



PDR Model Benchmark

M. Röllig
&

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M.J. Kaufman, J. Le Bourlot, F. Le Petit, R. Meijerink, O. Morata, V. Ossenkopf,
E. Roueff, G. Shaw, M. Spaans, A. Sternberg, J. Stutzki, W.-F. Thi,
E. F. van Dishoeck, P. A. M. van Hoof, S. Viti, M.G. Wolfire

PDR Model Benchmark





Lorentz Center

International Center for Workshops in the Sciences

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Benchmarking of PDR models

from 5 Apr 2004 through 8 Apr 2004

- **Description and aim** of the workshop
- **Registration** form for invited people and for those whose application has been approved
- **Participants**
- **Program**
- Scientific organizers:
Serena Viti (University College London, United Kingdom) 
Juergen Stutzki (Univ. Koeln, Germany) 
Ewine van Dishoeck (Univ. Leiden, Netherlands) 
- Workshop Coordinator: **Gerda Filippo**, Tel:  +31 71 5275401

Organizational Log-in (restricted)

2004

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A PDR-Code Comparison Study

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Preprint online version: February 13, 2007

Participating Models

<i>Model Name</i>	<i>Authors</i>
Aikawa	<i>H.-H. Lee, E. Herbst, G. Pineau des Forets, J. Le Bourlot, Y. Aikawa, N. Kuboi</i>
Bensch	<i>H. Störzer, B. Köster, M. Zilinsky, U. Leuenhagen, S. Jeyakumar, F. Bensch</i>
CLOUDY	<i>Gary J. Ferland, Peter van Hoof, Nick P. Abel, Gargi Shaw</i>
COSTAR	<i>I. Kamp, F. Bertoldi, G.-J. van Zadelhoff</i>
HTBKW	<i>D. Hollenbach, A.G.G.M. Tielens, M.G. Burton, M.J. Kaufman, M.G. Wolfire</i>
KOSMA	<i>H. Störzer, B. Köster, M. Zilinsky, U. Leuenhagen, S. Jeyakumar, M. Röllig</i>
Lee96mod	<i>H.-H. Lee, E. Herbst, G. Pineau des Forets, E. Roueff, J. Le Bourlot, O. Morata</i>
Leiden	<i>J. Black, E. van Dishoeck, D. Jansen and B. Jonkheid</i>
Meijerink	<i>R. Meijerink, M. Spaans</i>
Meudon	<i>J. Le Bourlot, E. Roueff, F. Le Petit</i>
Sternberg	<i>A. Sternberg, A. Dalgarno</i>
UCL_PDR	<i>S. Viti, Wing-Fai Thi, Tom Bell</i>

Benchmark Calculations

- standard chemistry:

- 31 species

H, H⁺, H₂, H₂⁺, H₃⁺, O, O⁺, OH⁺, OH, O₂, O₂⁺, H₂O, H₂O⁺, H₃O⁺, C, C⁺, CH, CH⁺, CH₂, CH₂⁺, CH₃, CH₃⁺, CH₄, CH₄⁺, CH₅⁺, CO, CO⁺, HCO⁺, He, He⁺, e⁻

- UMIST06 database

- elemental abundances:

He=0.1, C=1.0x10⁻⁴, O=3.0x10⁻⁴

- PAH's switched off

- standard radiation field

- normalized to Draine field (1978)

- cosmic-ray ionization:

$\zeta=5 \times 10^{-17} \text{ s}^{-1}$

- visual extinction:

$A_V=6.289 \times 10^{-22} \times N_{\text{Htotal}}$

- dust attenuation:

$\tau_{\text{UV}}=3.02 \times A_V$

Benchmark Calculations

Requested output

For the species: H, H₂, C⁺, C, CO, O, O₂, CH, OH, e⁻

1. local absolute volume densities (cm⁻³) vs. depth
2. column densities (cm⁻²) vs. depth
3. dissociation/ionization rates (s⁻¹) vs. depth for H₂, C, CO
4. local cooling/heating rates (erg s⁻¹ cm⁻³)
fine structure lines of CII(158m), OI(63μ, 146μ), and CI(610μ, 370μ), and
photoelectric grain heating
5. gas and dust temperature for models F5-F8

Benchmark Calculations

F1 completed by all 12 groups

F2-F4 complete by 10 groups

F5-F8 completed by 8 groups (some with numerical 'noise')

CLOUDY used different chemical network

KOSMA/Bensch used spherical geometry

results for Lee96mod are for $t=10^8$ yrs

F1 T=const $n=10^3 \text{ cm}^{-3}, \chi=10$	F2 T=const $n=10^3 \text{ cm}^{-3}, \chi=10^5$
F3 T=const $n=10^{5.5} \text{ cm}^{-3}, \chi=10$	F4 T=const $n=10^{5.5} \text{ cm}^{-3}, \chi=10^5$
F5 T=variable $n=10^3 \text{ cm}^{-3}, \chi=10$	F6 T=variable $n=10^3 \text{ cm}^{-3}, \chi=10^5$
F7 T=variable $n=10^{5.5} \text{ cm}^{-3}, \chi=10$	F8 T=variable $n=10^{5.5} \text{ cm}^{-3}, \chi=10^5$

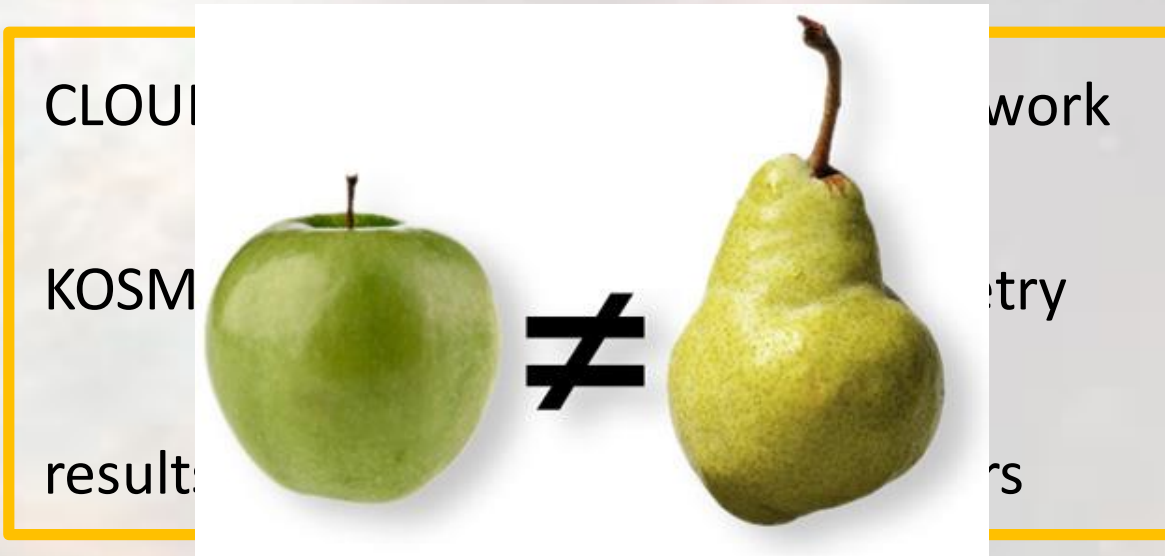
Benchmark Calculations

F1 completed by all 12 groups

F2-F4 complete by 10 groups

F5-F8 completed by 8 groups (some with numerical 'noise')

F1 T=const $n=10^3 \text{ cm}^{-3}, \chi=10$	F2 T=const $n=10^3 \text{ cm}^{-3}, \chi=10^5$
F3 T=const $n=10^{5.5} \text{ cm}^{-3}, \chi=10$	F4 T=const $n=10^{5.5} \text{ cm}^{-3}, \chi=10^5$
F5 T=variable $n=10^3 \text{ cm}^{-3}, \chi=10$	F6 T=variable $n=10^3 \text{ cm}^{-3}, \chi=10^5$
F7 T=variable $n=10^{5.5} \text{ cm}^{-3}, \chi=10$	F8 T=variable $n=10^{5.5} \text{ cm}^{-3}, \chi=10^5$



Benchmark Calculations

F1 completed by all 12 groups

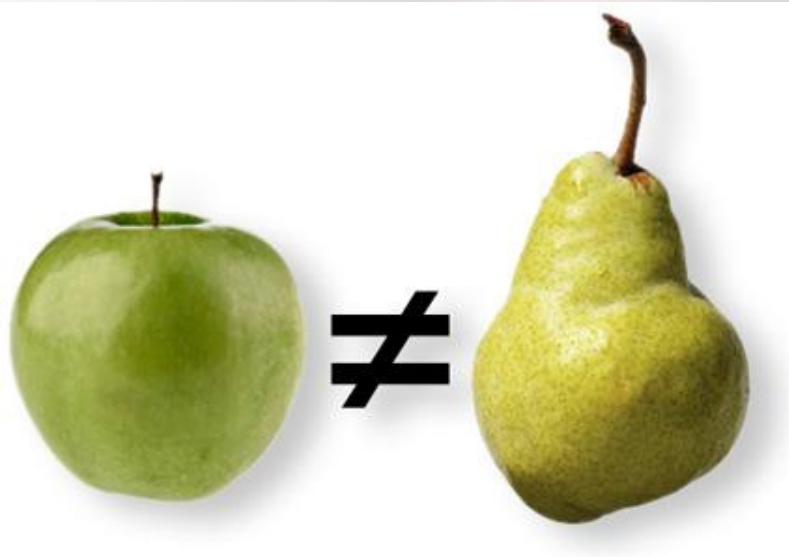
F2-F4 complete by 10 groups

F5-F8 completed by 8 groups (some with numerical 'noise')

CLOU

KOSM

result



work

etry

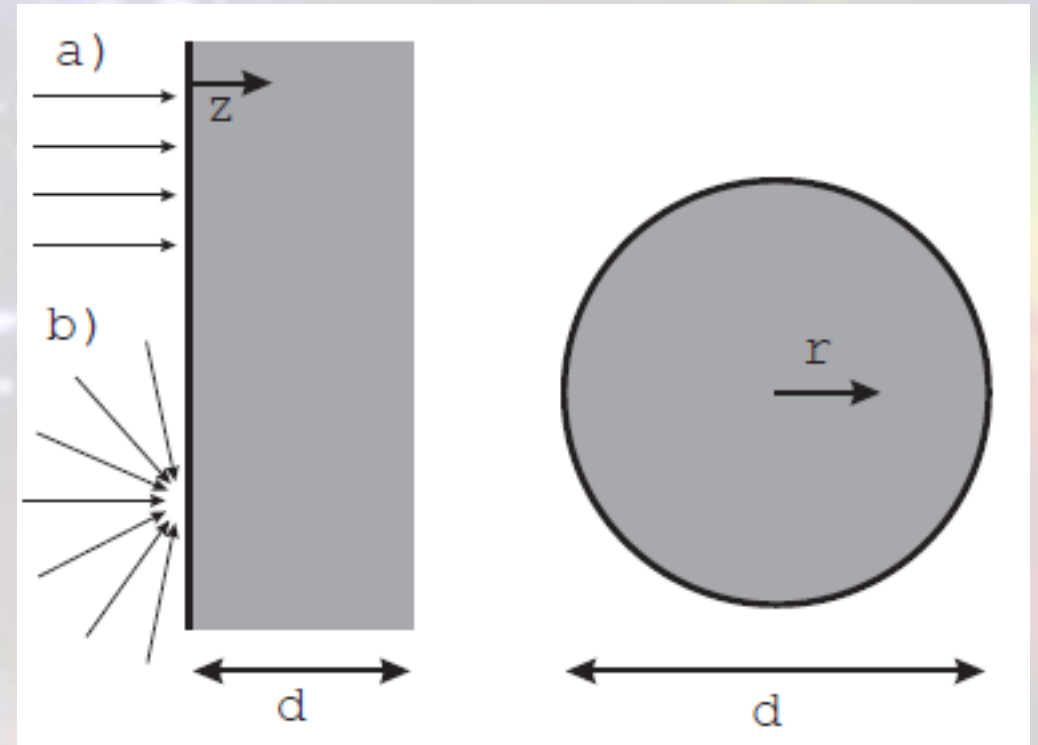
rs



Comparable?

H_0 : PDR models are all alike?

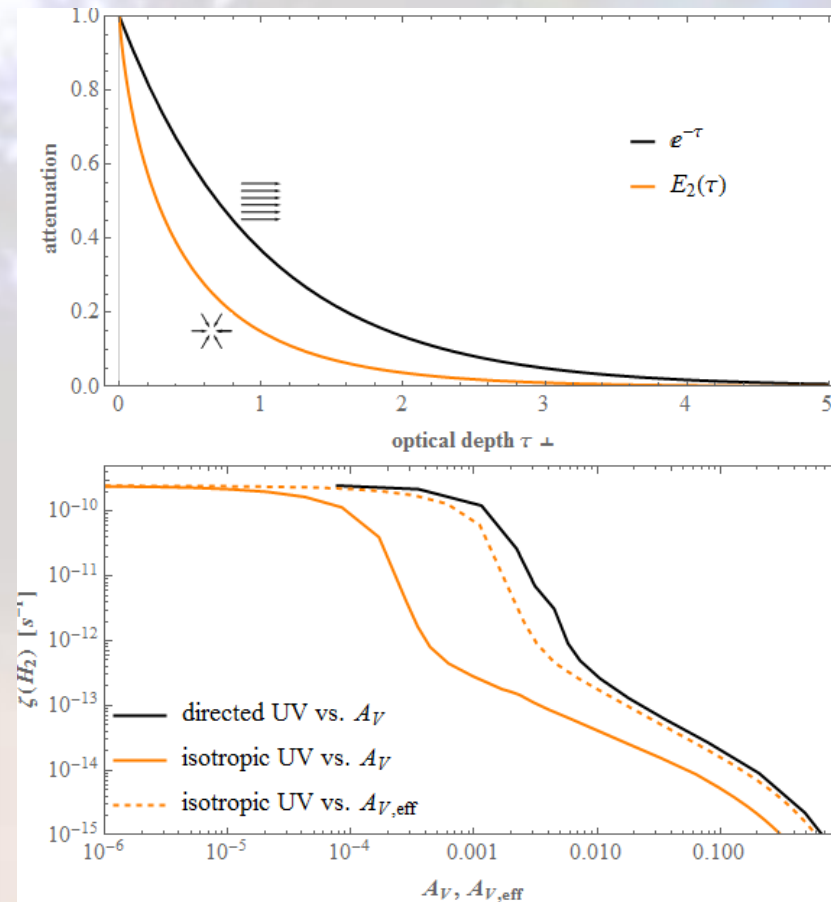
- Different model geometry complicates things
- When is a spherical cloud comparable to a plane-parallel slab? (semi-infinite, illuminated from both sides,...)



