SMA Line Observations of the CH$_3$OH-maser Outflow in DR21(OH)

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Abstract

We present a (sub)millimeter line survey of the methanol maser outflow located in the massive star-forming region DR21(OH) carried out with the Submillimeter Array (SMA) at 217/227 GHz and 337/347 GHz. We find transitions from several molecules toward the maser outflow such as CH$_3$OH, H$_2$CS, C$^{17}$O, H$_3^{15}$CO$^+$, and C$^{34}$S. However, with the present observations, we cannot discard the possibility that some of the observed species such as C$^{17}$O, C$^{34}$S, and H$_2$CS, might be instead associated with the compact and dusty continuum sources located in the MM2 region. Given that most of transitions correspond to methanol lines, we have computed a rotational diagram with CASSIS and an LTE synthetic spectra with XCLASS for the detected methanol lines in order to estimate the rotational temperature and column density in the small solid angle of the outflow where enough lines are present. We obtain a rotational temperature of 28 ± 2.5 K and a column density of 6.0 ± 0.9 × 10$^{15}$ cm$^{-2}$. These values are comparable to those column densities/rotational temperatures reported in outflows emanating from low-mass stars. Extreme and moderate physical conditions to excite the maser and thermal emission coexist within the CH$_3$OH flow. Finally, we do not detect any complex molecules associated with the flow, e.g., CH$_3$OCHO, (CH$_3$)$_2$CO, and CH$_3$CH$_2$CN.

Key words: circumstellar matter – ISM: jets and outflows – ISM: individual objects (DR21(OH)) – ISM: molecules

Supporting material: data behind figures

1. Introduction

DR21(OH) (also known as W75S) is a prominent high-mass star-forming region with a bolometric luminosity of about 1.5 × 10$^4$L$_\odot$ and with a total mass of about 1 × 10$^4$M$_\odot$ (Harvey et al. 1977; Chandler et al. 1993) located about 3′ north of DR21 in the Cygnus X molecular cloud complex (Downes & Rinehart 1966; Jakob et al. 2007; Motte et al. 2007; Reipurth & Schneider 2008; Zapata et al. 2013). From DR21 emanates an energetic molecular outflow, but its nature seems to be different from the typical flows excited mediate disks (Zapata et al. 2013, 2017). DR21(OH) and DR21 are embedded in a 4 pc long and massive filamentary ridge that extends in a north–south orientation (Harvey et al. 1986; Vallée & Fiege 2006; Schneider et al. 2010; Csengeri et al. 2011; Hennemann et al. 2012). The distance to DR21(OH) has been accurately determined recently by trigonometric parallax of its associated methanol masers as 1.50 ± 0.08 kpc (Rygl et al. 2012). This region has been extensively studied at infrared, millimeter, and submillimeter wavelengths (Lai et al. 2003; Davis et al. 2007; Kumar et al. 2007; Araya et al. 2009; Minh et al. 2011, 2012; Zapata et al. 2012; Girart et al. 2013). DR21(OH) contains two main dusty condensations MM1 and MM2 that are warm ~50 and 30 K and massive 350 and 570 M$_\odot$, respectively (see, e.g., Mangum et al. 1991). Recently, nine compact millimeter sources were revealed within both condensations, and with masses in a range of 4–25 M$_\odot$ (see, e.g., Zapata et al. 2012, Girart et al. 2013). Five of the compact sources are associated with the extended millimeter source MM1 (SMA 5–9) and four with MM2 (SMA 1–4). These sources are likely to be large dusty disks/envelopes around high-mass protostars. Two of the compact sources associated with MM1 (SMA6 and SMA7) have spectral features consistent with hot molecular cores (see, e.g., Minh et al. 2011, 2012, Zapata et al. 2012).

Several dense molecular outflows have been reported to emanate from within the MM1 and MM2 cores, traced by CO, SiO, H$_2$CO, H$_2$S, and CH$_3$OH emission (Lai et al. 2003; Minh et al. 2011, 2012; Zapata et al. 2012; Girart et al. 2013). In particular, a well-collimated east–west bipolar maser and thermal CH$_3$OH flow driven from within the SMA4 have been reported and discussed by Plambeck & Menten (1990), Kogan & Slysh (1998), Kurtz et al. (2004), Araya et al. (2009), Fish et al. (2011), and Zapata et al. (2012). The LSR radial velocity of CH$_3$OH flow is nearly ambient (10 to −5 km s$^{-1}$) and is elongated in an east–west direction. This might suggest that this outflow is close to the plane of the sky. The outflow in DR21(OH) has also been detected in formaldehyde transitions at millimeter wavelengths (Zapata et al. 2012).

