Setting up Cloudy for wHere Emission Meets Absorption at reionization (SCHEMA)

A. Sarkar[†](University of Kentucky), **G. Sun**[‡] (Caltech) **and N. Suzuki**[*] (Kavli IPMU, University of Tokyo)

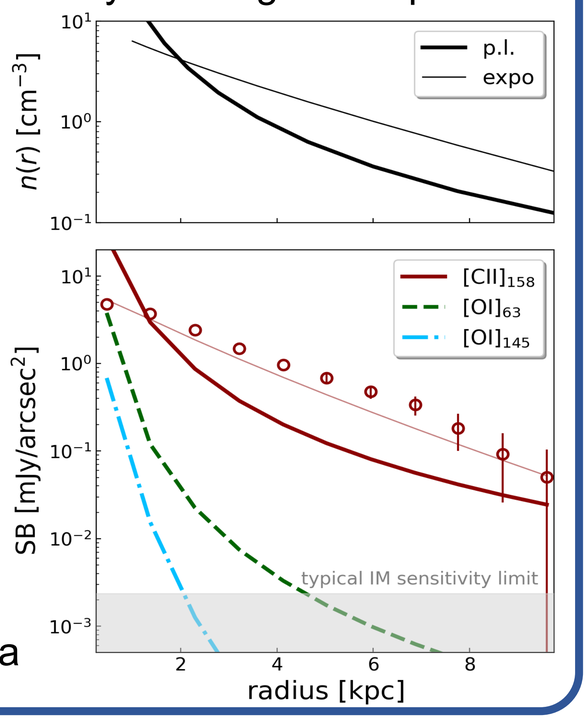
INTRODUCTION

The epoch of reionization (EoR) marks the last major phase transition in cosmic history, during which neutral intergalactic medium (IGM) was ionized by energetic photons emitted from high-*z* galaxies and QSOs. Detailed modeling the production of emission and absorption lines will provide invaluable insight into this frontier of astronomy. During CLOUDY 2019, we have investigated latent applications of CLOUDY in this context from two distinct angles: (1) modeling halo emission of ISM cooling lines and (2) modeling absorption spectrum of the IGM against high-*z* QSOs. We aim to show how EoR physics may be better extracted from novel observational methods with the help of CLOUDY.

EXTENDED EMISSION-LINE HALOS

Extended, 10-kpc scale [CII] emission from z~6 galaxies has been recently discovered and attributed to galaxy outflows by Fujimoto et al. (2019), though its exact origin remains uncertain. We develop a toy model of the surface brightness (SB) profile of halo emission by combining an analytic, power-law model of **gas density profile** and an emissivity-density model grid computed with **CLOUDY**:

$$\mathbf{SB}(b) = \int_b^\infty \frac{\epsilon[n(r)]}{4\pi} \frac{r\,dr}{\sqrt{r^2 - b^2}}$$



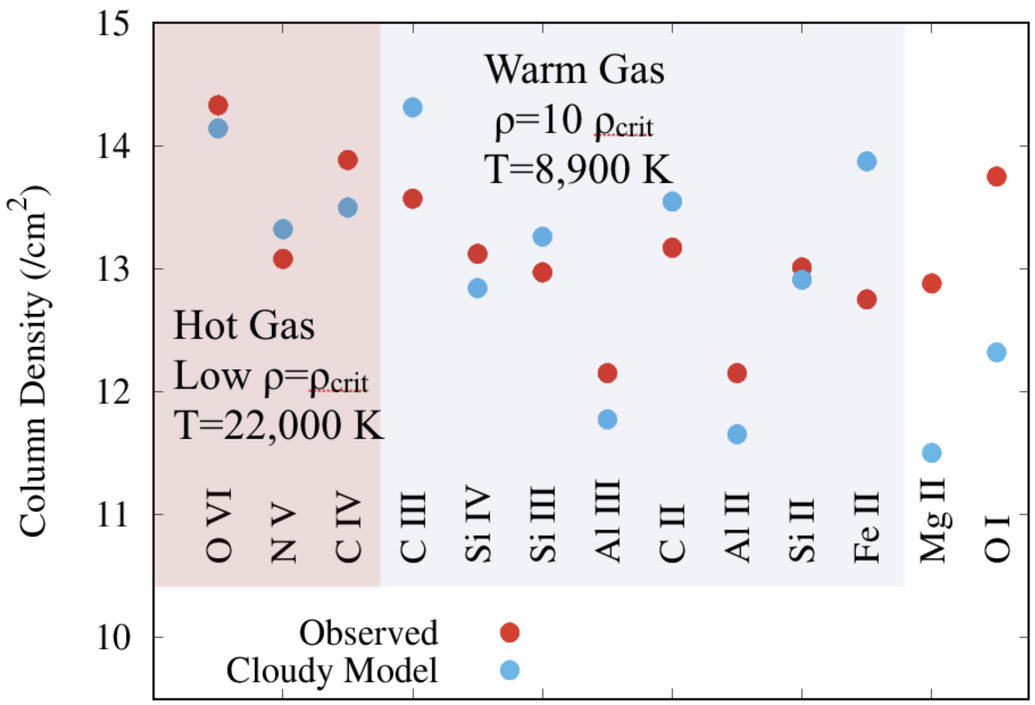
— Major Findings —

- Our toy model roughly captures the SB to the correct OOM
- Mismatched curvature may be due to incorrect gas profile
- Halos may be detectable with stacking or cross-correlating intensity maps with external data

INTERGALACTIC MEDIUM

Aim: Investigating the physical condition of the IGM (Pieri et al 2014) at z=2-3, and probe Supernova origin. HI column density is 17-18 and they are ionized by UV background where we need CLOUDY.

Findings: 1: Multi-Layer is needed. There exists density gradient
2: Abundance pattern indicate it is dominated by Core Collapse SN
3: Metal abundance is not so low, literature values are not quite right.



FUTURE DIRECTIONS

- Observed similarity between [CII] & Lya halos → extend current model to reproduce SB profile and growth curve of total Lya flux at z=2.3
- For the IGM, we need multi-layer density profile and supernova abundance