

# Measuring SMBH properties from binary inspirals in LISA

ADRIEN KUNTZ

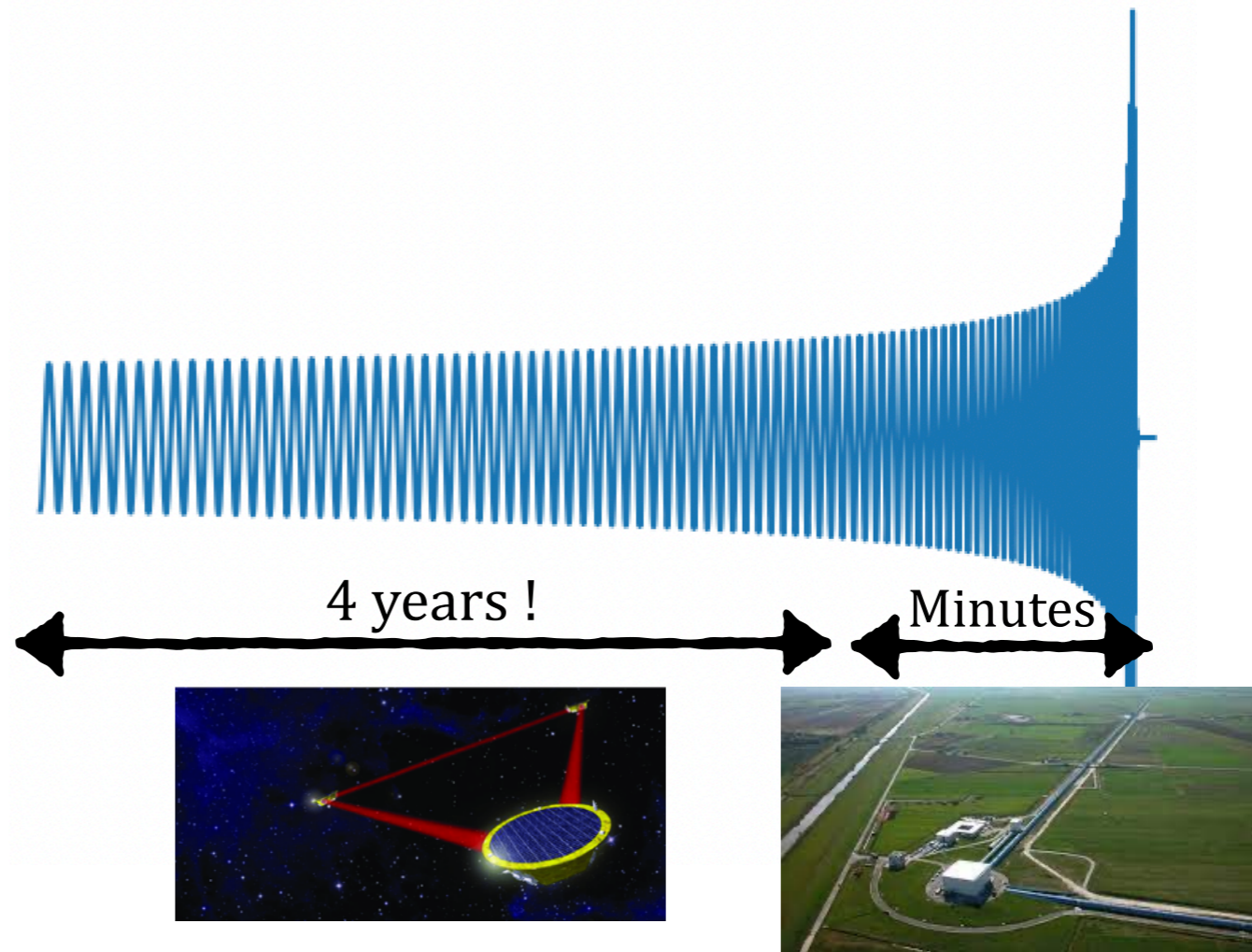
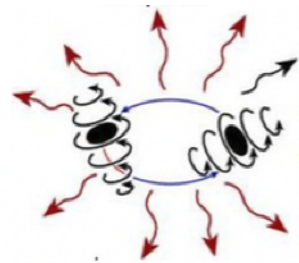
Conférence PONT - Avignon

