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Destruction of a Magnetic Mirror-Trapped Hot Electron Ring by a shear Alfvén Wave[1]

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Highly energetic electrons produced naturally or artificially can be trapped in the Earth's radiation belts for months, posing a danger to valuable space satellites. Concepts that can lead to radiation belts mitigation have drawn a great deal of interest. In this work, we demonstrate that a shear Alfvén wave (SAW) can effectively de-trap energetic electrons confined by a magnetic mirror field. The experiment is performed in a quiescent afterglow plasma in the Large Plasma Device (LaPD) at UCLA ($n_e = 0.1 - 1 \times 10^{12}/cm^3$, $T_e \approx 0.5eV$, $B_0 = 400 - 1600G$, $L = 18m$, and $diameter = 0.6m$). A hot electron ring, along with hard x-rays of energies of $100keV \sim 3MeV$, is generated by 2nd harmonic ECRH and is trapped in a magnetic mirror field ($L = 3.5m$, $R_{mirror} = 1.1 - 4$). A shear Alfvén wave ($f \sim 0.5 f_{ci}$, $B_{wave}/B_0 \sim 0.1\%$) is launched with a rotating magnetic field antenna with arbitrary polarization. Irradiated by the SAW, the electrons are lost periodically with the characteristic frequency of the SAW, and the ring m number changes. The periodical loss of electrons continues even after the termination the wave. The effect is found to be caused only by the right-hand (electron diamagnetic direction) circularly polarized component of the SAW. Hard x-ray tomography, constructed from more than 1000 chord projections at each axial location, shows electrons are lost in both the radial and axial direction. X-ray spectroscopy shows electrons over a broad range of energy de-trapped by the SAW. The de-trapping process is found to be accompanied by electro-magnetic fluctuations in the frequency range of $1 \sim 5 f_{LH}$, which are also modulated at the frequency of the SAW. To exclude the possible role of whistler waves in this electron de-trapping process, whistler waves at these frequencies are launched with an antenna in absence of the SAW and no significant electron loss found.

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