
# Diffrentially rotating quark stars with realistic $\Omega$ profile

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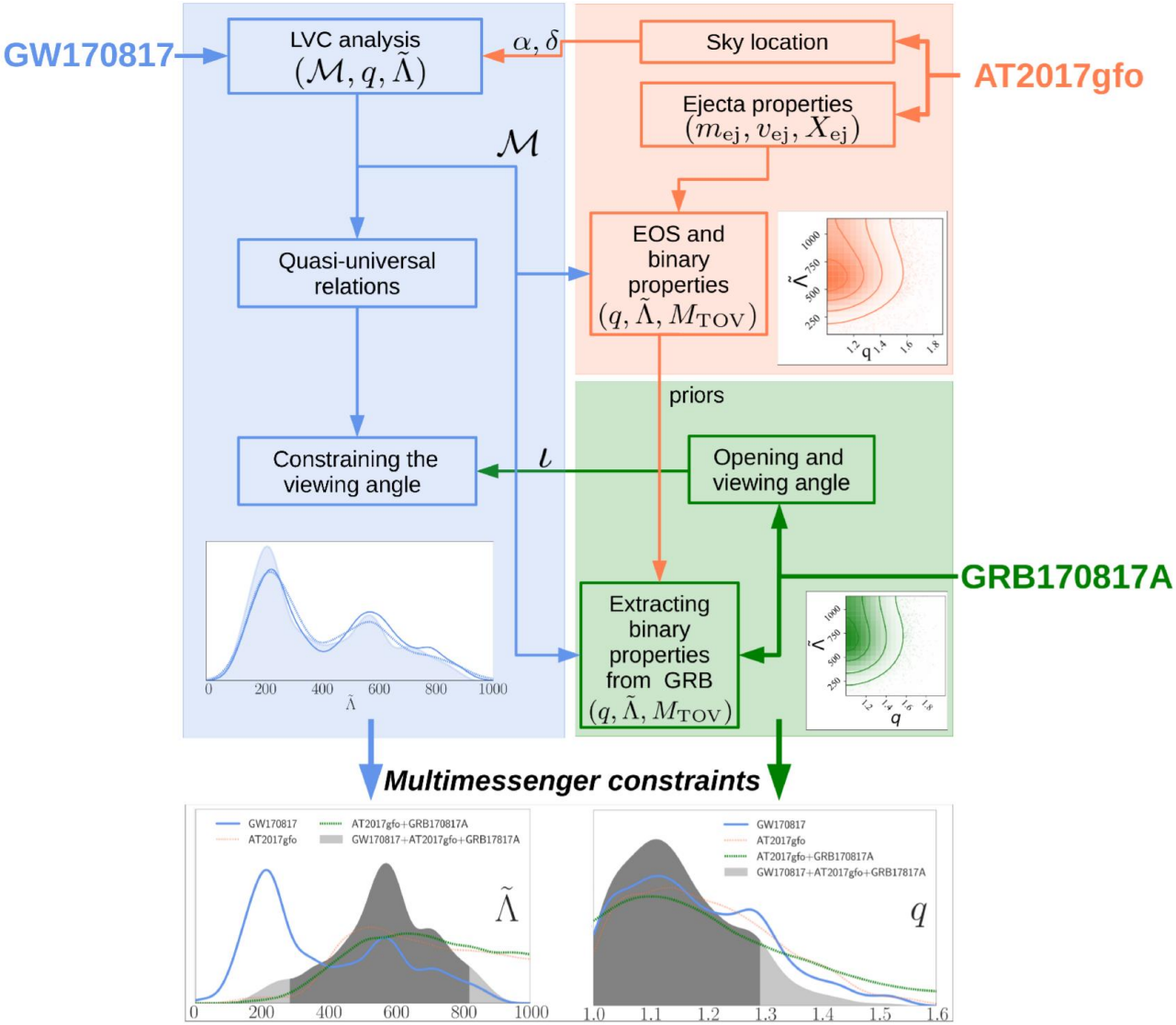
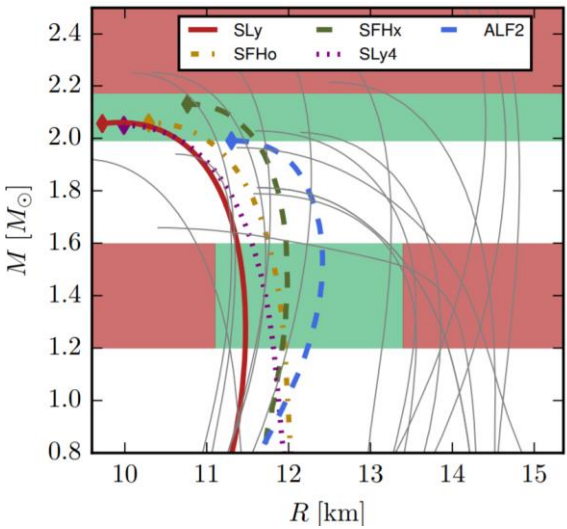
# Outline

