E-Poster flash session

Highlights and prospects for r ×

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ASTRO SIM

Highlights and prospects for numerical astrophysics in France

8-11 Oct 2018 Lyon (France)

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e-Posters

List of the e-posters (click on the title to open the poster):

- Evolution of rotation in rapidly rotating early-type stars during the main sequence with 2D models. Damien Gagnier - IRAP Toulouse
- Non-linear diffusion of CRs escaping from SNRs in the atomic/molecular ISM. Loann Brahimi - LUPM Montpellier
- Cosmic Rays transport in the interstellar medium: Role of the self-generated turbulence. Loann Brahimi - LUPM Montpellier
- Selection of Spitzer Young Stellar Object candidates using Deep Learning classifiers. David Cornu, UTINAM Besançon
- An electromagnetic precursor to binary pulsar coalescence?.Benjamin Crinquand, IPAG Grenoble
- Exploring the nature of a non-axisymetric disk around HD142527. Clément Robert, OCA Lagrange Nice
- Dust dynamics on adaptive-mesh-refinement grids: application to protostellar collapse. Ugo Lebreuilly, CRAL Lyon
- Monte Carlo tracers implemented for the adaptive mesh refinement code RAMSES. Corentin Cadiou, IAP Paris
- Modelling atmospheric dynamics in Jupiter's troposphere. Alexandre Boissinot, LMD Paris
- Hybrid Radiative Transfer Method for Prestellar Isolated Core Collapse. Raphael Mignon-Risse, AIM, Paris-Saclay
- 3D mesoscale modeling of the turbulence of Venus atmopshere. Maxence Lefèvre, LMD Paris
- A well-balanced and all regime scheme for stratified compressible flows. Thomas Padioleau, Maison de la Simulation, Paris

Evolution of rotation in rapidly rotating early-type stars during the main sequence with 2D models

Damien Gagnier

Institut de Recherche en Astrophysique et Planétologie (IRAP)

October, 8th, 2018

Context

- Early-type stars are very luminous, hence with a strong radiation pressure at the surface
- The induced radiation-driven wind is responsible for their significant mass and angular momentum loss
- Early-type stars are often fast rotators $\longrightarrow$ anisotropic wind
- With ESTER 2D-models we can evaluate the associated local mass and angular momentum losses & their consequences on the evolution of rotation

Results

- Rotation-induced bi-stability jump: discontinuity in $\dot{M}$–$T_{\rm eff}$
  - 2 wind regimes

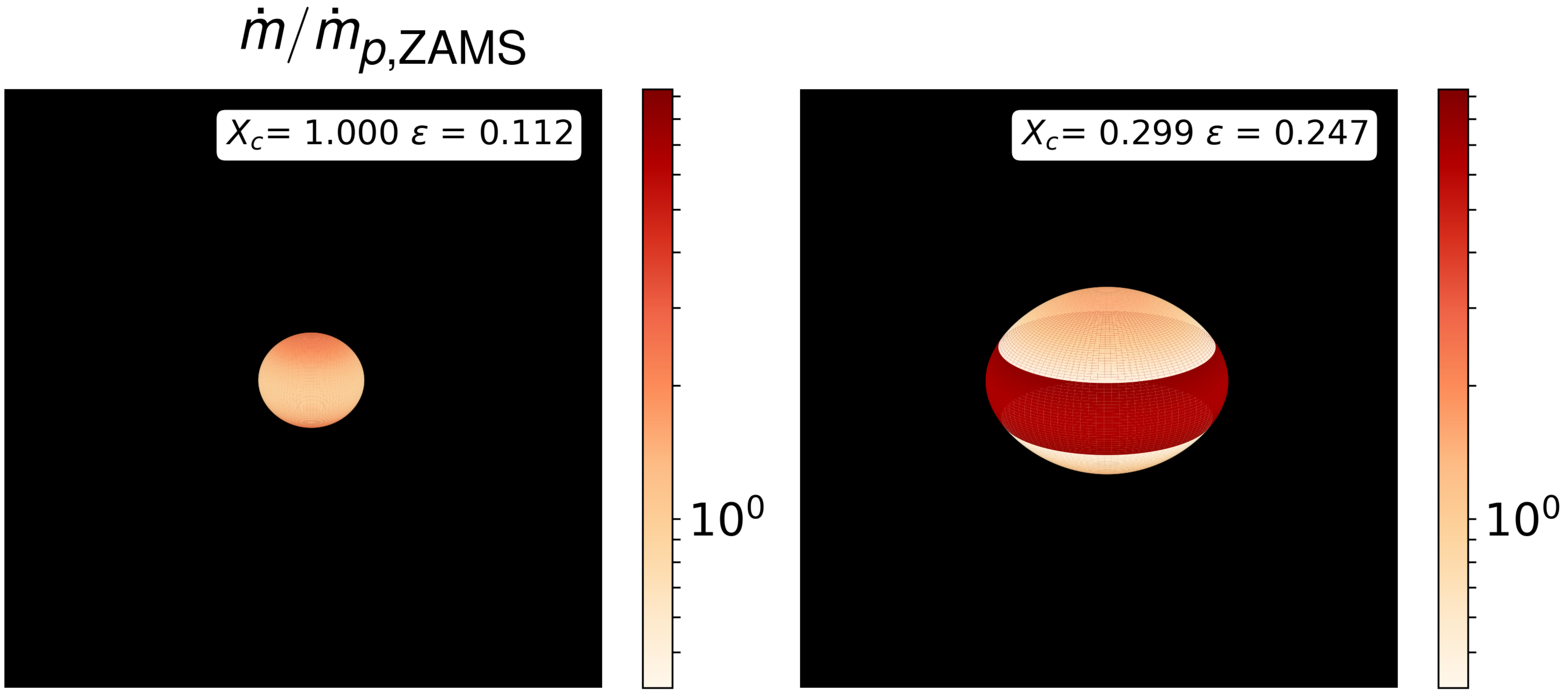
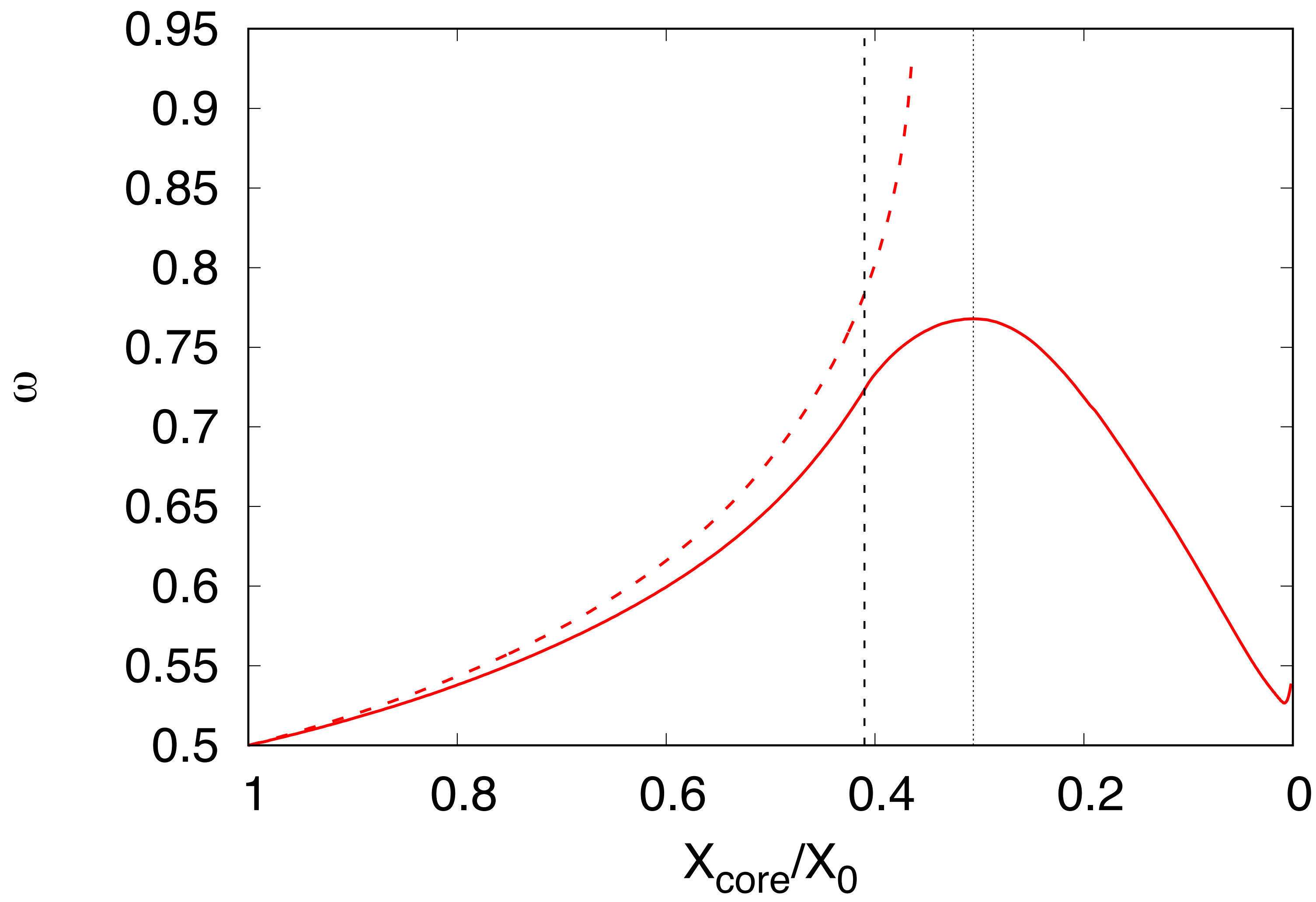


Figure 1: $M = 15\ M_\odot$ star initially rotating at 50% of the critical rotation. Left: ZAMS in a SWR; Right: Later on the MS, in a TWR

Results

- Rotation-induced bi-stability jump: discontinuity in $\dot{M}$–$T_{\rm eff}$
  - 2 wind regimes
  - Strong effect on the evolution of rotation



- Can prevent massive stars from reaching critical rotation
- Can induce strong spin-down of their surface layers

Non-linear diffusion of CRs escaping from SNRs remnants in the atomic/molecular ISM

Loann Brahimi - Astrosim 2018 (Lyon)

LUPM - Montpellier University

October 1, 2018

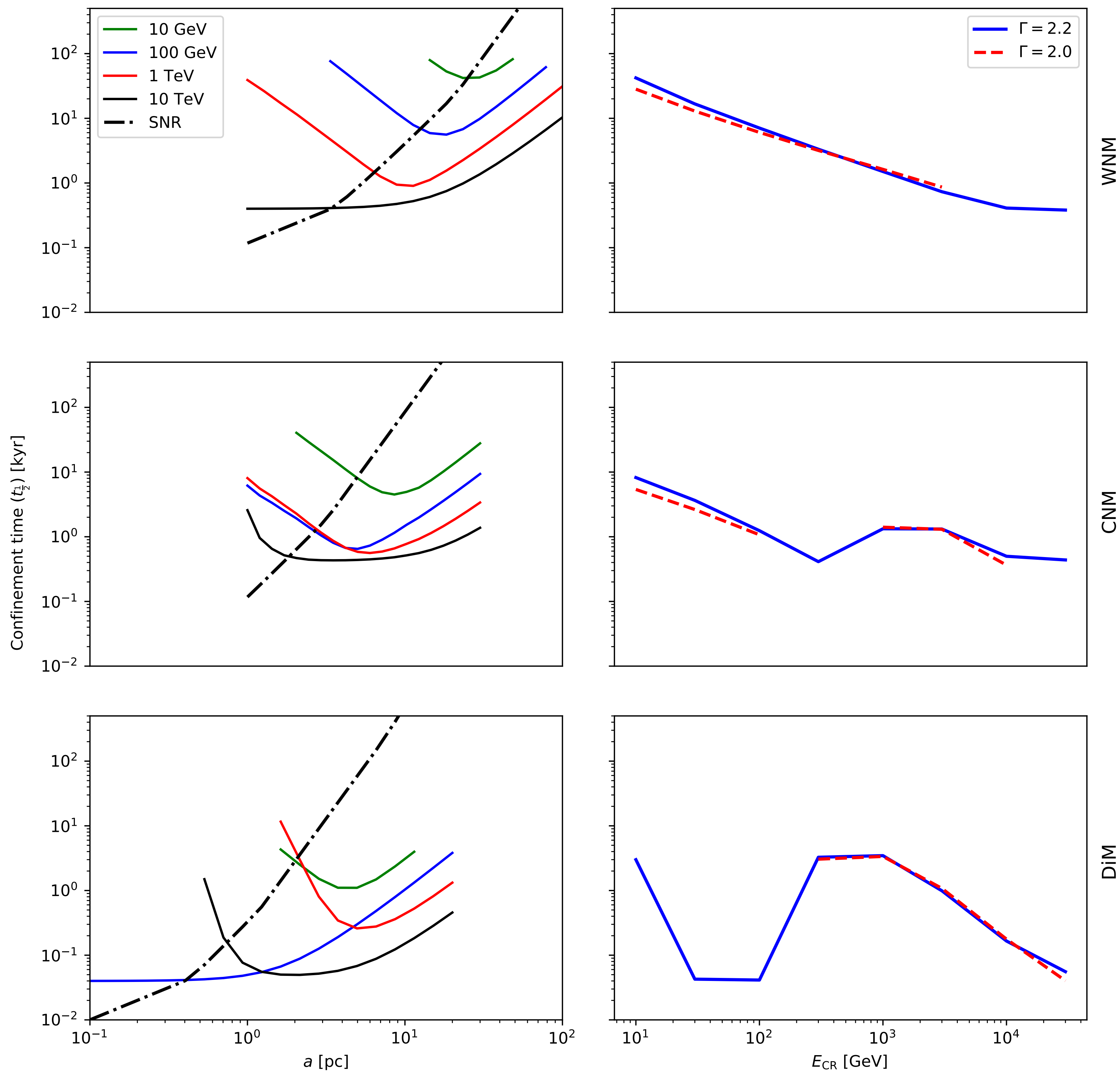
Role and effects of CRs self-generated turbulence - Developpement of the method and application

Equations

$$\boxed{\frac{\partial P_{\mathrm{CR}}}{\partial t} + V_{\mathrm{A}} \frac{\partial P_{\mathrm{CR}}}{\partial z}} = \boxed{\frac{\partial}{\partial z}\left(D \frac{\partial P_{\mathrm{CR}}}{\partial z}\right)}$$

$$\boxed{\frac{\partial I}{\partial t} + V_{\mathrm{A}} \frac{\partial I}{\partial z}} = \boxed{2\left(\Gamma_{\mathrm{growth}} - \Gamma_{\mathrm{d}}\right) I} + \boxed{Q}$$

Cosmic Rays Cloud model



Enjoy

Non-linear diffusion of CRs escaping from SNRs in the atomic/molecular ISM

L. Brahimi, A. Marcowith, L. Nava, S. Gabici and S. Recchia
loann.brahimi@umontpellier.fr (Brahimi et al. (2018) in prep)

LUPM LABORATOIRE MONTPELLIER UNIVERS & PARTICULES

Introduction

It is admitted that CRs play an important role in the ISM dynamics. SNRs strong shocks seem to be able to accelerate CRs by diffusive shock acceleration (DSA) up to few hundred of TeV or even to PeV at early times. The generated CRs streaming instability can produces magnetic perturbations propagating in the plasma and affecting back the CRs transport properties.

