Title: Binary Black Holes

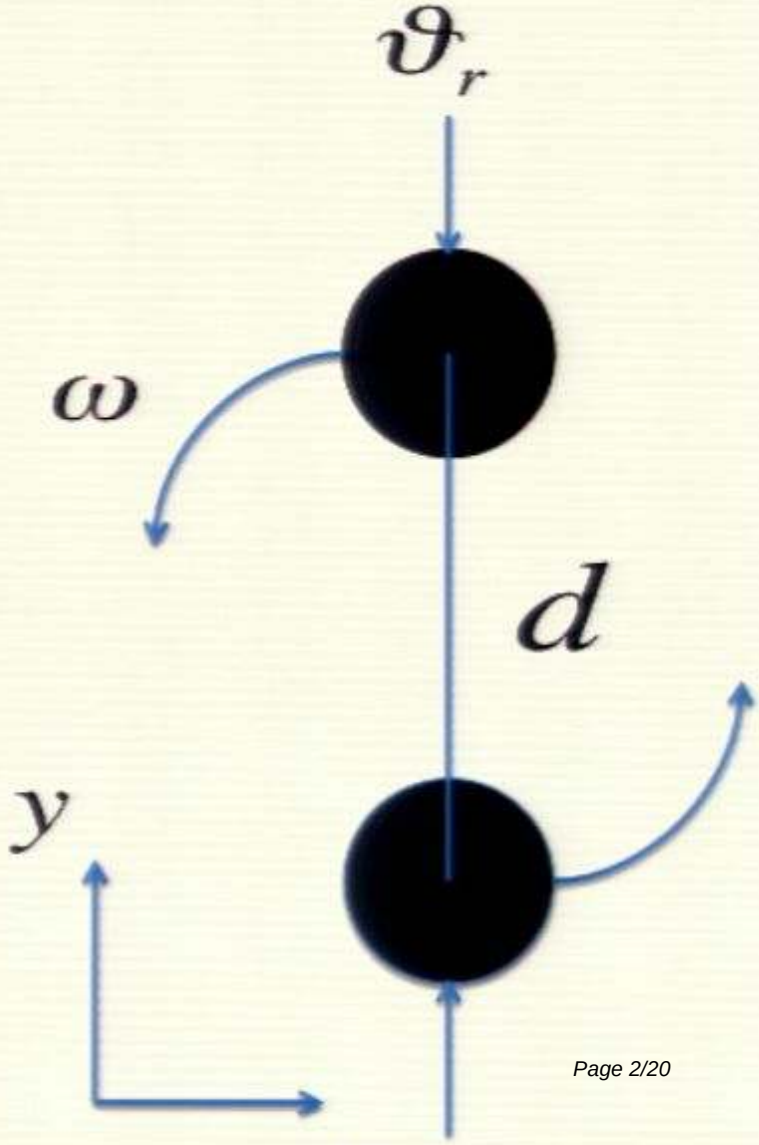
Date: Jun 25, 2010 02:30 PM

URL: http://pirsa.org/10060074

Abstract: TBA

Binary black holes

- Initial data parameters:
  - Orbital frequency
  - Separation
  - Radial velocity
- Initial PN guess: generate eccentric orbits



How to measure the eccentricity?

How to reduce it?

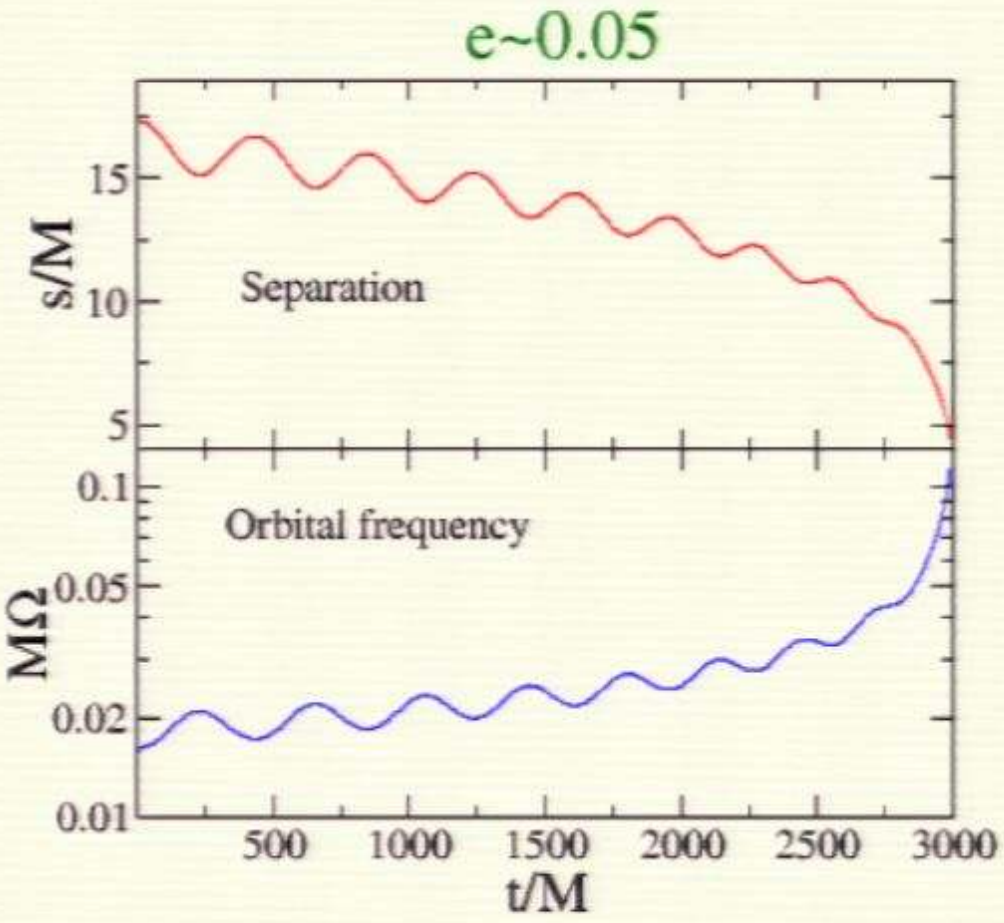
Why is it relevant?

- Equal mass non spinning binary
- Use PN values for the parameters

$$(\Omega_0, \vartheta_{r0}) \rightarrow e_0 \sim 0.01$$

- Iteratively reduce eccentricity:

Requires several iterations



Eccentricity reduction method

1- Fit ds/dt:

$$s = s_0[1 + e_0 \cos(\Omega_r t + \phi_0)]$$

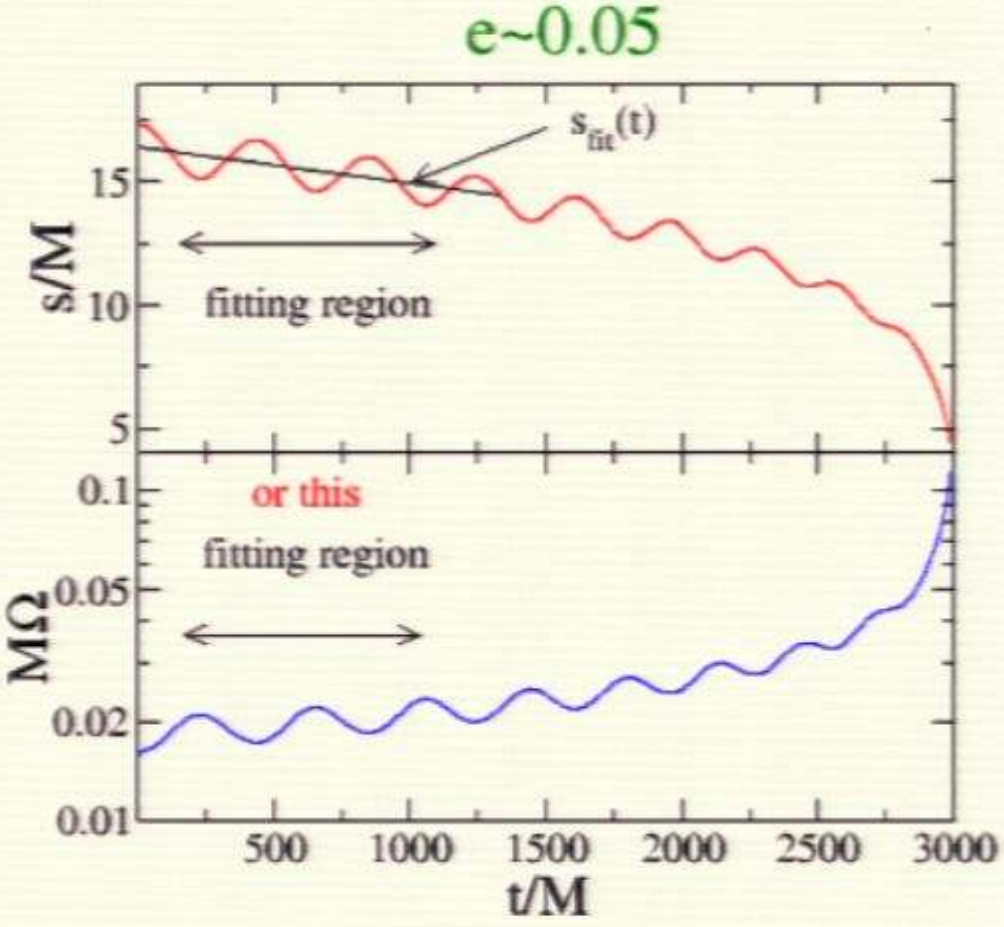
$$\frac{ds}{dt} = B\cos(\Omega_r t + \phi_0)]$$

2-Adjust Ω_0 and v_{r0} :

$$\Omega = \Omega_0 + \delta\Omega$$

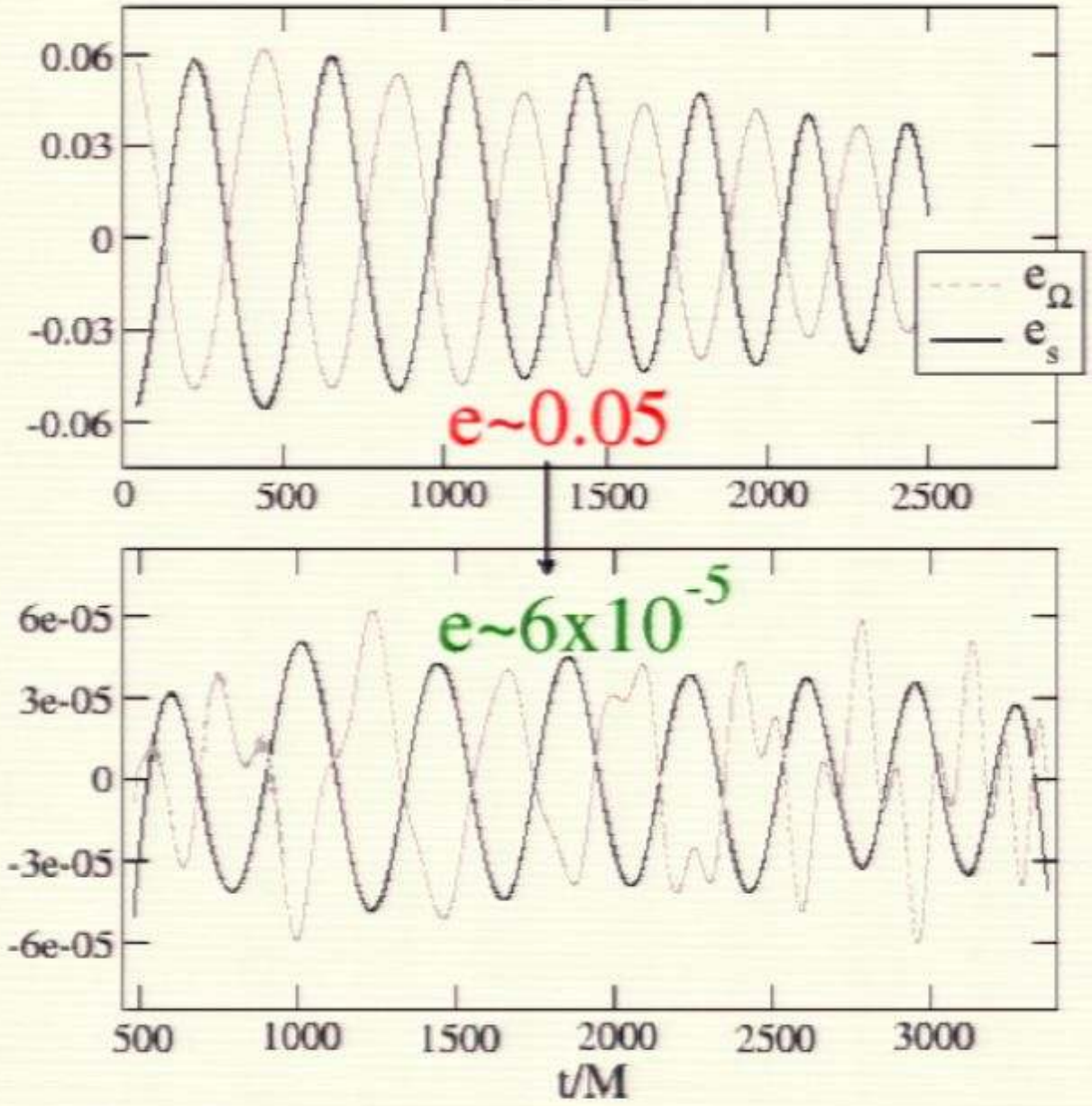
$$\vartheta_r = \vartheta_{r0} + \delta\vartheta_r$$

$$(\Omega, \vartheta_r) \rightarrow e$$



Check that $e < e_0$

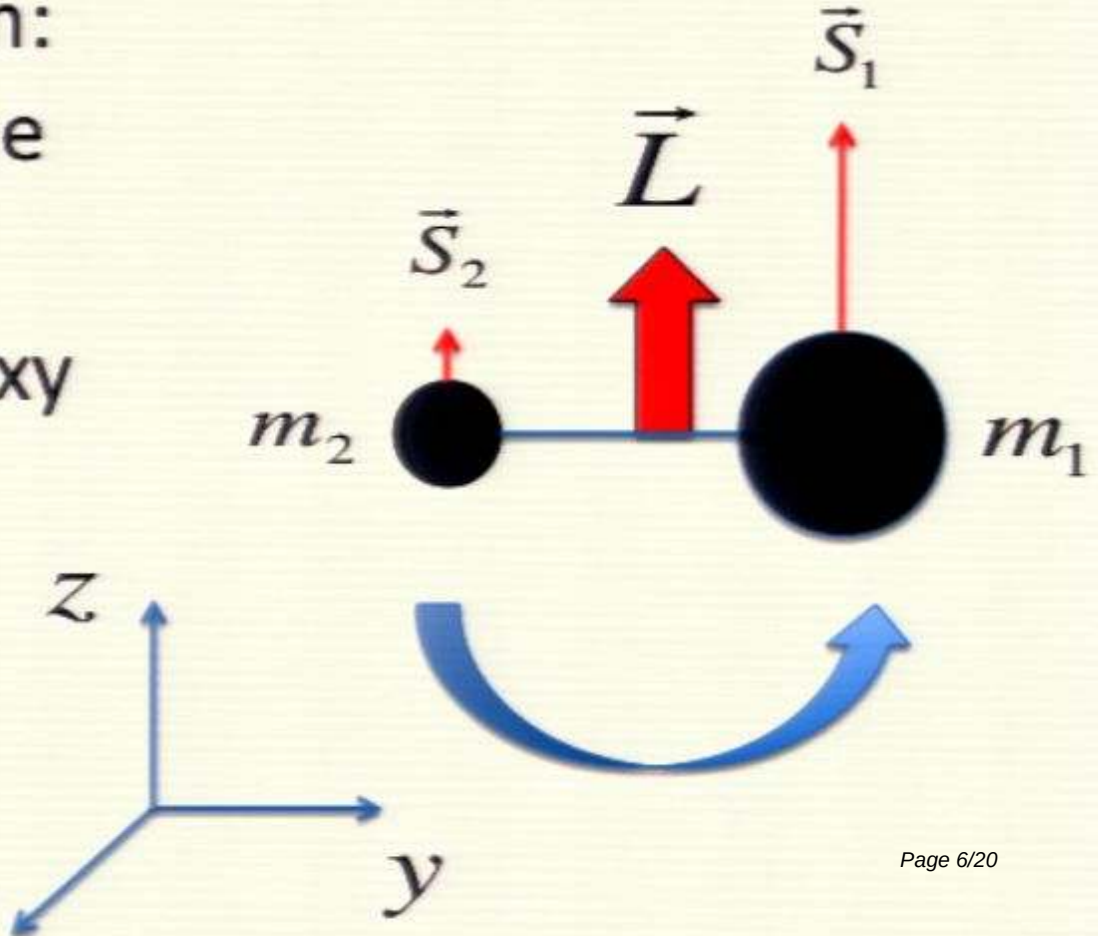
(also can use Ω instead of s)



