Stability of prograde and retrograde planets within binary systems

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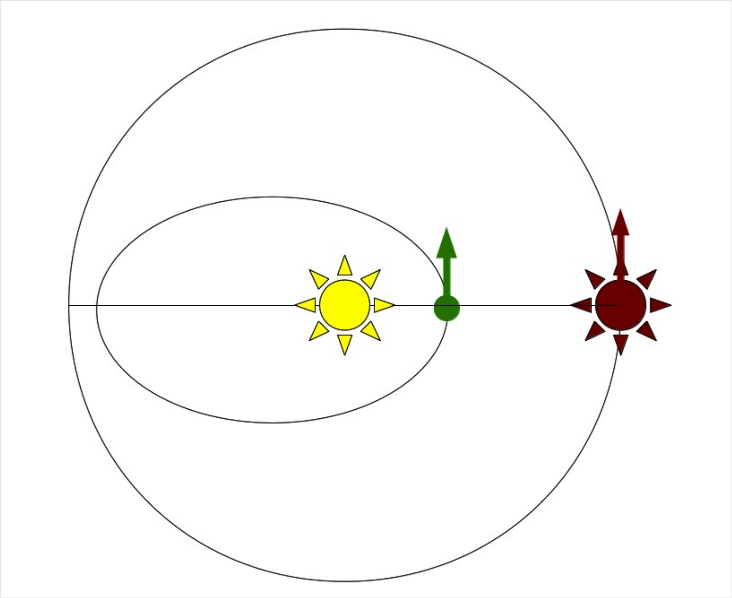
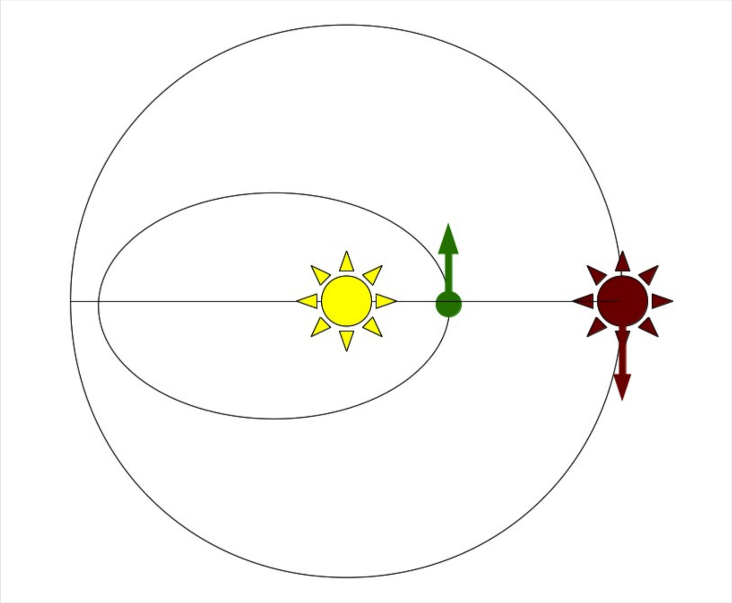
M.H.M. Morais & C.A. Giuppone (2012), Stability of prograde & retrograde planets in circular binary systems, MNRAS 424, 52–64

CR3BP: massless planet within circular binary system



PROGRADE



RETROGRADE

Terms in disturbing function are $$e^{j_3}\cos(j_1\lambda + j_2\lambda' + j_3\varpi)$$

with $$j_1 + j_2 + j_3 = 0$$

If orbital frequencies are commensurable $$\frac{n'}{n} = \frac{p}{q}$$

Then since
$$\dot{\lambda}' = n'$$
$$\dot{\lambda} = \pm n$$
$$\dot{\varpi} \ll n$$

The resonant (slow) terms in the disturbing function are

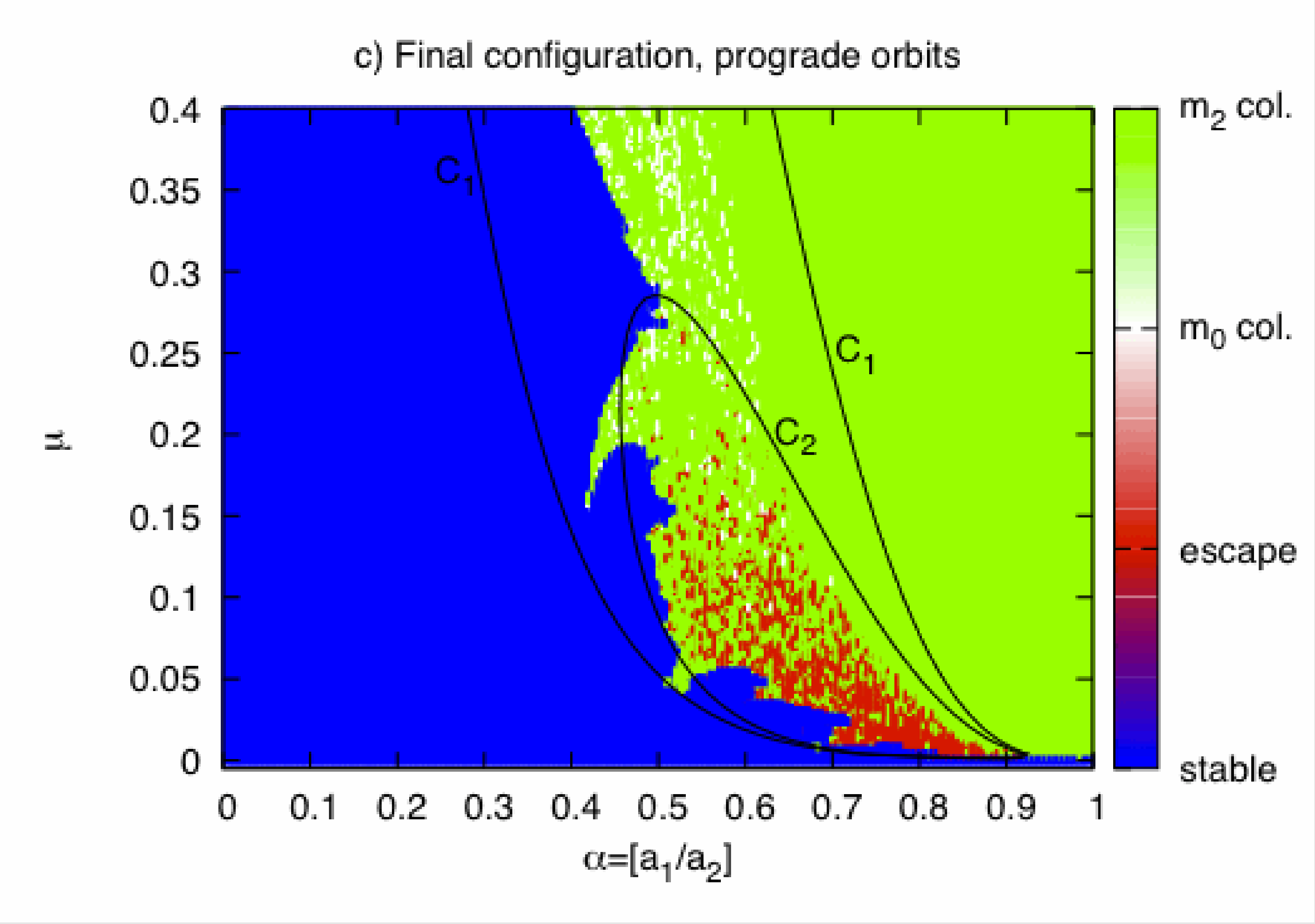
$$e^{p\mp q}\cos(p\lambda \mp q\lambda' - (p\mp q)\varpi)$$

