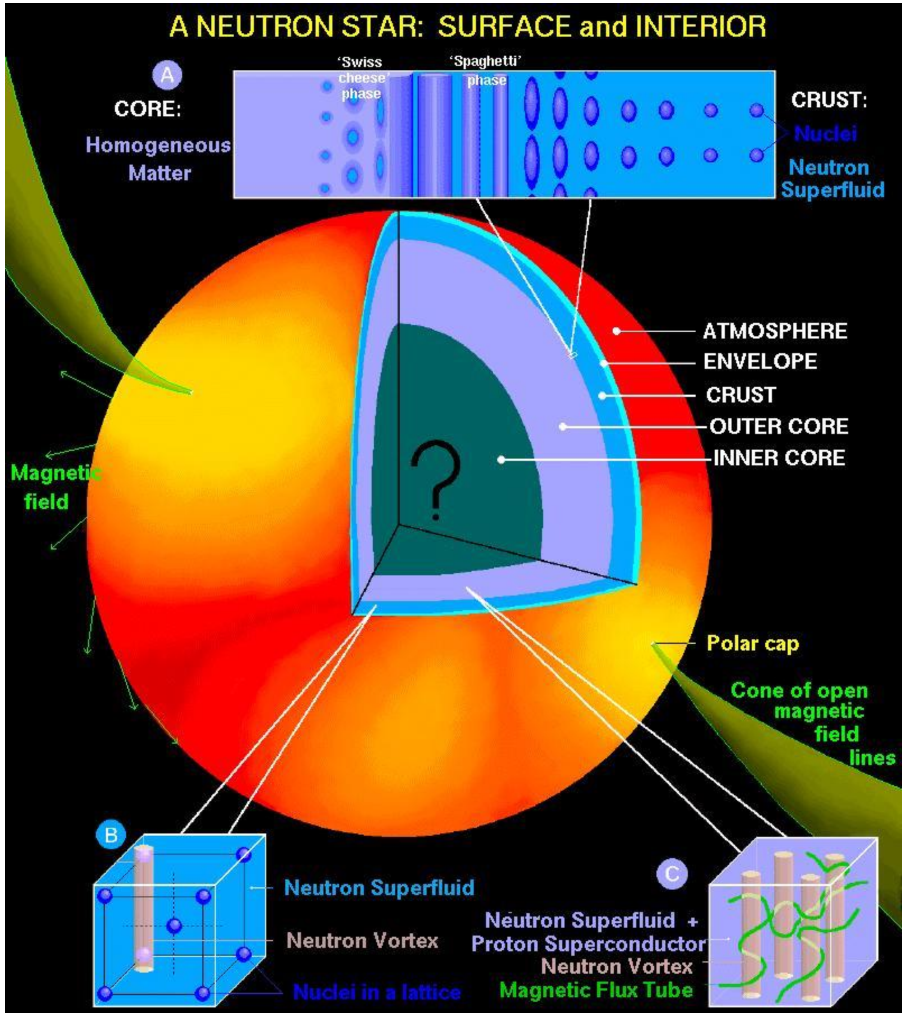
