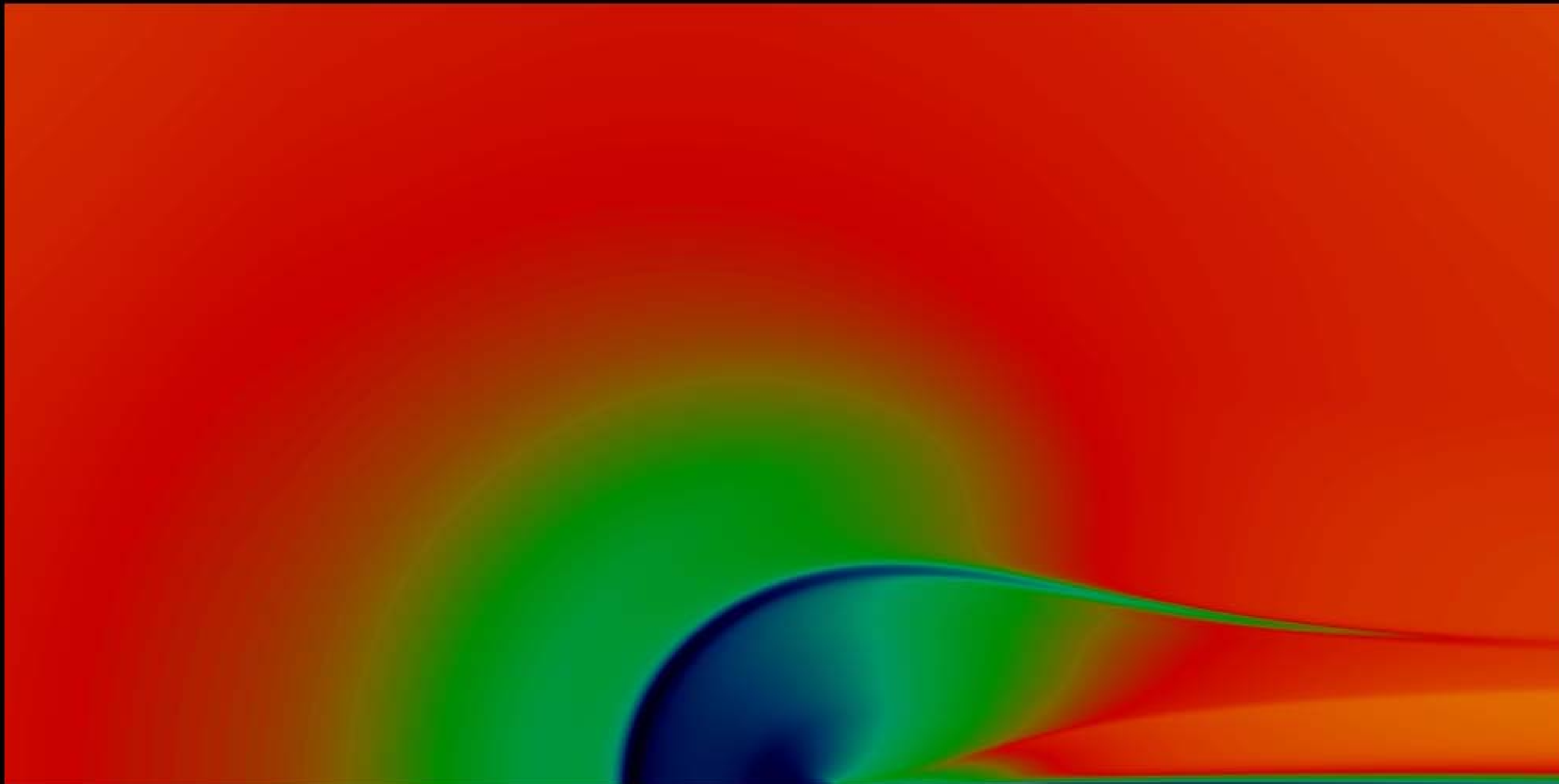


How the First Stars Regulated Local Star Formation: Radiative Feedback

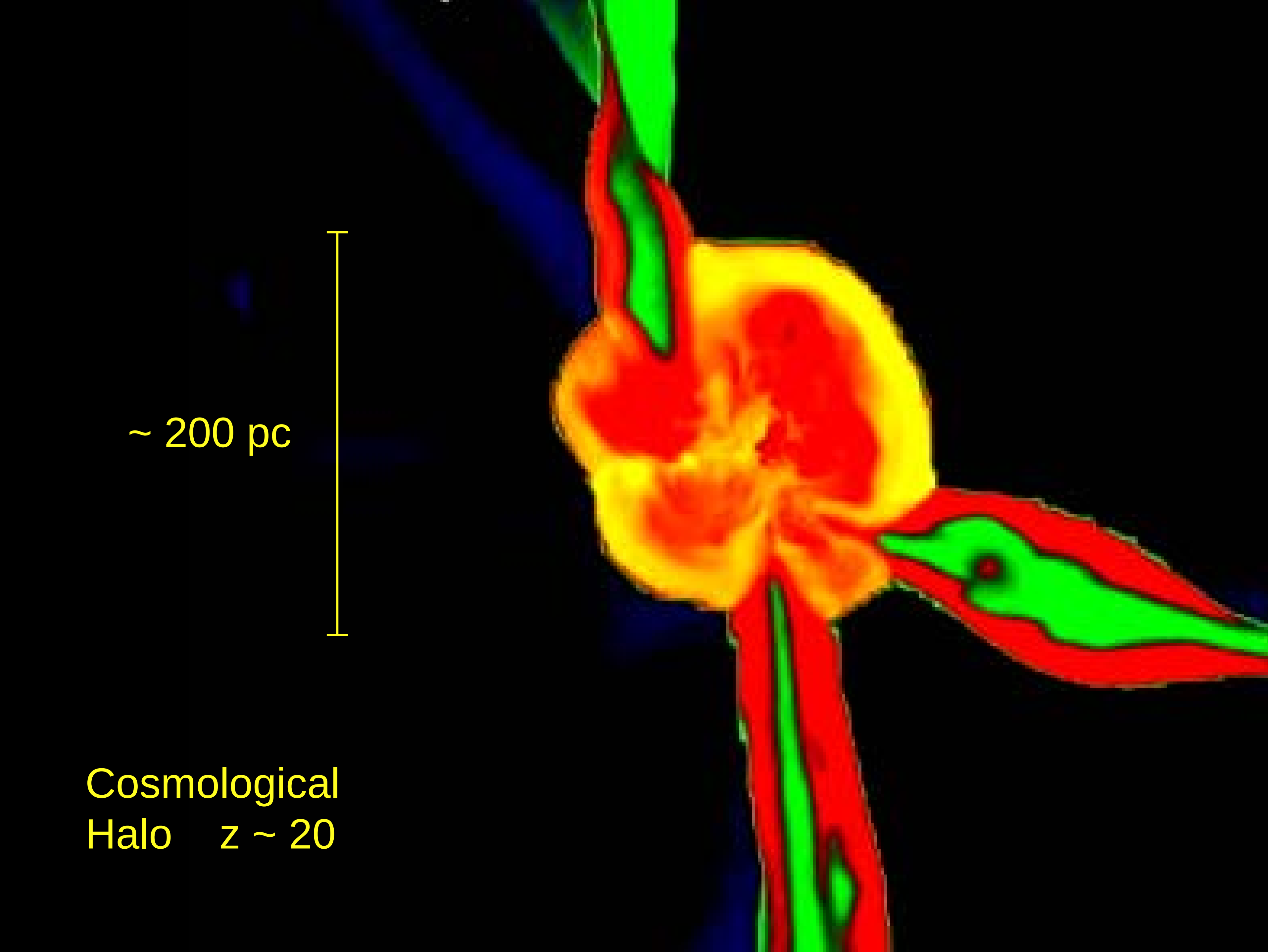
2008, ApJ, 679, 925

Dan Whalen, X-2, LANL

Our Collaboration

Brian O'Shea	T-6, LANL / MSU
