SUPRA ARCADE DOWNFLOWS with XRT INFORMED by DIPOLARIZATION FRONTS with THEMIS

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ABSTRACT:
Magnetic reconnection can rapidly reconfigure the magnetic field of the corona, accelerating plasma through the site of reconnection. Ambiguities due to the nature of remote sensing have complicated the interpretation of observations of the inflowing and outflowing plasma in reconnection regions. In particular, the interpretation of sunward moving density depletions above flare arcades (known as Supra Arcade Downflows — SADs) is still debated. Hinode/xrt has provided a wealth of observations for SADs and helped inform current understanding of these structures. SADs have been interpreted as wakes behind newly reconnected and outflowing loops (Supra Arcade Downflow Loops — SADLs). Models have shown the plausibility of this interpretation, though this interpretation has not yet been fully accepted. We present here observations of newly reconnected outflowing loops observed via situ instruments in the magnetosphere. These observations, provided by five THEMIS spacecraft, show that around retracting loops (dipolarization fronts in this context) similar dynamic temperature and density structures are found as seen in SADs. We compare data from multiple SADs and dipolarization fronts to show that the observational signatures implied in the corona can be directly observed in similar plasma regimes in the magnetosphere, strongly favoring the interpretation of SADs as wakes behind retracting loops.

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COMPARISON OF RECONNECTION IN THE REGIMES (Lin et al 2008):

<table>
<thead>
<tr>
<th>Region</th>
<th>Basic Plasma Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronal</td>
<td>$n_e$ (cm$^{-3}$)</td>
</tr>
<tr>
<td>SADs</td>
<td>10$^7$</td>
</tr>
<tr>
<td>Magnetosail</td>
<td>2x10$^6$</td>
</tr>
</tbody>
</table>

Plasma near the Sun

Simplified cartoons comparing the basic 2D geometry in the corona (left) and magnetosphere (above). While the language is different, the systems are notably similar.

CONCLUSIONS:
In the Earth's magnetosphere, wakes appear behind dipolarization fronts which are outflowing post reconnection loops retracting through the plasma neutral sheet in the magnetotail (as shown by Runov et al 2011). In simplistic terms, similar wakes should appear behind retracting coronal loops in the Supra Arcade Fan. We conclude that in the corona these wakes are SADs, as described in Savage et al 2019. We can now inform studies of SADs and retracting loops in the corona with situ details of retracting loops in the magnetosphere. In particular, we can now better understand the timescales for the density recovery in the loop retraction, how the temperature recovers, and how these compare to the recovery of the Fan magnetic field. These magnetospheric data can also provide insight into the turbulent scales in reconnection. Further analysis of these data are ongoing, and will also provide a better observational footing for the cross-interpretation of SADs and dipolarization fronts when MMS begins providing data from the magnetotail.

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References: