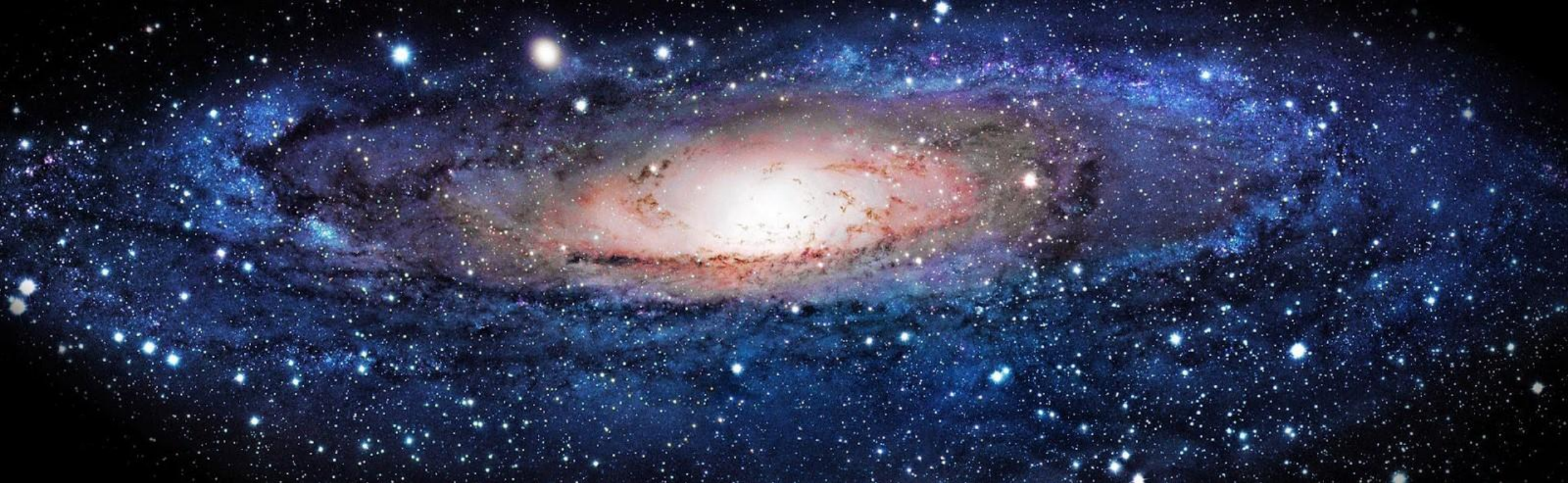


Модуль. Астрофизика.

Семинар 5. (27.11)

① Packing fraction ~90%

a) kick. Accumulation SN.

$v_{kick} \sim$ few. 100 km/s

$\Sigma_T > 0$

b). Close encounter $v_{kick} \ll v_{orb}$

M_1 ● —— r_1 × r_2 —— ● M_2 $\quad M_1 \sim M_2 = M$

$$P^2 = \frac{4\pi^2 a^3}{G(M_1+M_2)} = \frac{4\pi^2 8r^3}{2GM}$$

$$v_{orb} = \frac{2\pi r}{P} \qquad v_{orb}^2 = \frac{1}{4}\frac{GM}{r}$$

$$2a = r_{max} + r_{min} = 4r$$

$$a = 2r$$

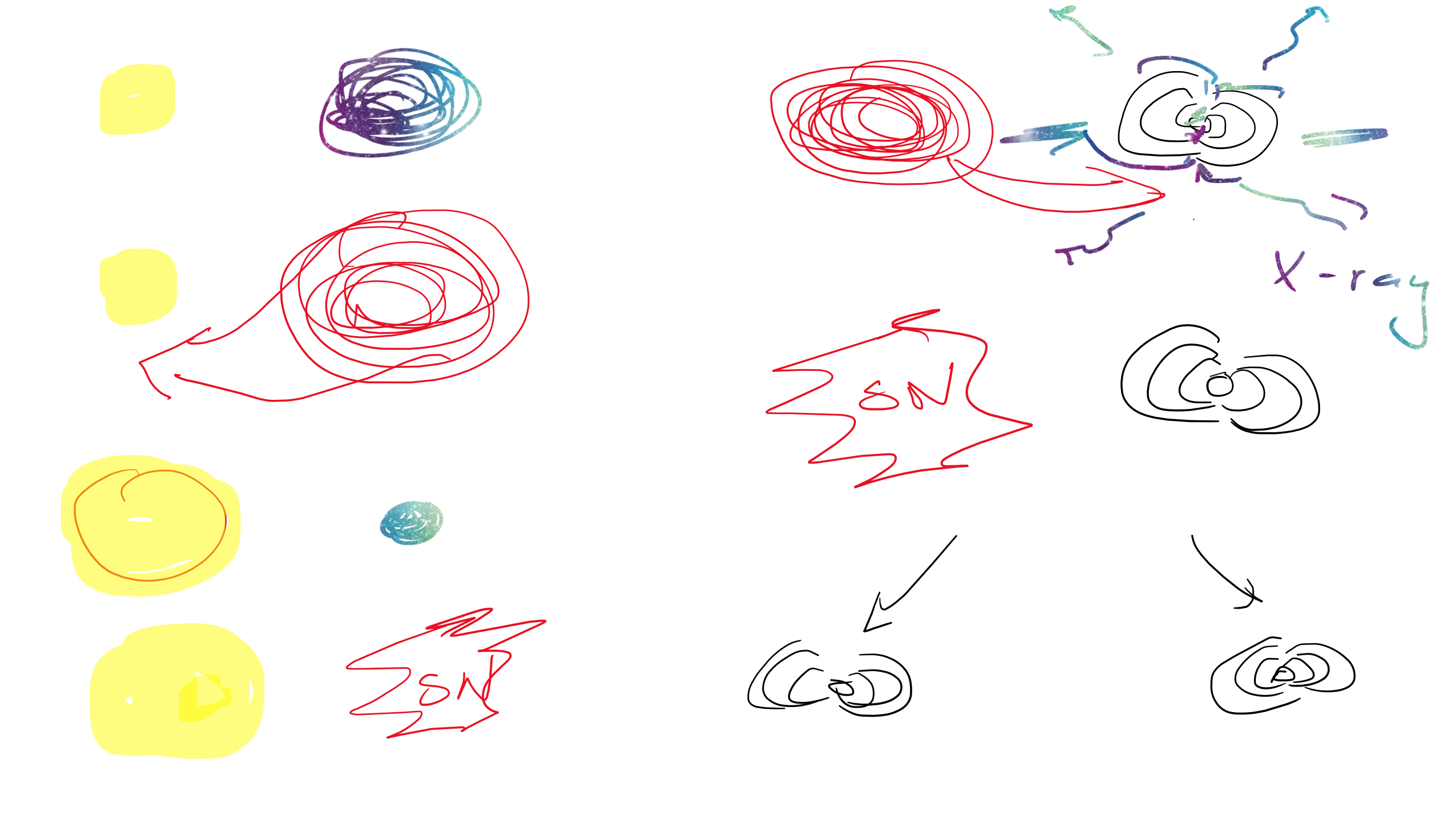
$$E_k = E_{kr}^{(1)} + E_k^{(2)} = \frac{GMM}{4r}$$

$$E_p = -\frac{GM^2}{2r}$$

$$E_T = E_k + E_p = -\frac{1}{4}\frac{GM^2}{r}$$

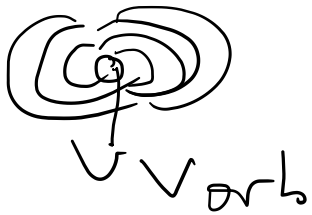
$\Rightarrow \quad \Delta M = \frac{1}{2} M_{tot}$, so

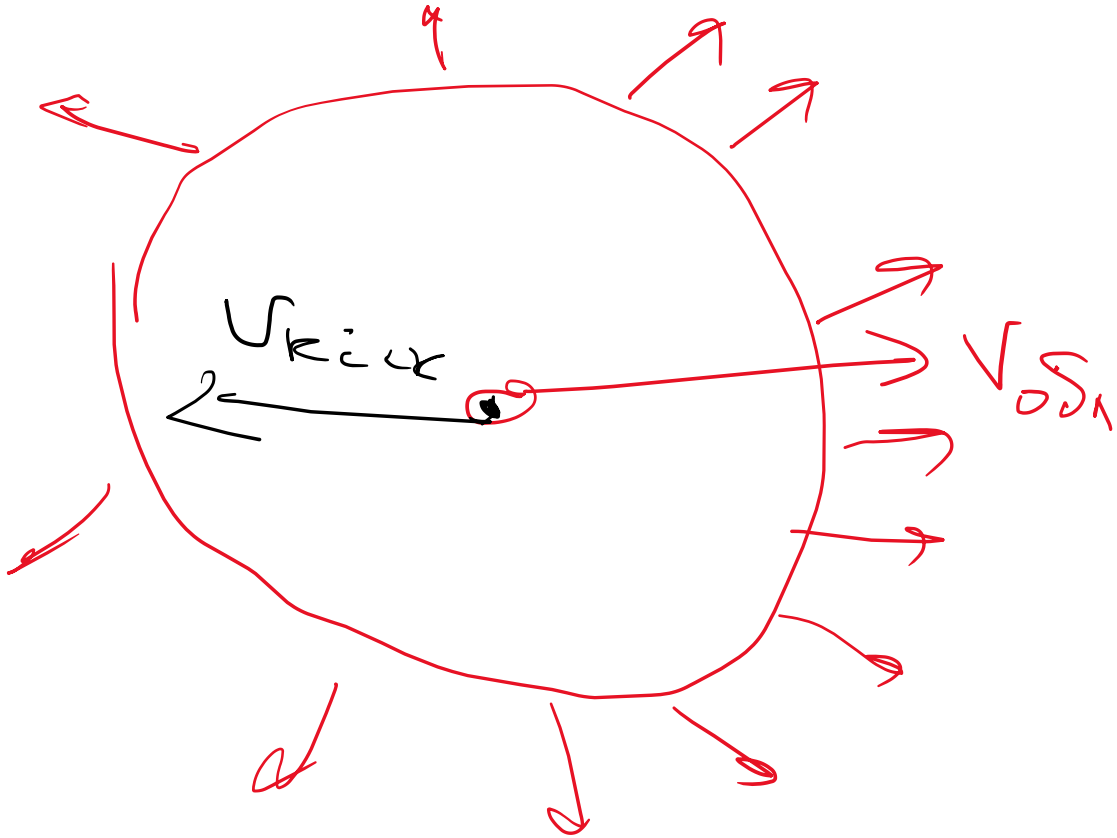
$E_T = 0$

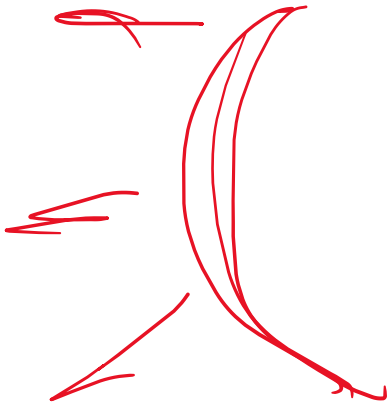

X-ray
SN
SN

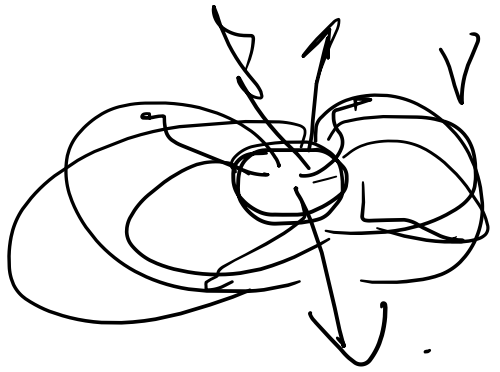

$v \sim 10^{-4}$
c
$v_{orb}^{(2)}$
X
$v_{orb}^{(2)}$
X
v_{orb}


$v_{orb}^{(1)}$

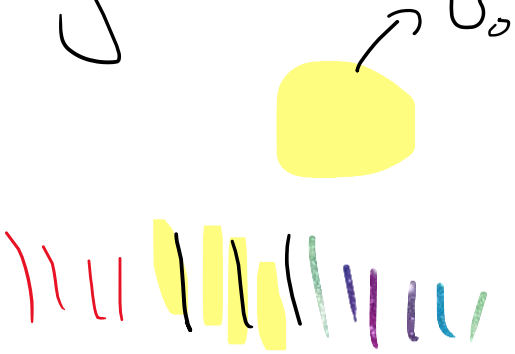

v_{orb}


v_{kick}
v_{osc}




v

2. Функция масс



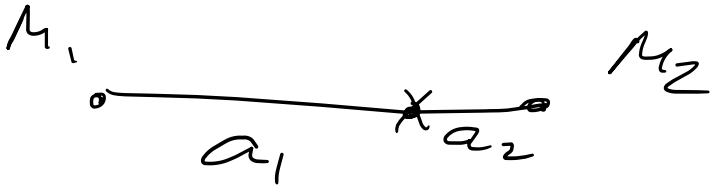
$M > 3M_\odot \Rightarrow$ BH

Ruffini

3,2 $M_\odot$

$\rho \uparrow \; v_s \uparrow$

$v_s = c$



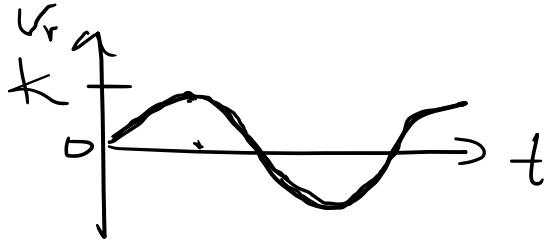
$$a = a_1 + a_2$$

$$a_1 M_1 = a_2 M_2$$

$$a = a_1\left(1 + \frac{a_2}{a_1}\right) = \frac{a_1}{M_2}(M_1 + M_2)$$

$$p^2 = \frac{4\pi^2 a^3}{G(M_1+M_2)} = \frac{4\pi^2}{G(M_1+M_2)} \frac{a_1^3}{M_2^3}(M_1+M_2)^3$$

$$v_1 = \frac{2\pi a_1}{P} \qquad \underline{\underline{K = a_1 \cdot \frac{2\pi}{P} \cdot \sin i}}$$

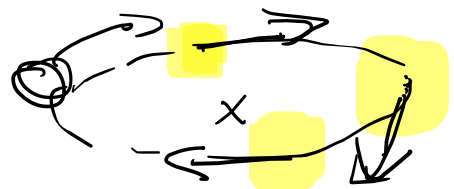


$$a_1 = \frac{P}{2\pi} \frac{1}{\sin i} K$$

$$P^2 = \frac{4\pi^2}{G} \frac{(M_1+M_2)^2}{M_2^3} \cdot \frac{P^3}{8\pi^3} \frac{1}{\sin^3 i} K^3$$

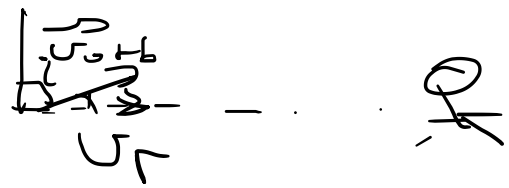
K – полуамплитуда кривой лучевых скоростей

$$\boxed{\frac{P}{2\pi} K \frac{1}{G}} = \frac{M_2^3}{(M_1+M_2)^2} \sin^3 i \equiv f$$



$$q \equiv \frac{M_1}{M_2} \qquad f = \frac{M_2}{(1+q)^3} \sin^3 i$$

$$M_2 = f \underbrace{(1+q)^3}_{>1} \underbrace{\sin^{-3} i}_{>1} \qquad f = M_2^{(m+4)}$$

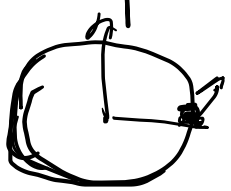


3. Энергия НЗ (вращение, мин. масса, аккреция)

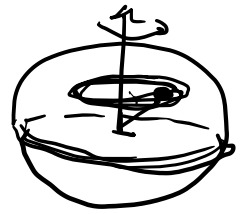
а) Вращение

$\omega = 2\pi/P$ P_{min}

$E_{вр} = \frac{I\omega^2}{2}$ I – момент инерции



$v_{eq} = \frac{2\pi R}{P_{min}} = \sqrt{\frac{GM}{R}}$



$I \sim MR^2$

$P_{min} = 2\pi\sqrt{\frac{R^3}{GM}}$

$I_{NS} \sim 10^{45}\ г\cdot см^2$

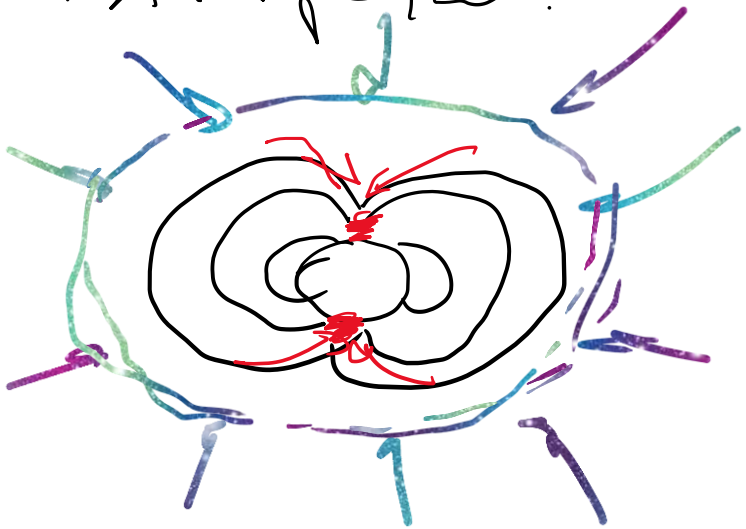
$P_{min}^{NS} \simeq 0.001\ с$

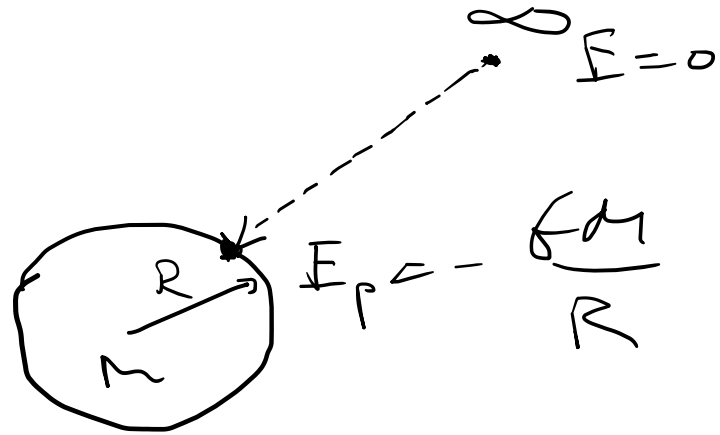
$\frac{M}{R^3} \sim \rho$ $P_{min} \sim \frac{1}{\sqrt{\rho}}$

$\frac{1}{P} = 716\ Гц \leftarrow$ наблюд.

