Possible CO clouds interacting with the SNRs G21.8-0.6 and G32.8-0.1

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Abstract: OH 1720 MHz maser associated with the SNRs are one confident signature indicating SNR-molecular cloud interaction. We made the first CO(1-0) mapping to the SNRs G21.8-0.6 and G32.8-0.1, both of them are associated with OH 1720 MHz maser. Based on the morphological correspondence between the radio remnant and CO clouds, and the velocity and position agreement between the OH maser and CO clouds, we tentatively suggest that the clouds interacting with G21.8-0.6 and G32.8-0.1. However, the shock excited line broadenings was not found in coud F, and is not very strong in cloud F, we discussed the possible reasons.

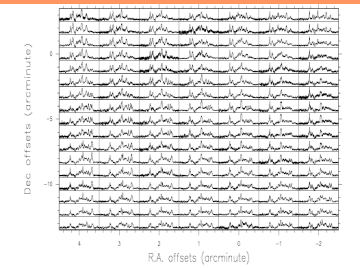

Fig. 1 Mosaic of ^{12}CO(1-0) spectra in SNR G21.8-0.6. The (0,0) refers to the position of OH maser (R.A.=$18^h33^m11.97^s$, DEC=-10°00′40.16″)(J2000). The velocity scale in each spectrum runs from V_{LSR}=-50 to +160 km s^{-1} and the antenna temperature scales from T_A=-1 to +5 K.

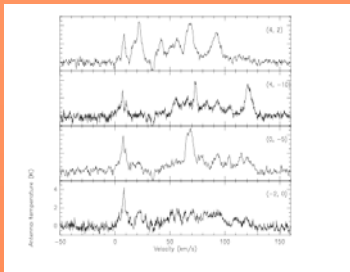

Fig. 2 Blow-up of ^{12}CO(1-0) spectra at selected positions in SNR G21.8-0.6. Offsets in arcminute from (0,0)(R.A.=$18^h33^m11.97^s$, DEC=-10°00′40.16″)(J2000) are indicated in the upper right corner. The integration time per spectrum is 1 minute.

Introduction: Recently OH masers at 1720 MHz have been proven to be good signature of SNR-molecular cloud interaction. The excitation of OH 1720 MHz maser requires very dense gas ~10^5cm^{-3}) with a temperature range of 50-125K. A C-type shock caused by the expanding SNR will create such conditions (Elitzur 1976; Wardle 1999; Lockett et al. 1999). This has been proven to be true by many molecular line observations to the SNRs associated with OH 1720 MHz masers (Koralesky et al. 1998; Reach & Rho 1998; Frail & Mitchell 1998; Reynoso et al. 2000). We performed the first CO(1-0) observations to the SNRs G21.8-0.6 and G32.8-0.1, they have been found to be associated with 1720 MHz OH maser. We hope to study the relation between the SNR and ambient CO clouds and search for the effects of SNR-molecular cloud interaction.

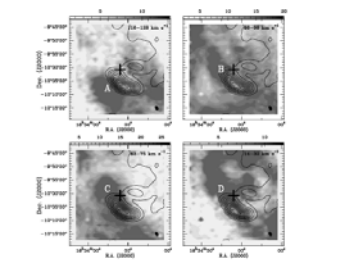

Fig. 3 Channel maps of ^{12}CO emission integrated over velocity ranges 116-128, 86-98, 63-75 and 14-30 km s^{-1} toward G21.8-0.6. The grey scale is in K km s^{-1} and is shown on top of the image. The 2σ noise level of these maps are 1.25, 1.65, 2.18, and 1.29 K km s^{-1} respectively. The beam, 106″×70″, is indicated by black filled ellipse in the bottom right corner. The contour map was obtained from the radio continuum survey of the Galactic plane at 11 cm wavelength(Reich et al. 1984), contour levels are from 3.74 to 37.4 Jy in steps of 3.74 Jy. G21.9-0.4 is a HII region. The plus sign shows the position of OH 1720 MHz maser.

Observation and results: Observations of the ^{12}CO(1-0) line and its isotopes were performed with 13.7m telescope located in Delingha, Qinhai province of China, in April 2004. The sensitivity of the telescope is 0.26 K (rms) for an integration time of 60 seconds. The spectra of G21.8-0.6 and G32.8-0.1 are displayed in Fig1 and Fig2, Fig4 and Fig5 respectively. There is a dip in the spectra of G21.8-0.6 between 30 and 40 km s^{-1} (see Fig1 and Fig2), and seem to be evidence of self-absorption. However, careful examination of the off-spectra indicates that there is emission at the same velocities at the off-position. But the small dip appeared in the spectra of G32.8-0.1 between 0 and 10 km s^{-1} may be caused by self-absorption. If this is true, self-observation would be weak. ^{13}CO(1-0) emission of these two SNRs are very weak, and C^{18}O(1-0) was not detected. The CO clouds around these two SNRs are displayed in Fig3 and Fig6, they are integrated over different velocity ranges.

