On the Origin of the Long-Lived Asteroids in the 2:1 Mean-Motion Resonance with Jupiter

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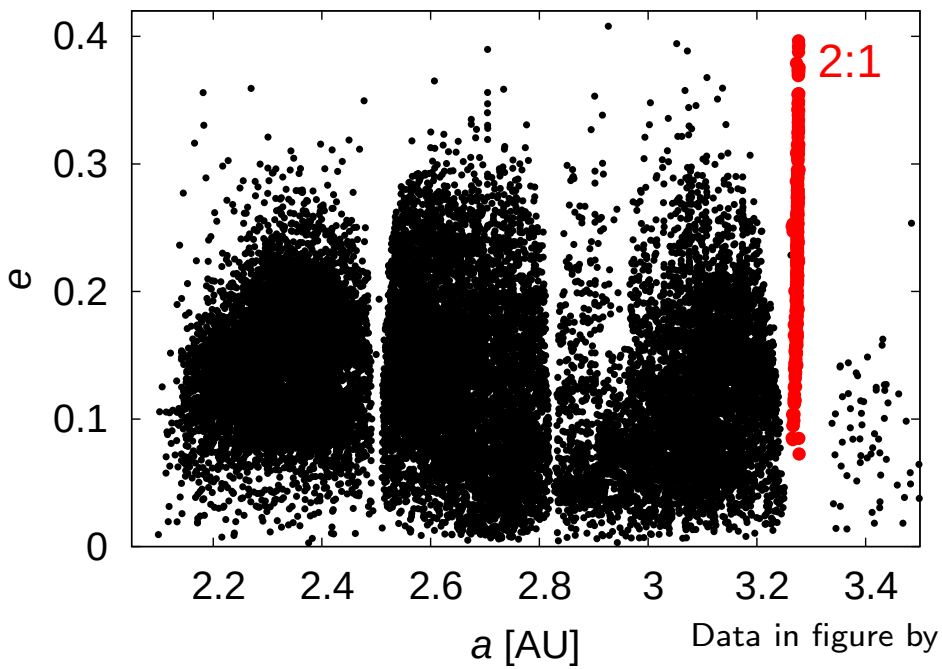
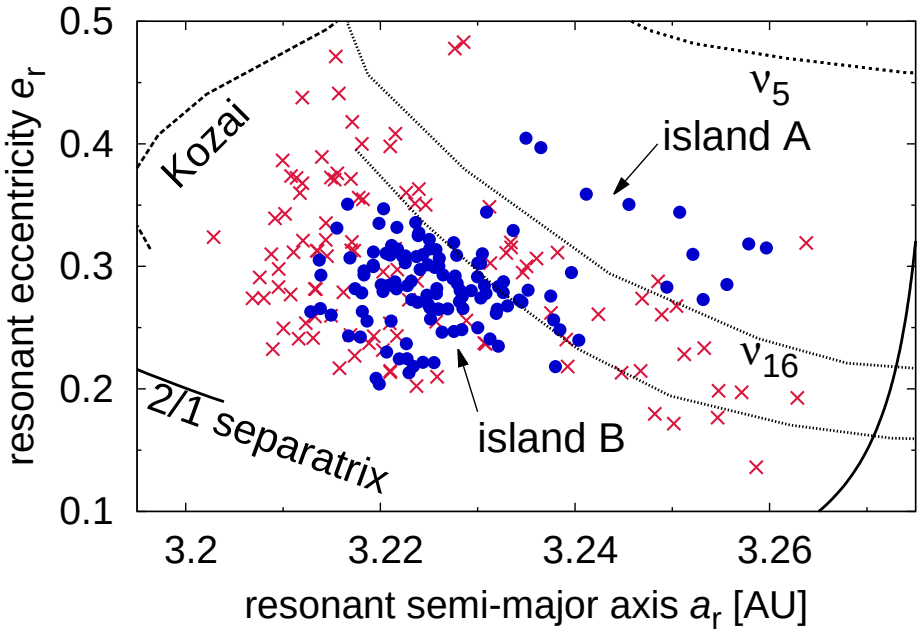
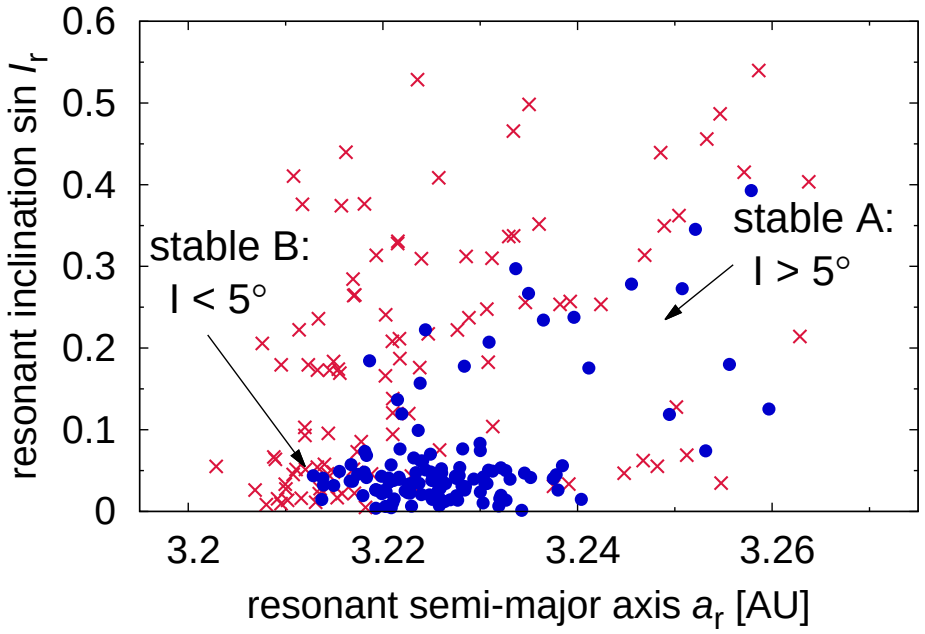


