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Quasi-Separatrix-Layers Channel Solar Wind Outflows in Coronal Hole

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Observations indicate that small-scale, transient jetlets at the base of plumes and upflows within coronal holes contribute substantially to the mass and energy flux of the solar wind[1,2]. We use three-dimensional radiation magnetohydrodynamic (MHD) simulations of a coronal hole plume, conducted with the MURaM code (shown in the left panels in Figures 1 and 2), to examine the magnetic origins and driving mechanisms of these upflows (shown in the right panels of Figures 1 and 2)/jets in the solar atmosphere. Our simulations show that interactions between the magnetic field of the plume with the surrounding like-polarity magnetic patches displayed in Figure 3 right panel, create a strong quasi-separatrix layers (QSLs) as shown in Figure 3 left panel, characterised by a filamentary fine structure. We analyse the resulting plasma flows and temperature structure, comparing them with synthesised 174 Å Extreme Ultraviolet Imager (EUI) emission at this QSL. We noted a transition from cooler downflows in the lower atmosphere to persistent hotter upflows in the corona at the QSL, with a substantial mass flux of 10^8 g cm^{-2} s^{-1}, that could in principle be channeled as the solar wind outflow. Our simulations go beyond the traditional picture of upflows originating from an interchange reconnection between open and closed field lines, and show the important role of QSLs in the formation of the solar wind.

References:
[1] P. Kumar, J. T. Karpen, V. M. Uritsky, C. E. Deforest, N. E. Raouafi, C. Richard DeVore, Quasi-periodic Energy Release and Jets at the Base of Solar Coronal Plumes. *Astrophys. J.* **933**, 21 (2022)
[2] Chitta, L. P., "Picoflare jets power the solar wind emerging from a coronal hole on the Sun", *Science*, vol. 381, no. 6660, pp. 867–872, 2023

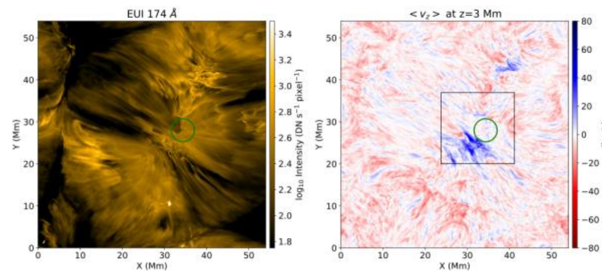

Figure 1. *Left:* Synthesized emission (integrated along vertical direction) from MURaM simulation in 174 angstrom passband of EUI instrument onboard solar orbiter. *Right*: Vertical component of flow velocity at z=3 Mm above solar surface highlighting the strong upflow region (enclosed within rectangle) at the plume boundary (marked in green circle).

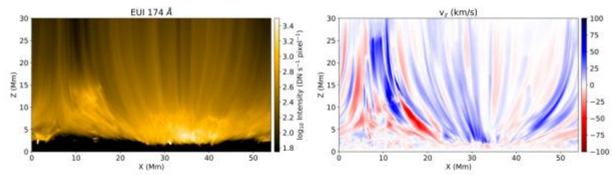

Figure 2. *Left:* Synthesized emission (integrated along *y* direction) from MURaM simulation in 174 angstrom passband of EUI instrument showing plume structure in intensity. *Right*: Vertical component of flow velocity on *xz* plane above solar surface highlighting the strong upflows.

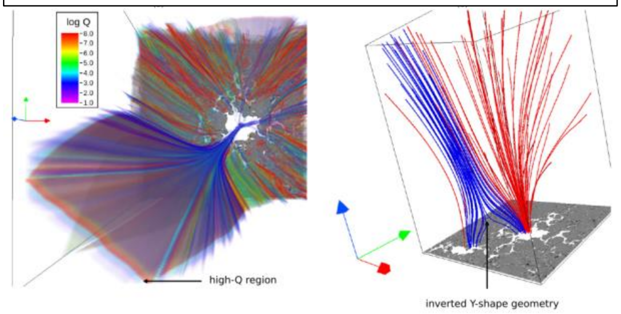

Figure 3. *Left:* Logarithm of squashing factor Q between two positive magnetic polarities at the location of strong upflows (region enclosed by rectangle in Figure 1 right side image). *Right*: Inverted Y-shaped magnetic structure at high-Q location or upflow region.