PROGRADE p/q resonance is of order p-q

RETROGRADE p/q resonance is of order p+q

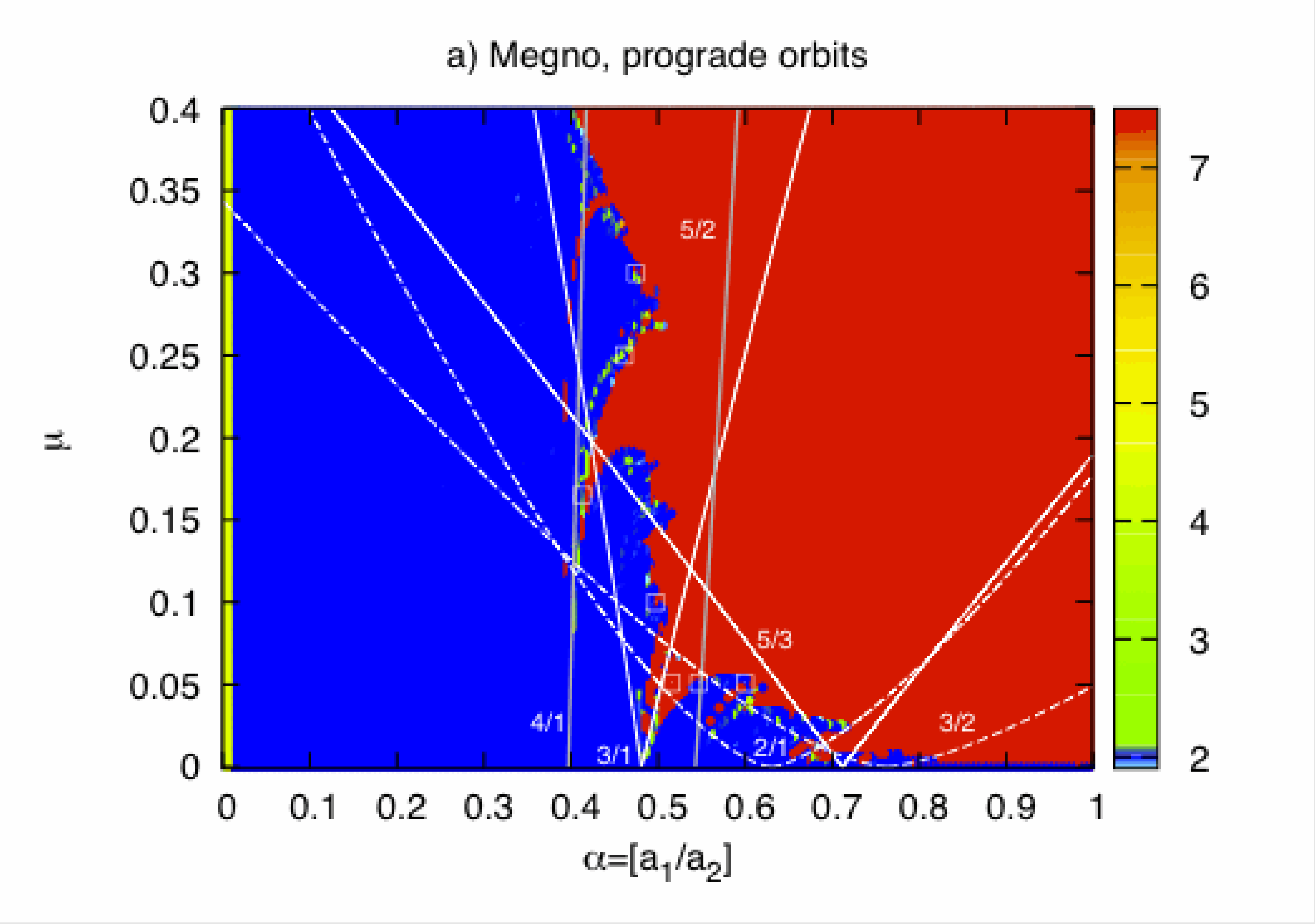
PROGRADE Circular Restricted 3 Body Problem
Simulations for 10^4 binary periods

$$\mu = \frac{m_2}{m_0 + m_2}$$



ZVC criterion is necessary but not sufficient condition for instability.

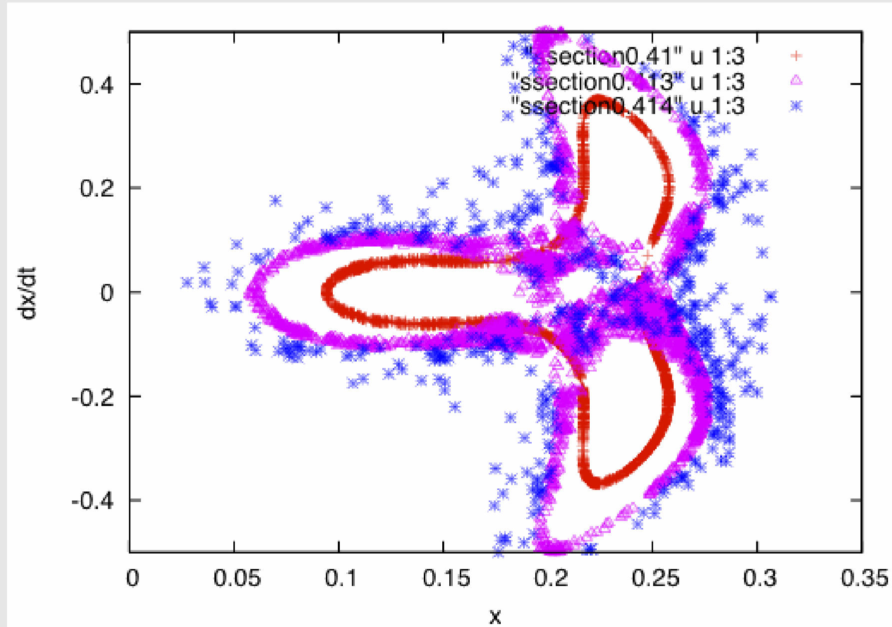
Instability is due to MMRs...

