Southern Hemisphere Asteroid Radar Program - SHARP-

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Canberra Deep Space Communication Complex (CDSCC)

1. Canberra/ATCA Bistatic Radar

Astronomical radar observations have been used to probe surfaces of all the solid planets and many smaller bodies in the solar system. More recently, there has been considerable interest in using radar observations both to characterize **near-Earth asteroids (NEAs)** and determine their orbits more precisely. The motivation for radar observations of asteroids is three-fold. First, asteroids represent primitive remnants of the early solar system and characterization of their properties such as shape, rotation state and existence of satellites can provide insights into their evolution and parent population(s). Secondly, precise knowledge of their orbits is essential to assess the extent to which they might represent impact hazards to the Earth, and finally, they represent targets for spacecraft, both robotic and crewed. Over the past years we have successfully developed and demonstrated a Southern Hemisphere radar capability using the **Canberra Deep Space Communication Complex (CDSCC)** as transmitters and Murriyang, the Parkes 64m Radio Telescope (Benson et al. 2018) and the **Australia Telescope Compact Array (ATCA)** as receivers (Horiuchi et al. 2021, Kruzins et al. 2023, Reddy et al. 2024). More recently, we also utilize University of Tasmania radio telescopes such as the Ceduna 30m Radio Telescope for bistatic radar receiver (White et al. 2025).

Reference

Benson, C. et al. 2018, Radio Science, 52, 1344

Horiuchi, S. et al. 2021, Icarus, 357, 114250

Kruzins, E. et al. 2023, Front. Space Technol., 4, 1162916

Reddy, V. et al. 2024, Planetary Science Journal, 5, 141

White, O. et al., 2025, Remote Sens., 17, 352

DSS-43 (Tidbinbilla 70m)

ATCA

Ceduna 30m

2. SHARP detection statistics

List of detected asteroids

(Canberra/ATCA unless otherwise noted)

2015: 2005 UL5 (Parkes), 1998 WT24 (Parkes)

2016: No observations

2017: Florence, 2012 TC4

2018: 2003 SD220

2019: 2019 EA2, 2019 GC6

2020: 2000WO107, 2020 XX3

2021: 2008 AF4, 2020 WU5, 2020 YE5, 2020 TB12, 2001 FO32, 2021 AF8, Nereus, 2003 SD220

2022: 1994 PC1, 2008 AG33, 1989 JA, 2022 LV, 2022 RM4, 2005 LW3, 2015 RN35,

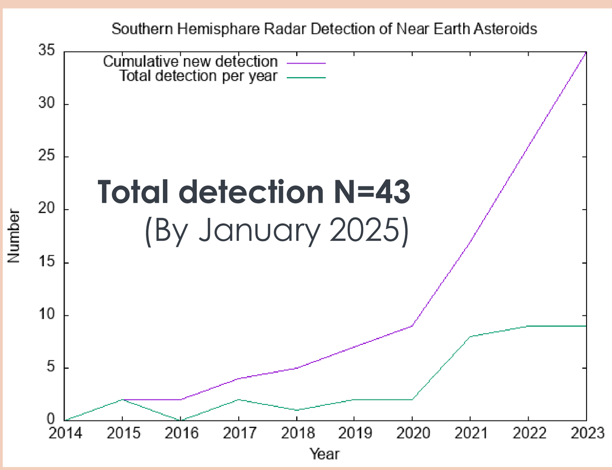
2010 XC15 (Ibaraki Univ. Hitachi telescope by Yonekura et al.)

2023: 2011 AG5, 2023 DZ2, 2012 KY3, 2006 HV5, 2018 UY, 2016 LY48, 1998 HH49, 2003 UC20, 2001 QQ142

2024: 2008 OS7, 2024 MK, 2012 OD1, 2024 ON, 1998 ST27, 2006 WB, 2020 XR

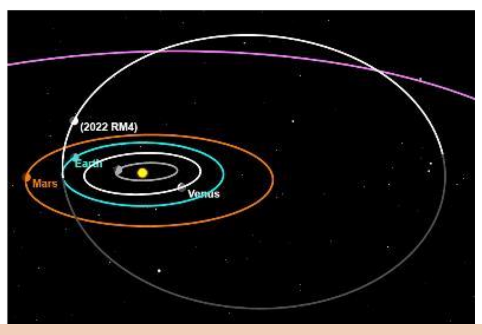
2025: Alinda

Red – Target of Opportunity (ToO)