It is thought that the molecular outflows provide a chemical enrichment to the surroundings of the young stellar objects through shocks, which can then destroy and/or release complex molecules trapped in the grains into the gas phase. This process is done by compressing and then heating the interstellar medium (Garay et al. 1998; Bachiller et al. 2001; Jørgensen et al. 2007; Arce et al. 2008). The molecular outflows that present an overabundance of species such as SiO, CH$_3$OH, H$_2$CO, HCO$^+$, HCN, and H$_2$O, or even complex molecules (with six or more atoms) are classified as “chemically active outflows” (Bachiller et al. 2001). Therefore, the E-W outflow in DR21(OH) could be considered as chemically active. However, as we will see in the next sections, no complex molecules are detected in the DR21(OH) outflow (e.g., CH$_3$OCHO, (CH$_3$)$_2$CO, and CH$_3$CH$_2$CN).

There are only a few cases where “chemically active outflows” have been reported in the literature. The list includes the L1157, B1-b, SMM4-W, BHR71, HH 114 MMS, and IRAS 20126+4104 outflows (Arce et al. 2008; Öberg et al. 2011; Tafalla & Hacar 2013; Palau et al. 2017). These flows are
The gray contours are from 5% to 85% with steps of 10% of the line emission peak. The color-scale bar on the right indicates the emission peak of the line emission. Contours magenta hexagon marks the position of the infrared source IRS1 observed with Spitzer at 8 μm (Araya et al. 2009). The synthesized beam of the image is shown in the bottom left corner of the image. The black contours are from 30% to 95% with steps of 5% of the 1.4 mm continuum emission peak; the peak is at 150 mJy beam$^{-1}$. The gray contours are from 5% to 85% with steps of 10% of the line emission peak. The color-scale bar on the right indicates the emission peak of the line emission.

ejected from low- and high-mass young stars. In particular, in these outflows, complex molecules have been detected, for example, HCOOCH$_3$ and C$_2$H$_5$OH. Chemical models indicate that complex molecules can form on grain surfaces (Garrod & Herbst 2006; Herbst & van Dishoeck 2009), present probably in the outflows.

Here, we have carried out a molecular line survey toward the CH$_3$OH outflow in DR21(OH), aiming to determinate its physical conditions, and to find evidence of complex organic molecules present in the flow.

2. Observations

The observations of DR21(OH) were made with the SMA (Ho et al. 2004) in 2006 May at $\nu \sim 217/227$ GHz and in 2006 August at $\nu \sim 337/347$ GHz in its extended and compact configuration, respectively. The total observing time on-source with the SMA at $337/347$ GHz was about 1.38 hr, while for the $217/227$ GHz band was around 2.22 hr. The pointing center for both data sets was $\alpha(J2000.0) = 20^h39^m01^s$, and $\delta(J2000) = 42^\circ 22'48''$. The Full Width Half Maximum (FWHM) is $55''$ and $36''$ at 230 and 345 GHz, respectively. The molecular emission arising from the outflow, and the emission from the continuum condensations fall well within both FWHMs.

The SMA digital correlator was configured to cover 4 GHz of bandwidth, 2 GHz in the Upper Sideband (USB), and 2 GHz in the Lower Sideband (LSB). Each 2-GHz sideband was covered by 24 chunks with a width of 104 MHz each and divided by 128 resolution channels. This correlator configuration provided a spectral resolution of about 0.8125 MHz (i.e., $\sim 0.7$ km s$^{-1}$ at 345 GHz and $\sim 1$ km s$^{-1}$ at 230 GHz). Heterodyne SIS receivers were used and system temperatures ranged between 120 and 240 K for the different antennas at both frequencies.

The zenith opacity ($\tau_{230\text{GHz}}$), measured with the NRAO tipping radiometer located at the Caltech Submillimeter Observatory, was between 0.1 and 0.25 at both frequencies, indicating reasonable weather conditions during the observations. Uranus and Callisto provided the absolute scale for the flux density calibration. The phase-gain calibrators were the quasars BL Lac and MWC349. The bandpass calibration was done using the quasar 3C454.3. The uncertainty in the flux scale is estimated to be about 15%–20%, based on SMA monitoring of quasars.  