Comparable?

~~H₀~~: PDR models are all alike?

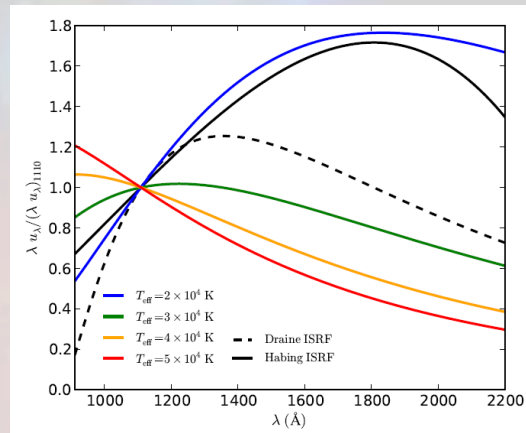
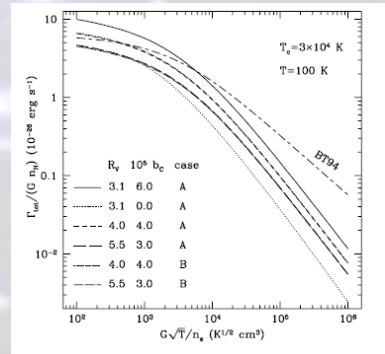
- Different model geometry complicates things
- When is a spherical cloud comparable to a plane-parallel slab? (semi-infinite, illuminated from both sides,...)
- Basic concepts such as A_V and column density change meaning in isotropically illuminated clouds



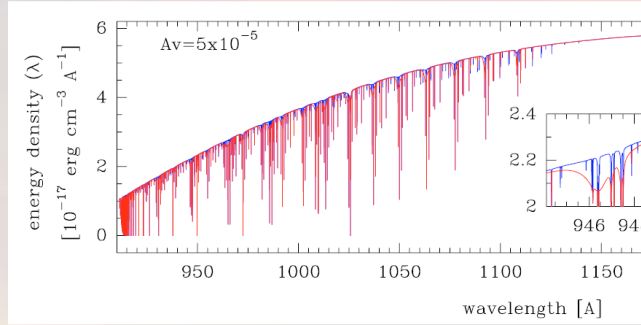
Comparable?

- FUV \neq FUV
- Hardwired parts of the models can not simply be replaced \rightarrow ~~Self-consistency~~
- Time-dependence/steady-state
- Dust treatment
- Approximations vs. detailed treatment
- Radiative transfer, scattering, shielding
- H₂ physics/chemistry (H₂^{*}, formation)
- Rate coefficients
- Heating/cooling

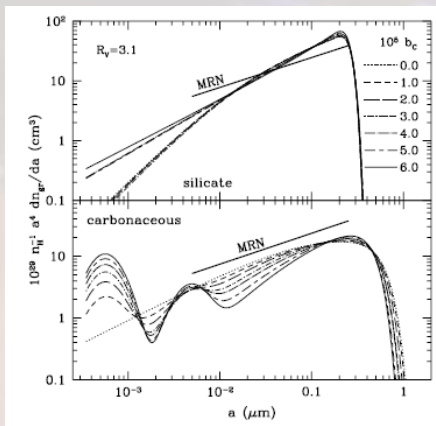
Weingartner & Draine 2001, ApJSS 134



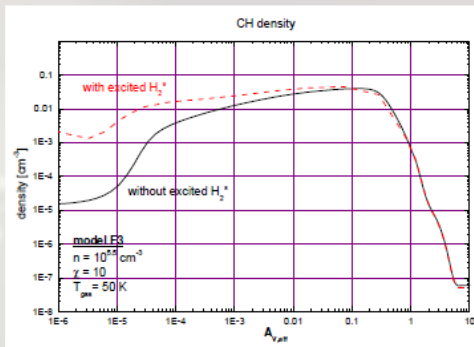
Baczynski et al. 2015



Goicoechea et al. 2007



Weingartner & Draine 2001, ApJ 548



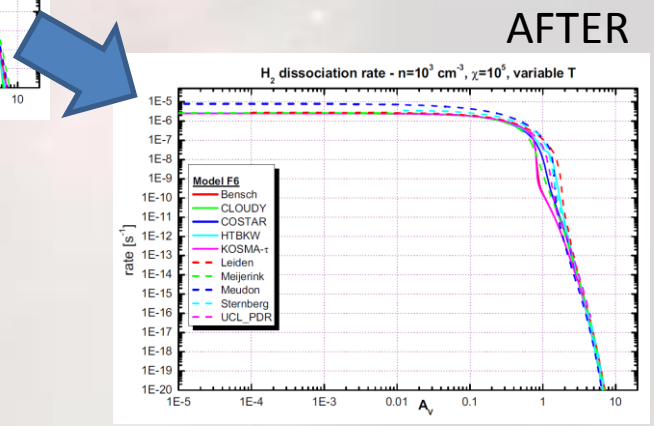
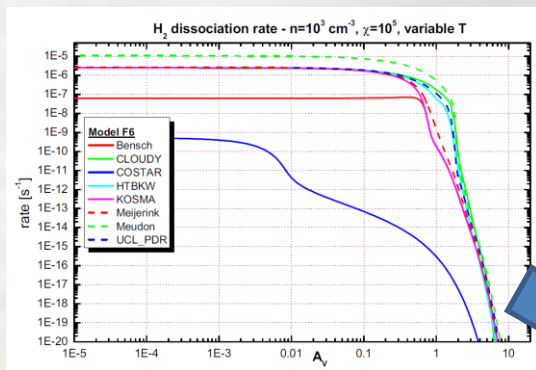
Röllig et al. 2007

Comparable

- **Crippling:** all codes had to limit their capabilities in various areas to allow comparison
- **Playground problems:** Simple & reduced problem setup to minimize impact of hidden factors
- Analysis focused mainly on **chemistry** and **shielding** in the isothermal model setups.

Benchmark Data Archive

- All the results (data files, plots, documents) have been published on a website.



PDR-Comparison Benchmark

Introduction

Codes

Benchmark

Results

PRE-Benchmark

POST-Data

POST-Plots

Documents

Links

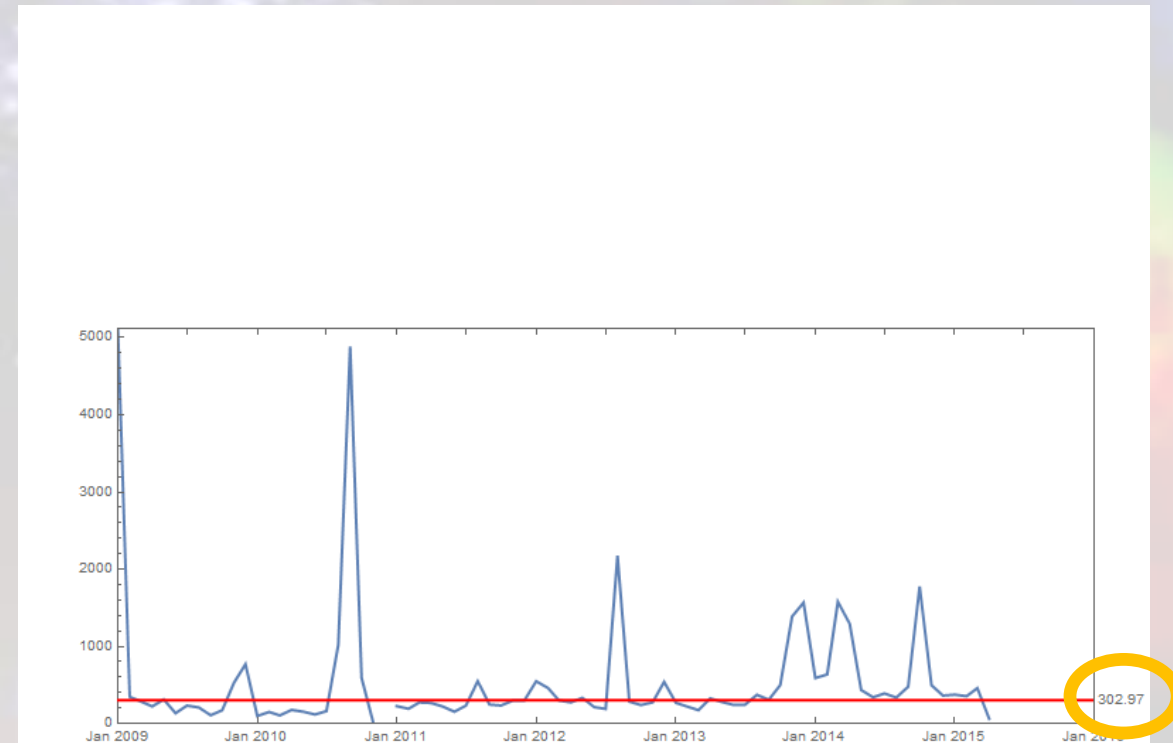
Data Files

	F1	F2	F3	F4	V1	V2	V3	V4
<u>Bensch</u>	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T
<u>Cloudy</u>	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T
<u>COSTAR</u>	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T
<u>HTBKW</u>	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T
<u>KOSMA-tau</u>	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T
<u>Leiden</u>	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T
<u>Lee96mod</u>	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T
<u>Meijerink</u>	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T	N, n, photo h/c, TB, T

<http://www.astro.uni-koeln.de/pdr-comparison/>

Benchmark Data Archive

- All the results (data files, plots, documents) have been published on a website.
- Surprising archive traffic (2009-15)



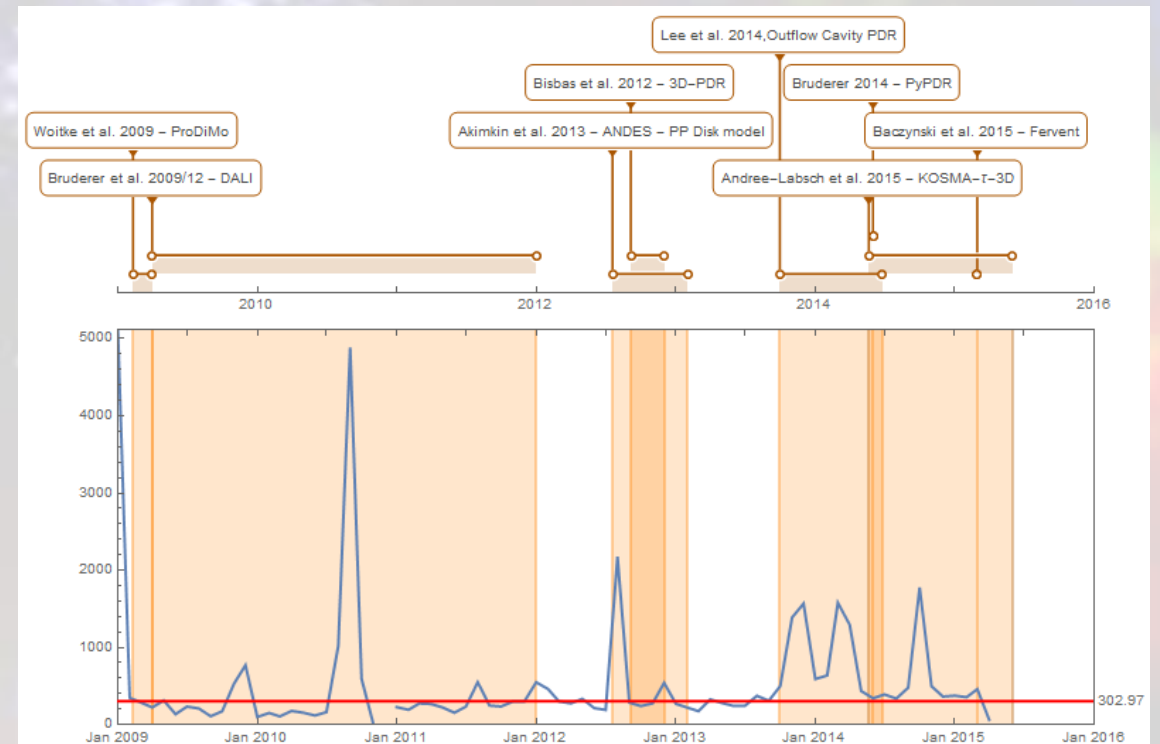
300/month

<http://www.astro.uni-koeln.de/pdr-comparison/>

Benchmark Data Archive

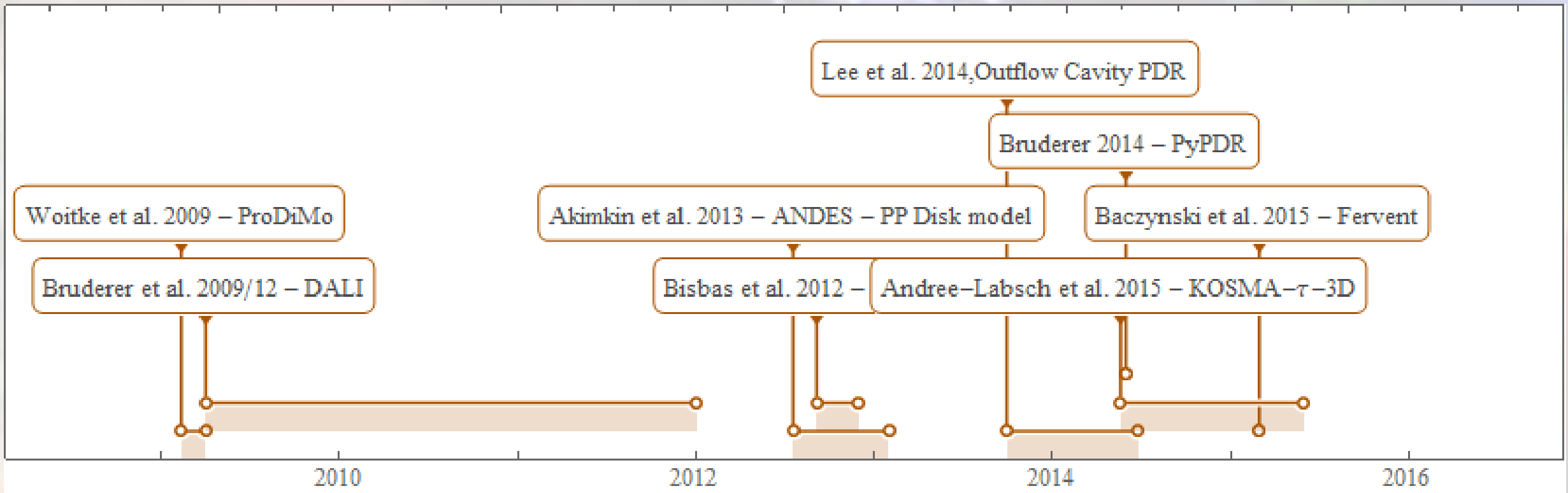
- All the results (data files, plots, documents) have been published on a website.
- Surprising archive traffic (2009-15)
- Modelers use the benchmark data to benchmark their new models against.

