

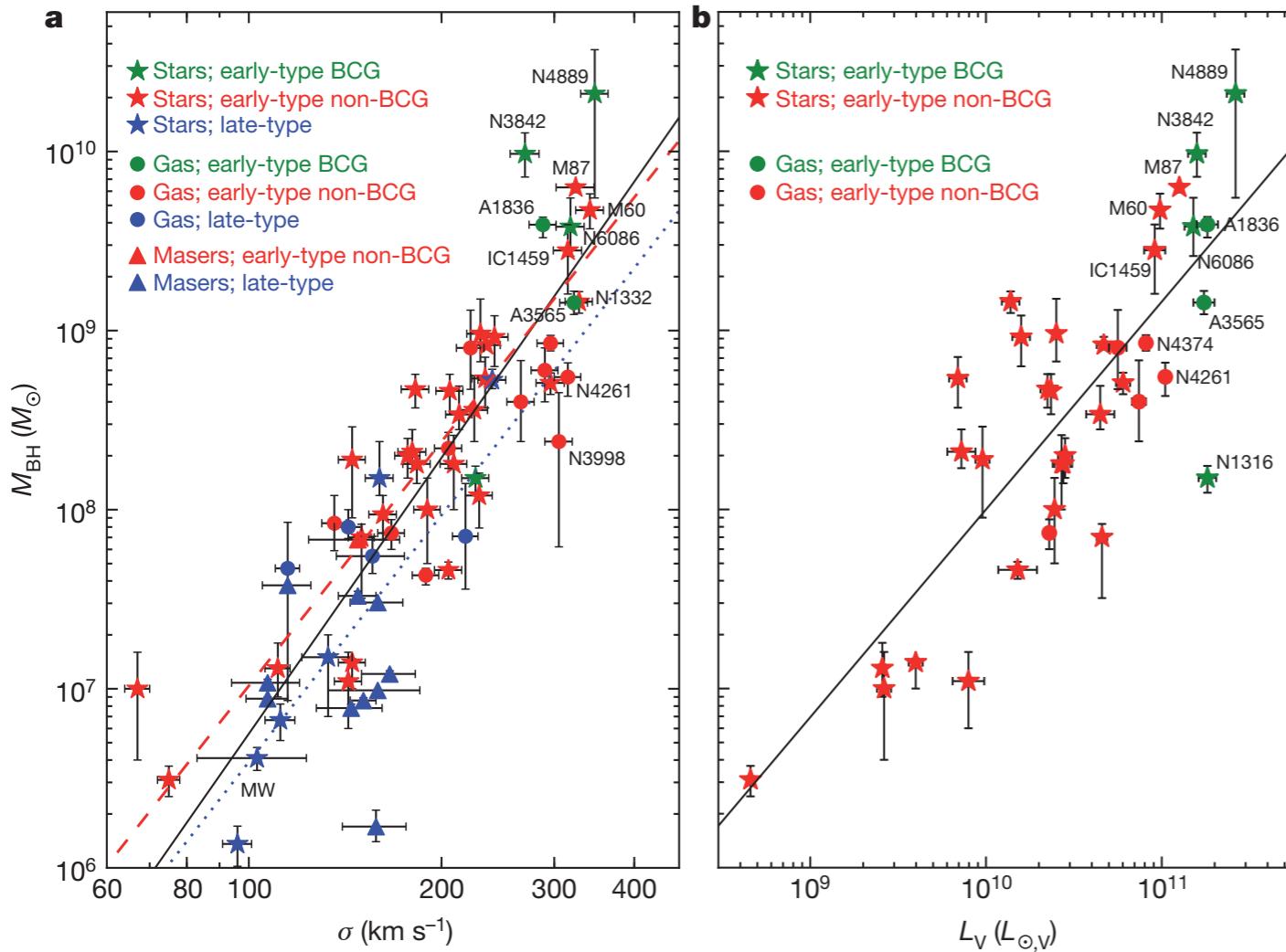
Continuous gravitational-wave signals

(...from individual supermassive
black-hole binaries)

Steve Taylor

Supermassive black hole binary signals in the PTA band

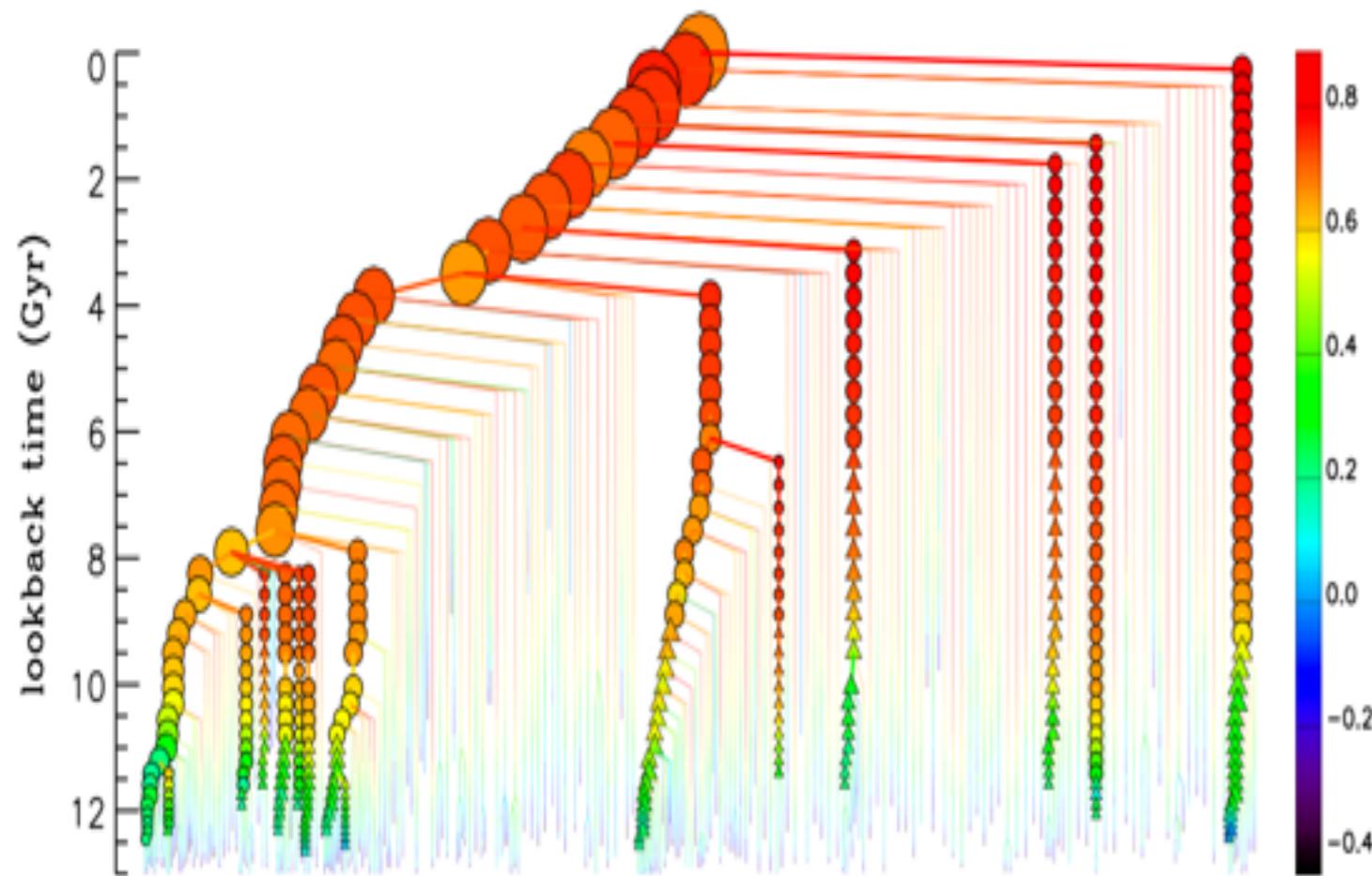
Supermassive black hole binaries (SMBHBs) are thought to form ubiquitously within models of galaxy formation



- Supermassive black holes are copious in the nuclei of nearby galaxies
- Several relationships exhibit **coevolution between galactic bulge properties and the central black hole, e.g. M-sigma, M-Lv**

Supermassive black hole binary signals in the PTA band

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- Supermassive black holes are copious in the nuclei of nearby galaxies
- Several relationships exhibit coevolution between galactic bulge properties and the central black hole
- Current paradigm of galaxy formation is that **galaxies undergo repeated merger events**, and accrete from cosmic web filaments [White & Rees (1978)]

