https://en.wikipedia.org/wiki/Quasar

Studying the CGM through Quasar Absorption

Maryland Space Grant Consortium Symposium
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http://tunews.towson.edu/2015/03/23/150-years-all-in-one-website/

https://www.nasa.gov

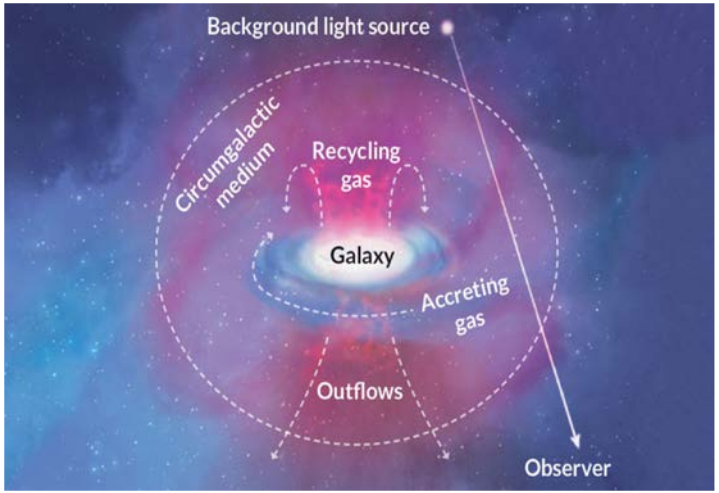
Data

- For our research we used sightlines of 44 low redshift quasars ($0.06 < z < 0.85$) and their absorption lines defined and provided by Danforth et al. (2016) and archived on the Mikulski Archive for Space Telescopes (MAST).

- These 44 quasars overlapped with the footprint of the Sloan Digital Sky Survey (SDSS) out of the 82 quasars observed with Hubble Space Telescope (HST)/Cosmic Origins Spectrograph (COS).

What is the Circumgalactic Medium?

- The CGM is the gas surrounding galaxies outside their disks and inside virial radii.

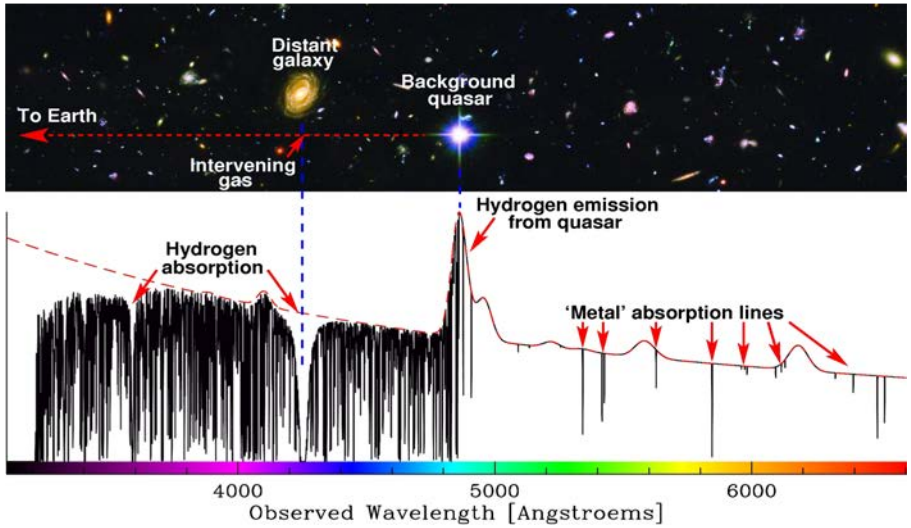


http://www.bnreport.com/the-ecosystem-that-controls-a-galaxys-future-is-coming-into-focus/

- Acts as a source of fuel for star formation.
- It is thought to contain a vast amount of baryons that are “missing”.
- These baryons are thought to contribute about 1% out of the 4% of the unaccounted for mass of the galaxies.
- Baryons in the CGM are studied using absorption spectroscopy and background quasi-stellar objects (QSOs).

