Title: What's Blowing up the Universe?

Date: Aug 19, 2009 01:05 PM

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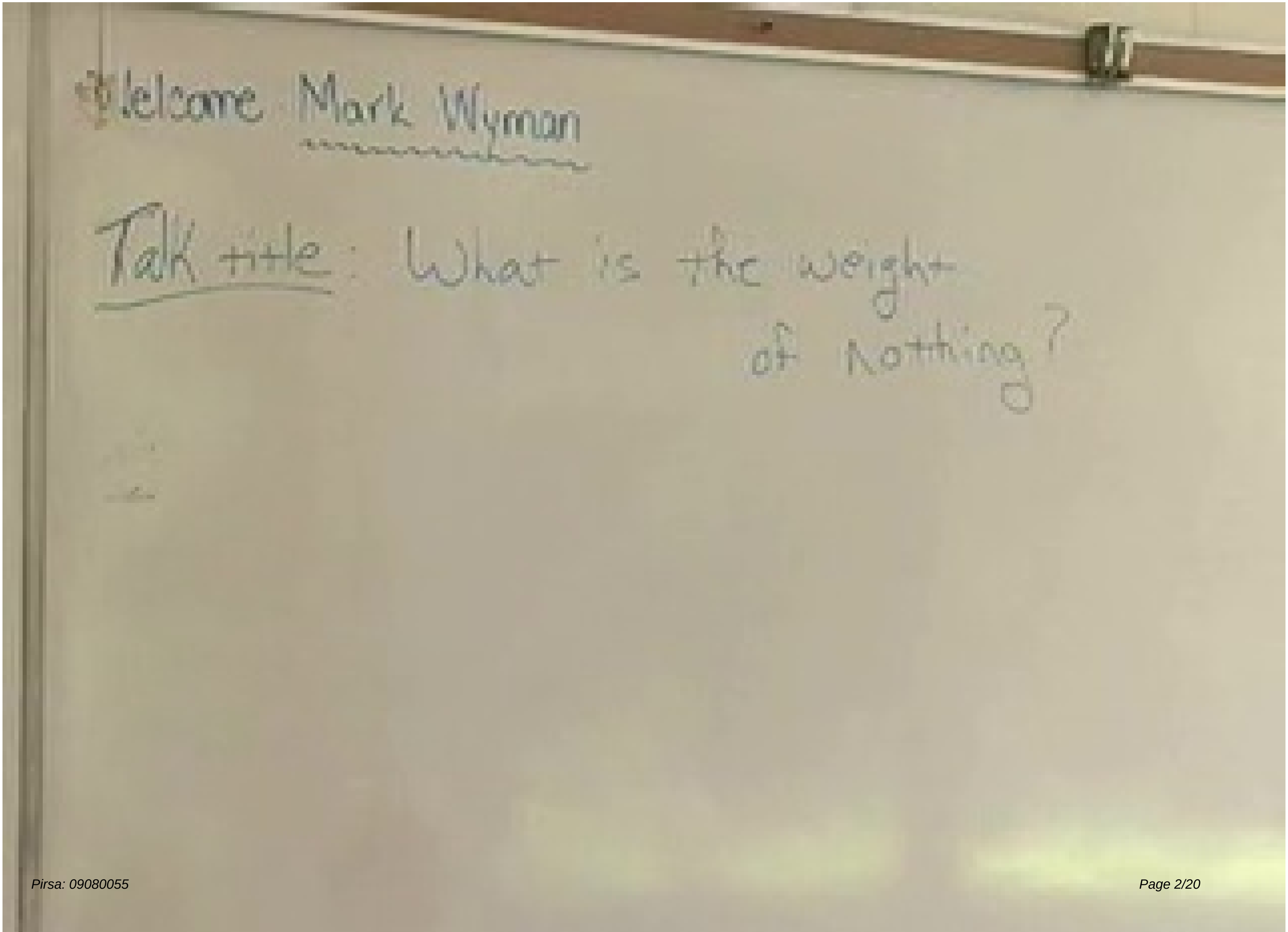
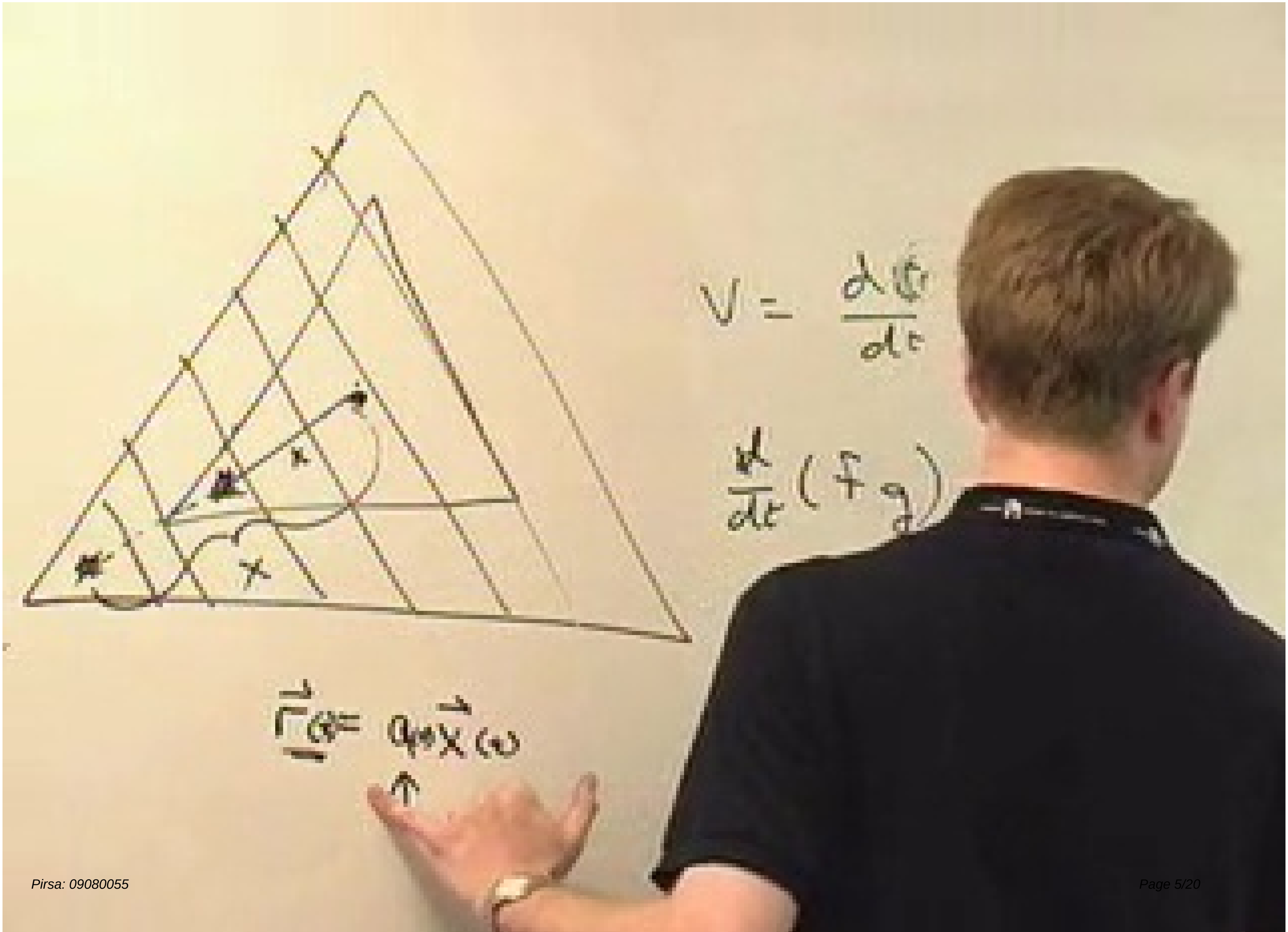
Abstract: The reason cosmologists have a job is that the Universe as a whole -- the stuff between planets and stars and galaxies -- is, despite first appearances, a pretty interesting place. The strangest fact about it is that it's expanding, and always has been, as far as we know (and though Einstein's 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.