Supermassive black hole binary signals in the PTA band

gas-rich disk galaxies



interact



AGN, starburst



post-starburst



gas-poor
quiescent
elliptical

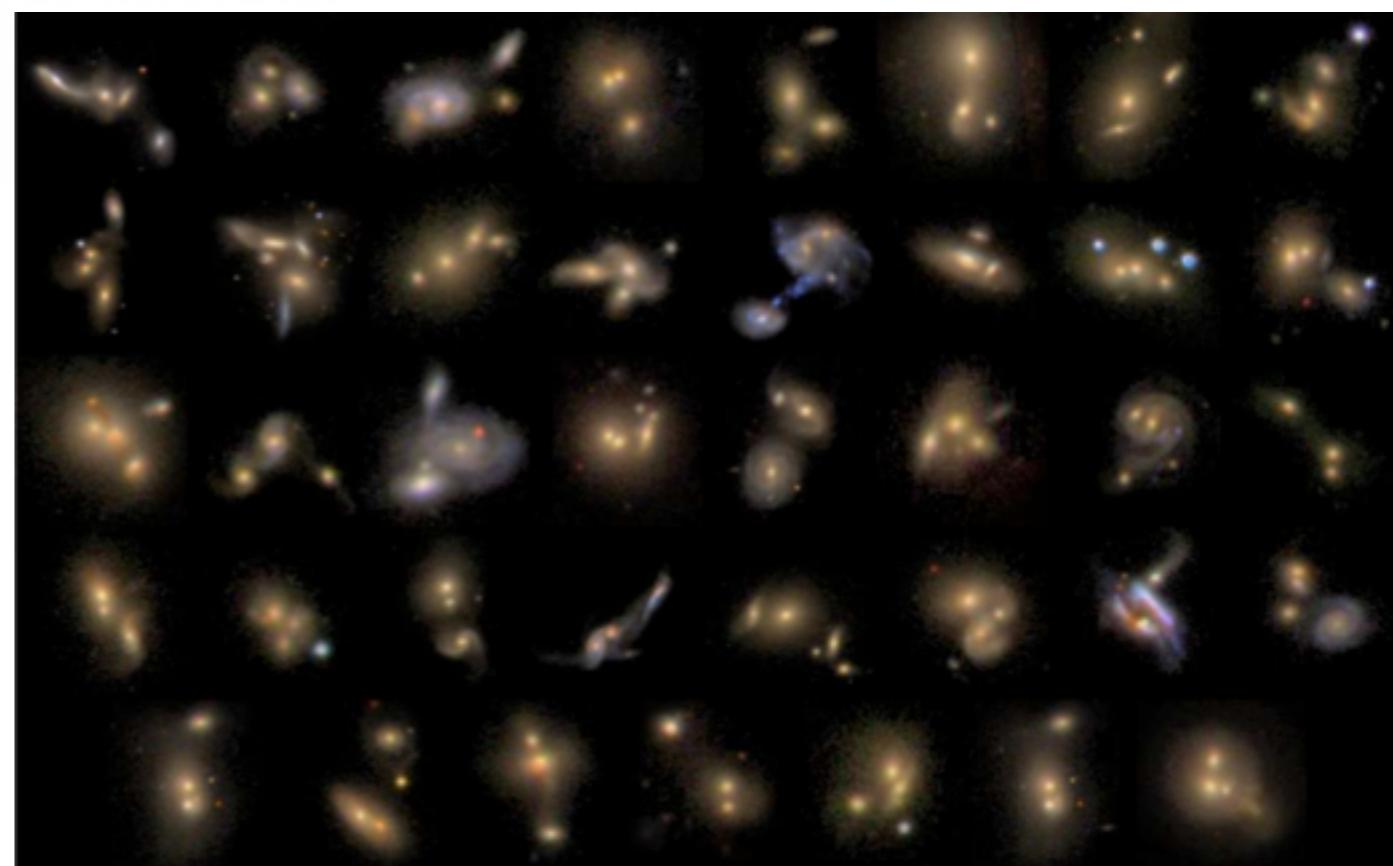


with shells



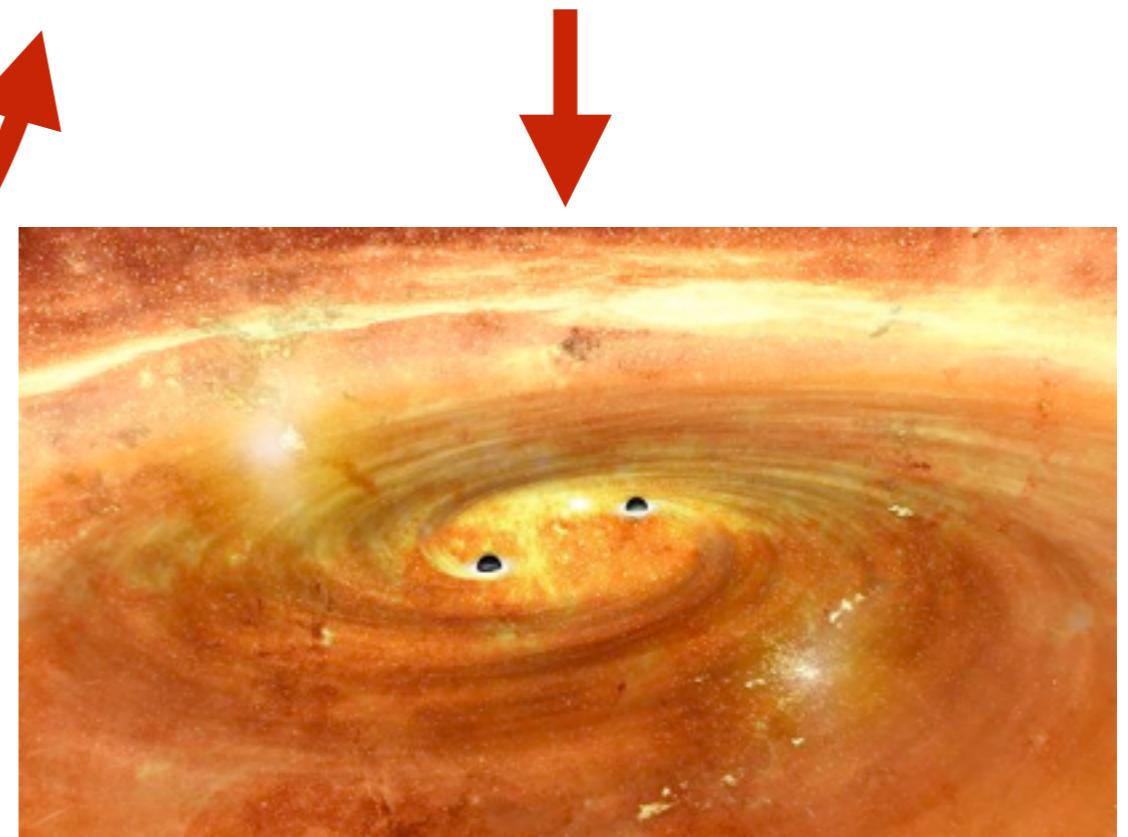
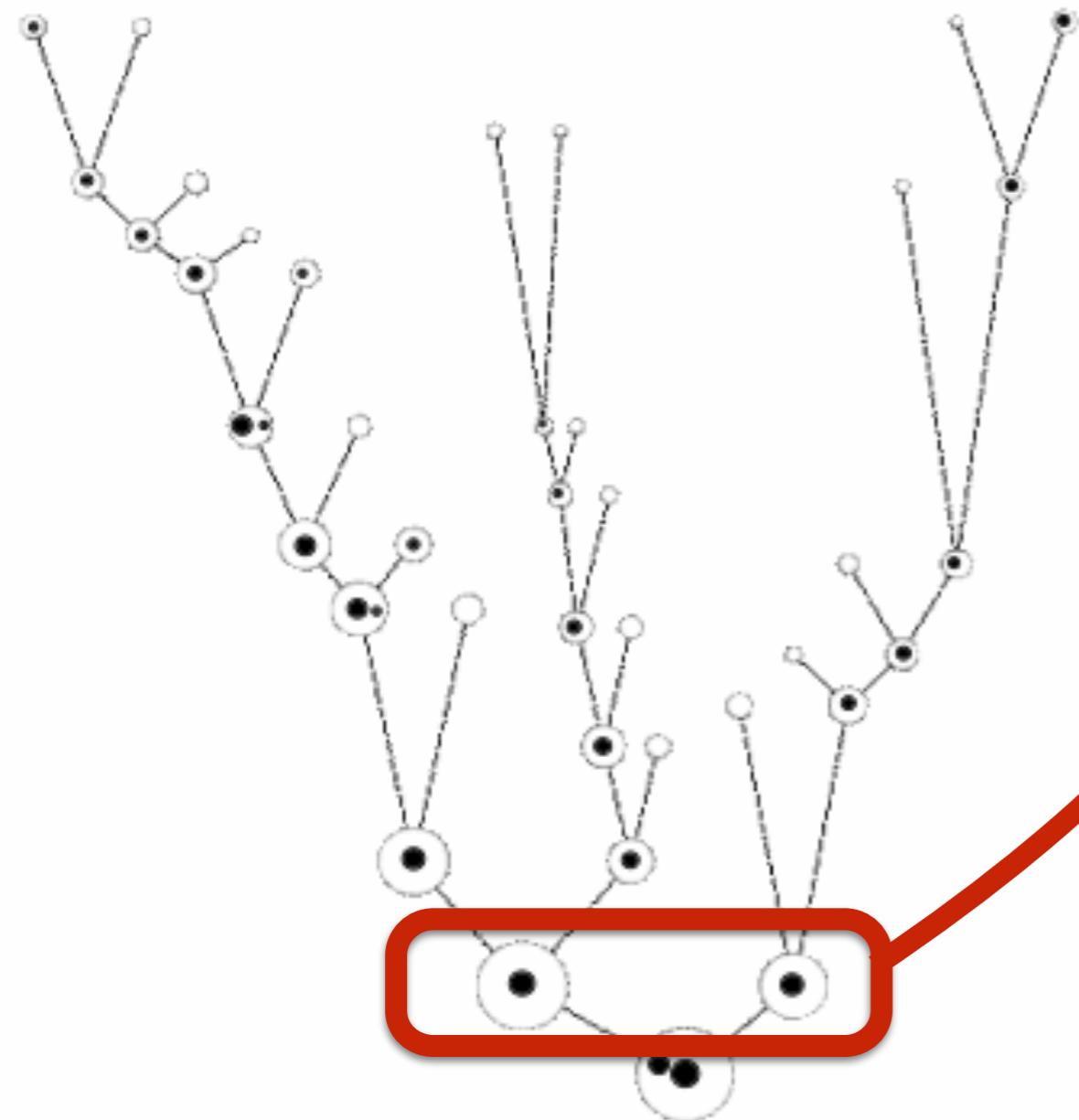
When gas blows out
a quasar is visible

