Differentially rotating quark stars and post-merger signal

Enping Zhou

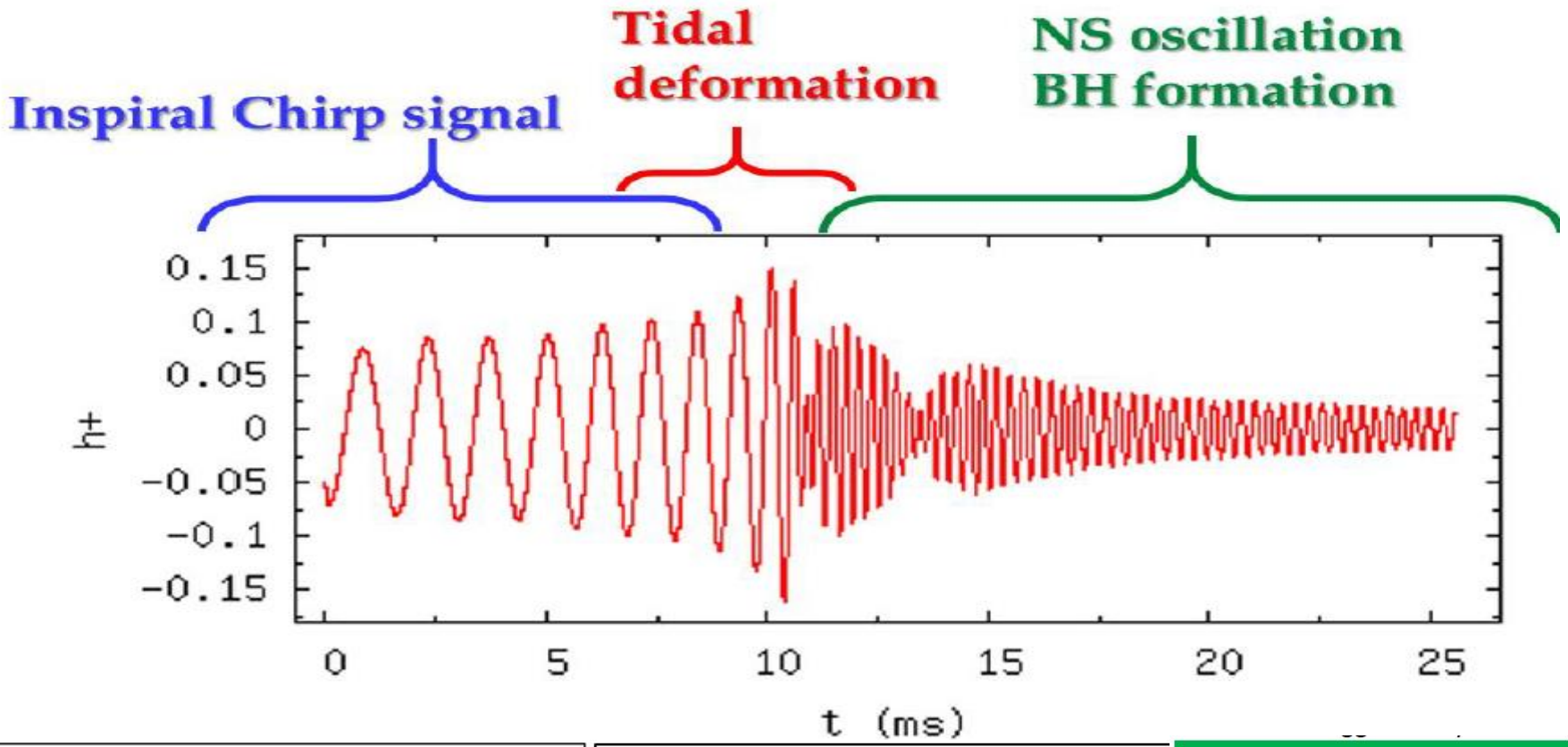
Peking University

Advisor: Prof. Renxin Xu, Prof. Luciano Rezzolla

FPS VII

July 5th 2018 @ Guangzhou

Constrain EoS in GW era



- Point particle approx.
- Information of orbits, NS mass

