The SDSS DLA and Metal-Strong Surveys

[Prochaska et al., 2005, ApJ, 635, 123]

[Herbert-Fort et al., 2006, PASP, 118, 1077]

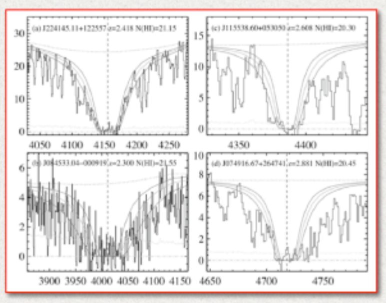
Stéphane Herbert-Fort[1], Jason X. Prochaska[2], Arthur M. Wolfe[3], M. Dessauges-Zavadsky[4], S.L. Ellison[5], J.C. Howk[6], G.E. Prochter[2]

([1]University of Arizona; [2]UCO/Lick, UC Santa Cruz; [3]UC Santa Barbara; [4]Observatoire de Genève; [5]University of Victoria; [6]Notre Dame)

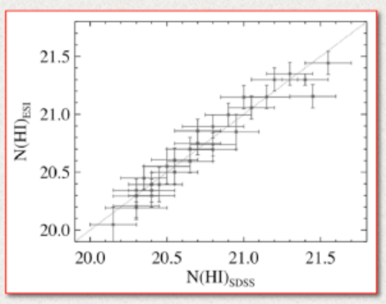
email: shf@as.arizona.edu

Our Projects

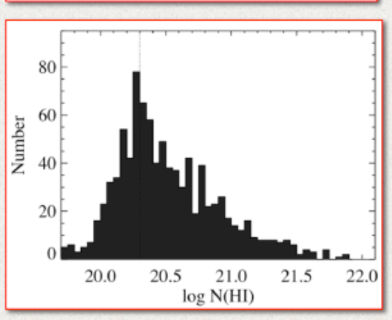
We search SDSS quasar spectra for signs of gas absorption along the line-of-sight, here due to damped Lyman-α (DLA) systems, some also showing strong metal-absorption profiles. The left panel focuses on The SDSS DLA Survey (Prochaska et al. 2005) and the right on The Metal-Strong DLAs (MSDLAs; Herbert-Fort et al. 2006). The MSDLA candidates, discovered in tandem with the DLA search, were later followed-up with the Echellette Spectrometer and Imager (ESI) at Keck for accurate column density measurements of weak lines. We are currently following-up more MSDLA candidates for higher-resolution data of their metal lines, as well as for *N*(HI) values of systems lacking Lyman-α coverage in the SDSS spectra (minimum z_{abs} ~ 2.1). We have updated many of our results using SDSS-DR5, and the full sample (over 1,000 DLAs) can be accessed at http://www.ucolick.org/~xavier/SDSSDLA/index.html



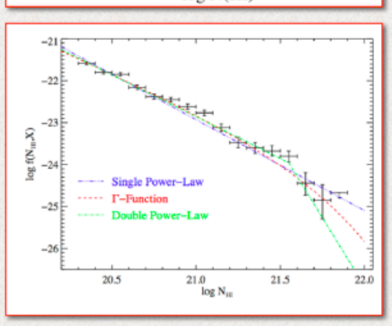
Example profile fits to four DLAs from our SDSS-DR3 DLA survey. The examples represent (a) a high SNR case with a well constrained quasar continuum and minimal line blending ($\sigma_{N(HI)}$= 0.15); (b) a low SNR case ($\sigma_{N(HI)}$= 0.30); (c) an example with severe line blending ($\sigma_{N(HI)}$= 0.20); and (d) an example where determining the redshift from associated metal-line absorption is very important ($\sigma_{N(HI)}$= 0.15).



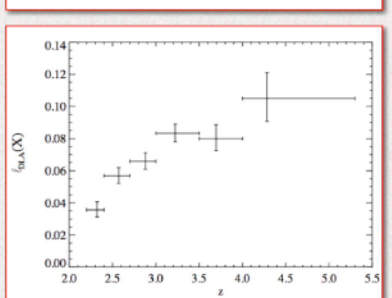
Comparison of the *N*(HI) values for a subset of the SDSS-DR3 sample as measured from the SDSS quasar spectra and, independently, data acquired with Keck/ESI. SDSS provides a wonderful dataset for this type of survey.