Galaxy zoo project



<http://www.astro.wisc.edu/>

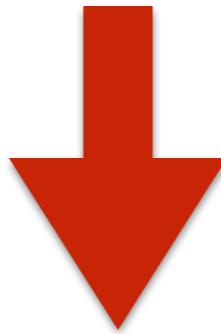
Supermassive black hole binary signals in the PTA band



Begelman, Blandford, Rees (1980)

Supermassive black hole binary signals in the PTA band

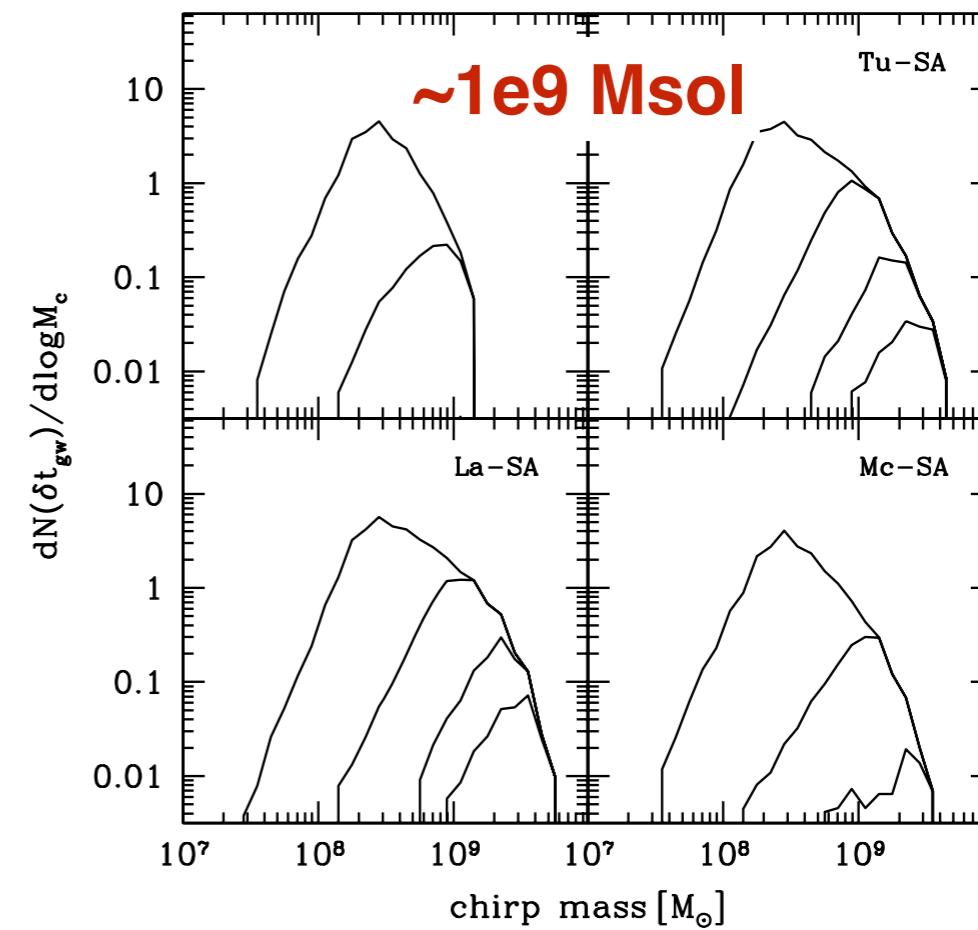
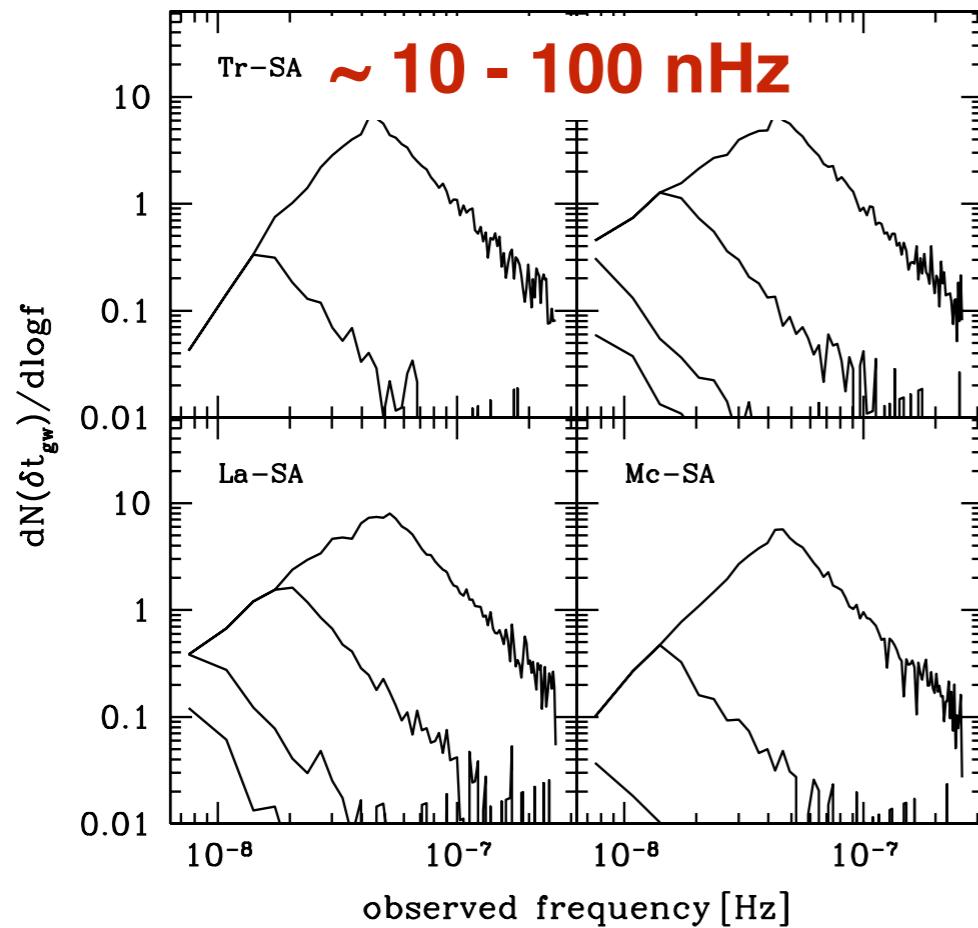
“Final parsec problem”



