A systematic method for determining neutron star parameters from kilohertz quasi-periodic oscillations

Research Centre for Computational Physics and Data Processing

Institute of Physics, Silesian University in Opava

Kateřina Klimovičová

Gabriel Török, Gabriela Urbancová, Martin Urbanec, Barbora Bílá, Monika Matuszková

Degeneracy of NS Parameters from HF QPOs

QPO data and models

↓

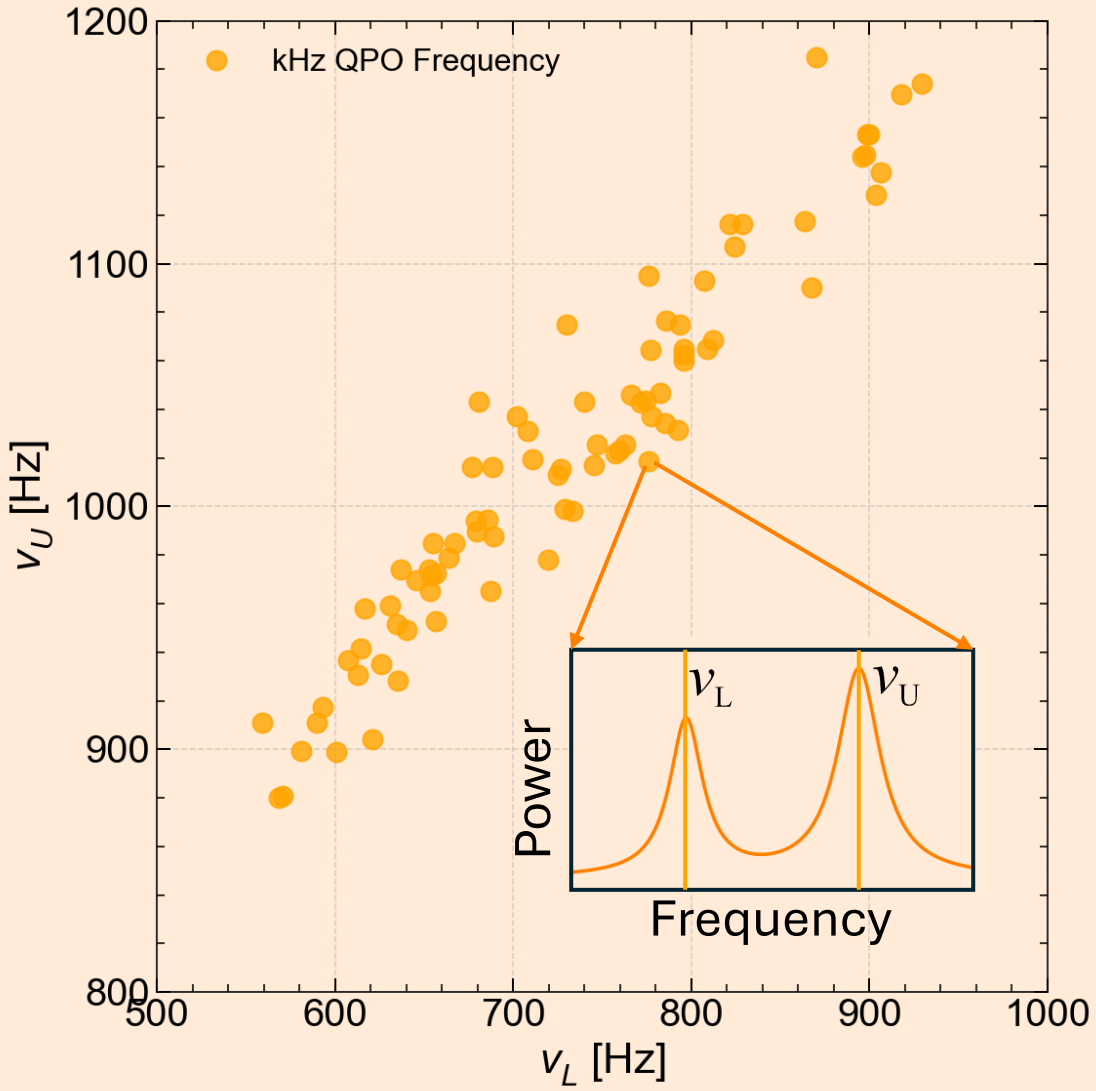
Degeneracy of NS Parameters from HF QPOs

↓

Limitations of EOS Constraints

↓

EOS Independent Mass Estimates



Reference

Ford et al. (1997), van Straaten et al. (2000), Boutelier et al. (2009), du Buisson et al. (2019), van Straaten et al. (2003), van Doesburgh & van der Klis (2017), Lin et al. (2011), Altamirano et al. (2008), Barret et al. (2005), Di Salvo et al. (2003), Jonker et al. (2002), Wijnands et al. (1997), Barret et al. (2006), Migliari et al. (2003), van Straaten et al. (2002), Di Salvo et al. (2001) , Mendez & van der Klis (1999), Ford et al. (1998), Barret et al. (2006), Lin et al. (2011), Mendez van der Klis (2000), van der Klis et al. (1996), Wijnands et al. (1997) ...