- Why quark star?
- Why differential rotation?
- Results
- Discussions

# Constraining EoS in GW era

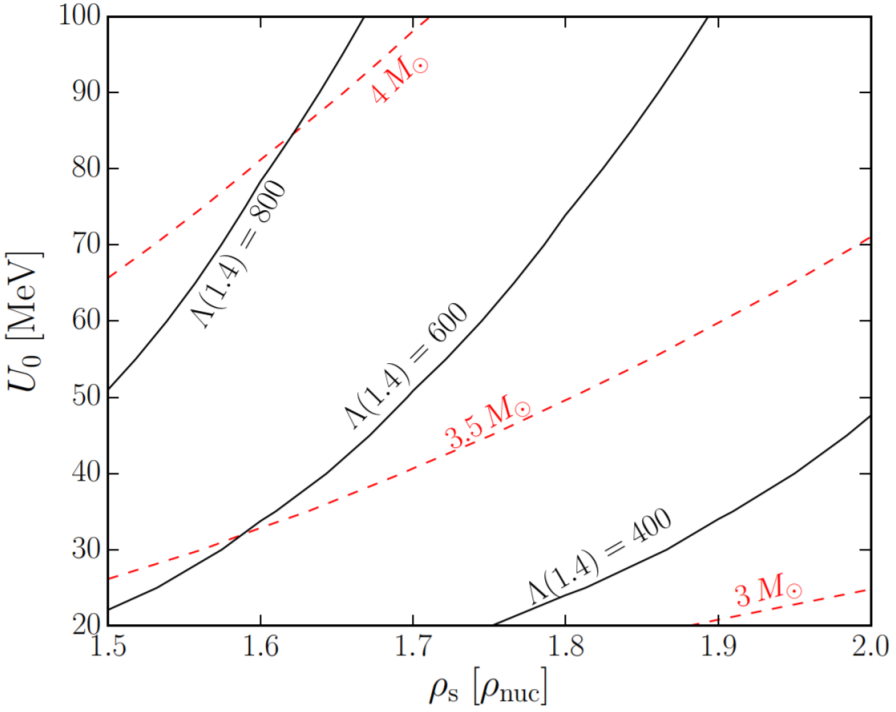


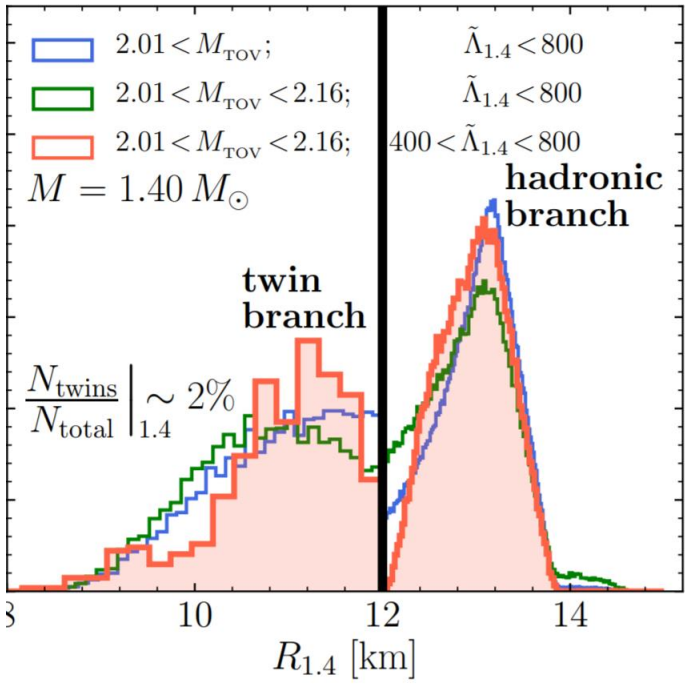

Coughlin et al
Arxiv:1812.04803

# Why quark star?

Considering QS branch can lead to different constraints on EoS with GW170817




Lai et al. 2018



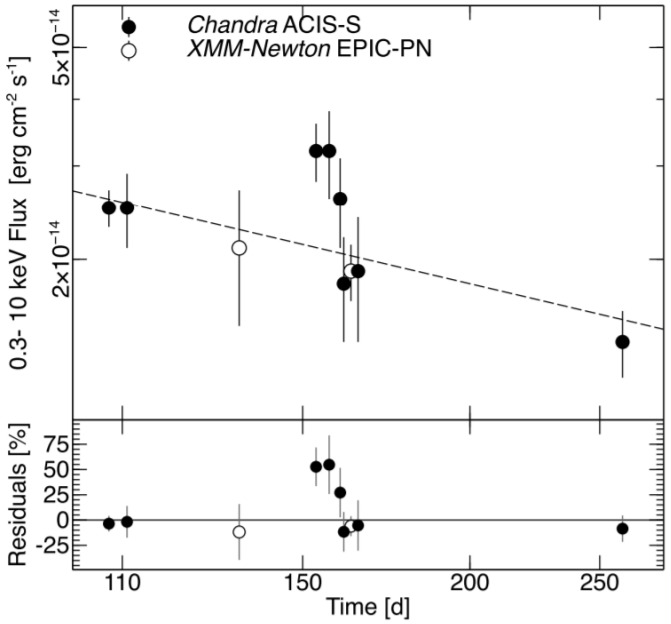

Most et al. 2018

# Why quark star?

TABLE 1
POTENTIAL SOURCES OF THE FAST BLUE KN EJECTA IN GW170817

| Ejecta Type | Quantity? | Velocity? | Electron Fraction? | References |
|---|---|---|---|---|
| Tidal Tail Dynamical | Maybe, if $M_1/M_2 \lesssim 0.7^{\dagger}$ | ✓ | **Too Low** | e.g., 1, 2 |
| Shock-Heated Dynamical | Maybe, if $R_{\rm ns} \lesssim 11$ km$^{\ddagger}$ | ✓ | ✓if NS long-lived | e.g., 3-5 |
| Accretion Disk Outflow | ✓if torus massive | **Too Low** | ✓if NS long-lived | e.g., 6-9 |
| HMNS Neutrino-Driven Wind | **Too Low** | **Too Low** | **Too High?** | e.g., 11, 12 |
| Magnetized HMNS Wind | ✓if NS long-lived | ✓ | ✓ | e.g., 12,13 |

Metzger et al. 2018




SMQSs are normally more massive than SMNSs. It's possible to explain the long-lived remnant and additional energy source from the spin down power at the same time.

Piro et al 2018

# Why differential rotation?

- Time consumption of NR simulations

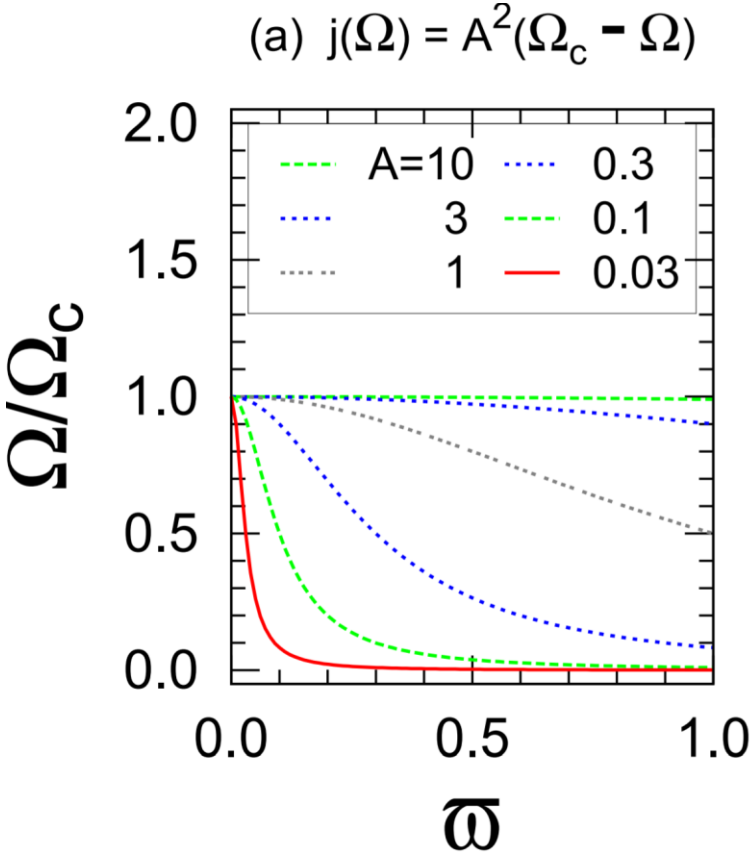
➢ Impossible to follow a merger event until the formation of BH (~100 ms vs ~1 s)

➢ Impossible to do parameter exploration to figure out the threshold of prompt collapse and so on

