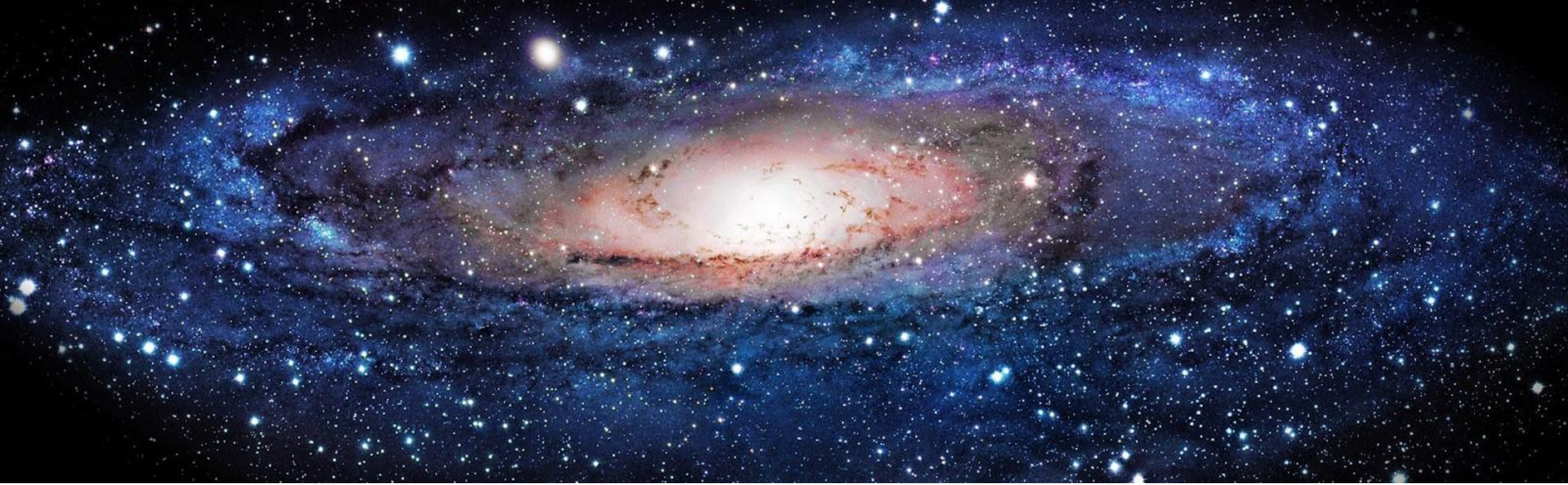


Майнор. Астрофизика.

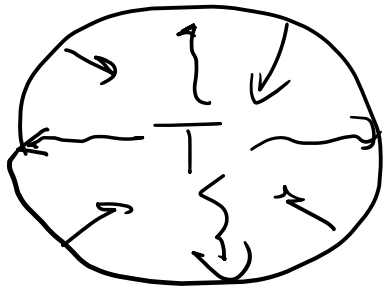
Семинар 4. (23.09)

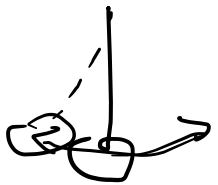
(1) $m \ll M$ $h_{orb} \ll R_p$ T ρ_p -?

$$T = \frac{2\pi R_p}{v} = 2\pi \frac{R_p \sqrt{R_p}}{\sqrt{GM}} = \frac{2\pi}{\sqrt{G}} \sqrt{\frac{R_p^3}{M}} =$$

$$= \frac{2\pi}{\sqrt{G}} \sqrt{\frac{\frac{4}{3}\pi R_p^3}{\frac{4}{3}\pi M}} = \frac{2\pi}{\sqrt{G}} \sqrt{\frac{3}{4\pi}} \frac{1}{\sqrt{\rho}}$$

