Master Thesis

Exploring the existence of prebiotic species: ALMA observations of amine-containing organic molecule in star-forming regions.

Harumi Minamoto

17M01629

Nomura Laboratory

Department of Earth and Planetary Sciences, Tokyo Institute of Technology

January 11, 2019

Abstract

A variety of complex organic moleculues have been observed for decades in the interstellar medium. Some of them are considered to be delivered to the primordial Earth by comets, and contributed to the chemical evolution leading to terrestrial life.One example of such prebiotic species is amino acid. Glycine, the simplest amino acid, has been detected in comet 67P/C-G but its presence in molecular clouds is still uncertain.

In this work we analyze the ALMA archival data toward a few star-forming regions such as Orion KleinmannLow nebula and IRAS 16293-2422 to search molecules with amine functional group, which are suggested as precursors to glycine. We compare the results considering their different chemical condition.

Contents

Chapter 1

Introduction

1.1 Origin of life

The interstellar medium (ISM), where more than 190 molecules ranging from simple linear molecules to complex organic molecules (hereafter COMs) were detected, show chemically rich environment. Astronomers usually regard the species with more than six atoms as COMs. Not only O-bearing species, CH3OH, CH3OCH3, HCOOCH3, but also N-bearing species such as CH3CH2CN and CH2CHCN are known COMs. In 2016, a chiral molecule propylene oxide (CH3CHHCH2O) was detected towards Sgr B2 (N) molecular cloud in absorption (McGuire et al. 2016). This detection implies that molecules can get sufficient complexity, and it will accelerate surveys of other chiral molecules, like amino acids. From this point of view, many observations were conducted to search for prebiotic molecules in the ISM, which might turn into the Seeds of Life when delivered to a planetary surface. Especially, a great attention was paid to amino acids, essential building blocks of terrestrial life; many surveys were made unsuccessfully to search for the simplest amino acid, glycine (NH2CH2COOH), towards Sgr B2 and other high-mass star forming regions (e.g., Brown et al. 1979; Snyder et al. 1983; Combes et al. 1996). In 2003, Kuan et al. (2003) claimed the

rst detection of glycine, however, several follow-up observations concluded denied the detection (e.g., Jones et al. 2007). The difficulty of the past glycine surveys would be originated from potential weakness of glycine lines and low sensitivities of telescopes used for the surveys.

1.2 Glycine and methylamine

1.3 Star forming region

1.3.1 Orion Kleinmann-Low nebula

1.3.2 IRAS 16293-2422

1.3.3 L483

1.4 Radio observation

1.4.1 Atacama Large Millimeter Array

1.4.2 Principle of interferometry

1.5 Purpose of this work

Chapter 2

Methylamine survey in Orion-KL

2.1 Observation data

2.2 Analysis

2.2.1 Continuum Subtraction of SV data

2.2.2 Line identification

2.3 Results

2.3.1 Transitions

Table 2.1: Observed rotational transitions of CH_3NH_2 in Orion-KL

Fequency [GHz]	Sμ^2 [D^2]	E_u [K]	Transition (J, K_a, Γ)	Comments
215.670	53.92	111.48	9, 2, $E_{1-1} \rightarrow$ 9, 1, E_{1+1}	Partially blended
245.202	37.84	168.31	12, 1, $B_2 \rightarrow$ 11, 2, B_1	
217.758	129.88	182.05	12, 2, $B_2 \rightarrow$ 12, 1, B_1	
221.755	35.06	133.11	10, 2, $A_2 \rightarrow$ 10, 1, A_1	
229.908	27.37	92.71	8, 2, $A_2 \rightarrow$ 8, 1, A_1	
235.735	82.06	92.76	8, 2, $B_2 \rightarrow$ 8, 1, B_1	
242.262	60.23	60.86	6, 2, $B_2 \rightarrow$ 6, 1, B_1	
244.887	49.54	48.09	5, 2, $B_1 \rightarrow$ 5, 1, B_2	

2.3.2 Distribution

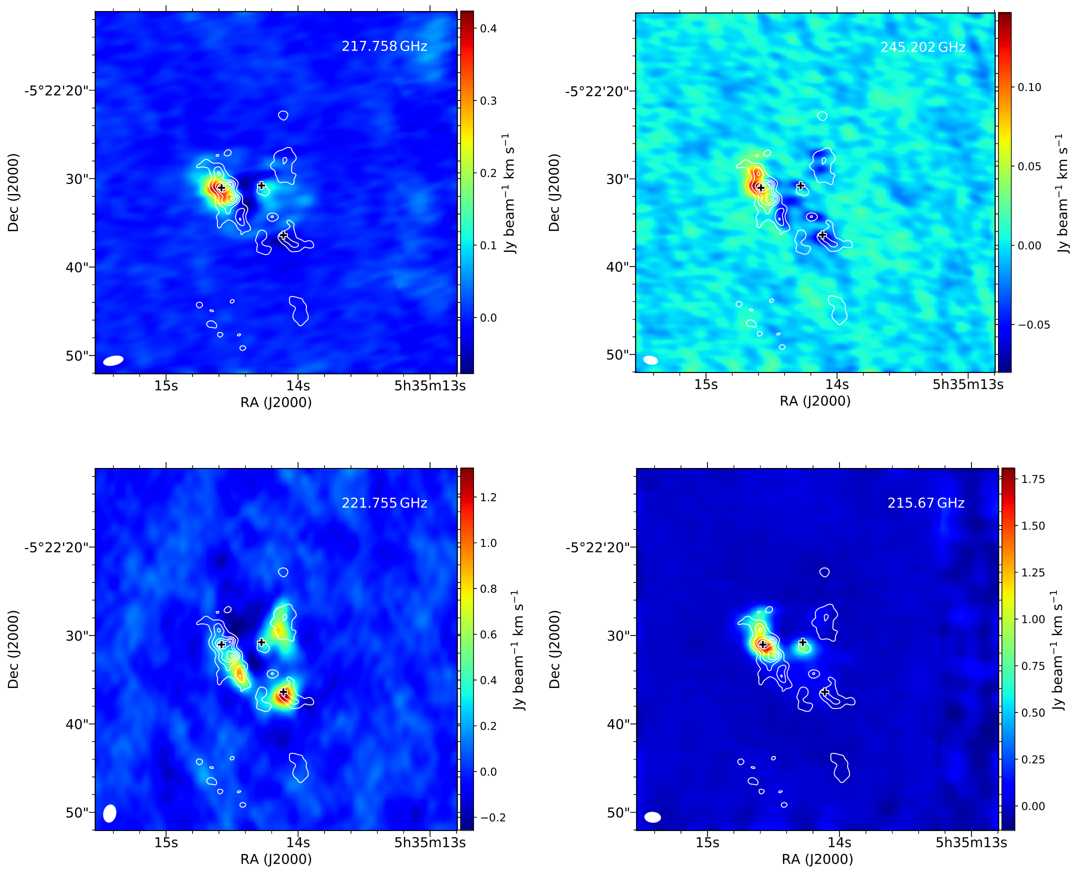

Figure 2.1: Integrated intensity map

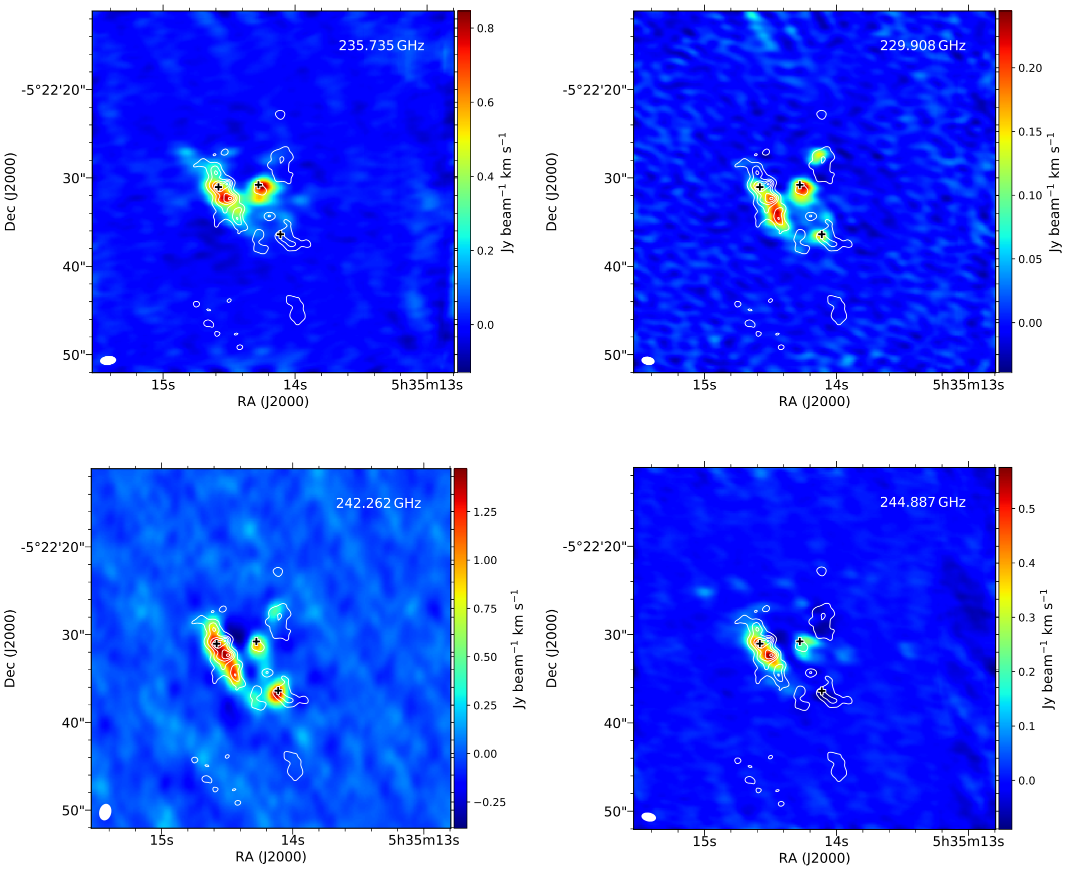

Figure 2.2: (Continued)

2.3.3 Spectrum

2.4 Disucssion

2.4.1 Column density and Rotation temperature

In this subsection we will describe the methodologies in deriving fractional abundances of COMs.

