A relation of star formation activity and cold-flow accretion process

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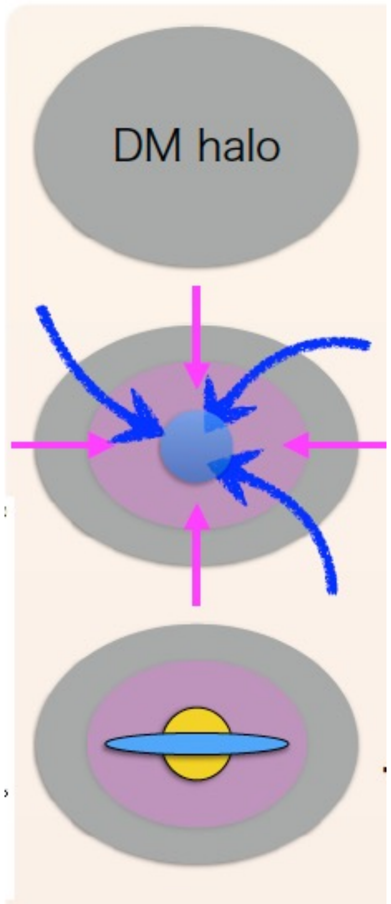
銀河・銀河間ガス研究会 (2021/8/18)

A schematic picture of galaxy formation

(Dekel et al. 2006, Keres et al. 2005)



1. DM Halo forms

2. Almost spherically accretion

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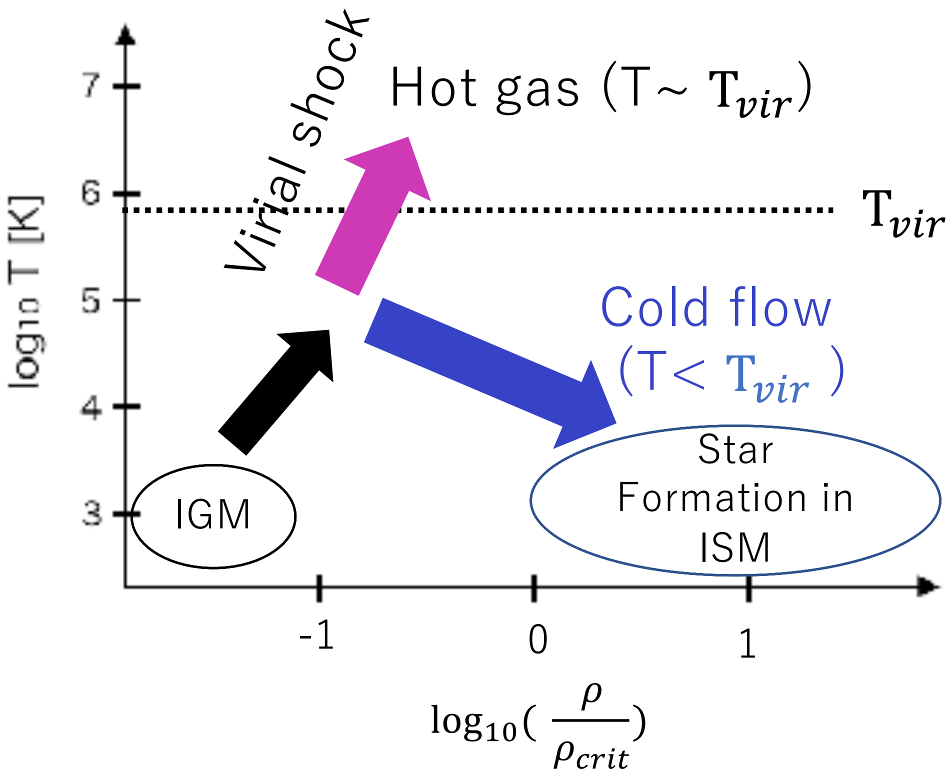
Filamentary accretion (Cold flow)

- Gas Phase Diagram



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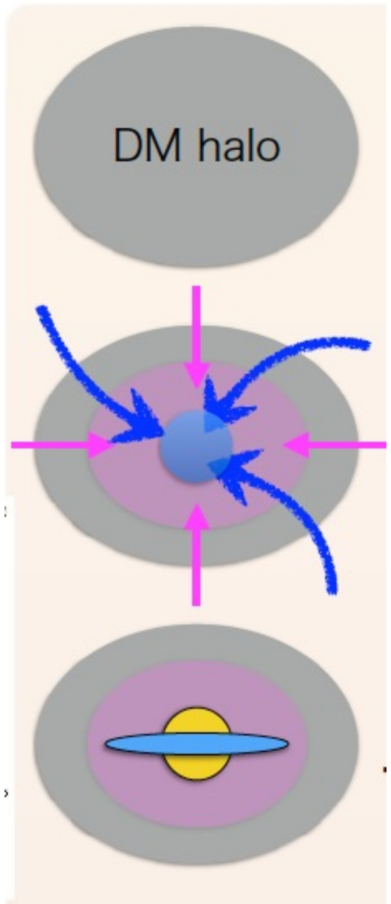