Works very well for nonspinning binaries

Spinning binaries

- Spins parallel to angular momentum: no precession of the spins
- Trajectory is in the xy plane: no orbital precession



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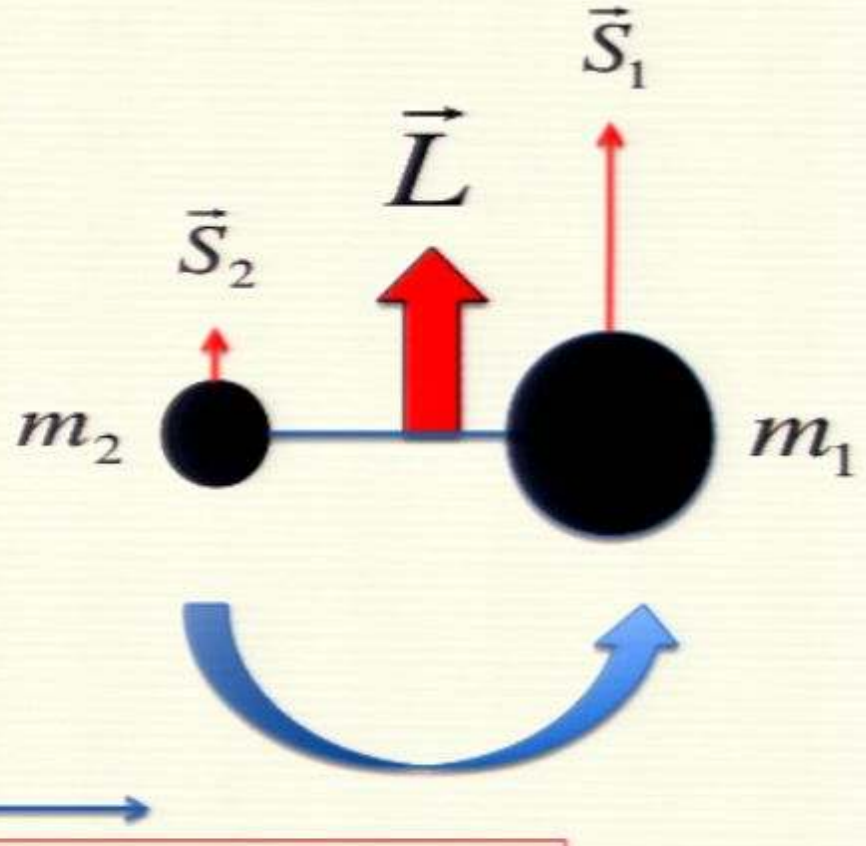


Eccentricity reduction still works fine

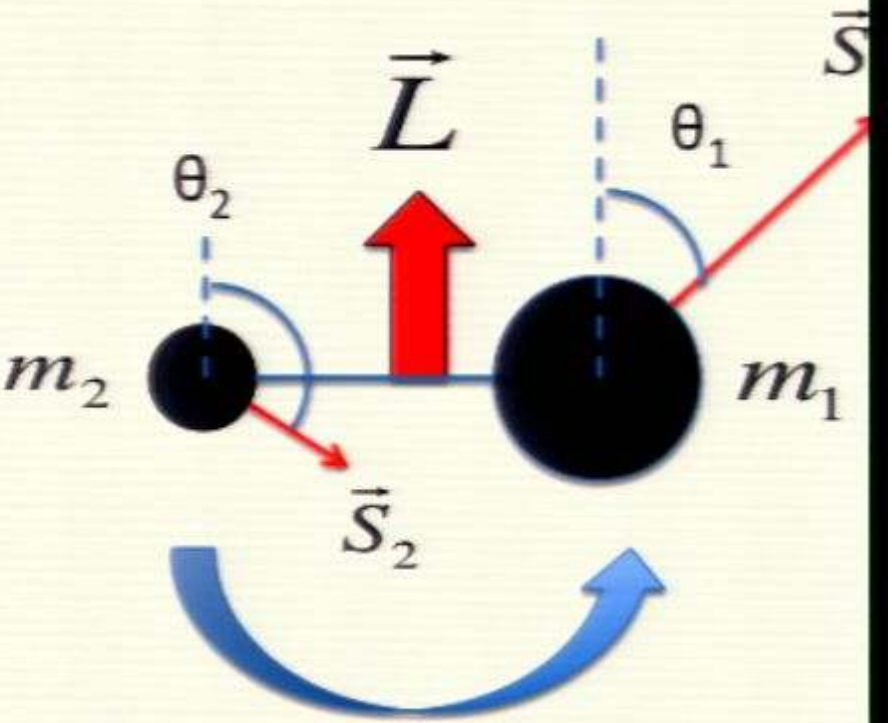
Precessing binaries

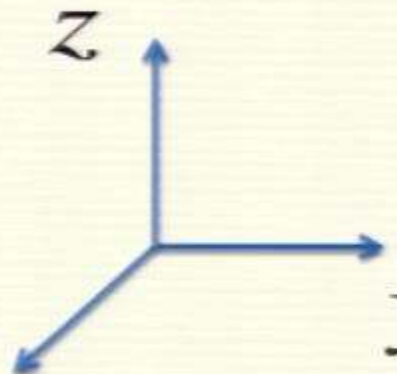
- Spins precession
- Orbital plane precession
- Spin-Orbit and Spin-Spin effects:

$$\ddot{\vec{r}} = ... + ..(S_{eff} \cdot \hat{n})/r^5 + ...(S_{eff} \times \hat{n})/r^3$$

