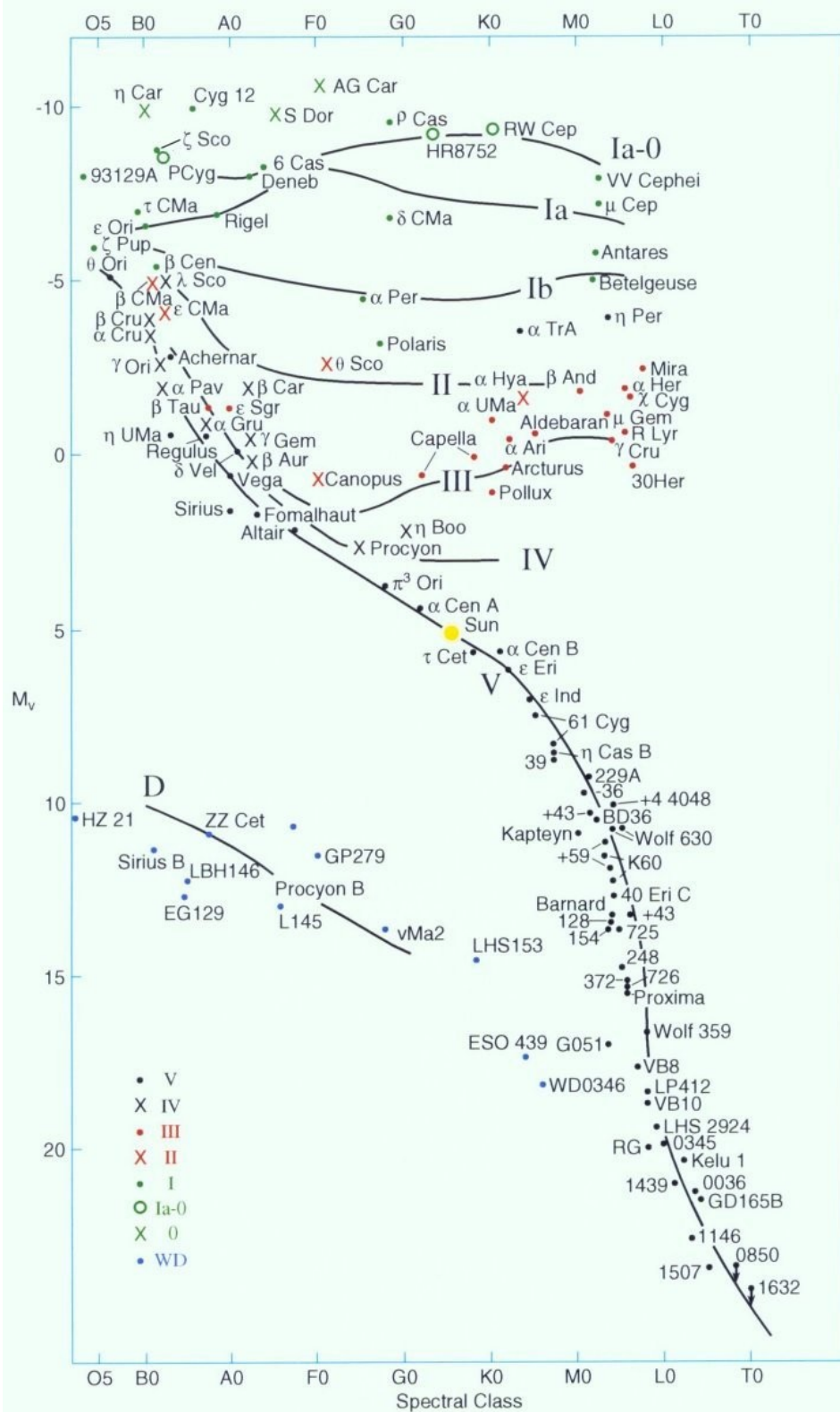
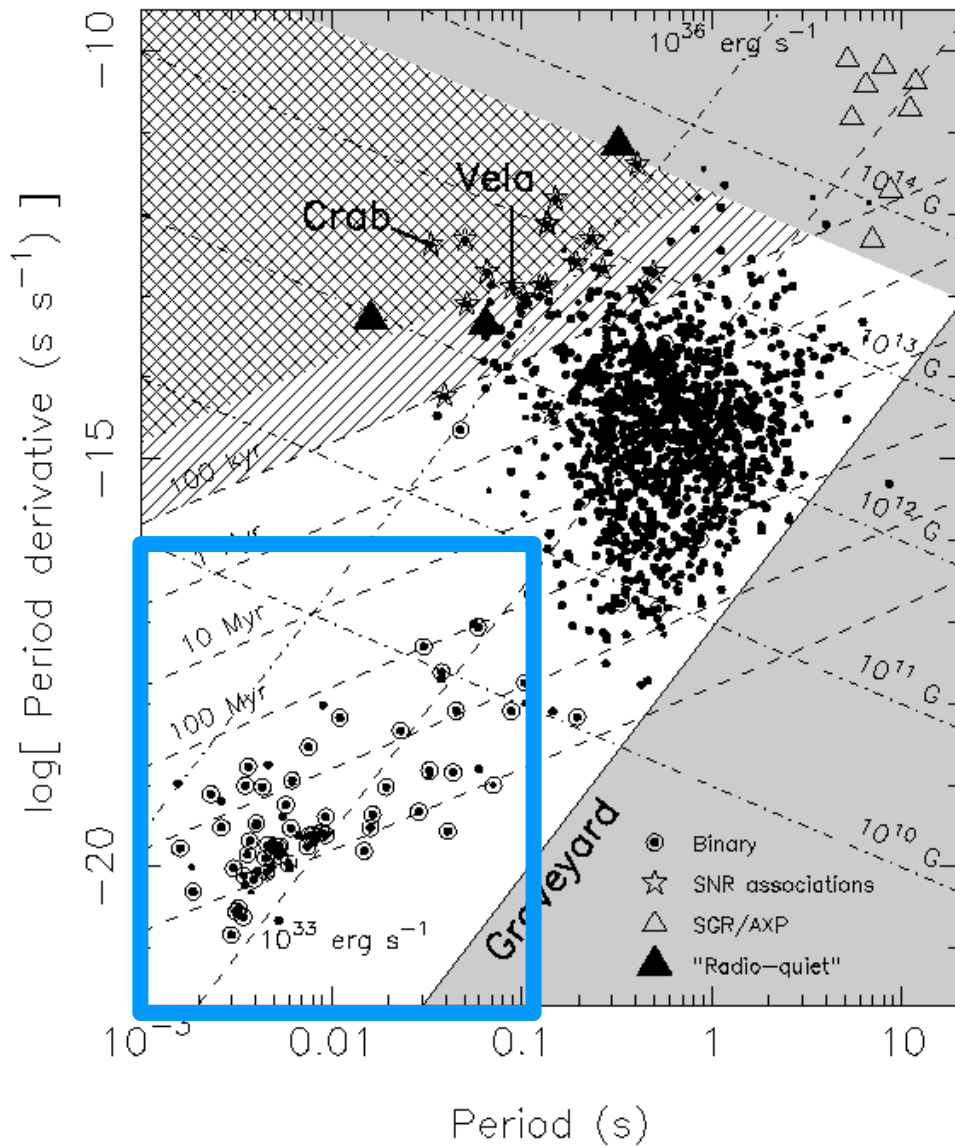


