

Code Test of Radiative Transfer for Ionization

Seok-Jun Chang

MPA

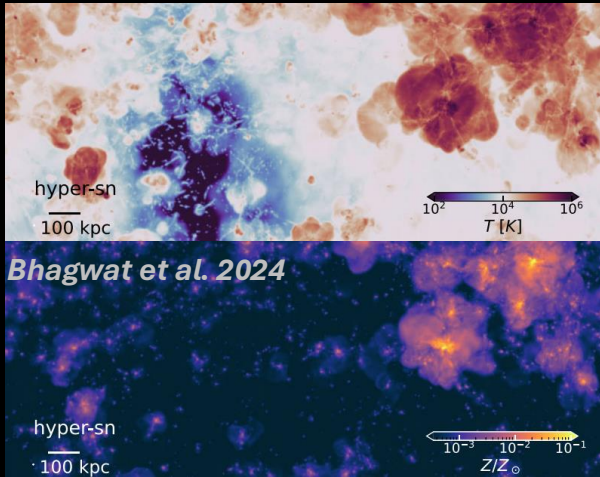


22 Feb 2026, 1st RECAP Workshop, MPA, Garching

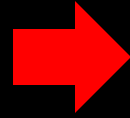
My Role in

RECAP

Development of Radiative Transfer Scheme for Post-Processing



Snapshots of hydrodynamic simulations



RT Codes for Post-Processing include

- Photoionization by Radiation from Stars & AGN
- Collisional Excitation & Ionization
- Recombination
- Continuum Pumping

Photoionization by UV and X-ray

Ray-tracing to estimate the ionization state in CGM/IGM and their temperatures

Non-Resonance Lines (ex., Hydrogen Balmer lines, [O III], [C II], [N II])

Peeling-Off Technique for mock observations

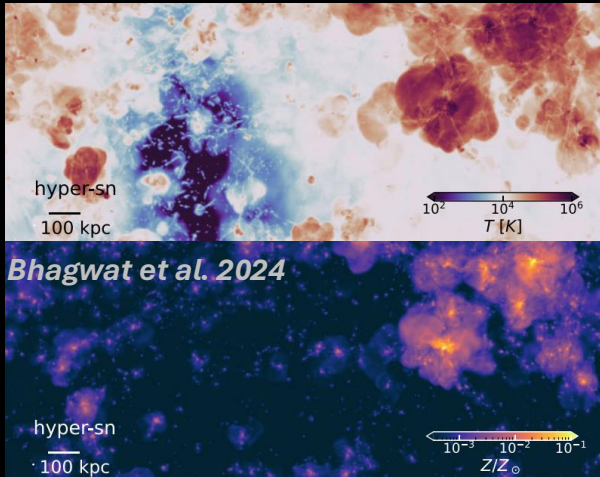
Resonance Lines ($\text{Ly}\alpha$ and metal resonance lines such as Mg II, C IV, O VI)

Ray-tracing for scattering + dust absorption & scattering

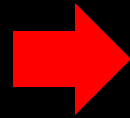
Mock Absorption Spectra

Sub-grid model for multiphase gas

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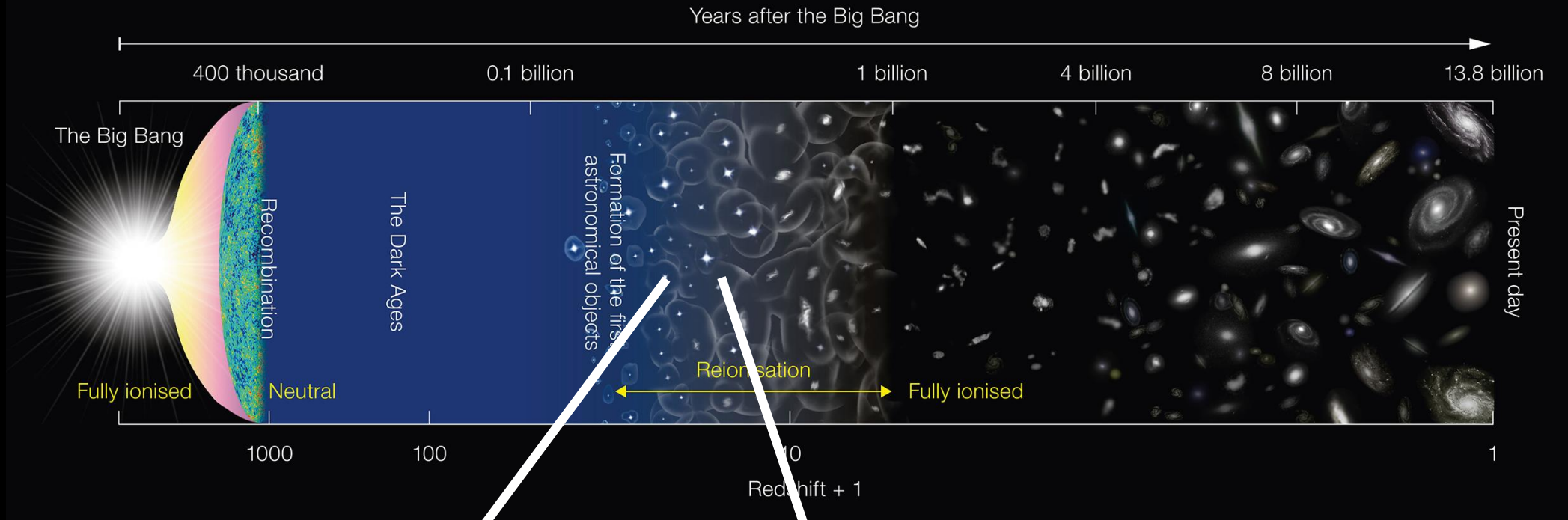
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Reionization of Universe



