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ENERGETIC NEUTRAL ATOM PRECIPITATION (ENAP)

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The objective of this experiment is to measure very faint emissions at nighttime arising from fluxes of energetic neutral atoms in the thermosphere. These energetic atoms have energies ranging up to about 50 keV, and arise from ions of hydrogen, helium, and oxygen trapped in the inner magnetosphere. Some of these ions become neutralized in charge exchange reactions with neutral hydrogen in the hydrogen geocorona that extends through the region. The ions are trapped on magnetic field lines which cross the equatorial plane at 2 to 6 Earth radii distance, and they mirror at a range of heights on these field lines, extending down to the thermosphere at 500 km altitude.

During magnetic storms the fluxes of trapped particles greatly increase, and their drift motion around the Earth constitutes the ring current. This current of several million amperes is one of the major elements of the magnetospheric current system detectable as a worldwide magnetic storm.

The energetic neutral atoms (produced when the ring current ions undergo charge exchange) travel on straight line trajectories, and the spray of neutrals impacts the thermosphere at low, middle, and high latitudes, as well as traveling freely through interplanetary space. Figure I-13 illustrates the geometry of the process. During magnetic storms, detection of these energetic neutrals by instruments on the IMP and ISEE spacecraft in interplanetary space has allowed a primitive image of the ring current to be made. Prospects are very good for high quality images to eventually be made with specialized instruments, which will show the distribution of H^+, He^+, and O^+ and their energies, as well as the location and the nature of the growth and decay of the ring current.

The ATLAS 1 measurements will not be of the neutral atoms themselves but of the optical emission produced by those on trajectories that intersect the thermosphere. At middle and high latitudes during magnetic storms the energetic neutrals will be accompanied by ions dumped directly from the ring current if the configuration of electric and magnetic fields in the magnetosphere is such (as it often is during the initial phases of magnetic storms) that the mirror height of the ions is lowered into the dense thermosphere below 500 km. When the processes which lower heights cease, the charge exchange at heights out to several Earth radii continues to produce the spray of energetic neutrals into interplanetary space and the thermosphere. Even under quiet magnetic conditions, small fluxes of energetic neutrals will be present.

In the thermosphere, the directly precipitated ions are likely to charge exchange and become neutrals, and some neutrals are likely to become re-ionized in collisions with thermospheric constituents. The net result of precipitation of either energetic neutrals or ions after the first few collisions in the thermosphere is a flux of energetic neutrals and ions (mostly neutrals) that produce optical emission, ionization, and heating of the thermospheric constituents.

The optical emission is one component of low-latitude aurorae that have distinctly different spectral properties from the normal polar aurora that is excited by kilovolt electrons. A characteristic of collisional excitation by heavy particles is that they transfer momentum and excite vibrational and rotational levels of molecules.

Thus, high vibration and rotational excitation levels of ionized molecular nitrogen (the N_2^+ 1N bands) is a signature of hydrogen atoms or protons with energy below 2 keV, of helium ions with energy below 8 keV, and of oxygen atoms or ions with energy below 30 keV. Other characteristics include Doppler broadened lines of H, He, and O. At times the low-latitude aurorae show a brilliant red color due to atomic oxygen (6300 Å) emission. This is not due to the energetic neutral atoms and ions, but rather to large currents of low-energy electrons (about 1 eV) which at times accompany the development of the ring current. When the low-energy electrons are absent, the aurora has a whitish color.

The ENAP measurements are to be made using the Imaging Spectrometric Observatory (ISO) that was designed and built by Marsha Torr. The ISO is being flown on the ATLAS mission primarily for daytime spectral observations, and the ENAP measurements will all be nighttime measurements because of the faintness of the emissions and the relatively low level of magnetic activity expected. Only in major magnetic storms does the emission become bright enough to be visible to the naked eye. The observations from orbit will be able to detect much fainter emissions than from the ground, owing to the sideways view through the emitting layer, the lack of the foreground of brighter airglow emissions at lower altitudes, and the very high sensitivity of the ISO instrument itself. From the latitude and time variations of different emissions, we hope to better understand the nature of neutral atom precipitation, its effects on the thermosphere, and the possibilities for future use of the phenomenon for imaging the ring current.

