Neutron Star Mass and Radius Constraint from X-ray Burst in LMXBs

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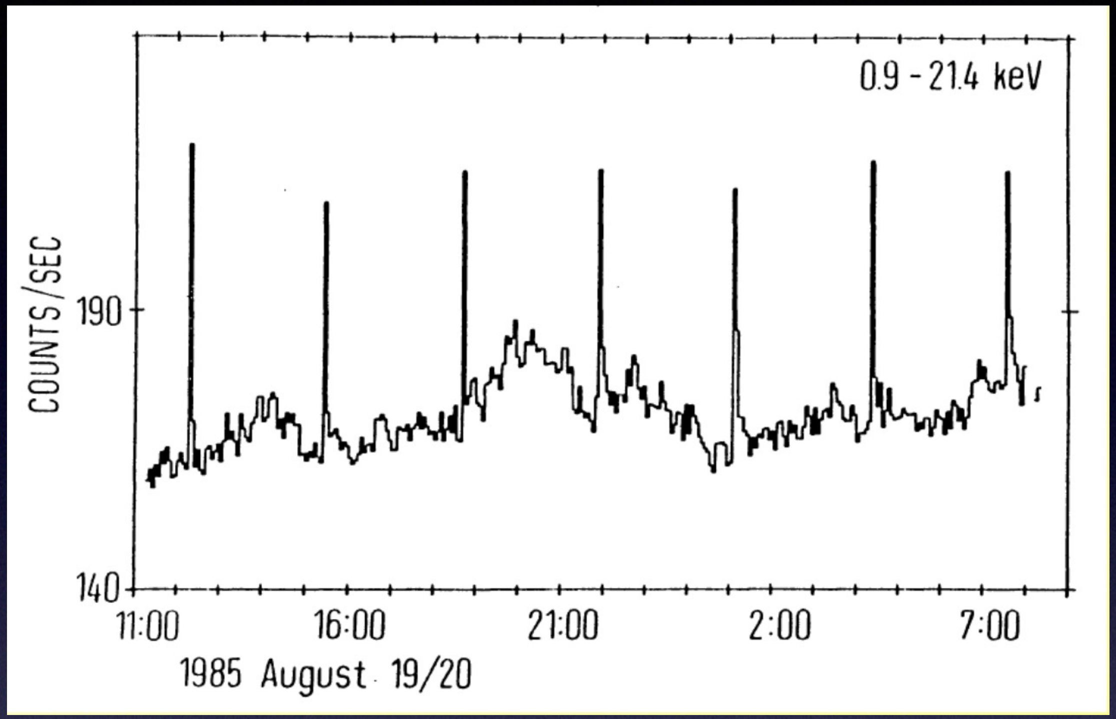
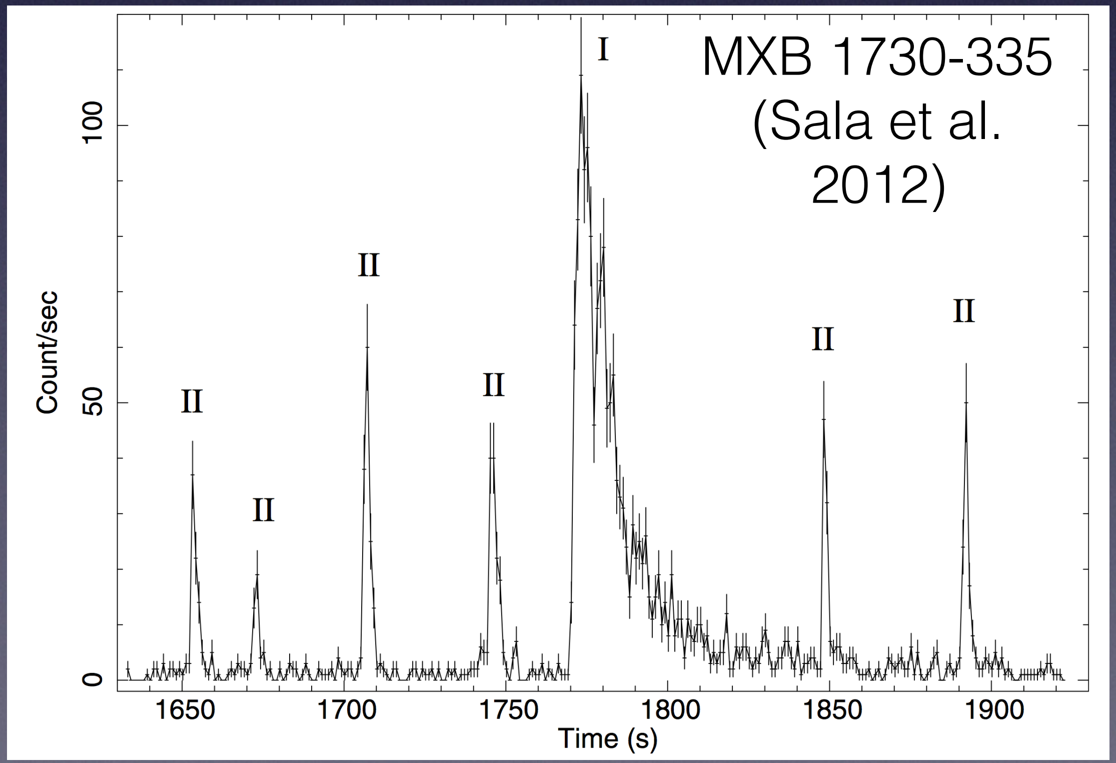
X-ray Binaries and X-ray burst