2.4.2 Blending

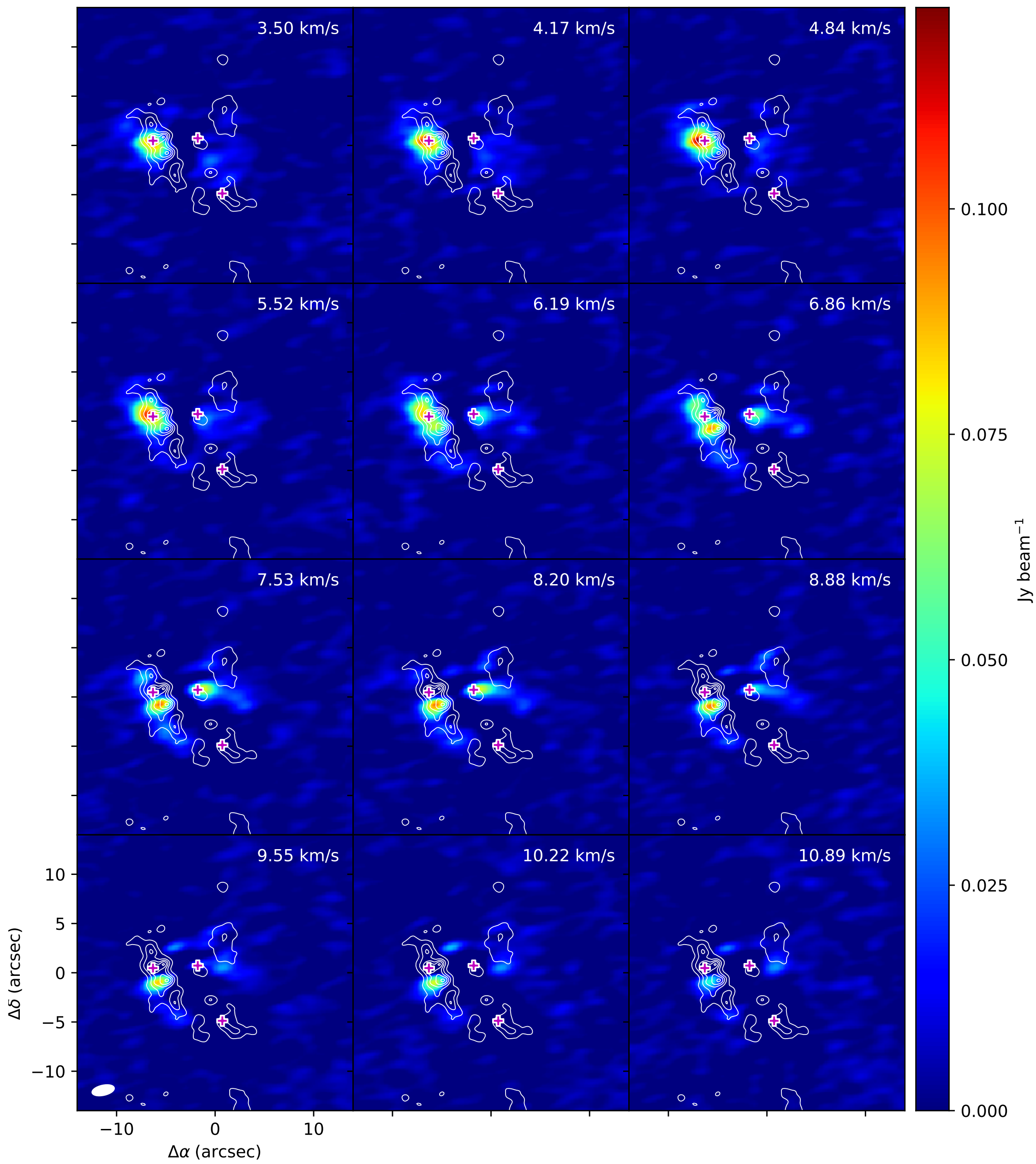

Figure 2.3: 217.758 GHz

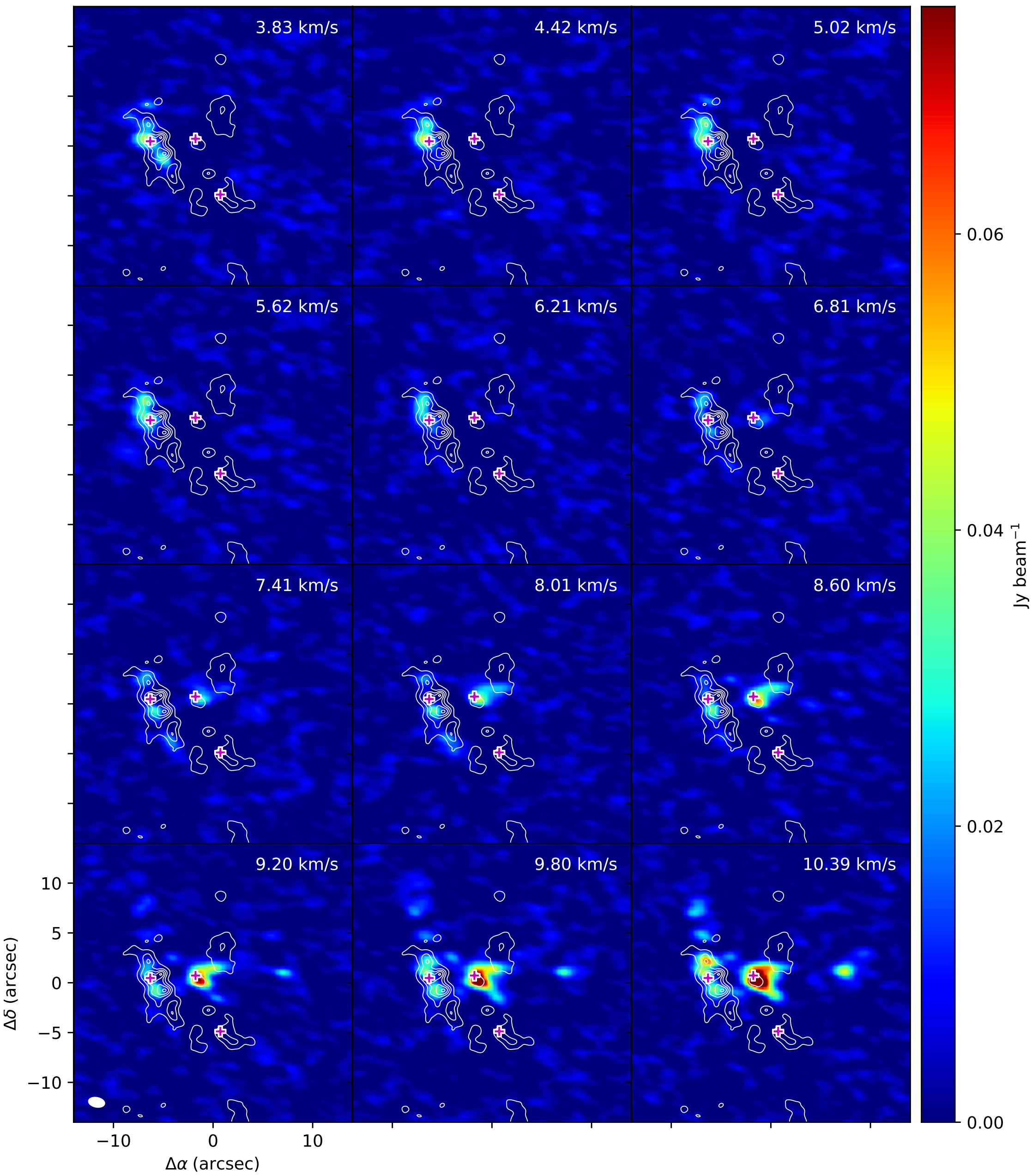

Figure 2.4: 245.202 GHz

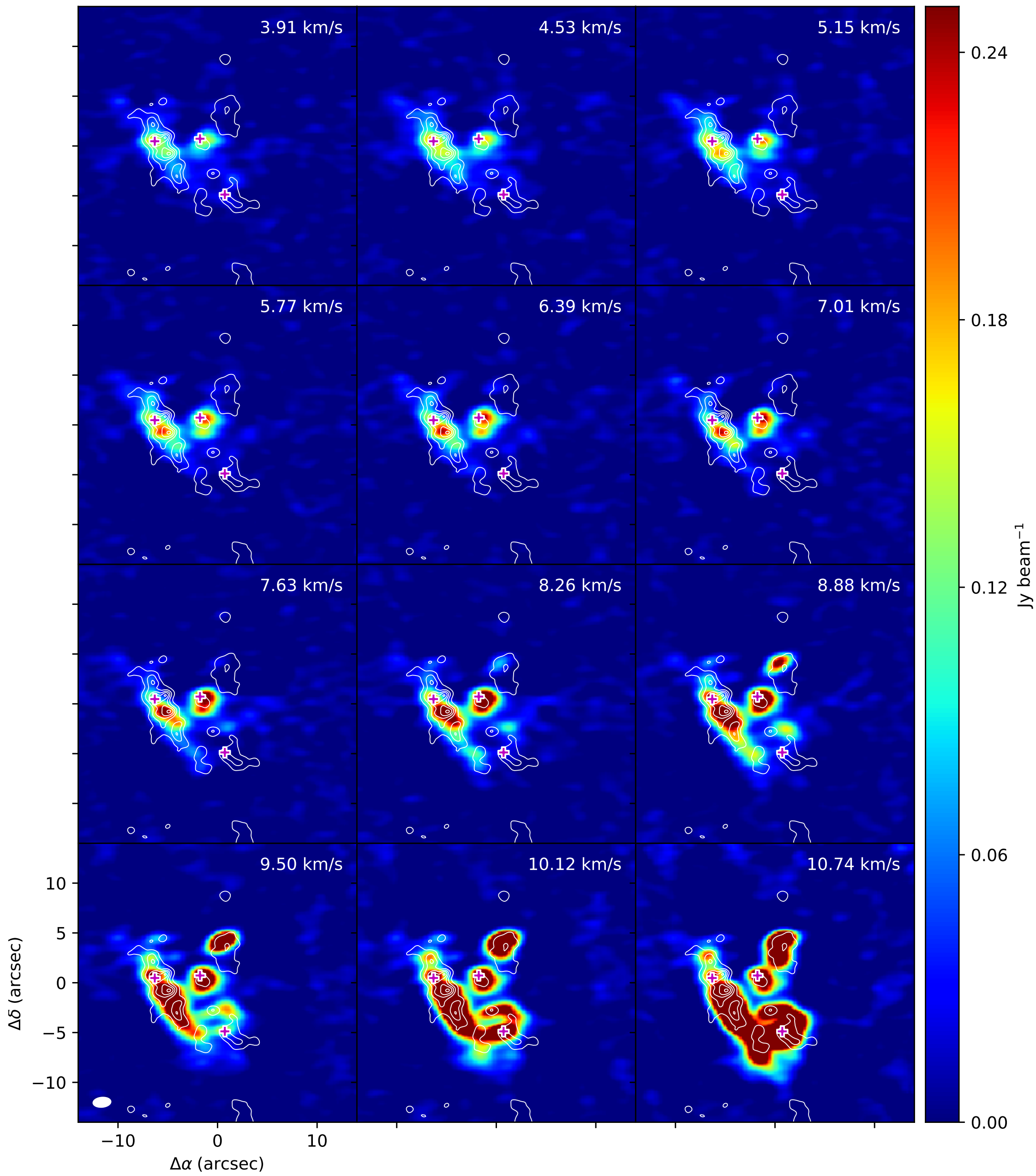

Figure 2.5: 235.735 GHz

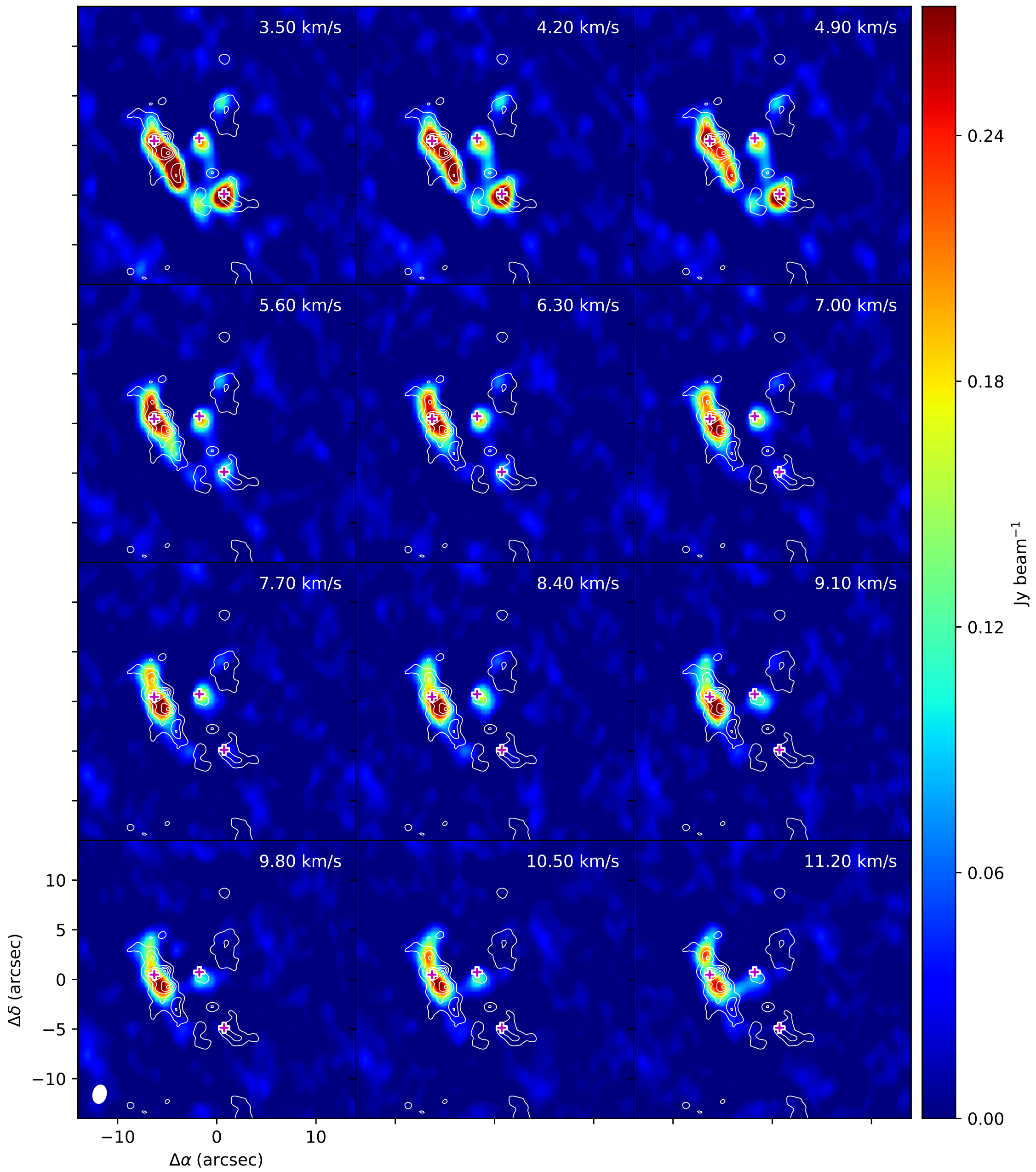

Figure 2.6: 242.262 GHz

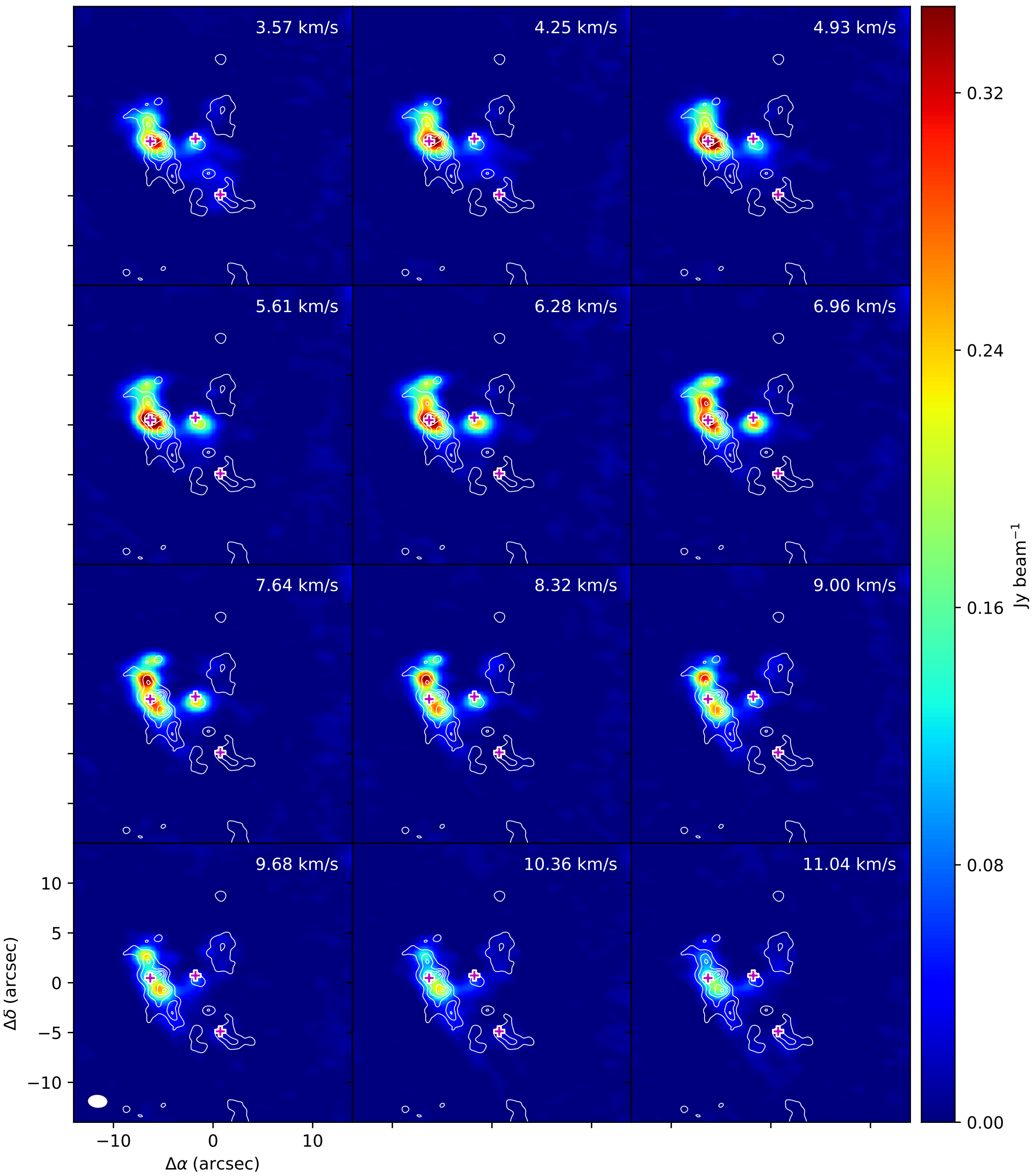

Figure 2.7: 215.670 GHz

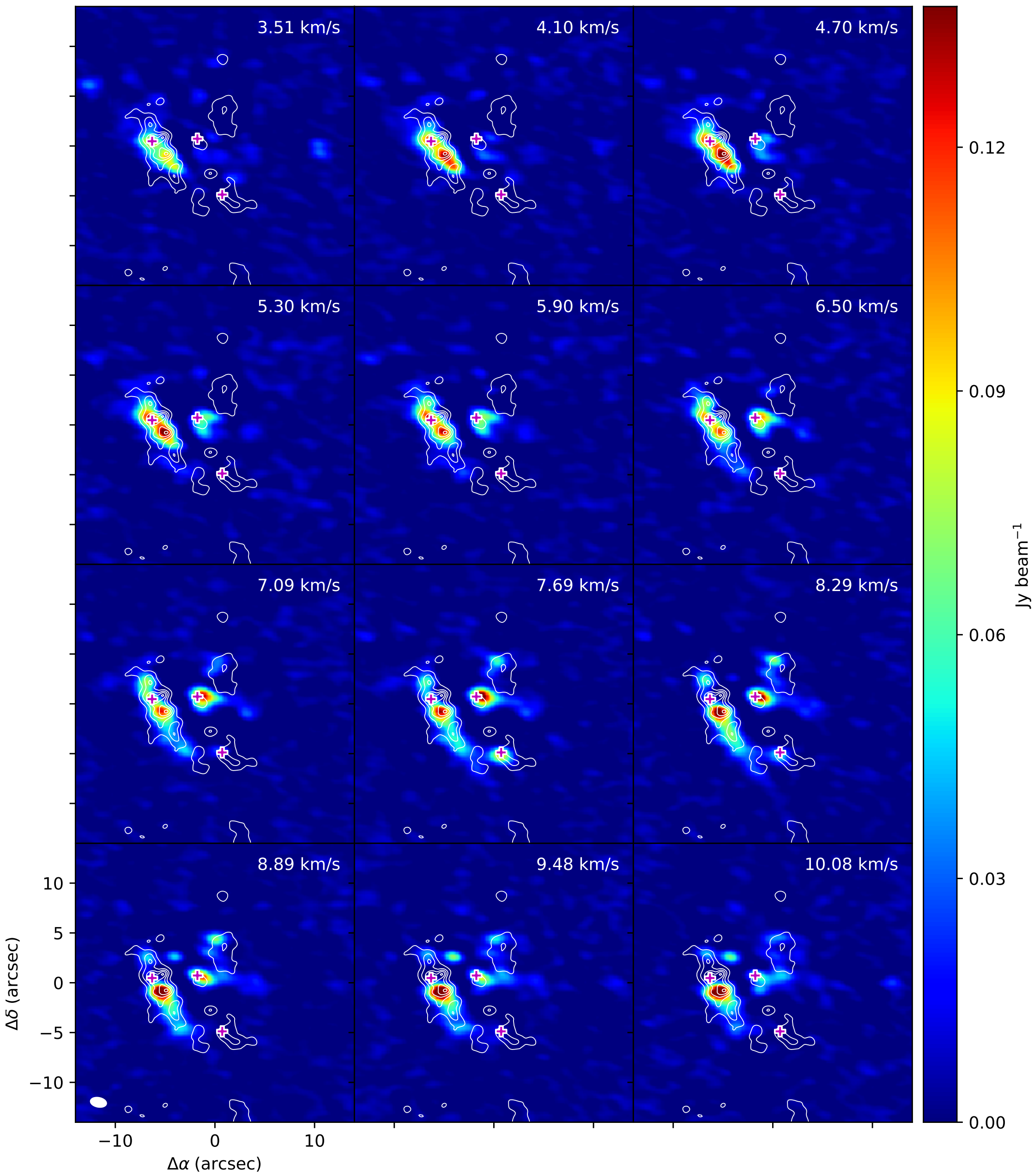

Figure 2.8: 244.887 GHz

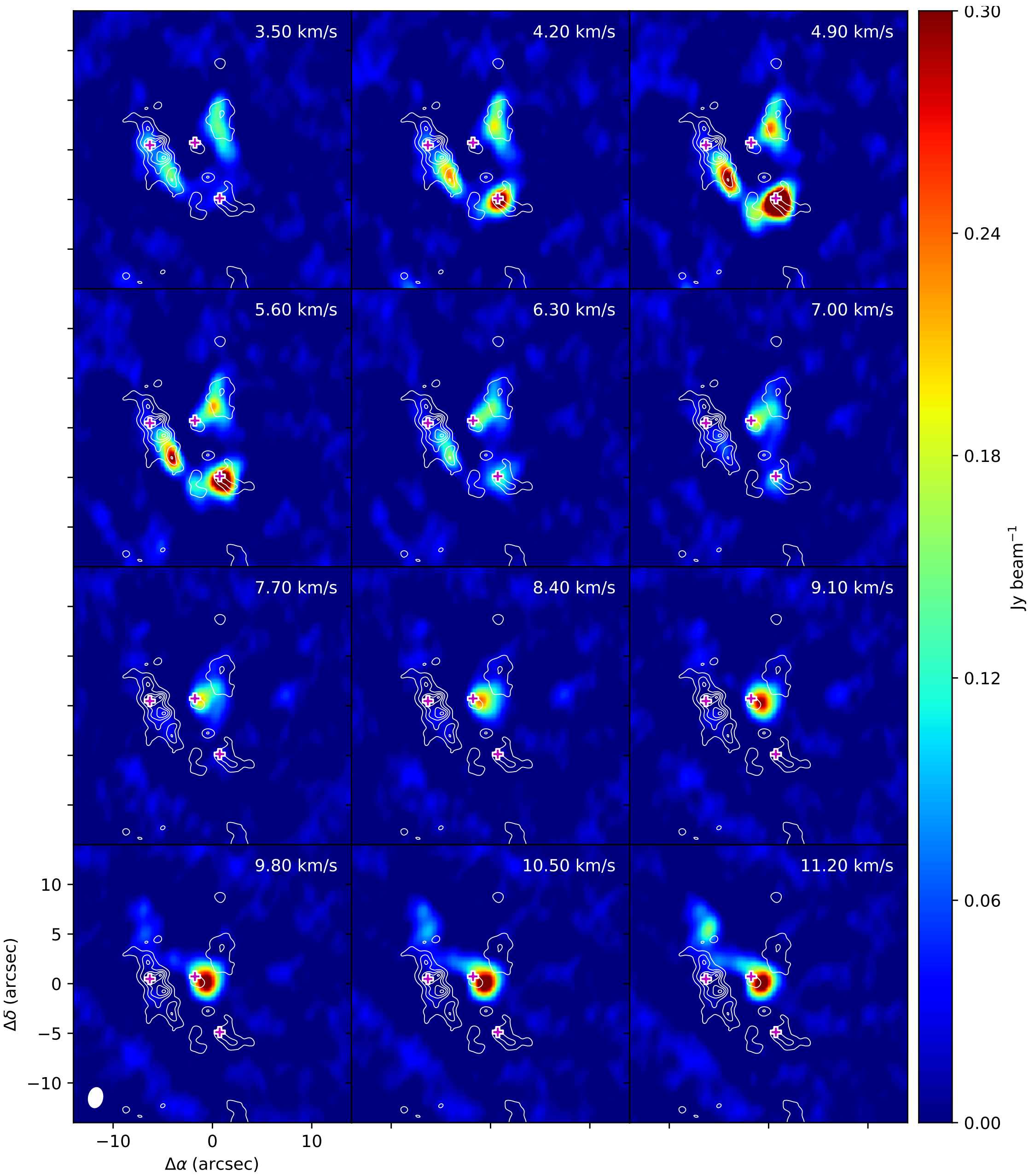

Figure 2.9: 221.755 GHz

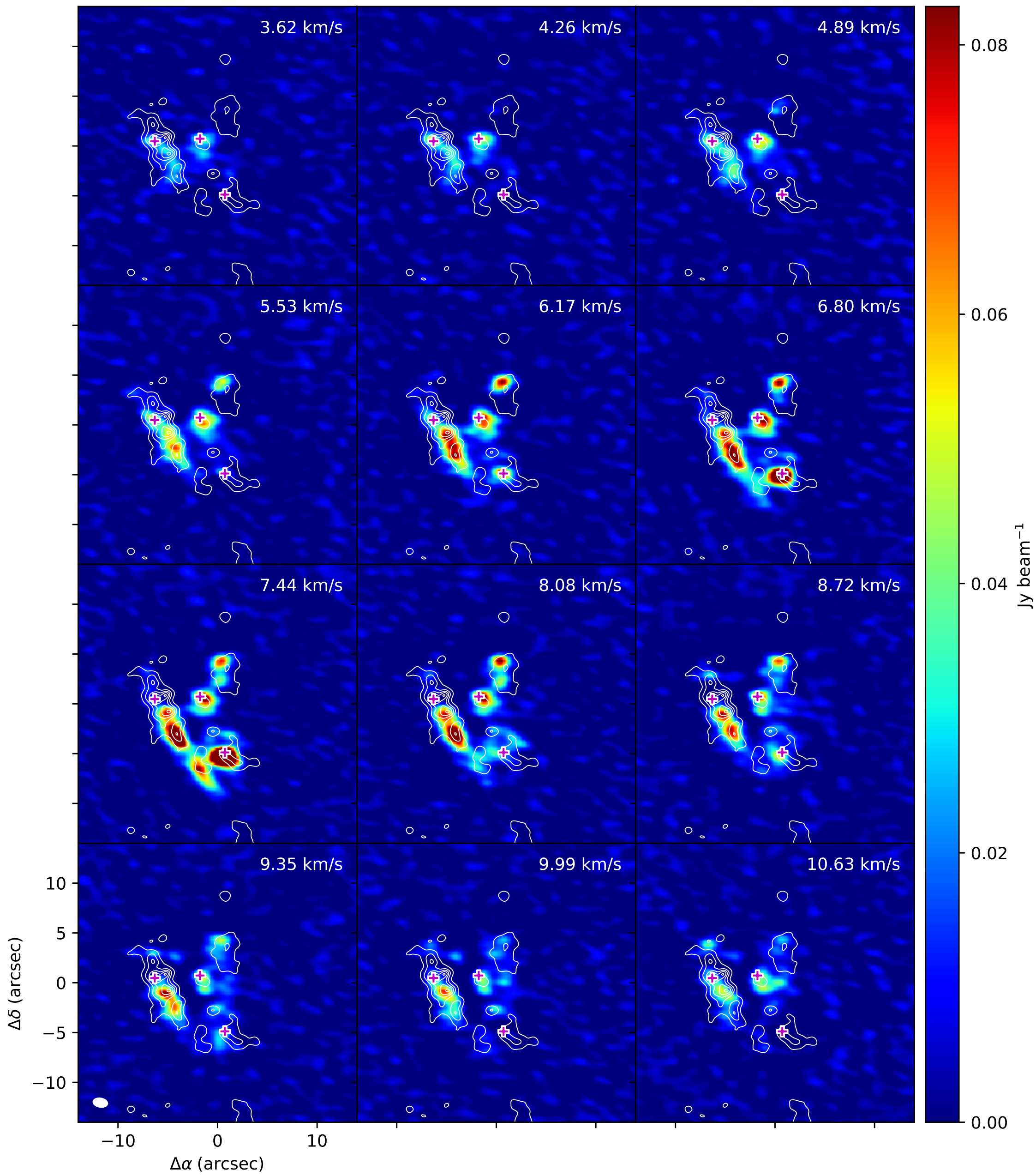

Figure 2.10: 229.908 GHz

Chapter 3

Methylamine survey in low mass star-forming regions

