

# Gadget-2 simulations of galaxy clusters on the McKenzie cluster

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November, 8 2006

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# Outline

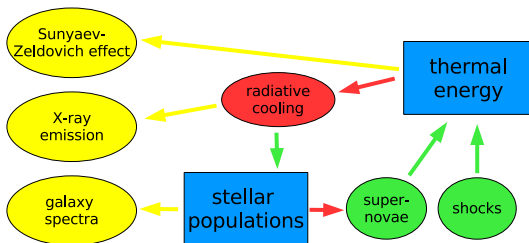
- 1 Gadget-2 simulations of galaxy clusters
  - Physical processes
  - Simulating super-clusters
  
- 2 Simulations and post-processing
  - Running Gadget-2 on bob
  - Post-processing



# Radiative simulations – flowchart

Cluster observables:

Physical processes in clusters:

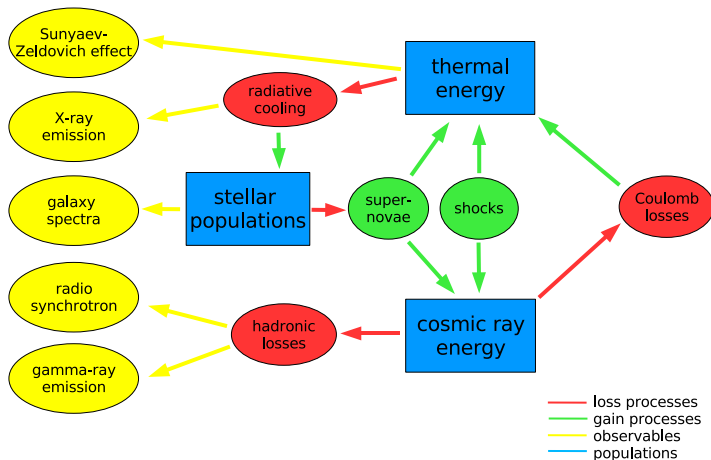


- loss processes
- gain processes
- observables
- populations

# Radiative simulations with cosmic rays

Cluster observables:

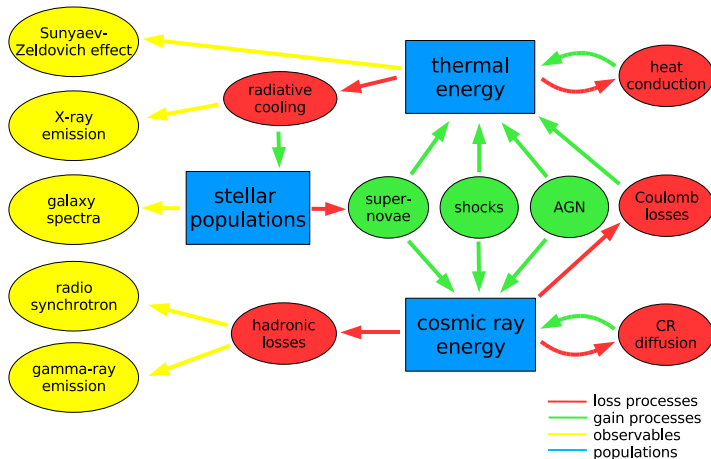
Physical processes in clusters:



# Radiative simulations with cosmic rays (future)

Cluster observables:

Physical processes in clusters:

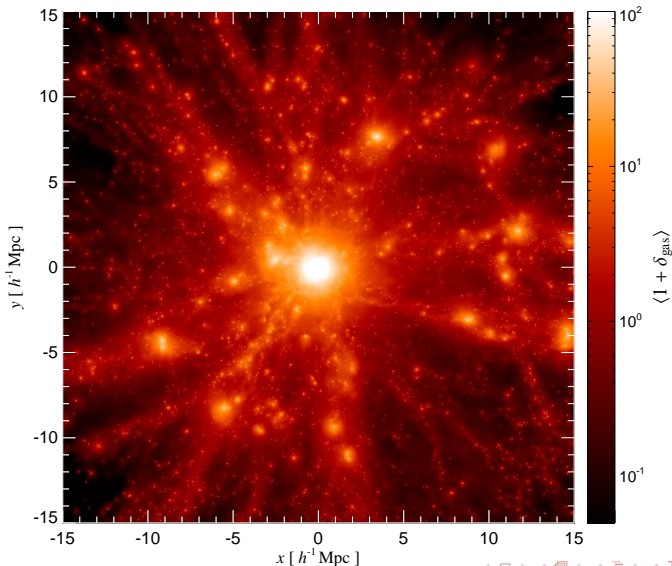


# How to do a 'zoomed initial conditions' simulation:

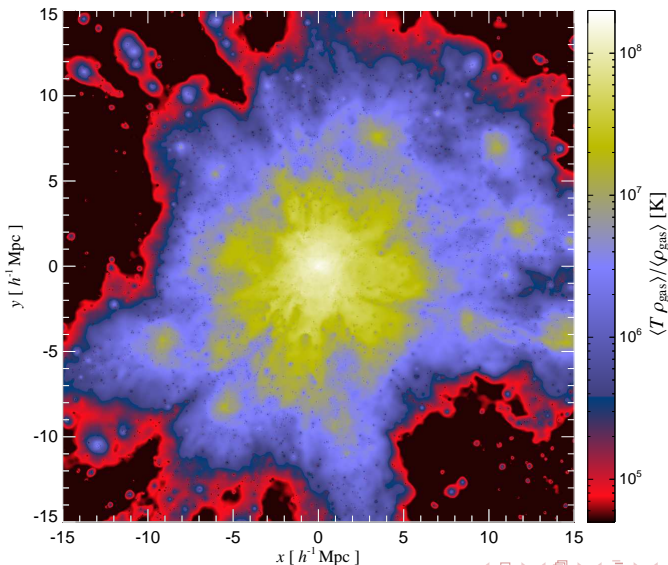
- select clusters from a large cosmological low-resolution DM-only simulation
- re-simulate the clusters with higher mass and force resolution by adding short-wavelength modes within the Lagrangian regions in the initial conditions that will evolve later-on into the structures of interest
- in high-resolution regions: DM particles of the parent simulation are split into a DM and gaseous part, with the mass ratio reflecting the value of the cosmic baryon fraction.
- degrade force and mass resolution at  $r > 3 - 5R_{\text{vir}}$  (limiting the computational cost while correctly representing the large scale tidal gravitational field)
- iteratively re-simulate until the high-resolution regions are not 'contaminated' with heavy DM particles