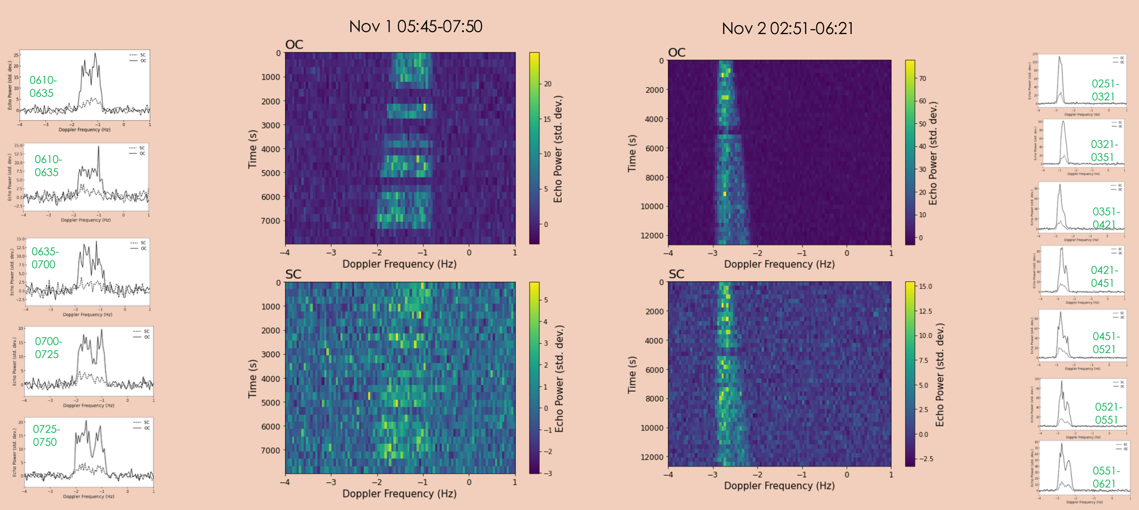


Hitachi 32m

3. 2022 RM4



NEA 2022 RM4 (about 400-m) was discovered on 12 September 2022 by Pan-STARRS2 and classified as Potentially Hazardous Asteroid (PHA). SHARPR observed it as Target of Opportunity and revealed its elongated structure and refined its orbit, allowing the close encounter predictions to be improved for the next 550 years.

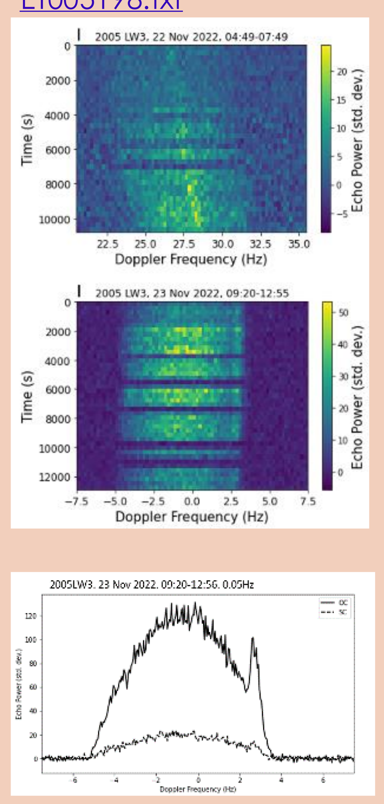


Tx: DSS-43 (Tidbinbilla), Rx: ATCA (Narrabri)

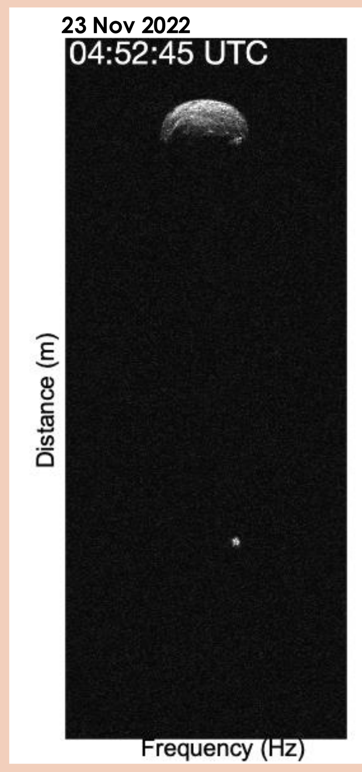
4. 2005 LW3 and its moon

NEA 2005 LW3 (about 150-m) was discovered by the Siding Spring Survey (Australia) on 5 June 2005 and approached within 0.0076 au (2.96 lunar distances). SHARP observations revealed a sharp spike in Doppler profiles as indicative of a moon orbiting the asteroid. Subsequent Goldstone delay-Doppler observations imaged the binary asteroid. The discovery was reported to CBAT.

