1.1

1.2

4Mpc

~~$V_A = 65 \; 2,094 \; km/s$~~

$V_A = 215 \; km/s$ 1,5' 1,7kpc

$V_B = 528 \; km/s$ 6,5' 7,6kpc

$V_C = 613 \; km/s$ 10' 12kpc

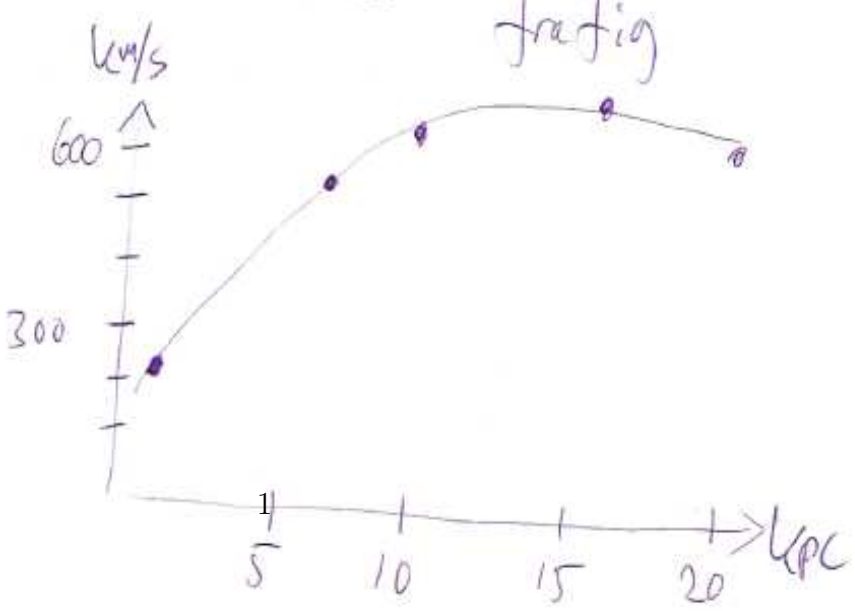
$V_D = 641 \; km/s$ 15,5' 18kpc

$V_E = 613 \; km/s$ 19' 22kpc

$V = \left(\frac{\lambda - \lambda_0}{\lambda_0}\right) c$

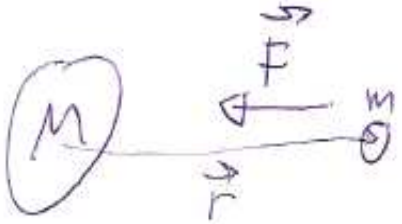
$d = 4Mpc \cdot \Delta t$

1.3



1.3

$$\vec{F} = m\vec{a}$$



$$-\frac{GMm}{r^3}\vec{r} = m\ddot{\vec{r}}$$

1.4

$$\vec{r} = r\vec{e}_r$$

$$\dot{\vec{r}} = \dot{r}\vec{e}_r + r\dot{\vec{e}}_r = r\dot{\theta}\vec{e}_\theta = V_\theta\vec{e}_\theta$$

Sirkulær bane!