Degeneracy of NS Parameters from HF QPOs

QPO data and models

↓

Degeneracy of NS Parameters from HF QPOs

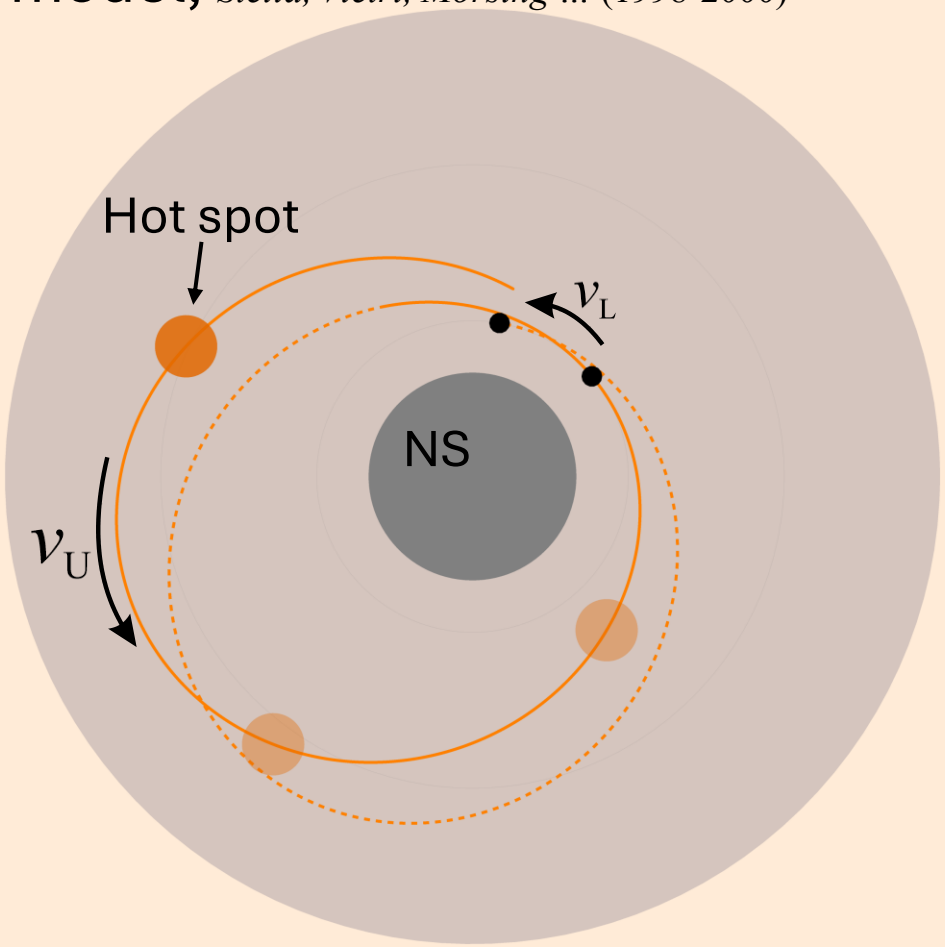
↓

Limitations of EOS Constraints

↓

EOS Independent Mass Estimates

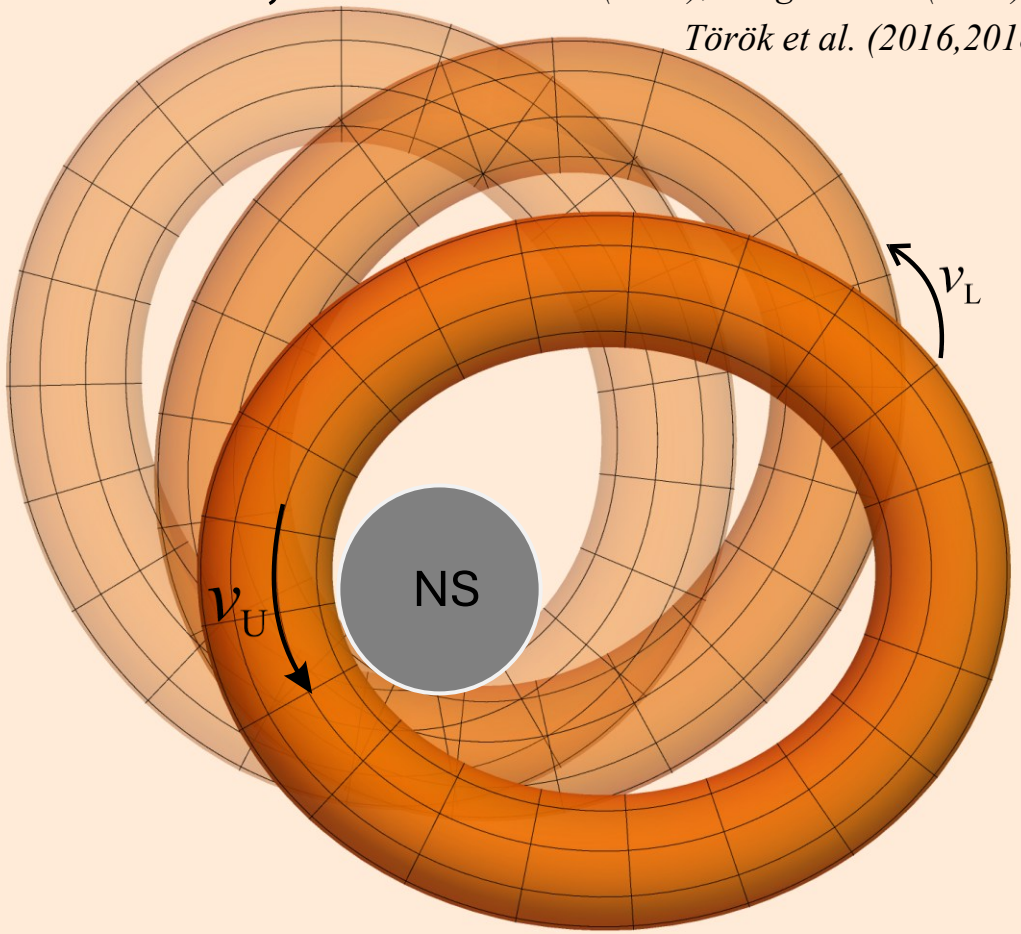
RP model, *Stella, Vietri, Morsing ...* (1998-2000)