3.1 Review of low mass star-forming region

3.2 Analysis

3.3 IRAS 16293

3.3.1 Observation data

3.3.2 Results

3.4 L483

3.4.1 Observation data

3.4.2 Results

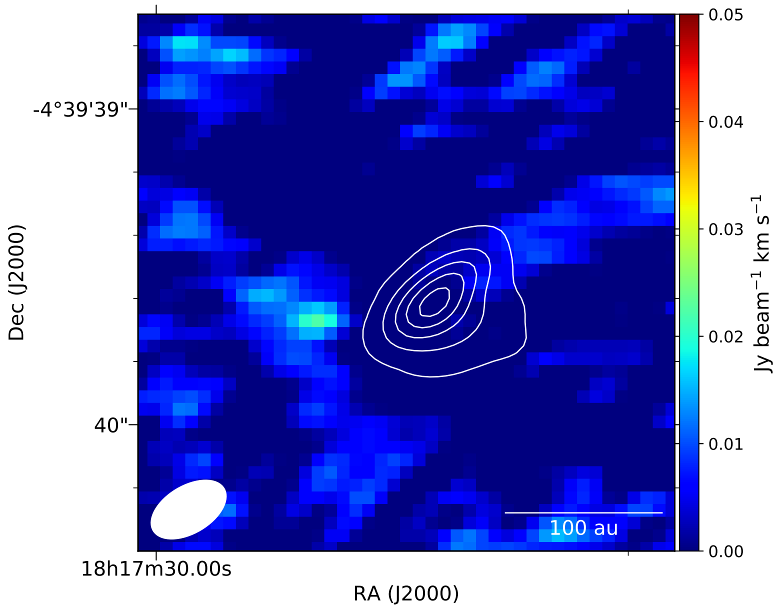

Figure 3.1: Integrated intensity map around 217.079 GHz. The white contours represent the 1.3 mm continuum map, where the contour levels are 10 %, 30 %, 50 %, 70 %, 90 % of the peak intensity.

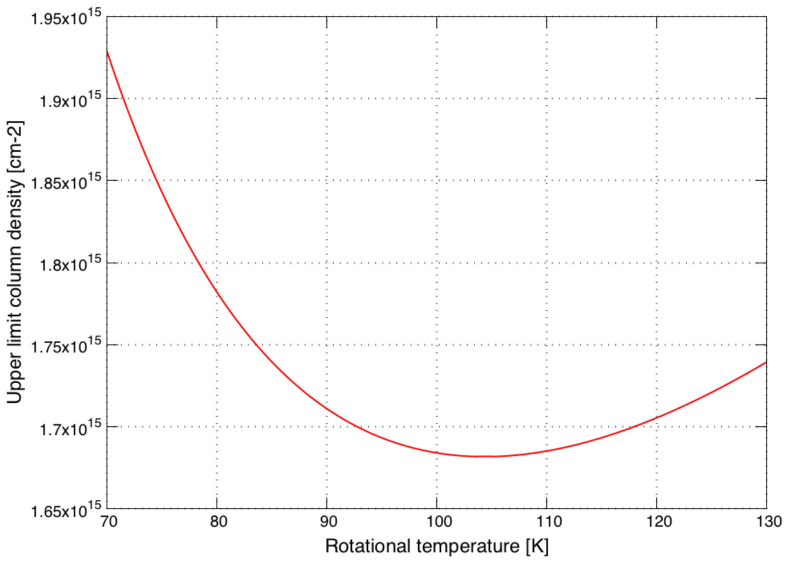

Figure 3.2: Upper limit column density for the strongest CH_3NH_2 transition ($11_2A_1 \rightarrow 11_2A_2$) as function of T_{rot}. A 3σ value of 75 Jy km s $^{-1}$ is used.