Mission accomplished!



<http://www.astro.uni-koeln.de/pdr-comparison/>

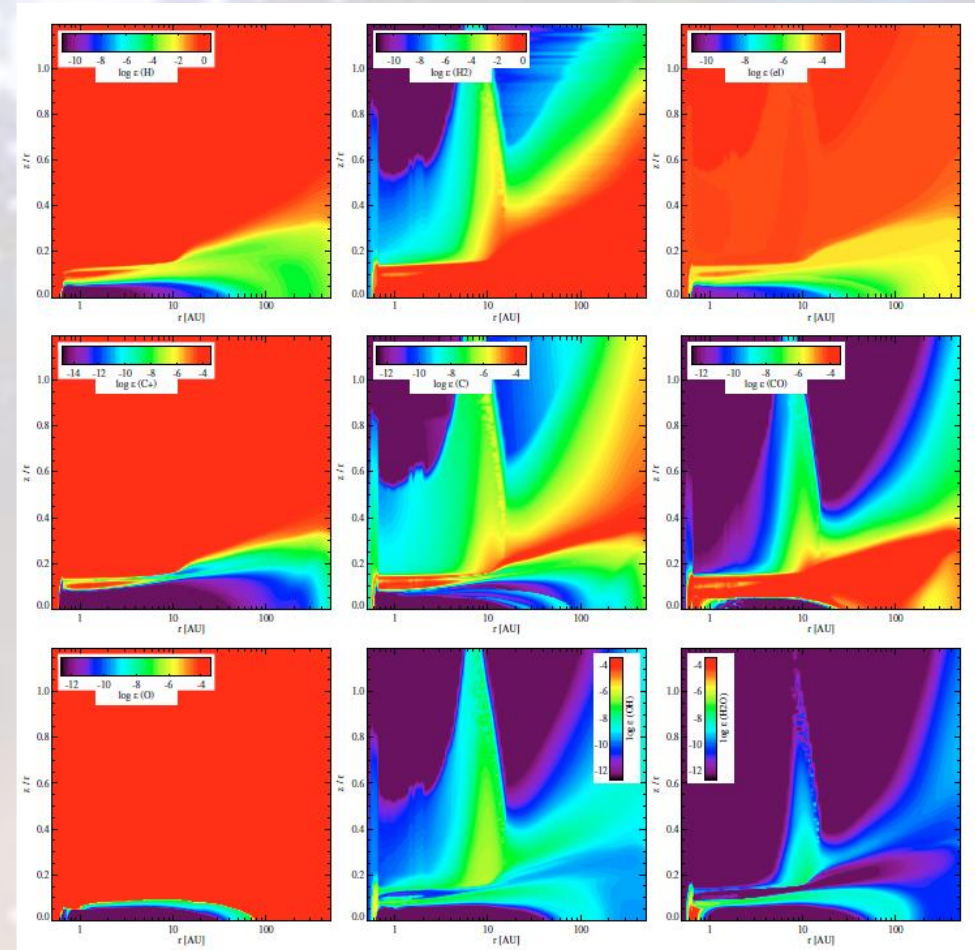
New kids on the block



Protoplanetary Disk Model

Woitke, Kamp & Thi, A&A 501, 383–406 (2009)

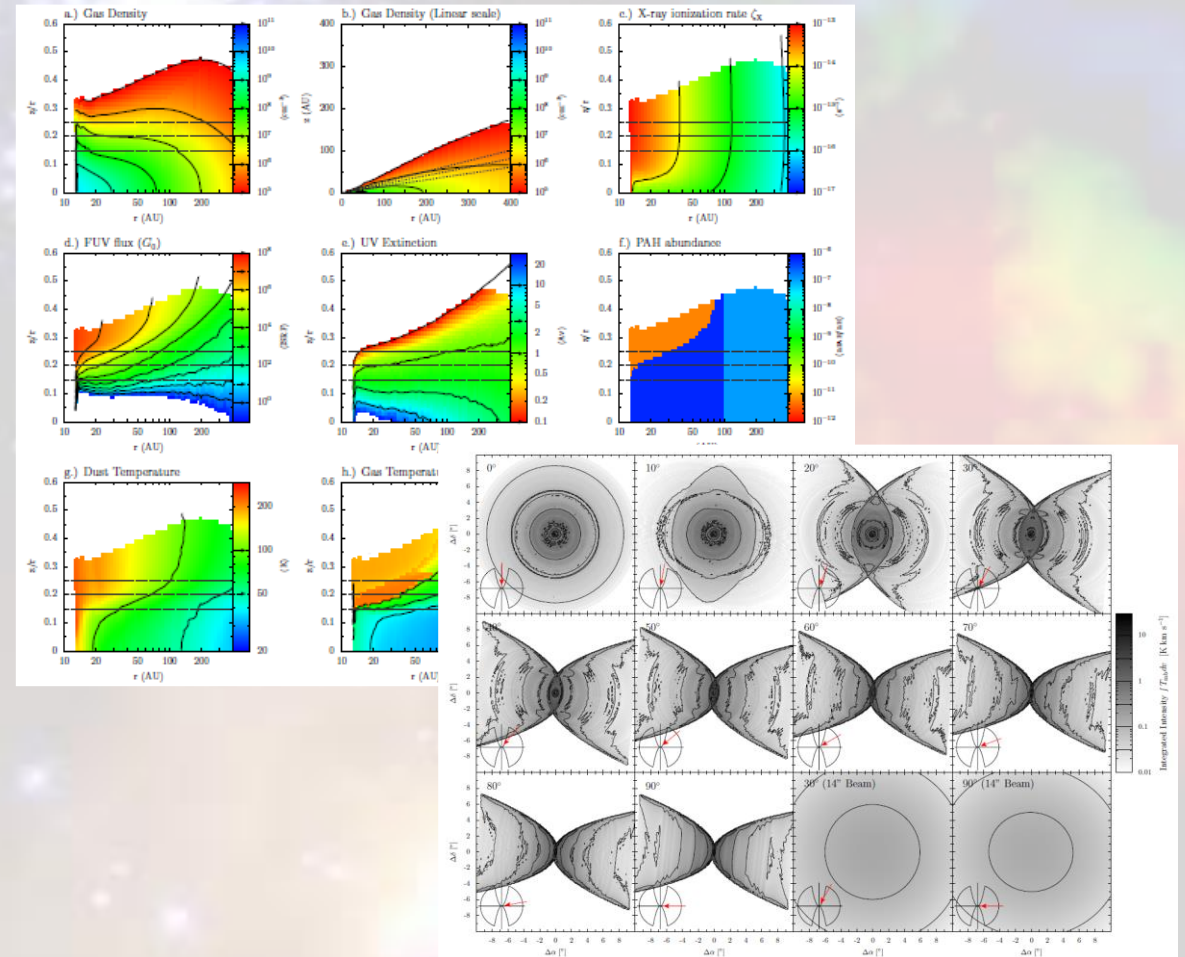
- Based on COSTAR (Kamp, Bertoldi, van Zadelhoff)
- 1+1 D model: physical, thermal and chemical structure of protoplanetary disks.
- 2D dust continuum radiative transfer,
- Gas-phase and photo-chemistry, ice formation/evaporation
- X-ray-driven chemistry and heating via H_2 ionization
- hydrostatic disk structure in axial symmetry



DALI

Bruderer, van Dishoeck, Doty, Herczeg, A&A 541, A91 (2012)

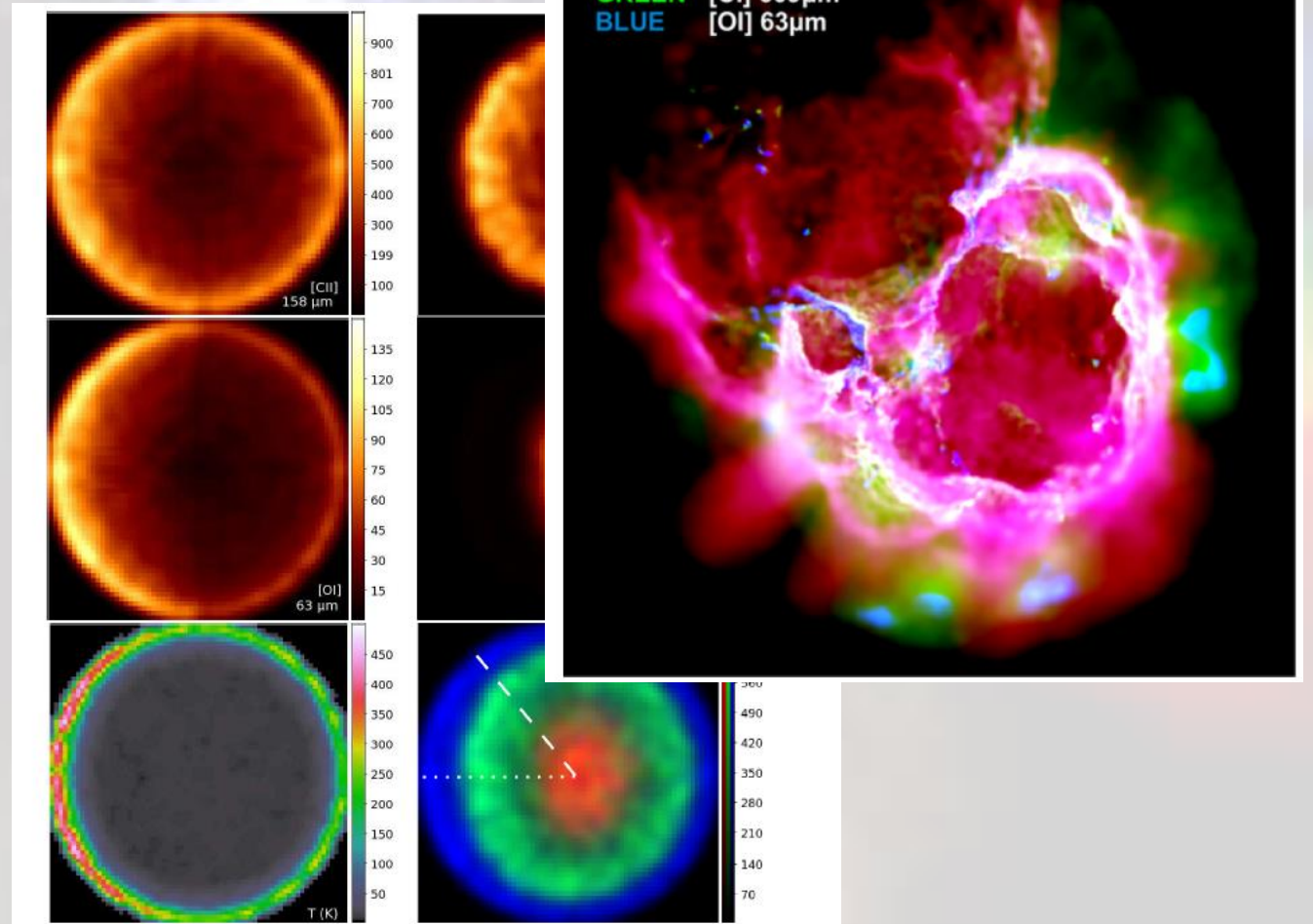
- Flexible geometry, pp-disks, envelopes
- Steady state & t-dependent chemistry
- gas-phase & simple surface hydrogenation
- X-ray induced chemistry
- PAH chemistry & H_2^*
- Photodissociation using shielding rates
- MC continuum RT
- 'escape formalism' for molecular excitation
- ray tracing for emission



3D-PDR

Bisbas et al. MNRAS, 427, 2100 (2012)

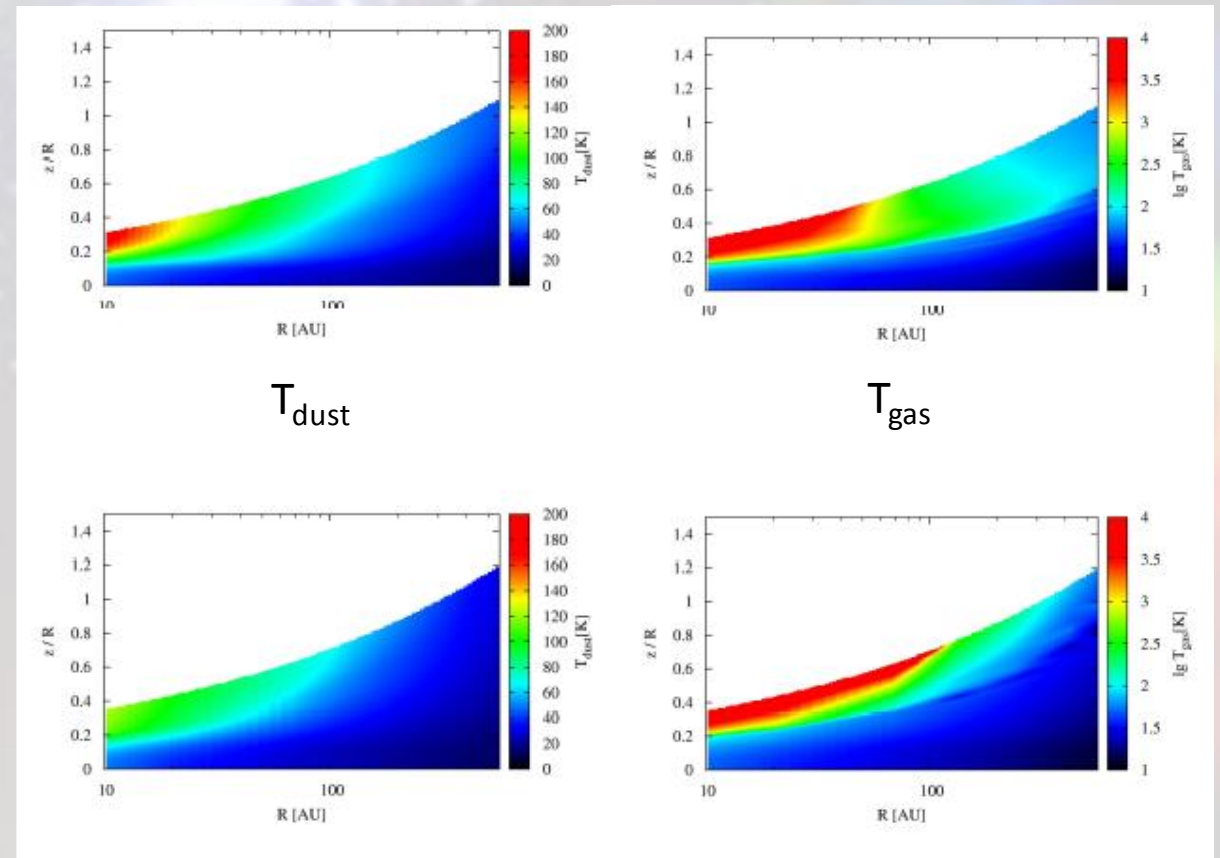
- 3D-PDR code (arbitrary geometry)
- HEALPIX-based ray tracing
- Further development of UCL_PDR
- Cooling by C^+ , C, O, CO
- 2-lev approximation of H_2
- Small (33 spec.) , time dependent chemistry
- CO and H_2 PD using shielding rates