# Super-cluster region: gas density [Pfrommer et al., astro-ph/0611037]

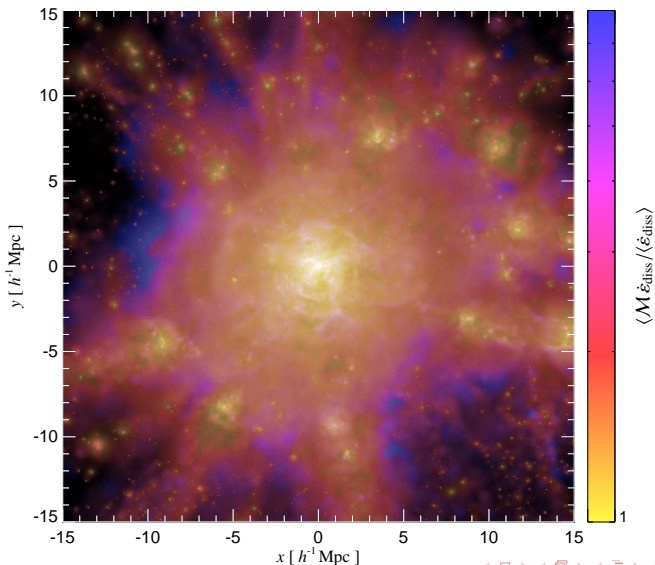


# Super-cluster region: gas temperature

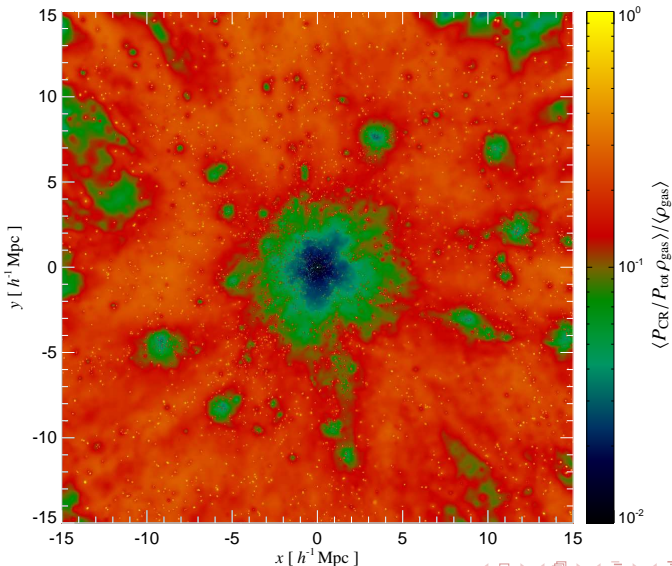




# Super-cluster region: Mach numbers



# Super-cluster region: relative CR pressure $P_{\text{CR}}/P_{\text{tot}}$



# Job file for Gadget-2

```
#!/bin/csh
#PBS -l nodes=24:ppn=2
#PBS -q workq
#PBS -r n
#PBS -l walltime=48:00:00
#PBS -l other=raid-pfrommer:raid-pfrommer2

module load fftw
module load hdf
cd $PBS_O_WORKDIR
lamboot
mpirun C P-Gadget2 parameterfile > stdout.txt
lamhalt
```



# Makefile adjustments

```
SYSTYPE="McKenzie"  
  
ifeq ($(SYSTYPE),"McKenzie")  
CC = mpicc  
OPTIMIZE = -g -O3  
GSL_INCL = -I/usr/include  
GSL_LIBS = -L/usr/lib  
FFTW_INCL= -I/opt/fftw/intel_8.1/2.1.5/include  
FFTW_LIBS= -L/opt/fftw/intel_8.1/2.1.5/lib  
MPICHLIB = -L/opt/lam-7.1.2b24-g77/lib -lmpi  
HDF5INCL = -I/opt/hdf5-oscar-1.6.4/include  
HDF5LIB = -L/opt/hdf5-oscar-1.6.4/lib -lhdf5 -lz  
endif
```



# Performance

No general statement possible, depends on simulation geometry ('box' versus 'zoomed' simulations) and on the simulated physics (cooling, star formation, CR physics, ...).

## **Cosmological simulation:**

cosmological box , side length  $L = 150 h^1$  Mpc,  $2 \times 256^3$  particles, included physics: cooling, star formation, feedback from galactic winds, 128 CPUs  $\rightarrow$  49 hours (wall-clock time),  $\sim 75\%$  load balanced on average

## **'Zoomed cluster' simulation:**

re-simulation of super-cluster region, central cluster resolved by  $4 \times 10^6$  particles, included physics: cooling, star formation, CR feedback, 64 CPUs  $\rightarrow$  14 days (wall-clock time),  $\sim 65\%$  load balanced on average



# Post-processing on hosehead

IDL and C routines:

- data stored on raid disks, potential problem: large numerical paper easily uses up  $\sim 300$  GByte of space
- halo-finder based on spherical overdensity as well as friends-of-friends algorithm
- merger tree analysis in order to get the mass accretion history of the main progenitor
- measuring profiles of various quantities
- projection code for various quantities (taking into account the SPH smoothing length)

