Characterizing the Dark Matter Halos of Galaxy Groups and Their Hidden Baryonic Content

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Introduction

A large fraction of galaxies reside in groups and the dominant form of baryons in these groups is predicted to be in a diffuse, intragroup medium (IGrM). Mulchaey et al. (2000) observed massive groups that had soft X-ray emission, but this technique was not applicable to less massive groups. However, Mulchaey et al. (1996) predicted the existence of a hot ($\gtrsim 10^6$K) gas that could be detected via broad, shallow O VI with Lyman-α absorption without lower ionization lines such as Si III, N V, or C IV. These absorption lines can be seen in the spectra of background quasars.

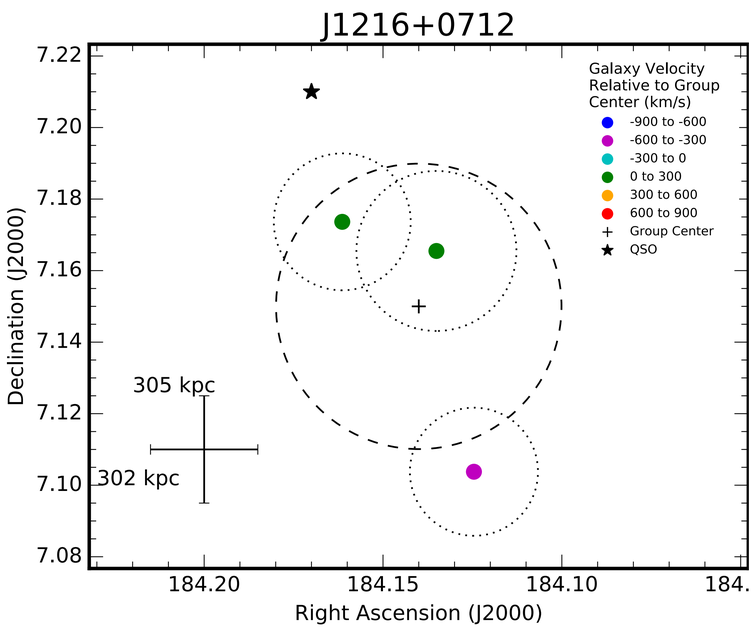

Figure 1: Environment of SDSS galaxy group J1216+0712 showing the velocity dispersions of the (>L*) member galaxies. The group's virial radius is shown by the dotted line and the virial radii of the group members is represented by the dotted circles.

Methods

We mounted a controlled, absorption line experiment, the COS-IGrM survey, using the Cosmic Origins Spectrograph (COS) on the *Hubble Space Telescope* (HST) to obtain spectra of 19 background, UV bright quasars to search for the IGrM. The galaxy groups were predetermined by the Tago et al. (2010) catalog based off of SDSS data release 7 data. The SDSS environment of one of the galaxy groups is shown in Figure 1.

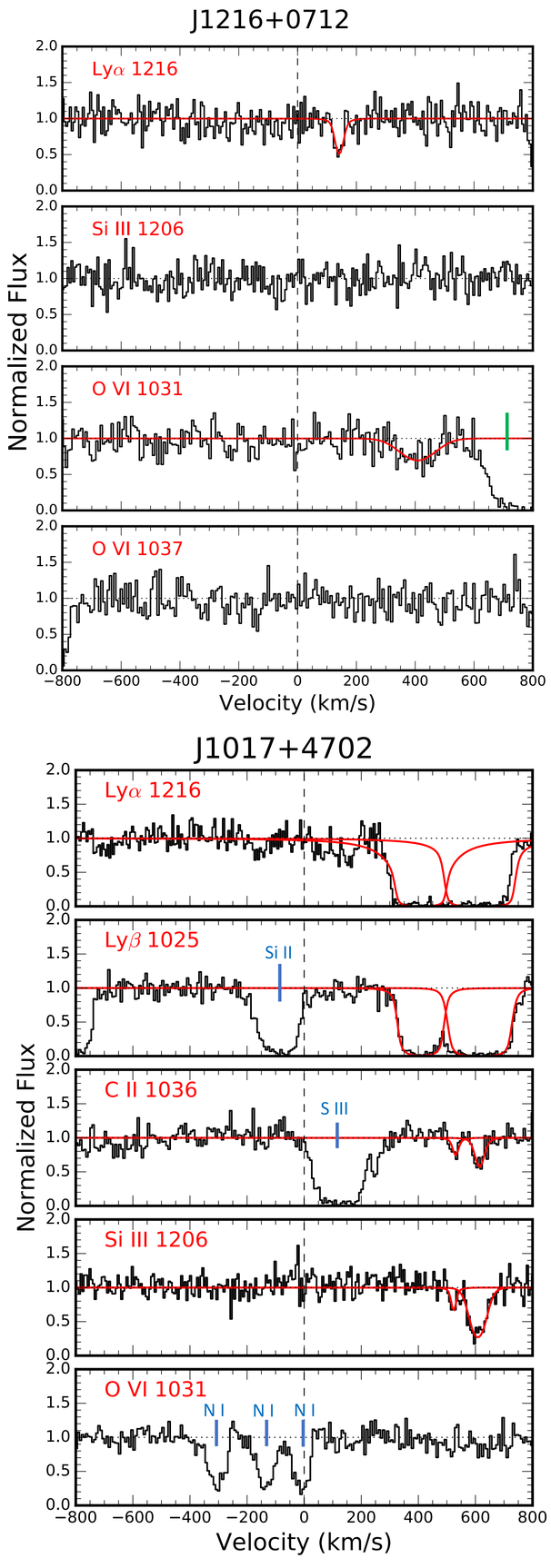

Figure 2: COS spectra of three galaxy groups showing the locations of various group absorption lines in red, intervening Milky Way lines in blue, and other intervening lines in green. *(Top)* Galaxy group J1216+0712 shows broad, shallow O VI without Si III absorption, which is indicative of a hot IGrM (*Bottom)* COS spectra of galaxy group J1017+4702 showing more typical CGM conditions where there is strong Ly-α, Si III, and C II absorption with minimal O VI, which is indicative of cooler, photoionized gas.