Data in figure by Kneževic & Milani (2003)

Motivation and update





124 dynamically stable asteroids (lifetime $> 1\,\mathrm{Gyr}$) and
106 marginally stable asteroids ($0.07\,\mathrm{Gyr} <$ lifetime $\leq 1\,\mathrm{Gyr}$)

- resonant elements computed according to Roig et al. (2002)
- **primordial origin or resonant capture?** the presentation is focused on the latter

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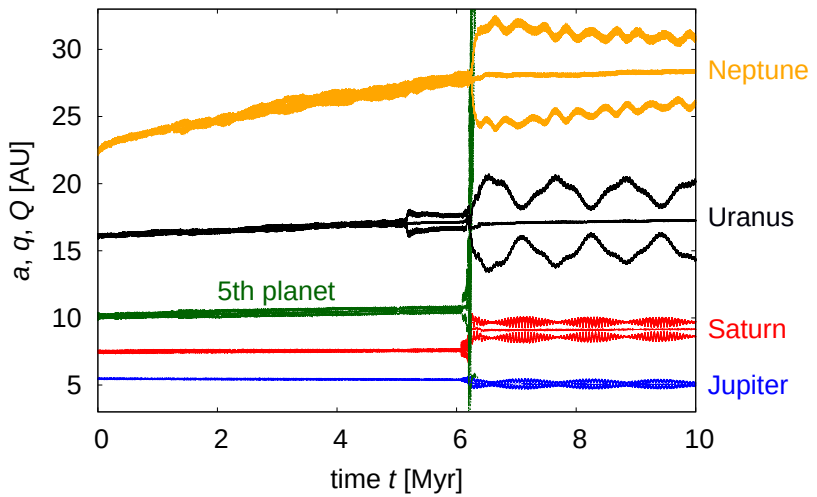
(some) previous papers on the origin: Moons et al. (1998), Ferraz-Mello et al. (1998), Roig et al. (2002), Brož et al. (2005), Brož & Vokrouhlický (2008)

Migration scenarios and methods

- orbital evolution of planets prescribed according to scenarios by Nesvorný & Morbidelli (2013), Morbidelli et al. (2010)
  - fifth giant planet scenario
  - jumping Jupiter scenario with four giant planets