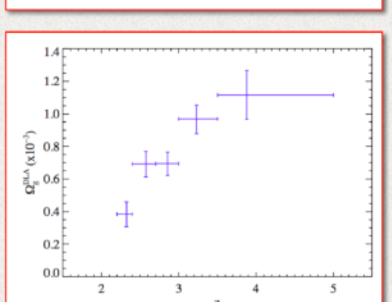
Histogram of the *N*(HI) values for every DLA candidate fit in the SDSS-DR3 sample. Note that the distribution peaks at log*N*(HI) < 20.3 suggesting a high level completeness at the DLA threshold (dotted line). We estimate the completeness level to be ~99%.



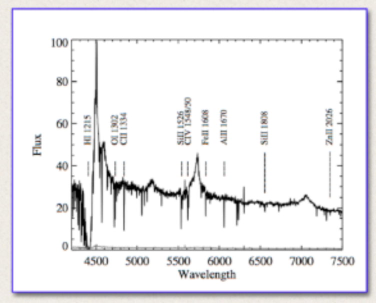
The HI frequency distribution (f_{HI}) for all of the DLAs identified in the SDSS-DR5 sample. Overplotted on the discrete evaluation f_{HI} are the fits of a single power-law, a Γ-function, and a double power-law. Only the latter two are acceptable fits to the observations (see paper for details). Integrating the Γ-function and double power-law shows convergence in the cumulative Ω_g^{DLA} by log*N*(HI) = 22, while the single power-law has yet to converge at log*N*(HI) = 23.



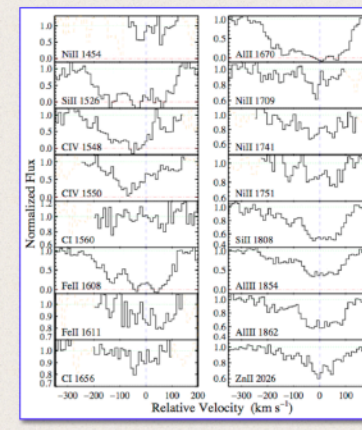
Plot of the line density of DLAs vs. redshift from the SDSS-DR5 sample. Contrary to previous studies (which focused on the line density in redshift space), we find statistically significant evolution in the line density per unit absorption distance.

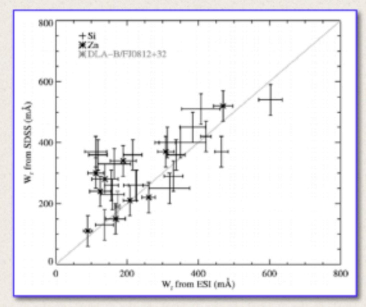


Neutral gas mass density of the DLAs as a function of redshift, from the SDSS-DR5 sample. There is an increase of ~2x in Ω_g^{DLA} from *z*=2 to 3, with the majority of rise occurring in only 500 Myr.

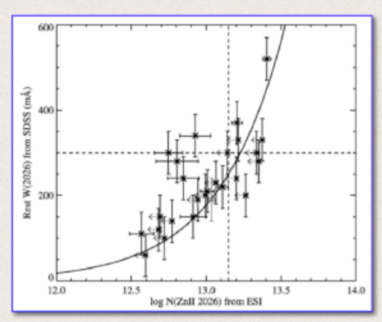


SDSS spectrum of DLA-B/FJ0812+32 (left), the prototypical Metal-Strong DLA (MSDLA) which helped motivate our SDSS MSDLA search. Notice the strong SiII 1808 and ZnII 2026 lines. Lines like these were used as metal-strong indicators in our automated search (see paper for details).
At right we show example follow-up moderate-resolution absorption profiles taken with Keck/ESI.

