Lyman-α Radiation Transfer in a virtual dwarf isolated galaxy

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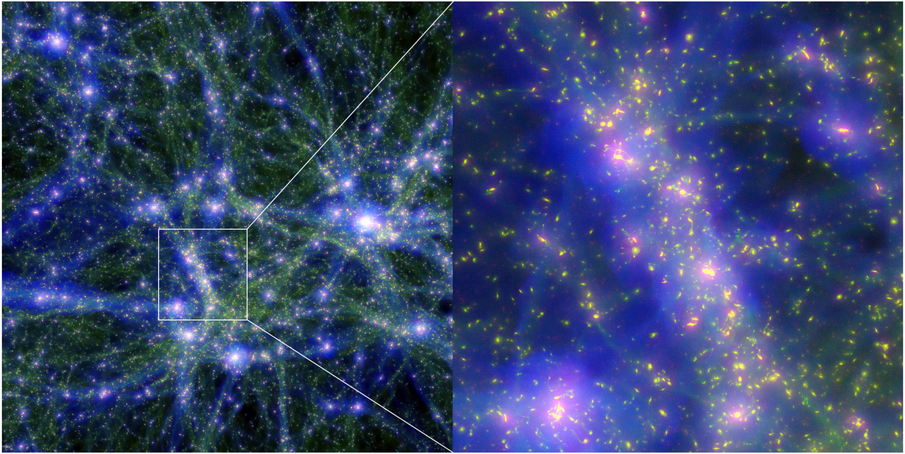
Motivations



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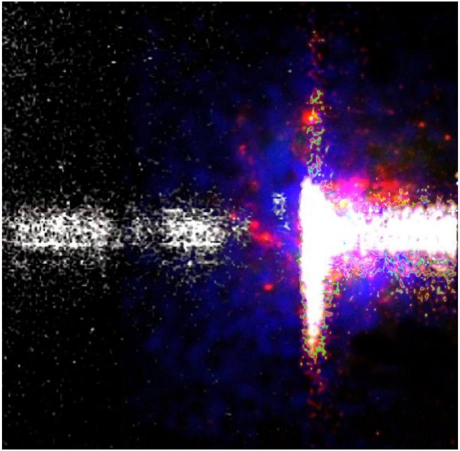
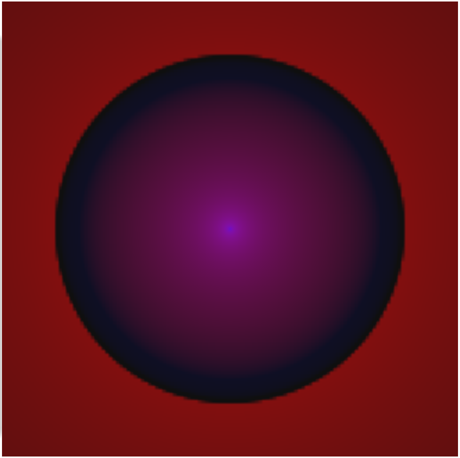


Hydrodynamical simulations of a dwarf isolated galaxy

Description of the simulations

- AMR code RAMSES *Teyssier 2002*
- dwarf : $M_{\rm gal} = 10^{10}$ M$_\odot$
- isolated : NFW density profile
- size of the box = 300 kpc
- gas fraction $f = \Omega_b/\Omega_m \sim 15\%$
- spin parameter $\lambda = 0.04$
- cooling,starformation,feedback $\longrightarrow$ see *Dubois & Teyssier 2008,* *Verhamme et al 2011, in prep*

Dubois & Teyssier 2008



MCLya : 3D Lyα radiation transfer code

General description of the code

- Monte Carlo technics, 3D, nested grid, Lyα + UV transfer
- MPI - parallelised
- physics included : HI, dust, Deuterium

Inputs

- distribution of sources
- H I distribution
- dust distribution
- velocity dispersion of the gas
- velocity field

Outputs

- integrated or resolved spectra
- Lyα images along any line of sight
- escape fraction
- non observables

nb of scatterings, time, altitude, emission location,etc...

