MASSIVE STAR FEEDBACK: CONVERGENCE BETWEEN OBSERVATIONS AND SIMULATIONS

SILCC Collaboration

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OR:
WHAT'S THE CONNECTION BETWEEN MICRO- AND MACRO-PHYSICS

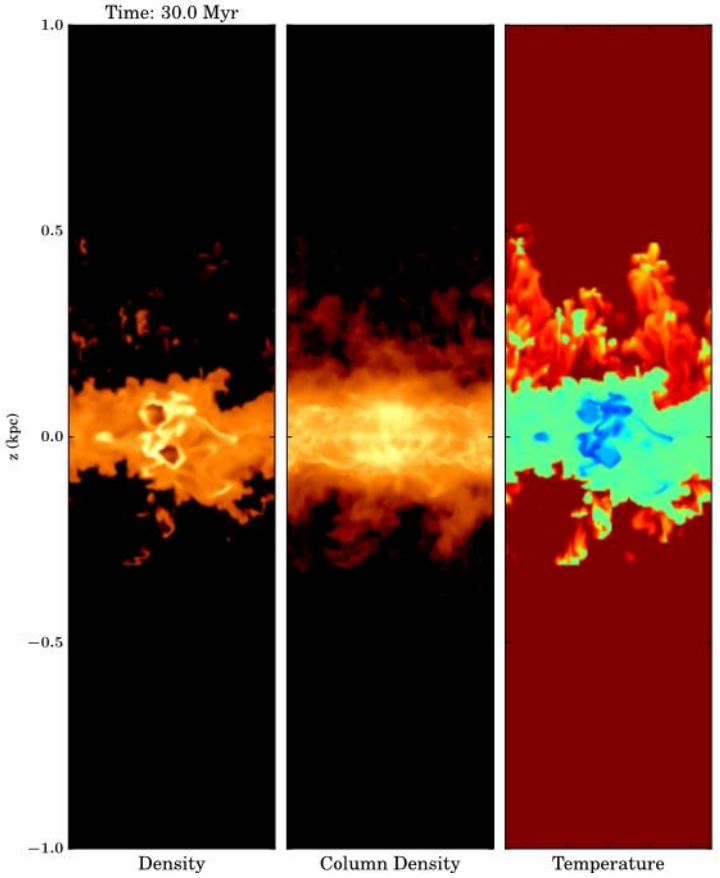
SILCC Collaboration

Simon Glover, Ralph Klessen, Christian Baczynski

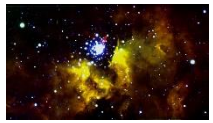
Macro-Physical Processing of Galaxies

SILCC – Simulating the Life Cycle of Clouds

- Simulations of stratified discs with thermal SNe
- Include SNe at fixed rate (momentum and thermal energy), Gatto+2014
- Include chemical evolution (H+, H, H2, CO, C+) Glover+2012, Walch+2014
- Include shielding of the gas (attenuation of ISRF), TreeCol (Clark+2012)
- Neglect winds, direct radiation
- Milky Way condistions (10 Msol/pc^2, solar Z)



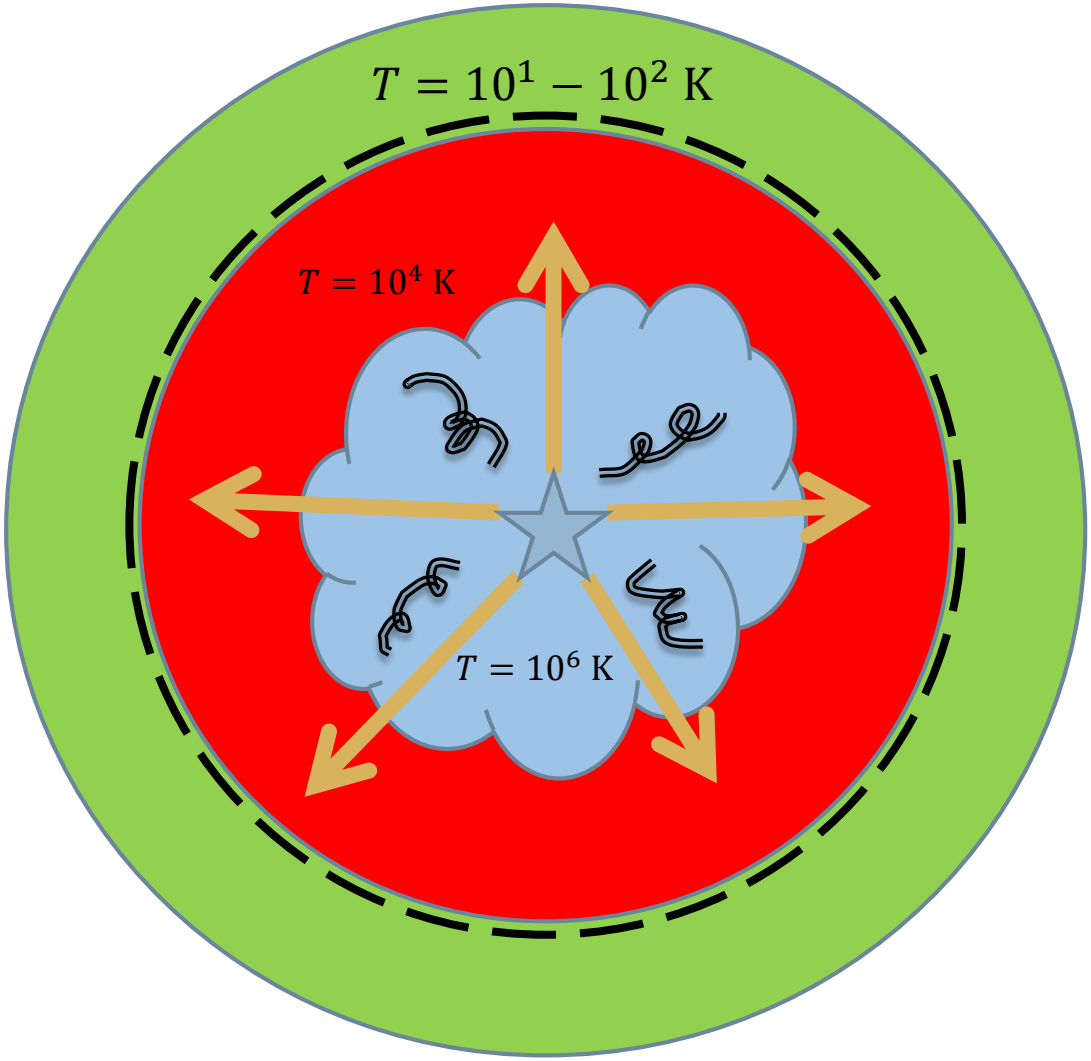
Overview



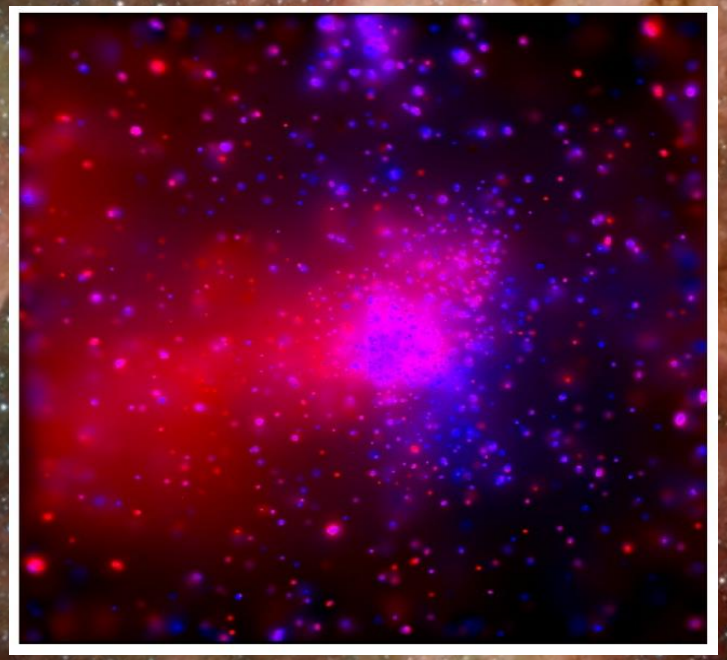
Feedback

X-Ray Plasma	Radiation	HII Region Gas
Thermalized Shocks from Stellar Winds and Supernovae $T = 10^6 - 10^7$ K $n(H) < 0.1$	Dominated by ionizing photon momentum Non-Isotropic Pressure Term- Think Force on Shell	Photoionized $T = 10^4$ K $n(H) = 10 - 1000$ cm^{-3}