In this work we study the non-linear diffusion of CRs escaping from SNRs in weakly ionized plasma. We use a 1D C++ fluid code written by Nava et al. (2016) and adapted to the atomic/molecular plasmas consisting to simultaneously solve two diffusion/advection eqs. of magnetic perturbation energy density of waves and CRs pressure. The dimensionnality of our problem implies to use a flux tube approximation.

Application

Through simulations of CRs sources expansion in the neutral atomic/molecular ISM, we shown that the CRs self-generated turbulence can have an important effect on the CRs propagation and on the dynamical plasma properties. That is why we need to quantify this effect in a more realistic simulation of the interstellar medium.

By retrieving non-red terms of master equations presented in the **The model** section, we are currently implementing a sub-grid CRs diffusion coefficient term in the magnetohydrodynamics RAMSES code. See our second poster for more informations.

Generalisation of the method

In order to study a realistic situation we need to take in account the medium properties spatial variations and increase the dimensionnality of our problem leading to a generalized system of equations

$$\frac{\partial P_{\rm CR}}{\partial \mathbf{r}} + \frac{\partial p^3 V_A}{\partial p^3}\frac{\partial P_{\rm CR}}{\partial \mathbf{r}} = \frac{4\pi p^4 v(p)}{3}\frac{\partial V_A p^3}{\partial \mathbf{r}}\frac{\partial P_{\rm CR}/(\frac{4\pi p^4 v(p)}{3})}{\partial p^3} + \frac{\partial}{\partial \mathbf{r}} D \frac{\partial P_{\rm CR}}{\partial \mathbf{r}} \quad (1)$$

$$\frac{\partial I}{\partial t} + \frac{\partial V_A I}{\partial \mathbf{r}} = (\Gamma_g - \Gamma_d) I + Q \quad (2)$$

where $\Gamma_g = -\frac{12\pi}{B_0^2 I}\frac{\partial P_{\rm CR}}{\partial \mathbf{r}}$, $P_{\rm CR} = P_{\rm CR}(\mathbf{r}, p, t)$, $V_A = V_A(\mathbf{r}, p)$ and $I = I(\mathbf{r}, k)$.

References

[1] Nava L., Gabici S., Marcowith A., Morlino G., Ptuskin V. S. : *Non-linear diffusion of cosmic rays escaping from supernova remnants - I. The effect of neutrals*, mnras (2016)

[2] Malkov M. A., Diamond P. H., Sagdeev R. Z., Aharonian F. A., Moskalenko I. V. : *Analytic Solution for Self-regulated Collective Escape of Cosmic Rays from Their Acceleration Sites*, apj (2013)

[3] Skilling : *Cosmic Rays streaming I-II-III*, mnras (1975)

[4] Cioffi D. F., McKee, Bertschinger E. : *Dynamics of radiative supernova remnants*, apj (1988)

[5] Truelove J. K. & McKee C. F. : *Evolution of Non-radiative Supernova Remnants*, apjs (1999)

The model

CRs and resonnant waves transport along the mean magnetic field lines is described by two transport eqs. given by

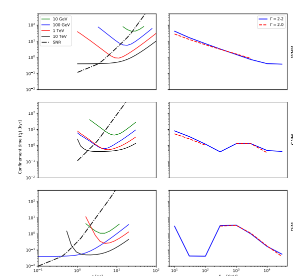
$$\boxed{\frac{\partial P_{\rm CR}}{\partial t} + V_{\rm A}\frac{\partial P_{\rm CR}}{\partial z}} = \boxed{\frac{\partial}{\partial z}\left(D\frac{\partial P_{\rm CR}}{\partial z}\right)}$$

$$\boxed{\frac{\partial I}{\partial t} + V_{\rm A}\frac{\partial I}{\partial z}} = \boxed{2\left(\Gamma_{\rm growth} - \Gamma_{\rm d}\right) I} + \boxed{Q}$$

where $P_{\rm CR}$ represents the CRs pressure and I is the Alven waves magnetic energy density. Red boxes represent the advective terms where the advection velocity is the Alfven one ($V_{\rm A}$). The blue box describe the way that CRs are diffused by the plasma turbulence where $D = D_{\rm B}/I$ corresponds to a non-linear diffusion coefficient depending on the magnetic perturbations energy density. $D_{\rm B}$ is the Bohm diffusion coefficient. The green box discuss the way that magnetic perturbations are generated/damped. $\Gamma_{\rm d}$ correspond to the waves damping rate while $\Gamma_{\rm growth} = -V_{\rm A}\,\partial P_{\rm CR}/\partial z\,/(2I)$ describes the waves generation by CRs streaming instability dissipation. The black box is a constant term describing the large scale turbulence magnetic energy inferred from observation.

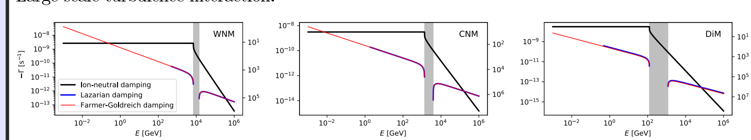
CRs Cloud model

Malkov et al. (2013) defined the CR cloud half-life time $t_{1/2}$ as the time it takes for the CRs integrated pressure in the initial sphere to be divided by two. By calculating this time for each initial CRC radius (see colored lines on the left part of the figure below) and intersecting it with shock radius evolution of SNR in each phase (see black dotted lines on the left part of the figure below) derived from (Cioffi et al. 1988, Truelove & McKee 1999), we can derive the characteristic confinement time as a function of the CRs energy (see blue lines on the right hand part of the figure below).



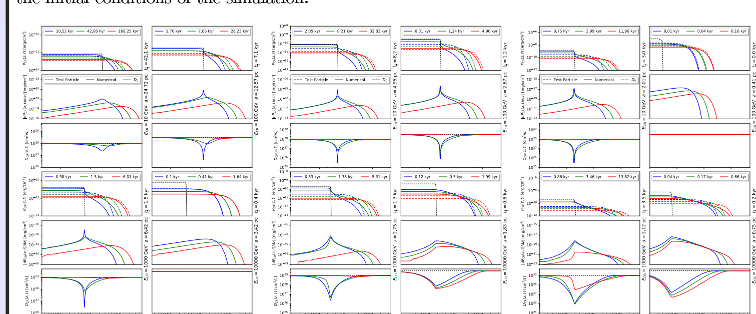
ISM phases properties

We modelised the CRs leakage problem in three homogeneous atomic/molecular phases of the ISM : Warm Neutral Medium (WNM), Cold Neutral Medium (CNM) and Diffuse Molecular Cloud (DiM) (see ref.). The self-generated Alfven waves are damped by two processes : Ion-Neutral collisions, Large scale turbulence interaction.



Non-linear diffusion solutions : Numerical approach

Knowing the CRs escape time and the associated SNR shock radius. We simulated CRC expansion for each solution in each phase : WNM (left), CNM (middle), DiM (right). Each numerical solution is calculated at $t_{1/2}/4$ (blue), $t_{1/2}$ (green), $4t_{1/2}$ (red) by solid lines for each CRs energies : 10 (top left), 10^2 (top right), 10^3 (bottom left), 10^4 (bottom right) GeV. For each energy, the top panel represents the CRs spatial pressure distribution and is compared to test particles solutions represented by colored dotted lines. The middle panel represents the CRs pressure gradient. The bottom panel represents the spatial diffusion coefficients due to self-generated turbulence compared to the large scale turbulence one represented by a black large dotted line. Black dotted lines represent the initial conditions of the simulation.



Cosmic Rays transport in the Interstellar Medium : Role of the Self-Generated turbulence

Loann Brahimi - CRISM 2018 (Grenoble)

LUPM - Montpellier University

25 juin 2018

Implementation of a sub-grid Cosmic Rays (CRs) diffusion coefficient and resonant Alfven waves drift velocity terms in the magnetohydrodynamics (MHD) RAMSES code

Anisotropic diffusion of CRs in the RAMSES code

Dubois & Commerçon (2016)

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{u}) = 0$$

$$\frac{\partial \rho \mathbf{u}}{\partial t} + \nabla \cdot \left(\rho \mathbf{u}\mathbf{u} + p_{\rm tot} - \frac{\mathbf{B}\mathbf{B}}{4\pi} \right) = 0$$

$$\frac{\partial e}{\partial t} + \nabla \cdot \left((e + p_{\rm tot})\mathbf{u} - \frac{\mathbf{B}(\mathbf{B} \cdot \mathbf{u})}{4\pi} \right) = -\nabla \cdot \mathbf{F}_{\rm CR}$$

$$\frac{\partial \mathbf{B}}{\partial t} - \nabla \times (\mathbf{u} \times \mathbf{B}) = 0$$

$$\frac{\partial e_{\rm CR}}{\partial t} + \nabla \cdot (e_{\rm CR}) = -p_{\rm CR} \nabla \cdot \mathbf{u} - \nabla \cdot \mathbf{F}_{\rm CR}.$$

$\mathbf{F}_{\rm CR} = -D_{\rm CR} \mathbf{b}(\mathbf{b} \cdot \nabla) e_{\rm CR}$ where $D_{\rm CR}$ is constant over all the simulation box.

CRs self-generated diffusion coefficient

The CRs global diffusion coefficient is given by

$$D_{\rm CR} = [D_0^{-1} + D_{\rm self}^{-1}]^{-1}. \qquad (1)$$

Implementation procedure

Nava et al. (2016)

$$\begin{aligned} \partial P_{\rm CR}(E)/\partial t + V_A(k)\,\partial P_{\rm CR}(E)/\partial z &= \partial(D_{\rm CR}\,\partial P_{\rm CR}/\partial z)/\partial z \\ \partial I(k)/\partial t + V_A(k)\,\partial I(k)/\partial z &= -V_A(k)\,\partial P_{\rm CR}(E)/\partial z - 2\Gamma_d I(k) \\ &+ Q(k) \end{aligned}$$

- $\rightarrow$ $I(k) = \frac{|v_{\rm st}|}{2\Gamma_{\rm in}} \nabla P_{\rm CR}$ where $\mathbf{v}_{\rm st} = -V_A\,\mathrm{sgn}(\mathbf{B} \cdot \nabla P_{\rm CR})$.
- $\rightarrow$ $D_{{\rm self},||} = 4\pi r_g c/(3I(k))$
- $\rightarrow$ $D_{{\rm self},\perp} = D_{{\rm self},||} I(k)^2$ ... according to the quasi-linear theory.

Resonant Alven waves drift velocity

$$\frac{\partial e_{\rm CR}}{\partial t} + \nabla(e_{\rm CR}(\mathbf{u}+\mathbf{v}_{\rm st}) + \mathbf{F}_{\rm CR}) = -P_{\rm CR}\nabla\cdot(\mathbf{u}+\mathbf{v}_{\rm st})$$

Implicit method

$$\frac{\partial e_{\rm CR}}{\partial t} + \nabla(e_{\rm CR}\mathbf{u}) + \gamma_{\rm CR}\nabla(D_{\rm st}\mathbf{b}\cdot\nabla e_{\rm CR}) = -\nabla\cdot\mathbf{F}_{\rm CR} - P_{\rm CR}\nabla\cdot\mathbf{u} + \mathbf{v}_{\rm st}\cdot\nabla P_{\rm CR}$$

where $D_{\rm st} = V_A e_{\rm CR}/|\nabla e_{\rm CR}|$.

Explicit method

$$\frac{\partial e_{\rm CR}}{\partial t} + \nabla(e_{\rm CR}\mathbf{u}) + \gamma_{\rm CR} e_{\rm CR}\nabla\mathbf{v}_{\rm st} = -\nabla\cdot\mathbf{F}_{\rm CR} - P_{\rm CR}\nabla\cdot\mathbf{u} - \mathbf{v}_{\rm st}\cdot\nabla e_{\rm CR}$$

Cosmic Rays transport in the interstellar medium (ISM) : Role of the self-generated turbulence

Implementation of a sub-grid Cosmic Rays (CRs) diffusion coefficient and resonant Alfven waves drift velocity terms in the magnetohydrodynamics (MHD) RAMSES code

Loann Brahimi[1], Alexandre Marcowith[1], Benoit Commerçon[2], Yohan Dubois[3]

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Context

Cosmic Ray (CR) transport is closely linked to the turbulent dynamics of the interstellar medium (ISM). In this frame, an implicit scheme for solving the anisotropic diffusion of heat and CRs in the RAMSES code has been developed by Dubois & Commerçon (2016). The CR diffusion coefficient is initially constant throughout the simulation volume and evolves according to the turbulent properties of the gas (Lazarian 2016) throughout the simulation time.
We implement a routine allowing to correct the CRs diffusion coefficient value by considering the sub-resolution turbulent motions and observe the consequences at small/intermediary scales (>40 pc). We also need to consider a streaming velocity term which takes in account the real resonant Alfvén waves velocity and their propagation direction along the magnetic field (Pfrommer et al. 2016).

Anisotropic diffusion of CRs in the RAMSES code

In order to take in account the CRs energy dynamics, Dubois & Commerçon (2016) implemented an equation of transport for CRs energy in the MHD RAMSES code.