- Issues in evolving BQSs

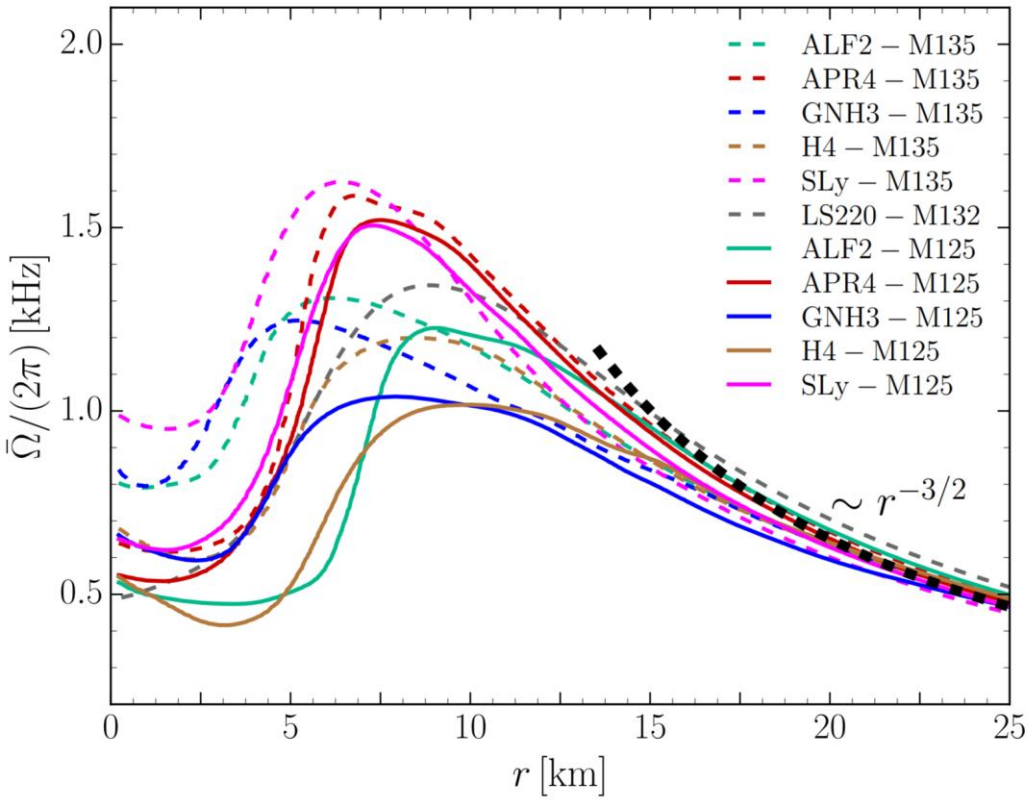
# Why differential rotation?