Bubble Model of SF regions



M17



Chandra X-ray Image

R = 8μm, O=5.8 μm, G=4.5 μm, B=3.6 μm

10/29/2015

Image credit: Robert Hurt, Matthew Povich

Basic PDR micro-Physics

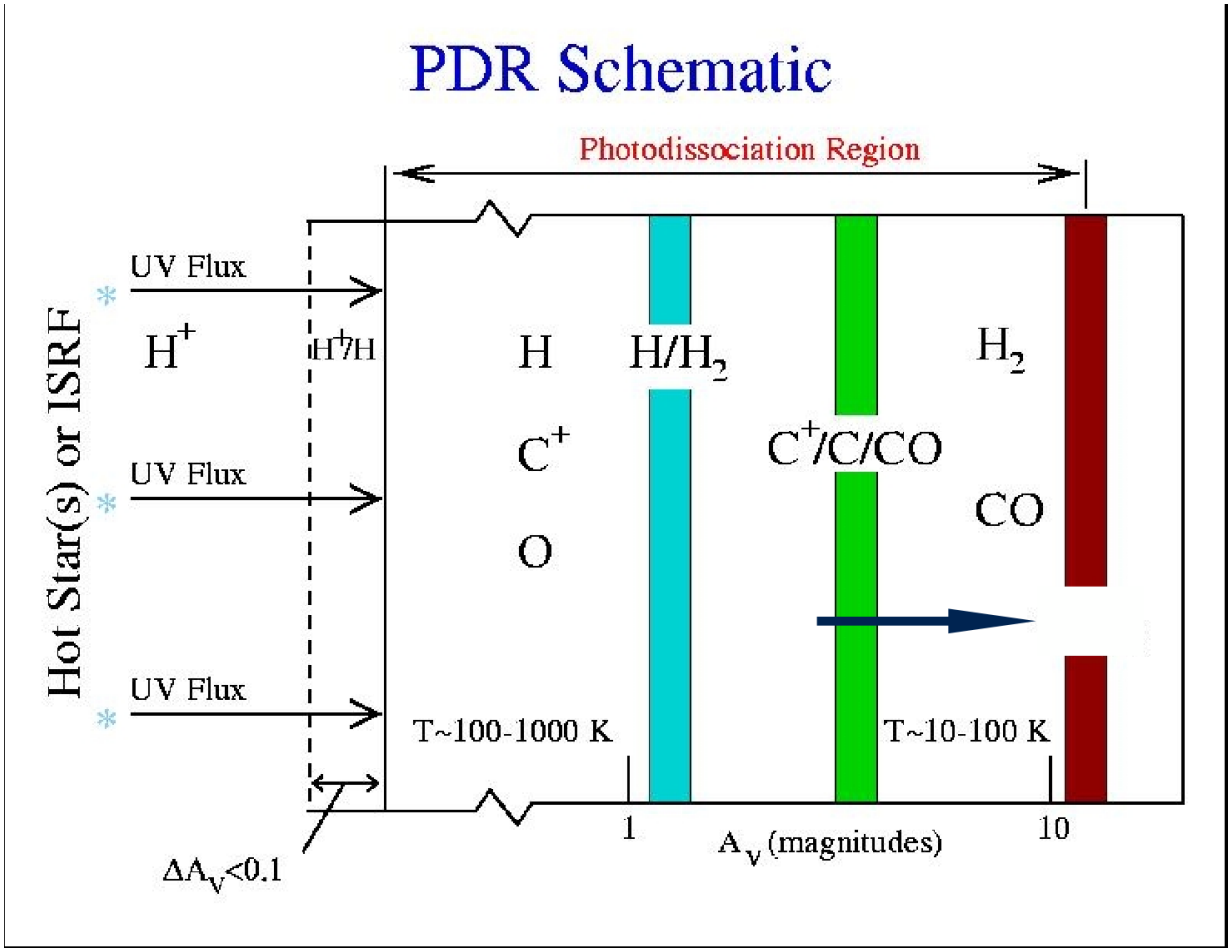
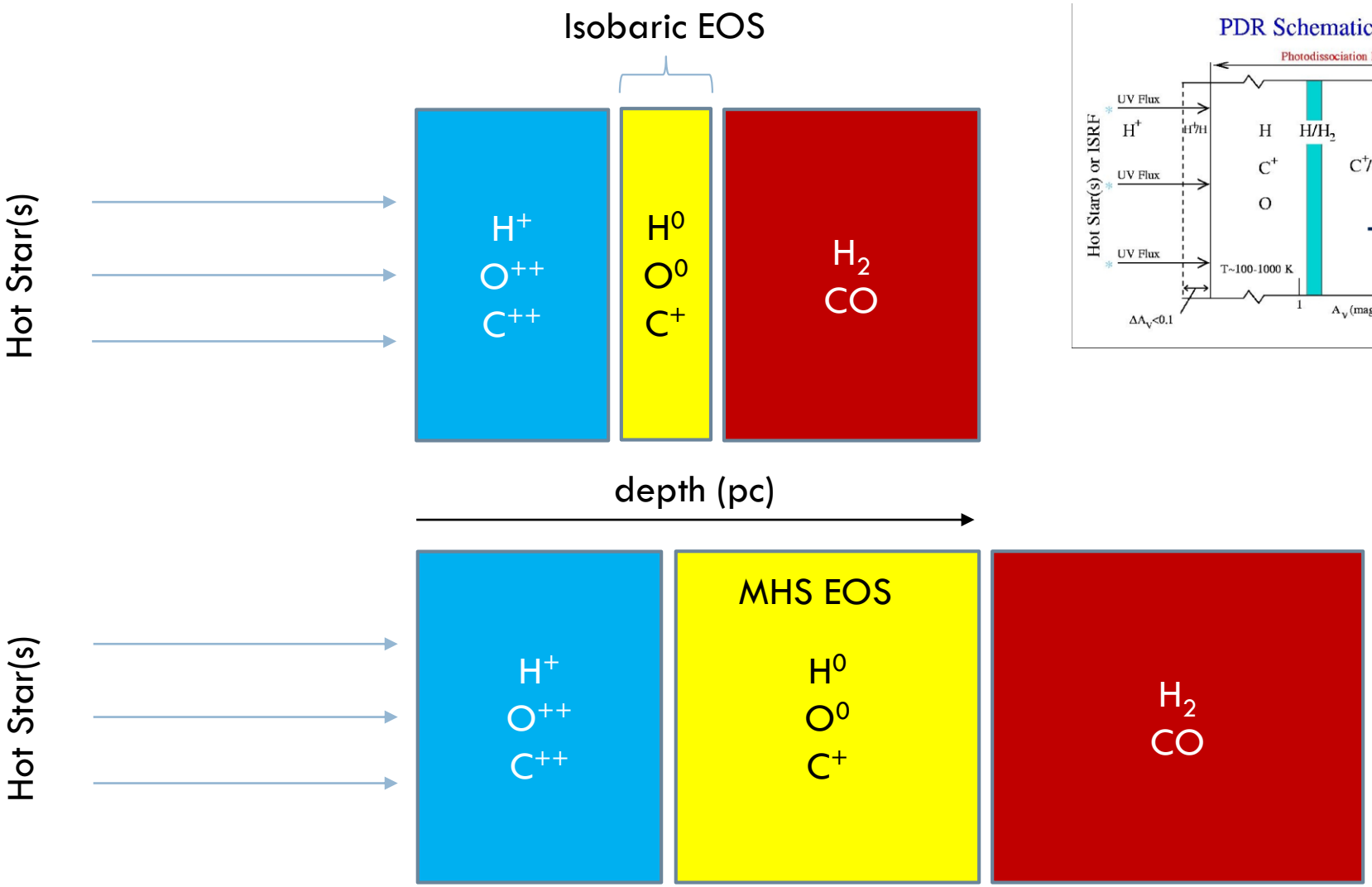


Figure Credit: Kaufman, "PDR30"

Advanced H^+/PDR Physics

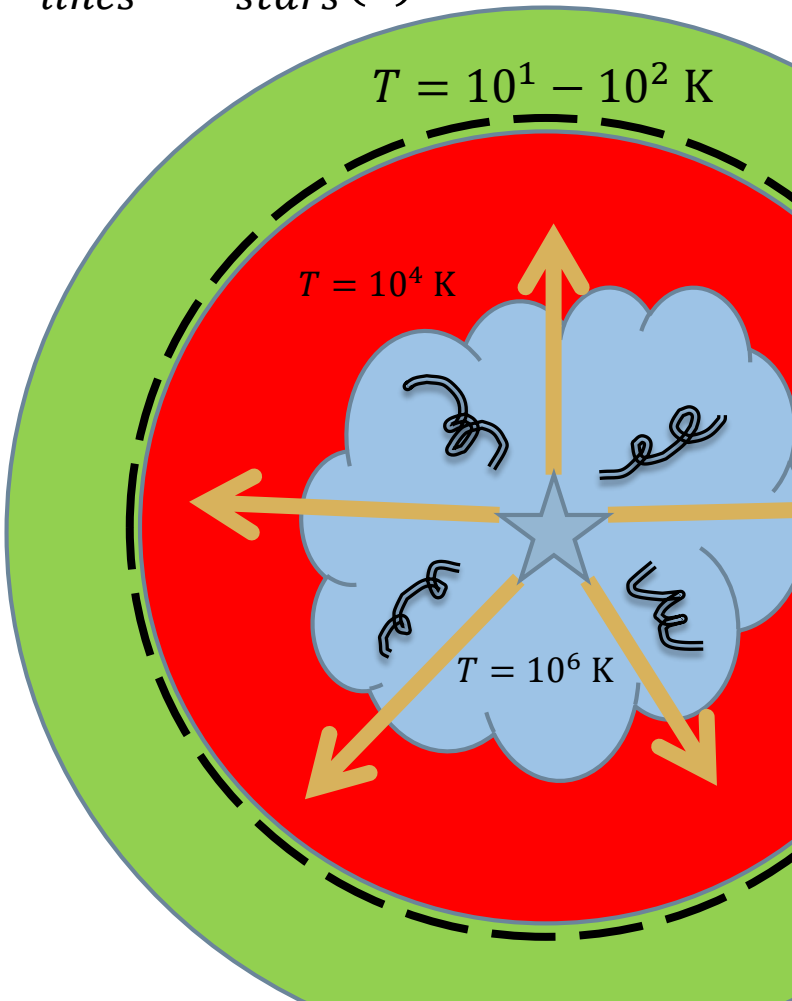


Magneto-Hydro-Static EOS

$$P_{tot}(r) = P_X + n(r)kT + \frac{B^2(r)}{8\pi} + P_{turb} + P_{lines} + P_{stars}(r)$$

$$B = B_0 \times \left(\frac{n}{n_0}\right)^{\frac{\gamma}{2}}$$

$$\int_0^{r_{IF}} P_{stars} = \frac{Q_0(H^0)\,\langle h\nu \rangle}{4\pi\, r^2\, c}$$



