

# The build-up of the Lyman-Werner background during cosmic structure formation

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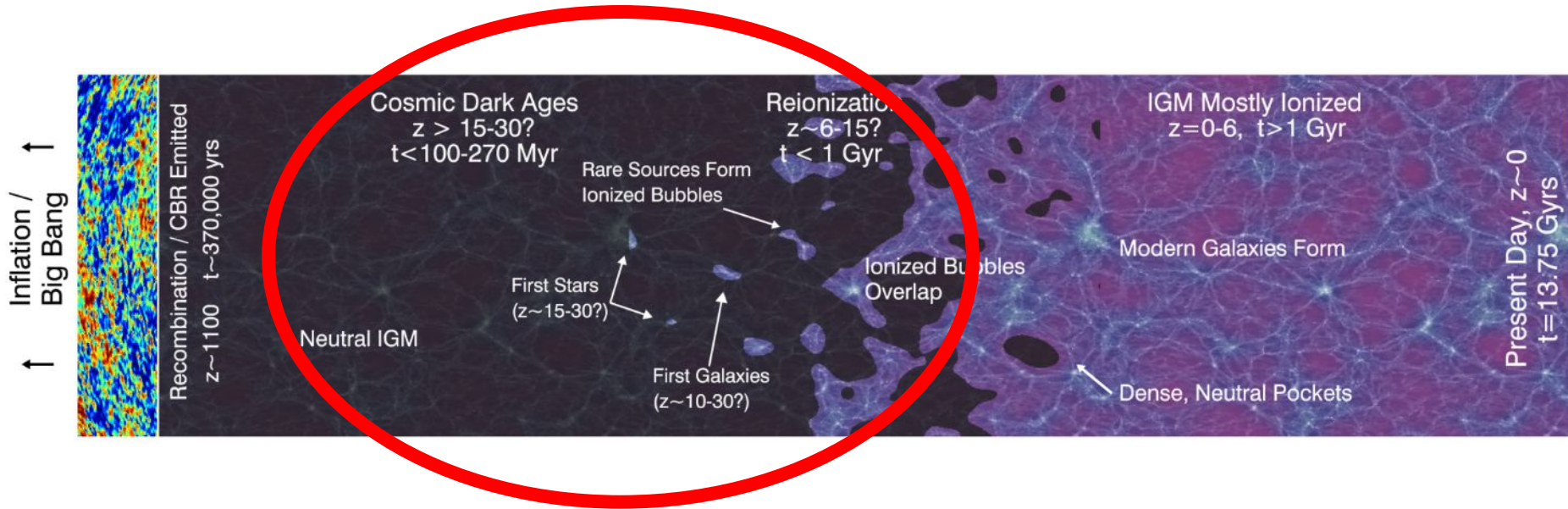
*he/him*

w/ Sadegh Khochfar (IfA) & Jose Oñorbe (Seville)

Special thanks to Britton Smith (IfA)

