Numerical Galaxy Formation & Cosmology

Lecture 7: 1st example - Galaxy mergers

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Outline of the lecture course

- Lecture 1: Motivation & Initial conditions
- Lecture 2: Gravity algorithms & parallelization
- Lecture 3: Hydro schemes
- Lecture 4: SPH, Radiative cooling & heating, Subresolution physics
- Lecture 5: Halo and subhalo finders & Semi-analytic models
- Lecture 6: Getting started with Gadget
- Lecture 7: Example galaxy collision
- Lecture 8: Example cosmological box

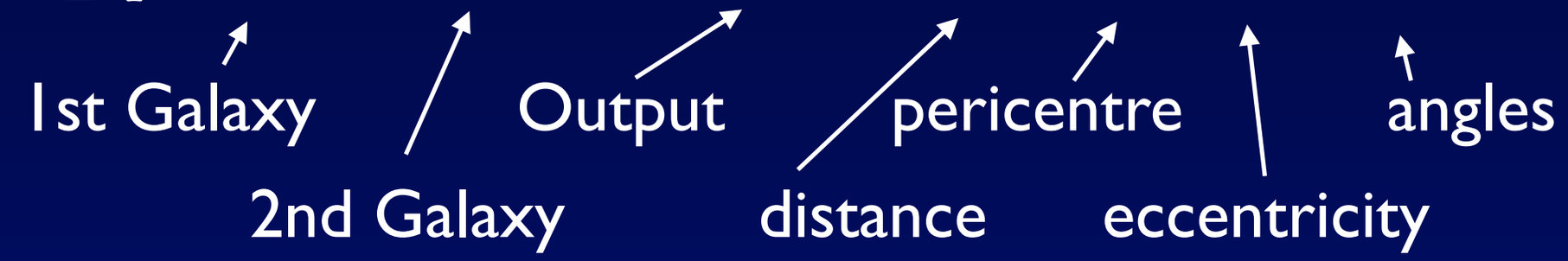
Initial conditions for galaxy mergers

- Main steps for creating initial conditions:
  - Choose parameters for each galaxy (mass, size, morphology, etc)
  - Create IC files for each galaxy
  - Choose parameters for galaxy orbit (initial distance, pericentric distance, eccentricity, orientation)
  - Merge both files and put galaxies on orbit

- Main steps for running the simulation:
  - Compile simulation code for galaxy merger simulations
  - Set parameters for simulation
  - Run simulation

Creating ICs for galaxy mergers

- Initial conditions have already been created for each galaxy
- Download IC files and code that puts galaxies on orbit:
  - wget http://www.ast.cam.ac.uk/~moster/lectures/csf2016/merger.tar
  - tar -xvf merger.tar
- Compile merger code:
  - module load intel
  - icc -o merge_cm_eps merge_cm_eps.c -lm
- Put galaxies on orbit:
  - ./merge_cm_eps Gal1.dat Gal1.dat Gal11.dat 200. 12. 0.9 0. 30. 0. 0.