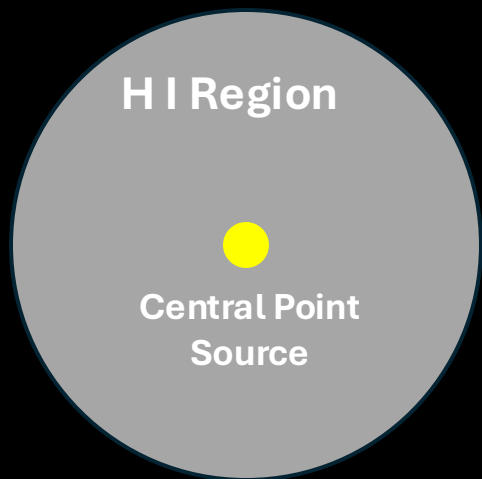
UV & X-ray



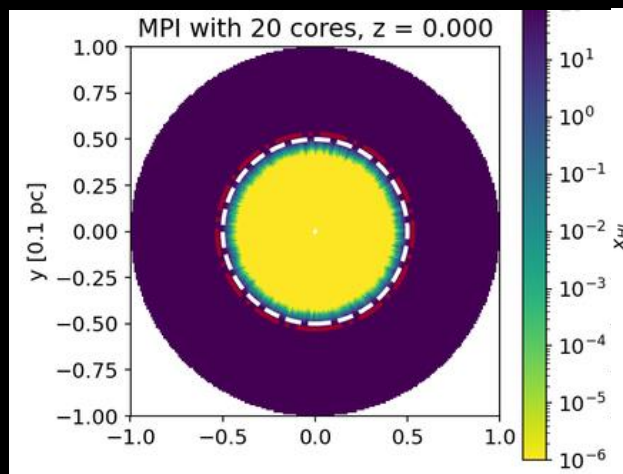
$$\dot{n}_{\text{Ionization}} = n_{\text{HI}} \int_{\nu > \nu_{\text{HI}}}^{\infty} \frac{4\pi J_{\nu}}{h\nu} \sigma_{\text{HI}}(\nu) d\nu$$

