Yarkovsky-driven leakage of Koronis family: the case of (2953) Vysheslavia

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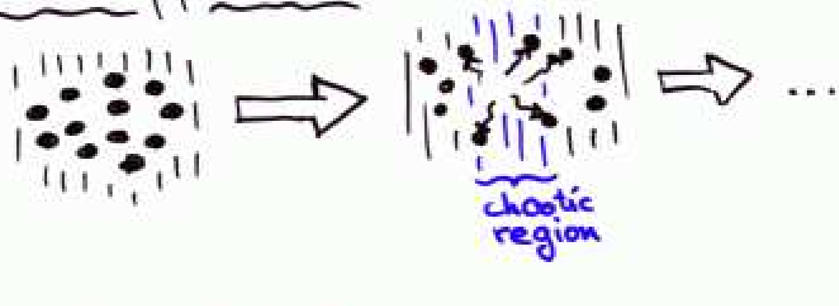
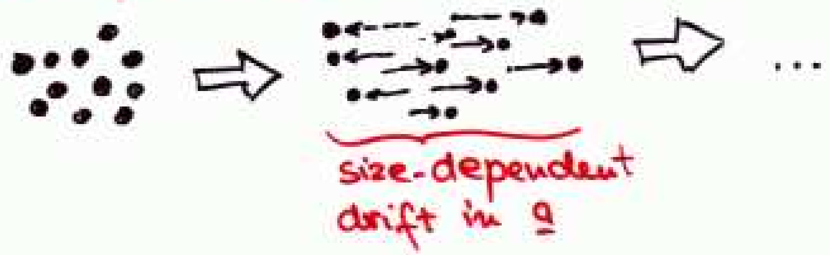
"Aging-processes" of the asteroid families:
(= "a broader context of this work")

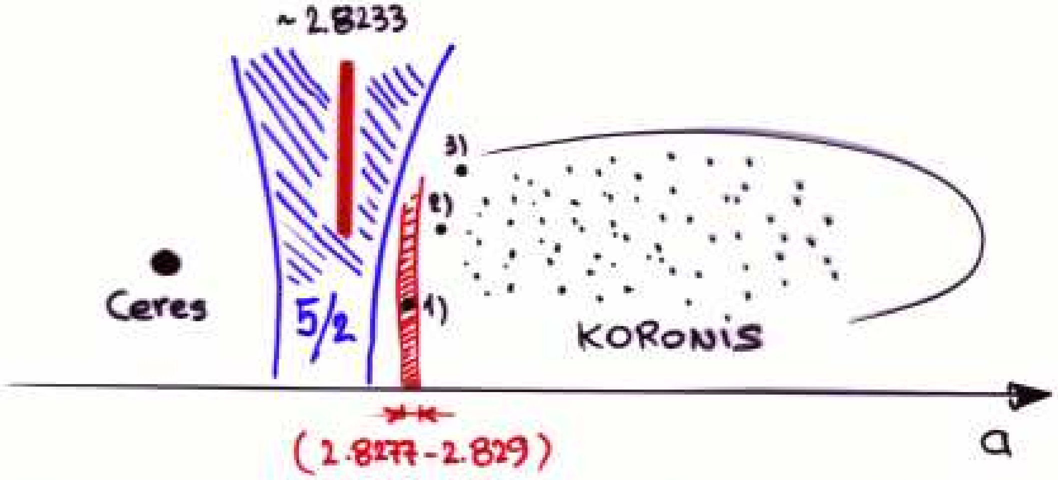
- collisional grinding

- chaotic diffusion



- Yarkovsky diffusion





1) = (2953) Vysheslavia , 2) = 1991 UA2 (7340), 3) = 1993 FR58

Milani & Farinella ('95) noticed a very short dynamical lifetime of the Vysheslavia-like orbits ($\gtrsim$ 50% close clones die within 30 Myr)

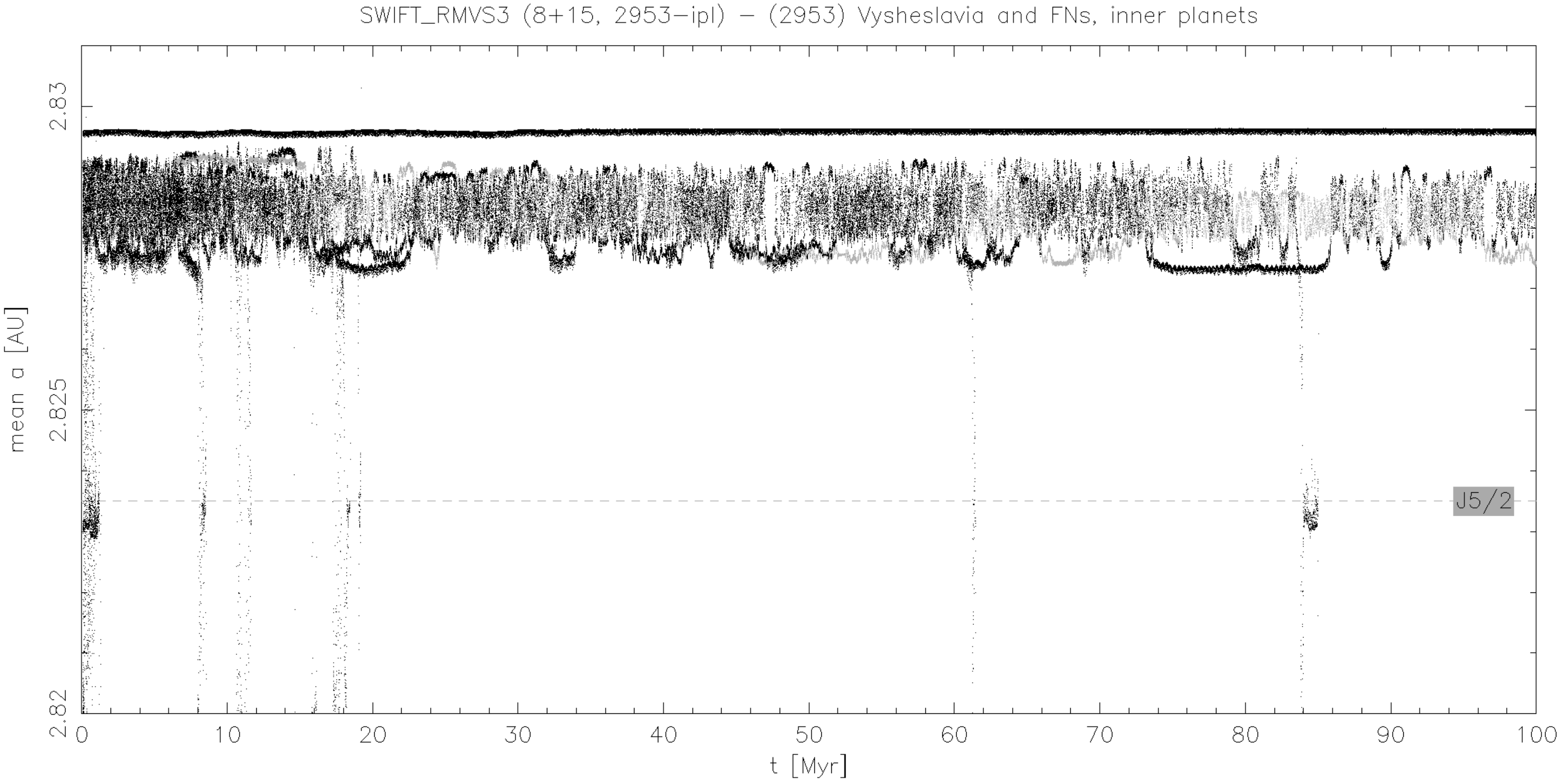
Knežević et al ('97) two other Koronis members very close to this chaotic zone