The initial data calibration and reduction were made using the IDL superset MIR. The spectra, molecular lines maps and the image analysis were made using the MIRIAD and KARMA softwares (Sault et al. 1995; Gooch 1996). The robust weighting parameter was set to two, giving a synthesized beam for 230 GHz of $1''3 \times 1''0$ (PA = $-74^\circ$) and for the 345 GHz $2''75 \times 1''96$ (PA = $-66^\circ 65$). The resulting image r.m.s. noise for the line images were $\sim 20$ mJy beam$^{-1}$ for each velocity channel at 230 GHz, and $\sim 50$ mJy beam$^{-1}$ at 345 GHz.

3. Results and Discussion

In Figure 1, we present the millimeter CH$_3$OH thermal emission from the maser outflow in DR21(OH). This image was adapted from Zapata et al. (2012) and shows the integrated intensity map (or the zero moment) of the E-CH$_3$OH [4(2, 2)-3(1, 2)] molecule at 218.44005 GHz, and the 1.4 mm continuum emission from objects present in DR21(OH). The millimeter methanol emission is tracing the bipolar low-velocity east–west maser outflow revealed for the first time by Plambeck & Menten (1990) at centimeter wavelengths. The emission appears to be concentrated into compact bow-shock structures along the bipolar outflow. Overall, the methanol millimeter emission follows a morphology very similar to that seen in the 36 and 44 GHz methanol maser lines (Plambeck & Menten 1990; Kogan & Slysh 1998; Araya et al. 2009), with the millimeter source (SMA4) being well in the middle of the flow. Zapata et al. (2012) proposed SMA4 as its excitation source (see Figure 1). However, an infrared source (IRAC1) that is prominent at 8 μm was also proposed by Araya et al. (2009) as a possible candidate for its exciting source.

In Figure 1, we have also included the regions from the methanol outflow where we have obtained the spectra (SPOT1-6 and THE CENTRAL SPOT) to compute their physical conditions. The thermal emission from the detected molecules, see Table 1, is very sparse and complicated to make a single averaged spectra. However, the technique applied here allowed

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4. http://sma1.sma.hawaii.edu/callist/callist.html
5. http://cfa-www.harvard.edu/~cqi/mircook.html
### Table 1