Previous studies not realistic



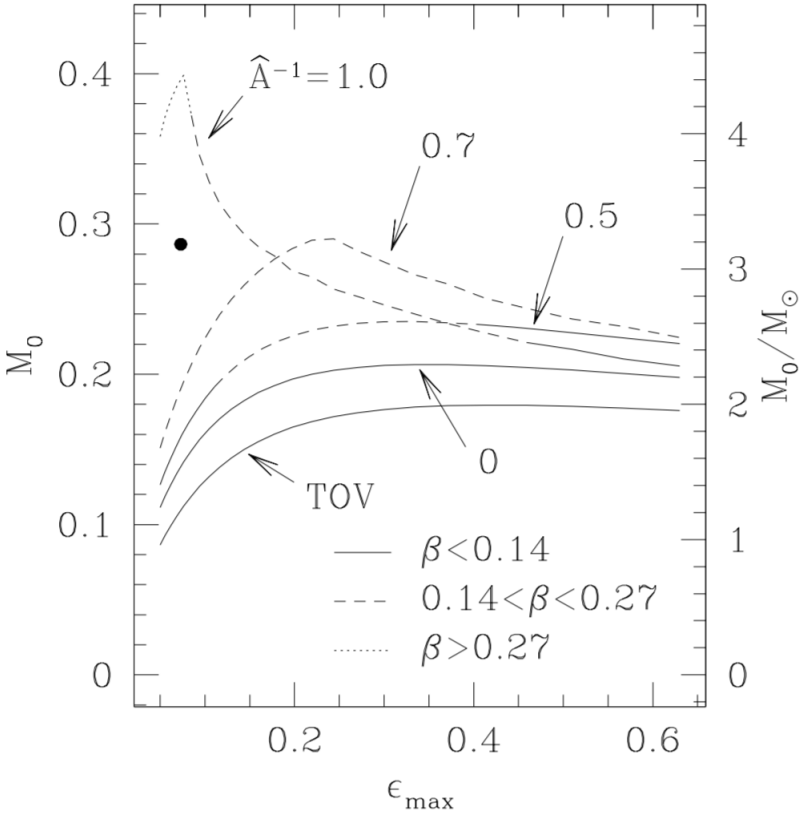

J-const law used in previous studies.
A monotonic omega profile

$$\Omega = \Omega_c \frac{1 + (j/B^2\Omega_c)^p}{1 + (j/A^2\Omega_c)^{q+p}}$$

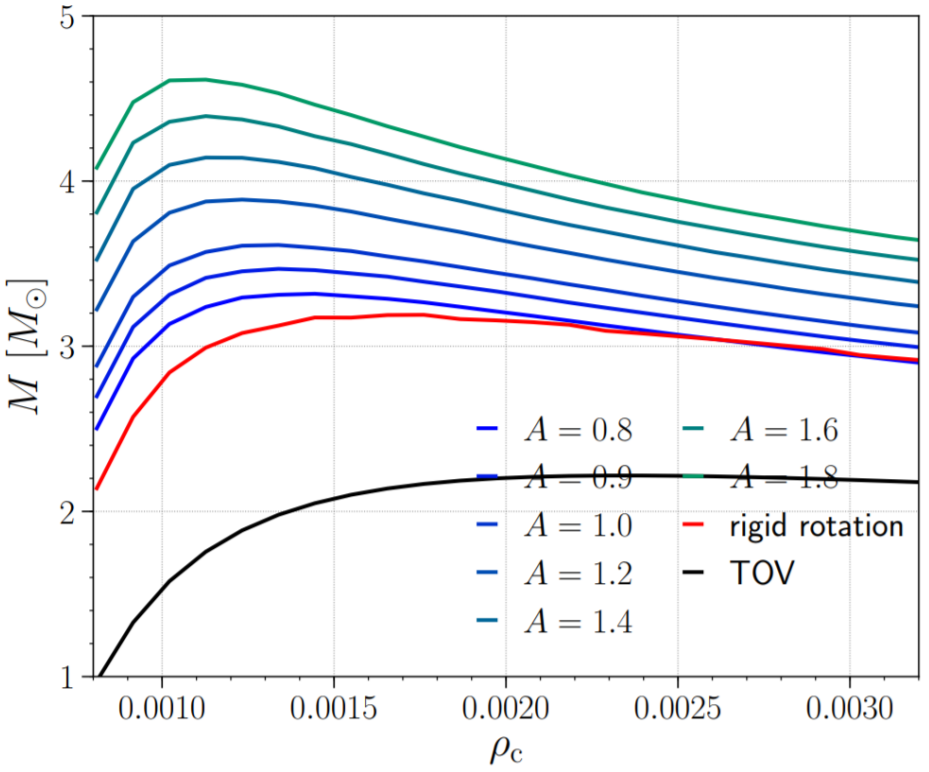



Actual omega profile seen in NR simulations
Hanauske et al. 2016

# Results: maximum mass

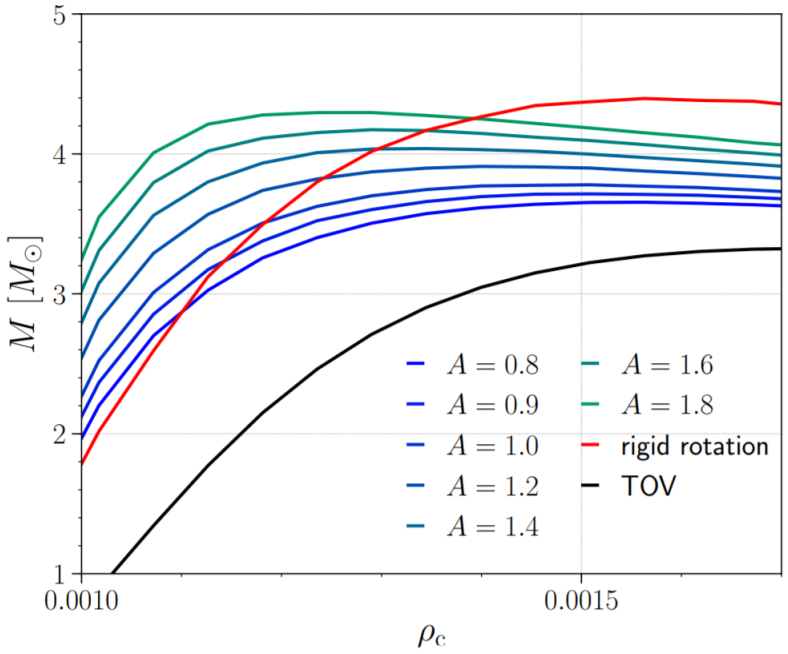