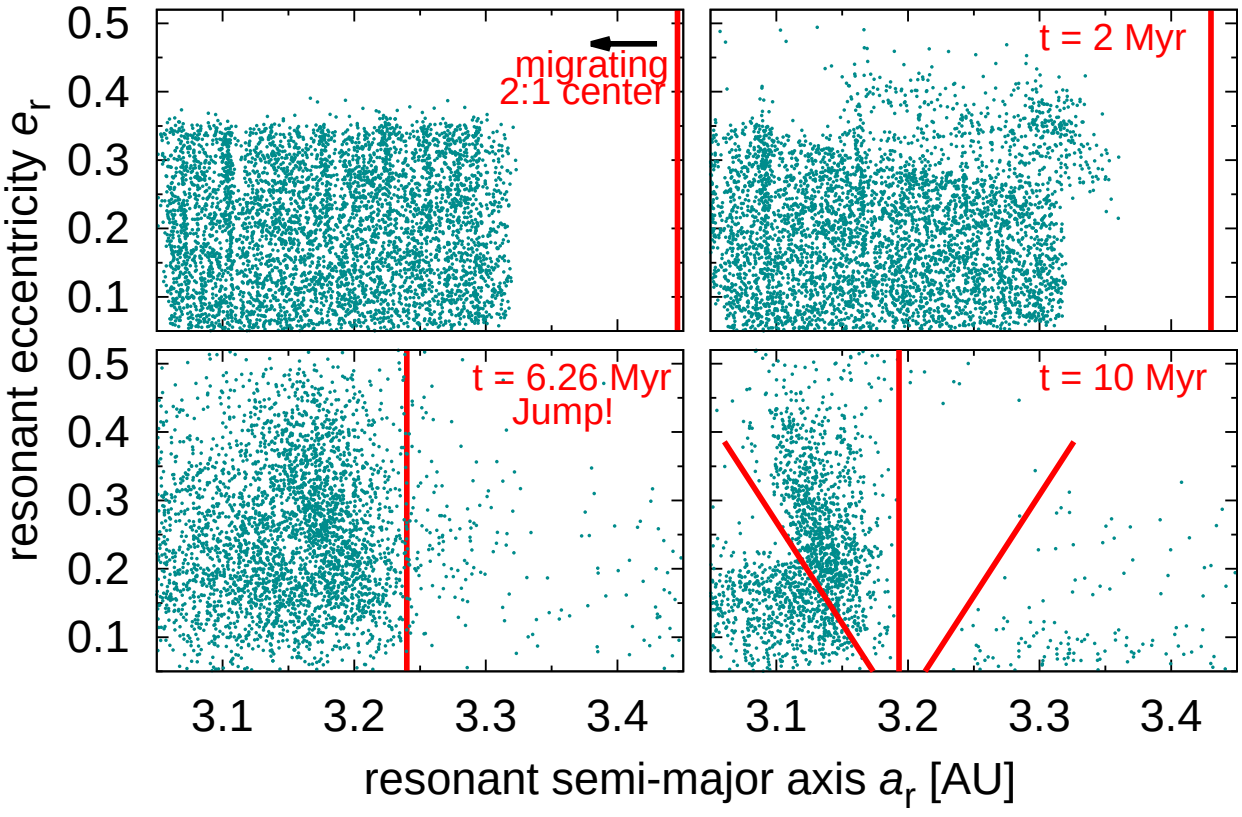
- planets: interpolation in cartesian coordinates (x, y, z) along Keplerian ellipses; input data sampling $\Delta t = 1\,\mathrm{yr}$



- test particles: symplectic `SWIFT-RMVS` algorithm (Levison & Duncan 1994) with $0.25\,\mathrm{yr}$ timestep