Our two ISM models

the HOT galaxy G1

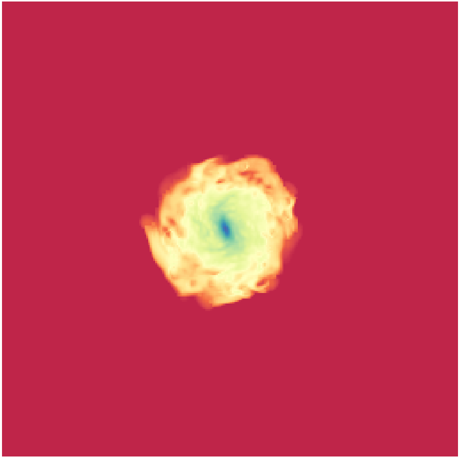
- EoS : $T_0 = 10^4$K and $\rho_0 = 0.1$H.cm^{-3}
- minimum cell size : $\Delta x = 147$pc
- 10^5 photons
- calculation time : $\sim$ 20000 hours

the COLD galaxy G2

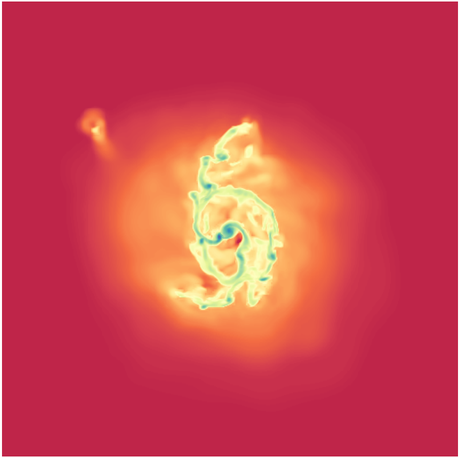
- EoS : $T_0 = 10^2$K and $\rho_0 = 10$H.cm^{-3}
- minimum cell size : $\Delta x = 18$pc
- 5×10^6 photons
- calculation time : $\sim$ 200000 hours

Distribution of neutral gas

the HOT galaxy G1

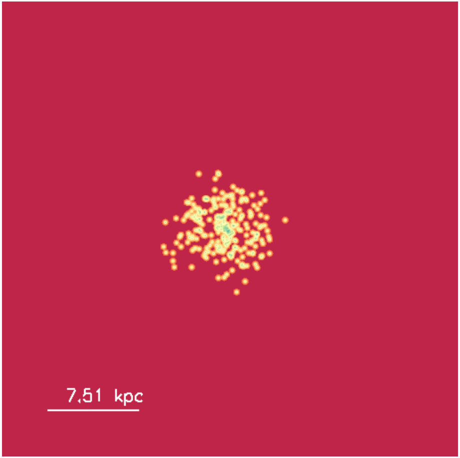


the COLD galaxy G2

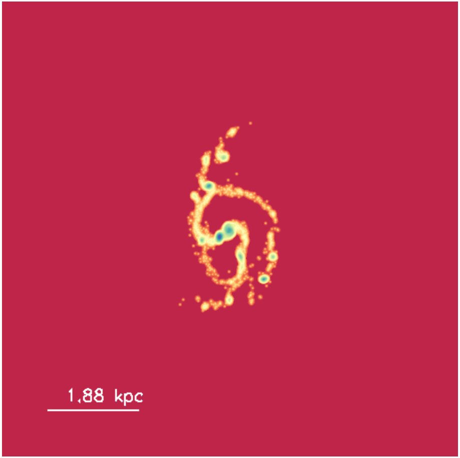


Distribution of sources

the HOT galaxy G1



the COLD galaxy G2



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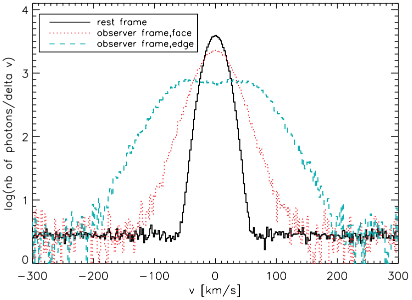