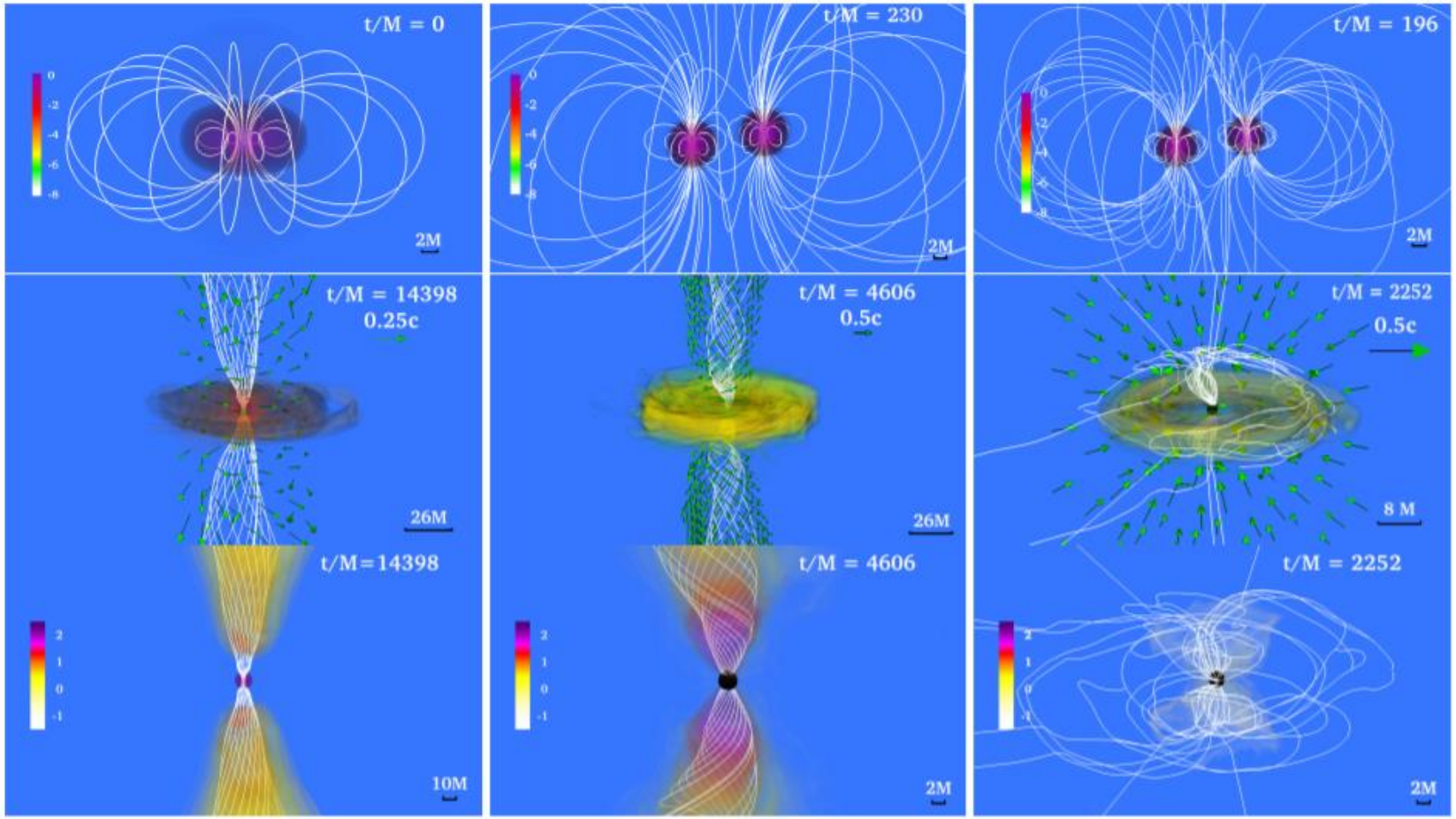
Sekiguchi's talk in QCS2017

- Finite size effects appear
- tidal deformability
- radius

- BH or NS ⇒ maximum mass
- GWs from massive NS ⇒ NS radius of massive NS

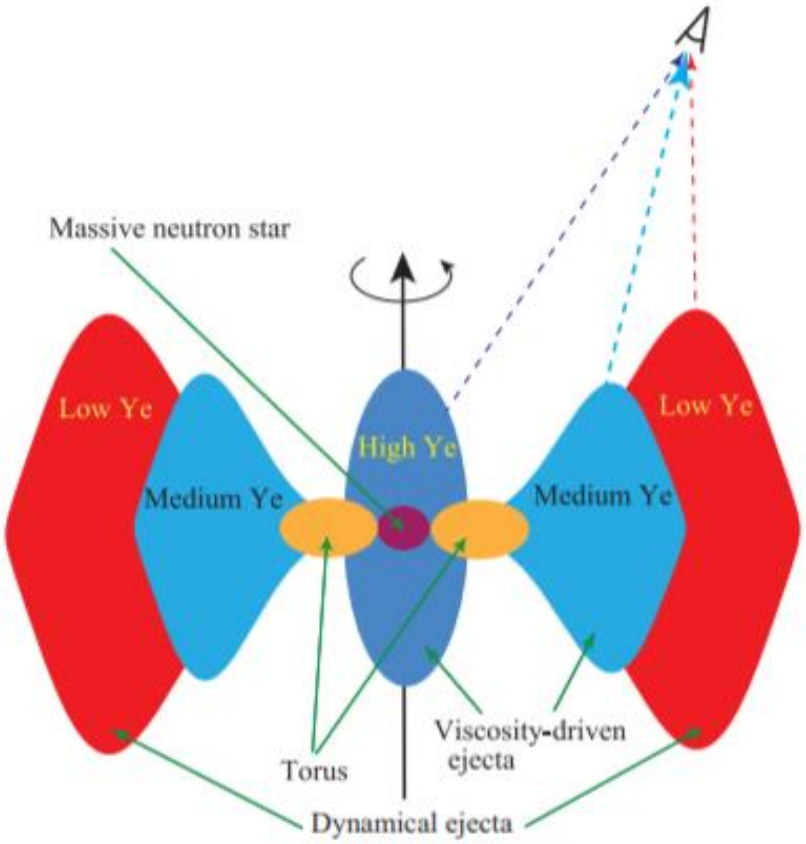
NS or QS or BH ? (Nuclear Physics; Astrophysics; Numerics)