Chapter 4

Discussion

Chapter 5

Conclusions

Appendix A

Distribution of methylamine lines contaminated by other molecular line emission in Orion-KL

A.1 Integrated intensity maps

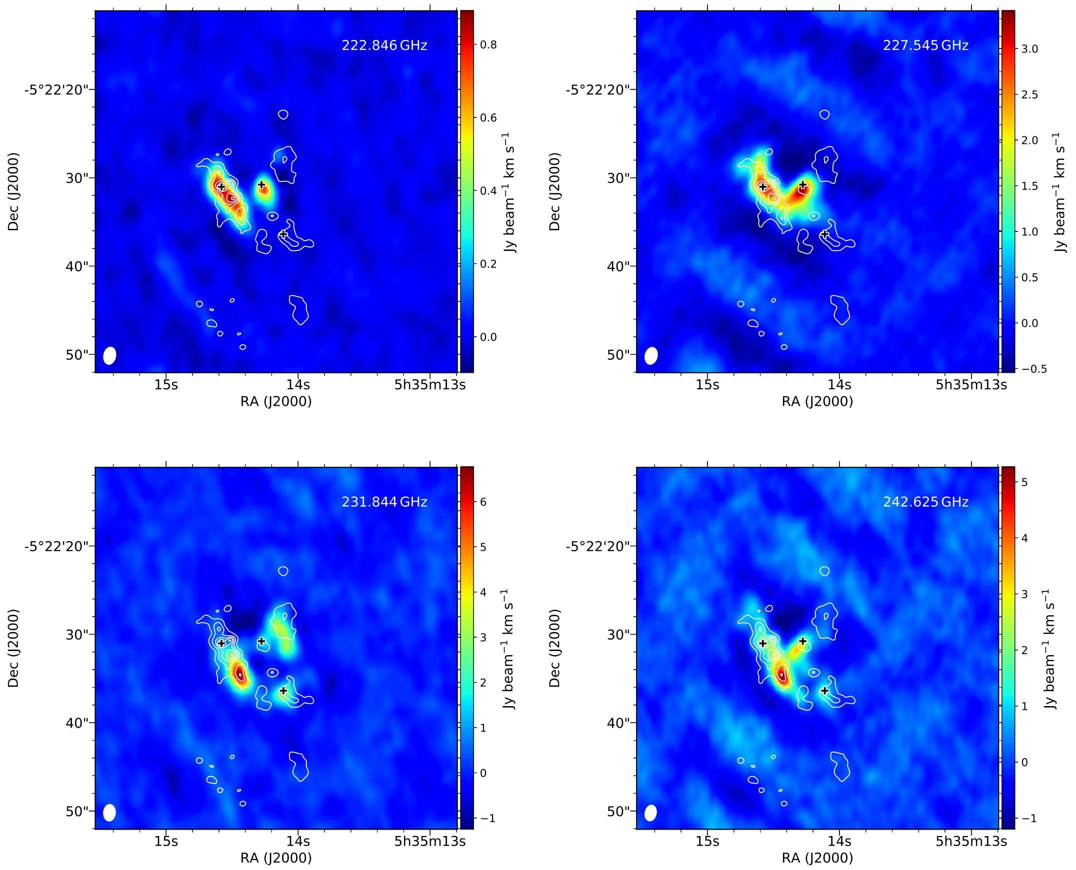

Figure A.1: Integrated intensity maps around methylamine line.

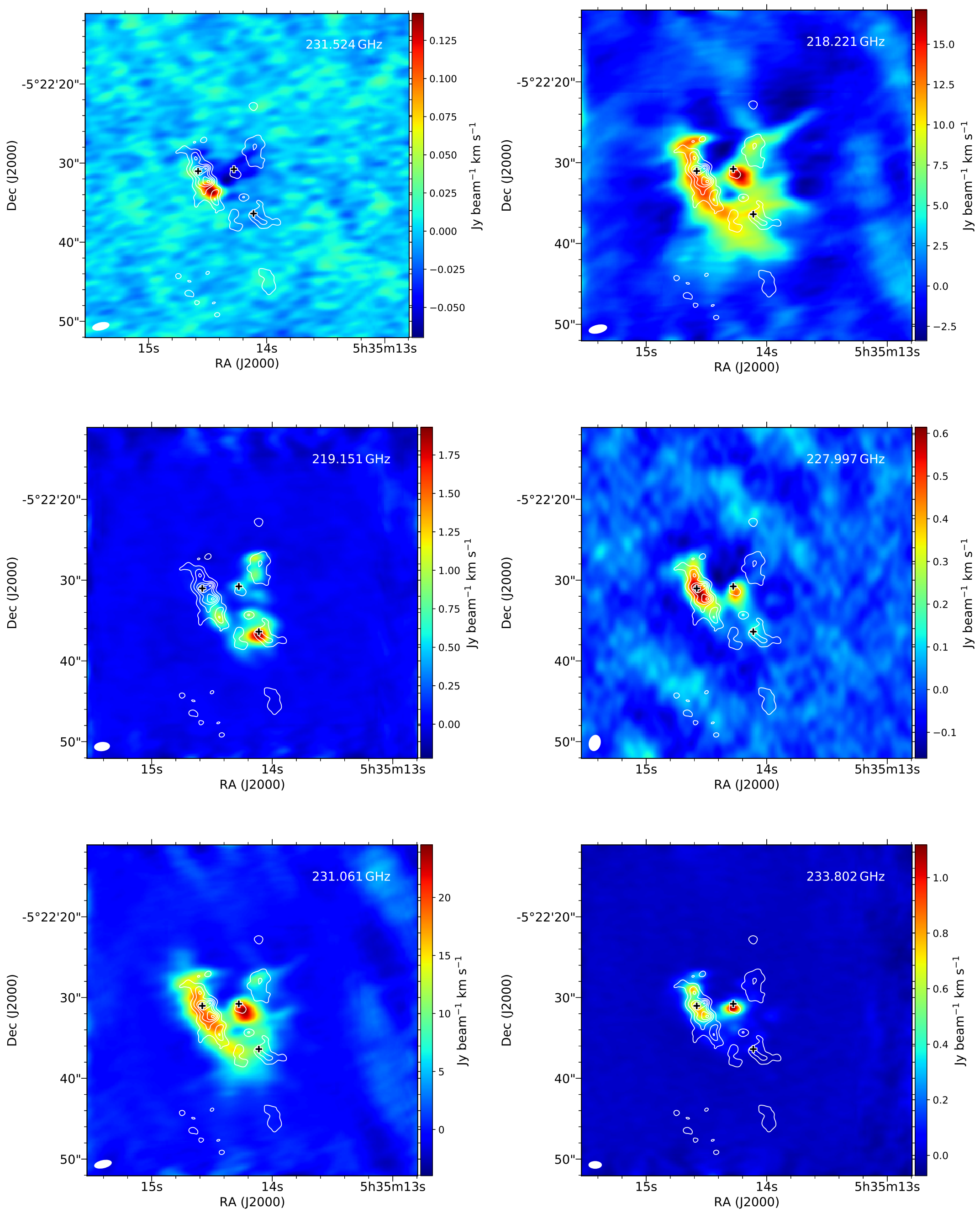

Figure A.2: (Continued)

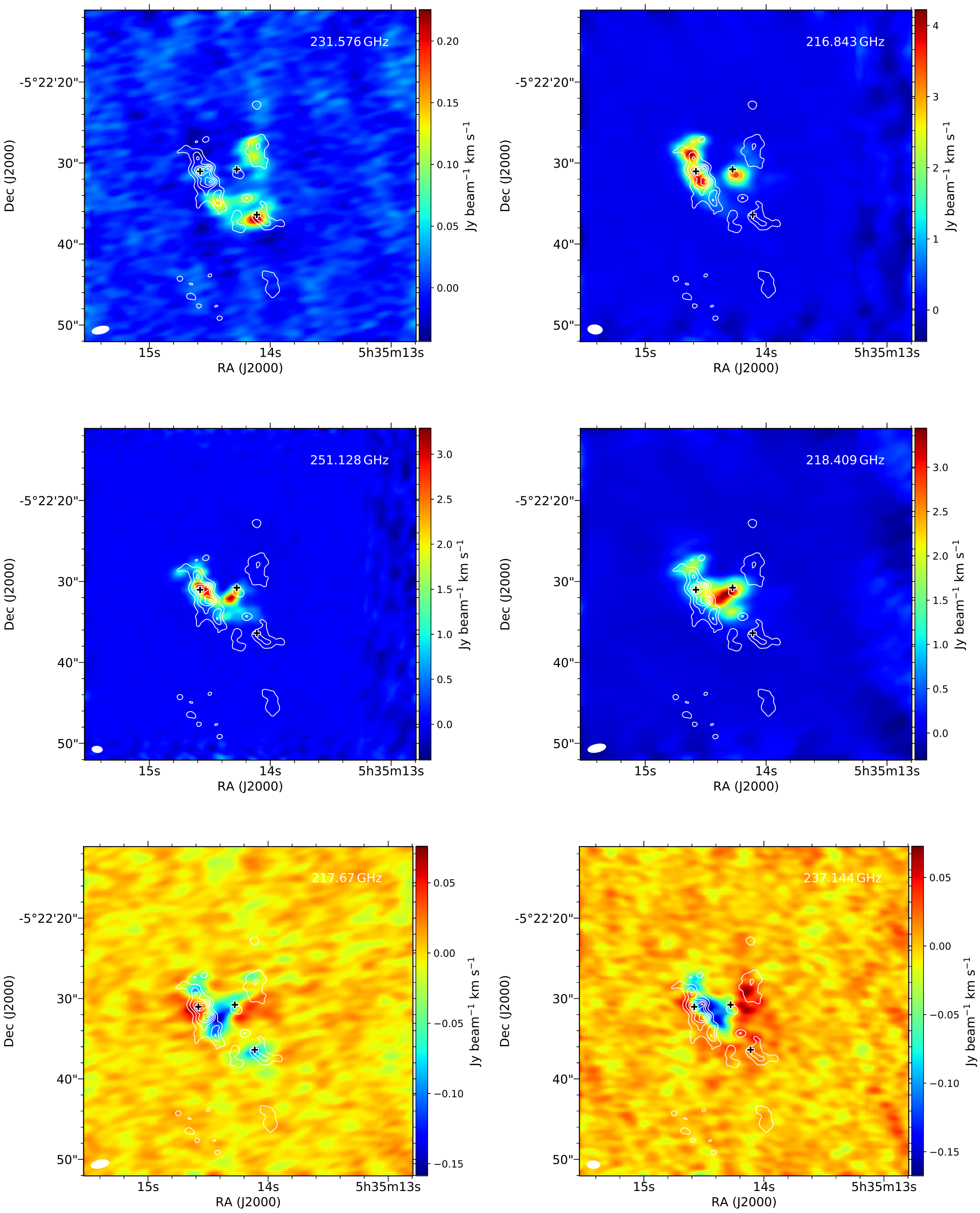

Figure A.3: (Continued)