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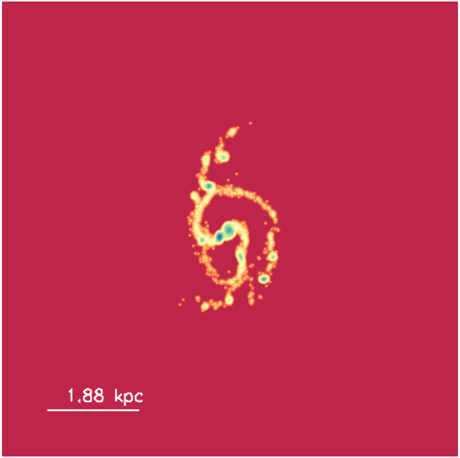
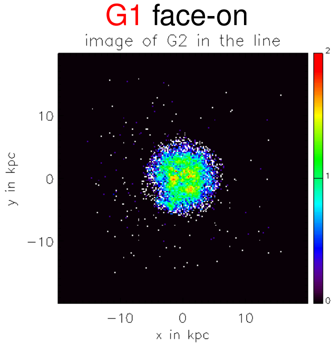
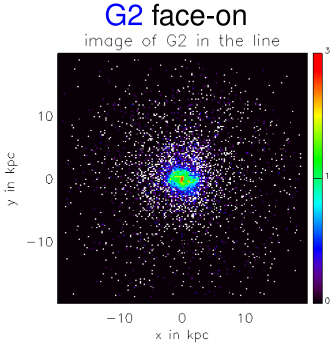


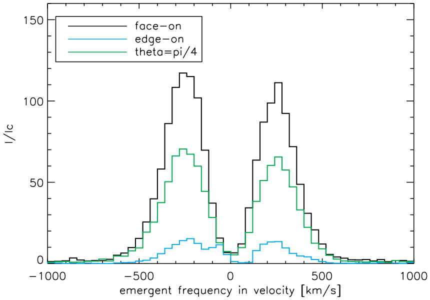
Comparison of the ISM models : Lyα images



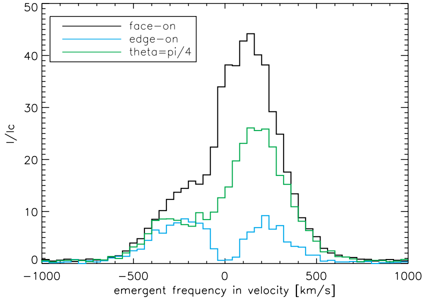


Comparison of the ISM models : spectral shapes

integrated spectra from G1

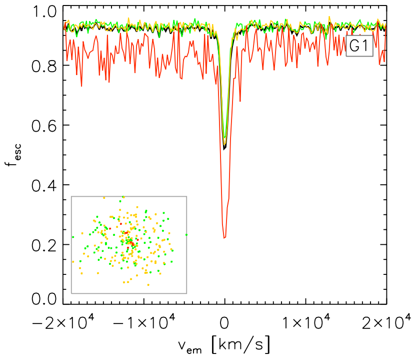


integrated spectra from G2

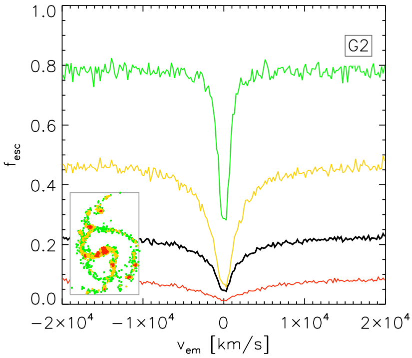


Comparison of the ISM models : escape fractions

f_{esc} vs density in G1



f_{esc} vs density in G2



Summary : Comparison of the ISM models

The HOT galaxy G1

- continuum escape fraction $f_{esc} = 0.95$

The COLD galaxy G2

- continuum escape fraction $f_{esc} = 0.22$

Summary : Comparison of the ISM models

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- Lyα escape fraction $f_{esc} = 0.55$

The COLD galaxy G2

- continuum escape fraction $f_{esc} = 0.22$
- Lyα escape fraction $f_{esc} = 0.05$

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- symetrical double-peaked spectra

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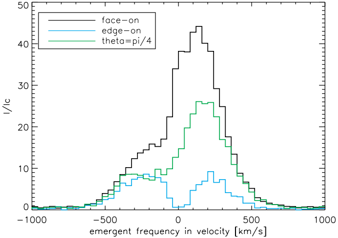
Comparison of the ISM models

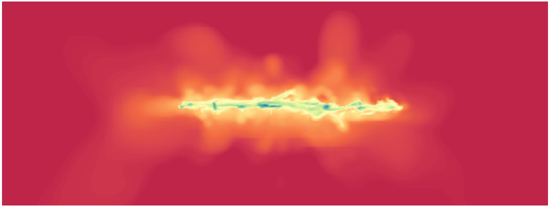
Strong discrepencies on Lyα AND UV properties
$\longrightarrow$ Lyα RT worth if small scales physics included