http://www.cbat.eps.harvard.edu/iau/cbet/005100/CBET005198.txt

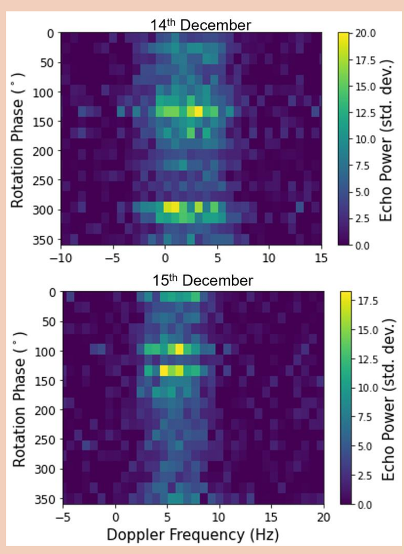


DSS-43/ATCA



Goldstone

5. 2015 RN35

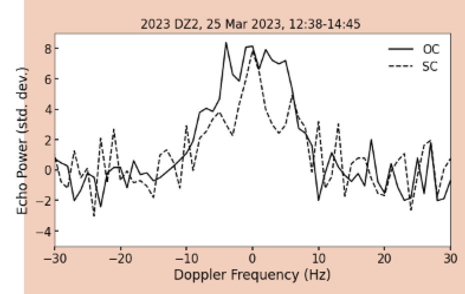


Canberra/ATCA Doppler vs. rotation phase, suggesting spin-axis shift

NEA 2015 RN35 (about 80-m) **was** discovered on 5 December 2010 by Catalina Sky Survey and approached within 0.00516 au on 27 December 2022. Radar observations have been planned/conducted at Goldstone, Canberra/ATCA and Madrid/Bologna. Goldstone Delay-Doppler image revealed a rapid rotation of 10-minutes. SHARP observed on 15 and 15 December and found a possible profile change due to "tumbling".

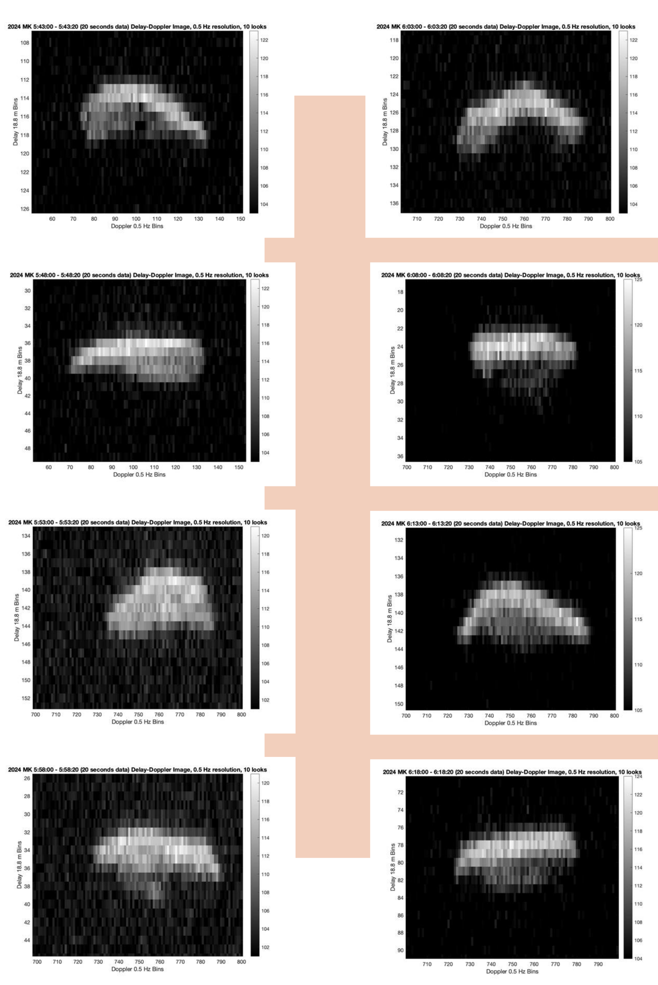
6. IAWN Campaign

DSS-35 (34m)