A.2 Channel maps

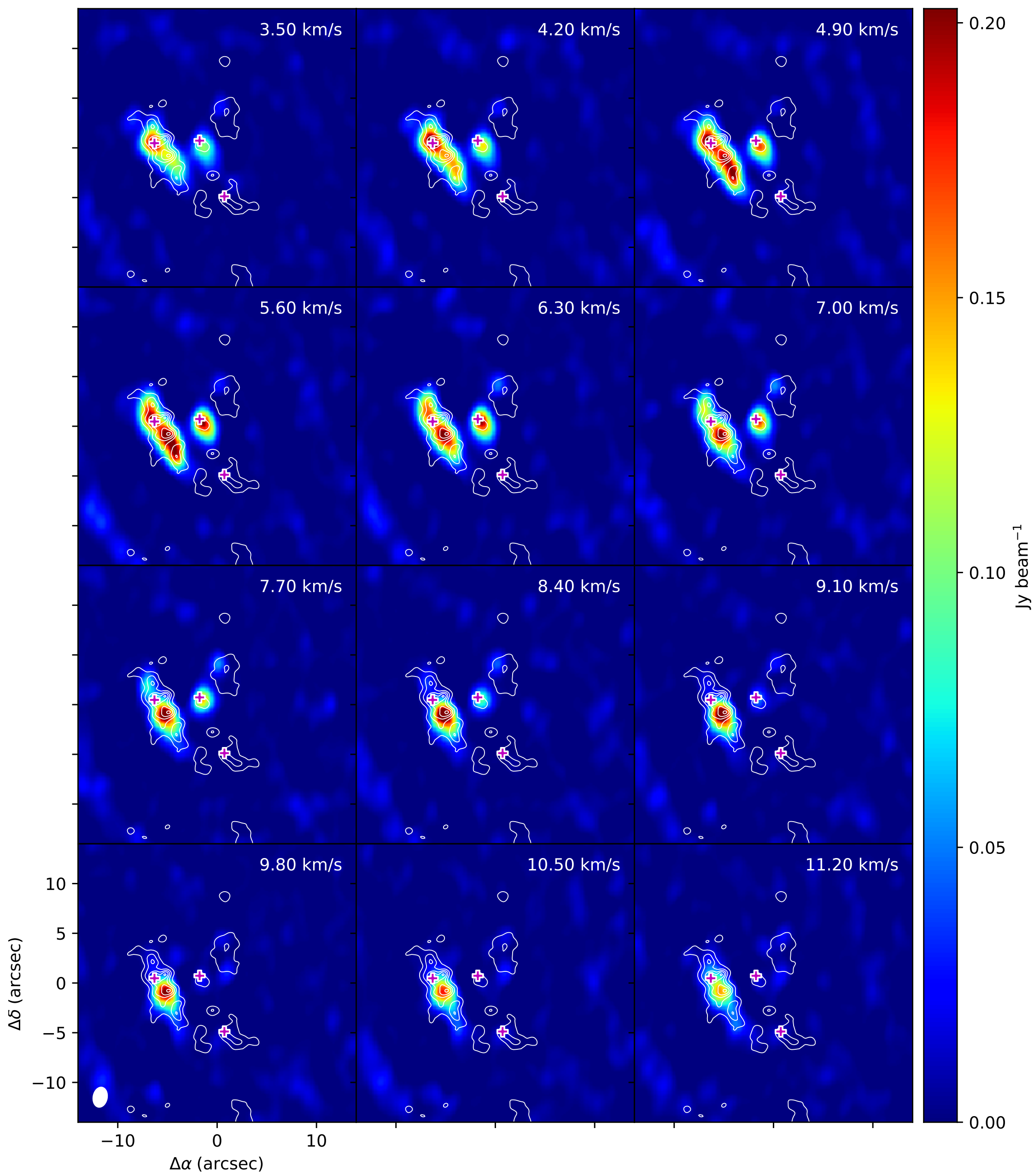

Figure A.4: 222.846GHz

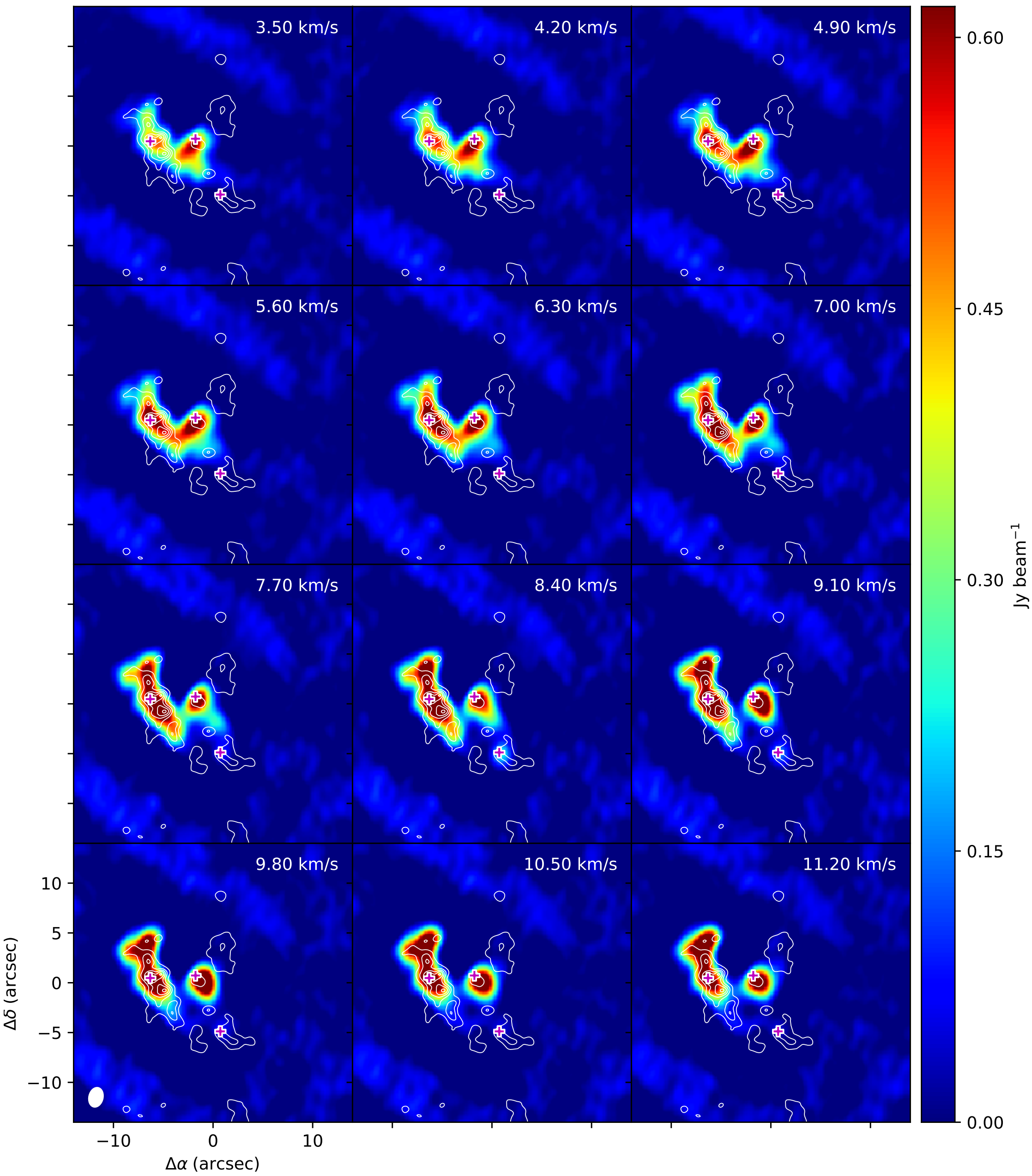

Figure A.5: 227.545GHz

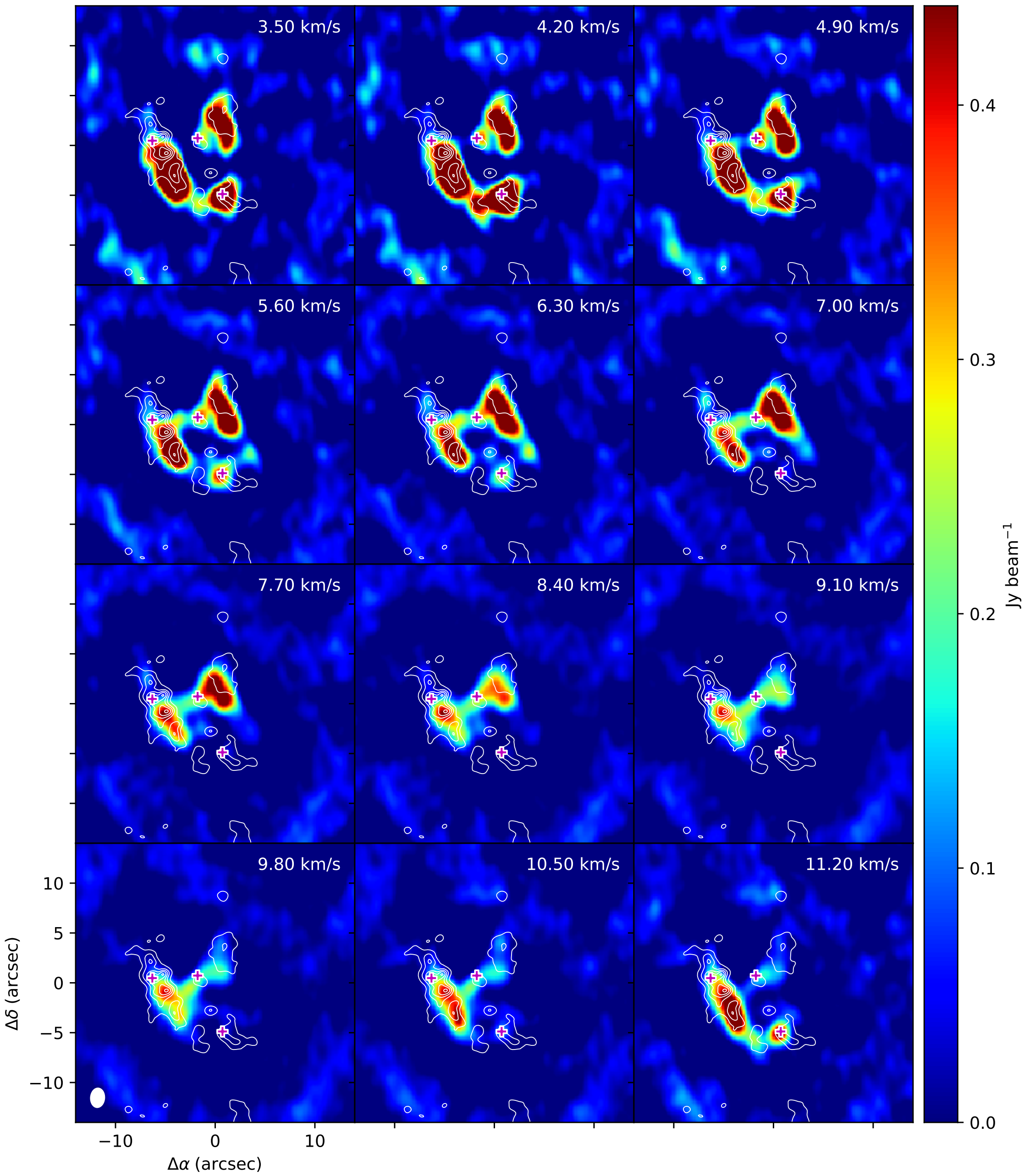

Figure A.6: 231.844GHz

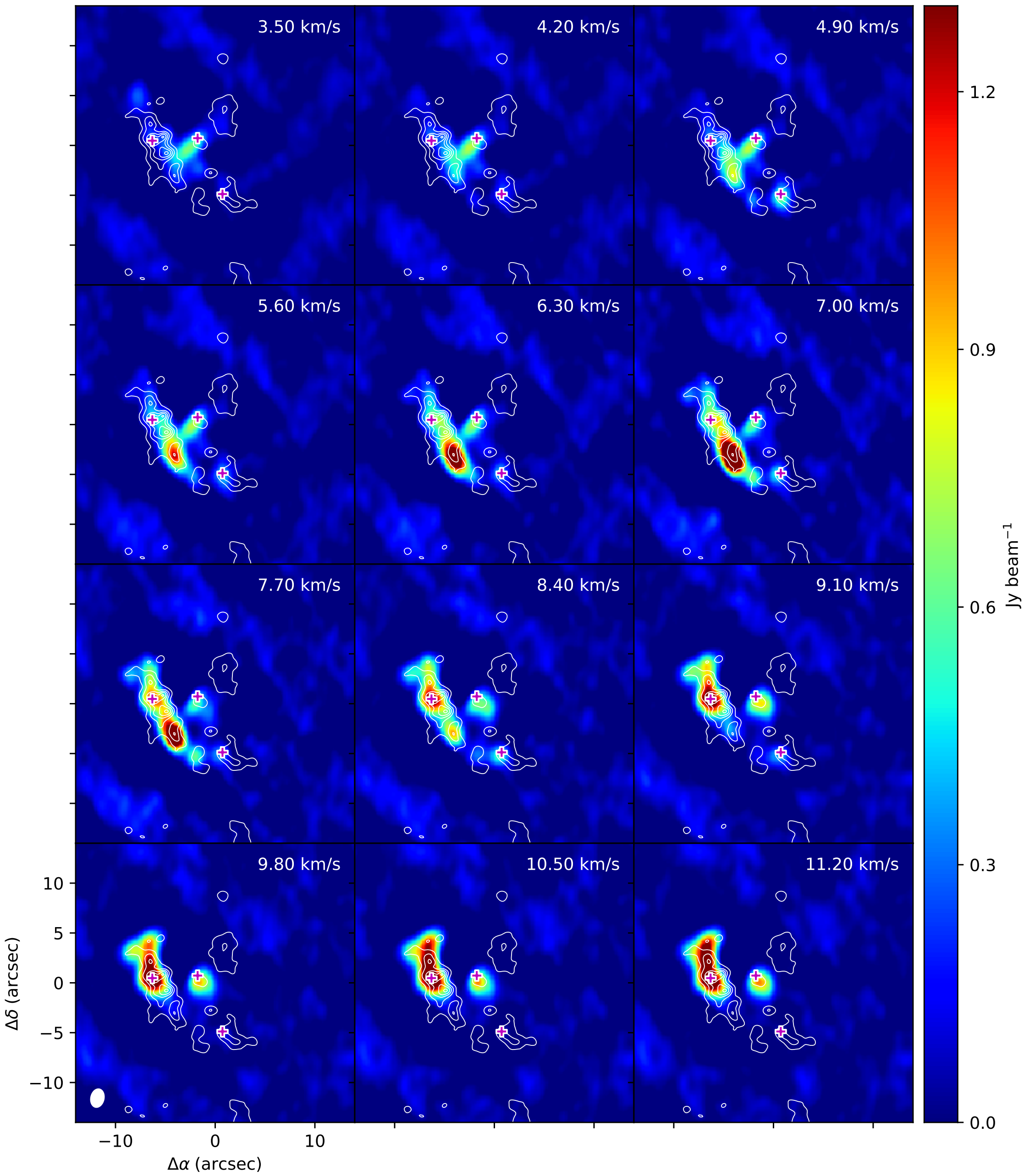

Figure A.7: 242.625GHz