Orientation effects on spectral shapes

integrated spectra

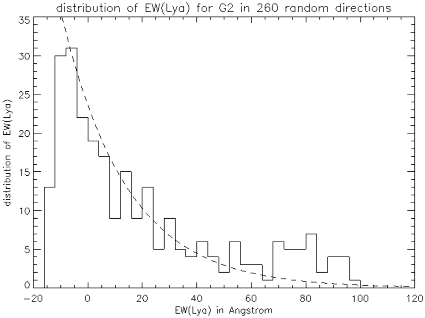


density map edge-on



Orientation effects on EW(Lyα) distributions

Distribution of EW(Lyα) in G2



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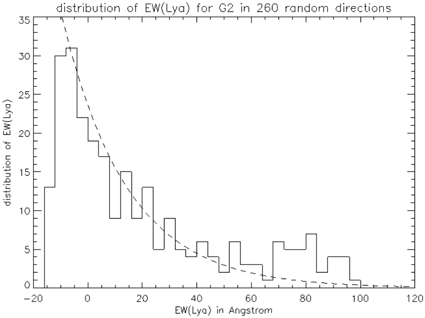
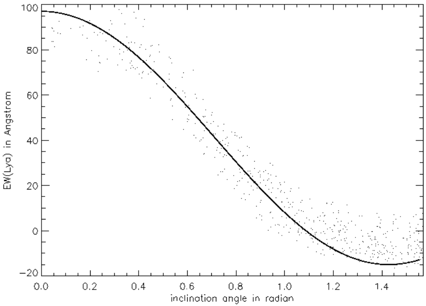


EW(Lyα) vs inclination in G2

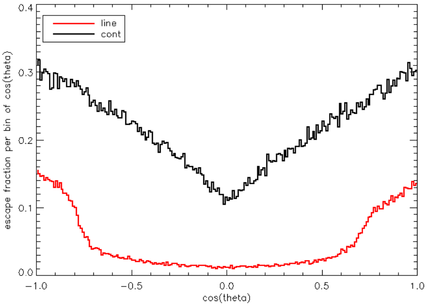


Orientation effects on the escape fractions

Angular escape fractions

- continuum $f_{\rm esc}$ face-on 3 times higher than edge-on
  $\longrightarrow$ variation of opacity with inclination
- Lyα $f_{\rm esc}$ (flux !) face-on 10 times higher than edge-on
  $\longrightarrow$ detection biased towards face-on galaxies ?

histogram of theta in G2



Summary : Orientation effects

Description

- f_{esc} (Lyα flux) 10 times higher face-on than edge-on
- strong correlation between EW(Lyα) and inclination
- correlation between spectral shape and inclination

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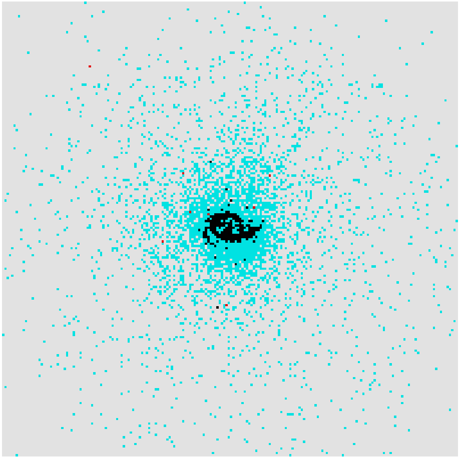
Implications

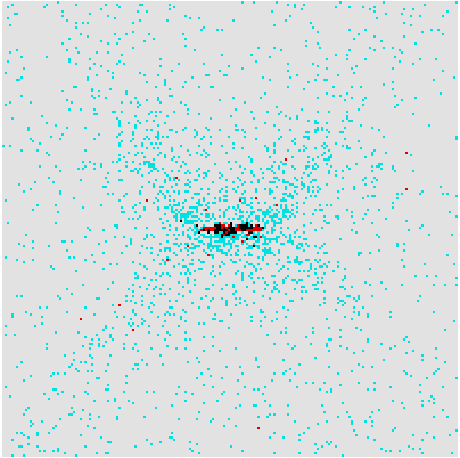
- detection biased towards face-on high-z galaxies
- over/under-estimate of $SFR(\mathrm{Ly}\alpha) = 9.1 \times 10^{-43} L(\mathrm{Ly}\alpha)$
- intrinsic scatter in the observed correlations (EW vs E(B-V), SFR, UV mag, mass...)

