

Organic molecules in the spectral line survey of Orion KL with the Odin Satellite from 486–492 GHz and 541–577 GHz

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Abstract. A spectral line survey of Orion KL has been performed over the frequency range of 486–492 GHz and 541–577 GHz using the Odin satellite. Over 1000 lines have been identified from 40 different molecular species, including several organic compounds such as methyl cyanide (CH₃CN), methanol (CH₃OH, ¹³CH₃OH), and dimethyl ether (CH₃OCH₃).

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1. Introduction

Although there have been over 20 ground-based spectral surveys of the Orion Kleinmann-Low Nebula, observations between 500 GHz and 600 GHz have not been possible from the ground due to atmospheric absorption by H₂O and O₂. The Odin Satellite (Hjalmarson *et al.* 2003) is capable of observing frequencies in the range of 486–504 GHz and 541–581 GHz via 4 tunable receivers. Odin therefore provides a great opportunity to observe this unexplored region of Orion KL's spectrum.

2. Observations and analysis

Odin performed a spectral line survey of the Orion KL region over a 1.5 year period from February 2004 to November 2005, spanning 1100 orbits. All four tunable receivers were used to observe between 486–492 GHz and 541–577 GHz. The observations were made with a beam size of 2.1' (at 557 GHz) in position switching mode where the entire telescope physically moved 15' between the target and an off position with a cycle period of 1 minute.

The data were processed and analyzed in parallel by the Space Astronomy Laboratory (SAL) in Calgary and the Onsala Space Observatory in Sweden. A part of the surveyed spectrum between 541–577 GHz is shown in Figure 3. The JPL Molecular Spectroscopy catalogue (Pickett *et al.* 1998) and the Cologne Database for Molecular Spectroscopy (CDMS, Müller *et al.* 2005) were used in the line identification. In the case of methanol, a separate list of transitions supplied by Eric Herbst was used. Gaussian profiles were fit to each observed feature using a least squares algorithm. In the case where more than one transition contributed to a single feature, special routines were used to fit the sum of several profiles. In some situations the number of blended lines was excessive and no fits were attempted due to substantial ambiguities.

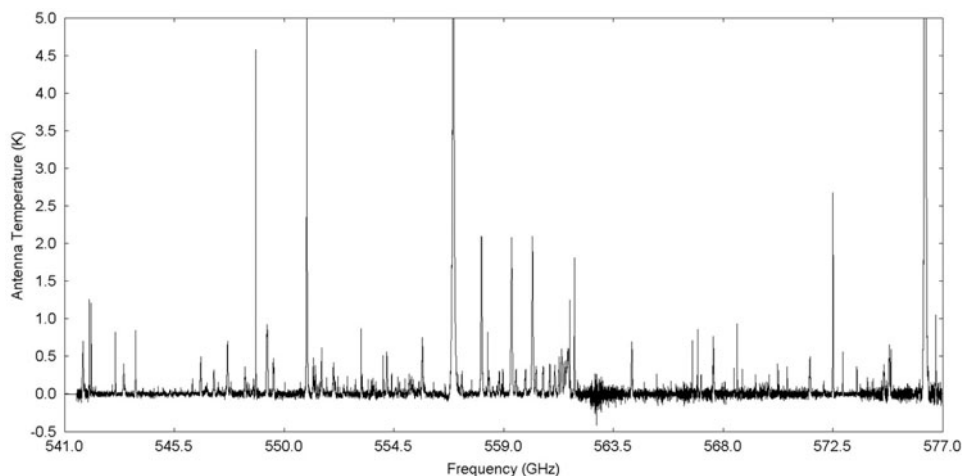


Figure 1. Spectrum of Orion KL from 541–577 GHz observed with the Odin satellite. Several organic molecules are present, including methanol, methyl cyanide, dimethyl ether, formaldehyde, thio-formaldehyde, thioformyl cation and hydrogen isocyanide. The strongest lines in this spectrum are CO $J = 5 - 4$ (576.27 GHz), $^{13}\text{CO } J = 5 - 4$ (550.93 GHz), $\text{C}^{18}\text{O } J = 5 - 4$ (548.83 GHz), and $\text{H}_2\text{O } 1_{10} - 1_{01}$ (556.94 GHz).

3. Organic Molecules

Seven organic molecules were detected in this survey: methanol (CH_3OH , $^{13}\text{CH}_3\text{OH}$), methyl cyanide (CH_3CN), dimethyl ether (CH_3OCH_3), formaldehyde (H_2CO , H_2^{13}CO , HDCO), thio-formaldehyde (H_2CS), thioformyl cation (HCS^+), and hydrogen isocyanide (HNC). Methanol dominates the entire survey with 83 detected lines making it ideal for rotation diagram analysis. Both A and E species were detected, with a ratio of $\sim 3:1$ for CH_3OH and $2:1$ for $^{13}\text{CH}_3\text{OH}$. The temperature determined for methanol is 181 K. $^{13}\text{CH}_3\text{OH}$ had enough lines to warrant a rotation diagram of its own, with a derived temperature of 110 K. Ninety-eight lines of methyl cyanide were detected, but due to overcrowding among fine structure lines, only 9 could be profiled. Using these lines, a rotation diagram was constructed yielding a highly uncertain temperature of 62 K and a column density of $5.7 \times 10^{17} \text{ cm}^{-2}$. Dimethyl ether had 413 transitions detected, although due to the AA, AE, EE and EA symmetries these were almost all fine structure lines and not resolvable. As such, too few lines could be profiled in order to create a reliable rotation diagram. Only three transitions of formaldehyde were detected and only a single transition of both HDCO and H_2^{13}CO were detected. The thioformyl cation was also detected only once. Odin observed 6 transitions of thioformaldehyde, enough to allow for a rotation diagram to be constructed. The derived temperature and column density is 124 K and $4.3 \times 10^{13} \text{ cm}^{-2}$, respectively. Hydrogen isocyanide was only detected once at 543.9 GHz, and is highly blended with several CH_3OCH_3 lines and one unidentified line.

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