

Title: What's Blowing up the Universe?

Date: Aug 19, 2009 01:05 PM

URL: <http://pirsa.org/09080055>

Abstract: The reason cosmologists have a job is that the Universe as a whole -- the stuff between planets and stars and galaxies -- is, despite first appearances, a pretty interesting place. The strangest fact about it is that it's expanding, and always has been, as far as we know (and though Einstein's theory of gravity predicts this, Albert himself didn't much care for the idea, at least at first). After about seventy years -- it was discovered in 1929 -- this expansion was kind of old hat, but then new observations came around that shattered the old complacency. The old idea was that the Universe was expanding, but slowing down as it went -- since gravity, as far as anyone knew, could only cause attractive forces. What the new observations demonstrated is that the Universe's expansion is, in fact, accelerating -- getting faster with time. This is so shocking that most astronomers and cosmologists couldn't believe it at first, and some still don't. In this talk, I'll explain a bit about how we know this, why it's so shocking, and tell you something about the crazy ideas people at Perimeter have for what's going on.

Welcome Mark Wyman

Talk title    What is the weight  
of Nothing?



vacuum

WHAT IS THE MEANING

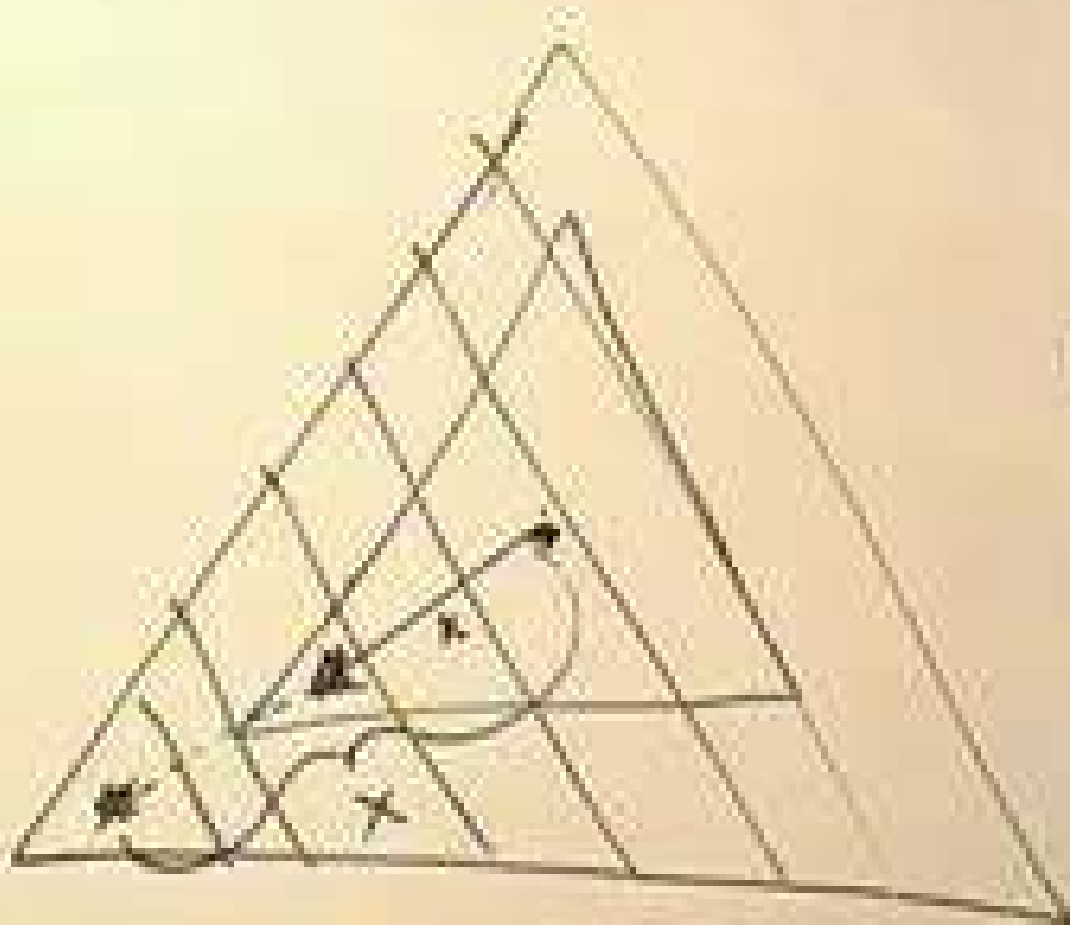
of Nothing

Vacuum



that state

that has no  
excitations



$$\begin{array}{c} \sim \\ \parallel \\ \frac{2}{2} \end{array}$$

$$\frac{2}{2} \left( \frac{1}{2} \right)$$

$$\begin{array}{c} \sim \\ \parallel \\ \frac{1}{2} \end{array} \rightarrow \frac{1}{2} \times \frac{1}{2}$$

$$V = PA$$

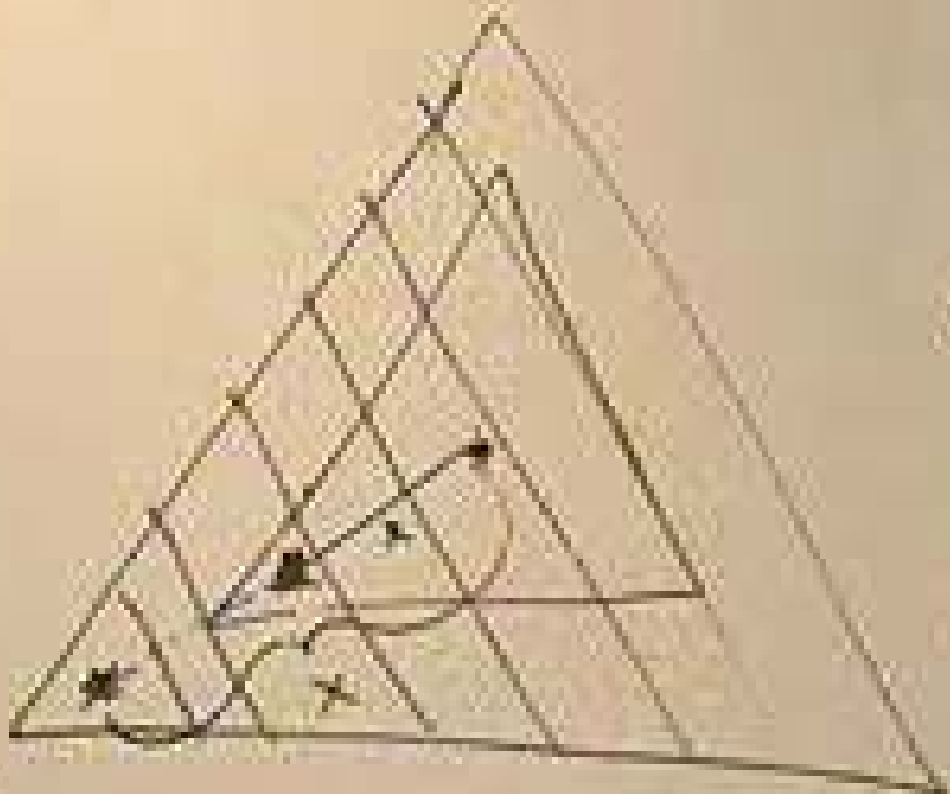
$$= \frac{dV}{dt} = \frac{d}{dt} \left( \frac{d}{dt} \right) + \frac{d}{dt} \left( \frac{d}{dt} \right)$$