$$\dot{n}_{\text{Recombination}} = n_e n_{\text{HII}} \alpha(T)$$

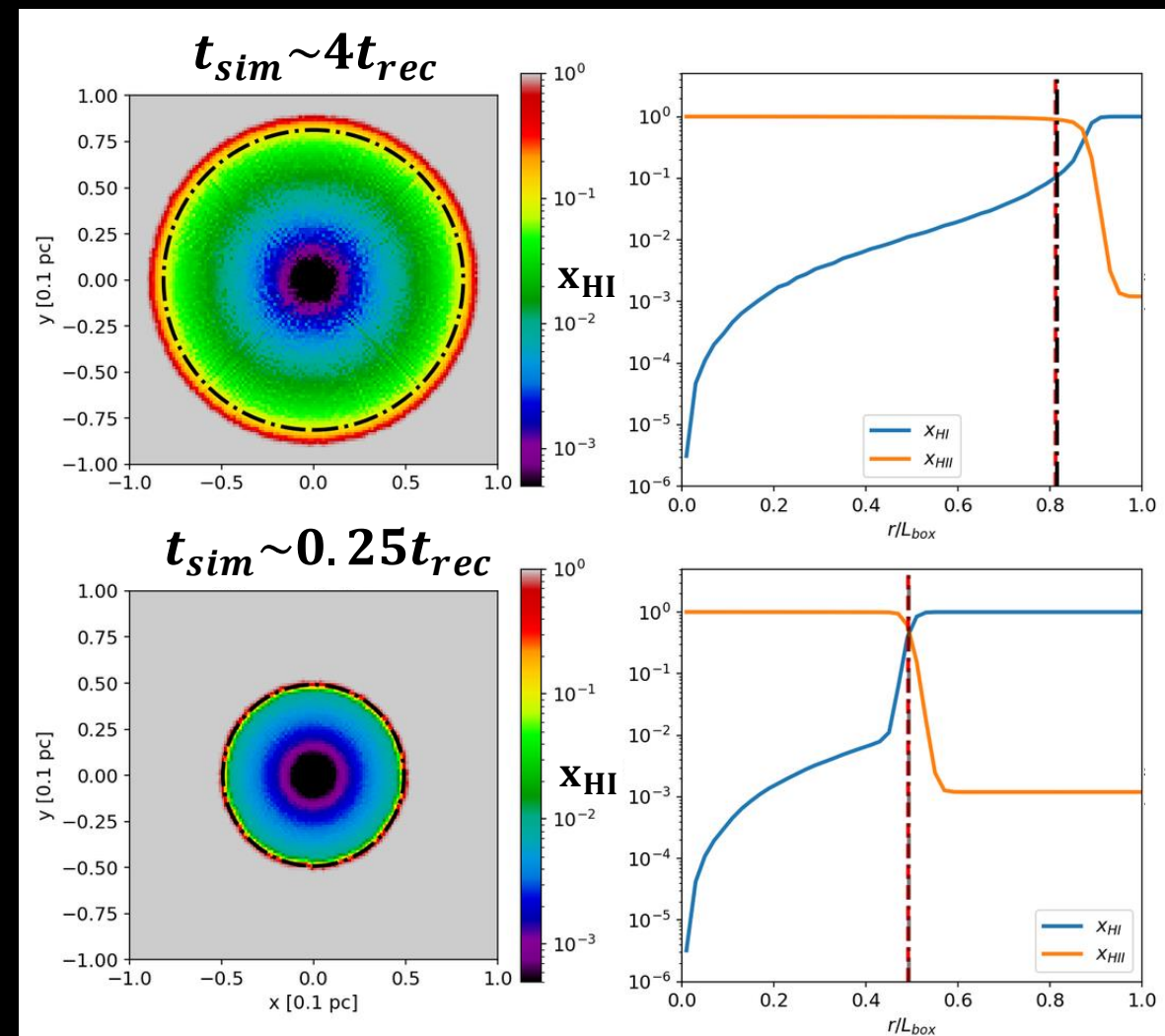
3D RT for Photoionization



Monochromatic source
with $E_{\text{photon}} = 13.6 \text{ eV}$

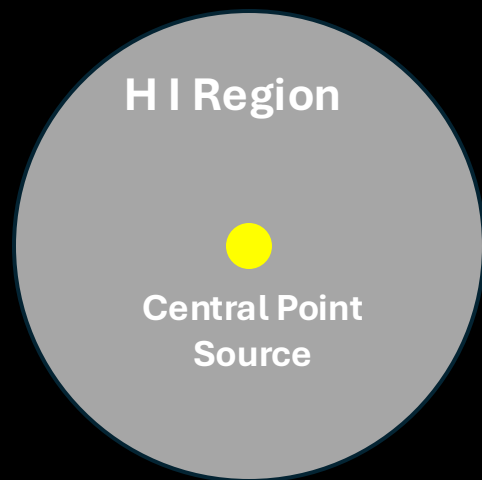