02/05/2023



# INTRODUCTION

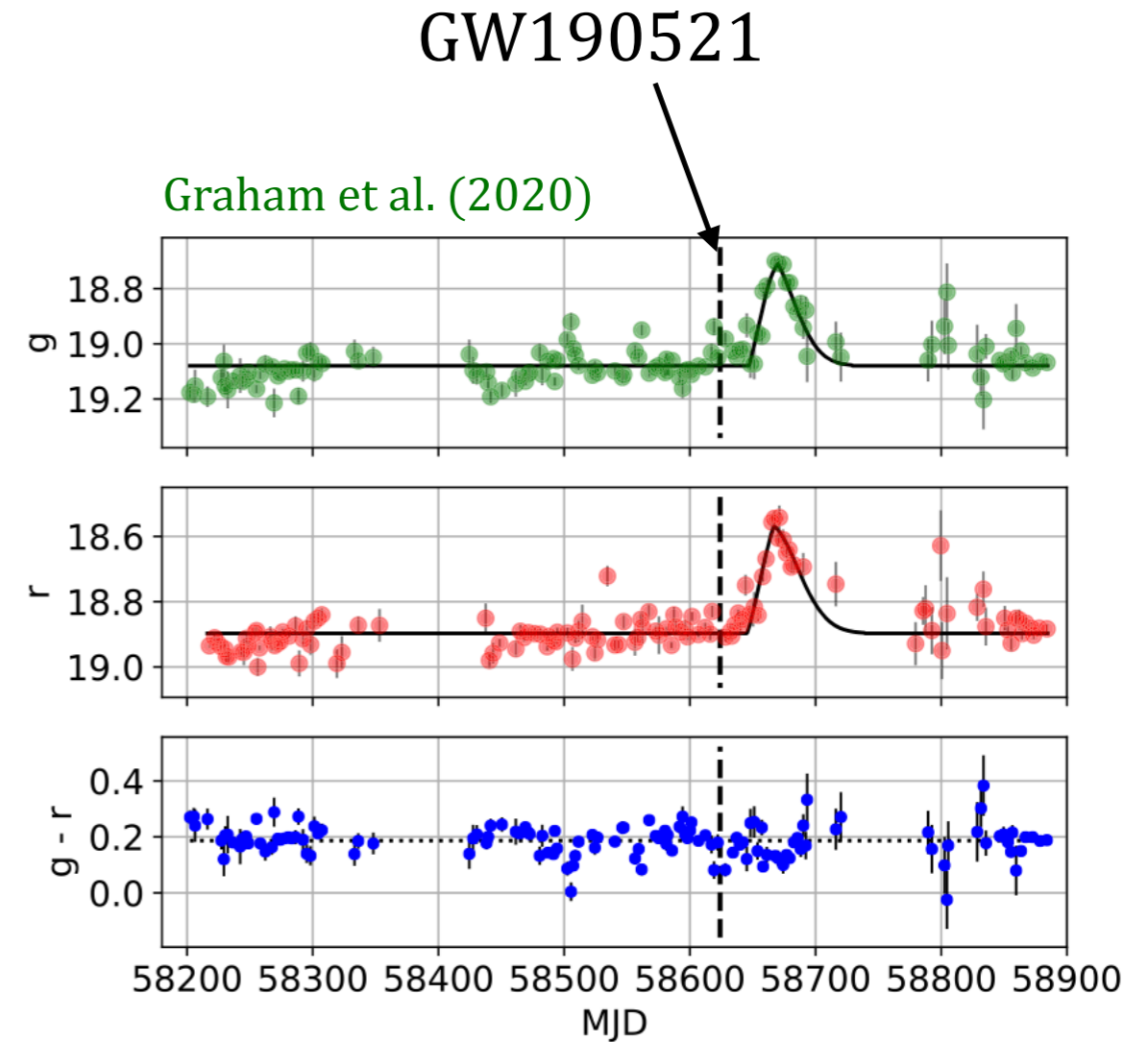
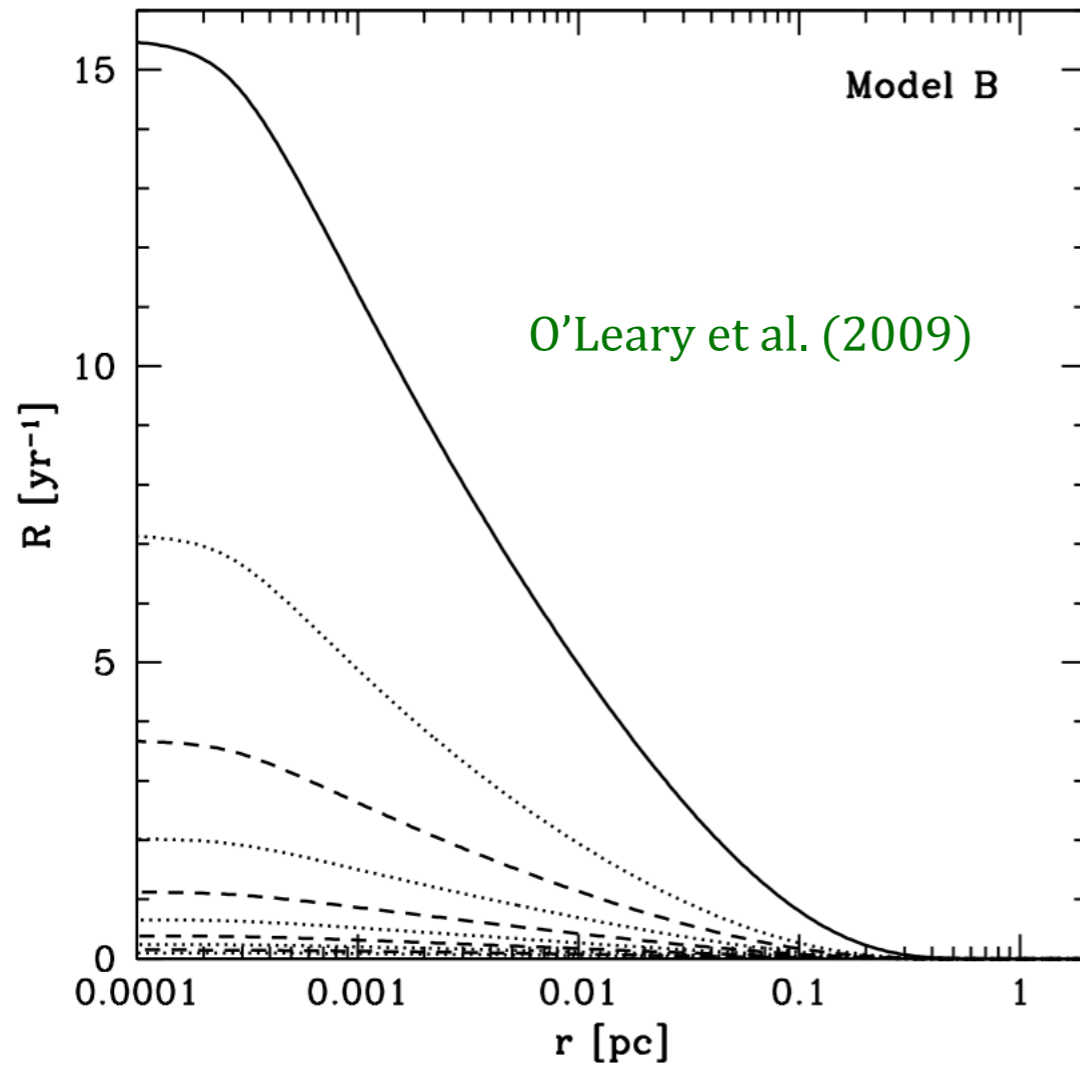
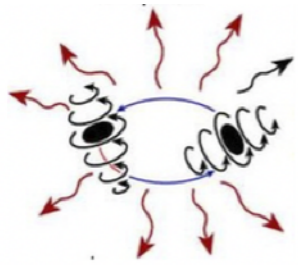
## BINARY INSPIRALS IN LISA



