Investigating Simulations of Emission Lines from the Narrow Line Region of Seyferts and LINERS

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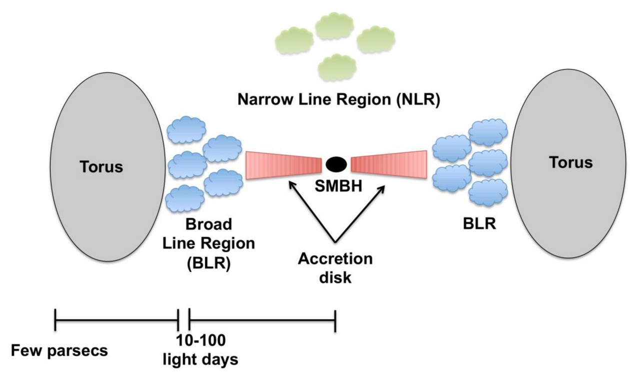
Background

- Low-Ionization Nuclear Emission Region (LINER) galaxies are possibly subset of Active Galactic Nuclei (AGN) .
- Computational modeling of LINERs has proven difficult due to a lack of understanding of the physical mechanism that drives LINER activity.
- Photoionization models of Seyfert galaxies have proven successful and this project looked to examine the viability of photoionization models for LINERs using an AGN continuum..



Methods

- We set up the incident radiation curve from:

$$f_\nu = \nu^{\alpha_{uv}}(-h\nu/kT_{bb})e^{-kT_{IR}/h\nu} + \alpha\nu^{\alpha_x}$$

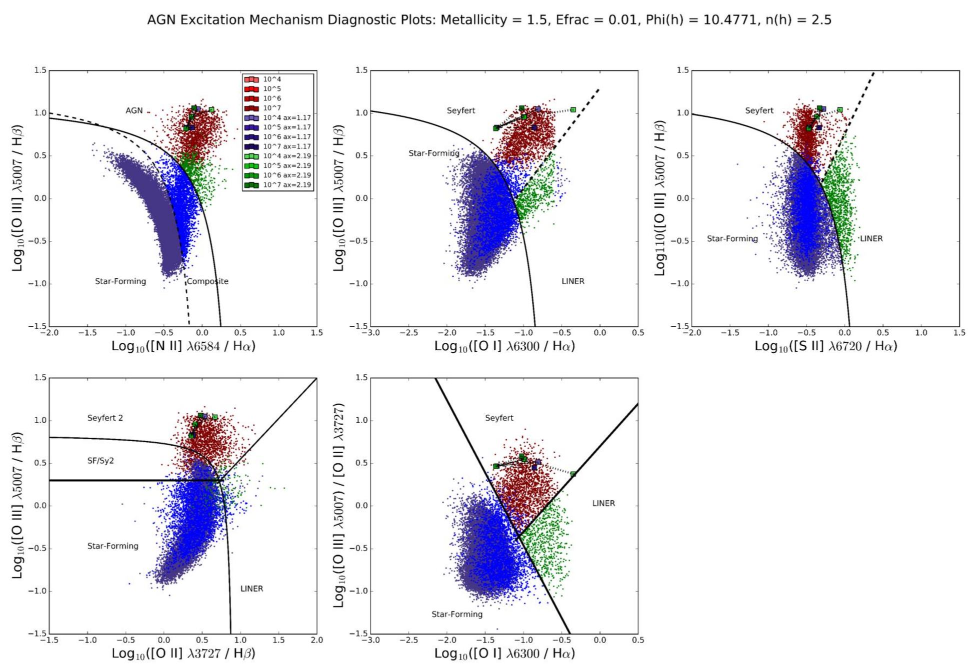
- For baseline curve, the blackbody temperature T_{BB} is set to 10^6 K based off of previous photoionization models.
- Spectral indices are determined from the average value of observations, $\alpha_x = -1.59$, $\alpha_{uv} = -0.6$, $\alpha_{ox} = -1.42$ (Grupe et al. 2010).
- Photon flux and hydrogen density of a simulated cloud constrain the degree of ionization within the cloud. The ratio of photon flux to hydrogen density is the ionization parameter.
- Values for metallicity are provided to the simulation relative to solar
- The stopping boundary condition for the simulation is based on electron fraction: $\frac{n_e}{n(H)} = 0.01$
- We fit the values of α_x and α_{uv} using Ordinary Least Squares regression, producing the line:

$$\alpha_{uv} = -0.3476\alpha_x + 1.1365$$

- We run simulations varying T_{BB} between 10^4 K and 10^7 K
- The value of α_x is varied according to the standard deviation of the mean, 0.51, and the value of α_{uv} is changed accordingly, while α_{ox} is kept constant at -1.42 for all simulations.
- Optical data is obtained via the Sloan Digital Sky Survey (SDSS) DR12