$\nu_L\ (M, j, \tilde{q})$ = Orbital frequency of the hot spot

$\nu_U\ (M, j, \tilde{q})$ = Periastron frequency

CT model, *Straub & Šrámková (2009), Fragile et al. (2016), Török et al. (2016,2018)*



$\nu_L\ (M, j, \tilde{q})$ = Central orbital frequency

$\nu_U\ (M, j, \tilde{q})$ = Radial oscillation frequency

Degeneracy of NS Parameters from HF QPOs

QPO data and models

↓

Degeneracy of NS Parameters from HF QPOs

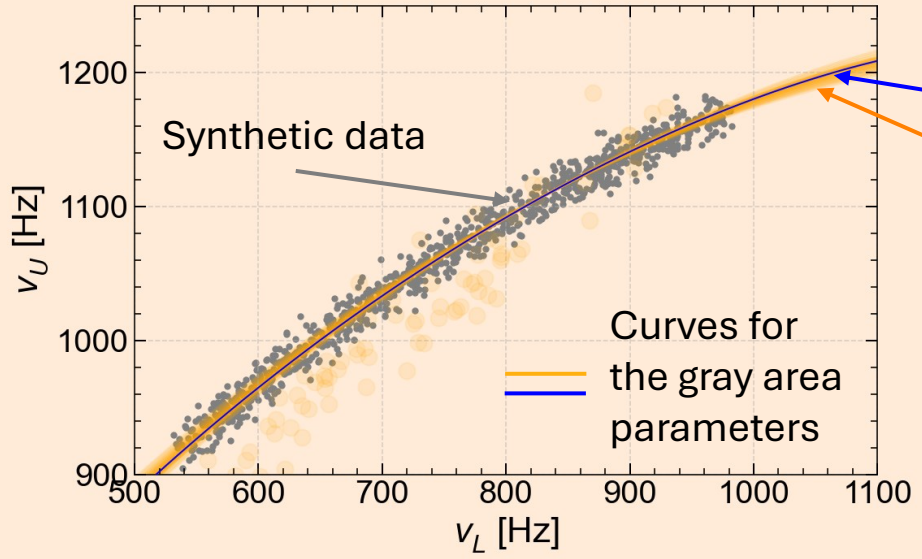
↓

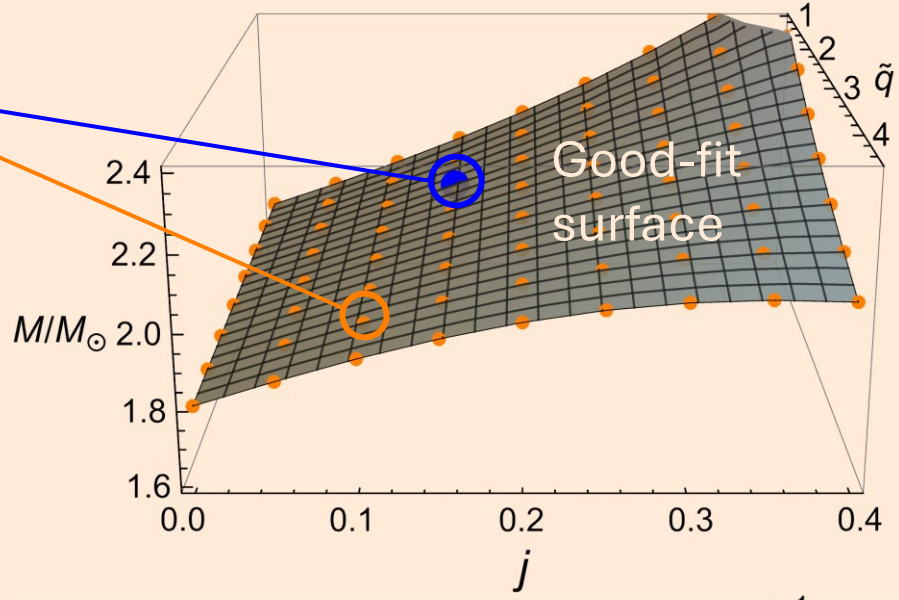
Limitations of EOS Constraints

↓

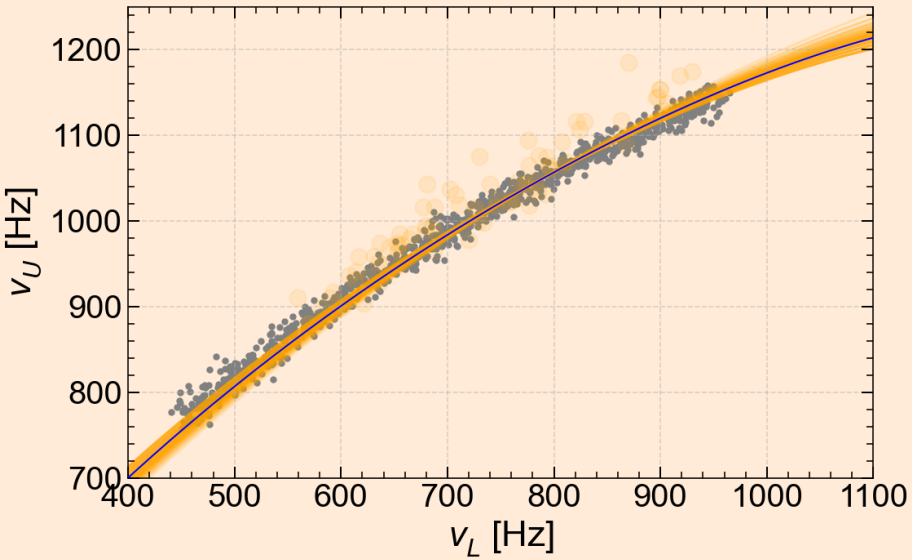
EOS Independent Mass Estimates

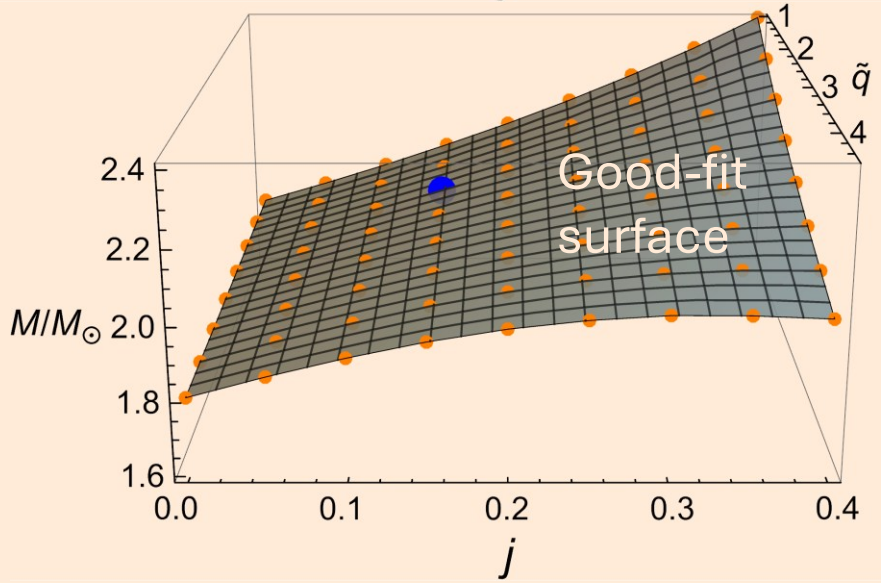
RP model





CT model





Limitations of EOS Constraints