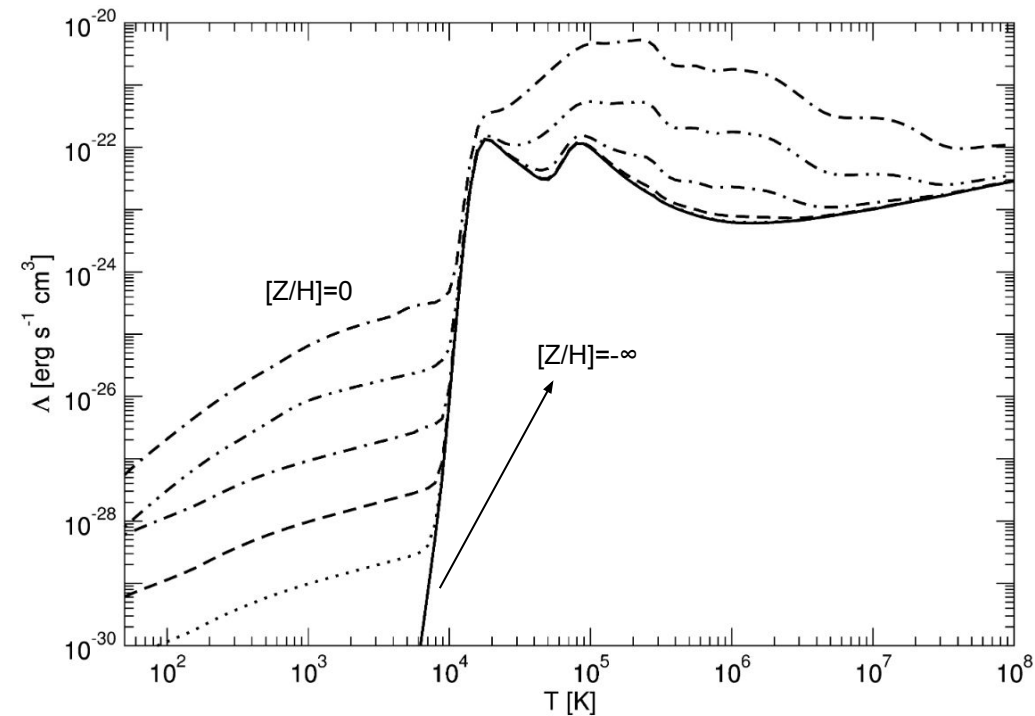


# A plot you may have never seen

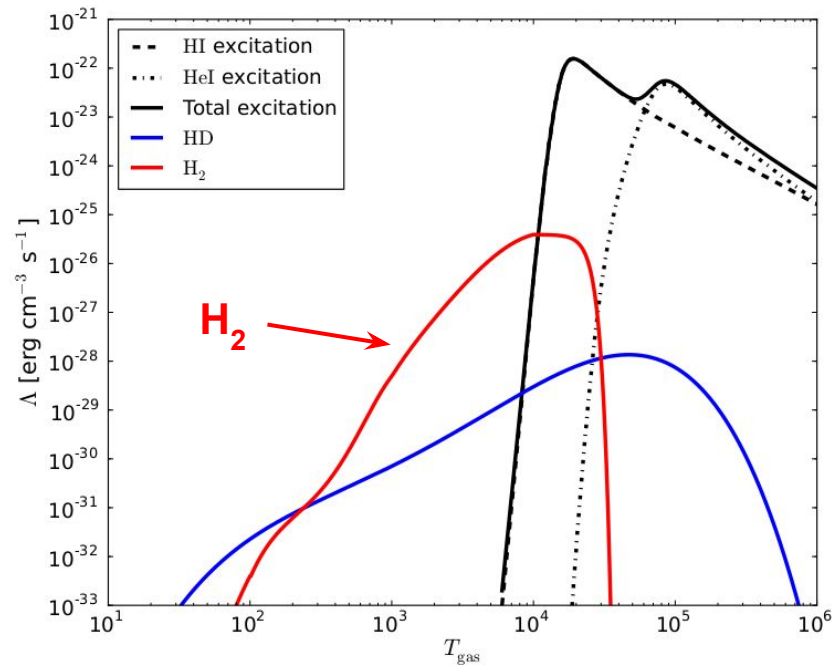




# It's all a matter of cooling

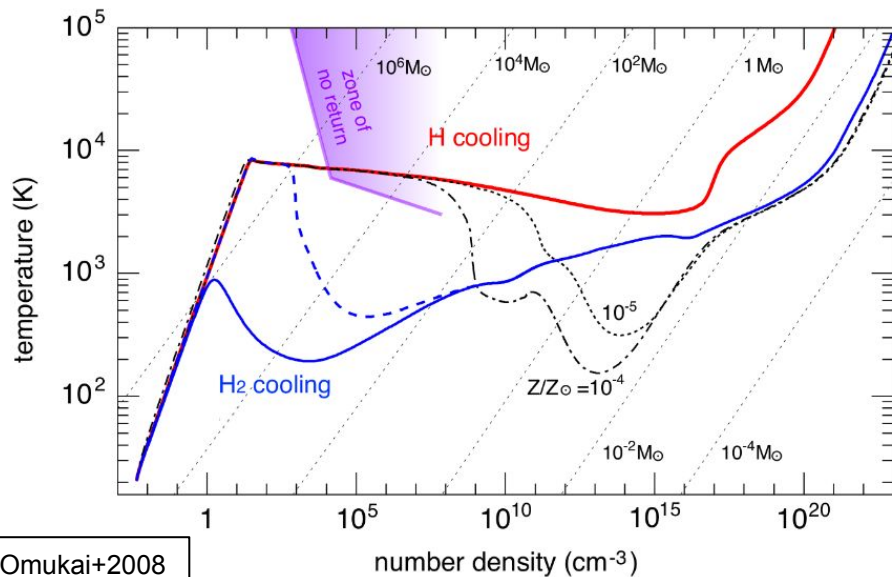


Smith+2008

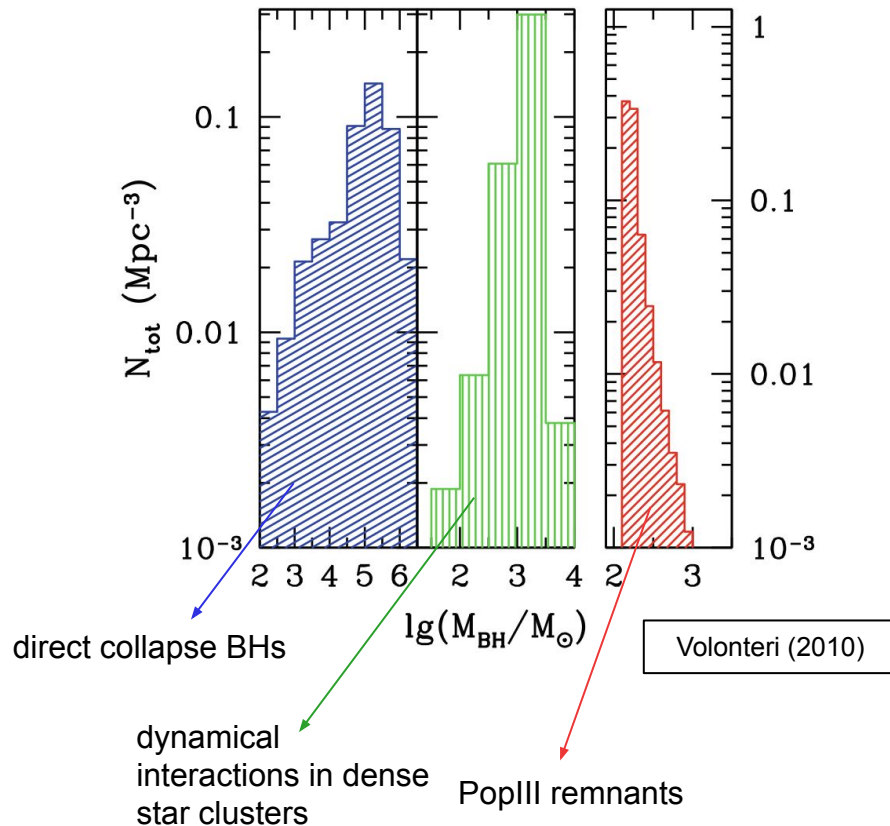


Bovino+2019

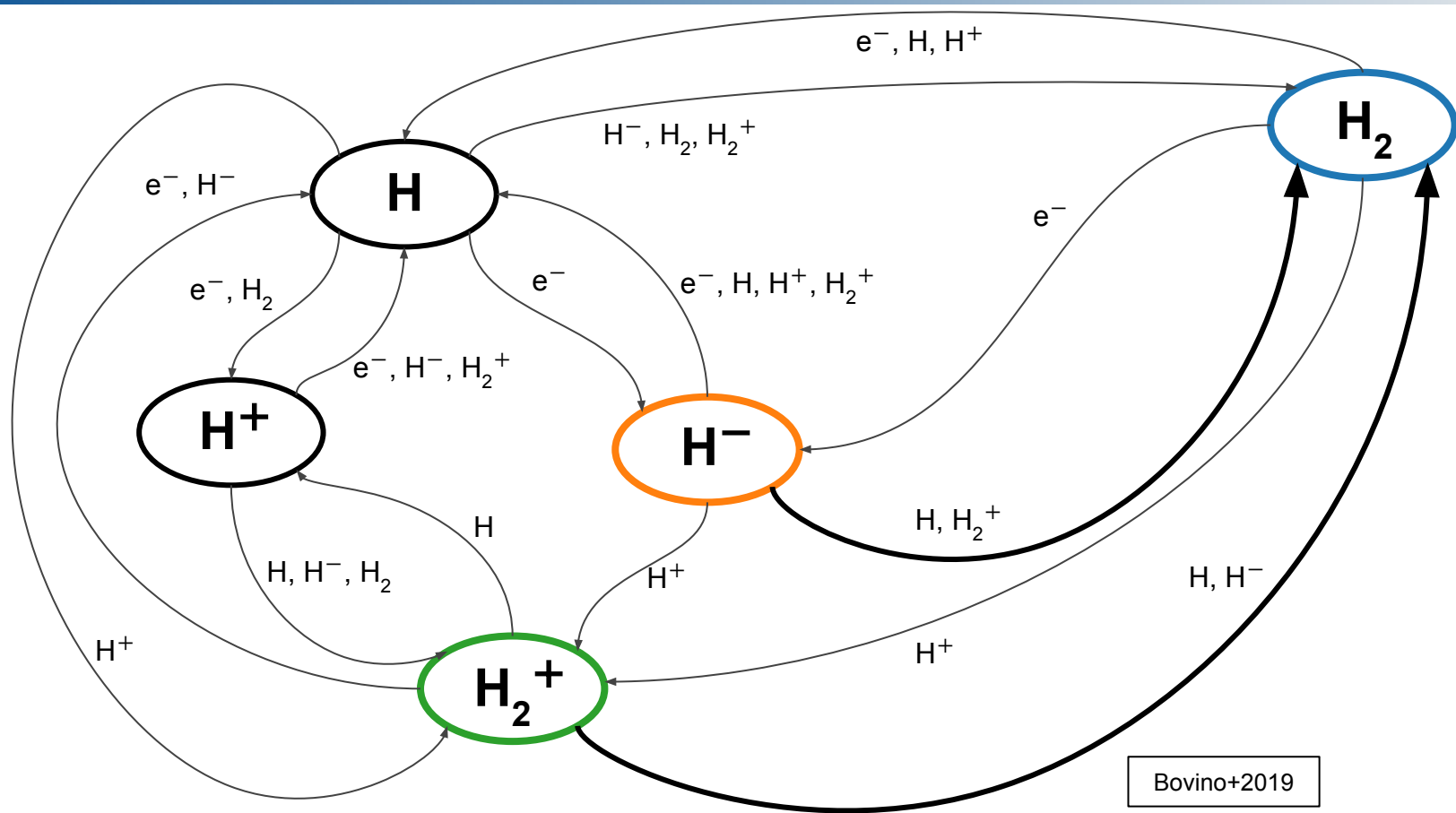
# Role of $H_2$



1D collapse of a pristine ( $Z=0$ ) gas cloud:  
different trajectories in n-T plane  
depending on the molecular content



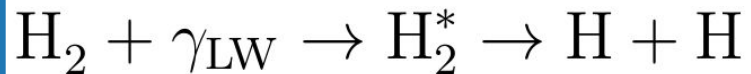
# Non-equilibrium chemistry



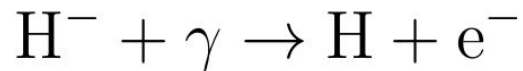
# Photochemistry

No. Reaction

- 1  $\text{H}_2 + \gamma \rightarrow \text{H} + \text{H}$
- 2  $\text{H}_2 + \text{H} \rightarrow \text{H} + \text{H} + \text{H}$
- 3  $\text{H}^- + \text{H} \rightarrow \text{H}_2 + \text{e}^-$
- 4  $\text{H}_2^+ + \text{H} \rightarrow \text{H}_2 + \text{H}^+$
- 5  $\text{H}^+ + \text{e}^- \rightarrow \text{H} + \gamma$
- 6  $\text{H} + \text{e}^- \rightarrow \text{H}^- + \gamma$
- 7  $\text{H}^- + \gamma \rightarrow \text{H} + \text{e}^-$
- 8  $\text{H} + \text{H}^+ \rightarrow \text{H}_2^+ + \gamma$
- 9  $\text{H}_2 + \gamma \rightarrow \text{H}^+ + \text{H}$
- 10  $\text{H} + \text{H} \rightarrow \text{H}^+ + \text{e}^- + \text{H}$
- 11  $\text{H}^- + \text{H} \rightarrow \text{H} + \text{H} + \text{e}^-$
- 12  $\text{H} + \text{e}^- \rightarrow \text{H}^+ + \text{e}^- + \text{e}^-$
- 13  $\text{H}_2^+ + \text{He} \rightarrow \text{HeH}^+ + \text{H}$
- 14  $\text{H} + \text{He} \rightarrow \text{H}^+ + \text{e}^- + \text{He}$
- 15  $\text{H}_2 + \text{H}^+ \rightarrow \text{H}_2^+ + \text{H}$
- 16  $\text{H}_2 + \text{He} \rightarrow \text{H} + \text{H} + \text{He}$
- 17  $\text{HeH}^+ + \text{H} \rightarrow \text{H}_2^+ + \text{He}$
- 18  $\text{H} + \text{H} + \text{H} \rightarrow \text{H}_2 + \text{H}$
- 19  $\text{H}^- + \text{He} \rightarrow \text{H} + \text{He} + \text{e}^-$
- 20  $\text{H}_2^+ + \text{H} \rightarrow \text{H} + \text{H}^+ + \text{H}$
- 21  $\text{He} + \text{H}^+ \rightarrow \text{HeH}^+ + \gamma$
- 22  $\text{H}^- + \text{H}^+ \rightarrow \text{H} + \text{H}$
- 23  $\text{H}_2^+ + \text{e}^- \rightarrow \text{H} + \text{H}$
- 24  $\text{HeH}^+ + \text{e}^- \rightarrow \text{He} + \text{H}$
- 25  $\text{H}^- + \text{H}^+ \rightarrow \text{H}_2^+ + \text{e}^-$
- 26  $\text{H}^- + \text{e}^- \rightarrow \text{H} + \text{e}^- + \text{e}^-$



$$11.2 \text{ eV} < h\nu < 13.6 \text{ eV}$$

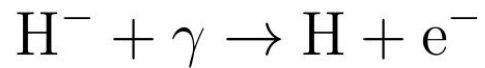
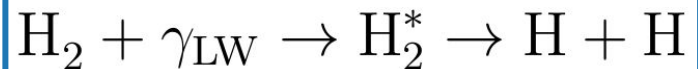