GRBs and HMNS



Ruiz et al. 2018

Ejecta and HMNS



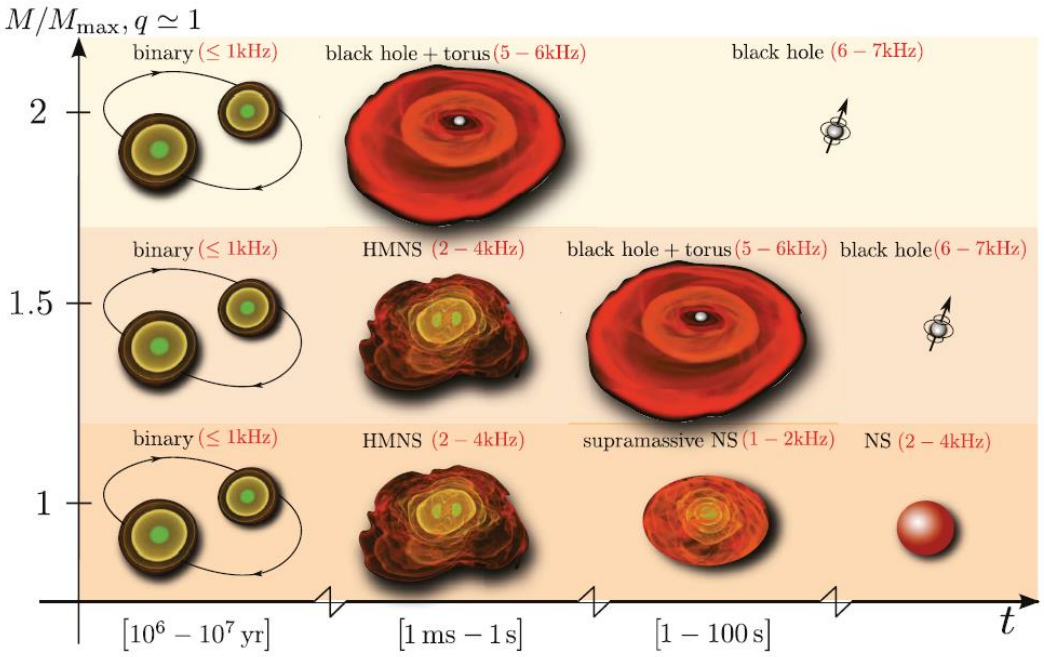
Shibata et al. 2017

Dynamical ejecta: 0.01 $M_\odot$ at most (0.05 to explain AT 2017gfo)

