A Search for High Redshift Absorption Lines (J=0–1) of CO Molecules toward Quasars

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Abstract

A search has been made for the first time for absorption lines by intervening CO molecules toward high redshift radio-loud quasars. The 45-meter telescope at the Nobeyama Radio Observatory combined with a wide band spectrometer was used to detect high redshift CO (J=0–1) absorption lines in the 40GHz band with 0.5~3.75GHz width. No significant features are found in the obtained spectra for six quasars, 0S+356, 0X+057, 0D+148, 0J+248, 0I-061 and Q1331+170.

§ 1. Introduction

Investigation of absorption lines in quasar spectra gives very important information about underlying galaxies and intervening material. As a result of extensive search in optical-UV bands, there is clear evidence for the existence of a hot gas ($T>10^4$ K) in the intervening galaxies and a primordial intergalactic gas. As for a cold gas ($T\sim10^2$ K), Varshalovich et al. asserted that they have found redshifted UV absorption lines of H_2 and CO molecules in

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++ NRO, a branch of the Tokyo Astron. Obs., University of Tokyo, is a facility open for the general use by researchers in the field of astronomy and astrophysics.

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some quasars.[1] They also proposed that CO and H_2CO molecules might appear as absorption lines in radio bands.[2]

Here we report the results of the first search for CO (J=0-1) redshifted absorption lines toward high redshift quasars which have strong continuum emission in millimeter wavelengths. We used the recently constructed 45-m telescope at the Nobeyama Radio Observatory which is appropriate for such a purpose because of its high surface accuracy and wide band acousto-optical spectrometer available.

§ 2. Observations

We select six quasars which have redshifts such that CO (J=0-1) line (rest frequency of 115.27GHz) is redshifted to 40GHz band. Among six sources thus selected, two objects have optical absorption lines and one has a HI absorption feature.

Observations were conducted on April 22, 1983 at the Nobeyama Radio Observatory. The frequency range was set around the expected redshifted frequencies with 0.5~3.75GHz band width. For all objects we used wide band spectrometers which have a resolution of 250kHz. In addition, for two objects which have optical and HI absorption lines, we used high resolution spectrometers with a resolution of 40kHz. In 40GHz band those resolutions correspond to a velocity resolution of about 2km/s and 0.3km/s, respectively. The system temperature was about 600K and the integration time was 45~90 minutes for each object with the standard on-off method.

§ 3. Results

In Table we list parameters and obtained results for each object. We estimate the expected antenna temperature ,T_A, of the continuum level , assuming reported flux densities and the aperture efficiency of 40 percent at 40GHz. The obtained rms temperature for a band width of 500kHz, T_{rms} , is about 0.05K. Then we could recognize absorption features due to intervening

CO molecules at the 3σ level, if the optical thickness, τ, satisfies $T_A(1-e^{-\tau})>3T_{rms}$. For example in case of OX+057 we could recognize absorption features if $\tau>0.2$ for a 4km/s width. Examples of the obtained spectra are shown in Figs. 1 and 2. In Fig. 1 is shown the case of OX+057 ,which has the strongest continnum emission among six sources studied. In Fig. 2 is shown the case of Q1331+170 which is known to have a HI absorption feature. As is seen in these figures no significant absorption features are found and the upper limits for the optical depth of intervening CO molecules, τ_{ul}, are shown to be an order of $0.1\sim 1$.

Table

source name	redshift	expected frequency (GHz)	conti. flux (Jy)	T_A (K)	frequency range (GHz)	integ. time (min.)	T_{rms} (K)	τ_{ul}
0S+356	1.814	40.96	1.7	0.39	40.885–42.885	45	0.05	0.5
0X+057	1.936	39.26	4	0.92	39.135–42.885	45	0.05	0.2
0D+148	2.065	37.61	1.3	0.28	37.485–39.485	45	0.06	1.0
0J+248	2.046	37.84	1.4	0.32	37.485–39.485	60	0.055	0.7
0I−061	1.901 1.9299* 1.9123*	39.735 39.343 39.580	1	0.23	39.300–39.800 39.323–39.363+ 39.560–39.600+	90	0.035 0.08++ 0.08++	0.6 — —
Q1331+170	2.081 1.7852* 1.7755* 1.7764**	37.413 41.387 41.531 41.518	0.5	0.12	41.350–41.850 41.367–41.407+ 41.511–41.551+ 41.511–41.551+	90	0.035 0.07++ 0.08++ 0.08++	2.1 — — —