| Frequency (MHz) | Species | Transition | $E_u$ (K) | $A_{ij}$ (s$^{-1}$) | Spot$^a$ | Range of Velocities$^b$ (km s$^{-1}$) | Gaussian Fit Center and FWHM (km s$^{-1}$) |
|----------------|---------|------------|-----------|------------------|---------|-------------------------------------|-----------------------------------|
| 217104.919     | SiO$^+$ | 5$_0$→4$_0$ | 31.26     | 5.20×10$^{-4}$   | C       | –22, +8                             | –6.1 ± 0.5; 20.0 ± 4.0           |
| 218222.192     | H$_2$CO$^+$ | 3$_{2,2}$→2$_{1,2}$ | 20.96     | 2.82×10$^{-4}$   | 1, 2, 3, 4, 5 | –10, +6 | –2.5 ± 0.6; 14.5 ± 2.0     |
| 218440.050     | E-CH$_3$OH$^+$ | 4$_{2,2,2}$→3$_{1,1,2}$ | 45.46     | 4.69×10$^{-5}$   | 1, 2, 3, 4, 5, 6 | –9, +4 | –2.7 ± 0.5; 10.5 ± 1.0     |
| 218475.632     | H$_2$CO$^+$ | 3$_{2,2}$→2$_{1,2}$ | 68.09     | 1.57×10$^{-4}$   | 1, 2, 3, 4, 5 | –10, +3 | –3.3 ± 0.3; 13.5 ± 1.0     |
| 336865.110     | A-CH$_3$OH | 12$_{1,1,1}$→12$_{0,0,0}$ | 197.07   | 4.07×10$^{-4}$   | 1, 4, C | –6, +6 | –0.5 ± 0.2; 11.3 ± 0.8     |
| 337061.471     | C$_3$O | 3→2 | 32.35     | 1.11×10$^{-6}$   | 4, C | –4, +5 | –0.3 ± 0.2; 4.6 ± 0.5     |
| 337396.459     | C$_3$S | 7→6 | 64.77     | 8.0×10$^{-4}$    | C       | –8, +2 | –1.4 ± 0.5; 9.6 ± 0.7     |
| 338083.195     | H$_2$CS | 10$_{1,0}$→9$_{1,0}$ | 102.43    | 5.77×10$^{-4}$   | C       | –8, +2 | –1.5 ± 0.5; 9.2 ± 0.7     |
| 338124.502     | E-CH$_3$OH | 7$_{0,0}$→6$_{0,0}$ | 78.08     | 1.70×10$^{-4}$   | 1, 2, 3, 4, C | –8, +4 | –1.8 ± 0.5; 8.4 ± 0.5     |
| 338344.628     | E-CH$_3$OH | 7$_{1,1}$→6$_{1,0}$ | 70.55     | 1.67×10$^{-4}$   | 1, 2, 3, 4, 5, 6, C | –8, +4 | –2.8 ± 0.5; 8.5 ± 0.4     |
| 338404.580     | E-CH$_3$OH | 7$_{2,2}$→6$_{1,1}$ | 243.79  | 4.48×10$^{-5}$   | 1, 2, 3, 4, 5, 6, C | –8, +6 | –1.9 ± 0.2; 10.5 ± 0.5     |
| 338512.627     | A-CH$_3$OH | 7$_{4,4}$→6$_{3,3}$ | 145.33    | 1.15×10$^{-4}$   | 2, 3, 4, C | –8, +5 | –1.4 ± 0.2; 9.5 ± 0.6     |
| 338540.795     | A-CH$_3$OH | 7$_{5,4}$→6$_{4,4}$ | 114.79  | 1.39×10$^{-4}$   | 4, C | –9, +4 | –1.9 ± 0.2; 9.0 ± 0.7     |
| 338559.928     | E-CH$_3$OH | 7$_{3,5}$→6$_{3,4}$ | 127.71  | 1.40×10$^{-4}$   | 4, C | –8, +2 | –2.1 ± 0.4; 9.4 ± 0.7     |
| 338583.195     | E-CH$_3$OH | 7$_{3,4}$→6$_{3,3}$ | 112.71  | 1.39×10$^{-4}$   | 4, C | –7, +5 | –0.8 ± 0.6; 9.0 ± 0.5     |
| 338614.999     | E-CH$_3$OH | 7$_{1,6}$→6$_{1,5}$ | 86.05   | 1.71×10$^{-4}$   | 1, 2, 3, 4, C | –9, +4 | –2.2 ± 0.5; 10.5 ± 0.6     |
| 338639.939     | A-CH$_3$OH | 7$_{2,5}$→6$_{2,4}$ | 102.72 | 1.57×10$^{-4}$   | 4, C | –8, +4 | –1.6 ± 0.3; 9.8 ± 0.3     |
| 338721.693     | E-CH$_3$OH | 7$_{2,5}$→6$_{2,4}$ | 87.26   | 1.55×10$^{-4}$   | 1, 2, 3, 4, 5, 6, C | –8, +6 | –3.1 ± 0.3; 8.7 ± 0.4     |
| 346998.344     | H$_2$CO$^+$ | 4→3 | 41.63     | 3.29×10$^{-3}$ | 4, C | –8, +2 | –1.5 ± 0.2; 4.7 ± 0.3     |
| 347330.578     | SiO | 8→7 | 75.01     | 2.20×10$^{-3}$   | C       | –10, +6 | –3.1 ± 0.5; 12.5 ± 4.0     |
| 348534.364     | H$_2$CS | 10$_{1,0}$→9$_{1,0}$ | 105.19    | 6.32×10$^{-4}$   | C       | –6, +2 | –1.0 ± 0.4; 10.7 ± 0.7     |

Notes. Columns are frequency, quantum numbers, upper level energy, $A_{ij}$ Einstein coefficient, spot where the transition was identified and the range of velocities for the molecule. These values are based on CDMS database.

$^a$ Line blended with CH$_3$OH at 338408.698 MHz.
$^b$ Line blended with CH$_3$OH at 338512.856 MHz.
$^c$ Line blended with $^{13}$CO at 338541.265 MHz and CH$_3$OH at 338543.204 MHz.
$^d$ Line blended with $^{13}$C at 338591.071 MHz.
$^e$ Line blended with SO$_2$ at 338611.807 MHz.
$^f$ Line blended with $^{18}$O at 338639.671 MHz.
$^g$ Line blended with H$_2$CS at 338722.898 MHz.

$^h$ The numbers correspond to the spots described in Figure 1.

$^i$ The velocity range is approximate since the exact values are complicated to determine. These values were obtained from Gaussian fittings to the spectra data.

$^j$ These lines were already reported in Zapata et al. (2012).