$E_{вр}^{max} = \frac{I}{2}\frac{2\pi^2}{P_{min}^2} \sim 2\cdot 10^{45}\cdot 10\cdot\frac{1}{10^{-6}} = 2\cdot 10^{52}\ эрг.$

δ. Аккреция.





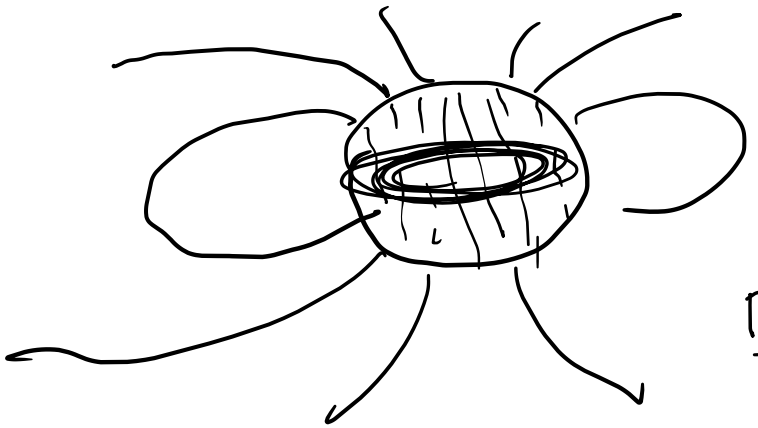
$mc^2 \sim 9 \cdot 10^{20}$ эрг

$1_2 \Rightarrow E \sim \frac{GM}{R}$

$\frac{10^{-7} \cdot 1{,}5 \cdot 2 \cdot 10^{33}}{1.5 \cdot 10^6} \simeq 2 \cdot 10^{20}$ эрг

эфф. КПД $\sim 10\% \, mc^2$

б. Маг. поле $\mathcal{E} = B^2/8\pi$



$B_d \sim \frac{1}{r^3}$

$[B] = \Gamma c$

$B_{max} = ?$

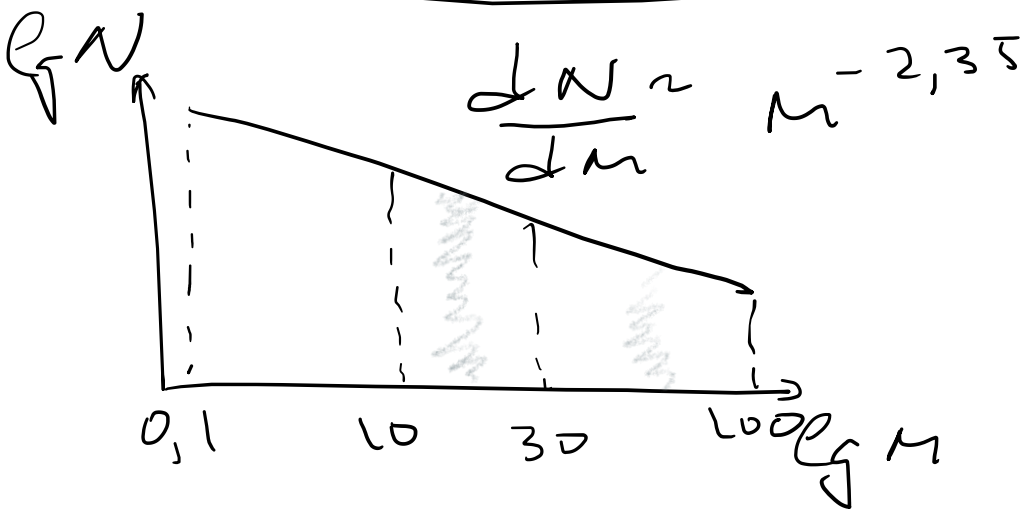
$\rightarrow E_{mag} = \frac{B^2}{8\pi} \frac{4}{3}\pi R^3 = \frac{B^2 R^3}{6} =$

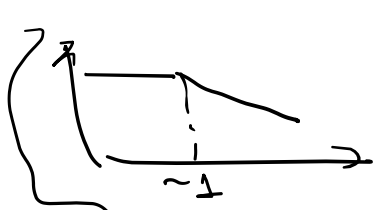
$= \frac{(10^{15}\Gamma c)^2 (10^6 см)^3}{} \simeq 1{,}5 \cdot 10^{47}$ эрг

$\frac{B^2 R^3}{6} = \frac{GM^2}{R}$

$B_{max} = \left[\frac{6GM^2}{R^4}\right]^{\frac{1}{3}} = \text{few} \cdot 10^{18} \Gamma c$

