Magnetized turbulence in galaxy clusters

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IFU

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astrophysique & planétologie

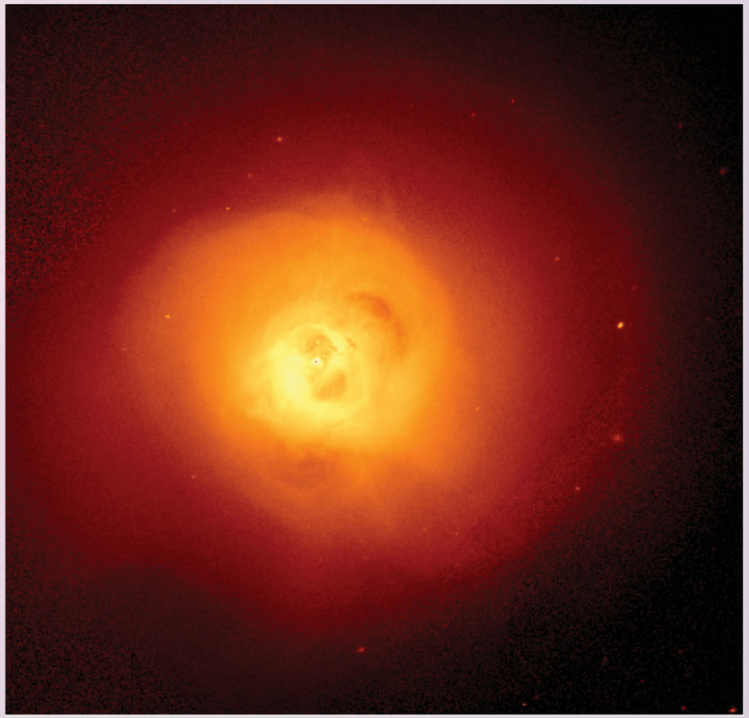
- Largest gravitationnaly bound objects
- 14 % in mass under the form of a **hot,** ionized**, magnetized** plasma: the **Intra–Cluster Medium (ICM)**

Some typical values for the ICM:

- T ~ 10^7 - 10^8 **K** (1 - 15 **keV**)
- n ~ 10^{-4} - 1 **cm**$^{-3}$
- B ~ 1 - 10 **µG**

Problems related to galaxy cluster

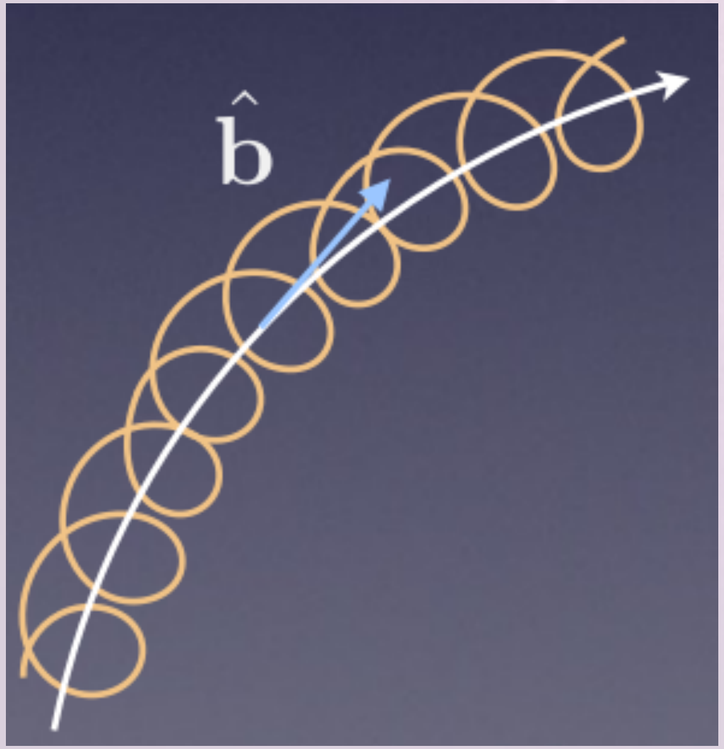
- The cooling catastrophe
- The hydrostatics mass bias
- Origin of the cold filaments in cluster cores
- Magnetic field dynamo and magnetic seed