Setting up Gadget

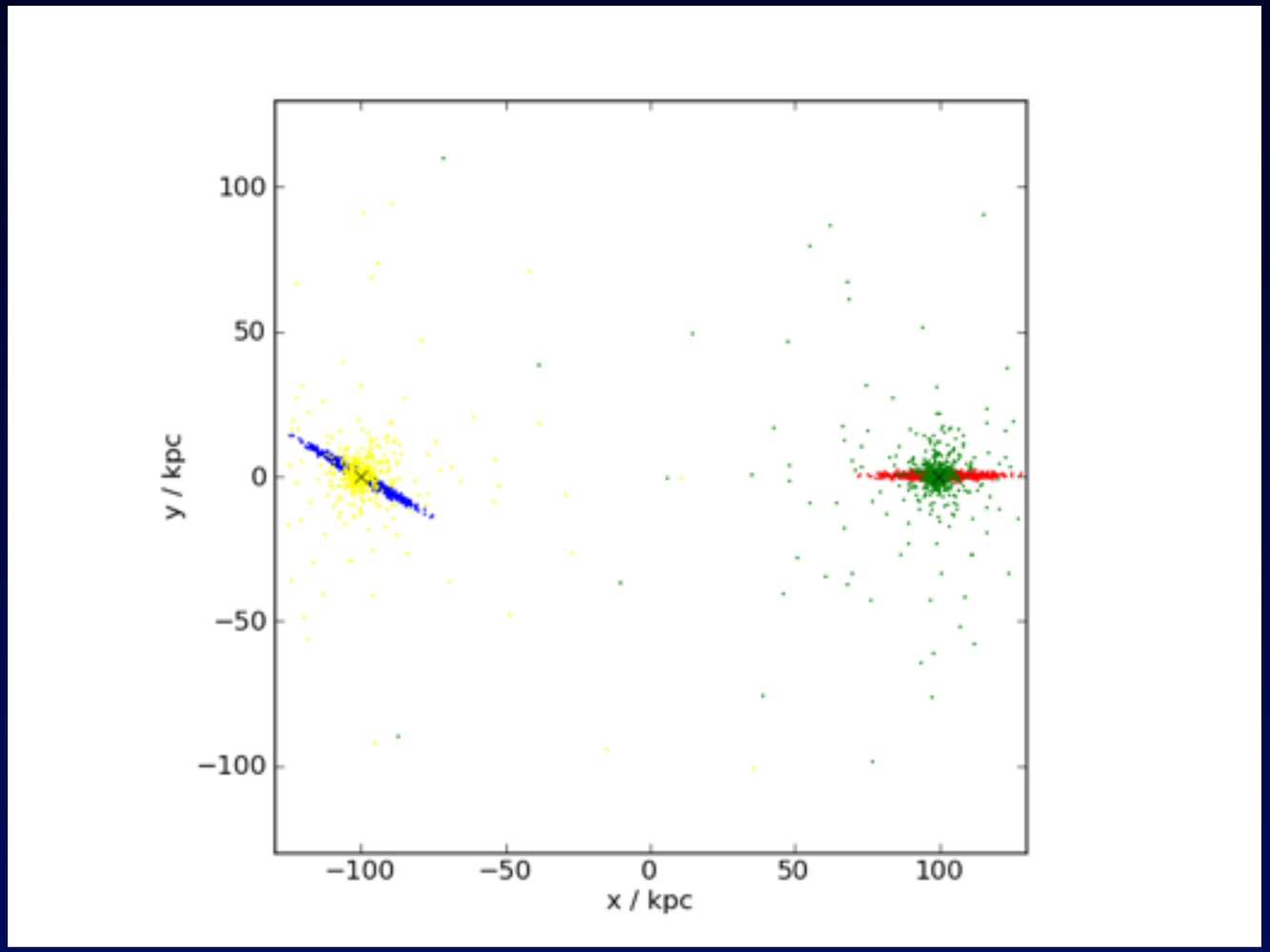
- Download Gadget (in case you haven't yet):
  - wget http://www.mpa-garching.mpg.de/gadget/gadget-2.0.7.tar.gz
  - tar -xvf gadget-2.0.7.tar.gz
- Edit Makefile
  - #OPT += -DPERIODIC
  - OPT += -DUNEQUALSOFTENINGS
  - #OPT += -DPMGRID=128
  - OPT += -DDOUBLEPRECISION
  - OPT += -DDOUBLEPRECISION_FFTW
  - #OPT += -DHAVE_HDF5
  - MPICHLIB = -lmpi
  - #SYSTYPE="MPA"
- Compile with make

Setting up the parameter file

- Edit the parameter file galaxy.param
  - `InitCondFile  ../ICs/Gall.dat`
  - `OutputDir  ../Output/Gall/`
  - `TimeMax  2.0`
  - `TimeBetSnapshot  0.1`
  - `SofteningGas  0`
  - `SofteningHalo  1.0`
  - `SofteningDisk  0.4`
  - `SofteningBulge  0.4`
  - `SofteningStars  0.4`
  - `SofteningBndry  0`
- Don't forget to put the IC file into the correct folder and to create the output folder!
- Run with:
  - `mpiexec -np 2 ./Gadget2 parameterfiles/param.txt`