The MHD mono-magnetized fluid equations are given by :

$$\frac{\partial \rho}{\partial t} + \boldsymbol{\nabla} \cdot (\rho \mathbf{u}) = 0 \quad (1)$$

$$\frac{\partial \rho \mathbf{u}}{\partial t} + \boldsymbol{\nabla} \cdot \left(\rho \mathbf{u}\mathbf{u} + p_{\rm tot} - \frac{\mathbf{B}\mathbf{B}}{4\pi} \right) = 0 \quad (2)$$

$$\frac{\partial e}{\partial t} + \boldsymbol{\nabla} \cdot \left((e + p_{\rm tot})\mathbf{u} - \frac{\mathbf{B}(\mathbf{B} \cdot \mathbf{u}}{4\pi} \right) = \quad (3)$$

$$-\boldsymbol{\nabla} \cdot \mathbf{F}_{\rm cond} - \boldsymbol{\nabla} \cdot \mathbf{F}_{\rm CR} \quad (4)$$

$$\frac{\partial \mathbf{B}}{\partial t} - \boldsymbol{\nabla} \times (\mathbf{u} \times \mathbf{B}) = 0 \quad (5)$$

where the source term $\boldsymbol{\nabla} \cdot \mathbf{F}_{\rm CR}$ correspond to the energy tranfert rates between the fluid energy and CRs energy. The latter are considered as fluid leading to one more transport equation for the CRs energy density ($e_{\rm CR}$) :

wider in models with $D_0 \geq 10^{26}$ cm^2 s^{-1}. For the CRs we observe the contrary, the CRs PDFs are wider for low values of diffusion coefficient suggesting that a too high value imply that large diffusion coefficients smooth CR gradients and prevent the development of kinetic CR driven instabilities.

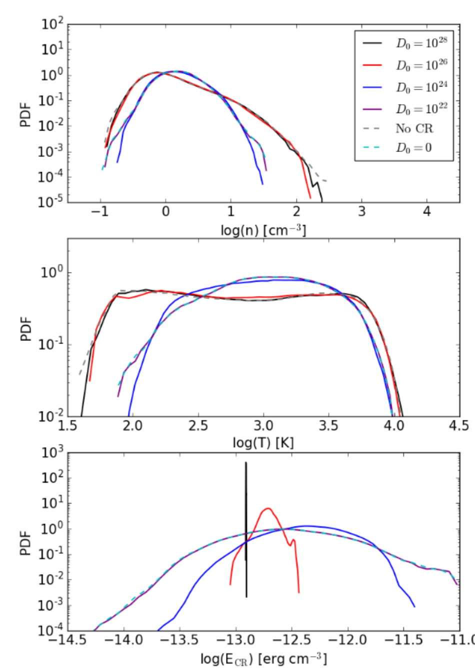


FIGURE 1 – PDF of the gas density (top), temperature (middle), and CR energy density (bottom), for $D_0 = 10^{22}$ (purple), 10^{24} (blue), 10^{26} (red), and 10^{28} cm^2 s^1 (black). Two models with $D_0 = 0$ (dashed cyan) and without CR (dashed grey) are also represented for comparison.

However, the critical value of the CRs diffusion coefficient can be reached by considering more sophisticated models of turbulence :

→ Large scale turbulence model based on the Alfvenic regime. The turbulence properties are widely dependant of the structural pro-

→ We retrieve eqs. (4) and (5) from Nava et al. (2016) but assuming that $\partial I/\partial t + V_{\rm A}\, \partial I/\partial z = 0$ implying

$$-2\Gamma_{\rm in} I(k) + |V_{\rm st}| \left| \frac{\partial P_{\rm CR}(p)}{\partial s} \right| + Q(k) = 0 \quad (11)$$

Where $I(k)$ represent the magnetic perturbations energy density at a scale k^{-1}. We fix p and k, $\partial P_{\rm CR}/\partial s$ represent the pressure gradient of CRs for a given energy. We consider resonating Alfvén waves and we neglect the effect of the large scale turbulence $\Rightarrow Q(k) = 0$.

→ For each cell, we calculate $\Gamma_{\rm in}$ by solving the dispersion relation of the Alfvén waves.

→ For each cell, we calculate the CRs pressure gradient along the magnetic field line.

→ From eq. (11) we derive the wave energy density for each cell.

→ The parallel propagating diffusion coefficient is then given by : $D_{\rm self,\parallel} = 4\pi r_g c/(3I(k))$ while the perpendicular propagating diffusion coefficient is given by $D_{\rm self,\perp} = D_{\rm self,\parallel} I(k)^2$ in the quasi-linear limit.

Resonant Alven waves drift velocity

The eq. (6) can be rewritten in a conservative form

$$\frac{\partial e_{\rm CR}}{\partial t} + \boldsymbol{\nabla}(e_{\rm CR}\mathbf{u} + \mathbf{F}_{\rm CR}) = -P_{\rm CR} \boldsymbol{\nabla} \cdot \mathbf{u}. \quad (12)$$

But the spatial transport of CR energy density is advected with the frame propagating at the velocity $\mathbf{u} + \mathbf{v}_{\rm st}$ where $\mathbf{v}_{\rm st} = -V_A\, {\rm sgn}(\mathbf{B} \cdot \boldsymbol{\nabla} P_{\rm CR})$ is the streaming velocity and corresponds to the Alfvén waves propagation velocity. The above eq. should be rewritten as

$$\frac{\partial e_{\rm CR}}{\partial t} + \boldsymbol{\nabla}(e_{\rm CR}(\mathbf{u} + \mathbf{v}_{\rm st}) + \mathbf{F}_{\rm CR}) = -P_{\rm CR} \boldsymbol{\nabla} \cdot (\mathbf{u} + \mathbf{v}_{\rm st}) \quad (13)$$

where $P_{\rm CR} = (\gamma_{\rm CR} - 1)e_{\rm CR}$.
The implementation of the streaming term can be done with two ways :

→ **Implicit way :**
In this case, the eq. above can be rewritten as

$$\frac{\partial e_{\rm CR}}{\partial t} + \boldsymbol{\nabla}(e_{\rm CR}\mathbf{u}) + \gamma_{\rm CR} \boldsymbol{\nabla}(e_{\rm CR}\mathbf{v}_{\rm st}) = -\boldsymbol{\nabla} \cdot \mathbf{F}_{\rm CR} - P_{\rm CR} \boldsymbol{\nabla} \cdot \mathbf{u}$$

Selection of Spitzer Young Stellar Object candidates using Deep Learning classifiers

David Cornu, PHD Student

UTINAM, Besançon Observatory, Univ. Franche-Comté

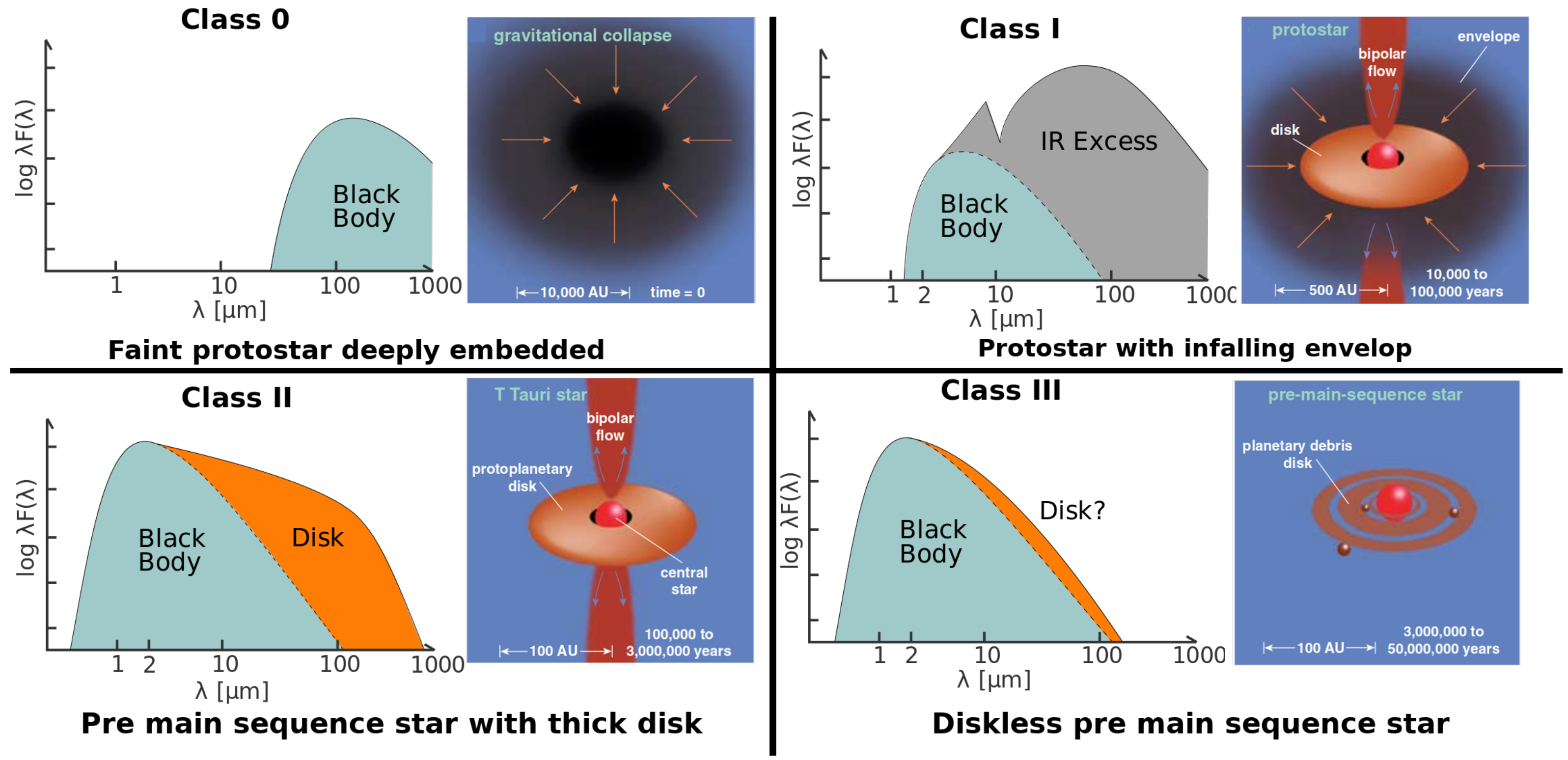
YSOs can be classified into evolutionary stages : Class I, Class II using their infrared SED with Spitzer 3.6, 4.5, 5.8, 8, 24 μm.

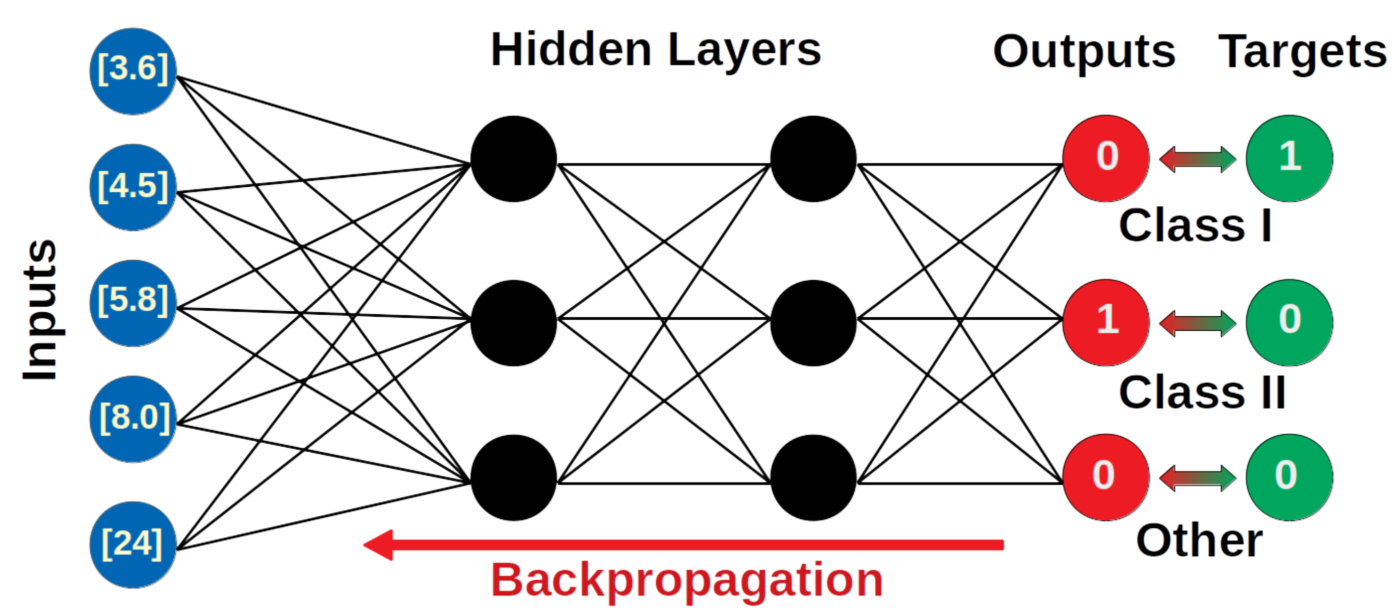
Complementary to full sky study like Marton+ 2016 with WISE. Spitzer cover a smaller fraction of the sky, but see further.

