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Laboratory Simulation of Basic Space Plasma Phenomena

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A rich variety of wave phenomena exist in virtually every region of the geospace environment. Understanding of the various wave signatures and driving mechanisms provided insight into the local conditions, not only at the instant that the waves are observed, but also into how the conditions may evolve in time. Comprehensive, controlled investigations of the detailed microphysics associated with these waves are difficult to accomplish through *in situ* methods alone. Space-based measurements typically offer a statistical picture, built up over long periods of time and under varying conditions. Consequently, properly scaled laboratory experiments performed under controlled, repeatable conditions can offer an important complementary approach to investigating the space plasma wave dynamics.

We present an overview of several key wave modes found in the various regions with a particular emphasis on significant contributions of laboratory investigations toward the present understanding of the wave dynamics, validation of theoretical models, and interpretation of the *in situ* observations.

We focus on examples of laboratory investigations carried out in the Naval Research Laboratory's Space Physics Simulation Chamber (SPSC), shown in Figure 1. The SPSC is one of the most unique devices in the world for basic plasma experimentation and for the realistic simulation of space plasma phenomena. Large volume, steady-state, space-like plasmas with conditions variable over wide ranges are created and used to simulate of many different regions of the near-Earth space plasma environment. SPSC experiments have investigated diverse phenomena such as radiation belt dynamics, radiation belt remediation, broadband ionospheric ion-cyclotron wave generation, wave and Joule heating of ionospheric plasma, and nonlinear magnetospheric particle and wave dynamics. Innovative new diagnostic instruments for space and laboratory use have been developed by the SPSC Group, with hardware testing/qualification performed in the SPSC's ionospheric-like plasmas prior to space flight.

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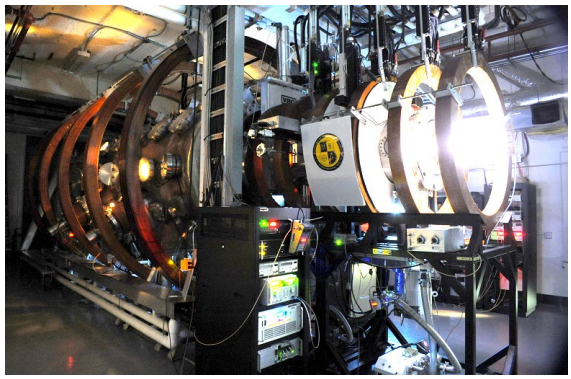

Figure 1. The NRL Space Physics Simulation Chamber.