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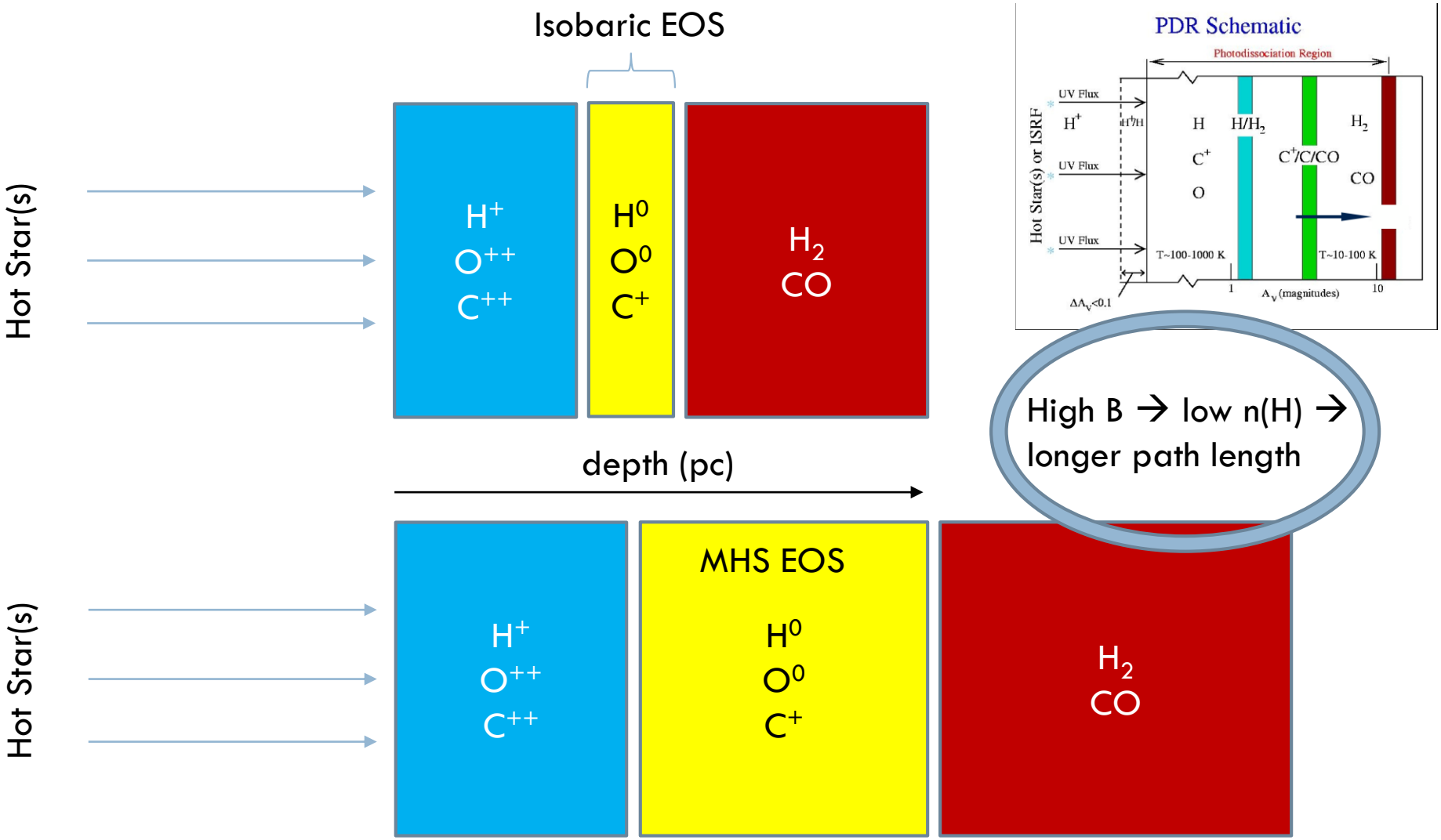

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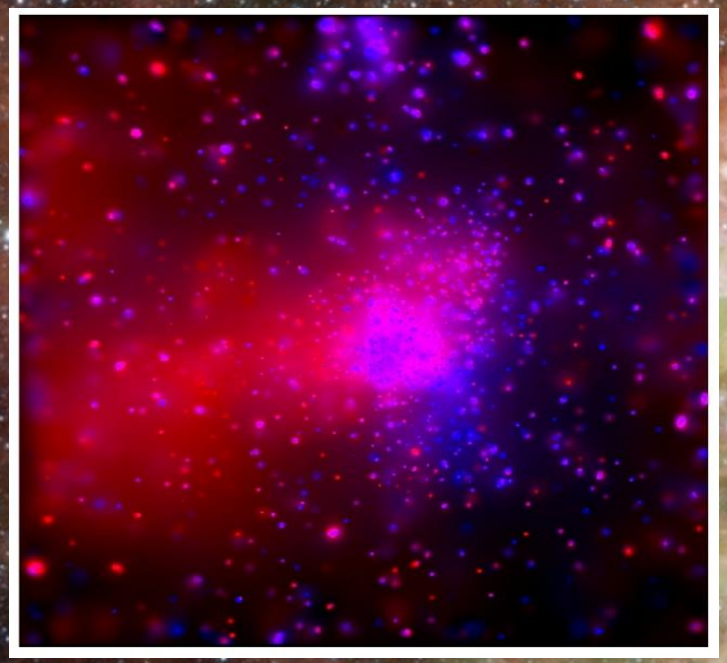

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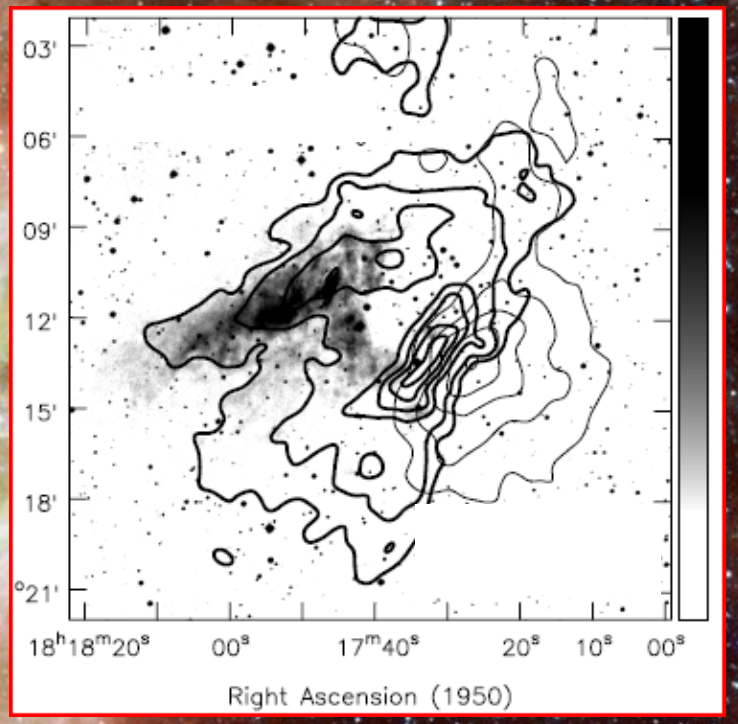

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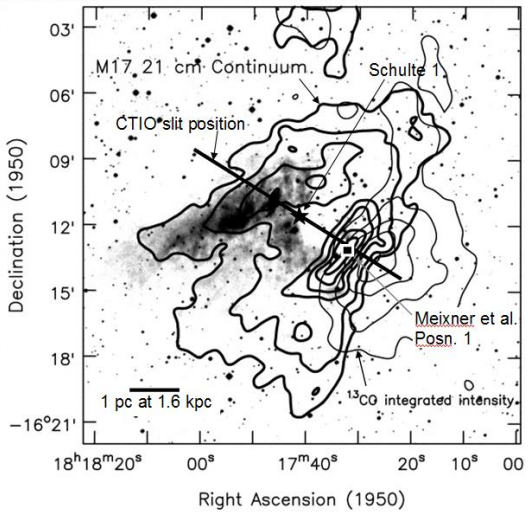
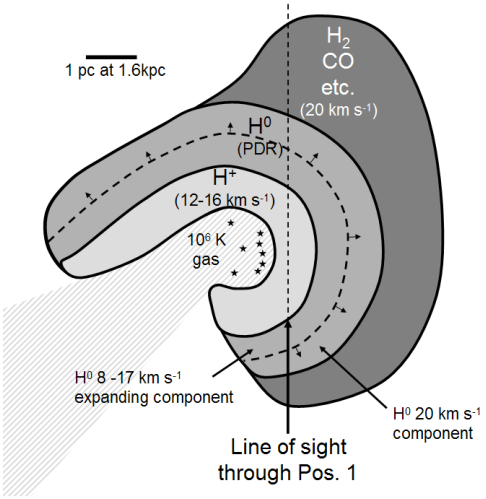
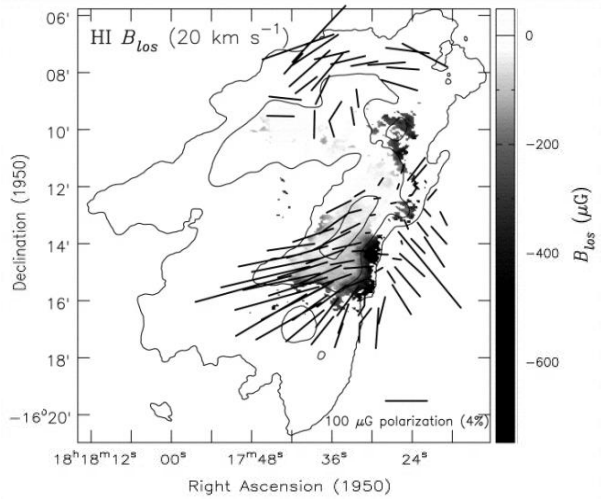
Image credit: Robert Hurt, Matthew Povich

Observed SF EOS







Pellegrini et al. (2007)

Brogan & Troland (2001)

