Sam Jenkins

**Introduction**

Nebular clouds in star forming regions and active galactic nuclei (AGN) typically show electron temperatures around *Te* = XXX (Osterbrock & Ferland 2006).

* Osterbrock and Ferland have a mean temperature for galaxies up to log4.3 and don’t mention that being abnormal
* A typical Te of 15k K is used in models for the OIII region (Shuder & Osterbrock temps are also in OIII region
* Are we in the OIII region?
* They’re also talking about nH being 3.2-4 E2 and we’re using 10E4? Something’s wrong (but then they mention low density limit being < 10E4, confused)

However, anomalously high values *Te* > 1.54x104 have been noticed in surveys for decades without a thorough explanation for the physical mechanism responsible for creating such conditions in narrow line emitting AGN [Shuder & Osterbrock, 1981, Komossa & Schulz 1997, Zhang et al., 2013, Richardson et al., 2014.

While more recent work has started to address the topic head on, signatures of high Te have been present in small spectroscopic samples of AGN. Shuder & Osterbrock (1981) show Te > 1.7E4 K in 5 of the 12 galaxies for which they measure electron temperature. Shuder & Osterbrock do not include any models in their work, which leaves the question of why such high Te is observed in some galaxies (I don’t like how this is worded).

* Ferland & Netzer study whether shocks are responsible for ionization, and state that by going to low values of ionization parameter they can show that the spectra they observe from “normal galaxies” can be reproduced from photoionization alone
* Their model predicts very little 4363 emission, meaning low Te? They say the strength of 4363 was initially the reason shock heating was considered by Koski and Osterbrock 1976.
* They also say 4363 is rarely seen in LINERs? Why?

[NOW GO THROUGH KOMOSSA AND SHULTZ 1997 AND SET UP HOW THE MODELLING IS TYPICALLY DONE.]

include the modelling setup and any important results, dopita tried shocks, include the shock parameters, groves includes grains

* Alpha uv-x from -1 to -2.5
* Blackbody temp 100k-250k
* Luminosity rate of the continuum source Qtot = 10^54 s^-1 of hydrogen ionizing photons isotropically emitted by the nucleus
* Distance from the clouds to the central source between 10^20 – 10^21.5 cm
* Hydrogen column densities 10^18-24 cm^-2 (What’s a matter-bounded cloud vs. an ionization bounded cloud?)
* nH 10^2-6 cm^-3 (How’s this different from column density?)
* Z/Zo 0.3-3.0
* LogU -6.58 – 0.42
* Are we looking at single component model?
* Komossa and Schulz include a much larger data set than Shuder & Osterbrock (37 galaxies)
* Dopita Table 1: What do the different shock velocities/ions mean?

To model these clouds in the narrow line region, some photoionization source is assumed, such as the accretion disk around a central supermassive black hole in active galactic nuclei (AGN), or stellar radiation in star forming galaxies. This ionizing radiation will go through the gas cloud, and spectra is measured from this cloud. Reasonable ranges for parameters of the cloud are assumed such as ionization parameter, metallicity, hydrogen density, grain content etc. from previous literature. We can input these conditions into a computer program called CLOUDY that will output emission lines for a galaxy with the given input characteristics. [show realistic ranges in parameters, those predict common temps, show evidence.]. As Zhang, Liang and Hammer (2013) mention, there has been no clear explanation of the temperature problem, and most attempts to explain it have relied on unrealistic combinations of parameters. Komossa & Schulz (1997) attempted to solve this problem by increasing density, but their density values caused inconsistencies in other measurements, specifically OI values. Richardson et al. (2014) investigated the possibility that the temperature problem is actually a density problem causing false readings in the temperature sensitive line ratios, but determined that this was not actually the case.

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EVERYTHING BELOW THIS LINE IS METHODS]

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Our research focuses on this temperature problem in narrow line region (NLR) emitting Active Galactic Nuclei (AGN) [move farther down]

Our research uses data from the Sloan Digital Sky Survey as well as constraints on galaxy types established in Kewley et al. to separate our data set by galaxy type. Interestingly, our data set contains no LINERs. Shock-wave heating is a possible heating mechanism, but LINERs are shocked AGN, so because we have no LINERs, we do not explore shocks.

We plot our SDSS data set on a collection of diagnostic diagrams in order to categorize them by characteristic conditions and type. The most popular and useful of these is the BPT Diagram, presented by Baldwin, Phillips and Terlevich in 1981. The BPT Diagram is a log[OIII] λ5007/Hβ vs. log[NII] λ6584/Hα plot that conveniently separates AGN from Star Forming (SF) galaxies, composites, and ambiguous objects, all of which are contained in our data set. log[OIII] λ5007/Hβ is a hydrogen density and ionization sensitive line ratio, and log[NII] λ6584/Hα is primarily sensitive to ionization. We used this log[NII] λ6584/Hα ratio again when we separate our galaxies by temperature, in a log[OIII] λ5007/4363 vs. log[NII] λ6584/Hα plot. This neatly categorizes our galaxies by their temperature, as 5007/4363 is a temperature sensitive emission line ratio. The high temperature outliers in our data set are apparent in this temperature plot, and we use it to compare with our simulations and check the temperature of our simulations. By comparing different iterations of simulations with these plots of our data set we are able to see the effects of changing different parameters, which helps us decide how to adjust our simulations. These plots also ensure that we are using realistic values of our parameters, and likely observed conditions, by showing us whether our simulations match our data.

ZLH find the high Te Seyfert 2 show low metallicity Fig 7

LINERs and composites show Te “far too high to be explained by only stellar photoionization”

Some strong [O III] λ4363 emission Seyfert 2 galaxies with Te > 15 000 K can be fitted with dusty AGN model grids at low metallicity (i.e. Z/Z ∼ 1).

**References [I commented on this in a previous draft…you need to put these in actual citation format]**

Baldwin, J., Phillips, M., Terlevich, R., 1981, PASP, 93, 5-19

Kewley, L., Groves, B., Kauffmann, G., Heckman, T., 2006, MNRAS, 372, 961

Osterbrock, D., Ferland, G., 2006, *Astrophysics of Gaseous Nebulae and Active Galactic Nuclei*

Richardson, C., Allen, J., Baldwin, J., Hewett, P., Ferland, G., 2014, MNRAS, 437, 2376

Ferland et al., 2013, arXiv: 1302.4485

Ferland, G., Netzer, H., 1983, ApJ, 264, 105-113

Albareti et al., 2015, arXiv: 1501.00963

Komossa, S., Schulz, H., 1997, Astronomy and Astrophysics, 323, 31-46

Zhang, Z.T., Liang, Y.C., Hammer, F., 2013, MNRAS, 430, 2605-2621