PROBING THE INTERSTELLAR MEDIUM OF EXTERNAL GALAXIES USING QUASAR ABSORPTION LINES: THE 3C 232/ NGC 3067 SYSTEM

John T. Stocke, James Case, Megan Donahue,
J. Michael Shull and Theodore P. Snow

Center for Astrophysics and Space Astronomy
University of Colorado

Quasar absorption lines offer unique opportunities to probe the interstellar medium of external galaxies. We present new optical and UV absorption line spectroscopy of the quasar 3C232 (z=0.55) revealing new detail in the foreground absorption system due to the bright, spiral galaxy NGC 3067 (cz=1420 km/s). Specifically, our spectra show evidence for two and possibly three separate absorption components in CaII and Na I spanning ~150 km/s. The original HI detection of Haschick and Burke (1975) corresponds to the strongest of these metal systems which exhibits doublet ratios consistent with saturation in both CaII and Na I.

Due to the recent detection in HI emission of a tidal tail or "finger" of HI extending from the western edge of NGC 3067 through the position of 3C 232 (Carilli, van Gorkom and Stocke, 1989), and this conference), the morphology of the HI absorber is now known and is not either a "warped disk" nor a spherical halo as had been proposed. New deep continuum and Hα imaging provides a sensitive upper limit on the the ionizing continuum impinging upon this cloud (and thus a limit on the intensity of the extragalactic ionizing radiation field).

Together with the observed UV spectrum of 3C 232, the optical emission line ratios and the deep Hα imaging set a minimum distance between the quasar and the HI cloud disregarding redshift information. This limit strains the "non-cosmological" redshift interpretation for 3C 232 -- and this quasar is one of the original 5 3C quasars found to be too close to NGC galaxies as if by chance (Burbidge, Burbidge, Solomon and Strittmatter, 1972).

Search for CaII absorption in Galactic Halos

David Bowen, Cambridge

Bowen, Pettini, Penston & Blades have concluded their survey to probe the outer halos of low redshift ($z < 2$) identified galaxies in CaII, using QSOs as probes. We have observed 11 QSO-galaxy pairs with sight-line separations of between 3 & $75h_{100}^{-1}$kpc ($h_{100} = H_0/100$), down to 2σ equivalent width limits of less than 110mÅ for 10 of them. From previously published work we know that this limit would secure the detection of CaII column densities within our own galaxy, yet we find calcium in only one pair, an anonymous galaxy within 0.7 arcmins or $41h_{100}^{-1}$kpc from the quasar 1543+489. The lines are weak and saturated ($\sim$ 65mÅ), and the separation is the largest known for CaII absorption beyond the optical extent of a galaxy. What makes this all the more surprising is that observations of Supernovae SNWILD in NGC2268, and SN1987N in NGC7606, made with Max Pettini, continue to show strong absorption lines of both CaII and NaI, a result is typical of all high resolution spectroscopic observation of bright Supernovae.

One particular pair, that of MK205 & the face-on galaxy NGC4319, continues to be the focus of our attention, since the quasar's line-of-sight passes within $4h_{100}^{-1}$kpc of the galaxy center and lies just adjacent to a spiral arm. Though expecting absorption by the disk and any extended halo, we are unable to detect CaII in this pair to a 2σ limit of 40mÅ, meaning that the covering factor of the disk alone in CaII is less than unity at these equivalent width thresholds. Whether this is due to severe depletion of calcium along the spiral arm, or is perhaps some indication of the ionization conditions, remains to be seen. Some preliminary observations do suggest however that *NaI* is detected, and it is clearly of some importance to establish the conditions of the ISM in such a galaxy that led to this result.

We conclude that there still exists *no* evidence for extended CaII *halos* beyond a Holmberg radius, and we consider that the reported cases of large equivalent widths in the five QSO-galaxy pairs where CaII *has* been detected to be a consequence of either absorption within the disk (at about 1 R_H), or absorption by disturbed or interacting galaxies. The most important example of this latter system is provided by Carilli, van Gorkom & Stocke (1), who detect a tail passing from NGC3067 across the line-of-sight of 3C232; up till now, this had provided the best case of halo absorption in CaII, with a strong equivalent width (2). *For whatever reasons,* the extent of CaII does not support the hypothesis that galaxies are responsible for QSO absorption lines, despite the fact that there now exists good evidence that the MgII absorption systems seen in QSO spectra are indeed due to the (extended) halos of intervening galaxies (3), and a preliminary attempt to understand the dynamics of these galaxies appears to be feasible.

References:

(1): Carilli, van Gorkom & Stocke (1989), preprint
(2): Boksenberg & Sargent (1987), *Ap J.* **220**, 42
(3): Bergeron (1987), "The Post-Recombination Universe", Ed. Kaiser & Lasenby, P201.

QSO – Galaxy Pairs Survey.

QSO	Galaxy	$V_\odot$ (Kms^{-1})	ρ (′)	ρ ($h_{100}^{-1}kpc$)	W_λ(CaII K)[b] (mÅ)
0026 + 129	0026 + 1304	1590	5.7	26	< 62
0318 − 196	NGC1300	1555	9.6	27	< 108
0838 + 770	UGC4527	721	2.3	5	< 46
1048 − 090	anon 1	a	0.38	···	< 68
	anon 2	z=0.1255	0.43	39	< 68
1211 + 143	IC3061	2269	11.5	75	< 42
	Virgo Cluster	−180-2400	*n/a*	*n/a*	< 42
1219 + 047	NGC4303(≡M61)	1589	4.7	11	< 164
	Virgo Cluster	−180-2400	*n/a*	*n/a*	< 164
1219 + 755	NGC4319	1390	0.7	3	< 38
1341 + 258	1341 + 2555	5802	1.8	30	< 48
1411 + 442	ZWG219.061	?[c]	6.9	?	< 72
	UGC09105	?[c]	8.3	?	< 72
1543 + 489	anon 1	22700	0.7	41	65±15
	anon 2	?	1.4	83	?
2308 + 098	anon	z=0.1726	0.15	18	< 84

NOTES: a. Stockton (1978) suggests z ≃ 0.228, 0.346 from poor quality data.
b. Where lower limits are given, these are to 2σ.
c. Awaiting redshift data.