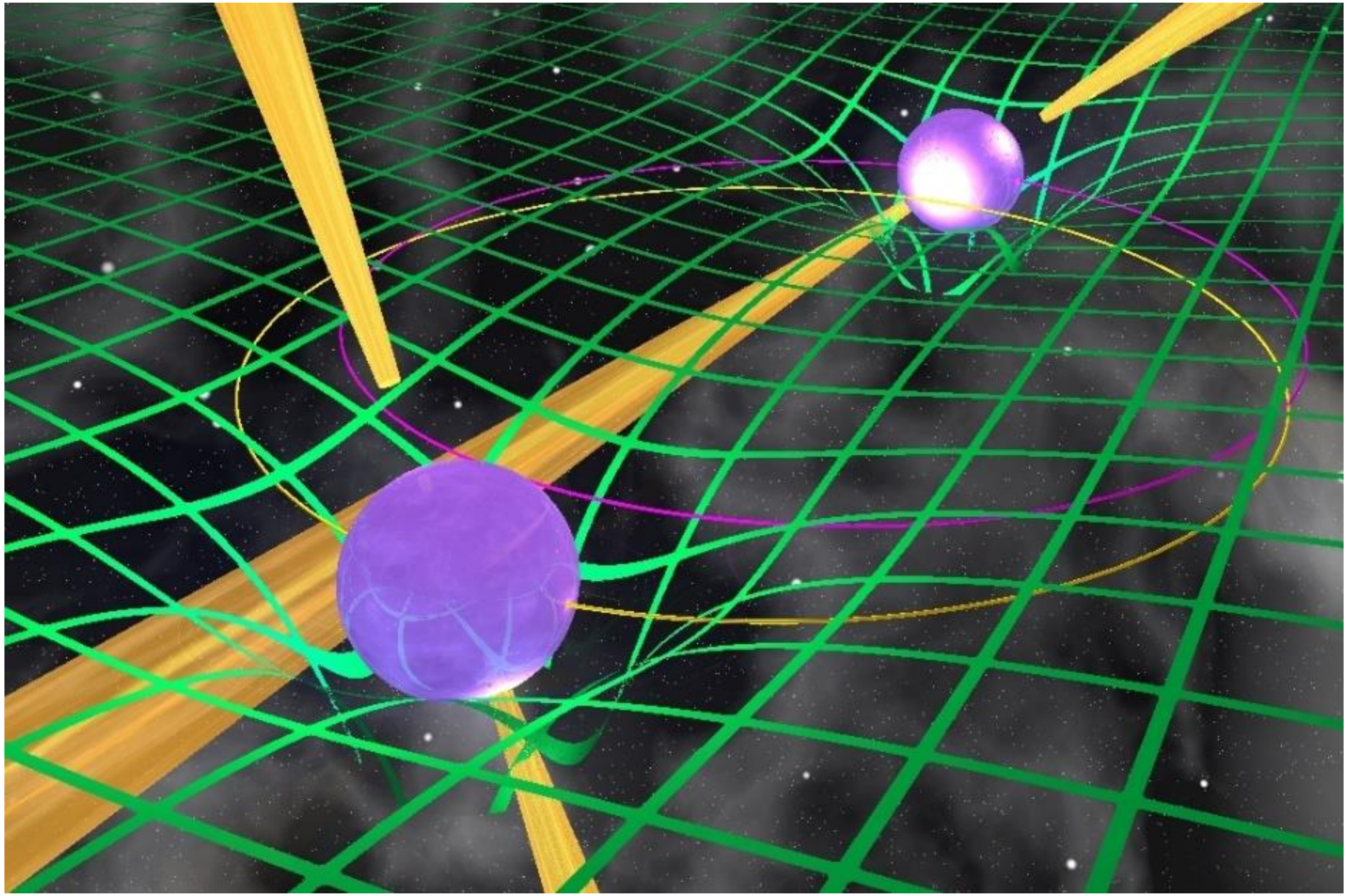