Capture in the fifth-giant-planet scenario

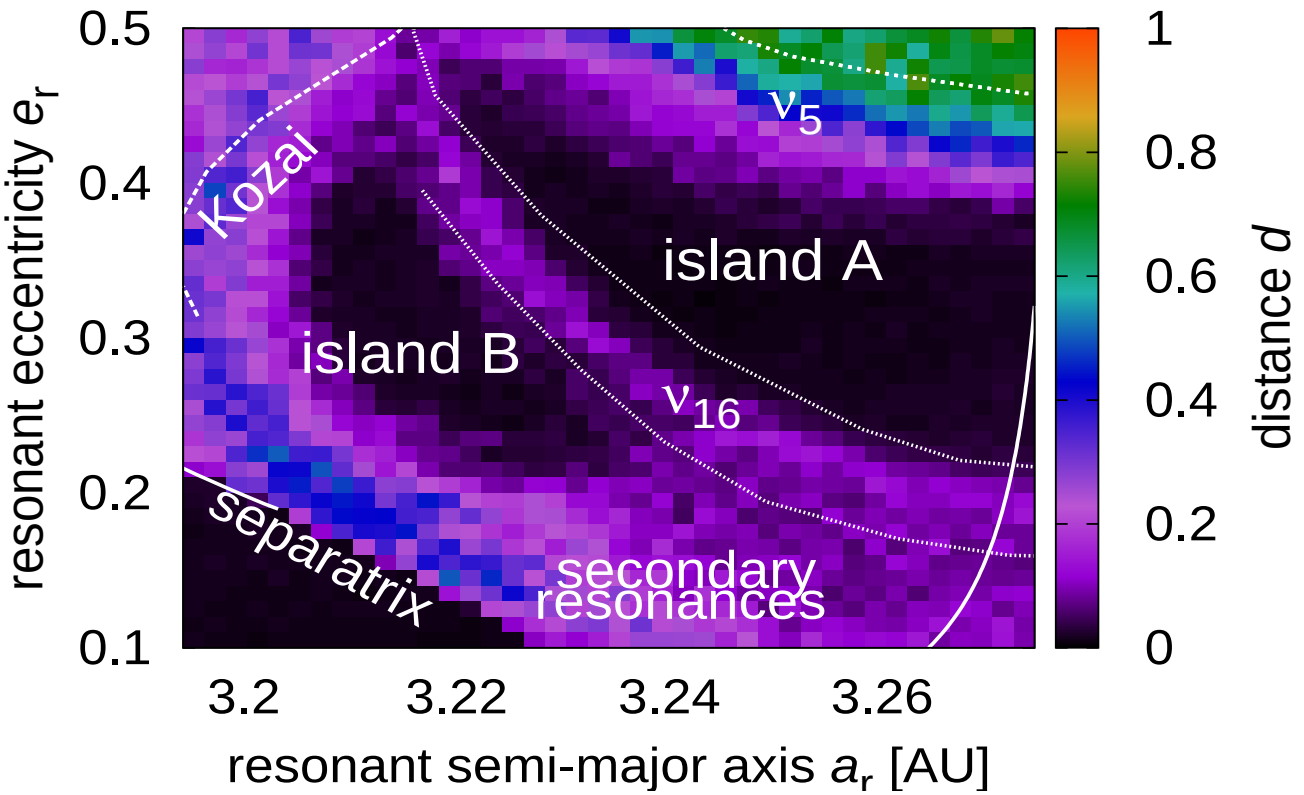
- initial population of 5000 test particles with isotropic (a, e, I) distribution in the outer main belt; $I \in (0°, 15°)$



- capture is significant, but which asteroids are long-lived?