QPO data and models

⬇

Degeneracy of NS Parameters from HF QPOs

⬇

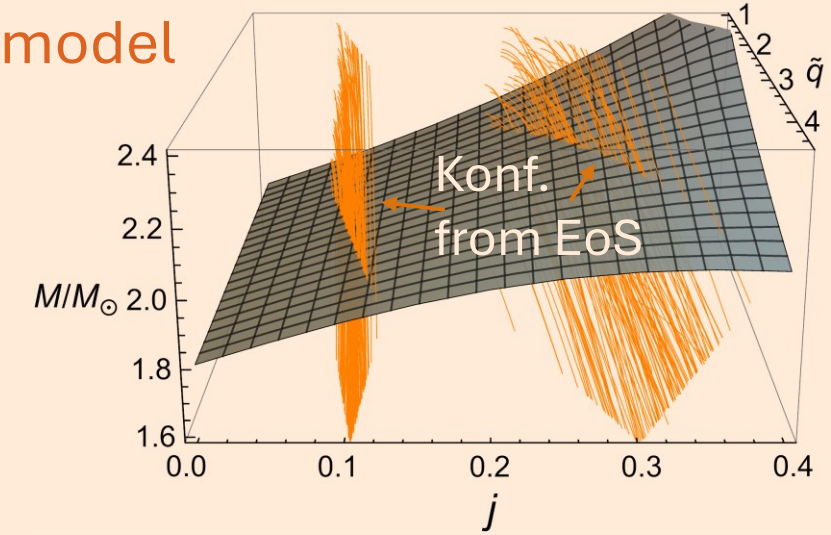
Limitations of EOS Constraints

⬇

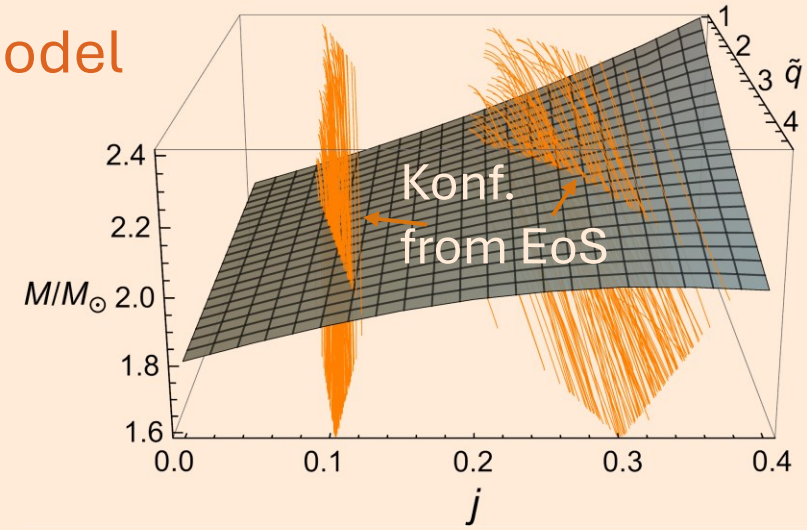
EOS Independent Mass Estimates

Synthetic data

RP model



CT model



Neutron star parameters

Theory: M (NS Mass), j (NS spin), q (Quadrupole momentum)

Observations: M_0, (Non rotating mass), f (Rot. freq., Hz), R (NS Radius)

The conversion depends on the choice of the EoS.

Universal relations
(Yagi & Yunes, 2013; Maselli et al. 2013; Urbanec et al. 2013)

$$M = M(M_0, R, f)$$
$$j = j(M_0, R, f)$$
$$q = q(R)$$

For given rot. freq. (in Hz), the NS parameters lie on one specific surface in M x j x q space.