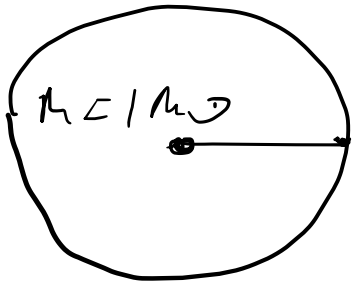
$$T^2 = \frac{4\pi^2}{G} \frac{3}{4\pi} \frac{1}{\rho} \qquad \rho = \frac{3\pi}{GT^2} \qquad T \sim \rho^{-1/2}$$

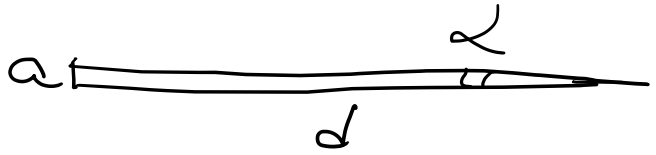




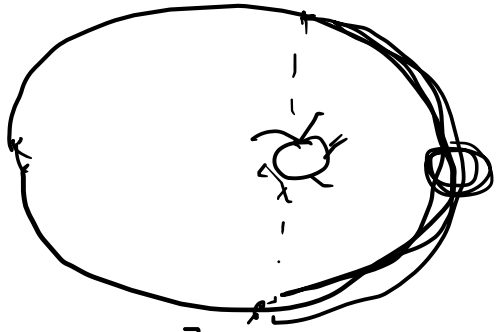
$$T \sim \frac{1}{\sqrt{G\rho}}$$

2a) $\alpha = 0,''1$ $\quad d = 40\,\text{Lk}$





$$a = d \cdot \sin\alpha = \frac{d\alpha''}{206265}$$

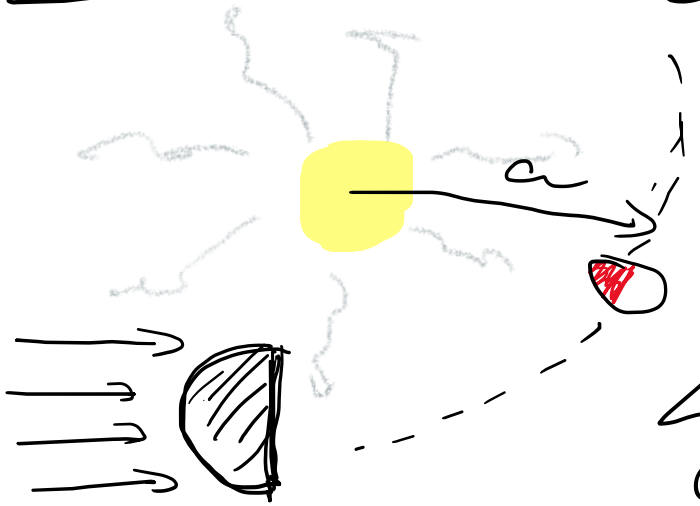


$$a[ae] = d[Lk] \cdot \alpha'' = 4ae.$$

$$P^2 = \frac{4\pi^2 a^3}{GM} = \frac{4\pi^2 \cdot 1,5\,64\,(1,5\cdot 10^{13})^3}{10^{-7}\cdot 2\cdot 10^{33}} = \ldots [s]$$

$P \equiv 8\,\text{ans}$

28) $L = 3L_0$ $A = 0.5$ $R_p = 1{,}4\, R_{Jup}$ $T = 1000\,K$



$$f_p = \frac{L}{4\pi a^2}$$

$$S = \pi R_p^2$$

$L_{упад} = f_p \cdot S$

$$[f_p] = \frac{эрг}{см^2 \cdot с}$$

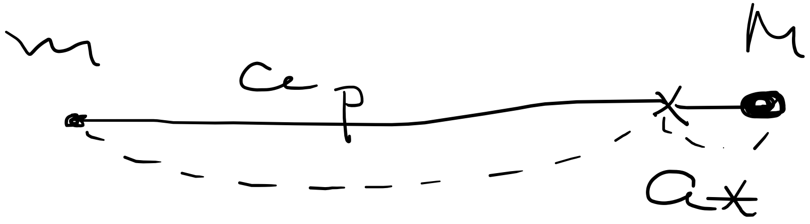
$L_{отр} = A \cdot L_{упад} = f_p \cdot S \cdot A =$