$$= \frac{d}{dt} \left( \frac{d}{dt} \right) \left( \frac{d}{dt} \right)$$

$$v = \frac{dr}{dt} = \frac{da}{dt} r(t) + \cancel{\frac{r}{dt}}$$

$$v = \left( \frac{da}{dt} r(t) \right)$$

Hubble's Law



$$V = \frac{d\Phi}{dt}$$

$\omega = \frac{d\theta}{dt}$

$$\frac{d}{dt} (F \cdot g) =$$

$$\vec{v} = \vec{g} \times \vec{\omega}$$

$$\vec{v} = \frac{d\vec{r}}{dt} = \frac{d}{dt} (r \hat{e}_r) = \dot{r} \hat{e}_r + r \dot{\theta} \hat{e}_\theta$$

$$v = \left( \frac{dr}{dt} \right) \hat{e}_r + r \left( \frac{d\theta}{dt} \right) \hat{e}_\theta$$

Handwritten notes and symbols at the bottom of the page, including what appears to be a vector diagram and some illegible text.

$Q = \text{scale}$   
 $\text{factor}$

$\frac{dG}{dt}$

$X = 1.7$

$$\frac{da^r}{dt^2}$$

$V_{eff}$

$$\frac{da}{dc} = -(\rho + 3p)$$

↑  
density

↑  
pressure



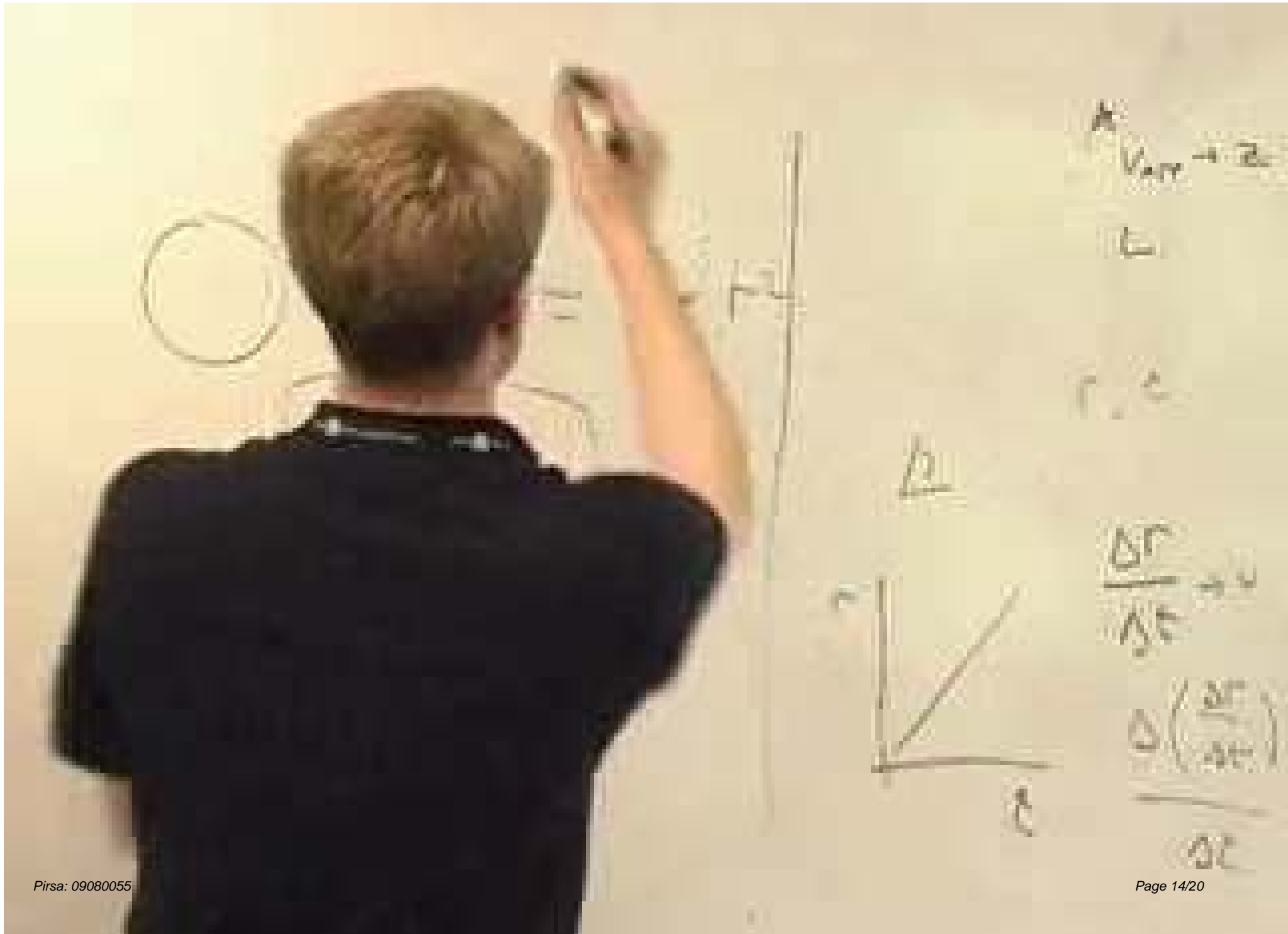
$$A = 4\pi r^2$$

$$L = \frac{1}{2} \pi r^2$$

Z

D

A  
Varr → Z



# Astronomy Night

$$P_{\text{string}} = \frac{1}{2} \rho$$

$$P_{\text{string}} = \frac{1}{2} \rho$$

$$P_{\text{space}} = \rho$$

red stars  
blue stars

red

blue



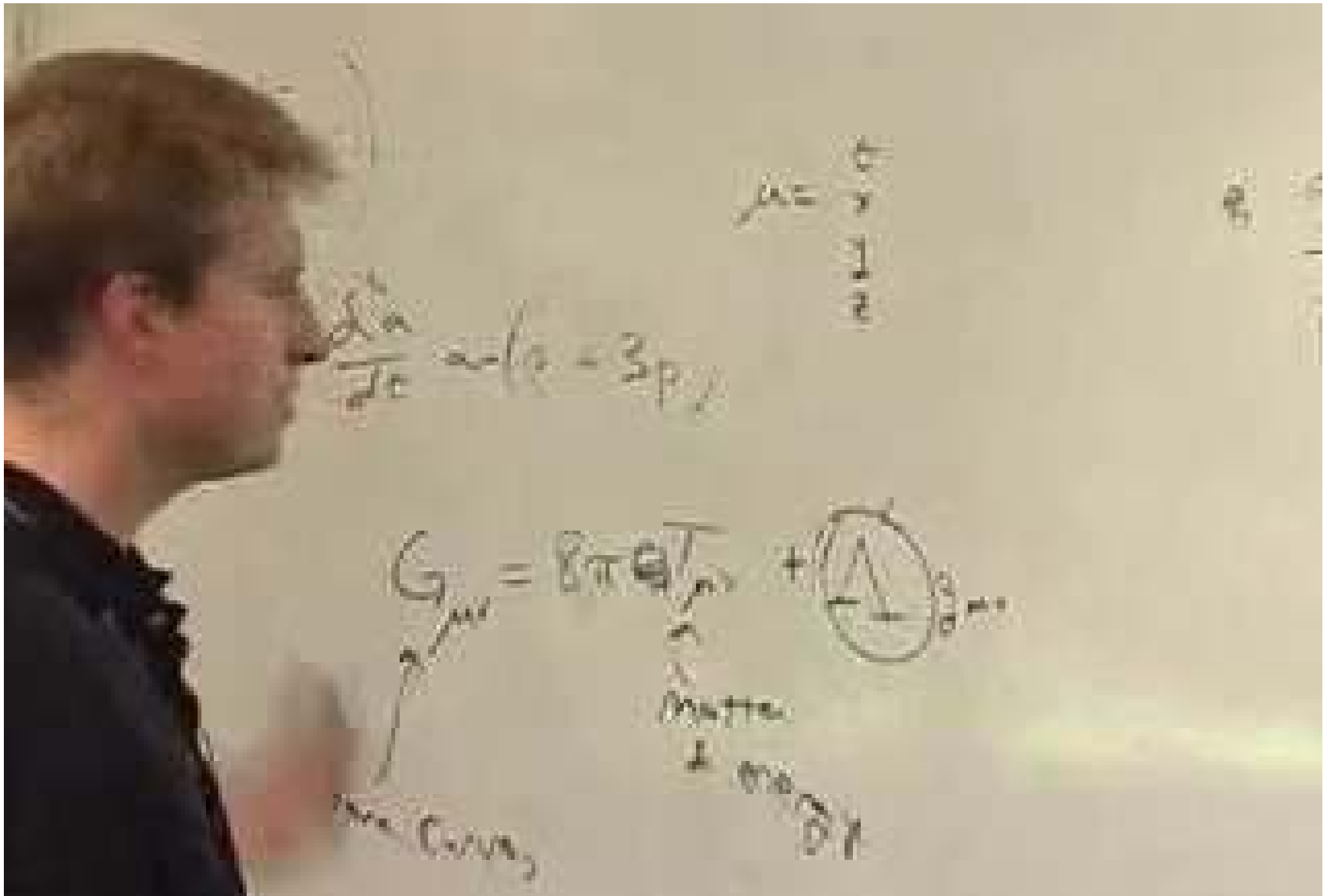
$$\frac{d^2r}{dt^2} = \frac{1}{r^2} \left( \rho + \frac{W}{r} \right)$$