On the role of orbital migration in the formation of the planetary system around the pulsar PSR B1257+12

Ewa Szuszkiewicz

CASA*, University of Szczecin, Poland





Taken from "Handbook of Pulsar Astronomy" by Lorimer & Kramer

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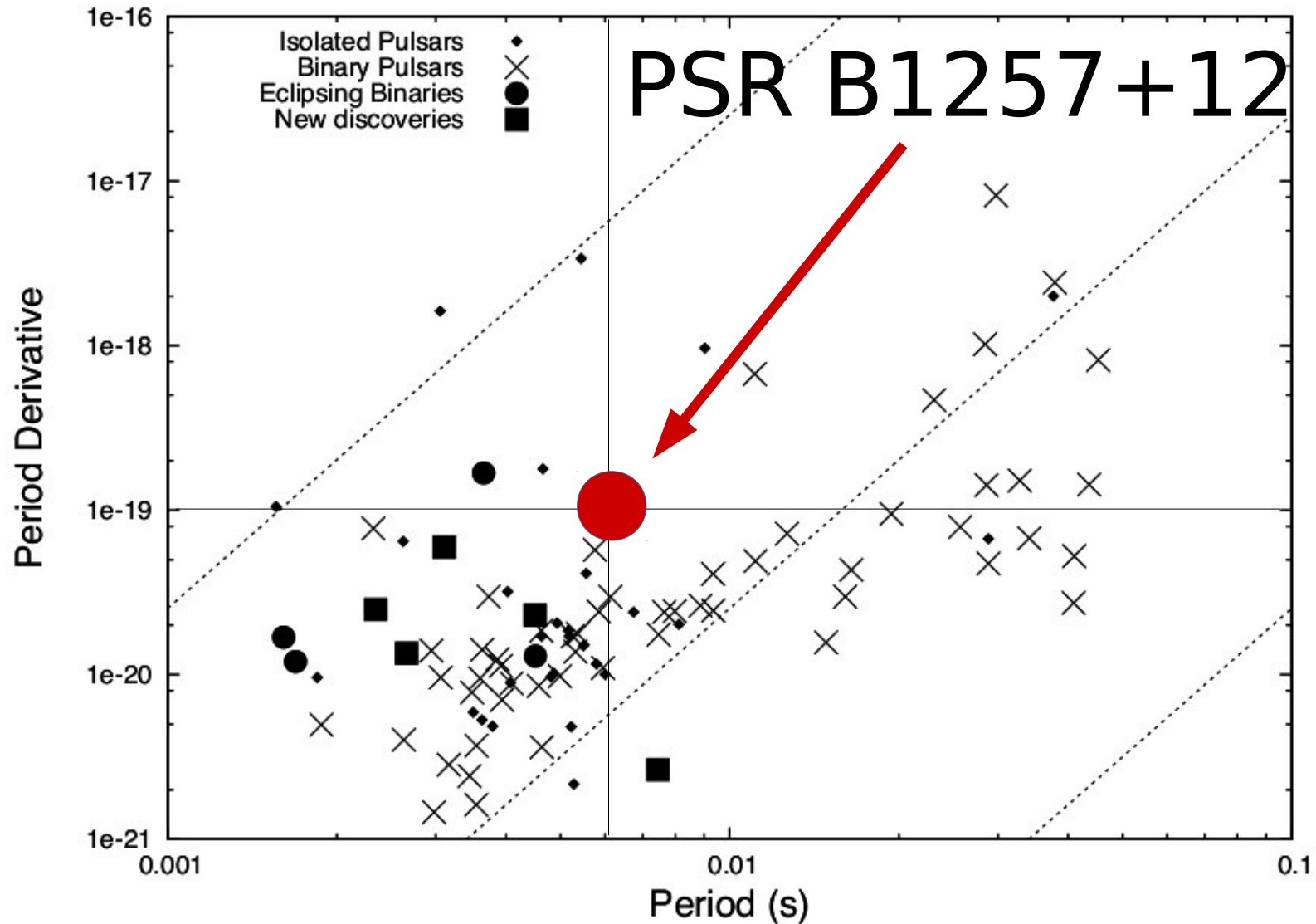