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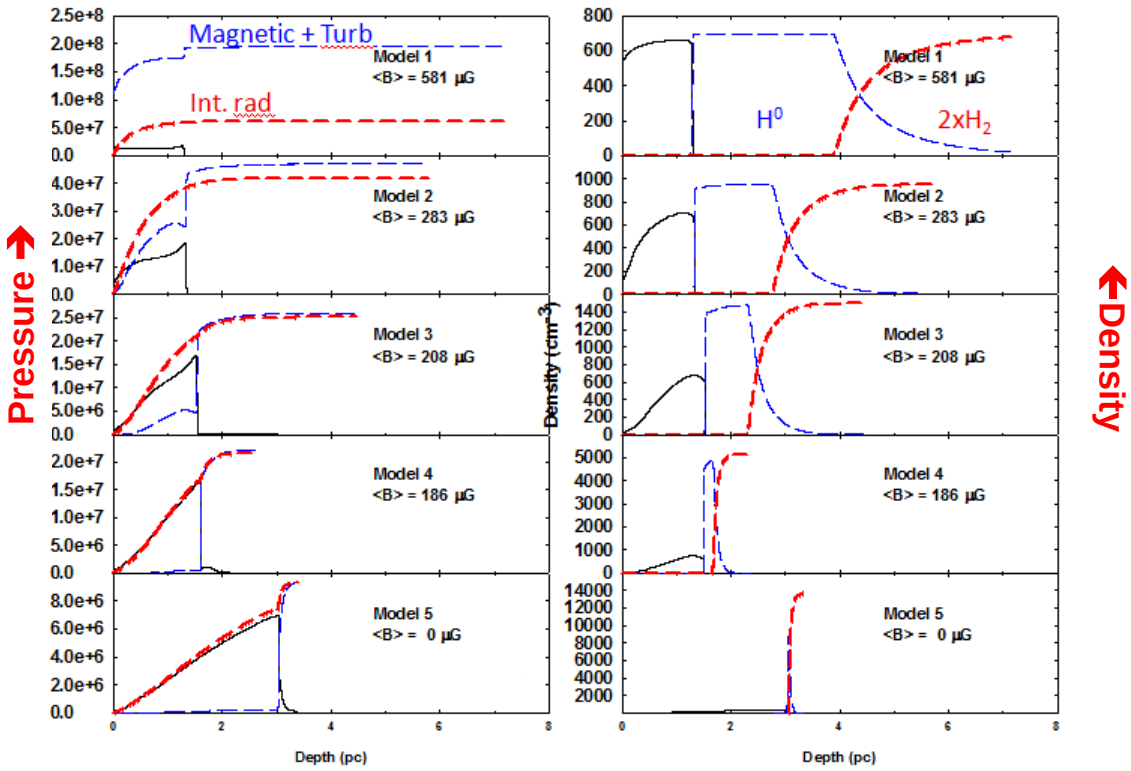

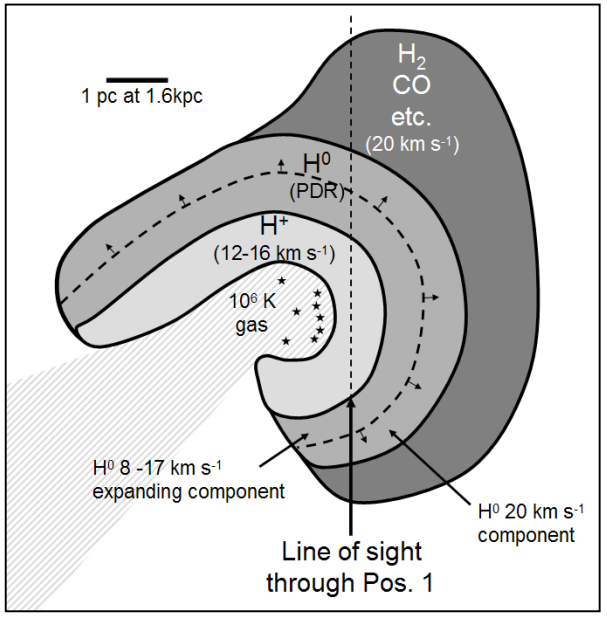

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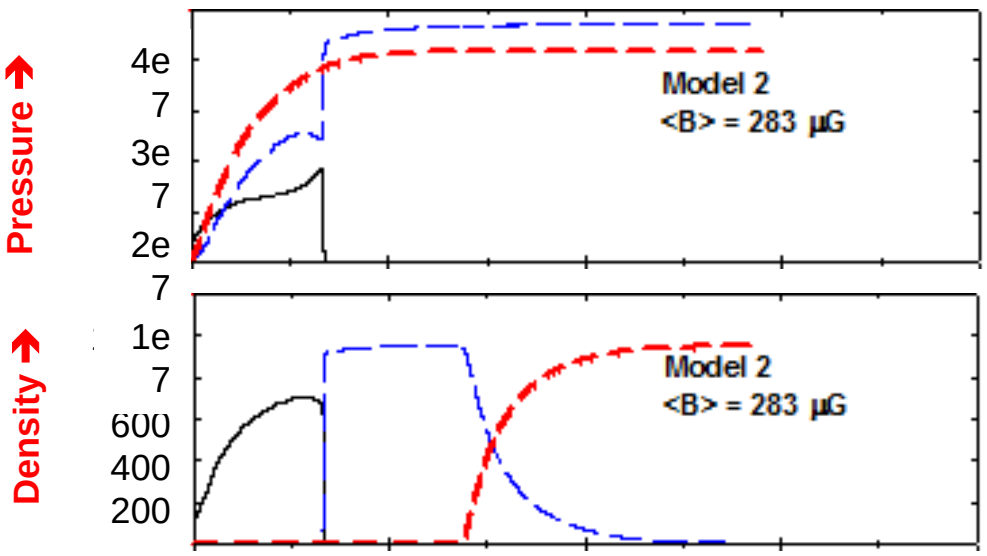
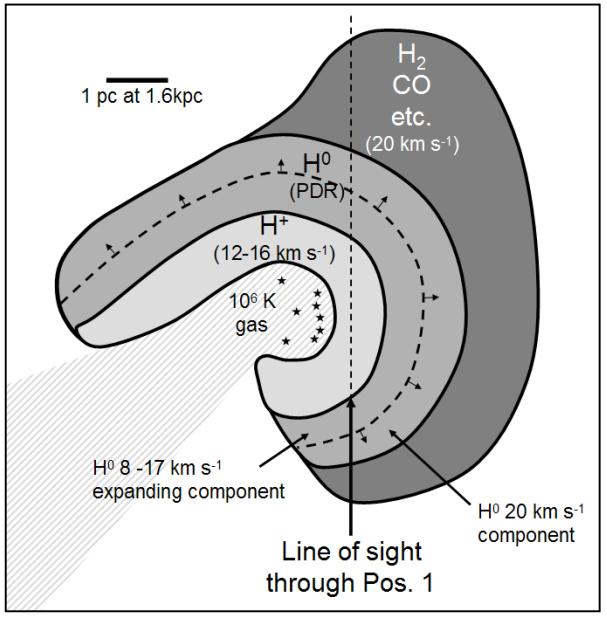


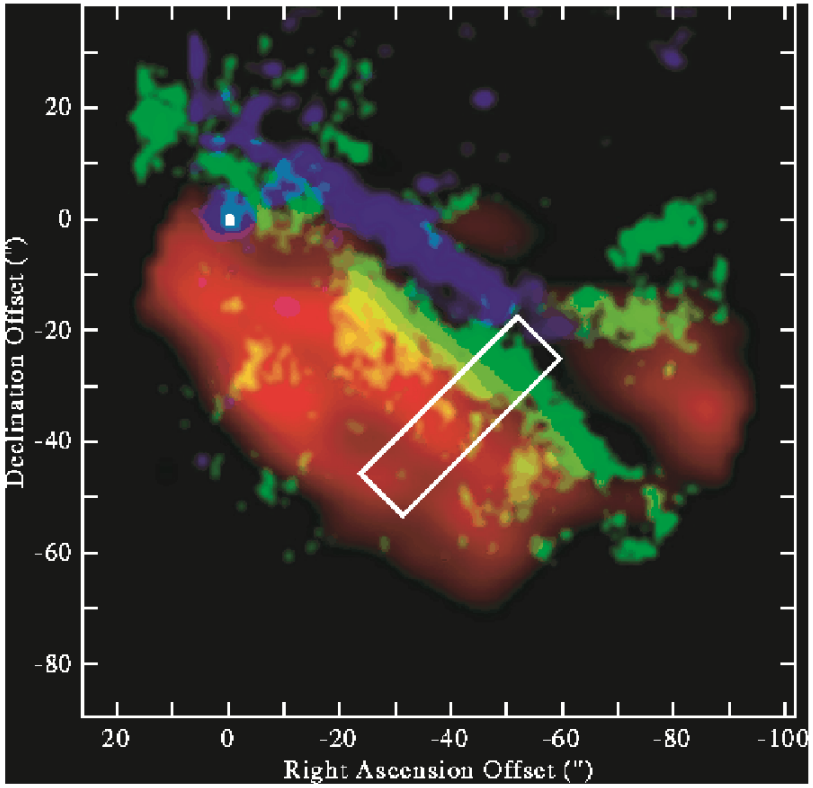


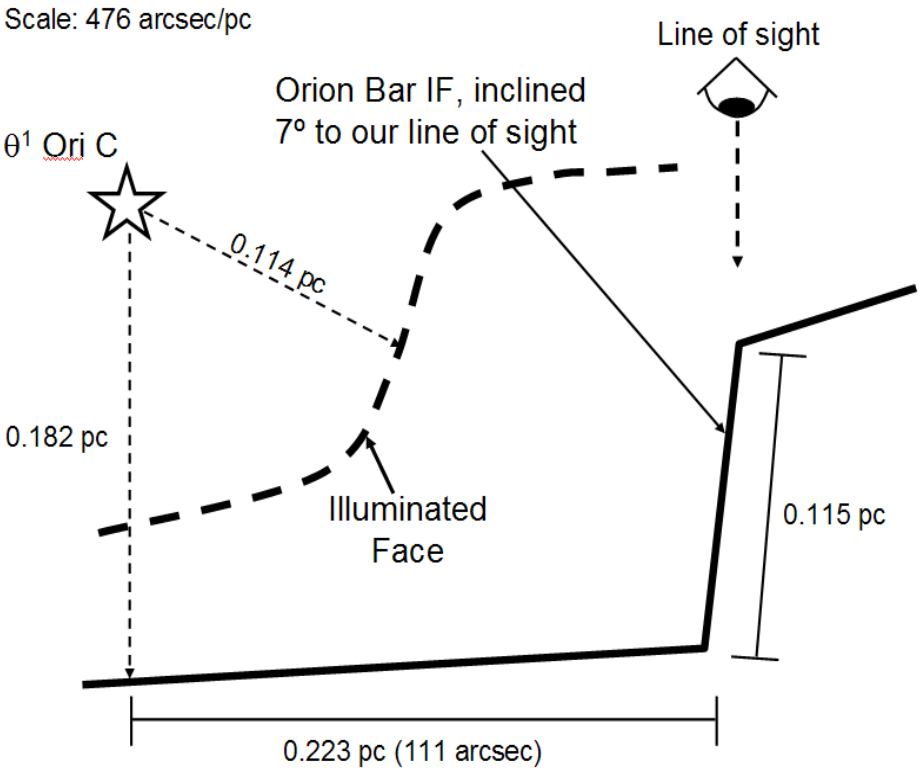
Observed SF EOS

$$B_{\mu G} = 59\sqrt{nT_{x6} + 4.8\frac{Q_{50}\, h\bar{\nu}_{15}}{R_1^2}}$$

$$\left.\begin{array}{c} R_1 = 0.32 \\ nT_{x6} = 3.5 \\ Q_{50} = 1.35 \\ h\overline{\nu_{15}} = 1 \end{array}\right\} \; 487\mu G$$

