed with the model predictions for hotter upflowing material in terms of temperature, velocity and timing. Credit: M. Druett et al. / Solar Dynamics Observatory (SDO) Credit: Royal Astronomical Society

A team of astronomers, led by PhD researcher Malcolm Druett of Northumbria University at Newcastle, have taken a big step forward in understanding a 30-year-old mystery in the process of formation of solar flares. Druett will present their work on Monday 3 July at the National Astronomy Meeting in Hull, and the research appears in a paper in *Nature Communications* on the same day.

Scientists study the Sun with a variety of techniques, including looking at the so-called H-alpha line in the solar spectrum, associated with hydrogen gas that makes up the bulk of the mass of our nearest star. The observed wavelength of this line changes as a result of the Doppler effect, where light emitted from gas is slightly bluer if the gas is moving towards us (blueshifted) and slightly redder if it is moving away from us (redshifted).

The team looked at solar flares, large explosions on the surface of the Sun, which can be associated with the eruption of large amounts of matter, sometimes headed towards the Earth. These coronal mass ejections can cause adverse 'space weather', disrupting communications and even electrical power supplies. The H-alpha emission associated with solar flares when observed from the ground is seen to be strongly redshifted, implying a high speed of 50-55 km/s for the flare material. In contrast, when observed by space probes such as the Solar Dynamics Observatory, the emission is seen blue-shifted with velocities up to 100 km/s.

Druett, supervised by Prof Valentina Zharkova and in collaboration with Dr Eamon Scullion, both also at Northumbria University at Newcastle, have for the first time created a model to explain this effect. The approach uses radiative transfer (transfer of electromagnetic radiation, including visible light) and hydrodynamic modelling (understanding fluid flow).

Druett and his team found that short (10 second) injections of super-energetic electrons, so-called solar energetic particles (SEPs) could be responsible for the H-alpha emission. Their work explains the redshift in H-alpha, and the formation of flares, and will help forecasters predict adverse space weather events, allowing agencies on Earth to take action to protect systems before it hits.

Prof Zharkova said: "Solar flares are magnificent energetic phenomena releasing huge amounts of energy in the form of particles, radiation, coronal mass ejections and interplanetary shocks into the atmospheres of all the planets, including the Earth."

"A greater understanding of how a solar flare can occur and how much energy they eject out of the Sun and heliosphere is a major priority for the space industry and space weather forecasts. Our paper sheds significant light on the main factors, which are able to account for the observations associated with these phenomena both in the Sun and in the heliosphere."

The team now hope that the research will advance the whole field of solar flare dynamics, allowing a better understanding of the process of flare formation and disruptive space weather.

More information: Malcolm Druett et al. Beam electrons as a source of Hα flare ribbons, *Nature Communications* (2017). DOI: 10.1038/ncomms15905

Provided by Royal Astronomical Society