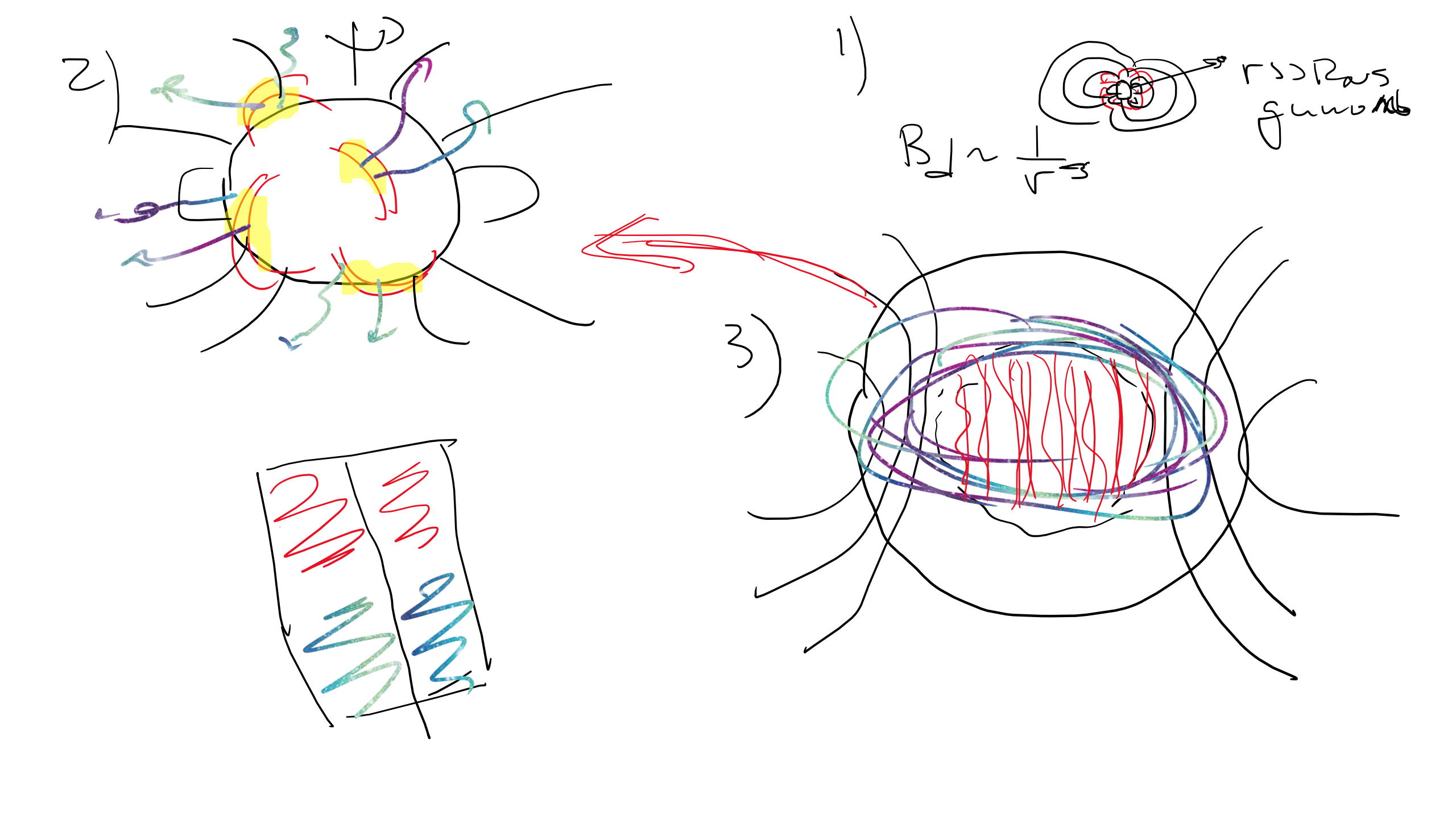
4. Donc NS - BH.



