2013 IAU Symposium abstract

Filament Eruptions, Jets, and Space Weather

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Previously, from chromospheric Hα and coronal X-ray movies of the Sun's polar coronal holes, it was found that nearly all coronal jets (>90%) are one or the other of two roughly equally common different kinds, different in how they erupt: standard jets and blowout jets (Yamauchi et al 2004, ApJ, 605, 511; Moore et al 2010, ApJ, 720, 757). Here, from inspection of SDO/AIA He II 304 Å movies of 54 polar X-ray jets observed in Hinode/XRT movies, we report, as Moore et al (2010) anticipated, that (1) most standard X-ray jets (>80%) show no ejected plasma that is cool enough ($T <\sim 10^5$ K) to be seen in the He II 304 Å movies; (2) nearly all blowout X-ray jets (>90%) show obvious ejection of such cool plasma; (3) whereas when cool plasma is ejected in standard X-ray jets, it shows no lateral expansion, the cool plasma ejected in blowout X-ray jets shows strong lateral expansion; and (4) in many blowout X-ray jets, the cool-plasma ejection displays the erupting-magnetic-rope form of classic filament eruptions and is thereby seen to be a miniature filament eruption. The XRT movies also showed most blowout X-ray jets to be larger and brighter, and hence to apparently have more energy, than most standard X-ray jets.

These observations (1) confirm the dichotomy of coronal jets, (2) agree with the Shibata model for standard jets, and (3) support the conclusion of Moore et al (2010) that in blowout jets the magnetic-arch base of the jet erupts in the manner of the much larger magnetic arcades in which the core field, the field rooted along the arcade's polarity inversion line, is sheared and twisted (sigmoid), often carries a cool-plasma filament, and erupts to blowout the arcade, producing a CME. From Hinode/SOT Ca II movies of the polar limb, Sterling et al (2010, ApJ, 714, L1) found that chromospheric Type-II spicules show a dichotomy of eruption dynamics similar to that found here for the cool-plasma component of coronal X-ray jets. This favors the idea that Type-II spicules are miniature counterparts of coronal X-ray jets. In Moore et al (2011, ApJ, 731, L18), we pointed out that if Type-II spicules are magnetic eruptions that work like coronal X-ray jets, they carry an area-averaged mechanical energy flux of $\sim 7\times10^5$ erg cm^{-2} s^{-1} into the corona in the form of MHD waves and jet outflow, enough to power the heating of the global corona and solar wind. On this basis, from our observations of mini-filament eruptions in blowout X-ray jets, we infer that magnetic explosions of the type that have erupting filaments in them are the main engines of both (1) the steady solar wind and (2) the CMEs that produce the most severe space weather by blasting out through the corona and solar wind, making solar energetic particle storms, and bashing the Earth's magnetosphere. We conclude that in focusing on prominences and filament eruptions, Einar had his eye on the main bet for understanding what powers all space weather, both the extreme and the normal.

This work was funded by NASA's Science Mission Directorate through the Living With a Star Targeted Research and Technology Program and the Hinode Project, and by NSF through its Research Experience for Undergraduates Program.