$= f_p \cdot \pi R_p^2 \cdot A = \frac{L}{4\pi a^2} \pi R_p^2 \cdot A$

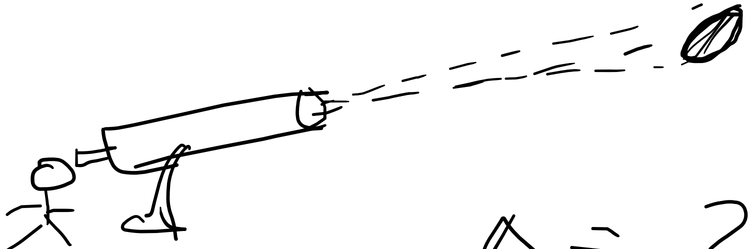
$L_{изл} = 4\pi R_p^2 \sigma T^4$ σ - пост. Стефана-Больцмана

$$\frac{L_{изл}}{L_{отр}} = \frac{4\pi R_p^2 \sigma T^4 \cdot 4\pi a^2}{L \cdot \pi R_p^2 A} = \frac{16\pi \sigma T^4 a^2}{L \cdot A} = 1{,}8 \cdot 10^6$$

3) Астрометрия



$$\frac{m}{M} = \frac{a_*}{a_p}$$



$$\Delta = 2a_*$$

$$\Delta = 2a_p \frac{m}{M}$$

$$\alpha_\Delta = \frac{\Delta}{d} = 2\frac{a_p}{d}\frac{m}{M}$$

5.2 а.е.
12 лет

Gaia → 4 года

$m \ll M \quad a_p \gg a_* \Rightarrow a_p \approx a$

$$a_p = \left(\frac{GMP^2}{4\pi^2}\right)^{1/3}$$

$$\alpha_\Delta = 2\frac{1}{d}\frac{m}{M}\left(\frac{GM}{4\pi^2}P^2\right)^{1/3} = 2\left(\frac{d}{\text{пк}}\right)^{-1}\left(\frac{m}{M}\right)\left(\frac{a}{\text{ае}}\right)$$

$\frac{1}{10}$ $\quad \frac{1}{1000} \quad \sim 10$

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5 Вариация луч. скорости

$$\frac{m}{M} = \frac{a_x}{a_p} \qquad v_x = \frac{2\pi a_x}{P_{orb}} =$$

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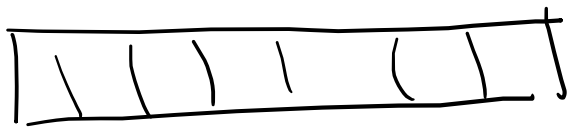
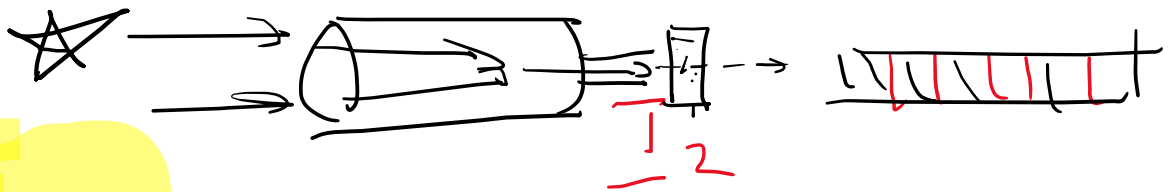
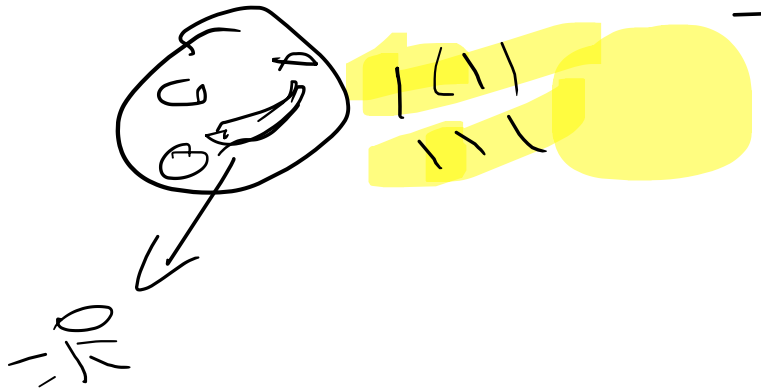
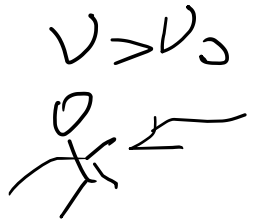
$$= 2\pi \frac{a_p}{P_{orb}} \frac{m}{M} =$$