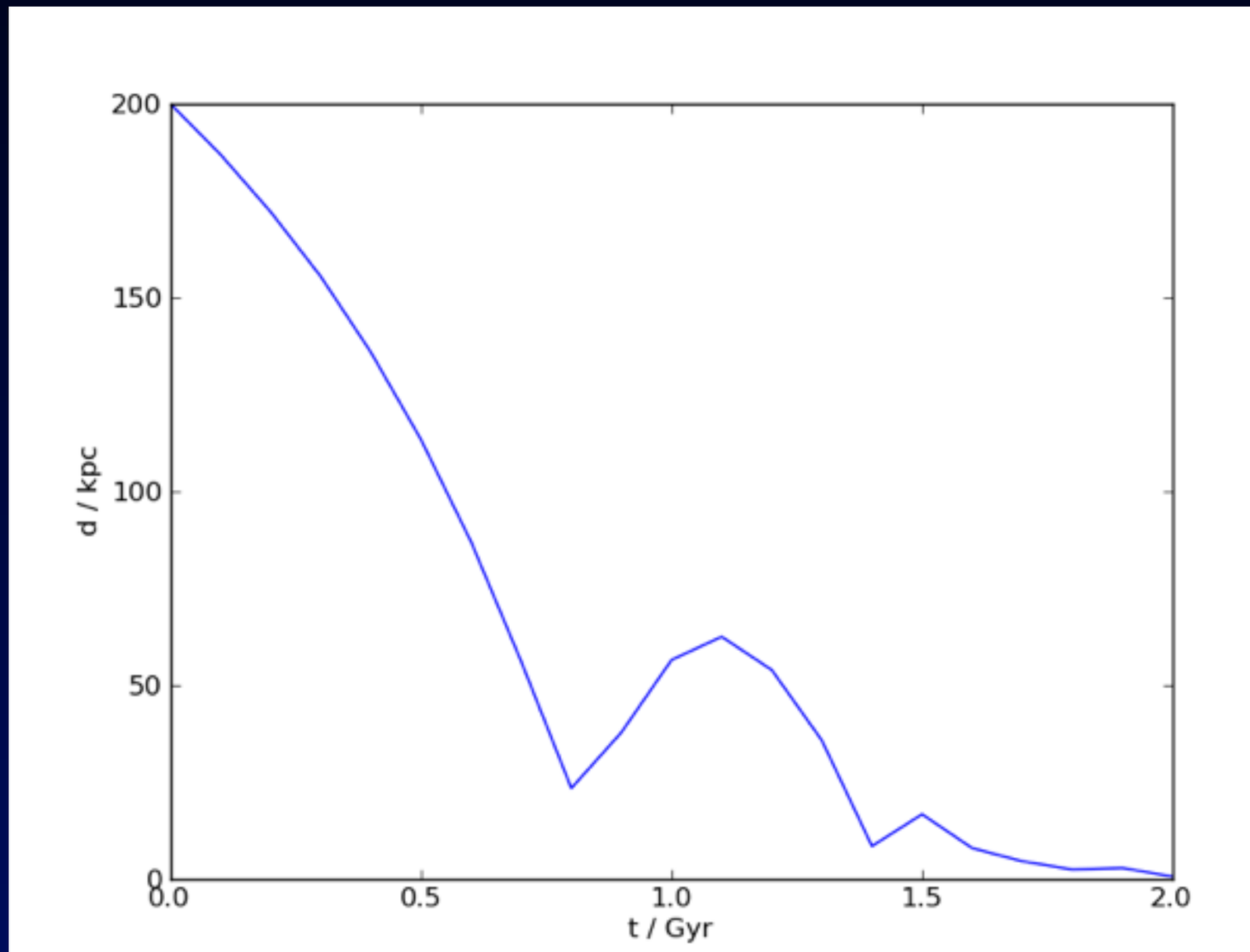
Plotting the initial conditions:

- Copy the file `plot_particles.py` to the folder with the ICs
- Edit the file and modify the input filename
  - `filename = "Gal1.dat"`
  - `y=1` (face-on) or `y=2` (edge-on)
- Plot the particles:
  - ipython
  - run plot_particles.py
- What do we see?
- Plot some snapshots from the output folder



Plotting the distance between the galaxies:

- Copy the file `distance.py` to the output folder
- Plot the particles:
  - ipython
  - run distance.py
- Why does the distance between the galaxies decrease?
- What has a larger merging-timescale: major or minor mergers?



Plotting the evolution of the simulation

- Copy the file `movie.py` to the output folder
- Plot the particles:
  - ipython
  - run movie.py
- Run both face-on and edge-on
- Does the centre of mass correspond to the centre of each galaxy?

Final notes

- Text Books:
  - Cosmology: Galaxy Formation and Evolution (Mo, vdBosch, White)
  - Galactic Structure: Galactic Dynamics (Binney, Tremaine)

- Papers:
  - Springel & White (1999), MNRAS, 307, 162
  - Springel et al. (2005), MNRAS, 62, 79

- Fun app to play with:

  http://burro.cwru.edu/JavaLab/GalCrashWeb/

- Gadget and N-GenIC website:

  http://www.mpa-garching.mpg.de/gadget/