$= V_\theta$

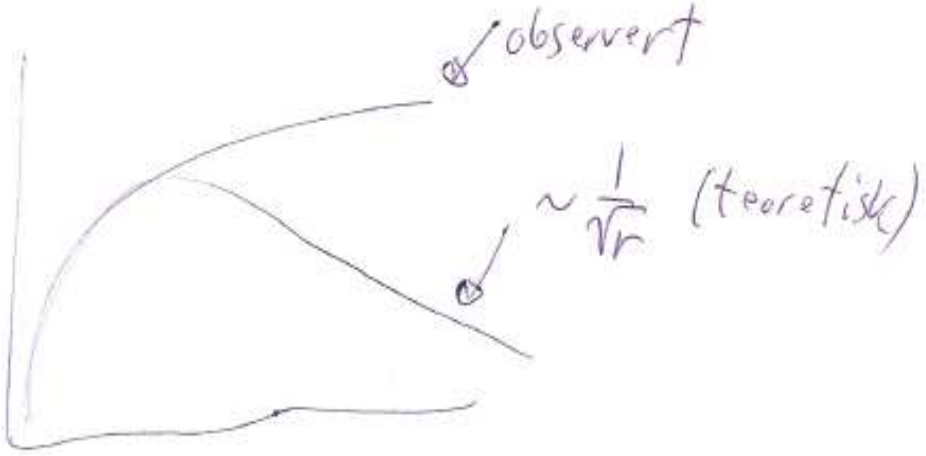
1.5

$$-\frac{GM}{r^2}\vec{e}_r = \ddot{\vec{r}} = \dot{V}_\theta\vec{e}_\theta + V_\theta\dot{\vec{e}}_\theta = -\dot{\theta}V_\theta\vec{e}_r = -\frac{V_\theta^2}{r}\vec{e}_r$$

konst. hast. i sirk. bane

$$\frac{GM}{r^2} = \frac{V_\theta^2}{r} \Rightarrow V_\theta = \sqrt{\frac{GM}{r}}$$

(1.6)



Mark materie $M = M(r)$

$$\Rightarrow V_\theta = \sqrt{\frac{GM(r)}{r}}$$

(1.7)

$$\vec{F} = m\vec{a}$$

$$-G\frac{M}{r^3}\vec{r} = \frac{|\ddot{\vec{r}}|}{a_0}\ddot{\vec{r}}$$

$$\Rightarrow G\frac{M}{r^2} = \frac{V_\theta^2}{r}\cdot\frac{|\ddot{\vec{r}}|}{a_0} = \frac{V_\theta^4}{r^2 a_0}$$

$$\ddot{\vec{r}} = \ddot{r}\vec{e}_\theta + r\ddot{\theta}\vec{e}_\theta - r\dot{\theta}^2\vec{e}_r$$

sink bev

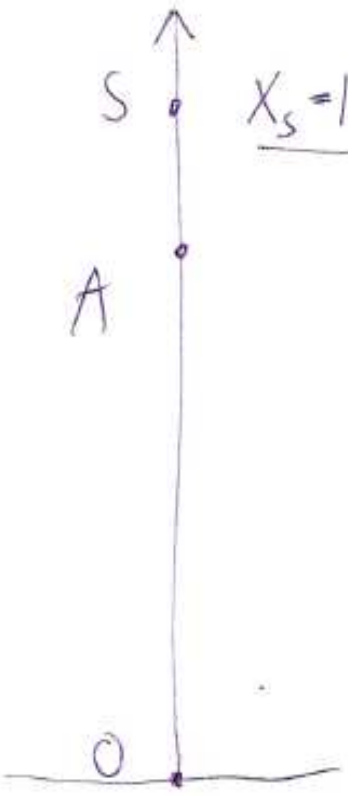
$$|\ddot{\vec{r}}| = |r\dot{\theta}^2\vec{e}_r| = \frac{V_\theta^2}{r}$$

(17) $\Rightarrow$ $G\frac{M}{r^2} = \frac{V_0^4}{r^2 a_0}$

$\Rightarrow$ $V_0 = \sqrt[4]{GMa_0}$ lagt ute!

$$a_0 = \frac{V_0^4}{GM} \approx \frac{(620\,km/s)^4}{G \cdot 2\cdot 10^{11} \cdot 2\cdot 10^{30} kg} \approx 5{,}5\cdot 10^{-9} \frac{m}{s^2}$$

2.1



event 0 = $X = X' = 0$
$t = t' = 0$

event A: $X = X_A = vt_A$
$t = t_A$
$X' = 0$
$t' = t'_S$ = 1,5 år

event S: $X = X_S$ = 130pc
$t = t_S$
$X' = X'_S$
$t' = t'_S$

2.1

OS: $t_s^2 - x_s^2 = t_s'^2 - x_s'^2$

OA: $t_A^2 - v^2 t_A^2 = t_s'^2 \Rightarrow t_A = \frac{t_s'}{\sqrt{1-v^2}} = 335$