Современная феноменология нейтронных звезд и черных дыр.

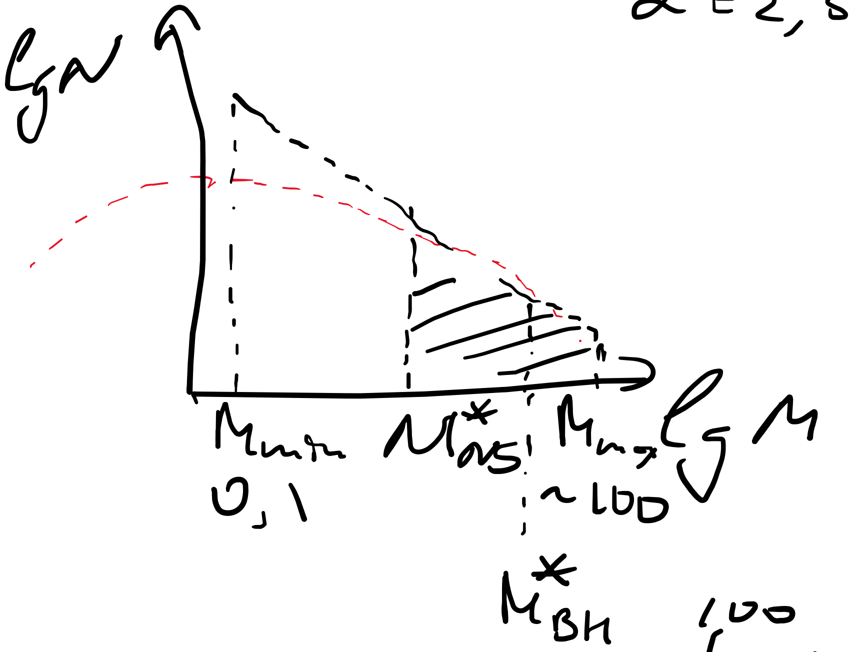
<u>Семинар 1</u>

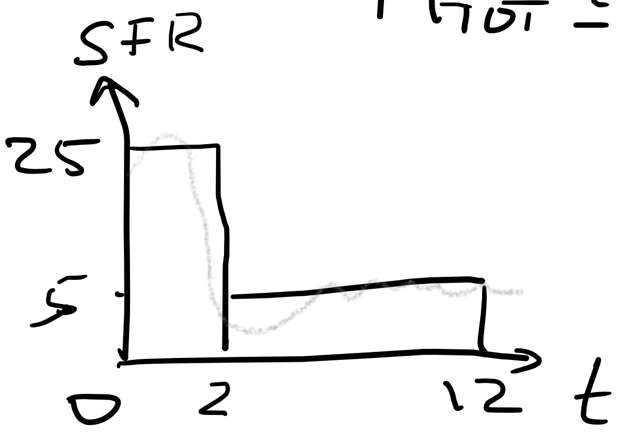
07.02.2022

1

$$\frac{dN}{dM} = A \cdot M^{-\alpha}$$

$$\alpha = 2,35$$





$$M_{TOT} = 25 \cdot 2 \cdot 10^9 + 5 \cdot 10^9 \, 10 =$$

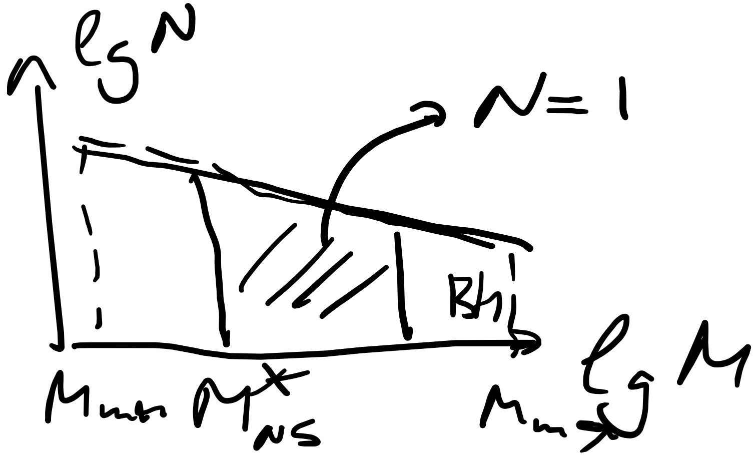
$$= 10^{11} M_\odot$$

$$\langle M \rangle = \frac{M_{TOT}}{N} = \frac{\int_{0.1}^{100} A \cdot M^{-2.35} M \cdot dM}{\int_{0.1}^{100} A \cdot M^{-2.35} dM} \simeq 0,4 M_\odot$$

$$M^*_{NS} = 10 M_\odot$$

$$\frac{N_{NS}}{N_{TOT}} = \frac{\int_{10}^{100} A \cdot M^{-2.35} dM}{\int_{0.1}^{100} A \cdot M^{-2.35} dM} \simeq \left(\frac{0.1}{10}\right)^{1.35} \simeq 10^{-2,7}$$

$$N_{SN} = N_{TOT} \cdot 10^{-2.7} = \frac{M_{TOT}}{\langle M \rangle} = \frac{10^{11}}{0.4} 10^{-2.7} = \frac{2,5}{10^{0.7}} \cdot 10^9$$



$$\int_{10}^{100} A \cdot M^{-2.35}\, dM = 1 = \tilde{N}_{TOT}\left(\frac{0.1}{10}\right)^{1.35}$$

$$\tilde{N}_{TOT} = \frac{\tilde{M}_{TOT}}{\langle M \rangle} = \frac{\overset{= 5\frac{M_\odot}{yr}}{SFR} \cdot T}{\langle M \rangle} \quad ?$$

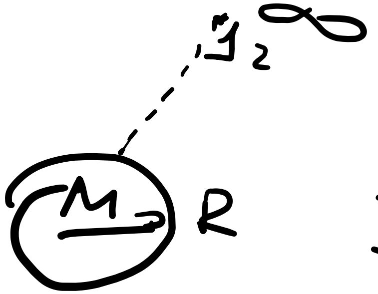
$$1 = \frac{5\frac{M_\odot}{yr}\, T}{0.4}\left(\frac{0.1}{10}\right)^{1.35}$$

$$T \approx 40\ yrs$$

② Энергия NS

$M = 1{,}5\,M_\odot \quad R = 10$ км

а) Аккр.