$$+...(S_0 \cdot \hat{n})/r^4 + ...$$

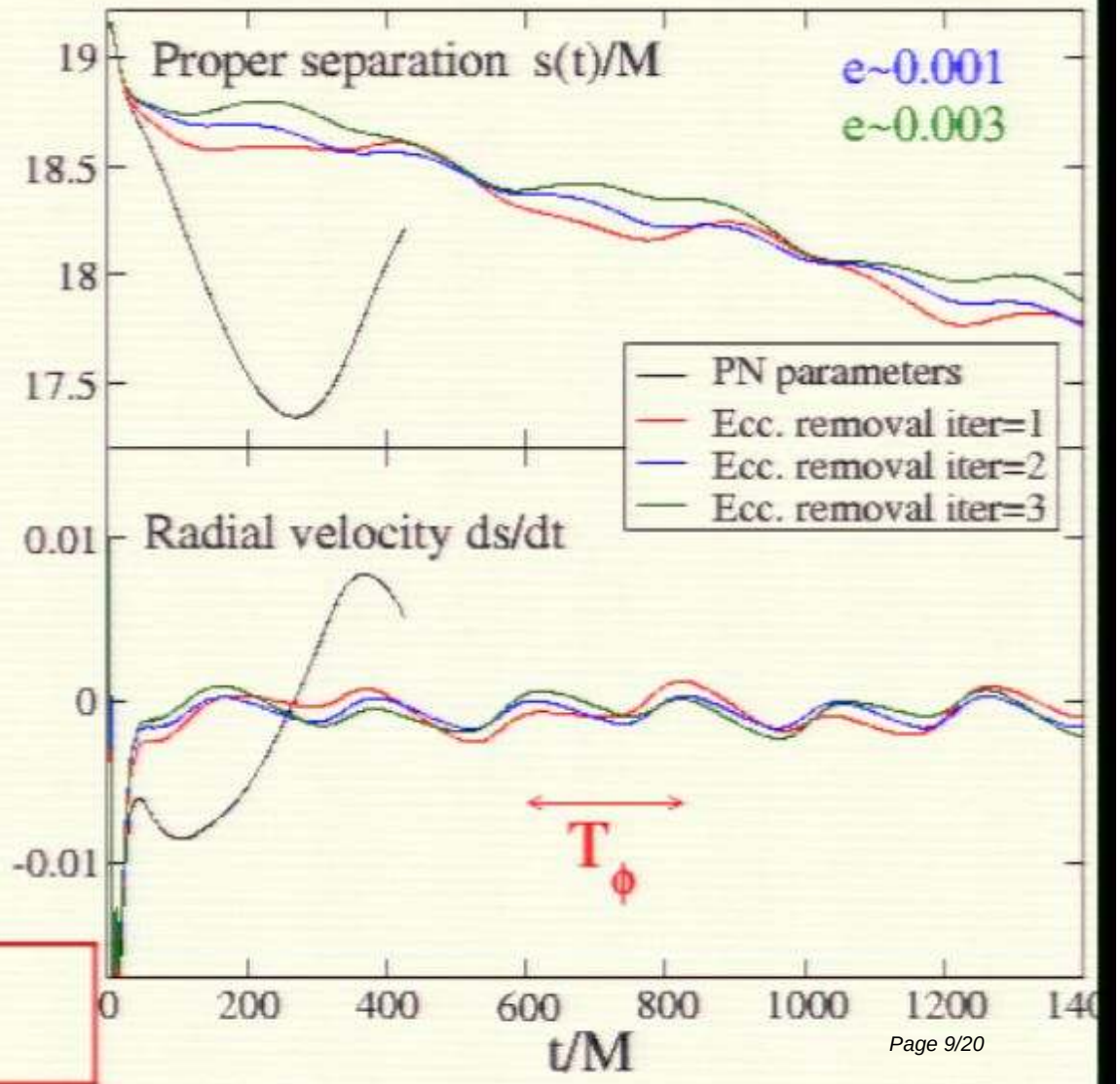
- Similarly for Ω





Eccentricity reduction using separation

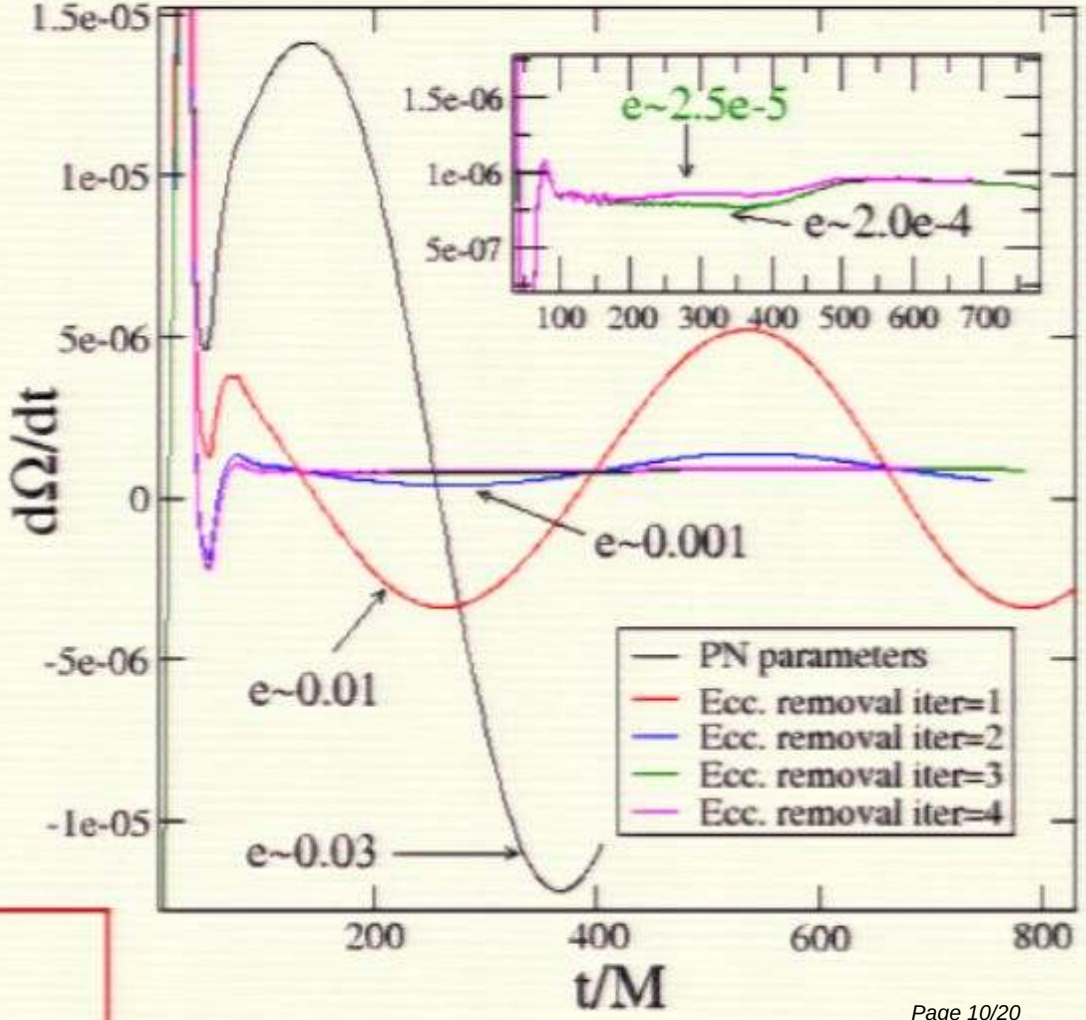
- Minimum e ~0.001
- "Oscillations" at half the orbital period