Joseph Smidt	UC Irvine
Alex Heger	T-6, LANL

Michael Norman, UC San Diego

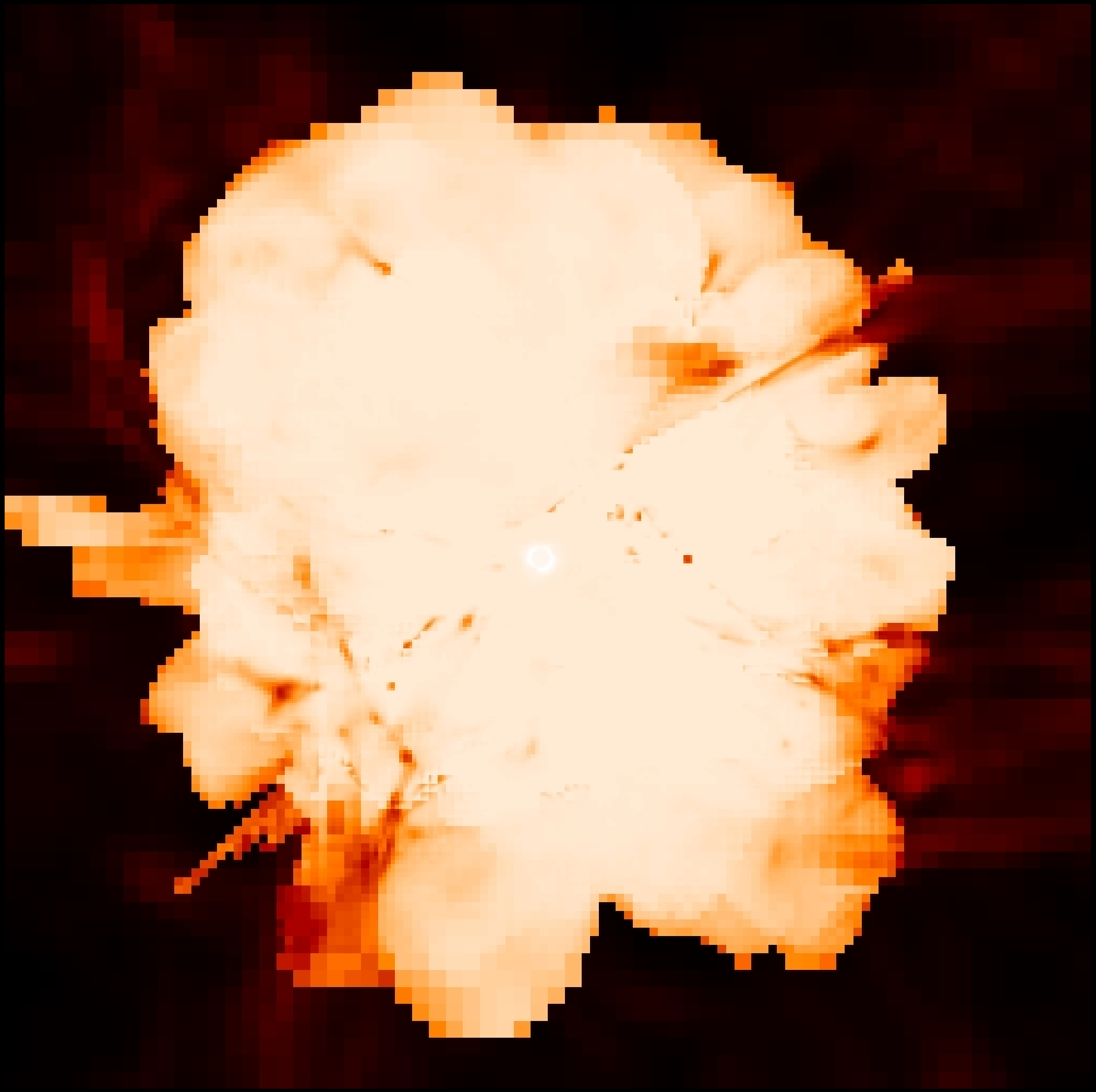

~ 200 pc
Cosmological
Halo z ~ 20

The Universe
at Redshift 20

128 kpc comoving

Population III Star Properties

