Hydrodynamical simulations of the disc-corona interaction in star-forming galaxies

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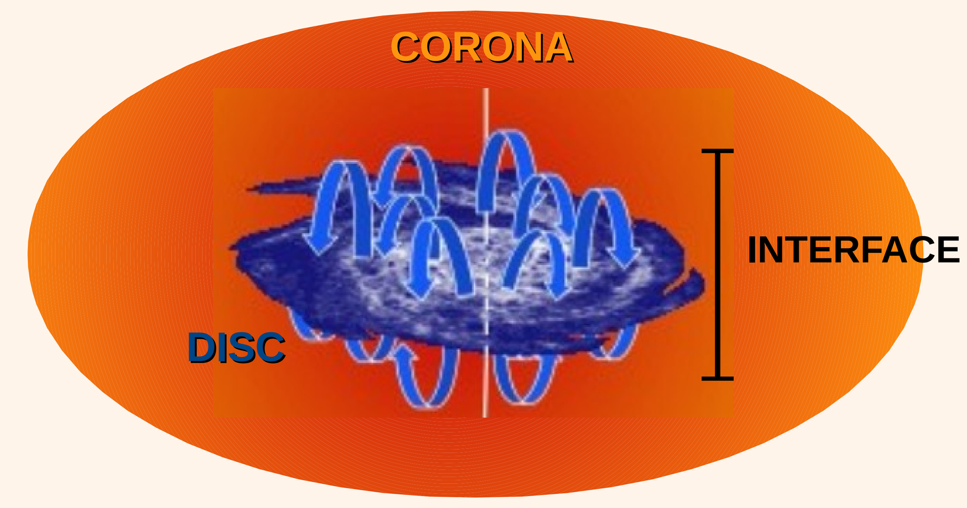
Abstract

We study the disc-corona interaction in different galactic environments through parsec-resolution hydrodynamical simulations. We find that this interaction could trigger the condensation of a fraction of hot coronal gas but the efficiency of this phenomenon is significantly reduced at increasing coronal temperature.

Context

Interaction between galactic fountain and corona :

- takes place at the interface
- cold metal-rich gas mixes with low-Z hot gas
- the mixing can cause the cooling of the hot gas (Marinacci et al., 2010)



Hydrodynamical simulations

Fountain cloud in motion through the hot coronal gas

- Including isotropic classic thermal conduction (Spitzer 1962)

$$F_{cond} = -f\,\kappa_{Sp} T^{5/2} \nabla T$$

with 10% efficiency → $f = 0.1$ (Narayan & Medvedev, 2001)

+ saturation (Dalton & Balbus 1993)

- Including radiative CIE cooling function (Sutherland & Dopita 1993)