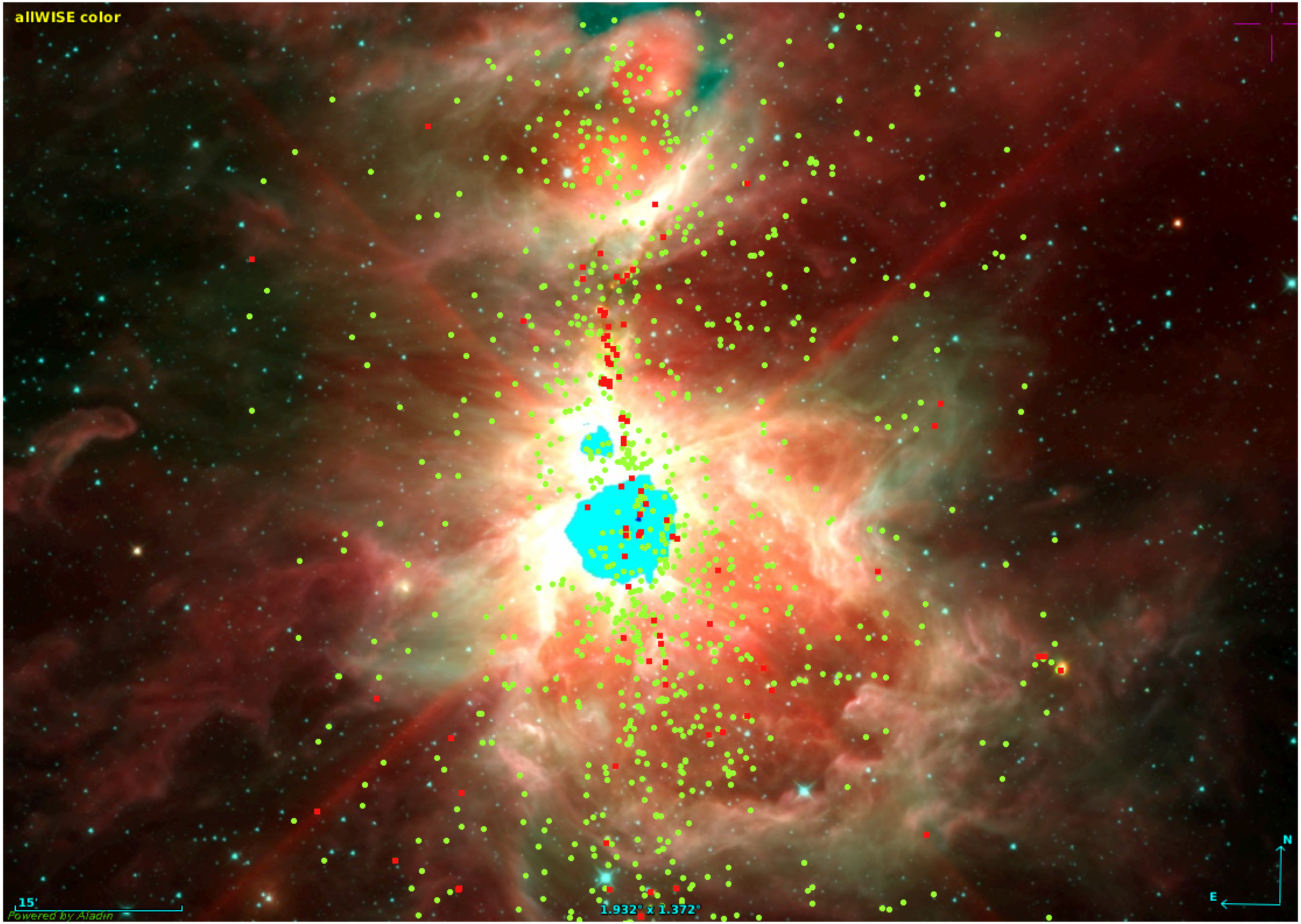
We developed a "Deep Learning" numerical framework based on Artificial Neural Networks using state of the art HPC methods.

Learning from the well known classification from Gutermuth et al. 2009, applied on nearby clusters.

Results in quick learning and forward capability on large Spitzer catalogues with precision $> 90\%$ on the most dilluted class. (in prep. 2018)







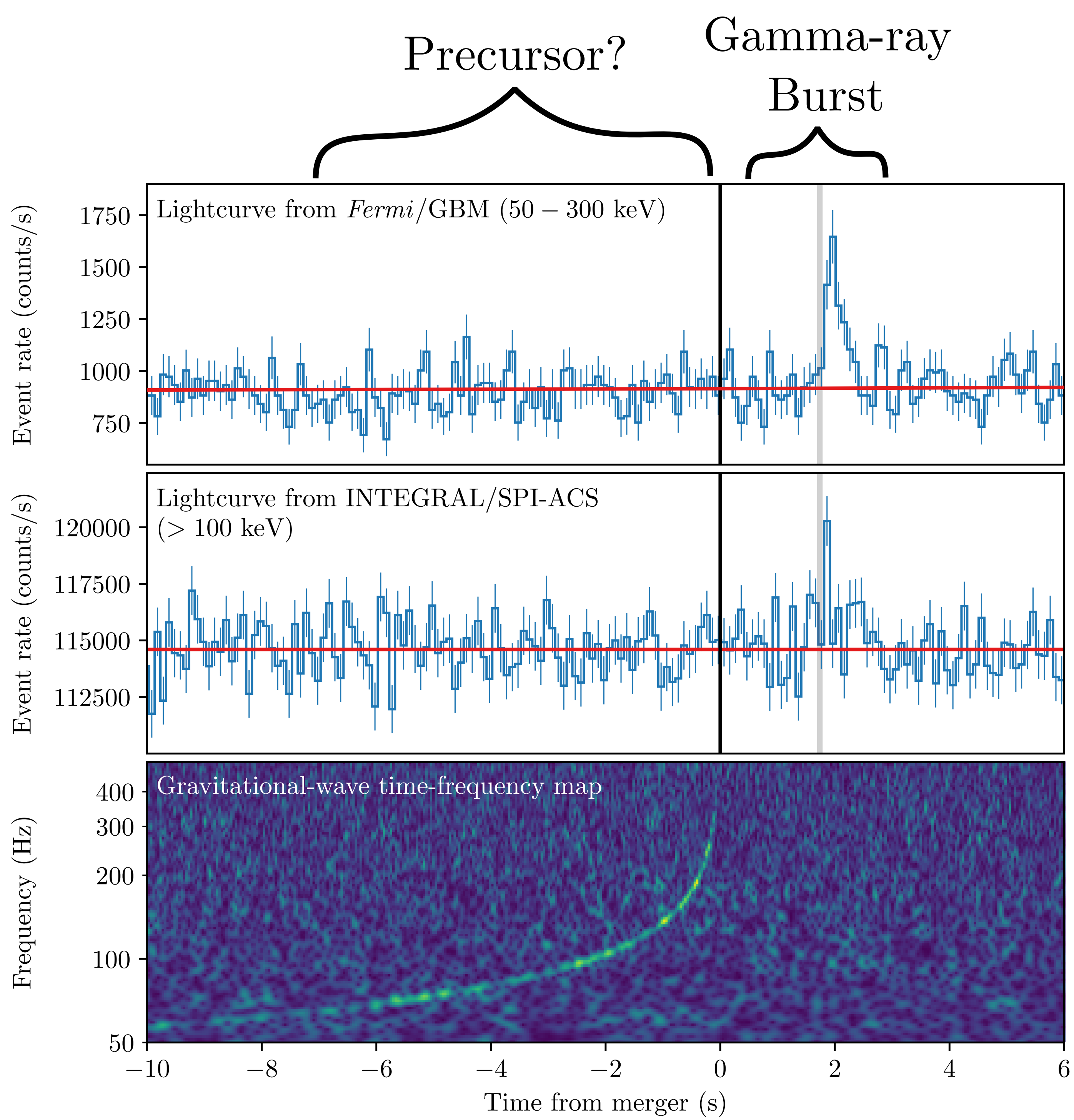
Application of the classification scheme to the Orion Nebula. YSOs candidates can be used with GAIA data to retrieve 3D interstellar medium structure.

Electromagnetic precursor of a binary neutron star coalescence

Benjamin Crinquand

Institut de Planétologie et d'Astrophysique de Grenoble

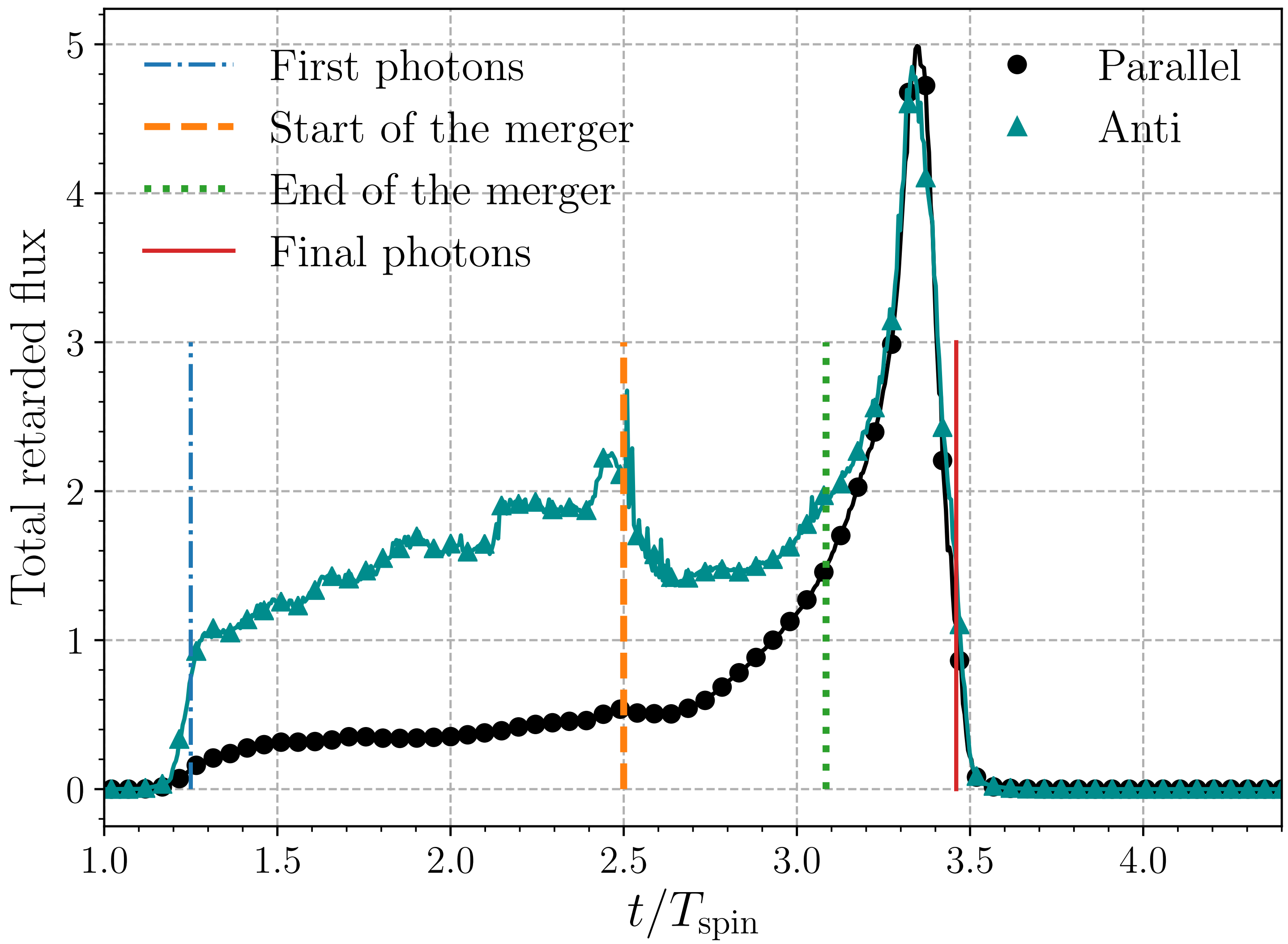
October 5, 2018



Abbott et al. (2017)

- Recent joint detection of EM and GW waves ⇒ Signature of a binary neutron star merger
- Multi-messenger astronomy
- Electromagnetic precursor signal?

Binary merger: an observable signature?



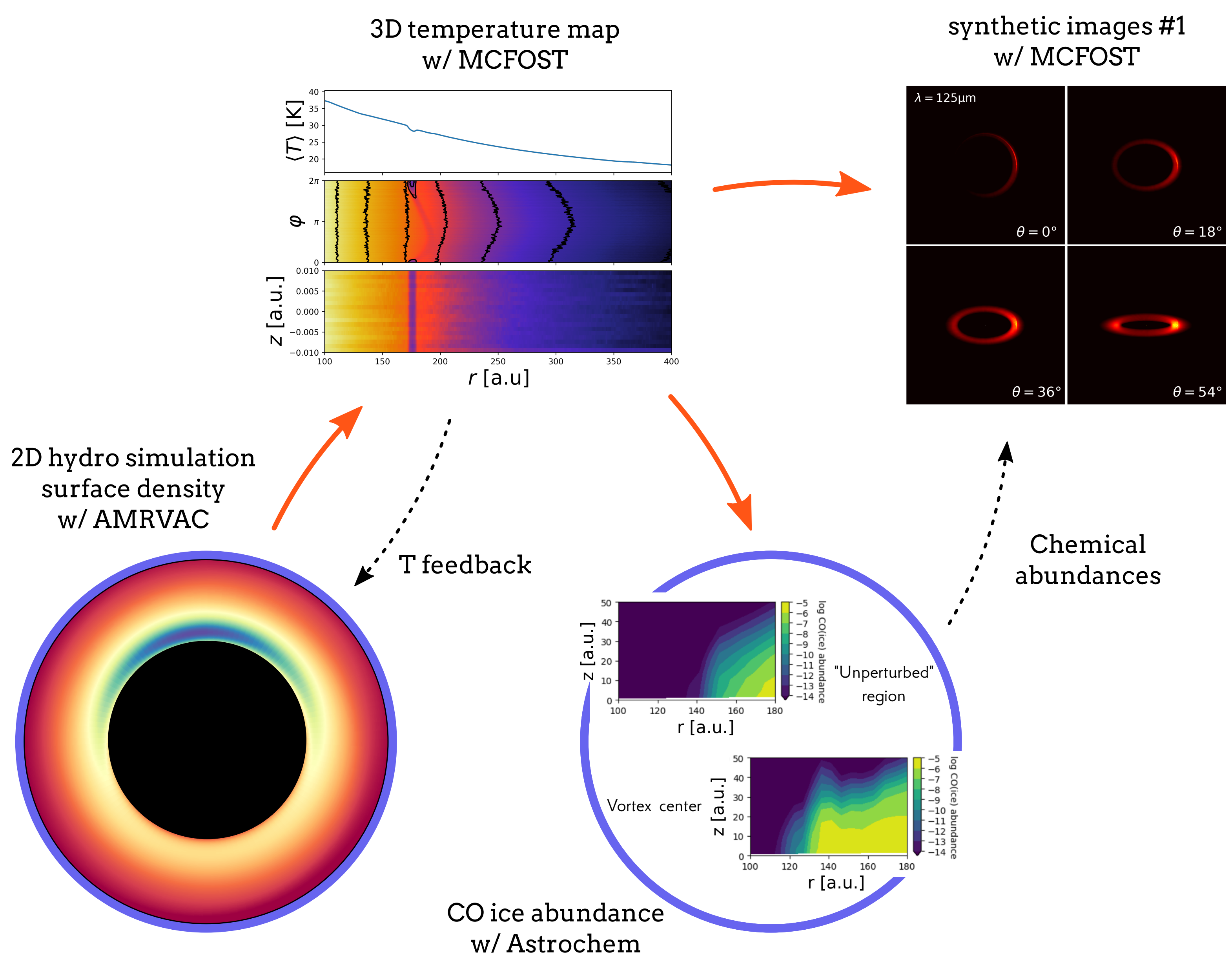
Computed lightcurves for aligned and anti-aligned pulsars

- Identification of the mechansims responsible for particle acceleration, prior to the merger
- Great increase in bolometric luminosity: Total radiated power increases by one to two orders of magnitude

  ↳ Energy flux $\sim 10^{38}$ erg/s

Exploring the nature of a non-axisymetric disk around HD142527

Clément Robert & H. Méheut F. Ménard S. Marret



From analytical models to synthetic imaging via:

* hydro simulations
* radiative transfer

UNIVERSITÉ CÔTE D'AZUR · Observatoire de la CÔTE d'AZUR · LAGRANGE · IPAG · ANR

DUST DYNAMICS ON ADAPTIVE-MESH-REFINEMENT GRIDS: APPLICATION TO PROTOSTELLAR COLLAPSE

UGO LEBREUILLY:
(UGO.LEBREUILLY@ENS-LYON.FR)

Goal: Simulation of star formation with multiple dust dynamics.

