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Out-of-Ecliptic Mission

Seminar

Solar Magnetic Fields and the Corona

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The state of the solar atmosphere, which is considered to include the solar wind, is largely determined by magnetic fields. Both the magnitude and the configuration of fields at photospheric level appear to determine the flux of non-radiative energy, mass, and momentum into the base of the corona. Likewise the interaction between coronal field and plasma modulates the flow and produces the density distribution we see in the corona as well as the state of the interplanetary medium. Rapid annihilations of the field in the lower atmosphere associated with flares and slower readjustments of the field associated with eruptive prominences both lead to disruptions in the structure of the overlying corona and solar wind.

Although a definitive test of the relation between coronal morphology and magnetic fields is still lacking, several characteristic coronal structures are associated with distinct topologies of the field:

- The tightly closed coronal loops and arches above active regions with similar configurations in the field.
- Coronal holes at low latitude or over the poles with magnetic fields which open directly into the solar wind. Such regions appear to be the origin of fast streams in interplanetary space.
- Coronal streamers with large arcades in the magnetic field below 2 to $2.5R_{\odot}$ and a current sheet above that height. Such features are detected as the "sector" boundary between large scale, oppositely directed fields in interplanetary space.
- Hot, dense knots of plasma in the very low corona and visible as "bright points" in X-ray images with minute bipolar regions

distributed more or less uniformly over the surface. In the upper corona and interplanetary space such regions are hypothesized to give rise to minute current sheets which play a role in determining the electrical and thermal conductivity, the propagation of radio waves and energetic particles, and, possibly, coronal heating.

The characteristics of the photospheric field in magnitude, spacial extent, and lifetime suggest that the corona and interplanetary medium can be divided into 3 regions having relatively distinct properties as shown in the table. We note that although interplanetary measurements have sampled both the plasma originating in the latitude zone $\lesssim 10^0$ and shocks originating at higher latitudes, the influence of the 10^0 - 50^0 zone, which contains active regions, on the interplanetary medium is still uncertain.

A real understanding of the structure and evolution of the corona and interplanetary medium can be claimed only after we have constructed a self consistent 3-D model of the entire region and have tested it with concomitant observations in the lower solar atmosphere, in the corona, and in interplanetary space. The Out-of-the-Ecliptic Mission will provide not only the critical tests of such models but will also afford insight into the fundamental mechanisms governing this entire region through the sampling of zones where different field topologies, magnitudes, and evolutionary timescales (and presumably different mechanisms of mass, energy and momentum transport) dominate. Several specific questions may be considered:

- Are the polar regions identical to the coronal holes at low latitude?
- If this is so, how do we account for the fact that polar regions with apparently identical magnetic configuration display a vastly different appearance in the corona?
- Does the coronal and interplanetary microstructure change with latitude? What influence does this have upon the heating, electrical and thermal conductivity, wave content, and energetic particle propagation of the medium?
- How is the corona "mapped" into interplanetary space?
- How does the solar-interplanetary field couple to the interstellar field?
- What role does the continuous occurence of coronal transients, which originate at $\ell \leq 60^{\circ}$, play in determining the state of the interplanetary medium and energetic particle propagation?
- What mechanisms control coronal and interplanetary abundances?

These are but a few of the questions concerning the role of solar magnetic fields in determining the structure of the corona and interplanetary medium which will be explored by an Out-of-Ecliptic Mission.

Concerning the mission options two points should be kept in mind:

1) Although the appearance of the corona suggests that a mission restricted to $\ell < 40^{\circ}$ <u>might</u> be successful in reaching the polar zone, <u>only</u> a polar mission can guarantee that a truly new region of the interplanetary medium is to be explored.

2) The corona and interplanetary medium are continually evolving. To assure success the Out-of-Ecliptic Mission must encompass a coordinated program of solar and interplanetary measurements so that a coherent attack can be made upon the important problems which beckon.

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	PHOTOSPHERE		CORONAL	INTERPLANETARY
Latitude	Field Pattern*	Lifetime	Counterpart	Counterpart
$<10^\circ$	Large Scale Weak	Months to Years	Open Field-Hole Large Closed Field-Streamer	Fast Streamer Sector Boundary
10° to 50°	Active Region	Minutes-Hours	Transient	Shocks + ?
		Month	Open B - ? Closed B - Arches	? None
	Large Scale	S A M E	A S "	$< 10^\circ$
$> 50^\circ$	Large Scale	Years	Open B - Hole	?

*Very Small Scale Patterns With Lifetime ~ Hours Exist at All Latitudes With Only a Weak Decrease Towards the Poles