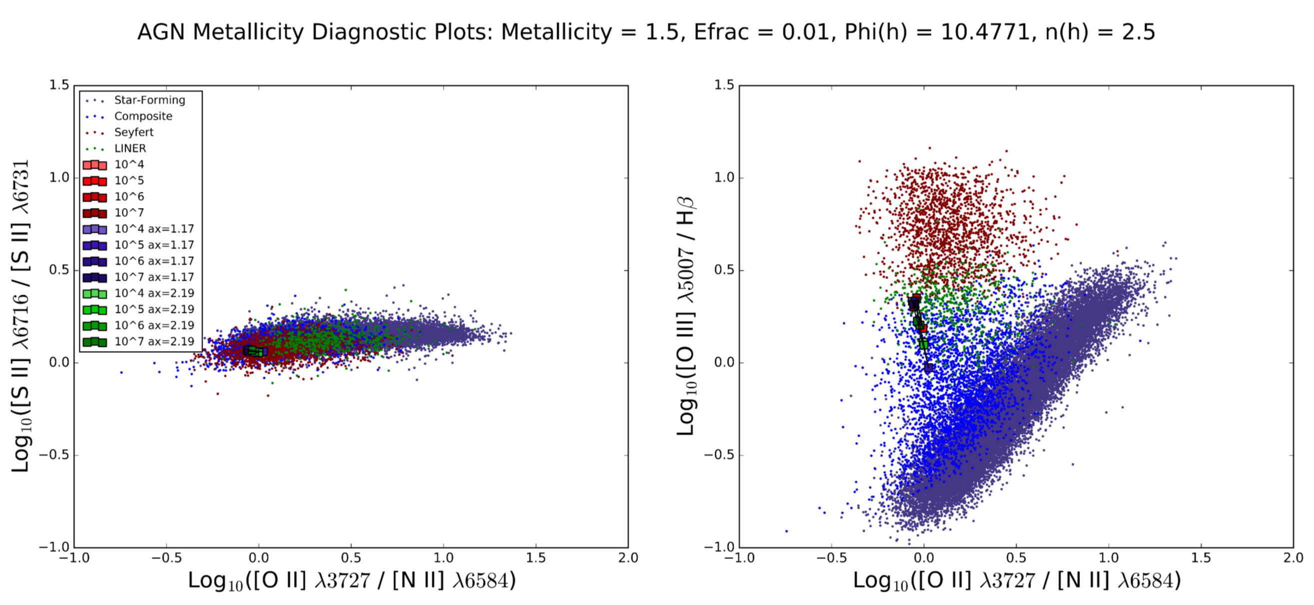
Results

- Our initial photoionization models were designed to simulate Seyfert galaxies.
- The BPT diagram and diagnostics from empirically derived from Osterbrock & Veilleux (1983) were produced, as well as plots of ratios found by Lamareille (2010) and Kewley et al (2006), with log U = -2.5.