Fabian et al., MNRAS 2011 [1]

The **Larmor radius** of particles in the ICM is **very small** compared to their **mean-free path**

Thermal conduction and **viscosity** are **anisotropic** with respect to the **magnetic field**
(Braginskii,1965 [2])

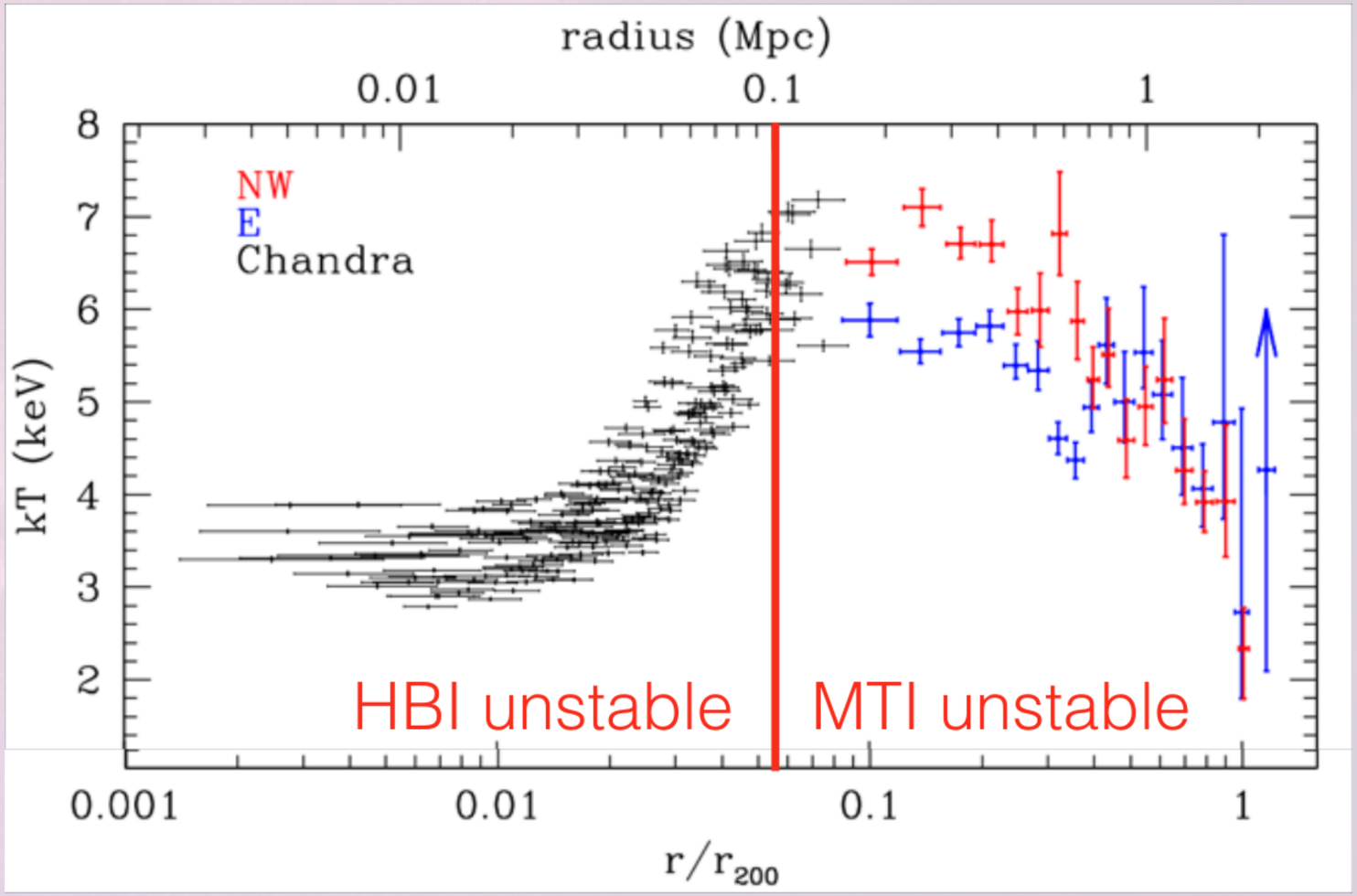


Implemented in **IDEFIX,** a new finite volume astrophysical code developped by Geoffroy Lesur (IPAG)