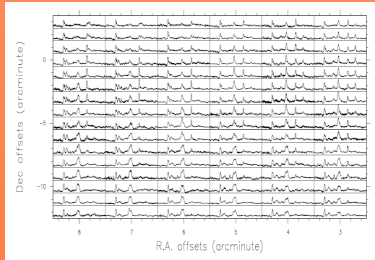

Fig. 4 Mosaic of ^{12}CO(1-0) spectra in SNR G32.8-0.1, it covers the eastern boundary of the remnant and OH maser site. The (0,0) refers to the position (R.A.=$18^h51^m23.97^s$, DEC=-00°08′22.54″)(J2000). The velocity scale in each spectrum runs from V_{LSR}=-20 to +130 km s^{-1} and the antenna temperature scale from T_A=-1 to +4 K.

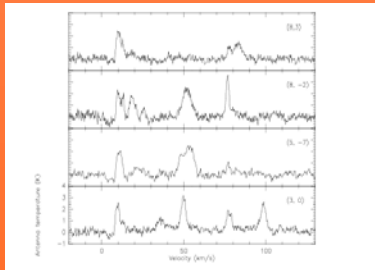

Fig. 5 Blow-up of ^{12}CO(1-0) spectra at selected positions in SNR G32.8-0.1. Offsets in arcminute from (0,0)(R.A.=$18^h51^m23.97^s$, DEC=-00°08′22.54″)(J2000) are indicated in the upper right corners. The integration time per spectrum is 1 minute.

Discussion: Based on the analysis of position and velocity agreement between the OH maser and CO clouds , the morphological signature of the CO clouds and spectral line broadenings, we tentatively suggest that cloud C of G21.8-0.6 and cloud F of G32.8-0.1 may be related to the SNR physically (Fig3, Fig6). However, line broadenings is lack in the CO(1-0) spectra of G21.8-0.6 and is not very strong in G32.8-0.1 (see Fig1, Fig2, Fig4 and Fig5). Possible reason is that the shocked molecular gas may be highly excited and therefore weak in emission from the low-lying CO(1-0) transition (Wilner et al. 1998). The CO(1-0) spectra of G21.8-0.6 and G32.8-0.1 are complex, many blending features appear on it. This indicates that the confusion due to different velocity components along the line of sight may play an important role here and make it more difficult to discern such weak line broadenings. Our CO(1-0) observation results indicate that CO(1-0) is not appropriate for observe shock-excited molecular gas..

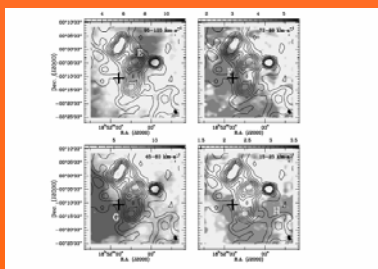

Fig. 6 Channel maps of ^{12}CO emission integrated over the velocity ranges 95-105, 76-82, 45-60 and 15-25 km s^{-1} toward G32.8-0.1. The grey scale is in K km s^{-1} and is shown on top of the images. The 2σ noise level of these maps are 1.46, 1.11, 1.53 and 0.99 K km s^{-1} respectively. The beam, 106″×70″, is indicated by black filled ellipse in the bottom right corner. the continuum contour of G32.8-0.1 was also obtained from the radio continuum survey of the Galactic plane at 11 cm wavelength (Reich et al. 1984), which including two HII regions, G32.8+0.2 and G33.1-0.1 (Clark et al. 1975). The rms is about 50 mJy/beam. Contour levels are from 0.3 to 3 Jy in steps of 0.3 Jy. The plus sign indicates the position of OH maser.

Reference

Elitzur M., 1976, ApJ, 203, 124
Frail D. A., Mitchell G. F., 1998, ApJ, 508, 690
Koralesky B., Frail D. A., Goss W. M., Claussen M. J., & Green A. J., 1998, AJ, 116, 1323
Lockett T. L., Gauthier E, Elitzur M., 1999, ApJ, 511, 235
Reach W. T., Rho J., 1998, ApJ, 507, L93 Reach W. T., Rho J., 1999, ApJ, 511, 836
Reich W., FÜrst E., Steffen P., Reif K., Haslam C. G., 1984, A & AS, 58, 197
Reynoso E. M., Mangum J. G., 2000, ApJ, 545, 874
Van Dishoeck E. F., Jansen D. J., Phillips T. G., 1993, A&A, 279, 541
Wardle M., 1999, ApJ, 525, L101
Wilner D. J., Reynoso s. P., Moffett D. A., 1998, ApJ, 115, 247