Accretion on a moving object

Accretion Shocks and cold flows

Z=1

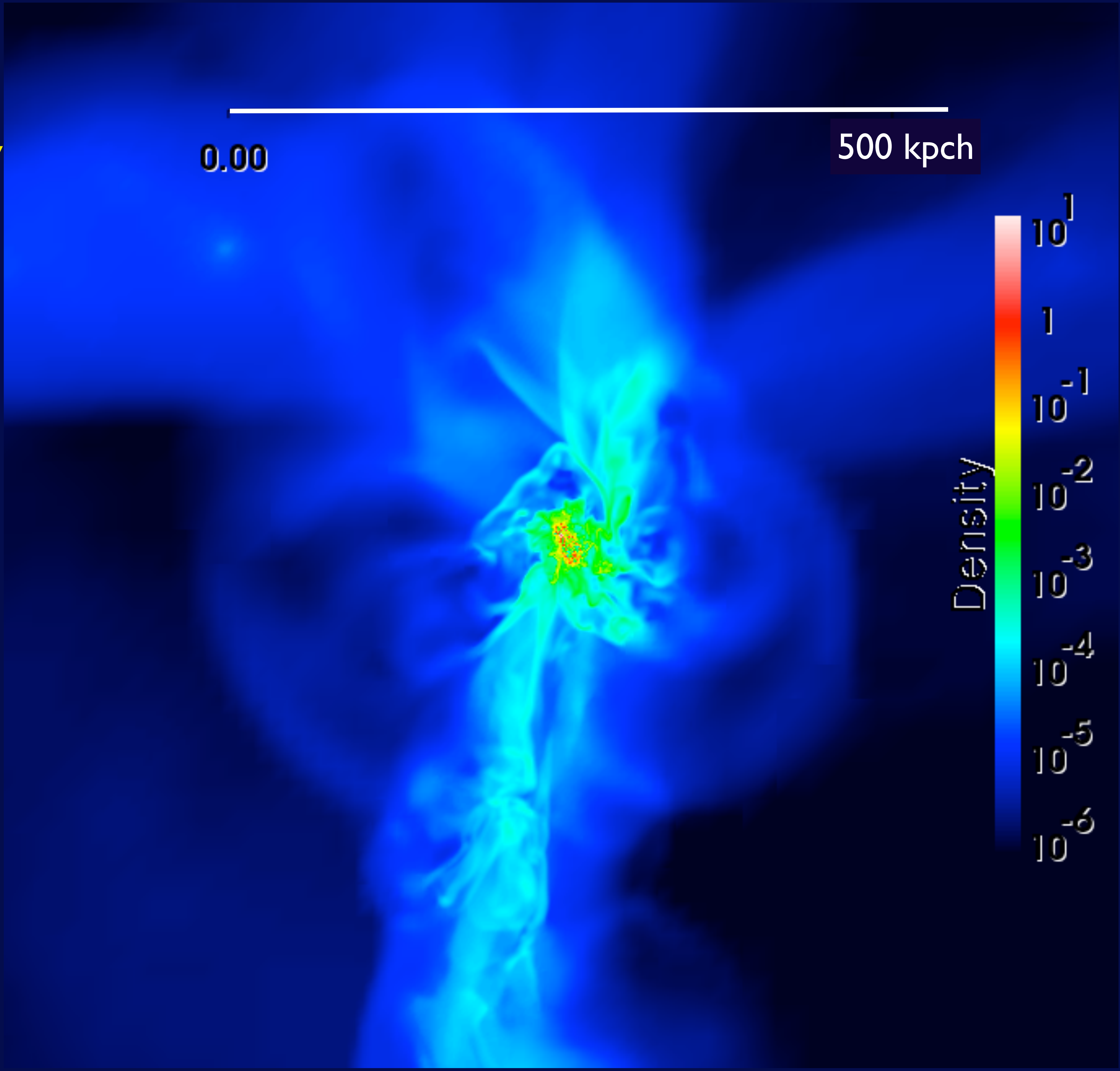
Progenitor of M33-size galaxy

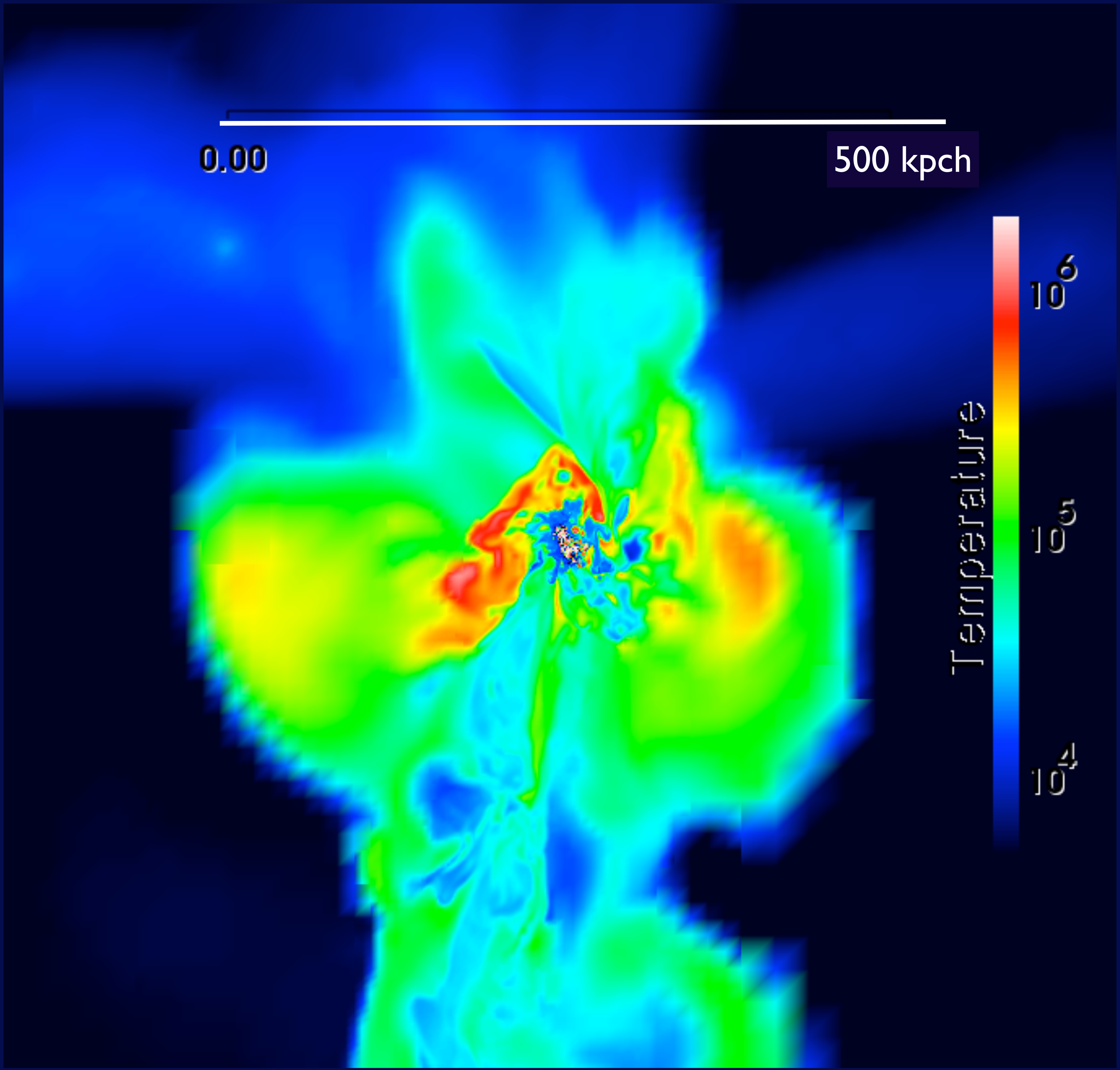
Photoheating + Radiation pressure + SN + ...

