Feasibility of the exploration of the subsurface structures of Jupiter's icy moons by Jovian hectometric radiation

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A new method for detection of the subsurface structures in the ice crust of Jupiter's moons by using interference patterns found in the spectrogram of the Jovian hectometric radio emissions (HOM) have been proposed. In Jupiter icy moon explorer (JUICE) mission, plasma wave observation around icy moons are planned by using radio and plasma wave instrument (RPWI). In this observations, we will be able to obtain spectrograms of the HOM propagating from Jupiter. Because the emissions directly from Jupiter can be interfered with the emissions reflected at the icy moon's surface and subsurface boundaries, we will find interference patterns in the measured spectrograms. In case of the Earth's Moon, the lunar orbiter SELENE detected the interference patters in the spectrograms of auroral kilometric radiation (AKR) [Ono et al., 2010; Goto et al., 2011]. Because the interference occurs between AKR directly from the earth and AKR reflected at the lunar surface, the amplitude of the interference patterns are almost constant. In case of Jupiter's icy moons, HOM directly from Jupiter, HOM reflected at the icy crust surface, and HOM reflected at the fully-freezed/partial-melted or high/low-porosity boundary in the ice crust. Due to slight phase difference between HOM emissions reflected at the surface and subsurface boundaries, the amplitude of the interference patterns will be modulated. The depth of the liquid ocean can be determined the frequency width of the modulation. Assuming that the frequency of HOM is ~10 MHz, the permittivity of the icy crust is 3, permittivity of the melted ice is 87, loss rate in the icy crust is 2-9 dB/km, and spacecraft height is 500 km, the maximum detection depth is estimated to be 6-23 km, which is less than the estimated ice thickness of the Ganymede, 150 km [Kivelson et al., 2002]. On the other hand, we can also expect lower attenuation rate than 2-9 dB/km in a depth range where the ice temperature is much lower than 240 K. The receiver's specifications needed for measurement of the interference patterns in the spectrogram are as follows: (1) Frequency resolution: 100 Hz, and (2) The interval of spectrum measurements: 30 sec. In addition, the following two issues have to be considered in actual application: (a) HOM itself has band structures in the spectrogram due to anisotropy of the emission at the source. (b) The roughness of the surface and subsurface boundaries has to be within the half wavelength (~15 m). (c) The delay by inhomogeneity of TEC of the moon's ionosphere has to be less than the half of the period of the HOM (~0.05msec), which corresponds to the dTEC ~ 9.3 x 10^{12} m^{-2}.

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