DYNAMICAL STABILITY OF MULTI-PLANET SYSTEMS

APPLICATION TO EXTRASOLAR SYSTEMS WITH MEAN MOTION RESONANCES

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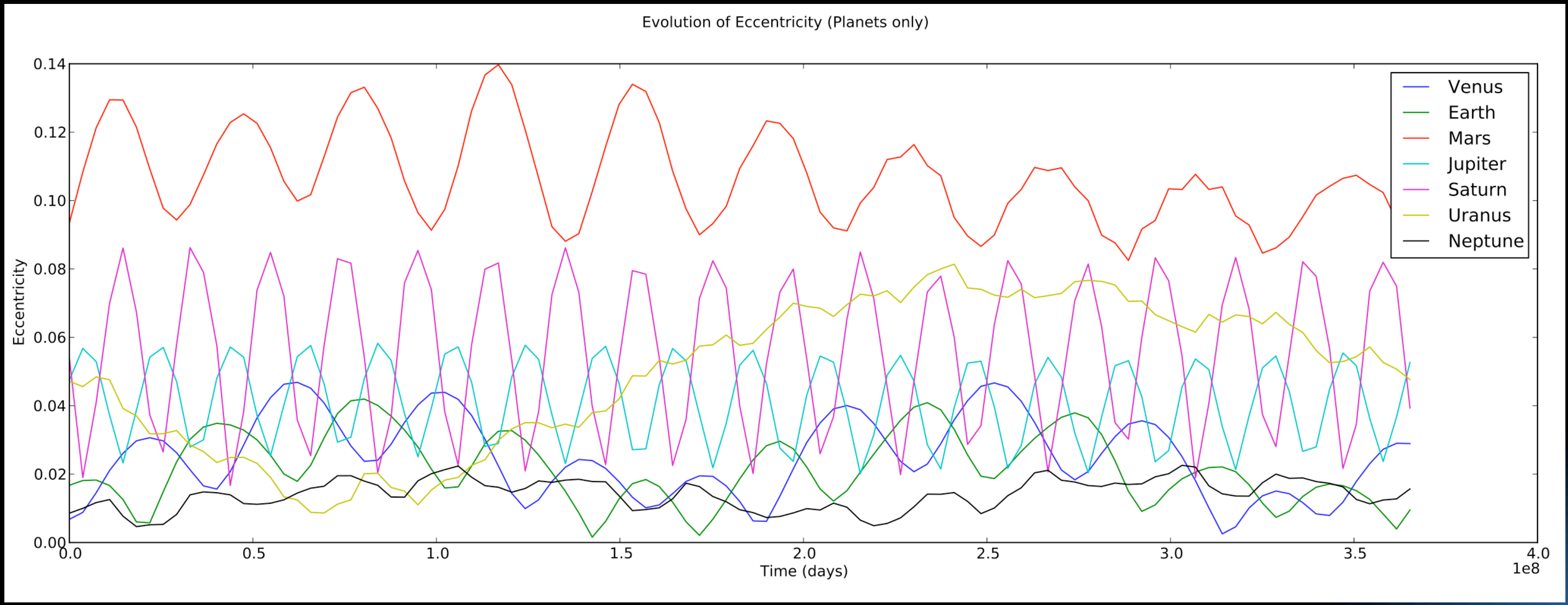
Introduction:

- Why studying the dynamics of planetary systems?



General approach

- Hill-stability criterion
  - ✓ Order of planets remains constant, but outer planet can escape
  - ✓ Analytical expression