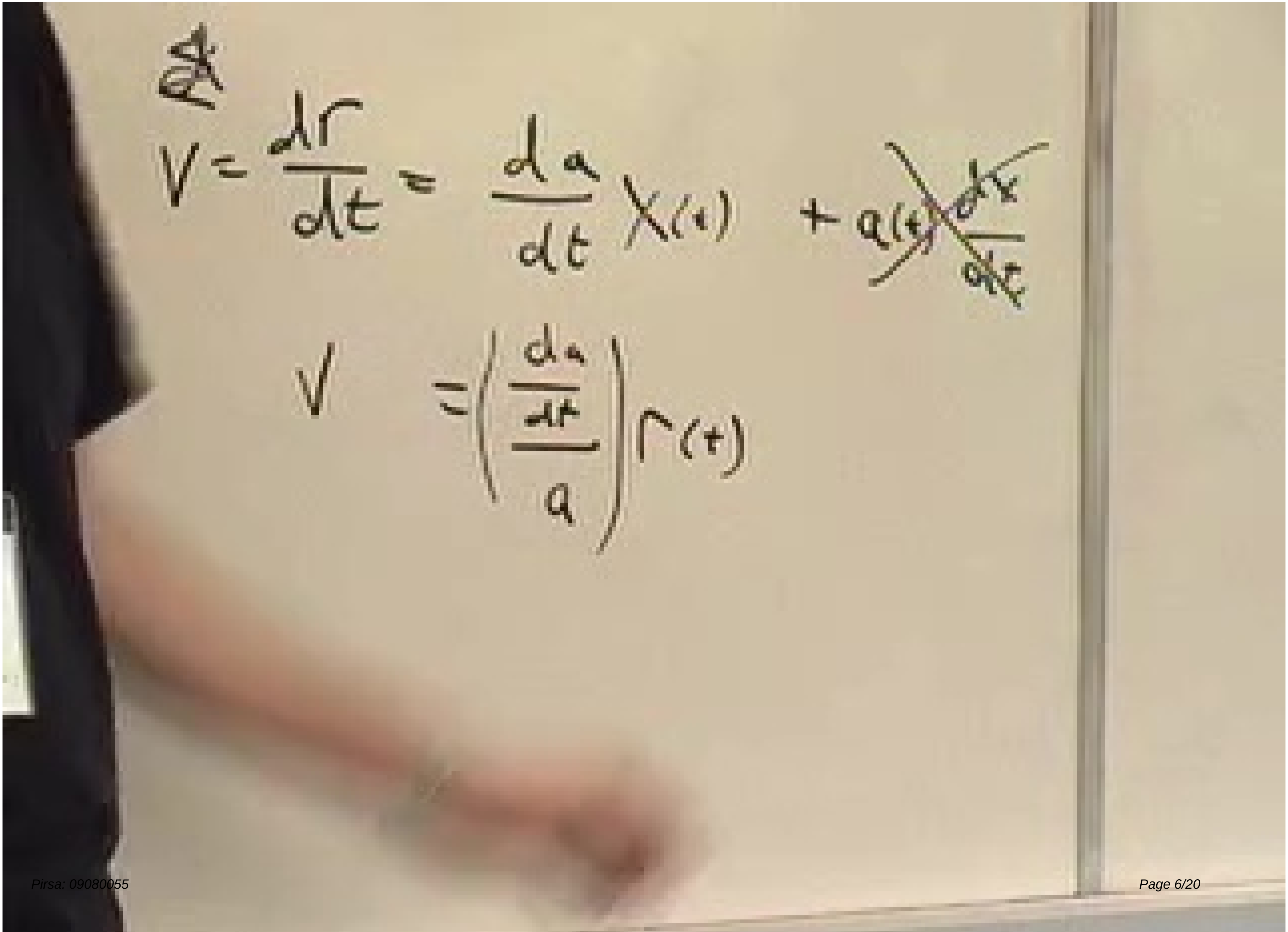

Welcome Mark Wyman
Talk title: What is the weight of nothing?


