Space Measurements of A Rocket-Released Turbulence (SMART) is a Future Experiment to Study Turbulence Effects on the Radiation Belts

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We describe a future experiment, Space Measurements of A Rocket-Released Turbulence (SMART), which will explore the role of the weak turbulence process known as nonlinear (NL) scattering in space plasmas. The experiment will seed electrostatic lower-hybrid (LH) waves in the ionosphere and make coordinated measurement of the scattered electromagnetic (EM) waves (e.g., whistlers) with both a sounding rocket in the ionosphere and remotely by a satellite in the magnetosphere. The effect of Very Low Frequency (VLF) whistler turbulence is of particular importance to the dynamics in the inner magnetosphere and the radiation belts, but also has more global relevance, e.g. in solar wind turbulence.

The SMART sub-orbital sounding rocket is modeled after similar, but not identical experiments conducted since the mid-1970s which generated high speed Barium (Ba) atoms using shape-charge explosion to accelerate Ba atoms to velocities of 8 – 10 km/s perpendicular to the Earth's magnetic field. In SMART, the Ba atoms are photo-ionized forming a ring velocity distribution of heavy Ba+ that is unstable and known to generate LH turbulence. Recent theoretical analysis indicate that weak turbulence processes, in particular the NL scattering of LH waves into whistlers, is critical to the radiation belt dynamics but has not been characterized in the space environment. This critical feature will be tested and validated in the proposed experiment. Previous experimental Ba explosive releases measured large amplitude electric fields; indicate the generation of electromagnetic waves and, in one case, energetic particle precipitation. However, none of these experiments had sufficient measurements to separate the EM contribution to the electric field and confirm NL scattering.

Satellite measurements will detect the propagation of the SMART-generated waves and their effects in the radiation belts. Possible satellites to be used in SMART are the NASA Van Allen Probe, Japanese Arase/ERG Air Force DSX, Canadian Cassiope/ePOP or NASA Themis satellites. The SMART mission will lead to a better understanding of the ability of NL scattering to convert electrostatic LH waves into EM whistlers, the loss processes in the radiation belts, and their connection to weak turbulence.