Dynamics inside the intra-cluster medium

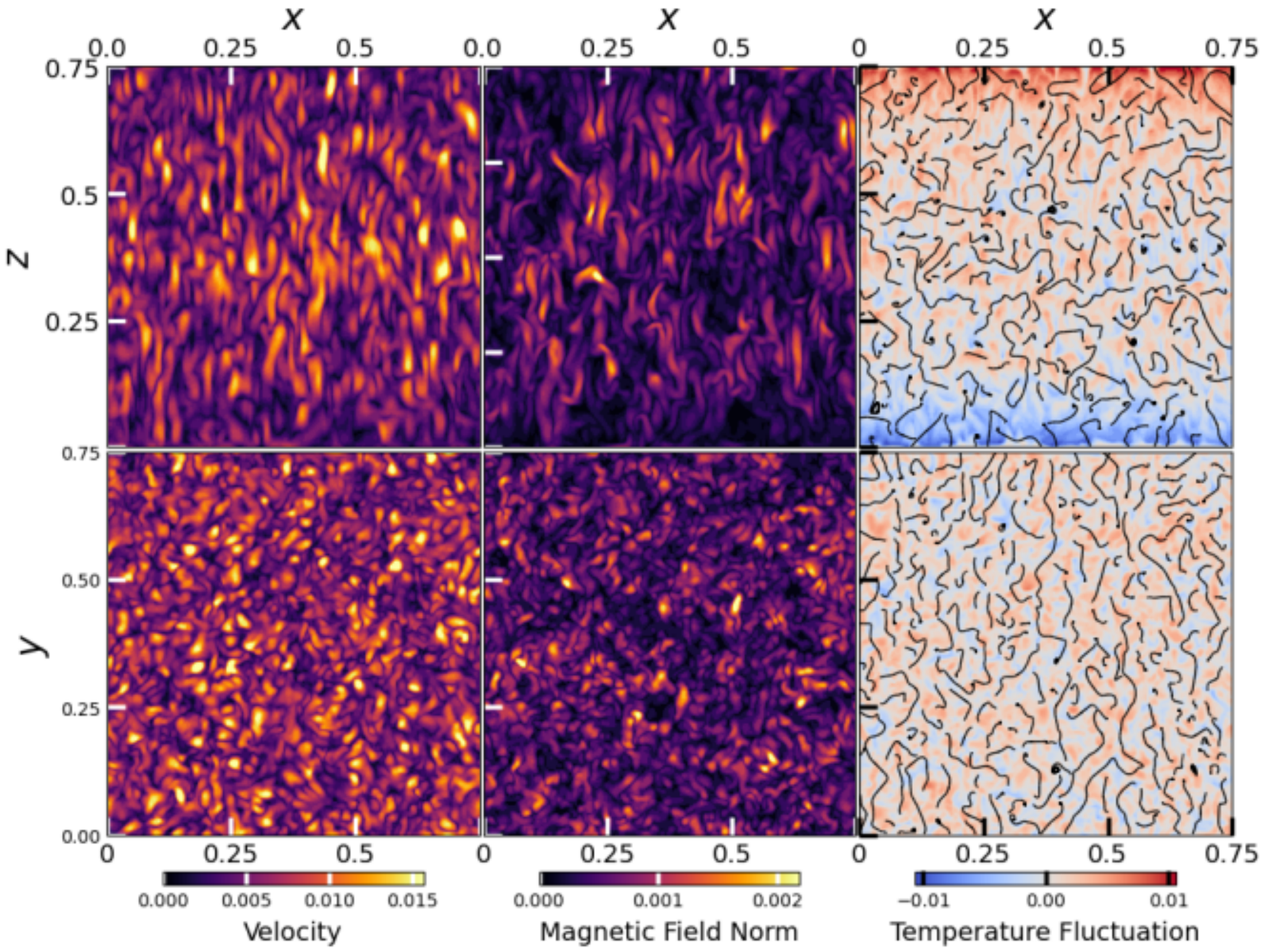
- Matter accretion on cluster edges
- AGN feedback
- Fluid and kinetic instabilities

