Summer school on the ISM of nearby galaxies

Hands-on 2: Cloudy - emission lines

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<u>Basics of CLOUDY</u>

Microphysics code to predict the thermal, ionization and chemical structure of a cloud
Accurate simulation of physical processes at the atomic and molecular level

<u>How does it work?</u>
<u>Integration of the step-by-step (slabs) absorbed/transmitted and re-emitted photons **kayaking** through a defined medium</u>

- **Incident RF** (<u>shape</u> T and Q, ionizing photons, & <u>intensity,</u> distance (pc) or Luminosity)
- **Interacting medium** (densities/metallicities/abundances)

- <u>Cooling (emission)</u>
- Heating (absorption) functions

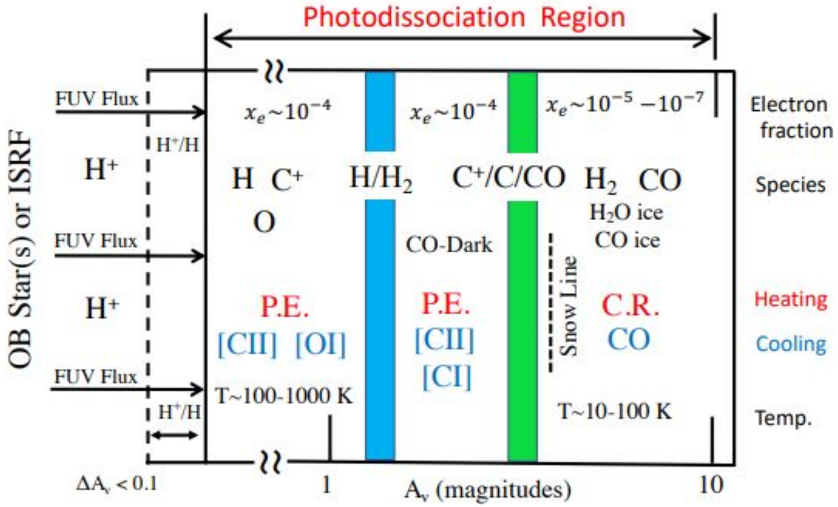
Project 1: Structure of a PDR

Radial profile for several emission lines of different atoms/molecules for a set of physical conditions in a photon-dominated region (Rollig et al. 2007).

Our case:

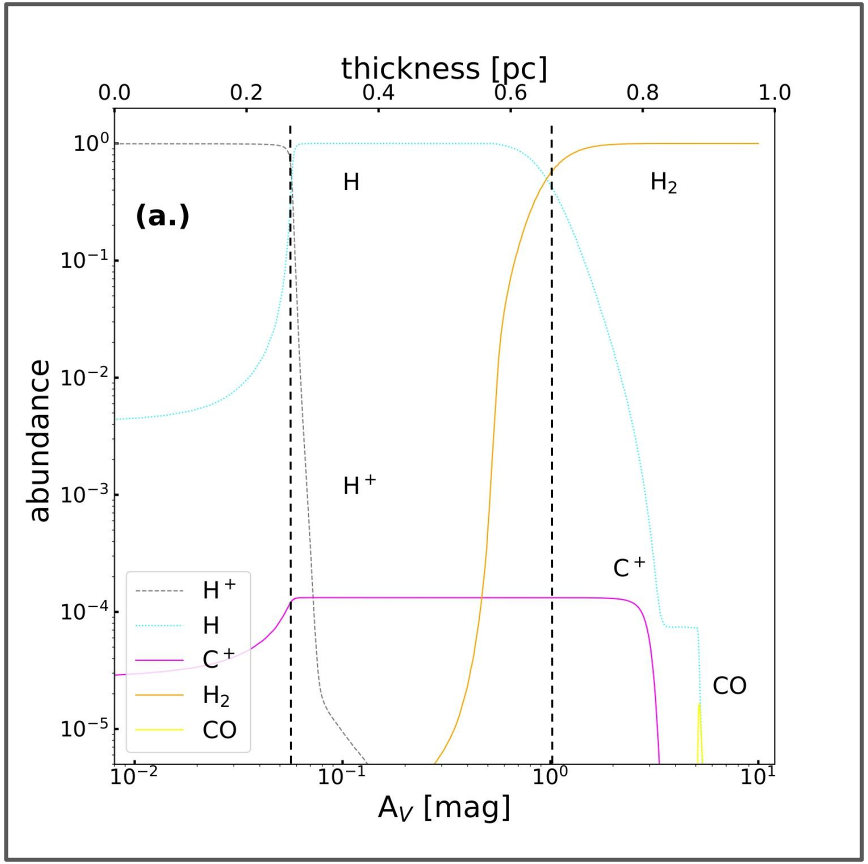
Selected lines (H+, H_2, C+, C, CO) and Av as stop condition (10) to constrain a PDR