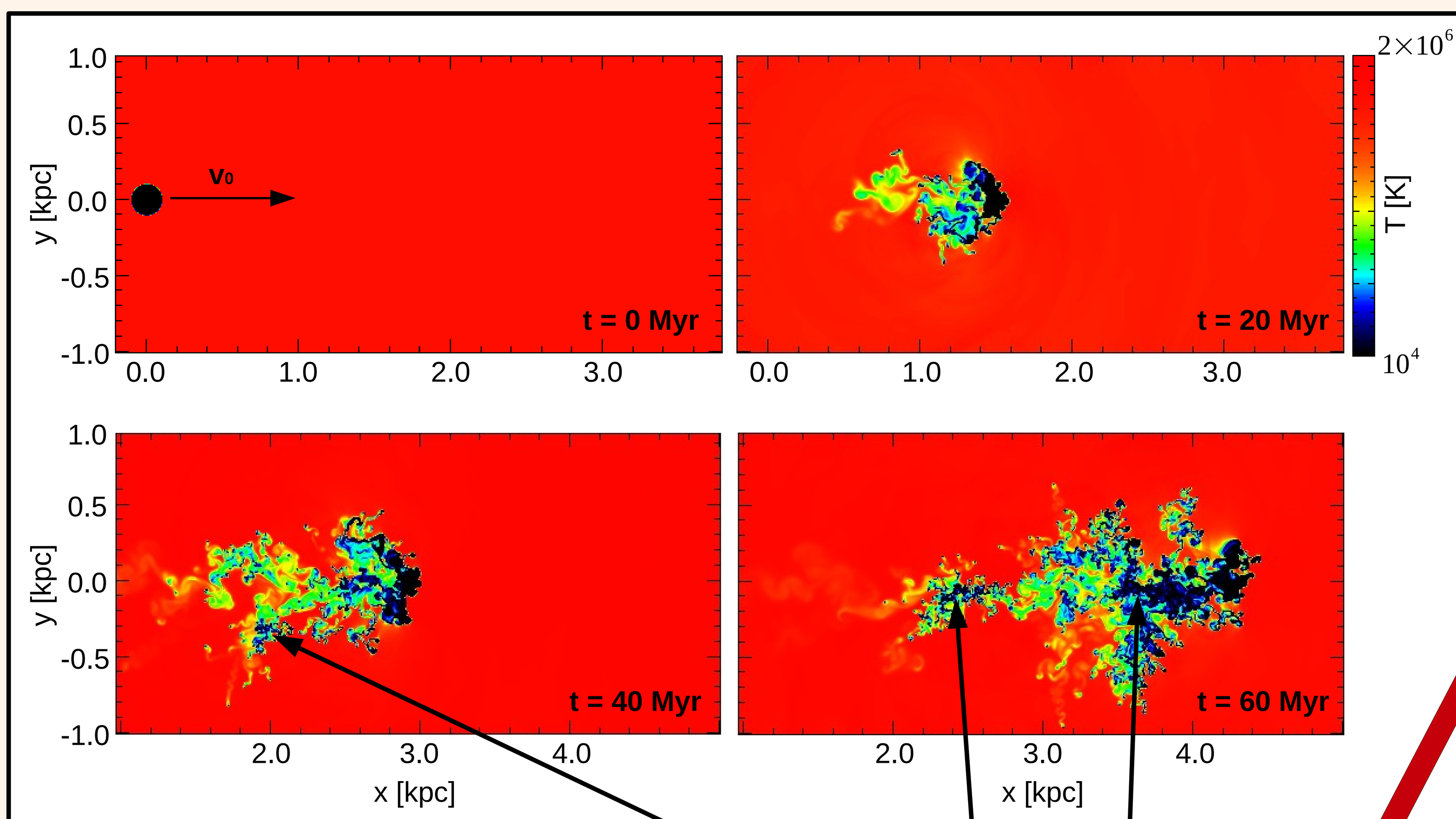


Fig.1 : Temperatures snap-shots of a 2D hydrodynamical simulation after 0, 20, 40 and 60 Myr. The coronal temperature is $2\times10^6 K$. The simulations were performed by ATHENA code (Stone et al., 2008) with a resolution of 2 pc.

Coronal gas cools here!

MIXING : TURBOLENT WAKE

CORONA CONDENSATION ? | **CLOUD EVAPORATION ?**

- Does the coronal condensation efficiency depend on the coronal temperature?

$$T_{cor} \propto M_{vir}^{2/3}$$

Table 1 : Initial parameters of our simulations. The cloud density is calculated assuming pressure equilibrium between the cloud and the corona. The cloud radius is the typical size of the Intermediate Velocity Cloud.

T_{cloud} (K)	R_{cloud} (pc)	v_{cloud} (km/s)	Z_{cloud} ($Z_\odot$)	Z_{corona} ($Z_\odot$)	n_{corona} (cm^{-3})
10^4	100	75	1.0	0.1	10^{-3}

Results (I)