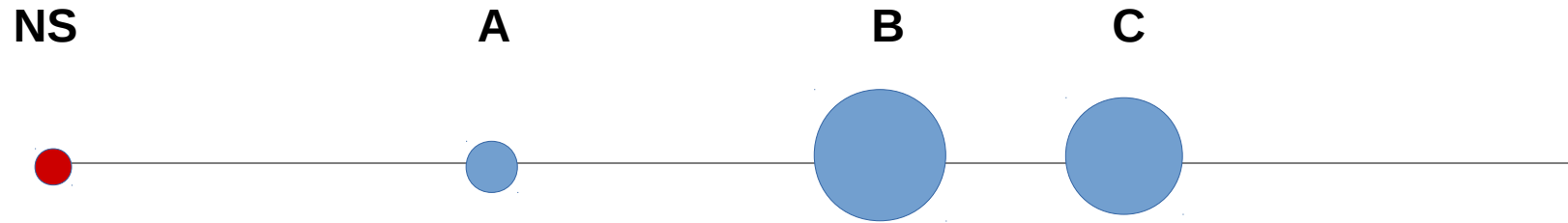
Figure 1. $P - dP/dt$ diagram of the millisecond pulsars, divided by binary ‘type’. Lines of constant dE/dt cross the population at (from left to right) 10^{36} , 10^{33} and 10^{30} erg s^{-1} . Pulsars in globular clusters have been excluded from this figure (Bates et al. 2011).

PSR B1257+12

Characteristic age ~ 1 Gyr

Magnetic field strength, $B \sim 10^9$ G

Planetary companions

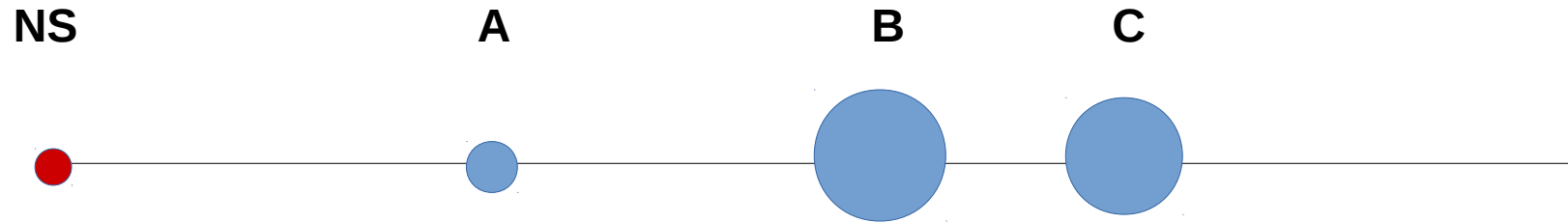


PSR 1257+12 PLANETARY SYSTEM (Goździewski et al. 2005)

TABLE 1
 ASTROCENTRIC OSCULATING ORBITAL ELEMENTS OF THE PLANETS IN PSR 1257+12 PLANETARY SYSTEM AT THE EPOCH MJD = 49,766.50

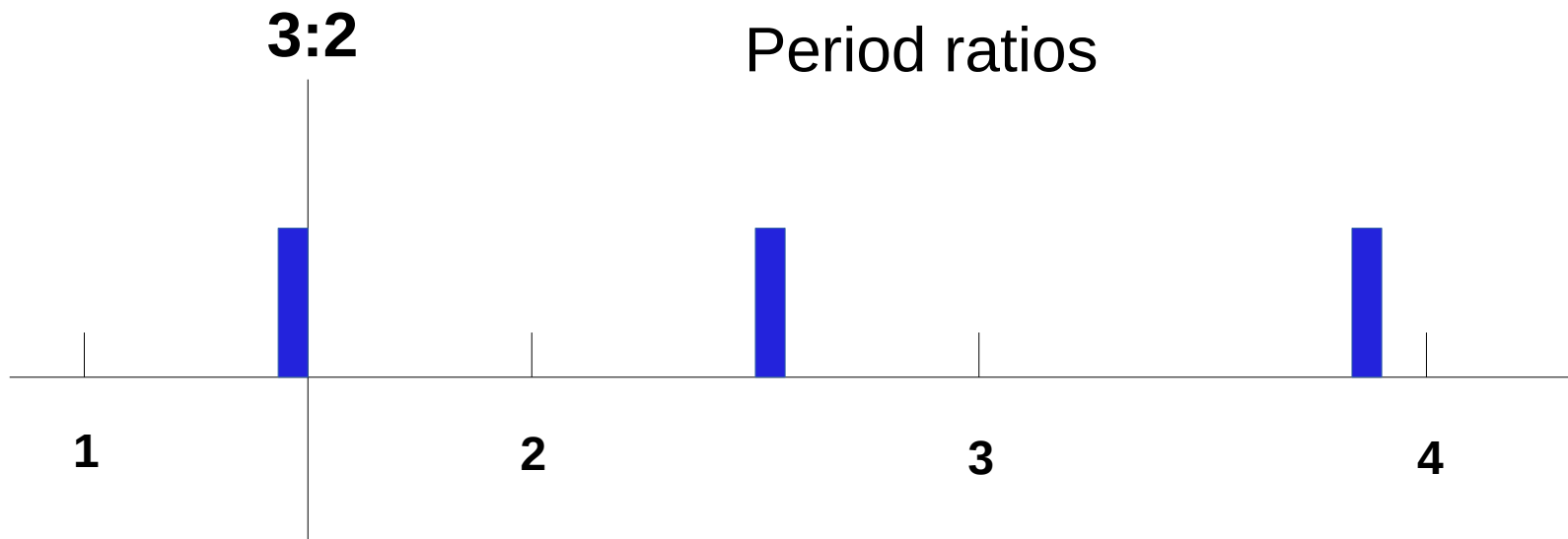
| Planet | Mass (M_{\oplus}) | a (AU) | e | i (deg) | Ω (deg) | ω (deg) | M (deg) |
|--------|--------------------------|-------------|--------|--------------|-------------------|-------------------|--------------|
| A..... | 0.019 | 0.18850 | 0.0000 | 50.00 | 0.00 | 0.0 | 14.25 |
| B..... | 4.250 | 0.35952 | 0.0186 | 53.00 | 0.00 | 250.4 | 5.41 |
| C..... | 3.873 | 0.46604 | 0.0252 | 47.00 | 3.26 | 108.3 | 3.66 |