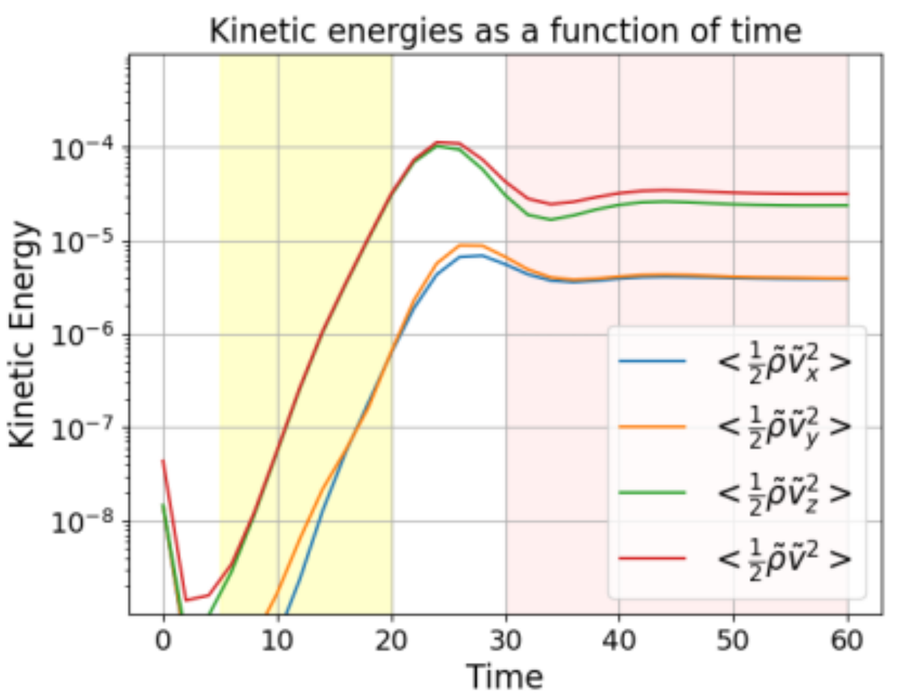
The ICM is **unstable** against **any temperature gradient,** especiallly to the **magneto-thermal instability** in the **outskirt**



Perseus profiles by Simionescu et al., Science 2011 [3]