Precessing binary with
m_1/m_2=1.5, S_1=(0.5,0,0), S_2=0

Eccentricity reduction using orbital frequency

- Minimum e ~0.00003
- Suppressed oscillations at half the orbital period



Precessing binary with
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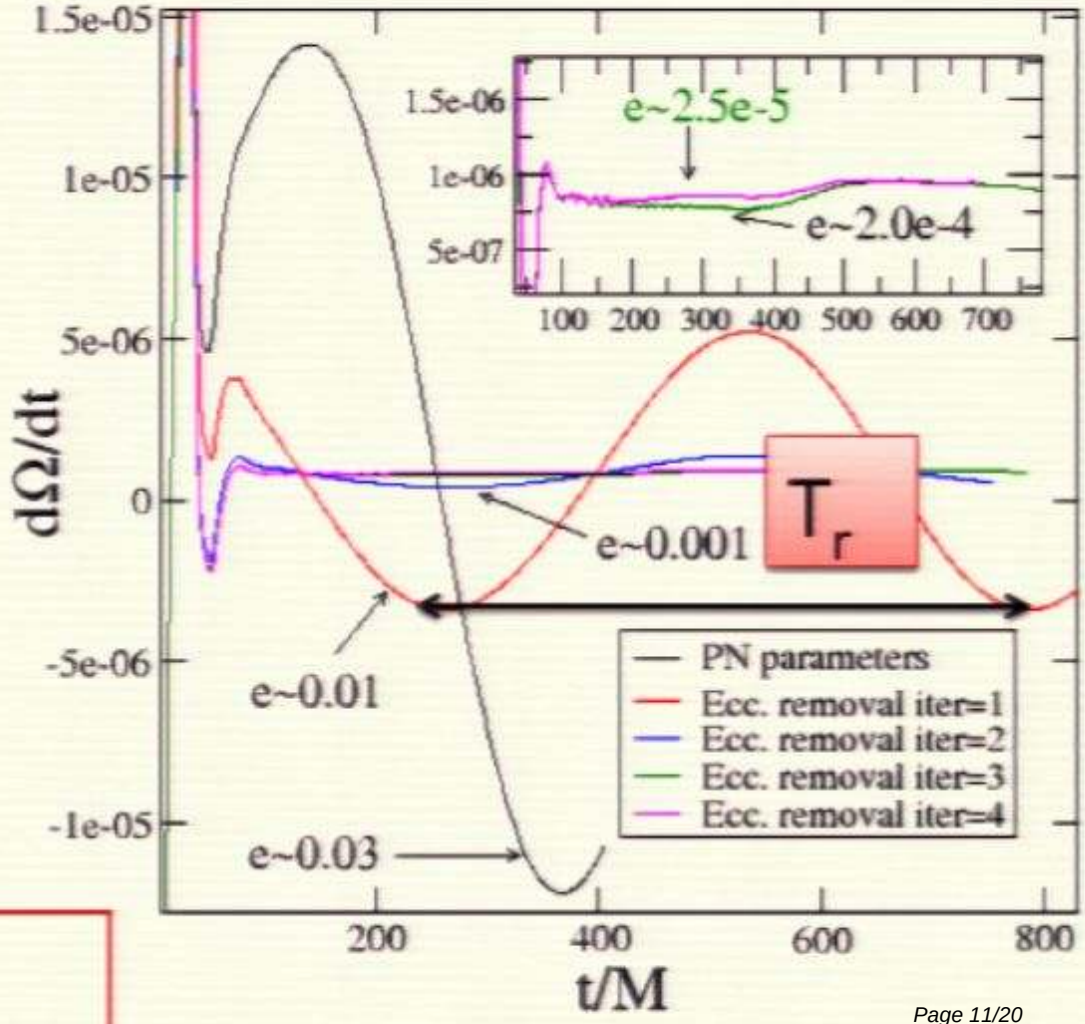
Eccentricity reduction using orbital frequency

- Minimum e ~0.00003
- Suppressed oscillations at half the orbital period
- Oscillations at radial period mainly: T_r