without recombination

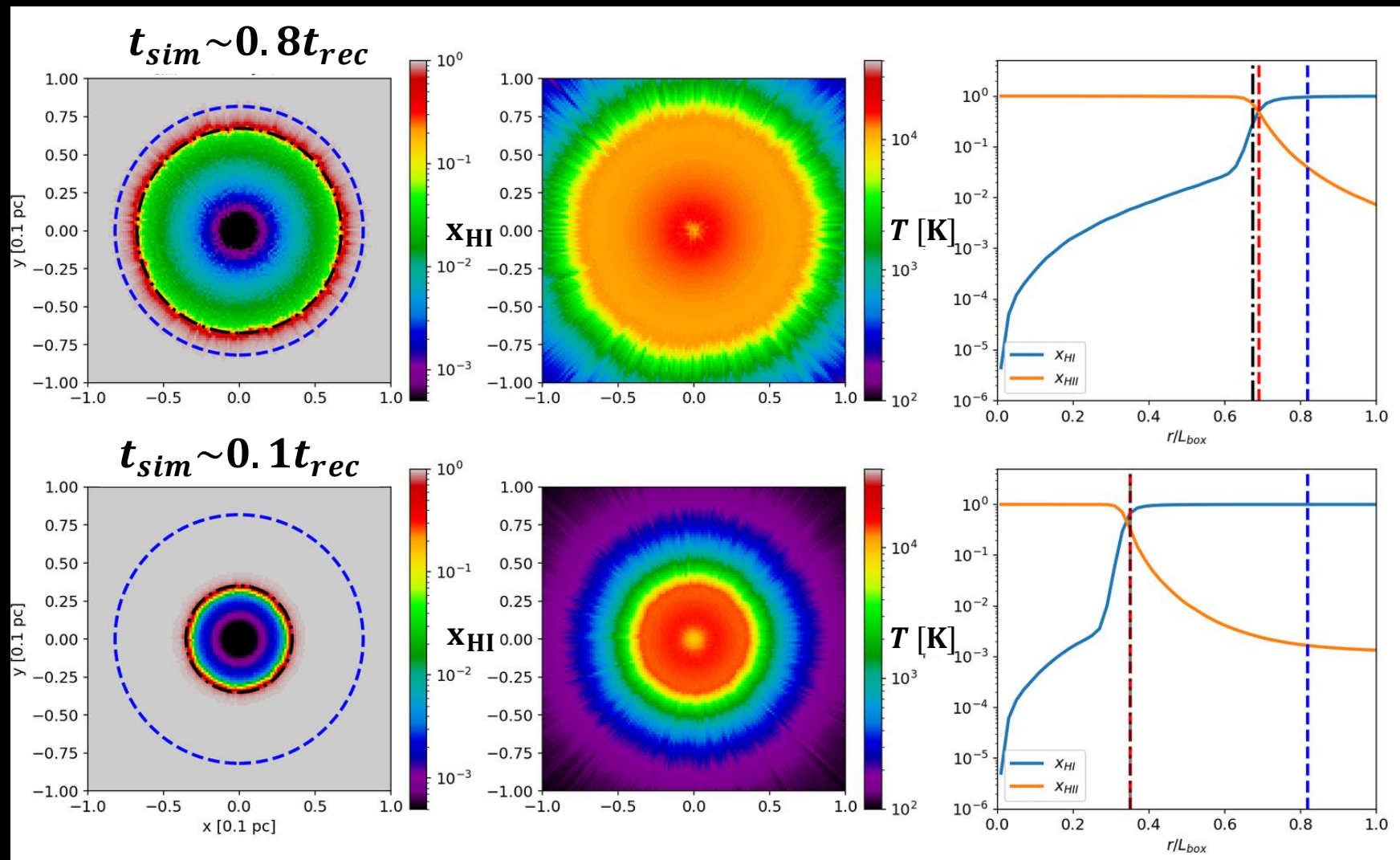


with recombination

3D RT for Photoionization



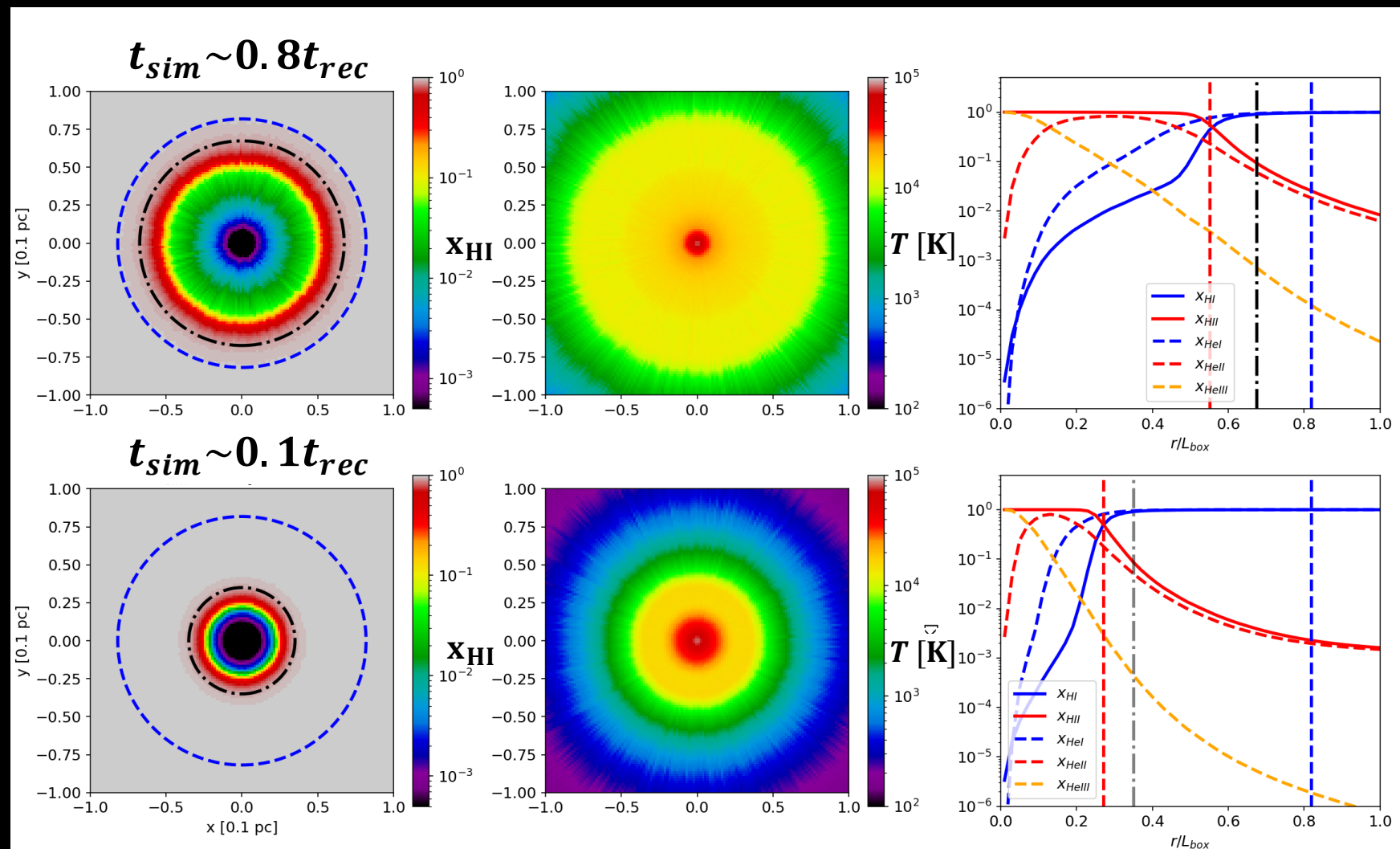
Blackbody radiation
at $T = 10^5$ K
+ heating & cooling



