THREE-BODY AND SPIN-ORBIT RESONANCES IN THE PLUTO SYSTEM. D. P. Hamilton¹ and T. de Santana², Astronomy Department, University of Maryland, (College Park, MD) dphamil@umd.edu, ²UNESP, (Guaratinguetã, SP, Brazil) t.santana@unesp.br.

Introduction: The four small satellites of Pluto, Styx, Nix, Kerberos, and Hydra, orbit near simple two-body mean motion resonances with Pluto’s large moon Charon: the 3:1, 4:1, 5:1, and 6:1, respectively. Somewhat paradoxically, however, while near the resonances, the satellites are decidedly not in the resonances. How can these resonances be simultaneously important (suggested by the satellites’ proximity to them) and unimportant (all resonances are inactive)? Further mysteries involve the rotation states of the satellites which all feature non-synchronous rotation and large obliquities.

Three-Body Resonance: Showalter and Hamilton [1] showed Hydra, Nix and Styx do participate in a 2:5:3 three-body resonance that is analogous to the 2:3:1 three-body resonance that affects Jupiter’s Ganymede, Europa, and Io. At Jupiter, additional 2:1 resonances between Io and Europa and between Europa and Ganymede are also active; at Pluto, conversely, no two-body resonances are active. We suggest a history for Pluto’s satellites, driven by the tidal migration of Charon, that first temporarily put satellites in two-body resonances, then activated the 3:5:2 three-body resonance, and finally moved the satellites out of the original resonances [2]. The two body resonances that would most naturally activate the observed three-body resonance are the 5:4 Styx-Nix and 2:1 Styx-Hydra two-body resonances. When the two body resonances both involve the pericenter of Styx, the three-body resonance activates. We also show that the three-body resonance, once activated, can drive the system away from the two-body resonances, thus leaving a system near, but not in, these resonances. A similar situation may have also occurred for Kerberos, which today is found close to, but not precisely in, the 43:85:42 Styx-Nix-Kerberos three-body resonance.

Spin-Orbit Resonance: Hamilton and Ward [3][4] invoked a spin-orbit resonance to explain the 27 degree tilt of Saturn and there is some hope that a similar mechanism can be found to explain the more extreme tilt of Uranus [5]. These spin-orbit resonances may also be important in the Pluto system. There, tidal migration of Charon early in Pluto’s history causes the relevant frequencies to slowly change, bringing satellites into spin-orbit resonances that can potentially drive obliquities up. The main secular spin-orbit resonance studied by [3][4] is an attractive possibility for producing the obliquities of the small satellites, as it is insensitive to satellite spin rates and can drive initially small obliquities toward 90 degrees. More exotic families of spin-orbit resonances also exist, including those that involve multiple satellite orbital frequencies, satellite spin rates, or both. These resonances, however, require more specialized circumstances to activate [6]. Nevertheless, given the unknown, but likely complicated, past history of the satellites we remain open to all of these possibilities.

Numerical Approach: We use the N-body code nhbody for both the three-body resonances and secular spin-orbit resonances. We are currently evaluating several promising scenarios and will report on our most recent results. On a longer timescale, we are extending nhbody to handle the spin-orbit resonances that depend explicitly on the spin rates of the satellites [5].