QSOs and their Spectra

- QSOs are extremely luminous and distant active galactic nuclei.
- We use these bright points as background sources and we can take spectra of their sightlines.
- In each sightline we see absorption lines that are grouped into ‘systems’ that are then connected to the CGM of nearby galaxies.



https://www.hs.uni-hamburg.de/jliske/qsoal/

Our goal is to match the absorption lines to their sources. These are known as QSO absorber-galaxy matches.

Spectra Continued

- The absorption features tell us characteristics of the CGM and the galaxy it is a part of.

- We are mainly focusing on Lyα absorption lines but we will also be looking at many other absorption lines as well.

Bayesian Code

- We use low photometric redshifts from SDSS, along with the relationship between equivalent widths of absorbers in the quasar spectra and the impact parameters of the galaxies as input into our Bayesian code.

- This input gives probabilities of each absorber-galaxy match.

- In general the galaxy's spectrum would then used to confirm its relationship to the QSO absorber with a more accurate redshift.

- Thus far the code has identified 1,182 QSO-galaxy matches 44 QSO sightlines. Some of the matches were also identified in other sets of literature as the top match or was in the top probable matches.

Current Work

- Currently not all galaxies in our study have recorded spectra so over the summer I have been preparing to write a proposal to take spectra at the the Multiple Mirror Telescope (MMT) using the Binospec located in Arizona.

- The Binospec is an optical multi object spectrograph and imager that was newly renovated in November of 2017.

- If granted time data will be taken the the spring semester between February and July.

Identifying Associated Absorbers

- Using spectra and line lists from Danforth et al. 2016
  - Sample size of 44 QSO spectra

- Associated absorber
  - An absorption system with 5,000 km/s or less between the redshifts of the quasar and the absorber
  - These systems are usually galaxies which may be affected by the QSO and its host galaxy
    - Gravitation
    - Ionization

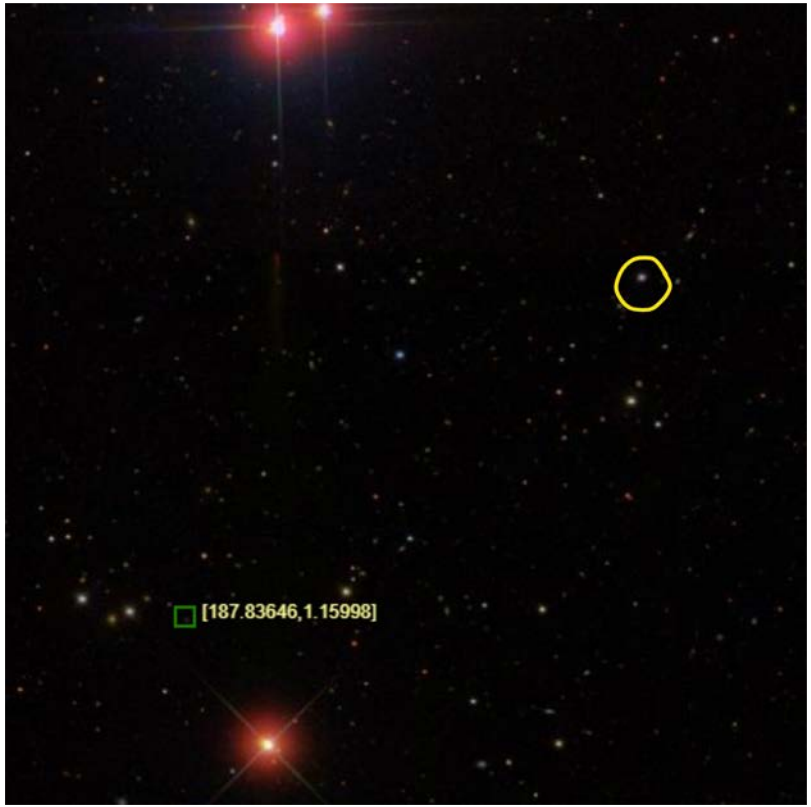
Procedure

- Took spectra of each QSO and grouped absorption lines into systems
  - Grouped by redshift (within 300 km/s)
  - Interested in associated absorbers (close to the QSO)
    - only using absorption lines with a velocity separation of 5,000 km/s or less
- Identified possible intrinsic absorbers, and discard them
  - An intrinsic absorber is an outflow from the accretion disk of the QSO
  - Referencing Dunn et al. 2007 and Ganguly et al. 2013