1. Abundance vs Av
2. Comparison with obs (NGC 278 &IC10)



Schematic of a PDR as a function of visual extinction from Wolfire+(22)

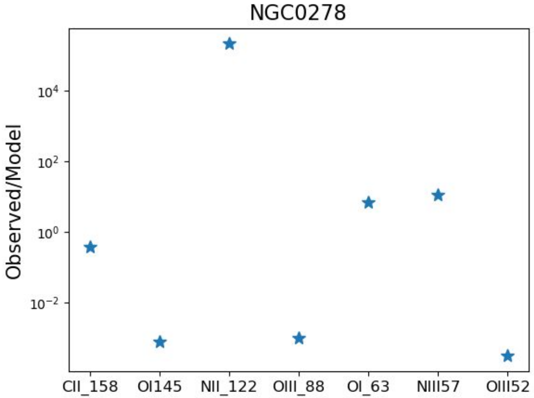
Project 1: Results



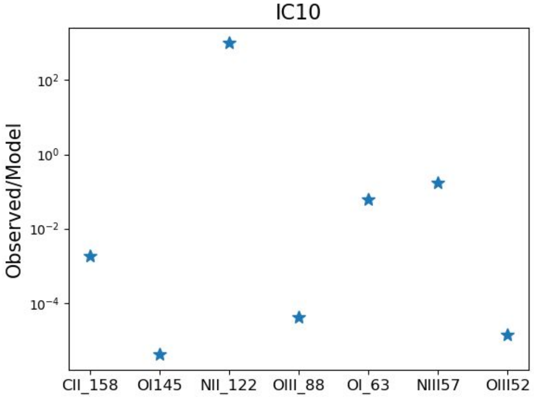
Schematic of a PDR: abundance of H+, H, H2, C+, CO as a function of visual extinction

Project 1: Comparison with obs

NGC 278

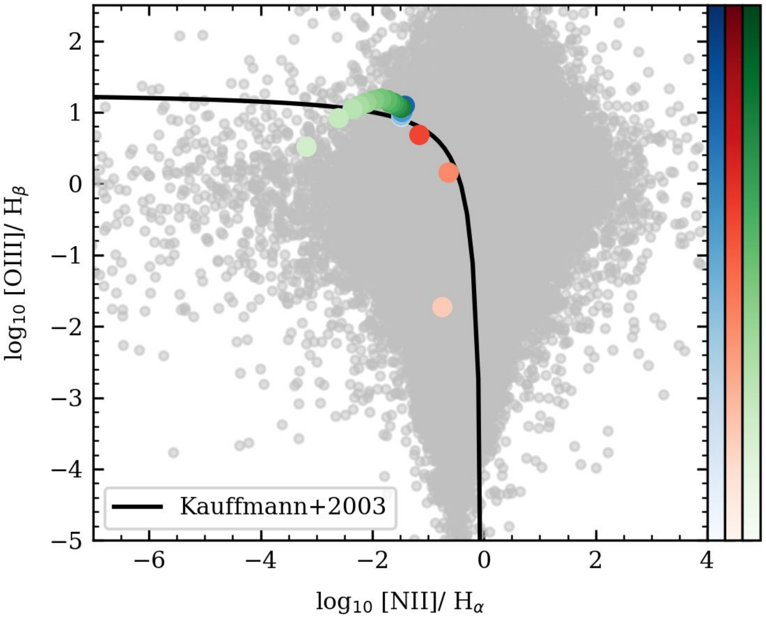


IC 10



Luminosity ratio, PDR model/obs (NCG 278, top, and IC10, bottom), for 6 selected lines.