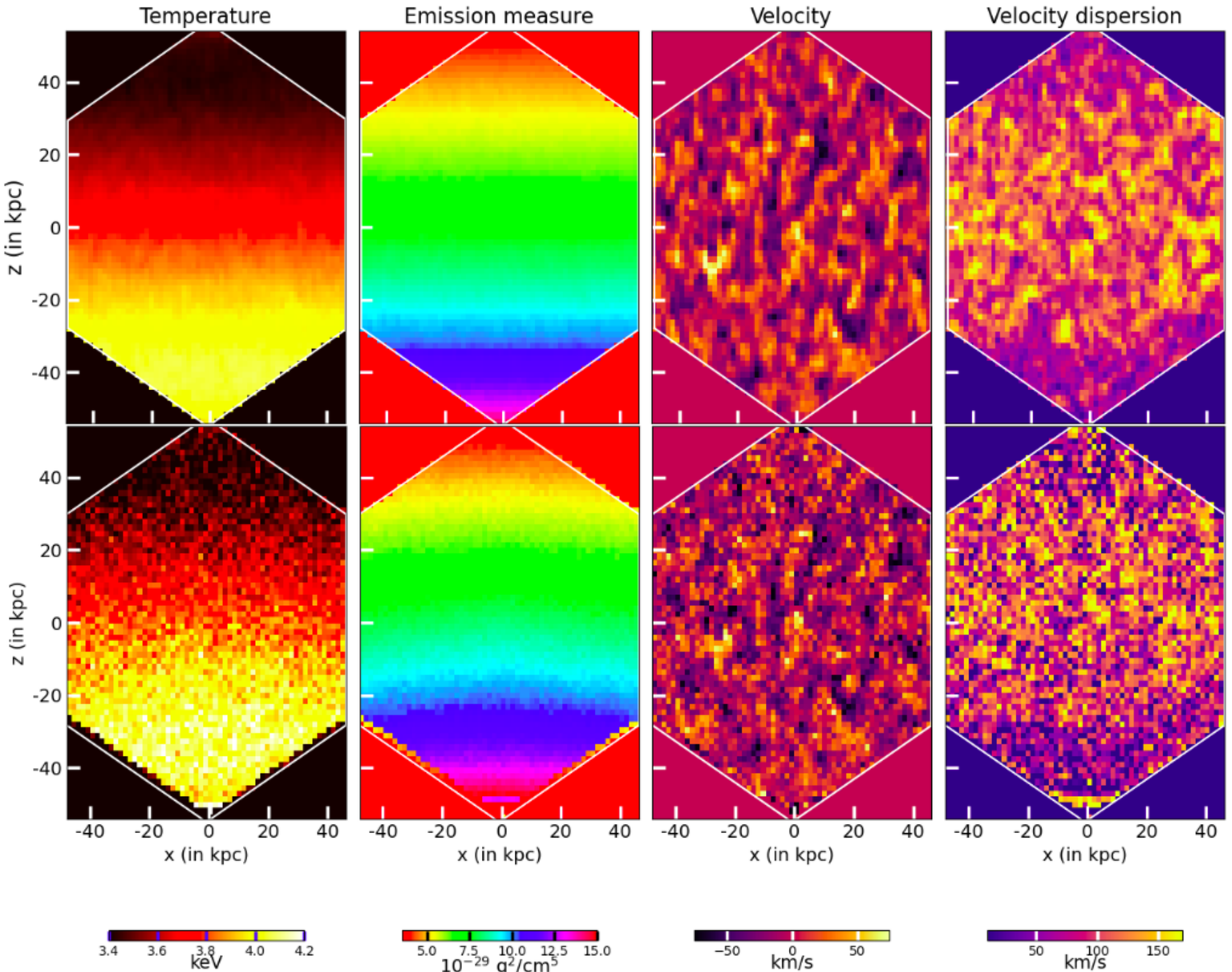
Snapshot at t = 60





MHD simulation of **MTI**-driven **turbulence**

Constraining the gas motion thanks to (mock) observations



1 Ms of synthetic **observation** with X-IFU

Very very **preliminary** results

Thanks for your attention !

Bibliography

[1] Fabian, A. C., et al. "A wide Chandra view of the core of the Perseus cluster." Monthly Notices of the Royal Astronomical Society 418.4 (2011): 2154-2164.
[2] Braginskii, S. I., and M. A. Leontovich. "Reviews of plasma physics." (1965): 205.
[3] Simionescu, Aurora, et al. "Baryons at the Edge of the X-ray-Brightest Galaxy Cluster." Science 331.6024 (2011): 1576-1579.

Spectroscopy of high-redshift galaxies

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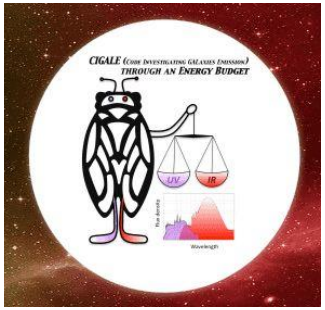