- Occurs on the neutron star surface in LMXBs by nuclear ignition (unstable H or He)
- Energy range ~ 10keV (soft X-ray)
- Maximum luminosity ~ 10^{38}erg/s (Eddington limit)
- recurrence time ~ hours to days
- X-ray softening during decay
- regular or irregular bursts recurrence

4U 1820-30

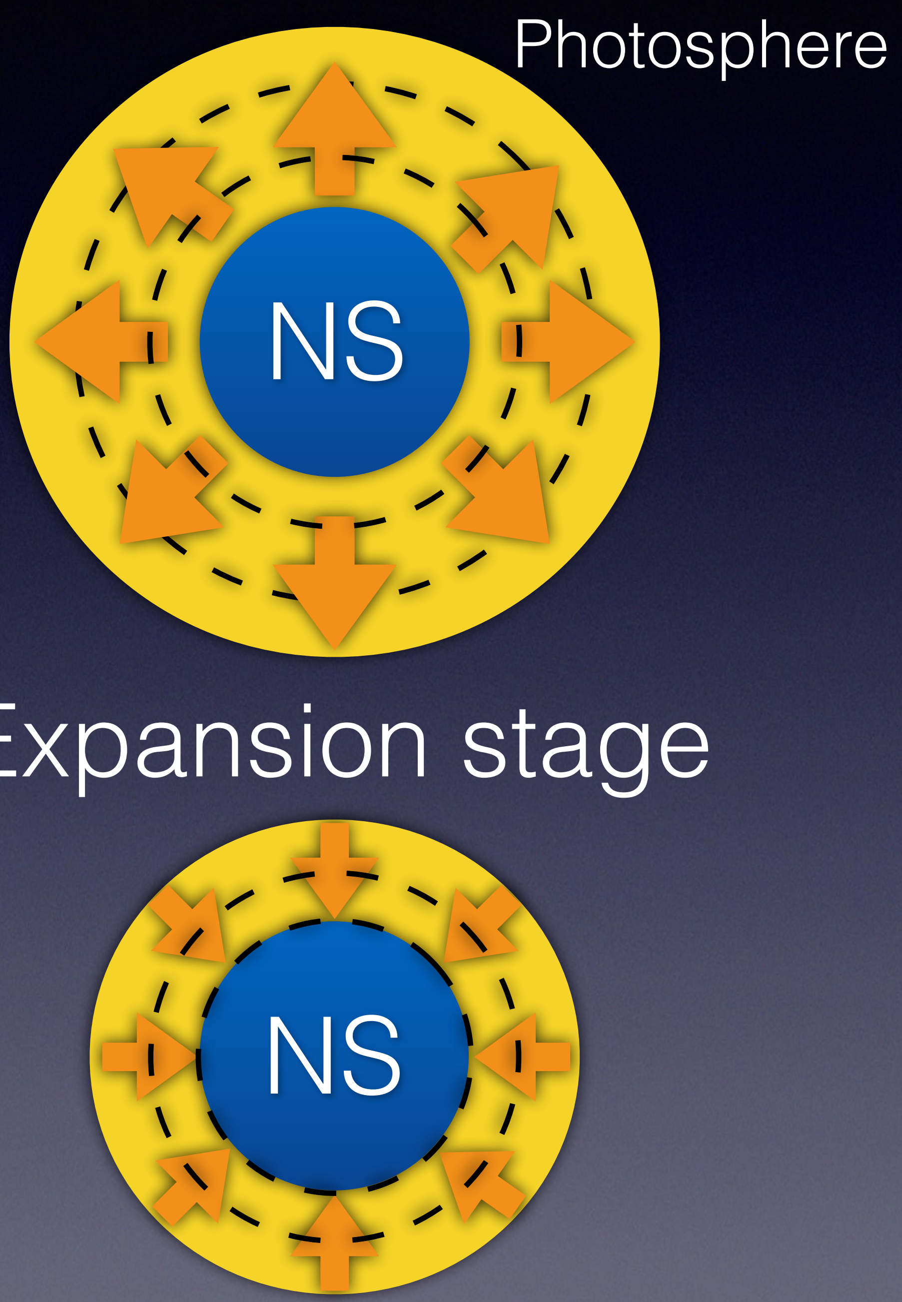




number of Type I X-ray bursters ~ 84(2007)
