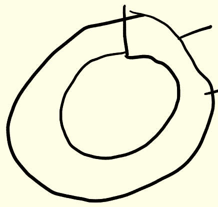
1.) $d = 1 \; mm^3 = 10^{-3} \; m^3$

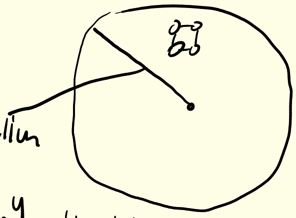


10%

$V = \frac{4}{3}\pi r^3$

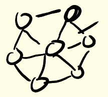
$N \sim 5 \cdot 10^{22}$

with $4\pi R^2 \cdot d$



r = 15 billion

$r = 15 \cdot 10^9$ light years



triangle

$\frac{15 \text{ billion}}{5 \text{ billion}} = 3000$

$5 \cdot 10^6$ light years

$15 \cdot 10^9$ light years

$\underline{V}(3000) \sim 10^{22}$

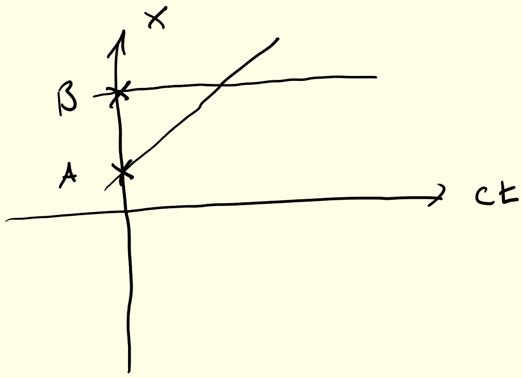
3.) $ds^2 = -dt^2 + a(t)^2 (dx^2 + dy^2 + dz^2)$

$g_{\mu\nu} = \begin{pmatrix} -1 & & \\ & a & \\ & & a_{\omega} \end{pmatrix}$

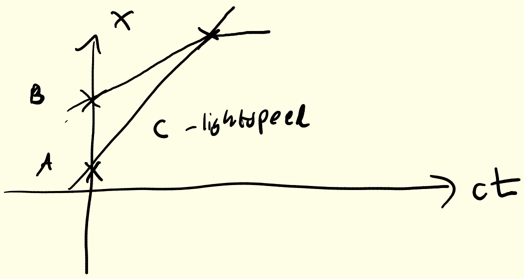
6.)

a.) What is outside of the universe?
There is no outside. Imagine a sphere, the universe is sphere. This sphere has no boundaries.
b.) What does the universe expand into?
The expansion happens everywhere. It is just expanding the space, not into something.
c.) Why equipment not expanding?
Because, the used math modell just works in empty space, in the near of gravitating objects we have the Schwarzschild metric. So there is no expands in our equipment.
d.) Center of universe the Earth?
No, everywhere we have expansion. It is like to be on the sphere, everywhere it looks the same.
e.) Where did the big gang happen?
Everywhere, there is no point of origin. Like on the sphere. Every point is accelerating.

5.) Redshift:
Situation A,B
A static universe. So no expansion
A and B at rest. A send a signal. B is moving



no redshift



Situation C,D
universe is expanding. We have redshift, the spacetime is expanding.

$$v_0 = v_R \frac{a(t_R)}{a(t_0)}$$

$$v_R = v_0 \frac{a(t_0)}{a(t_R)} = \frac{v_0}{2}$$

4.)