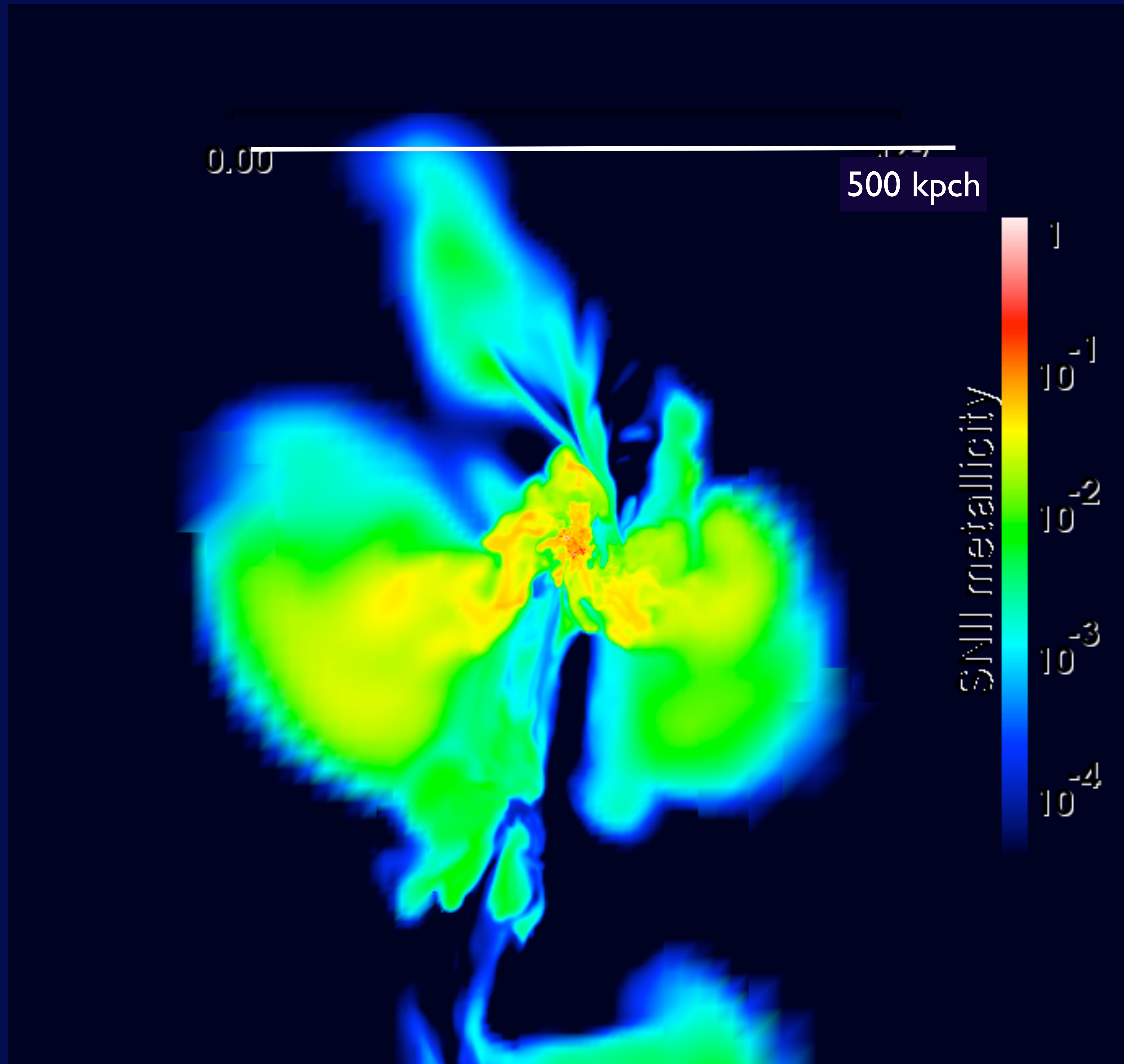
~50 pc resolution

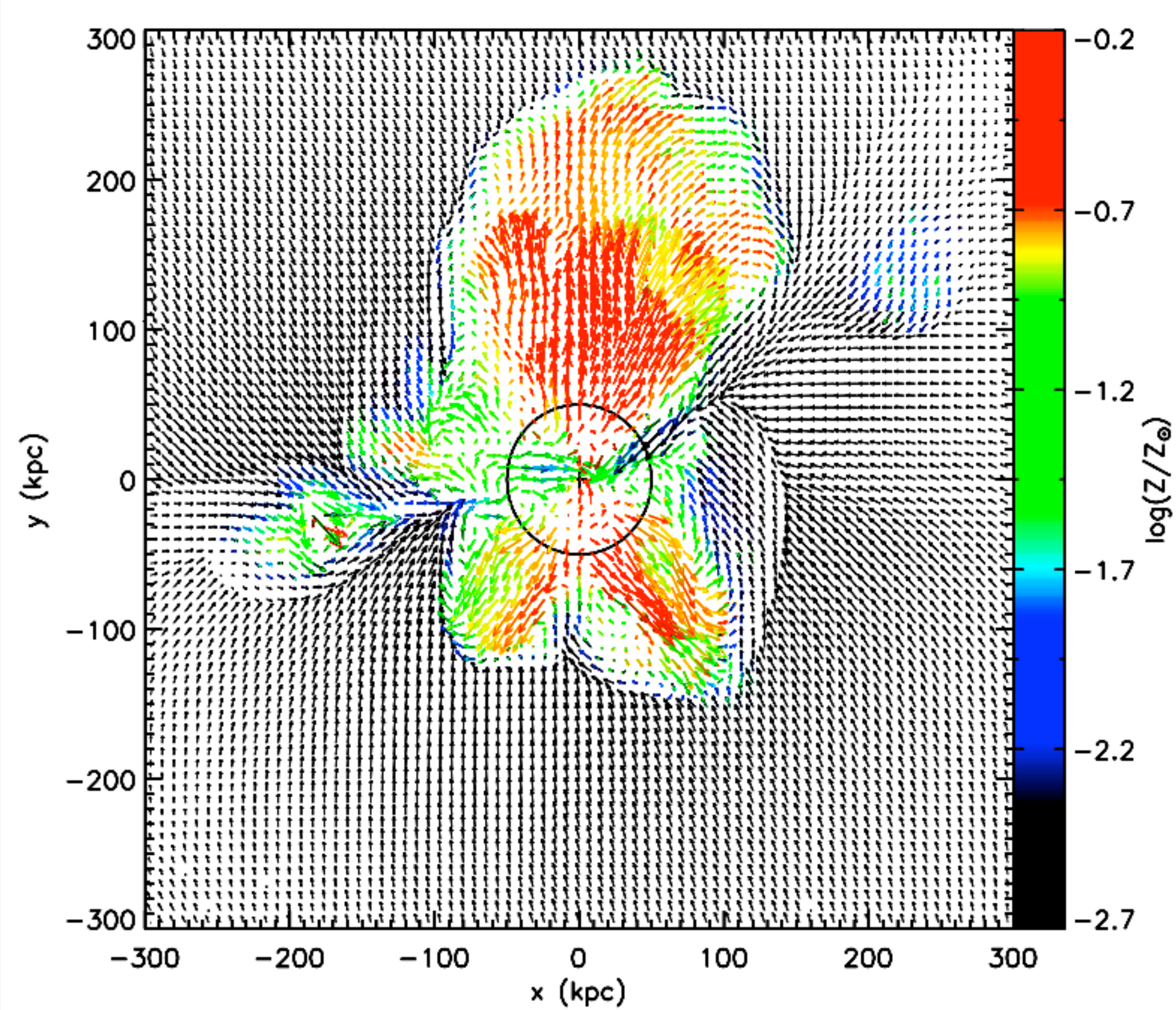
Gas density

Trujillo-Gomez etal 2013




0.00
500 kpch
Temperature
10^6
10^5
10^4

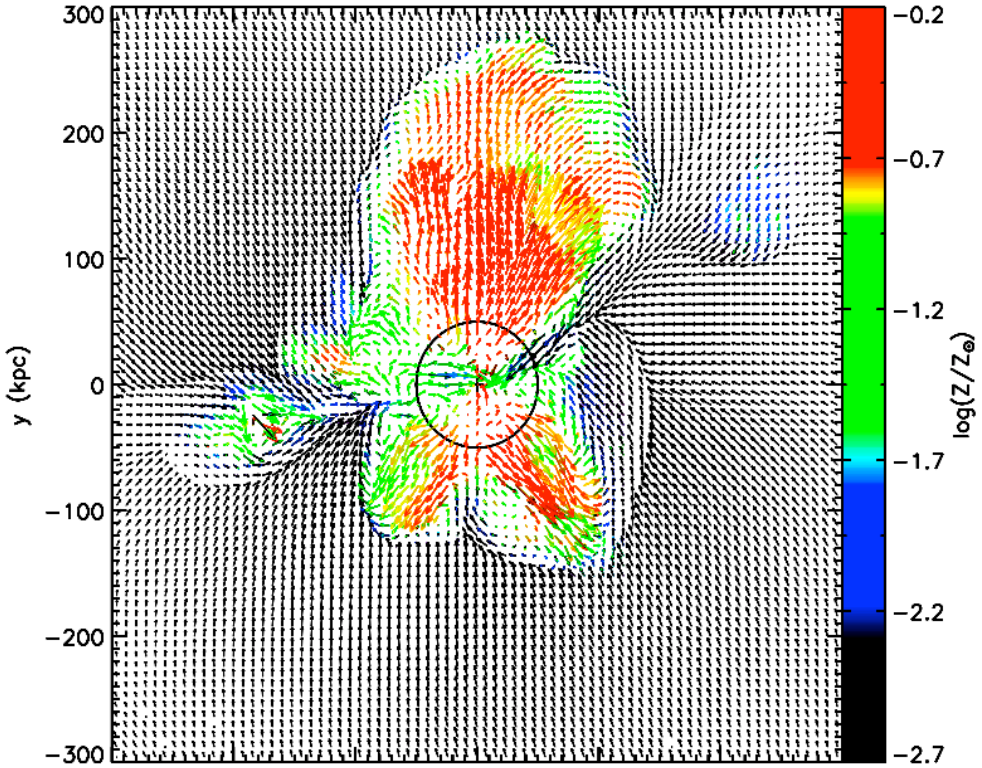

0.00
500 kpch
SNII metallicity
1
10^-1
10^-2
10^-3
10^-4



Eris2 simulation
Shen et al 2013

MW-size galaxy

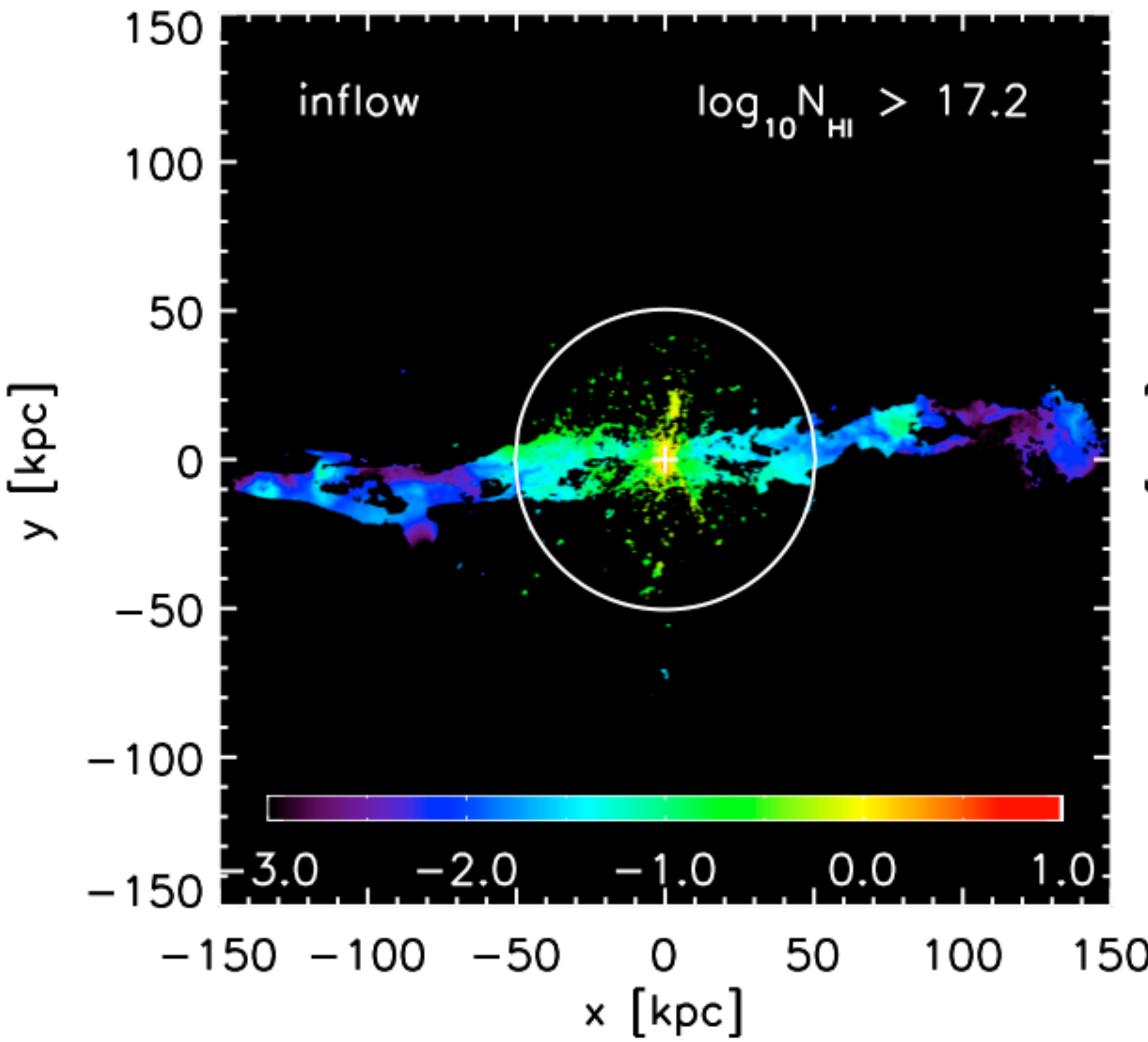
Blast wave approximation

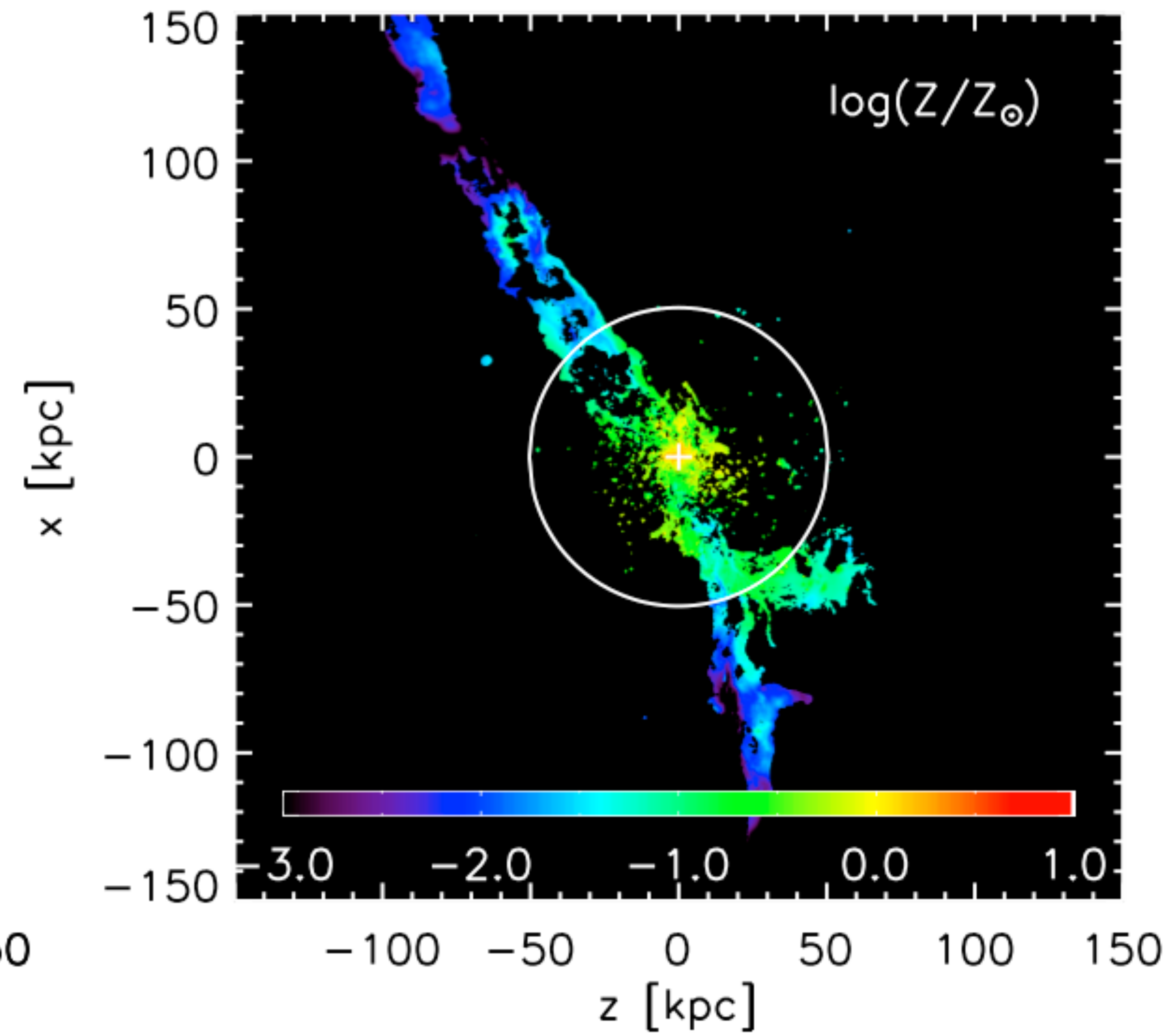


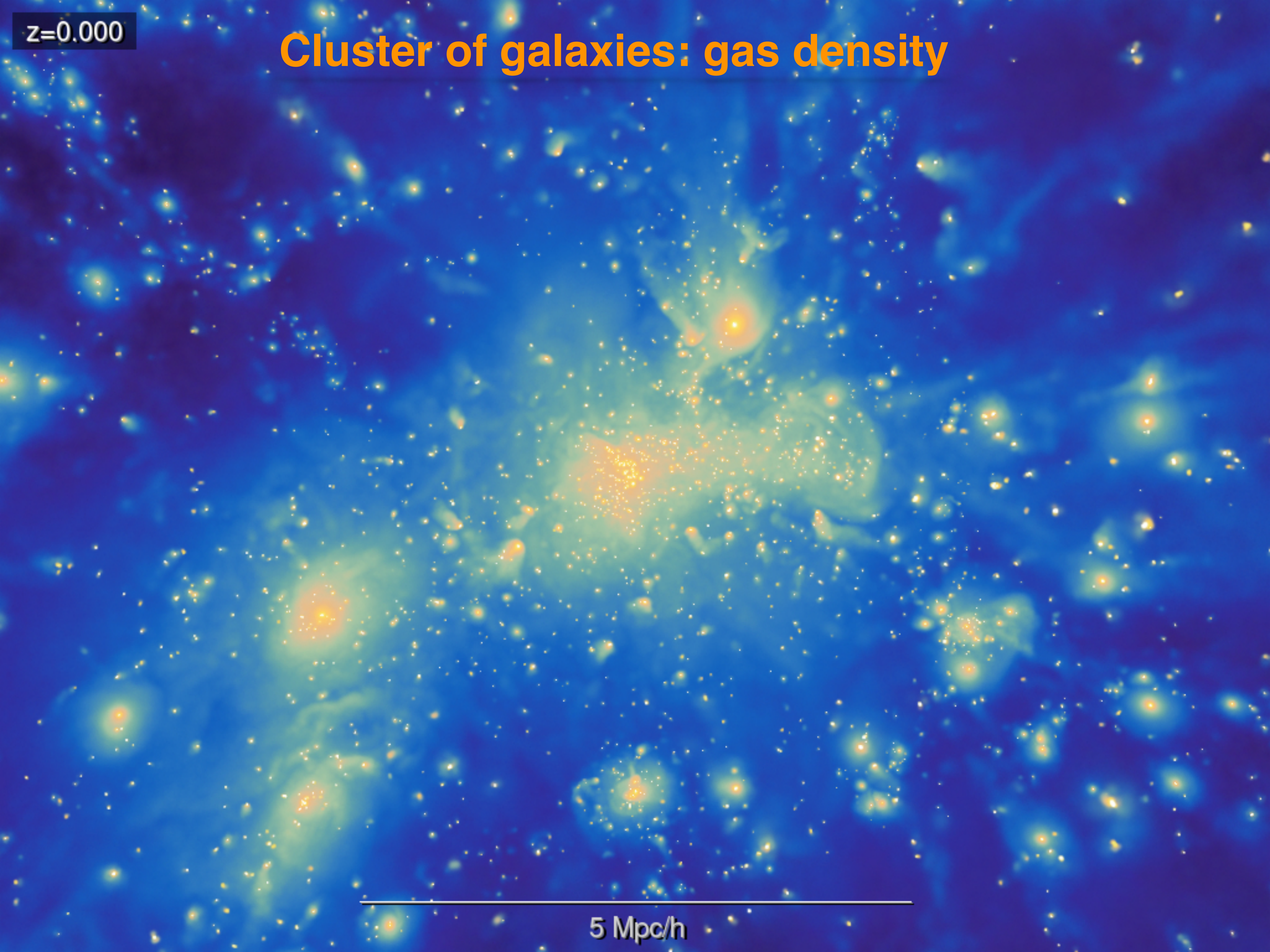
Eris2 simulation
Shen et al 2013

MW-size galaxy

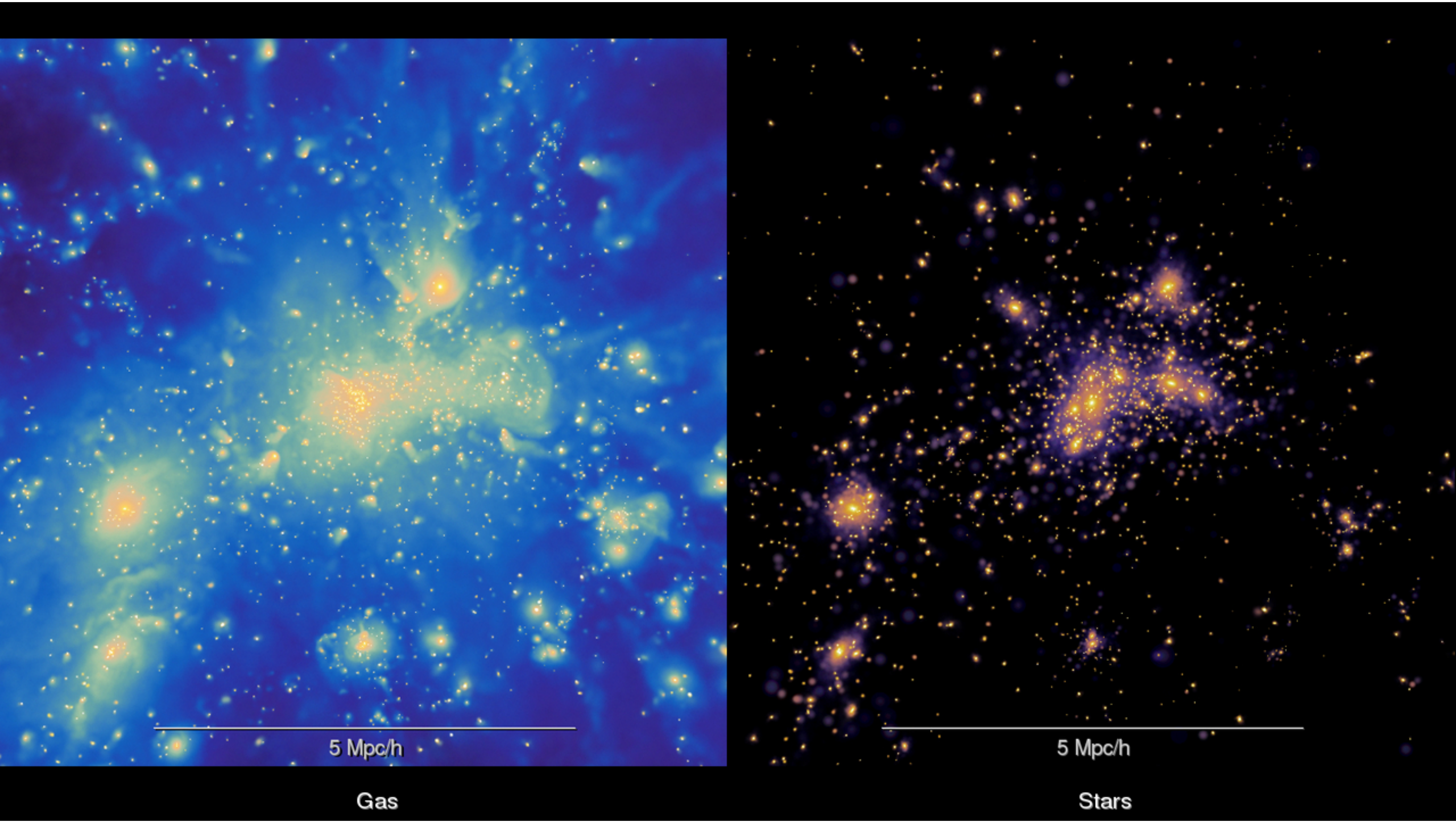