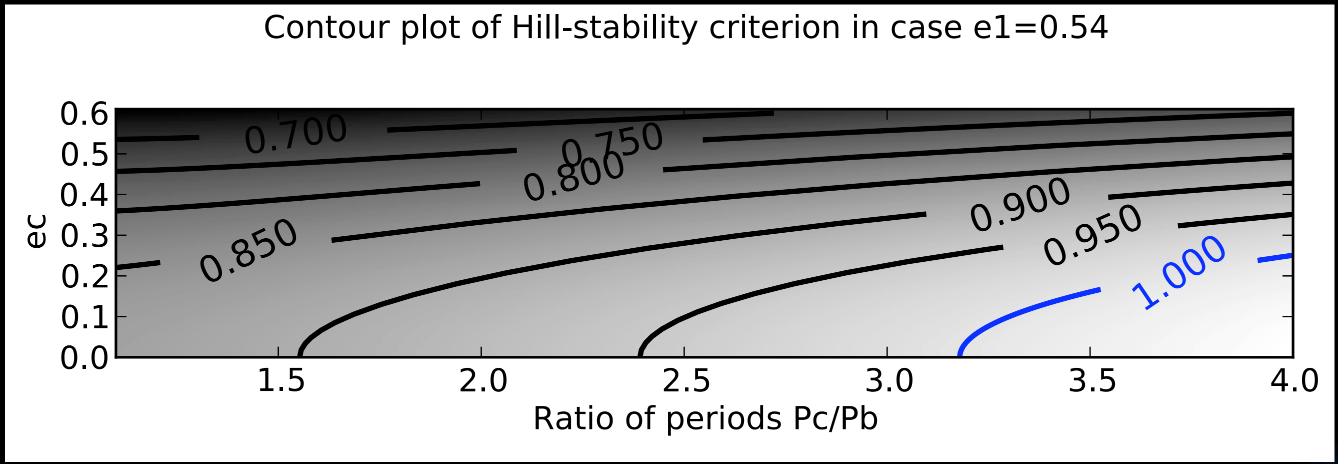
James Garry

- Lagrange-stability criterion
  - ✓ All planets remain bound to the star
  - ✓ Numerical simulations

Hill Stability

- Determined by masses, total energy h, total angular momentum c
- $\beta(h,c,m_i) > \beta_{crit}(m_i)$ => Hill stable

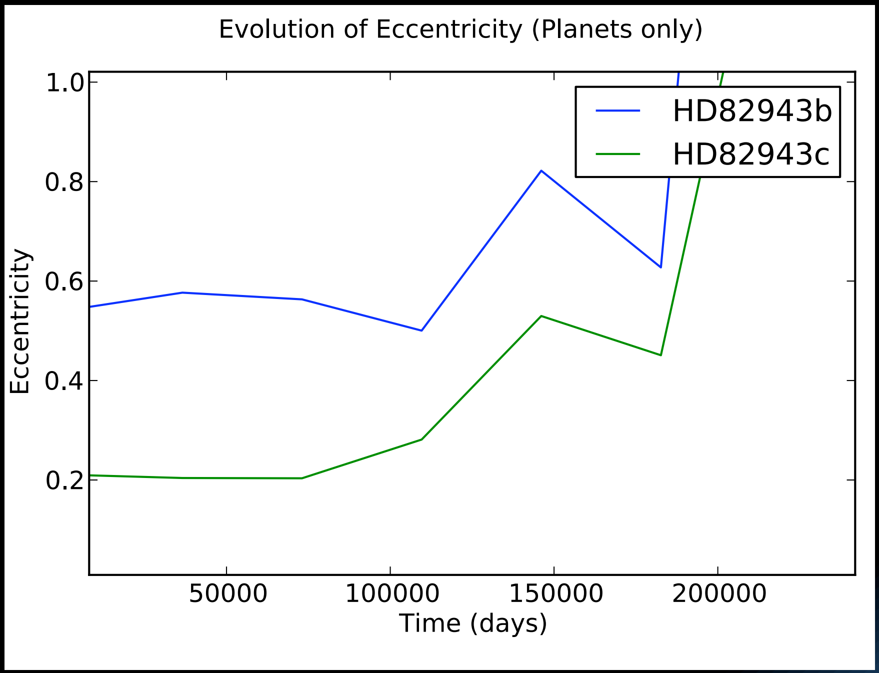
Two-planet system HD 82943



Lagrange Stability

- Use of symplectic integrators
- Can test cases of instability
- Lagrange stability boundary ≈ Hill stability boundary!

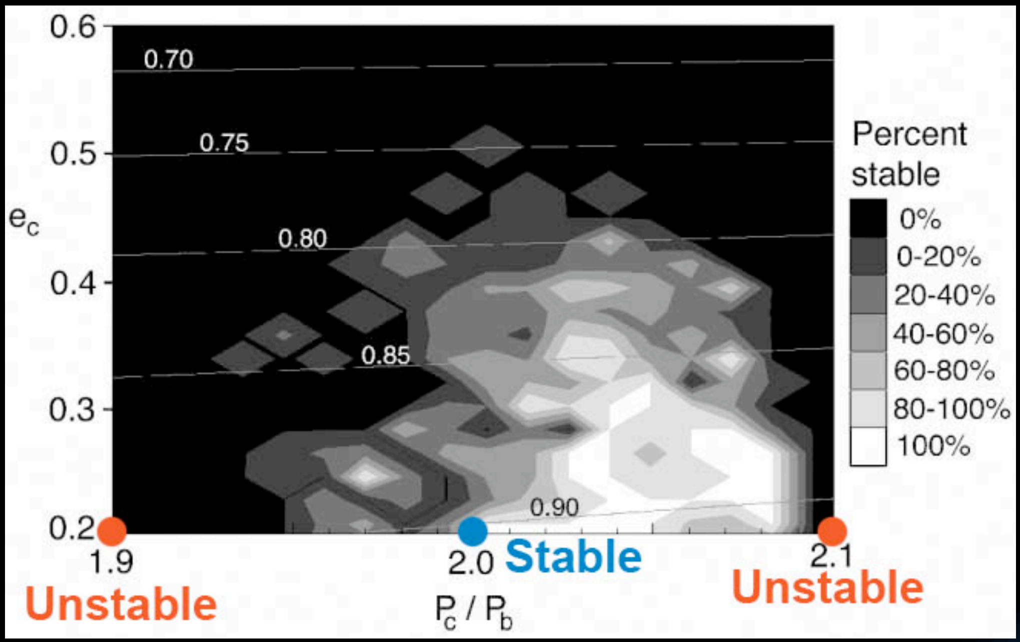
Two-planet system
HD 82943
P_c/P_b =1.9
e_c=0.21 (simulation)