11/11/11

$$G_{\text{eff}} = 8\pi S_{\text{eff}} + \Delta \phi$$

Space Curves

Matter  
+ energy  
or  
DP



$$\mu = \nu \sigma$$

$$\mu = \nu \sigma = 3p$$

$$G = 8\pi G T_{\mu\nu} + \Lambda g_{\mu\nu}$$

matter  
+ energy

Einstein's

①

1/4

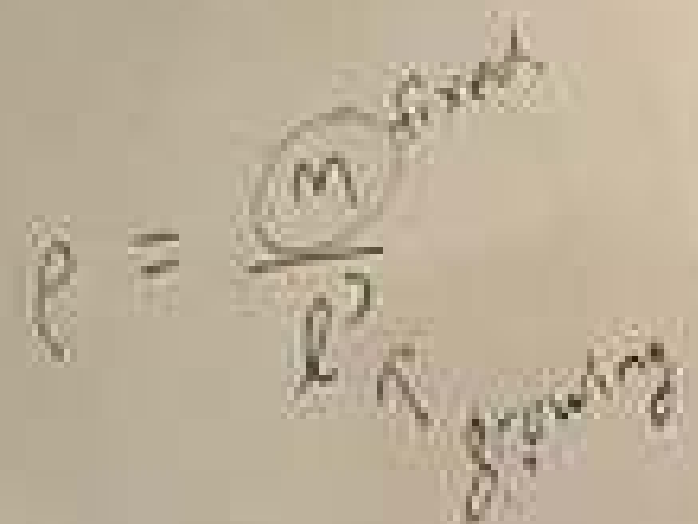
$$\left( \begin{matrix} \dots \\ \dots \\ \dots \\ \dots \end{matrix} \right) \xrightarrow{\text{need rate}} \left( \frac{1}{2} + \frac{1}{2} \right) = \text{const}$$

1/2

$$\frac{1}{2} \rightarrow (2 + 3p)$$

$$G = \dots + \text{circle with } \Delta$$

2016 x Q



ρ → shrink

- Farewell sheet
- SNO LAB journal
- PI t-shirts
- labing Fri
- Departures
- Astronomy Night

2016 x Q

2016 x Q

2016 x Q

2016 x Q

2016 x Q

2016 x Q

$$\rho = \frac{M}{V} \text{ growing}$$

$\rho \rightarrow$  shrinks

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$$\rho_{\text{observed}} = \frac{M_{\text{actual}}}{V_{\text{actual}}}$$

- SNO LAB period
- PI t-shirts
- Labring Fri
- Departures
- Astronomy Night
- ...