Project 2: BPT Diagram of a HII region



Varying:

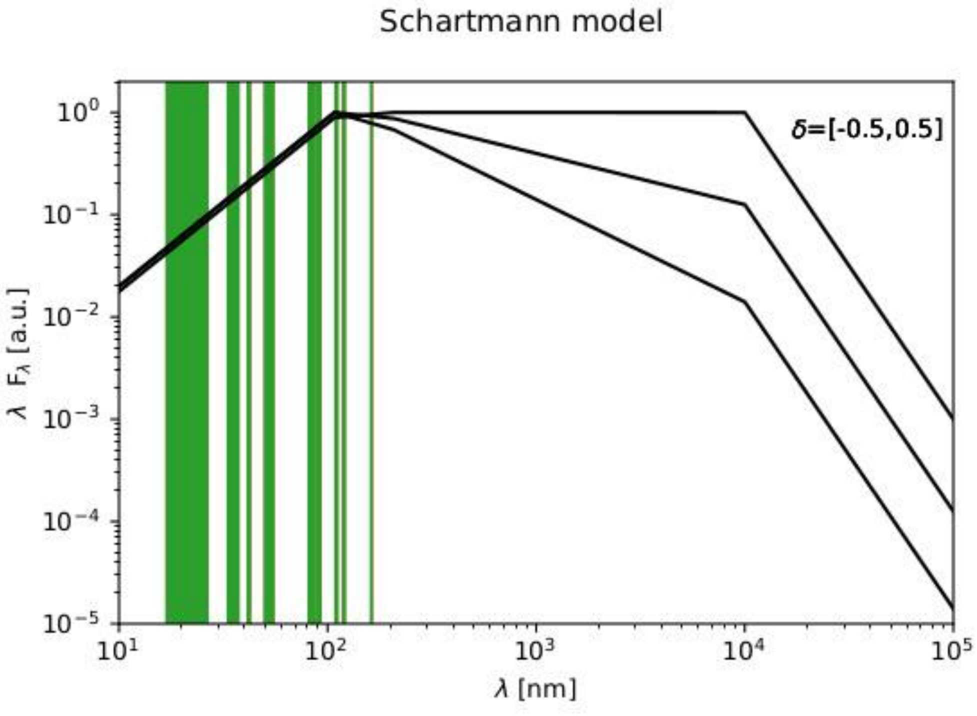
1. Number density of H $(0 \leq \log n_H \leq 3$ [cm^{-3}])
2. Ionisation parameter $(-4 \leq \log u \leq -1)$
3. Metallicity $(-3 \leq \log Z \leq 0$ in steps of 0.25 [$Z_\odot$])