Observed SF EOS





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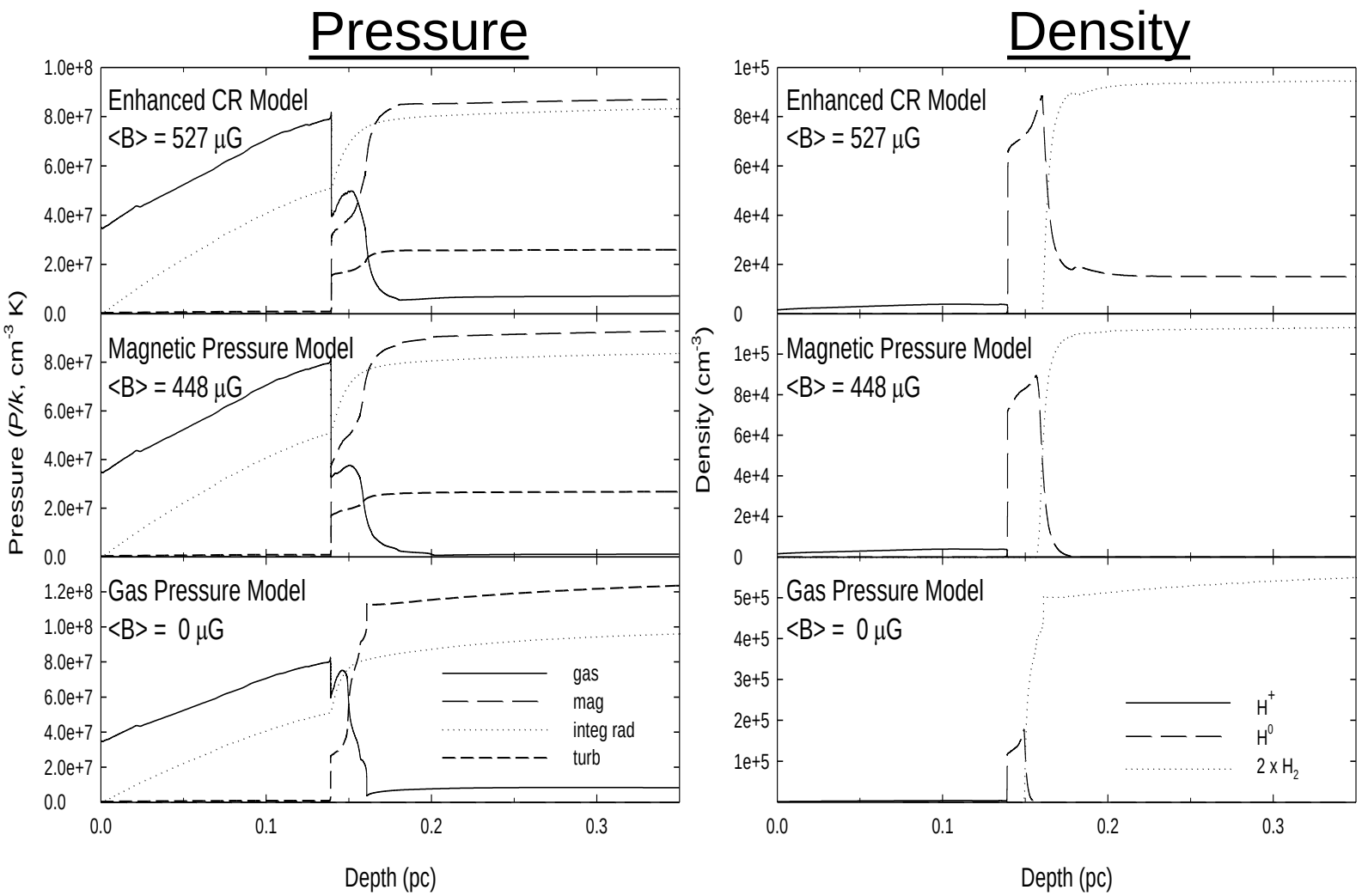
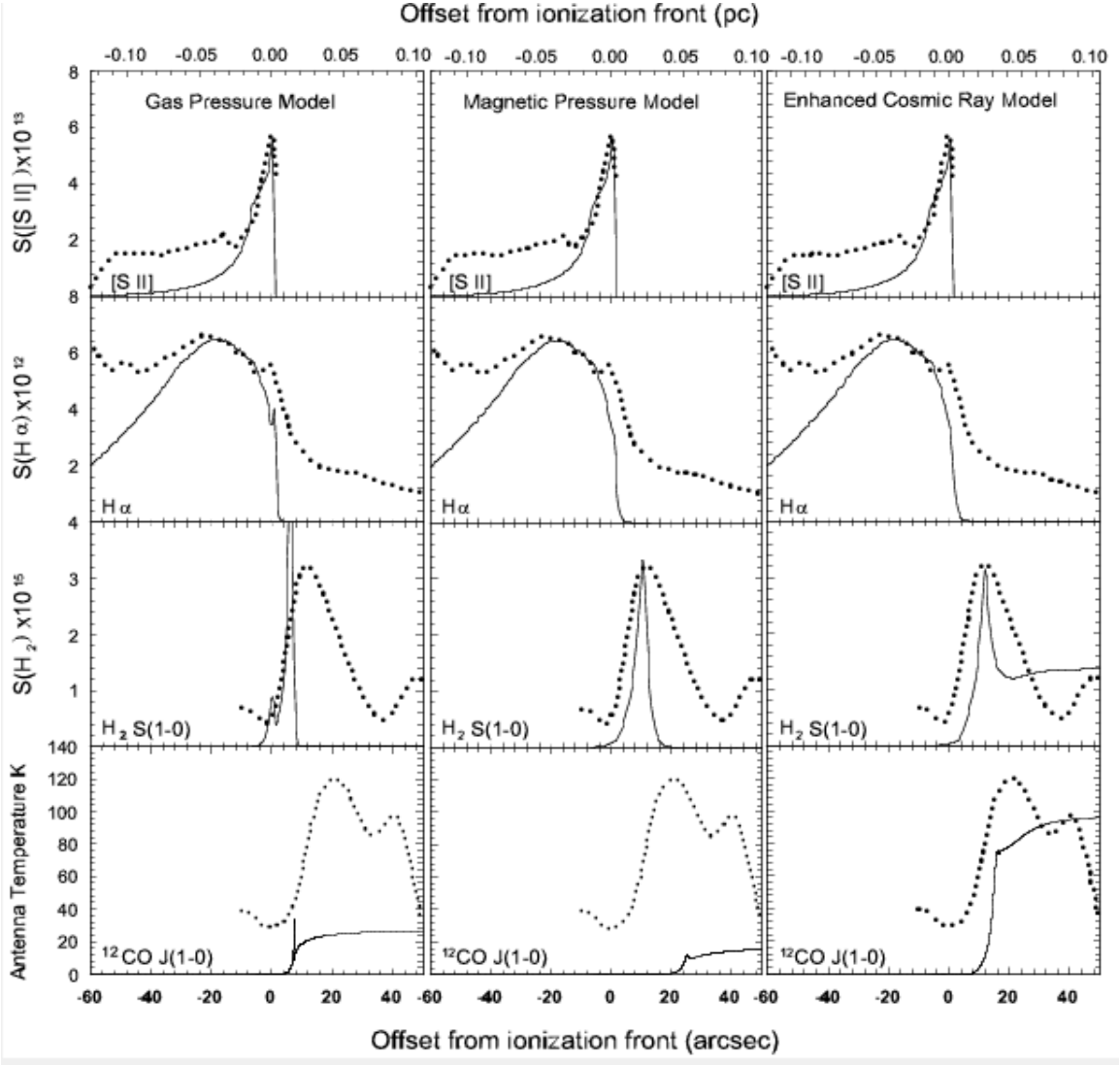