Matching Galaxies to Absorbers along a QSO sightline

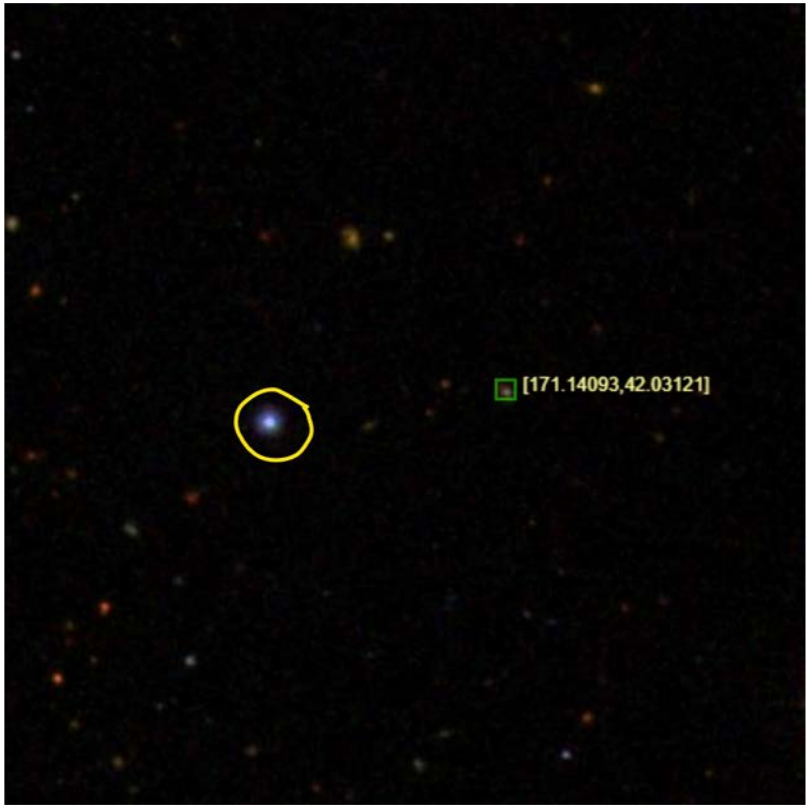
- Applied the Bayesian code to each associated absorber
- The Bayesian code outputs the galaxy that is mostly likely related to that absorber, as well as the probability

