What is dark matter?

- Dark matter seems to…
  - influence visible matter via gravity (and weak force).
  - not interact with light
  - not have charges
  - be "cold" in the sense that their average velocity is much less than the speed of light, so that it can cluster
    - C.f. neutrinos are "hot" dark matter
  - be almost pressure-less
    - w=0: w=pressure/density
- Candidates
  - Particles of "supersymmetry"
  - Axions
  - among others…

What is dark energy?

- Dark energy seems to…
  - have existed during inflation as well as at present
    - There may be two different dark energy components.
  - influence visible or dark matter via gravity only
  - distribute almost uniformly
    - It can't cluster
  - have a large, *negative* pressure
    - w~-1
- Candidates
  - Vacuum energy
  - Quintessense
  - Modification to gravity
  - among others…

How do we detect dark matter?

- Dark matter
  - Direct detection of actual particles might be possible in 2007-
  - LHC (Large Hadron Collider) @ CERN (Geneva)
  - Collide two proton beams to create lots of particles: LHC will reach the energy that is equivalent to 7×10^{16} K!!
  - Physicists are expecting to detect supersymmetric particles.

How do we detect dark energy?

- There are no "particles" of dark energy
  - So, there is no way to detect dark energy directly.
- To constrain nature of dark energy, one has to rely on cosmological observations such as
  - Brightness-redshift relation
  - Size-redshift relation
  - The key parameter is w. (w=pressure/density)
    - Density of dark energy evolves as $1/R^{3(1+w)}$
    - w=-1: density does not change → cosmological constant
  - The current observational data: w<-0.8