Blast wave approximation

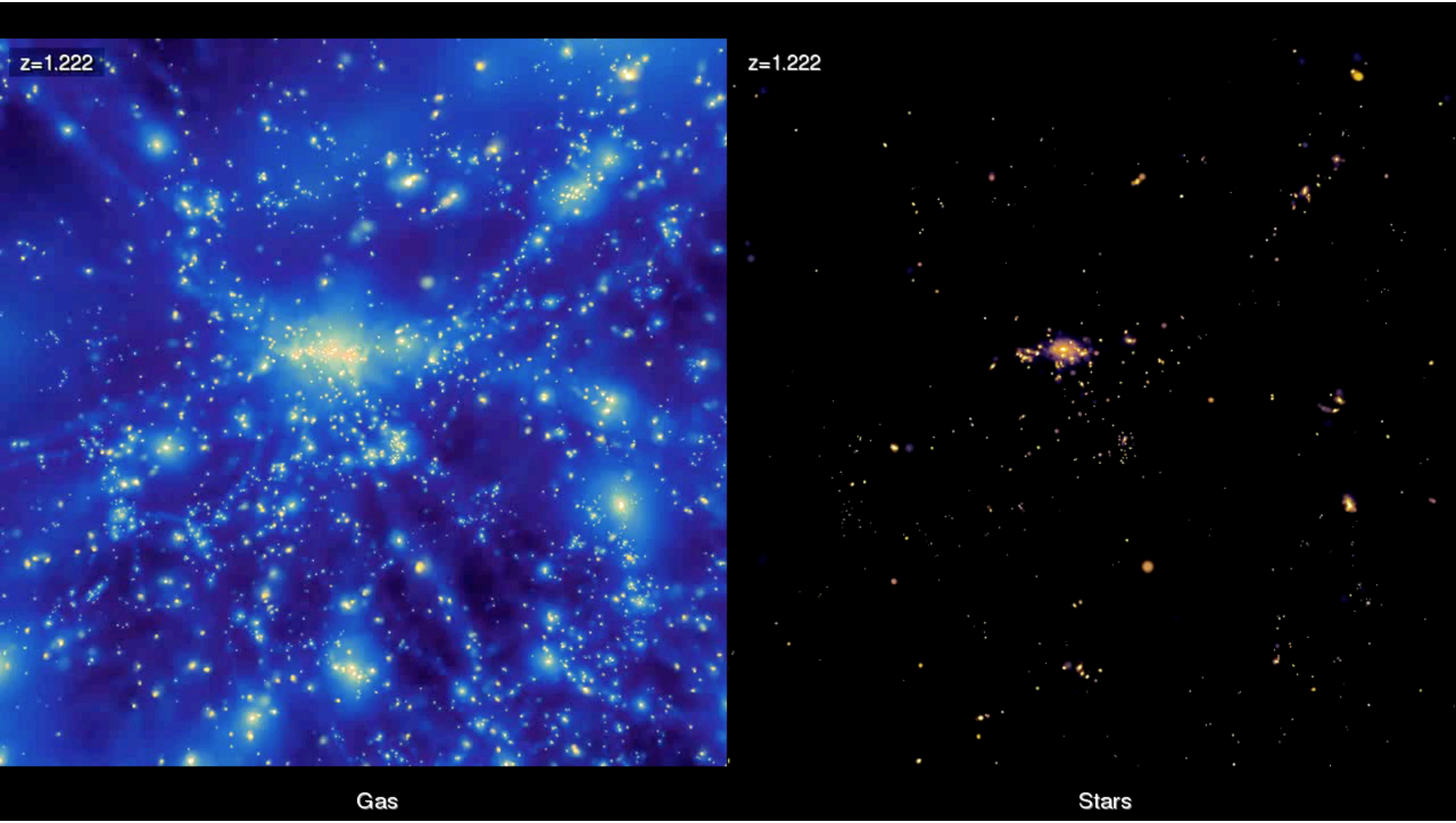


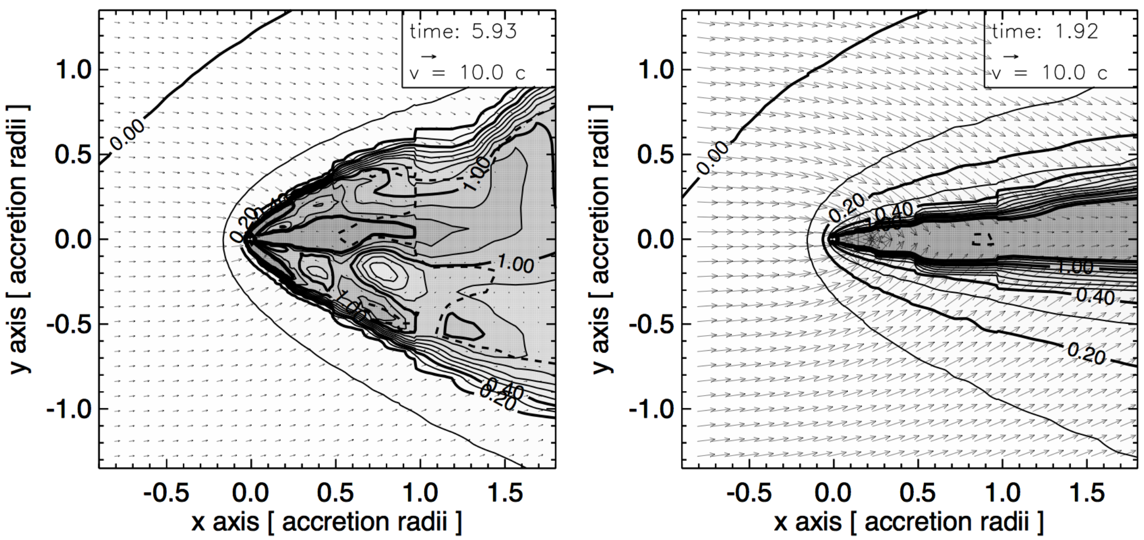




z=0.000
Cluster of galaxies: gas density
5 Mpc/h


5 Mpc/h
5 Mpc/h
Gas
Stars


z=1.222
z=1.222
Gas
Stars



analytically for spherically symmetric accretion (Bondi, 1952):

$$d_s = \frac{5-3\gamma}{4} R_B \quad , \tag{1}$$

with the Bondi radius given by

$$R_B = \frac{GM}{c_\infty^2} \quad . \tag{2}$$

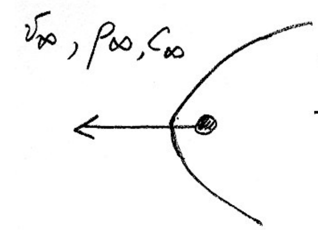
For further reference we define the accretion radius (Hoyle & Lyttleton, 1939, 1940a, 1940b, 1940c; Bondi & Hoyle, 1944) as