From the spectra of SPOT4, we have made a search in the SPITZER images for a compact infrared source located in this position, since we might have contamination from the submillimeter condensations associated with young protostars reported by Zapata et al. (2012), Girart et al. (2013), or other sources in MM2 cluster.

Indicated by the magenta hexagon in Figure 1, the position of the closest infrared SPITZER source to MM2 is shown, which is the infrared source IRS1 detected with Spitzer at 8 μm by Araya et al. (2009). We did not find any infrared source within the MM2 cluster (especially associated with the millimeter compact source SMA2); so, at this point the possibility of protostellar contamination seems to be low.

In addition, as the molecular emission reported in this paper is very sparse toward the MM2 cluster, especially the high-density tracer CH$_3$OH (see Figures 12–15), the presence of a protostellar hot corino can also be discarded. However, species such as C$^{17}$O, C$^{13}$S, and H$_2$CS could be tracing cold and compact dusty condensations within MM2 (see Figures 9–11).

Within the methanol outflow we only found simple molecules such as CH$_3$OH, H$_2$CS, H$_2$CO, SiO, and HCO$^+$ (see Table 1). More complex molecules were not found at the 4σ level of 80 mJy at 230 GHz and 200 mJy at 345 GHz. These complex molecules include Methyl Formate (CH$_3$OCHO), Acetone (CH$_3$$_2$CO), and Ethyl Formate (CH$_3$CH$_2$CN). This is in agreement with that proposed in Garrod & Herbst (2006),

5 https://www.astro.uni-koeln.de/cdms
Herbst & van Dishoeck (2009), given that these simple molecules considered as first generation, or parent molecules, are probably released by shocks directly into the gas phase from the icy and dusty mantles.

State-of-the-art tools (such as CASSIS and XCLASS for (sub)millimeter observations) were used to make a powerful analysis of the physical conditions of the outflow.

3.1. Physical Parameters of the Outflow in the SPOT4

We have used the methanol lines identified in the outflow (SPOT4) to determine its physical parameters. We used the rotational diagram method to calculate the column density and rotational temperature associated with the lines. This physical method takes into account that the measured integrated intensity of the lines, \( I_dv \) (Jy beam\(^{-1}\) km s\(^{-1}\)), is related to the column densities of the molecules in the upper level \( N_u \) through

\[
\frac{N_u}{g_u} \approx \frac{N_{\text{tot}}}{Q(T_{\text{rot}})} e^{-E_u/T_{\text{rot}}} = \frac{1.7 \times 10^{14}}{\mu \mu^2 S} \int I_dv,
\]

where \( g_u \) is the statistical weight of level \( u \), \( N_{\text{tot}} \) is the total column density in cm\(^{-2}\), \( Q(T_{\text{rot}}) \) is the partition function for the rotational temperature \( T_{\text{rot}} \), \( E_u \) is the energy of the upper level in Kelvin, \( \mu \) is the permanent dipole moment in Debye, and \( S \) is the strength value. Therefore, a logarithmic plot of the quantity on the right-hand side of the equation above as a function of \( E_u \) provides a straight line with slope \( (1/T_{\text{rot}}) \) and intercepts in \( N_{\text{tot}}/Q(T_{\text{rot}}) \). This gives the rotational temperature and column density. This method assumes that all level populations can be characterized by a single rotational temperature \( T_{\text{rot}} \) and the lines are optically thin.

In Figure 3, we show the rotational diagram obtained with CASSIS\(^7\) (Centre d’Analyse Scientifique de Spectres Instrumentaux et Synthétiques, Caux et al. 2011). We have avoided blended methanol lines to not over-estimate the integrated flux for these lines. From the fit, we obtain a rotational temperature of \( 28 \pm 2.5 \) K and a column density of \( 6 \pm 0.9 \times 10^{15} \) cm\(^{-2}\). The error bars are associated with the error from the Gaussian fitting to compute the integrated intensity. These bars includes 15% of calibration error from the observations. We have not included blended lines in the fitting.

\[^7\] http://cassis.irap.omp.eu
However, because in the other spots there were a few methanol transitions or they were blended, the calculation could not be done with good certainty.

Using these values obtained from the rotational diagram for the column density and rotational temperature, we have computed a synthetic model with XCLASS (Möller et al. 2017) to compare it with the observations. In Figure 4 we show the results. The synthetic model reproduces very well the spectra for the SPOT4 and in the window of 337 GHz where many methanol are present. Some of the CH₃OH lines are not well fitted because of line blending or contamination of other spectral lines. We also tried to make LTE XCLASS synthetic spectra for the rest of the spots, but again, the blending and the sparsity of the molecular emission along the outflow did not allow it.