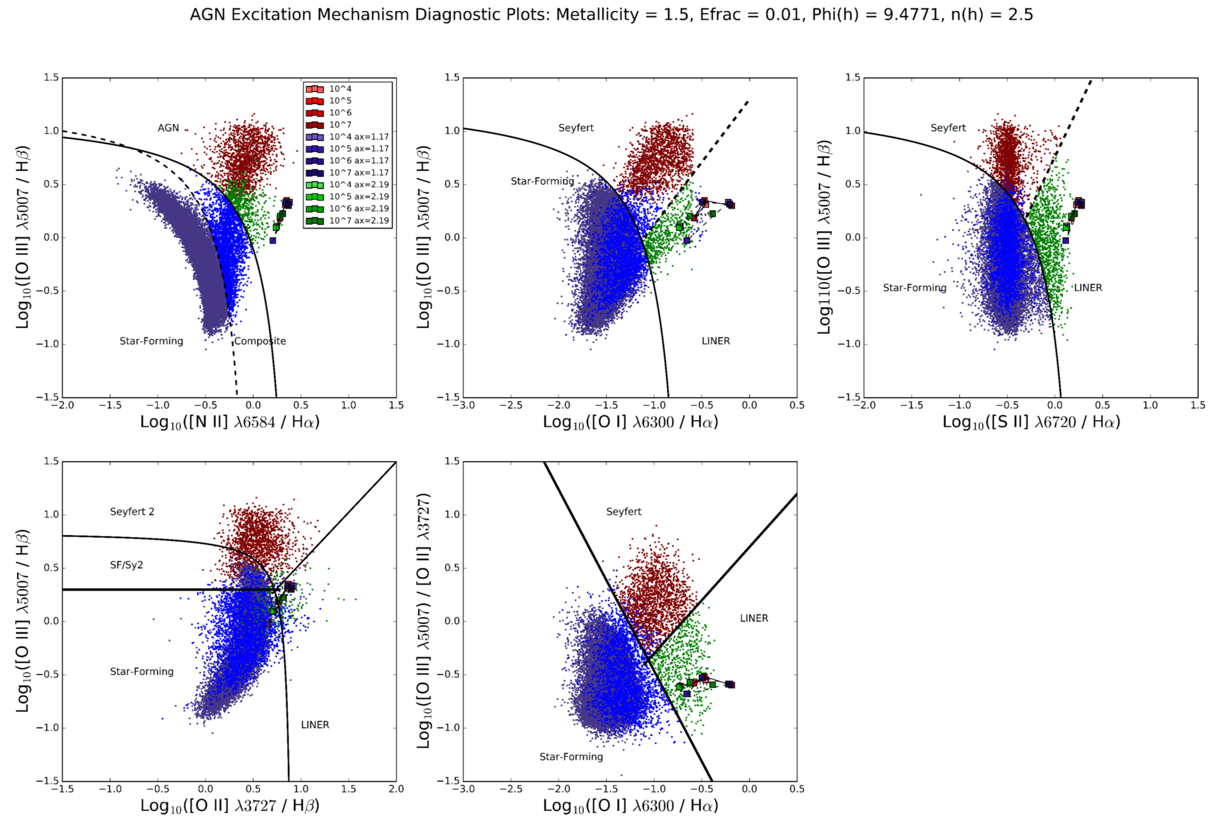


The ratio [O II] 3727/ [N II] 6584 is sensitive to elemental abundances, and was used to constrain our abundance set.

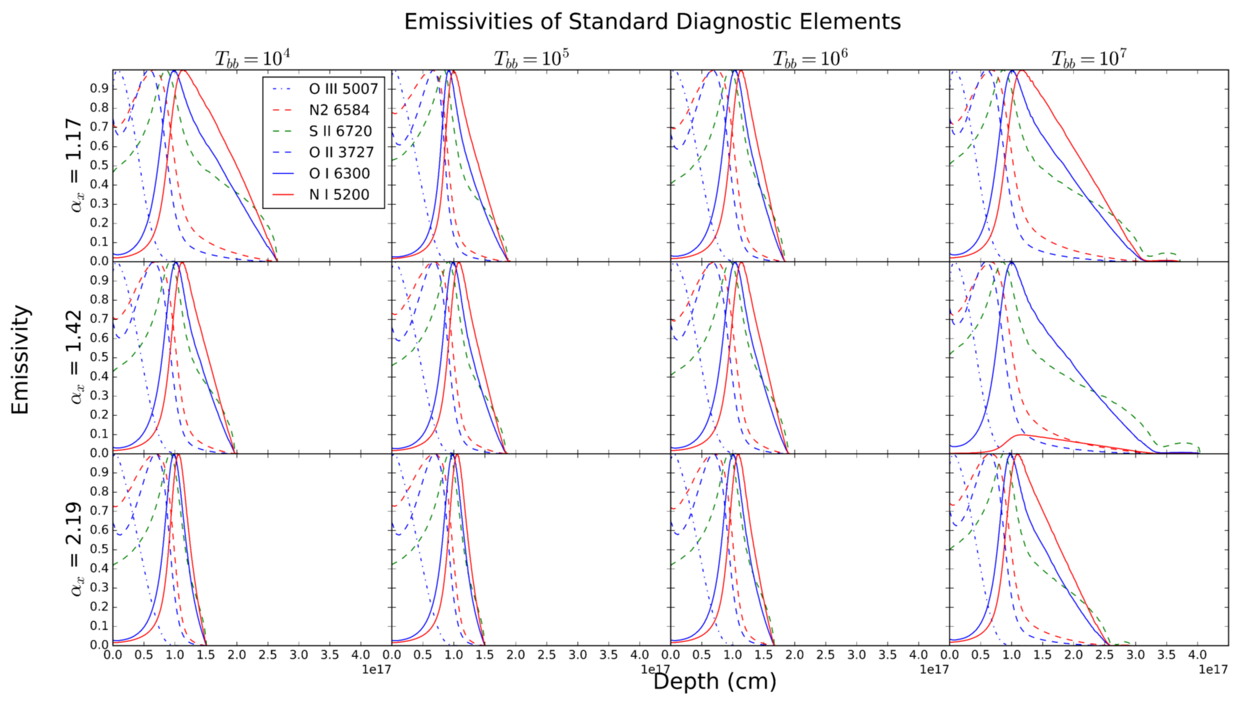
- At a metallicity of 1.5, it appears that [O II] 3727/ [N II] 6584 is slightly underpredicted when compared to [S II] 6716 / [S II] 6731, which constrains the density.
- Variation in α_x and T_{BB} does not significantly affect the simulated values.