Dynamical map

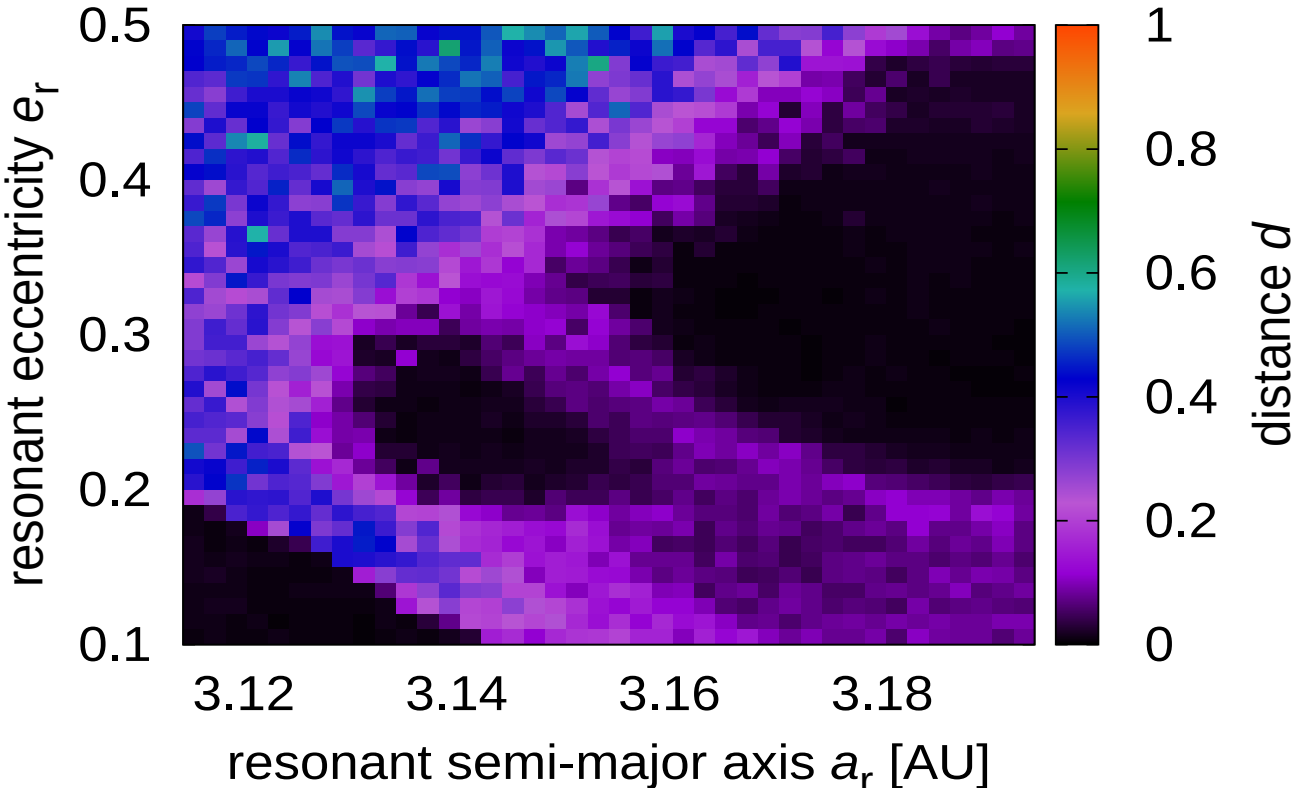
present configuration of planets



- $\delta \equiv$ the difference between the initial and final resonant element over 10 Myr timespan
- distance $d \equiv \sqrt{\left(\frac{\delta a_r}{\bar{a}_r}\right)^2 + (\delta e_r)^2 + (\delta \sin I_r)^2}$
- 24000 test particles per simulation