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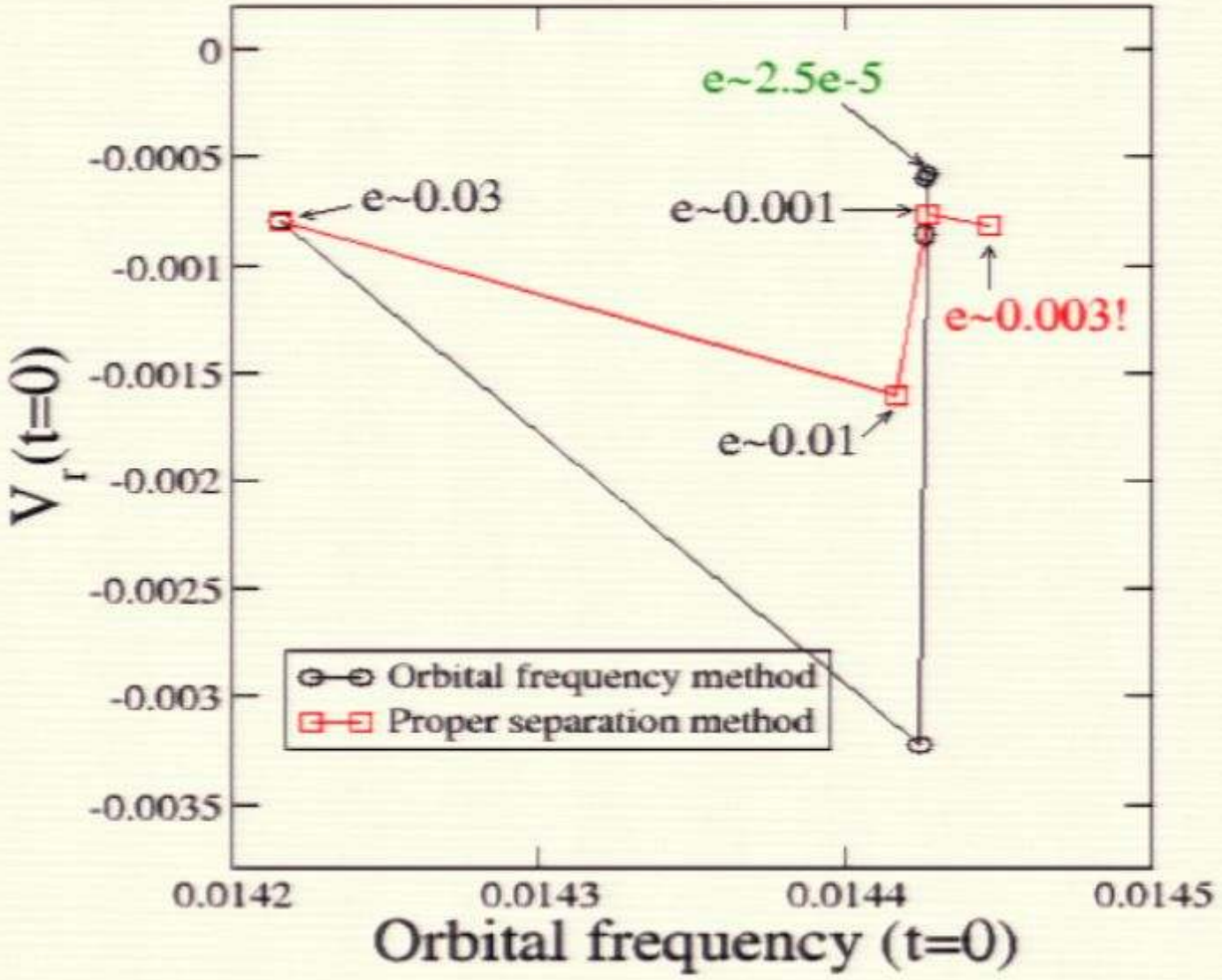
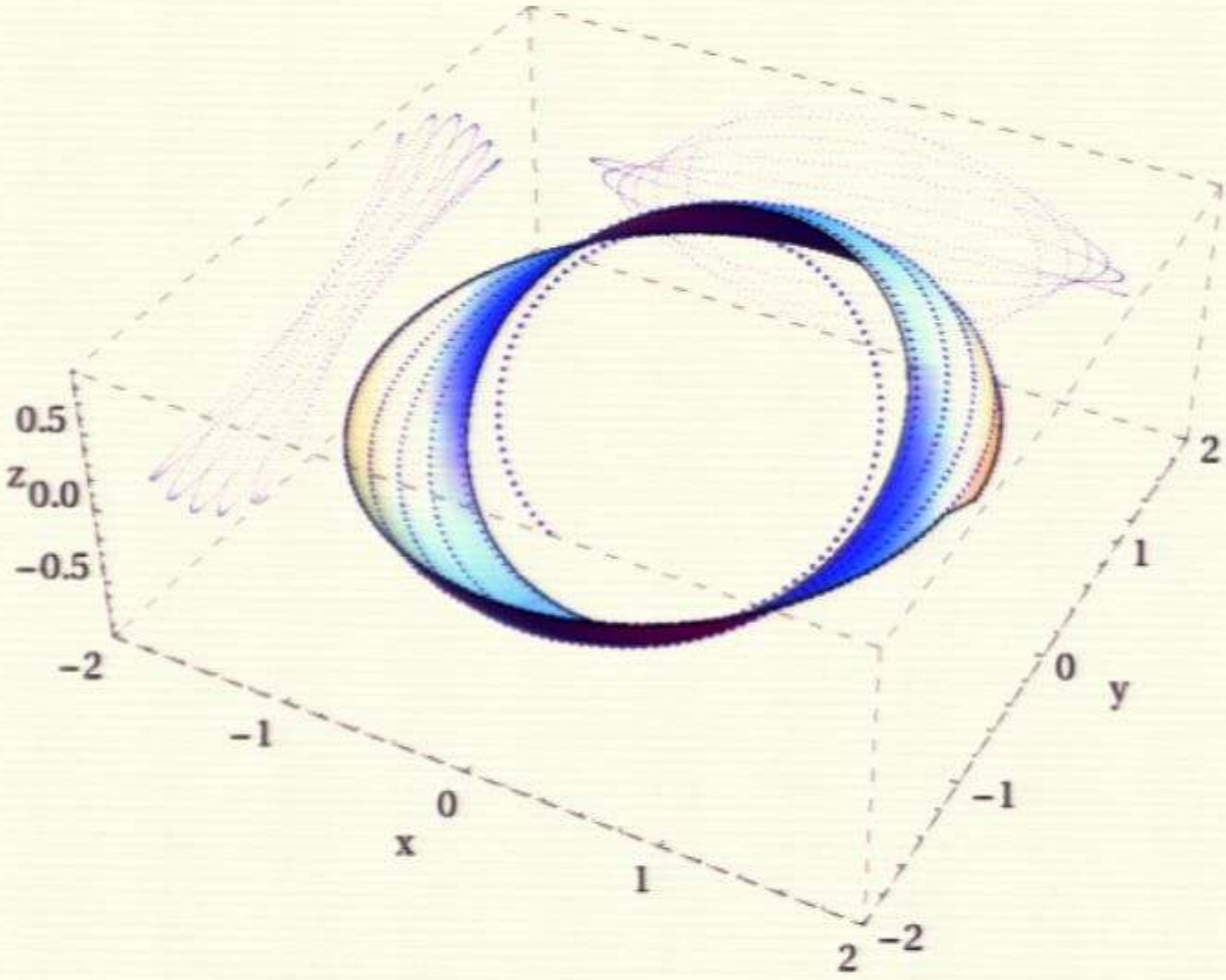
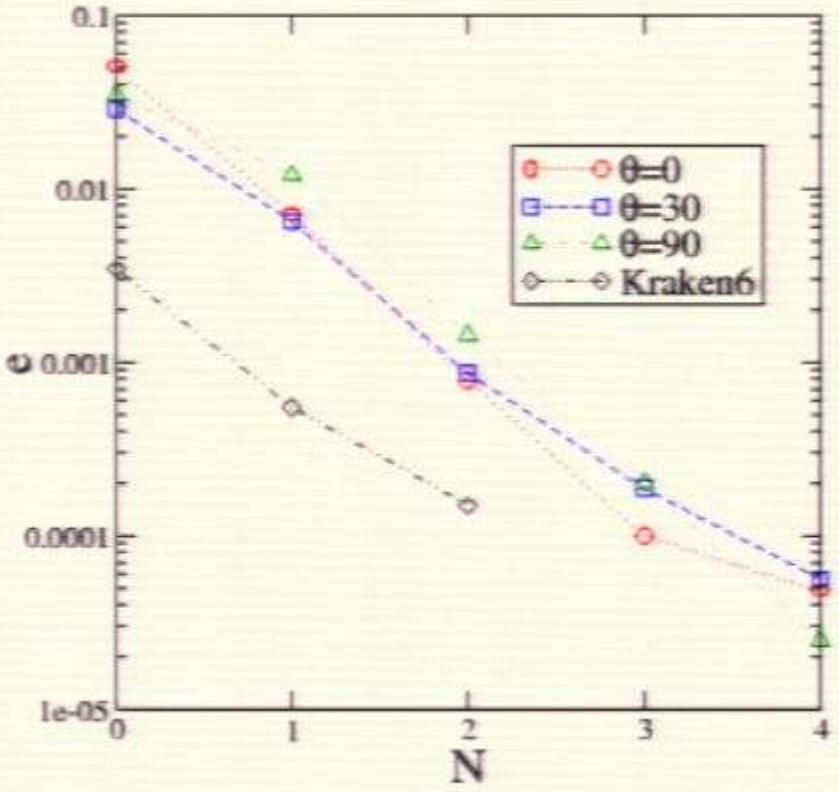


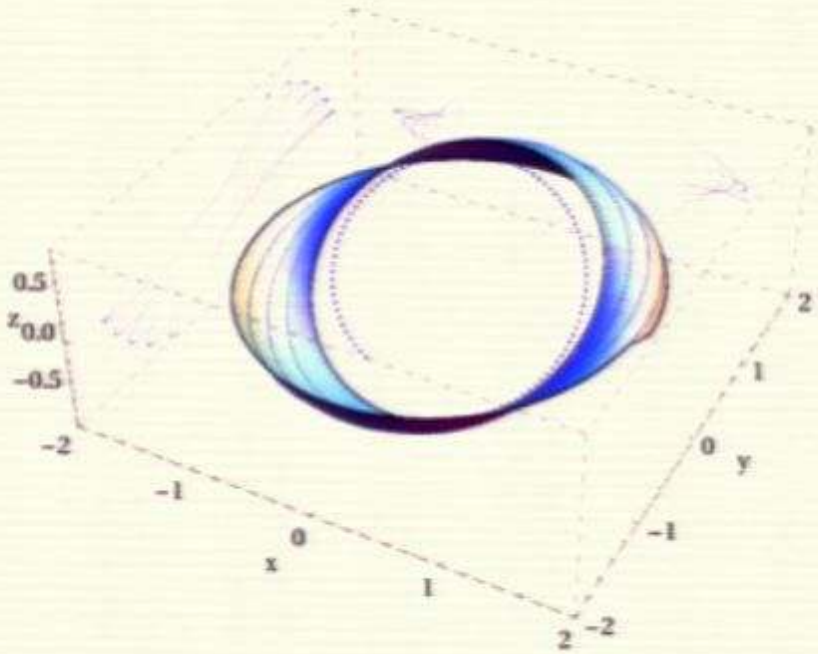
Use orbital frequency Ω to reduce eccentricity



Quasi-circularize binaries with random spins orientations

Trajectory of the precessing binary with $m_1/m_2=5$, $S_1=(0.35,-0.28,-0.22)$, $S_2=0$





