Infrared molecular hydrogen lines in GRB host galaxies

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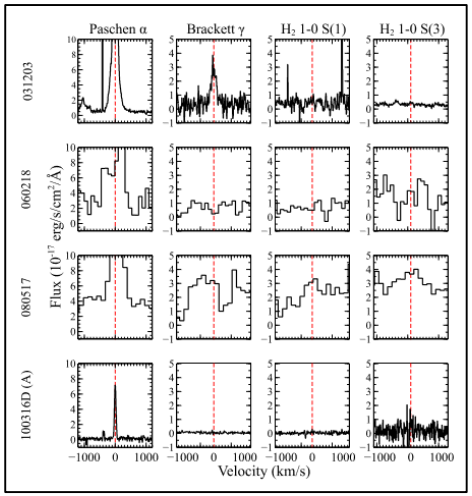
ABSTRACT

Molecular species, most frequently H_2, are present in a small, but growing, number of gamma-ray burst (GRB) afterglow spectra at redshifts $z \sim 2-3$, detected through their rest-frame UV absorption lines. In rare cases, lines of vibrationally excited states of H_2 can be detected in the same spectra. The connection between afterglow line-of-sight absorption properties of molecular (and atomic) gas, and the observed behaviour in emission of similar sources at low redshift, is an important test of the suitability of GRB afterglows as general probes of conditions in star formation regions at high redshift. Recently, emission lines of carbon monoxide have been detected in a small sample of GRB host galaxies, at sub-mm wavelengths, but no searches for H_2 in emission have been reported yet. In this paper we perform an exploratory search for rest-frame K band rotation-vibrational transitions of H_2 in emission, observable only in the lowest redshift GRB hosts ($z \lesssim 0.22$). Searching the data of four host galaxies, we detect a single significant rotation-vibrational H_2 line candidate, in the host of GRB 031203. Re-analysis of *Spitzer* mid-infrared spectra of the same GRB host gives a single low significance rotational line candidate. The (limits on) line flux ratios are consistent with those of blue compact dwarf galaxies in the literature. New instrumentation, in particular on the *JWST* and the *ELT*, can facilitate a major increase in our understanding of the H_2 properties of nearby GRB hosts, and the relation to H_2 absorption in GRBs at higher redshift.

Key words: gamma-rays: bursts, ISM:molecules

GRB afterglow
近くの星形成領域を照らす
➢ 輝線などにより性質を推定可能

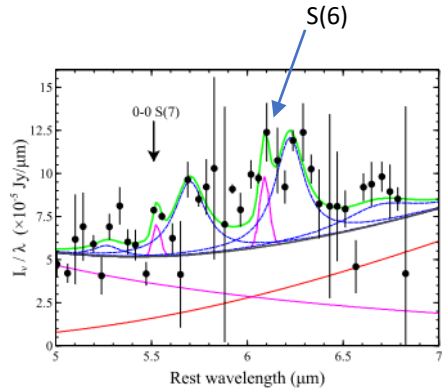
4個のGRB母銀河を分光
031203：中間赤外データあり
080517：COが検出されている
➢ Paα, Brγ, 1-0S(1), 1-0S(3)



GRB host	Instrument	Obs date	Redshift	Host IR (Vega) magnitude	12 + log(O/H)
031203	VLT X-Shooter	17 March 2009 [1]	0.105	$K' = 16.54 \pm 0.02$ [5]	8.20 [9]
060218	VLT ISAAC	17 July + 10 Sep. 2008 [2]	0.033	$K_s = 17.94 \pm 0.09$ [6]	7.54 [10]
080517	WHT LIRIS	3/4 March 2015 [3]	0.089	$K_s = 15.51 \pm 0.06$ [7]	~8.7 [11]
100316D*	VLT X-Shooter	17 March 2010 [4]	0.059	$K_s = 15.93 \pm 0.09$ [8]	8.23 [12]

すべての銀河でPaαを検出
✓ H_2はGRB031203の1-0S(3)のみ(4σ)
Black & van Dishoeck 1987でH_2輝線の比をモデル計算
➢ 1-0S(1)のフラックスを推定
✓ 1-0S(1)/Brγ < 0.12 (BCDとconsitent)

Spitzerの中間赤外線(5-35um)を解析
✓ 連続的な温度でフィット
$dN \propto T^{-n} dT$
✓ S(7)輝線のみ検出(tentative)
➢ H_2 gas：1.7x10^9 Msun
H_2 dustは10^8 Msunが上限
➢ Gas/dust=500とconsistent



Izotov & Thuan 2016, Table 3

Line	SBS1415+437	Fluor[a]	Coll[a]
1.233 H_2 3-1 S(1)	...	0.5	0.0
1.238 H_2 2-0 Q(1)	...	0.4	0.0
1.311 H_2 4-2 S(1)	...	0.4	0.0
1.314 H_2 3-1 Q(1)	...	0.6	0.0
1.601 H_2 6-4 Q(1)	...	0.4	0.0
1.957 H_2 1-0 S(3)	0.9	...	...
2.034 H_2 1-0 S(2)	0.4	0.5	0.3
2.073 H_2 2-1 S(3)	0.2	0.2	0.0
2.122 H_2 1-0 S(1)	1.0	1.0	1.0
2.223 H_2 1-0 S(0)	0.3	0.6	0.3
2.248 H_2 2-1 S(1)	0.4	0.5	0.0
2.355 H_2 2-1 S(0)	0.6	0.3	0.0

右2列： Black & van Dishoeck 1987
1-0S(3)はIzotov & Thuan 2016が観測的に補間

(18個のBCD, 6個のHII領域に対して再結合線と鉄輝線も観測)