Are vacuum templates precise enough for LISA?

# INTRODUCTION

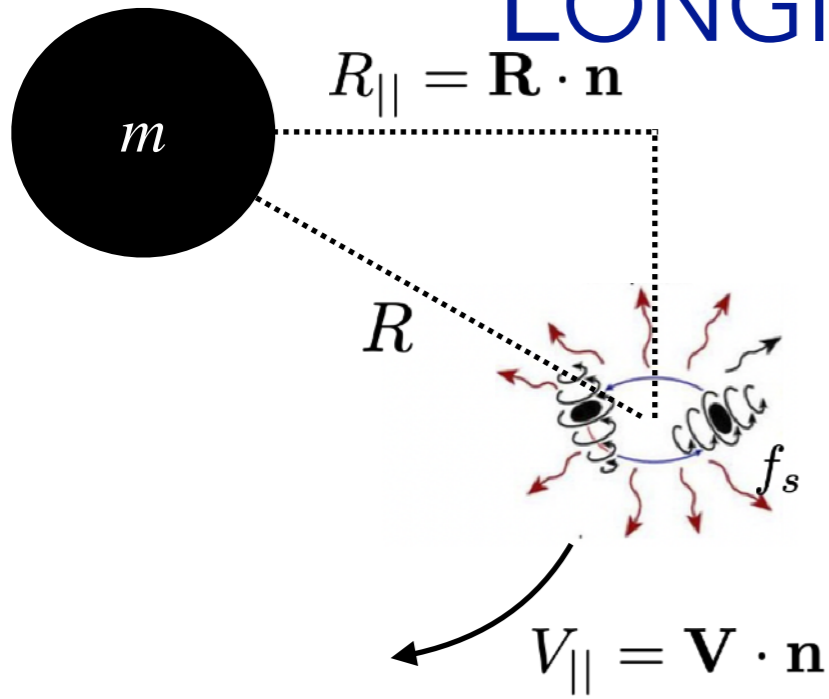
## AGN: A FABRIC OF BBH MERGERS



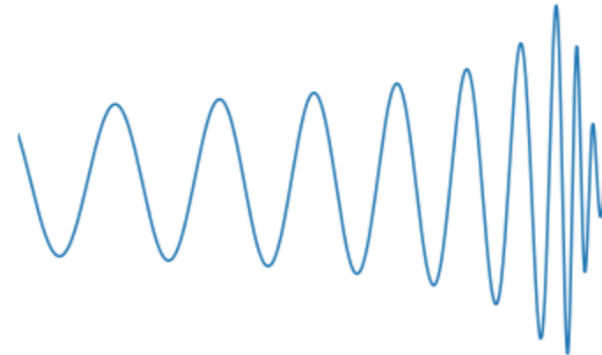
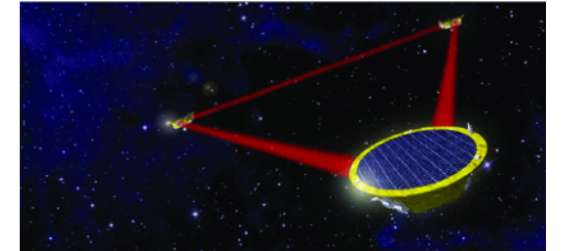
$$a \sim 700 R_{\text{Sch}}$$

Can the SMBH influence the waveform of the binary ?