Project 3: Modelling AGN with CLOUDY

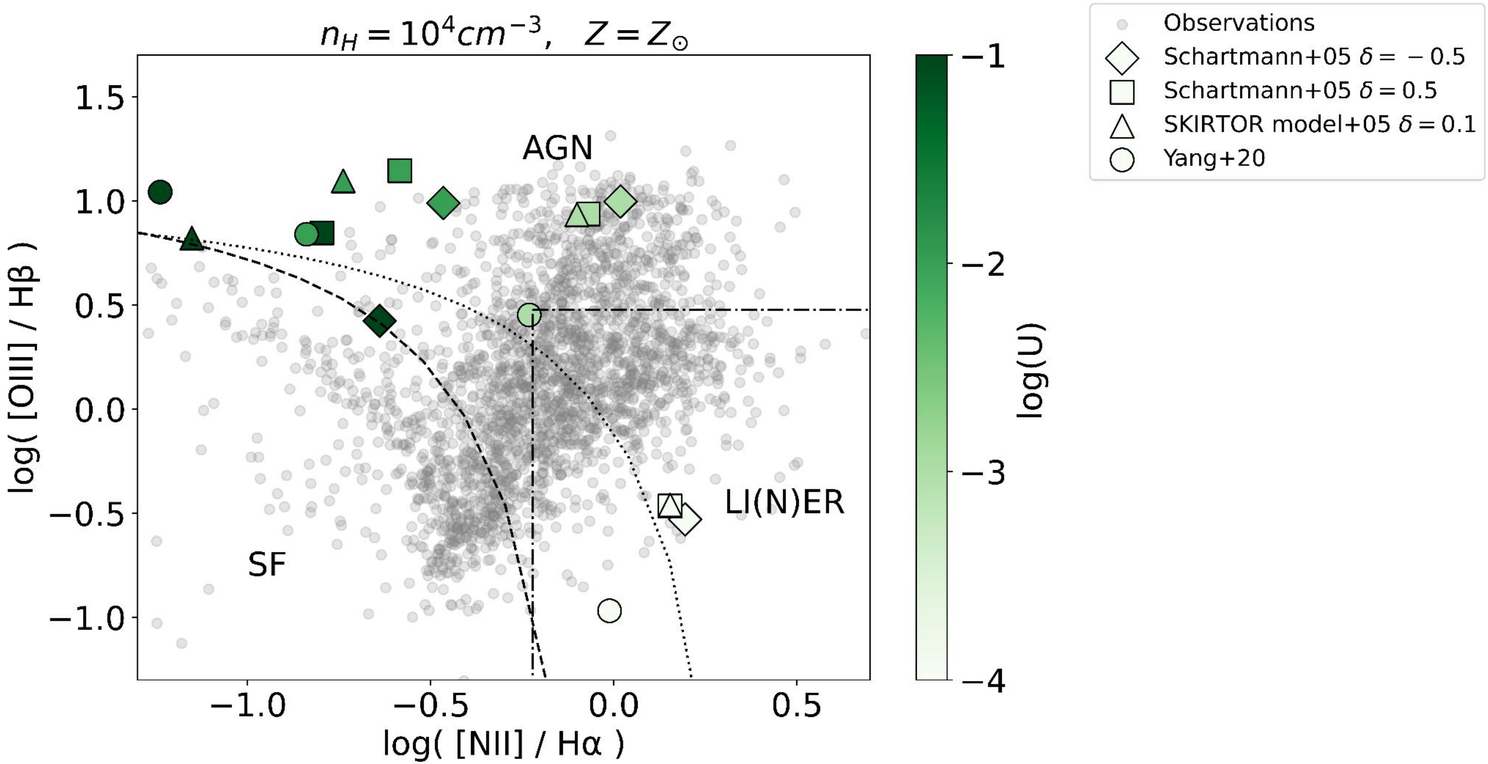
- Radiation field: SED

Varied parameters

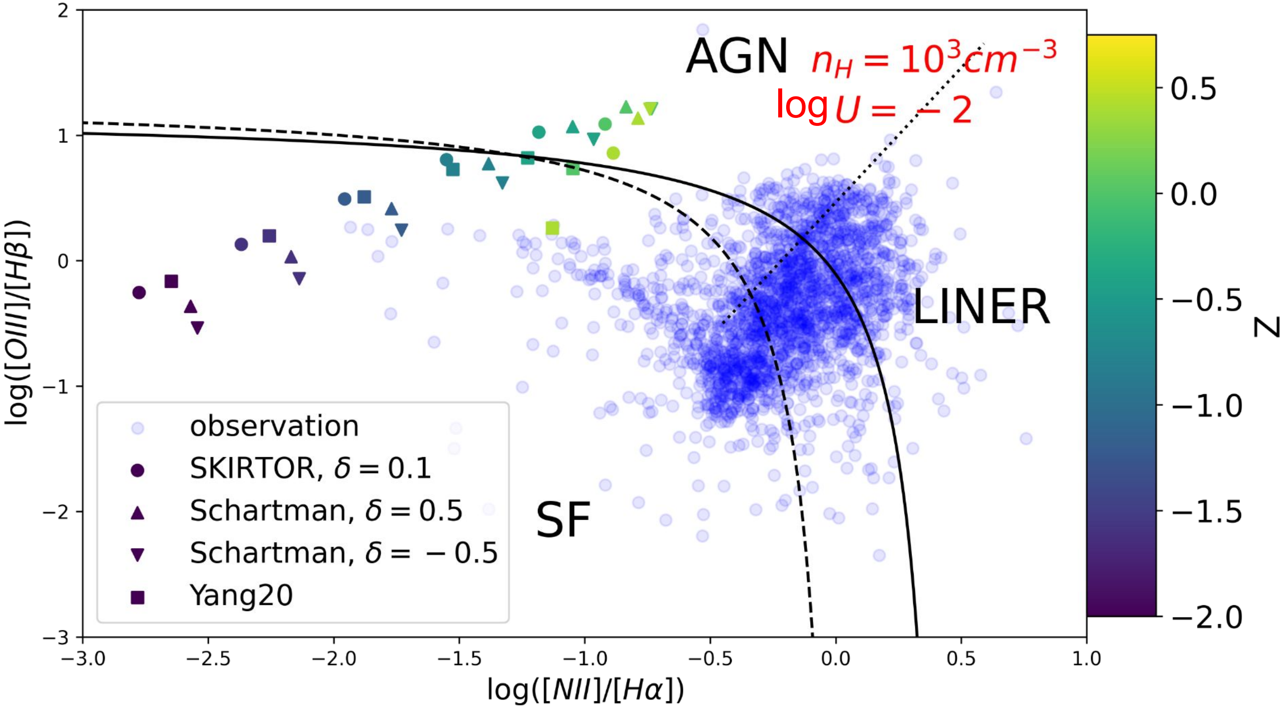
- Ionisation parameter U
- Metallicity Z
- Hydrogen density n_H