Observed SF EOS

Predicted Surface Brightness



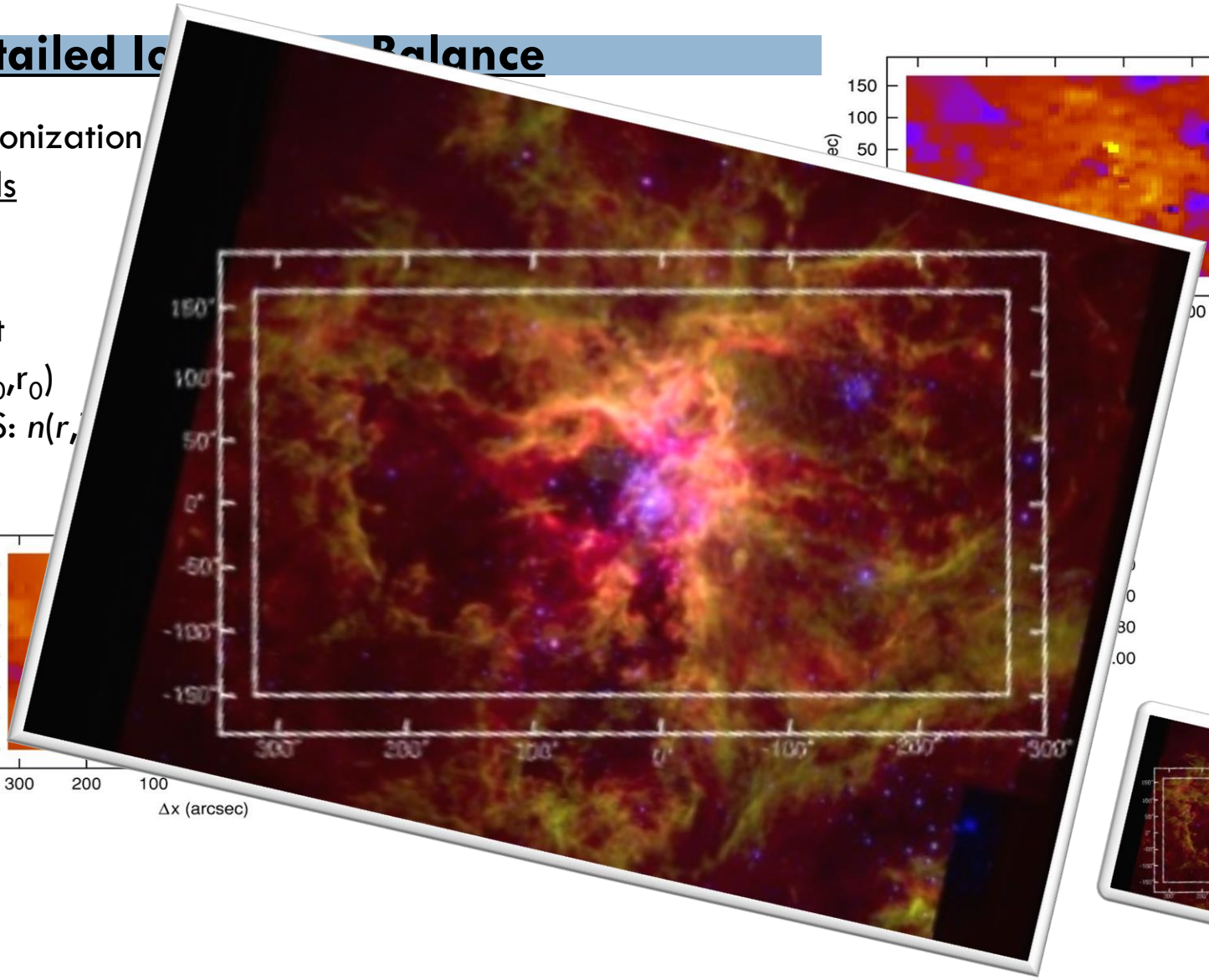
Massive Star Forming Region EOS

Detailed Ic Balance

Photoionization

Models

- Z
- T_{eff}
- Dust
- $U(n_0,r_0)$
- EOS: $n(r,$



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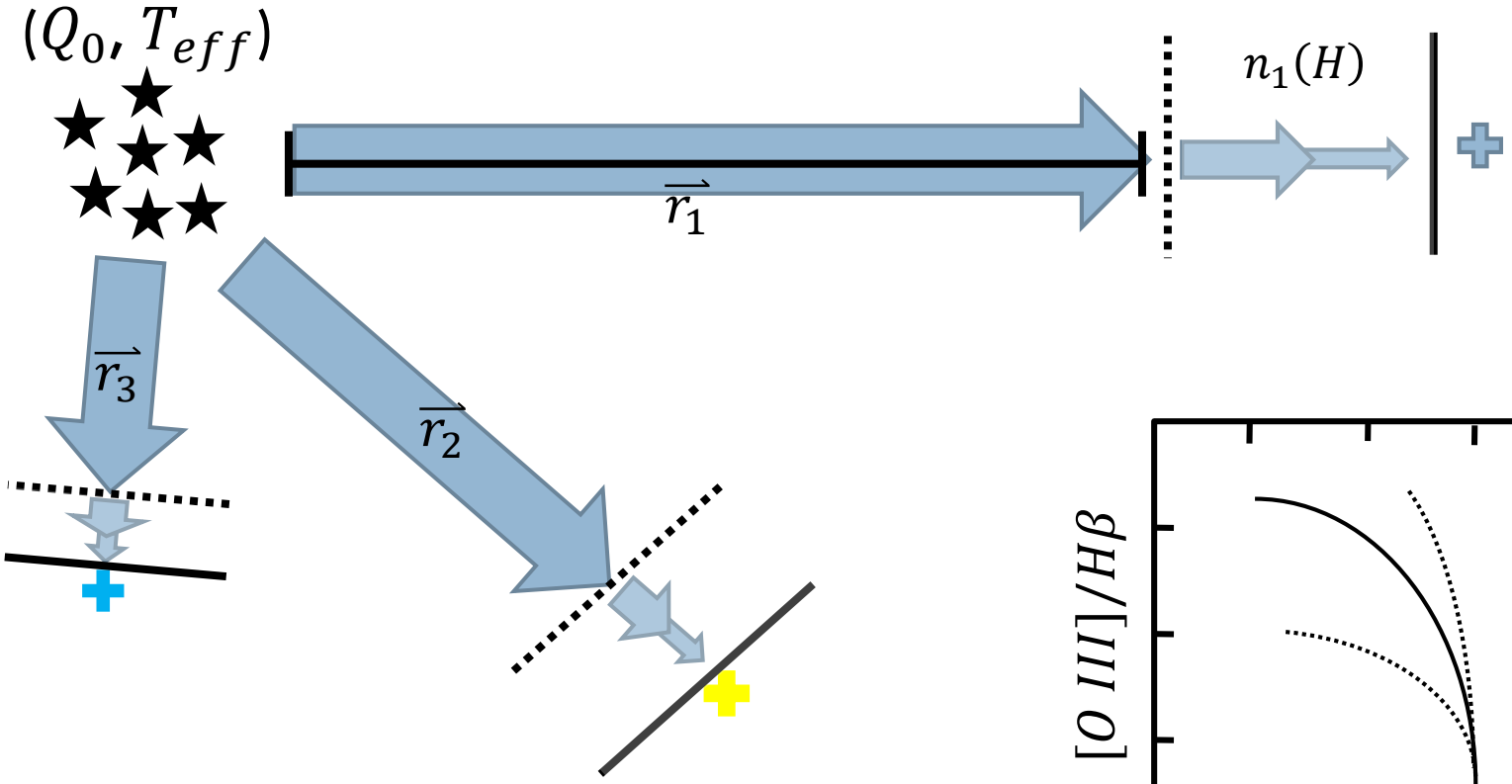
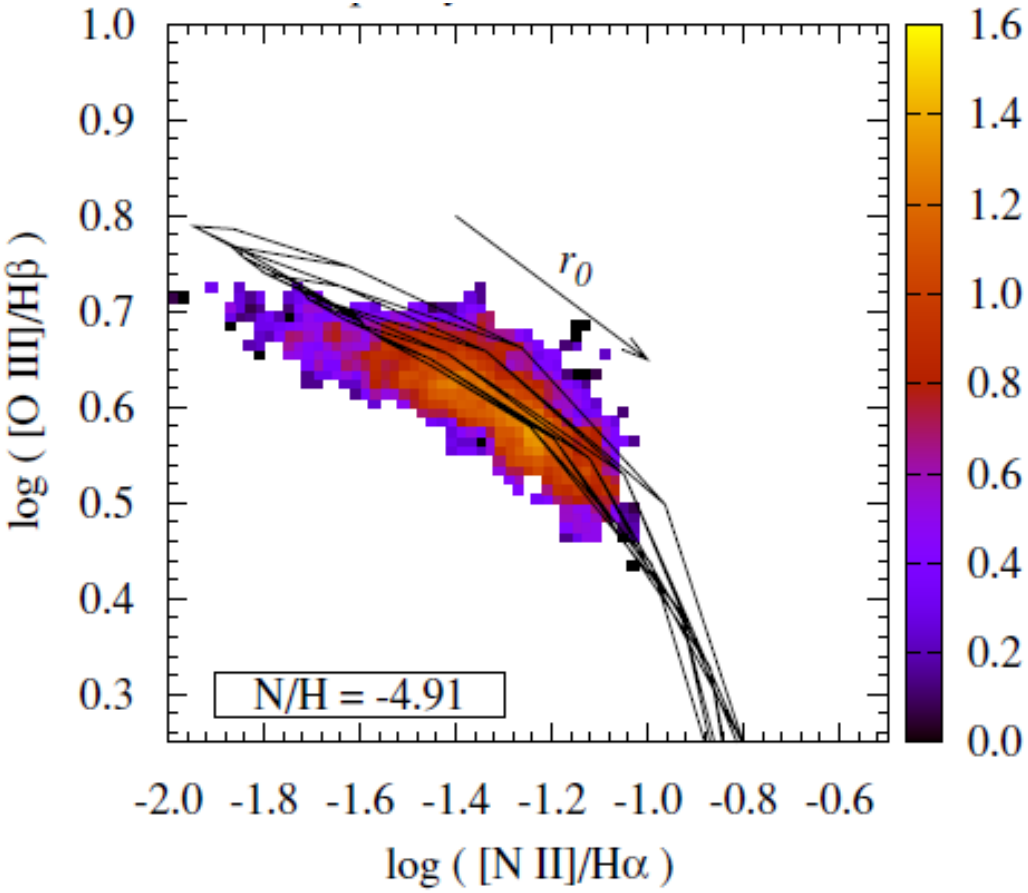