(of ~160 LMXBs), 2/3 located in the Galactic Bulge

Photospheric Radius Expansion

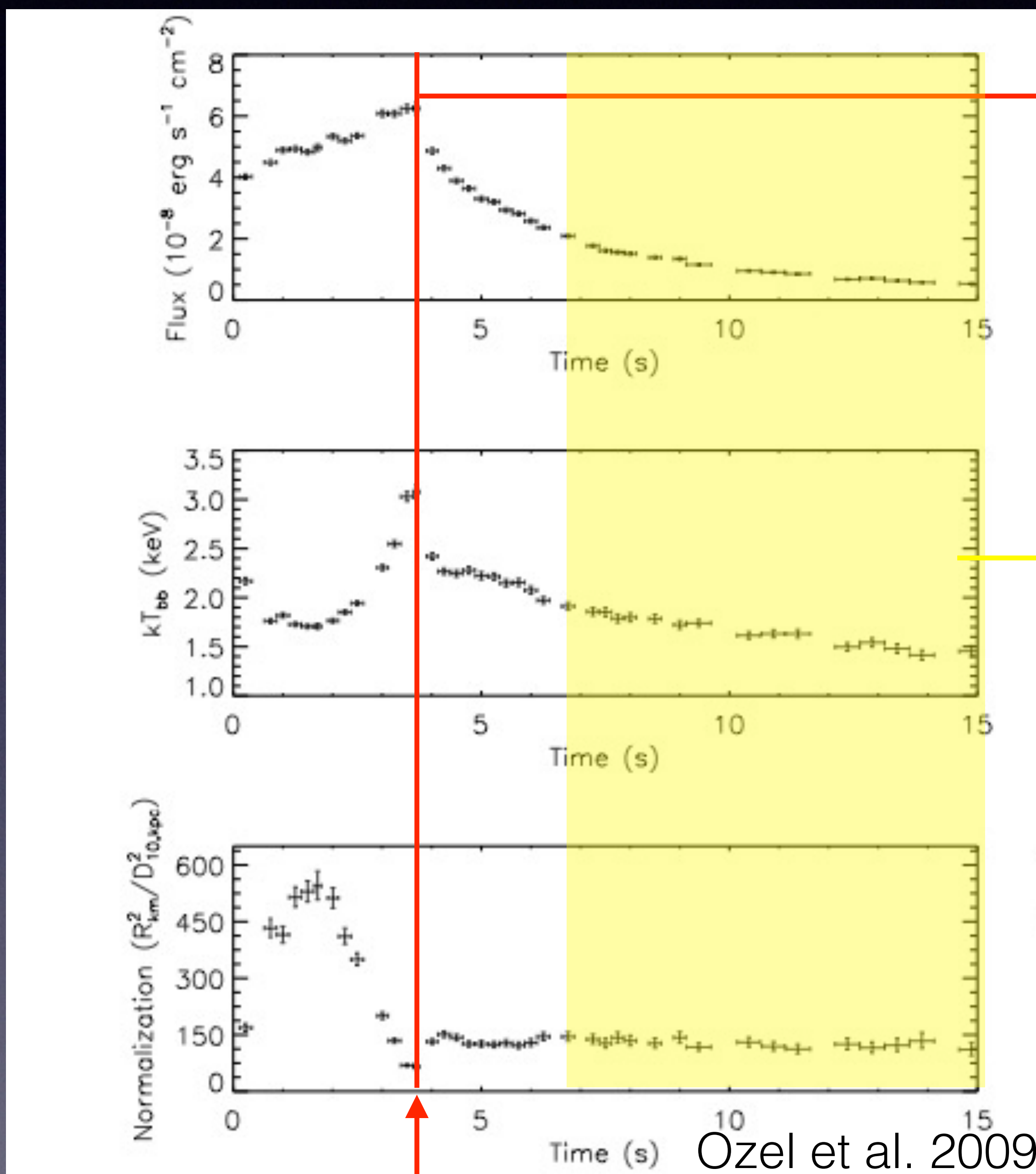
- In bright bursts, the luminosity L can reach the Eddington limit L_{Edd}
    - *$P_{radiation}$ >> $P_{gravitation}$*
    - *Photospheric layers are lifted off*
- During PRE the luminosity is nearly constant(near L_{Edd})
- About 20% shows the evidence of PRE bursts (Galloway et al. 2008)