Viscous-driven ejecta from HMNS

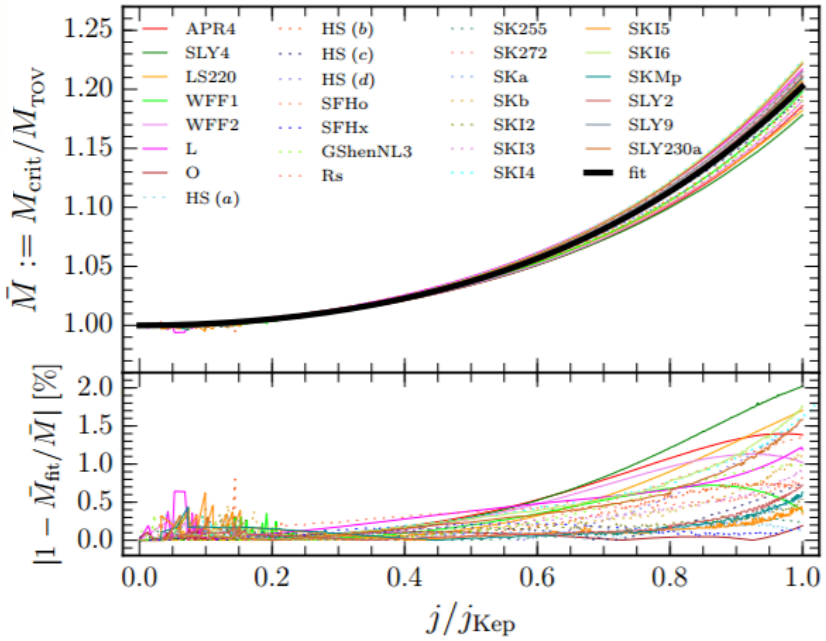
Neutrino irradiation from HMNS

GRBs and HMNS



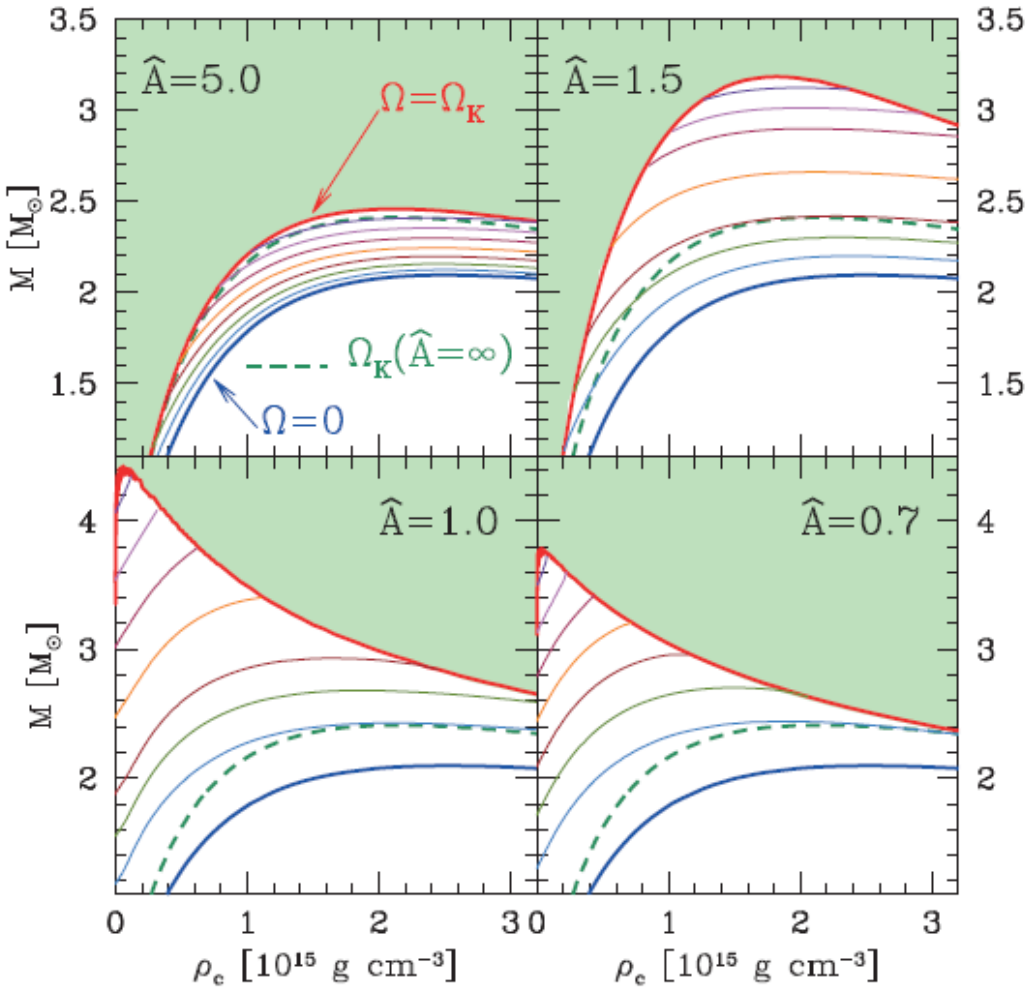
Rezzolla & Zanotti 2013

Breu & Rezzolla 2016



Question: How about quark stars?