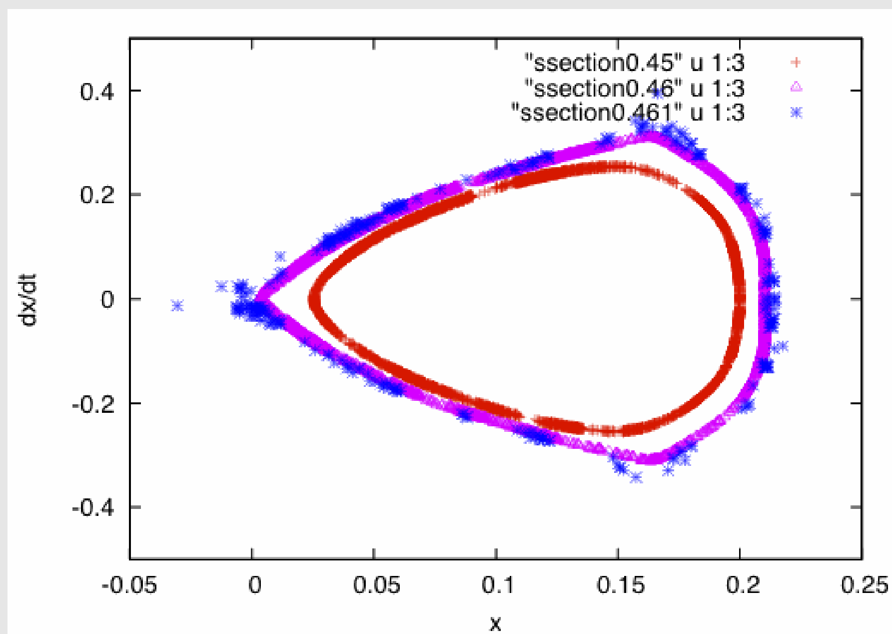


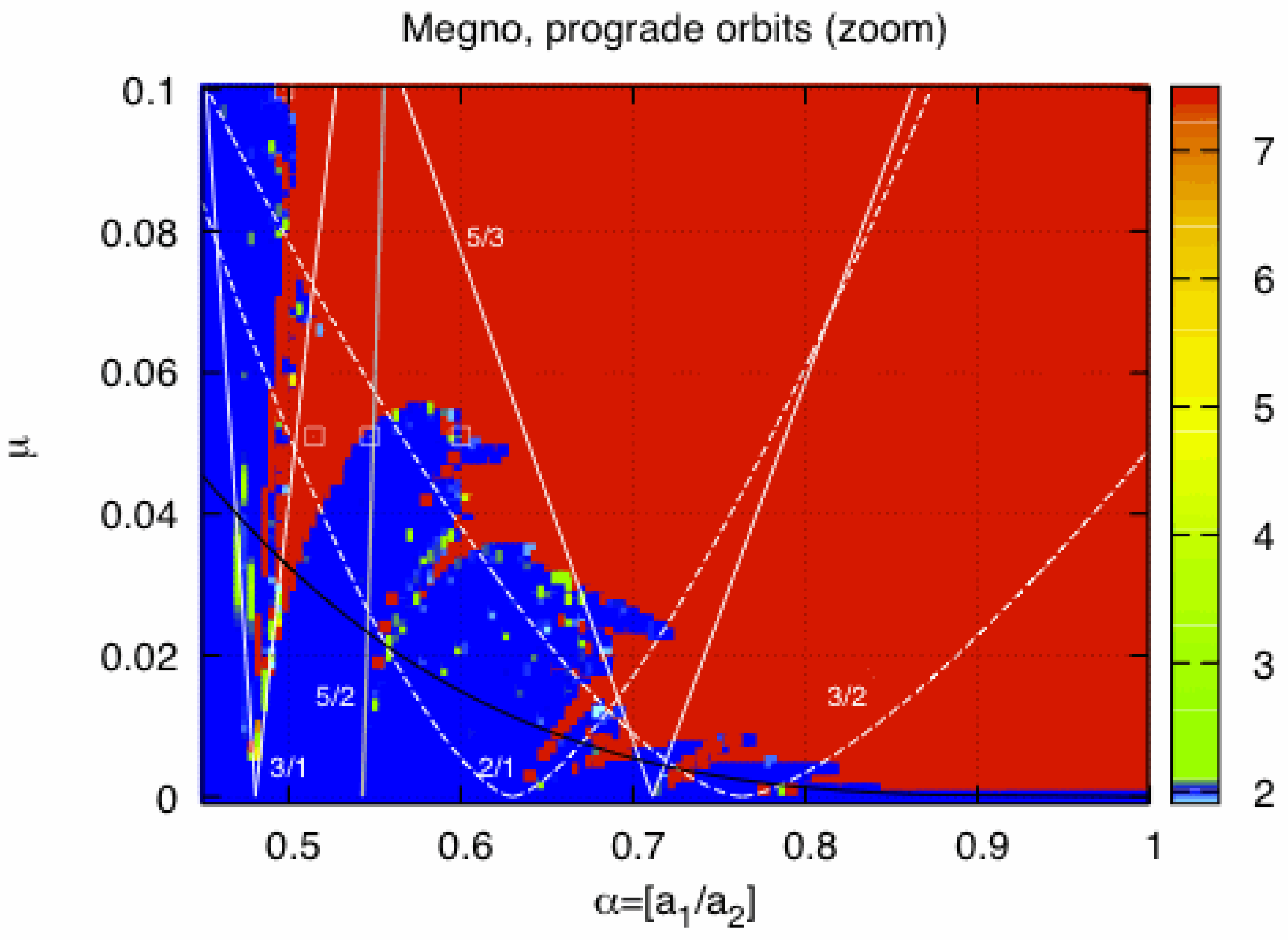
$\alpha \approx 0.4$

4/1 MMR

$\lambda - 4\lambda' + 3\varpi$



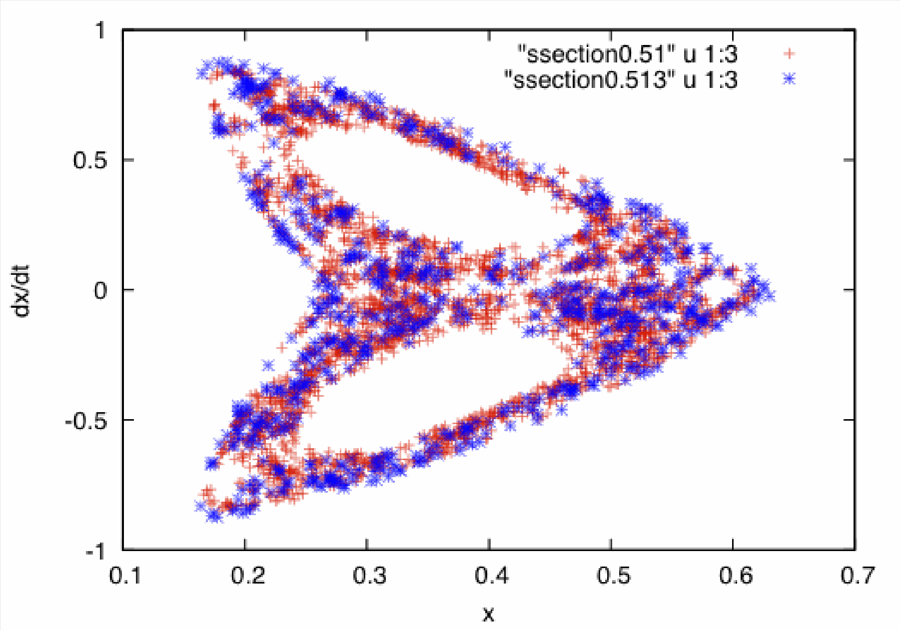