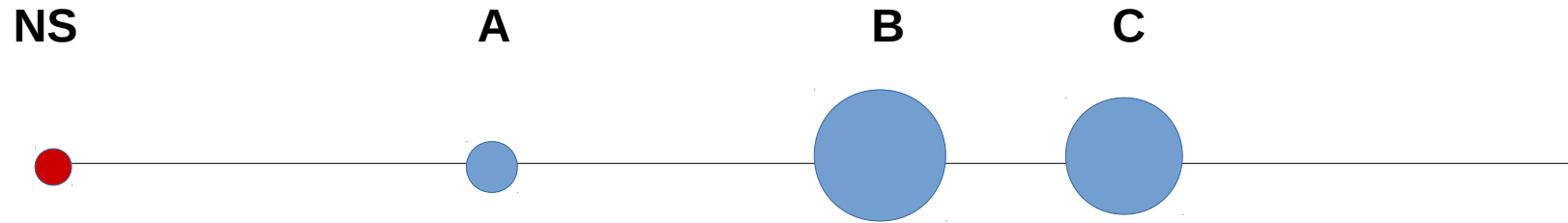
NOTES.—The semimajor axis a , eccentricity e , inclination i , longitude of ascending node Ω , argument of periastron ω , and mean anomaly M of the planets in the PSR 1257+12 planetary system at the epoch MJD = 49,766.50 are derived from the best-fit orbital parameters by Konacki & Wolszczan (2003). The mass of the central star is equal to $1.4 M_{\odot}$.



Orbital Periods in the PSR B1257+12 (from Table 2 in Goździewski et al. 2005)

25.264 66.544 98.218 days





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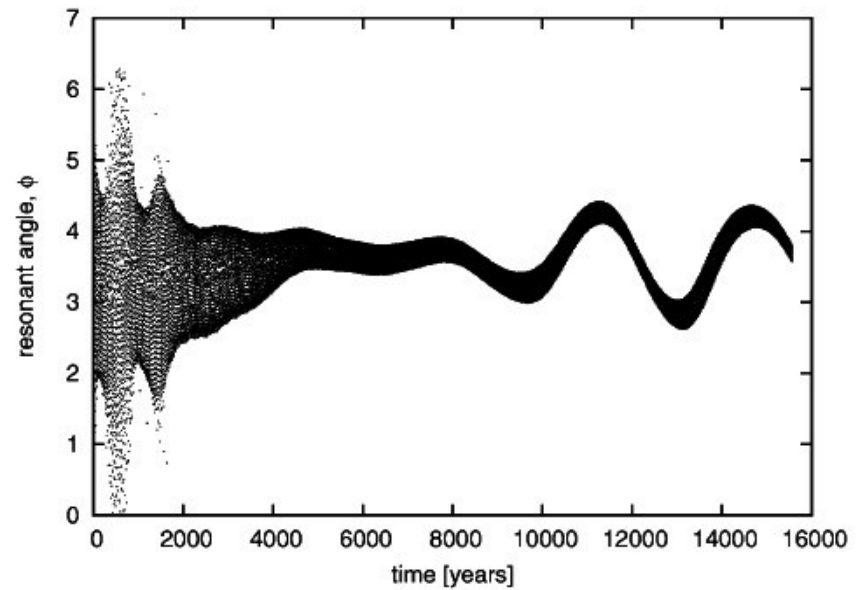
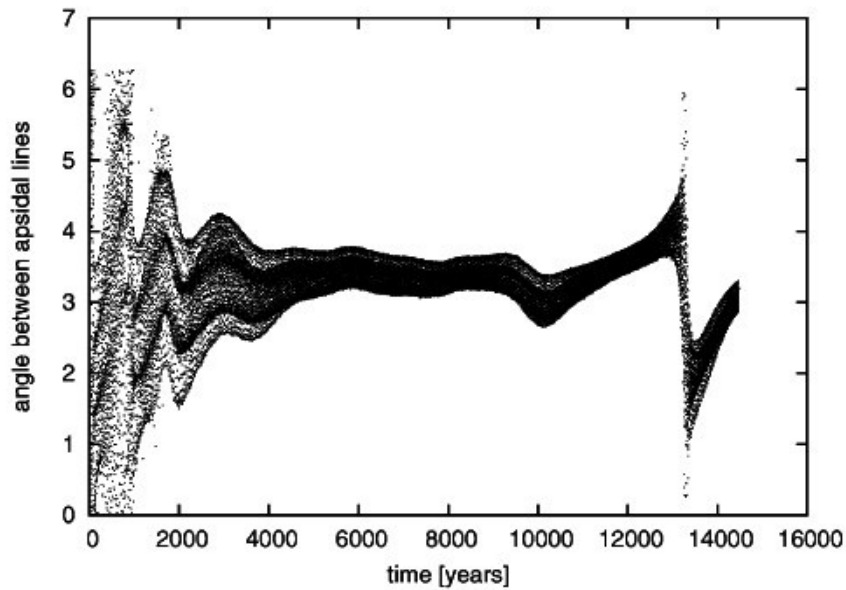
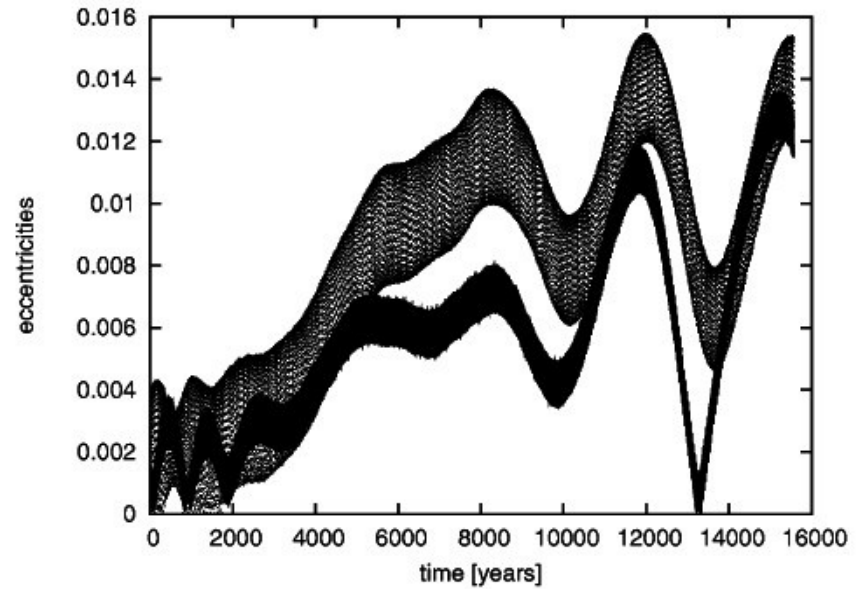
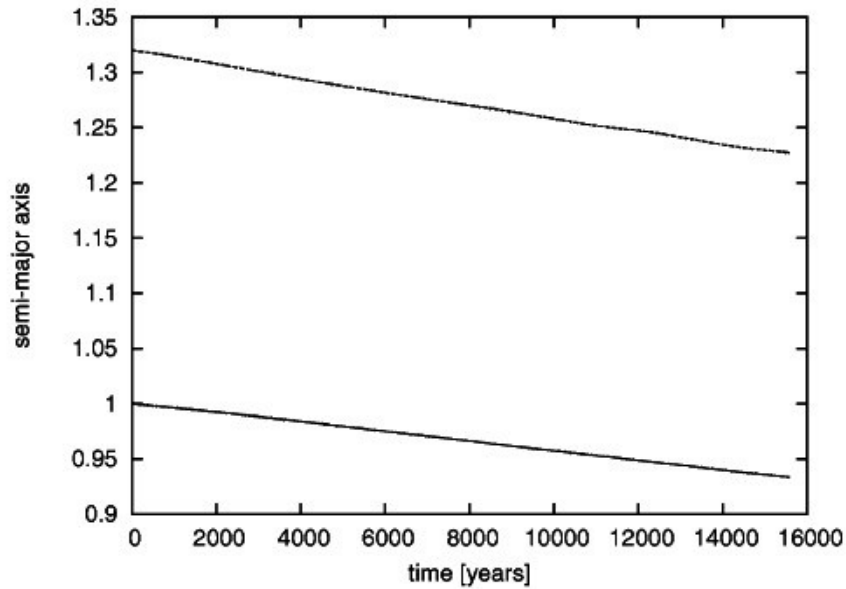
Another interesting relation:

$$3n_A - 14n_B + 9n_C \simeq \frac{0.01^\circ}{\text{year}}$$

A Possible Formation Scenario?

Migration brings planets easily
into a resonance !!!!!!!!!!!

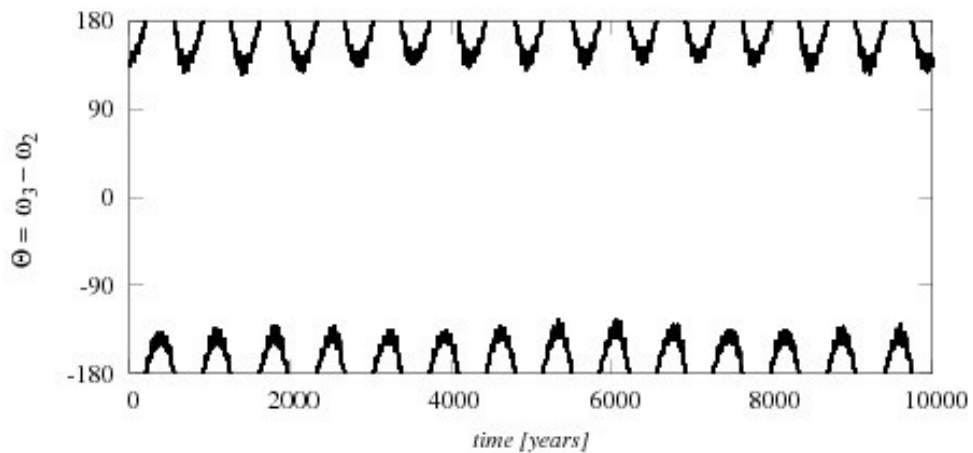
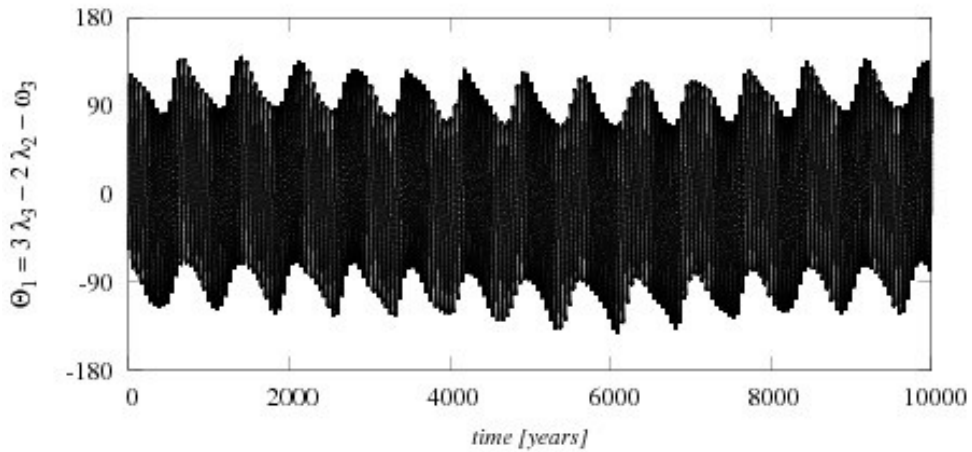
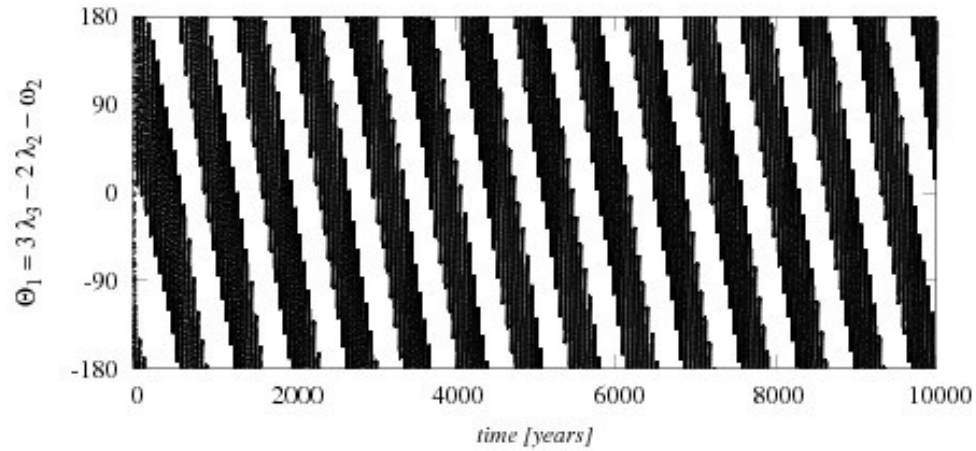
Migration-induced 3:2 resonance



