DIRECT ESTIMATION OF YARKOVSKY ACCELERATION ON NEAR-EARTH ASTEROIDS.

S. R. Chesley[1], D. Vokrouhlický[2], S. J. Ostro[3], L. A. M. Benner[3], J.-L. Margot[4], R. L. Matson[5], M. C. Nolan[6] and M. K. Shepard[7]. [1]JPL/Caltech, M/S 301-150, Pasadena, CA 91109 (steve.chesley@jpl.nasa.gov), [2]Charles Univ., Prague, Czech Rep., [3]JPL/Caltech, Pasadena, CA, [4]Cornell Univ., Ithaca, NY, [5]SAIC, Seal Beach, CA, [6]Arecibo Obs., Arecibo, PR, [7]Bloomsburg Univ., Bloomsburg, PA.

Introduction: We report the results of a comprehensive search for evidence of the Yarkovsky Effect in the orbital fits of near-Earth asteroids. The Yarkovsky Effect is a weak nongravitational acceleration associated with the anisotropic emission of thermal radiation. Despite its small magnitude, it has important implications for the dynamical evolution of asteroid populations [1]. It has so far been directly observed affecting the trajectories of only two asteroids, 6489 Golevka [2] and 152563 (1992 BF) [3]. In previous studies the Yarkovsky acceleration was modeled by solving the surface heat diffusion problem on the asteroid's surface, either through linear or finite element methods. Here we take a less cumbersome and more direct approach, modeling the Yarkovsky Effect as a purely transverse acceleration that is inversely proportional to the square of the heliocentric distance. This permits a rapid scan of the asteroid catalog for objects whose orbital fits are markedly improved by the incorporation of a transverse acceleration, which can be readily translated into a rate of change in orbital semimajor axis.

Results: The estimated semimajor axis drift rates *da/dt* for several notable asteroids are detailed in Table 1. The table is sorted according to the Signal-to-Noise Ratio (SNR), i.e., the significance of *da/dt* relative to its 1-sigma formal uncertainty. The two cases with the greatest SNR, 1992 BF and Golevka, are already published [2,3] and serve as a verification of the approach. Other results are preliminary and require in-depth analyses of astrometric errors and dynamical and thermal models before the estimated drift rate can be definitively linked to the Yarkovsky Effect.

In several of these cases a spin state and diameter are known, allowing a bulk density to be derived from the strength of the Yarkovsky acceleration, given reasonable assumptions for the asteroids thermal properties. In other cases, typically those without planetary radar observations, little is known about the body and one can only compare the estimated drift rate to an approximate upper bound. This may afford some constraints on the obliquity of the asteroid's spin axis, as is the case for 1992 BF. For 1685 Toro, both the drift rate and drift uncertainty are small, leading to lower SNR, and yet a very significant constraint on the semimajor axis mobility is revealed.

The predominance of negative drift rates in this sample is consistent with the presumed delivery method of near-Earth asteroids from the main belt, namely Yarkovsky–induced resonance injection [4].

References: [1] W. F. Bottke et al. (2006), *Ann. Rev. Earth Planet. Sci.*, *34*, 157. [2] S. R. Chesley et al. (2003), *Science*, *302*, 1739. [3] D. Vokrouhlický et al. (2008), *Astron. J.*, in press. [4] A. La Spina et al. (2004), *Nature*, *428*, 400.

Acknowledgements: This work was conducted in part at the Jet Propulsion Laboratory, California Inst. of Technology, under a contract with the National Aeronautics and Space Administration.

TABLE 1. ESTIMATED SEMIMAJOR AXIS DRIFT RATE FOR SELECTED NEAR-EARTH ASTEROIDS

Object	*da/dt* ($\times 10^{-4}$ AU/My)	SNR	Observed Arc	Radar Apparitions	Absolute Mag.
152563 (1992 BF)	-10.78 ± 0.73	14.8	1953-2005	N/A	19.7
6489 Golevka	-6.39 ± 0.44	14.4	1991-2007	1991, 1995, 2003	19.2
1862 Apollo	-2.44 ± 0.26	9.3	1930-2008	1980, 2005	16.3
2100 Ra-Shalom	-7.09 ± 0.88	8.0	1975-2007	1981, 1984, 2000, 2003	16.1
85953 (1999 FK21)	-14.13 ± 2.35	6.0	1971-2008	N/A	18.0
2063 Bacchus	-10.59 ± 2.21	4.8	1977-2007	1998	17.1
54509 YORP	-25.12 ± 6.18	4.2	2000-2005	2001, 2004	22.6
2340 Hathor	-13.94 ± 3.84	3.6	1976-2007	N/A	19.2
1865 Cerberus	-7.80 ± 2.28	3.4	1971-2007	N/A	16.8
101955 (1999 RQ36)	-15.69 ± 4.99	3.1	1999-2006	1999, 2005	20.8
1620 Geographos	-1.18 ± 0.39	3.0	1951-2008	1983, 1994	15.6
1685 Toro	-0.52 ± 0.27	2.0	1948-2008	1980, 1988	14.2