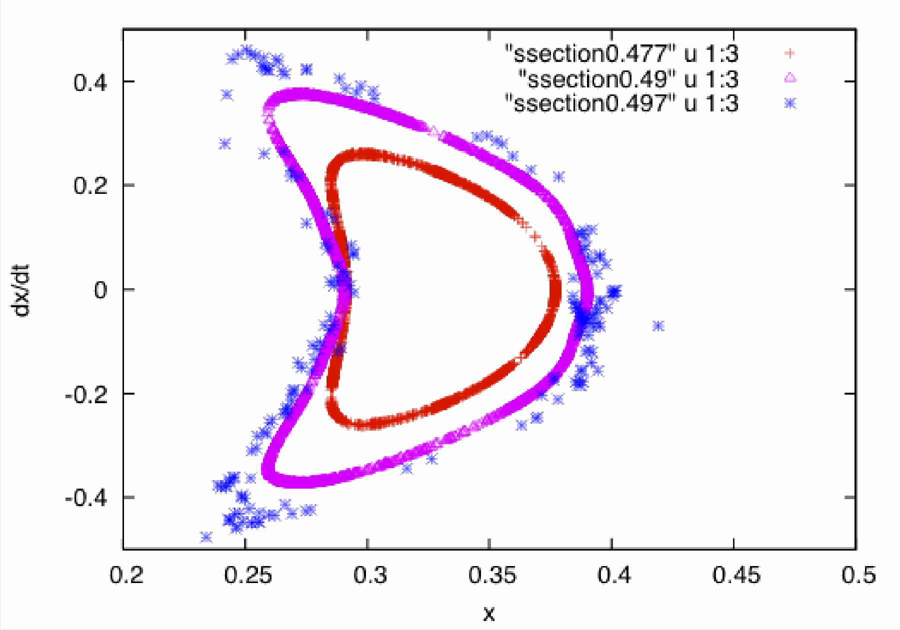

Megno, prograde orbits (zoom)
0.1
0.08
0.06
0.04
0.02
0
μ
0.5
0.6
0.7
0.8
0.9
1
α=[a1/a2]
5/3
5/2
3/2
3/1
2/1
7
6
5
4
3
2