$$\int d\tilde{t} = \int_0^{a=1} \frac{da}{aH} \qquad \left(\frac{H}{H_0}\right)^2 = \frac{\Omega_r}{a^4} + \frac{\Omega_m}{a^3} + \frac{\Omega_k}{a^2} + \Omega_\Lambda$$

$$H = \sqrt{H_0\left(\frac{\Omega_r}{a^4} + \frac{\Omega_m}{a^3} + \frac{\Omega_k}{a^2} + \Omega_\Lambda\right)}$$

$$\int d\tilde{t} = \int_0^{a=1} \frac{da}{a\sqrt{H_0\left(\frac{\Omega_r}{a^4} + \frac{\Omega_m}{a^3} + \frac{\Omega_k}{a^2} + \Omega_\Lambda\right)}}$$

$$t = \int_0^{a=1} \frac{da}{\sqrt{H_0\left(\frac{\Omega_r}{a^2} + \frac{\Omega_m}{a} + \Omega_k + a^2\Omega_\Lambda\right)}}$$

maybe use $u = \frac{a}{a_0}$

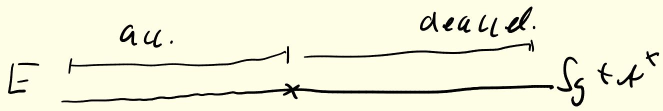
i.) $t = 0{,}960 \frac{1}{H_0} = 13{,}8 \cdot 10^9$ yr

ii.) Ω_m only $\Omega_m = 1$

$t_0 = \frac{2}{3H_0}$ $\quad t = \int \frac{da}{H_0} \sqrt{a}$

iii.) $t_0 = 13{,}76 \cdot 10^9$ yrs for $\Omega_r = 0$

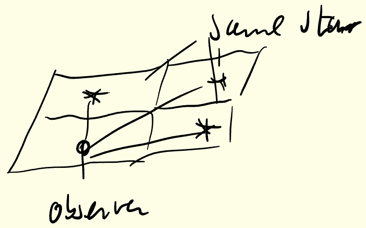
2.)



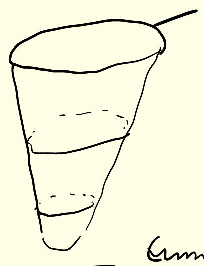
$t = \frac{1}{g} \sinh(g\tau)$ — Hyperbolic motion

$x = \frac{1}{g} \cosh(g\tau)$

repeating patterns for hzperbolic universe



you would see them in see sky repeated star points from the same star



7.) age $\sim 10^{60}$

size $\sim 10^{60}$

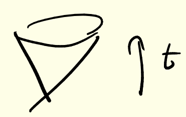
scale factor

$\ell = a \cdot \ell_0$

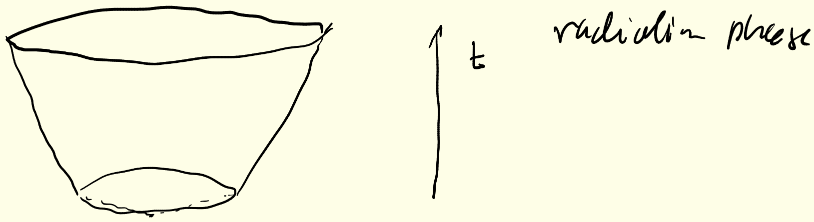
$a = a_0 t^{1/2}$

$= 10^{60} \left(\frac{t}{10^{60}}\right)^{1/2} \approx 10^{30} t^{1/2}$

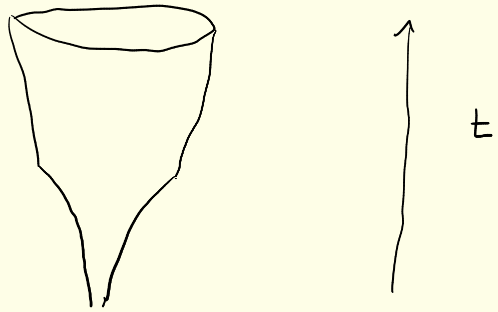
at $t = 1$ Planck time $\quad a = 10^{30}$



in the first planck time is has to be grow over 10^30 magnitudes some solution:



or



total energy in GR not well defined or complicated to define and us

try to define entropy in GR is not well made

where the energy of the redshift light goes?
Maybe in gravitational fields