Bounce Resonance between ˜10 keV Protons and Poloidal Pc4 waves Observed by Van Allen Probe A

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We report the bounce resonance between ˜10 keV protons and poloidal Pc4 waves with a wave frequency of 7.2 mHz observed by Van Allen Probe A on 28th January 2014. There were two onsets of the poloidal waves at 2010 and 2055 UT with simultaneous proton flux oscillations at 11.2-24.7 keV for the first event and at 8.3-17.4 keV for the second event. We determined that the poloidal waves are second harmonic waves. The onset coincidence of the waves and the flux oscillations implies a causal relationship between the second harmonic poloidal waves and the low energy protons. These proton flux oscillations are embedded in the injection of protons, suggesting the injection may create unstable particle distribution and excite the waves. Using the ion sounding technique (e.g., Min et al., 2017; Takahashi et al., 2018), we confirmed eastward propagation of the poloidal waves (m $>$0) and m is estimated to be 170-270.

The m number of poloidal waves excited by the bounce resonance was not concerned in previous studies (e.g., Hughes & Kivelson, 1978; Liu et al., 2013), because they assumed a resonance condition of w = w_b ˜0, where w is a wave frequency and w_b is a bounce frequency. We estimated the m number from a more general form of the resonance condition (w - mw_d = Nw_b, where w_d is drift frequency (Southwood et al., 1969), with the wave frequency of 7.2 mHz and the resonance energy of protons of ˜10 keV), and obtained m ˜+270 for the bounce resonance (N = +1). Therefore, the bounce resonance with eastward propagating waves indeed took place in this event. It has been considered that westward propagating waves are generated through drift-bounce resonance (e.g., Takahashi et al., 1990; Dai et al., 2013; Oimatsu et al., 2018). This study, however, suggests that eastward propagating waves are also excited through the bounce resonance.

From the ion sounding technique, we also examined the radial gradient of the phase space density.The steep radially-outward gradient of the proton phase space density was found at the two onsets of the waves. This indicates that the injected protons enhance the phase space density in the outside region, and the resulting outward gradient provides energy for the waves.