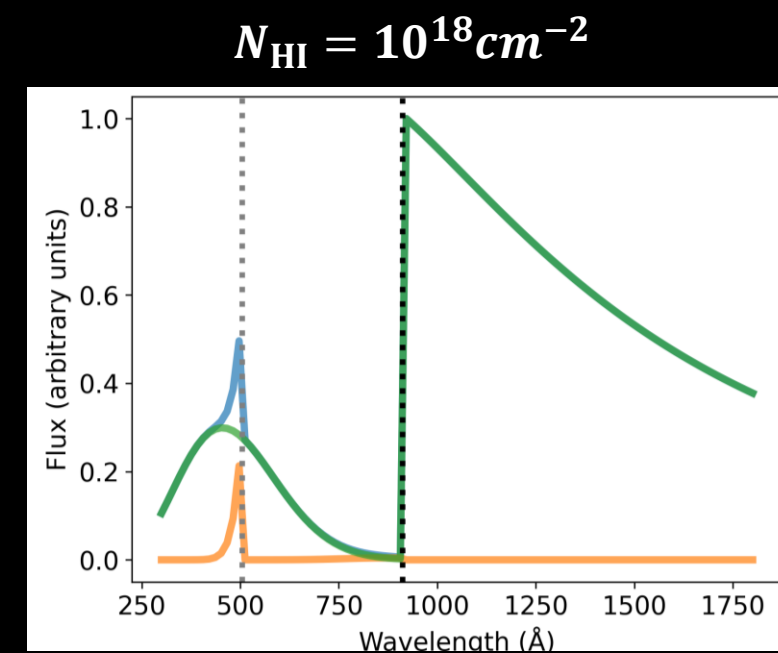
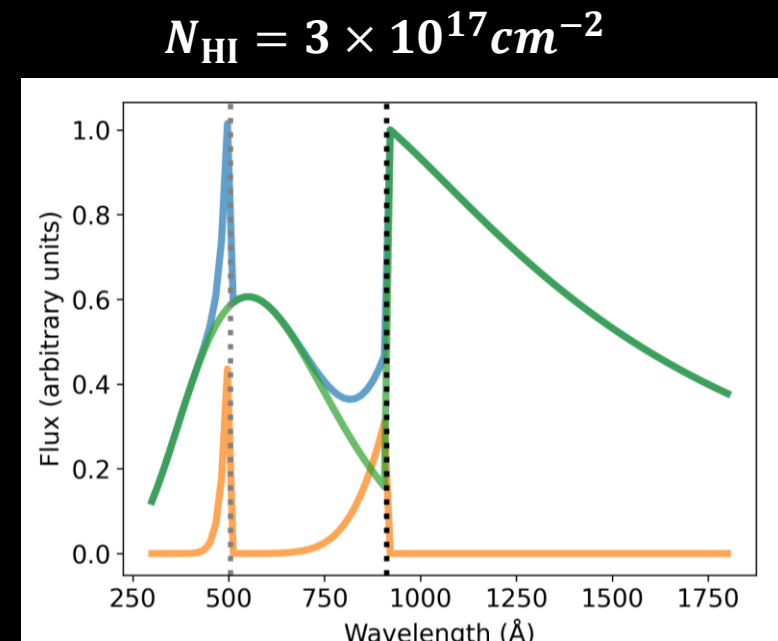
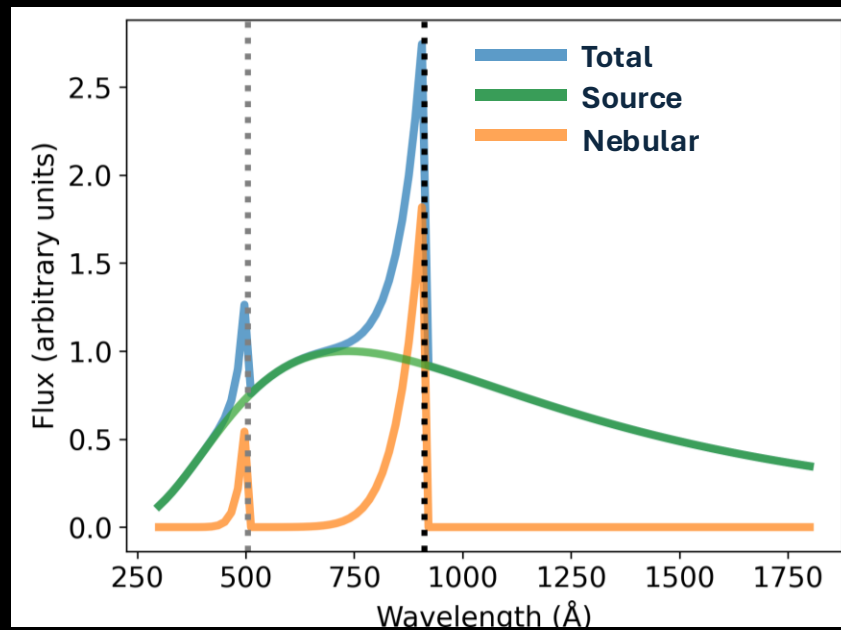
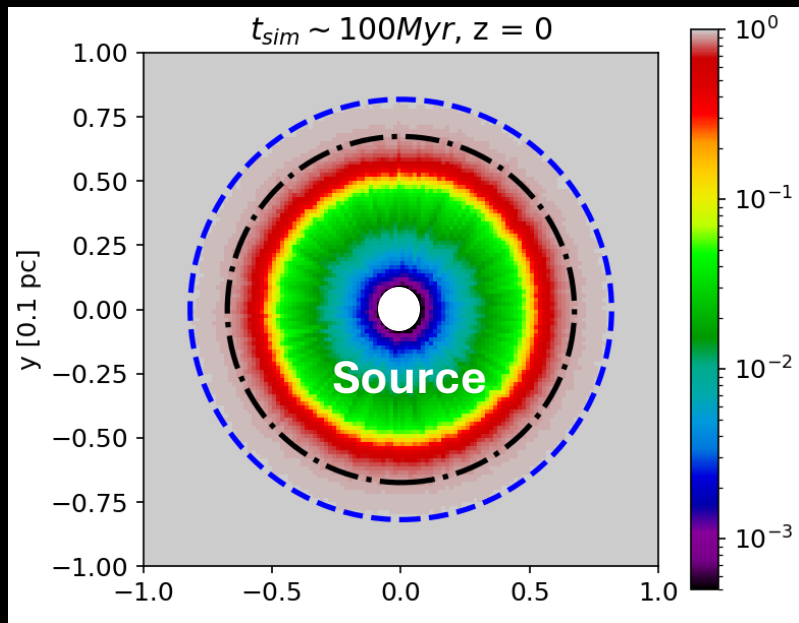
