DYNAMICAL STATE OF THE PLUTO SYSTEM. D. J. Tholen[1], M. W. Buie[2], and W. M. Grundy[2], [1]Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, HI 96822, [2]Lowell Observatory, 1400 W. Mars Hill Road, Flagstaff, AZ 86001.

Introduction: In 2005, two new satellites of Pluto were discovered with the Hubble Space Telescope [1]. Now named Nix and Hydra, the satellites are in orbits about 49240 and 65210 km from the Pluto system barycenter, compared with the Plutocentric 19570 km orbit of the large satellite Charon, known since 1978. Both of the new satellites are fainter than 23rd magnitude. Ward and Canup [2] have proposed that Charon, Nix, and Hydra coalesced from the debris produced by a giant impact into the Pluto parent body (much in the same way that the Moon is believed to have formed from material excavated from Earth by a giant impact). Such a model would imply similar compositions for the three satellites.

The dynamics of the four-body system are also interesting. The orbital periods of Hydra, Nix, and Charon [3] place Nix close to the 4 : 1 resonance with Charon, and Hydra close to the 6 : 1 resonance with Charon. More importantly, the two satellites are close to the 3 : 2 resonance with each other, which dominates the effect on their motion [4]. Ward and Canup [2] have proposed that Nix and Hydra may have been trapped in the corotation resonances at this commensurability during the tidal expansion of Charon's orbit, if Charon formed with a larger orbital eccentricity following the hypothesized giant impact.

We are improving our knowledge of both the physical nature of the new satellites and the dynamical state of the system to test these hypotheses. The emphasis in this presentation will be on the latter.

Data: The two positions of Nix and Hydra from the 2005 discovery images and the two positions from the 2006 confirmation images were quickly supplemented with a dozen prediscovery positions extracted from stacked HST images taken in 2002 and 2003 during Cycle 11 [5]. During HST Cycle 15 in 2007, we more than doubled the amount of astrometry available for Nix and Hydra, and now we are supplementing the data set with new ground-based adaptive optics observations. We have also detected Hydra in three prediscovery adaptive optics images from 2001. Additional Charon astrometry was obtained in 1992 and 1993 during HST Cycle 2, and we are in the process of synthesizing astrometry of Charon from the mutual event photometry obtained in 1985 through 1990.

Analysis: Our orbit solution was performed using a four-body model with full mutual perturbations. We ignored solar perturbations because they are undetectable over the few years that the available data span. However, we have determined that solar perturbations can become detectable on time scales of a Pluto orbital period. The 22 solution parameters include the Plutocentric position and velocity vectors for each satellite and the masses of the four bodies.

Results: A 1σ upper limit of about 0.07 km^3 sec^{-2} on the GM values for Nix and Hydra has been established, indicating that they cannot be both as dense as Pluto and of low albedo. The 1σ lower limit for Hydra includes zero, and for Nix is 0.002 km^3 sec^{-2}, which place only weak constraints on how high their albedos might be. The best-fit masses and an assumed Charon-like density suggest albedos one-quarter to one-half that of Charon and diameters less than 100 km.

The azimuthal orbital periods have been estimated by counting positive x-axis crossings during a 2 million day numerical integration that includes solar perturbations. The results are 6.38723 days for Charon, 24.855 days for Nix, and 38.204 days for Hydra, which yields ratios of 5.98 : 3.89 : 1; however, we have not identified any instances of resonance among any of the 59 resonant arguments that we investigated. We expect that the incorporation of the new Cycle 15 HST and ground-based adaptive optics data in the four-body solution will improve the results considerably.

References: [1] Weaver, H. A. et al. (2006) *Nature*, 439, 943-945. [2] Ward, W. R. and Canup, R. M. (2006) *Science*, 313, 1107-1109. [3] Tholen, D. J. et al. (2008) *AJ*, 135, 777-784. [4] Lee, M. H. and Peale, S. J. (2006) *Icarus*, 184, 573-583. [5] Buie, M. W. et al. (2006) *AJ*, 132, 290-298.