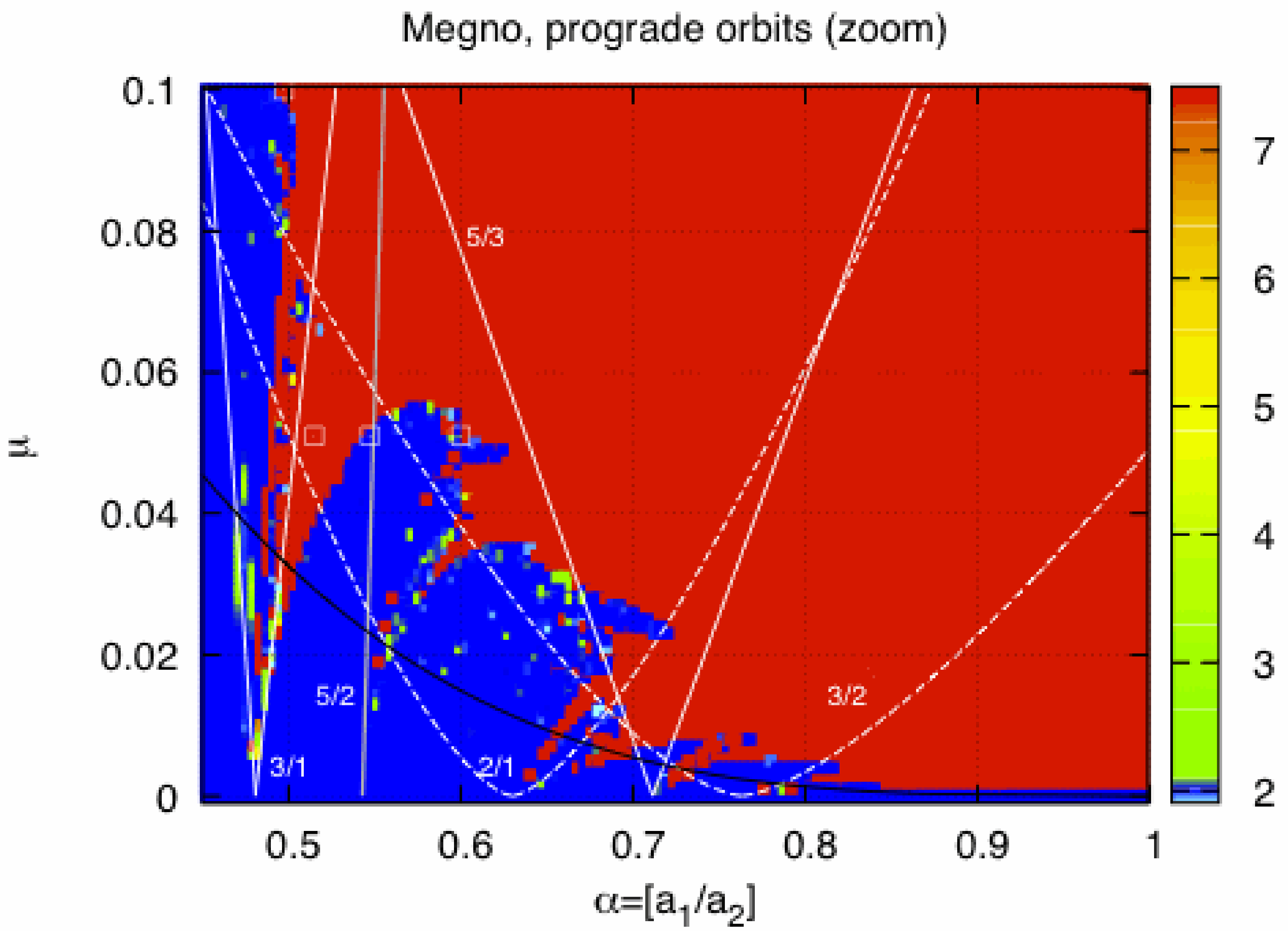
$\alpha \approx 0.5$

3/1 MMR

$\lambda - 3\lambda' + 2\varpi$



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