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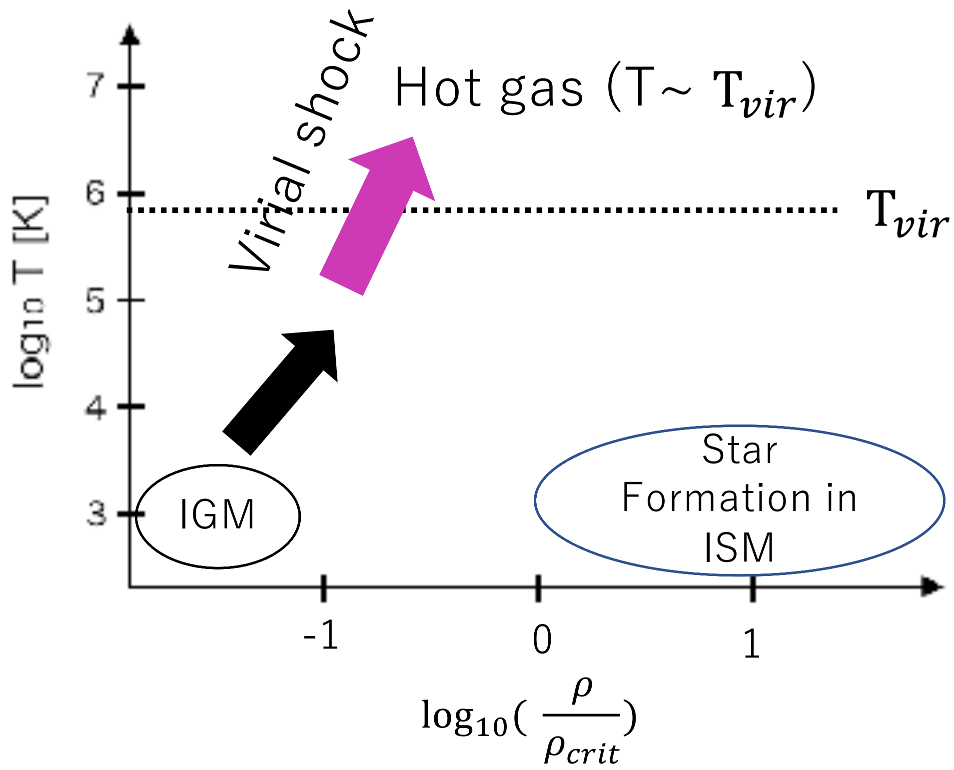

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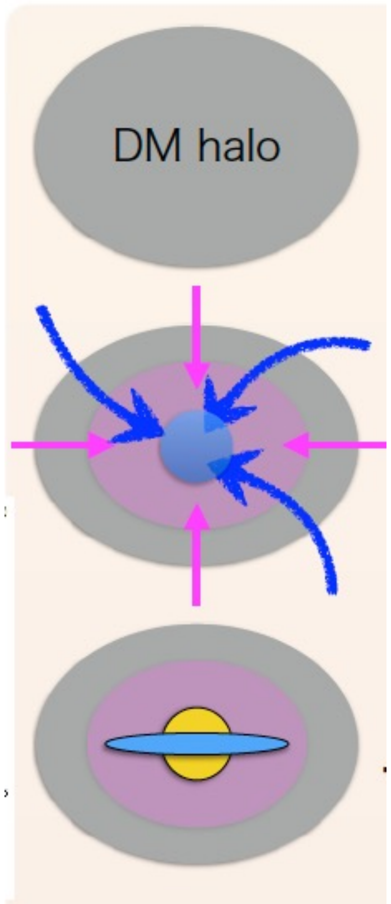

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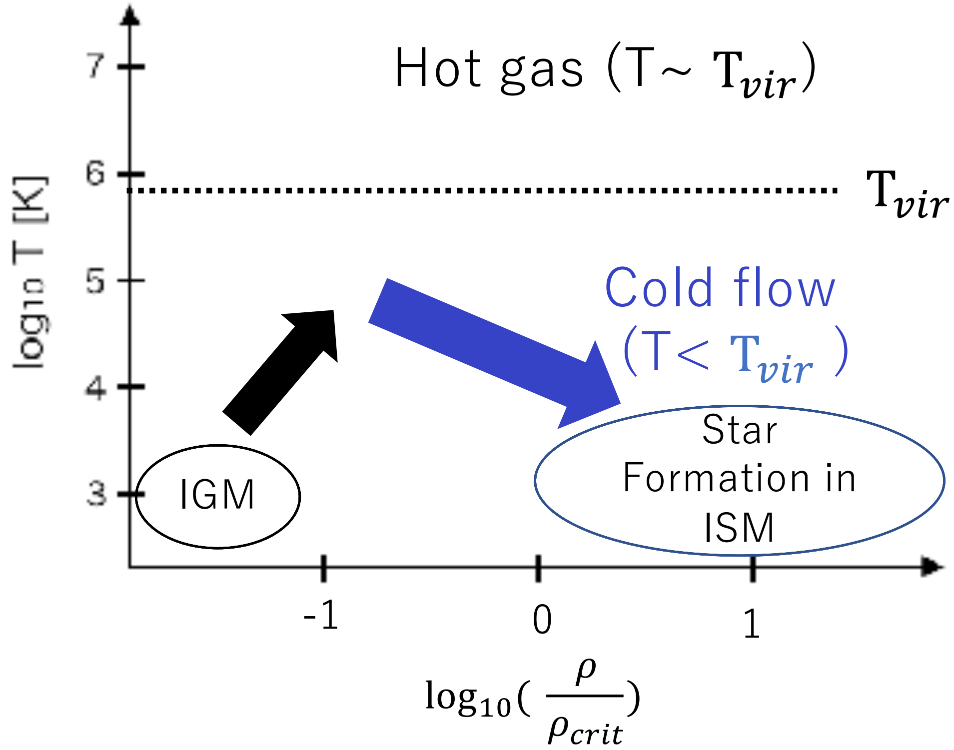

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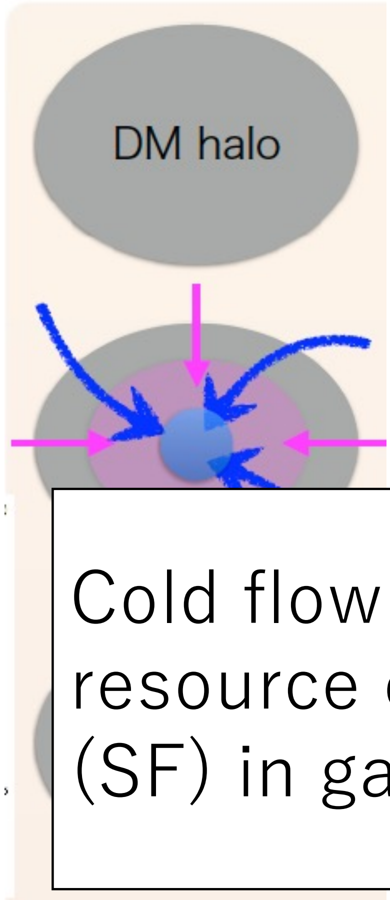