Accretion disk with Dust Evolution & Sedimentation

Akimkin et al., ApJ 766:8 (24pp), (2013)

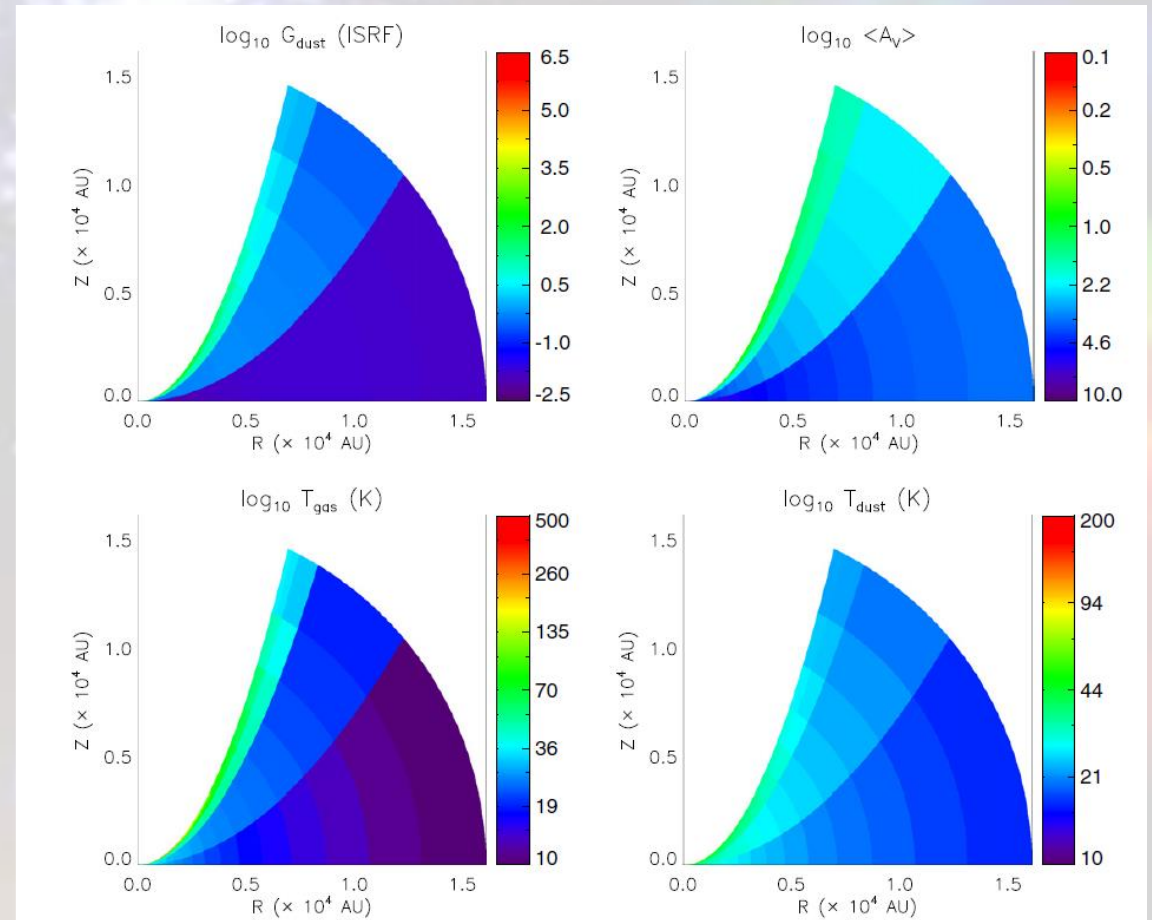
- Hydrostatic, quasi-static disk
- 1+1D freq.-dependent continuum RT
- dust growth (coagulation & fragmentation) and sedimentation
- chemical evolution using an extended gas-grain network with UV/X-ray-driven processes surface reactions
- Explicit PD rate computation
- gas thermal energy balance



Embedded protostar with outflow cavity PDR

Lee et al. , ApJSS, 213:33 (23pp), 2014

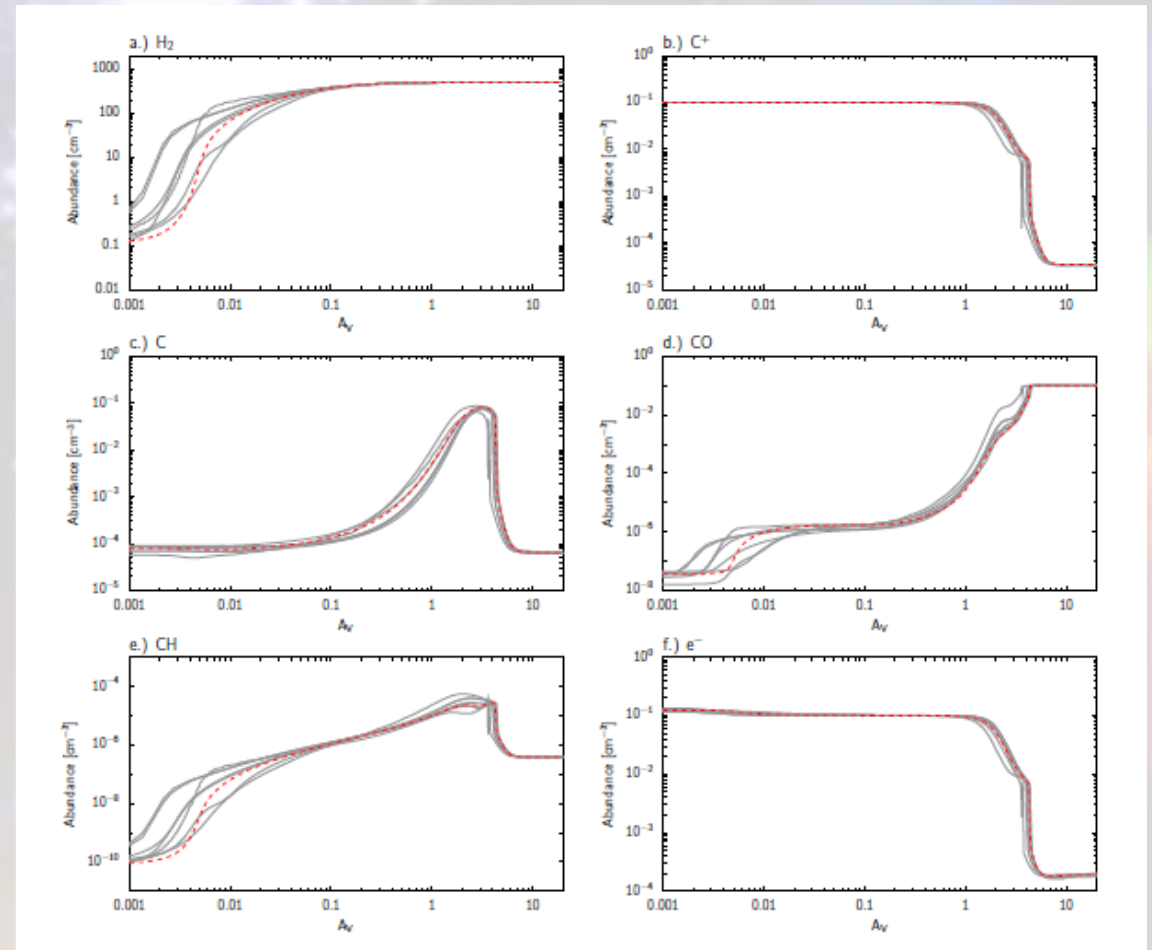
- Custom coordinates based on circular paraboloid
- dust continuum radiative code RADMC-3D $\rightarrow T_d$
- grid-based Monte Carlo RT \rightarrow FUV
- RATRAN upgrade: RIG
- Gas+dust chemistry (ALCHEMIC derivate)
- H₂ formation (C&T 2002-10)



PyPDR

Bruderer 2014: http://www.mpe.mpg.de/~simonbr/research_pypdr/index.html

- tiny/minimal PDR code written in Python
- Plane-parallel slab (semi-infinite)
- basic chemistry with about 30 molecules, time dependent
- NLTE excitation of [OI], [CII], [CI], CO, and ^{13}CO using an escape probability approach
- Major heating & cooling processes implemented

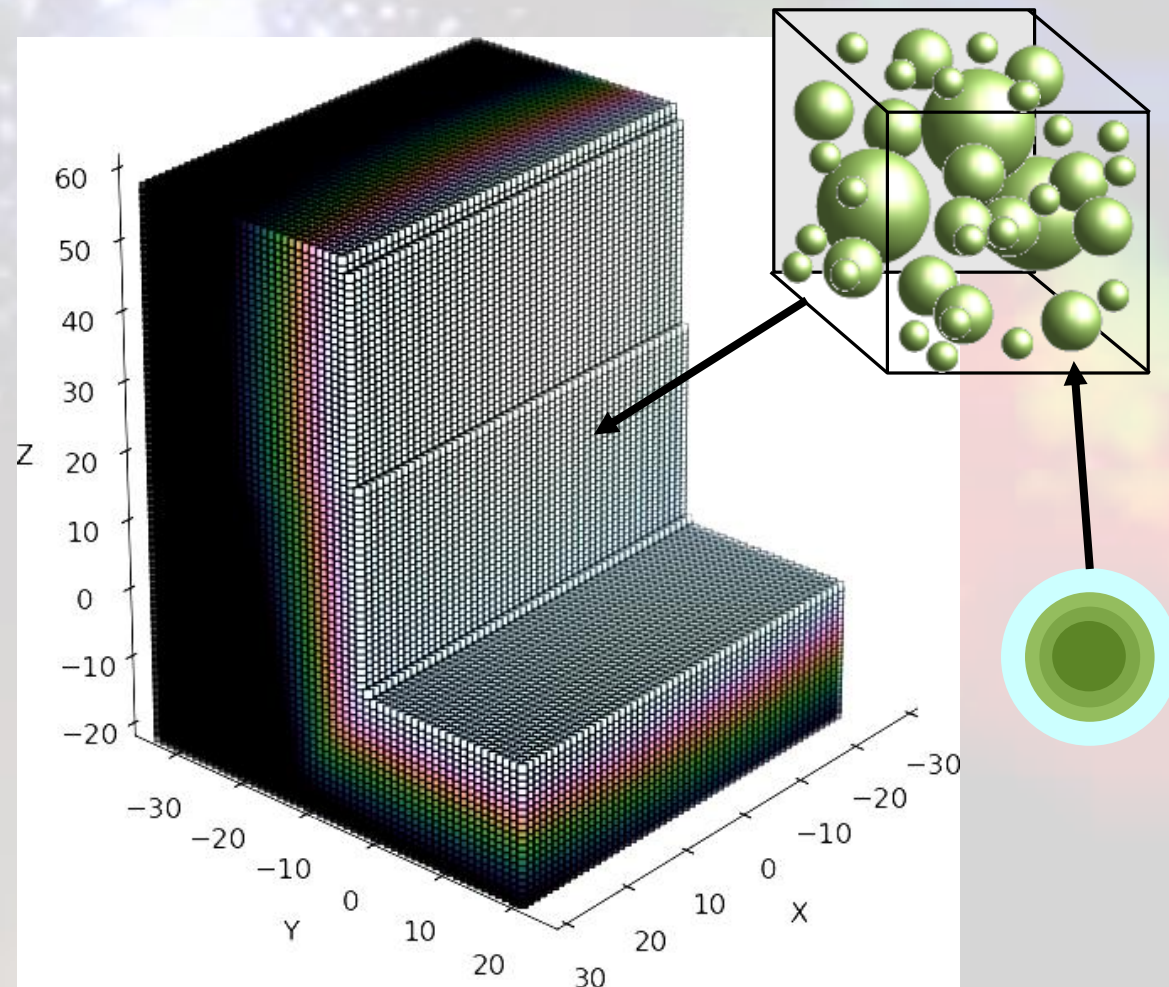


KOSMA- τ 3D

Andree-Labsch et al. , A&A, 2015, submitted

- 3D PDR with arbitrary geometry & velocity structure
- Post-processing of KOSMA clumpy PDR ensembles
- Voxel filled with fractal cloud ensembles
- Stochastic shielding and attenuation
- Ray tracing RT for FUV attenuation and line emission