$$= 2\pi \frac{1{,}5\cdot 10^{13}\ \text{cm}}{3{,}15\cdot 10^{7}\ \text{c}} \cdot \frac{6\cdot 10^{27}\ \text{г}}{2\cdot 10^{33}\ \text{г}} = g\,\frac{\text{cm}}{\text{c}} \left(\frac{a_p}{\text{a.e.}}\right)\left(\frac{P_{orb}}{\text{год}}\right)^{-1} \frac{m/M_\oplus}{M_*/M_\odot}$$

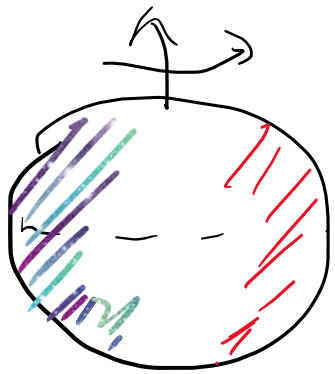


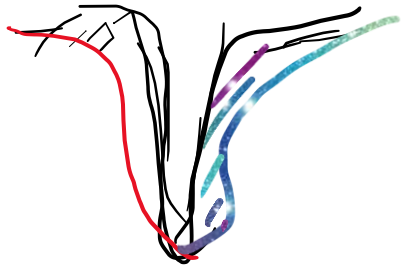






$$v_{бдам} = \frac{2\pi R_x}{P_{бдам}} = \frac{2\pi \cdot 6.9 \cdot 10^{10}\,см}{30 \cdot 24 \cdot 3600\,с} = 1{,}7 \cdot 10^{5}\,\frac{см}{с} = 1{,}7\,\frac{км}{с}$$





$$\rho = \frac{M_\odot}{\frac{4}{3}\pi R_\odot^3} \approx 1{,}4\,г/см^3$$

Пульсар $h = 10\,км$

$$P_\varphi \sim \frac{1}{\sqrt{G\rho}} \sim \sqrt{10^7}\,с \sim 3000\,с$$

$$v = \frac{2 \cdot 10^6\,см}{2 \cdot 10^3\,с} \cong \frac{10^3\,см}{с} \simeq 10\,\frac{м}{с}$$

5

$$T = \frac{2R_*}{v_{orb}} = \frac{2R_*}{2\pi a} P_{orb} = \frac{1}{14} P_{orb} \frac{R_*}{a}$$

$$v_{orb} = \sqrt{\frac{GM}{R}} = \frac{2\pi R}{P}$$

$$= \left(1{,}5 \cdot 10^{-3}\right)^{-1} \frac{R_*}{R_\odot} \left(\frac{a}{a_e}\right)^{-1} P_{orb}$$

$$\frac{dv_r}{dt} = \dot{v}_r = \frac{v_x^2}{a_x} = \frac{v_x}{a_x} \quad v_x = \frac{2\pi a_x}{P_{orb}} \quad v_x = 2\pi \frac{v_x}{P_{orb}}$$

$$\dot{v}_r = \frac{Gm}{a^2} =$$

$$F = G\frac{Mm}{a^2} = Mg$$

$$= \frac{Gm}{R_p^2} \frac{R_p^2}{a^2} = g_p \cdot \frac{R_p^2}{a^2} =$$

$$g = \frac{Gm}{a^2}$$

$$g_p = \frac{Gm}{R_p^2}$$

$$= g_p \frac{R_p^2}{R_x^2} \frac{R_x^2}{a^2} = 2\pi \frac{v_x}{P}$$

$$g_p = 2\pi \frac{v_x}{P_{orb}} \left(\frac{R_x}{R_p}\right)^2 \left(\frac{a}{R_x}\right)^2$$