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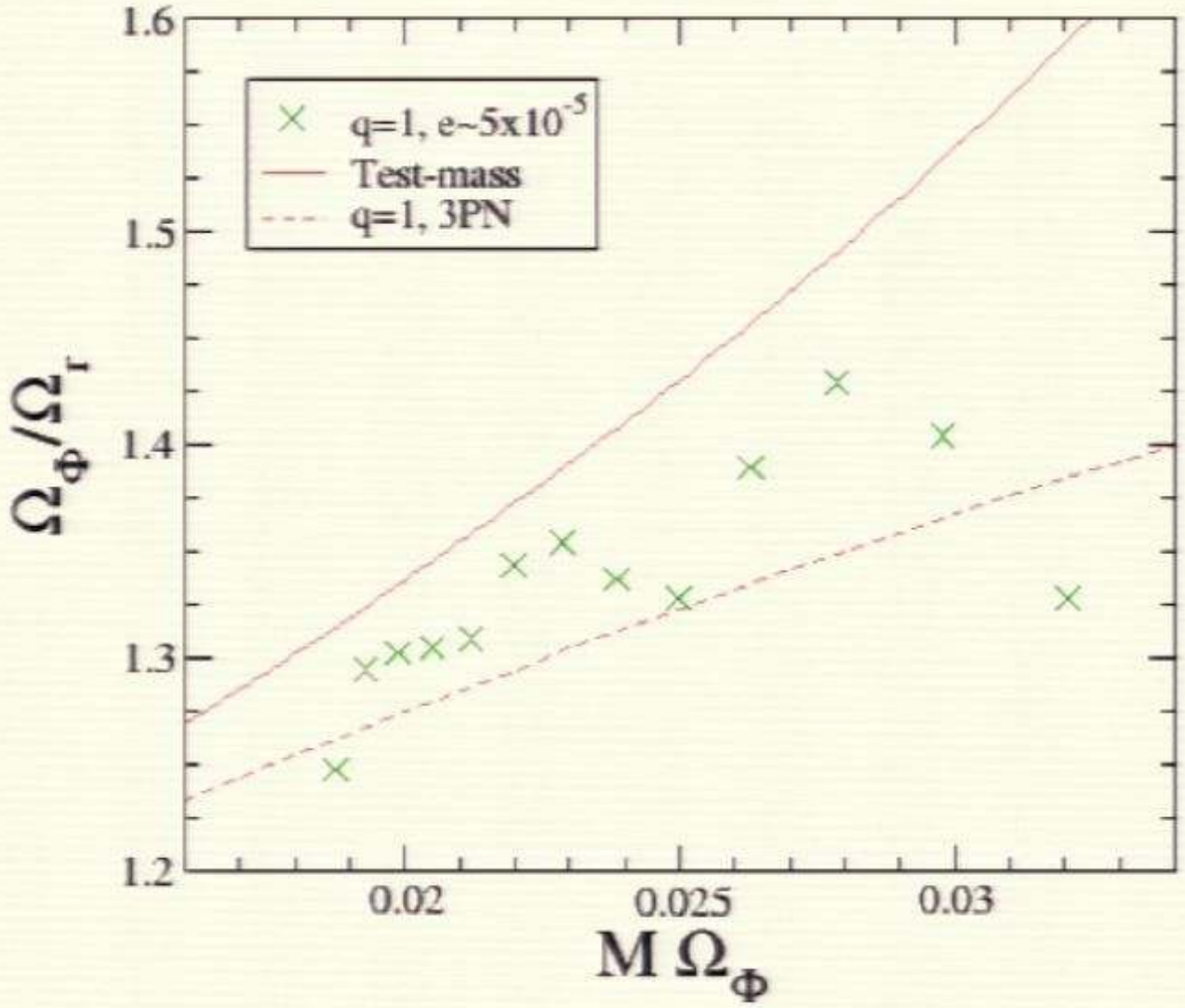
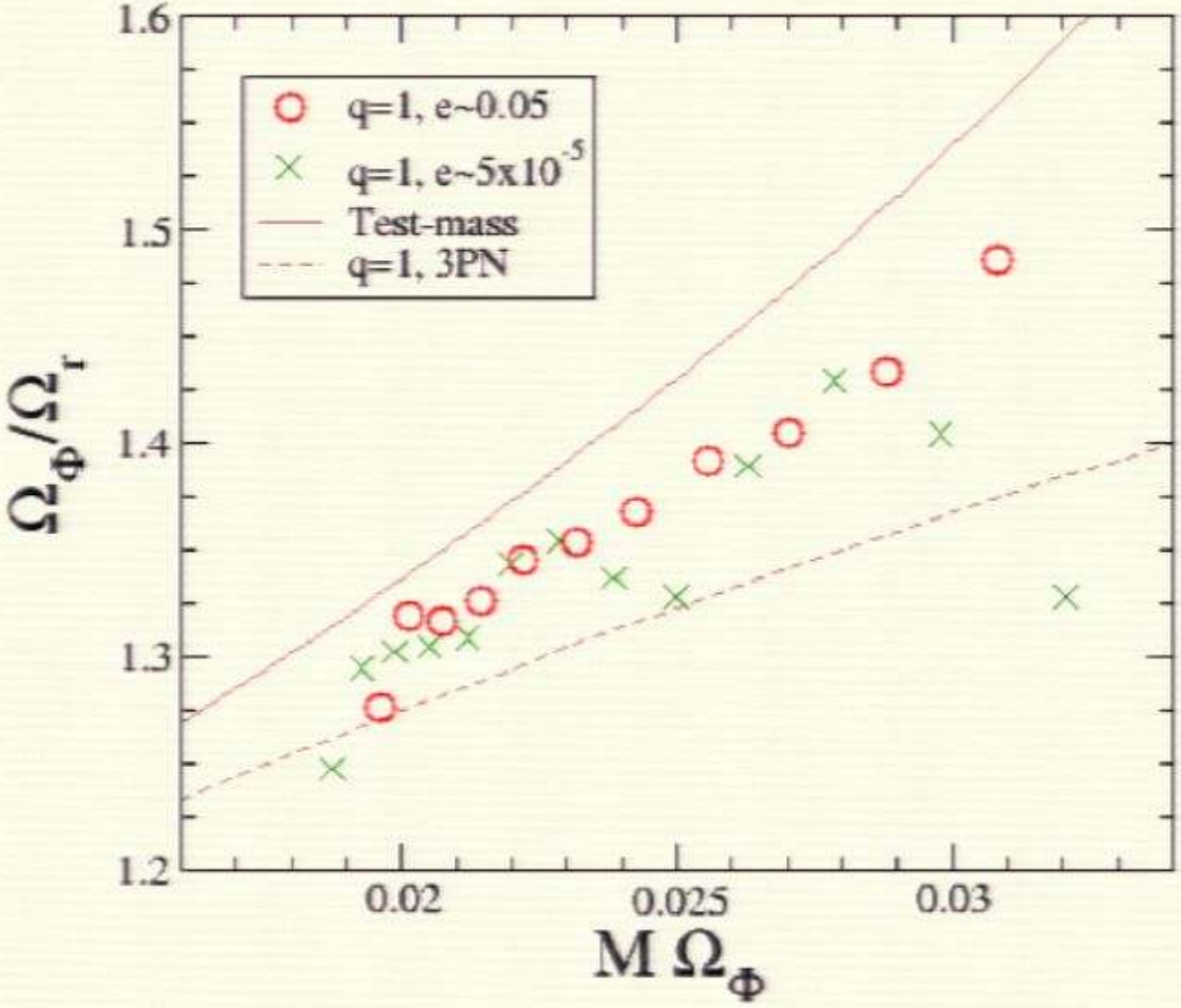