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Cold flow accretion is a resource of star formation (SF) in galaxies

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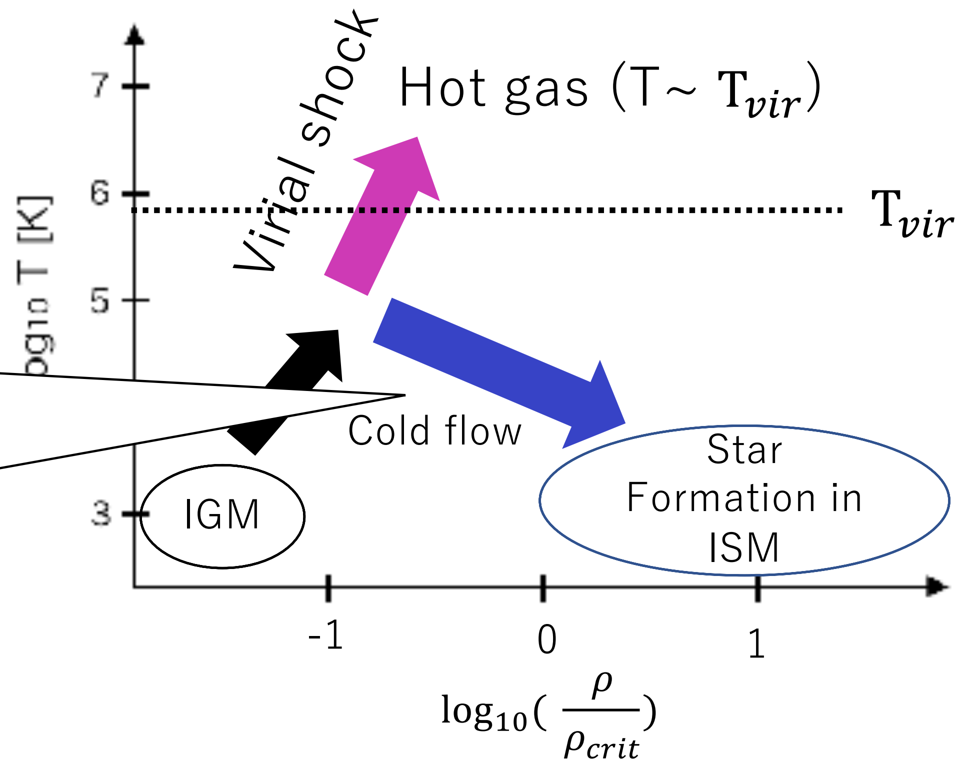


Previous works about gas accretion mode

- Analytic model (Dekel +2006)

→Cold gas accretion exists at halos at high-z or low mass Halos at low-z

- Numerical simulations

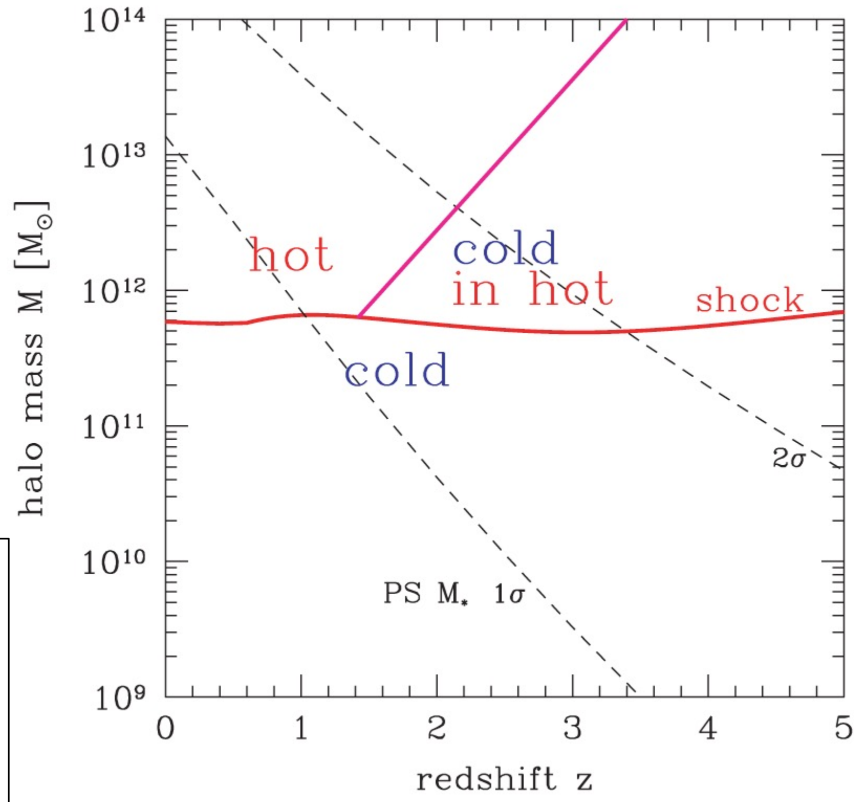
Does AGN or SF Feedback model suppress cold gas accretion ?

