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Recently Pettini, Hunstead, Smith and Mar (PHSM 1991) have performed an analysis of the Lyα forest of QSO 2206-199N at very high resolution (FWHM$\simeq 6 kms^{-1}$). On the basis of their observations they concluded that most Doppler parameters $b = \sqrt{2}\sigma$ of Lyα forest lines are below 22 km s^{-1} , with a range down to a few km s^{-1} and a median of 17 km s^{-1} . They also found a strong intrinsic correlation between Doppler parameter b and colum density N.

These results are in contrast to those of a similar study by Carswell, Lanzetta, Parnell and Webb (CLPW 1991) at comparable resolution with the same instruments, who find that most of the Lyα lines towards QSO 1100-264 have Doppler parameters above 15 km s^{-1} (median b=34 km s^{-1}), and that there is no significant correlation between b and N.

Whilst an intrinsic difference between the lines of sight to 2206-199 and to other QSOs can not be excluded a priori, previous disagreement between Doppler parameter estimates obtained by both groups (see the discussion in Blades et al., 1988 pp.100-105) pointed to a potential difference in estimation techniques and in the interpretation of the results. To investigate this possibility we have reanalysed the AAT/UCLES spectrum of 2206-199, obtained by PHSM. We extracted the spectrum from the raw data and determined the line parameters using the method described by CLPW.

Our main results can be summarized as follows:

• We agree with PHSM in finding at face value a substantial fraction of low Doppler parameters, and a strong b-N correlation, even after omitting a few additional metal lines which were previously misidentified as Lyα. It is unlikely that the sample of narrow lines is *dominated* by further unidentified metals, since in this case there would be too few real Lyα lines left.

• The bulk of the difference between the *median* Doppler parameters obtained for 2206-199 (PHSM) and 1100-264 (CLPW) arises because of the different sample selection criteria. PHSM selected for their sample only lines which appeared to be unblended and unsaturated. The second criterion restricts their sample to the low column density regime, whereas CLPW's sample of 1100-264 and our 2206-199 sample include *all* lines. Since there is a

strong positive correlation between the estimates for b and N restricting the sample to lower column densities yields a lower median Doppler parameter.

The median and mean Doppler parameters for the full Lyα sample of 2206-199 are b_{med}=26.5 km s^{-1} and $\bar{b}$=27.5$\pm$1.2 km s^{-1} , respectively. When we choose only lines above the column density completeness limit log$N$=13.3 these value become b_{med}=30.7 km s^{-1} and $\bar{b}$=33.9$\pm$1.3 km s^{-1} , in good agreement with $\bar{b}$=34 km s^{-1} for 1100-264.

• We have compared PHSM's parameter estimates to ours (obtained with the CLPW fitting method) for the individual lines we have in common. While our Doppler parameters for lines we estimate to be below 15 km s^{-1} agree well with PHSM's, their b values for lines above that value are systematically lower than ours by about 3 km s^{-1} . We identify differences in the size of the chosen fitting regions as possible causes of this discrepancy. It appears that PHSM's fitting regions are typically smaller than ours and do not always include both line wings. This amounts to a loss of information and results in a bigger scatter for the resulting Doppler parameter estimates.

• Extensive simulations were performed to study possible selection effects and the impact of finite signal-to-noise on the estimation of line parameters. We found that *the Doppler parameter estimates of low column density lines are systematically biassed towards lower values.* The bias appears to be due to the distortion of a weak line's Voigt profile by noise spikes, and its impact increases with decreasing signal-to-noise ratio and/or decreasing intrinsic column density of a line. The deviation of a Doppler parameter estimate from its intrinsic value can be so strong for low column density lines that error estimates (derived from χ^2 error contours in b-logN-z space and based on the assumption that the line is well-fitted by a Voigt-profile) may be too small by a factor of 2 or more.

The reality of the low Doppler parameters found by PHSM has to be assessed in view of this bias. Spuriously low Doppler parameter values and a strong artificial correlation between b and N, features reminiscent of the real line sample of 2206-199, can be produced in simulations where the underlying population of lines has $\bar{b}$=30 km s^{-1} at all column densities, and the signal-to-noise ratio of the spectrum is as in the real data of 2206-199. Although the presence of this effect *does not* disprove the existence of intrinsically narrow Lyα lines, the results of our simulations imply that an interpretation of the low b values towards 2206-199 as being intrinsic to the Lyα clouds might be premature on the basis of the data available.

We conclude that the present data of 2206-199 and in fact any data published to date provide little evidence for a significant population of cool clouds with Doppler parameters less than about 15 km s^{-1} .

References:

Blades,C., Turnshek, D., Norman, C.A., (eds.) "QSO Absorption lines: Probing the Universe", Cambridge 1988.

Carswell, R.F., Lanzetta, K.M., Parnell, H.C., and Webb, J.K., 1991, *Astrophys. J.*, **371**, 36.

Pettini, M., Hunstead, R.W., Smith, L., and Mar, D.P., 1990, *Mon. Not. R. astr. Soc.*, **246**, 545.