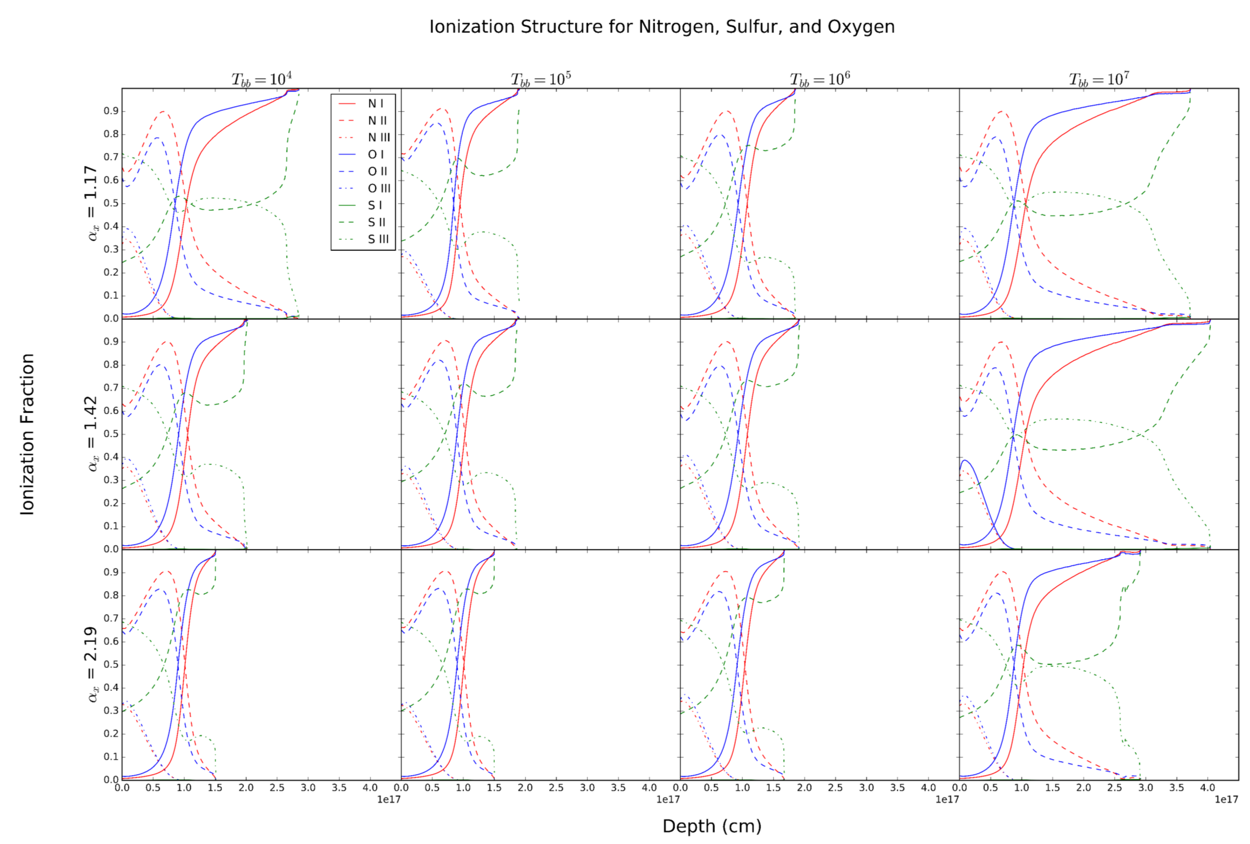
- After constraining metallicity and density, diagnostic plots of excitation mechanism were produced, with log U = -3.5.



- [N II] 6584 appears at the fringe of observed LINERs, indicating that our metallicities may be overestimated.
- [S II] 6720 also falls close to the edge of our observational data, falling off the group of data with larger T_{bb}
- To examine these peculiarities, plots of the ionization structure and emissivity of nitrogen, oxygen, and sulfur were produced.



- The high emissivity of O I is typical of LINER emission.
- Increasing α_x decreases the depth of peak emissivity, while increasing T_{bb} increases how deep the elements will emit.



- S II and S III have the most interesting ionization structure, with higher temperatures significantly lengthening the depth where there is more S II and S III. This could explain the overprediction in our diagnostic diagrams.

Conclusions

- Ionization structure profiles indicate that our simulations overestimate nitrogen abundance.
- Emissivity and Ionization Fraction profiles are most affected by T_{BB} but also varies with α_x, our emissivity plots show that a combination of $\alpha_x = 1.42$ and $T_{bb} = 10^7$ produce the strongest O I and S II emissions
- After adjusting metallicity in new simulations, the spread in the emission line ratios of LINERs could possibly be explained by variations in the AGN SED.

Future Work

- Adjust metallicity scaling to fit observational data.
- Examine T_{bb} ranges between 10^6 and 10^7 K to determine the cause of the elongation of emissivity and ionization.

Acknowledgements

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