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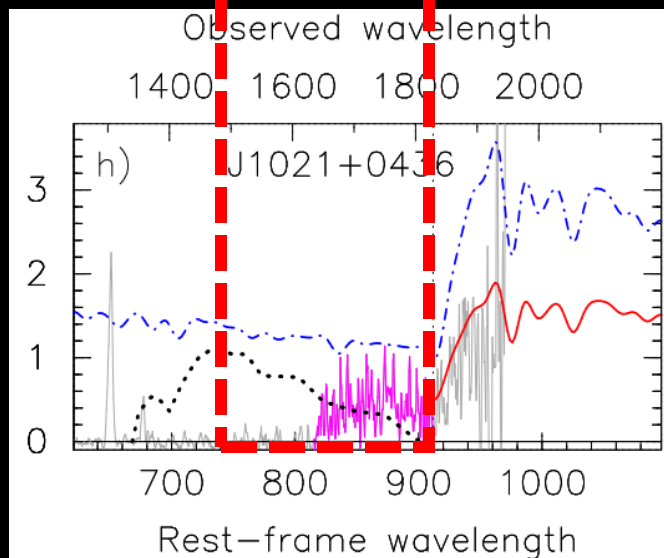
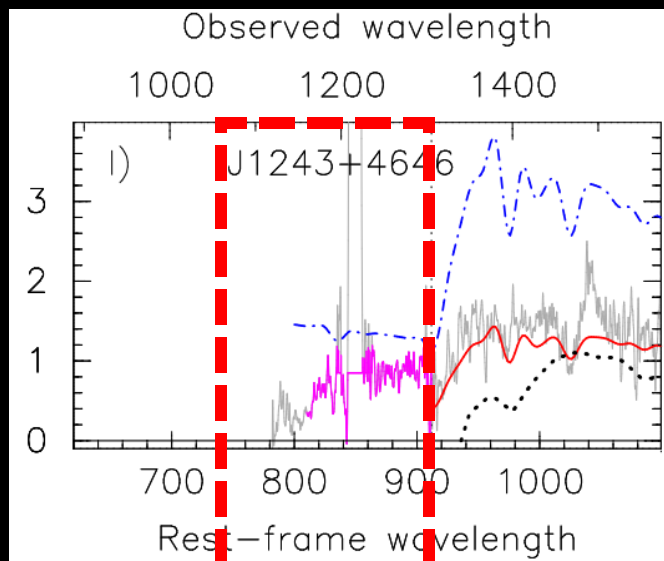
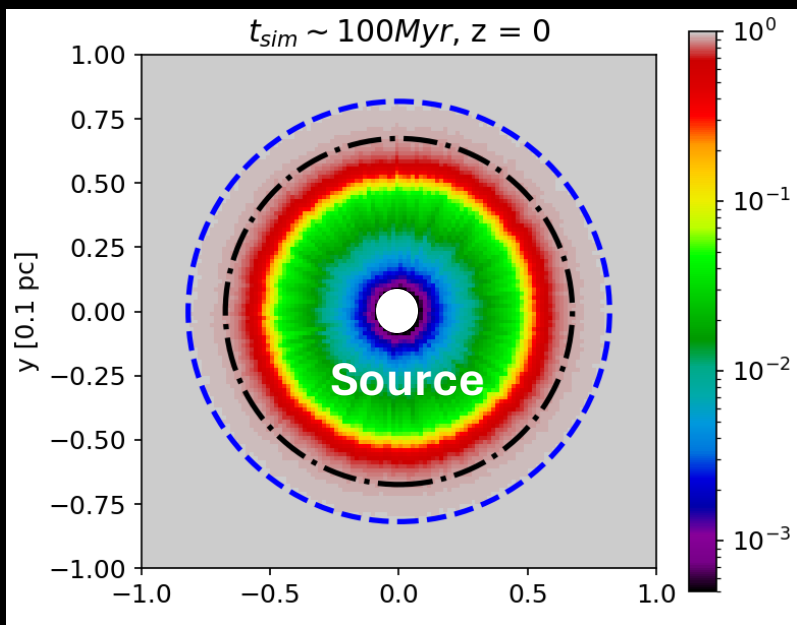


