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# NEOWISE observations of the potentially hazardous asteroid (99942) Apophis

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Near-Earth Asteroid (NEA) Apophis (99942) will make a close fly-by in 2029 with an altitude of merely 37,000 kilometers. Although any chance of impact has been ruled out, the close approach has made it a suitable subject for an exercise designed to assess the current systems and test the capability of research groups to identify and rapidly characterize potentially hazardous objects. Reddy et al. (2019) performed one such activity for the NEA 2012 TC4 [1]. As a part of the current exercise and study, Apophis is being treated as a newly discovered asteroid, and here, we report the characterization of its diameter and albedo using freshly obtained data from the Near-Earth Object Wide-field Infrared Survey Explorer (NEOWISE; Mainzer et al. 2014, Wright et al. 2010) [2] [3].

NEOWISE was the first survey to obtain a *discovery* tracklet for Apophis late last year, and ten detections were made by the two active bands (3.4 µm and 4.6 µm) in the first epoch (December of 2020) spanning 23.5 hours. At the time of observation, the signal-to-noise ratio at 4.6 µm was approximately five, and the solar elongation angle was roughly 90º. For the object's diameter and albedo, the Near-Earth Asteroid Thermal Model (NEATM; Harris 1998) [4] was used with various assumed parameters for the beaming factor and the G-value. Near-simultaneous visible photometry obtained using the SMARTS 1.0 meter telescope from the Cerro Tololo Inter-American Observatory (CTIO) was also used to provide an improved constraint on the absolute visual magnitude (H). Our preliminary results appear to be consistent with results from previous studies by Delbo et al. (2007) [5], Müller et al. (2014) [6], and Brozovic et al. (2018) [7].

A second epoch is expected in April 2021, and it will be crucial for two reasons: first, we will be able to observe the asteroid from a different viewing geometry, and second, the apparent magnitude will be roughly a magnitude brighter with a corresponding improvement in signal-to-noise ratio. The second epoch may enable the use of more sophisticated thermophysical models capable of constraining thermal inertia.

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Although Apophis is a well-studied object, the principal purpose of this work is to demonstrate that the NEOWISE data pipeline allows us to estimate characteristics such as diameter and albedo rapidly (and it also highlights the accuracy of the thermal fit model given the consistency of the results with prior studies). Such expeditious data processing could prove to be essential in mitigating hazards and distinguishing regional catastrophes from global ones and vice versa. In the case of Apophis, the diameter derived from the NEOWISE *discovery* observations has allowed exercise participants to quickly determine that the object would be merely capable of causing regional damage and not a global disaster.

**Comments:**
*Oral presentation preferred.*

### References


[1] V. Reddy, M. S. Kelley, D. Farnocchia, W. H. Ryan, C. A. Thomas, L. A. M. Benner, J. Dotson, M. Micheli, M. J. Brucker, S. J. Bus, M. Brozovic, L. Wheeler, V. Abbasi, J. M. Bauer, A. Bonsall, Z. L. Brown, M. W. Busch, P. Chodas, Y.-J. Choi, N. Erasmus, K. E. Fast, J. P. Faucher, R. B. Fernandes, F. D. Ghigo, D. G. Gilbank, J. D. Giorgini, A. Gustafsson, O. Hainaut, W. M. Harris, J. S. Jao, L. S. Johnson, T. Kareta, M.-J. Kim, D. Koschny, E. A. Kramer, R. R. Landis, D. G. Laurin, J. A. Larsen, C. G. Lee, C. Lejoly, T. Lister, R. McMillan, J. R. Masiero, D. Mathias, M. Mommert, H.-K. Moon, N. A. Moskovitz, S. P. Naidu, R. T. Nallapu, H. K. Niazi, J. W. Noonan, D. Polishook, E. V. Ryan, L. Schatz, J. V. Scotti, B. Sharkey, B. M. Shustov, A. A. Sickafoose, M. A. Silva, M. A. Slade, L. R. Slick, L. G. Snedeker, A. Springmann, D. Tholen, D. E. Trilling, A. Q. Vodniza, R. Wainscoat, R. Weryk, M. Yoshikawa, Near-Earth asteroid 2012 TC4 observing campaign: Results from a global planetary defense exercise, 326 (2019) 133–150.

[2] A. Mainzer, J. Bauer, R. M. Cutri, T. Grav, J. Masiero, R. Beck, P. Clarkson, T. Conrow, J. Dailey, P. Eisenhardt, B. Fabinsky, S. Fajardo-Acosta, J. Fowler, C. Gelino, C. Grillmair, I. Heinrichsen, M. Kendall, J. D. Kirkpatrick, F. Liu, F. Masci, H. McCallon, C. R. Nugent, M. Papin, E. Rice, D. Royer, T. Ryan, P. Sevilla, S. Sonnett, R. Stevenson, D. B. Thompson, S. Wheelock, D. Wiemer, M. Wittman, E. Wright, L. Yan, Initial Performance of the NEOWISE Reactivation Mission, 792 (2014) 30.

[3] E. L. Wright, P. R. M. Eisenhardt, A. K. Mainzer, M. E. Ressler, R. M. Cutri, T. Jarrett, J. D. Kirkpatrick, D. Padgett, R. S. McMillan, M. Skrutskie, S. A. Stanford, M. Cohen, R. G. Walker, J. C. Mather, D. Leisawitz, I. Gautier, Thomas N., I. McLean, D. Benford, C. J. Lonsdale, A. Blain, B. Mendez, W. R. Irace, V. Duval, F. Liu, D. Royer, I. Heinrichsen, J. Howard, M. Shannon, M. Kendall, A. L. Walsh, M. Larsen, J. G. Cardon, S. Schick, M. Schwalm, M. Abid, B. Fabinsky, L. Naes, C.-W. Tsai, The Wide-field Infrared Survey Explorer (WISE): Mission Description and Initial On-orbit Performance, 140 (2010) 1868–1881.

[4] A. W. Harris, A Thermal Model for Near-Earth Asteroids, 131 (1998) 291–301.

[5] M. Delbo, A. Cellino, E. Tedesco, Albedo and size determination of potentially hazardous asteroids: (99942) apophis, Icarus 188 (2007) 266–269.

[6] T. Mueller, C. Kiss, P. Scheirich, P. Pravec, L. O'Rourke, E. Vilenius, B. Altieri, Thermal infrared observations of asteroid (99942) apophis with herschel, Astronomy Astrophysics 566 (2014).

[7] M. Brozovic, L. Benner, J. McMichael, J. Giorgini, P. Pravec, P. Scheirich, C. Magri, M. Busch, J. Jao, C. Lee, L. G. Snedeker, M. Silva, M. Slade, B. V. Semenov, M. Nolan, P. A. Taylor, E. Howell, K. Lawrence, Goldstone and arecibo radar observations of (99942) apophis in 2012–2013, Icarus 300 (2018) 115–128.