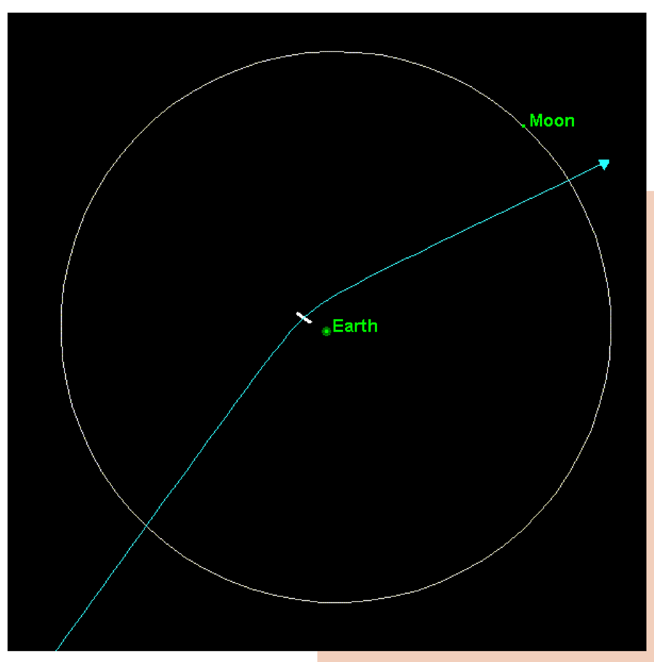
NEA 2023 DZ2 (about 50-m) was discovered on 27 February, 2023, at the Isaac Newton Telescope at Observatorio de Roque los Muchachos on La Palma, Canary Islands, Spain, approached within 0.45 lunar distances on 25 March, and became a target of the International Asteroid Warning Network IAWN) campaign (Reddy et al. 2024). SHARP tracked the NEA in rapid response.

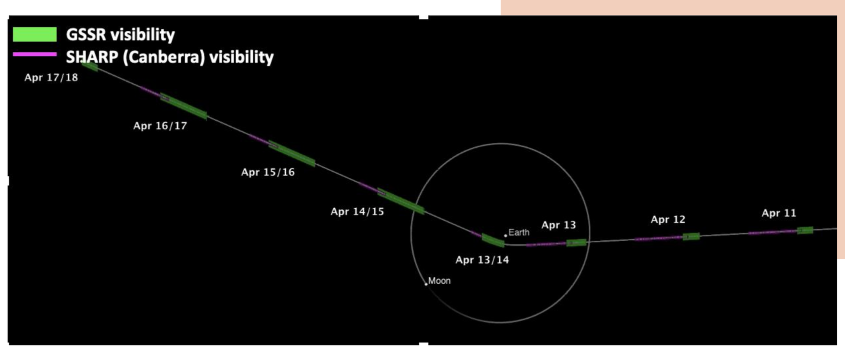
7. Goldstone/Canberra bistatic radar



2024 MK was discovered by ATLAS-Sutherland (funded by NASA and located in South Africa) on June 16, 2024. 2024 MK approached within 0.00197 au (0.77 lunar distances) at 13:50 on 30 June. While Goldstone 70m (DSS-14) transmitted nonlinear chirp signal for delay-Doppler imaging of 2024 MK with Goldstone DSS-13 (34m) on 29 June, Canberra 70m (DSS-43) successfully received echo to produce delay-Doppler images.

8. Apophis Encounter in April 2029





In 2029, Apophis will encounter Earth within 4.9 Earth radii of the Earth surface. Apophis will approach from the south at a declination of about -30 deg, rapidly move past Earth, and then recede at a declination of +17. Apophis will be observed extensively by the Deep Space Network radars at Goldstone and Canberra. SHARP can track Apophis considerably more rotation coverage than is possible at Goldstone due to its longer view period prior to April 13, for 12 hours as day as it approaches (and 9 hours as it recedes). Also, SKA-mid will be operational in South Africa by then and be able to receive radar echo from Apophis at different subarrays, allowing speckle observations to determine asteroid's spin axis, and contribute to dramatically enhancing asteroid charactering capability.

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