Limitations of EOS Constraints

QPO data and models

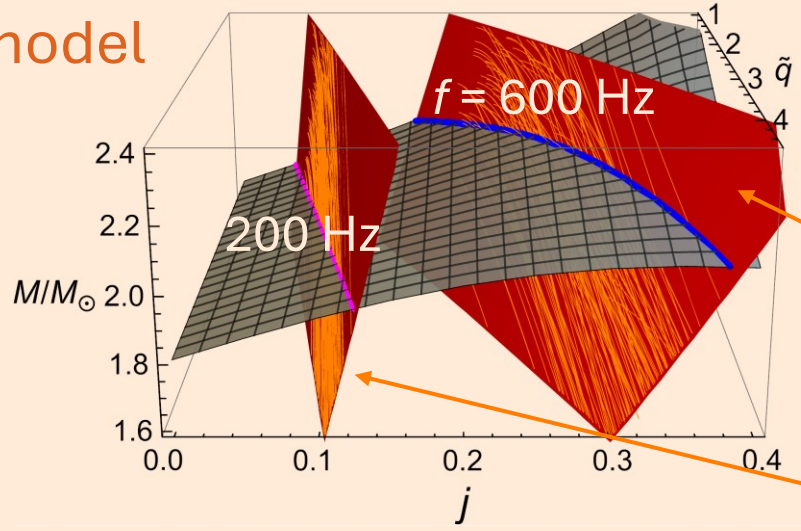
Degeneracy of NS Parameters from HF QPOs

Limitations of EOS Constraints

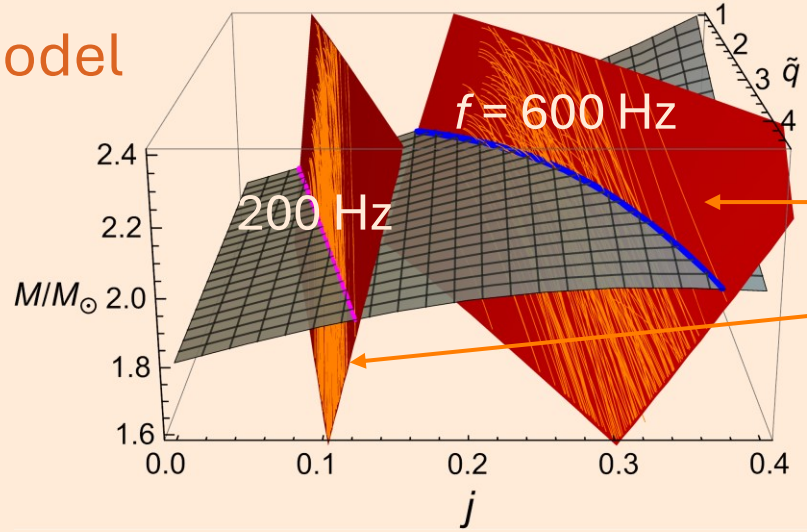
EOS Independent Mass Estimates

Synthetic data

RP model



CT model



Neutron star parameters

Theory: M (NS Mass), j (NS spin), $\tilde{q}$ (Quadrupole momentum)

Observations: M_0, (Non rotating mass), f (Rot. freq., Hz), R (NS Radius)

The conversion depends on the choice of the EoS.

Universal relations

(Yagi & Yunes, 2013; Maselli et al. 2013; Urbanec et al. 2013)

$$M = M(M_0, R, f)$$
$$j = j(M_0, R, f) \quad => \quad M = M(M_0, R)$$
$$q = q(R) \qquad\qquad j = j(M_0, R)$$
$$q = q(R)$$

For given rot. freq. (in Hz), the NS parameters lie on one specific surface in M x j x $\tilde{q}$ space.

EoS independent mass estimates

QPO data and models

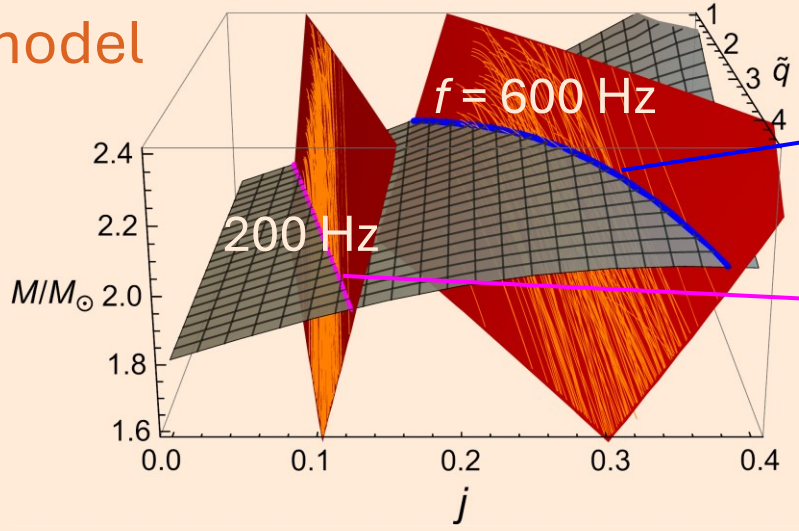
Degeneracy of NS Parameters from HF QPOs