The physical values for the rotational temperature obtained here are similar to those reported in the peak B1 in the blue lobe of the chemically rich active outflow L1157 ejected by a low-mass young star (Arce et al. 2008). However, it is not clear if the physical conditions are the same since the column densities differ by a factor of 100. These values for the column density and rotational temperature are very low (more obvious for the rotational temperatures) compared with those values reported for hot molecular cores (40–485 K, and 10¹³–10¹⁷ cm⁻²; Hermández-Hernández et al. 2014). Moreover, Palau et al. (2017) for the the case of the massive outflow in IRAS 20126+4104 reported column densities between 10¹⁵ and 10¹⁷ cm⁻², and rotational temperatures of 100–235 K. These values are also significantly higher than those reported here.

Compared with other molecular outflows reported in the literature (L1157, HH 114 MMS, and IRAS 20126+4104), no complex molecules were found in the methanol outflow. One explanation for this non-detection could be a relation with the age of the molecular outflow. The dynamical age of the outflow is about 15000 years old. This time is too short for the formation of complex molecules in the gas phase after the shock-induced sputtering of the grain mantles (see Garrod & Herbst 2006; Herbst & van Dishoeck 2009). However, Arce et al. (2008) noted that it is more likely that complex species form on the surface of grains and then are ejected from the grain mantles by the shocks.

There is also a possibility that the emission from the C³⁴S and H₂CS may be contaminated from the sulfur-dominated region discovered by Plambeck & Menten (1990), likely originated from the northern part of the flow. However, our maps, which have better angular resolution from the H₂CS line, reveal some emission very close to SMA4, which could be tracing the outflow material ejected from this object. This possibility favors our interpretation that this emission (C³⁴S and H₂CS) is excited by the outflow. However, we think that more sensitive observations from sulfur molecules could help to reveal its origin.

4. Conclusions

The main results of our work can be summarized as follows:

1. We report the detection of 21 molecular lines, 12 of which correspond to methanol toward the methanol outflow in DR21(OH). These lines include CH₃OH, H₂CS, C¹⁷O, H¹³CO⁺, and C³⁴S. This is the first time that these lines are detected within the outflow. However, we cannot discard the possibility that some of the observed species such as C¹⁷O, C³⁴S, and H₂CS, might be instead associated with compact dust continuum emission from cores in MM2 region. We suggest that this outflow is rich chemically active in simple molecules.

2. Given that most of the detected transitions correspond to methanol lines, we have computed a rotational diagram with CASSIS and an LTE synthetic spectra with XCLASS for the detected methanol lines in order to estimate the rotational temperature and column density in the small solid angle of the outflow where enough lines are present. We obtain a rotational temperature of 28 ± 2.5 K and a column density of 6 ± 0.9 × 10¹⁵ cm⁻². These values are comparable to those column densities/rotational temperatures reported in outflows emanating from low-mass stars.

3. No complex molecules were found in the methanol outflow, e.g., CH₃OCHO, (CH₃)₂CO, and CH₃CH₂CN.

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Appendix

A.1. Molecular Spectra

In this section, we show the obtained spectra from the spots (see Figure 1).
Figure 5. SMA spectra for all spots in the window of 216–218 GHz. The data used to create this figure are available.
Figure 6. SMA spectra for all spots in the window of 226–228 GHz. The data used to create this figure are available.
Figure 7. SMA spectra for all spots in the window of 337–338 GHz. The data used to create this figure are available.
A.2. Integrated Intensity Maps

In this section, we include the moment zero maps for all molecules reported in Table 1. We have used an exponential or logarithmic brightness scale depending on the maximum for each map to show the emission distribution.
Figure 9. Same as Figure 2, but with the SiO, $^{17}$O and H$_2$CO molecules.
Figure 10. Same as Figure 2, but with the SiO and H$_2$CO molecules.
Figure 11. Same as Figure 2, but with the C\textsuperscript{34}S, H\textsubscript{2}CS, and H\textsuperscript{13}CO\textsuperscript{+} molecules.
A.4. Figures of Methanol Lines

Figure 12. Same as Figure 2, but with the CH$_3$OH molecule from different transitions.
Figure 13. Same as Figure 2, but with the CH$_3$OH molecule from different transitions.
Figure 14. Same as Figure 2, but with the CH$_3$OH molecule from different transitions.
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Figure 15. Same as Figure 2, but with the CH$_3$OH molecule from different transitions.

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