$$h\nu > 0.76 \text{ eV}$$

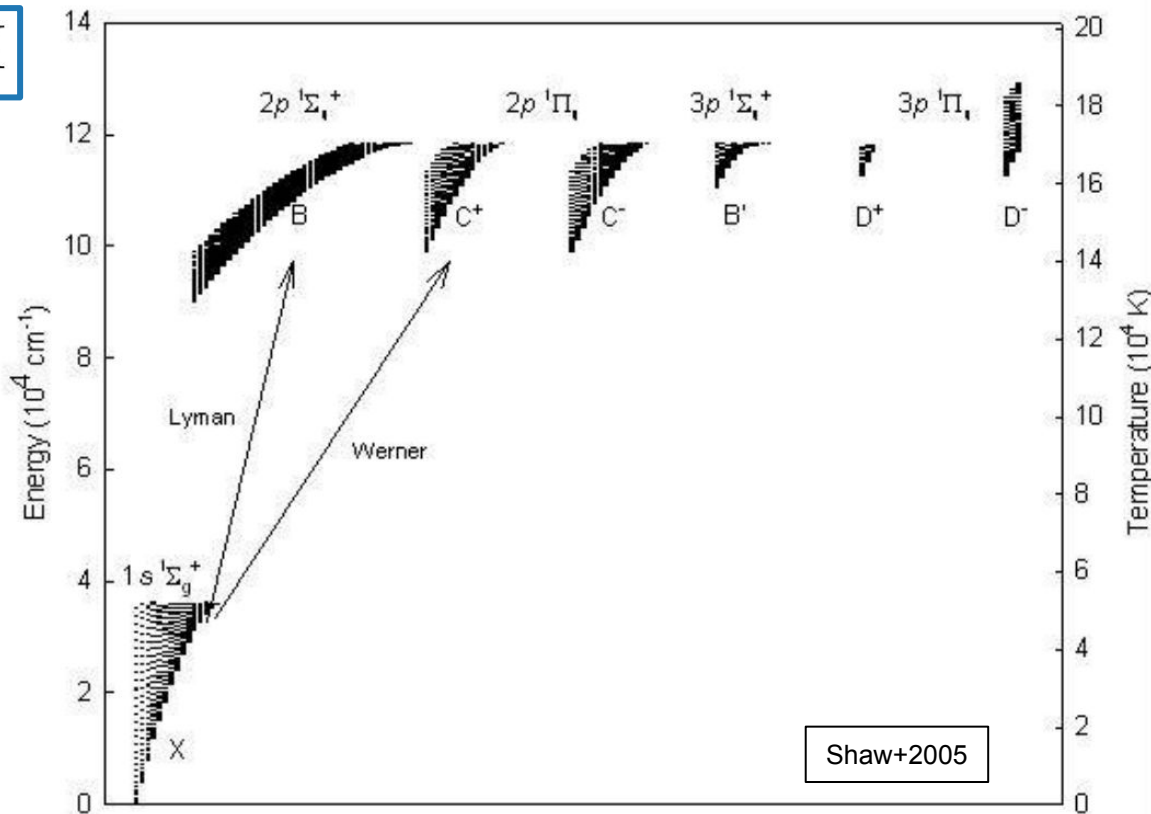


$$h\nu > 2.65 \text{ eV}$$

# A self-consistent model for LW radiation



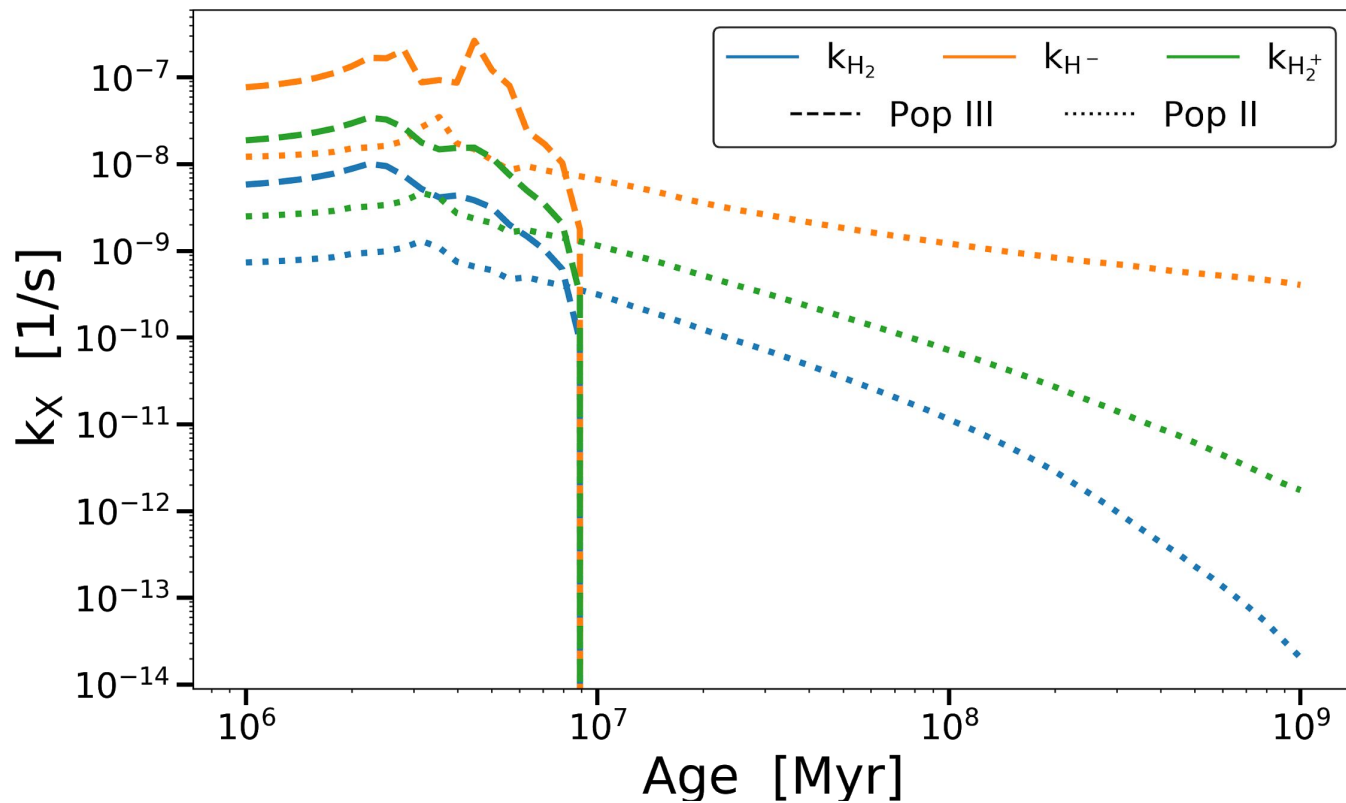
- Spectroscopy data from labs