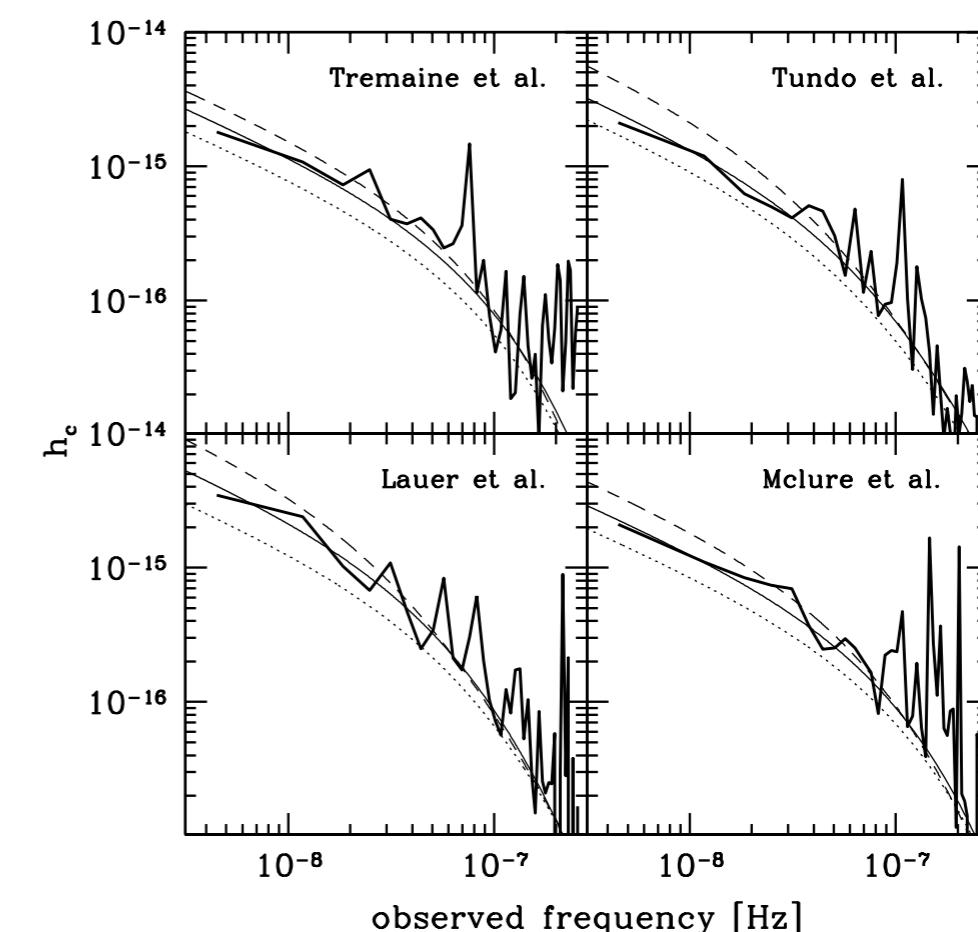
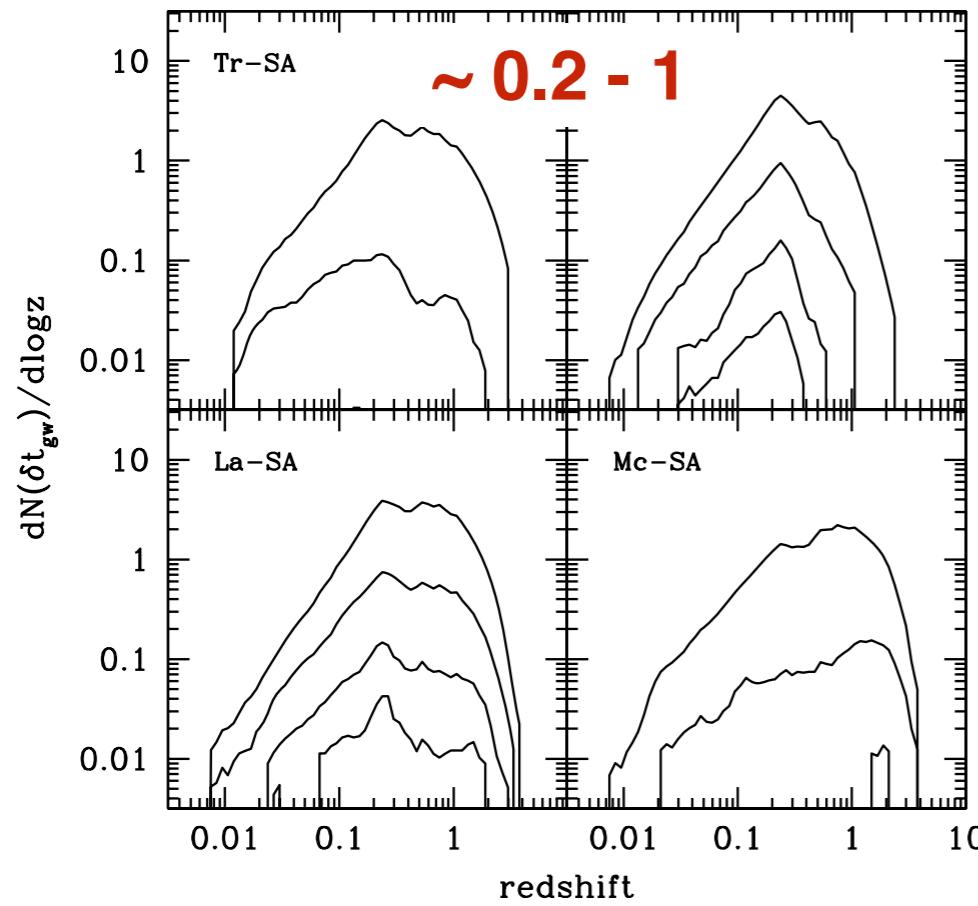
Dynamical friction not a sufficient driving mechanism to induce merger within a Hubble time

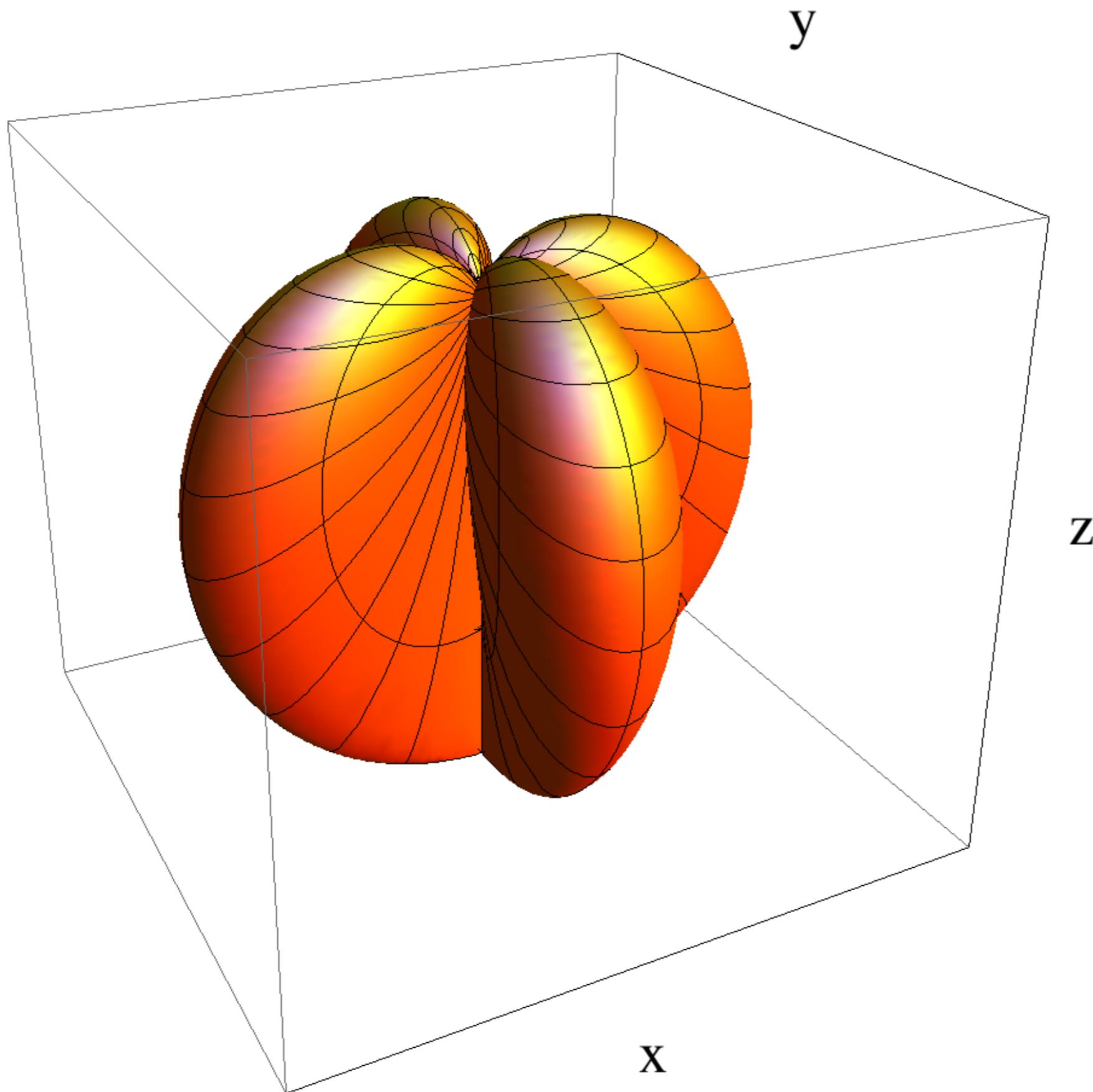
e.g., Milosavljevic & Merritt (2003)