CONSEQUENCES & SCENARii

- Vysheslavia is an offspring of a secondary collision in the family
- Vysheslavia has been placed on its peculiar orbit by chaotic diffusion or scattering on nearby asteroids (? Ceres?)
- [Vysheslavia has been transported on its peculiar orbit by the Yarkorsky drift [~(0.01 - 0.02) AU within the estimated lifetime of Vysheslavia ; ~1.3 Gyr]]

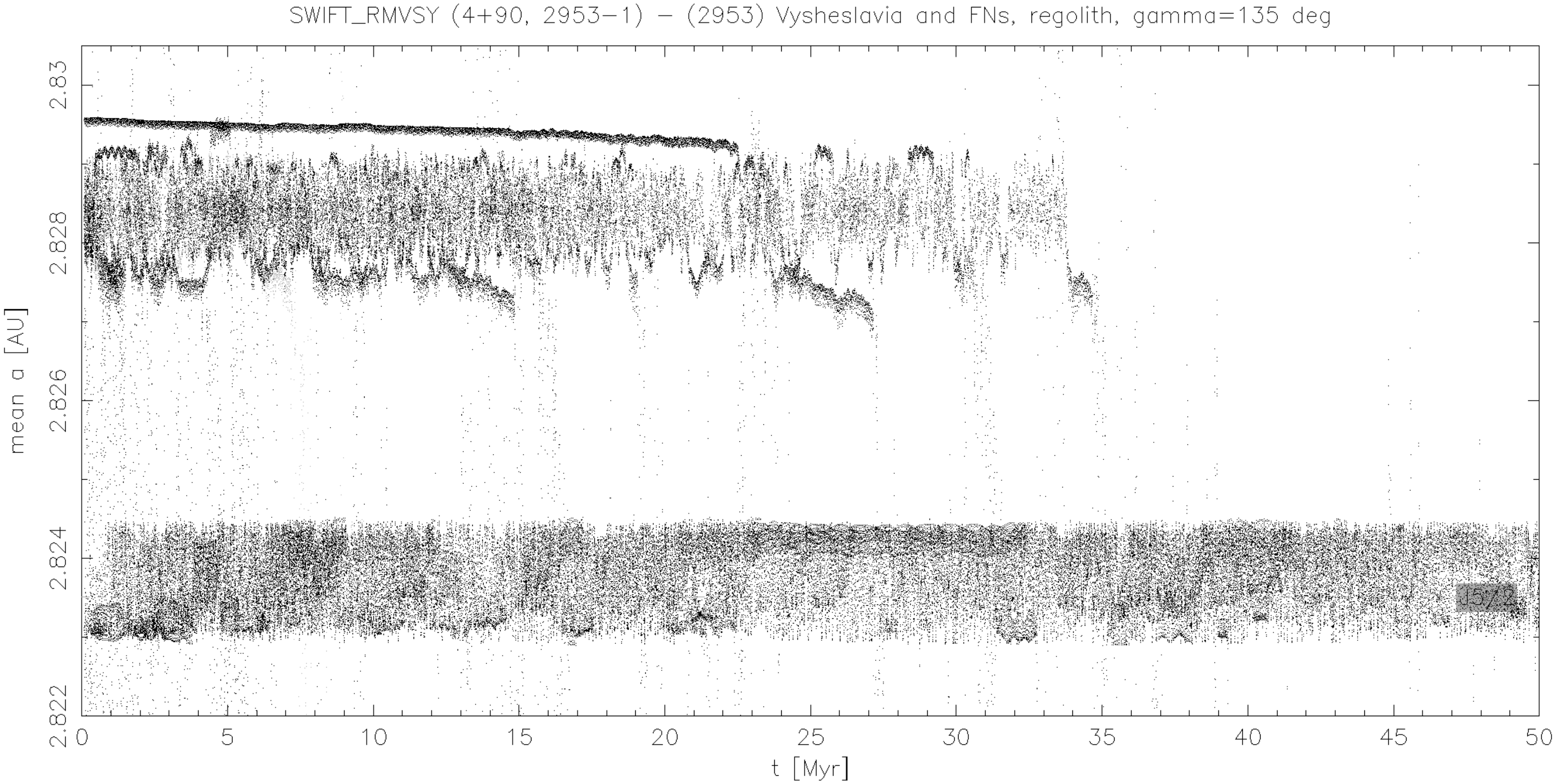
Long-term orbital evolution of (2953) Vysheslavia and its clones

- no Yarkovsky effect
- if 4 outer planets only (& barycentric correction) ⇒ longer residence in the 5:2 resonance region