- Indirect H<sub>2</sub> photodissociation through Solomon process
- Molecules: variation with gas temperature and density (Glover, 2015)



# SEDs

PopIII:  
Salpeter  
21-300  $M_{\odot}$

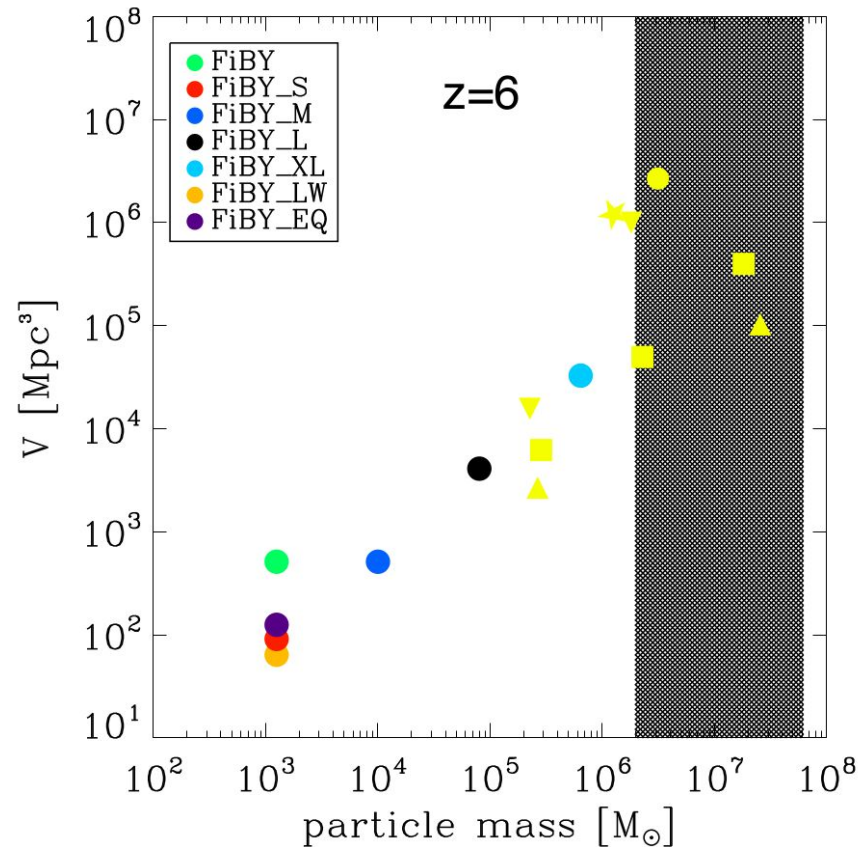
PopII:  
Chabrier  
0.08-120  $M_{\odot}$



