Asteroid Radio Tomography : Looking Inside Small Bodies at 10 meter wavelengths.

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Asteroid mining will require evaluation not only of the surface geology of a candidate asteroid, but ideally also a view of the interior of the body. This ability is important for either mission concept currently under consideration for the NASA Asteroid Retrieval Mission (ARM), and also for asteroid prospecting (the evaluation of asteroids as mining candidates). It should be possible to use 10 - 40 MegaHertz (MHz) radio waves to observe completely through the interior of many types of small (< 100 meter diameter) Near Earth Objects (NEO), as the MARSIS (1.3 - 5 MHz) and SHARAD (15 - 25 MHz) radar systems in orbit around Mars, which have demonstrated the ability for ground penetrating radar to image many 100‘s of meters underneath the Martian surface. These radars, however, have horizontal resolutions of 100’s of meters based on aperture (delay-Doppler) synthesis using the ~ 2 km / sec orbital velocity of a Mars satellite. In addition an orbiting radar is ~ 300 km from the Martian surface, which both requires a fairly powerful radar (SHARAD, for example, is a 10 W radar) and, with ~ 2 msec Round Trip Time (RTT) for radar pulses, allows for a temporal separation of transmit and receive windows (SHARAD uses a 85 microsecond transmit chirp and a 135 microsecond receive window).

The physics of radio tomography of small NEO is almost entirely different from the Martian case. The current ARM mission plan intends for an examination of a target NEO at ~ 1 km, at which distance the spacecraft stationkeeping velocity is negligible (orbital velocities of a small NEO at 1 km are of order 1 cm / sec), RTTs are of order a few microseconds, and the entire asteroid is of a size comparable to the first Fresnel zone at 30 MHz (implying that diffraction cannot be ignored for these small bodies). In addition, for both ARM and for asteroid prospecting the mass and power consumption of radio systems would be severely constrained.

This talk will describe the principles of Asteroid Radio Tomography (ART). While ART could potentially use both active radar, the Jupiter-Io decametric S-bursts are an interesting possible radio source for ART. These bursts are predictable, circularly polarized, very strong (~10^5 Janskies as seen from a NEO orbit), naturally chirped in frequency, and very coherent, with brightness temperatures > 10^{10} K. A 10 meter helical radio antenna being designed for the Solar Scout mission would have a 30 MHz sensitivity of 500 Janskies or better, and could potentially observe these Jupiter bursts completely through a 100 meter rubble-pile type asteroid. The ability to forgo the mass and power consumption of a radar transmitter would have, of course, numerous benefits, and this technique should be considered for future asteroid missions.