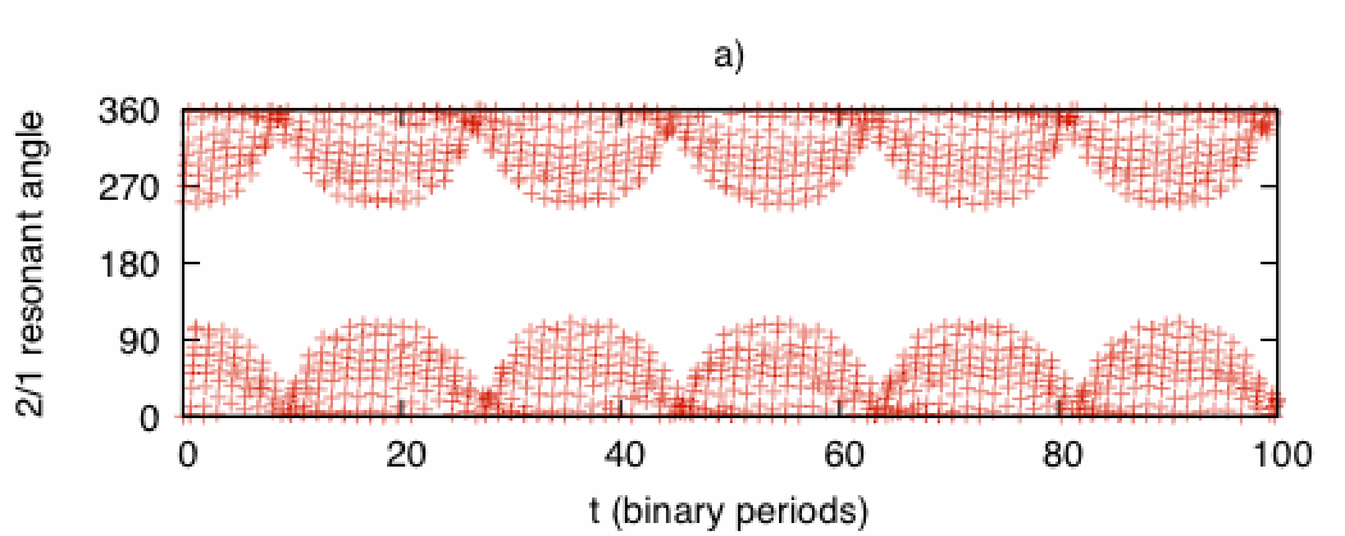
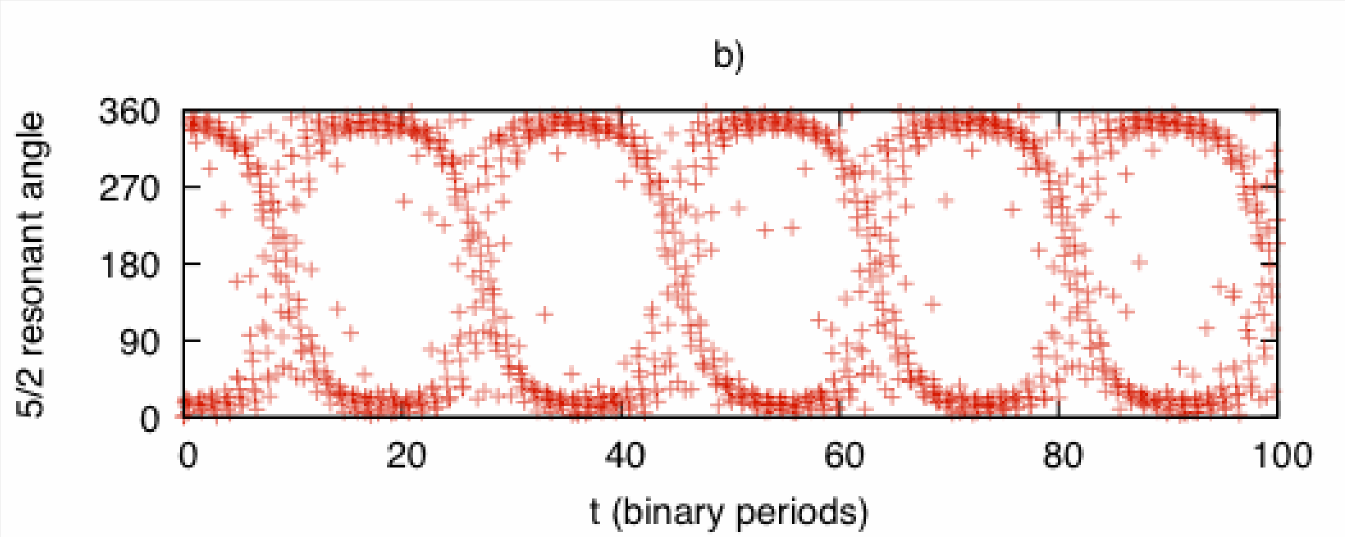
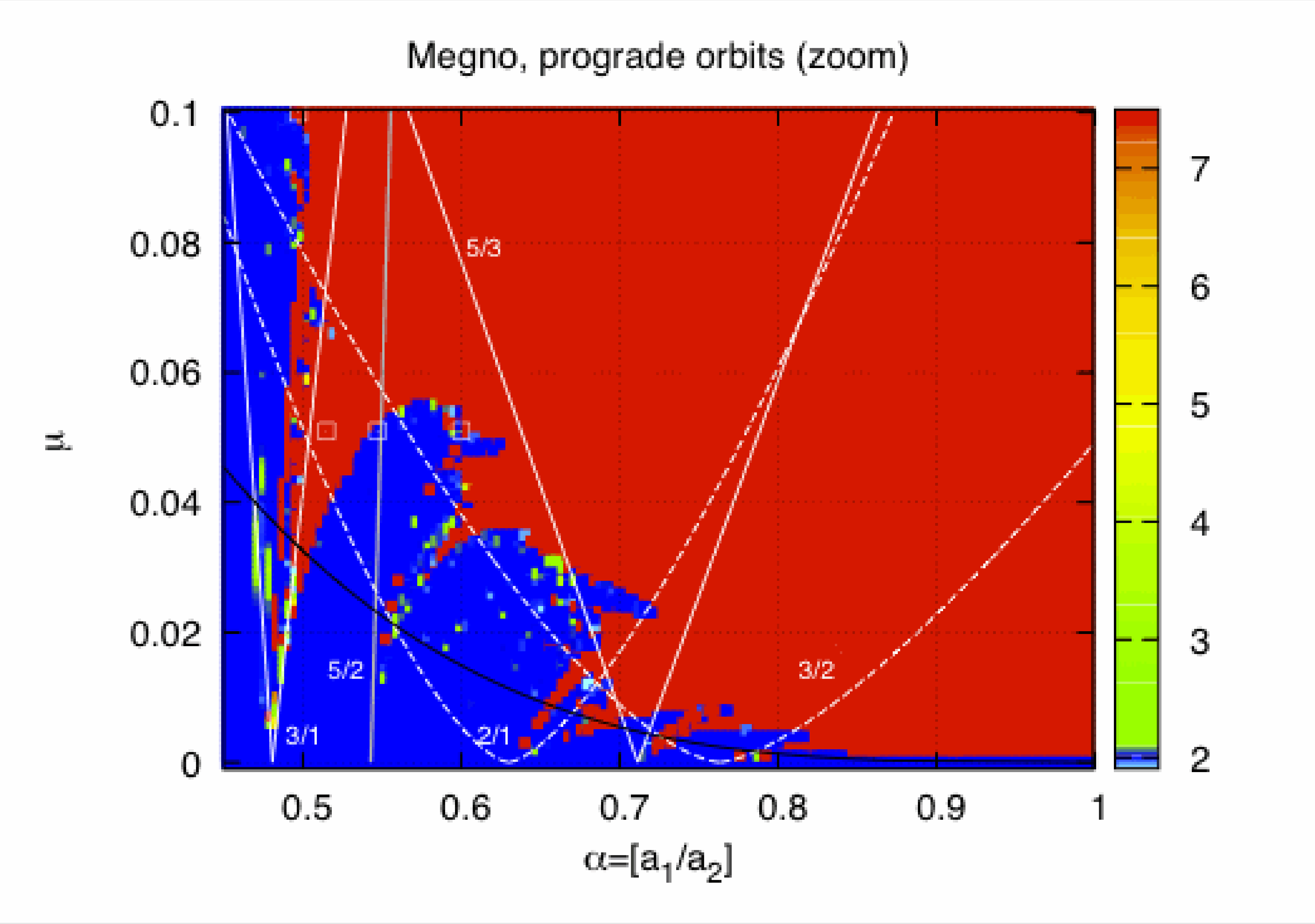
$\alpha \approx 0.55$ OVERLAP OF 5/2 AND 2/1 MMRS