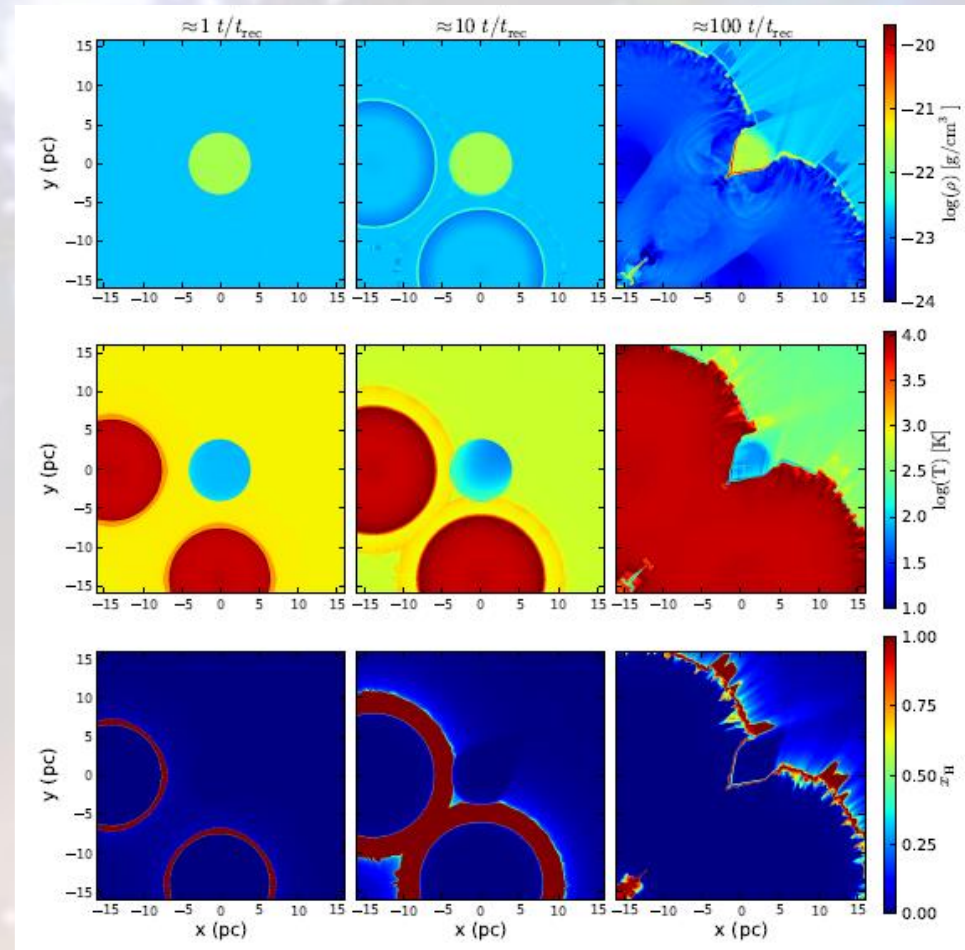
See S. Andree-Labsch's talk



Fervent

Baczynski, Glover, and Klessen., MNRAS, 2015, submitted

- RT module for the MHD adaptive mesh refinement code FLASH 4.
- Self-consistent, time dependent evolution of energetics, chemistry and density of the ISM
- No scattering or continuum yet
- Only H ionization
- Very small chemistry (NL97 chemical network) H-H₂ transition well reproduced



Benchmark codes keep updating

Cloudy

- Upgrade of atomic & molecular structure
- Enhanced Chemistry (s.s. & t-dep., freeze-out)
- Grain physics/chemistry
- pyCloudy, Cloudy_3D

KOSMA- τ

- Clumpy PDR ensembles
- Dust upgrade & new cont. RT
- New H₂ formation (C&T 2002-10)
- Upgraded chemistry (UDfA12 + isotop., surface chemistry, s2s chemistry)
- Shielding, PD rate scaling, heating,...
- KOSMA- τ 3D

Meijerink

- XDR
- Mechanical heating
- Chemistry

HTBKW

- H₂ treatment (link to Meudon) (Kaufman et al. 2006)
- Merging with HII region (Stardust99)
- Chemistry upgrade (t-dep., surface chem.)
- Dust upgrade (PAHs, VSG,...)
- Coupling to shock-code

Meudon

- RT upgrade (FUV & line)
- Grain upgrade (composition, growth)
- Stochastic grain chemistry
- H₂ formation (LH & ER processes)
- Stochastic grain heating
- Chemistry upgrade (s2s chemistry,...)

Apologies for all modelling/upgrade efforts not mentioned here!

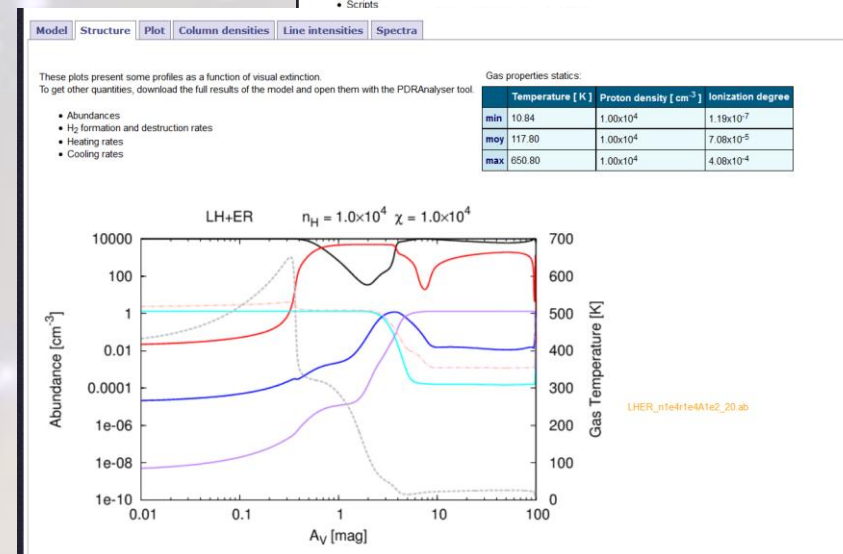
Availability of the Codes/Results

Meudon

<http://pdr.obspm.fr/PDRcode.html>

- Code freely available
- PDR Database access (online & download)
- VO integration

The screenshot shows the 'PDR Tools' website. The navigation bar includes 'PDR CODE', 'PDR DATABASE', 'PDR TOOLS', 'TIPS', 'DOCUMENTATIONS', and 'CREDITS'. The main content area features a header with a starry background and the text 'PDR Tools'. Below this, a section titled 'PDR Tools' contains introductory text: 'Tools have been developed to facilitate the use of the Meudon PDR code and its integration in the Virtual Observatory.' A sub-section for 'PDRAnalyser (beta version)' describes it as a tool for navigating results, extracting data in ASCII, and sending results to plotting tools. It lists functionalities like 'Scripts' and includes a small inset image of a software interface.

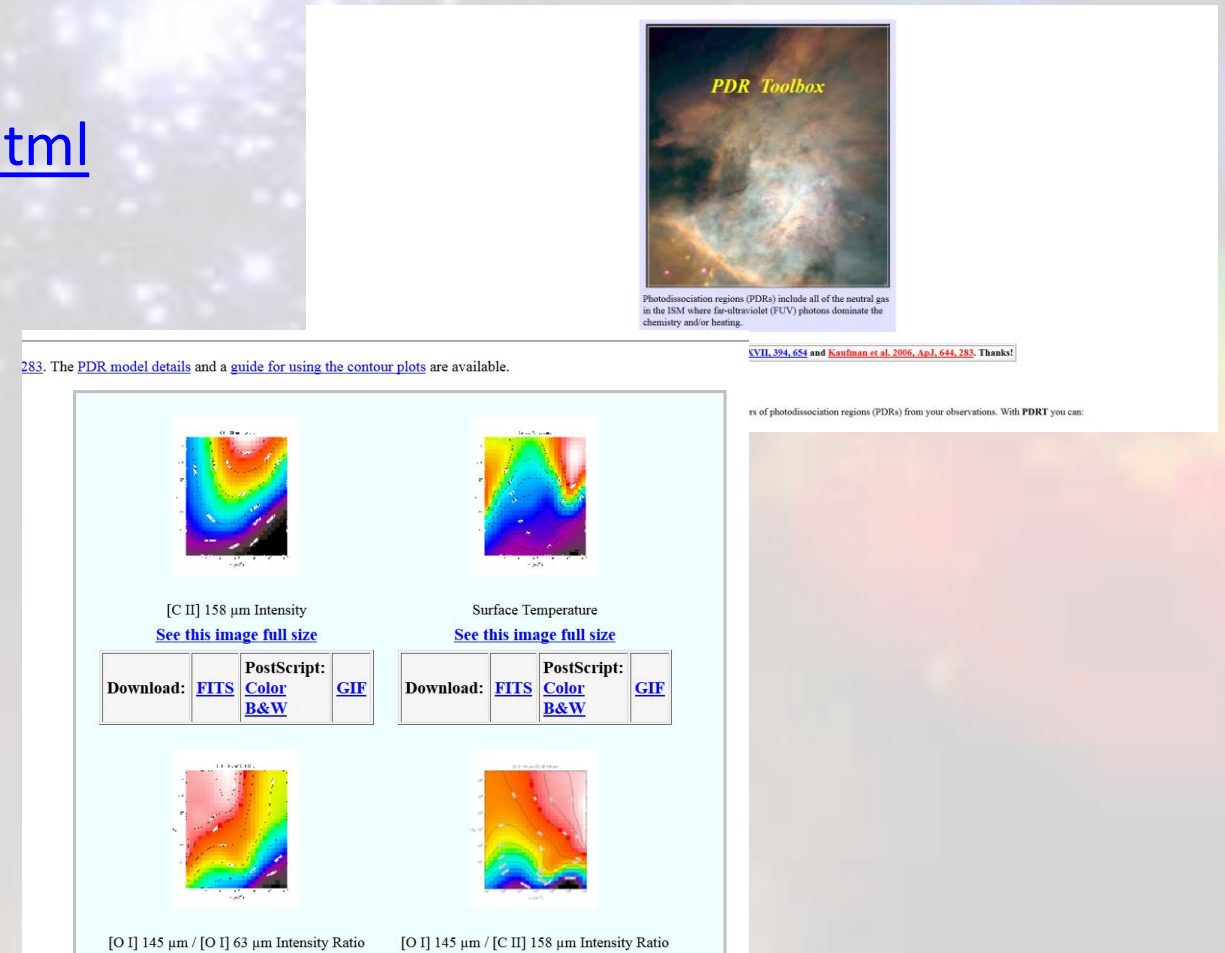


Availability of the Codes/Results

HTBKW

<http://dustem.astro.umd.edu/pdrt/index.html>

- Browse contour plots from PDR models
- Access desired model plot
- Use Line Ratio Fitting program
- IDL & Python scripting interface for PDR Line Ratio Fit



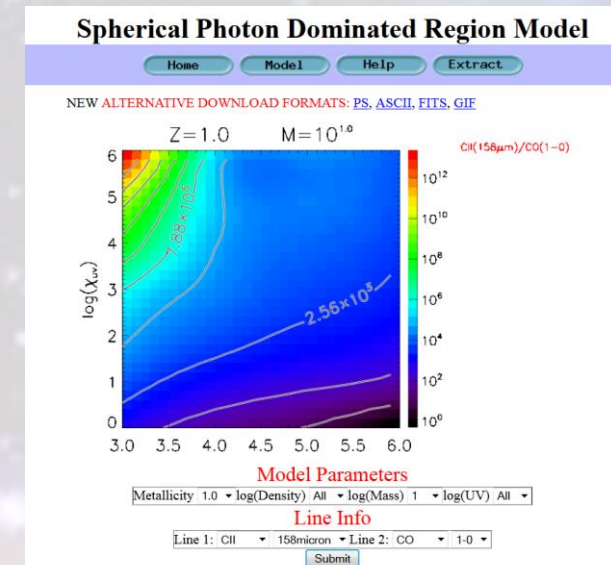
The screenshot displays the PDR Toolbox website. At the top right is a nebula image titled "PDR Toolbox" with a caption: "Photodissociation regions (PDRs) include all of the neutral gas in the ISM where far-ultraviolet (FUV) photons dominate the chemistry and/or heating." Below this is a link: "283. The PDR model details and a guide for using the contour plots are available." To the right of this link is another link: "VII, 394, 654 and Kaufman et al. 2006, ApJ, 644, 283. Thanks!". The main content area features four contour plots arranged in a 2x2 grid. The top-left plot is labeled "[C II] 158 μm Intensity" with a "See this image full size" link and download options: "Download: FITS", "PostScript: Color B&W", and "GIF". The top-right plot is labeled "Surface Temperature" with a "See this image full size" link and download options: "Download: FITS", "PostScript: Color B&W", and "GIF". The bottom-left plot is labeled "[O I] 145 μm / [O I] 63 μm Intensity Ratio" and the bottom-right plot is labeled "[O I] 145 μm / [C II] 158 μm Intensity Ratio".

Availability of the Codes/Results

KOSMA- τ

<http://hera.ph1.uni-koeln.de/~pdr/>

- Browse contour plots from PDR models (interface upgrade to access all results is coming)
- **Isotopic fractionation material**
<http://www.astro.uni-koeln.de/kosma-tau-downloads>
- *Mathematica* script to insert Isotopes into UdfA
- UdfA06 chemistry file including ^{13}C and ^{18}O
- plots



KOSMA-tau - The Cologne PDR code

KOSMA-tau is a numerical code to compute the physical and chemical structure of a spherical molecular cloud, it is called photo-dissociation region (PDR). This code has been developed from an earlier PDR code, written by A. Sternberg from Tel Aviv University in Israel (Sternberg & Dalgarno 1989; Sternberg & Dalgarno 1995). His original code uses a plane-parallel geometry and was updated to employ spherical geometry (Carreras, Stutzki and Wimmerauer 1992; Köhler et al. 1994; Stutzki and Sternberg 1996; Zaslavsky, Stutzki & Störzer 2000).

The figure to the right shows the numerical solution scheme, i.e. the main blocks of the problem to be solved:

- **Chemistry:** Solving the chemical problem is equivalent to solving a nonlinear system of rate equations, one equation for each chemical species that is included in the model. The rate equation includes all formation and destruction reactions of the particular species.
- **Energy balance:** Solving the energy balance means balancing all heating and cooling processes to derive the local kinetic gas (and dust) temperature.
- **Level population:** Solving the excitation problem, i.e. compute the energy level population of species that are relevant for the energy balance and for the emission of the model clump. This is again a system of nonlinear rate equations where all populating and depopulating processes, such as collisions and radiative decay, are included (one rate equation per energy level).
- **Radiative transfer:** The radiative transfer computes the emission and absorption processes along a line-of-sight through the model clump. This brings geometry into play and couples remote cloud volumes with each other, i.e. couples the physical and chemical conditions of different parts of the cloud together.

The different 'blocks' in the mentioned scheme depend on each other which makes an iterative solution necessary. The result is the chemical and physical structure of the model cloud as a function of radius.