Cosmology
Cosmology is the Universe
as a Whole

What is the weight
of nothi

Vacuum
↑
that state
that has no
excitations

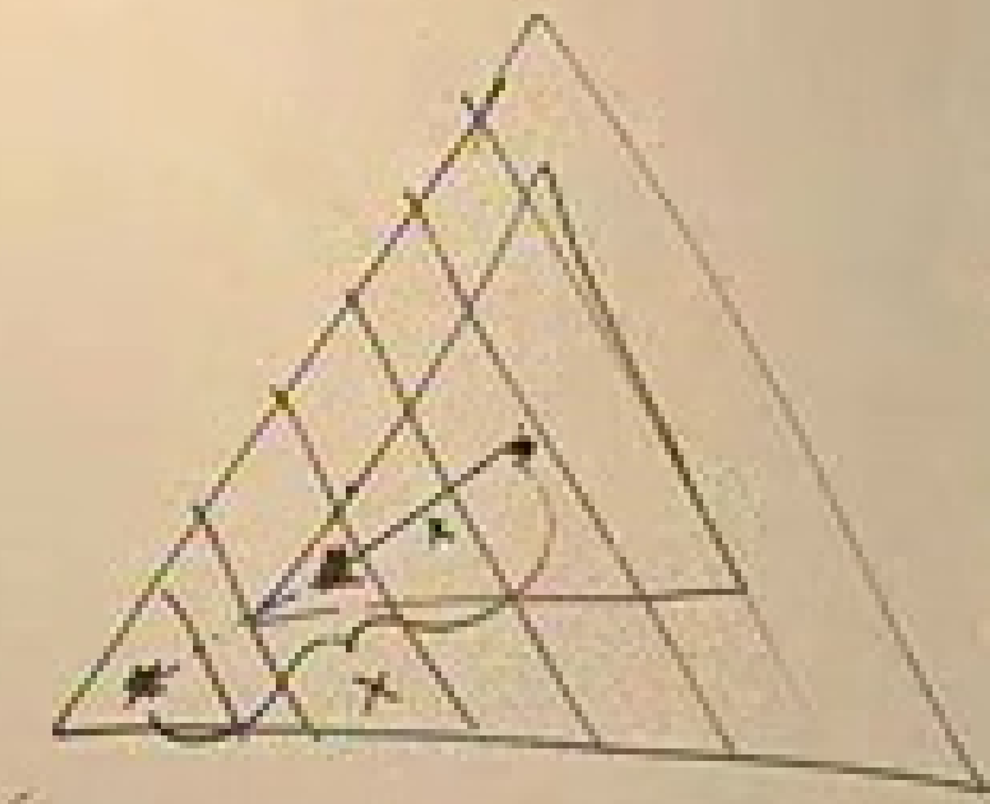



$V = \frac{dr}{dt} = \frac{da}{dt} X(t) + a(t)\frac{dx}{dt}$
$V = \left(\frac{\frac{da}{dt}}{a}\right) r(t)$