Yes: Dubois +2012b, Nelson +2015

No : Stwert +2011, Woods +2014

Questions

- How cold gas accretion affects star formation of galaxy
- how SF feedback in our numerical model suppresses cold gas accretion

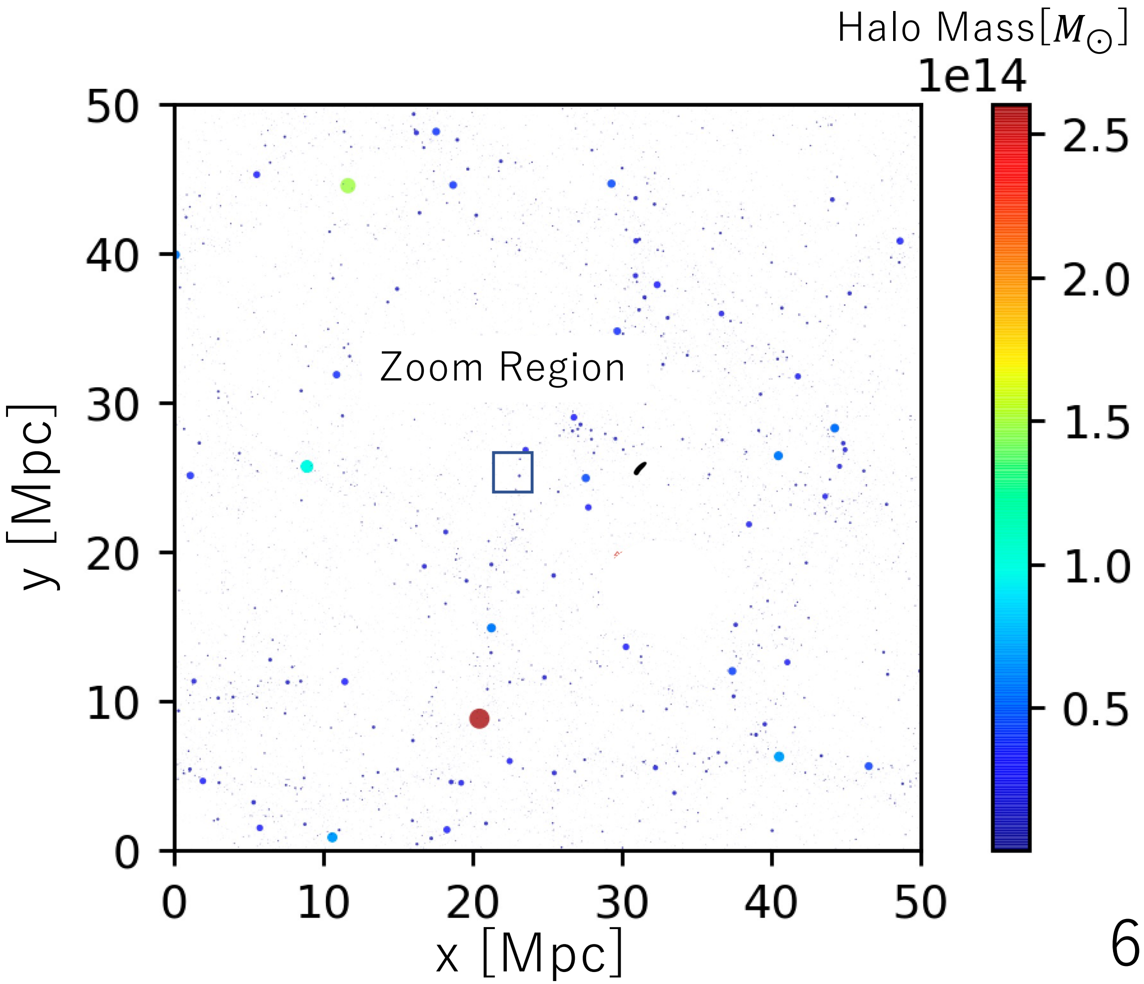


Method

GADGET3-Osaka Simulation

(Shimizu et al. 2019, Aoyama et al. 2018)

- Zoom in simulation
  $\mathrm{M_{halo}} \sim 10^{12} M_{\odot}$ @z=0
  ($2.7 \times 0.38 \times 5$ [Mpc^3])
- Softening length $\varepsilon = 814$ pc
- $\mathrm{m}_{DM} = 1.05 \times 10^6 \ [\mathrm{M}_{\odot}/h]$
- $\mathrm{m}_{gas} = 1.96 \times 10^5 \ [\mathrm{M}_{\odot}/h]$
- Feedback Model
  SN II, SN Ia, AGB Star, Early stellar Feedback
- ISM ($R \leqq 0.2\,\mathrm{R}_{vir}$)
- CGM ($0.2\,\mathrm{R}_{vir} < R \leqq \mathrm{R}_{vir}$)
- Cold flow ($T < \mathrm{T}_{vir}$)



