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Cosmole	sgy 18/9-14	·
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For 24 Park	7+1=	Defendre value
	a(te)	light was
observe z-sceta(t)		emitted!

## Cosmology 18/9-14

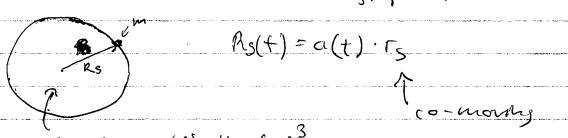
Wow to physics ... we need GR

27 but we'll first in traduce

equations they device theces

Fredman:

-We'll derive it from thutorian physics.



 $M_S = \rho V = \rho(f) \cdot \frac{u}{3} \pi (R_S)^3$ 

 $M_S = p(t) \frac{\mu}{3} \pi (a(t) r_s)^3$  \quad \quad \quad \text{unass of sphere}

Acceleration on surface is important.

Acceleration on surface is important.

We dropped up

That noteina=
$$f = CrMsMr$$
 $R_s(t)^2$ 

Multiply these theorems

L>=a

$$=) \quad \alpha = -\frac{GMs}{R_s(t)^2} = \frac{d^2R_s}{dt^2}$$

$$= \frac{dR_s}{dt} \frac{d}{dt} \left( \frac{dR_s}{dt} \right) = -\frac{GM_s}{R_s(t)^2} \left( \frac{dR_s}{dt} \right)$$
that i went by dt.

=> 
$$\int \left(\frac{dR_s}{dt}\right) d\left(\frac{dR_s}{dt}\right) = \int -\frac{GM_s}{R_s lt]^2} dR_s$$

$$= \frac{1}{2} \left( \frac{dR_s}{dt} \right)^2 = + \frac{GMs}{R_s(t)} + \frac{1}{R_s(t)} \left( \frac{e^{-t} e^{-t} g(t)}{R_s(t)} \right)^2$$

hine tie energy

crown taken on pot energy per unit mass

18/9-14
Freedman
We have that drs = ars a Rs=ars
We much My from before: Ms= p(t) 4 7 93(t) vs3
$= \frac{1}{2} \frac{a^{2} r_{s}^{2} - G}{a(t) \frac{3\pi a(t)^{3} \cdot r_{s}^{3}}{a(t) r_{s}}} + U$
$= 5 \frac{1}{2} a^{2} r_{8}^{2} = \frac{4}{3} \pi \ln \varphi(t) a(t)^{2} r_{8}^{2} + 4$
=) $a^2 = \frac{8}{3} \pi \ln p(t) a(t)^2 + \frac{7u}{r^2}$
$= \frac{\left(\frac{\dot{a}}{a}\right)^2}{\left(\frac{\dot{a}}{a}\right)^2} = \frac{e}{3} \pi G p(t) + \frac{24}{5^2 a(t)^2}$ $= \frac{e}{3} \pi G p(t) + \frac{24}{5^2 a(t)^$
Freedman
est cases :
=) à is also positive  => à is also positive  => expoursion & never stops.
# UCO: Right-hand-side unight start positive
expansion -> Contraction (Closed)
it à = o at one point screu

24 Ms = 24 =) [amax = MsG /

Cosmology 1879-14

1879-14	
Freeduren .	
xif u=0 high hand side always positive	
Flat] => Universe expands forever.	
Neutonian feur	
$\frac{a}{a} = \frac{8}{3} \pi \ln \alpha(t) + \frac{2u}{rs^2 a(t)^2}$	
CAR-form 08 Freedman:  18(4) hebre 2u be tire.	10=E
CAR form of Freedman: $\frac{(a)^2 - 8\pi G}{3} \mathcal{E}(f) - \frac{(c^3)}{R^2} \frac{1}{a^2} $ $h$	conaher
evergy den sity	constant.
(consist of ractuather + dosh every)	and the second s
Non we play with Freedman eq ( hih:	J. C.
$v_p(t) = \frac{\dot{a}}{a}dp(t)$ $H(t) = \frac{\dot{a}}{a}$ $H(t_0) = 70$	nils/mpc
Find Hubble diThane with Freedman	and a second contract of the c
$H(fo)^2 = Ho^2 = \frac{8\pi G}{3} e_0 - \frac{kc^2}{R^2}$ if $e_0 = 0$	

=)  $R^2 = -\frac{kc^2}{H^2}$  will only work for k < 0 = -1

Hubble distance with Freduce
If k=-1
=) R = = dh(fu) =
The * compute energy donsity Eo?
$H(t)^{2} = \frac{817G}{3} E(t) - \frac{kc^{7}}{R^{2}a^{2}}$
if k = = > flat uni => criptal energy cleus.
$H(t) = \frac{8\pi G}{3}  \epsilon(t) = \int \frac{\epsilon(t)^2}{\delta G}  \frac{3c^2}{\delta G}$
if k=D we get this.
Hono if E(+) is flus execut thing our Universers
$f(at)$ if $\mathcal{E}(t) > \mathcal{E}_{e}(t) = 5$ $K=+1$ $f(at)$ pastive comp
2) If $E(t) \leq E_{c}(t) = J$ $k = -1$ } negative course
3) if E(t) = E((t) => u=0 F(at wii!
that; imp to leave in curvature but our observations imply that $k=0$ kind of weird coincide are.
We leave in k for non for school completeness of equations

Cosmo 18/9-14
me can can pute $\frac{1}{8}$ (to) = Holl $\frac{2}{3}$ (to)
House we know what it should be
today.
Ec(to)= \$200 del & Contracterary durity podows.
ge(to) = Ee(to) = 9.2.10 -27 mg = 1.4.10 11 No
density today if k=0.
We naw define $\Omega$ : $I(t) = \frac{\mathcal{E}(t)}{\hat{\mathcal{E}}_c(t)}$ $\frac{\mathcal{E}(t)}{\hat{\mathcal{E}}_c(t)}$ $\frac{\mathcal{E}(t)}{\mathcal{E}_c(t)}$
$=)  \mathcal{E}(t) = \mathcal{N}(t) \cdot \mathcal{E}_{c}(t)$
=) $E(t) = \mathcal{N}(t) \cdot H(t)^{2} \cdot 3c^{2}$ $E(t) = \mathcal{N}(t) \cdot H(t)^{2} \cdot 3c^{2}$ But Mus into Freedmann eq
to get Freed was (II)
$H(t)^{2} = \frac{81757}{362} \left( \Lambda(t) \cdot H(t)^{2} \right) \cdot \frac{362}{816} - \frac{kc^{2}}{R^{2}a^{2}}$ Chevent
-> $(1-\Lambda(t))H(t)^{2} = -\frac{hc^{2}}{R^{2}a^{2}}$ Les $\frac{k}{R^{2}} = \frac{a(t)^{2}H(t)(\Lambda(t)-1)}{c^{2}}$
indian al + 1 m

K = Ho2 (20-1)

if k=0 frey run is fich and No=1