AS: $(t_A - t_s)^2 - (v t_A - x_s)^2 = 0 - x_s'^2$

OS-AS: $t_s^2 - x_s^2 - t_A^2 - t_s^2 + 2 t_A t_s + v^2 t_A^2 + x_s^2 - 2 v t_A$

$= t_s'^2$

$\Rightarrow t_s = \frac{t_s'^2 + 2 v t_A x_s - v^2 t_A^2 + t_A^2}{2 t_A}$

Setter inn for t_A:

$t_s = \frac{t_s' \sqrt{1-v^2}}{2} + v x_s + \frac{t_s' \sqrt{1-v^2}}{2}$

$= t_s' \sqrt{1-v^2} + v x_s =$ [redacted]

423,80247

OS: $x_s' = \sqrt{t_s'^2 + x_s^2 - t_s^2} = 0,4$ ly.

2.2 Legger x-aksen langs fartsretningen og får

$$V_\mu = \frac{1}{\sqrt{1-v^2}}(1, v, 0, 0)$$

$$U_\mu = \frac{1}{\sqrt{1-u^2}}(1, u, 0, 0)$$

2.3 $V'_\mu = C_{\mu\nu} V_\nu$

$$\begin{pmatrix} \gamma_{v''} \\ \gamma_{v''}v'' \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} \gamma_{rel} & -v_{rel}\gamma_{rel} & 0 & 0 \\ -v_{rel}\gamma_{rel} & \gamma_{rel} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \gamma_v \\ \gamma_v v \\ 0 \\ 0 \end{pmatrix}$$

$$\gamma_v = \frac{1}{\sqrt{1-v^2}} \quad \gamma_{v'} = \frac{1}{\sqrt{1-v'^2}} \quad \gamma_{rel} = \frac{1}{\sqrt{1-v_{rel}^2}}$$

$$\boxed{v_{rel} = u} \quad \boxed{\gamma_{rel} = \gamma_u}$$

v'' er hast. av mitt romskip observert fra det andre romskipet

$$\Rightarrow \begin{aligned} \gamma_{v''} &= \gamma_u\gamma_v - u\gamma_u\gamma_v v \quad (1) \\ \gamma_{v''}v'' &= -u\gamma_u\gamma_v + \gamma_u\gamma_v v \quad (2) \end{aligned}$$

deler (2)/(1):

$$v'' = \underline{\frac{v-u}{1-uv}}$$

(2.4) Ditt romskip har akselerert, kan IKKE bruke ditt ref. syst (vi kalde måtet vite alle detaljer omkring akselrasjonen).

Posisjonen til romskipet ditt X_1, sett fra jorden på et gitt tidspunkt t ETTER t_A:

$$X_1 = \underbrace{vt_A}_{\text{posisjon til event A}} - \underbrace{v(t-t_A)}_{\text{avstand tilbakelagt på tilbakeveien}}$$

$$= 2vt_A - vt$$

Posisjon til det andre romskipet X_2:

$$X_2 = ut$$

~~Det~~ Vi møtes: $X_1 = X_2$

$$\Rightarrow 2vt_A - vt = ut$$

$$\Rightarrow t = \frac{2vt_A}{u+v}$$

Som er tidspunktet når vi møtes sett fra jorda.

$= 338{,}17$ år

(2.5) Vi skal finne tidspunktet til event M (når vi møtes) i det andre romskipet

event M: $x = ut_M$, $t = t_M$

$x'' = 0$, $t'' = t_M'' = ?$

Bruker Δs_{OM}: $t_M^2 - u^2 t_M^2 = t_M''^2$

$$t_M'' = t_M\sqrt{1-u^2} = \frac{2vt_A}{u+v}\sqrt{1-u^2}$$

$$= 15 \text{ år}$$