$$R_A = \frac{2GM}{v_\infty^2} \quad , \tag{3}$$

in which M is the mass of the accretor, G the gravitational constant, c_∞ the sound speed of the medium at infinity and v_∞

Ruffert, Arnett (94, ApJ)
Ruffert (99, A&A)

Bondi–Hoyle Accretion



- accretion on moving compact object
- relativistic effects can be neglected
- Object: absorbing sphere. It does not have solid surface.
- at large distance from the object the medium has parameters $v_\infty, \rho_\infty, c_\infty$
- gas is adiabatic with equation $P = A\rho^\gamma$
- ideal gas

Accretion of pressureless medium on a compact object moving with velocity v_∞ is equal to

$$\dot{M} = \pi R_A^2 \rho_\infty v_\infty$$

where

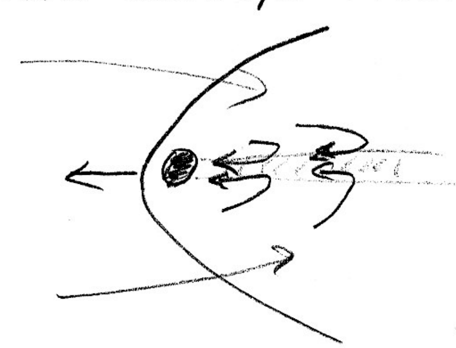
$$R_A = \frac{2GM}{v_\infty^2}$$

This should be corrected to take into account pressure of the gas. Approximate correction is:

$$\dot{M} = \pi R_A^2 \rho_\infty v_\infty \left(\frac{\mathcal{M}_\infty^2}{\mathcal{M}_\infty^2 + 1} \right)^{3/2},$$

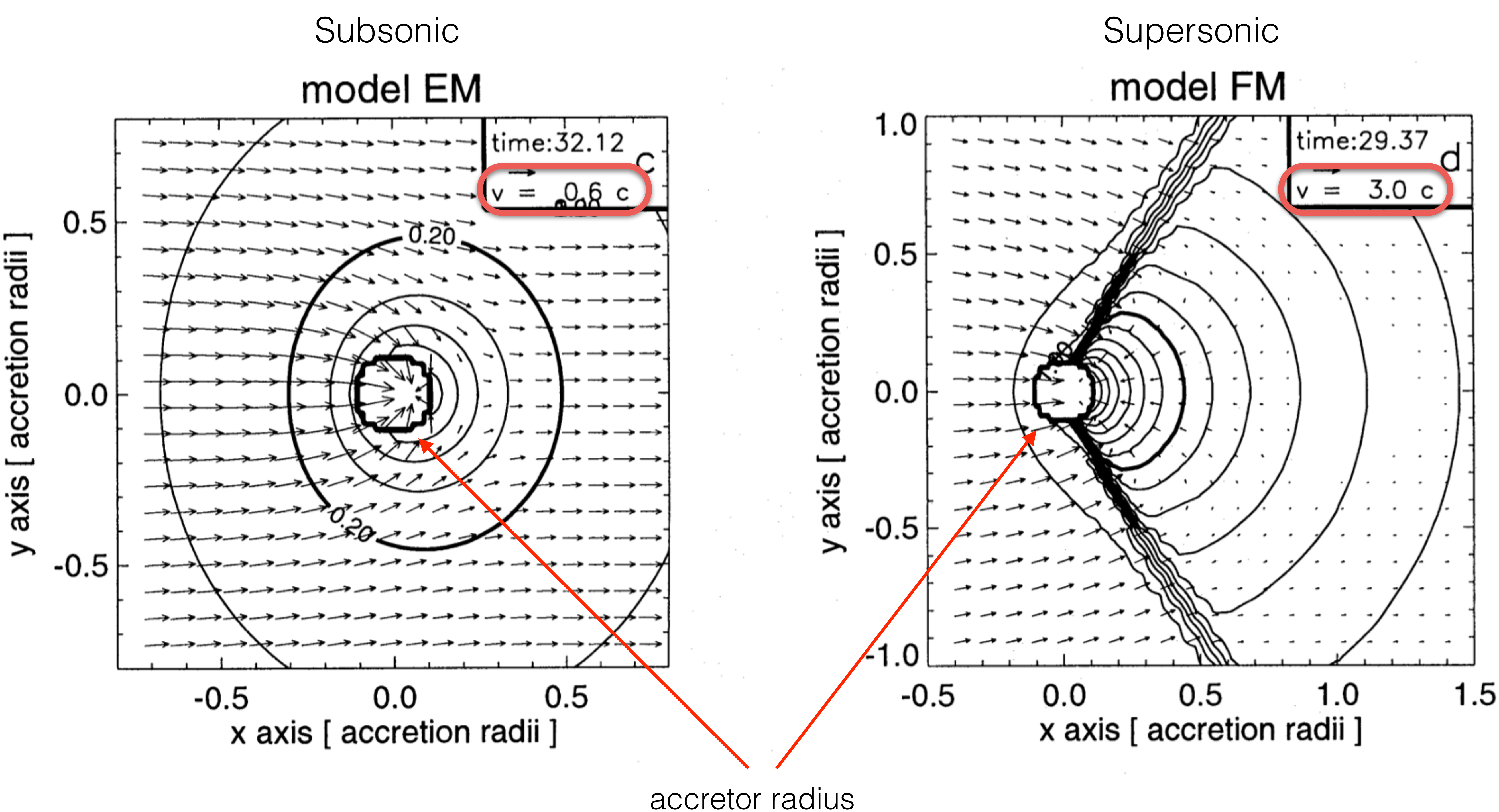
where $\mathcal{M}_\infty = v_\infty / c_\infty$ is the Mach number. Correcting term for $\mathcal{M}_\infty = 3$ is $\simeq 0.85$.