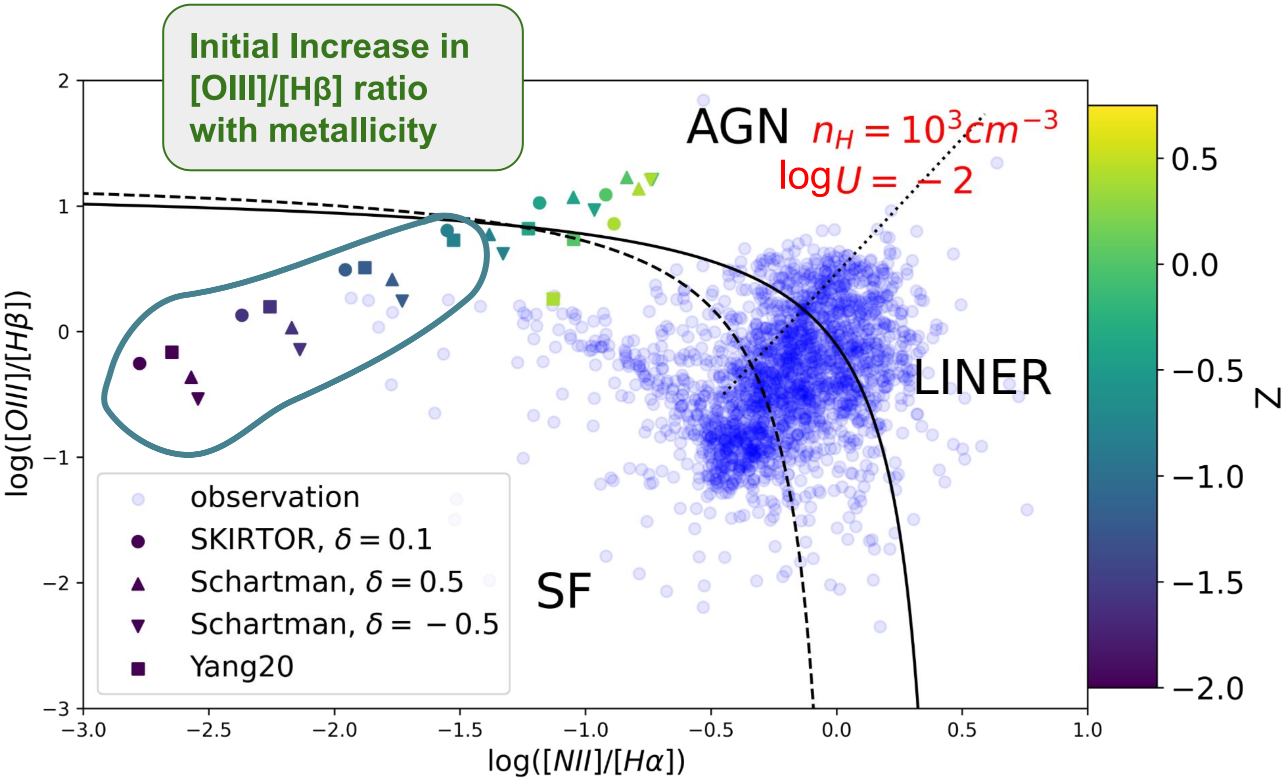
Varying the Ionisation Parameter



Varying the Metallicity



Varying the Metallicity



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