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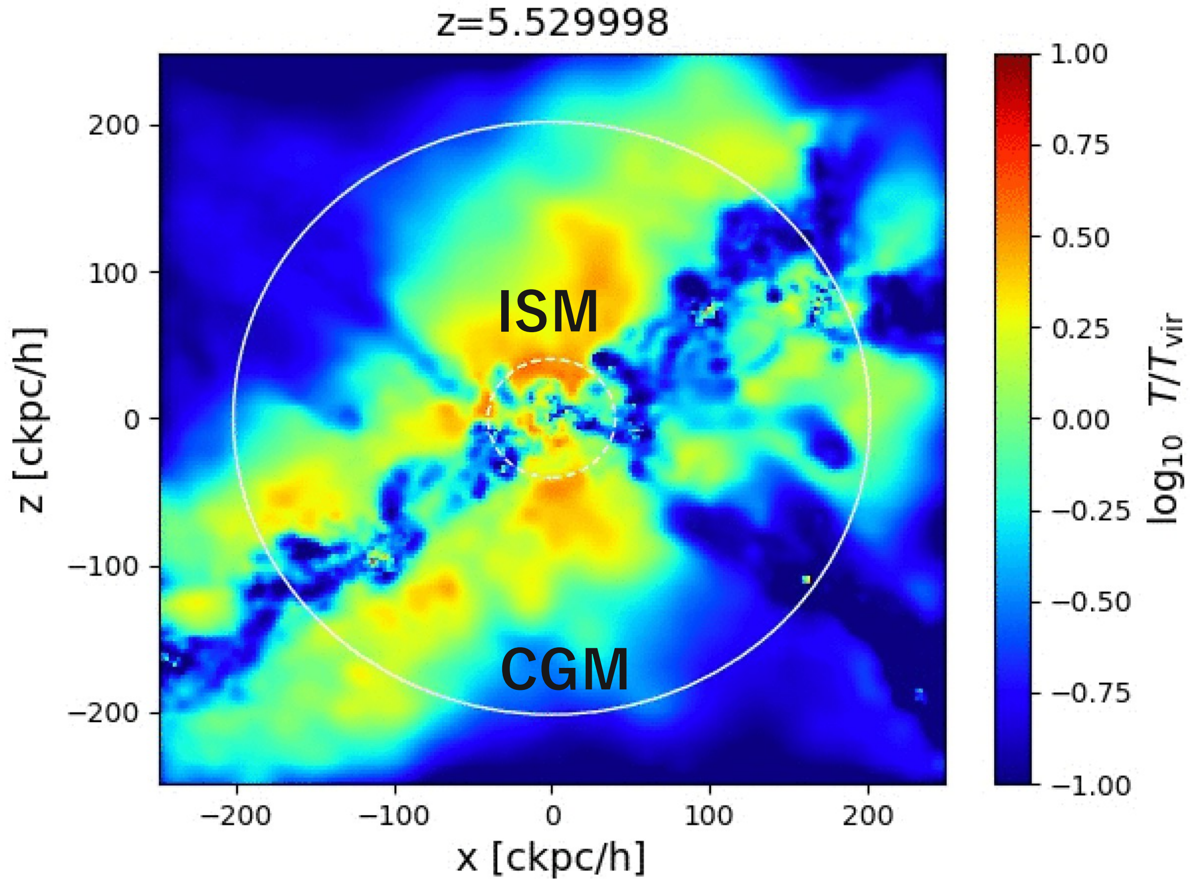
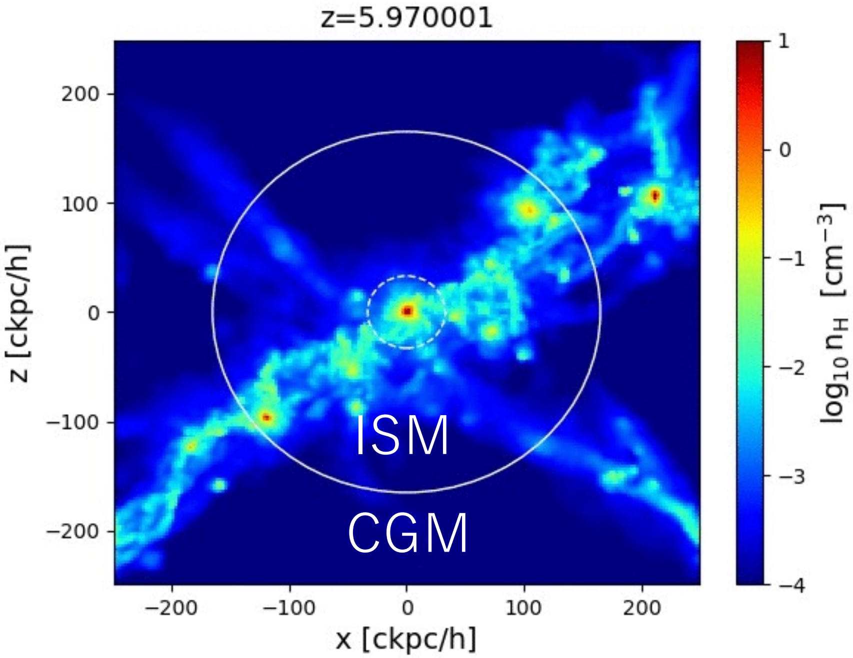


Results

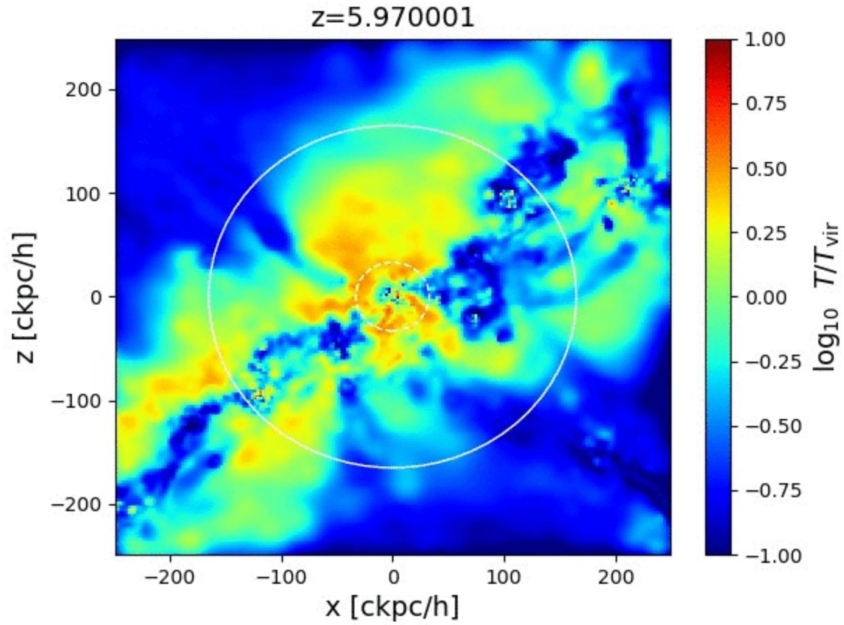
1. Cold gas accretion and star formation
2. SF feedback can suppress cold gas accretion ?

