Radar sounder for exploration of ices below the surface of the Moon and the Mars

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Design of high resolution radar sounders onboard the orbiter and rover for exploration of the ice below the surface of the Mars and the Moon has been investigated.

In the polar regions of the Mars, there are thick ice layers called polar layered deposits, which were investigated in detail by radar sounders onboard the Mars Express [Orosei et al., 2015] and Mars Reconnaissance Orbiter [Philips et al. 2008; Foss et al., 2017]. However, the presence of the subsurface ices in low and mid-latitude regions is still being discussed. Some theoretical studies suggest that ice has been lost due to sublimation [Grimm et al., 2017] while some observations such as surface radar echoes [Mouginot et al., 2012; Castaldo et al., 2017] and gamma ray spectrometer [Feldman et al., 2004; Boynton et al., 2007] suggest the presence of the subsurface ice. Because the subsurface ice layers in low and mid-latitude regions are considered to be thin if it exists, we propose radar onboard the orbiter with an operation frequency of 50-150 MHz to perform global survey of the ice up to depth of 100 m at a resolution of 1.5 m, which is better than that of the previous Martian radar sounders.

In the polar region of the Moon, presence of the subsurface ice has been discussed in many studies [Watson et al., 1961; Arnold 1979; Feldman et al., 1998; Haruyama et al., 2008; Colaprete et al., 2010; Spudis et al., 2013]. Although we have no information on the depth, size, and abundance of the subsurface ice, we proposed a ground penetrating radar (GPR) onboard the rover with operation frequency of 1-15 GHz to detect the ice up to depth of 3 m at a resolution of 1 cm because we will not be able to utilize deeper ice if we find it.

The bulk permittivity of the regolith with porosity of 45% is estimated to be 2.8. If 10% and 100% of pore are filled by ice, the bulk permittivities of the regolith change to 2.9 and 4.9 respectively. So, we will find the subsurface ice as (1) bulk permittivity contrast derived from echo delay, and (2) amount of the bulk permittivity estimated from echo intensity.