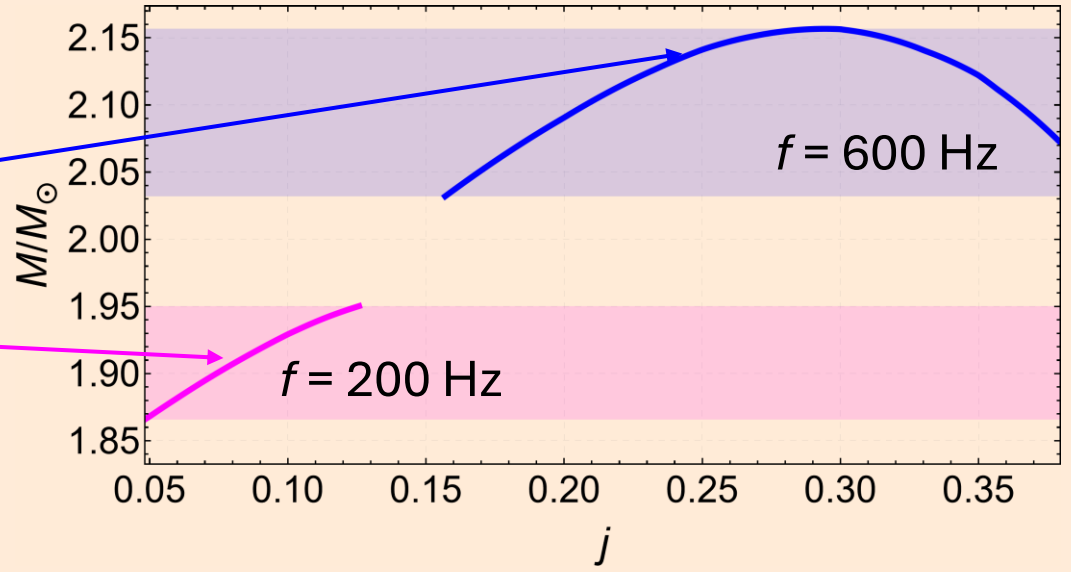
Limitations of EOS Constraints

EOS Independent Mass Estimates

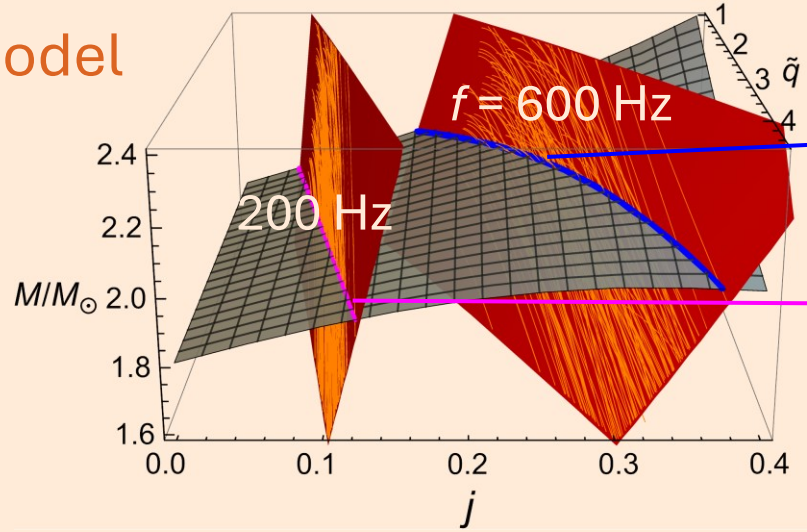
Synthetic data

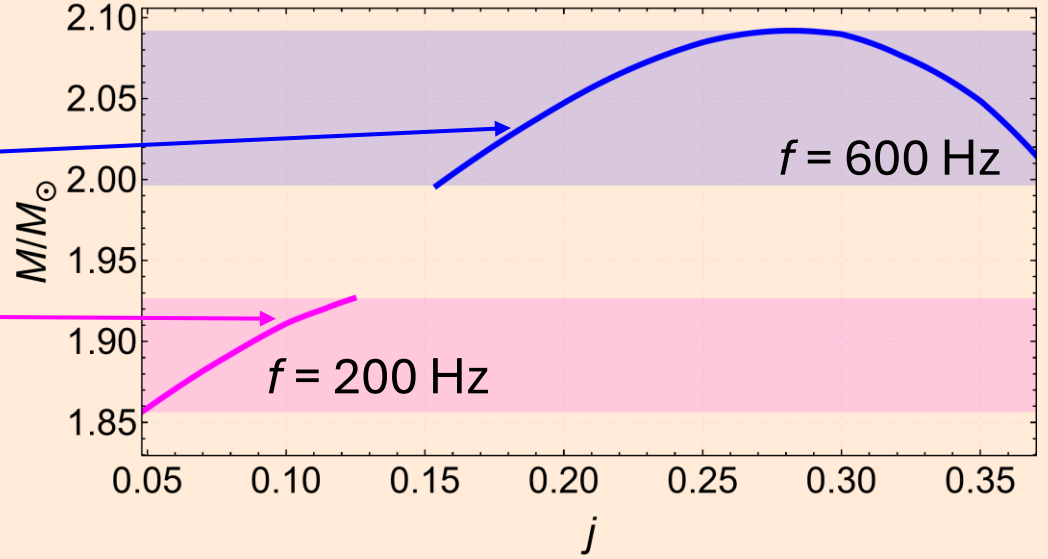
RP model





CT model





EoS independent mass estimates

QPO data and models

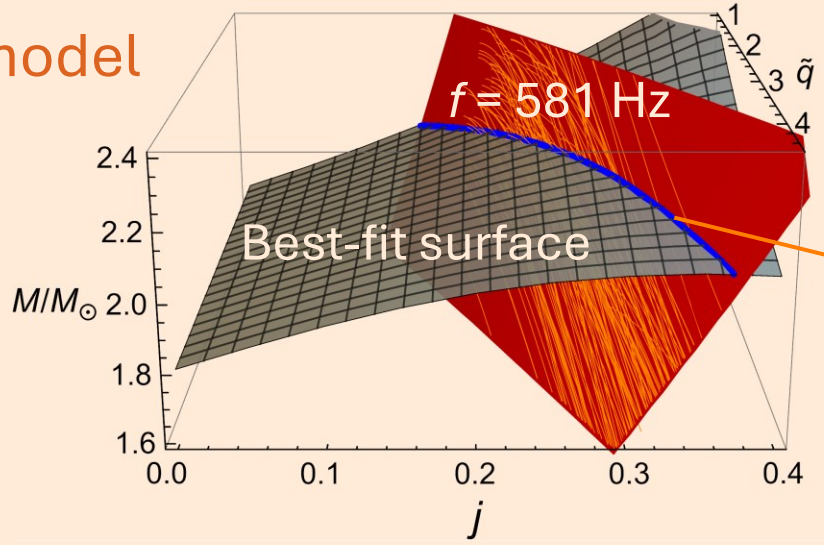
Degeneracy of NS Parameters from HF QPOs