Movies of our simulation

- Gas density (500 × 500 kpc)

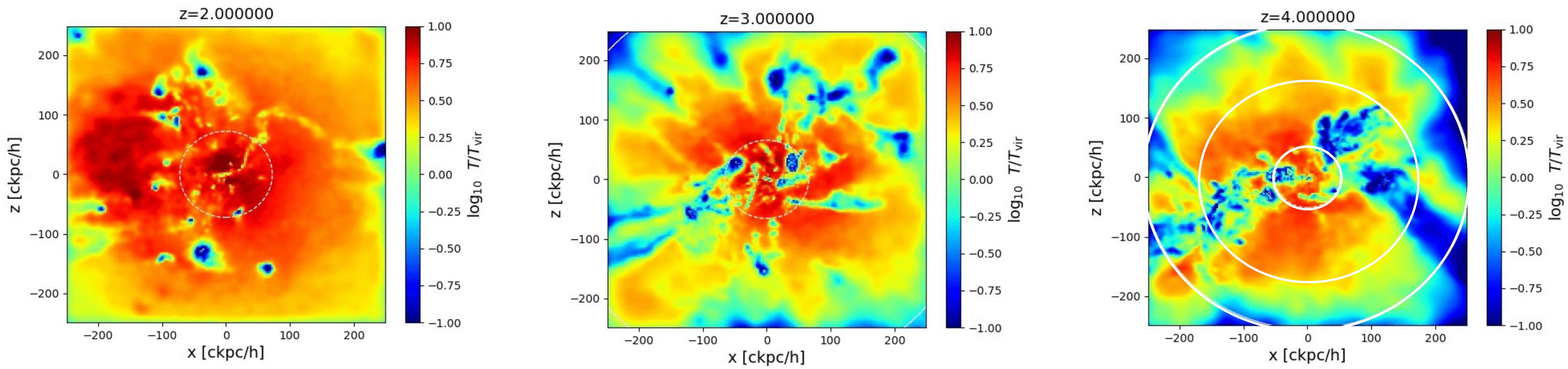


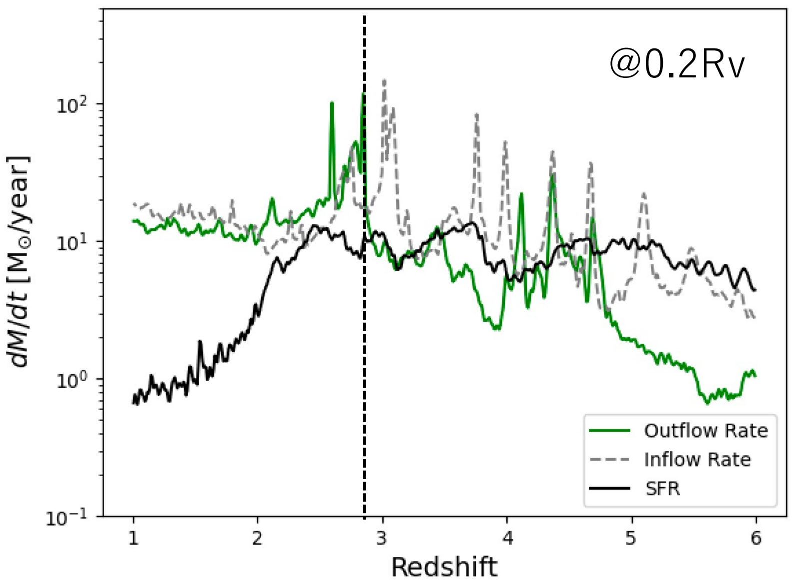
- Temperature (500 × 500 kpc)



- Cold gas accretes into ISM clearly at z>3
- Hot outflow is around the galaxy after z~3

1.Star formation and gas circulation in ISM

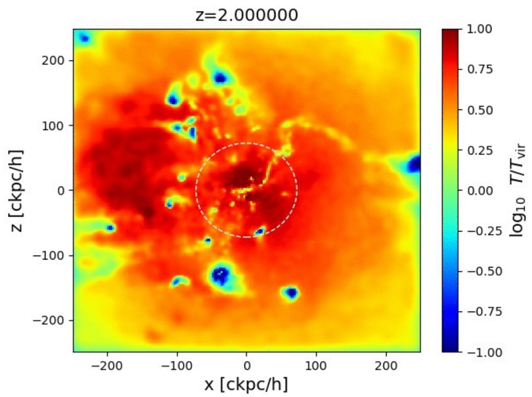


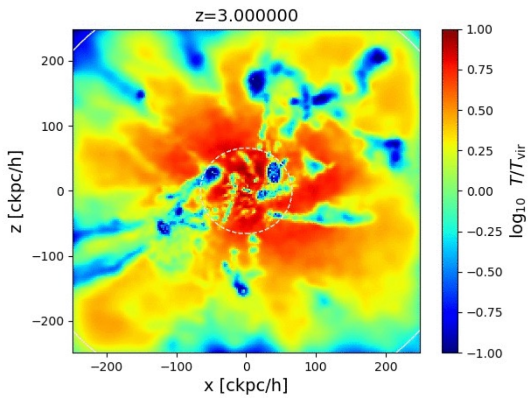


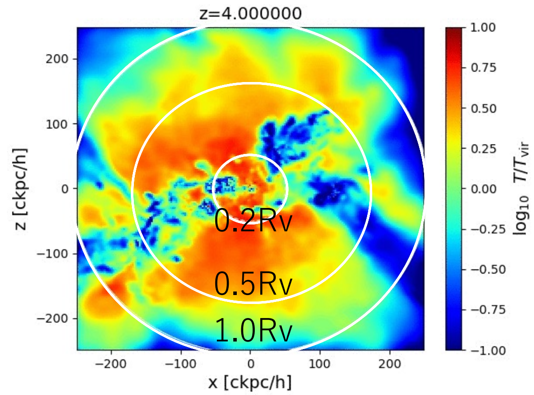
Outflow happens at z~3
→ Star formation is quenched at z~2.5 and does not recover though plenty of inflow still exists after z=2.5