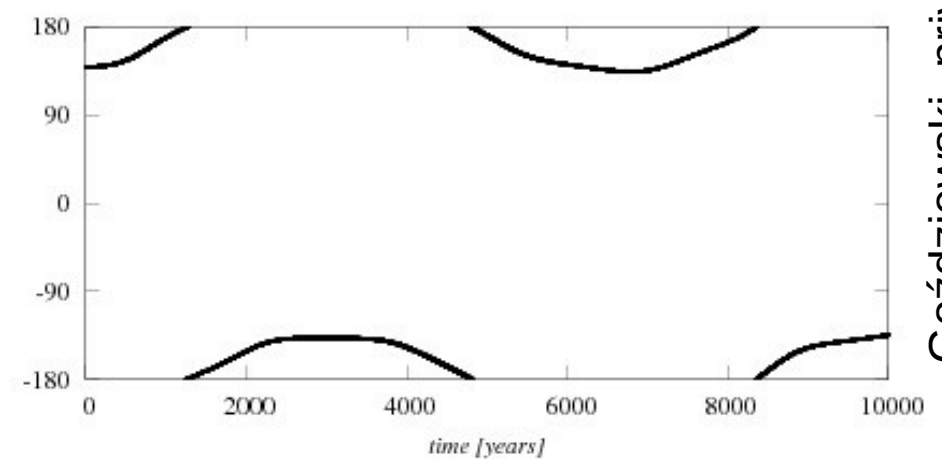
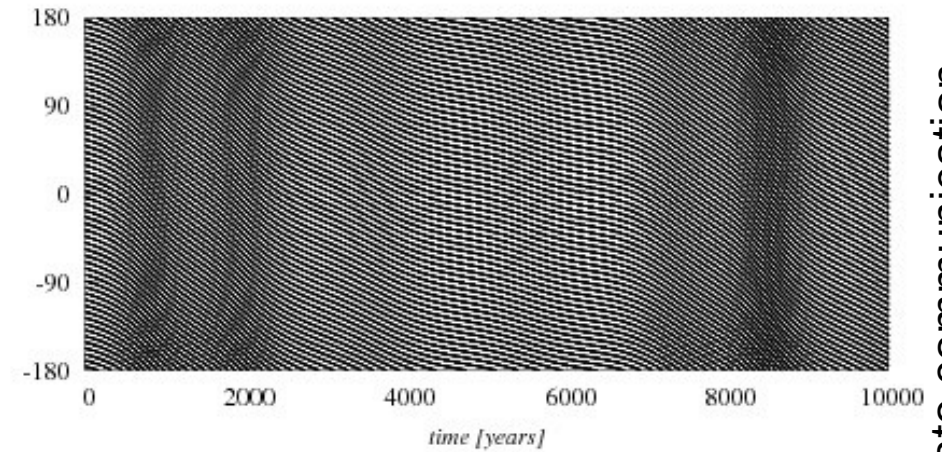
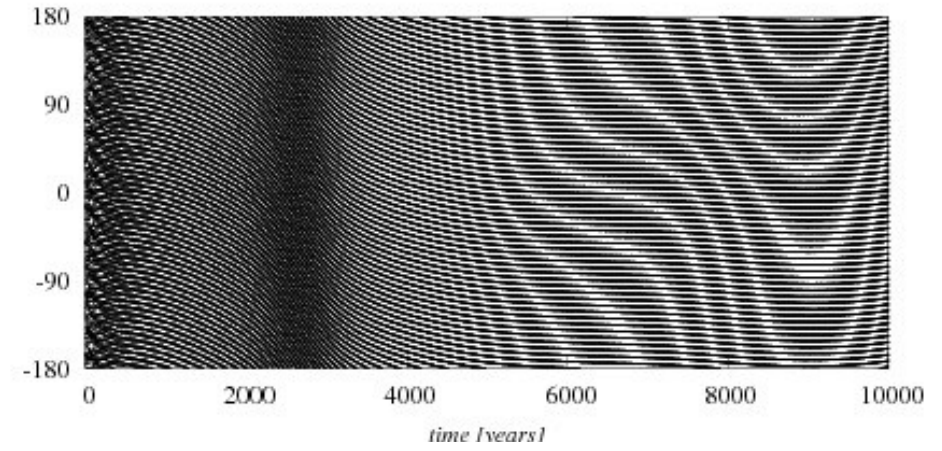
From Papaloizou and Szuszkiewicz (2005)