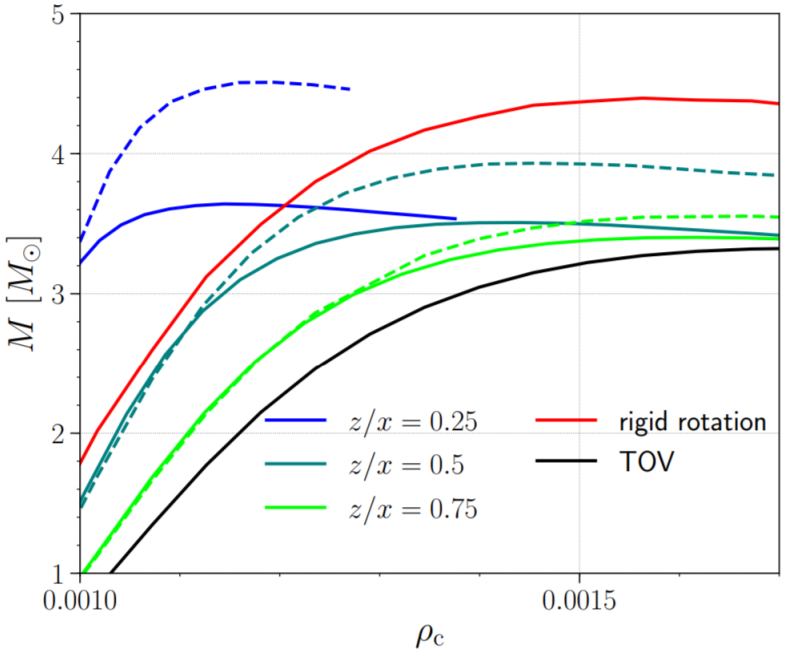

Baumgarte et al 2000
For HMNS




Zhou et al. in preparation
For HMQS with MIT bag model

# Results: maximum mass



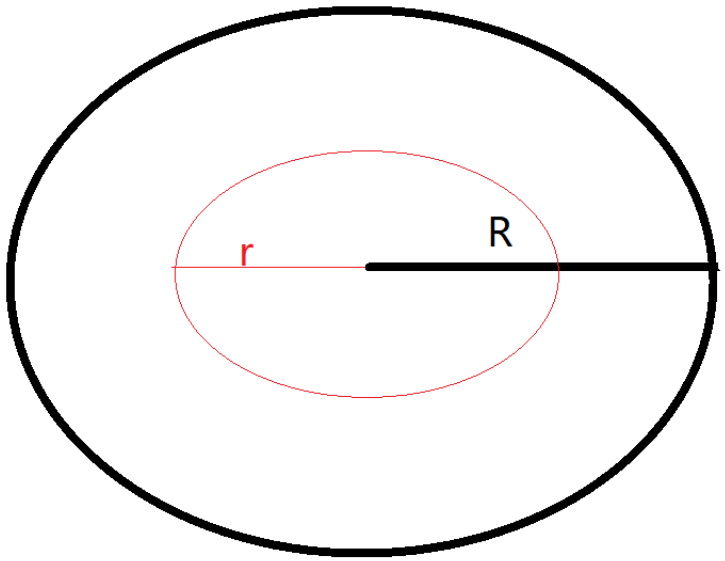

Zhou et al. in preparation

For HMQS with strangeon star EoS

The new differential rotation law can increase the maximum mass if the deformation is large.

Angular momentum and kinetic energy will become much larger as a trade off.