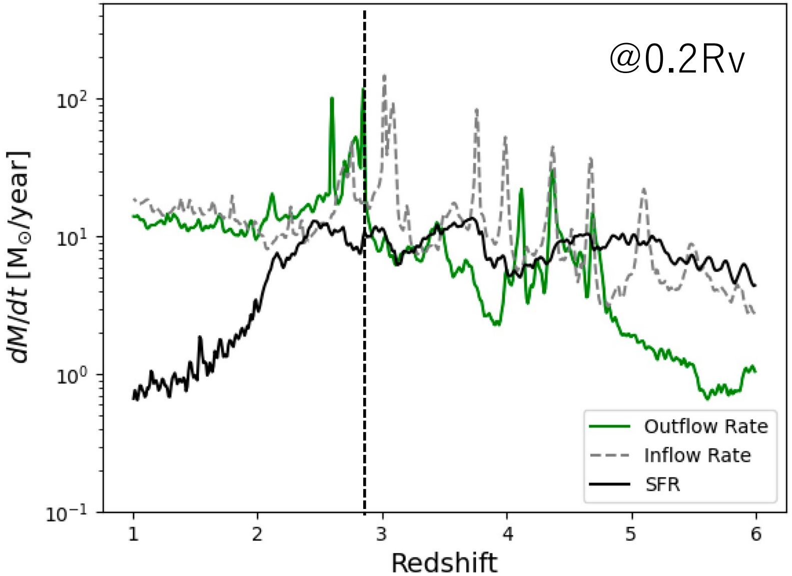
Cold gas accretion can be a key ?

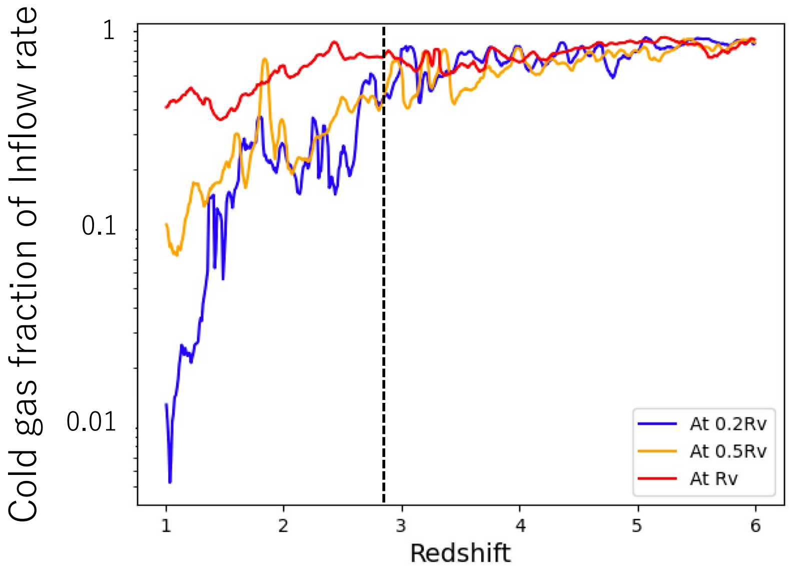
1.Star formation and gas circulation in ISM











