Prevalence of Micro-jets from the Network Structures of the Solar Transition Region

Hui Tian1, Edward E. DeLuca1, Steve R. Cranmer2, Bart De Pontieu2, Hardi Peter3, Sean McKillop1, Katharine K. Reeves1, Mari Paz Miralles1, Patrick McCauley3, Juan Martínez-Sykora2, Rebecca T. Arbercher4, and the IRIS team

1Harvard-Smithsonian Center for Astrophysics 2Lockheed Martin Solar and Astrophysics Laboratory 3Max Planck Institute for Solar System Research 4Columbia University

Abstract

IRIS observations in the 1330Å, 1400Å and 2796Å passbands have revealed prevalent small-scale jet-like features with apparent speeds of ~80-250 km/s from the network structures in coronal holes and quiet Sun regions. Their widths are often ~300 km or less. Many of these jets show up as elongated features with enhanced line width in maps obtained with transition region (TR) lines, suggesting that these jets reach at least ~10^10 K and they constitute an important element of TR structures. These ubiquitous high-reaching jets are likely an intermittent but persistent source of mass and energy for the corona and solar wind. The generation of these jets in the network and the accompanying Alfvén waves is also consistent with the “magnetic funnel model” of solar wind. The large speeds suggest that magnetic forces may play an important role in the generation and acceleration of the network jets. Many network jets are likely the on-disk counterparts and TR manifestation of type-II spicules observed in the chromosphere above limb.

Prevalent network jets in the solar wind source region

Fig. 1. A snapshot of IRIS 1330Å movie showing the prevalence of TR network jets (Tian et al. 2014). http://www.jsoweb.org/sensor/overlay/overlay index.html.

• Most prominent dynamic features in the networks of the TR and chromosphere in on-disk observations.
• Temperature: 10^7 K – 10^8 K
• Best seen in 1330Å (Å: Mg II); shorter in 2796Å (Å: Mg II)
• Apparent speed: mostly 80-250 km/s.
• Lifetime: 20-80 s.
• Width: 300 km.
• Extension: ~10 Mm, some reach ~15 Mm.
• Originate from small-scale bright regions in the network, often preceded by footpoint brightenings.
• Primary signature of network jets in TR line profiles: enhanced line width caused by parallel flows or unresolved transverse motions (see also De Pontieu et al. 2014).
• Accompanied Alfvén waves: amplitude ~20 km/s.
• Networks are suggested origin sites of the solar wind.
• Solar wind models usually predict a steady outflow with a speed of a few km/s in the interface region. Such steady network outflows have never been directly imaged.
• Mass loss rate: (2.3-3.6) x 10^19 g/s; Energy flux: 4-24 kW m^2.
• Are these intermittent high-speed jets the nascent solar wind?

(1) If yes, solar wind models might need to be updated to account for this highly intermittent component.
(2) If no, at least their interaction with/impact on the wind should be carefully evaluated, because they are the most prominent dynamic features in the solar wind source region.
• Support earlier observations of heating of spicules in off-limb coronal holes that feed into the solar wind (De Pontieu et al., 2011).

Fig. 2. Apparent speeds and lifetimes of network jets.

Fig. 4. Signature of network jets in Si IV line profiles – enhanced line width caused by either parallel flows or unresolved Alfvén wave.

Fig. 5. The magnetic funnel model proposed by Audard & McKenzie (1992).

Heating and generation of network jets

• Coronal propagating disturbances and TR network jets are propagating in the same directions.
• Blue shift of Ne VII 730Å at loop footpoints in network junctions: mass supply to coronal loops (Tian et al. 2009) & solar wind (Hassler et al., 2009, Tu et al. 2005).
• Investigation of spatial correspondence between these blue shifts and network jets is underway.
• Pressure driven jets hardly reach speeds higher than 60 km/s. Lorentz-force driven jets can produce such high speeds (Goodman 2014).

Comparing QS and CH

• QS jets appear to be slower & shorter.
• Bright low-lying loops with ~5 Mm size often in QS but seldom in CH.

Fig. 10. A snapshot of a movie of unsharp masked AIA 171 and IRIS 1330 images.

Fig. 11: Left: Dopplersgram of Ne VII 730Å in a quiet sun region (Tian et al 2005): Right: An IRIS 1330Å image showing some network jets (Tian et al. 2014). http://sunoda.haverford.edu/~sunoda/mov.html

References

De Pontieu, B., et al., 2014, Science, 346, 1207562
De Pontieu, B. et al., 2014, Science, 346, 1207561