Method: Operator splitting scheme in RAMSES

Tests: Works (figures 1 and 2)

Protostellar collapse: Large grains (size>0.1mm) settle! (figure 3)

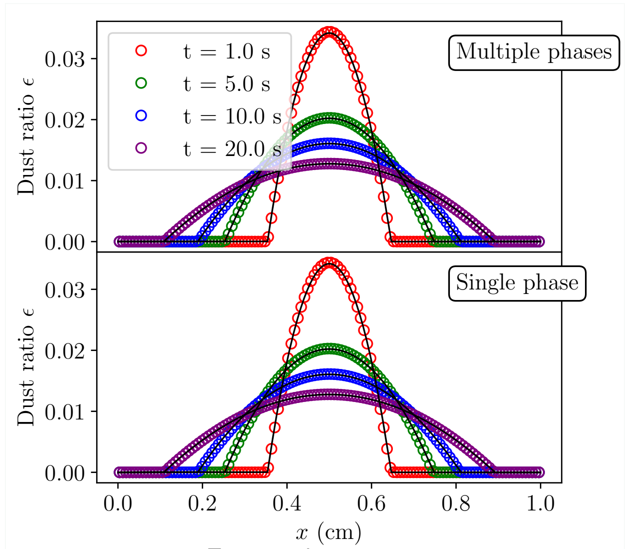


Figure 1

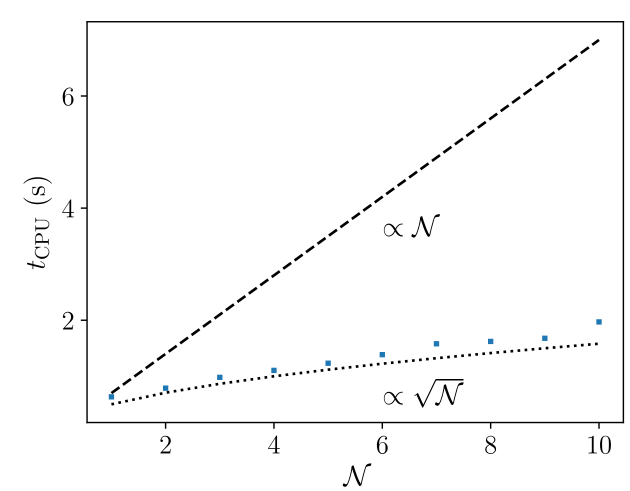


Figure 2

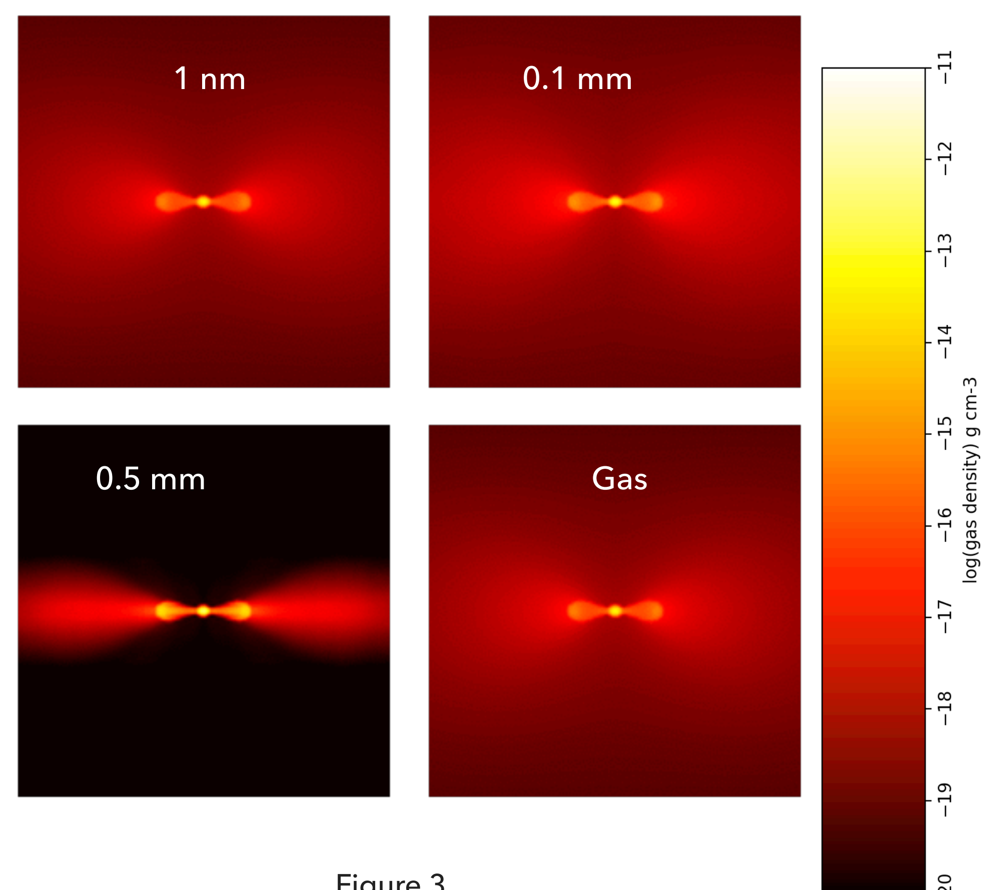
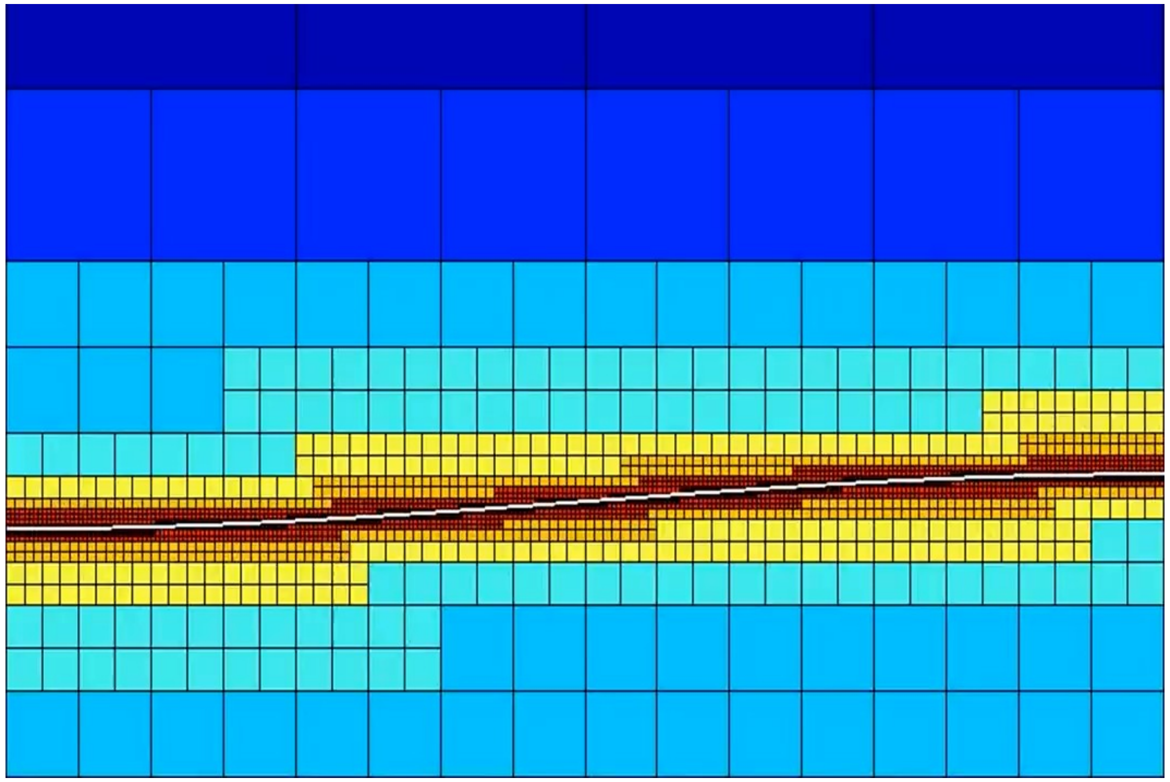


Figure 3

Monte Carlo tracers implemented for the AMR code RAMSES



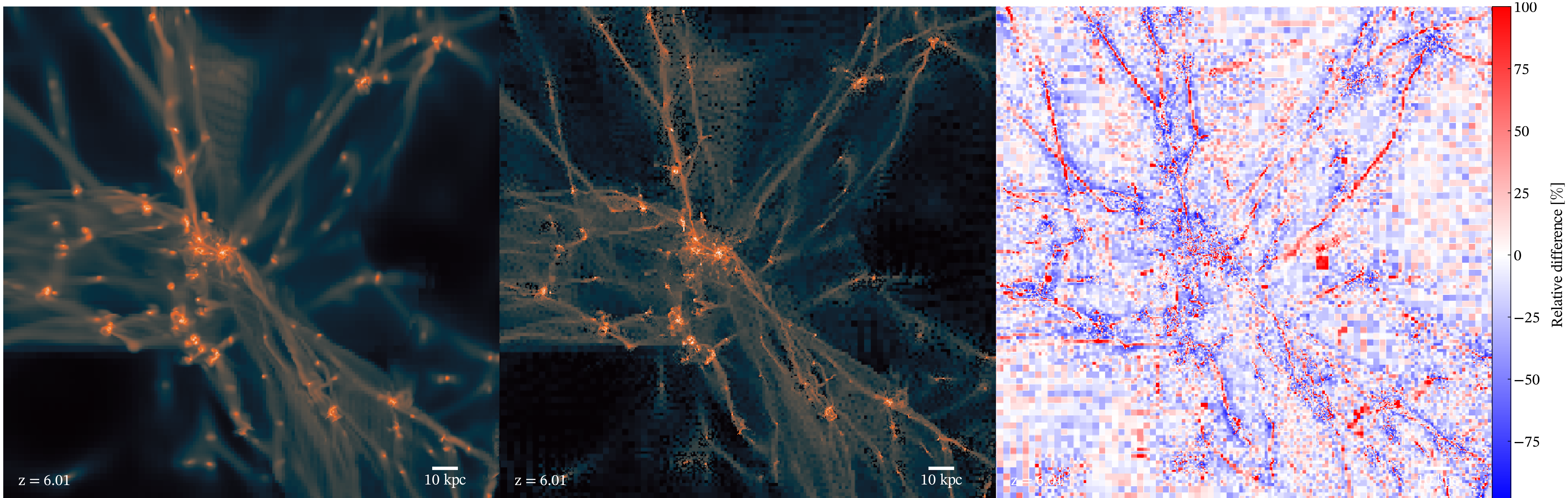
AMR on Rayleigh-Plateau instability

- Where does the gas come from?
- Where does it go?
- What it's thermodynamical evolution?

Need Lagrangian info

Using tracer particles

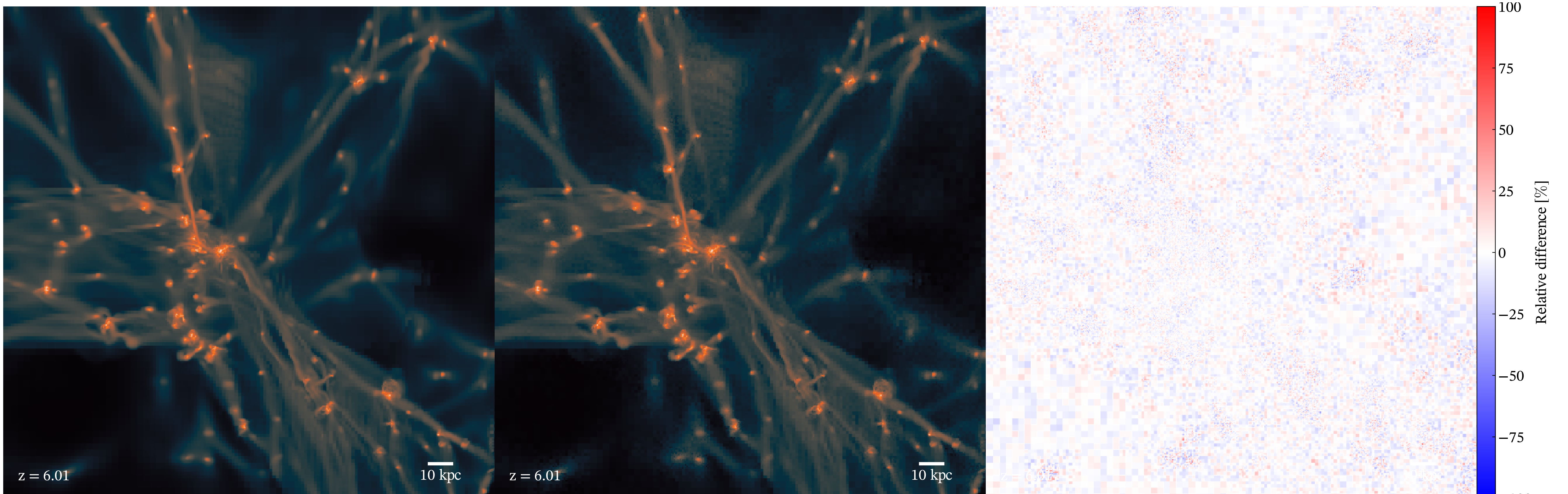
Idea 1: advect tracers with (interpolated gas velocity)



Problems: it only takes into account advection, not diffusion!
what about stars? SMBH? Dust formation?