Model features

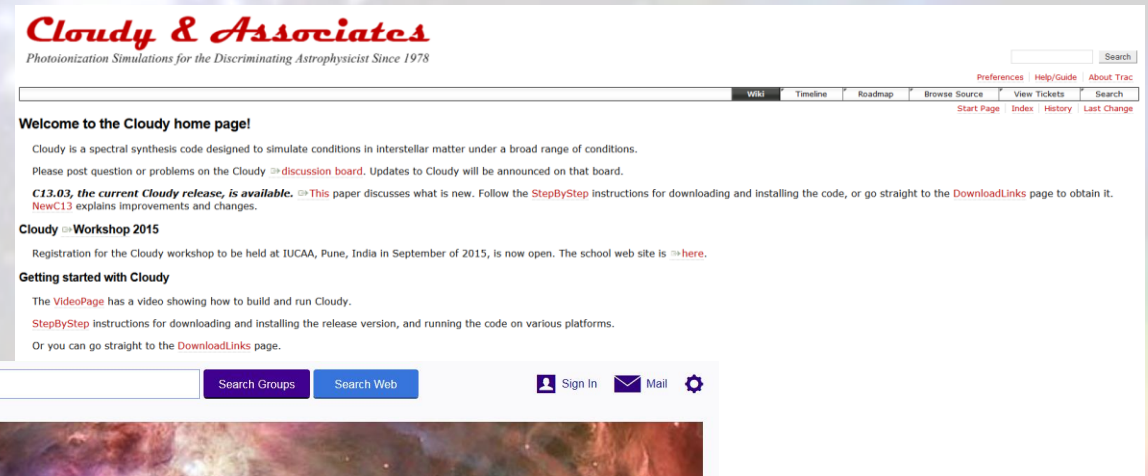
- spherical geometry
- modular chemistry including carbon and oxygen isotopes

Availability of the Codes/Results

Cloudy

<http://www.nublado.org/>

- Code freely available
- User discussion board available



Cloudy & Associates
Photoionization Simulations for the Discriminating Astrophysicist Since 1978

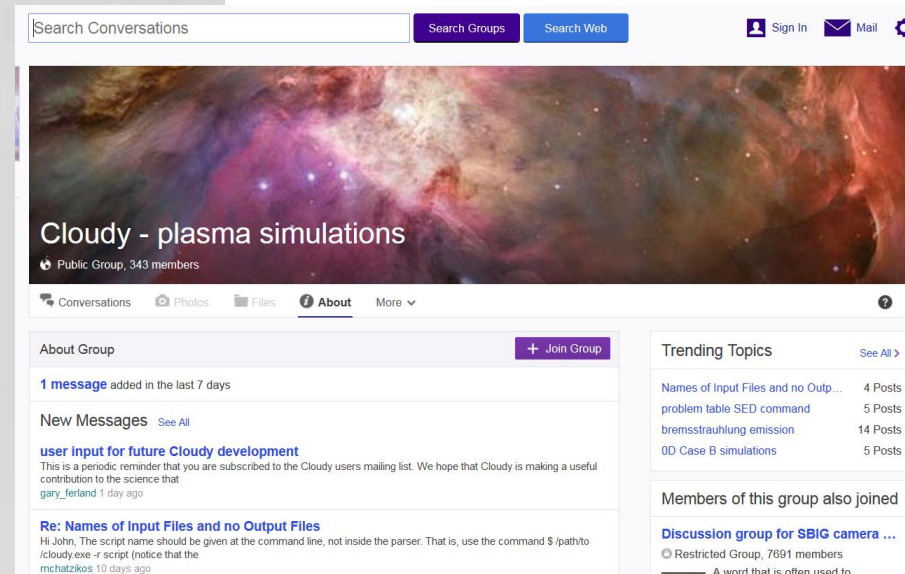
Welcome to the Cloudy home page!

Cloudy is a spectral synthesis code designed to simulate conditions in interstellar matter under a broad range of conditions. Please post question or problems on the Cloudy [discussion board](#). Updates to Cloudy will be announced on that board.

C13.03, the current Cloudy release, is available. [This paper](#) discusses what is new. Follow the [StepByStep](#) instructions for downloading and installing the code, or go straight to the [DownloadLinks](#) page to obtain it. [NewC13](#) explains improvements and changes.

Cloudy [Workshop 2015](#)
Registration for the Cloudy workshop to be held at IUCAA, Pune, India in September of 2015, is now open. The school web site is [here](#).

Getting started with Cloudy
The [VideoPage](#) has a video showing how to build and run Cloudy.
[StepByStep](#) instructions for downloading and installing the release version, and running the code on various platforms.
Or you can go straight to the [DownloadLinks](#) page.



Search Conversations Search Groups Search Web Sign In Mail

Cloudy - plasma simulations

Public Group, 343 members

Conversations Photos Files About More

About Group [+ Join Group](#)

1 message added in the last 7 days

New Messages [See All](#)

user input for future Cloudy development
This is a periodic reminder that you are subscribed to the Cloudy users mailing list. We hope that Cloudy is making a useful contribution to the science that
gary_ferland 1 day ago

Re: Names of Input Files and no Output Files
Hi John, The script name should be given at the command line, not inside the parser. That is, use the command \$ /path/to /cloudy.exe -r script (notice that the
mchatzikos 10 days ago

Trending Topics [See All >](#)

Names of Input Files and no Outp...	4 Posts
problem table SED command	5 Posts
bremsstrahlung emission	14 Posts
OD Case B simulations	5 Posts

Members of this group also joined

Discussion group for SBIG camera ...
Restricted Group, 7691 members
A word that is often used to

Availability of the Codes/Results

ProDiMo

<http://homepage.univie.ac.at/peter.woitke/ProDiMo.html>

- Code available after registration
- Wiki page access for registered users

ProDiMo is a scientific software package in FORTRAN 90 to model protoplanetary disks including gas phase, X-ray and UV-photo-chemistry, gas heating and cooling balance, disk structure and (dust & line) radiative transfer. The following is a preview of the wiki pages for ProDiMo hosted at forge.ros.ac.uk in Edinburgh. **The links do not work (on purpose)!** To get access to the ProDiMo web-pages, the FORTRAN source code, and the IDL visualisation tools, please apply at <https://forge.ros.ac.uk/ForgeRegistration.html> for a new ProDiMo user account, mentioning my name.

Disclaimer

This code is available on a collaborative basis, meaning ...

- You are not permitted to pass (parts of) the code to anyone else. If another person is interested to join, please tell him/her to follow the same procedure as you have done, namely to apply at <https://forge.ros.ac.uk/ForgeRegistration.html> for a new ProDiMo user account.
- You have to give all developers of ProDiMo, currently Peter Woitke AND Inga Kamp AND Wing-Fai Thi co-author right, i.e. you should ask us prior to paper submission whether we want to be included as co-authors. If you want to use the X-ray module, you should also give Giambattista Aresu co-author right.
- If you contribute significant changes to ProDiMo, you get co-author right on all papers that use these changes.
- In order to claim his/her co-author right on a paper going to be submitted, he/she needs to send his/her scientific comments on the paper on timescales of one or two weeks. Otherwise he/she loses that right for this paper.

Remember that, as you can read this wiki page, you have signed up for these conditions.

Welcome to the ProDiMo manual pages

See how to [Get Started](#) here (Code download and compilation - **Note the top of page!**).

See how to [Run ProDiMo](#) here.

Find some more useful [Tips and Tricks](#) how to run complex disk models and set parameters here.

See how to calculate gas emission lines with [RATRAN](#) here.

Check out [Known Problems](#) with some solutions.

Description of [Atomic and molecular data](#) and [Dust opacities](#)

Current [Work In Progress](#) and [Referenced Papers](#) using ProDiMo

[Program structure](#)

Availability of the Codes/Results

UCL_PDR

https://www.ucl.ac.uk/star/research/stars_galaxies/codes/uclpdr

- The code is available on request

Meijerink XDR

<http://home.strw.leidenuniv.nl/~meijerink/grid/>

- A grid of PDR and XDR models

A grid of PDR and XDR models by:
Rowin Meijerink (rowin@astro.berkeley.edu)
Marco Spaans (spaans@astro.rug.nl)

Purpose
To interpret atomic and molecular

Grid
The PDR grid comprises the following ranges:

Range	Density (cm^{-3})	Radiation field (G_0)	Cloudsize (pc)
I	10^2 - 10^3	$10^{0.5}$ - 10^3	50
II	10^3 - 10^4	10^1 - 10^4	10
III	10^4 - $10^{6.5}$	10^2 - 10^5	1

The XDR grid comprises the following ranges:

Range	Density (cm^{-3})	Radiation field ($\text{erg s}^{-1} \text{cm}^{-2}$)	Cloudsize (pc)
I	10^2 - 10^3	0.016-1.6	50
II	10^3 - 10^4	0.16-16	10
III	10^4 - $10^{6.5}$	1.6-160	1

UCL DEPARTMENT OF PHYSICS AND ASTRONOMY
ASTROPHYSICS GROUP

UCL Home Astrophysics Group Research Topics Stars and Galaxies Numerical Codes (UCL) UCL PDR

UCL Astrophysics Group

- Home
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- Astrophysics Seminars
- Departmental Events
- Research Topics
 - Instrumentation
 - Cosmology
 - (Exo-)Planetary Systems
 - Stars and Galaxies
- Undergraduate Studies
- PhD Admissions
- University of London Observatory
- Outreach
- Publications
- Useful Links
- Astrophysics Wiki Pages
- Vacancies page

UCL PDR

UCL_PDR is time dependent photon-dissociation regions model that calculates self consistently the thermal balance. It can be used with gas phase only species as well as with surface species. It has been benchmarked with other existing PDR models (Rollig et al. 2007). It is very modular, it has the possibility of accounting for density and pressure gradients and can be coupled with UCL_CHEM (Martin et al. 2009) as well as with SMMOL (e.g. Vasta et al. 2010). It has been used to model small scale (e.g. knots in proto-planetary nebulae) to large scale regions (high redshift galaxies).

Quick Links

Stars in the Local Group

- Massive Star Binary Systems
- CoBRAS e-MERLIN Legacy Survey
- Evolved Binaries

Galaxy Evolution

- Galaxy Evolution from Surveys
- High-redshift radio galaxies
- Antennae Galaxies
- Starburst Galaxies

Galactic Star Formation

- Galactic Star Formation and the ISM
- IPHAS
- Astrochemistry and the Birth of Massive Stars
- The Dust Grain Ice Formation Inverse Problem

Flux (in Jy) without continuum

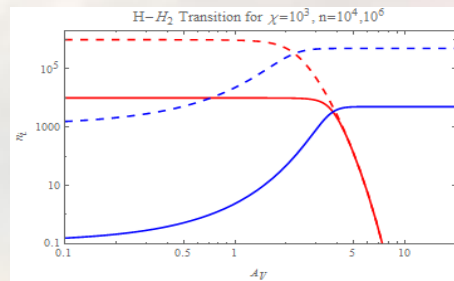
Velocity (km s⁻¹)

Model access

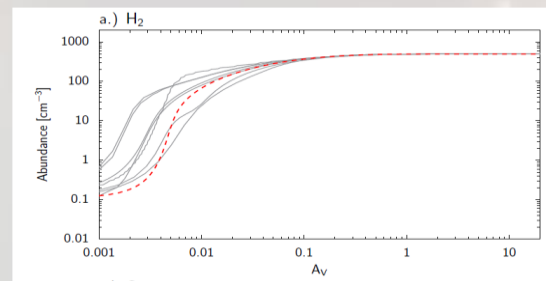
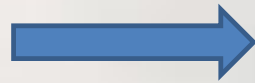
- The conclusion from Benchmark paper still valid:
“.. observers should not take the PDR results too literally to constrain [...] physical parameters like density and radiation field in the region they observe.”
- Influence of PDR model input parameters on results difficult to predict – number of crucial model parameters growing
- Fitting model computations to observations requires experience.
- Detailed PDR modelling remains difficult for non-experts
- Easier to collaborate with modeler than to quickly run some PDR models yourself.
- But, ...

Model access

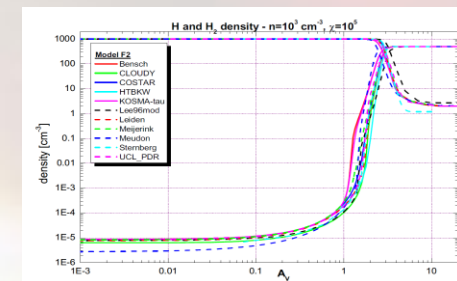
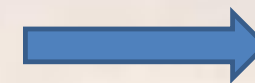
- Simple analysis based on published contour plots/data became much easier thanks to the many 'public' outreach efforts.
- Toy models, such as PyPDR span a bridge between simple analytic calculations and full complexity models.



analytic



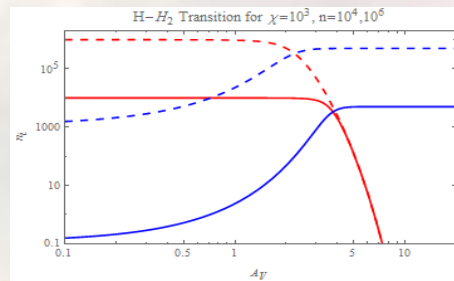
PyPDR



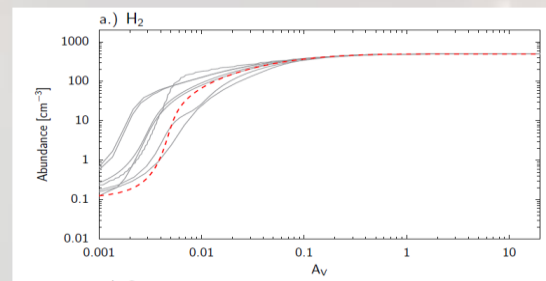
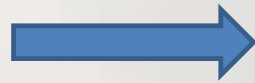
full models

Model access

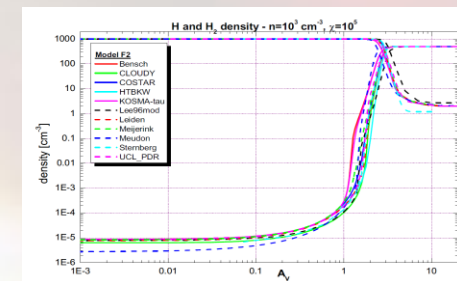
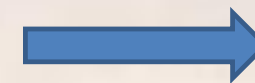
- Simple analysis based on published contour plots/data became much easier thanks to the many 'public' outreach efforts.
- Toy models, such as PyPDR span a bridge between simple analytic calculations and full complexity models.
- If you really want to run models yourself, you have now a number models to choose! Good user-support.



