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CaII Quasar Absorbers: Statistics, Metals, Dust, and Associated Galaxies

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Abstract. We summarize results from our recent SDSS survey for CaII quasar absorbers. The survey finds 435 absorbers at $z < 1.34$, which corresponds to ~ 9 Gyrs of the Universe's history. Two CaII absorber populations are identified, which we call weak and strong. Metal abundance ratios derived from normalized composite spectra show that weak absorbers can be identified with halo-like gas, while strong absorbers are a mix of halo+disk-like gas. Consistent with these abundance ratio results, fluxed composites show that strong absorbers are ~ 6 times more reddened than weak absorbers (i.e., they contain more dust). Four individual examples of galaxies associated with CaII absorption are found in the SDSS images, and three are star forming galaxies (SFGs). Image composites show that galaxies associated with strong absorbers have mean luminosity-weighted impact parameters, b, which are ~ 2.4 times smaller than the weak absorbers ($b_{strong} \sim 19$ kpc versus $b_{weak} \sim 45$ kpc). Studies of CaII absorbers suggest links to molecular clouds, SFGs, and circumgalactic gas (CGG).

Keywords. surveys, galaxies: abundances, galaxies: general, galaxies: quasars: absorption lines

1. Background

The above abstract very briefly summarizes the results from our studies of the relatively rare CaII quasar absorbers. The CaII$\lambda\lambda 3934, 3969$ absorbers comprise about 8% of the ubiquitous MgII$\lambda\lambda$2796,2803 quasar absorbers at a similar detection threshold. The papers by Sardane, Turnshek, & Rao (2014, 2015, 2016) provide the details and references. Our studies were enabled by SDSS spectroscopic and imaging data on $> 92,000$ quasars. Along with characterizing the CaII absorber statistics (e.g., see Figure 1 and its caption), composite spectra and images were formed and analyzed to arrive at the results (e.g., see Figure 2 and its caption, in addition to the abstract). Importantly, a subset of the CaII absorbers can be studied down to near zero redshift using optical spectra. This is not possible with the bulk of quasar absorbers, which have rest-frame transitions in the UV. Studies of the lowest-redshift systems permit the most sensitive searches for any low impact parameter galaxies that may be associated with the absorbing gas.

2. Molecular Clouds, SFGs, CGG

H_2 absorption has been detected in a few CaII absorbers, and it may be common, suggesting a link to molecular clouds and SFGs. The observed element depletions on to dust grains and reddening support this. The observed extended impact parameter distribution, and the absence of $L > 0.01L^*$ associated galaxies with smaller impact parameters in some very low redshift cases, indicate that CGG gives rise to some of the CaII absorbers. Understanding molecular gas at such large galactocentric distances is a theoretically challenging problem.

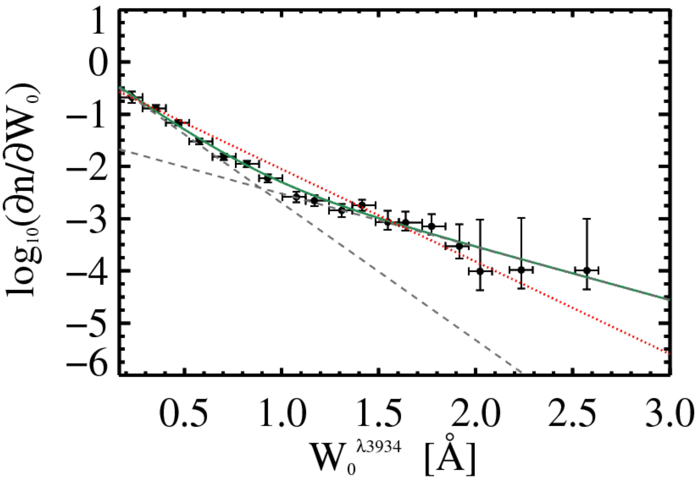

Figure 1. CaII absorber statistics suggest two populations. One indication of this is the observed break in the CaIIλ3934 rest equivalent width distribution, separating strong and weak CaII absorbers. Other results presented in Sardane *et al.*(2014, 2015, 2016) confirm this.

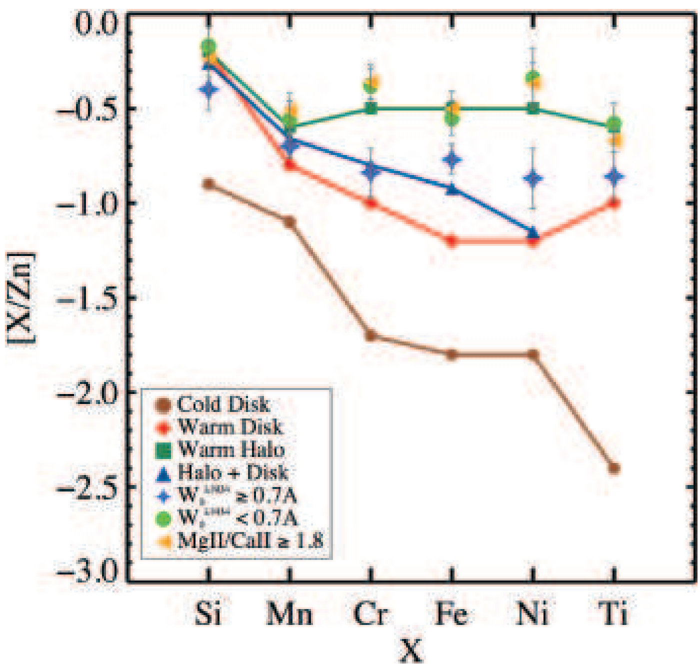

Figure 2. Measurements of metal lines in CaII composite spectra show that strong absorbers have element abundance ratios and depletions similar to disk+halo gas, while the weak absorbers match halo gas. These results are consistent with results on reddening and the impact parameters of associated galaxies derived from the analysis of composite spectra and images presented in Sardane *et al.*(2015, 2016). Some of the associated galaxies are SFGs (Sardane *et al.*2014).

References

Sardane, G.M., Turnshek, D.A., & Rao, S. M. 2014, *MNRAS*, 444, 1747
Sardane, G.M., Turnshek, D.A., & Rao, S. M. 2015, *MNRAS*, 452, 3192
Sardane, G.M., Turnshek, D.A., & Rao, S. M. 2016, *MNRAS*, submitted

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