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Deep Searches for High Redshift Molecular Absorption

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Abstract. Millimetre-band scans of the frequency space towards optically dim quasars is potentially a highly efficient method for detecting new high redshift molecular absorption systems. Here we describe scans towards 7 quasars over wide bandwidths (up to 23 GHz) with sensitivity limits sufficient to detect the 4 redshifted absorbers already known. With wider frequency bands, highly efficient searches of large numbers of possibly obscured objects will yield many new molecular absorbers.

1. Introduction

Webb et al. (these proceedings) discussed constraints on possible variations in fundamental constants offered by quasar absorption lines. Optical studies (Webb et al. 1999; Murphy et al. 2003) find a statistically significant variation of the fine-structure constant, $\Delta\alpha/\alpha \approx (-0.54 \pm 0.12) \times 10^{-5}$, over the redshift range $0.2 < z_{\rm abs} < 3.7$. Comparison between H I-21cm and molecular rotational (millimetre) absorption lines can yield an order of magnitude better precision (per absorption system) than these purely optical constraints (Drinkwater et al. 1998; Carilli et al. 2000; Murphy et al. 2001): a statistical sample of H I-21cm/mm comparisons will provide an important cross-check on varying-α. Currently, however, only 4 such redshifted millimetre absorption systems are known (Wiklind, these proceedings). To increase this number we have employed the following search strategies:

1. Deep integrations of damped Lyman-alpha absorbers (DLAs), the highest column density ($N_{\rm HI} \gtrsim 10^{20}$ cm^{-2}) quasar absorbers known. Since we observe at a known redshift and therefore frequency, optical depth limits better than $\tau \lesssim 0.1$ are often obtained. The DLA results are discussed in detail by Curran et al. (2004).

2. Scanning the frequency space toward visually dim millimetre bright quasars in search of a possible absorber responsible for the visual obscuration. Here we summarize our results as obtained with the Swedish-ESO Sub-

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millimetre Telescope (SEST) and Nobeyama Radio Observatory's 45-m telescope (NRO).

2. Results

From an extensive literature search we selected four millimetre-loud quasars yet to be optically identified (Table 1, top). For each of these we performed a

Table 1. The SEST (top) and NRO (bottom) search results. V is the visual magnitude with the Galactic extinction, A_B, given. z_{em} is the quasar redshift, S the approximate flux density in Jy at the observed frequency band, ν, and τ is the typical 3σ optical depth limit (quoted for a resolution of 1 km s^{-1}, see Curran et al. 2002).

Quasar	V	A_B	z_{em}	Ref	S	ν [GHz]	τ
0500+019	21.2	0.289	0.58457	2	0.5	78.30–80.90	2
...	...	...	...	...	0.5	85.50–86.50	0.8
...	...	...	...	...	0.5	112.10–113.10	0.8
...	...	...	...	...	0.4	130.00–141.40	1
0648–165	–	2.456	–	–	1.6	78.30–80.90	0.2
...	...	...	...	...	1.5	83.90–90.50	0.2
...	...	...	...	...	0.7	138.00–141.40	0.5
...	...	...	...	...	0.6	142.80–149.40	0.7
0727–115	22.5	1.271	–	–	2.9	78.30–80.90	0.2
...	...	...	...	...	2.7	83.90–90.50	0.1
...	...	...	...	...	1.5	138.00–141.40	0.2
...	...	...	...	...	1.2	142.80–148.60	0.4
1213–172	21.4	0.253	–	–	1.0	78.30–80.90	0.4
...	...	...	...	...	0.9	83.90–90.50	0.4
...	...	...	...	...	0.5	138.00–141.40	0.8
...	...	...	...	...	0.4	142.80–151.00	1
0742+103	~ 24	0.111	–	–	0.6	46.90–47.50	–
...	...	...	...	...	0.4	77.25–87.50	0.9
...	...	...	...	...	0.4	88.45–89.35	0.4
1600+335	23.2	0.137	1.1	3	0.7	46.90–47.50	2
...	...	...	...	...	0.5	77.25–87.50	0.5
...	...	...	...	...	0.5	88.45–89.35	0.4
1655+077	20.1	0.66	0.621	1	1.5	46.90–47.50	1
...	...	...	...	...	1.2	77.25–87.50	0.7
...	...	...	...	...	1.2	88.45–89.35	0.3