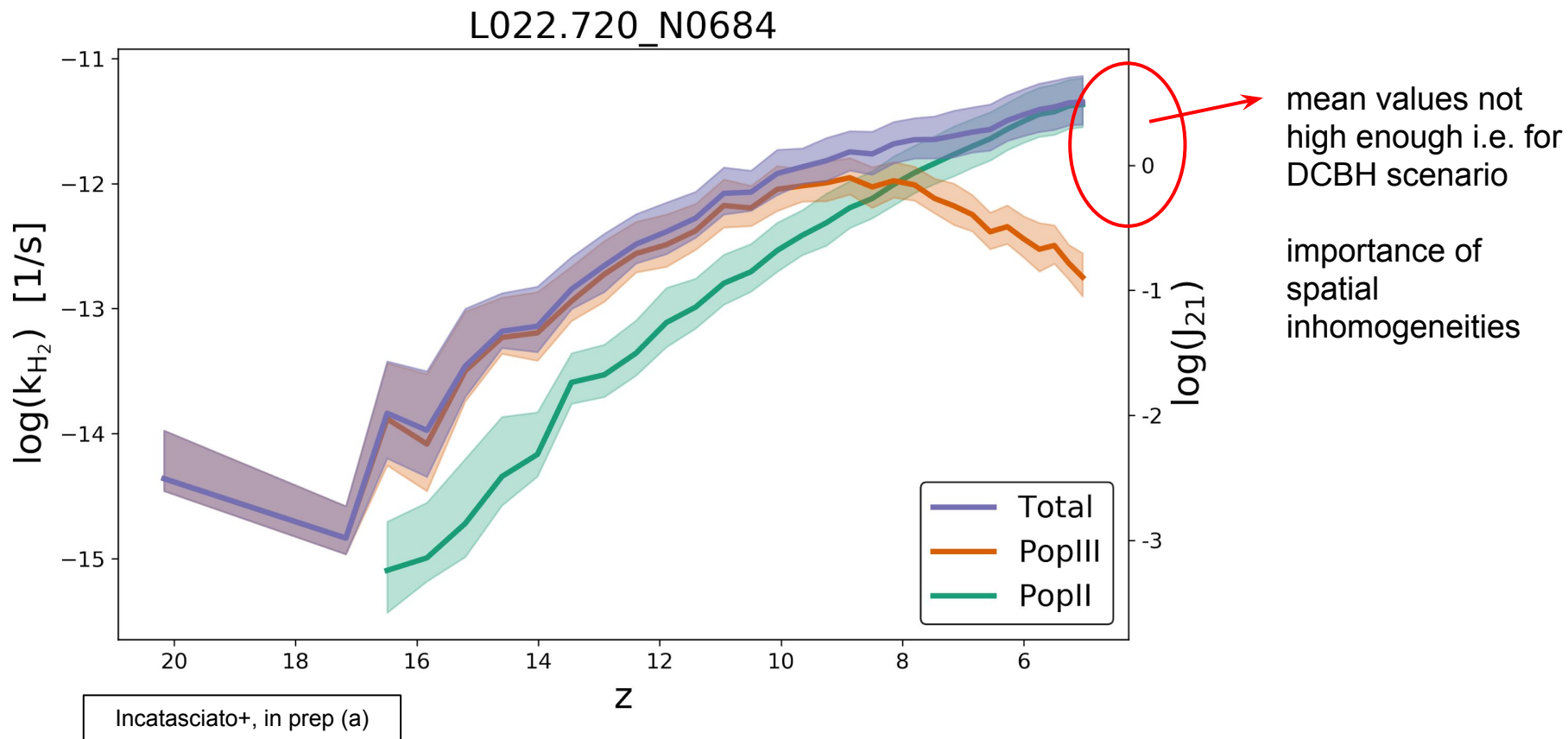


# FiBY postprocessing

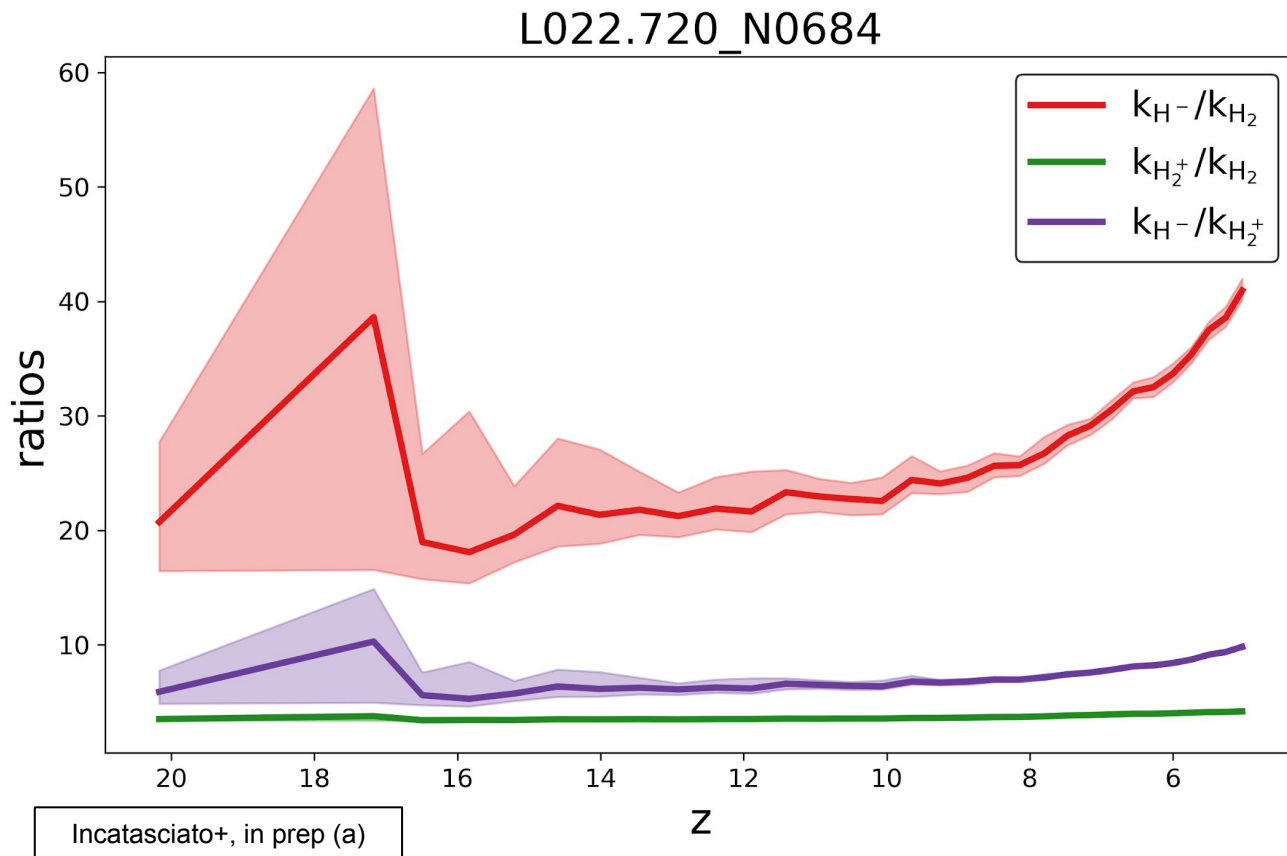
- GADGET-2 version used for the OWLS project (Schaye+2010): SF (Schaye & Dalla Vecchia, 2008); metal enrichment; metal line cooling from 9 elements; BH growth and feedback
- Thermal SN feedback (Dalla Vecchia & Schaye 2012)
- Molecular non-eq network and cooling
- PopIII formation, evolution and yields + BHs seeds
- Dust from PISN, AGB & SNIi; thermal sputtering
- LWB +  $H_2$  self-shielding