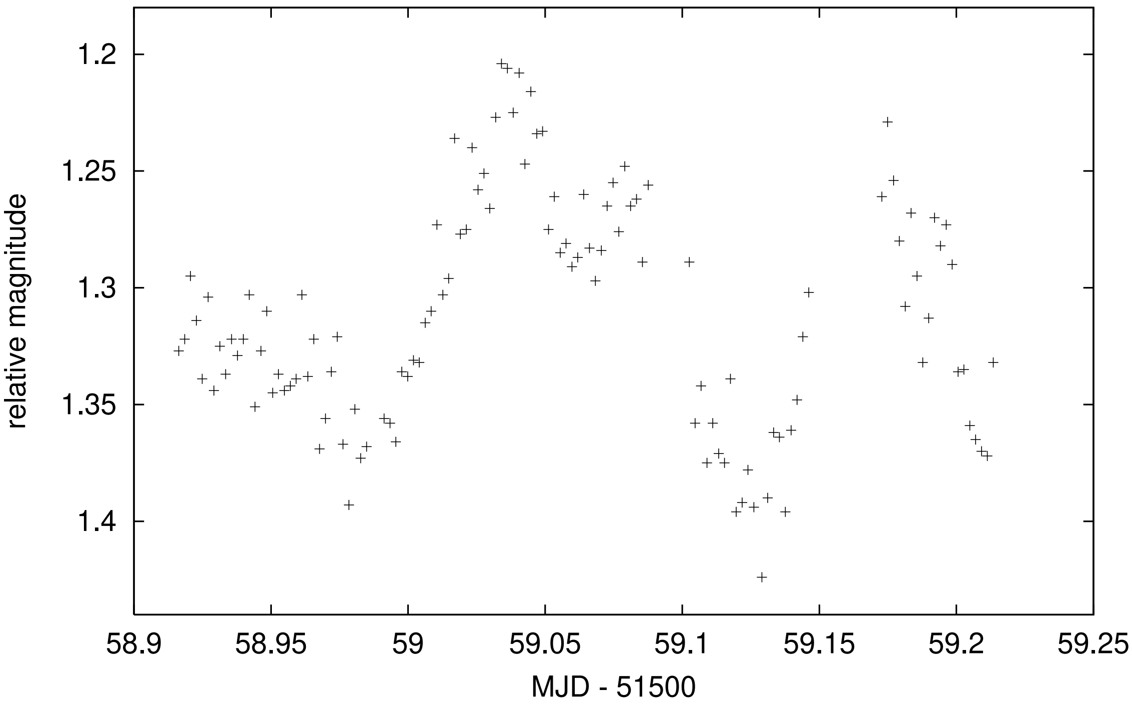
Long-term orbital evolution of (2953) Vysheslavia and its clones

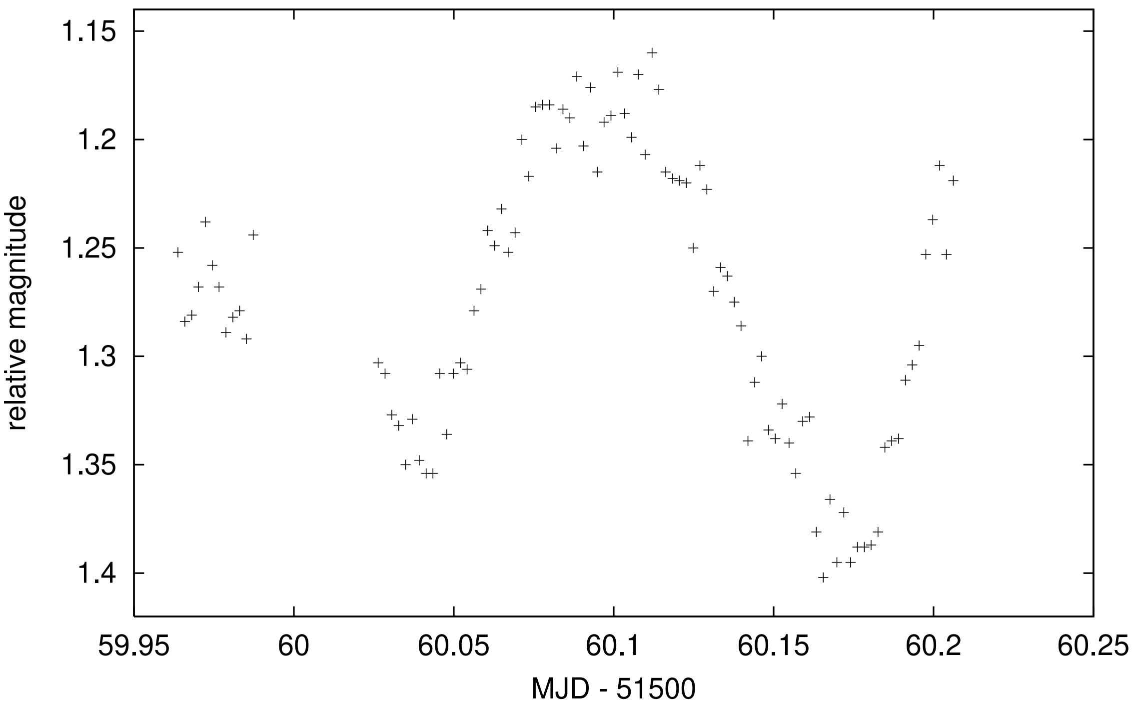
- **Yarkovsky effect** included, low conductivity surface assumed, fixed spin axis orientation (initial obliquity = 135°)
- results in a **shorter lifetime** before falling in the 5:2 resonance



Photometry of (2953) Vysheslavia (Šarounová, 2000)

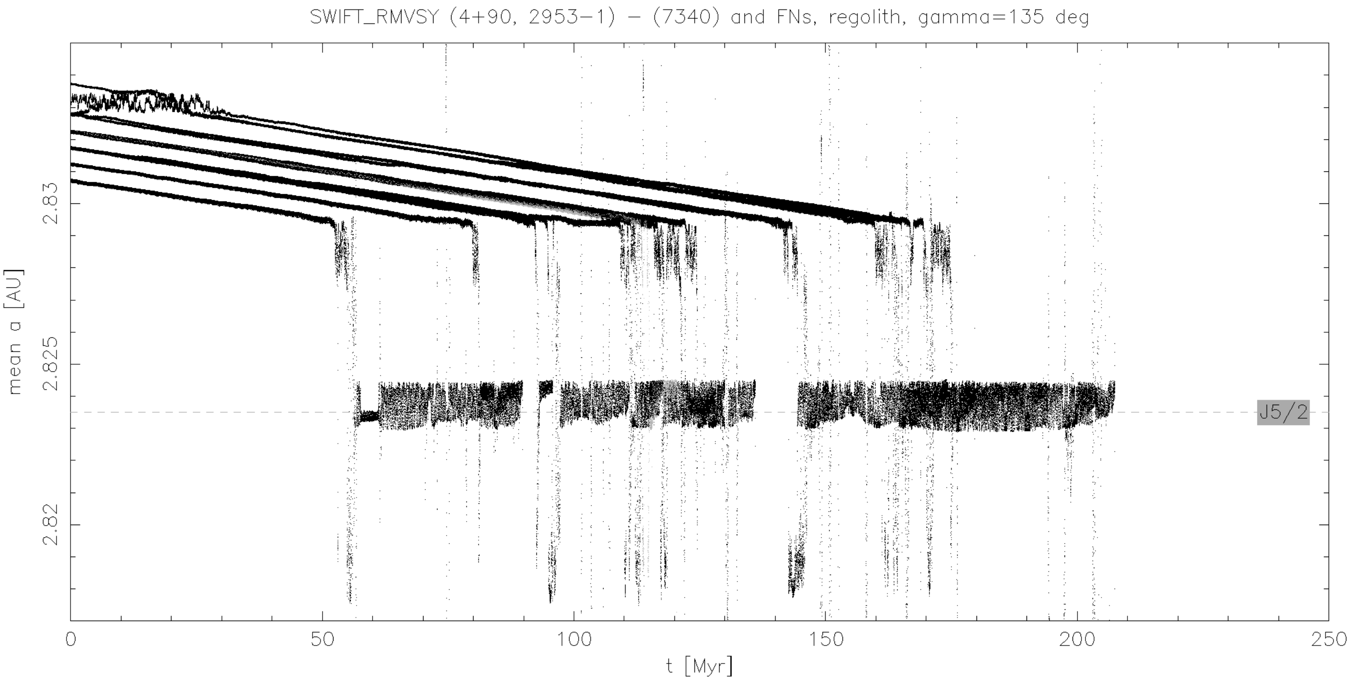
- observation on Jan 15/16/17th 2000 at St. Veran, France, apparent magnitude $\sim$ 15.5 mag
- preliminary reduction: **period** (6.29 ± 0.05) h, **amplitude** ~ 0.2 mag
- acknowledgements: A. Paschke, L. Šarounová, L. Vašta, Astroqueyras Society