Expansion stage

'touchdown' stage

Method to estimate Mass and Radius I



Özel et al. 2009

'touchdown' point

$$F_{\mathrm{TD},\infty} = \frac{GMc}{\kappa D^2}\sqrt{1-2\beta(r_{\mathrm{ph}})}$$

$$\beta(r) = GM/(rc^2)$$

$$\kappa = 0.2(1+x)\mathrm{cm}^2/\mathrm{g}$$

$$A \equiv \frac{F_\infty}{\sigma T^4_{\mathrm{bb},\infty}} = f_c^{-4}\left(\frac{R}{D}\right)^2(1-2\beta)^{-1}$$

$$\alpha \equiv \frac{F_{\mathrm{TD},\infty}}{\sqrt{A}}\frac{\kappa D}{c^3 f_c^2} \qquad \alpha = \beta\sqrt{1-2\beta}$$

$$\gamma \equiv \frac{Ac^3 f_c^4}{F_{\mathrm{TD},\infty}\kappa} \qquad \gamma = \frac{R}{\beta(1-2\beta)}$$

$$R = \alpha\gamma\sqrt{(1-2\beta_{1,2})} \quad M = c^2\alpha^2\gamma/G$$

Method to estimate Mass and Radius II

Quantities	EXO 1756–248	4U 1608–522	4U 1820–30	4U 1746–37	EXO 0748-676
D	6.3 ± 0.6	5.8± 2.0	8.2± 0.7	11.05± 0.85	7.1± 1.2
A	1.17± 0.13	3.246± 0.024	0.9198± 0.0186	0.109± 0.044	1.14± 0.10
$F_{TD,\infty}$	6.25± 0.2	15.41± 0.65	5.39± 0.12	0.269± 0.057	2.25± 0.23