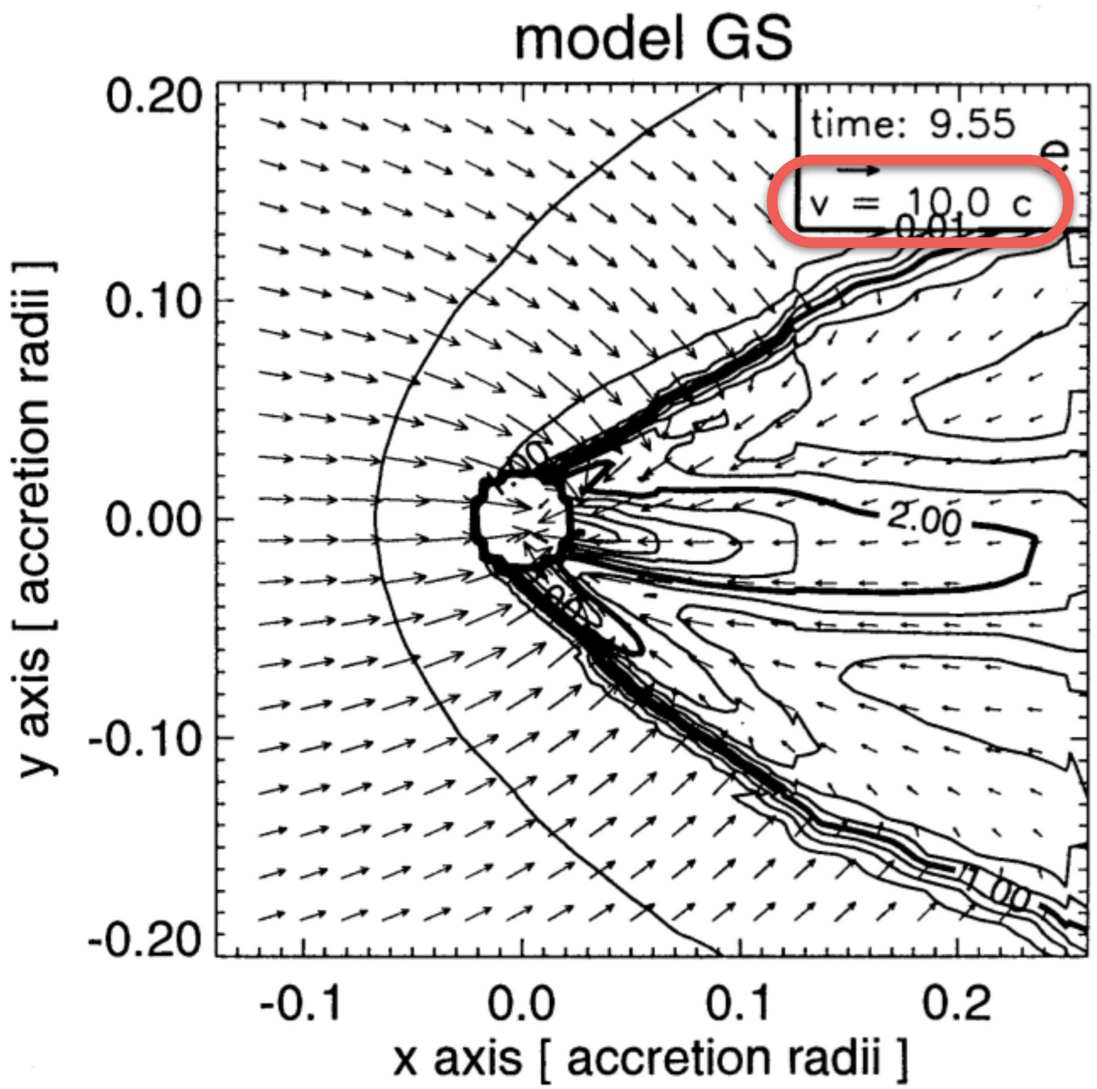
Early analytical estimates indicated that behind the accretor develops a relatively thin accretion line.

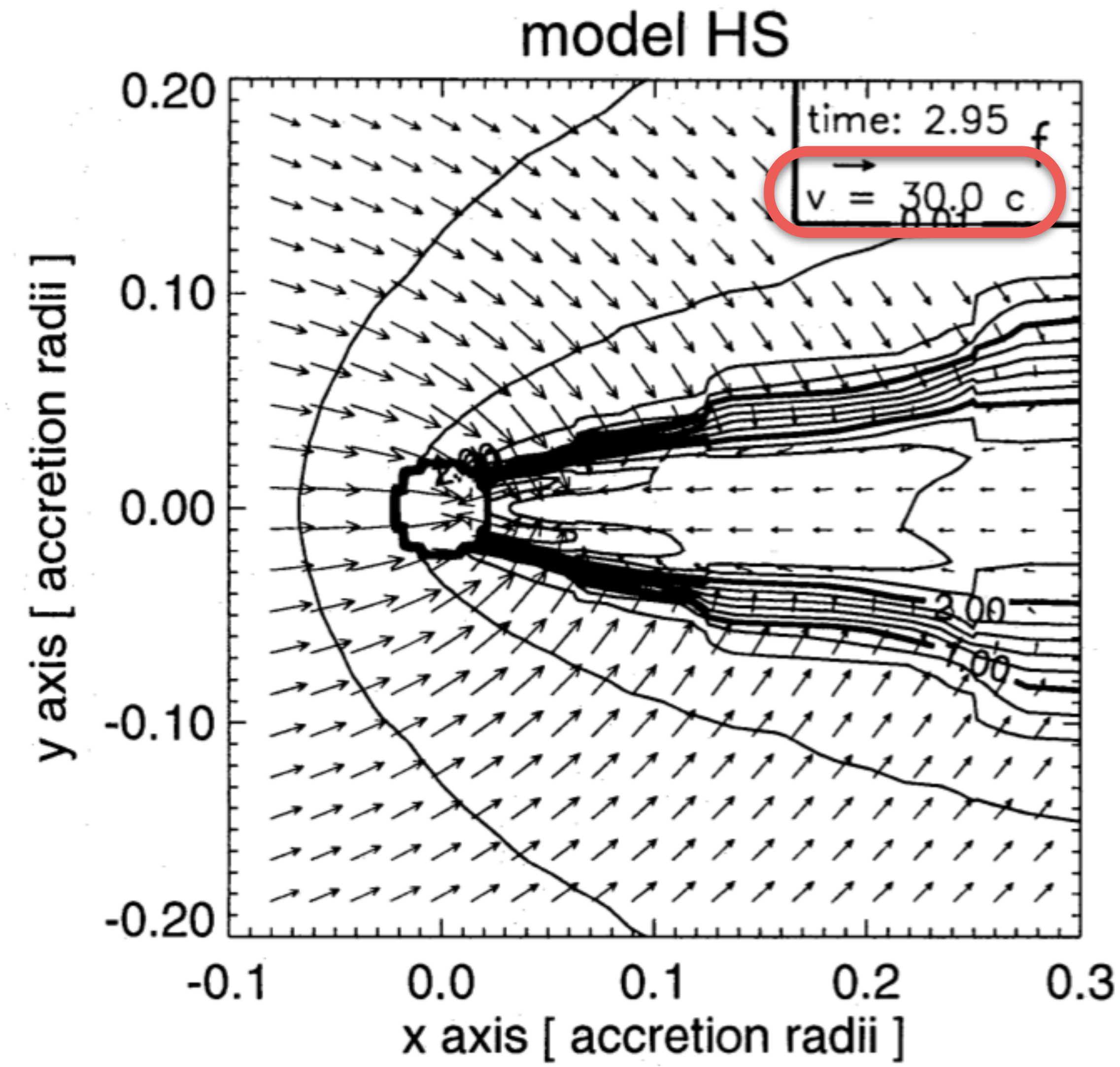


This line does form at early stages of evolution, but it is soon destroyed by developing instabilities

Dependance of mass flow pattern on Mach number







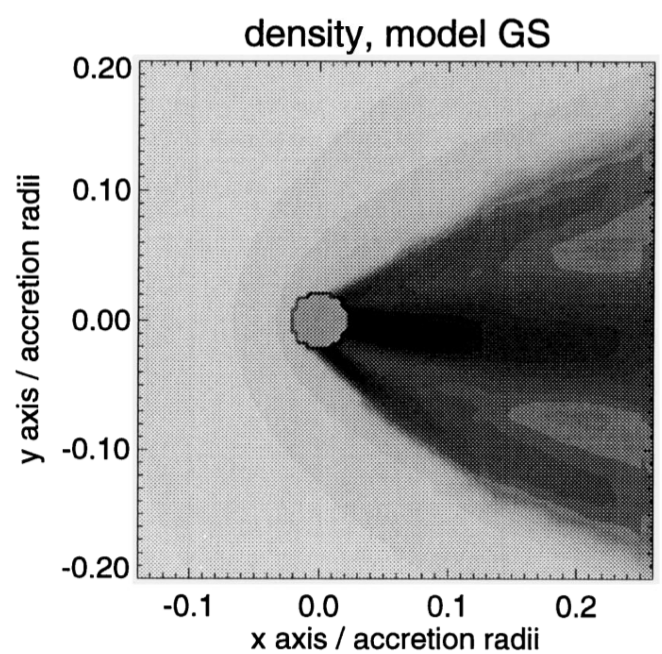


Fig. 6. Gray scale plots showing the density distribution of model GS in a plane containing the center of the accretor. Darker shades represent higher densities. The time of the snapshot is the same as in Fig. 4a–fe.

