**AN ESTIMATION OF THE YARKOVSKY EFFECT ON ASTEROID (99942) APOPHIS VIA HIGH-ORDER TAYLOR POLYNOMIALS.** J. A. Pérez-Hernández[1,2] and L. Benet[1], [1]Instituto de Ciencias Físicas, Universidad Nacional Autónoma de México, UNAM, Apdo. Postal 48-3, 62251 Cuernavaca, Mor., México. [2]jperez@icf.unam.mx.

**Introduction:** It has been shown that for asteroid (99942) Apophis the leading source of uncertainty for predictions of its orbital motion is due to non-gravitational accelerations arising from anisotropic thermal re-emission of absorbed solar radiation, known as the Yarkovsky effect [1]. Yet, previous attempts to obtain this parameter from astrometry for Apophis have only yielded marginal detections [2]. Here, we present an independent estimation for the Yarkovsky effect on Apophis from optical and radar astrometry. Our approach is based on automatic differentiation techniques in terms of high-order Taylor series expansions both with respect to time and deviations with respect to a given orbital solution [3].

**Dynamical model:** Our dynamical model for Apophis takes into account post-Newtonian accelerations from the Sun, the eight planets, the Moon and Pluto, oblateness effects from Earth's $J_2$ zonal harmonic, perturbations from the 16 most-massive main-belt asteroids and a non-gravitational acceleration term in the transverse direction accounting for the Yarkovsky effect. We implement our own planetary ephemeris integrator, which essentially reproduces the JPL DE430 ephemeris integration below the ~1m level during the time span of our numerical integrations [4].

**Results:** Exploiting these techniques, we implement a Newton method for orbit determination, and perform two orbital fits to optical and radar astrometry: a 6 degrees-of-freedom (DOF) gravity-only orbital fit for the initial conditions, and a 7 DOF orbital fit, which includes the Yarkovsky parameter $A_2$ as an additional fit parameter, obtaining a secular semimajor axis drift $\langle\dot{a}\rangle = (-25 \pm 13)\times10^{-4}$ au/Myr. Our optical astrometry error model accounts for biases present in star catalogs [5], and accounts for other sources of systematic errors via an appropriate weighting scheme [6]. Using our orbital solutions, we provide predictions (nominal and 3-sigma uncertainty ellipses) for optical and radar observations for the upcoming close approach that Apophis will have with Earth on March 2021. Finally, we project the orbital uncertainty onto the 2029 B-plane, and propose a parameterized orbit determination scheme, which allows us to compute the time-evolution of the orbital uncertainty of Apophis via a high-order Taylor series parameterization.

**Acknowledgments:** We acknowledge financial support provided by UNAM-PAPIIT AG100819.

**References:** [1] D. Vokrouhlický et al. (2015). *Icarus*, 252, 277-283. [2] M. Brozović et al. (2018). *Icarus*, 300, 115-128. [3] J.A. Pérez-Hernández and L. Benet. (2020). TaylorIntegration.jl v0.8.3. URL: https://github.com/PerezHz/TaylorIntegration.jl/tree/v0.8.3 [4] W.M. Folkner et al. (2014). *Interplanetary Network Progress Report*, 196(1). [5] S. Eggl et al. (2020). *Icarus*, 339, 113596. [6] D. Farnocchia et al. (2013). *Icarus*, 224, 192-200.