Results

Figure 2 shows two examples if absorption systems that represent the predicted IGrM conditions as well an example of a system showing cooler gas transitions without any O VI absorption. This is similar to what is expected from the circumgalactic medium (CGM) of an individual member galaxy. Out of the 19 galaxy groups studied, one group had QSO spectra with signal to noise too low to be used. The remaining 18 groups had 7 detections of O VI absorption. Figures 3 and 4 show some of the results from the COS-IGrM survey.

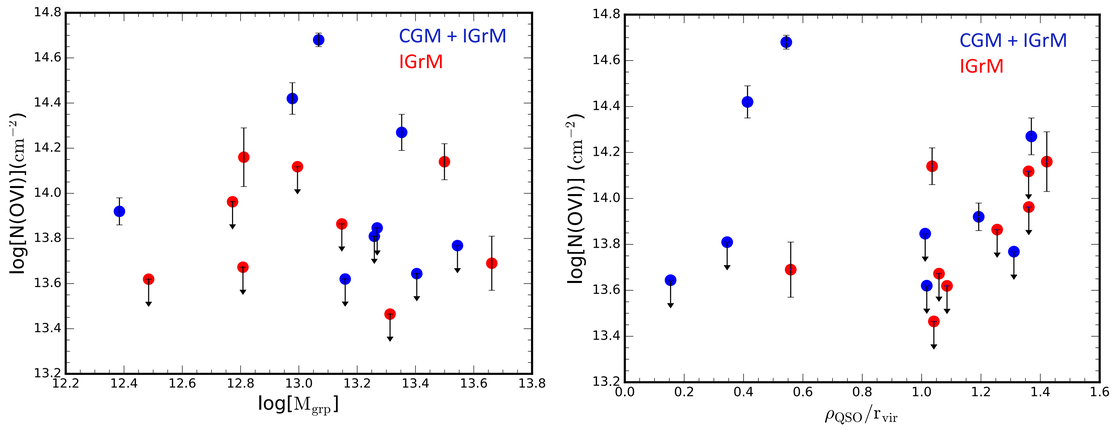

Figure 3: O VI column densities as a function of group halo mass (*left)* and impact parameter (*right)*. The blue points show groups where the QSO sightline should probe CGM + IGrM, while the red point show sightlines passing through the IGrM.

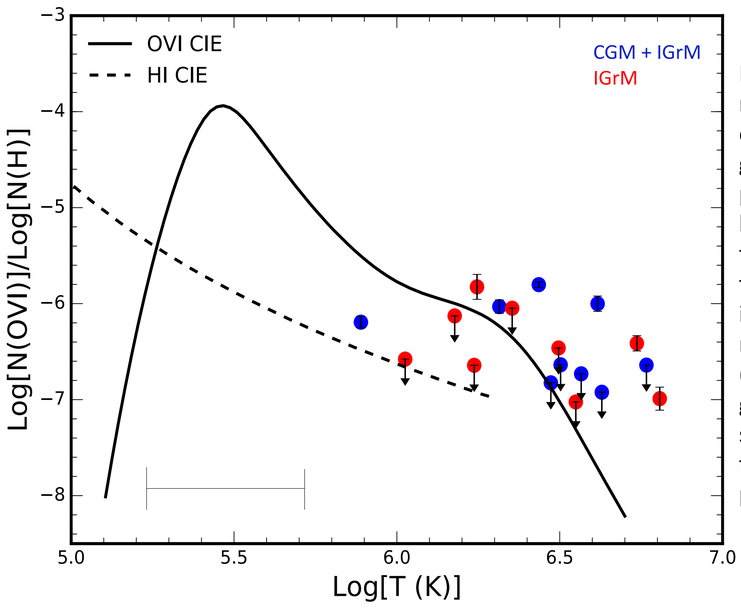

Figure 4: O VI column densities normalized by the column density of hydrogen as a function of group virial temperature. These points lie close to the solid, black line, which represents the fraction of O VI at various temperatures based on collisional ionization equilibrium (CIE) models from Gnat & Sternberg (2007). The blue points show groups where the QSO sightline should probe CGM + IGrM, while the red point show sightlines passing through the IGrM.

Conclusions and Future Work

While the O VI detections are relatively close to the CIE predictions, they show no distinct correlation between column density and group mass or QSO impact parameter. However, clear distinctions between CGM absorption and IGrM absorption have been detected in these COS spectra. The broad, shallow O VI detections indicating a hot, collisionally ionized gas are in agreement with other studies such as Savage et al. (2010), Narayanan et al. (2018), and Stocke et al. (2019). Two of the groups showing broad O VI absorption have been observed with Gemini North to increase group membership, which will provide a more accurate estimate of the virial radius and halo size of the groups.

References

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