3rd Asia-Pacific Conference on Plasma Physics, 4-8,11.2019, Hefei, China

Nonlinear drift resonance between charged particles and ultra-low frequency waves

Xu-Zhi Zhou[1], Li Li[1], Yoshiharu Omura[2], Qiu-Gang Zong[1], Sui-Yan Fu[1]
[1] School of Earth and Space Sciences, Peking University, Beijing, China
[2] Research Institute for Sustainable Humanosphere, Kyoto University, Kyoto, Japan
e-mail (speaker): xzzhou@pku.edu.cn

In Earth's Van Allen radiation belts, ultralow frequency (ULF) waves play an important role in accelerating and transporting charged particles via a resonant process named drift resonance[1,2]. When such a resonance occurs, a resonant particle observes a constant phase of the wave electric field, and therefore experiences a net energy excursion. In the conventional theory of drift resonance, a linearization approach is often applied with assumption of a weak wave-particle energy exchange. Here we extend the linear theory of drift resonance into the nonlinear regime[3], to express the particle motion in the form of pendulum equation that describes the nonlinear trapping of particles in the wave-carried potential well, and to predict characteristic signatures of the nonlinear process observable from a virtual spacecraft. Such newly predicted signatures are found to agree with observations from NASA's Van Allen Probes, which provides the first identification of nonlinear drift resonance. We further consider the roles of magnetospheric convection in this nonlinear process, which provides a location-dependent driver term to the pendulum equation of particle motion. The driven pendulum equation suggests a significant particle diffusion and thermalization, especially for ULF waves with large wavenumbers. This study, therefore, shed new light on the understanding of particle dynamics in the inner magnetosphere.

References

1. Southwood, D. J., and M. G. Kivelson (1981), Charged particle behavior in low-frequency geomagnetic pulsations: I. Transverse waves, J. Geophys. Res., 86, 5643.
2. Southwood, D. J., and M. G. Kivelson (1982), Charged particle behavior in low-frequency geomagnetic pulsations. II - Graphical approach, J. Geophys. Res., 87, 1707.
3. Li, L., X.-Z. Zhou, et al. (2018), Nonlinear drift resonance between charged particles and ultralow frequency waves, manuscript in preparation