Limitations of EOS Constraints

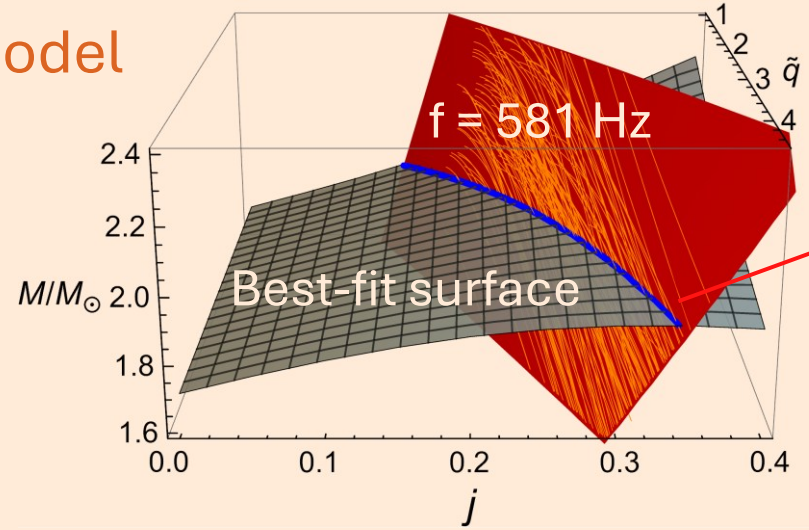
EOS Independent Mass Estimates

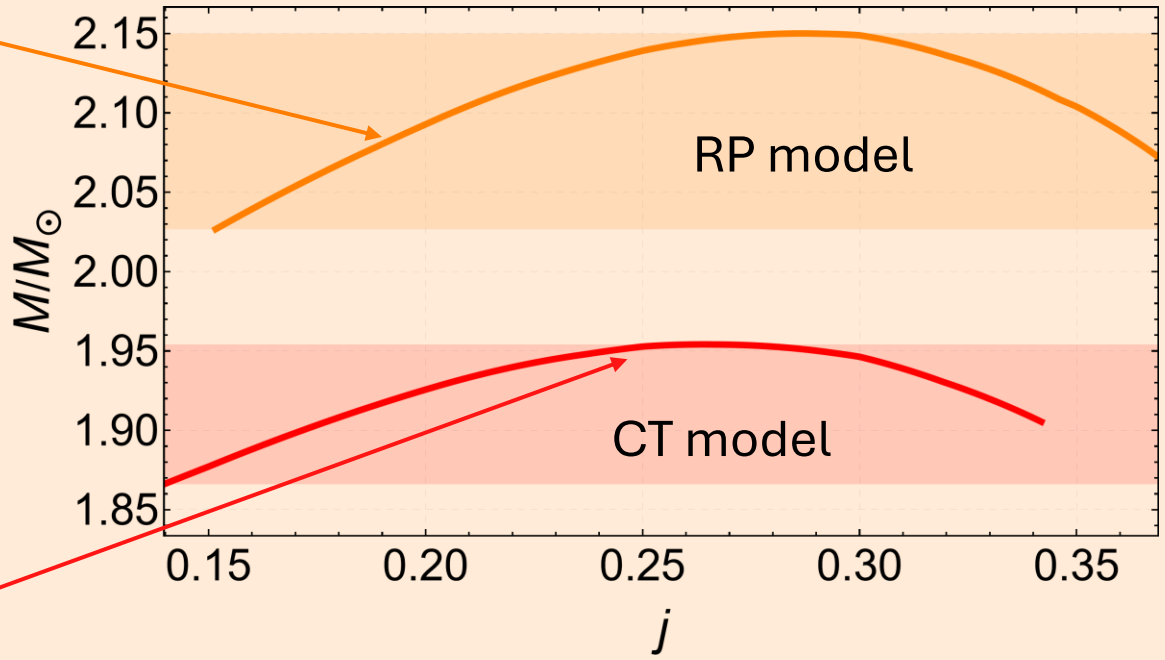
4U 1636–53, real data

RP model



CT model





EoS independent mass estimates

QPO data and models

⬇

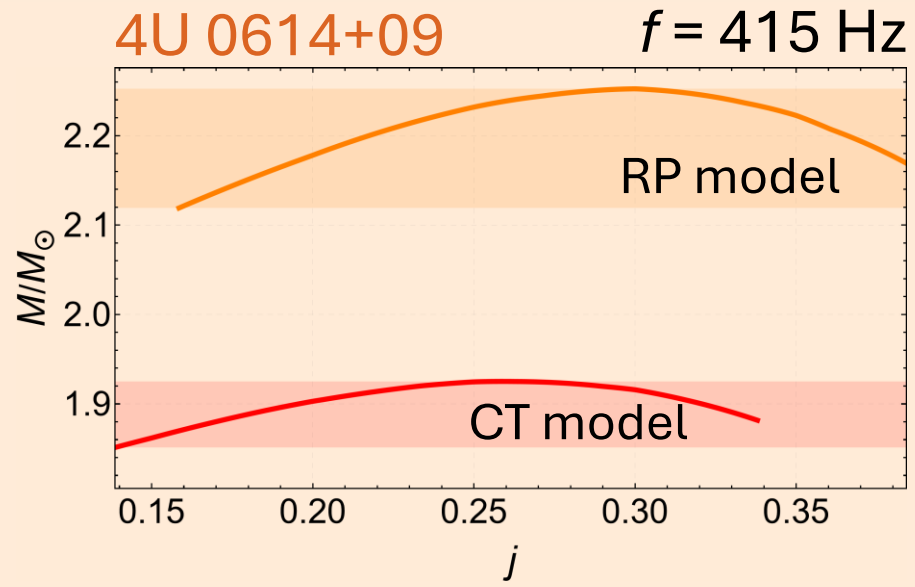
Degeneracy of NS Parameters from HF QPOs