* optical absorption, ** HI absorption

+ high resolution spectrometers, ++ values for a bandwidth of 80kHz

Although the present preliminary search has revealed no significant absorption features, this type of observations is of great importance in

searching for cold gas in distant galaxies and intergalactic matter.

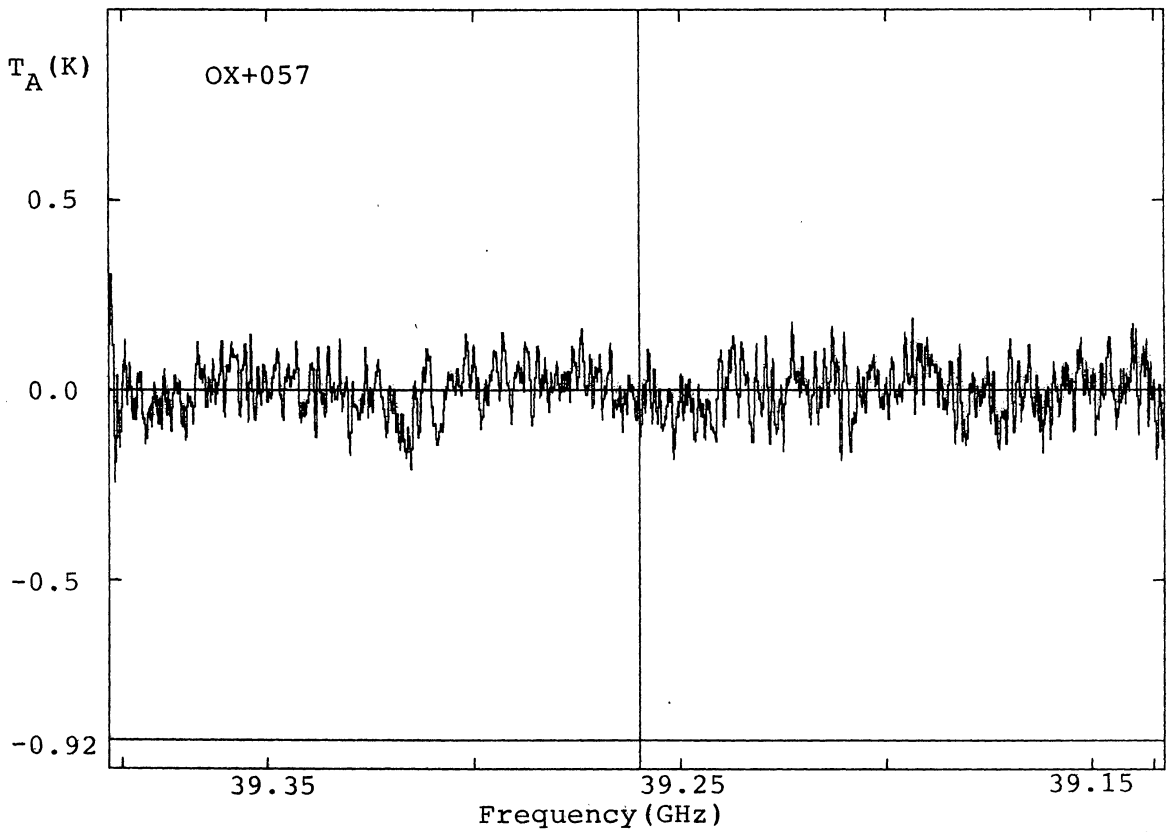
This work is carried out under a collaborating observation program at NRO.