$$E = -\frac{1}{2}\frac{GM}{R} \Rightarrow \frac{1}{2\cdot 1{,}5}\,10^{-7}\,\frac{1.5\cdot 2\cdot 10^{33}}{10^{6}} \simeq 10^{20}\ \text{эрг}$$

$1\ \text{г} \to 10^{20}$ эрг

$\sim 10\%\ mc^2$

$$L_{Edd} = 10^{38}\,\frac{\text{эрг}}{\text{с}}\,\frac{M}{M_\odot}$$

$$\dot{M}_{Edd} \simeq 10^{18}\ \text{г/с} \simeq 10^{-8}\,\frac{M_\odot}{\text{год}}$$

б) Тепл. энерг.

$T \sim 10^6$ K

$$L = 4\pi R^2 \sigma T^4$$

$$L \simeq 4\pi\cdot 10^{12}\, 5.67\cdot 10^{-5}\; 10^{24} \simeq 10^{33}\,\frac{\text{эрг}}{\text{с}}$$

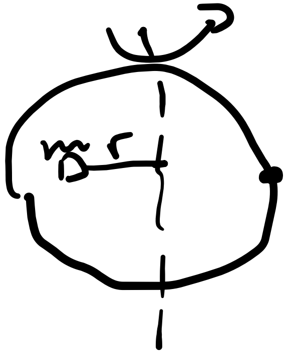
$10^6\ K \to 100$ эВ

$$\lambda = \frac{0{,}29\,(\text{см})}{T} \simeq 3\ \text{нм} \to \text{рентг.}$$

б) Вращение

$E_{вращ} = \frac{I\omega^2}{2}$ $\qquad \omega = \frac{2\pi}{P} \qquad I \sim MR^2$

$$I = \underset{<1}{k} MR^2 = \underbrace{k\cdot 3}_{\approx 1}\cdot 10^{33}\cdot 10^{12} \cong 10^{45}$$



$v_e = v_1 \qquad v_e = \frac{2\pi R}{P} = \omega R$

$v_1 = \sqrt{\frac{GM}{R}}$

$$\frac{2\pi R}{P_{min}} = \sqrt{\frac{GM}{R}} = \sqrt{2\pi}\, 10^{-4}\, c$$

$$P_{min} = 2\pi \frac{R^{3/2}}{\sqrt{GM}} \simeq 1\,\text{msec}$$

$$E^{max}_{вращ} = \frac{10^{45}}{2}\,\frac{4\pi^2}{10^{-6}} \simeq \underline{\underline{2\cdot 10^{52}}}\ \text{эрг}$$

$$\tau_0 = \frac{E^{max}_{вращ}}{L_0} \approx \frac{2}{3\ldots}\, 10^{19}\ \text{сек} \approx \underline{\underline{2\cdot 10^{11}\ \text{лет}}}$$

$$\dot{E}_{вращ} \sim \omega^4 B^2$$

2) Mag. mode.

$$\mathcal{E} = \frac{B^2}{8\pi} \qquad E_{mag} = \mathcal{E} \cdot V = \frac{B^2}{8\pi} \frac{4}{3}\pi R^3 = \frac{B^2 R^3}{6} =$$

$$\tilde{t}_0 = \frac{E_{mag}}{L_0} = \frac{10^{46} B_{14}^2}{6 \cdot 4 \cdot 10^{33} \cdot 3 \cdot 10^7} = \frac{1}{6} \cdot 10^{46}\, erg\ B_{14}^2 = 10^4\, sec\ B_{14}^2$$

$$\mathcal{E} = \rho_B \cdot c^2 \qquad \rho_B = \frac{B^2}{8\pi c^2} = \frac{10^{30}\, B_{15}^2}{8\pi 10^{21}} \simeq \underline{4 \cdot 10^7\, g/cm^3}$$

B_{max}: $\mathcal{E} \cdot V = - E_p$

$$\frac{B_{max}^2 R^3}{6} = \frac{G M^2}{R}$$

$$B_{max} = \left[6 \frac{G M^2}{R^4}\right]^{1/2} = \left[6 \cdot \frac{10^{-7}\, 9 \cdot 10^{66}}{1.5\, 10^{24}}\right]^{1/2} = 6.3 \cdot 10^{17}\, G \simeq 2 \cdot 10^{18}\, G$$