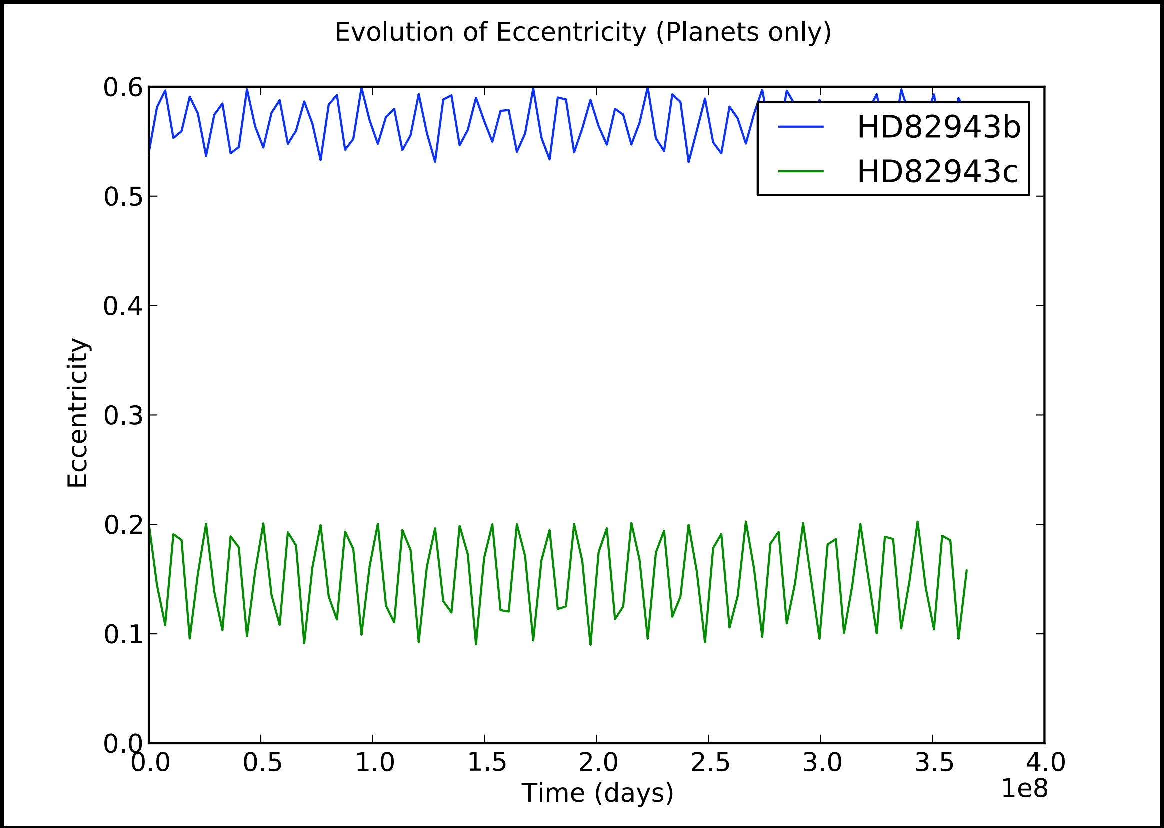


Resonant systems

- Strong resonance -> can add stability regions
- Most extrasolar systems are believed to be in resonance