The CIGALE code

CIGALE = Code Investigating GALaxy Emission

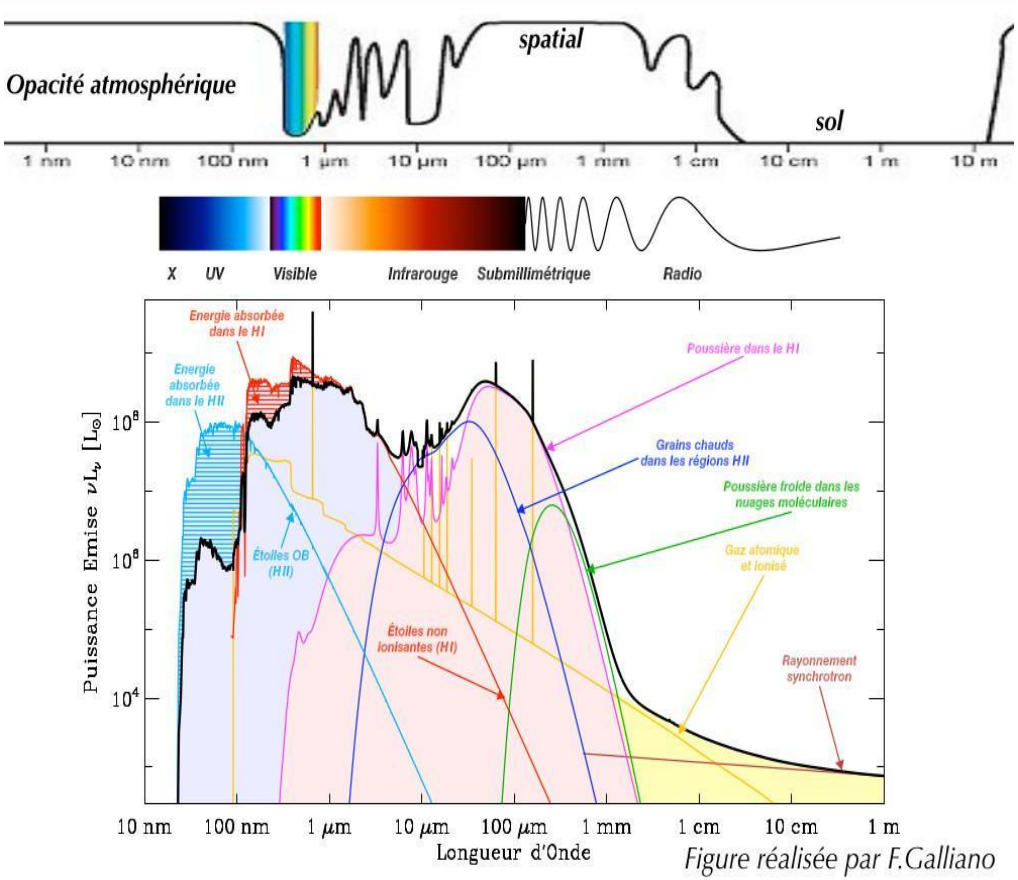
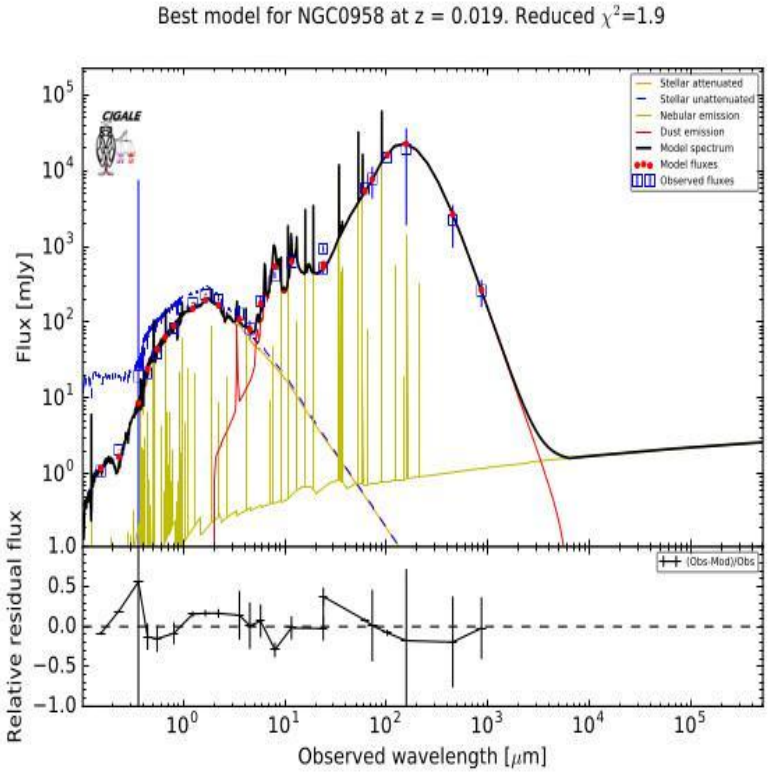
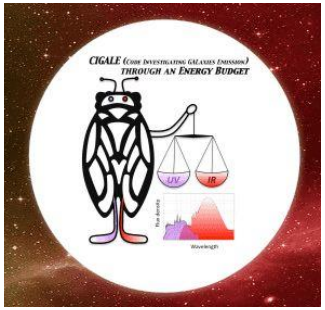