$$P_{rad} = \frac{Q_0(H^0)\,\langle h\nu \rangle}{4\pi\, r^2\, c}$$

$$P_{rad} = U(r)\langle h\nu \rangle n(H)$$

Massive Star Forming Region EOS



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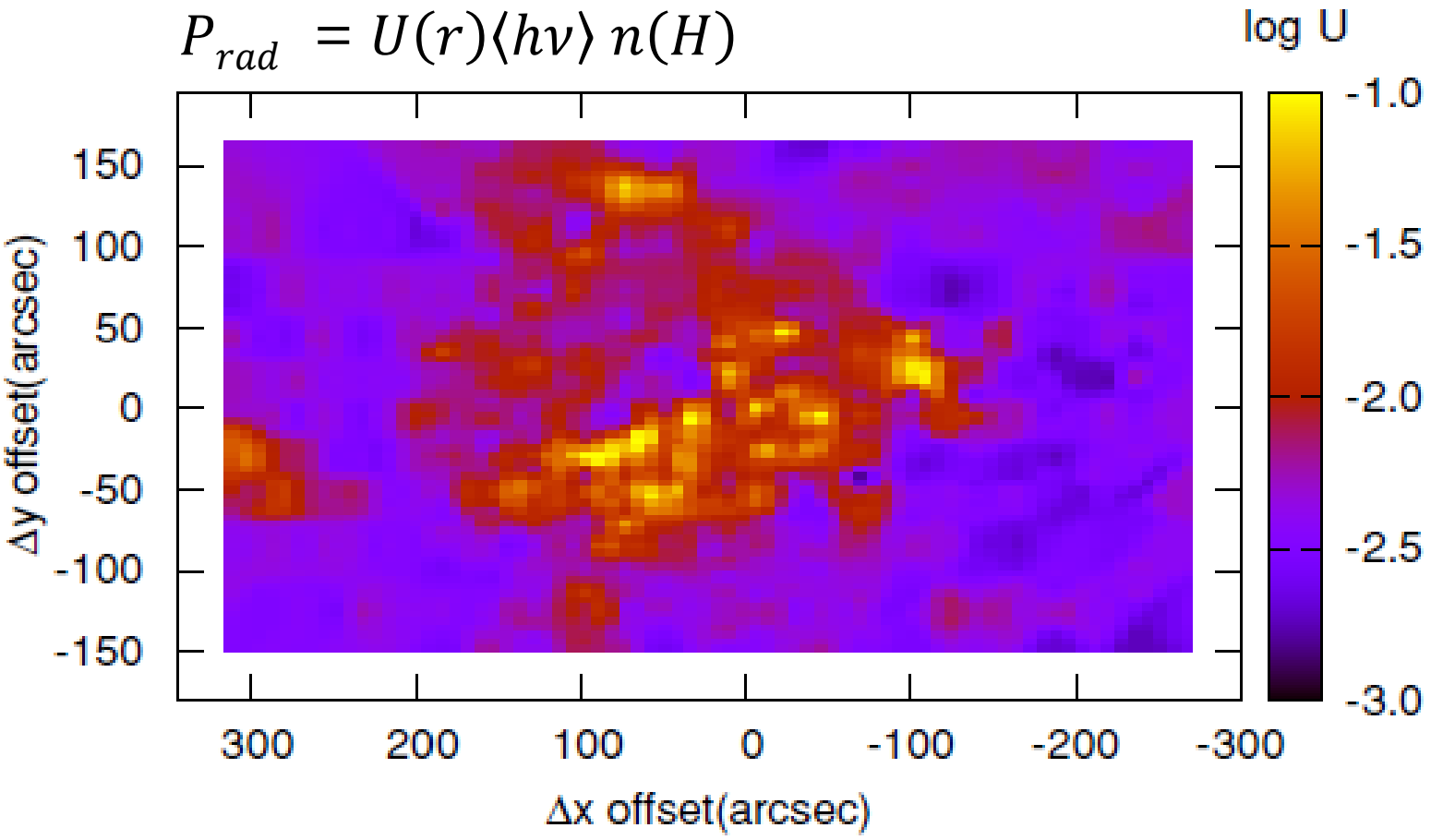

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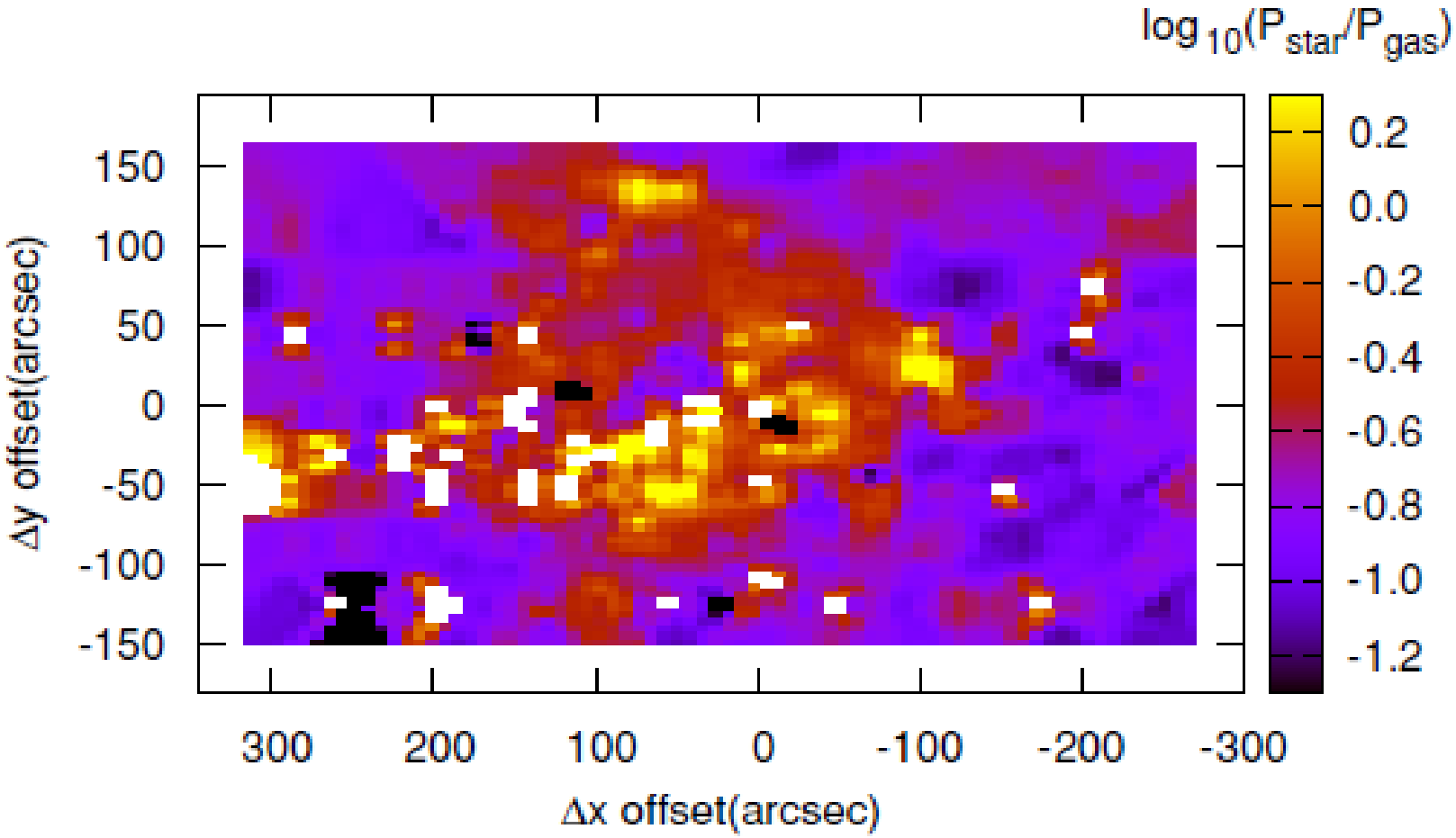