Differentially RNS



Differentially rotation law: J-const law

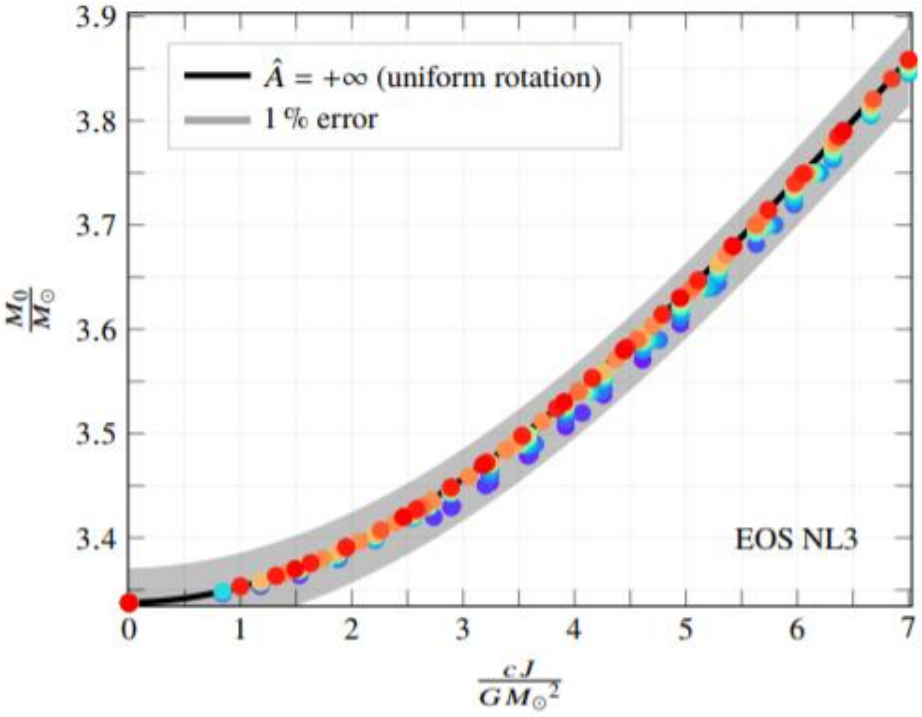
$$j(\Omega) = A^2(\Omega_c - \Omega)$$

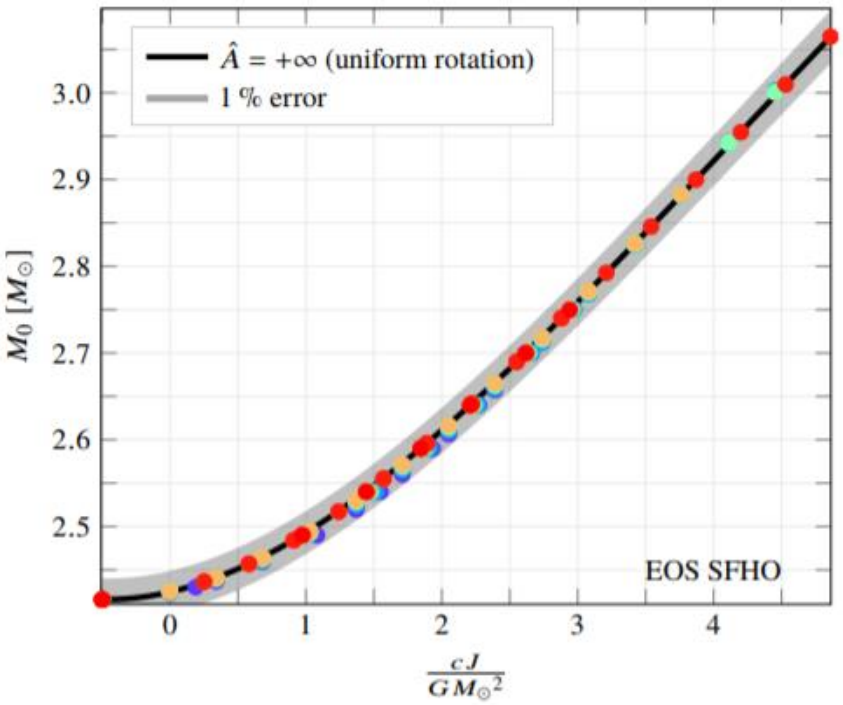
(Newtonian limit):

$$\Omega_c - \Omega = \frac{\Omega_c r^2 \sin^2\theta}{\hat{A}^2 r_e^2 + r^2 \sin^2\theta}.$$

Rezzolla & Zanotti 2013

Differentially RNS

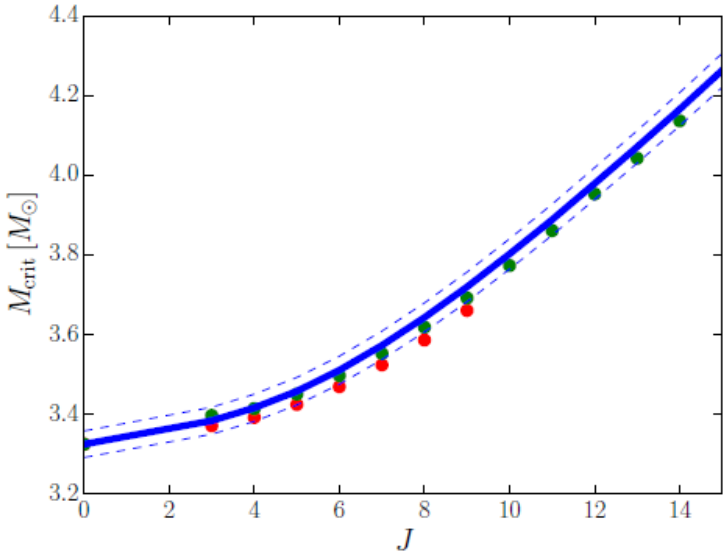


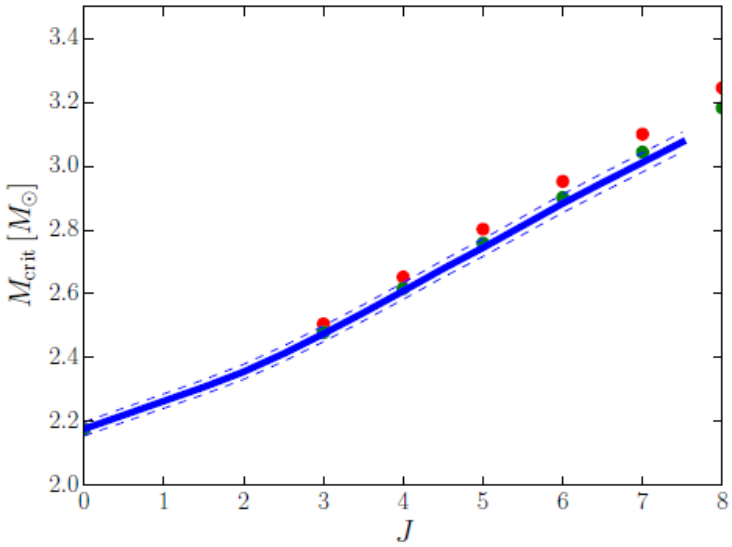


Bozzola et al. 2017

Universal relation for each EoSs with respect to different drot degree.
Held for $\hat{A}$ ~(0.5,2)

Drot RQS





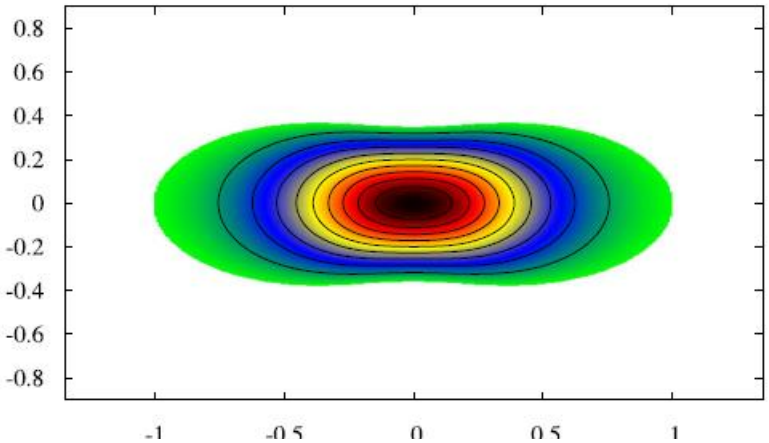
For both LX model and MIT model
Critical $\hat{A}$ for 1% deviation from uniform rotating is equal to 3.