Figure réalisée par F.Galliano

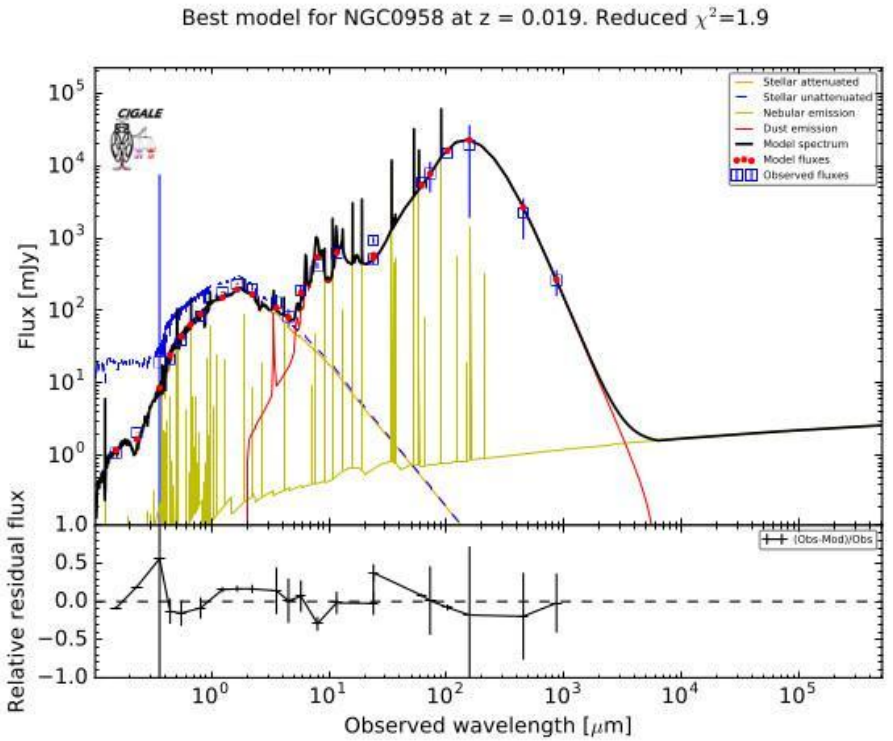




UV-to-FIR spectro-photometry

CIGALE = Code Investigating GALaxy Emission

- energy balance principle
- a SED fitting code (Bayesian analysis)
- produces mock spectra to compare with observations



fit of the UV-to-MIR photometric data

→ SFH (star formation rates, stellar mass)

SFH = delayed + burst

Calzetti attenuation curves for the lines and for the continuum

Step 3 : compute nebular emission lines

density $\mathbf{n_H}$
metallicity $\boldsymbol{\zeta_O}$
elementary atomic abundances

the CIGALE nebular emission module

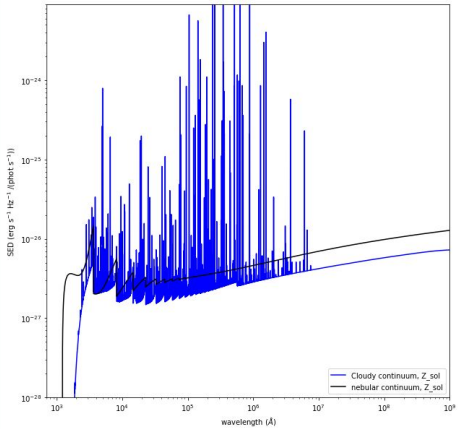
ionizing radiation field :
shape + intensity

BC03 SSP
U ionization parameter

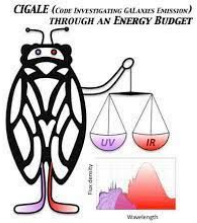
H
He
C
N
O
Mg
Fe
...