- likely very massive (30 - 500 solar masses)
- 2 - 3 Myr lifetimes
- extremely luminous sources of ionizing UV and Lyman-Werner (LW) photons (10^{50} s^{-1})
- probably no winds (and hence little mass loss)
- no known dynamically important magnetic fields



Primordial Stars Engulfed Neighbor Halos with both Ionizing and LW UV Radiation

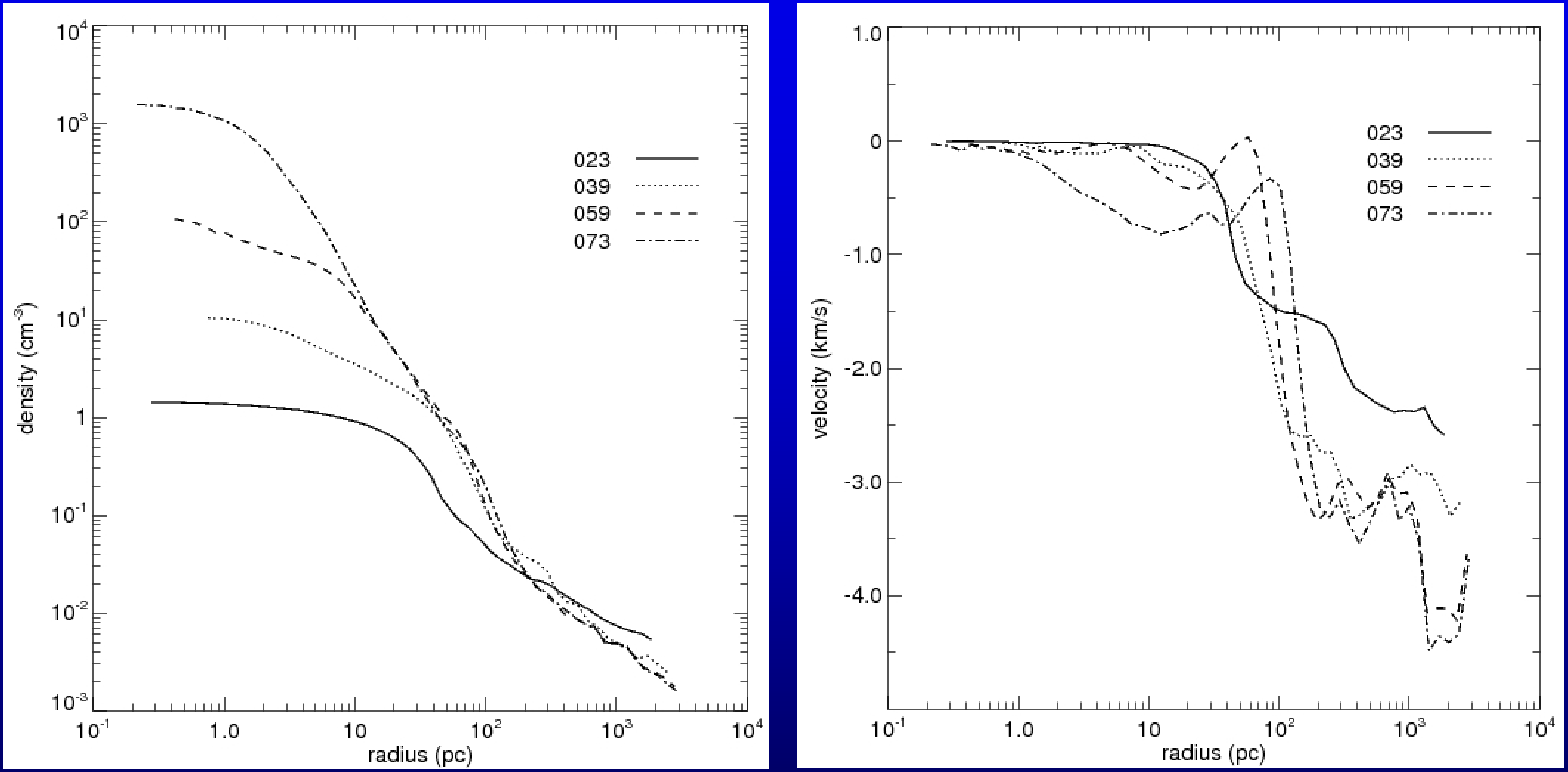
- LW photons can destroy H_2 in halos and halt their collapse
- ionizing photons can evaporate halos with supersonic flows

