Pc4 ULF waves and proton flux oscillations observed by the Arase satellite in the morning sector during satellite-ground conjunction: Evidence for giant pulsations

*山本 和弘[1]、能勢 正仁[1]、笠原 慧[2]、横田 勝一郎[3]、桂華 邦裕[2]、松岡 彩子[4]、寺本 万里子[5]、野村 麗子[4]、高橋 主衛[6]、Massimo Vellante[7]、Balazs Heilig[8]、藤本 晶子[9]、田中 良昌[10]、篠原 学[11]、篠原 育[4]、三好 由純[5]
*Kazuhiro Yamamoto[1], Masahito Nose[1], Satoshi Kasahara[2], Shoichiro Yokota[3], Kunihiro Keika[2], Ayako Matsuoka[4], Mariko Teramoto[5], Reiko Nomura[4], Kazue Takahashi[6], Massimo Vellante[7], Balazs Heilig[8], Akiko Fujimoto[9], Yoshimasa Tanaka[10], Manabu Shinohara[11], Iku Shinohara[4], Yoshizumi Miyoshi[5]

1. 京都大学大学院理学研究科、2. 東京大学、3. 大阪大学、4. 宇宙航空研究開発機構、5. 名古屋大学、6. Johns Hopkins University Applied Physics Laboratory、7. University of L'Aquila、8. Geological and Geophysical Institute of Hungary、9. 九州大学、10. 国立極地研究所、11. 鹿児島工業高等専門学校
1. Graduate School of Science, Kyoto University, 2. The University of Tokyo, 3. Osaka University, 4. Japan Aerospace Exploration Agency, 5. Nagoya University, 6. Johns Hopkins University Applied Physics Laboratory, 7. University of L'Aquila, 8. Geological and Geophysical Institute of Hungary, 9. Kyushu University, 10. National Institute of Polar Research, 11. National Institute of Technology, Kagoshima College

We studied interaction between westward propagating ULF waves and energetic protons observed in the morning sector by the Arase satellite and ground magnetometers on April 15, 2017. Arase was passing the equatorial region during 01-02 UT and found that the compressional component of the magnetic field was oscillating at a frequency of 12.5 mHz. Proton flux at energy of > ~70 keV and pitch angles around 90° was also oscillating at the same frequency. By using a finite Larmor effect that appeared in proton flux observation, we estimated the azimuthal wave number (*m* number) to be -30 to -40. We also studied wave polarization and *m* number using data from the European quasi-Meridional Magnetometer Array (EMMA) [*Lichtenberger et al.*, 2013]. A polarization reversal from counter clockwise at low latitude to clockwise at high latitudes was detected at Ranua (MLAT = 62.1°), Ivalo (MLAT = 65.1°), and Kevo (MLAT = 66.3°). This is one of the common properties of giant pulsations (Pgs) observed on the ground. The estimated *m* number is -30 to -50, slightly higher than those reported in previous studies [e.g., *Takahashi et al.*, 1992; *Chisham et al.*,1997; *Glassmeier et al.*, 1990; *Motoba et al.*, 2015]. The eigen-frequency of the field line at the Arase satellite obtained using the MHD wave equation derived by *Singer et al.* [1981] suggests that the waves were excited at the fundamental mode. The pitch angle dependence of proton flux oscillations also implies odd mode waves according to *Southwood and Kivelson* [1981]. We theoretically estimated the *m* number to be -47 from a drift resonance signature, an amplitude peak of proton flux oscillations at 109.6 keV. Since this *m* value is comparable to those obtained using the other methods, the drift resonance between fundamental mode ULF waves and ~100 keV protons is considered to be present in this event. In addition, we found intensification of the radial gradient of proton phase space density at 109.6 keV, which can explain the excitation of the observed waves. The time evolution of the unstable distribution suggests a causal relationship between the ULF waves and energetic protons.

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