Additional environmental couplings may extract energy and angular momentum from binary to drive it to sub-pc separations



Sesana, Vecchio, Volonteri (2009)





Z

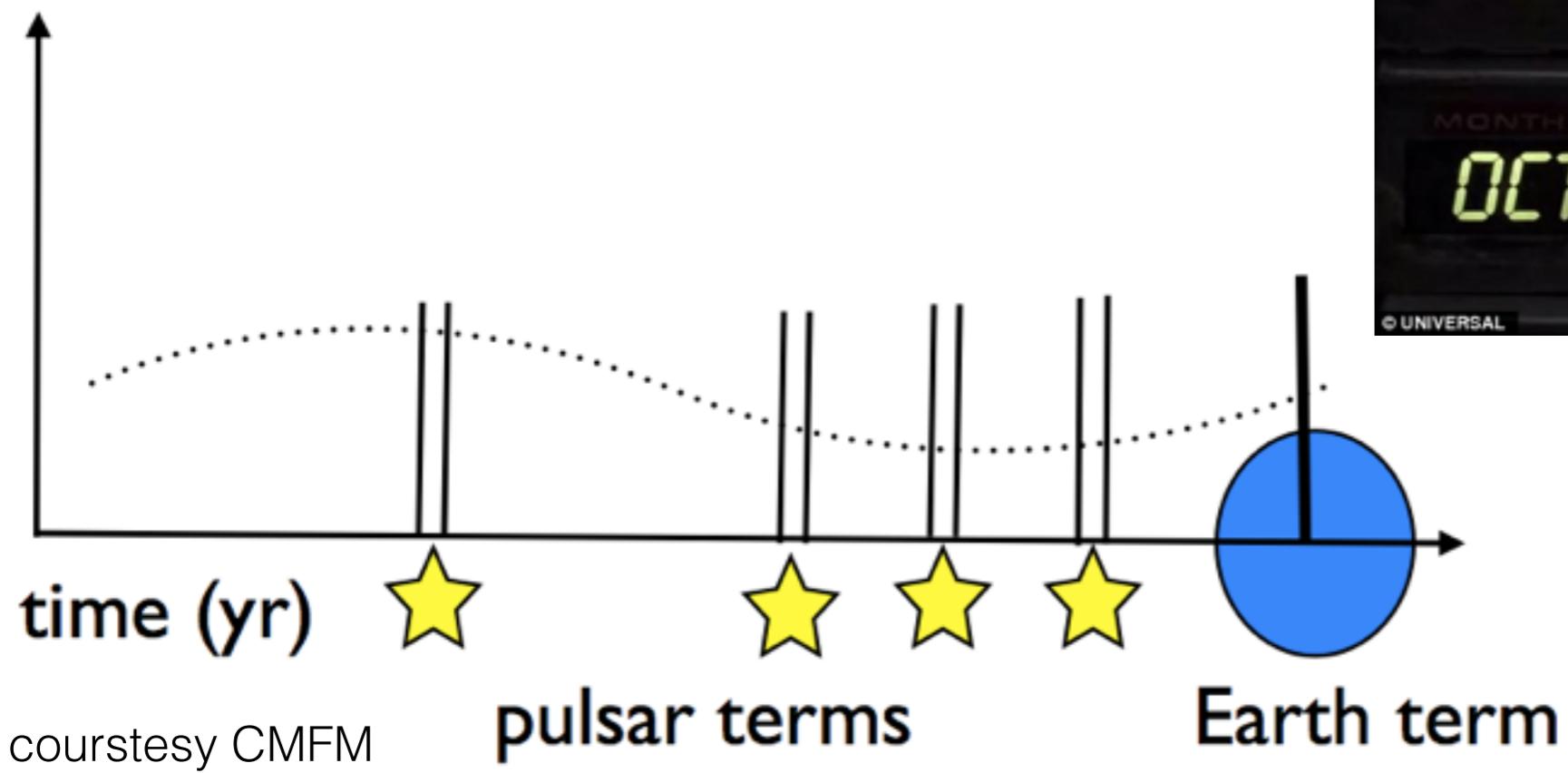
y

X

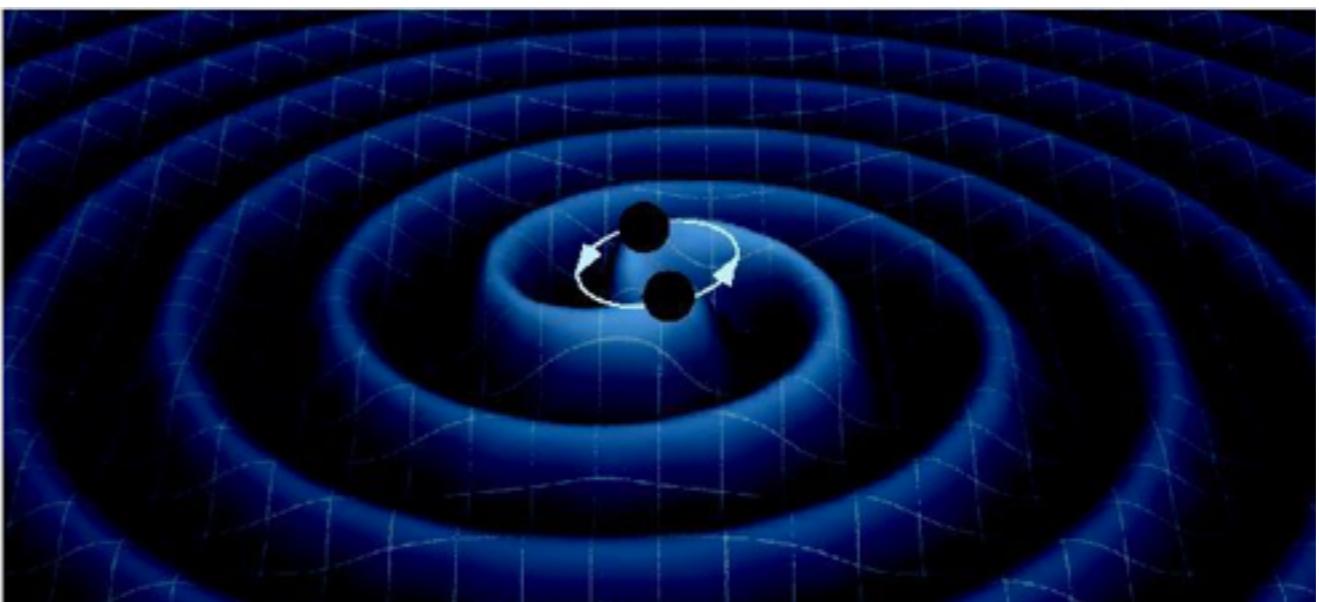
GW



Chamberlin & Siemens (2012)