analytic



toy



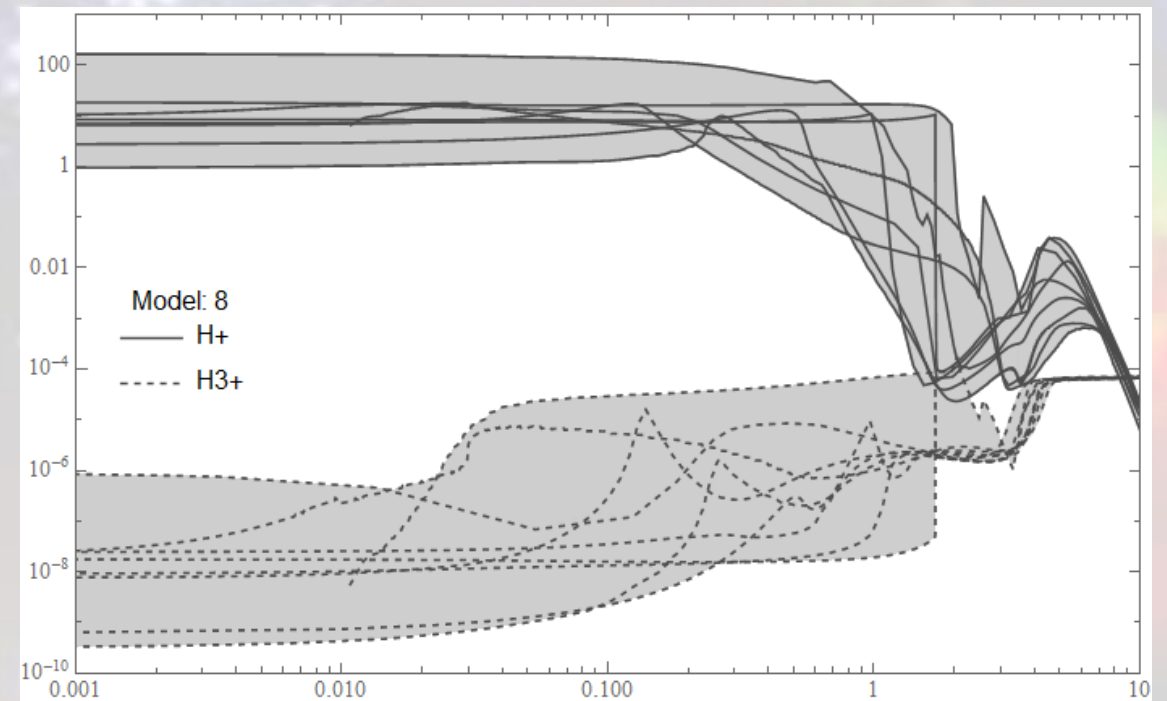
full models

Benchmark V.2?

So much left to do:

- 2007 benchmark left many open issues

Status after the benchmark 2007



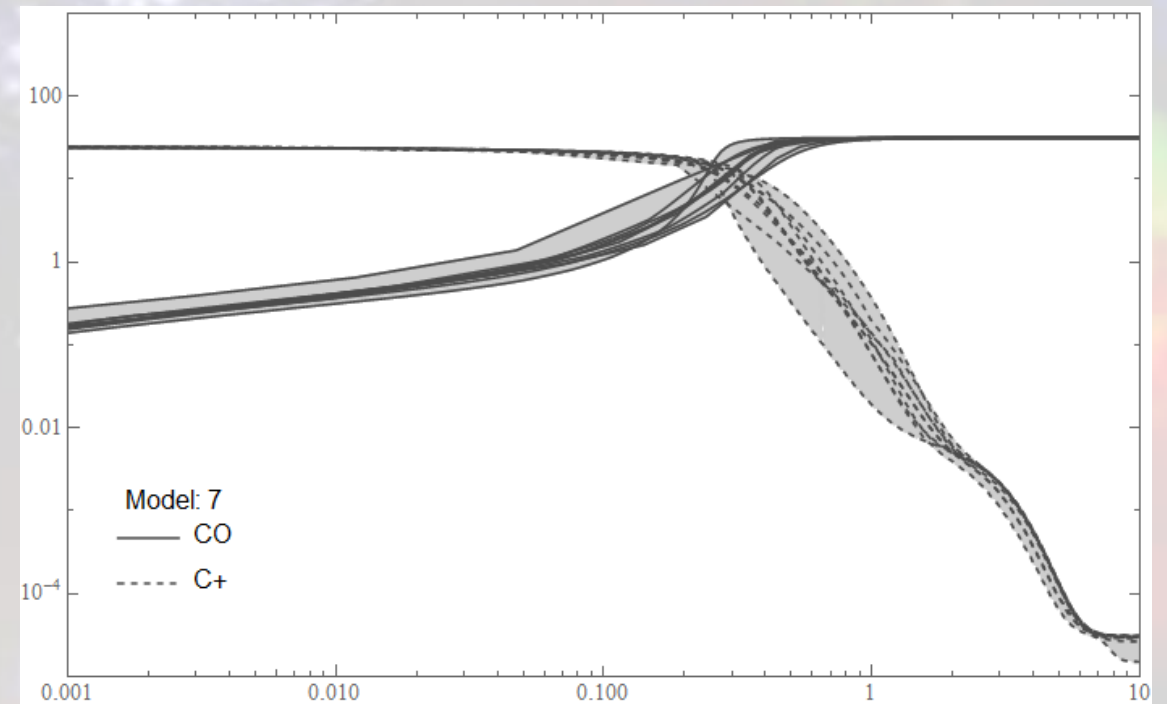
$$n=10^{5.5} \text{ cm}^{-3}, \chi=10^5$$

Benchmark V.2?

So much left to do:

- 2007 benchmark left many open issues
- Discuss numerics
- New physics/chemistry
- Follow up on CO excitation and C+ workshops
- Benchmark against real world problems
- Exchange of experience, include the new models
- PDR modelling roadmap

Status after the benchmark 2007

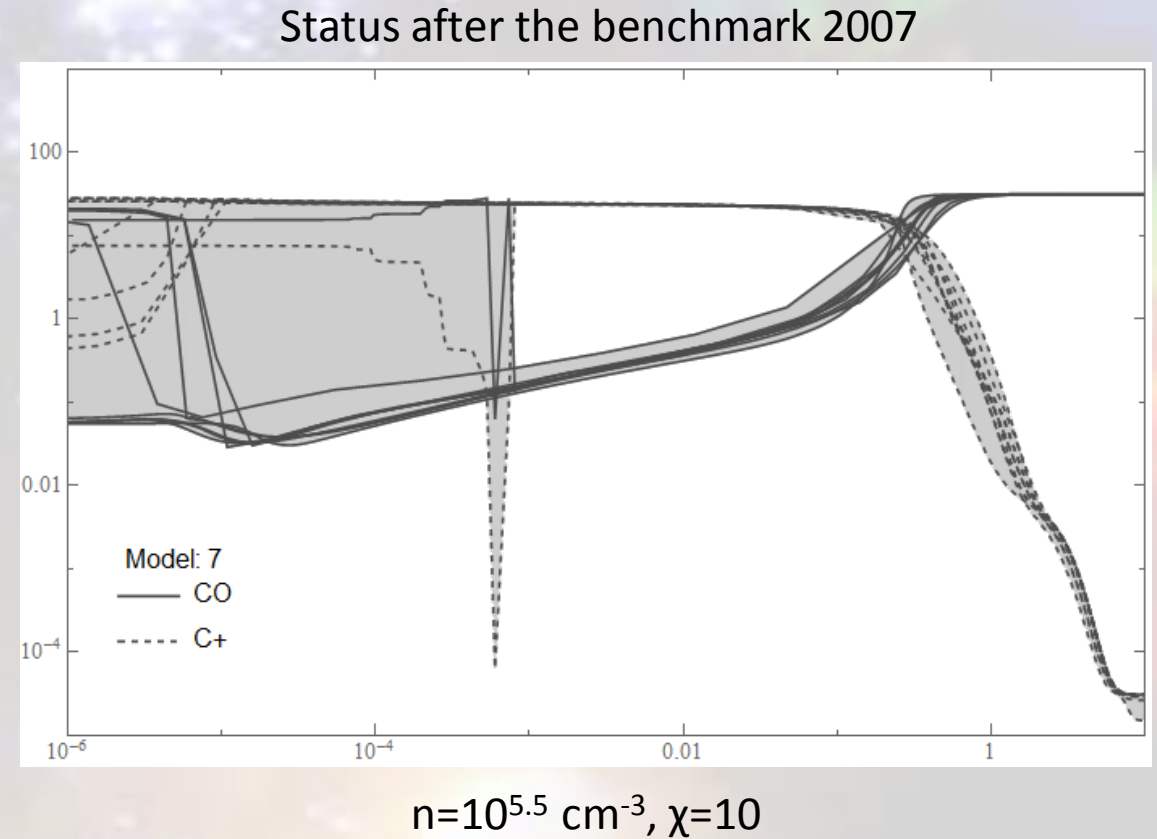


$$n=10^{5.5} \text{ cm}^{-3}, \chi=10$$

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So much left to do:

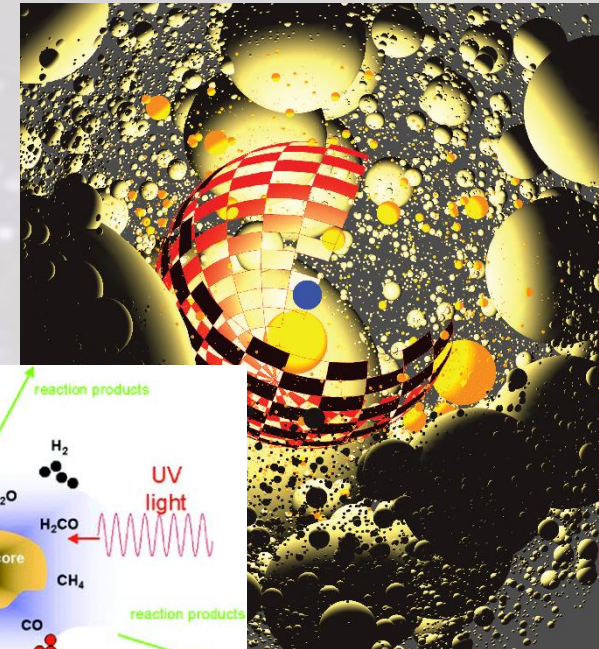
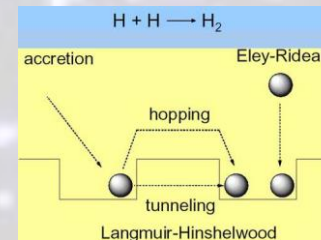
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So much left to do:

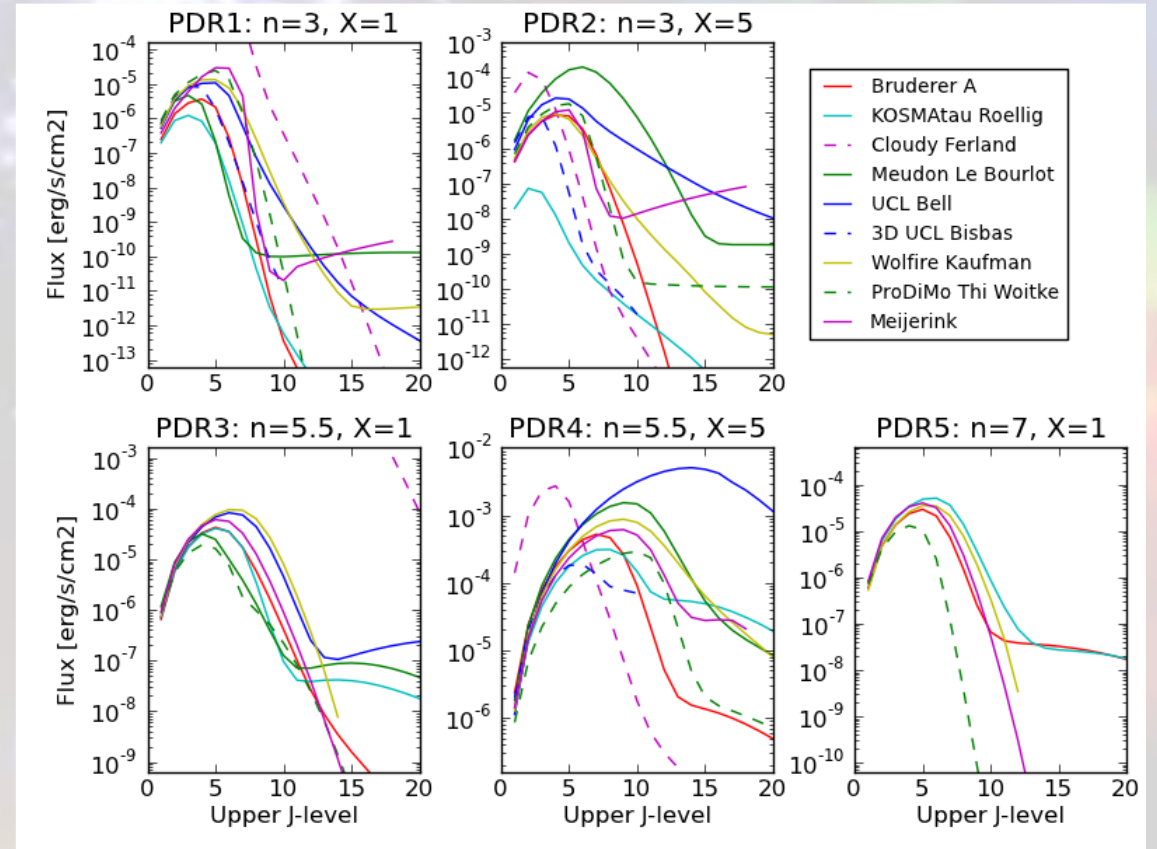
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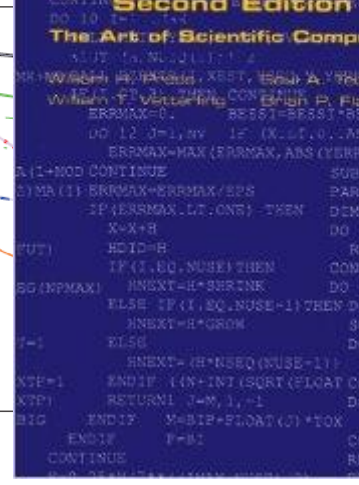
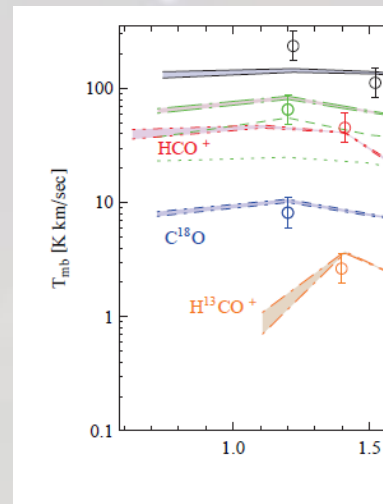
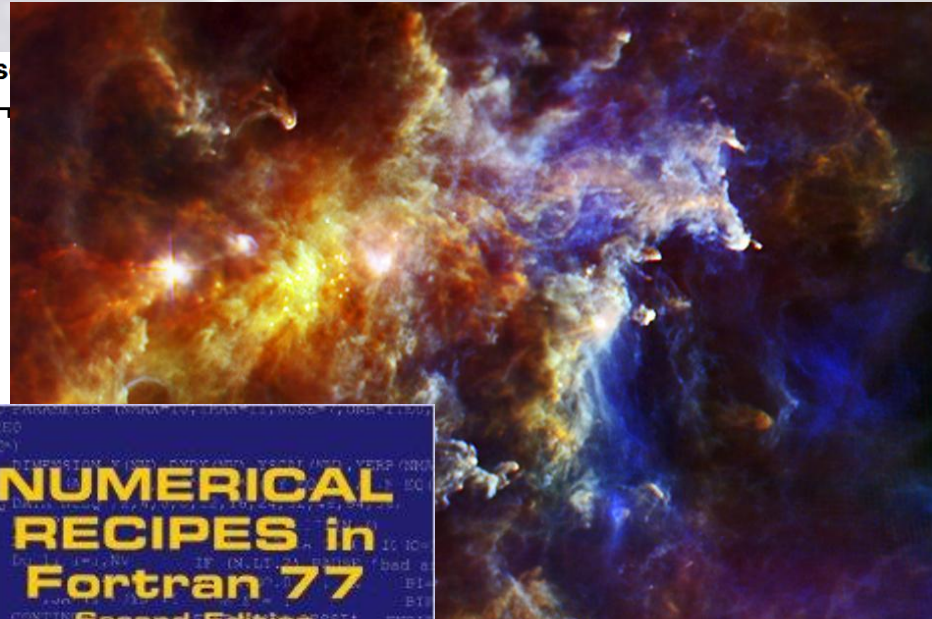
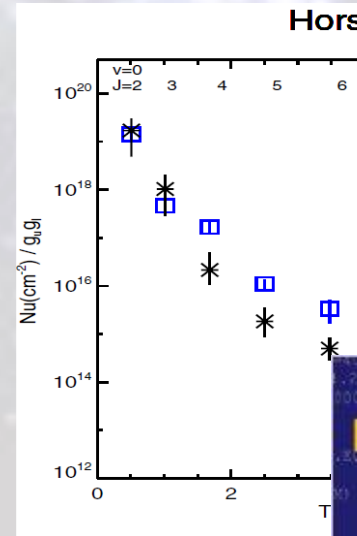
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Benchmark V.2!