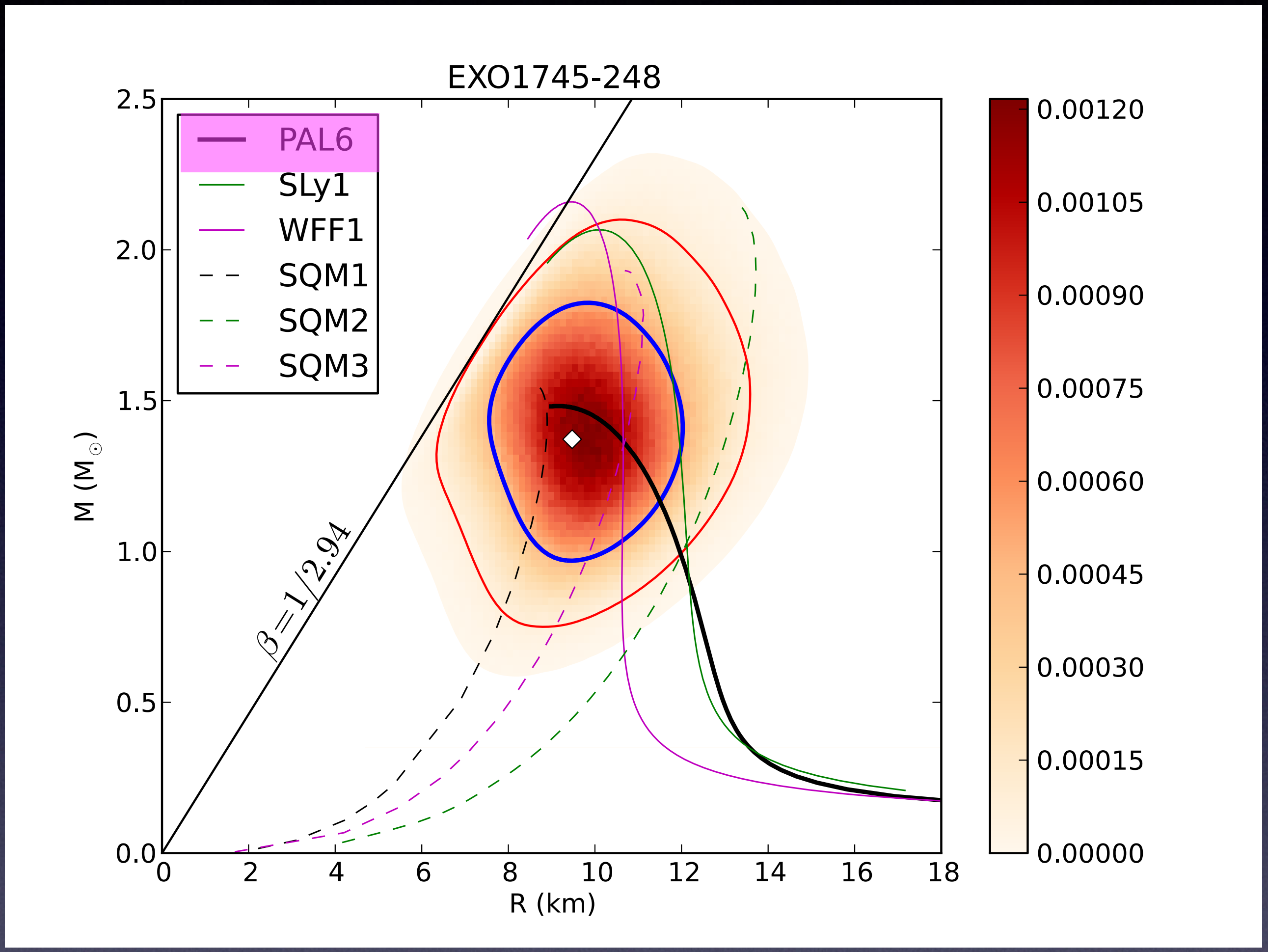
D (kpc): distance
A (km^2 kpc^{-2}): normalised surface area
F_{TD} (10^{-8} erg cm^{-2} s^{-1}): touchdown flux