LyC Escape & Nebular LyC

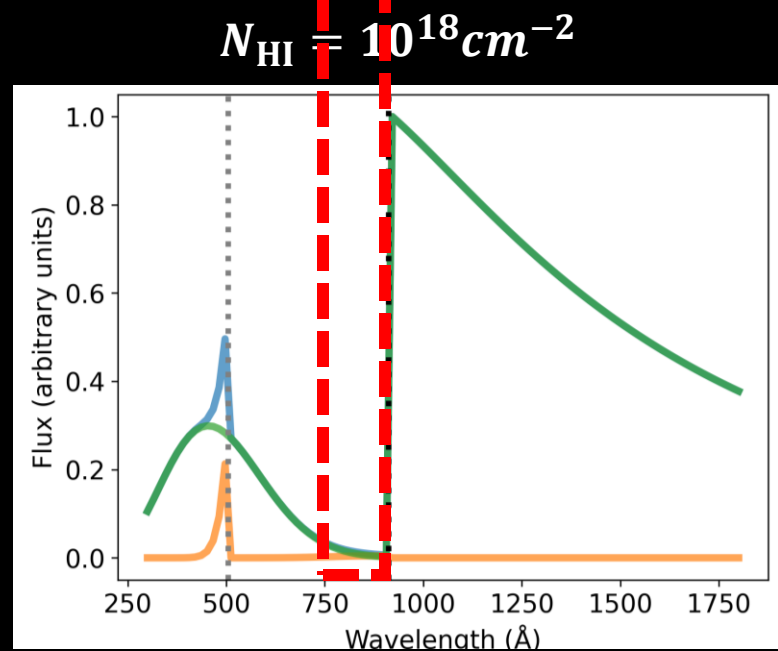
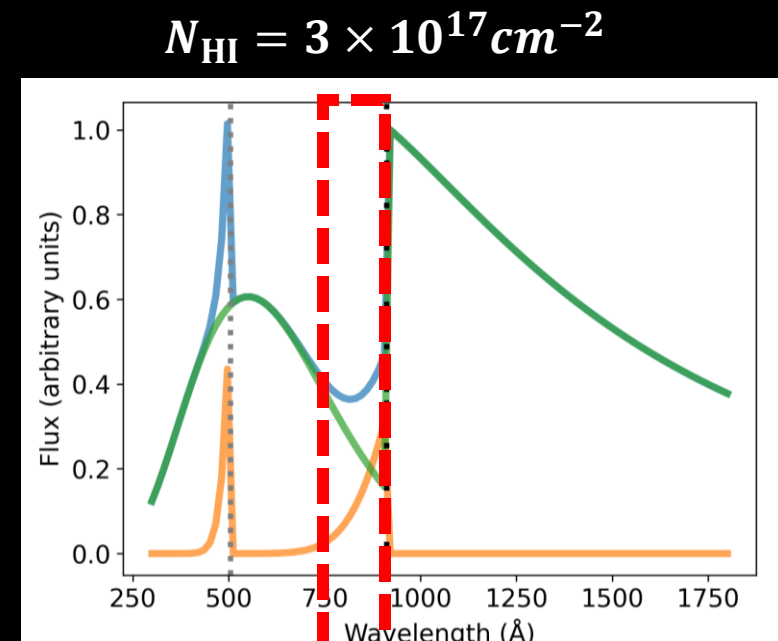