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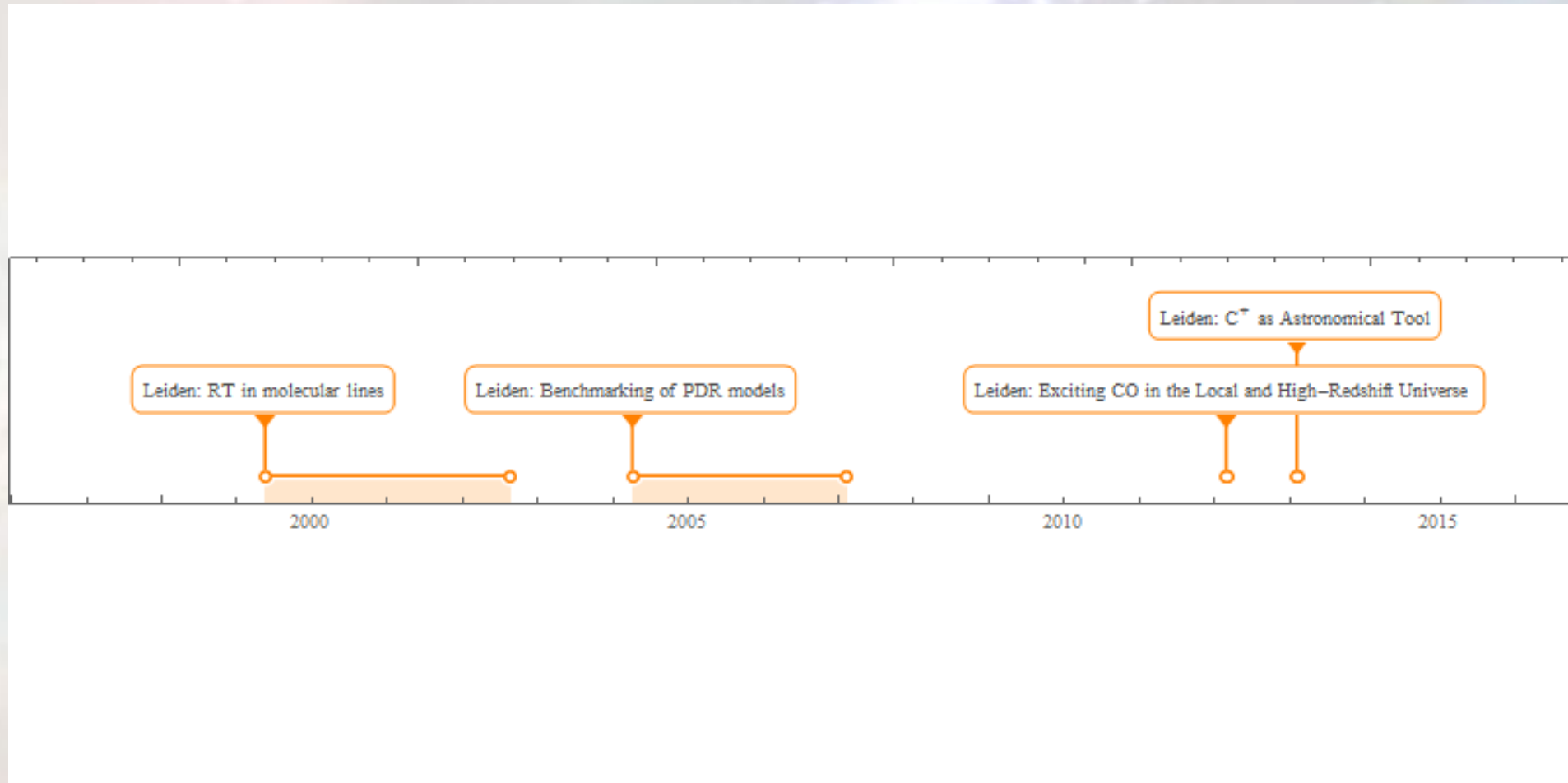




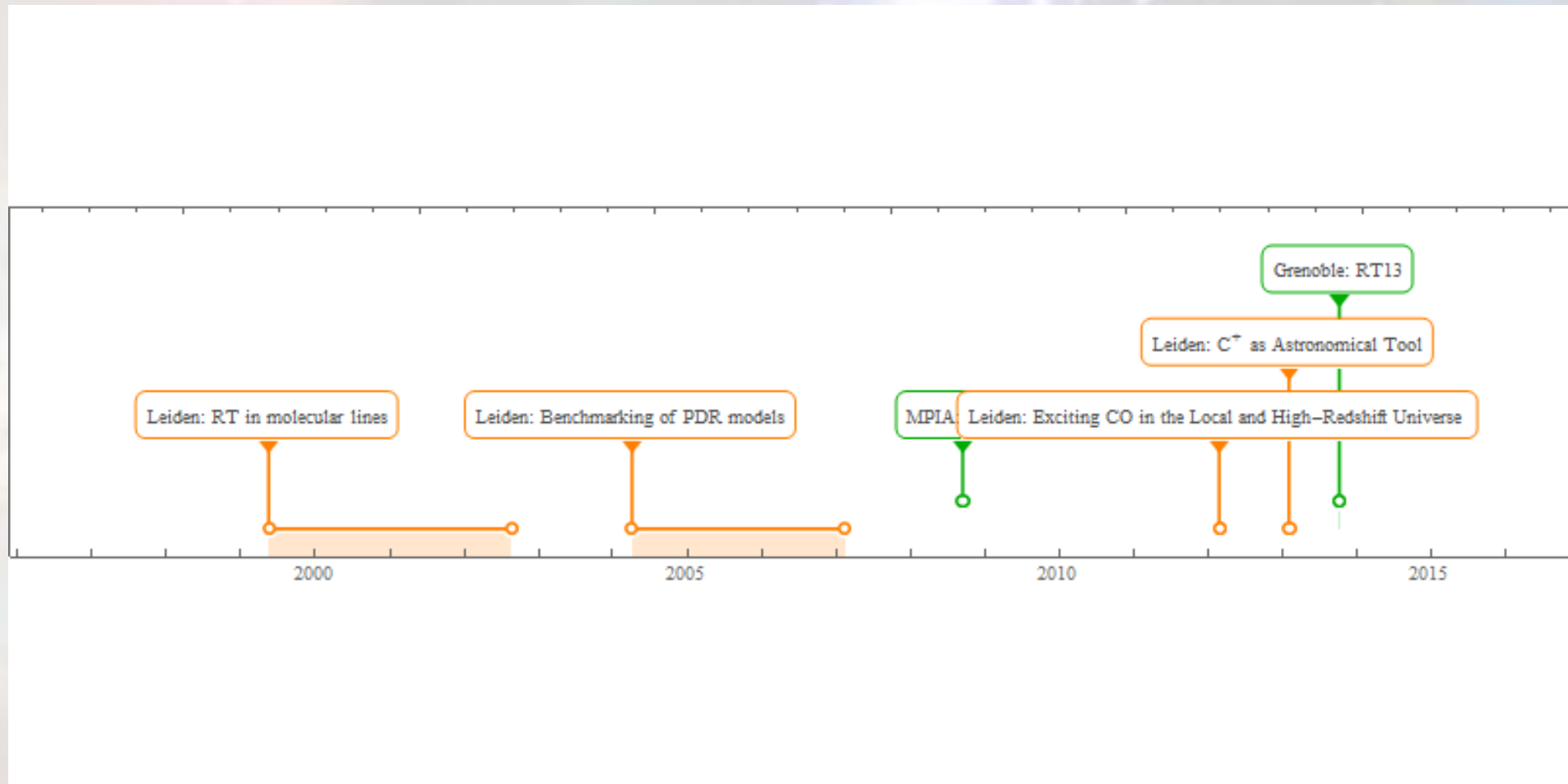
Thank you for the invitation!

Thank you for your attention!

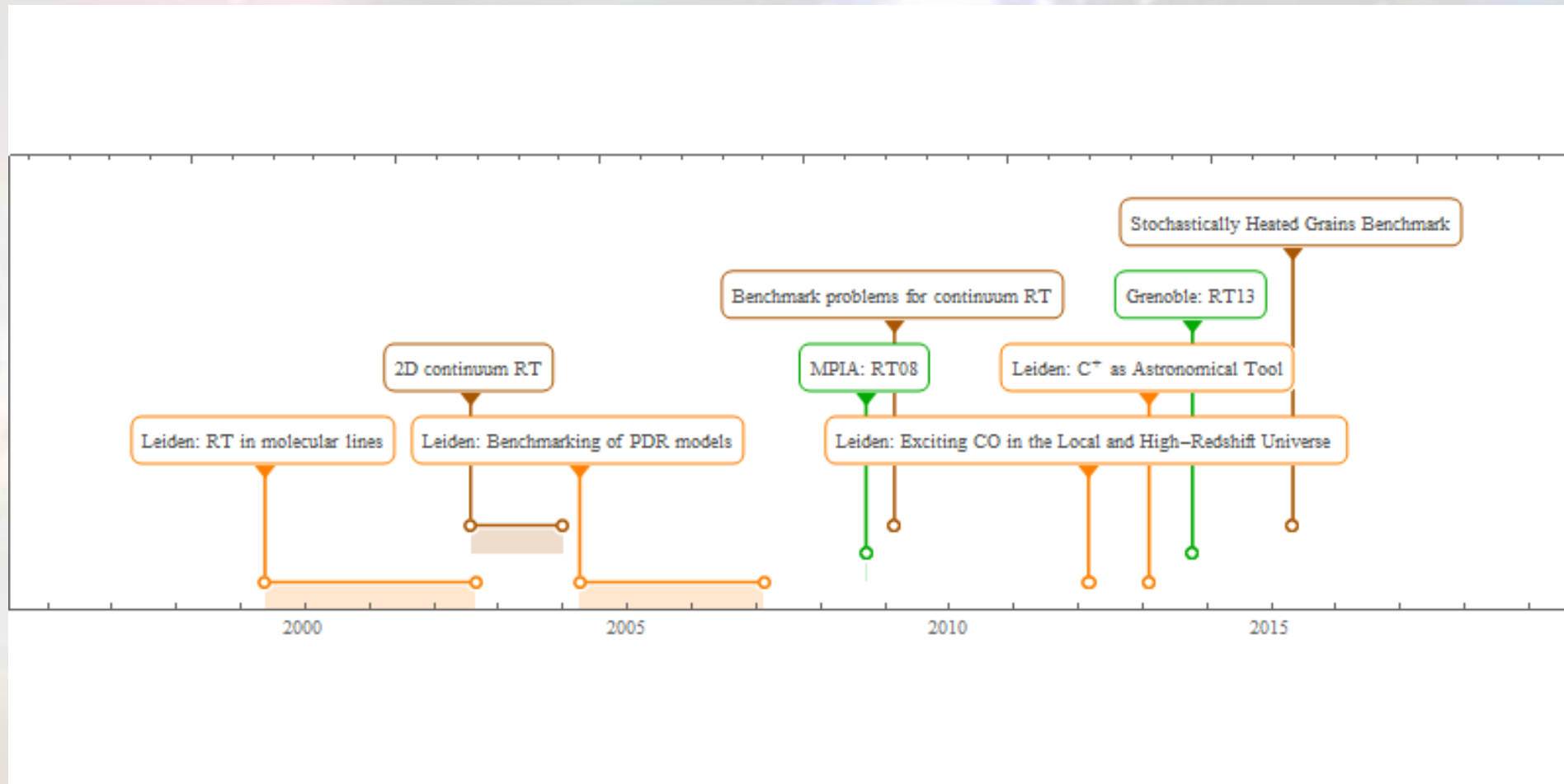
History of Benchmarks



History of Benchmarks



History of Benchmarks



History of Benchmarks