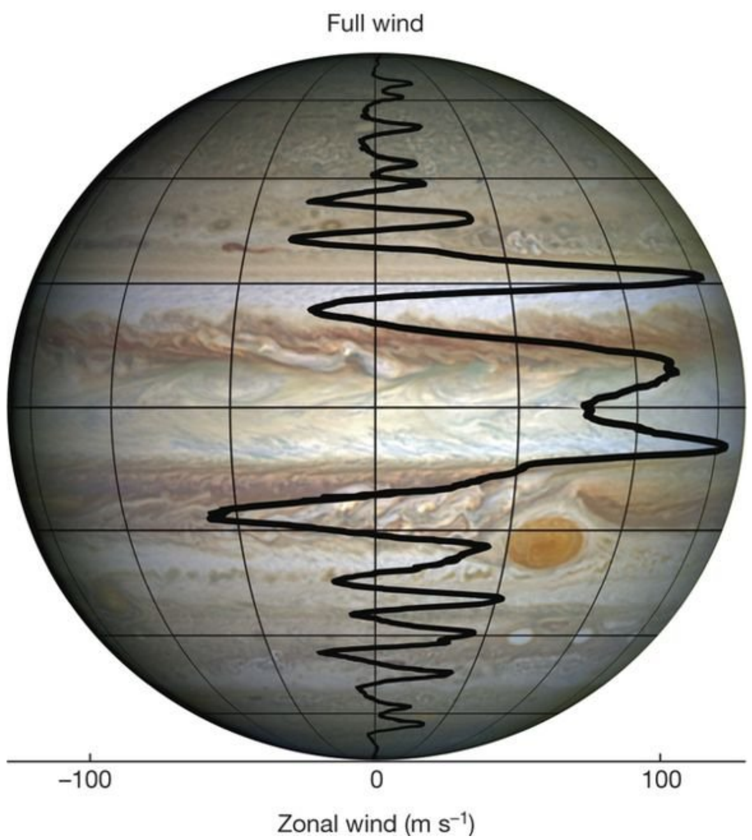
Using tracer particles

Idea 2: move as many particle as gas flux using stochastic approach

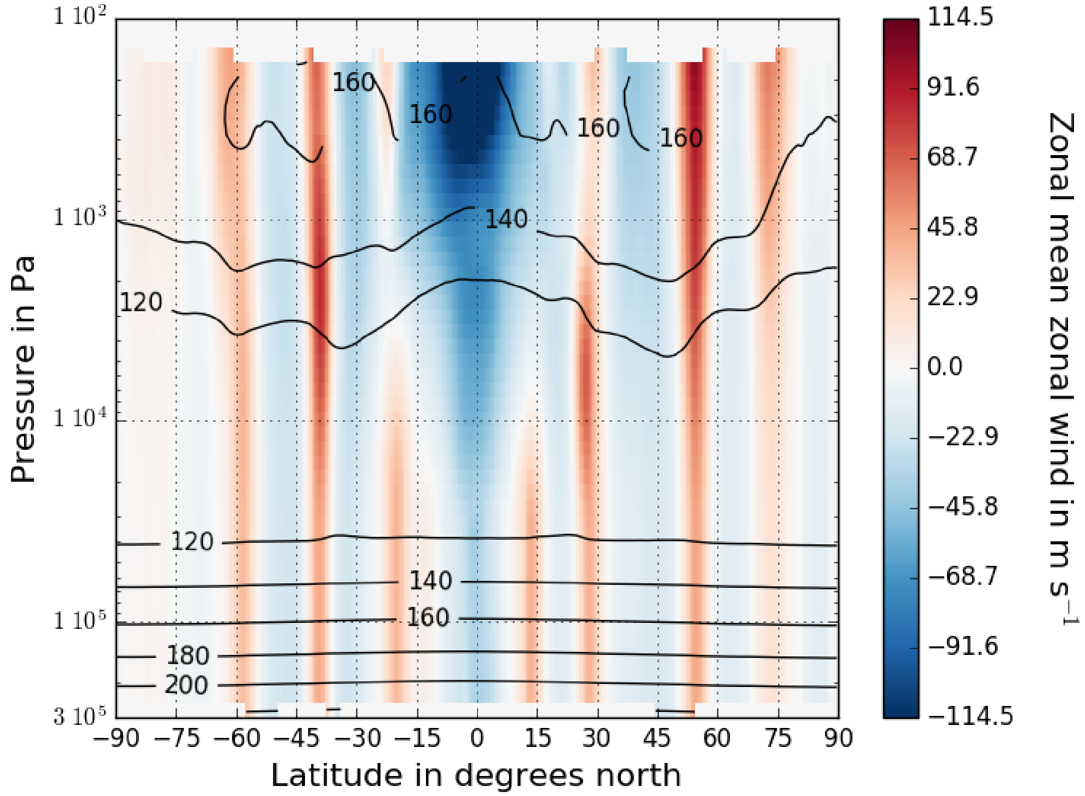


The new scheme reproduces well the gas distribution, can now be used for science cases!

Dynamics modelling in Jupiter's troposphere



Zonal wind measured by Juno
(*Kaspi, Galanti et al., Nature, 2018*)



Modelled zonal mean zonal wind

- About 20 jets
- Alternately eastward and westward
- Equatorial jet is superrotating
- Speeds between 10 and 150 m s^{-1}

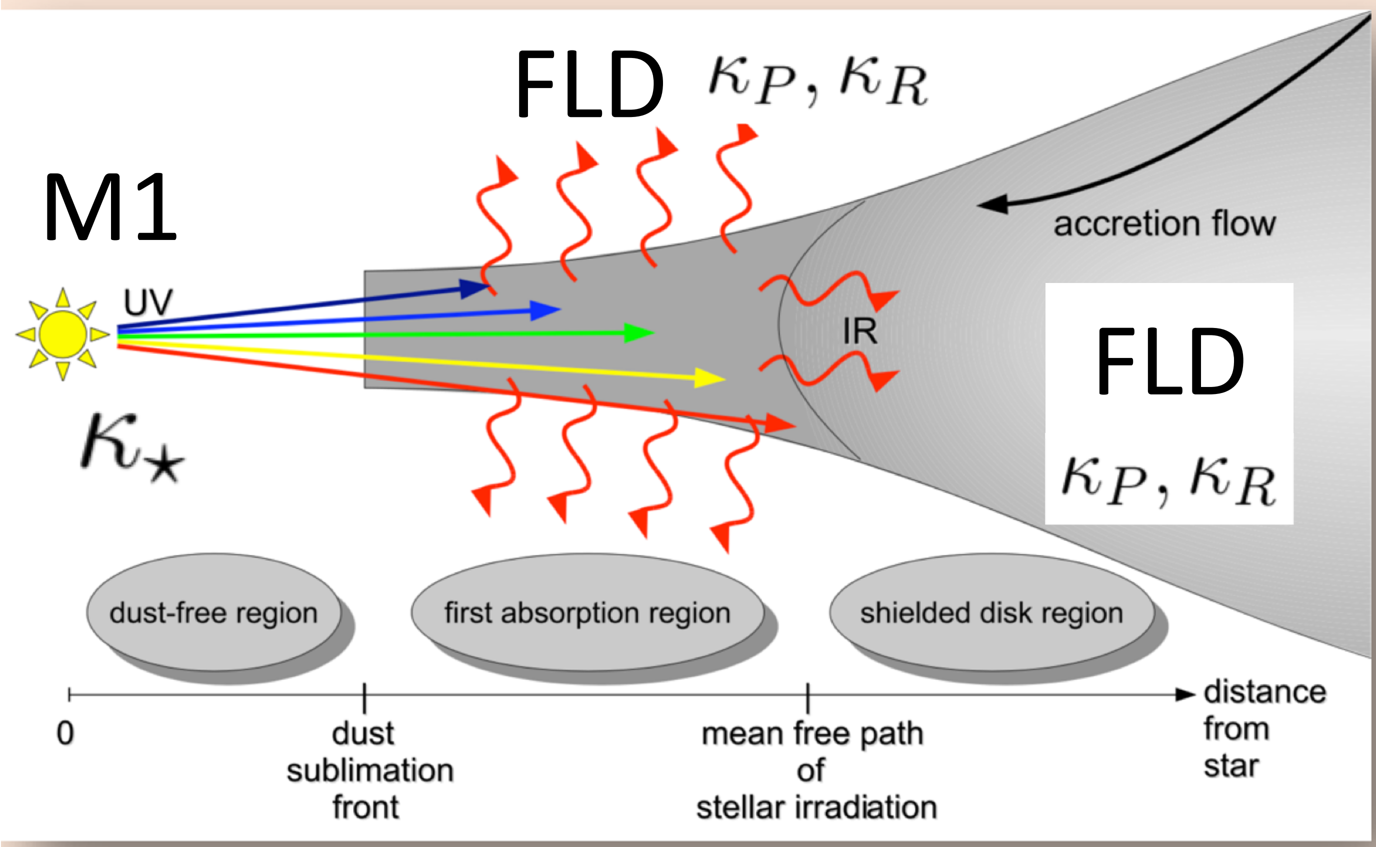
- About 13 Jets
- Alternately eastward and westward
- Equatorial jet is subrotating
- Speeds between 10 and 50 m s^{-1}

Hybrid Radiative Transfer Method for Prestellar Core Collapse

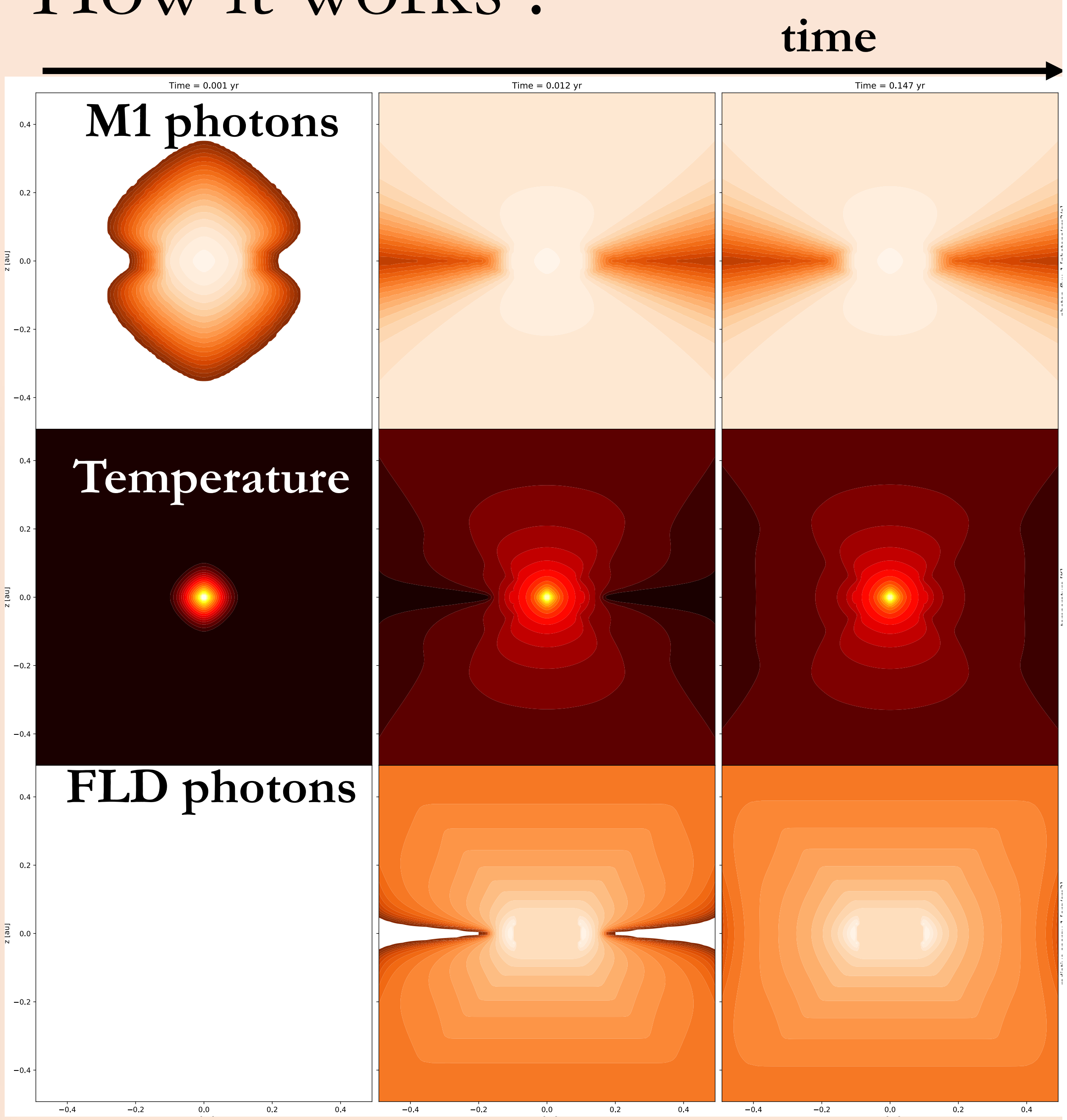
Raphaël Mignon-Risse, Matthias González, Benoît Commerçon, Joki Rosdahl
AIM (CEA Saclay), CRAL (Lyon)

This approach :

FLD (Commerçon+11, González+15)
M1 : RAMSES-RT (Rosdahl+13)