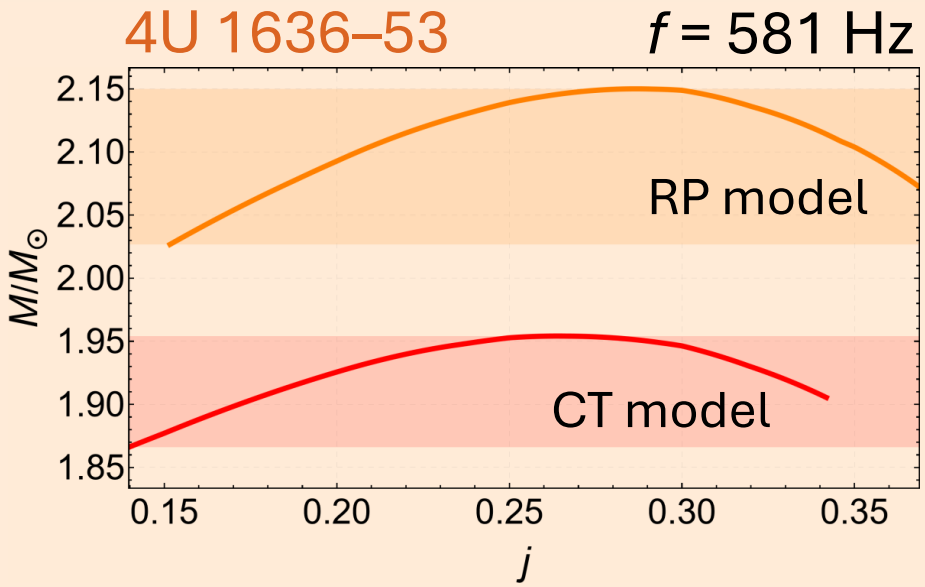
⬇

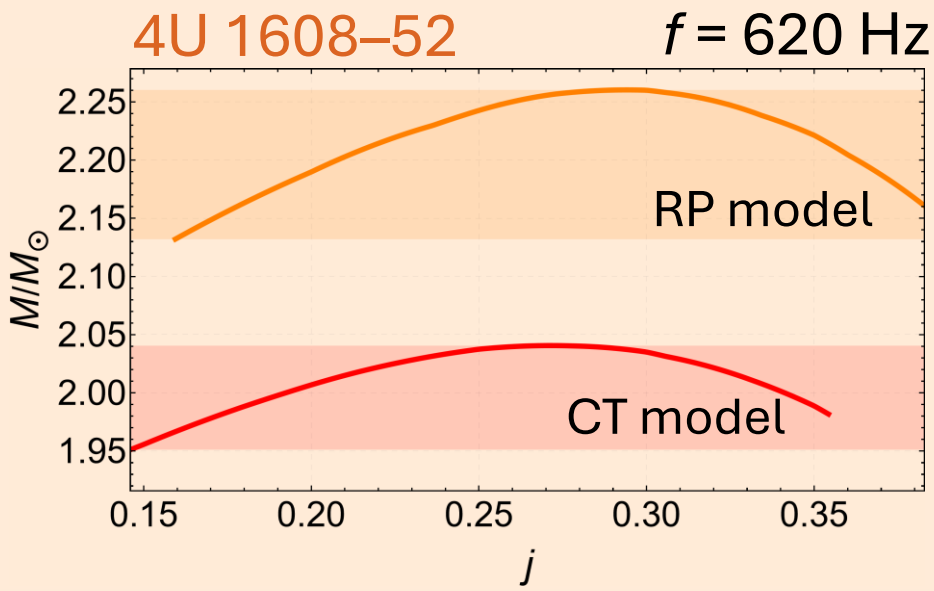
Limitations of EOS Constraints

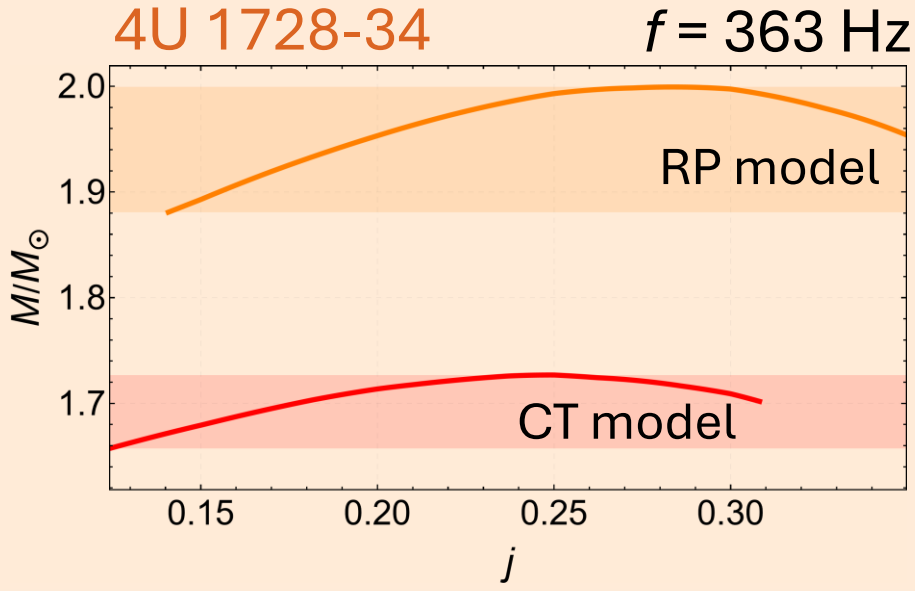
⬇

EOS Independent Mass Estimates









Thank you for your attention