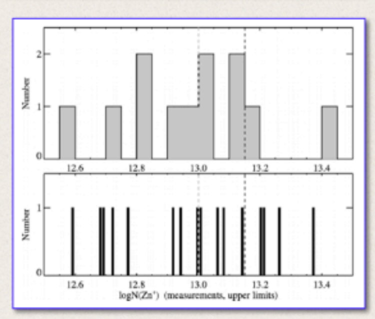




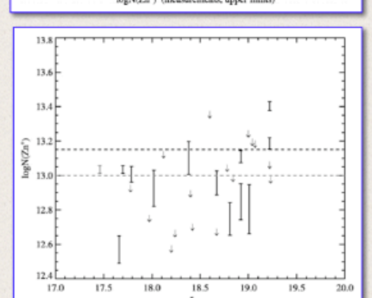
Rest equivalent width (W_r) values from ESI vs. those from SDSS, for both SiII 1808 and ZnII 2026 from all cases with secure column density values. DLA-B/FJ0812+32 is plotted in gray. Note that these values do not account for minor blends, low SNR or saturation effects; weaker W_r lines systematically have higher, false contribution from noise in lower-resolution and lower-SNR SDSS data.



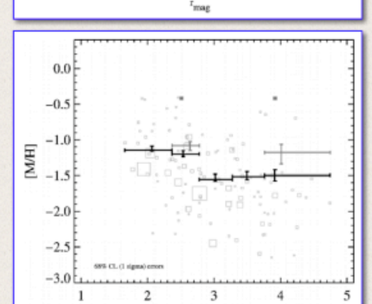
W_r(ZnII 2026) from SDSS vs. log*N*(ZnII 2026) from ESI. DLA-B/FJ0812+32 is plotted in gray. Also plotted in black dashed linestyle are the proposed log*N*(ZnII 2026) and W_r(ZnII 2026) metal-strong thresholds. The solid black line traces W_r(ZnII 2026) vs. log*N*(ZnII 2026) for optically-thin gas. The SDSS data appear accurate to ~1.5σ, and so provides the reliable, large-scale dataset crucial for this work. Thousands of quasar sightlines must be searched to discover just a handful of MSDLAs.



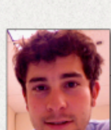
Histogram of log*N*(ZnII 2026) from the ESI data (including DLA-B/FJ0812+32, with log*N*(ZnII 2026) = 13.04 ± 0.02). Measurements are plotted as filled gray in the top panel, upper limits as black lines in the bottom panel, and the metal-strong threshold (log*N*(ZnII 2026) ~ 13.15) as a dashed black line. Note that systems with log*N*(ZnII 2026) ~ 13 (dashed gray line) may be underestimated due to line saturation in ESI spectra.



log*N*(ZnII 2026) vs. *r* magnitude from our ESI sample. The metal-strong threshold is marked as a dashed black line and DLA-B/FJ0812+32 is marked in gray. A nearly 2 magnitude statistically constant scatter in the magnitudes of metal-strong sightlines is observed; a Spearman rank correlation test on the measured values (excluding limits) gives a linear correlation coefficient of 0.49 at <2σ significance. Finding MSDLAs along fainter quasar sightlines (i.e. *r* > 19.5 mag) will provide a better means to test the effects of dust on this population.



N(HI)-weighted cosmic mean metallicity <*Z*(*z*)>. DLAs are shown as squares scaled to the *N*(HI) of the system (open are from the 'chemical-enrichment' DLA sample of Prochaska et al. 2003, filled are the ad hoc points from SDSS1610+4724, one of the strongest MSLDA found in our study). <*Z*(*z*)> is plotted for 5 bins with 1σ uncertainties given by bootstrap analysis. The dark gray errors for the z_{abs} ~ 2.6 & 4 bins are the new <*Z*> values in each bin (offset by 0.1 in *z* for presentation) after SDSS1610+4724 is added. We show that MSDLAs could have a modest impact on the <*Z*> of a single bin, but are unlikely to have a significant impact on the overall DLA <*Z*(*z*)> evolution. This is because MSLDAs comprise just ~5% of the entire z_{abs} > 2.2 DLA population in quasar sightlines with *r* < 19.5 mag.



This research was supported by the National Science Foundation (AST 03-07824, AST 03-07408 and AST 05-48180). SHF would like to thank the SOC & LOC of the 2008 SDSS symposium for their generous support.