# FiBY postprocessing

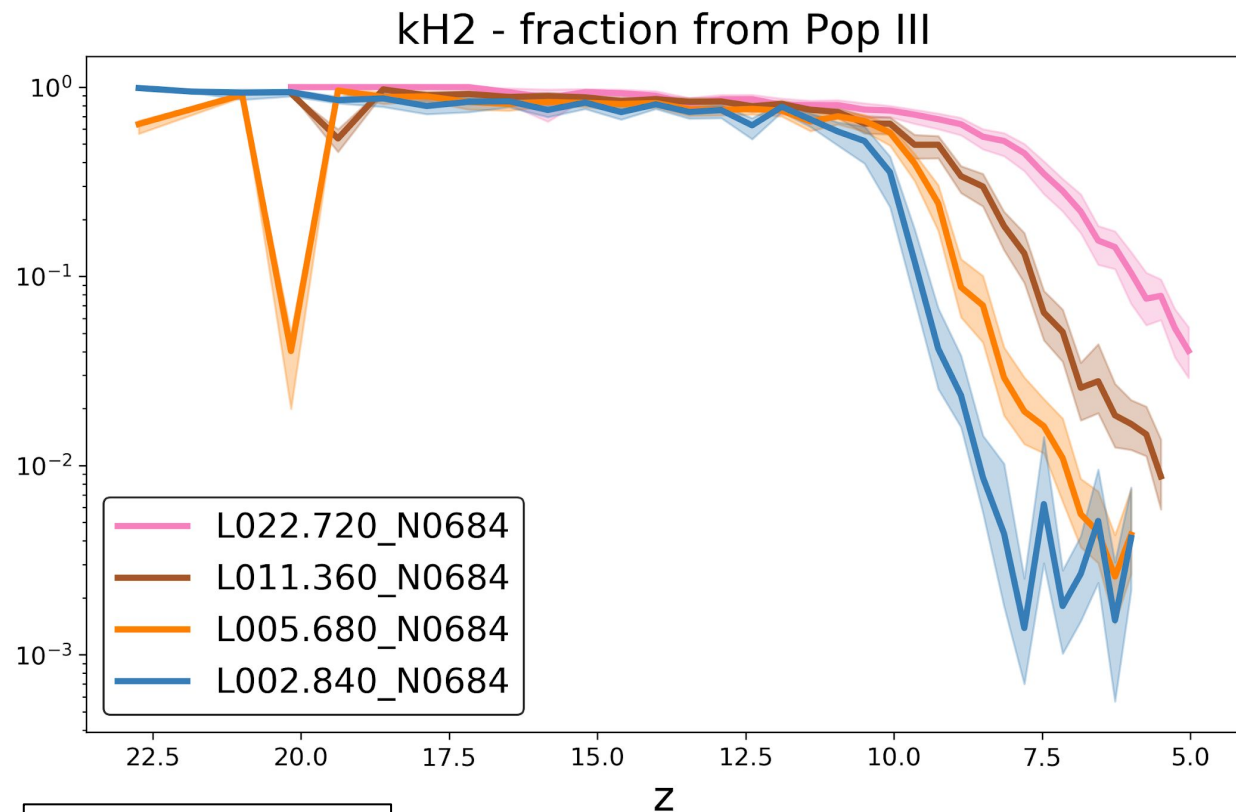


# FiBY postprocessing



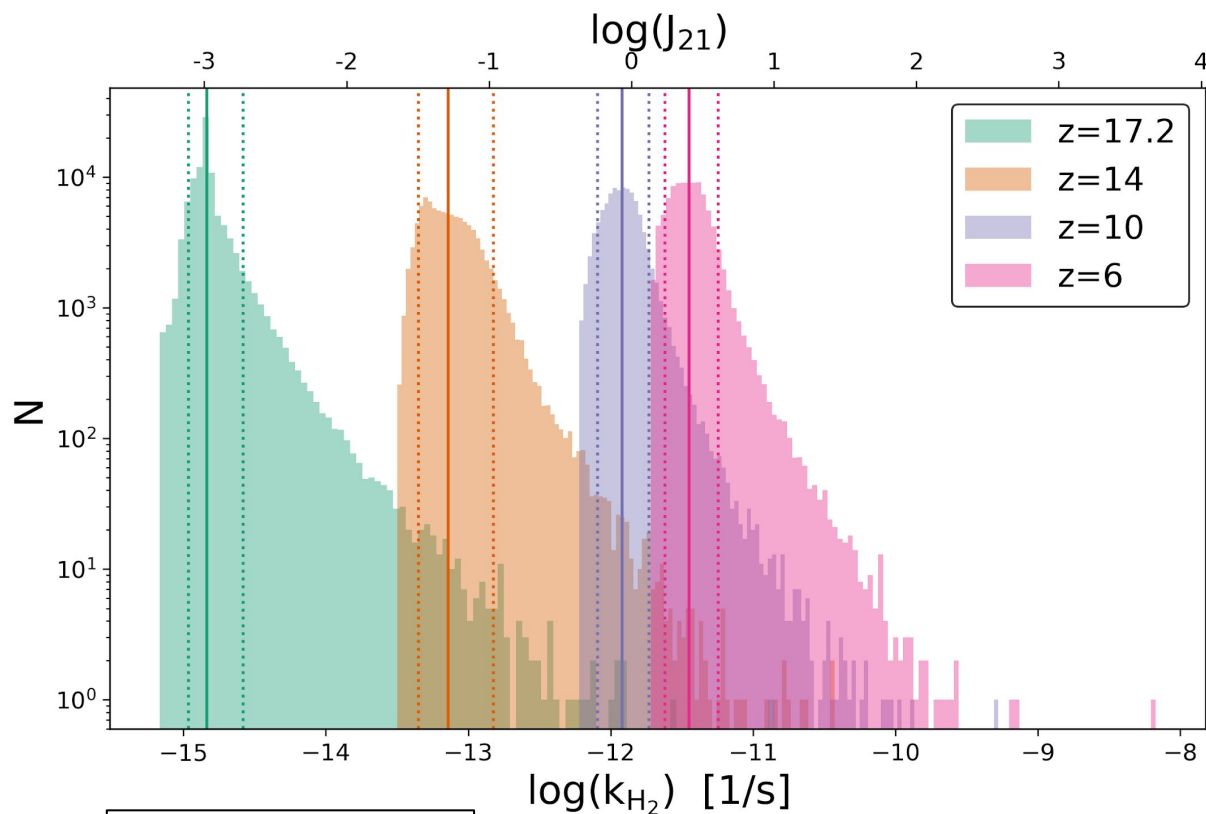
change in  $k_{H^-}$  to  $k_{H_2}$  ratio is a sign of transition from PopIII to PopII stars

# FiBY postprocessing

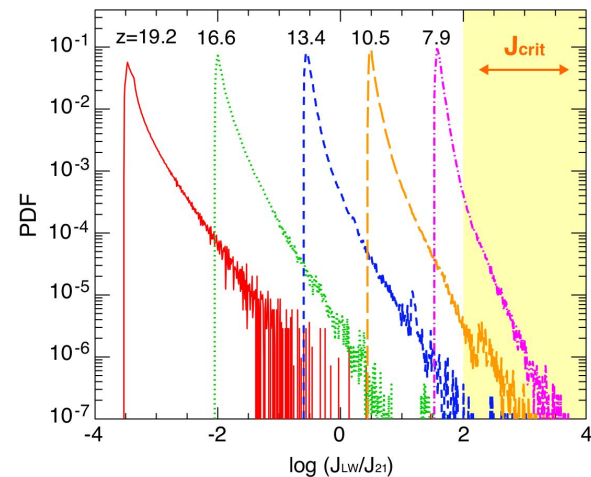


possible resolution  
effect?

# FiBY postprocessing



Incatasciato+, in prep (a)



Ahn+2009



# Conclusions & future plans

- Importance of the spectral shape of the stellar radiation + how it changes with time
- Super preliminar: able to reproduce results from Ahn+2009, further investigation on most dense regions and power spectrum
- Future
  - Stochasticity in IMF sampling
  - Implications on Jeans filtering and minimum halo mass for PopIII formation
  - Cosmo sim with non-equilibrium  $H_2$  chemistry and accurate treatment of local LW radiation