An Experimental Concept for Probing Nonlinear Physics in Radiation Belts*

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A sounding rocket based experiment, Space Measurement of Rocket-Released Turbulence (SMART), to probe the nonlinear response to a known stimulus injected into the radiation belt has been developed. Release of high-speed neutral barium atoms (8- 10 km/s) generated by a shaped charge explosion perpendicular to the Earth's magnetic field in the ionosphere can be used as the source of free energy to seed turbulence in the ionosphere. The Ba atoms are photo-ionized forming a ring velocity distribution of heavy Ba+ that is known to generate lower hybrid waves [1]. Induced nonlinear scattering of the lower hybrid waves into EM whistler/magnetosonic waves has been established [2,3]. 3D PIC simulations confirm the generation of lower hybrid turbulence by an ion ring distribution [4] and the scattering of these waves into EM whistlers [5]. The escape of the whistlers from the ionospheric region into the radiation belts and the effects of nonlinear scattering on the evolution of these waves have been studied and their observable signatures quantified [6]. The fraction of the neutral atom kinetic energy converted into waves in the ionosphere is estimated at 10 – 12 % [7].

The novelty of the SMART experiment is to make coordinated measurement of the cause and effect of the turbulence in space plasmas and from that to deduce the role of nonlinear scattering in the radiation belts. Sounding rocket will carry a Ba release module and an instrumented daughter section that includes vector wave magnetic and electric field sensors, Langmuir probes and energetic particle detectors. The goal of these measurements is to determine the whistler and lower hybrid wave amplitudes and spectrum in the ionospheric source region and look for precipitated particles. The Ba release may occur at ~ 600-700 km near apogee. Ground based cameras and radio diagnostics can be used to characterize the Ba and Ba+ release. The Van Allen Probes can be used to detect the propagation of the nonlinear scattering-generated whistler waves and their effects in the radiation belts. By detecting whistlers and measuring their energy density in the radiation belts the SMART mission will confirm nonlinear scattering of electrostatic lower hybrid waves into whistlers and other nonlinear responses of the radiation belts and their connection to weak turbulence.

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