Dependance of mass accretion rate and shock opening angle on Mach number

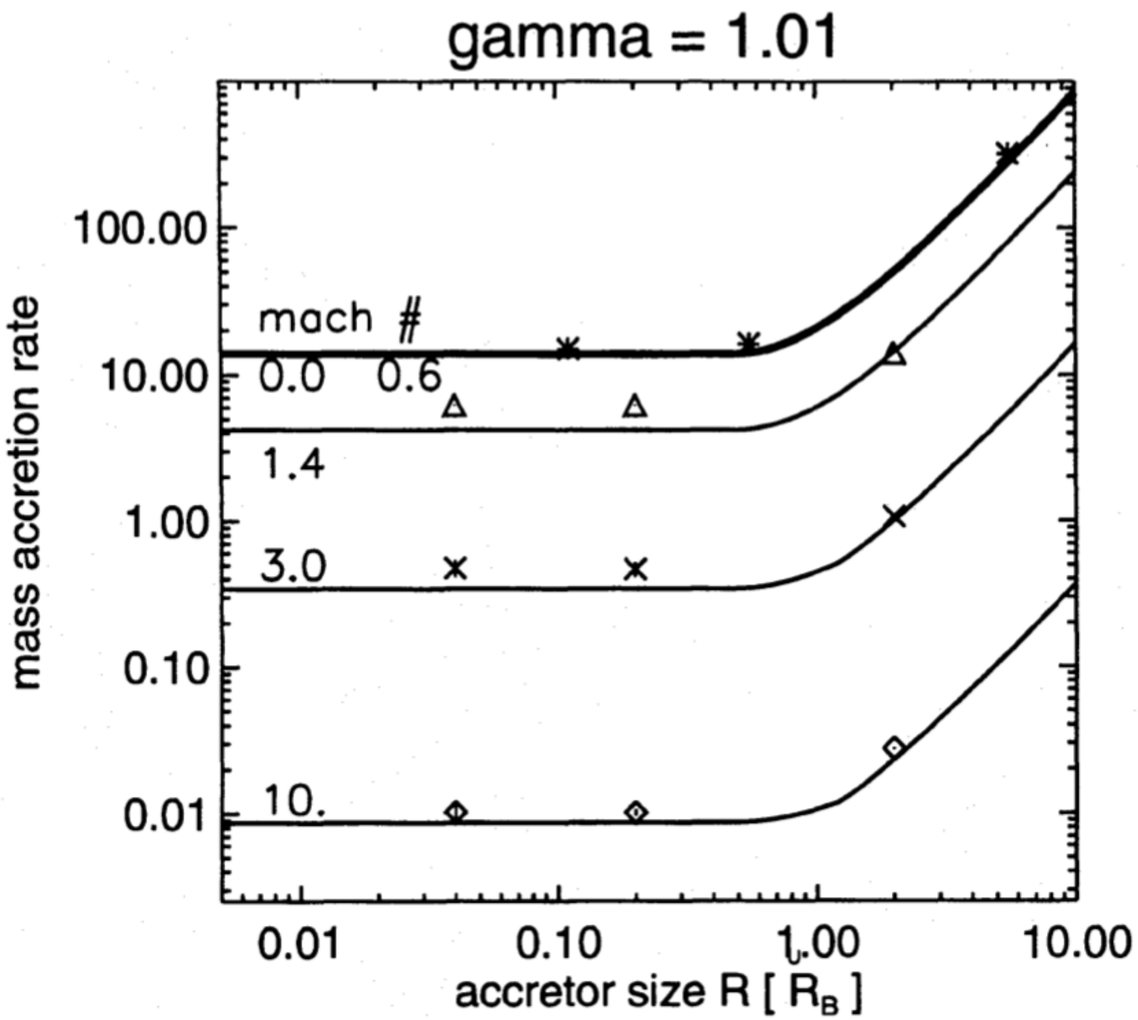


Fig. 9. Mass accretion rates (units: $4\pi R_B^2 c_\infty \rho_\infty$) as a function of accretor size (units: $\breve{R}_B$ (Eq. 7 in Paper III), *not* accretion radii). The Mach

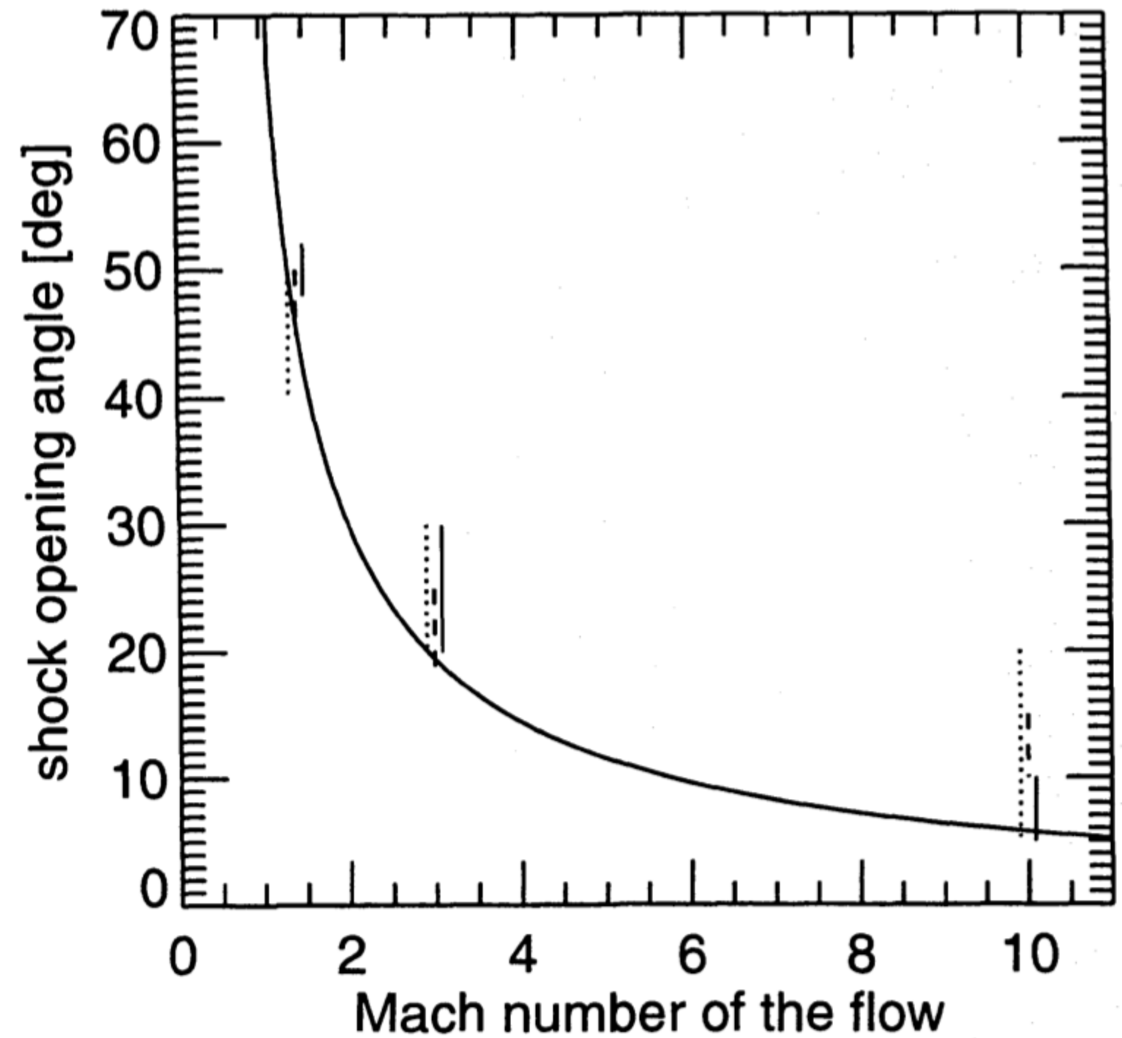


Fig. 15. The shock opening angles for various models are plotted versus speed of the flow. The vertical lines show the numerical models, solid represents the $\gamma = 1.01$ models, dashed the $\gamma = 4/3$ models and dotted the $\gamma = 5/3$ models. The vertical lines have slightly been shifted horizontally to facilitate the distinction of the lines. The curve decreasing shows the relation $\Theta = \arcsin(1/\mathscr{M})$.