But ... the system is not
in 3:2 resonance...nor
in 3,-14,9 three-body
resonance

Resonant pair of planets

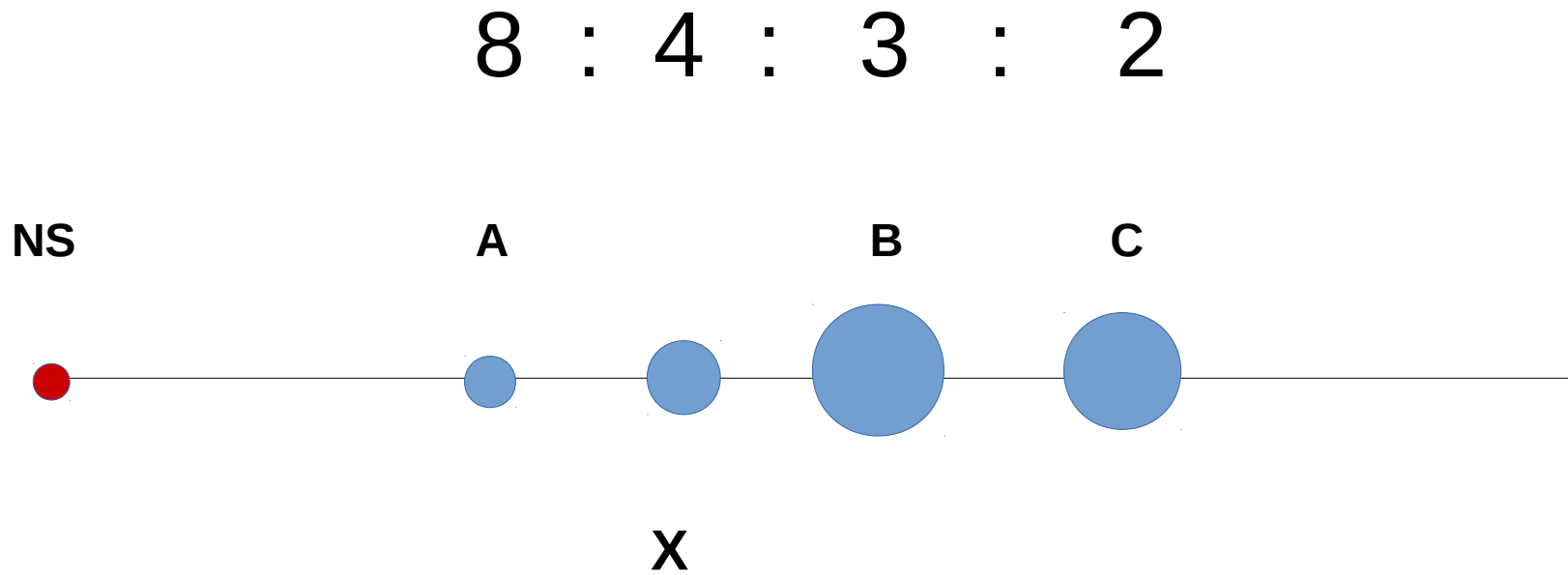


PSR B1257+12

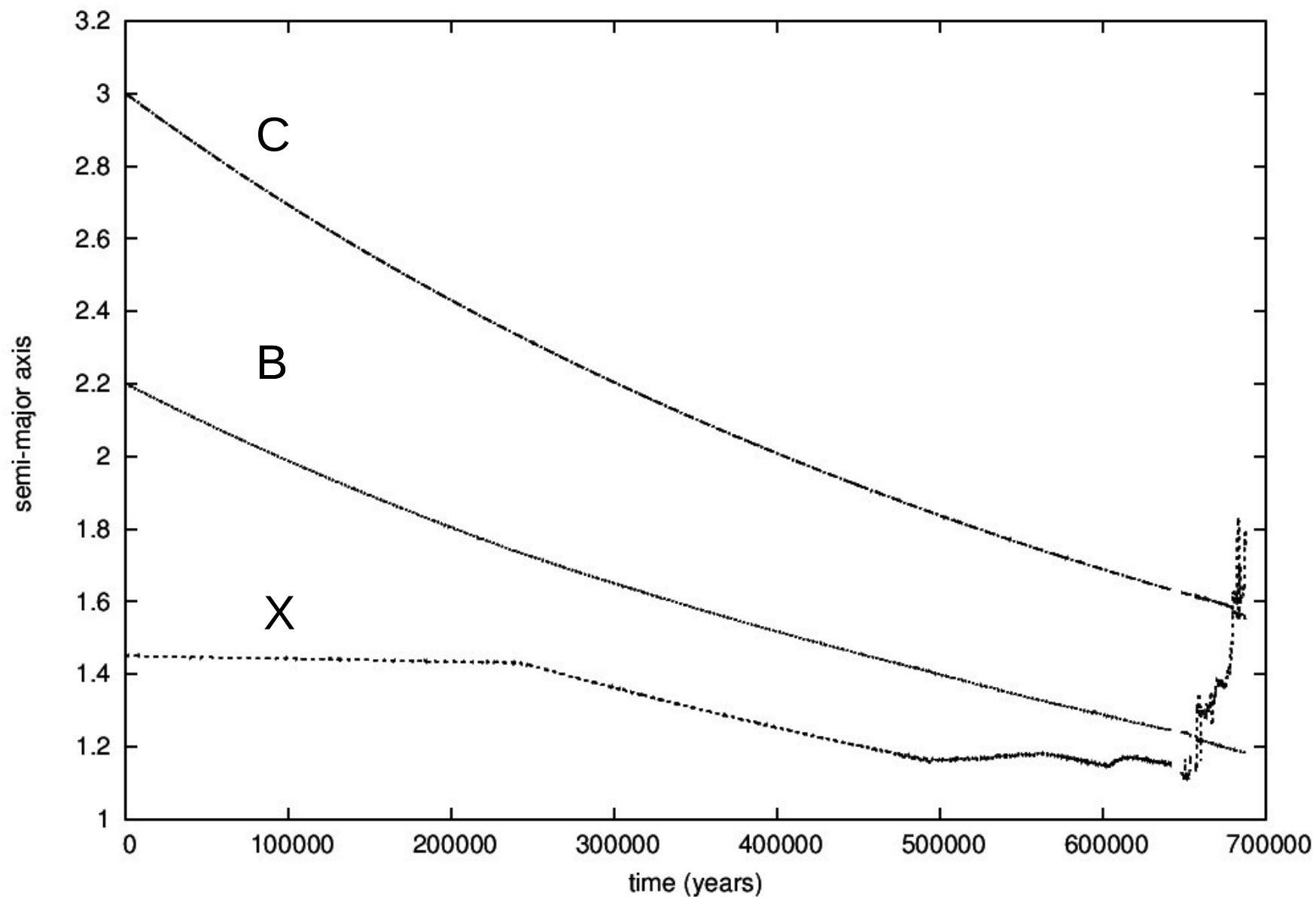


Migration + additional effect

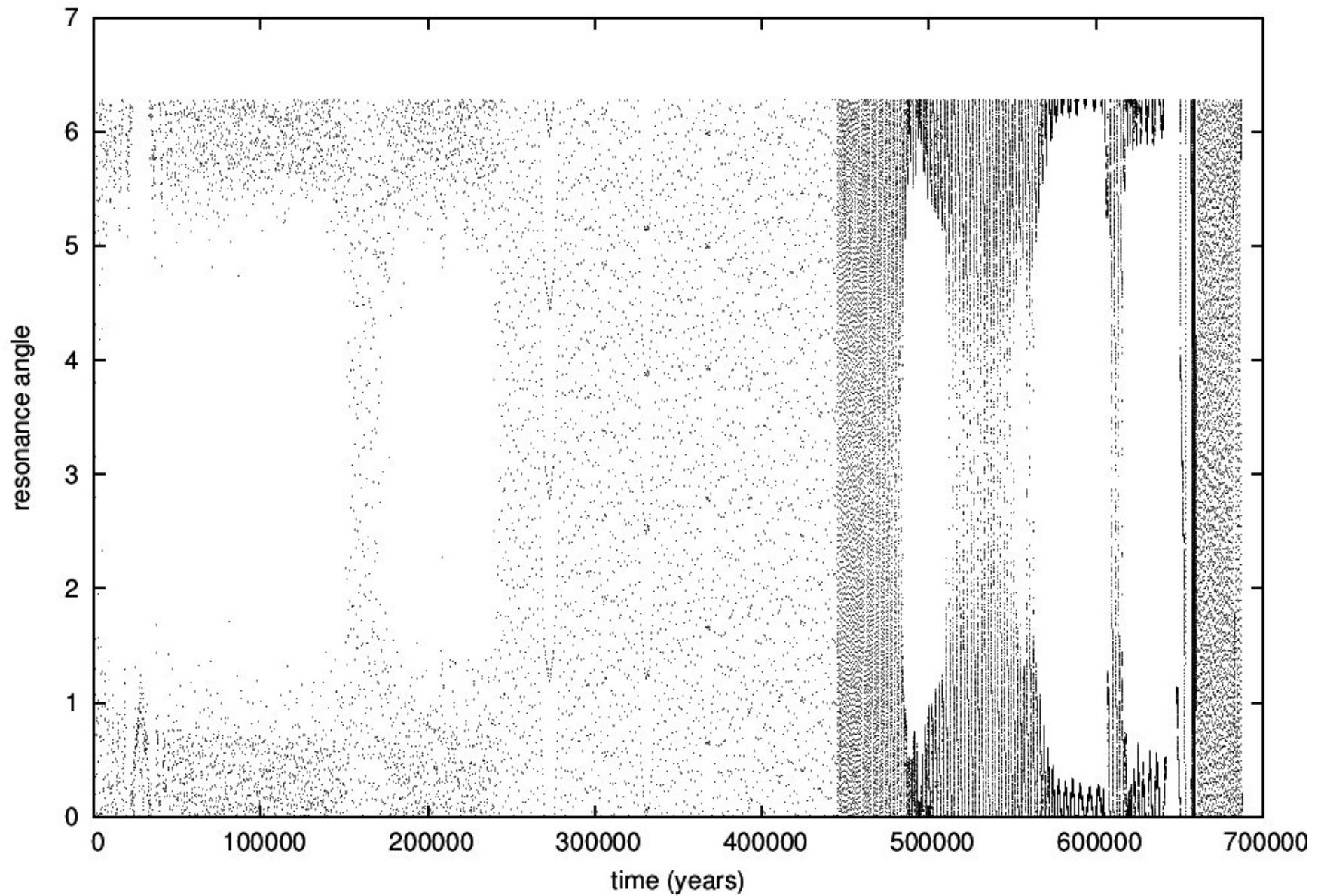
Migration only



The evolution of the semi-major axis



The evolution of the resonance angle between planets B and C



Conclusions:

a particular planetary configuration observed around PSR B1257+12 may result from the evolution of four planet system approaching a chain of mean-motion resonances via orbital migration.



NATIONAL SCIENCE CENTRE
POLAND

Project:

Formation and evolution of mean-motion resonances in planetary systems

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