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# Search for Radio Recombination Lines towards the Gravitational Lens PKS1830-211

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**Abstract.** A search for radio recombination lines near 20 cm at z=0.193 and z=0.886 towards the gravitational lens system PKS1830-211 has yielded upper limits of $|\tau_L| \leq 5 \times 10^{-5}$ and $\leq 5 \times 10^{-4}$ at the two redshifts respectively. Based on the non-detections, we derive upper limits to the emission measure of the ionized gas in the absorbing systems. We also present continuum flux density measurements over the frequency range 0.3−45 GHz made at a single epoch.

## 1. Introduction

There is evidence that the gravitational lens system PKS1830-211 has two absorbers at two different redshifts of 0.886 and 0.193. The main lens, a normal galaxy at z=0.886, has been studied in HI, OH and a host of molecular lines (Chengalur, de Bruyn, & Narasimha 1999 and references therein). The only evidence for an additional absorber at z=0.193 is from HI absorption (Lovell et al. 1996; Verheijen et al. 1999) studies. Searches for molecular lines at this redshift have been unsuccessful.

## 2. Observations

Taking advantage of the strong radio continuum of the background source ($S_{1.4\ GHz}$ =10 Jy), we searched for stimulated emission recombination lines at both redshifts, using the VLA[1] at 20 cm ; the H158$\alpha$ line from the z=0.193 system ($\nu_{rest}$=1.65 GHz) using a bandwidth of 1.56 MHz and a velocity resolution of 5.3 km s$^{-1}$ and the H136$\alpha$ line from the z=0.886 system ($\nu_{rest}$=2.59 GHz) using a bandwidth of 3.125 MHz and a resolution of 21 km s$^{-1}$. Neither line was detected with 5$\sigma$ upper limits to $|\tau_L|$ of $5 \times 10^{-5}$ and $5 \times 10^{-4}$ corresponding to z=0.193 and z=0.886 respectively.

Since this source is highly variable, we used the VLA to measure the continuum flux density at a single epoch over the frequency range 327 MHz to 45 GHz, to determine the intrinsic spectrum of the background source. The observations

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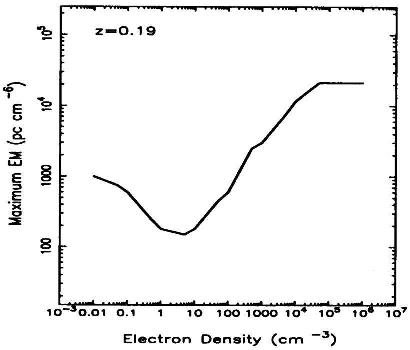


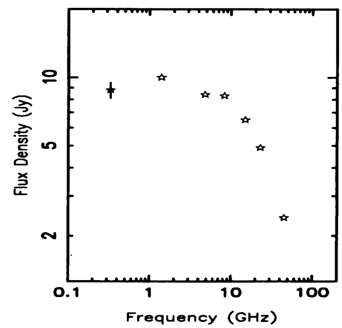


Figure 1. *Left:* The maximum allowable emission measure of the ionized gas in the z=0.193 system as a function of its density, based on the upper limit to the H158$\alpha$ recombination line. *Right:* The measured radio continuum spectrum of PKS1830-211

were made on 27 Oct, 1997 with 3C 286 as the primary calibrator. Figure 1 (right) shows the continuum flux density as a function of frequency. Assuming that the core radiation at low frequencies has a flat spectrum, we derive upper limits to the free-free optical depth of $\tau_c \leq 0.13$ at 330 MHz. For $T_e$=7500 K, the corresponding upper limit to the beam averaged emission measure is EM $\leq 4 \times 10^4$ pc cm$^{-6}$ if the gas is at z=0.193 and EM $\leq 10^5$ pc cm$^{-6}$ if the gas is at z=0.886.

Since the HI optical depth in the z=0.193 system is the same against both the lensed images of the quasar (Verheijen et al. 1999), we assume that the line emitting gas is uniformly distributed in a slab against the entire continuum source. Figure 1 (left) shows the maximum allowable emission measure of the gas as a function of density that is consistent with the upper limits to the line strength and the continuum optical depth, assuming a line width of 80 km s$^{-1}$.

Fig 1 shows that our experiment is most sensitive to low density gas ($n_e$ = $1-10$ cm$^{-3}$) and indicates an upper limit to the *beam averaged* emission measure of 100 pc cm$^{-6}$ for this gas in the z=0.193 system. If the line emitting gas is predominantly of density $5-10$ cm$^{-3}$, then the size of such a region located anywhere in the observed beam is constrained to be less than $200-300$ pc in size, assuming a homogenous gas distribution. On the other hand, if the gas is in compact structures with density $\sim 10^3$ cm$^{-3}$, then its beam filling factor is constrained to be less than $6 \times 10^{-4}$. Higher resolution observations of the line at comparable sensitivities and the knowledge of the system's inclination angle will greatly improve the constraints on the ISM in the z=0.193 absorber. The limits for the z=0.886 system are about ten times higher.

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