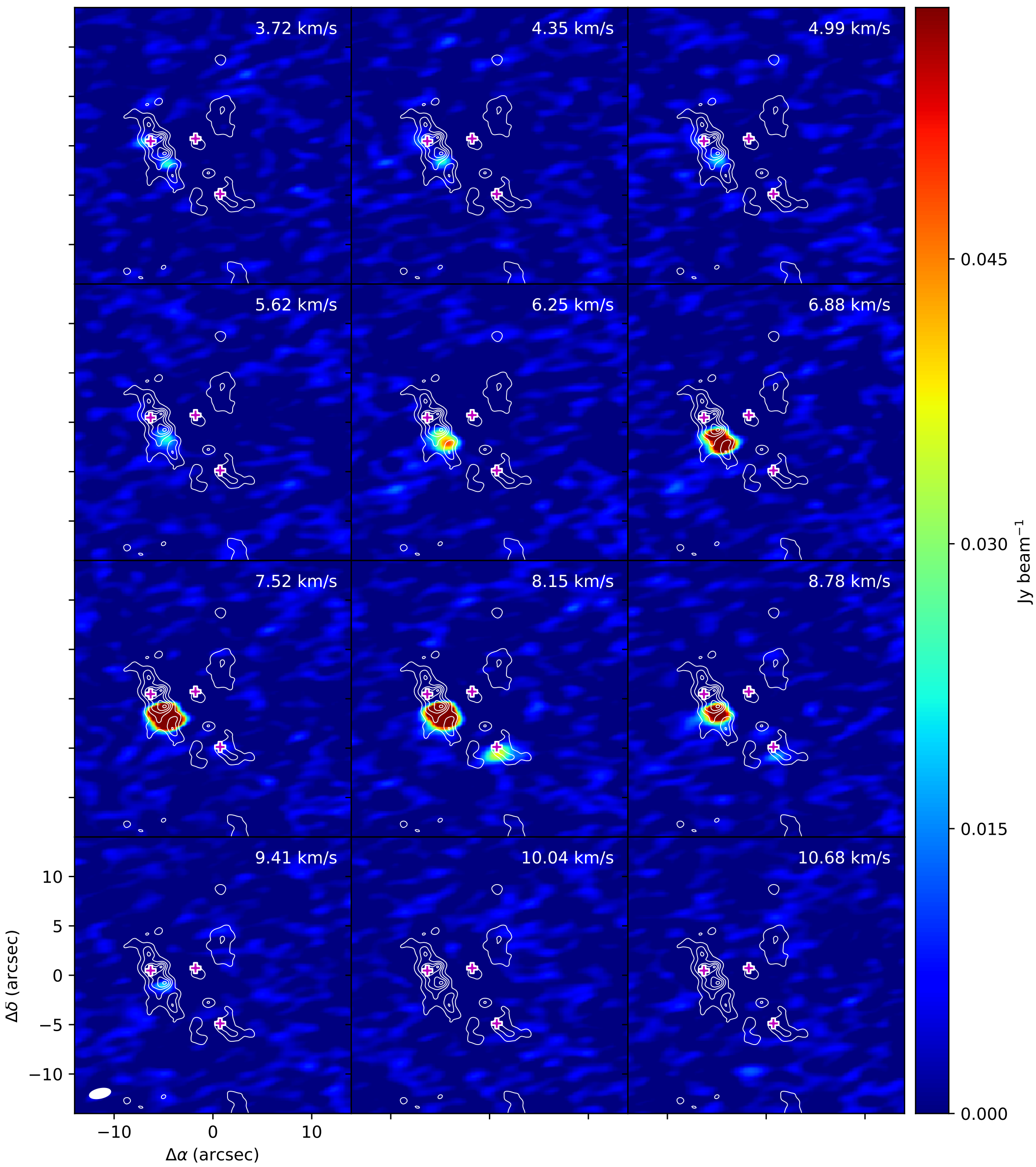

Figure A.8: 231.524GHz

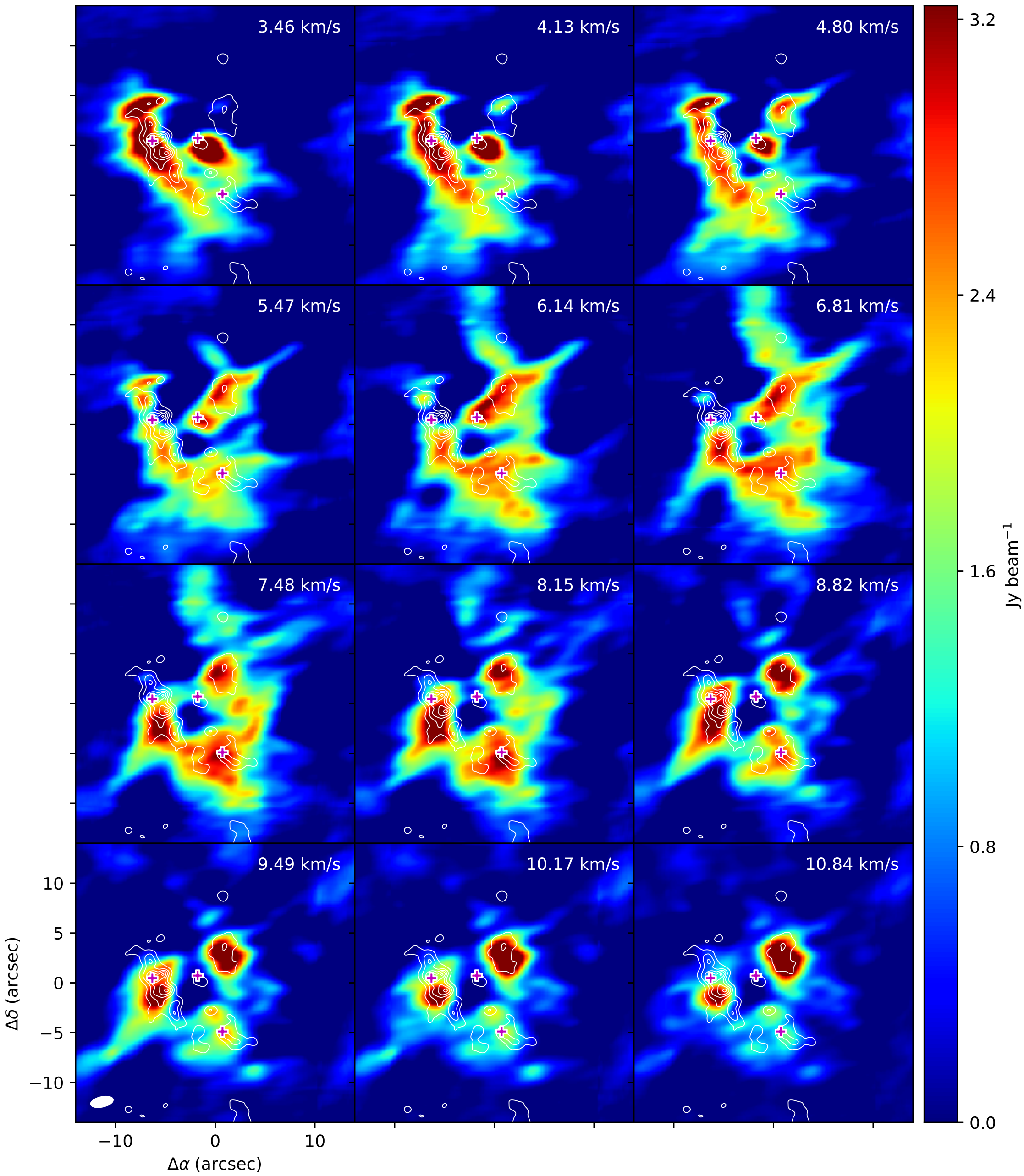

Figure A.9: 218.221GHz

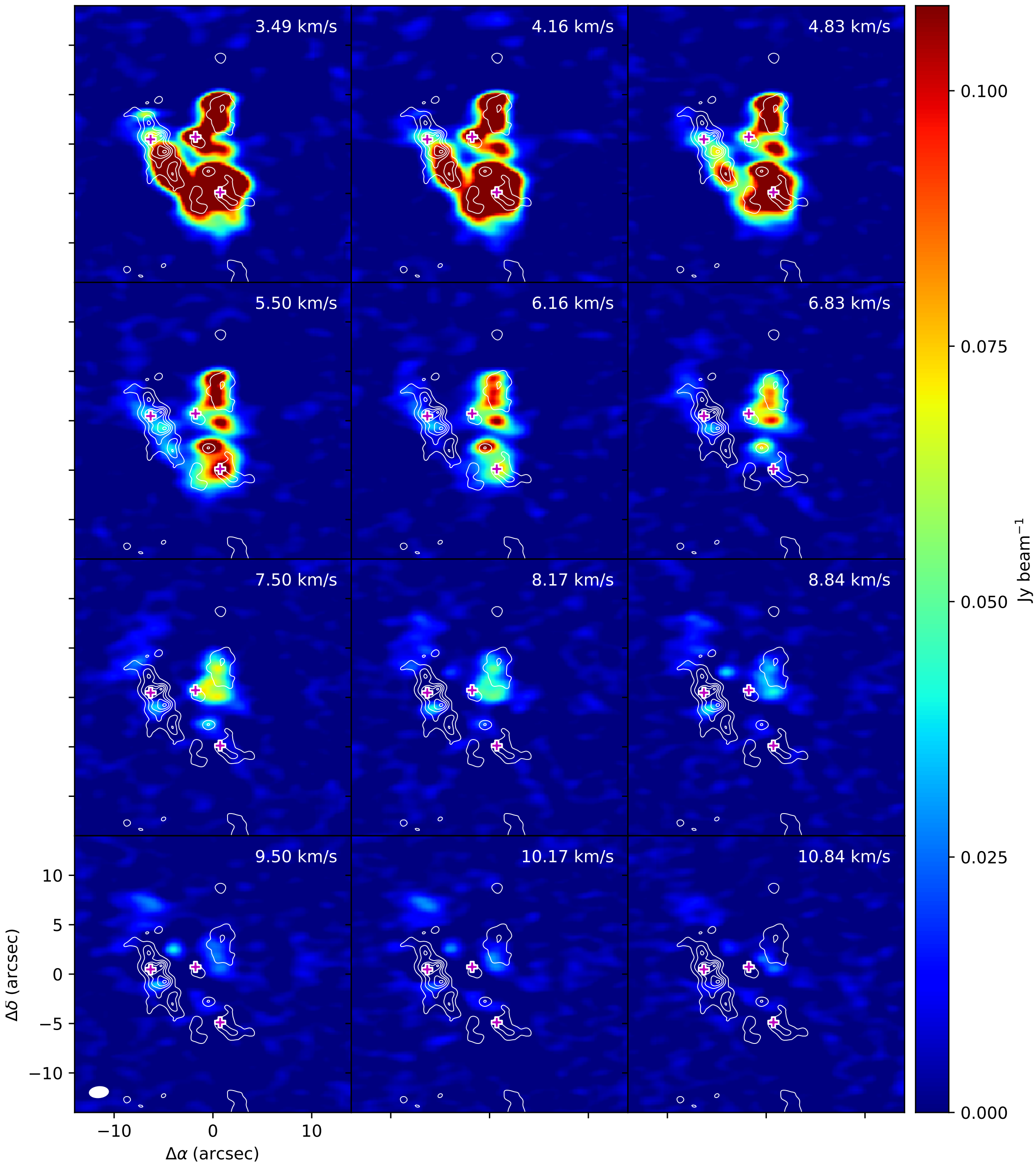

Figure A.10: 219.151GHz

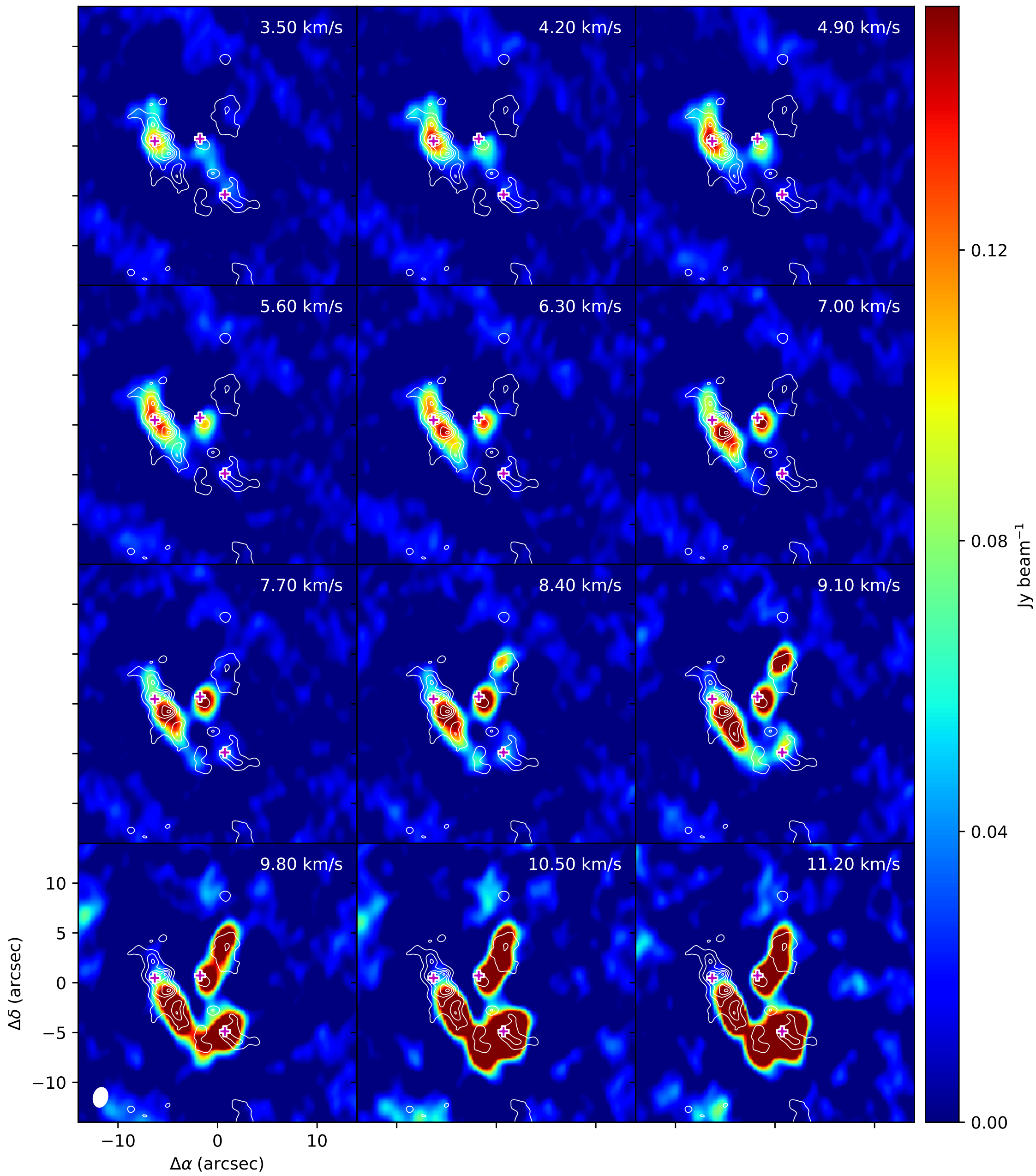

Figure A.11: 227.997GHz