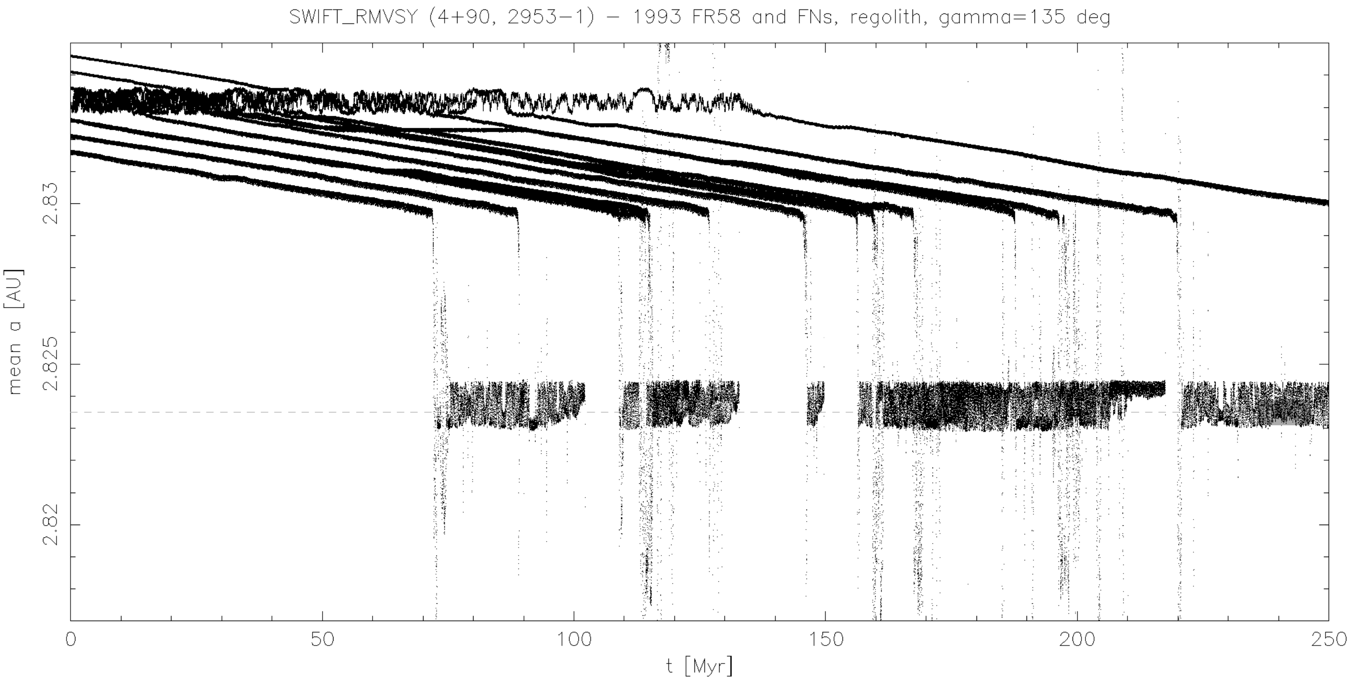




(7340) and 1993 FR_{58} — transport towards the 5:2 resonance

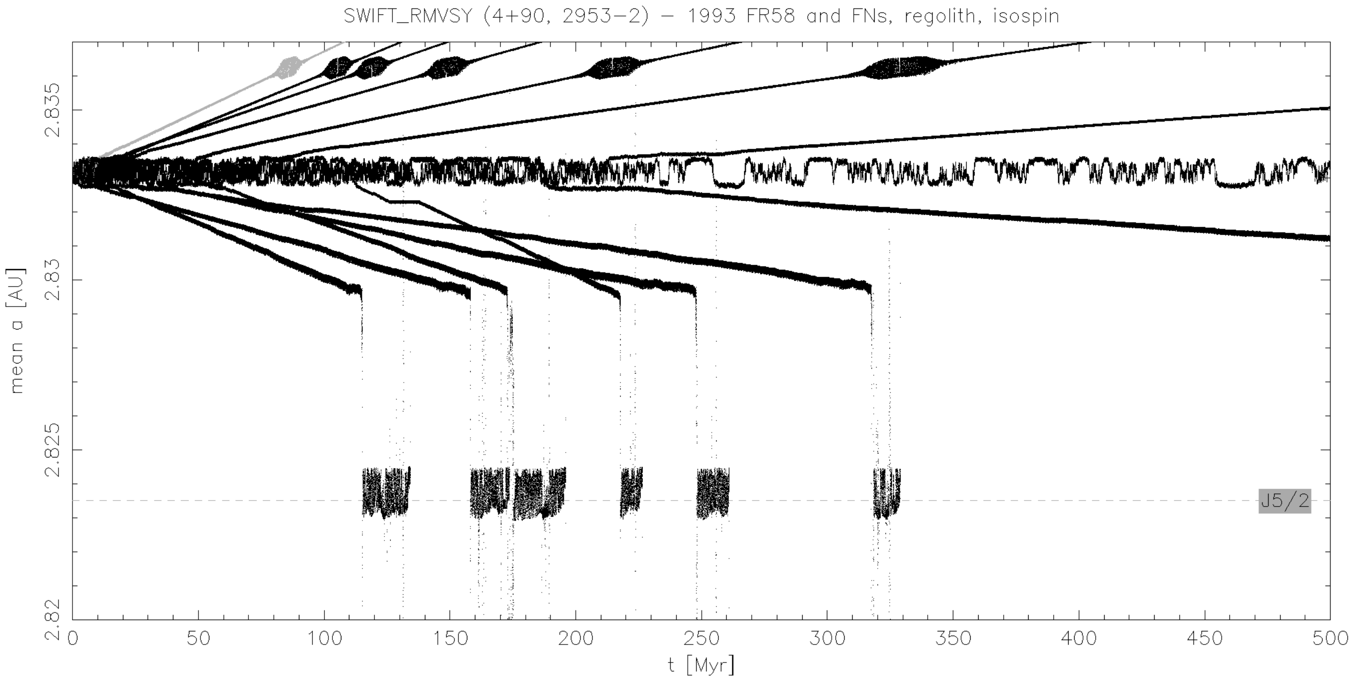
- **Yarkovsky effect** included, low conductivity surfaces (K = 0.0015 W/m/K), fixed orientation of spin axes (initial obliquity γ = 135°)
- (7340), 1993 FR_{58} and their ficticious neighbours reach the 5:2 resonance within 50 – 250 Myr
- two **chaotic zones** between 2.8275 – 2.829 AU (jumped over, when particles drift from higher semimajor axes) and 2.8329 – 2.8335 AU