References: (1) Wilkes (1986), (2) Carilli et al. (1998), (3) Snellen et al. (2000).

spectral scan along the line-of-sight. The high sensitivity and large bandwidth (1 GHz), combined with the possibility of observing simultaneously with two receivers, permitted us to scan a range of $\approx$ 10 GHz in both the 2-mm and 3-mm bands. Over these ranges we reached optical depth limits in both bands sensitive enough the detect the 4 known redshifted millimetre absorbers (Table 1 cf. $\tau \approx 0.7$ to ≈ 2 at $\gtrsim 4$ km s^{-1} resolution), although no $\geq 3\sigma$ absorption features were found (Murphy, Curran & Webb 2003).

Of the remaining visually dim quasars, 10 have 3-mm flux densities $\gtrsim 0.5$ Jy. Four of these are located in the north and with the NRO[10] we were able to observe the three listed in Table 1. While the 6-mm limits are poor, again at 3-mm our search is sensitive enough to detect the 4 known absorbers over the observed redshift range: For the $J = 0 \rightarrow 1$, $1 \rightarrow 2$ and $2 \rightarrow 3$ of transitions CO, HCN and HCO^+, i.e. the most commonly detected transitions in the 4 known absorbers, the observed frequencies give a 50% coverage for 0742+103 up to $z \approx 3$ and 30% for both 1600+335 and 1655+077 up to the emission redshift[11]. The coverage for the SEST sources are discussed in Murphy, Curran & Webb (2003); for the above transitions up to 90% is achieved due to the large bandwidth and dual receiver capability.

References

Carilli, C.L., Menten, K.M., Reid, M.J., Rupen, M.P., & Yun, M.S. 1998, ApJ, 494, 175

Carilli, C.L., Menten, K.M., Stocke, J.T., Perlman, E., Vermeulen, R., Briggs, F., de Bruyn, A.G., Conway, J., & Moore, C.P. 2000, PhRvL, 85, 5511

Curran, S.J., Murphy, M.T., Webb, J.K., Rantakyrö, F., Johansson, L. E.B., & Nikolić, S. 2002, A&A, 394, 763

Curran, S.J., Murphy, M.T., Pihlström, Y.M., Webb, J.K., Bolatto, A.D., & Bower, G.C. 2004, MNRAS, 345, 609

Drinkwater, M.J., Webb, J.K., Barrow, J.D., & Flambaum, V.V. 1998, MNRAS, 295, 457

Murphy, M.T., Curran, S.J., & Webb, J.K. 2003, MNRAS, 342, 830

Murphy, M.T., Webb, J.K., & Flambaum, V.V. 2003, MNRAS, 345, 609

Murphy, M.T., Webb, J.K., Flambaum, V.V., Drinkwater, M.J., Combes, F., & Wiklind, T. 2001, MNRAS, 327, 1244

Snellen, I.A.G., Schilizzi, R.T., Miley, G.K., de Bruyn, A.G., Bremer, M.N., & Röttgering, H.J.A. 2000, MNRAS, 319, 445

Webb, J.K., Flambaum, V.V., Churchill, C.W., Drinkwater, M.J., & Barrow, J.D. 1999, PhRvL, 82, 884

Wilkes, B.J. 1986, MNRAS, 218, 331

[10]The fact that each of the 6 AOSs on the NRO only covers 0.25 GHz is compensated by the high efficiency of the 45-m antenna (4 Jy K^{-1} cf. 25 Jy K^{-1} at SEST).

[11]Note that we have included the possibility of HCN or HCO^+ $0 \rightarrow 1$ Galactic absorption towards all 3 sources as well as HCN or HCO^+ $1 \rightarrow 2$ in the host of 1600+335.

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