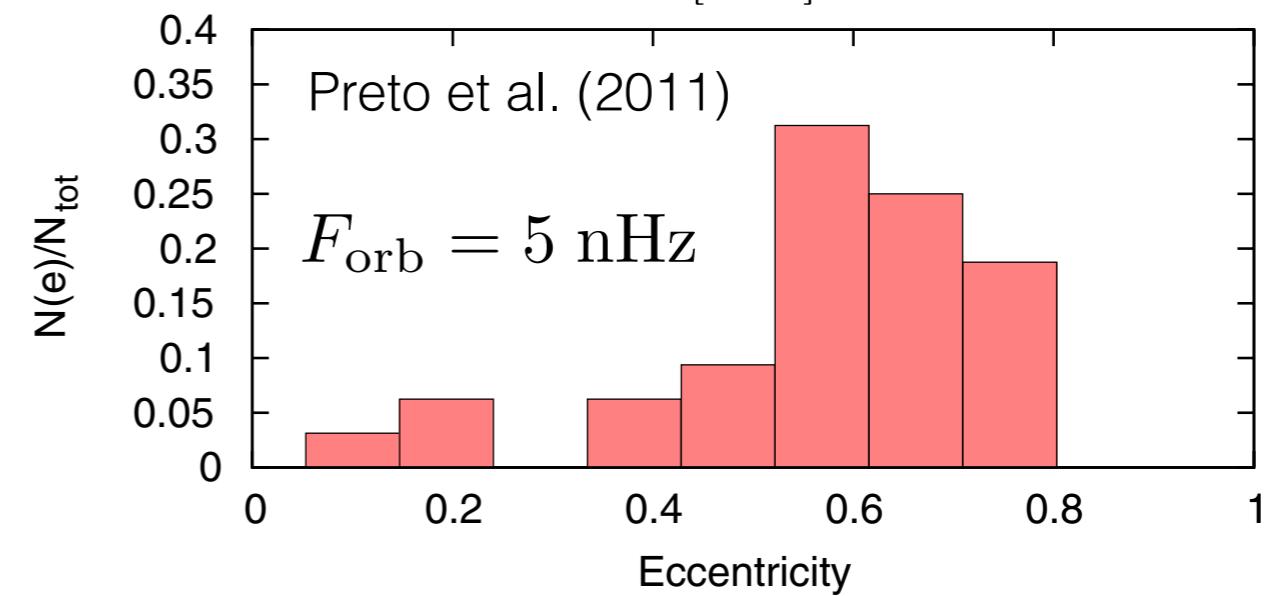
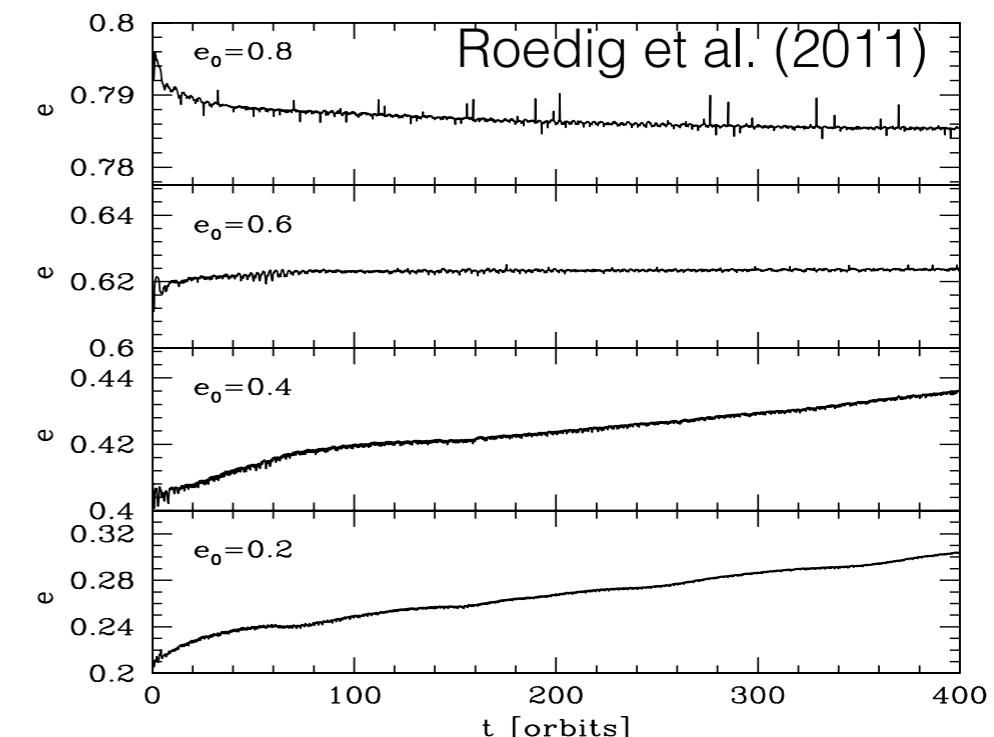
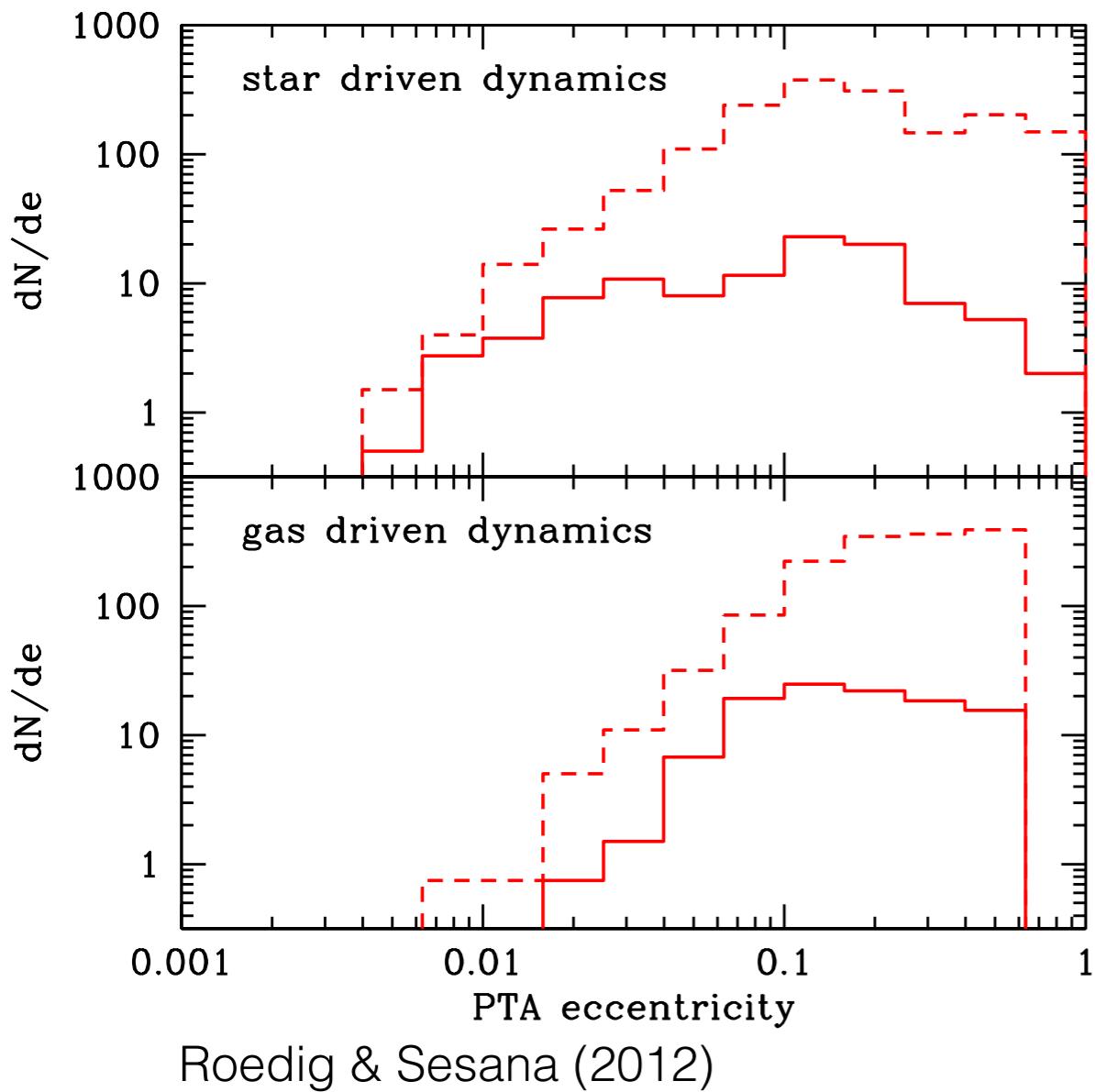


