Astrophysical Censorship

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with

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"Astrophysical Censorship"

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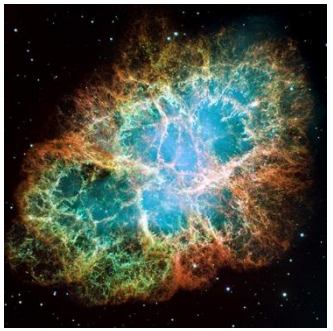


- We (try to) examine whether the Cosmic Censorship Hypothesis (CCH) holds or not in astrophysically realistic gravitational collapse (using the LTB model).

- Conclusion:
  The weak CCH will be preserved in astrophysics!

Cosmic Censorship Hypothesis (CCH)

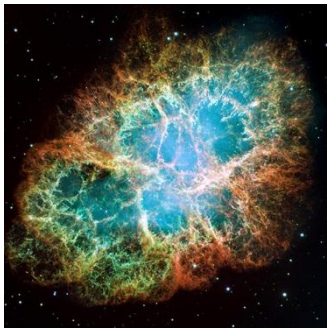
Penrose 1969

- *"A singularity forming in gravitational collapse of a physically realistic matter from a generic initial condition is hidden behind an event horizon."*
  - Strong CCH prohibits even a locally NS (naked singularity) (a singularity cannot be seen even in a BH)
  - Weak CCH prohibits only a globally NS (a singularity can be seen in a BH)

- Many "counterexamples" to both strong & weak CCH.
- If CCH is violated, one will observe **Planckian physics.**

Stellar collapse & our strategy

- Collapse in the final stage of stellar evolution
  - e.g. **core collapse** of a massive star
  - e.g. **delayed collapse** of a proto neutron star
  - Outer region: ~free-fall
  - Central region: supra-nuclear (UNKNOWN)



- We CANNOT predict if a NS forms in central region.
- So, we ASSUME a NS to appear in central region of **LTB**, then we examine its GLOBAL visibility w/ astrophysically motivated parameters (ρ_c, M, r_b)

LTB as stellar collapse

LTB: Spherical collapse of a pressure-less fluid (=dust) $T^{\mu\nu} = \rho(t,r)\delta^\mu_t\delta^\nu_t$

$$ds^2 = -dt^2 + \frac{R'^2(t,r)}{1+f(r)}dr^2 + R^2(t,r)d\Omega^2$$ (synchronous comoving coord)

$$\dot{R}^2 - \frac{F(r)}{R} = f(r) \qquad \rho(t,r) = \frac{F'(r)}{8\pi R^2 R'}$$

Astrophysical assumptions

Density profile $\rho(0,r) = \rho_c\left(1-\left(\frac{r}{r_b}\right)^2\right)$ (➔ Locally naked at least Dwivedi+Joshi 1993)

$\rho_c \sim 10^{15}$ g/cm^3 $r_b \sim 10$ km

Velocity profile $\dot{R}(0,r) = 0 \Leftrightarrow f(r) = -\frac{F(r)}{R(0,r)}$ (momentarily static)

Total mass $M = \frac{1}{2}F(r_b) = 4\pi\int_0^{r_b}\rho(t=0,r)r^2dr \sim 1.5\text{–}2.0M_\odot$

