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The capabilities and future of the Arecibo planetary radar system in 2019-2023

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We present a summary of the expected role of the Arecibo planetary radar program on planetary defense in 2019-2023.

The Arecibo Observatory (AO) hosts the world's most sensitive and most powerful planetary radar system (up to 1 MW of output at 2.38 GHz) as a part of the 305-meter William E. Gordon radio telescope [1]. In April 2018, a new consortium led by the University of Central Florida took over management of AO. In September 2017, Hurricane Maria devastated Puerto Rico and damaged the radio telescope causing a roughly 30 % decrease to the antenna gain at 2.38 GHz. We present prospects for what role the damage repairs and the change of AO management play in the future of the planetary radar program.

Furthermore, we present a summary of the continuing capabilities of AO in terms of near-Earth object (NEO) characterization. The Arecibo planetary radar program has observed hundreds of NEOs, including hundreds of potentially hazardous asteroids (PHAs), with the current S-band setup since 1998 (Fig. 1), contributing to planetary defense by rigorous post-discovery astrometry refinement and physical characterization of NEOs. With delay-Doppler radar measurements, it is possible to measure the target's distance with a precision of ∼10 m and the radial velocity with a precision of ∼1 mm/s, and provide unparalleled information on the target's shape, size, possible satellites, and indications of the decimeter-scale surface roughness, porosity or bulk density, and abundance of metals [1, 2]. These clues can be used further to derive information about the density, mass, or internal structure of the asteroid, which is crucial knowledge in terms of impact risk evaluation and mitigation.

Some targets of high interest in 2019-2023 include unprecedented radar opportunities for past or future spacecraft mission targets such as the NEAR-Shoemaker mission target (433) Eros in Jan 2019, the Hayabusa-2 spacecraft mission target (162173) Ryugu in Dec 2020, and the DART mission target (65803) Didymos in Oct 2022. The strongest PHAs visible to Arecibo radar in 2019-2023, as measured in signal-to-noise ratio (SNR) per light-travel round-trip time (RTT), are 1999 RM_{45} in Mar 2021 (est.

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SNR≈4,400), (7482) 1994 PC_1 in Jan 2022 (est. SNR≈60,000), and 2010 XC_{15} in Dec 2022 (est. SNR≈13,000). All three of those PHAs are larger than 150 m in diameter and pass the Earth at ∼7 Lunar distances or less.

At least 9 NEOs in 2019-2023 require bistatic observations, for example, transmitting from AO and receiving at the Green Bank Observatory. This type of observation setup is required if the distance of the target is less than about 4 light-seconds (∼3 Lunar distances) due to the transmit-to-receive change time. Furthermore, it can provide a better Doppler resolution than monostatic measurements. The Doppler resolution is limited by the length of continuously recorded data. In monostatic measurements, switching between transmit and receive limits continuous integration time to 1 RTT per scan, whereas in bistatic measurements the recording can continue as long as the target is visible [1].

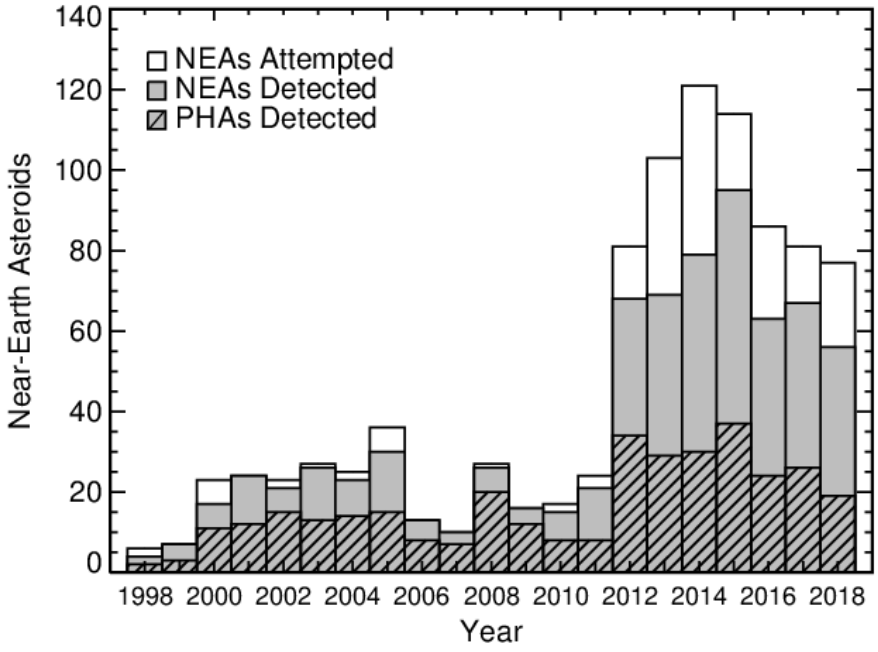

Figure 1: Potentially hazardous asteroids (PHAs) and other near-Earth asteroids (NEAs) observed at AO from 1998 to November 2018.

References

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