

8.286 Lecture 6
September 24, 2013

**DYNAMICS OF
 HOMOGENEOUS
 EXPANSION**

**Review: Can a Uniform Infinite
 Distribution of Mass Be Stable?**

Gauss's Law of Gravity:

$$\vec{g} = -\frac{GM}{r^2} \hat{r} \implies \oint \vec{g} \cdot d\vec{a} = -4\pi GM_{\text{enclosed}}$$

Poisson's Equation:

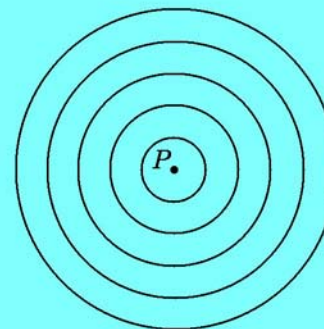
$$\nabla^2 \phi = 4\pi G\rho, \quad \text{where } \vec{g} = -\vec{\nabla} \phi.$$

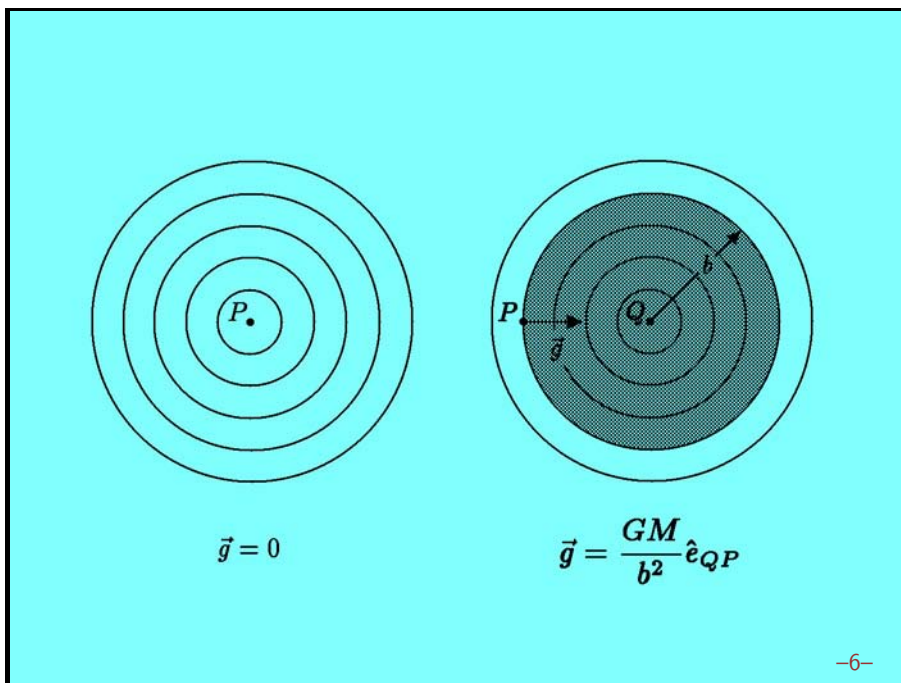
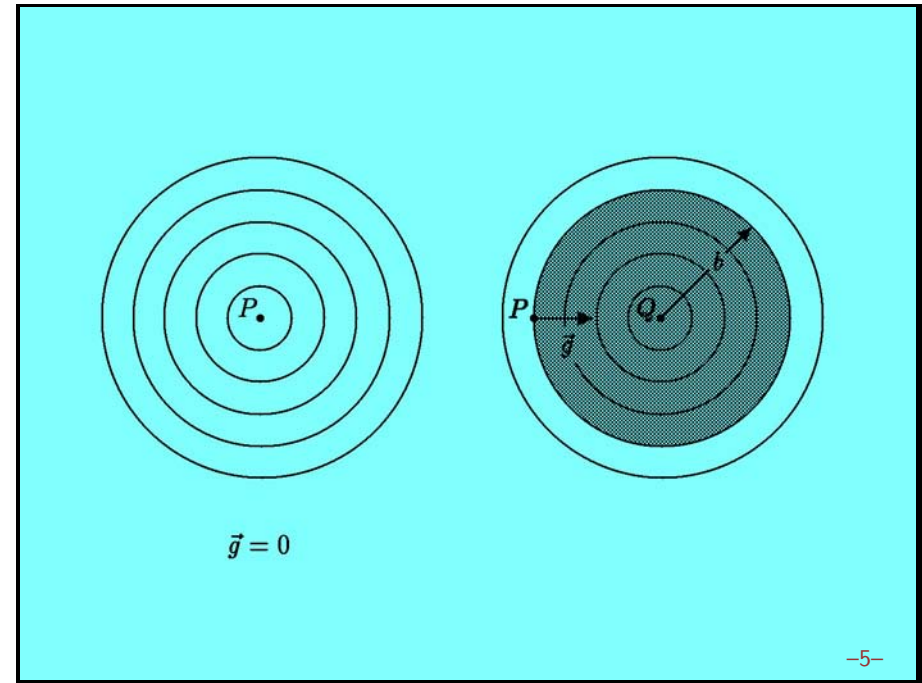
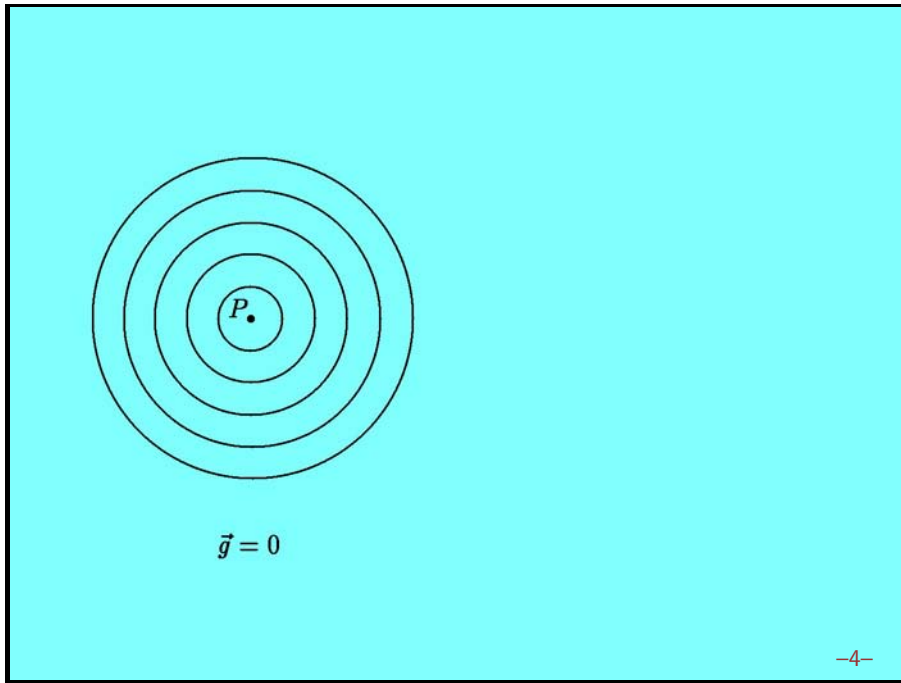
where ρ is the mass density, ∇^2 is the Laplacian:

$$\nabla^2 \equiv \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2},$$

and $\vec{\nabla}$ is the gradient:

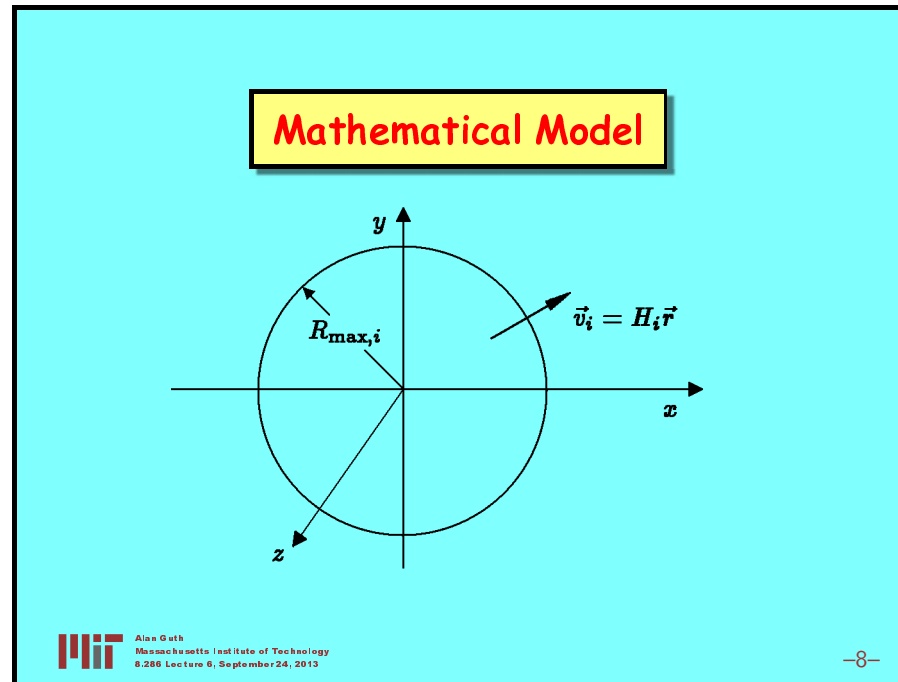
$$\vec{\nabla} \equiv \hat{i} \frac{\partial}{\partial x} + \hat{j} \frac{\partial}{\partial y} + \hat{k} \frac{\partial}{\partial z}.$$





But What About Symmetry?

- ★ Newton argued that there could be no acceleration, because there is no preferred direction for it to point.
- ★ Complication: acceleration is measured relative to an inertial frame, which Newton defined as the frame of the “fixed stars”. But if the universe collapses, then there are no fixed stars.
- ★ In the absence of an inertial frame, all accelerations, like velocities, are relative.
- ★ When all accelerations are relative, any observer can consider herself to be non-accelerating. She would then see all other objects accelerating radially toward herself. Like the velocities of Hubble expansion, this picture looks like it has a unique center, but really it is homogenous.



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8.286 The Early Universe
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