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THE ARECIBO OBSERVATORY'S LEGACY AND FUTURE RADAR CAPABILITIES

Abstract

Ground-based radar systems are critical for physical and dynamical characterization of near-Earth objects (NEOs) and space debris. The operational aspect and applications of radar for planetary defense and space situational/domain awareness (SSA/SDA) are similar, but there are some factors that should be taken into account for an instrument to support both areas: planetary defense is focused on asteroids and comets in heliocentric orbit with perihelion distance <1.3 au. Special attention is given to potentially hazardous objects (PHOs), which are NEOs larger than 140 meters that can get closer than 0.05 au. Radar can quickly and accurately determine their future trajectory, therefore, the sooner an object can be observed, the safer it is to asses any possible threat, as well as to obtain information about its properties to plan for an impact mitigation mission if needed; for SSA, the focus is artificial objects orbiting Earth. Different from planetary defense, even debris of order of millimeters are a concern, as it can affect space operations. Since debris is much closer to Earth than NEOs when being observed, the system needs to be able to both track and switch between transmitting and receiving quickly, which can be remediated by operating in a bistatic configuration. Tracking objects above LEO requires a more powerful radar transmission. The strength of the radar return signal is proportional to the inverse fourth-power of the distance, consequently, the more distant and/or smaller an object, the higher the power needed in order to detect it. For this reason, space debris radars perform better in LEO than GEO or the cislunar region; and planetary radar systems need a lot of transmitting power, large collecting areas, and are usually continuous-wave radars, which have higher average power than pulse radars. The Arecibo's S-band (2.38 GHz, 12.6 cm, 1 MW) planetary radar system in Puerto Rico was the most powerful and sensitive planetary radar facility in the world, and since the tragic collapse of the 305-meter William E. Gordon telescope platform on December 01, 2020, there are currently no other facilities with comparable capabilities. The second most powerful planetary radar system is the Goldstone Solar System Radar in California, which is at least 15 times less sensitive than the former Arecibo system. We will present the radar capabilities of the legacy Arecibo telescope, and explore synergetic future concepts at Arecibo for planetary defense and SSA.