Δf_{-1} — $\Delta f \left(\frac{R_p}{R_x}\right)$

наδ. транзит.

грави. транз

$$\rho_P = \frac{m}{\frac{4}{3}\pi R_P^3}$$

$$g_P = \frac{Gm}{R_P^2} = 1 \qquad m = \frac{g_P R_P^2}{G}$$

$$\rho_P = \frac{3 g_P}{4\pi G R_P} = \frac{3 g_P}{4\pi G R_K} \left(\frac{R_K}{R_P} \right)$$

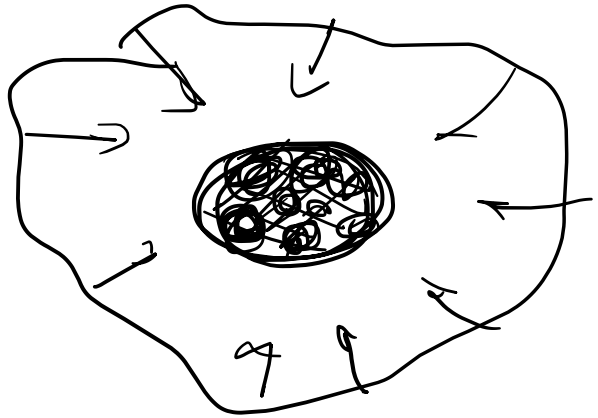
$$R_K = \theta \cdot d = \frac{\theta}{\pi''}$$

$$\rho_J = \frac{3 g_P \pi''}{4\pi G \theta}$$

$$\Delta f \sim \left(\frac{R_P}{R_K} \right)^2$$

$$\frac{\pi''}{R_P} \left(\frac{R_K}{R_P} \right)$$

6) Коллапс облака

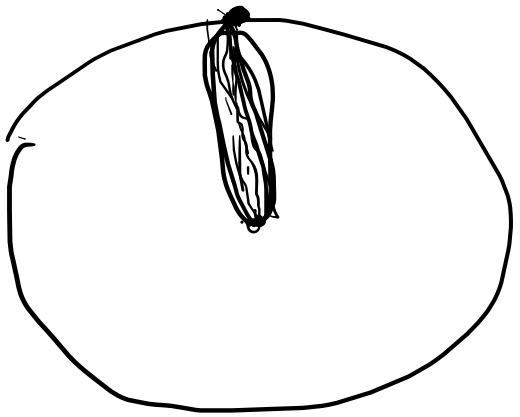


$M \simeq 10^6 M_\odot \quad D = 30$ пк

$$\rho = \frac{M}{\frac{4}{3}\pi\left(\frac{D}{2}\right)^3} = \frac{10^6 \cdot 2 \cdot 10^{33} \cdot 8 \cdot 3}{4\pi\left(30 \cdot 3{,}1 \cdot 10^{18}\right)^3} = 4{,}75 \cdot 10^{-21}\ г/см^3$$

$M: m_0 \simeq 10^{-24}$ г

$$n = \frac{\rho}{m_0} \simeq 5000\ см^{-3}$$



$$a = \frac{1}{2}R = \frac{1}{4}D = 7{,}5\ пк$$

$$T = \frac{1}{2}P_{орб} \qquad P_{орб}^2 = \frac{4\pi^2 a^3}{6m}$$

$$T = \frac{1}{2}\sqrt{\frac{4\pi^2 a^3}{6m}} = 10^6\ лет$$