# LONGITUDINAL DOPPLER SHIFT



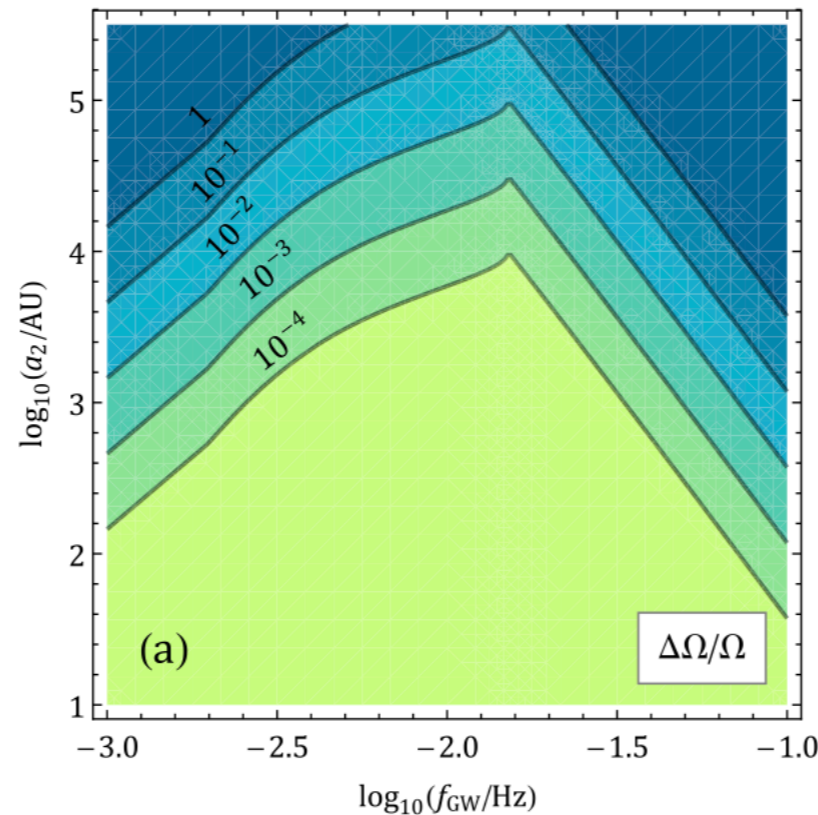
$$f_r = \frac{f_s}{1 + V_{||}}$$



Temporal space

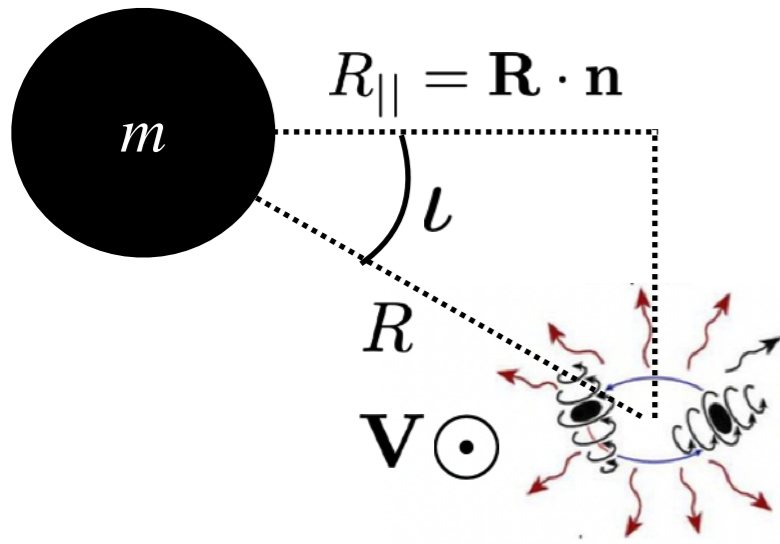
Frequency space

$$h_O(t) = h_S(t - R_{||}(t)) \longleftrightarrow \phi_O(f) = \phi_S(f) + 2\pi f R_{||}(f)$$



Randall Xianyu (2019)