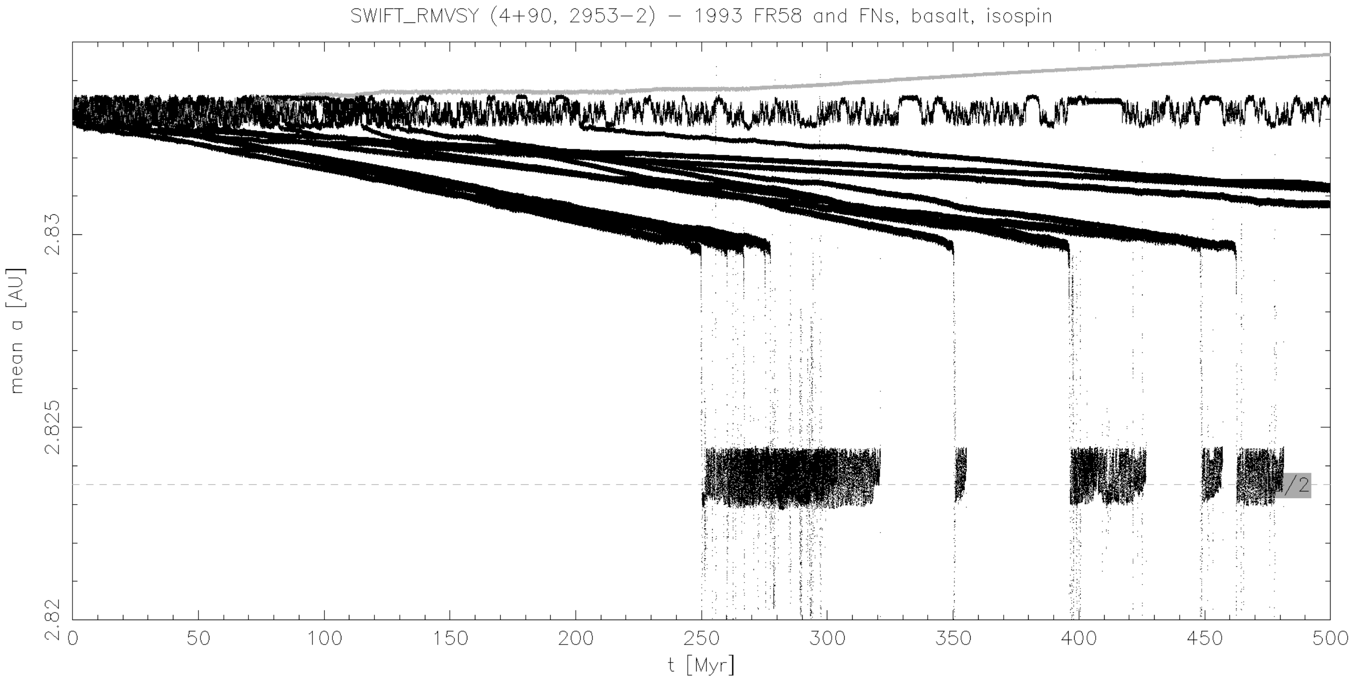




1993 FR_{58} — isotropic spin axes, low and high surface conductivity:

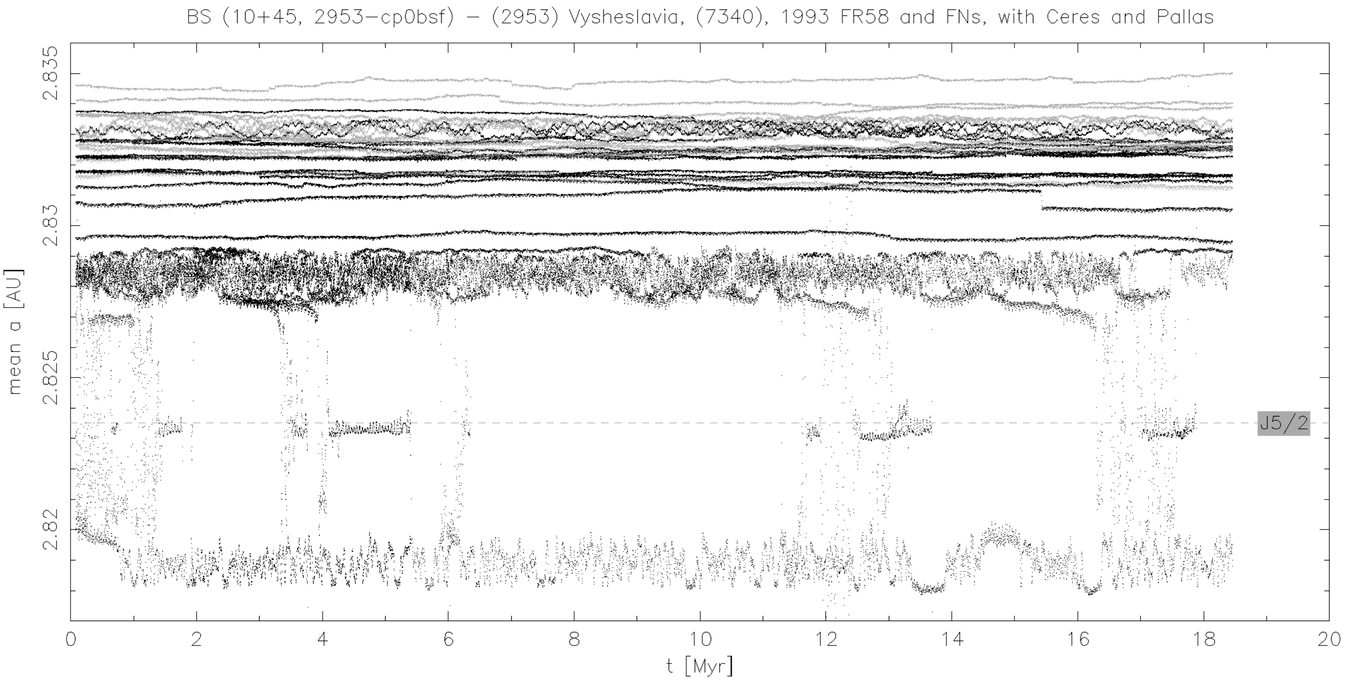
- regolith covered bodies (K = 0.0015 W/m/K) — diurnal Yarkovsky effect dominates, $\sim$ 1/2 of clones drift towards the 5:2 resonance (first fall after 100 Myr)
- bare basalt bodies (K = 1.0 W/m/K) — seasonal variant dominates, most of particles drift to the 5:2 resonance, $\sim$ 2.2 times slower drift