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RETROGRADE Circular Restricted 3 Body Problem
Simulations for 10^4 binary periods

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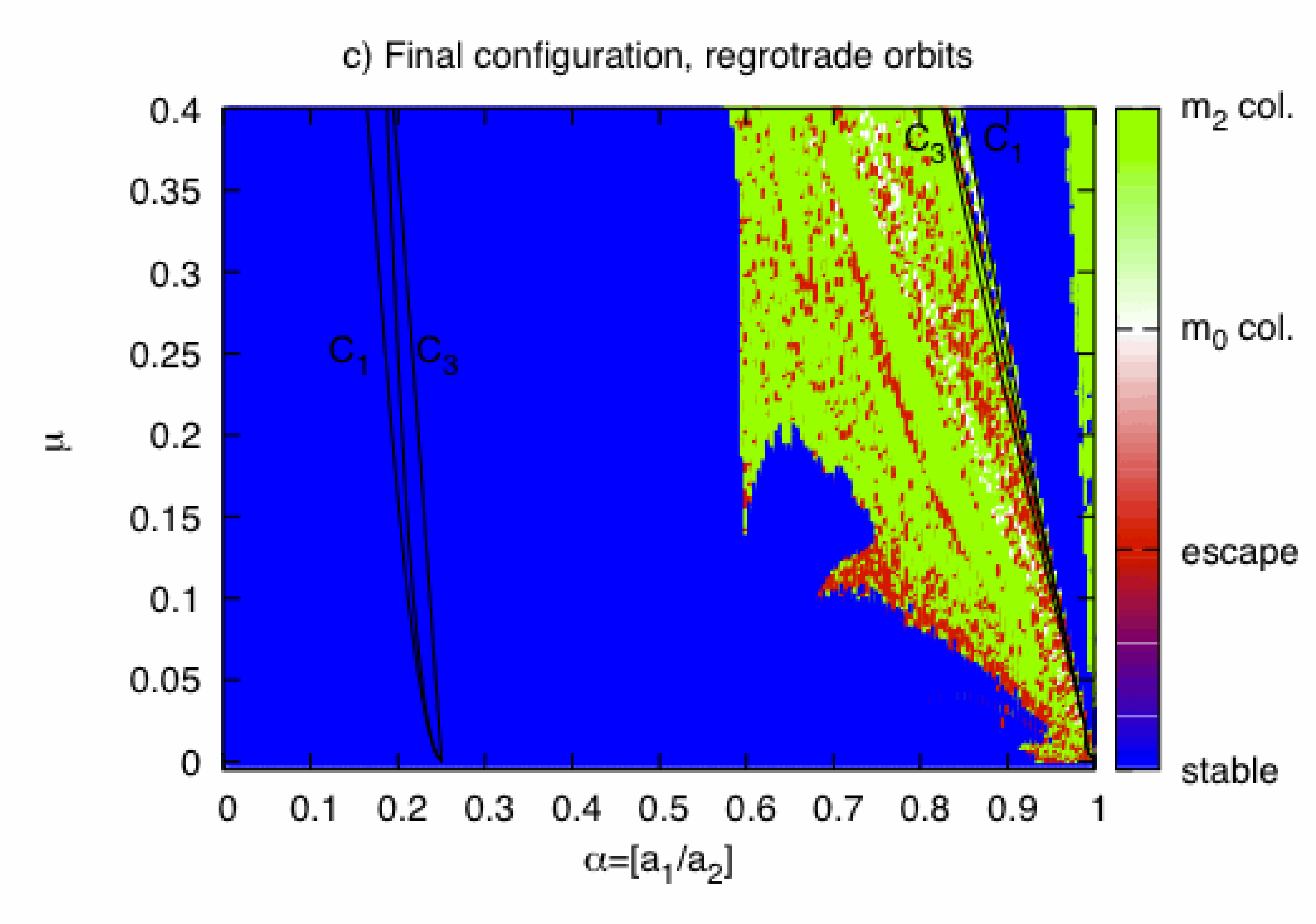
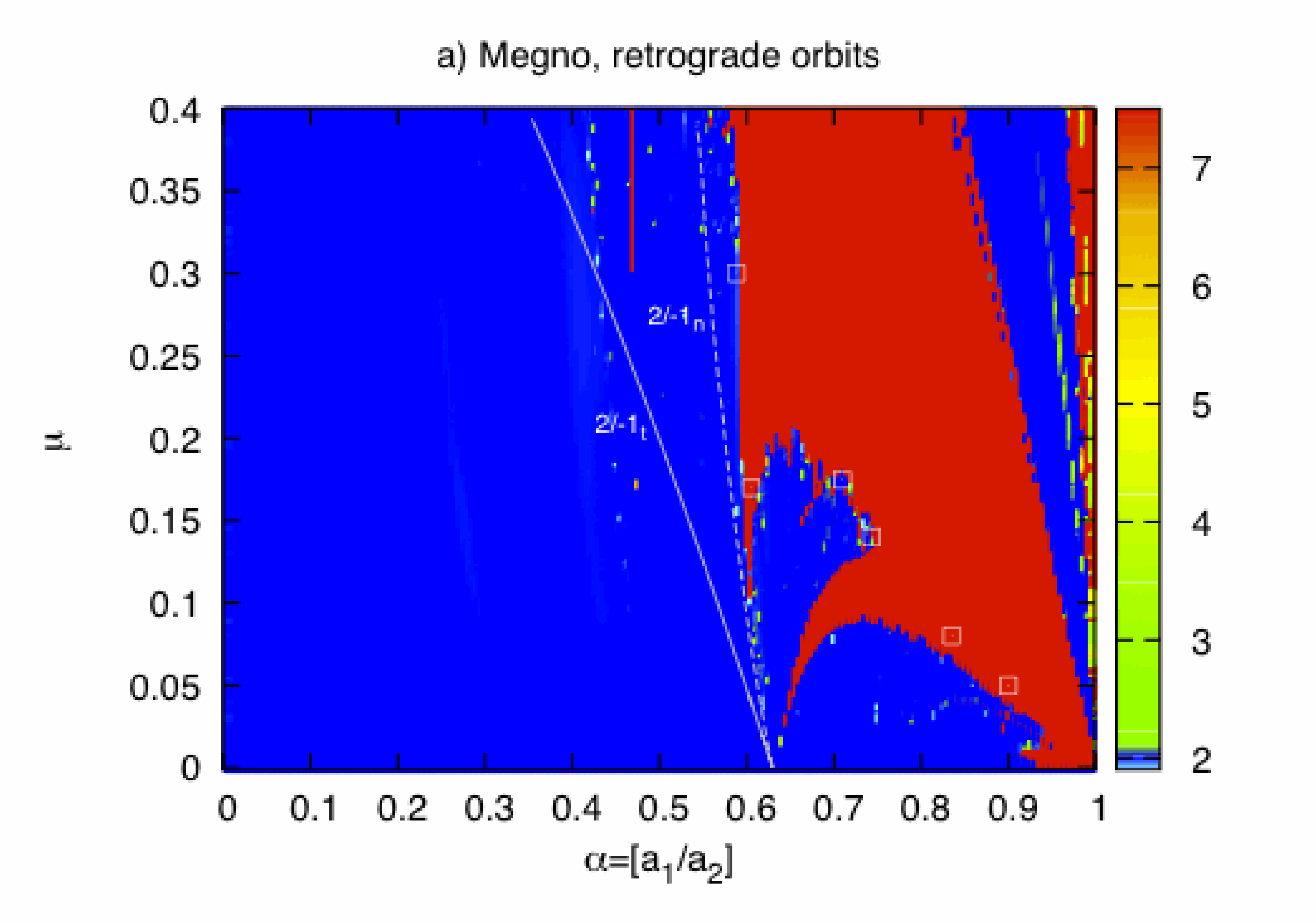


ZVC criterion is necessary but not sufficient condition for instabilty.

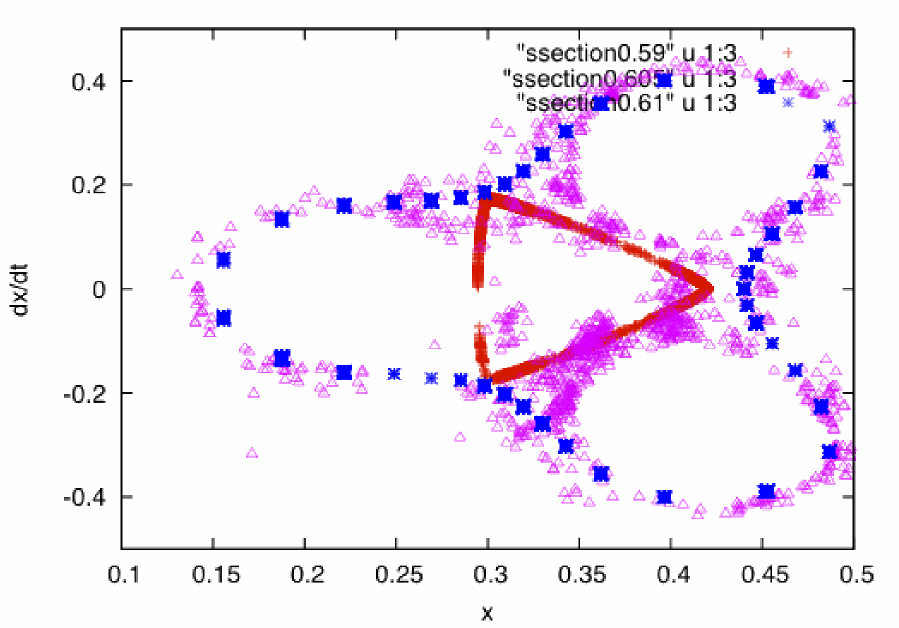
Instability is due to MMRs...