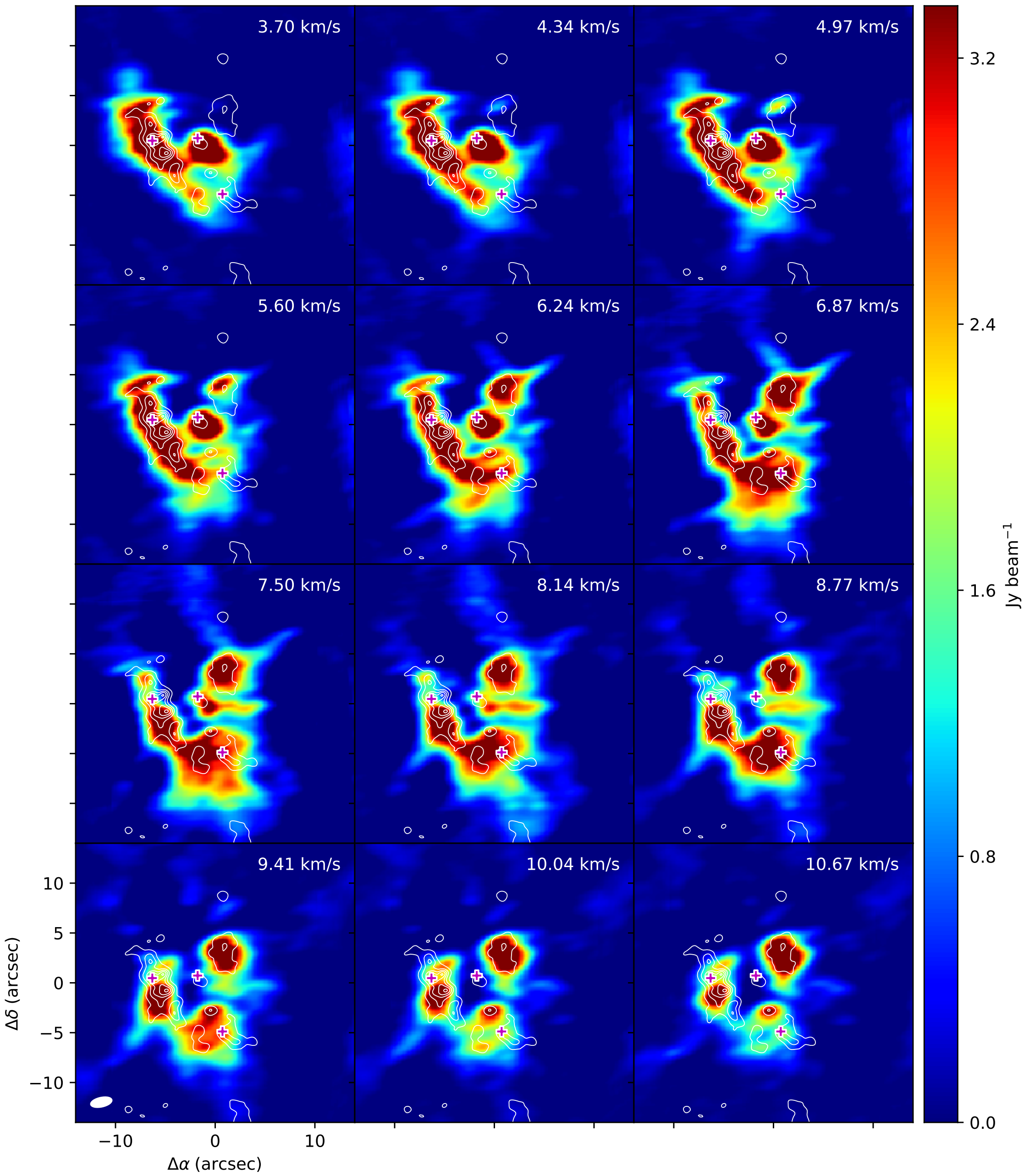

Figure A.12: 231.061GHz

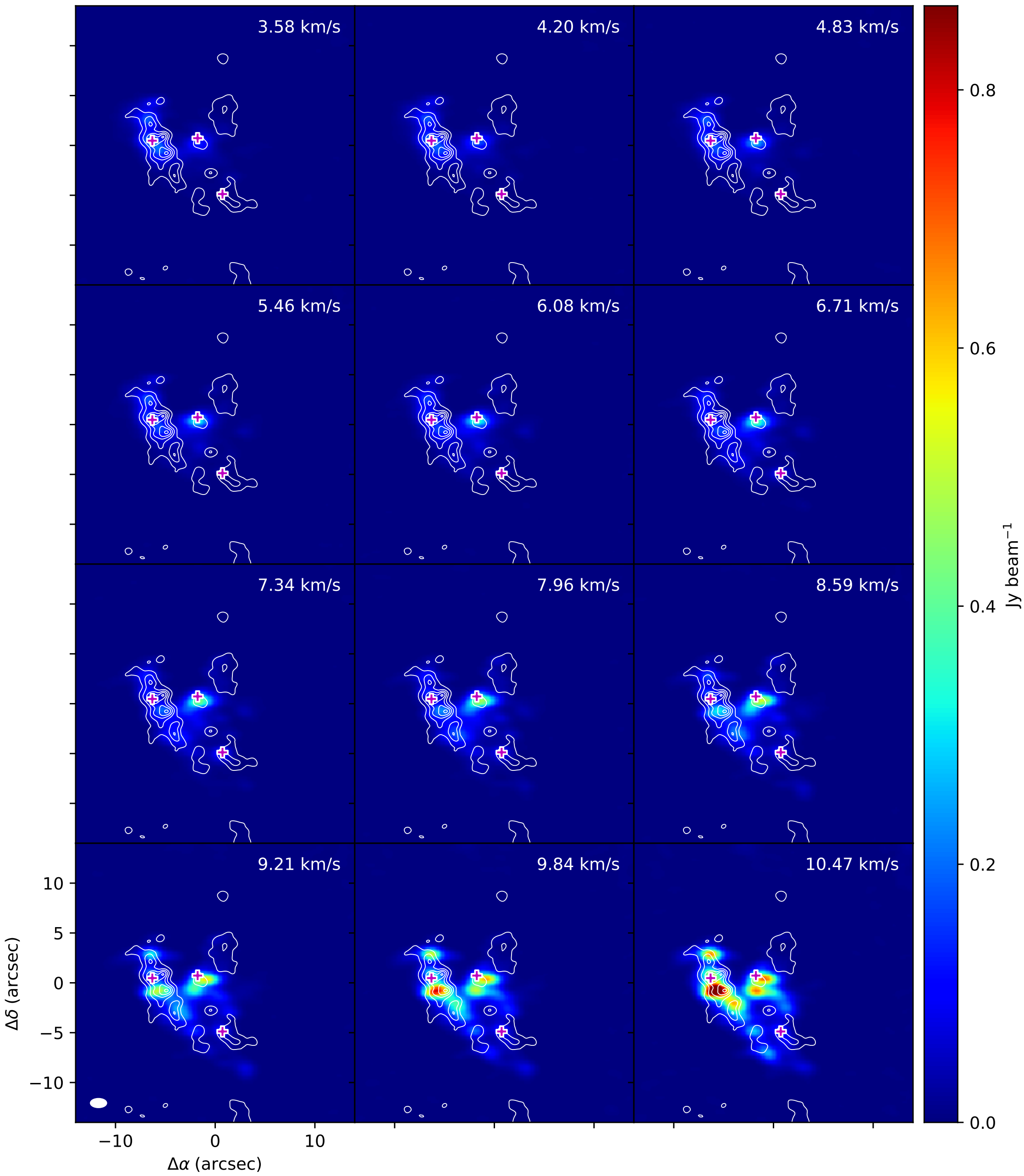

Figure A.13: 233.802GHz

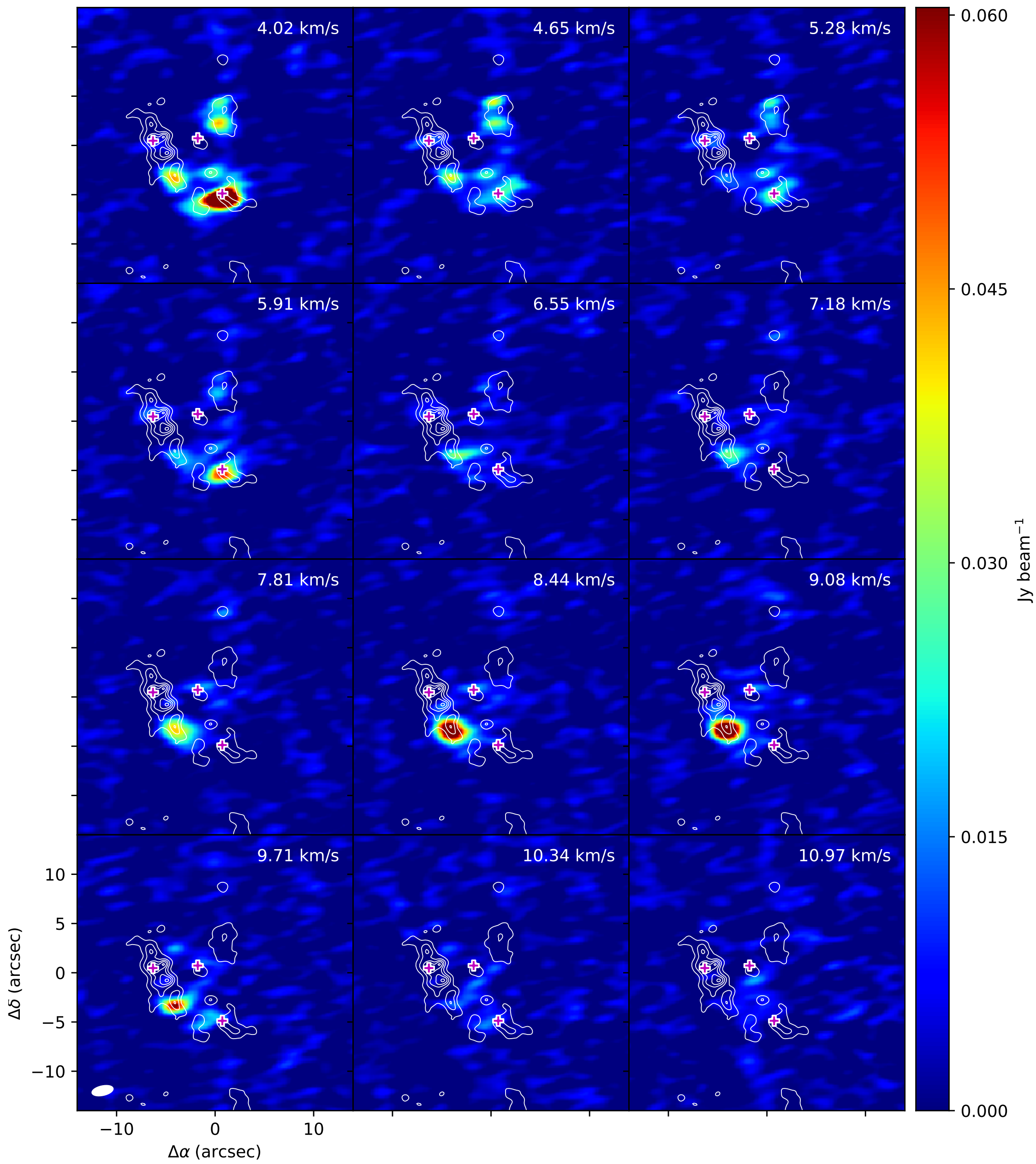

Figure A.14: 231.576GHz

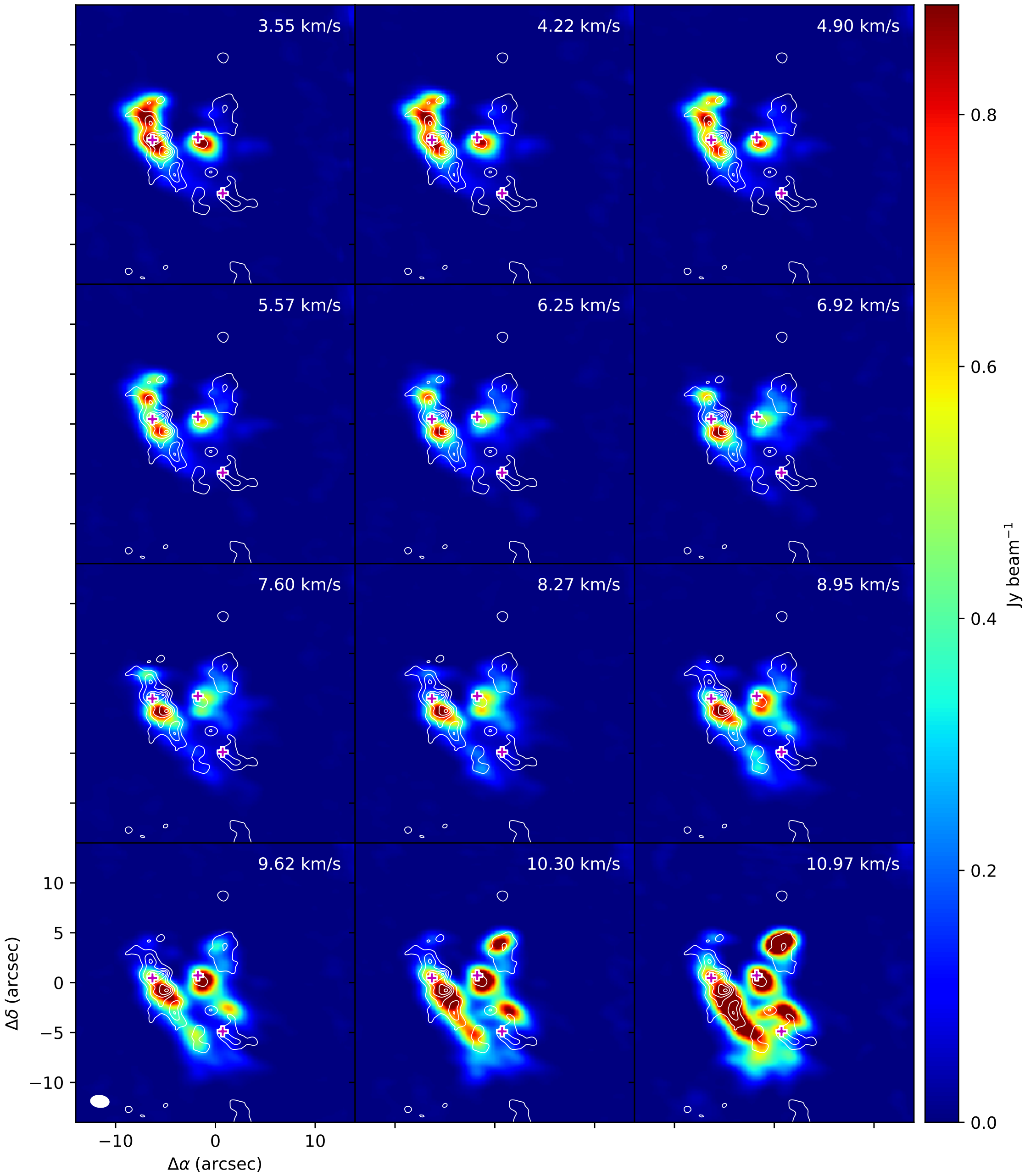

Figure A.15: 216.843GHz