References

1) D.A.Varshlovich and S.A.Levshakov, Comm. Astrophys. 9 (1982),199.

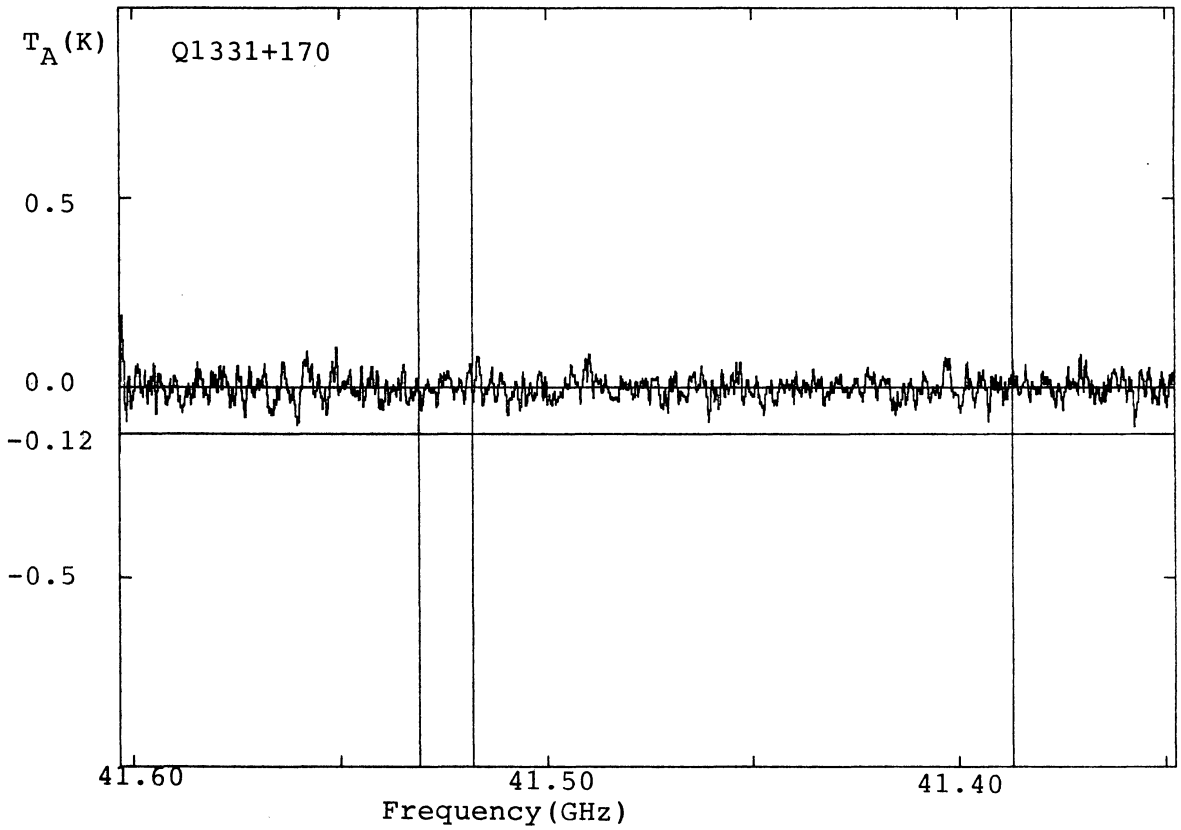
2) V.K.Khersonskii et al., Sov.Astron.-A.J, 25 (1981),16.

Fig.1



The obtained spectrum of OX+057 for a frequency range of 39.135-39.385GHz. Vertical line indicates the expected location of a redshifted CO (J=0-1) line (z=1.936).Horizontal lines show the expected continuum level.

Fig.2



The obtained spectrum of Q1331+170 for afrequency range of 41.35-41.60GHz. Vertical lines indicate the expected locations of redshifted CO lines (z=1.7755,1.7764 and 1.7852). Horizontal lines show the expected continuum level.