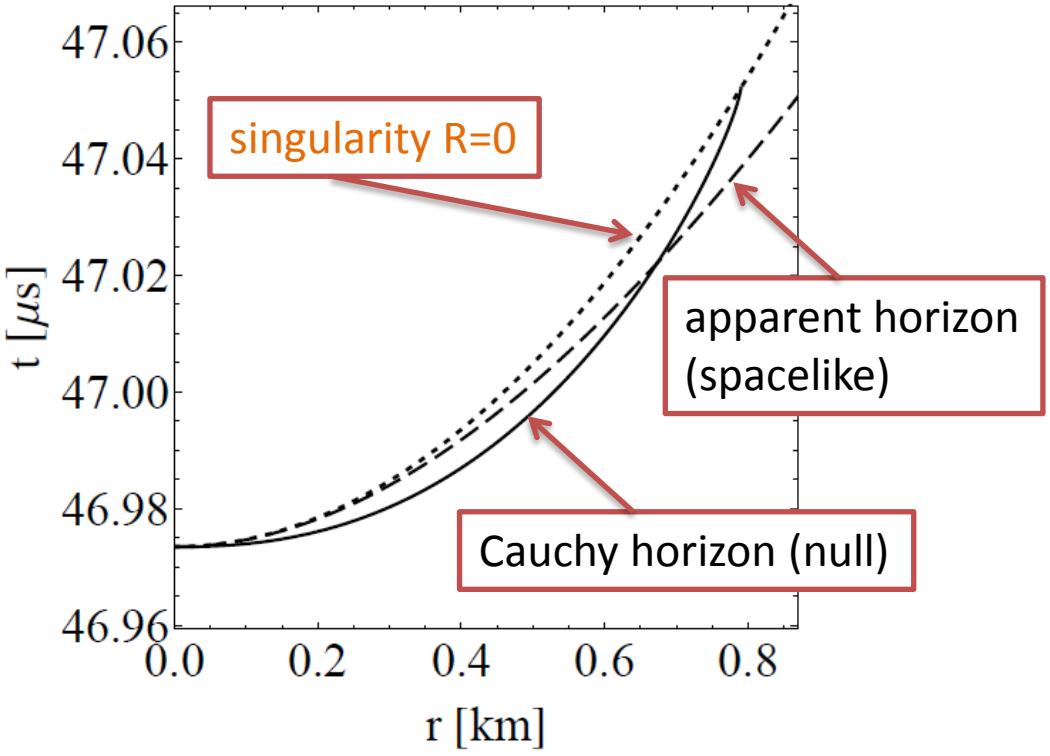
Prohibition of a global NS

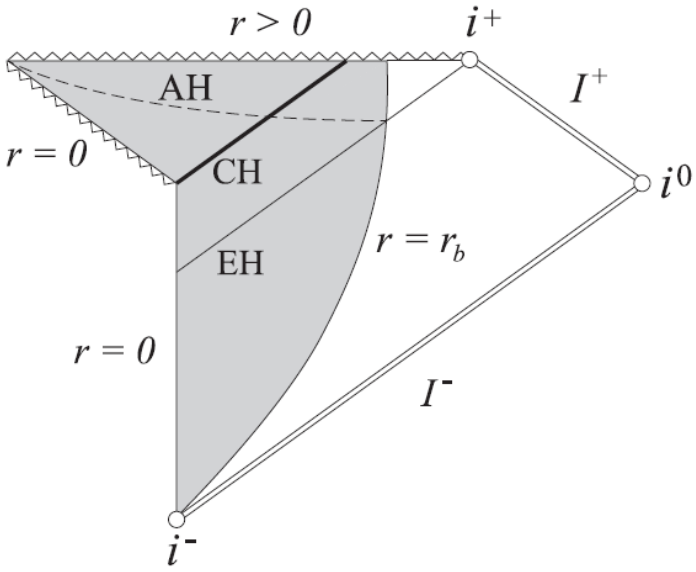
We numerically obtain the Cauchy horizon (CH, i.e. first outgoing null ray from the singularity)

$$\rho_c = 2 \cdot 10^{15}\ \mathrm{g/cm^3}$$

$$M = 2M_\odot$$

$$r_b = 10.5\ \mathrm{km}$$

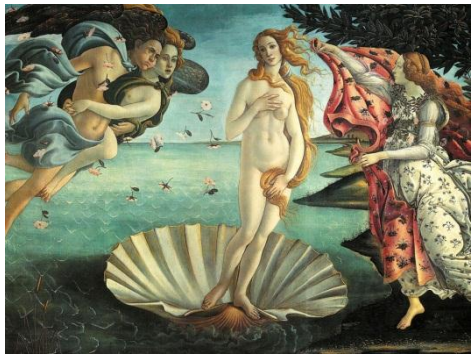




The Cauchy Horizon is trapped by an apparent horizon and plunges into the singularity DEEP INSIDE the star!!

$$\frac{R_{\mathrm{trap}}}{R_{\mathrm{bdry}}} \sim 0.05\%$$

Concluding remarks



- Conclusion:
  A **weak astrophysical censor** would exist:
  Even if a NS appears, it cannot be globally visible in astrophysically realistic collapse.

- Remarks:
  - We do NOT claim that a NS appears in astro collapse (just an assumption)
  - Difficult to argue a STRONG astrophysical censor (unknown supra-nuclear physics)
  - The conclusion will be robust coz LTB is “most dangerous.”