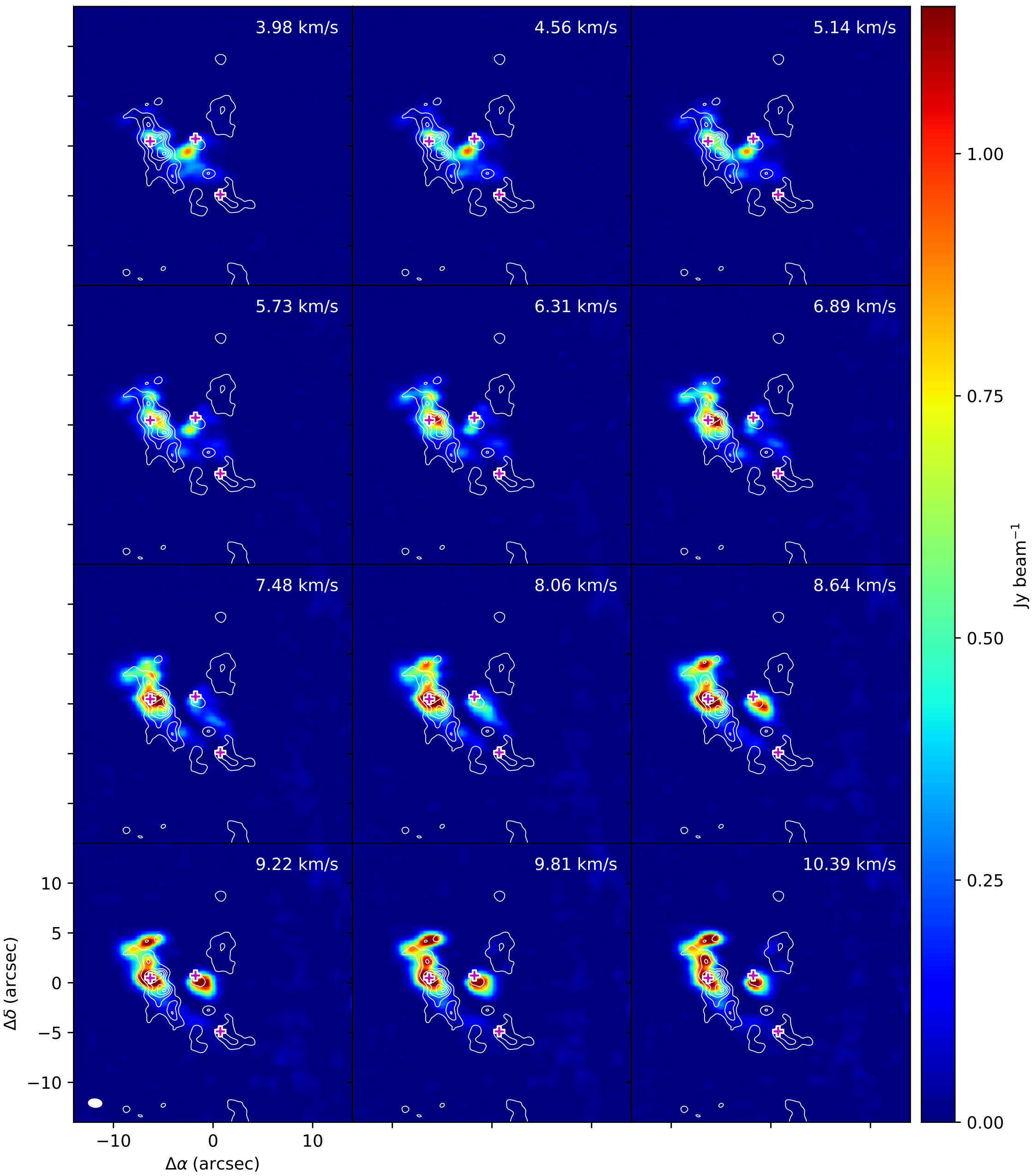

Figure A.16: 251.128GHz

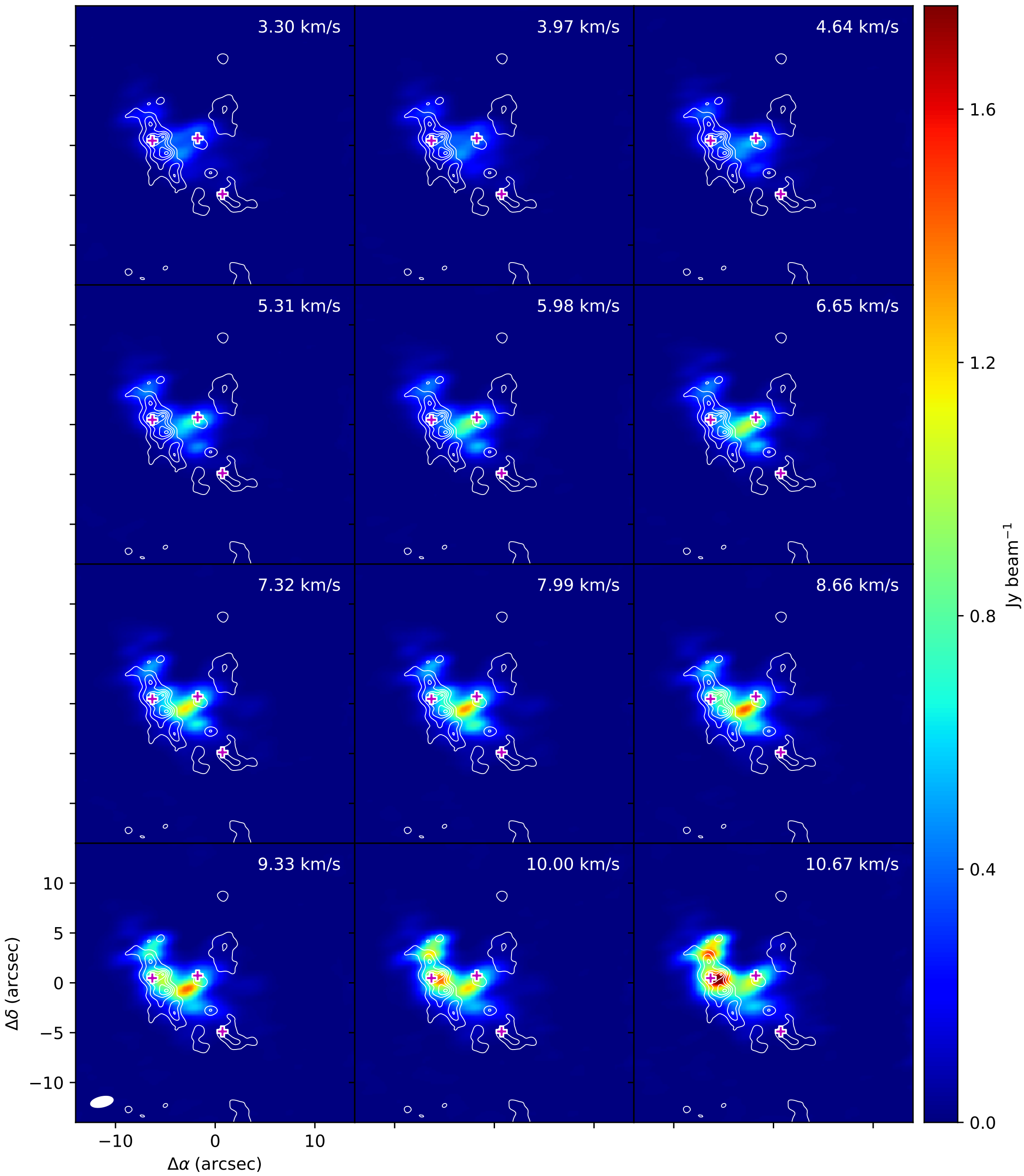

Figure A.17: 218.409GHz

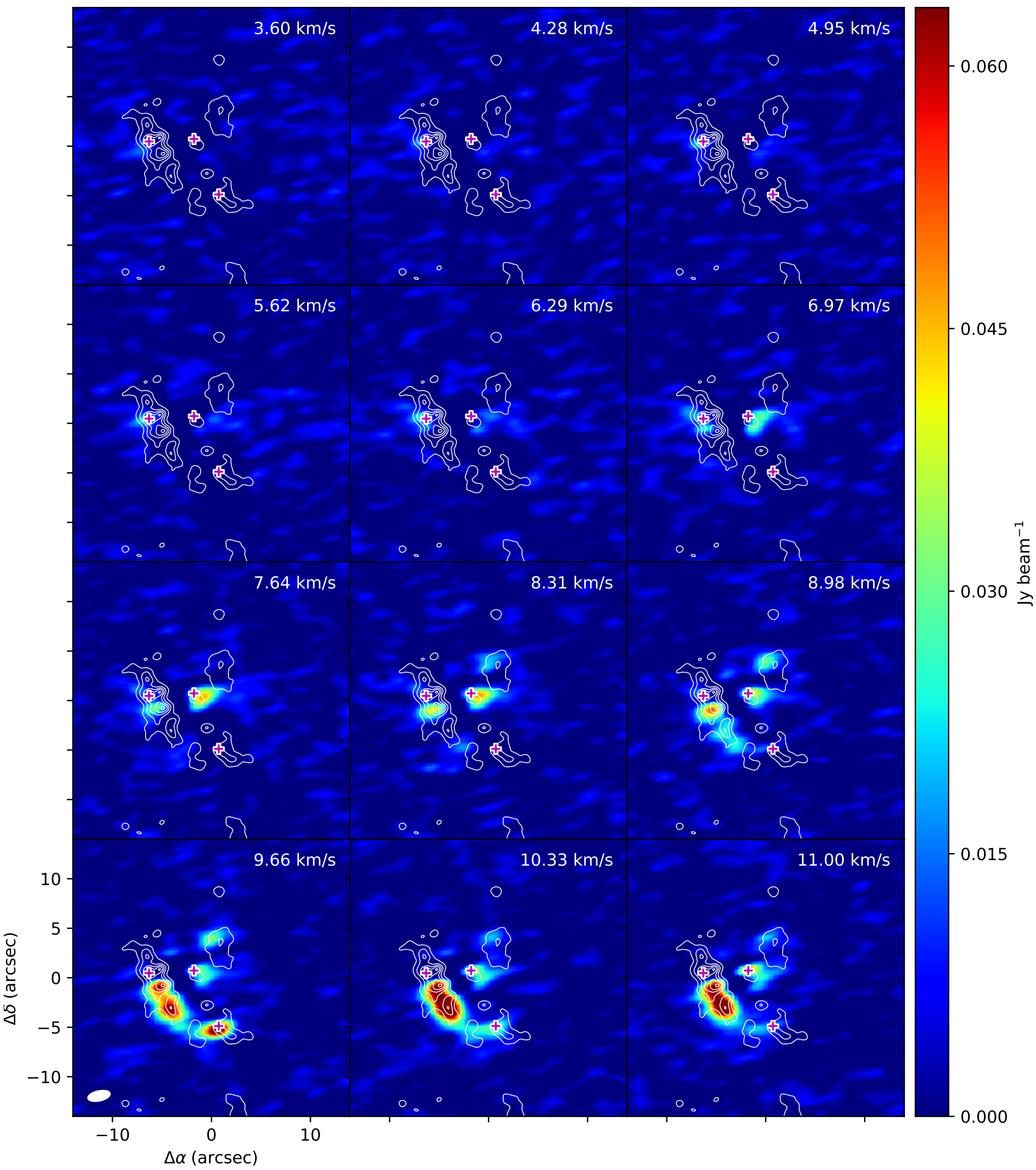

Figure A.18: 217.670GHz

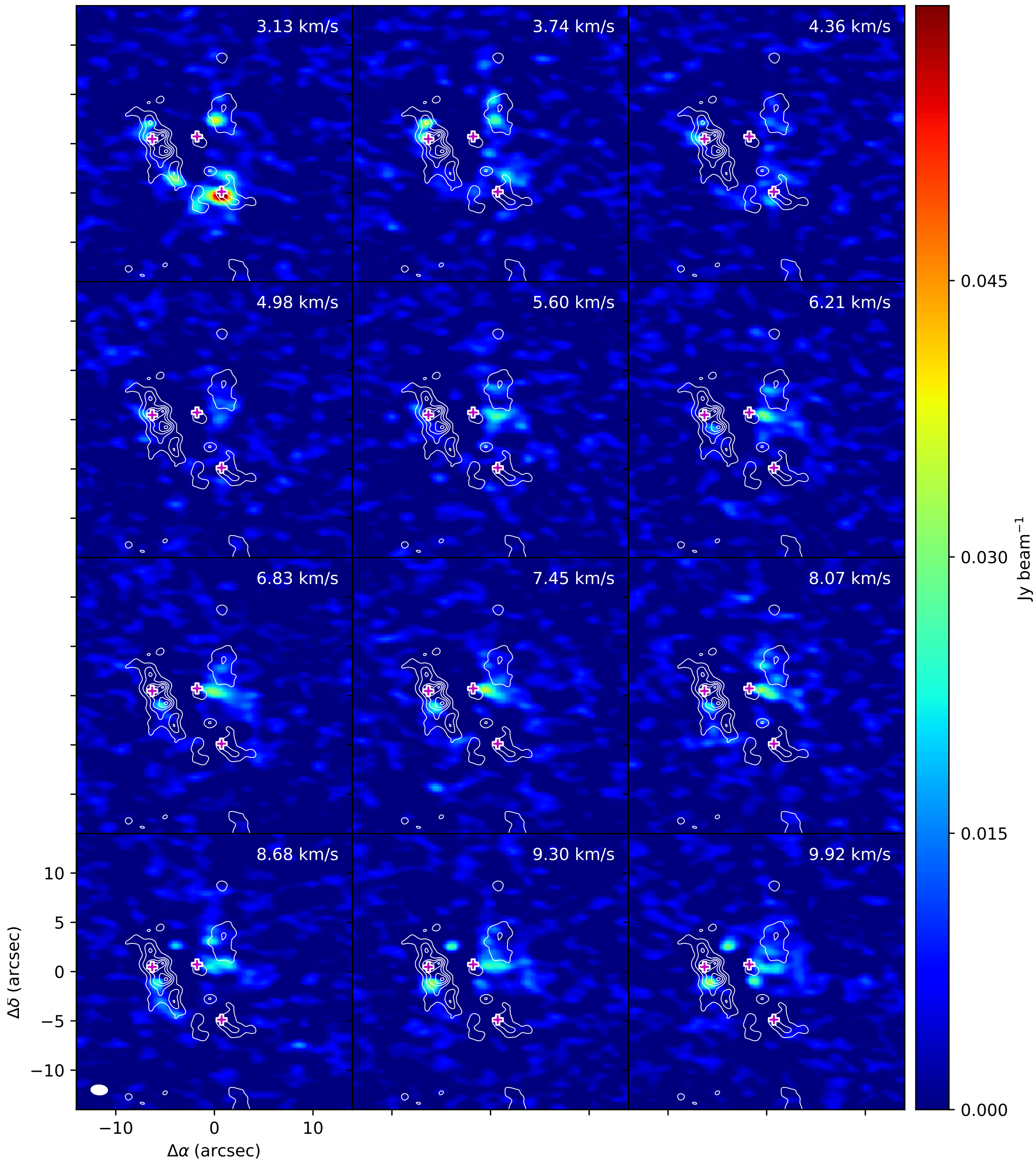

Figure A.19: 237.144GHz

Acknowledgments

References