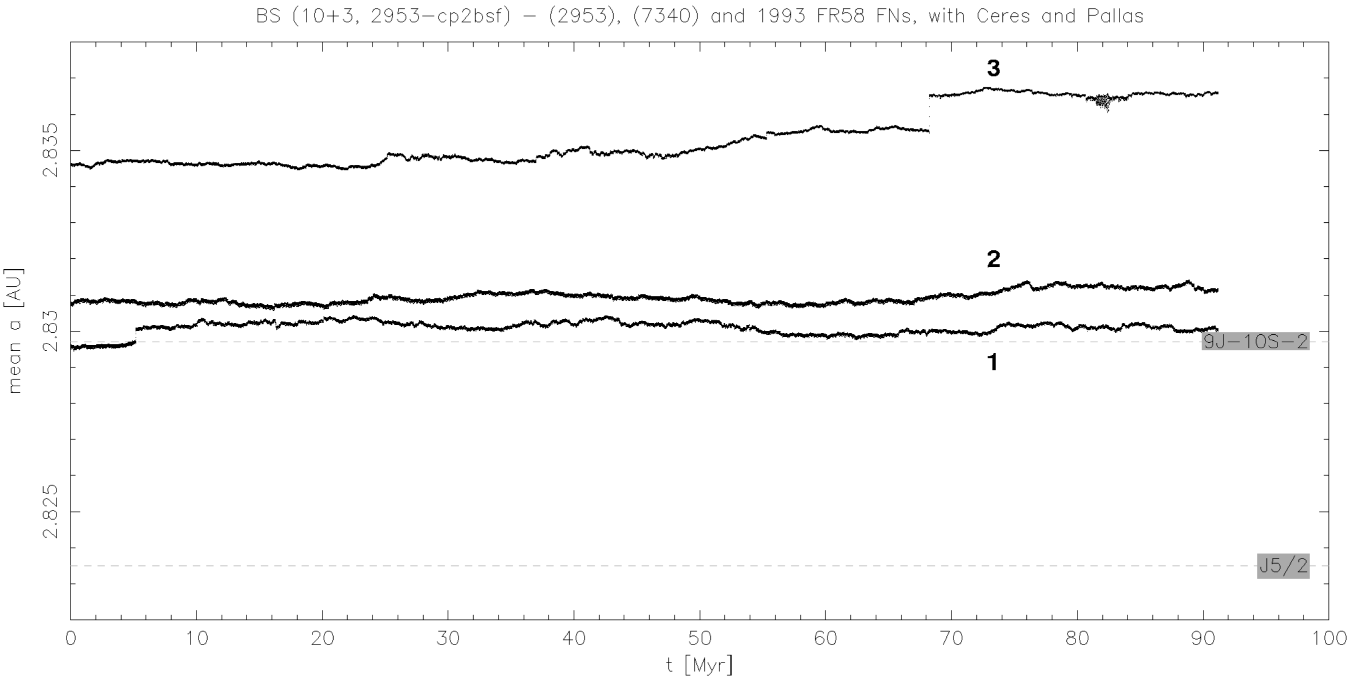


Gravitational perturbations by Ceres and Pallas

- inner planets and asteroids (1) Ceres, (2) Pallas included
- integration with **Burlish–Stoer**, $\varepsilon = 10^{-8}$ (close encounters $\Rightarrow$ instability of SWIFT_RMVS3)
- semimajor axis fluctuations $\leq 10^{-3}$ AU, "random walk"



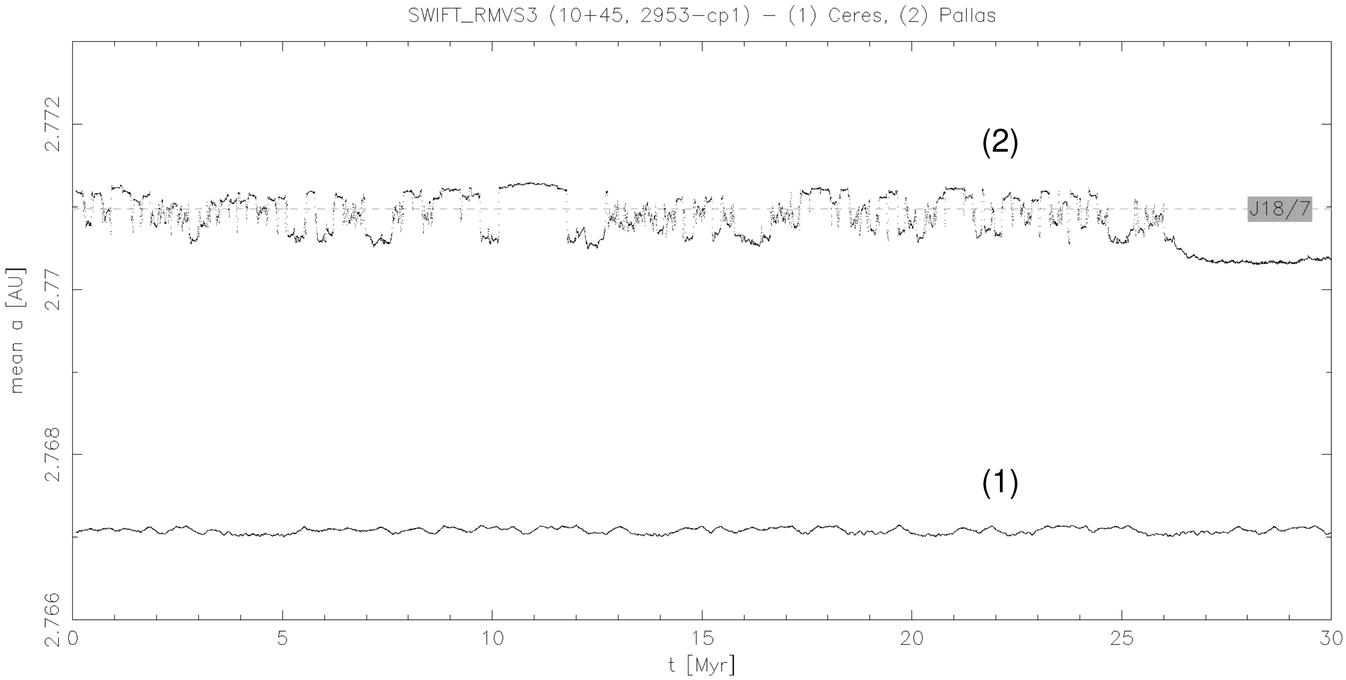
- longer time-span for FN^0_{+3} of (2953) Vysheslavia – curve 1, FN^0_{-3} of (7340) – curve 2, FN^0_{+3} of 1993 FR_{58} – curve 3