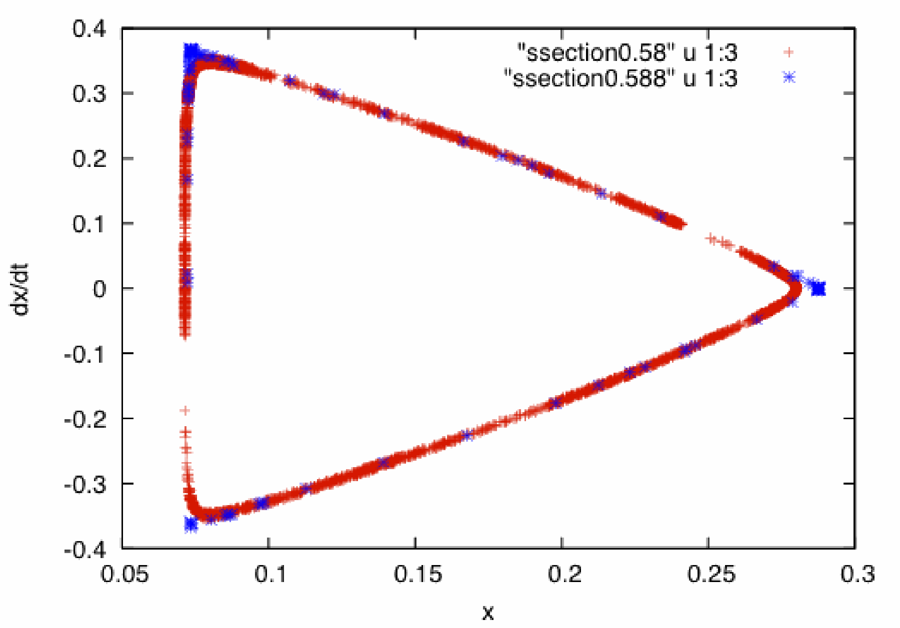


$\alpha \approx 0.6$

2/-1 MMR

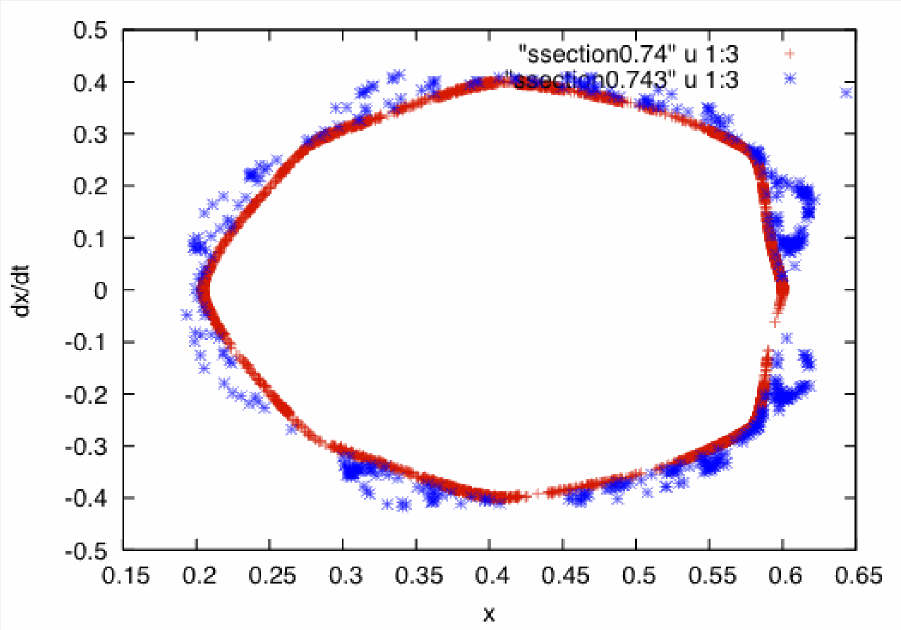
$\lambda + 2\lambda' - 3\varpi$





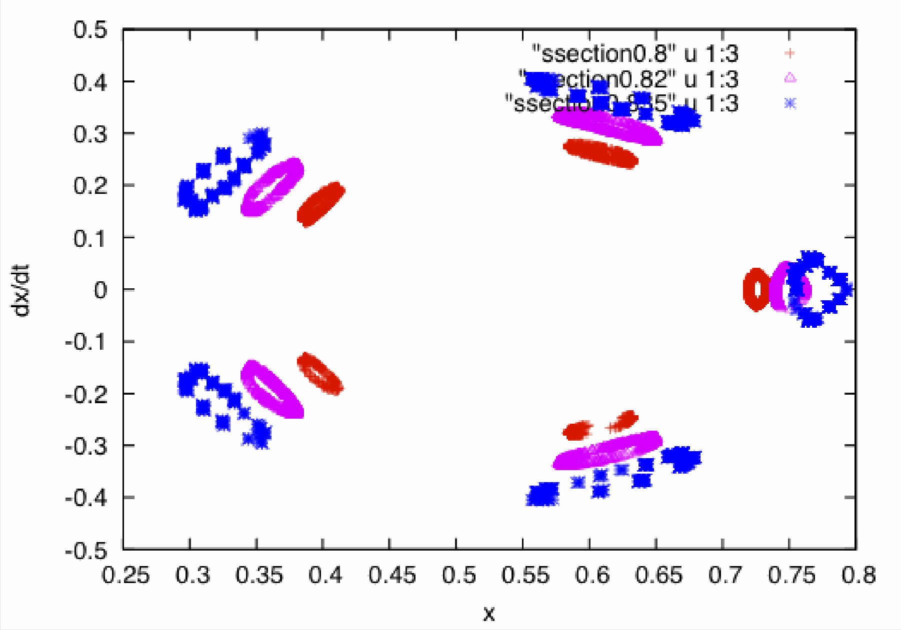
5/-3 MMR

$$3\lambda+5\lambda'-8\varpi$$



3/-2 MMR

$$2\lambda+3\lambda'-5\varpi$$



Stability of prograde and retrograde planets within circular binary systems

- Retrograde planets are stable closer to the secondary than prograde planets.

- ZVC criterion is necessary but not sufficient condition for instability.

- Instability is due to MMRs overlap (chaos) or due to effect of a single MMR...

- Differences are due to topology of prograde versus retrograde MMRs: prograde p/q MMR is of order p-q while retrograde p/q MMR is of order p+q