EFFECT OF THERMAL CONDUCTION

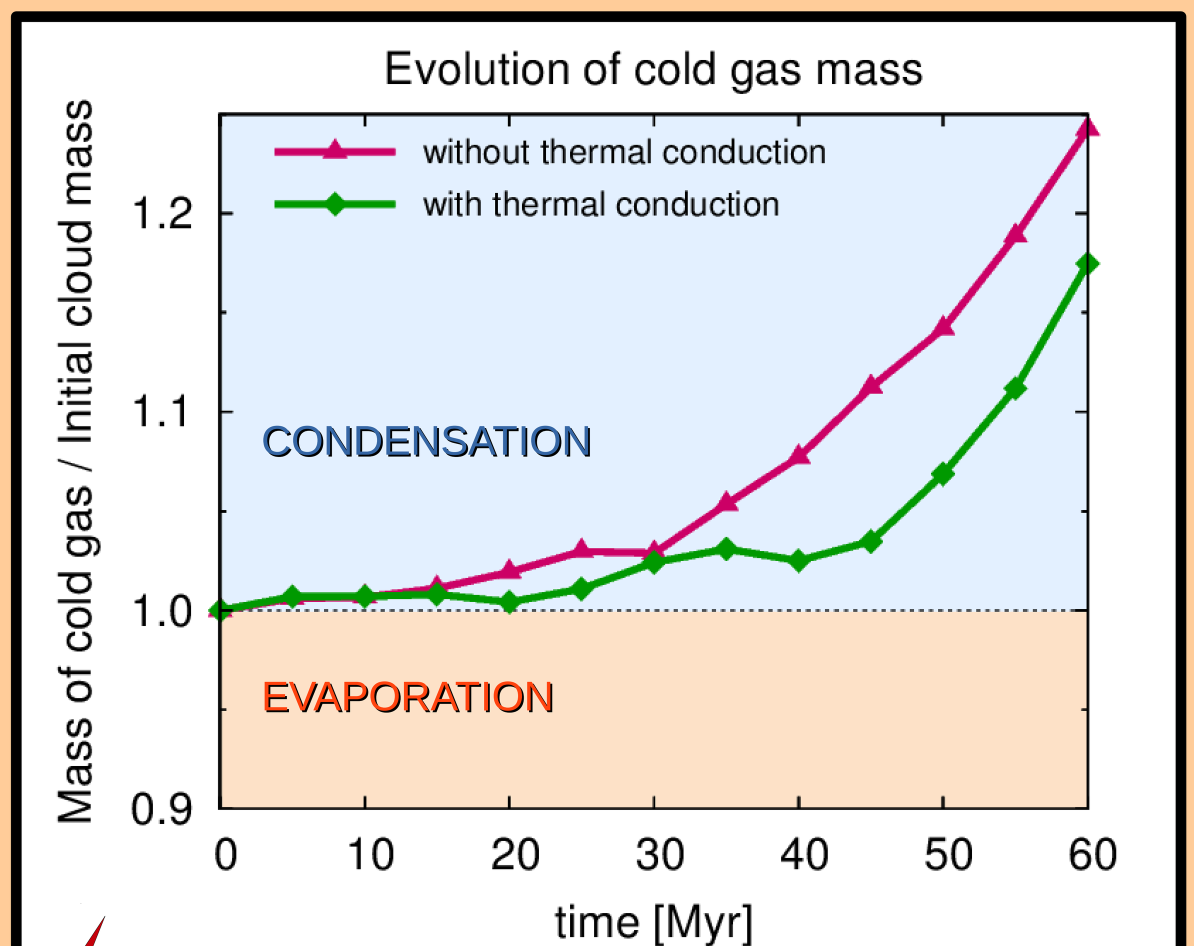


Fig.2 : Evolution of mass of cold gas ($T<10^{4.3}K$) with time for two simulations with coronal temperature $2\times10^6 K$: one without thermal conduction and one with thermal conduction. The mass of cold gas increases with time because more and more coronal gas cools down in the wake.

Thermal conduction slows down the **condensation** of coronal gas but can not inhibit it.

CONDENSATION WINS!