$$V = \frac{dr}{dt} = \frac{da}{dt} x(t) + \cancel{a(t)\frac{dx}{dt}}$$

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

Hubble's Law



$\vec{r}(t) = a(t)\,\vec{x}(t)$

$\hat{i}$

$V = \frac{d\vec{r}}{dt}$

$x = \frac{r}{a}$

$\frac{d}{dt}(f\,g) =$

$V = \frac{dr}{dt} = \frac{da}{dt}\,x(t) + a\dot{x}$

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

Hubble's Law

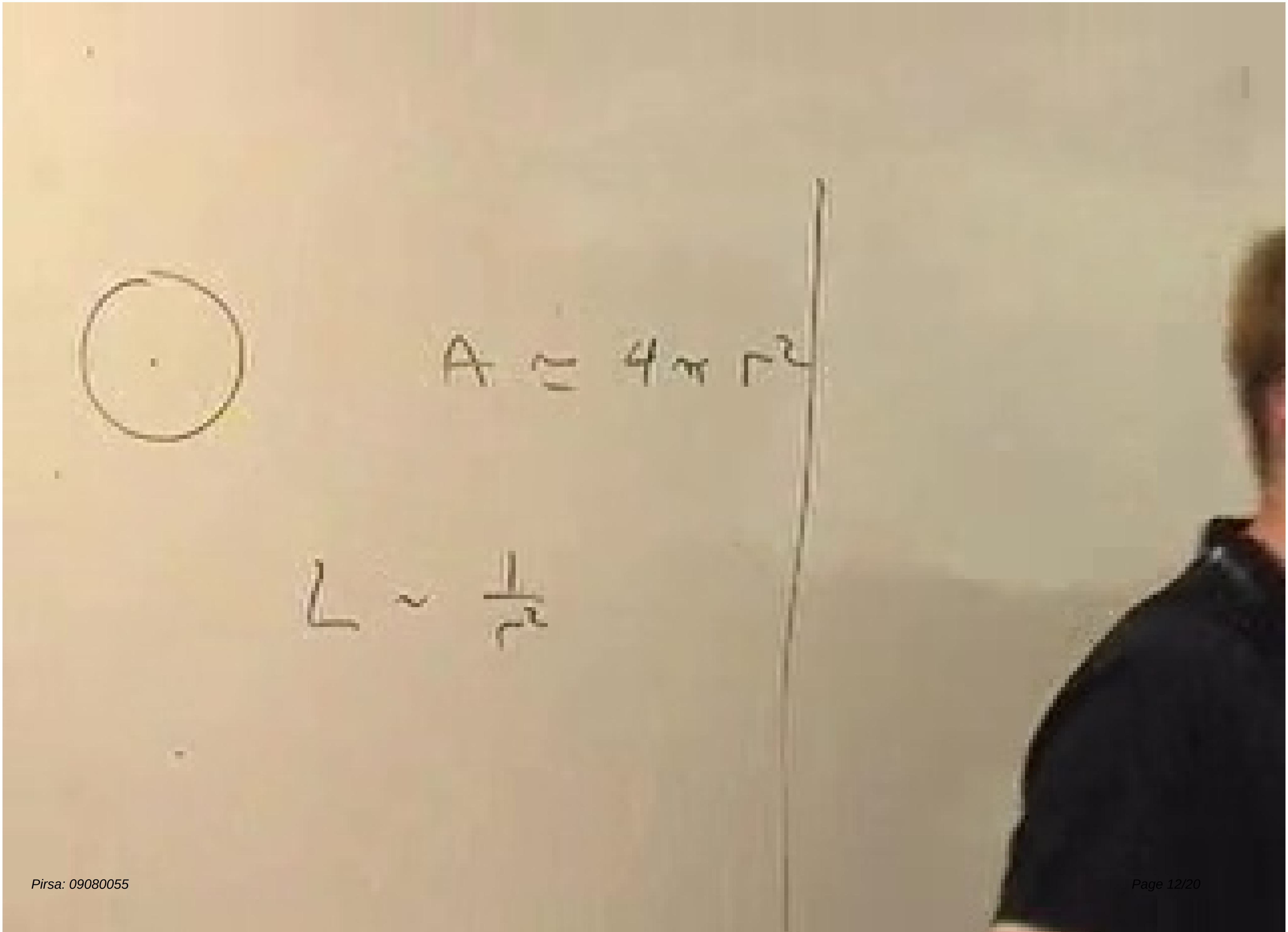
a = scale factor

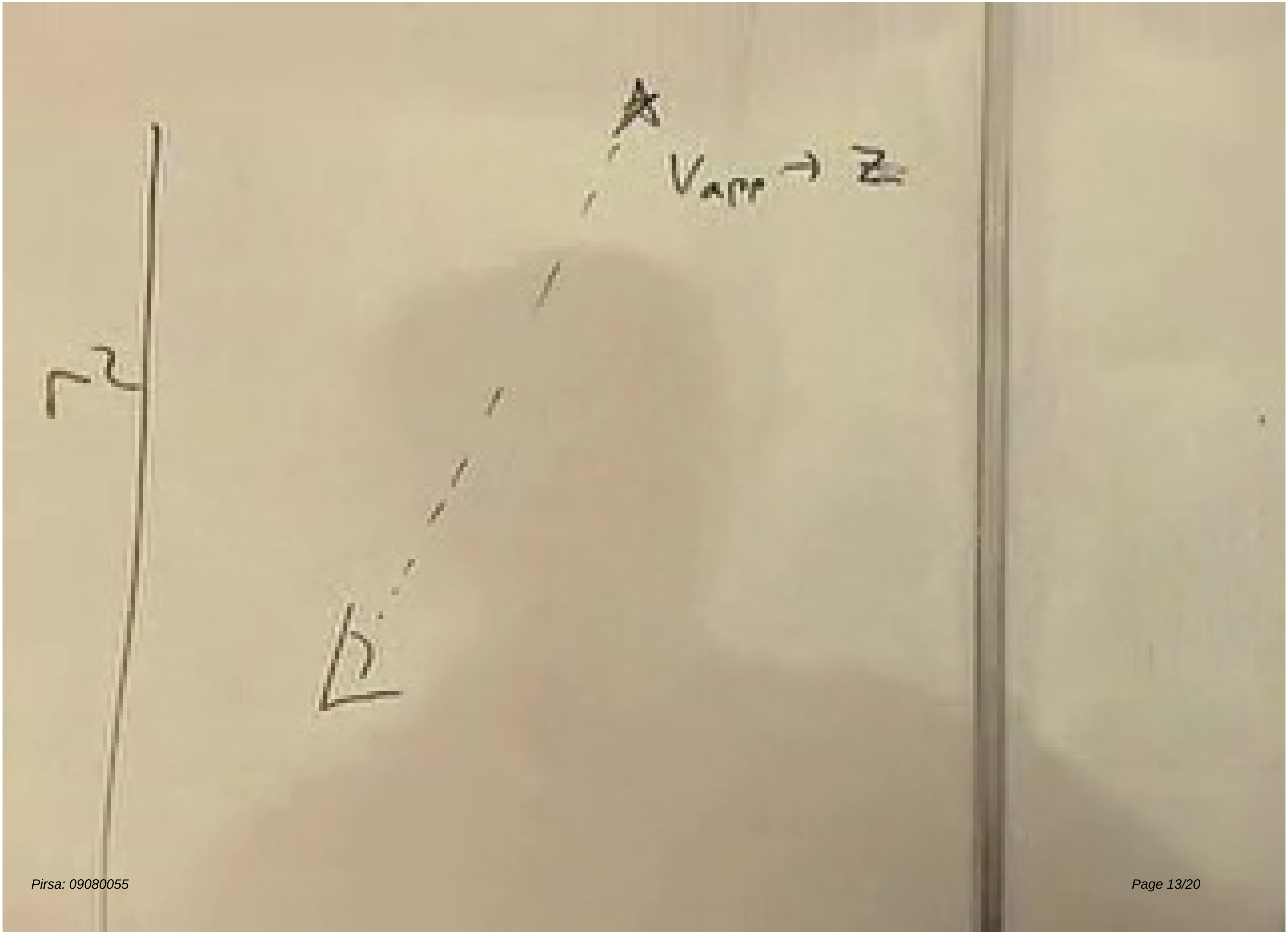
$$\frac{d\,[illegible]}{dt}$$

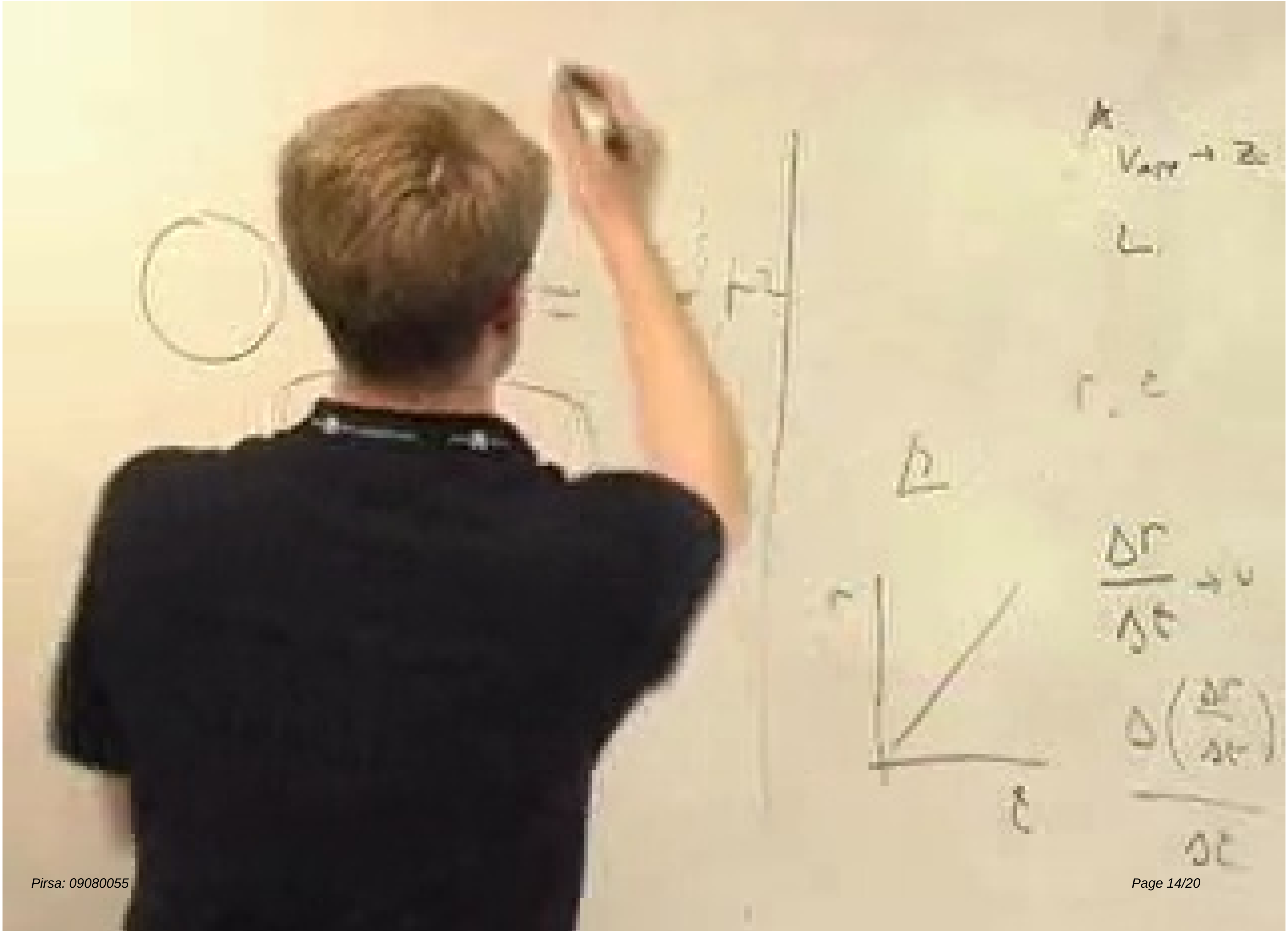
$$x = \frac{r}{a}$$

$$\frac{d a^{2}}{d\tau^{2}}$$


pressure
density