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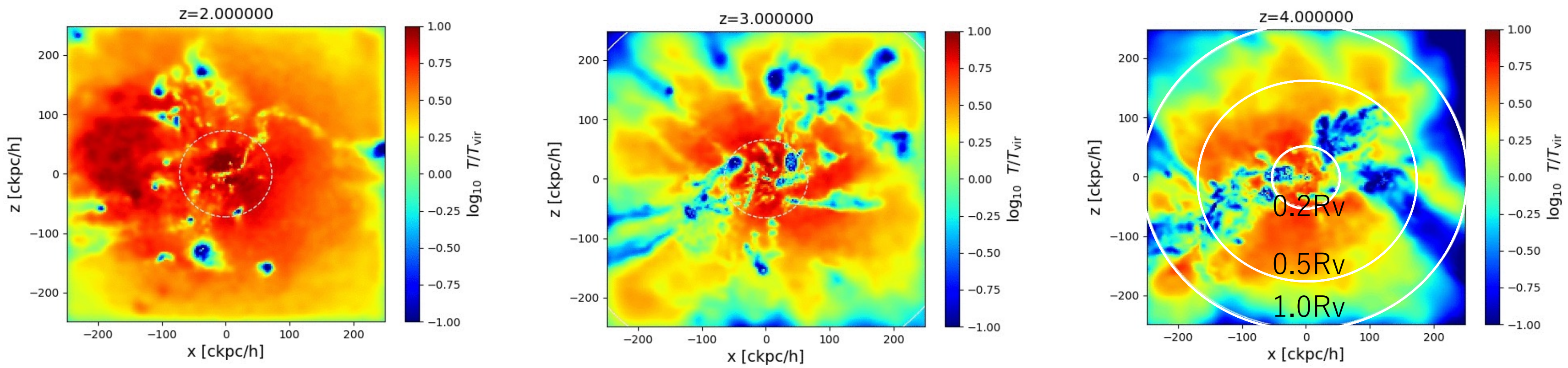
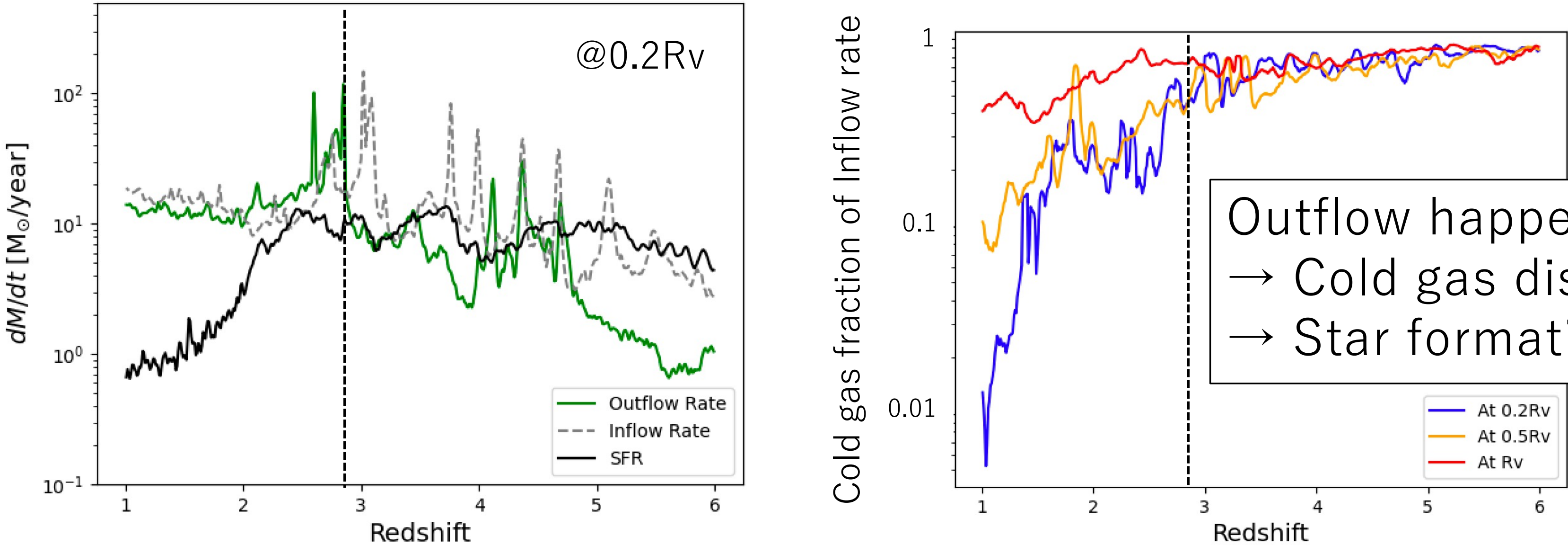
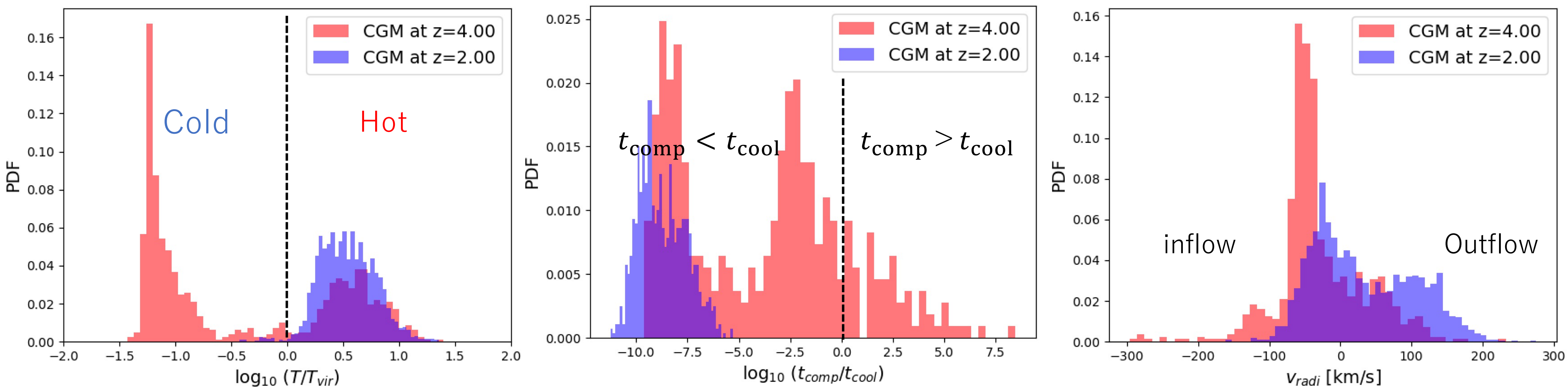




Outflow happens
→ Cold gas dissipation
→ Star formation quenching

2. Dissipation of Cold Gas in CGM at z=2



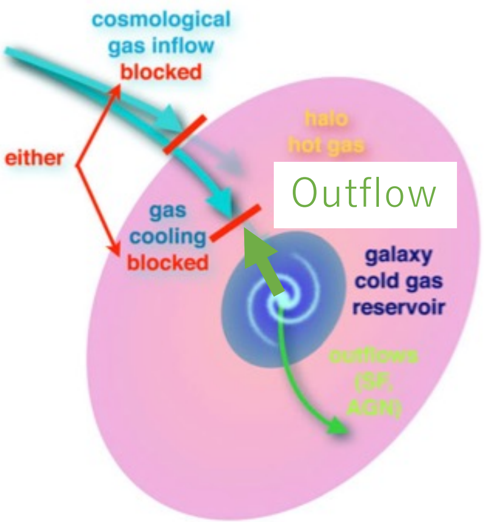
$$t_{\mathrm{comp}} = \frac{3\gamma+2}{\gamma(3\gamma-4)} \frac{\rho}{\frac{d\rho}{dt}}$$

$$t_{\mathrm{cool}} = \frac{k_{\mathrm{b}} T}{n_H \Lambda(Z,T)}$$

No hot gas, $t_{\mathrm{comp}} > t_{\mathrm{cool}}$ and some of outflow at z=2
→ Imply that outflow enhances cold gas dissipation due to gas compression

Conclusion

- Star formation become inactive after cold gas is dissipated
- Outflow may enhance cold gas dissipation due to gas compression



Schawinski +2014