Q1230+0115 and SDSS J123120.74+010935.9



Probability: 0.1546
Impact Parameter: 960.802 kpc

PG1121+422 and SDSS J112433.82+420152.3

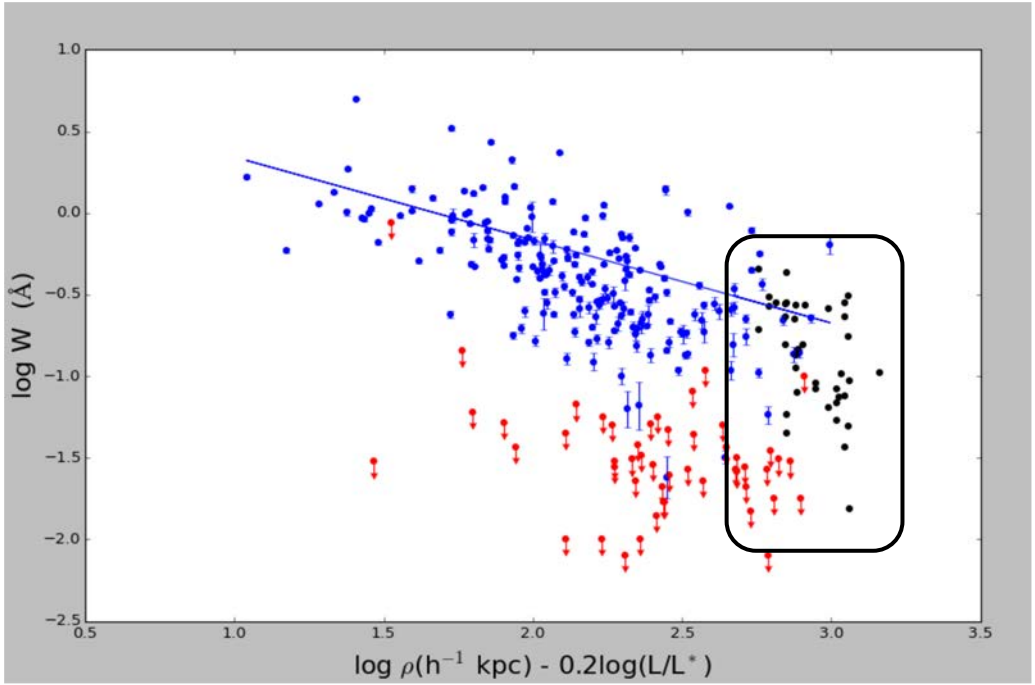


Probability: 0.2157
Impact Parameter: 194.049 kpc

Galaxy Proximity Effect

- Objects near a quasar may be may be affected by its radiation leaving an “ionization signature”.
- The hydrogen in associated absorbers may be ionized by the quasar which leads to a smaller envelope of neutral hydrogen.
- These absorbers with a smaller amount of CGM may not be detected in QSO sightlines, where as a non-associated absorber would be detected.

Results



Y axis: scaled equivalent width

X axis: scaled impact parameter

- The black points show the pairs of our associated absorbers
- The red and blue points are of intervening absorbers found from literature
- Our sample trend towards larger scaled impact parameter, this could be the “proximity effect”

Future Work

- 0btaining more galaxy spectra
- Graphing intervening absorbers from our sample against our associated absorbers
- Further developing Bayesian code
  - Double matching
  - Multiple ion systems

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https://www.amazon.com/Dolce-Mia-Space-Birthday-Thank/dp/B0026DR7JQ

References

Danforth, C. W., Keeney, B. A., Tilton, E. M., Shull, J. M., Stocke, J. T., Stevans, M., . . . Osterman, S. N. (2016). Anhst/cos Survey Of The Low-Redshift Intergalactic Medium. I. Survey, Methodology, And Overall Results. *The Astrophysical Journal,817*(2), 111.

Dunn, J. P., Crenshaw, D. M., Kraemer, S. B., & Gabel, J. R. (2007). A Survey of Intrinsic Absorption in Active Galaxies using the Far Ultraviolet Spectroscopic Explorer. *The Astronomical Journal,134*(3).

Ganguly, R., Lynch, R. S., Charlton, J. C., Eracleous, M., Tripp, T. M., Palma, C., . . . Jones, T. M. (2013). A census of quasar-intrinsic absorption in the Hubble Space Telescope archive: Systems from high-resolution echelle spectra. *Monthly Notices of the Royal Astronomical Society,435*(2), 1233-1264. doi:10.1093/mnras/stt1366

Liang, C. J., & Chen, H. (2014). Mining circumgalactic baryons in the low-redshift universe. *Monthly Notices of the Royal Astronomical Society,445*(2), 2061-2081. doi:10.1093/mnras/stu1901

Tumlinson, J., Peeples, M. S., & Werk, J. K. (2017). The Circumgalactic Medium. *Annual Review of Astronomy and Astrophysics,55*, 389-432.

http://skyserver.sdss.org/dr9/en/tools/chart/navi.asp

https://www.hs.uni-hamburg.de/jliske/qsoal/


http://mindfuljourney.ca/blog-2/2015/2/6/thank-you-universe
Thank You!
Any Questions?