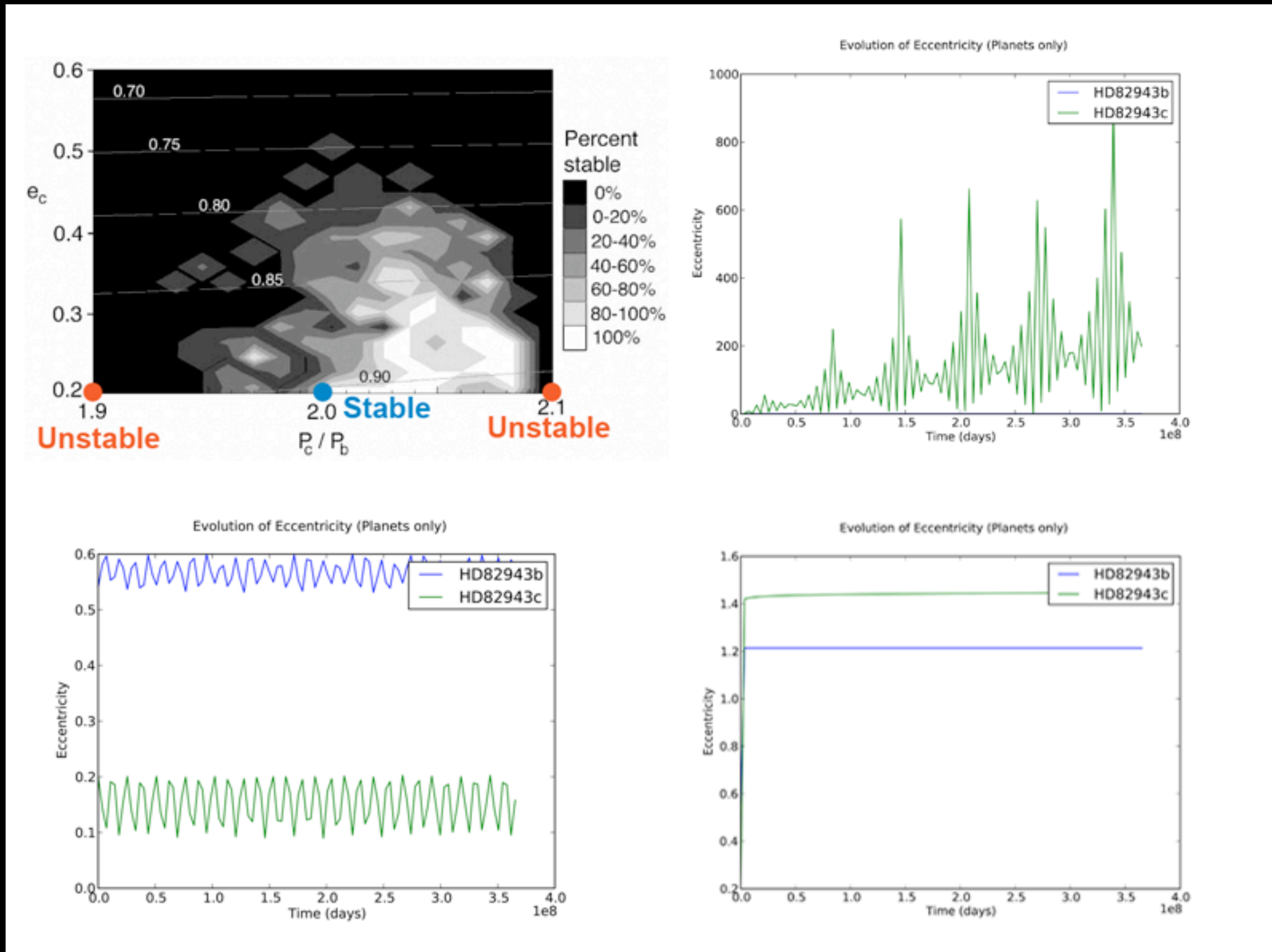
Statistical analysis on HD 82943, 1e6 years (Barnes et al. 2007)





Unexpected stability for e_c = 0.2 and P_c/P_b=2

Thank you for your attention!!


0.6
0.5
0.4
0.3
0.2
e_c
0.70
0.75
0.80
0.85
0.90
1.9
2.0
2.1
Stable
Unstable
Unstable
P_c / P_b
Percent stable
0%
0-20%
20-40%
40-60%
60-80%
80-100%
100%
Evolution of Eccentricity (Planets only)
HD82943b
HD82943c
Eccentricity
Time (days)
1e8
Evolution of Eccentricity (Planets only)
HD82943b
HD82943c
Eccentricity
Time (days)
1e8
Evolution of Eccentricity (Planets only)
HD82943b
HD82943c
Eccentricity
Time (days)
1e8