

*8.286 Lecture 7*  
*September 26, 2018*

# THE DYNAMICS OF NEWTONIAN COSMOLOGY, PART 2

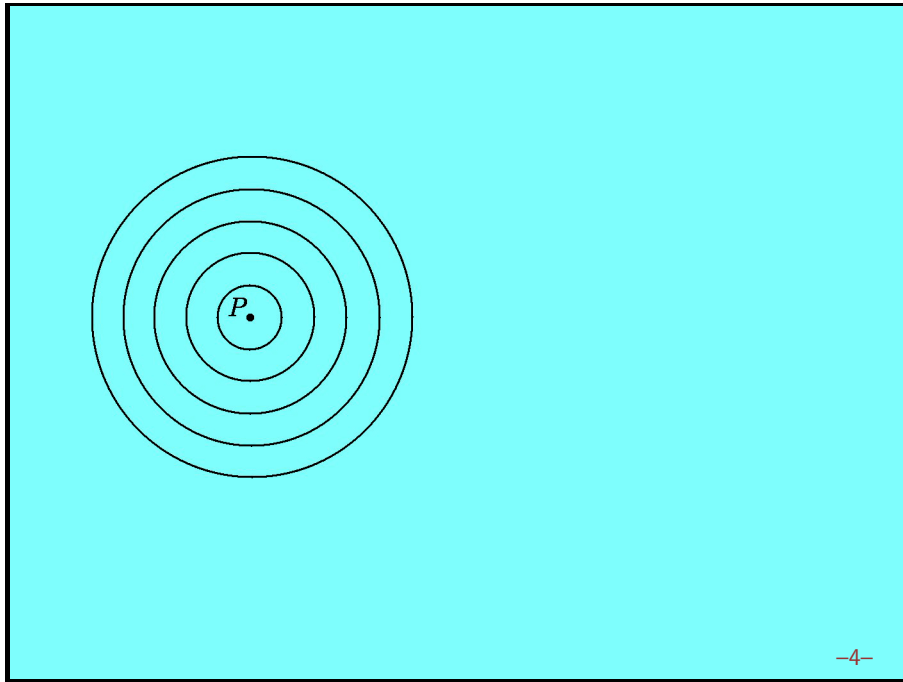
## Announcements

- ★ The class contact list is up and running. Want changes? Want to join? Send me email.
- ★ Problem Sets 1 and 2 are graded. Grades are posted. Problem Set 2 Solutions will appear this afternoon.
- ★ Problem Set 3 is due Friday, 5:00 pm.
- ★ Quiz 1 is Wed Oct 3, one week from today.
- ★ Review Problems for Quiz 1, with solutions, will be posted on the website by tonight. It will include a formula sheet, which you will also be given at the quiz. There will be 20+ problems, about 8 of which are highlighted by stars. The 1up version will be hyperlinked, so you can navigate easily between problems and their solutions.

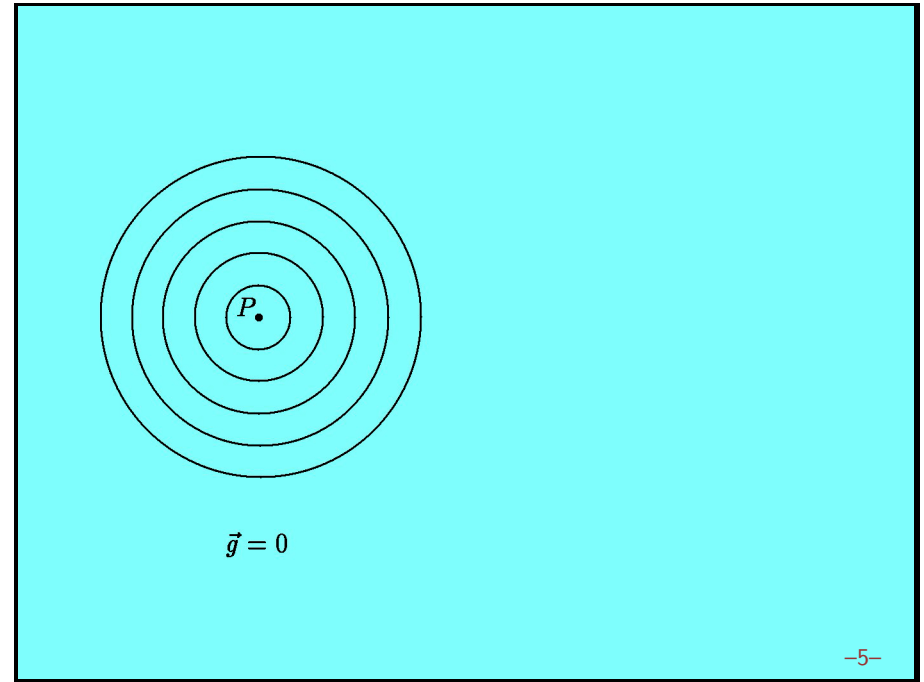
- ★ The coverage of the quiz is listed on the website and on the Review Problems: Lecture Notes 1-3, Problem Sets 1-3, Weinberg chapters 1-3, Ryden chapters 1, 2, and section 3.1.
- ★ One problem on the quiz will be taken verbatim, or almost verbatim, from either the homework assignments or from the starred Review Problems. For the homework, extra credit problems are eligible to be the problem used on the quiz.
- ★ Old exams are on the web, going back to 1994. Follow the link “8.286 Web Page Information from Previous Years”.