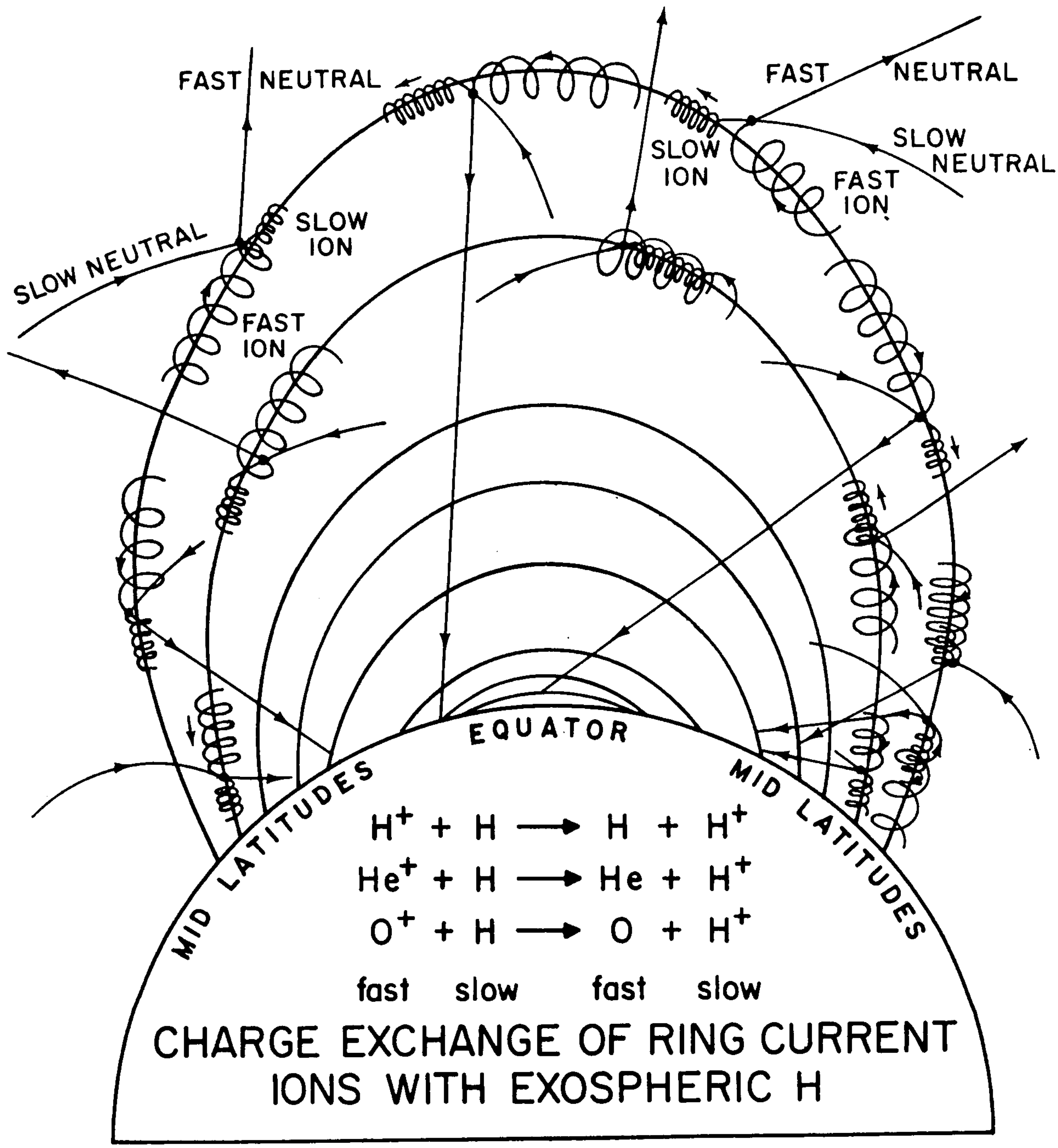

Figure I-13. Geometry of the production of energetic neutral atoms of H, He, and O from the corresponding trapped ions H^+, He^+, and O^+ in the ring current.