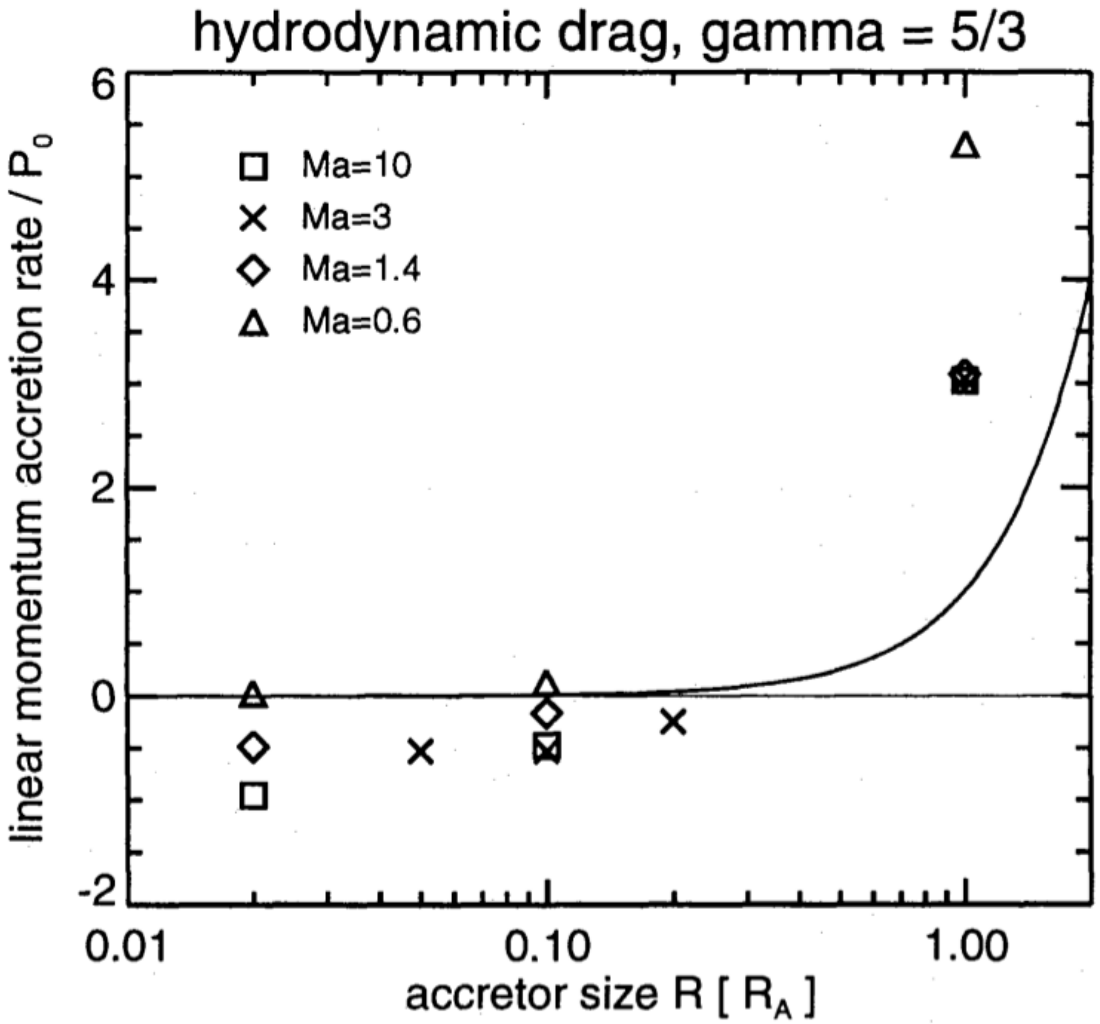


Fig. 13. The linear momentum accretion rate is plotted as a function of accretor size for all models: the $\gamma = 5/3$ values are taken from Papers II and III, the $\gamma = 4/3$ values from Paper IV and the $\gamma = 1.01$ values are shown in Figs. 2a–f, 3a–f, 5a–f, and 7a–f. The bold curve over the horizontal straight line (separating positive and negative values) represents the amount of momentum that would be accreted purely through the geometric cross section (i.e. $\pi R^2 \rho v_\infty^2$). The units are $P_0 = \pi R_A \rho v_\infty^2$; negative values indicate an acceleration, positive values a drag.

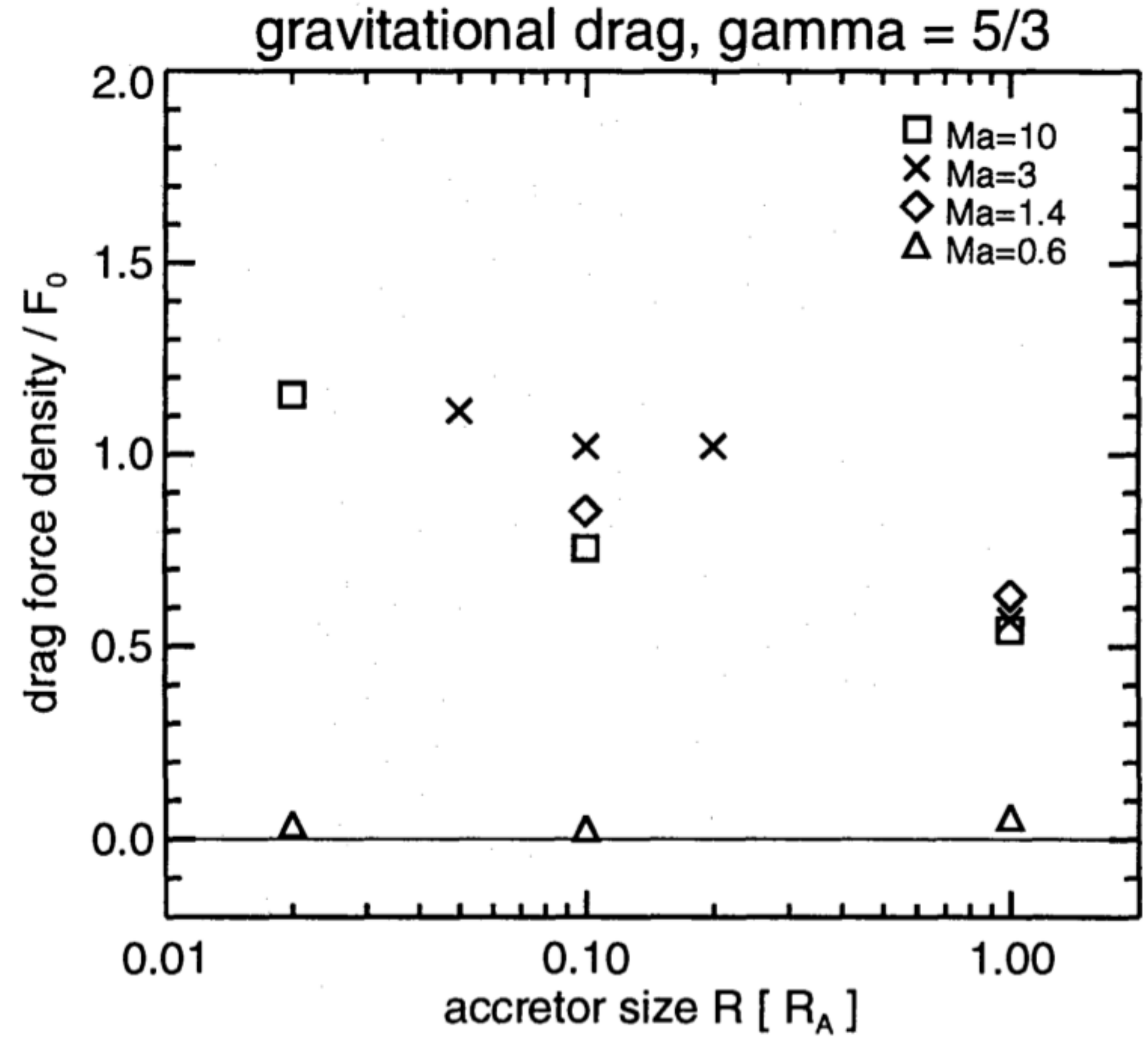


Fig. 14. The gravitational drag force density is plotted as a function of accretor size for all models: the $\gamma = 5/3$ values are taken from Papers II and III, the $\gamma = 4/3$ values from Paper IV and the $\gamma = 1.01$ values are shown in Figs. 2a–f, 3a–f, 5a–f, and 7a–f. The units are $F_0 = P_0 \ln(L/R_A)$, with P_0 defined in the caption of Fig. 13, and L is the size of the largest grid (cf. Table 1). The zero line is plotted for reference only.

Subsonic accretion: no hydrodynamic or gravitational drug

Supersonic accretion: drugs are most efficient at Mach numbers slightly above M=1