## Scheduling for the Quiz

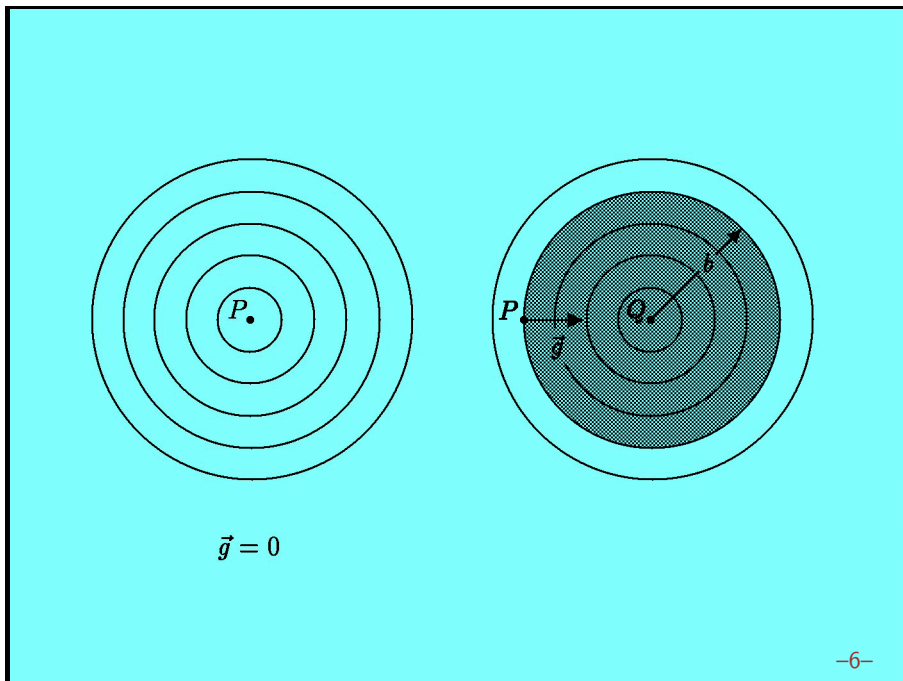
- ★ Review session by Honggeun Kim: Sunday, 3:30 pm until whenever, Room 3-333 (easy to remember!).
- ★ Office hours:
  - Me: Today at 7:30 pm, 6-322, and also Monday (Oct 1) evening, 7:30 pm, 6-322.
  - Honggeun: Tomorrow at 5 pm, 8-306, and also Tuesday (Oct 2) at 5 pm, 8-308.



-4-

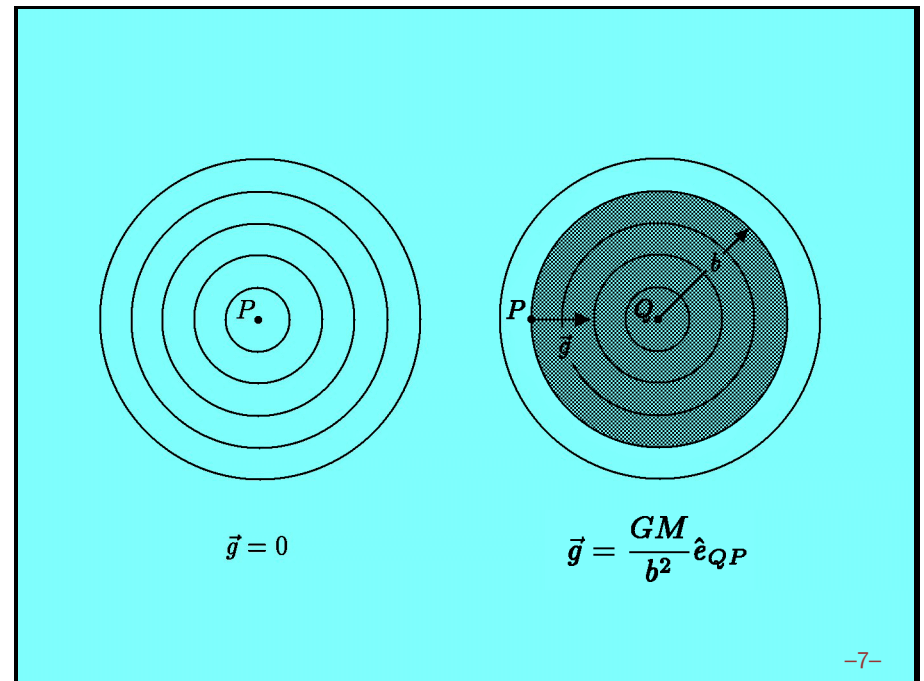


-5-



$$\vec{g} = 0$$

-6-



$$\vec{g} = 0$$

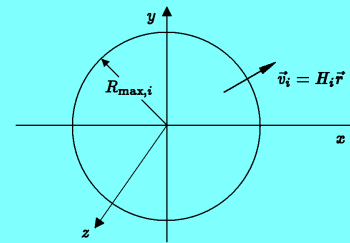
$$\vec{g} = \frac{GM}{b^2} \hat{e}_{QP}$$

-7-

## 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 homogeneous.

## Mathematical Model



$$t_i \equiv \text{time of initial picture}$$

$$R_{\text{max},i} \equiv \text{initial maximum radius}$$

$$\rho_i \equiv \text{initial mass density}$$

$$\vec{v}_i = H_i \vec{r}.$$

## Shell Crossings?

Can shells cross? I.e., can two shells that start at different  $r_i$  ever cross each other?

The answer is no, but we don't know that when we start.

But we do know that Hubble's law implies that any two shells are initially moving apart. Therefore there must be at least some interval before any shell crossings can happen.

We will write equations that are valid assuming no shell crossings.

These equations will be valid until any possible shell crossing.

If there was a shell crossing, these equations would have to show two shells becoming arbitrarily close.

We will find, however, that the equations imply uniform expansion, so no shell crossings ever happen in this system.