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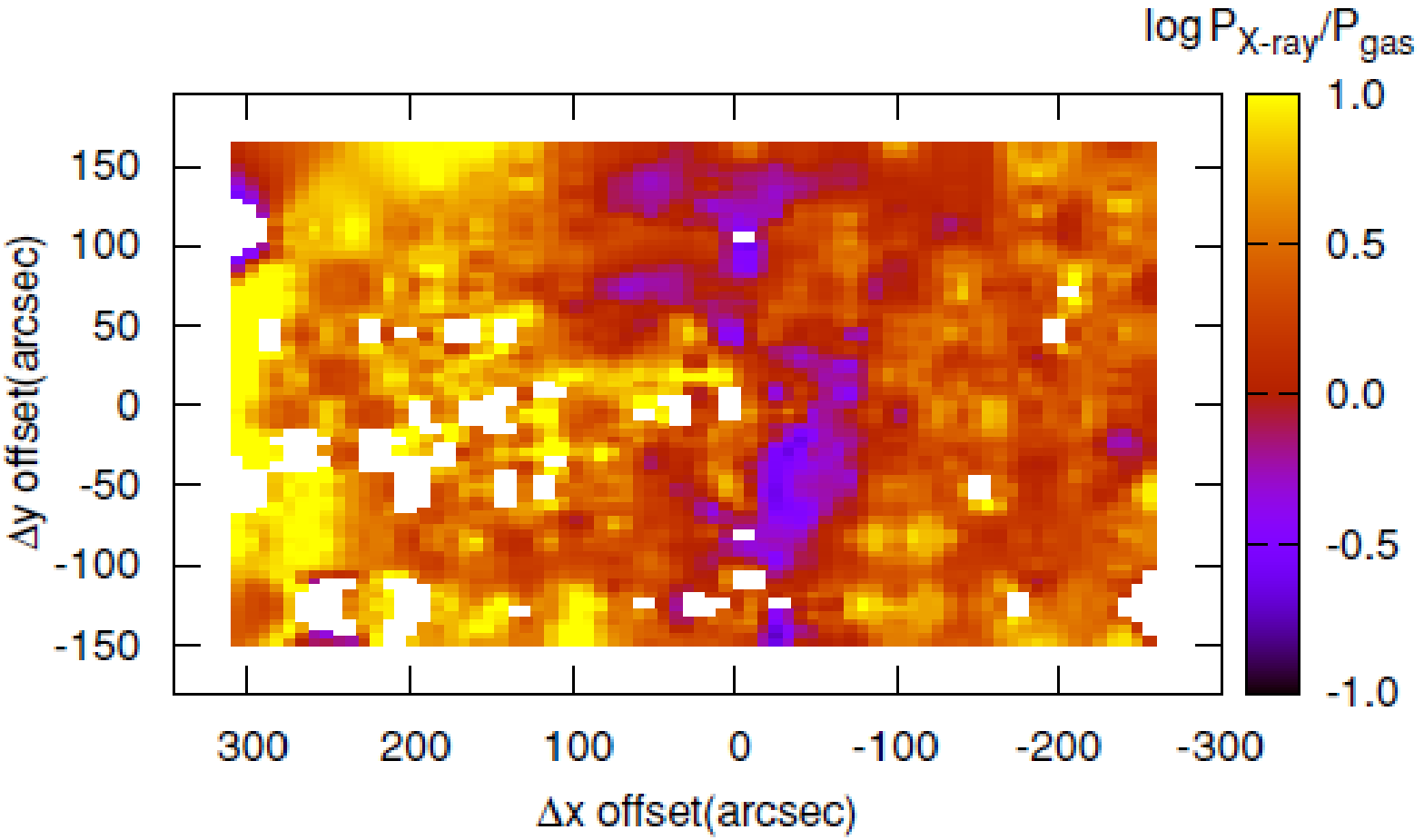
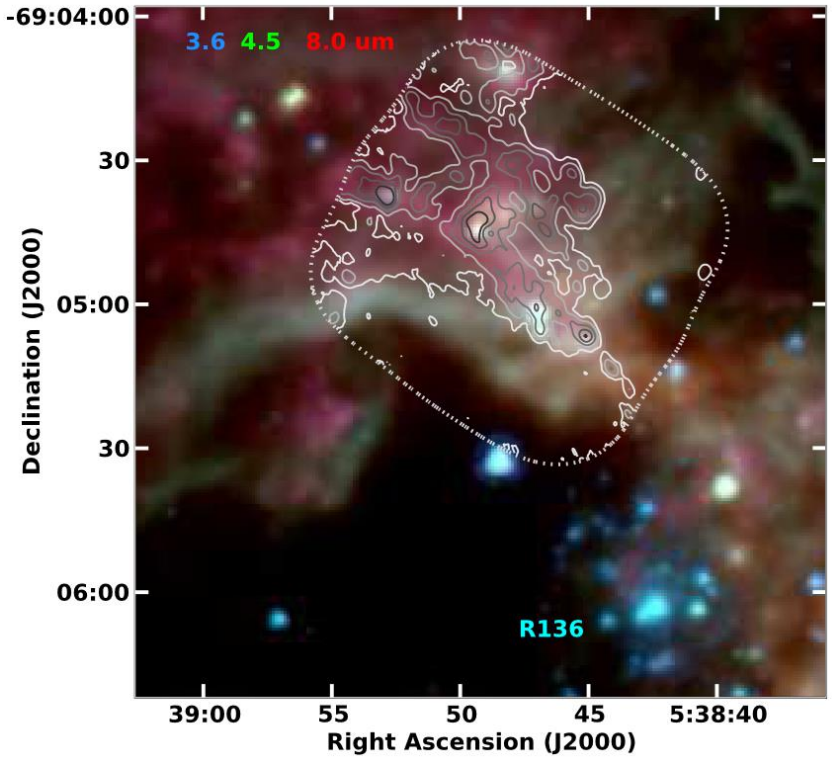
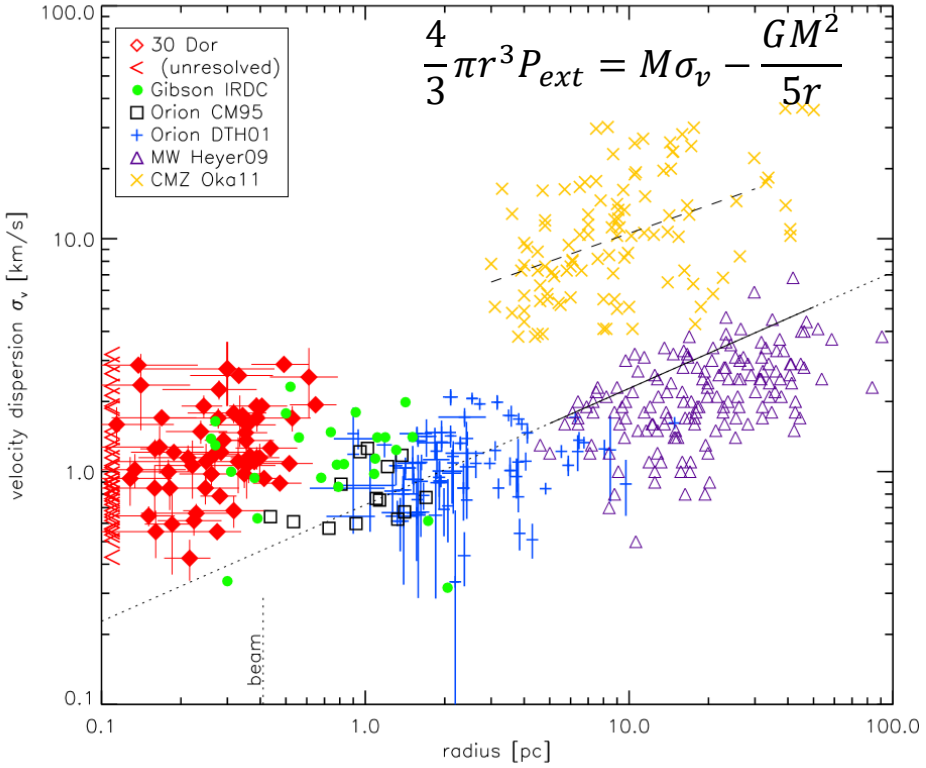


Impact of SF on Molecular Clouds





Indebetow et al. 2013

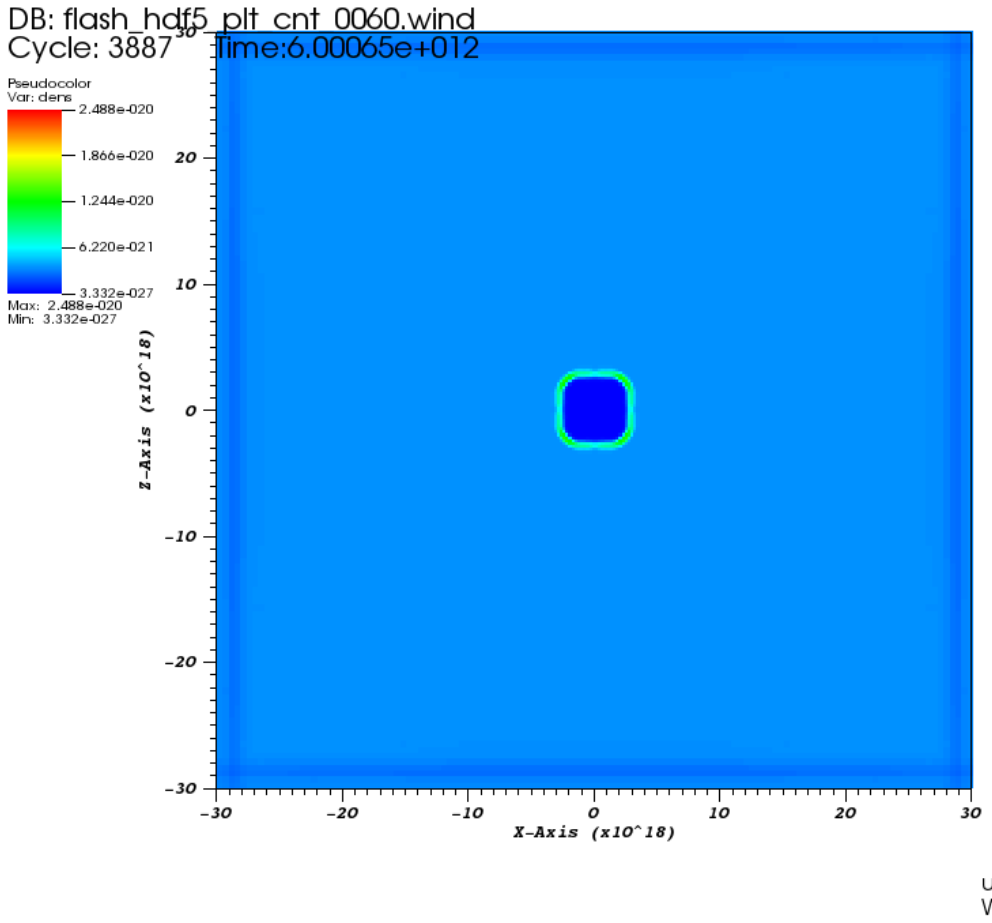
Feedback Summary

	30 Doradus	M17	Orion-Bar
Q(H) s^{-1} Log R (cm) Age (Myr)	52.0 19.8 – 22.5 25	50.0 17.9 1	49.0 17.5 ≤ 0.5
$\frac{P_{rad}}{P_{gas}}$	<0.1-0.4	2	0.4
$\frac{P_X}{P_{gas}}$	1-10	0.2	≤ 1
$\frac{P_{\vec{B}}}{P_{gas}}$	?	2	~0.5

Convergence

- "Full" 5 species chemistry
  - H, H_2, H^+, CO
- Adaptive mesh ray-tracing
- NLTE produces (important @IF)
- ISM heating/cooling
  - ISRF self-shielding (Treecol)

- Self-gravity
  - Sink Particles
- Winds (Andrea Gatto)
- ~~SNe~~
- Radiation
  - w/ stellar evolution
  - Ionization
  - Momentum



user: Chri
Wed Oct

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