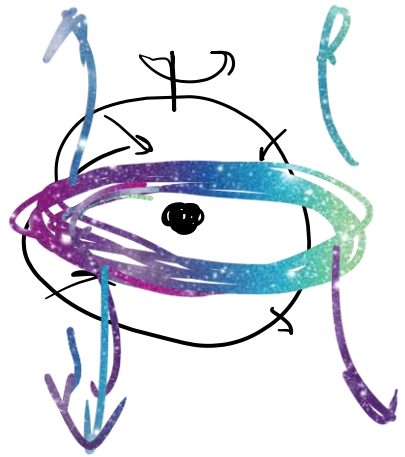


$$\langle a \rangle = \frac{A_1 \int + A_2 \int}{A_1 \int + A_2 \int}$$

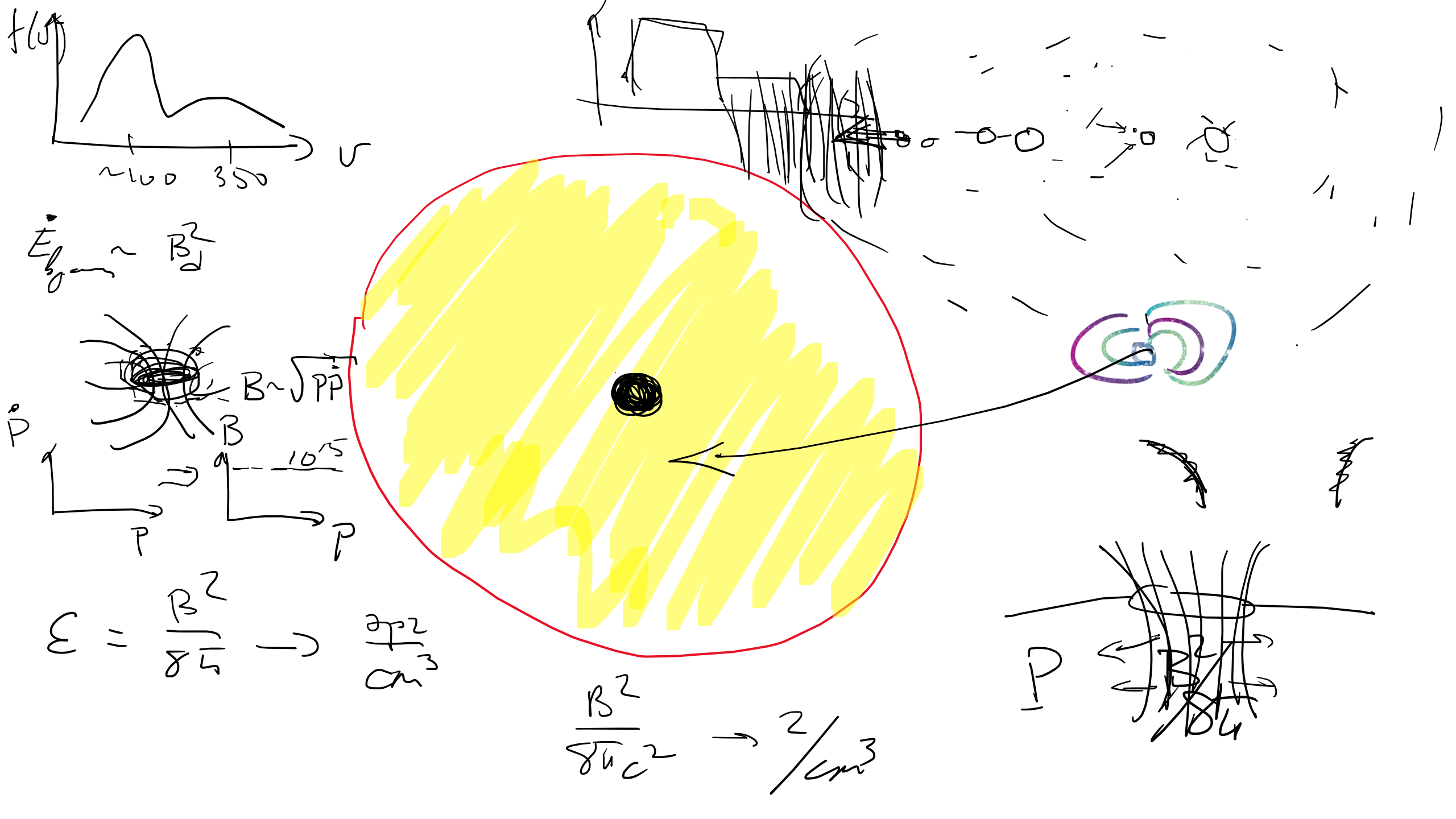
$$\frac{N_{NS}}{N_{BH}} = \frac{A \int_{10}^{30} M^{-2,35} dM}{A \int_{30}^{100} M^{-2,35} dM} \simeq \left(\frac{30}{10}\right)^{1.35} \simeq 4,5$$