LyC Escape & Nebular LyC

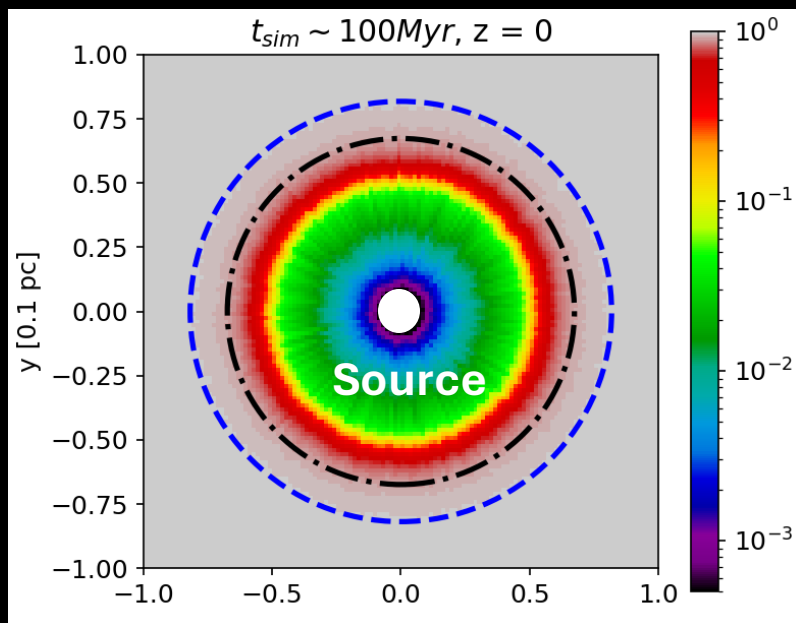
Izotov et al. 2025



Spectra of LyC Leakers

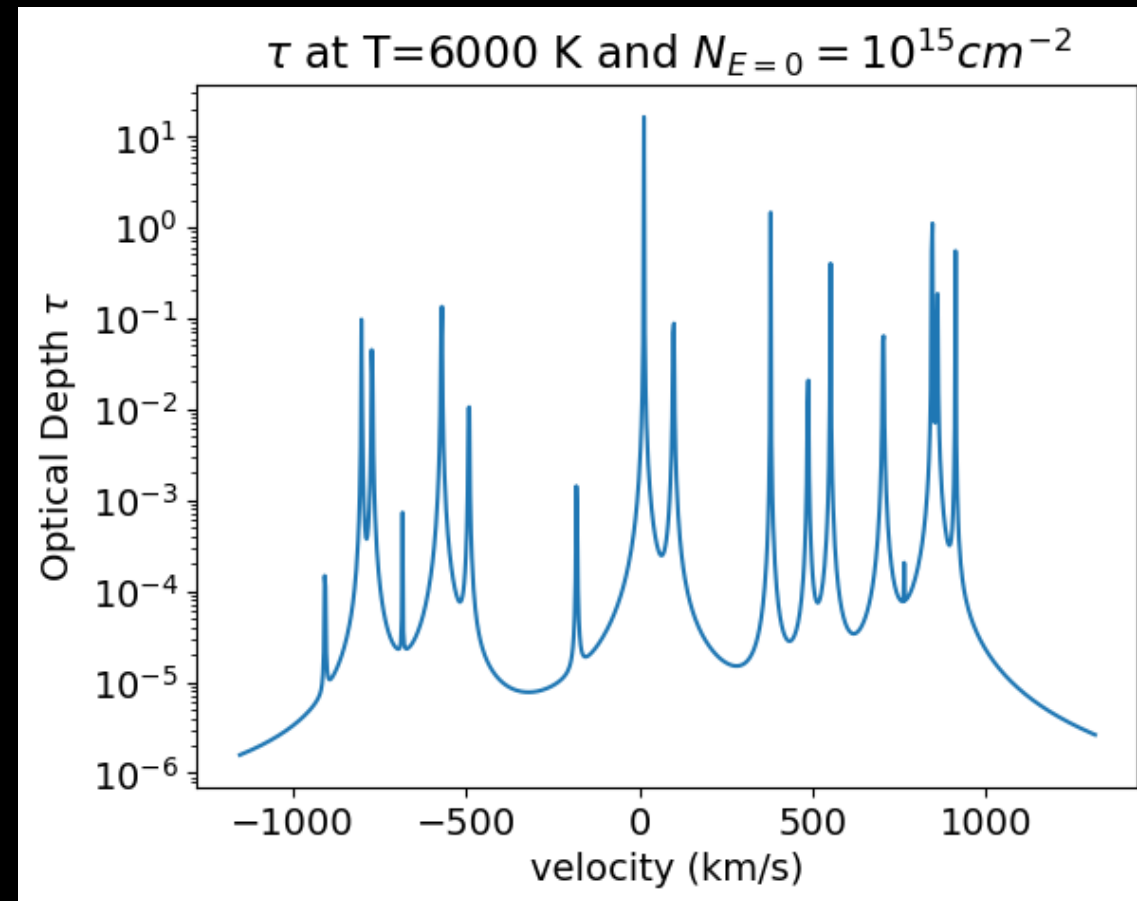
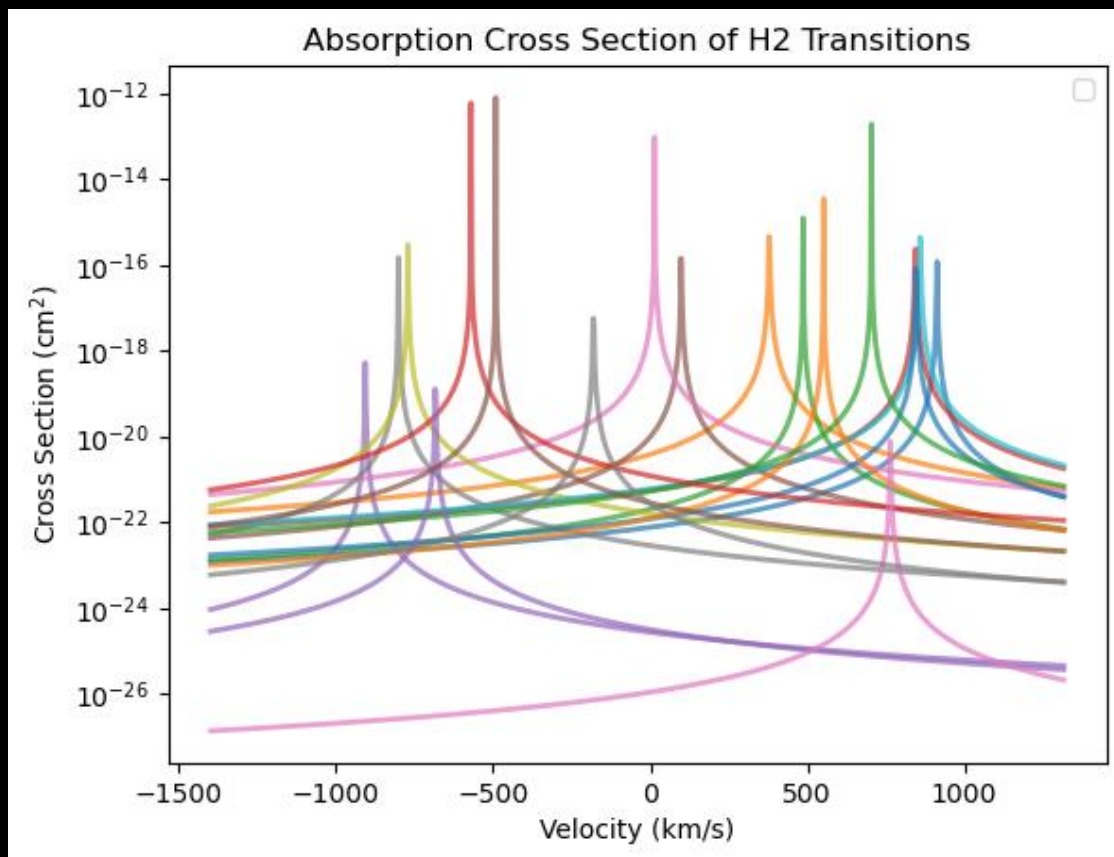


LyC & Ly α Escape in H II Region



- Ionized state of H & He
- Intrinsic nebular continuum (free-bound transition)
- Ly α emission (recombination + collisional excitation)
- Mock SED and emission line spectra (Ly α and H α)
considering the kinematics of H I & H II gas
- Compare with observed spectra
- Consider anisotropic radiation & geometry

H₂ Molecules Impact on Ly α Formation



Acknowledgement & Disclaimer

- Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Council Executive Agency. Neither the European Union nor the granting authority can be held responsible for them.
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