Cloudy & Associates

Photoionization simulations for the discriminating astrophysicist since 1978



nebular continuum + emission lines

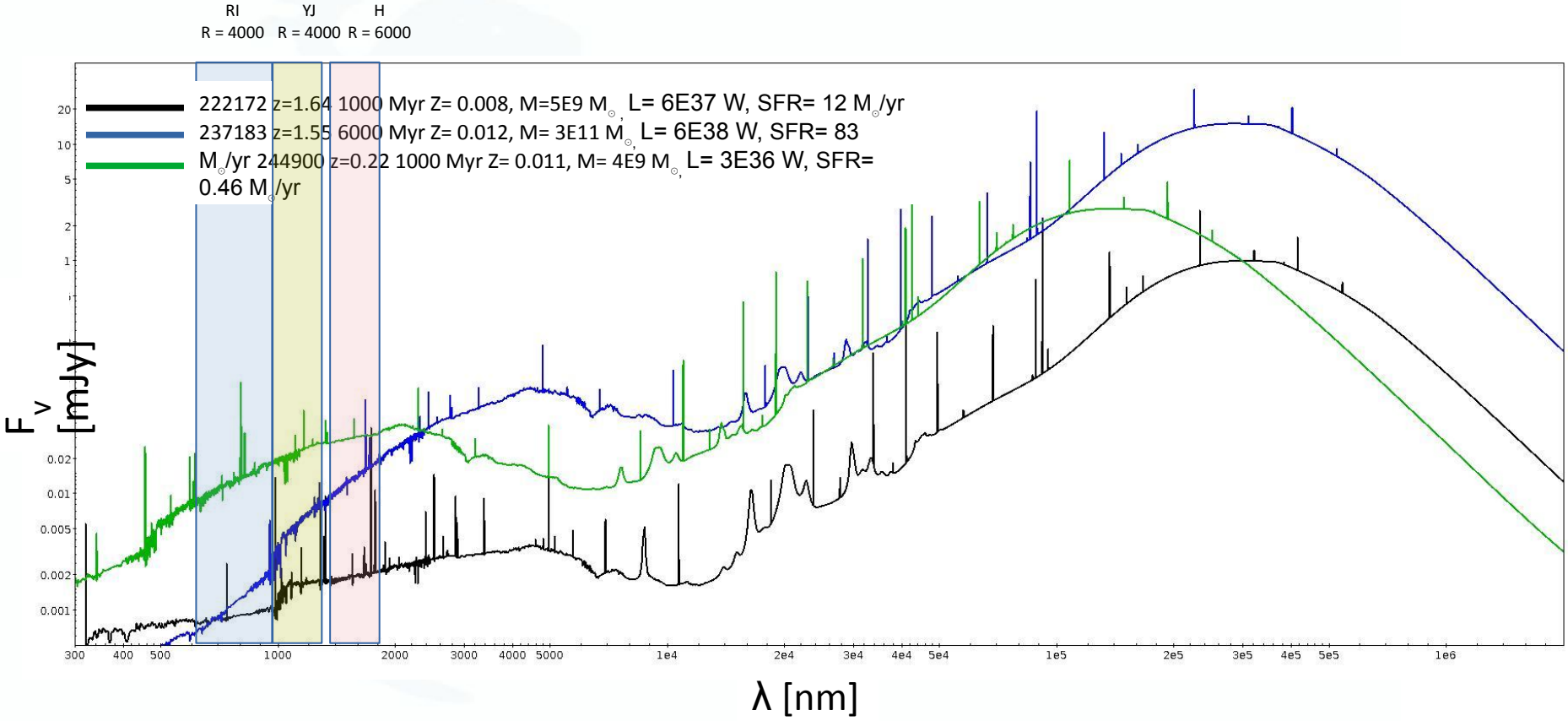


(U, n_H, ζ_O)

fixed extinction MW + Calzetti E_{B-V}= 0.44
variable extinction on line flux fitting

1. calculate the abundances of each species (chemical reaction networks)
2. calculate the populations for each level for each species (collisional/radiative level excitation)
3. compute radiative transfer for each emission line
4. generate grids of emission lines as a function of a set of parameters (U, n_H, ζ_O)

Spectra of galaxies



mock spectra for 2508 galaxies (COSMOS field)

- continuum only
- continuum + lines (U fixed)

Active Nuclei Galaxies spectra