Modeling the Interactions between Plasma Waves and Energetic Particles in the Inner Magnetosphere

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Recent in situ satellite observations showed changes by orders of magnitude in the intensity of near-Earth ion and electron fluxes occurring in less than a day. Such nonlinear response of the space environment is usually attributed to competing acceleration and loss processes that affect the global state of the system on various spatial and temporal scales. The interactions of ions and electrons with plasma waves play a significant role in this process and represent some of the main research topics of Prof. Richard M. Thorne distinguished career. In honor of his scientific achievements and leadership, we present recent advances in understanding wave-particle interactions in the inner magnetosphere. In this complex near-Earth plasma environment, electrons and ions are transported from the magnetotail, undergo "betatron" acceleration, and lead to the excitation of whistler mode chorus and electromagnetic ion cyclotron (EMIC) waves, respectively. The generated waves, in turn, scatter the energetic particles to reduce their anisotropy and restore stability. During successful collaborations with Prof. Thorne and his research group, we developed state-of-the-art physics-based models to simulate the excitation of these waves, as well as their subsequent propagation and feedback on the energetic particles. We have found that as geomagnetic activity increases, sufficient free energy is available in the unstable particle distributions to induce the growth of plasma waves in the equatorial magnetosphere with high spatial and temporal variability. We show representative results from these collaborative investigations of wave-particle interactions under various geomagnetic conditions. In addition, we discuss the further need of more self-consistent modeling studies to quantify the integrated global effect of these waves on the near-Earth radiation environment.