# DEGENERESCENCE

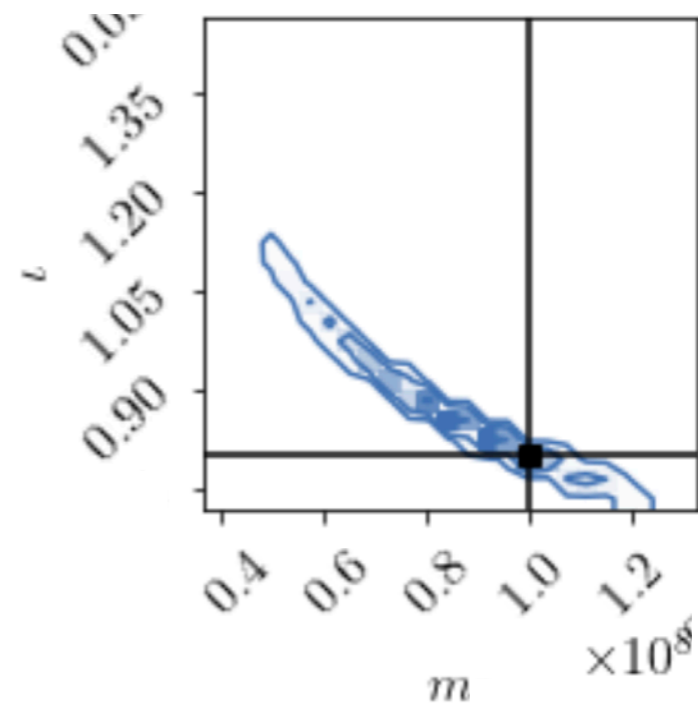


Observer  $\rightarrow$

$$R_{||} \simeq R \cos \iota \sin \left( \frac{2\pi t}{P} + \varphi \right)$$

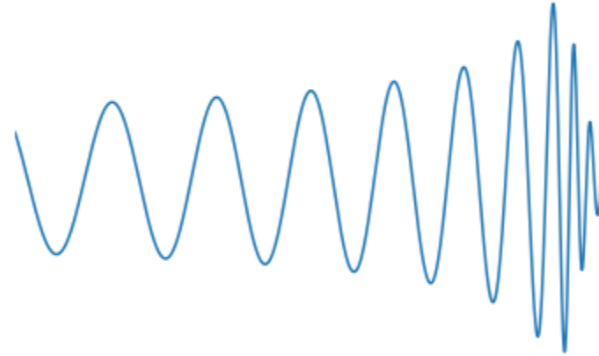
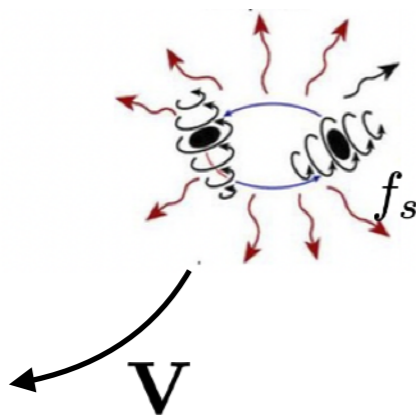
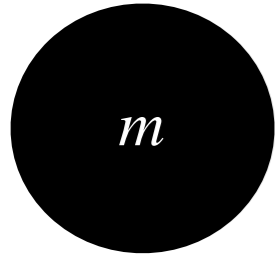
Measure  $P$  and  $R \rightarrow Gm = \frac{4\pi^2 R^3}{P^2}$

Mass-inclination degeneracy !

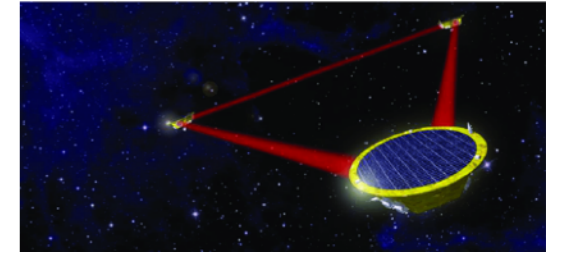


# TRANSVERSE DOPPLER

AK, K. Leyde (2022)