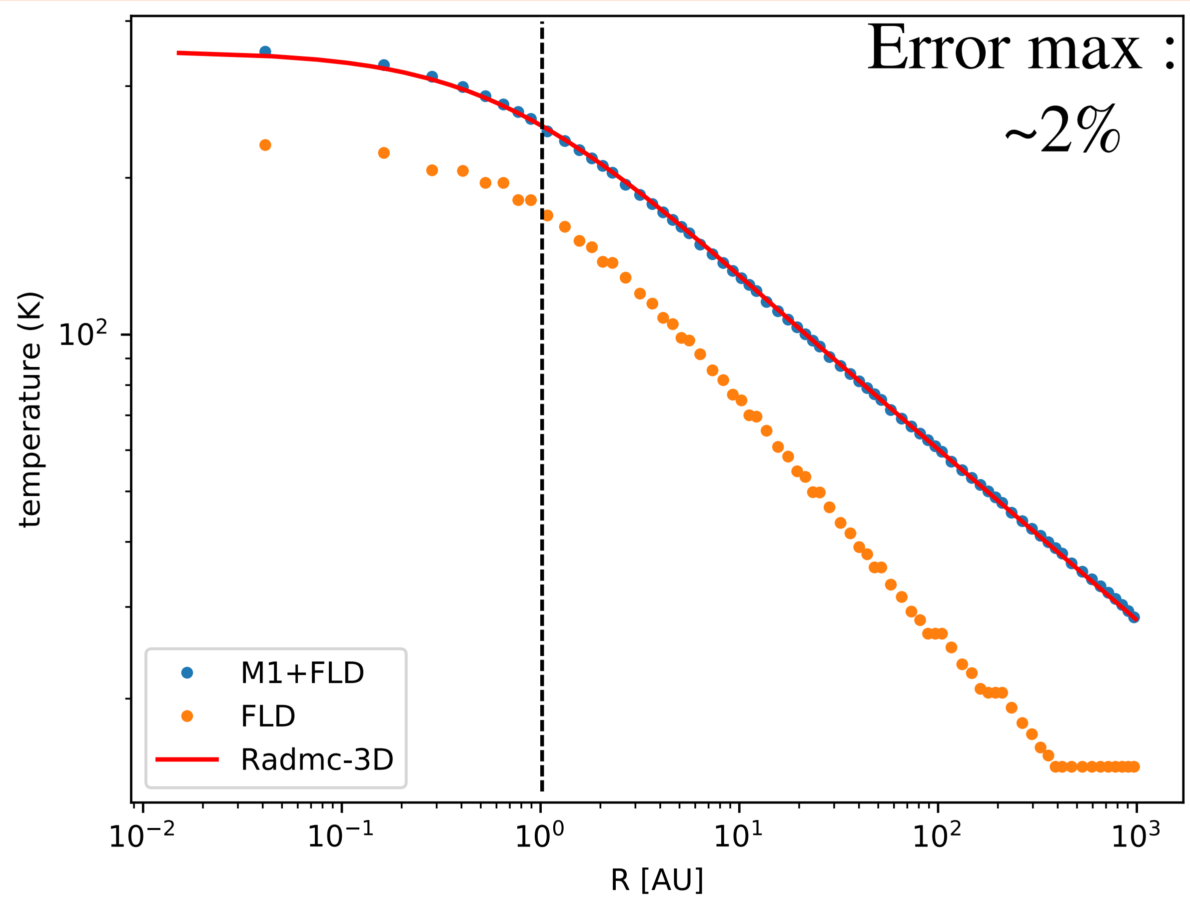
How it works :

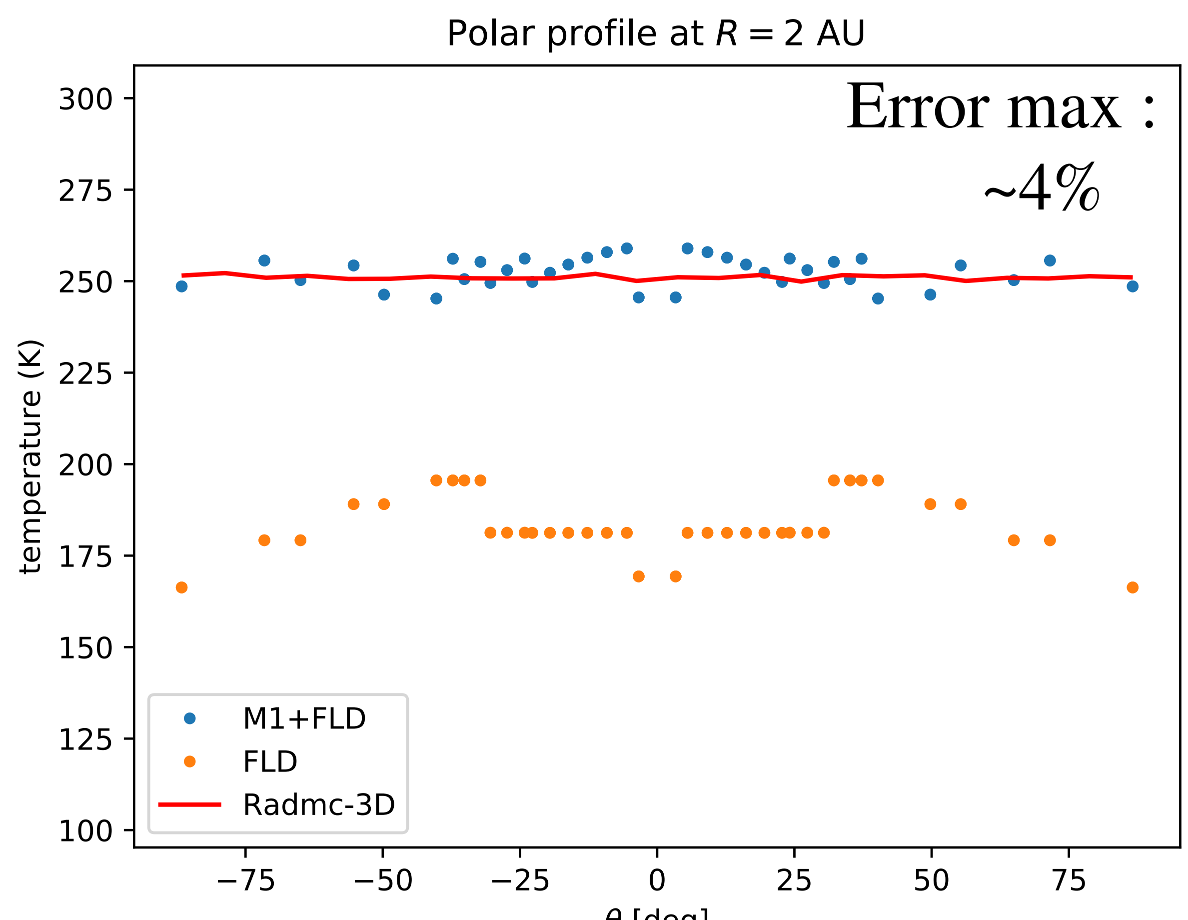


Disk seen edge-on

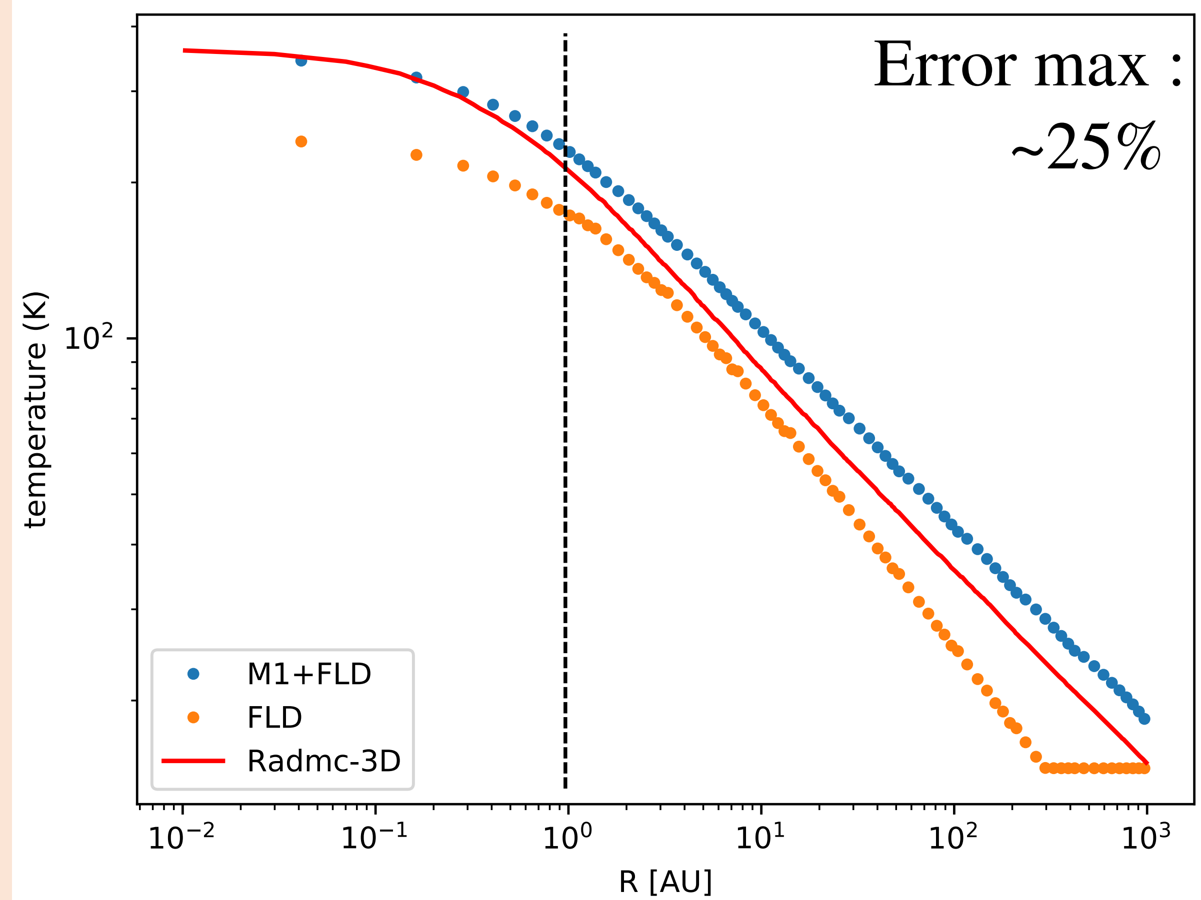
Results

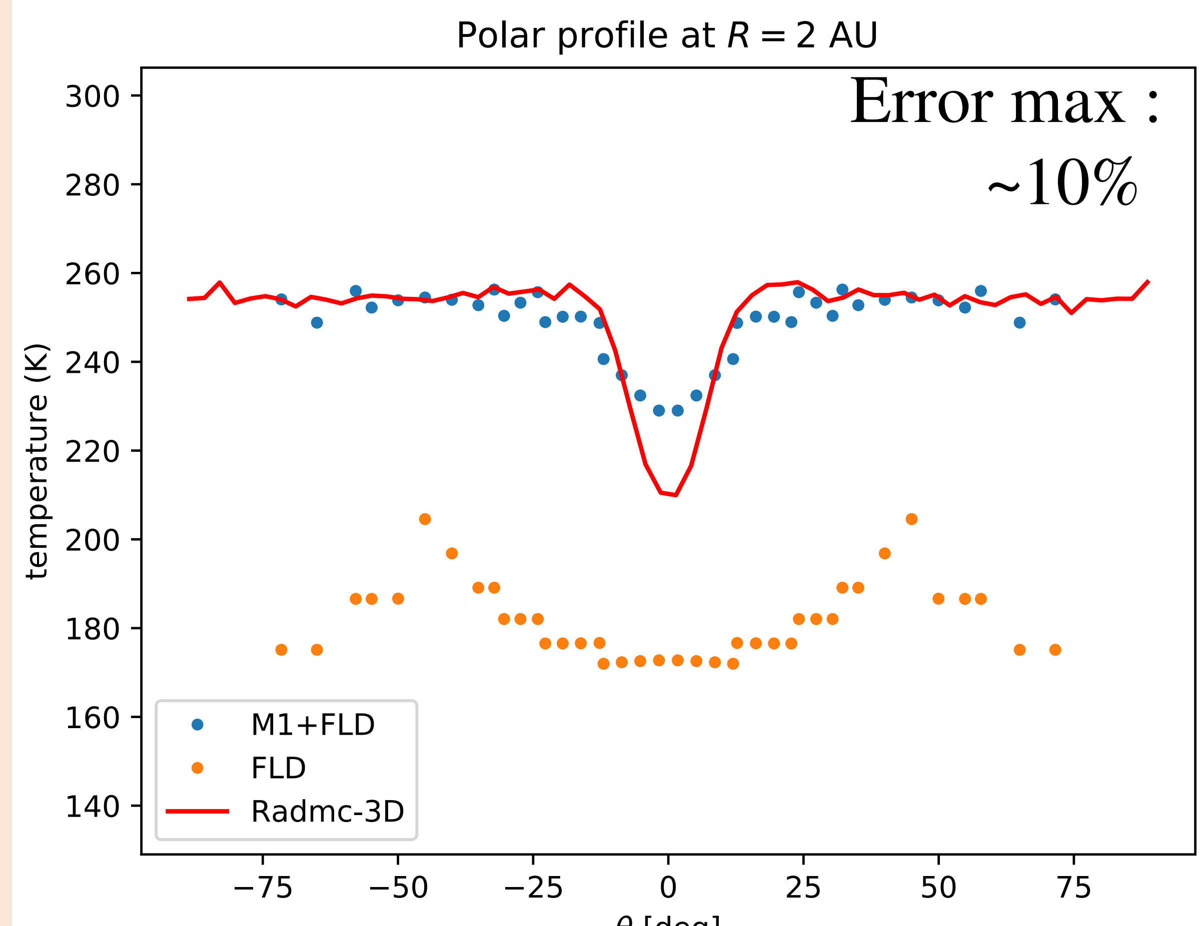
Optically-thin regime





Moderately optically-thick





Modélisation petite échelle de l'atmosphère de Vénus : Convection et ondes de gravité