$A \simeq 4\pi r^2$
$L \sim \frac{1}{r^2}$


Vapp → Z

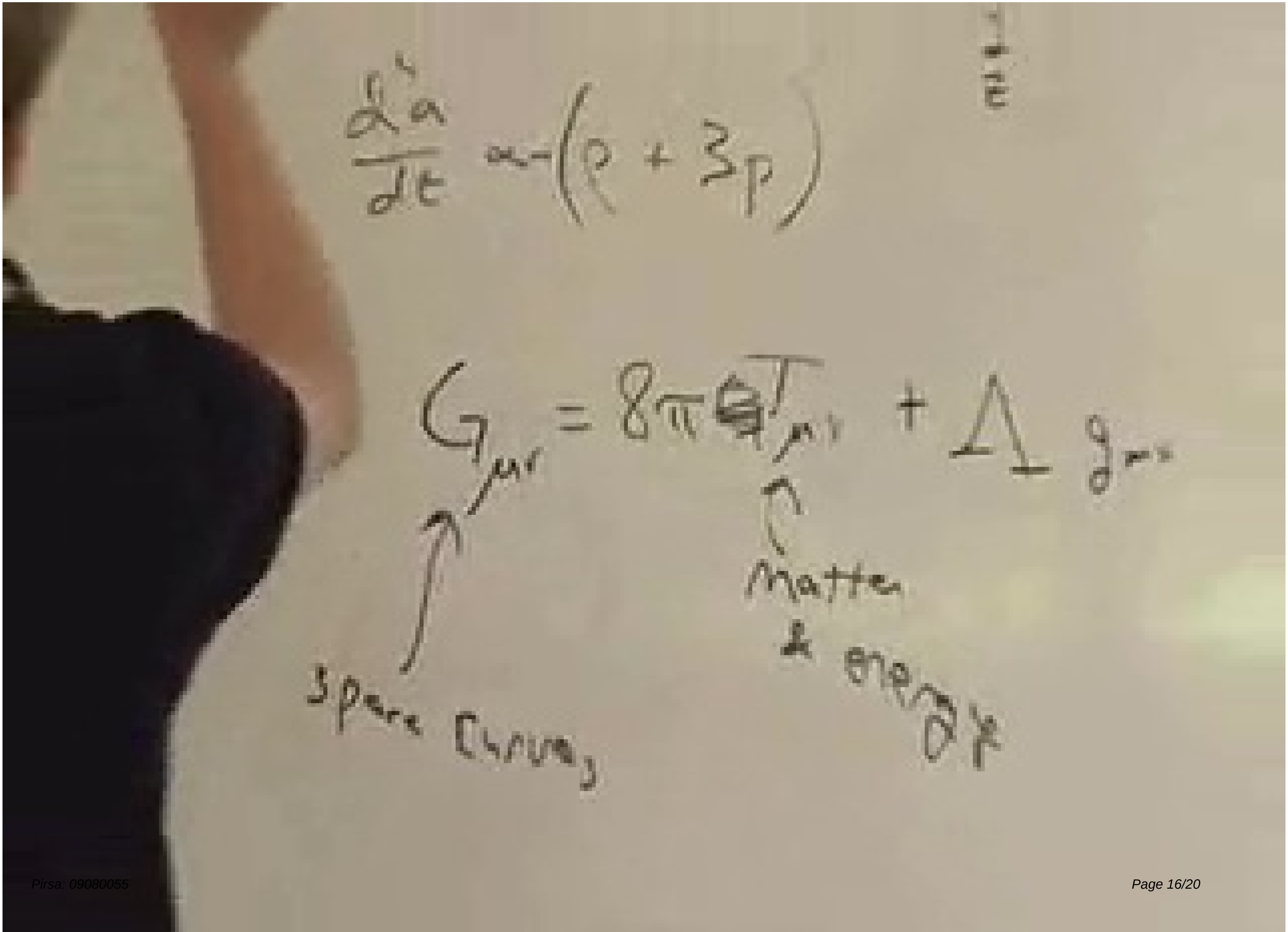


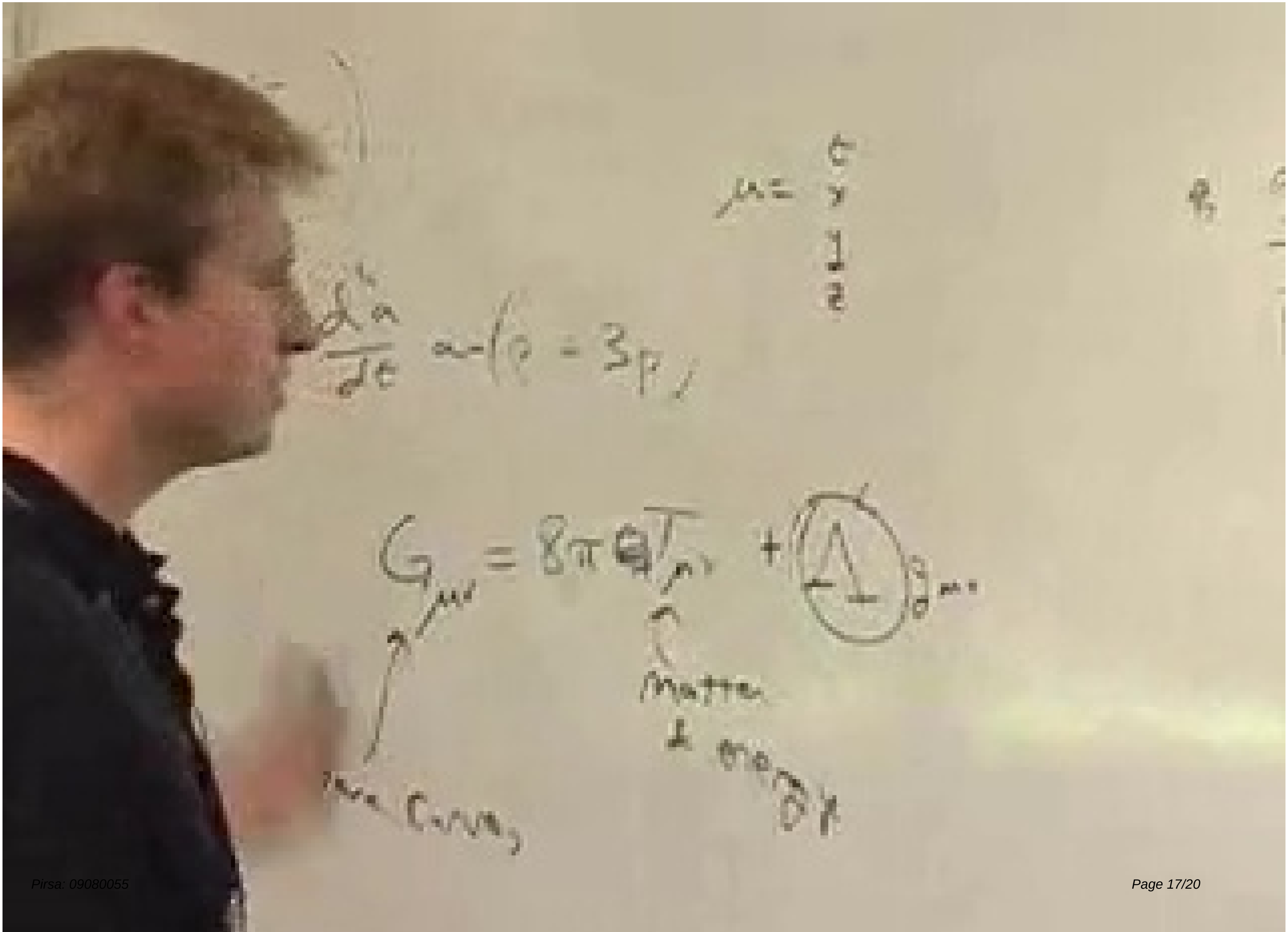
$$P_{string} = -\frac{1}{3}\rho$$

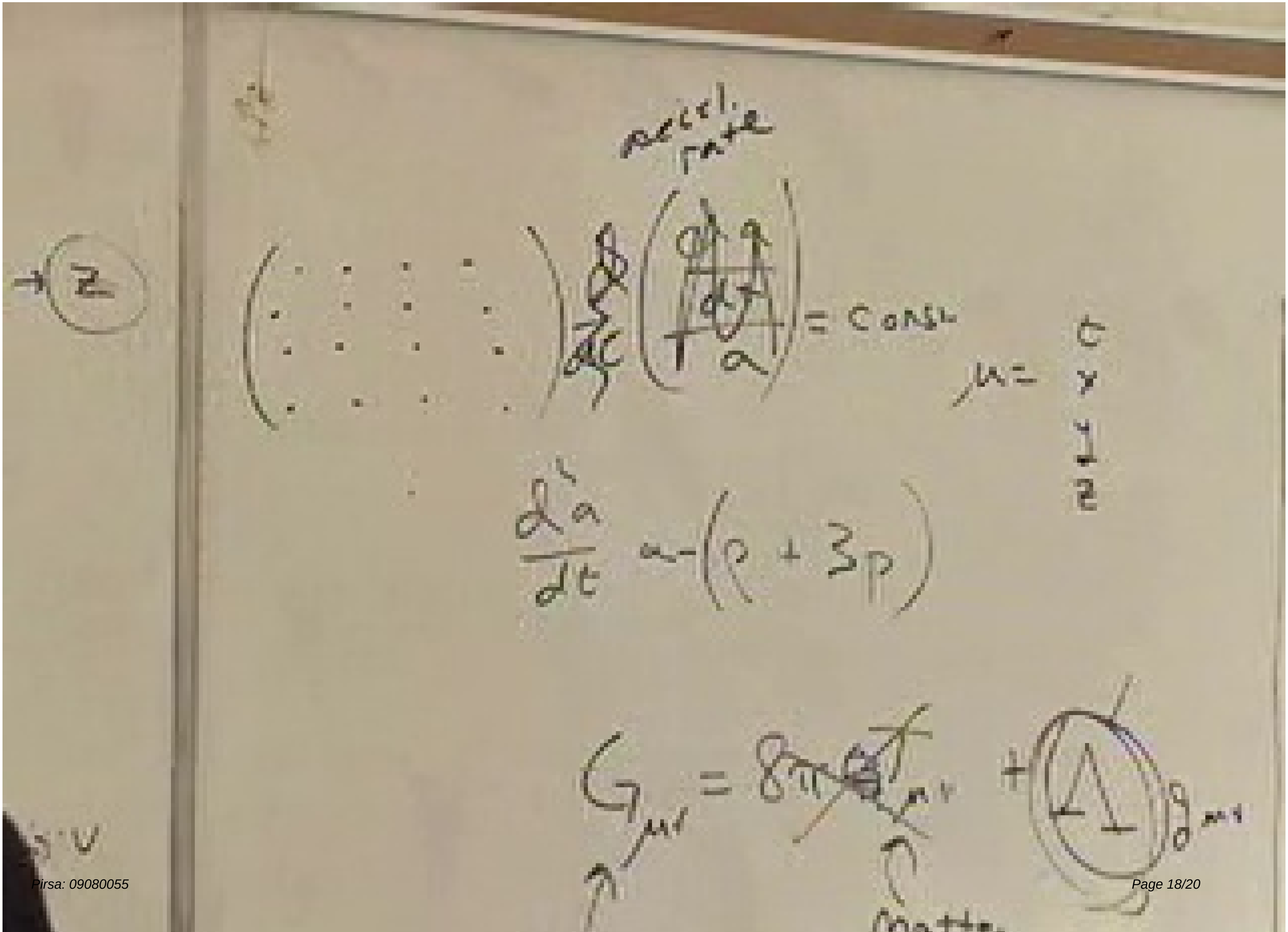
$$P_{sheet} = -\frac{2}{3}\rho$$

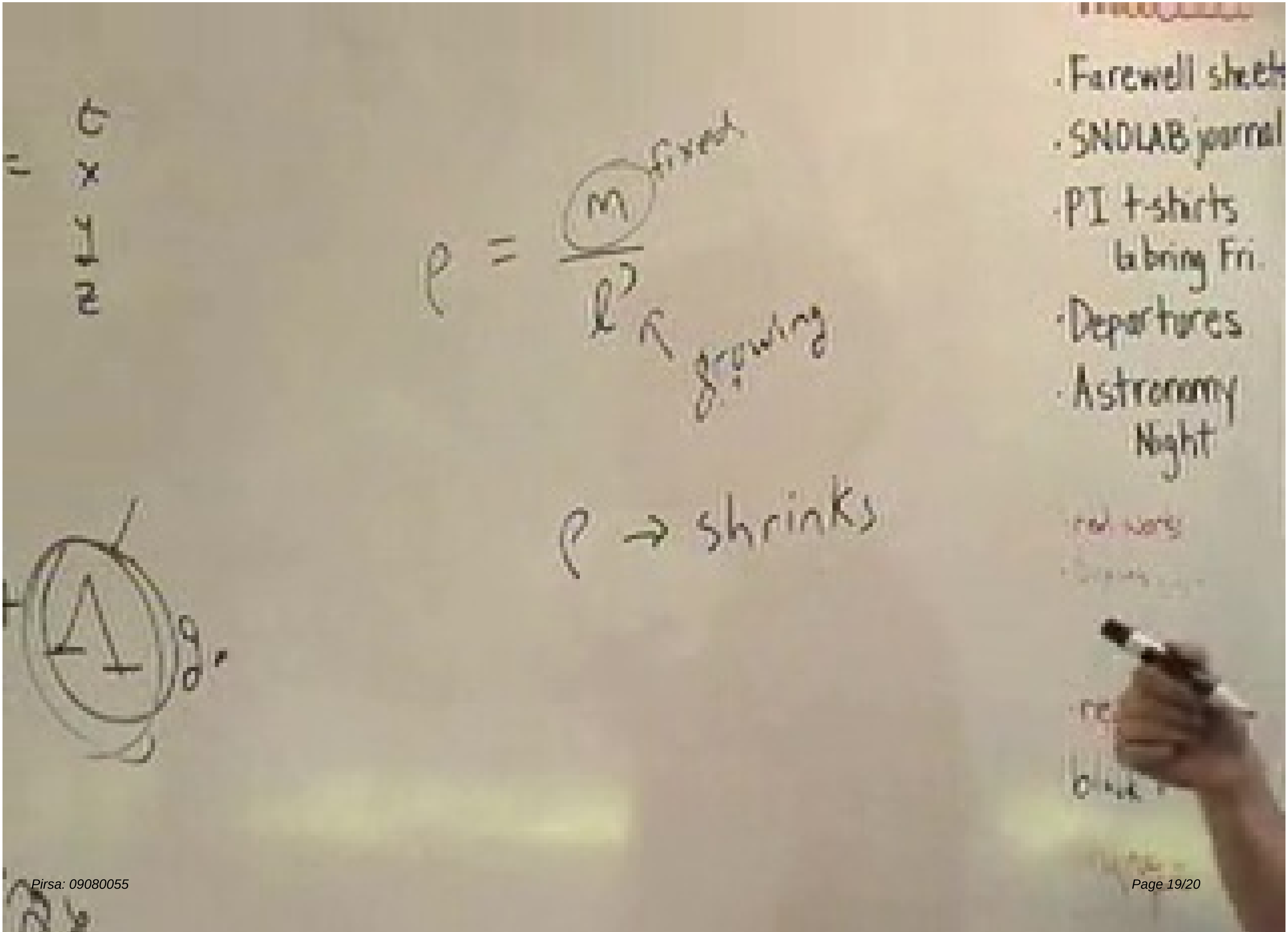
$$P_{space} = -\rho$$

