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Gamma-ray bursts from dusty regions with little molecular gas

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Abstract. We detected CO line and 1.2-mm continuum emission from the two GRB host galaxies (GRB 020819B and GRB 051022) by using the Atacama Large Millimeter/submillimeter Array (ALMA). This is the first case for detecting molecular gas emission in GRB hosts. The ratio of molecular gas to dust mass of the GRB 020819B site is significantly lower than those of the Milky Way and nearby star-forming galaxies, suggesting that the star-forming environment where the GRB occur is different from those in local galaxies. The possible reason is that much of the dense gas is dissipated by a strong interstellar ultraviolet radiation field.

Keywords. gamma rays: bursts, galaxies: ISM, radio continuum: galaxies, radio lines: galaxies

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Long-duration gamma-ray bursts (GRBs) are associated with the explosions of massive stars and are accordingly expected to reside in star-forming regions with molecular gas. Previous searches for CO, a tracer of molecular gas, in GRB host galaxies did not detect any emission (e.g., Kohno *et al.* 2005; Endo *et al.* 2007; Hatsukade *et al.* 2007; Hatsukade *et al.* 2011). Molecules have been detected as absorption in the spectra of GRB afterglows, but absorption lines probe the interstellar medium only along the line of sight, so it is not clear whether the molecular gas represents the general properties of the regions where the GRBs occur (e.g., Prochaska *et al.* 2009).

We conducted spatially resolved observations of CO line and 1.2-mm continuum emission in two GRB hosts (GRB 020819B at $z = 0.41$ and GRB 051022 at $z = 0.81$) by using the Atacama Large Millimeter/submillimeter Array (ALMA) (Hatsukade *et al.* 2014). We observed the redshifted CO(3–2) line for the GRB 020819B host and the CO(4–3) line for the GRB 051022 host with an angular resolution of $\sim 1''$. We detected CO line and 1.2-mm continuum emission from the two hosts. This is the first case for detecting molecular gas emission in GRB hosts. The spatially resolved maps of the GRB 020819B host show that the CO emission is detected at the nuclear region, while the continuum emission is detected only at a star-forming region $\sim 3''$ (16 kpc in projection) away from the nuclear region, where the GRB explosion occurred. The ratio of molecular gas mass to dust mass of the GRB 020819B site is significantly lower than that of the nuclear region, indicating that the GRB occurred under particular circumstances within the host. The

ratio at the GRB site is also lower than those of the Milky Way and nearby star-forming galaxies, suggesting that the star-forming environment where the GRB occur is different from those in local galaxies. The possible reason for the deficit of molecular gas in the GRB site is that much of the dense gas is dissipated by a strong interstellar ultraviolet radiation field, which is expected in regions with intense star formation.

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