EMIC wave injection in space at the several nanotesla level based on a novel, compact Single Domain Nanoparticle Antenna (SDNA)

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Recent observations from the *Van Allen*, *Themis* and *Cluster* missions confirmed the ubiquity and importance of left hand polarized *Electromagnetic Ion Cyclotron* (*EMIC*) waves in controlling the observed fast precipitation of MeV *Radiation Belt* (*RB*) electrons and plasma-sphere protons. The EMIC waves are generated by instabilities due to the presence of anisotropic ion distributions in regions of high plasma density. Many of the observations indicate that threshold *EMIC* amplitudes in excess of 1-10 nT result in: (i) Strong scattering of ring current ions and >1MeV electrons especially near the loss cone (Thorne et al., JGR 2006); (ii) Triggered non-linear rising tone coherent EMIC emissions (Omura et al., JGR 2010). We present here evidence that such amplitudes can be injected from *CubeSats* using a novel antenna concept, based on *Single Domain Nanoparticles* (*SDN),* with important implications on using active experimentation in both the understanding of the critical EMIC wave-particle interactions at high amplitudes as well as potential practical applications, including *Radiation Belt Remediation.* The new antenna concept -*SDNA*- is based on recently manufactured, small (10-20 nm radius), single domain, non-interacting magnetic grains with uniaxial magnetic anisotropy, dispersed in low viscosity or solid non-conducting matrix. *SDN*s can be described as ensembles of non-interacting magnetic moments **m** that when driven by an AC magnetic field behave in manner similar to ordinary paramagnets, except that SPNs are composed of many thousands of magnetic atoms and as a result have susceptibilities comparable to ferromagnets but with very low coercivity and almost no hysteresis loss. The Langevin function accurately describes the dynamic behavior of the magnetization in the presence of low frequency AC fields since their response time to the driver AC magnetic field is less than 10 μsecs. The ensemble of magnetic grains is driven to rotation at the desired *EMIC* frequency by a pair of crossed solenoid coils surrounding the grain container tubes. The near field electric field associated with the rotating magnetic field drives plasma currents such as were observed in *Rotating Magnetic Field* (*RMF*) experiments at the UCLA/LAPD chamber [Gigliotti et al., Phys. of Plasmas 2009; Karavaev et al., Phys. of Plasmas 2010]. The magnetic moment of the AC coil is amplified by the susceptibility χ of the SPN ensemble that depending on the grain size and material can reach values of 10^4-10^5. Proof of principle experiments at LAP using ferrites as a proxy for the high μ indicated good coupling to the plasma and increase of the radiation resistance by a factor of μ^2. This increase combined with the high gain associated with the less than one degree injection angle of guided *EMIC*s near the H^+ resonance results in wave amplitudes larger than 10 nT over distances of 1000 km from the injection point for driving currents less than 10 A.

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