Results (II)

CORONAL CONDENSATION vs CORONAL TEMPERATURE

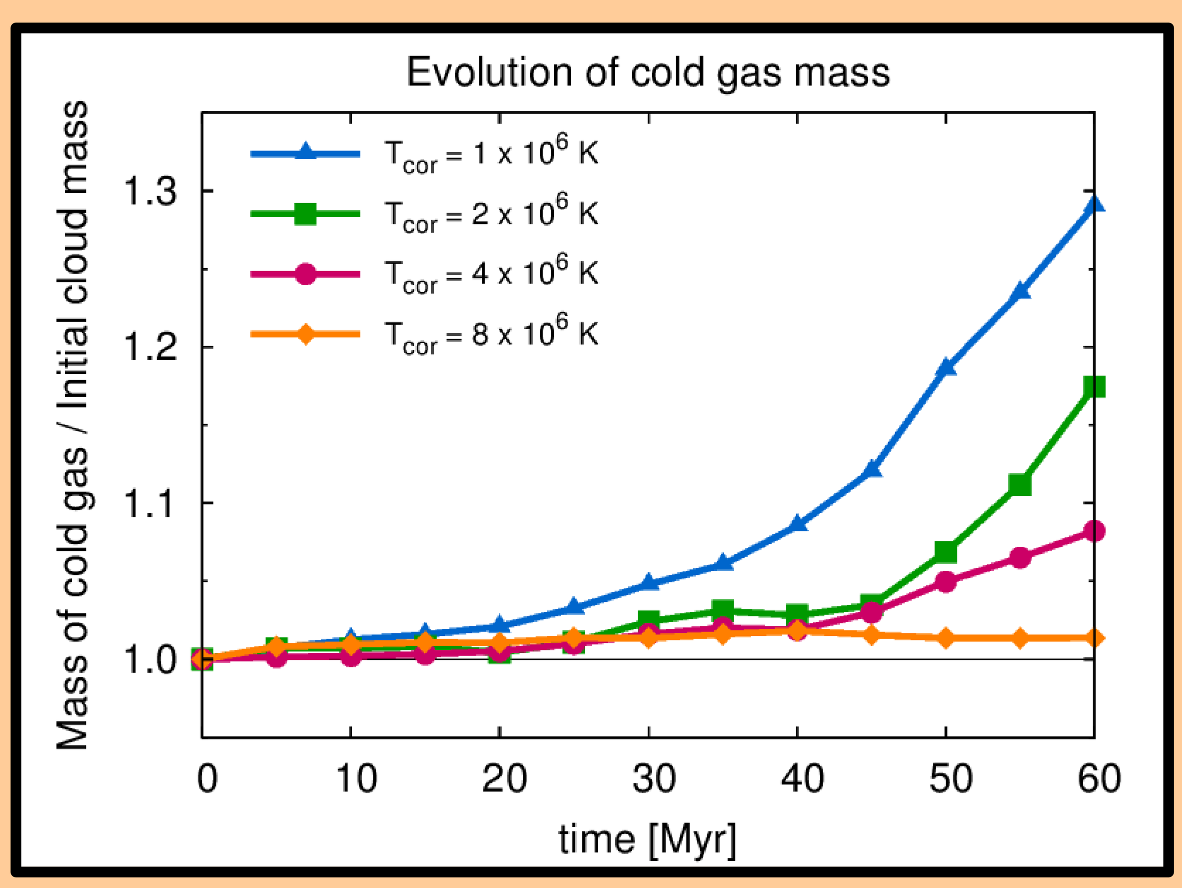


Fig.3 : Evolution of mass of cold gas ($T<10^{4.3}K$) with time for four different values of coronal temperature $(1, 2, 4, 8\times10^6 K)$.

$T_{cor} \leqslant 2\times10^6 K$

Significant increase of the mass of cold gas

$T_{cor} \geqslant 8\times10^6 K$

No condensation or evaporation

The higher the **galaxy virial mass**, the higher the **coronal temperature** the lower the **coronal gas condensation**.

↓

Quenching of star-formation ?

References

Dalton W. W., Balbus S. A., 1993, ApJ, 404, 625; Marinacci F., Binney J., Fraternali F., et al., 2010, MNRAS, 404, 1464; Narayan R., Medvedev M.V., 2001, ApJ, 562, L129; Spitzer L., 1962, Physics of Fully Ionized Gases, Interscience, New York; Stone J. M., Gardiner T. A., Teuben P., et al., 2008, ApJS, 178, 137; Sutherland R. S., Dopita M. A., 1993, ApJS, 88, 253

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