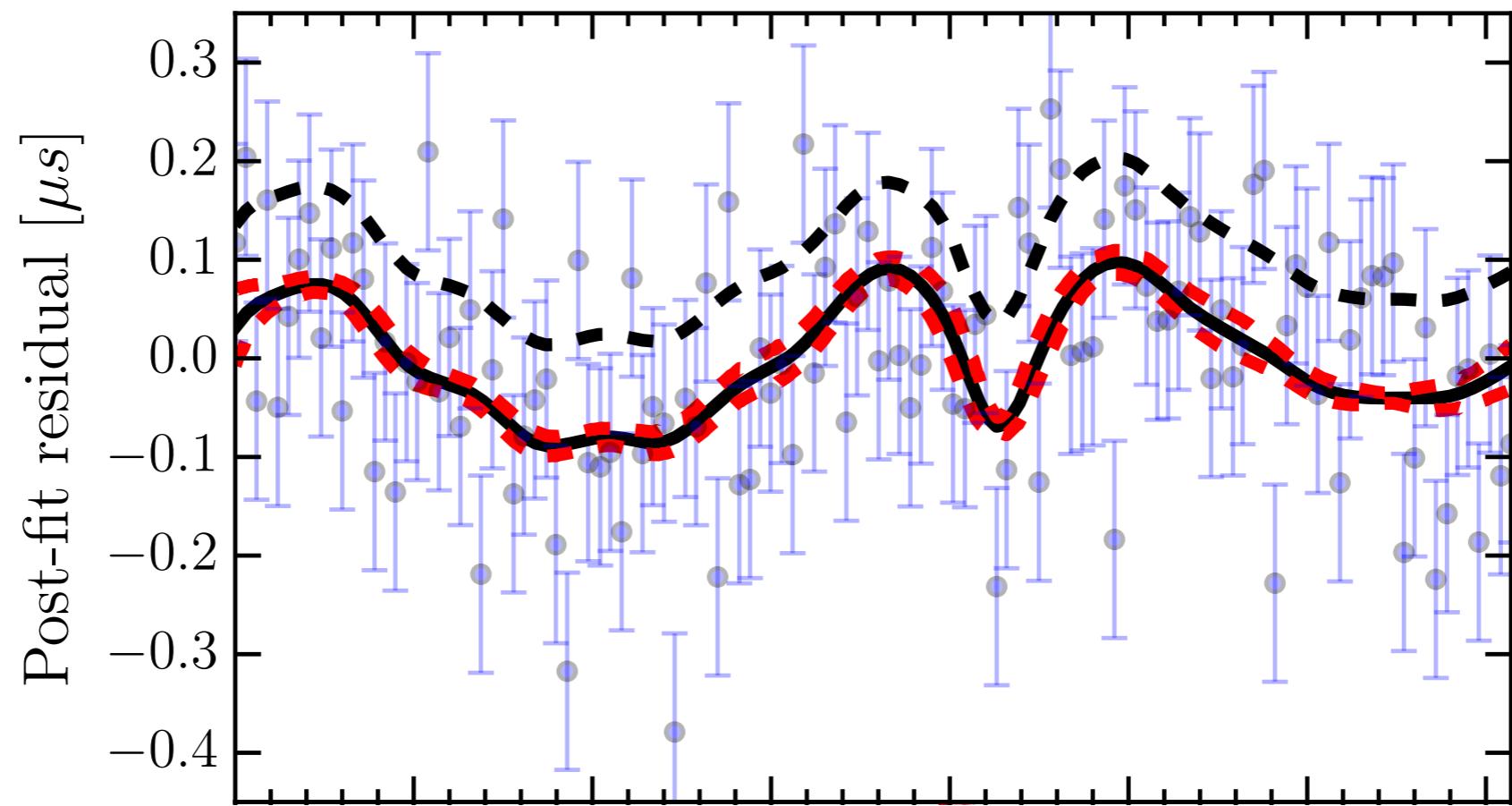
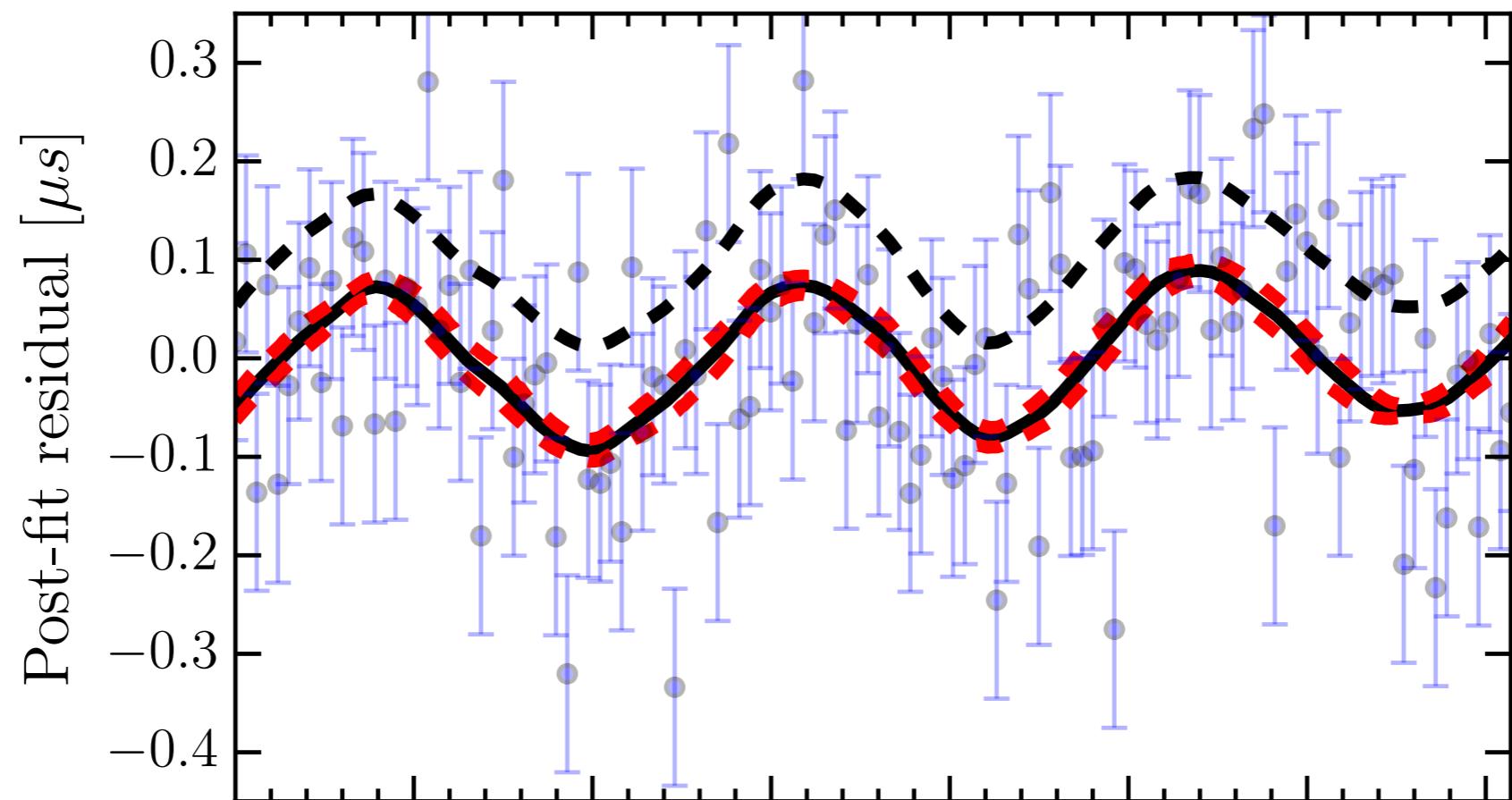
temporal aperture synthesis!

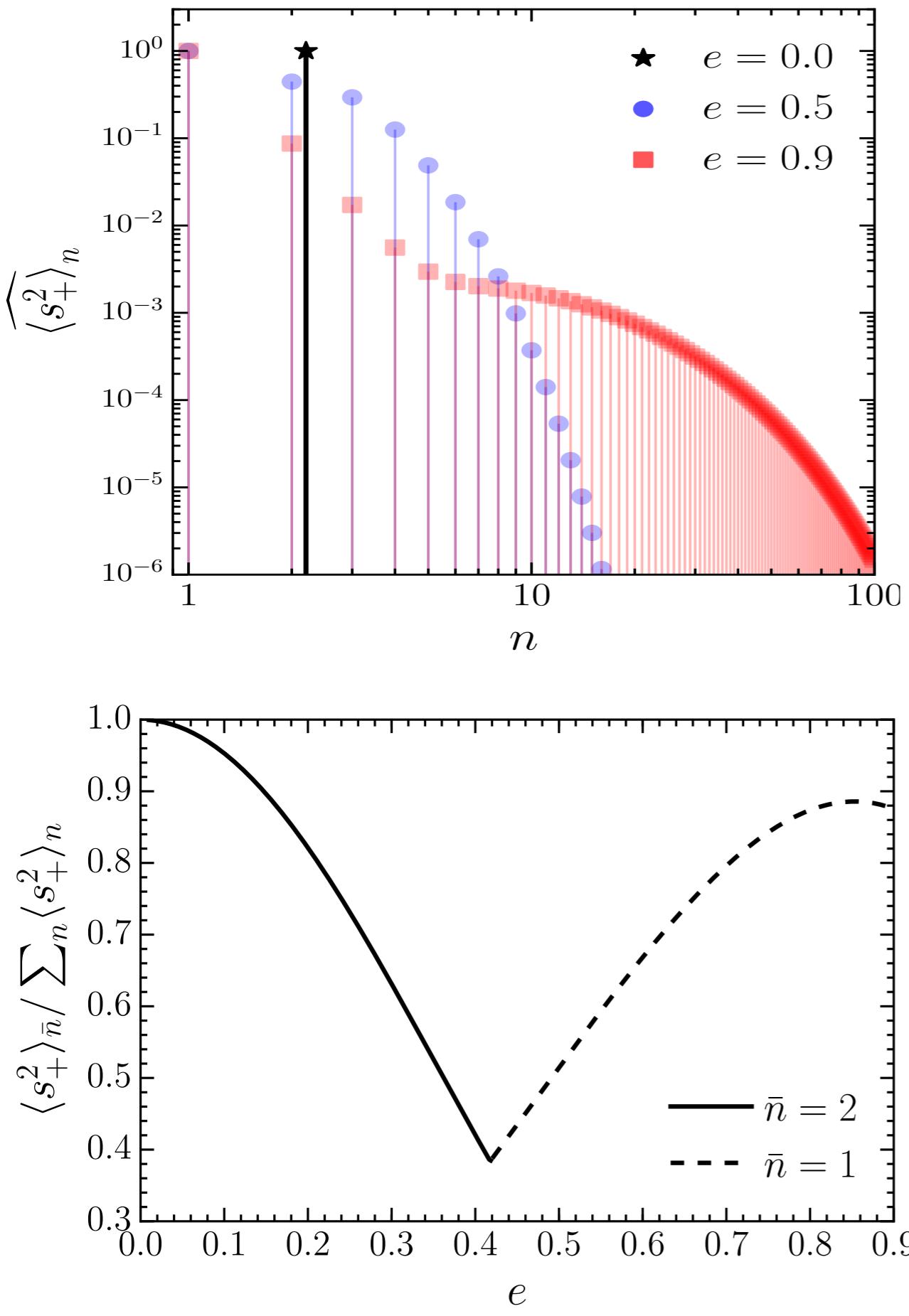


Binary eccentricity

Galactic environment (stellar scattering or circumbinary disk interaction) can *increase eccentricity*