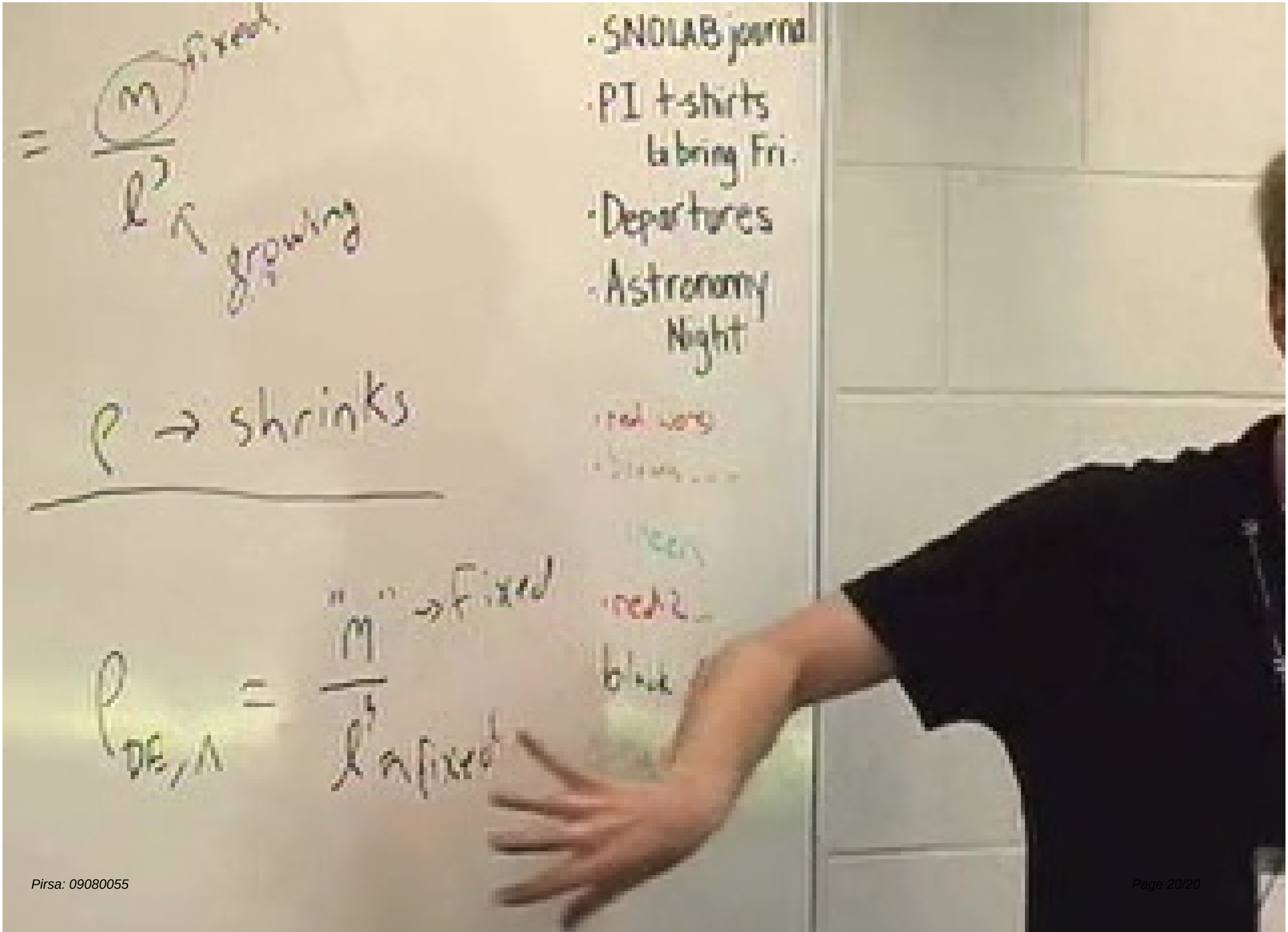
- Astronomy Night
- red works
- brown ...
- green
- red2 ...
- black ✓
- orange


$\frac{d^2a}{dt^2} \propto -(\rho + 3p)$
$G_{\mu\nu} = 8\pi T_{\mu\nu} + \Lambda g_{\mu\nu}$
space curve
matter
& energy


μ = t x y z
G_μν = 8πG T_μν + Λ g_μν
matter
& energy


accel. rate
= const
μ =
t
x
y
z
$G_{\mu\nu} = 8\pi G T_{\mu\nu} + \Lambda g_{\mu\nu}$


t
x
y
z
ρ = M / R³
fixed
growing
ρ → shrinks
Λ
· Farewell sheet
· SNOLAB journal
· PI t-shirts
to bring Fri.
· Departures
· Astronomy
Night


fixed
growing
ρ → shrinks
fixed
fixed
· SNOLAB journal
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Night