Lyα diffuse emission face-on

G2 face-on

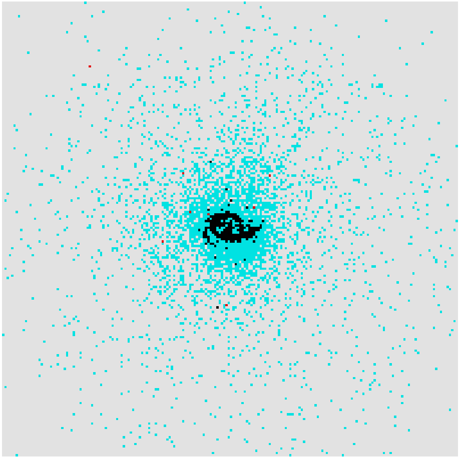


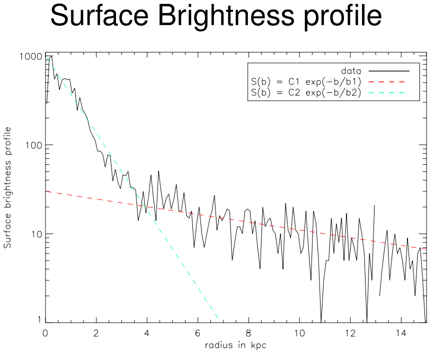
G2 edge-on



Surface Brightness profiles

G1 face-on



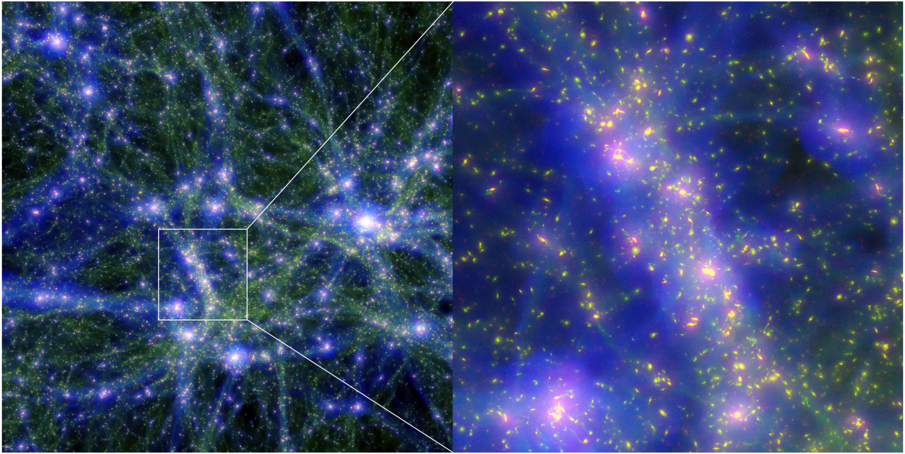


Summary

Results

- Strong discrepancies in the Lyα properties of G1 and G2
  $\longrightarrow$ Lyα RT worth in simulations where the physics of the cold gas is followed
- Orientation effects on Lyα properties of a virtual galaxy
  $\longrightarrow$ detection bias toward face-on galaxies
  $\longrightarrow$ correlation EW(Lyα) vs inclination, spectral shape vs inclination
- diffuse Lyα halo around G2 face-on, SB profile a la *Steidel et al. 2011*

Conclusions



Next steps

isolated galaxies

- coupling with ionising radiation transfer code *Rosdahl et al. 2011*
  $\longrightarrow$ ionisation state of the ISM better modeled
- galaxies 10 times, 100 times more massive
  $\longrightarrow$ decrease of Lyα escape with galaxy mass ?

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galaxies in their cosmological context

- on going work on a galaxy at z$\sim$ 3
  $\longrightarrow$ Circum/Inter-galactic interactions ?
  $\longrightarrow$ do orientation effects still play a role ?
- ongoing work on Lyα blobs simulations *Rosdahl et al. in prep*