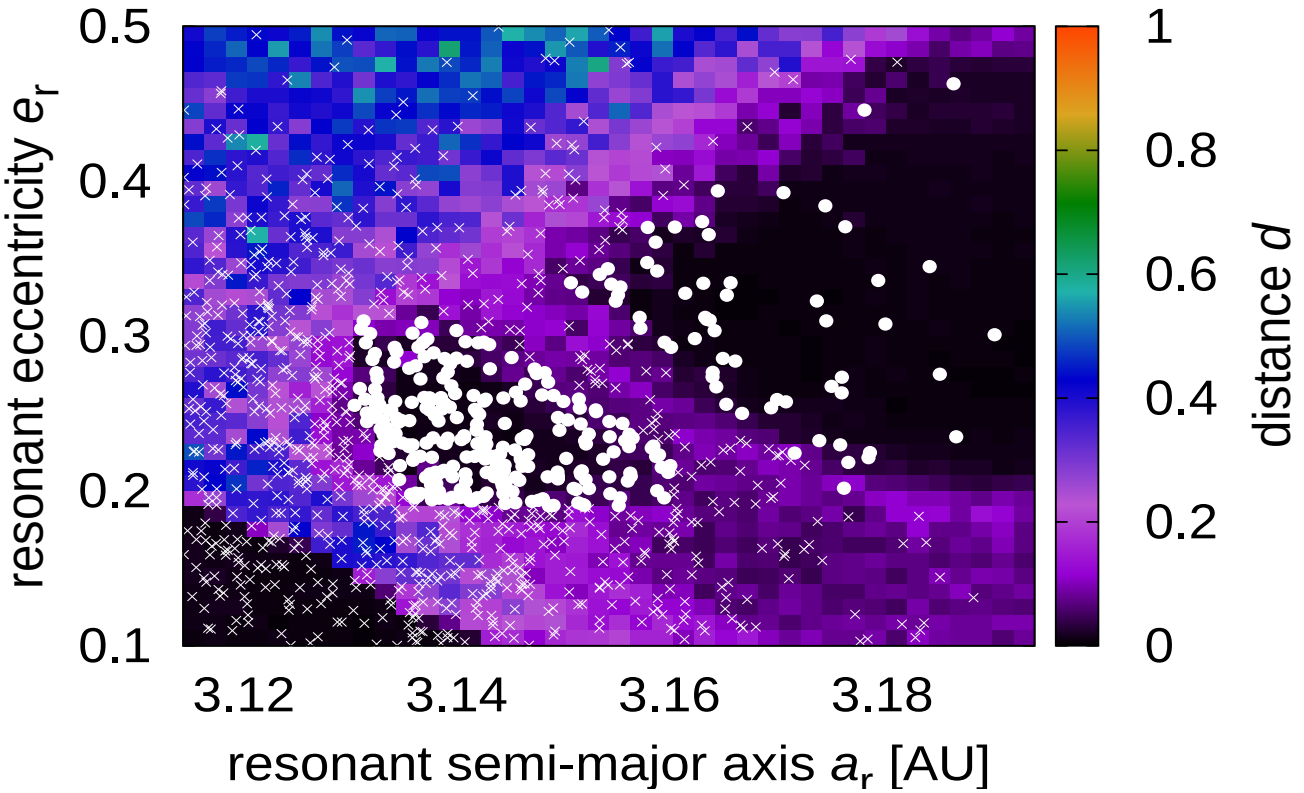
Dynamical map

post-migration configuration of planets



- the post-migration map is used to extract the **long-lived** asteroids at the end of our simulations
  (i.e. similar structure, stable islands exist)

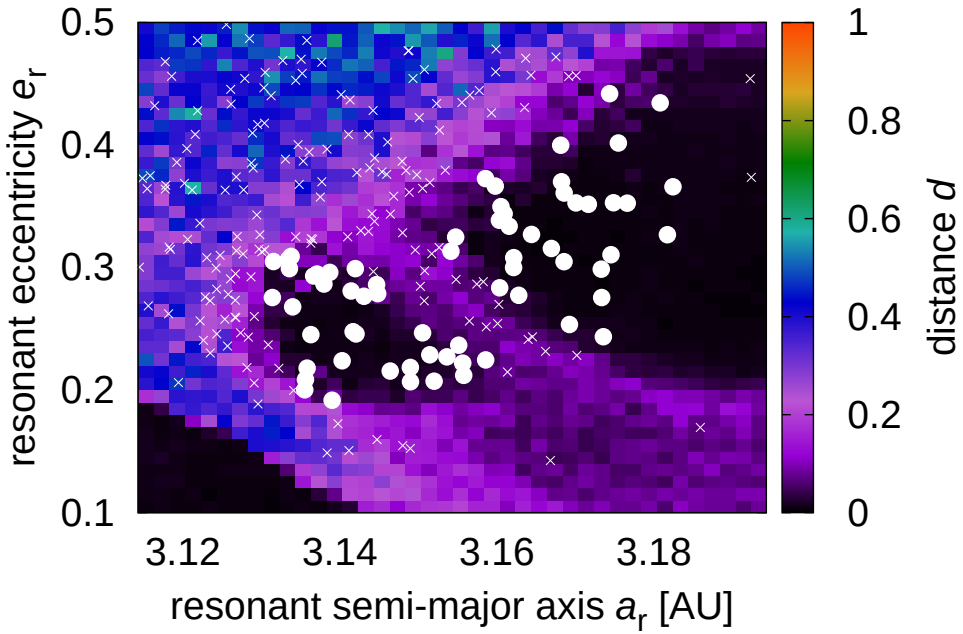
Result: Captured long-lived asteroids



- initial population rescaled to outer main belt values
  – captured population increased by factor 10 to 13
- long-term depletion rate applied
  – 93% to 95% decay over 4 Gyr; by Skoulidou et al. (CPS-IAU, 2014)
- 158 to 219 test particles in B (vs 180 observed) - match
- 37 to 51 test particles in A (vs 11 observed) - mismatch

Conclusions (and confusions)

- **capture** works in the fifth-giant-planet scenario with 1.5% efficiency in the island A and with 5% efficiency in B
- moreover, 3% of the **primordial** population survives the jump!



- how to explain the observed steep SFD (cumulative slope -4.3)?
- is primordial population really primordial?