Maxence Lefèvre, Sébastien Lebonnois and Aymeric Spiga

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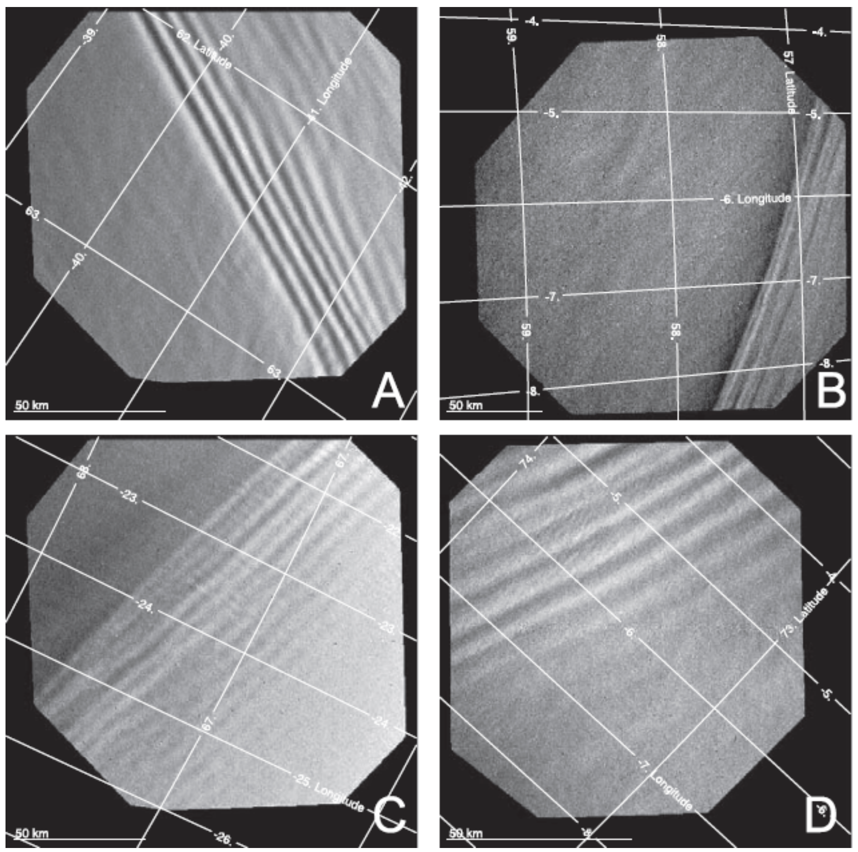
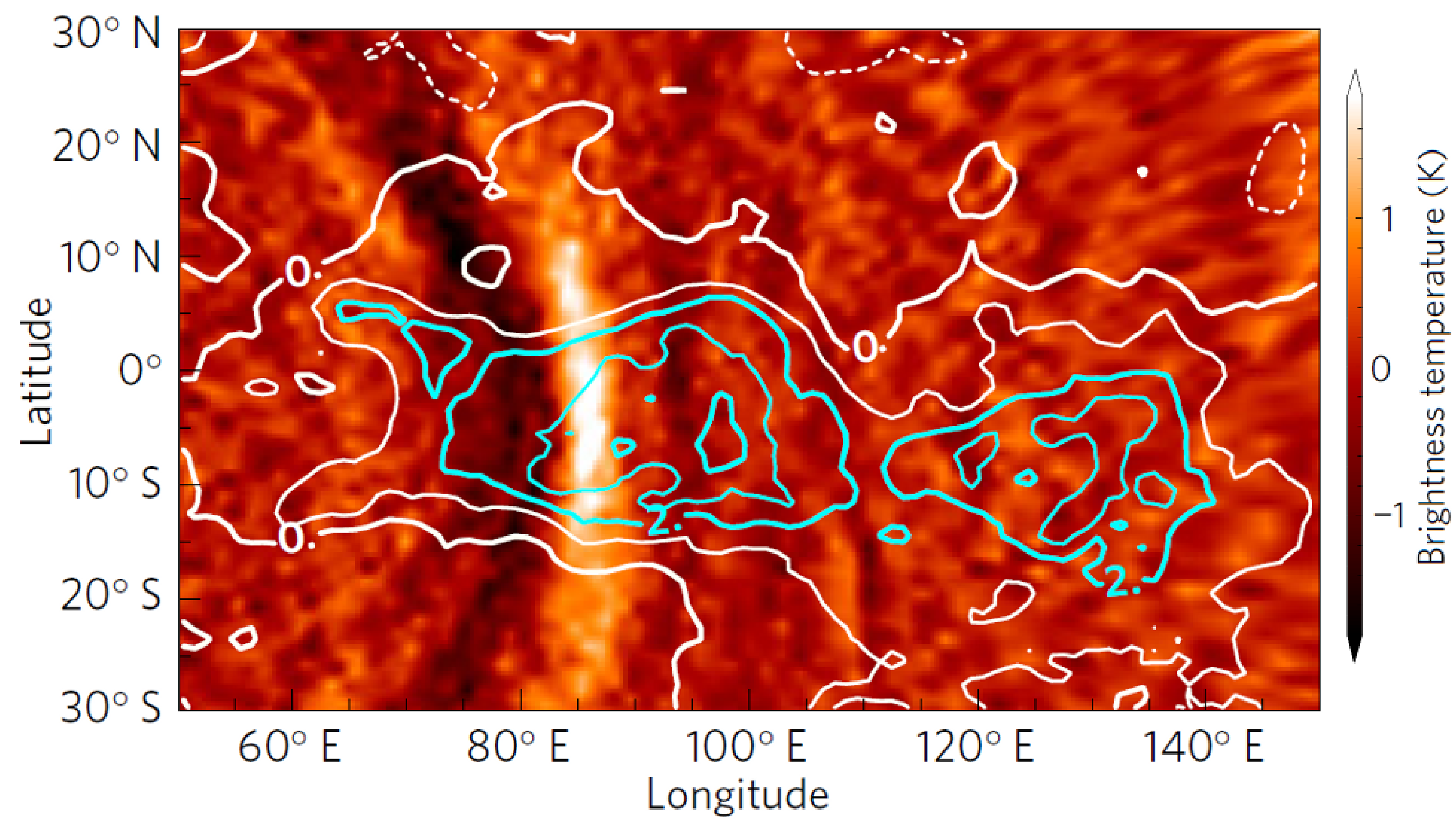
Laboratoire de Météorologie Dynamique, Paris, FRANCE

Astrostim 8-11 octobre 2018

Observations of waves at cloud top (70 km)





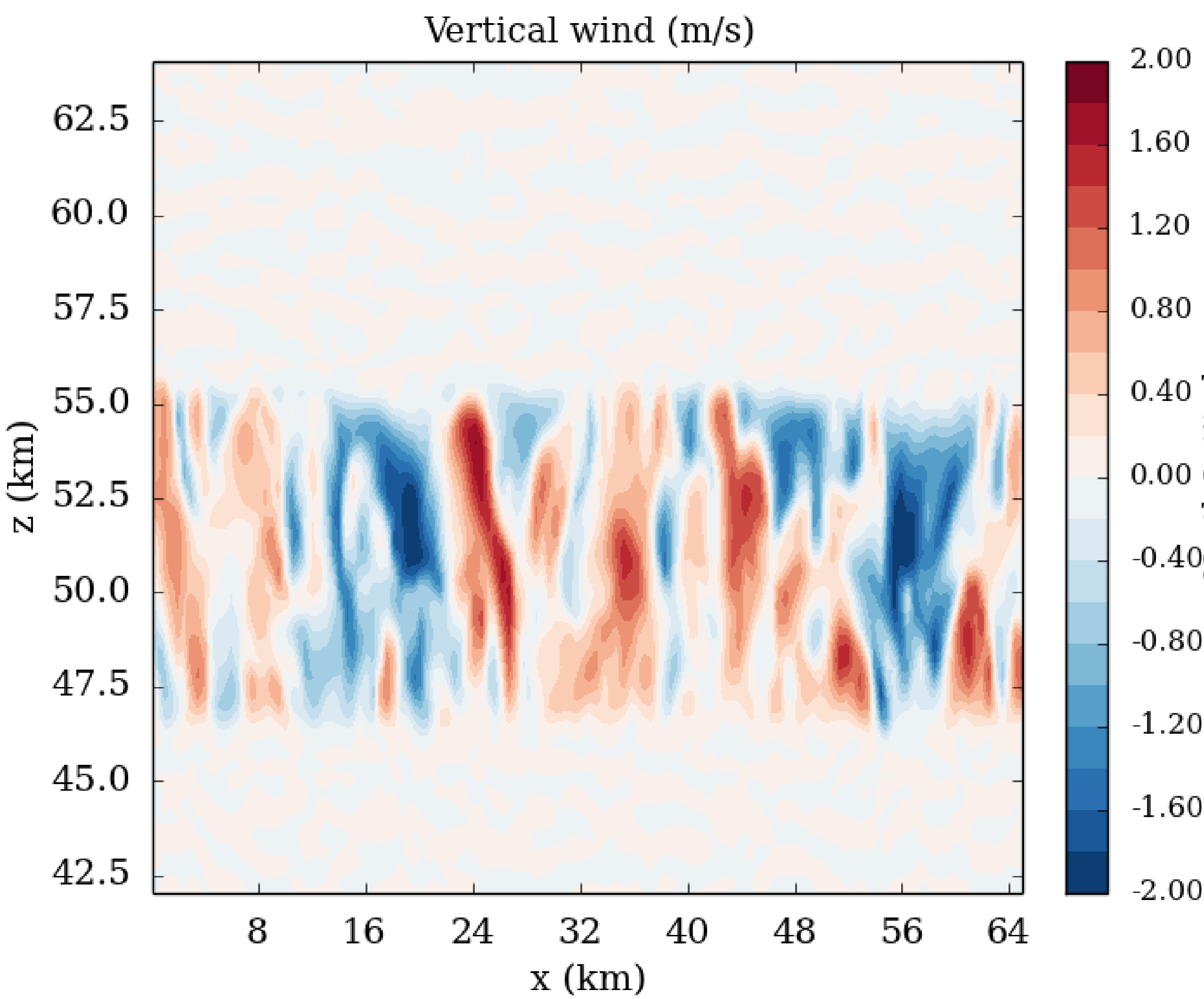
Picciali et al., 2014

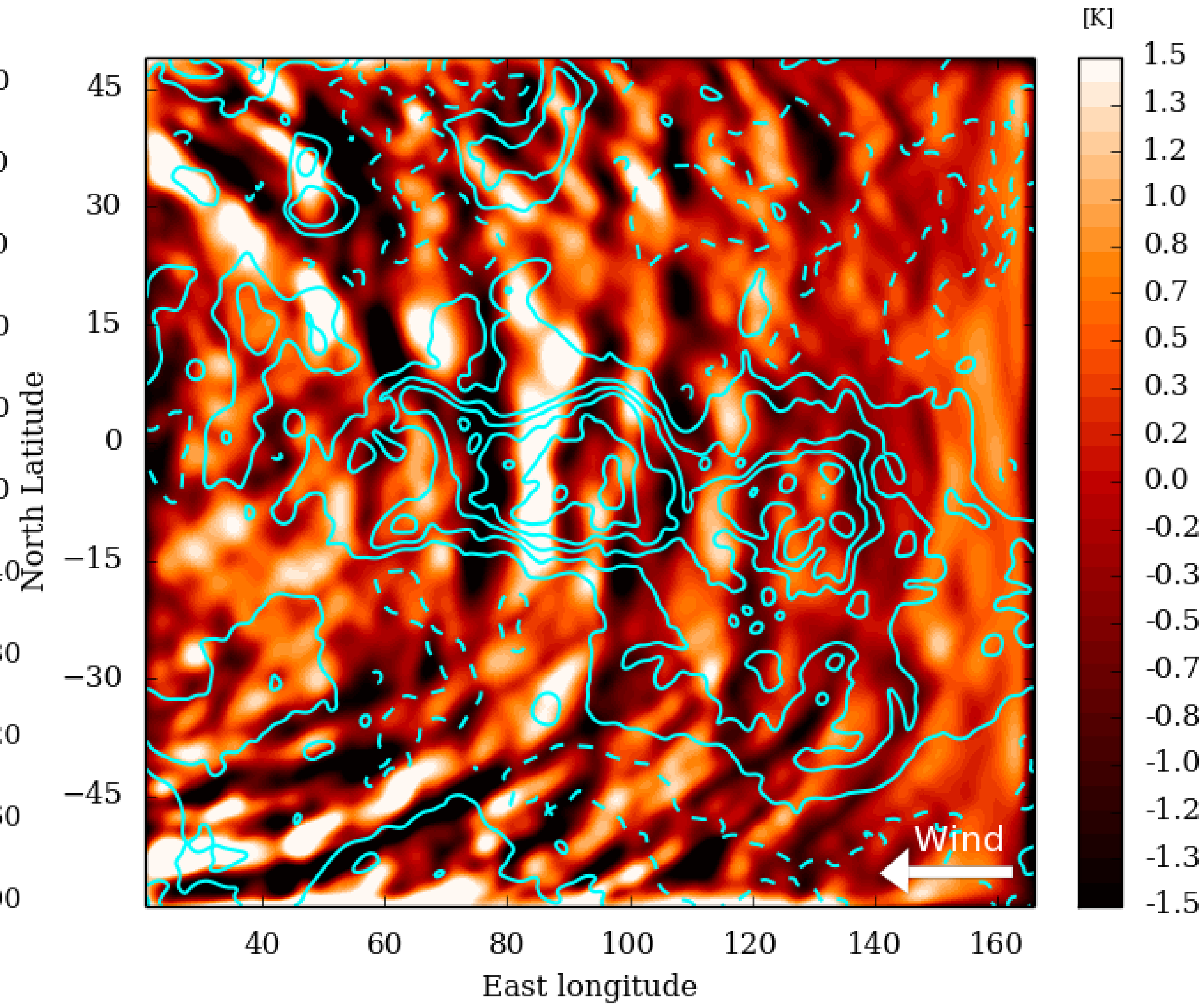
Fukuhara et al., 2017

Observations of convection and small scale and stationary bow-sape gravity waves

LMD Venus Mesoscale model

We use WRF dynamical core coupled to LMD Venus physics





Large-Eddy simulations

Mesoscale

A well-balanced scheme for compressible flows with gravity at all Mach number

Thomas Padioleau

Advisors: E. Audit, S. Kokh, P. Tremblin, P. Kestener

MAISON DE LA SIMULATION

Mon 8^{th} Oct, 2018

- Navier-Stokes system in conservative form:

$$\begin{aligned}
\partial_t \rho \quad &+ \nabla_{\mathbf{x}} \cdot (\rho \mathbf{u}) &&= 0 \\
\partial_t (\rho \mathbf{u}) &+ \nabla_{\mathbf{x}} \cdot (\rho \mathbf{u} \otimes \mathbf{u} - \boldsymbol{\sigma}_{\text{stress}}) &&= -\rho \nabla_{\mathbf{x}} \phi \\
\partial_t (\rho \mathcal{E}) &+ \nabla_{\mathbf{x}} \cdot (\rho \mathcal{E} \mathbf{u} - \boldsymbol{\sigma}_{\text{stress}} \cdot \mathbf{u} - \mathbf{q}_{\text{heat}}) &&= 0
\end{aligned}$$

$$\rho \mathcal{E} = \rho e + \frac{1}{2} \rho \mathbf{u}^2 + \rho \phi$$

- Numerical procedure:
  1. Acoustic - transport splitting to treat implicitly fast waves
  2. Pressure relaxation to solve a linear system instead of a non-linear system
  3. Flux correction in the low-Mach regime
  4. Well-balanced discretization of the gravity source term with conservative treatment of the energy equation
- Implemented in a parallel code using Kokkos (shared memory) and MPI (distributed memory).