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[X] NEO Characterization

2020 BX12: THE LAST BINARY ASTEROID DISCOVERED BY ARECIBO OBSERVATORY

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ABSTRACT

The loss of the Arecibo Observatory, with the world's largest, most sensitive and most powerful planetary radar system, severely hinders our ability to rapidly discover and characterize secondary or additional bodies accompanying near-Earth objects (NEOs). The Arecibo Observatory (AO) planetary radar system characterized hundreds of NEOs during its 50 years of operation. Almost 60 binary and triple asteroid systems were discovered or confirmed by AO's radar observations. We present results and analysis of the radar observations of the last binary asteroid system discovered at the AO.

Near-Earth asteroid 2020 BX12 was classified as a potentially hazardous asteroid (PHA) after its discovery by the Asteroid Terrestrial-impact Last Alert System (ATLAS) survey at Mauna Loa Observatory on 2020 Jan 27. With an absolute magnitude of 20.8, an Earth minimum orbit intersection distance (MOID) of 0.0021 au, and a close approach at 0.0292 au (within 11.4 lunar distances), this Apollo-group object had its closest approach in 89 years on 2020 Feb 03, just seven days after its discovery, making it a high priority radar target.

AO's schedule adaptability allowed for a quick request of telescope time for this observation, as soon as the object was within its field of view, on 2020 Feb 04 and 05. During radar observations with the S-band planetary radar system (2380 MHz, 12.6 cm), the object was found to be a binary system. Measurement of the Doppler frequency shift and the Doppler spectrum bandwidth, obtained from continuous-wave observations with this system, provided incredibly sensitive astrometric corrections and initial limits for an object's apparent diameter and period of rotation. For 2020 BX_{12}, we submitted astrometric corrections on the order of less than a meter per second for its line of sight velocity from the measured Doppler shift, incredibly sensitive for an object traveling at a velocity of 25 km/s! From the Doppler spectrum, we observed a narrow echo of about 0.08 Hz bandwidth superimposed on the broader 1.6 Hz echo of the primary component (Fig. 1) indicating the presence of

a companion. Following range measurements, we found an astrometric correction for the line of sight distance of a few kilometers for an object 4 million kilometers away!

Subsequent radar imaging unequivocally resolved the two components of this binary system (Fig. 2). The primary seems to have a spheroidal shape, and although the secondary's shape is unresolved, it could be roughly half of the visible extent derived diameter of the primary. We present in this work results of these observations, providing radar-derived constraints on the system components, diameter, rotation state, taxonomic class, component separation, satellite orbital period, density, and cohesion.

The loss of the Arecibo Observatory, a ground-based instrument of this magnitude and sensitivity that could provide so much information about NEOs and PHAs, is truly a setback in our efforts to understand these objects' physical and dynamical properties. This is vital information for selecting the appropriate deflection mechanism when needed.

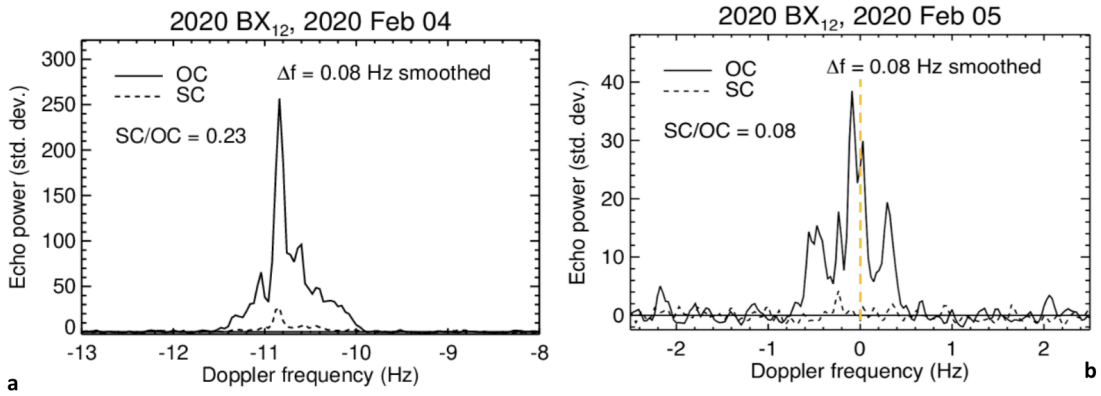

Fig 1: Continuous wave power spectra of 2020 BX12 during both nights of observation with the Arecibo Observatory.

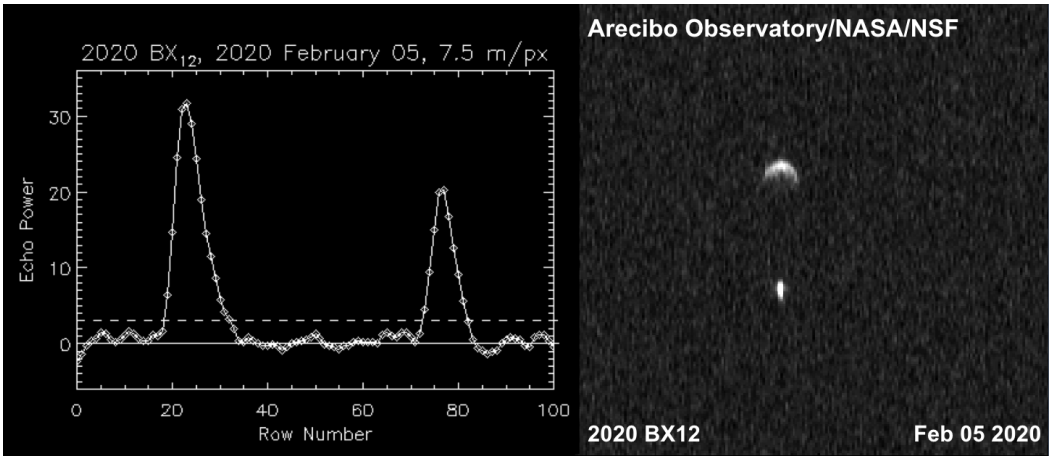

Fig 2: Left: Echo power plot per bin (row) from Arecibo Observatory delay-Doppler radar images of binary near-Earth asteroid 2020 BX12 showing both components. Right: delay-Doppler image with range (delay) resolution of 7.5 m/pixel (vertical axis) and Doppler frequency resolution of 0.075 Hz/pixel (~5 mm/s) horizontal axis. This image suggests the primary is 14 pixels deep at 7.5 m/pixel or 105 meters in radius; the secondary is at least 9 pixels deep or 67.5 m.

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Comments:

(Alternative session: if there is a session about the Arecibo Observatory Legacy and Future or planetary radar specifically. Generally we would prefer an oral presentation if possible)