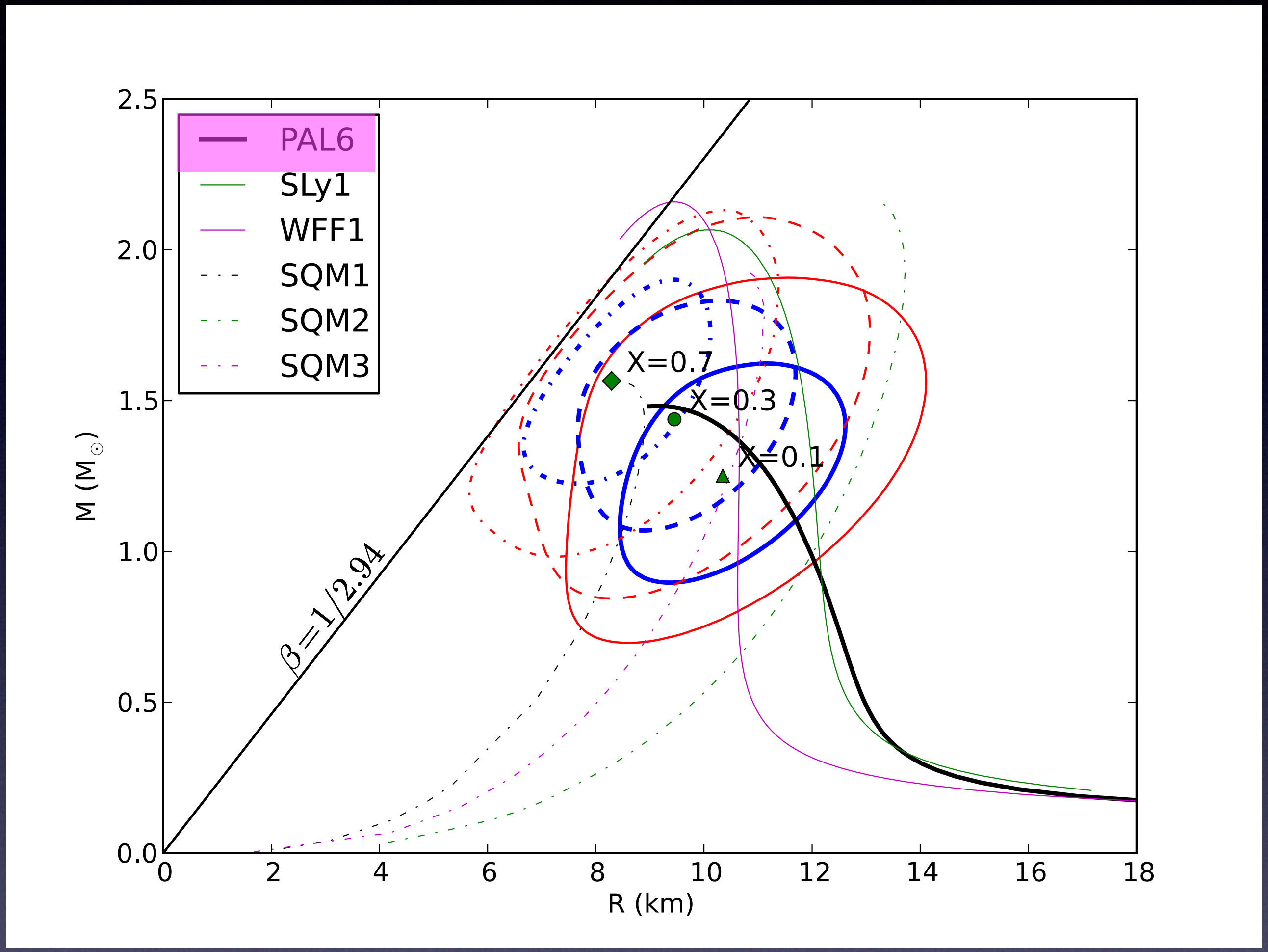
- Previous - Gaussian distribution of F_{TD}, A, and D (observation)
  uniform distribution of f_c and *x (theoritical)*
  $f_c(=T_{bb}/T_{eff})$: 1.3 -1.4,
  x : 0.0 - 0.7

- Our work - x dependence (0.1, 0.3, 0.7)
  The accreted material effect

M-R probability distribution I

uniform distribution / fixed distribution





- mass increases and radius decreases as x increases
- mass (M/M⊙) : 1.24 - 1.57
  radius (km) : 8.29 - 10.38

Thank You
for your attention