Halo Photoevaporation Models

- four 1.35 x 10^5 solar mass spherically-averaged halo profiles extracted at consecutive evolutionary stages from an Enzo AMR simulation
- 120 solar mass central star located at 150, 250, 500, and 1000 pc from the halo
- each halo is illuminated for the 2.5 Myr lifetime of the star and then allowed to evolve another 2.5 Myr in the fossil H II region

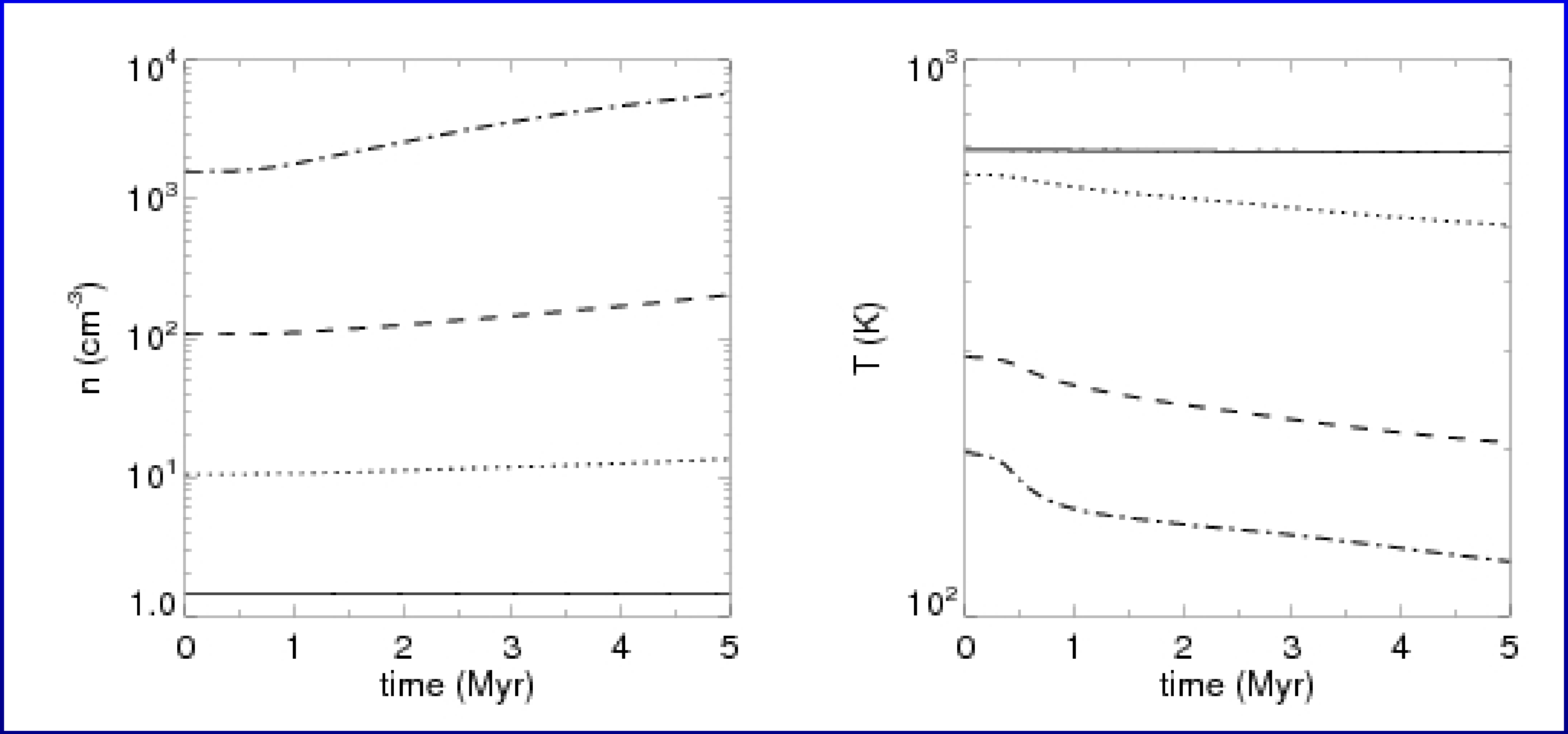
ZEUS-MP Reactive Flow Radiation Hydrodynamics Code