# Results: maximum mass




Newtonian limit:

$$\omega_{\mathrm{kep,star}} \sim \sqrt{\bar{\rho}_*}$$

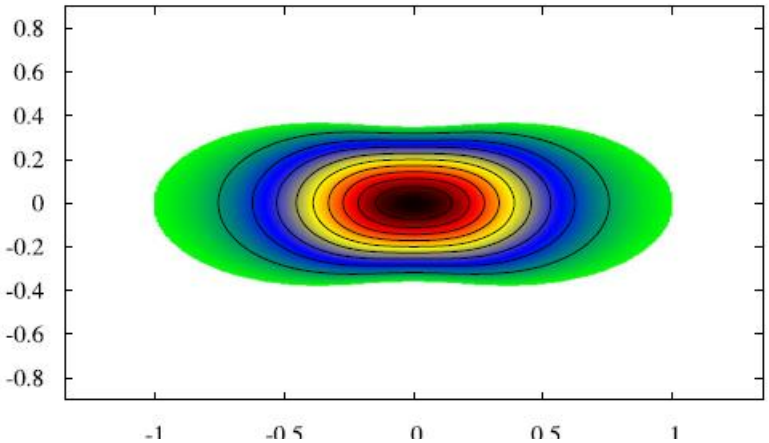
Consider the density profile inside the star $\bar{\rho}(r)$ decreases as r increases

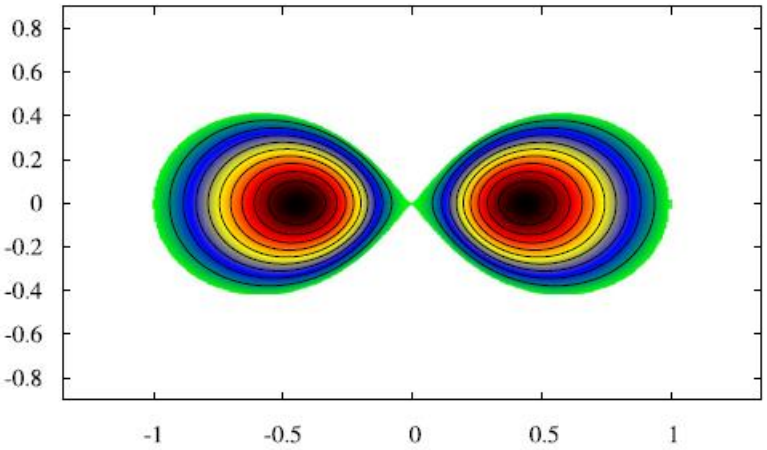
$$\omega_{\mathrm{kep}}(r) \sim \sqrt{\bar{\rho}(r)}$$

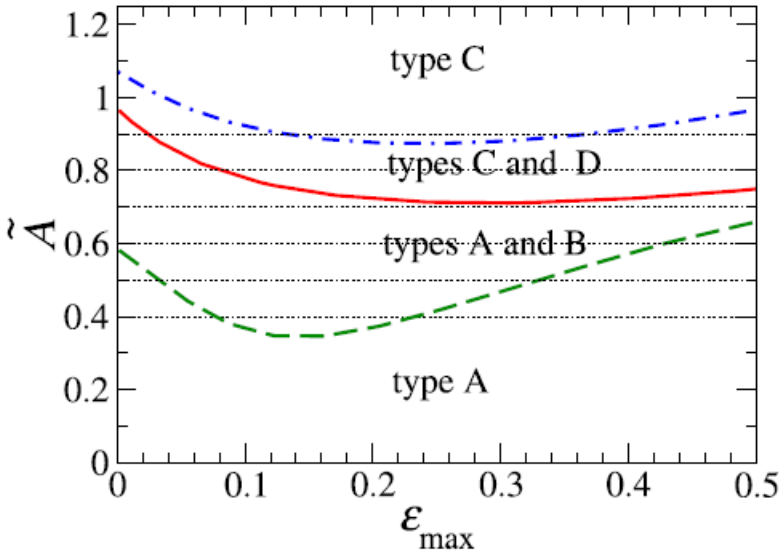
Note that QS are more similar to incompressible fluid