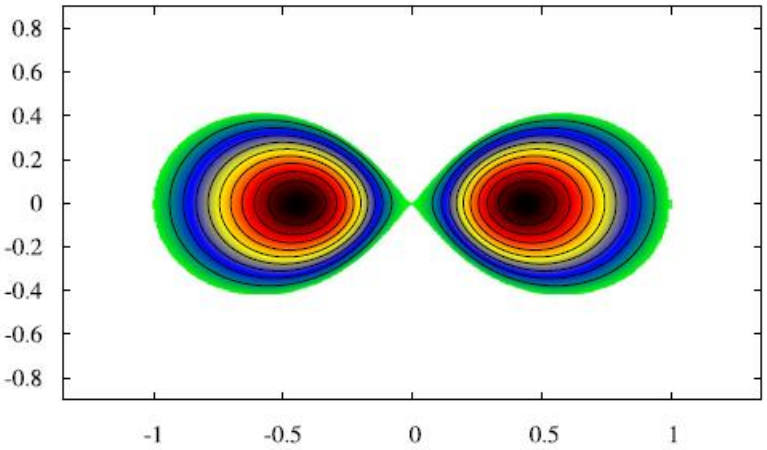
$\hat{A}$ ~ 1 is already significantly different

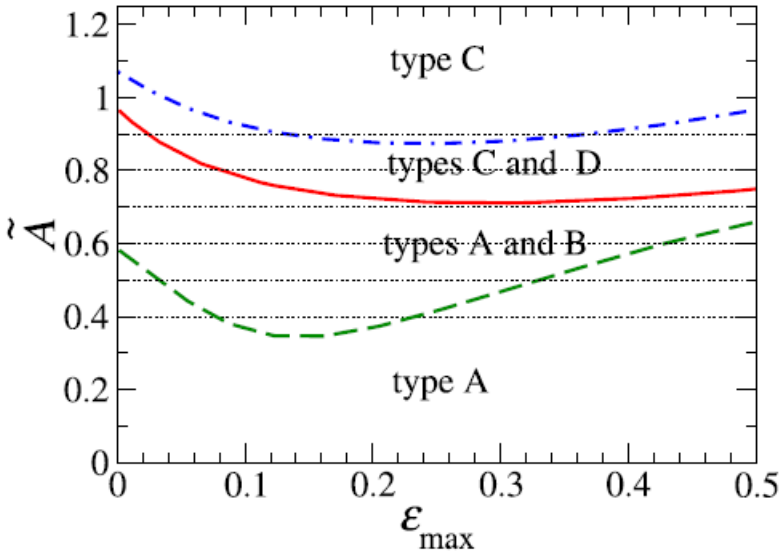
The GR initial data code Compact Object CALculator is modified to accommodate the calculation of quark stars to produce those results.

