On the dynamics of Trojans and outer Main Belt resonant families

M. Brož ¹, D. Vokrouhlický ¹

¹ Charles University, Prague

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Resonant populations:

- families in J3/2 and J1/1, no families in J2/1, J4/3
- constrains migration of Jupiter and collisional models
Trojans — how many families?

- $\sim 1500$ bodies in each $L_4$ and $L_5$ clouds
- definitely not many prominent clusters...
Trojans — only 1 family in L4?

- $N(v_{\text{cutoff}})$ plots compared with (random) background
- **Eurybates family** is the most robust case: it has only C-type members, no D-types (Roig *et al.* 2008), its SFD is steeper than the background population, parent body size $\approx 100$ km, PB/LF $\approx 0.4$
Trojans vs Trojans collisional rates:

- Bottke et al. (2006):
  
  \[ d_{\text{disrupt}} = \left( \frac{2Q^*}{V_{\text{imp}}^2} \right)^{\frac{1}{3}} D_{\text{target}} \sim 20 \text{ km} \]

- Dahlgren (1998):
  
  \[ f_{\text{disrupt}} = P_i \frac{D_{\text{target}}^2}{4} n_{\text{project}} n_{\text{target}} \]

  \[ \tau_{\text{disrupt}} = \frac{1}{f_{\text{disrupt}}} \sim 12 \text{ Gyr} \]

- collisional rates too low \( \Rightarrow \) large \# of families unlikely
Eurybates family — chaotic diffusion:

- present shape was attained due to the chaotic diffusion
- age have to be $\gtrsim 1$ Gyr ('filament' must disappear)
The role of planetary migration:

- SWIFT-RMVS3 integrator, with analytic dissipation and eccentricity damping (Levison et al. 2008)
Eurybates family — planetary migration:

- even late migration disperses the Eurybates too much
  ⇒ family is younger than \( \leq 3.5 \) Gyr
Hilda collisional family in J3/2:

- Hilda collisional family at higher inclinations; 
  \( v_{\text{cutoff}} \approx 150 \text{ m/s}, \approx 200 \text{ km parent body}, \ LF/PB \approx 0.5, \)
  mostly C/X-type members, SFD steeper than J3/2, 
  but current \( \tau_{\text{disrupt}} \approx 10^{12} \text{ yr} \) for J3/2 vs Main Belt
Simulated disruption in J3/2:

- the simulated cluster was initially very narrow in $e$
Evolution over 4 Gyr:

- usually, YE causes a drift in semimajor axis, but...
- Yarkovsky effect and resonant lock combined
  $\Rightarrow$ systematic drift in eccentricity
Hilda family — age estimate:

- K-S test of e-distributions $\Rightarrow$ age $\gtrsim 4$ Gyr
- possibly an LHB origin (within the Nice model)?
Hilda family — \((e, H)\) plot:

- ‘ears’ like in \((a, H)\) for Eos, Erigone, Massalia, Merxia, …
Merxia family — \((a, H)\) plot for comparison:

- **YORP effect** changes spins (Vokrouhlický et al. 2005)
  \(\Rightarrow\) more precise age?
Hilda — \((e, H)\) method:

- binning in the parameter \(C = (a - a_c)/10^{0.2H}\)
- practical test: not yet statistically significant solution, but age \(\gtrsim 4\) Gyr \(\leftarrow\) isn’t it too much?!
Hilda family at the beginning of migration:

- Jupiter at 5.28 AU, Saturn at 8.85 AU, $\tau_{\text{migration}} \approx 30$ Myr
Hilda family after migration has ended:

- planetary perturbations might disperse eccentricities sufficiently → then Yarkovsky drift in $e$ takes over
Conclusions:

- planetary migration likely dispersed the Hilda family, note also $f_{\text{disrupt}}$ was probably larger at that time
- Eurybates seems to be the only one collisional family among Trojans
- no D-type families anywhere? pulverisation of target?

Future work:

- more precise age for the Hilda family if enough bodies
- more migration scenarios $\Rightarrow$ info on $\tau_{\text{mig}}$, $\tau_{\text{damp\,ecl}}$?
- collisional models of resonant populations