5. Toward Accomplishment of Science Goals

The unprecedented capabilities of the MIMI investigation, coupled with the comprehensive nature of the overall Cassini mission, will result in an epochal change in our understanding of the space environment of the Saturnian system. A summary of the measurement advances that the MIMI investigation will make over previous measurements would include: (1) the first global magnetospheric imaging of the hot ion populations of the Saturnian magnetosphere, Titan and possibly icy satellite exospheres, and dust interactions within the inner magnetospheric regions; (2) unambiguous composition analysis of hot ions, critical for ascertaining plasma sources, and the first measurement of charge state distributions, critical for the study of processes, such as charge exchange, that fractionate the compositional distributions; and (3) much more comprehensive in situ angular coverage and finer angular resolutions, critical for calculating the charge particle invariant quantities that order the transport of hot plasma populations. These instrumental advances must be added to the advances that will accrue simply from the fact that the Cassini is an orbital mission, allowing a comprehensive in situ survey of all of the critical regions of the Saturnian system. We have emphasized in this paper that the energetic charged particle populations interact strongly with other components of the Saturnian space environment, including Saturn's atmosphere, the rings and dust particulates, neutral gas populations, icy satellite surfaces, and Titan's atmosphere. When the advanced capabilities of the MIMI investigation are combined with other measurements, our understanding of these interactions will also increase dramatically.

Table 5.1 summarizes the anticipated accomplishments of the MIMI investigation. It lists the major science objectives, the observations required for those objectives, and the results expected. Needless to say, such a table must be limited in scope. There is not the space here to discuss the rich array of possible multi-instrument studies involving MIMI and all of the other advanced instrumentation that is flying with the Cassini mission.

TABLE 5.1
Expected accomplishments of the MIMI investigation

OBJECTIVE	MIMI PRODUCT	INTERPRETATION
Global Morphology of Saturn's Magnetosphere	ENA Images (remote) Orbital Intensity Survey (in situ)	Direct views of remote images; Image inversion; Combine with UVIS neutral gas images; Orbital data assimilation statistics and models.
Plasma Source(s)	Composition and Charge State Distributions, Energy spectra	Species identification; Ionization states; Source process modeling; Analysis of CRAND spectral features
Plasma Energization	Energy spectra (in situ); Pitch angle distributions (in situ); ENA images (remote)	Location and evolution of energization events; Spatial and temporal evolution of spectra
Global dynamics and possible substorms	ENA images (remote); Orbital intensity survey (in situ)	Direct views of remote images; Image inversion; Orbital data assimilation and orbit-to-orbit comparisons
Plasma Convection	Ion angular Distributions (in situ)	Quantitative plasma flow analysis
Hot plasma and radiations transport	Phase space densities (in situ); Intensity profiles (in situ); ENA dust interaction image (remote)	Diffusion theory analysis of phase space densities; Material interaction feature evolution analysis (e. g. satellite macro/micro signatures), dust interaction modeling
Saturnian Aurora energy source	ENA images (remote); Orbital survey of electron and ion spectrum moments (in situ), phase space densities.	Correlate hot plasma dynamics with auroral dynamics; Quantitative analysis of electron and ion energy precipitation limits; Pitch angle diffusion analysis.
Hot plasma/Saturnian atmosphere interactions	Composition spectra (in situ)	Identification of atmospheric species by location
Hot plasma/satellite and Ring interactions	ENA images (remote); Intensity profiles, phase space densities, composition spectra (in situ)	Quantitative ENA intensity analysis of dust emissions; Micro/macrosignature transport analysis; Species identification; Quantitative surface deposition sputtering calculations
Titan Remote Monitoring of Magnetospheric Dynamics	Remote ENA images of Titan	Analysis of position of magnetopause based on the intensity of Titan ENA emissions
Jovian Science	ENA Images (remote), Ion Composition and Charge State distributions (in situ)	Images analysis and sorting by various system drivers (solar wind, Jupiter rotation, Io position, etc.); Composition source analysis; Analysis of charge state in context of hot plasma transport models

6. Summary

It is beyond doubt that the Cassini Orbiter mission to Saturn will increase manyfold our knowledge of the overall Kronian system, beginning with the rings, Titan, icy moons, magnetosphere, atmosphere, aurora, dust environment, etc. If any proof were needed, it has been provided by the spectacular Galileo results from the Jovian system and the preliminary results from Cassini's flyby at Jupiter.

The MIMI investigation is designed to make key contributions to each of the subjects enumerated above, using an array of sensors that will provide comprehensive measurements of the hot plasmas in Saturn's environment with unprecedented resolution in energy and species. Furthermore, MIMI's ability to image plasmas indirectly, through their ENA emissions, represents a heretofore unreachable objective of space plasma research that has long eluded instrument designers in this field. It has been amply demonstrated on the IMAGE mission in Earth orbit (Mitchell et al., 2001). This new capability opens up a large class of studies on plasma dynamics that may enable us to not only address long-standing unsolved questions (e.g., substorm initiation and development) in magnetospheric physics, but also lead to radically new insights on the large-scale structures and evolution of such systems.

The inflight performance of the instrument has been nominal so far, and we expect that to continue through Saturn orbit insertion and the 4-year encounter operations. The comprehensive Orbiter payload will make possible a large array of collaborative studies that guarantee an exciting harvest of scientific results.

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