- massively-parallel (MPI) Eulerian hydrocode with 1-, 2-, or 3D cartesian, cylindrical, or spherical meshes
- 9-species primordial H/He gas network coupled to photon conserving multifrequency UV transfer
- adaptive time step hierarchy enforces respective Courant, heating, and chemistry times without holding the entire algorithm hostage to the shortest time scale
- Poisson solver for gas self-gravity
- includes the dark matter potential of the halo, which remains frozen for the duration of these calculations



Spherically-Averaged Enzo AMR Code Halo Radial Density and Velocity Profiles (O'Shea & Norman 2007b)

z = 23.9, 17.7, 15.6 and 15.0



Evolution of Halo Cores in the Absence of Radiation

059_500pc

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

	1000 pc	500 pc	250 pc	150 pc
1.43 cm^{-3}	D	D	D	D
10.5 cm^{-3}	P	P	D	D
108 cm^{-3}	P	P	?	P
1596 cm^{-3}	N	N	P	?

P = positive feedback, D = disrupted, N = neutral

	1000 pc	500 pc	250 pc	150 pc
1.43 cm^{-3}	D	D	D	D
10.5 cm^{-3}	D,R	D	D	D
108 cm^{-3}	S,E	P	D	D,E
1596 cm^{-3}	S	S	P	D

D = dissociated, P = partly dissociated, S = shielded
E = enhanced, R = restored

Four Outcomes:

- complete core disruption
- nearly undisturbed cores
- accelerated collapse
- core drainage/partial disruption

Conclusions

- partial or complete dissociation of satellite halos is temporary--they often end up with more H_2 in their cores than they would have formed on their own
- I-fronts do partly strip halos of gas, but they also compress their cores and in many cases accelerate star formation in the process
- due to coeval nature of halos in a cluster, local radiative feedback tends to be neutral or positive

Future Work

- 3D ZEUS-MP / Enzo AMR evolution of the halo--star formation if core migrates in the dark matter potential?
- variable stellar luminosities? ---> stellar evolution models
- lower-mass Pop III star illumination (30 - 70 solar masses) ?
- miniquasar flux could partially ionize halo without fatal heating ---> enhanced H_2 production?
- supernova / halo interaction ---> metal mixing, prompt lower-mass star formation?
- 3D Enzo halo photoevaporation ---> 2nd star formation?