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Active Control of the Radiation Belt Particle Populations with Ionospheric Amplification of VLF Waves

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Ground-based VLF transmitters located around the world generate signals that leak through the bottom side of the ionosphere in the form of whistler mode waves. Wave and particle measurements on satellites have observed that these man-made VLF waves can be strong enough to scatter trapped energetic electrons into low pitch angle orbits, causing loss by absorption in the lower atmosphere. This precipitation loss process is greatly enhanced by intentional amplification of the whistler waves in the ionosphere using a newly discovered process called Rocket Exhaust Driven Amplification (REDA). Satellite measurements of REDA have shown between 30 and 50 dB intensification of VLF waves in space using a 60-second burn of the 150 g/s thruster on the Cygnus satellite that services the International Space Station (ISS) [Bernhardt et al. 2021; Bernhardt 2021]. This controlled amplification process is adequate to deplete the energetic particle population in the radiation belts in a few minutes rather than the multi-day period it would take naturally. Numerical simulations of the pitch angle diffusion for radiation belt particles use the UCLA quasi-linear Fokker Planck model (QLFP) to assess the impact of REDA on radiation belt remediation (RBR) of newly injected energetic electrons [Bernhardt et al., 2022]. The simulated precipitation fluxes of energetic electrons are applied to models of D-region electron density and bremsstrahlung x-rays for predictions of the modified environment that can be observed with satellite and ground-based sensors.

References:

Bernhardt, P.A., et al., Strong Amplification of ELF/VLF Signals in Space Using Neutral Gas Injections from a Satellite Rocket Engine (2021), Radio Science, 56(2), e2020RS007207, https://doi.org/10.1029/ 2020RS007207.

Bernhardt, P.A., The Whistler Traveling Wave Parametric Amplifier (WTWPA) Driven by an Ion Ring-

Beam Distribution from a Neutral Gas Injection in Space Plasmas (2021), IEEE Transactions on Plasma Science. 49, 6, 1983-1996, DOI: 10.1109/TPS.2021.3079130.

Bernhardt, P.A., et al., Active Precipitation of Radiation Belt Electrons using Rocket Exhaust Driven Amplification (REDA) of Man-Made Whistlers, Submitted to the Journal of Geophysical Research, 2022.