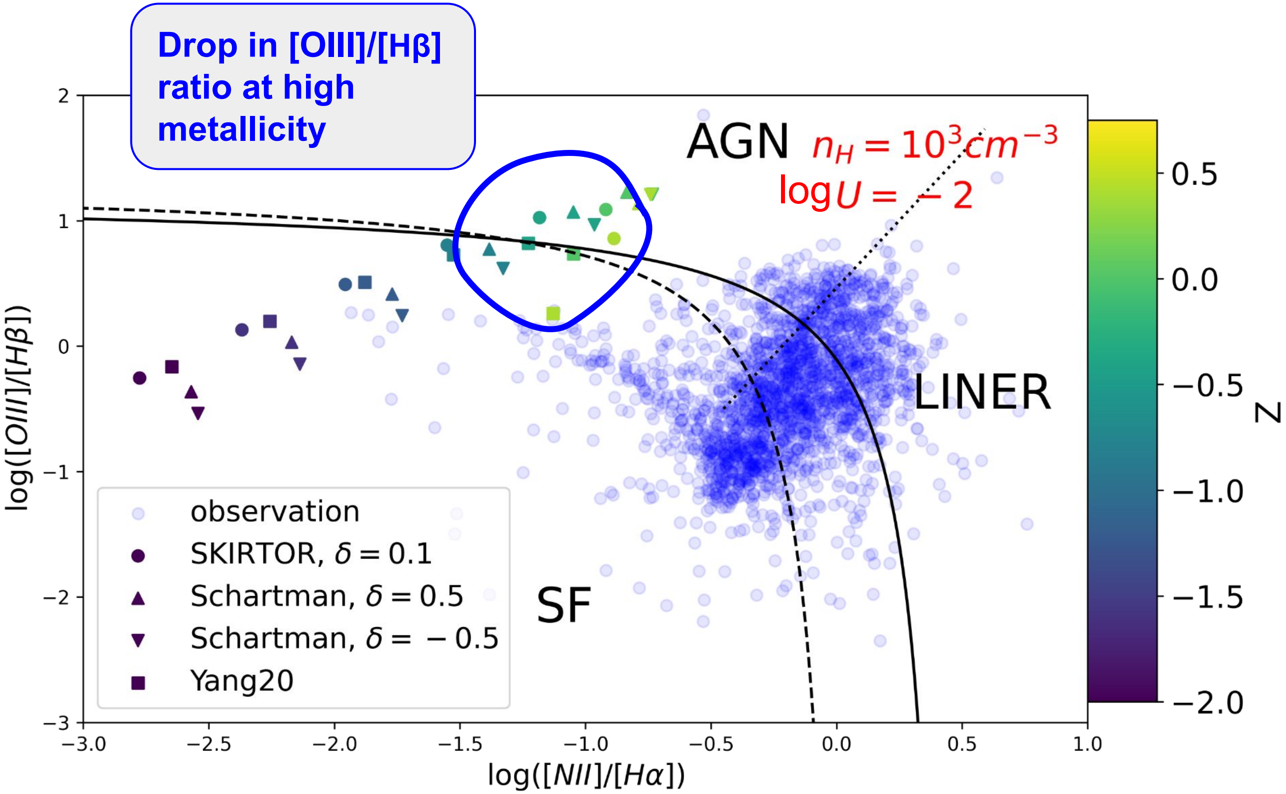
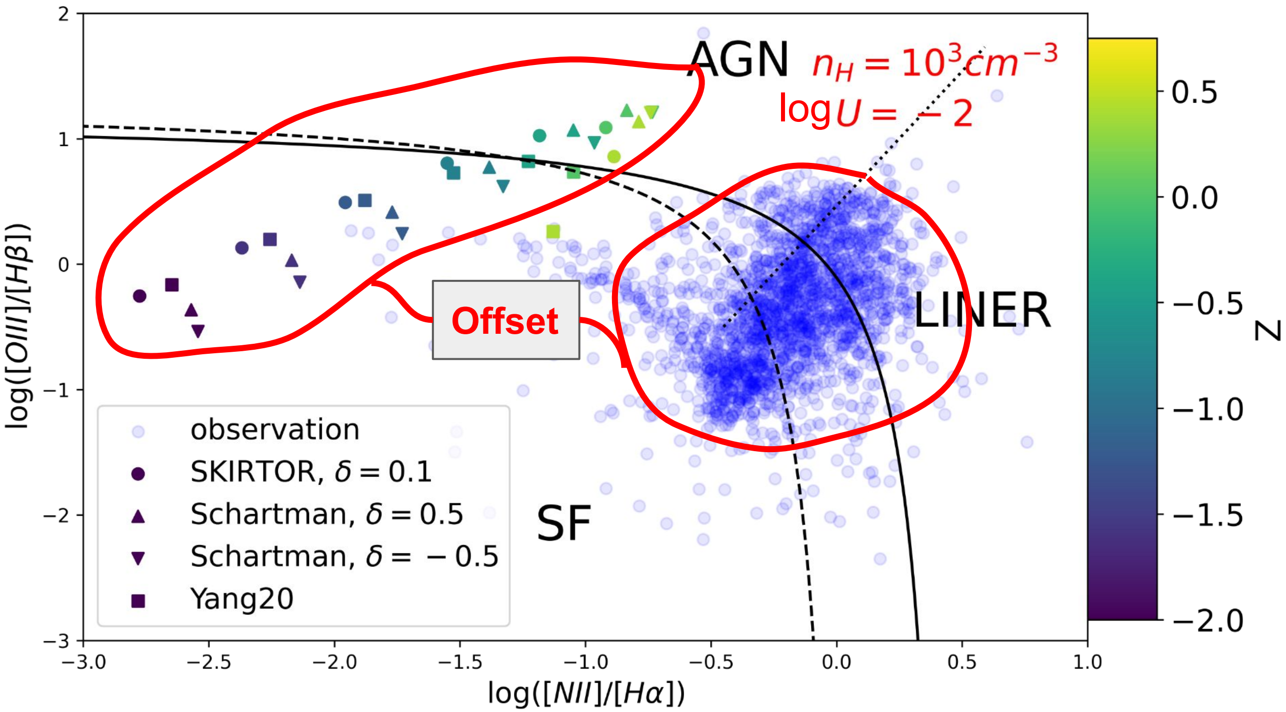
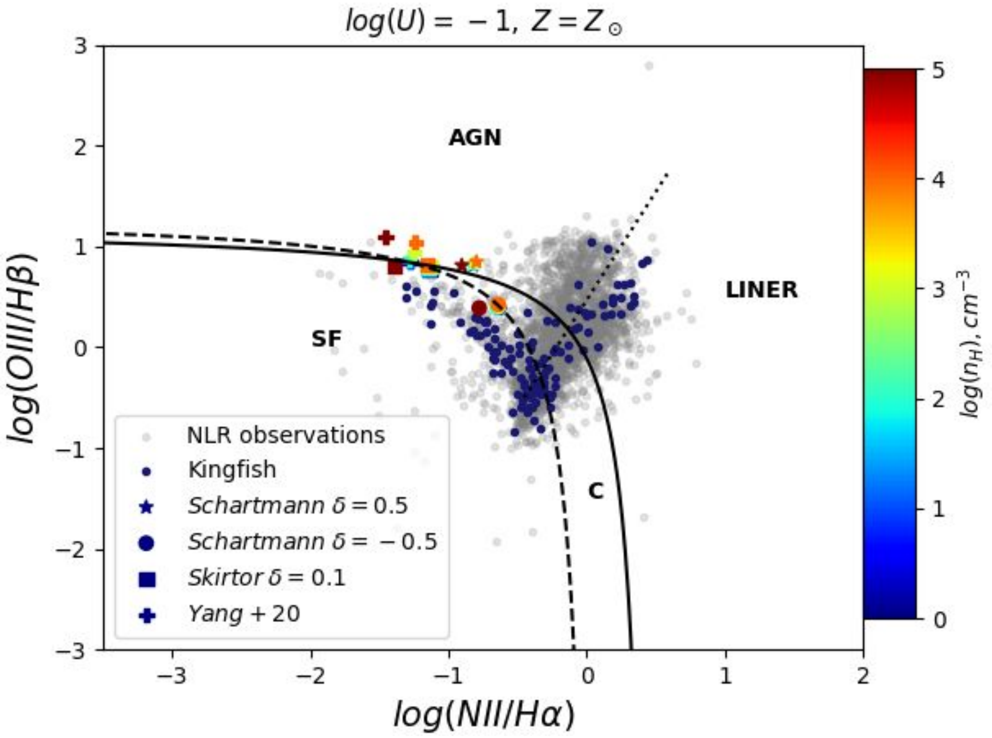


Varying the Metallicity



Varying the Hydrogen Density

- 10 cm^{-3} < n_H < 10^3 cm^{-3}
  low density regime, almost no effect
- n_H > 10^4 cm^{-3} - critical density, collisional de-excitation



More: (Ji et. al. 2020)

Summery