Distribution of Galaxies

• NOT random throughout space
  – tend to form groups
    • Satellite (dwarf) galaxies around Milky Way (LMC…)
    • local groups contains Andromeda, more satellites
  – which form clusters \((10^4 \text{ galaxies, } 1 \text{ Mpc})\)
    • local group belongs to Virgo cluster
    • Coma cluster about 100 Mpc away \((z = 0.023)\)
      – has 250 times more mass than luminosity! (about 10% is gas visible in x-rays)
  – which form superclusters \((100 \text{ Mpc})\)
  – or walls, strings, etc. surrounding voids
    • bubbly appeareance of the Universe
We can simulate how a nearly smooth distribution of dark matter turns into our lumpy, grainy Universe with its hierarchy of structures - from galaxies to superclusters, great walls and voids.
Large Scale Structure of Universe

- The Universe is expanding...
  - Hubble Constant \( H_0 = 70 \) km/s/Mpc = 1/14Gyr
- Initially it was filled with a smooth distribution of dark matter
  - and a smaller amount of nucleons + electrons
    - very small initial density fluctuations
- ...which began to clump to create the seeds of filaments, superclusters, walls...
  - galaxies (central black holes?)