$T_r > T_\Phi$ → Periastron advance



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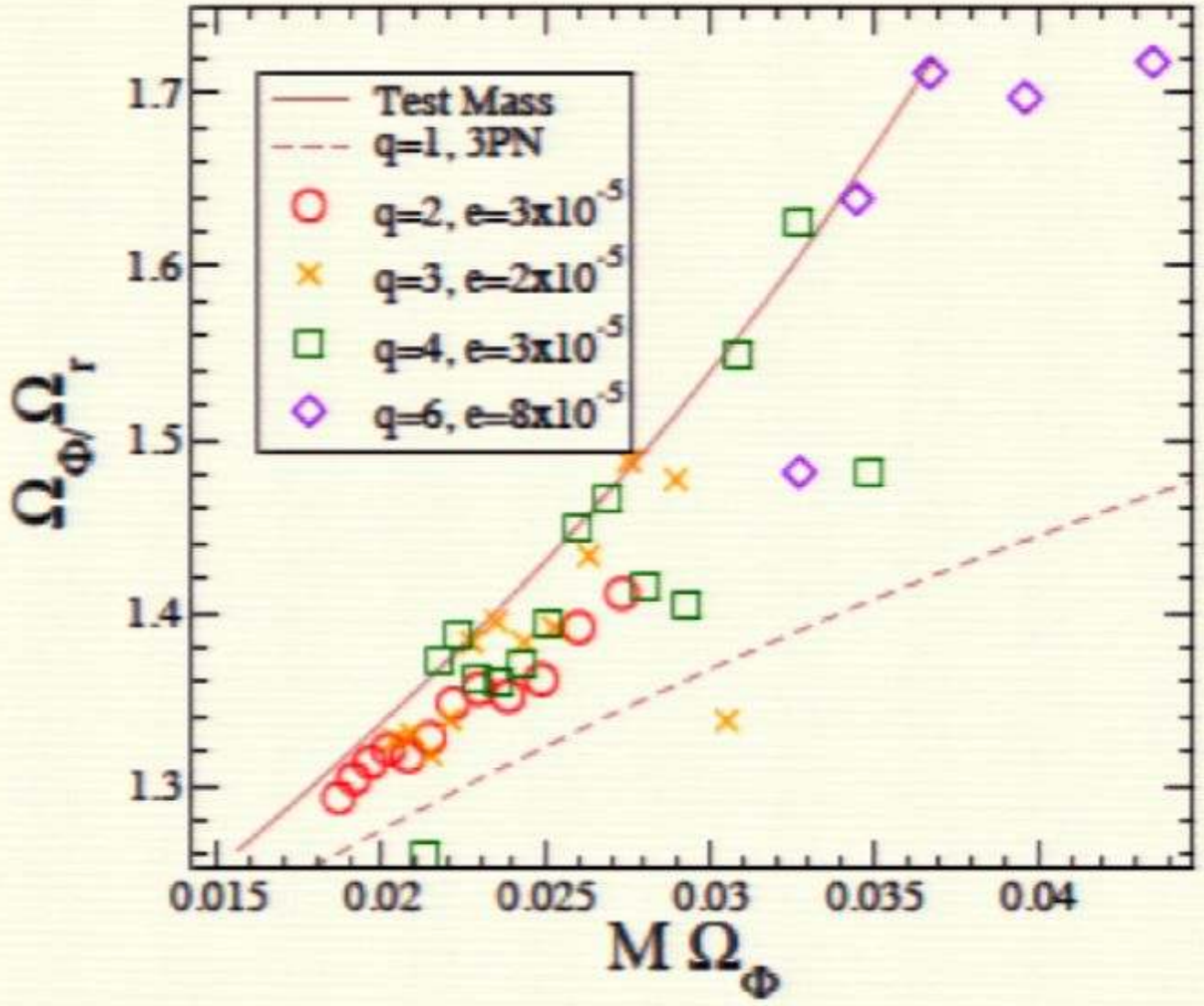
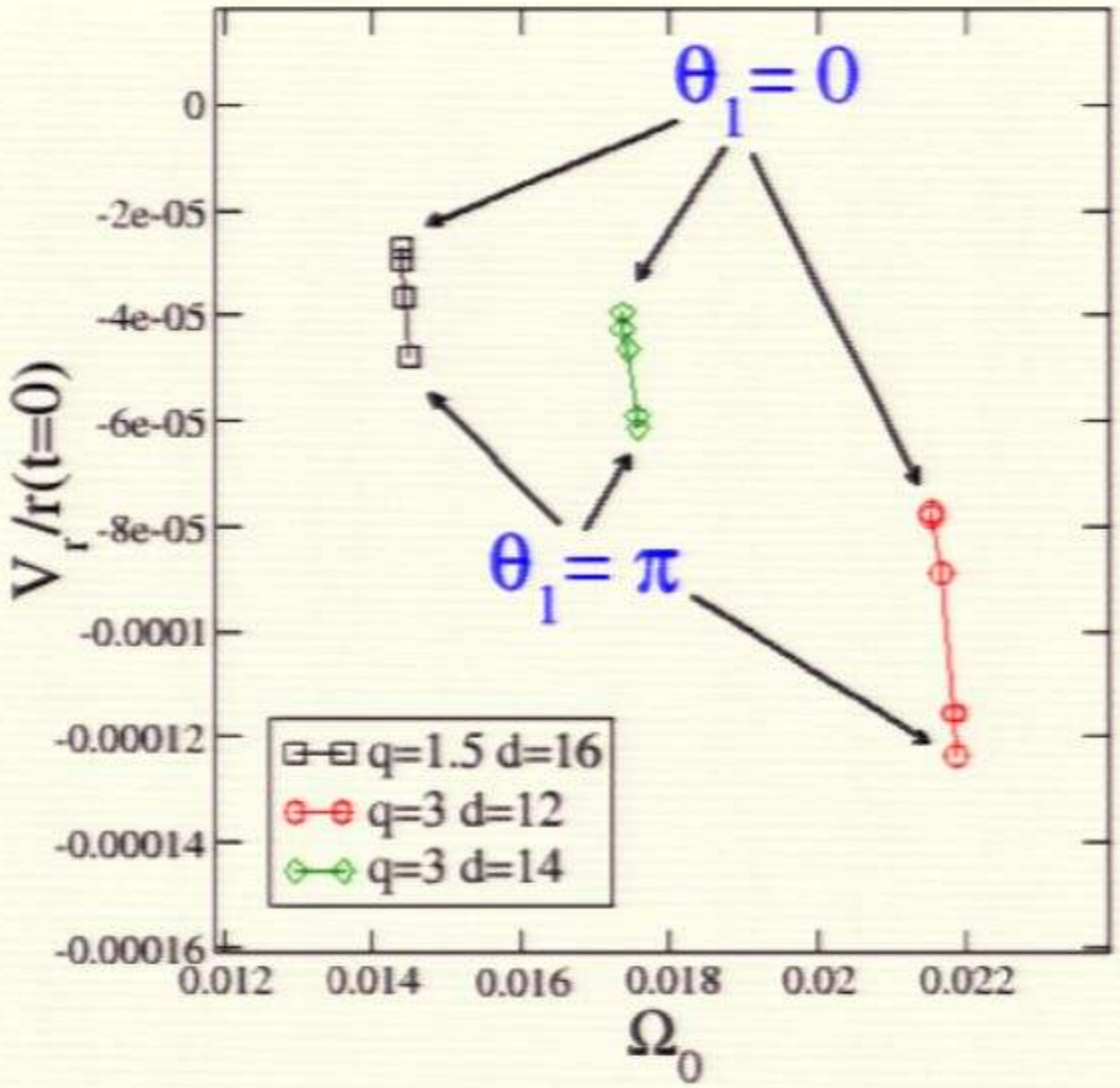


Unequal mass binaries



15 binary configurations with spin 0.5, e~0.00005

Fitting formulas to reduce the number of ecc-

- 39 binaries with 0.5 spin magnitude
  - One/two spinning holes
  - Majority precessing
  - Good quasi-circularization for $\chi_{1,2}$ =0.5
  - 9-15-23-36 orbits/ orbital frequency> 0.013
- Additional binaries with spin 0.6 (SPAWN-KRAKEN)

$$m_1/m_2 = \begin{pmatrix} 1.5 \\ 3 \\ 5 \end{pmatrix} \quad \theta_{1,2} = \begin{pmatrix} 0° \\ 30° \\ 90° \\ 150° \\ 180° \end{pmatrix} \quad \phi_{1,2} = \begin{pmatrix} 0° \\ 90° \\ 180° \\ 270° \end{pmatrix}$$

- Waveforms…
- Compare Spin effects to PN
- …