# Results: Type C solutions

- Type C solutions more significant for Drot QS



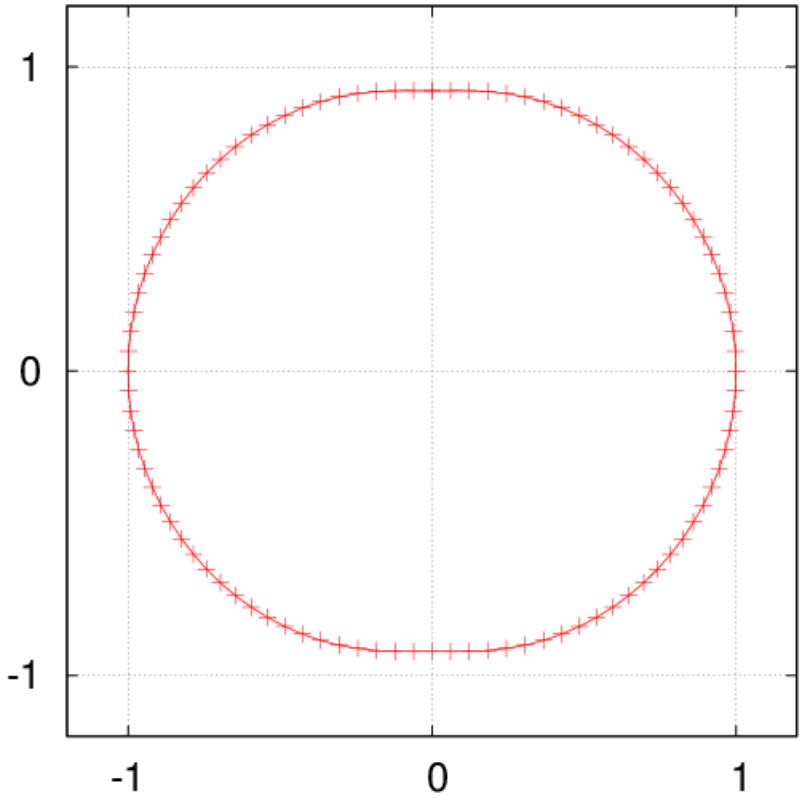



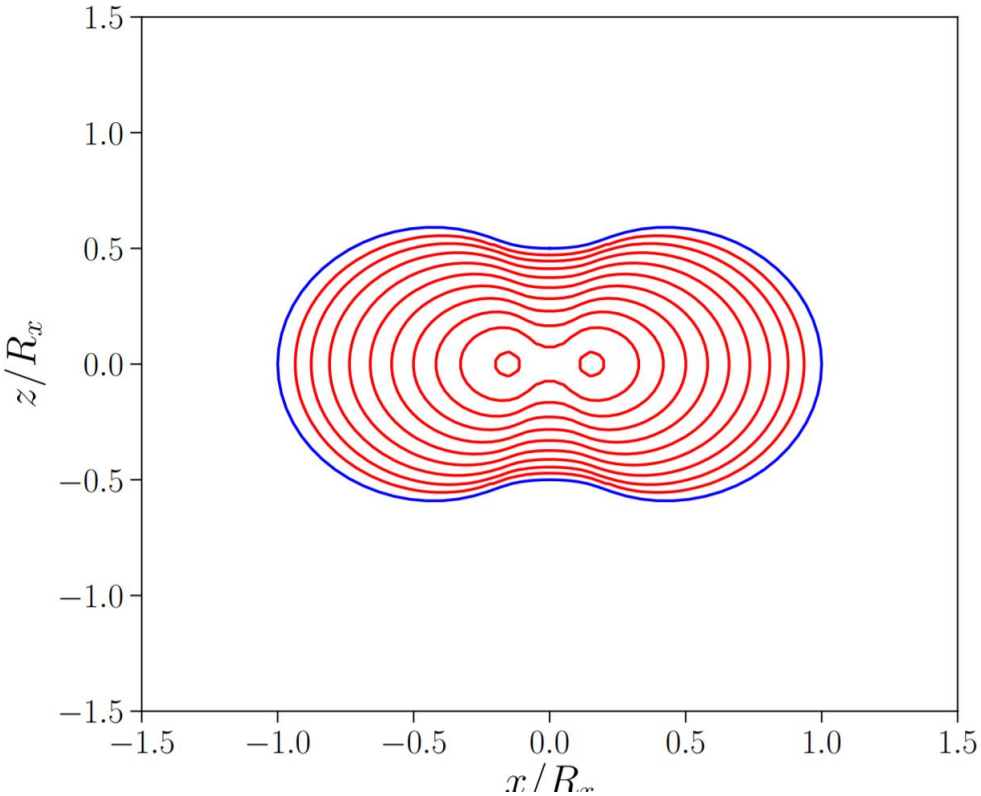




Ansorg et al. 2016

For drot NSs

# Results: Type C solutions



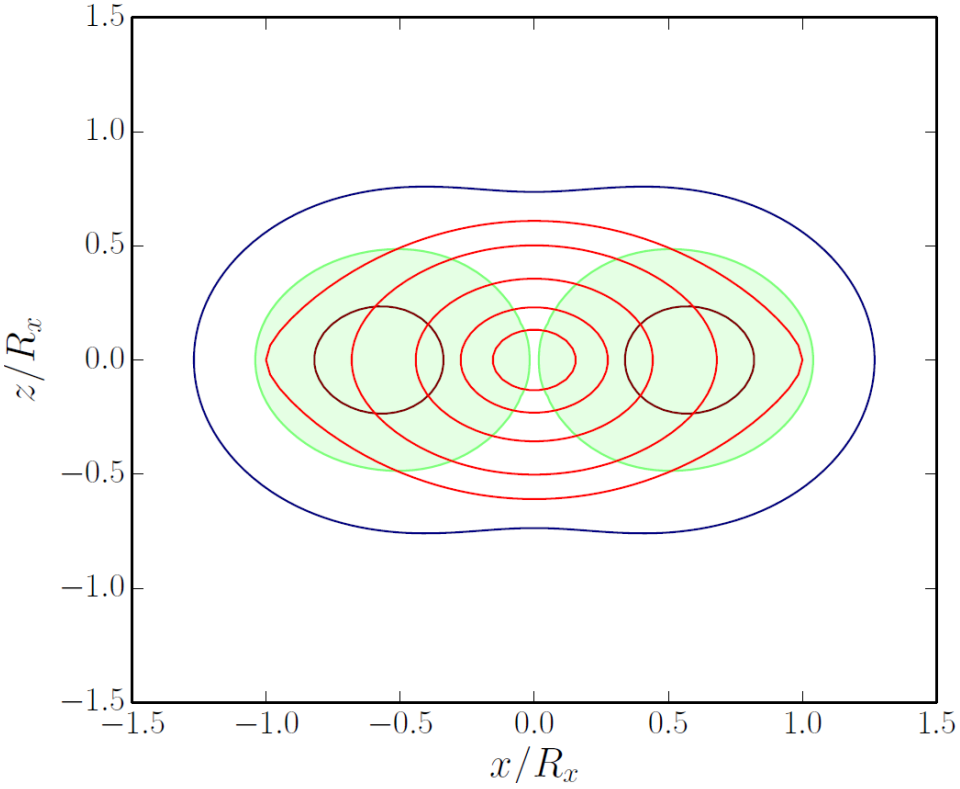



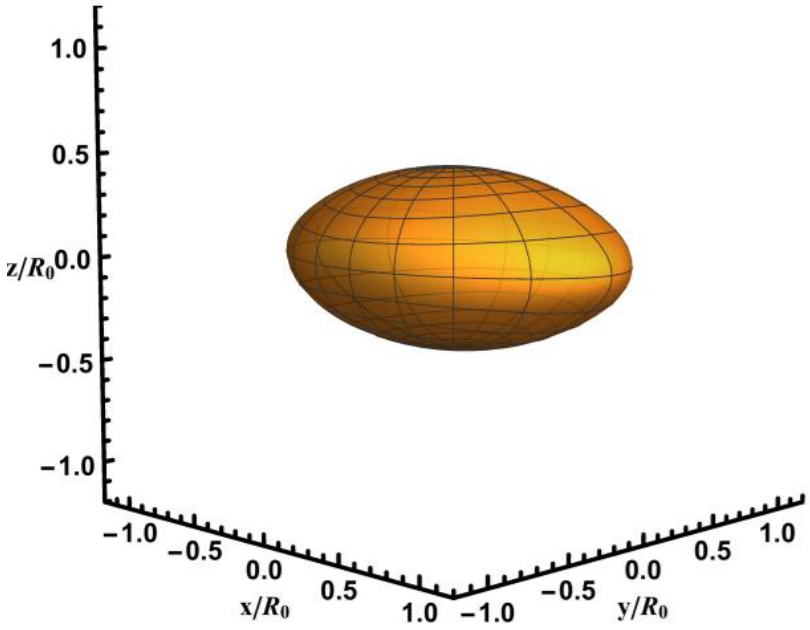

Transition at much smaller differential rotation rate & smaller angular momentum

Type C solution also found with the new differential rotation law

# Discussion

- Consequence of Larger compactness and larger T/W of RQS



# Discussion

- Differential rotating QSs are quite different from NSs, as they are more like a incompressible fluid
- Considering QSs will lead to different interpretation from GW170817/AT2017gfo/GRB170817A
- QSs are totally consistent with current constraints and should be treated more seriously in the future

- Thanks for your attention!