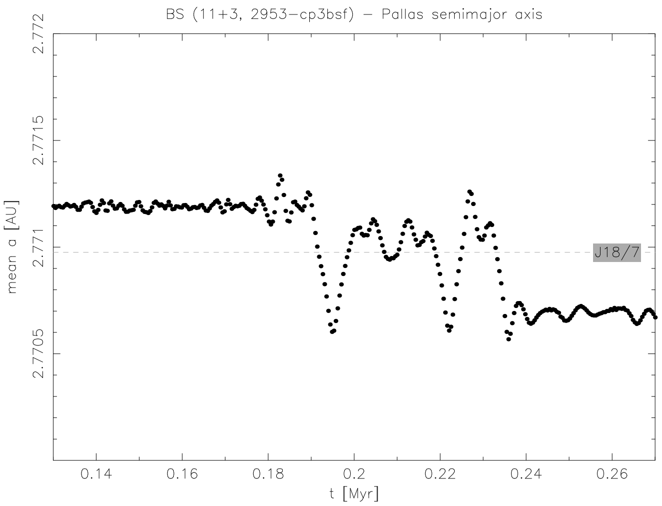


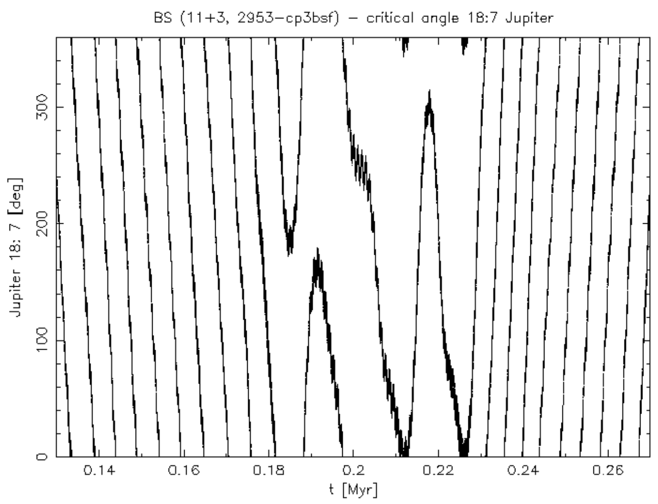
Pallas chaotic orbit — 18:7 resonance with Jupiter

1. orbital evolution of (2) Pallas and (1) Ceres
2. detail of mean semimajor axes evolution (0.13 – 0.27 Myr) for (2) Pallas
3. **critical angle** of the 18:7 mean motion jovian resonance, temporary libration

1
2|3

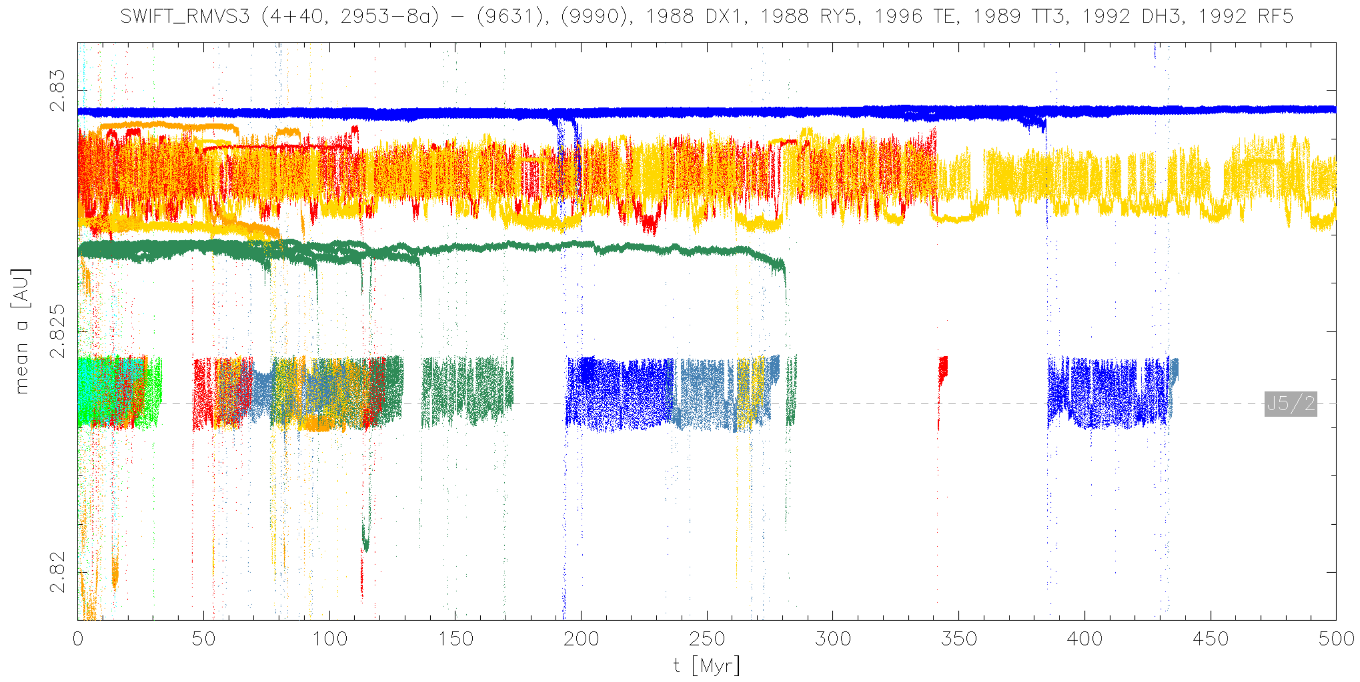






Asteroids in the surroundings of the 5:2 jovian resonance

- 8 real asteroids (9631) Hubertreeves, (9990), 1988 DX_1, 1989 TT_3, 1988 RY_5, 1996 TE, 1992 DH_3, 1992 RF_5 and their 32 close clones ($\mathrm{d}a = 10^{-7}$ AU)
- orbital elements from Bowell's `astorb.dat`, planetary ephemeris DE405 (4 outer planets)
- numerical integration using SWIFT_RMVS3 without Yarkovsky upto 500 Myr, $\mathrm{d}t$ = 36 days