$$f_r = \frac{f_s \sqrt{-g_{\mu\nu} V^\mu V^\nu}}{1 + V_{||}}$$

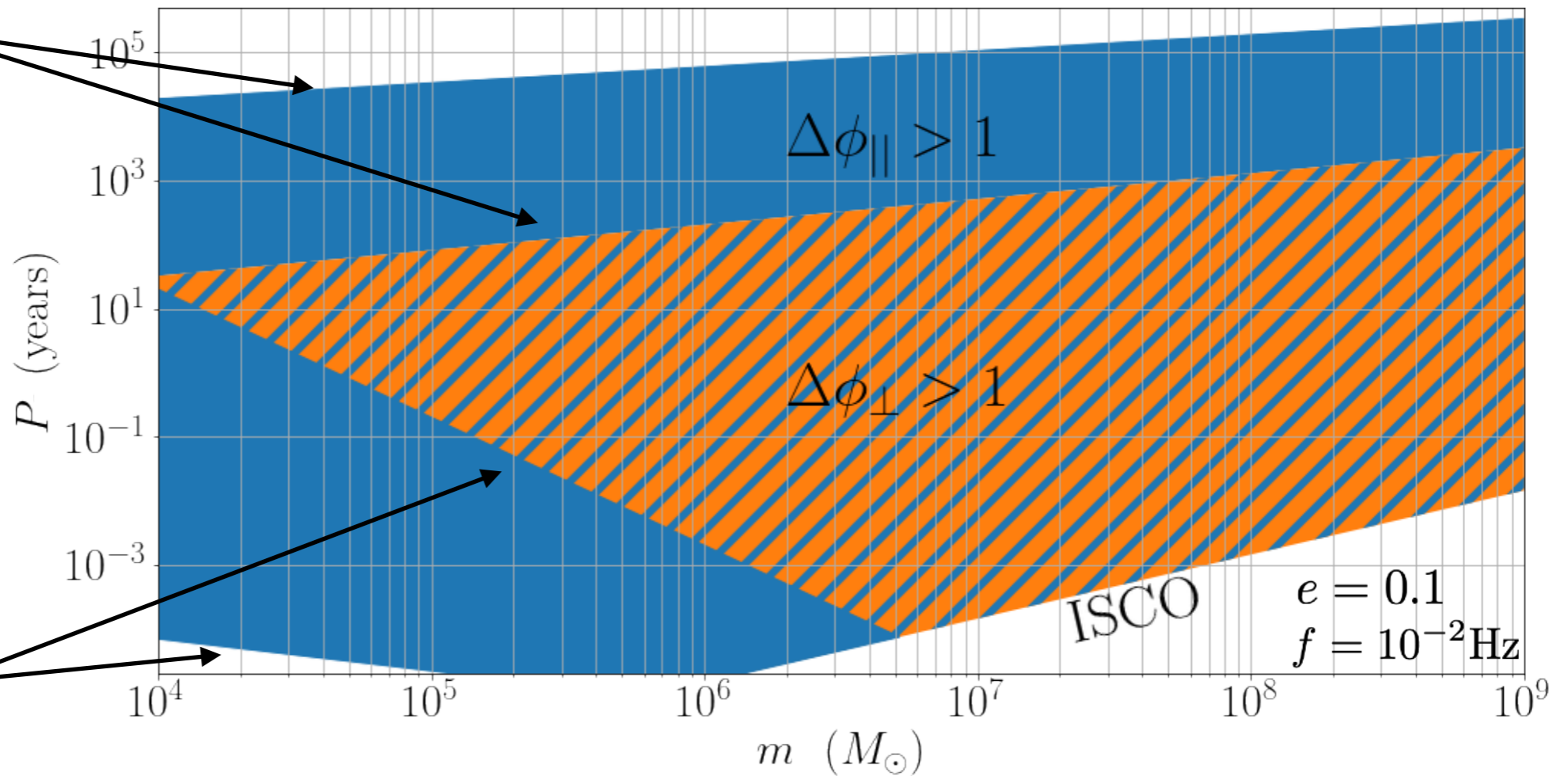


$$\sqrt{-g_{\mu\nu} V^\mu V^\nu} \simeq 1 - \frac{V^2}{2} - \frac{Gm}{R}$$



$$\Delta\phi_{\perp} \simeq 4\pi f (GmR)^{1/2} e \sin\left(\frac{2\pi t}{P} + \varphi\right)$$