Type C Drot NS

- Type C solutions more significant for Drot QS



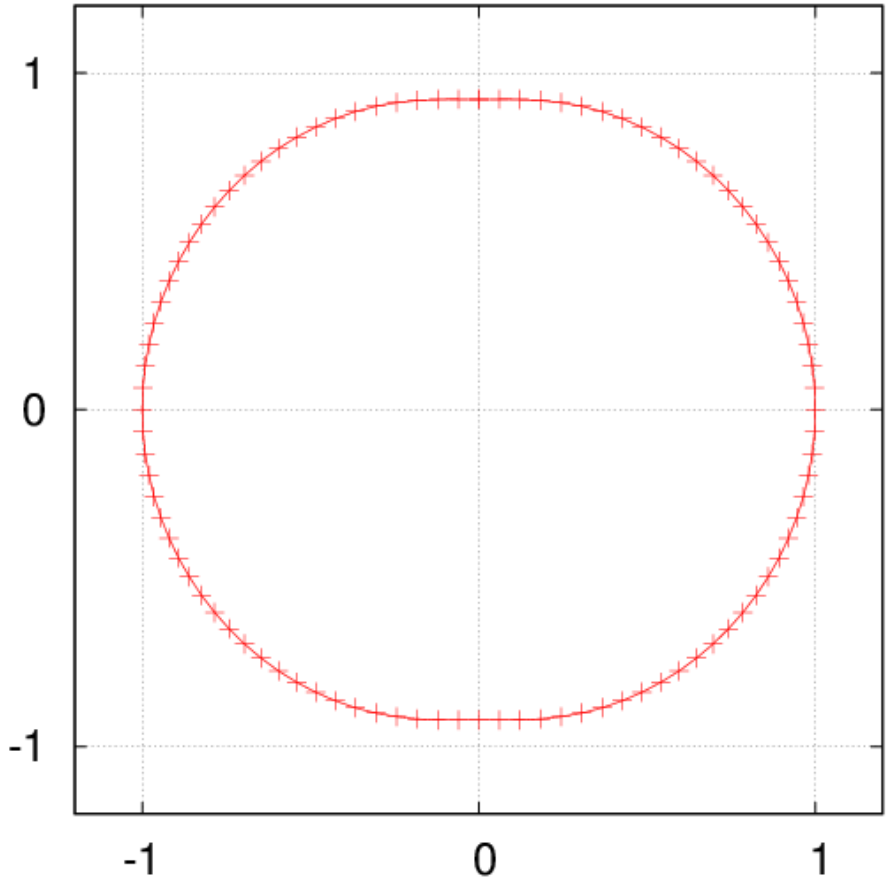




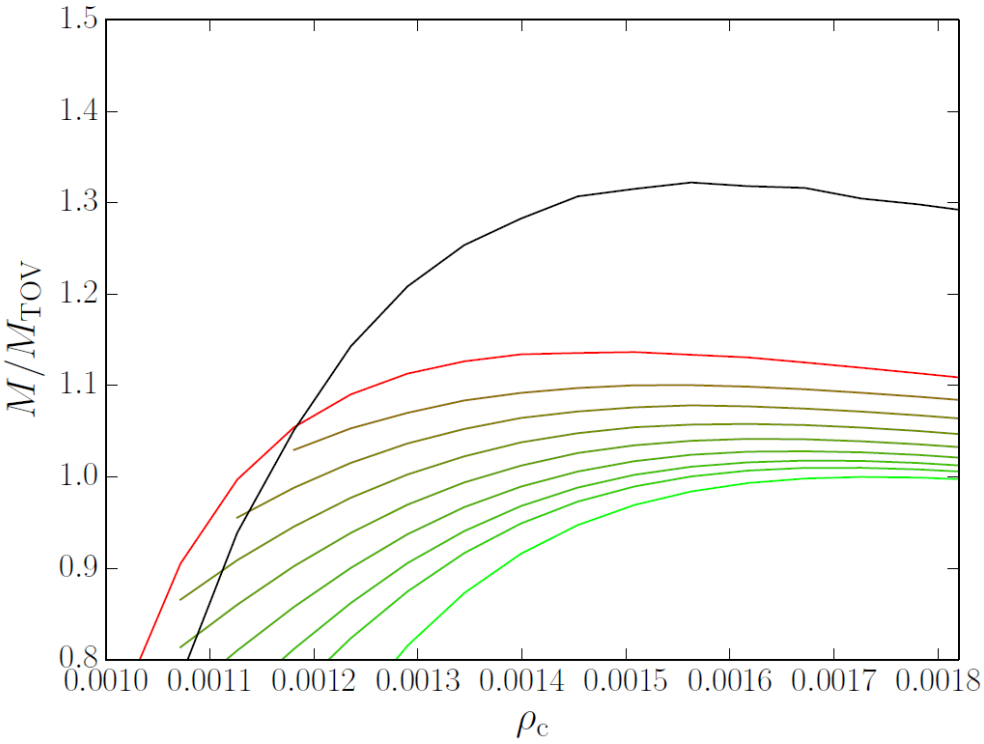
Ansorg et al. 2016

For drot NSs

Type C Drot RQS

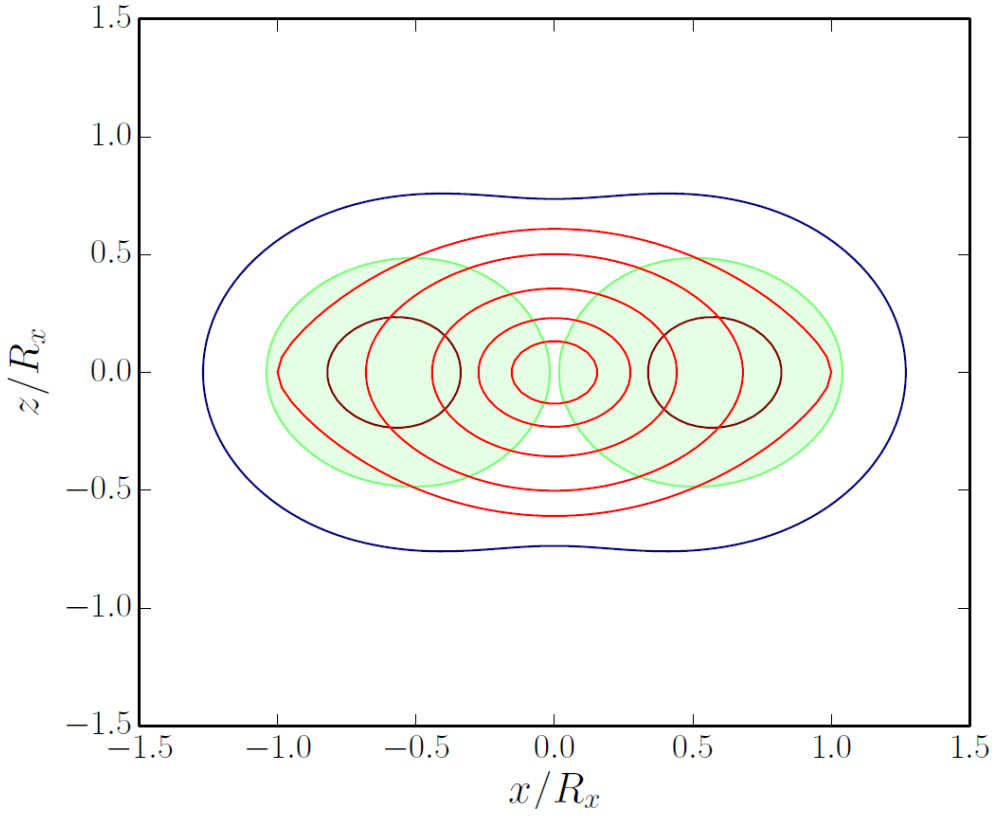


A type C solution for LX model with $\hat{A}$ =1



Hyper-massive QS < Supra-massive QS!!
More mass ejected

Ergosphere in RQS



Spherical M/R=0.4 Mass shedding limit

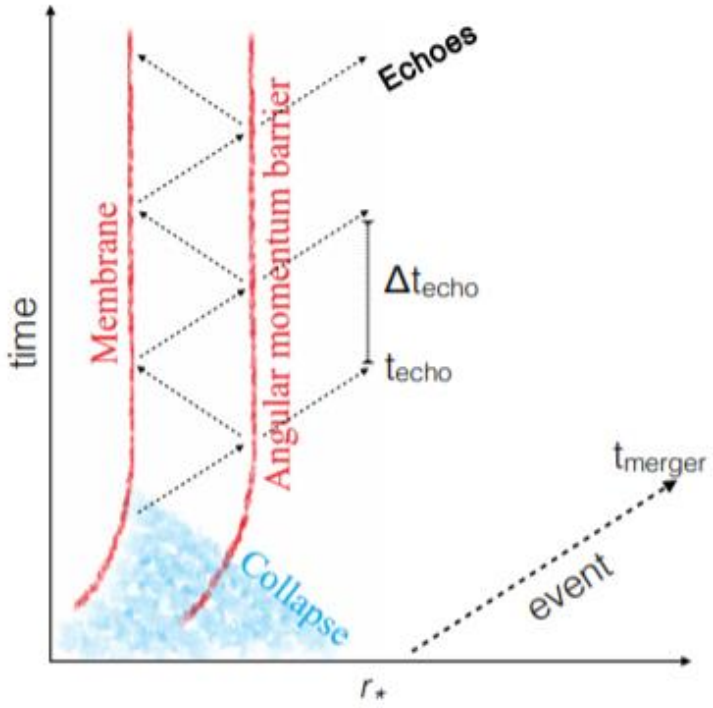
0.1 Solar mass (10^53 erg) energy release to a configuration when ergosphere just disappears.

Timescale:??

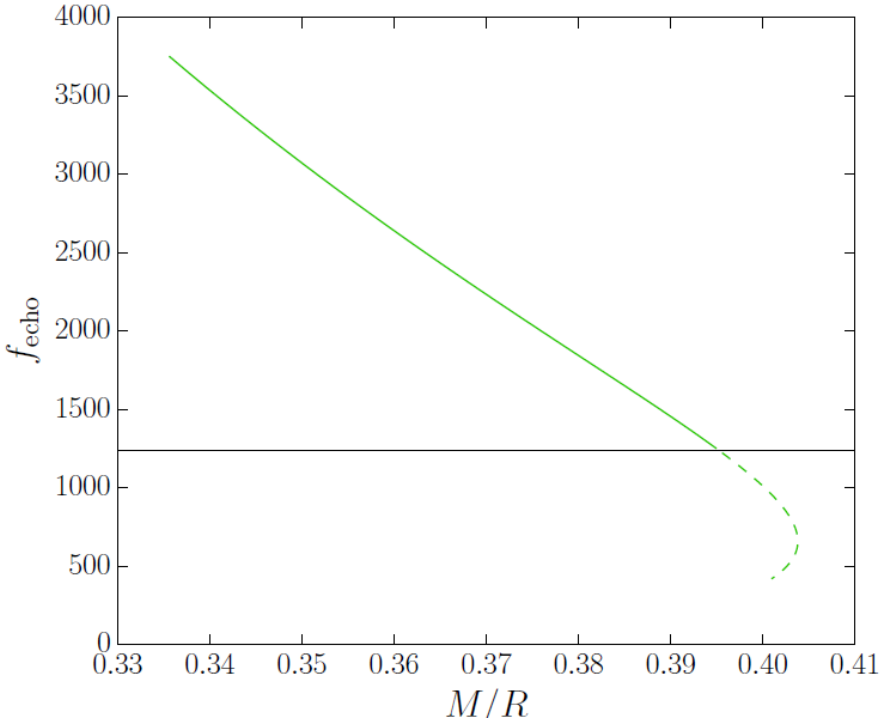
A RQS with an ergosphere can **play the role of a black hole, and more than a black hole.**

Ergosphere in RQS

- GW echo



An echo at 72Hz is claimed by Abedi & Afshordi at 4.2σ for GW170817.



The compactness of a QS can exceed 1/3, but not enough to explain the low frequency of the echo.

Ergoshpere can reduce this frequency to 0.

Conclusion

- EM counterparts of a binary merger event can tell a lot about the post merger phase (remnant type/lifetime/B-filed).
- The post merger phase behavior is closely related to the rotating configuration of the compact star.
- The rotating configuration is quite different for NS and QS in both uniform and differential rotating case.
- Distinguish between NS and QS with EM counterpart of BNS mergers.

- Thanks for your attention!