Median lifetimes before the fall into the 5:2 resonance:

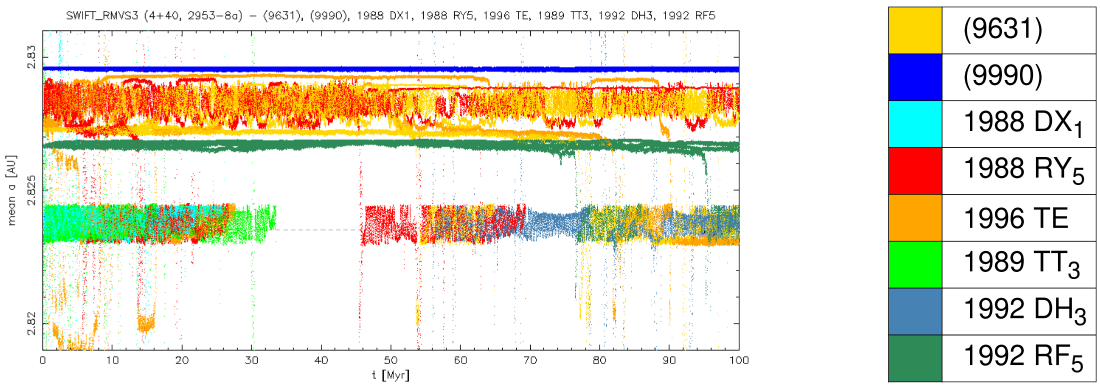
- τ_A — lifetimes for the run without Yarkovsky
- τ_B — simulation including Yarkovsky effect, fixed orientation of spin axes γ = 135° (initially), assumed low conductivity surfaces K = 0.0015 W/m/K (see next page)

asteroid	τ_A/Myr	τ_B/Myr
(9631)	268	30
(9990)	395	22
1988 DX_1	0.2	0.2
1988 RY_5	47	11
1996 TE	14	22
1989 TT_3	0.1	0.1
1992 DH_3	239	$>$100
1992 RF_5	116	11

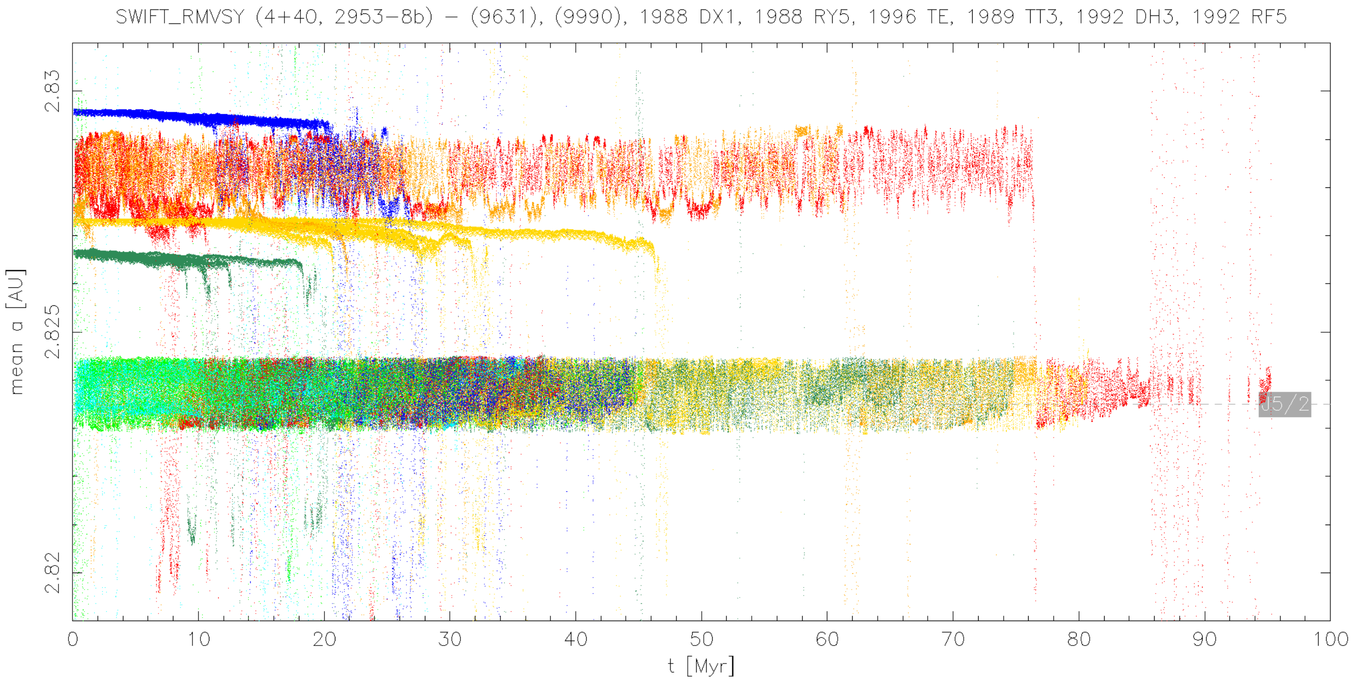
	(9631)
	(9990)
	1988 DX_1
	1988 RY_5
	1996 TE
	1989 TT_3
	1992 DH_3
	1992 RF_5

Behavior of asteroids and their clones:

- (9631) — the first fall of a clone into the 5:2 resonance after 50 Myr
- (9990) — stays **above** the "chaotic zone" for more than 200 Myr
- 1988 DX_1, 1989 TT_3 — initially inside the 5:2 resonance
- 1988 RY_5, 1996 TE — initially in the chaotic zone, $\tau \approx 10^1$ Myr
- 1992 DH_3 — mean elements below the resonance
- 1992 RF_5 — stays for 100 Myr **below** the chaotic zone and above the 5:2 resonance



Comparsion with integrations including Yarkovsky effect:



- Yarkovsky parameters: low conductivity surfaces K = 0.0015 W/m/K, albedo 0.2 ($\Rightarrow$ radii 1.5 – 4.3 km)
- fixed orientations of the spin axes, initial obliquity γ = 135° ($\Rightarrow$ drag)

- the spin axes with initial γ = 45° lead to outward drift, longer lifetime of asteroids initially located outside the 5:2 resonan-ce