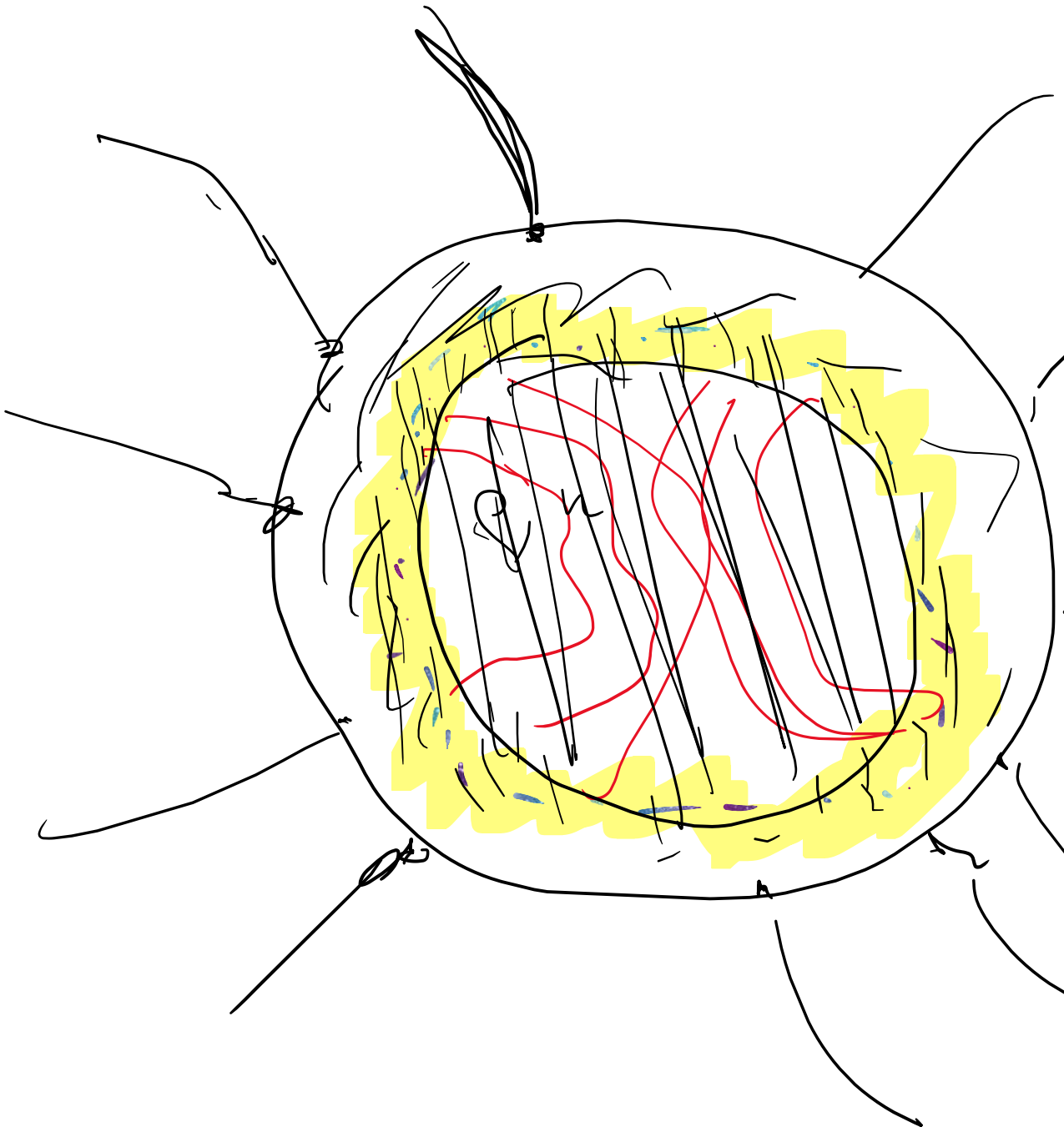

2)
1)
$B_\perp \sim \frac{1}{r^3}$
3)

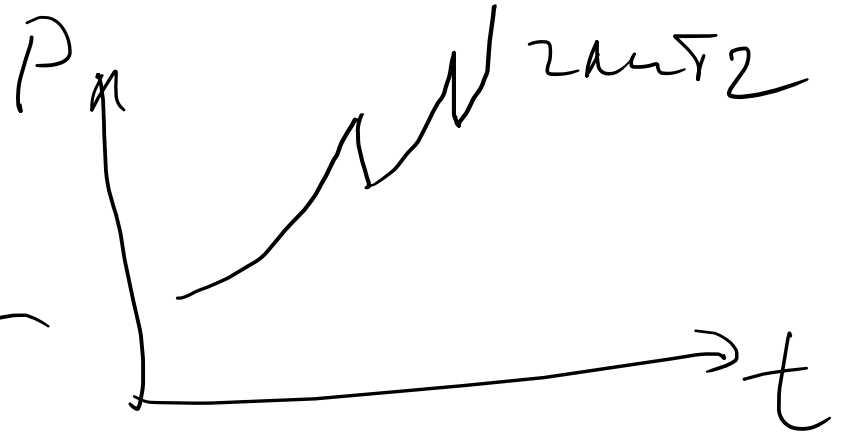

μ
QC
R




P, μ
Pc


f(ν)
~100
350
ν
$\dot{E}_{loss} \sim B_d^2$
B
$B \sim \sqrt{P\dot{P}}$
$\dot{P}$
P
10^{15}
P
$\varepsilon = \frac{B^2}{8\pi}$
$\frac{erg}{cm^3}$
$\frac{B^2}{8\pi c^2}$
g/cm^3
P





$$\frac{I_{sh}}{I} \sim 1{,}4\%$$

$$-\frac{\Delta V}{V} \rightarrow$$

$$V = \frac{1}{P}$$