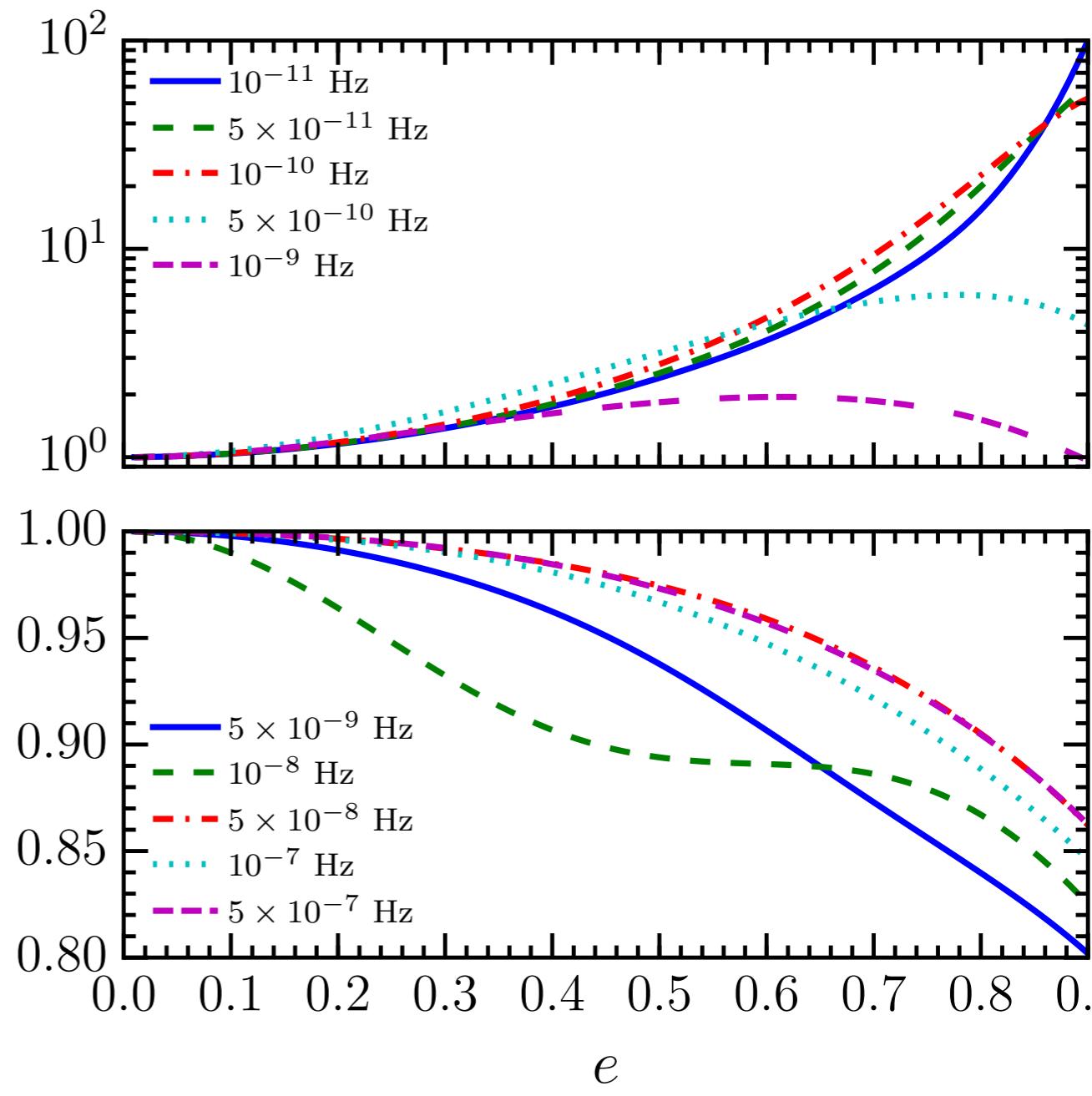






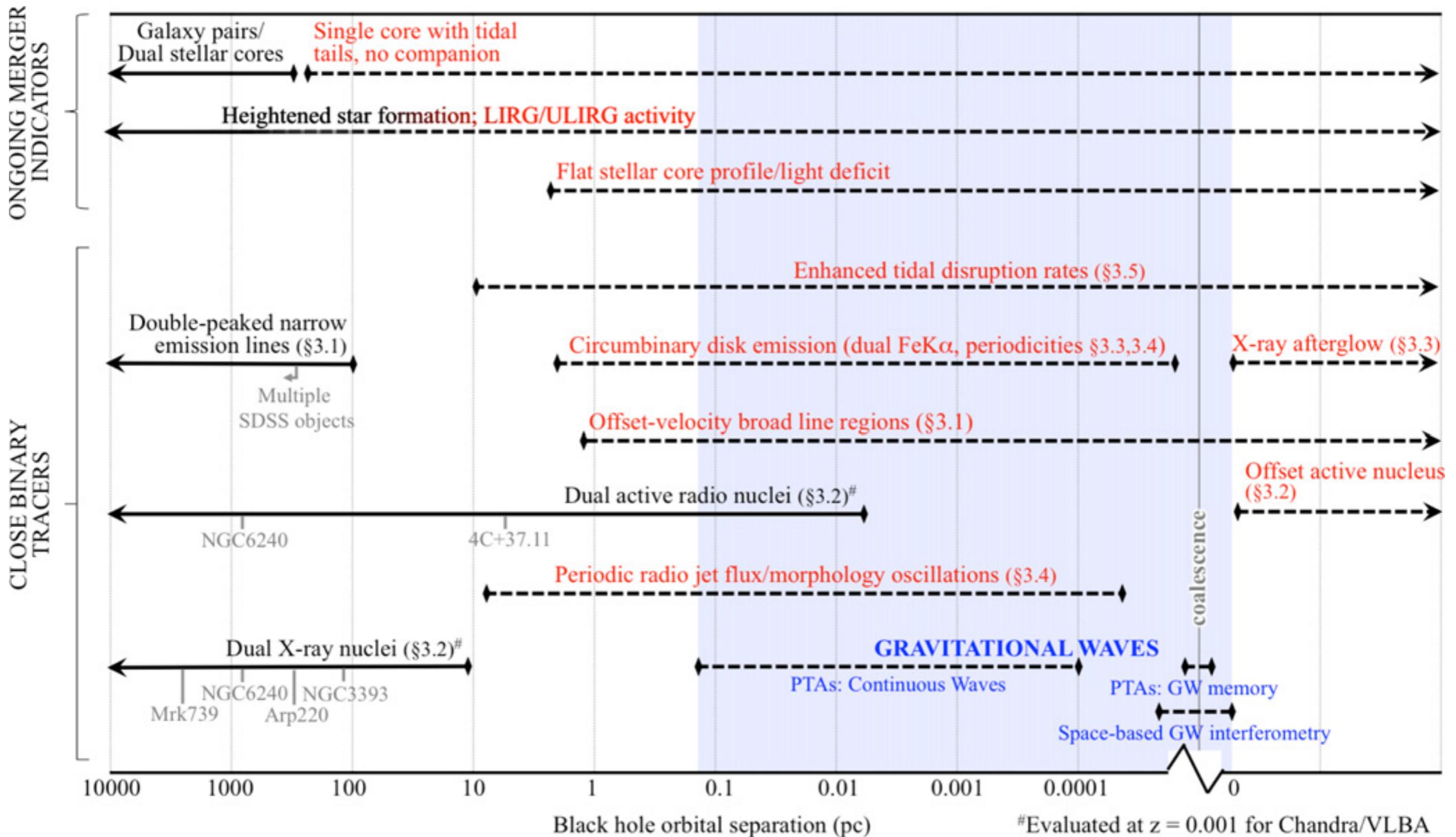
$$\langle s_+^2 \rangle_{\bar{n}} / \sum_n \langle s_+^2 \rangle_n$$

— $\bar{n} = 2$
 - - - $\bar{n} = 1$



Taylor et al. (2015)

Electromagnetic counterparts



Burke-Spoliar (2013)