Small portion  
of the orbit

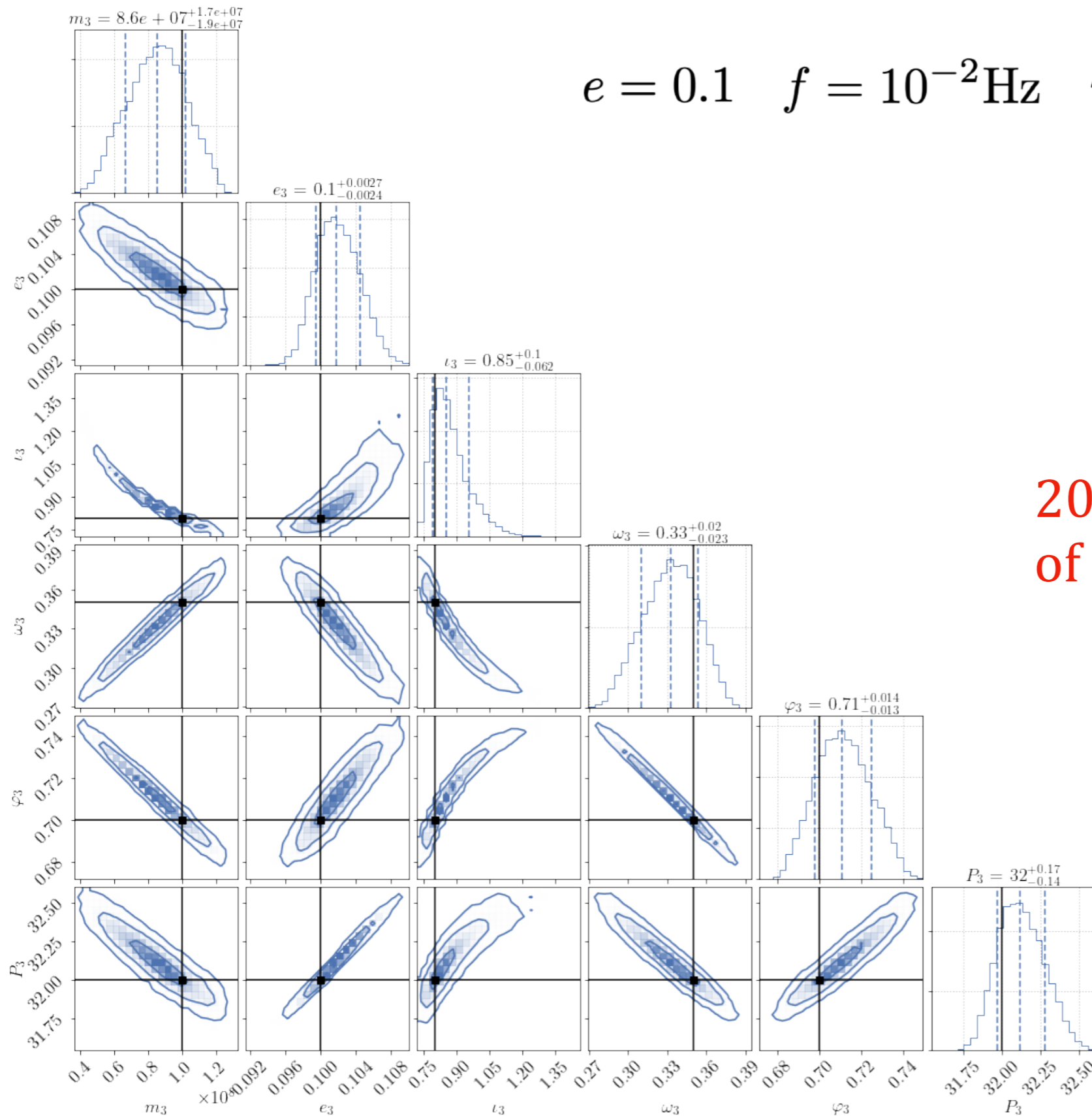


$R$  is too small!

# MCMC

AK, K. Leyde (2022)

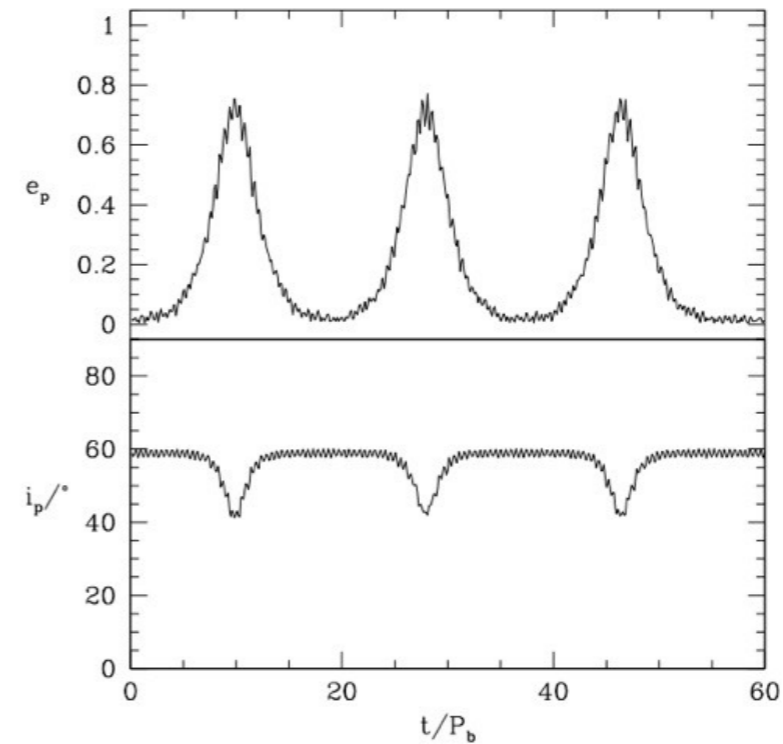
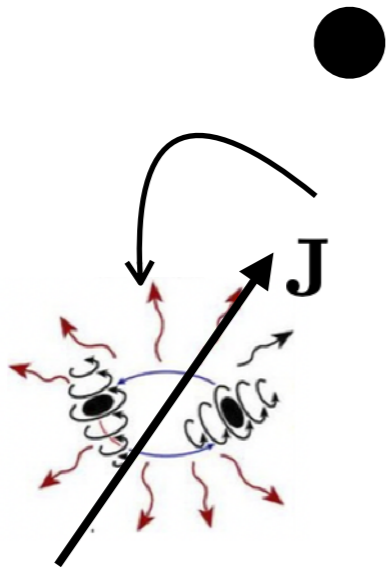
$$e = 0.1 \quad f = 10^{-2} \text{Hz} \quad m = 10^8 M_{\odot} \quad P = 32 \text{yr}$$



20% determination  
of the SMBH mass

# CONCLUSIONS

- New way of measuring SMBH mass
- Other 3-body effects: spin-orbit coupling, Kozai-Lidov oscillations...





# MCMC

AK, K. Leyde (2022)

