

Master Thesis

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

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Abstract

A variety of complex organic molecules 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.

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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 first 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

Frequency [GHz]	$S\mu^2 [\text{D}^2]$	$E_u [\text{K}]$	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

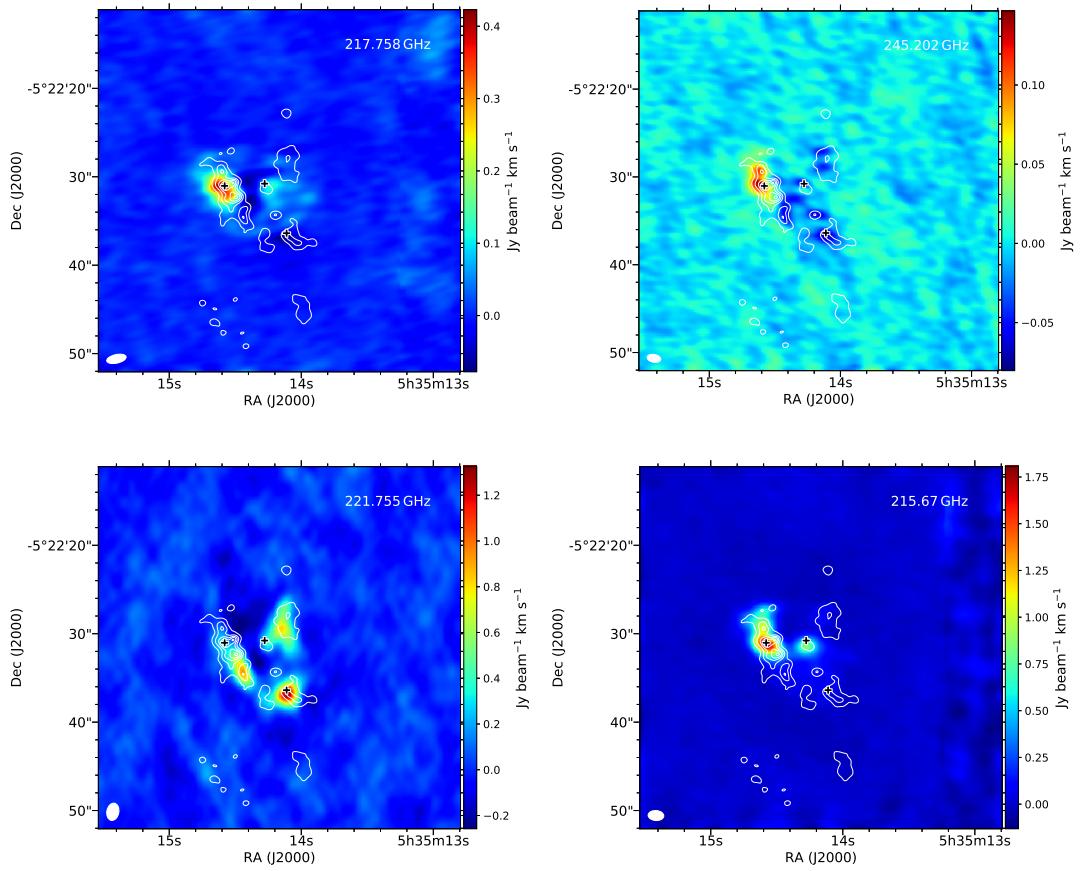


Figure 2.1: Integrated intensity map

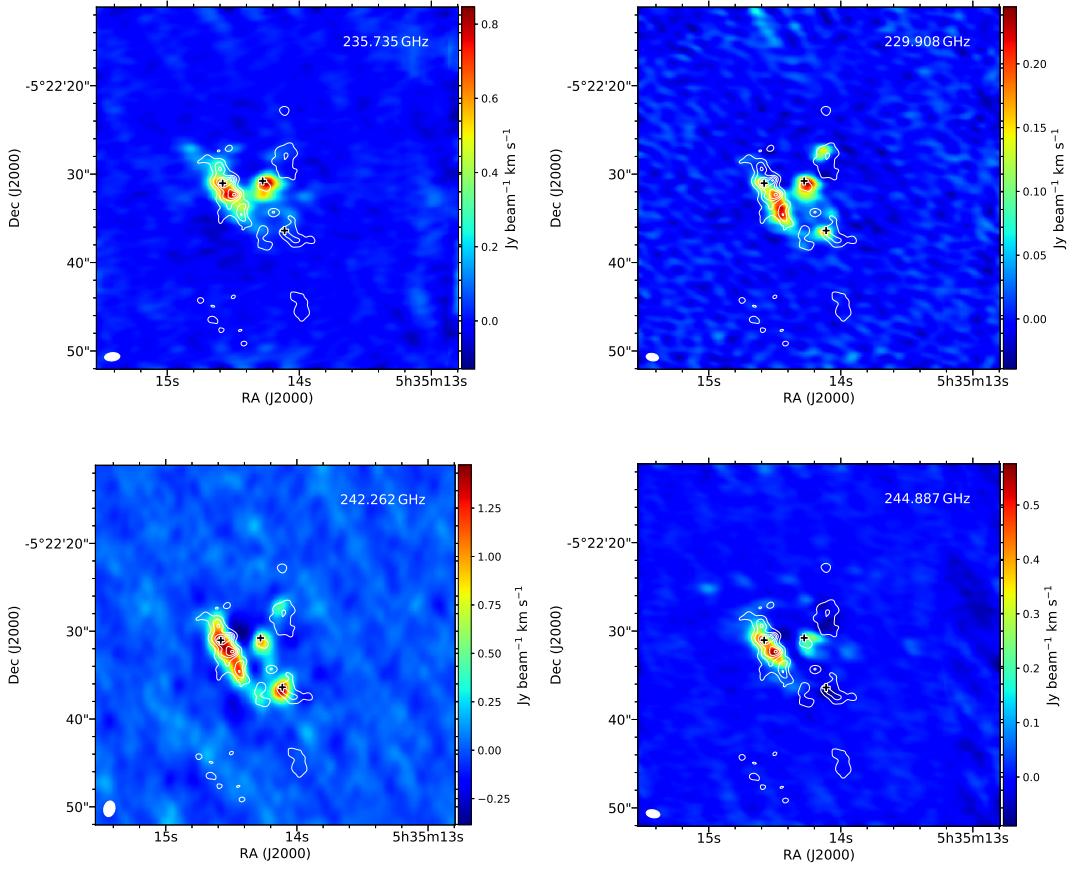


Figure 2.2: (Continued)

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

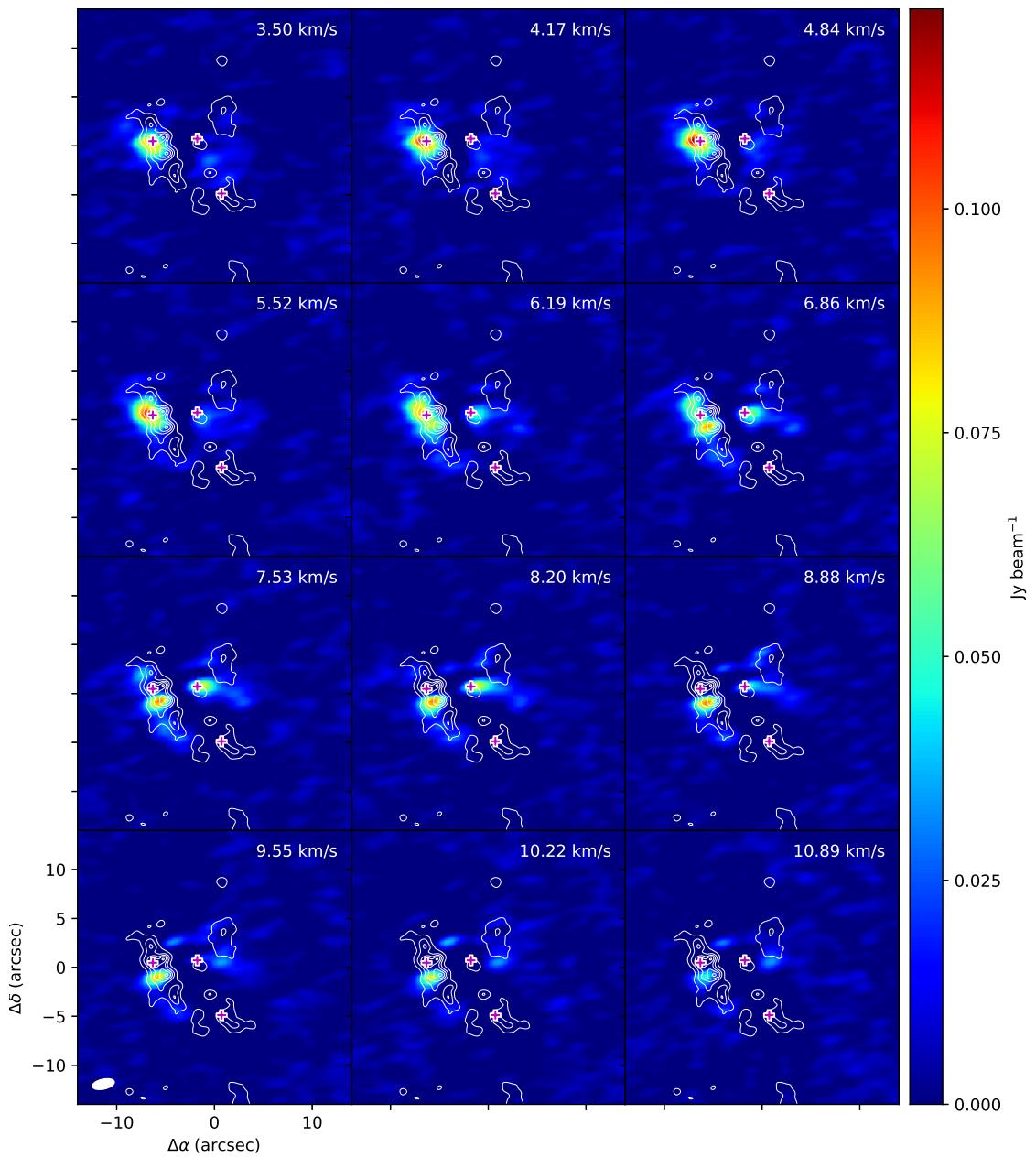


Figure 2.3: 217.758 GHz

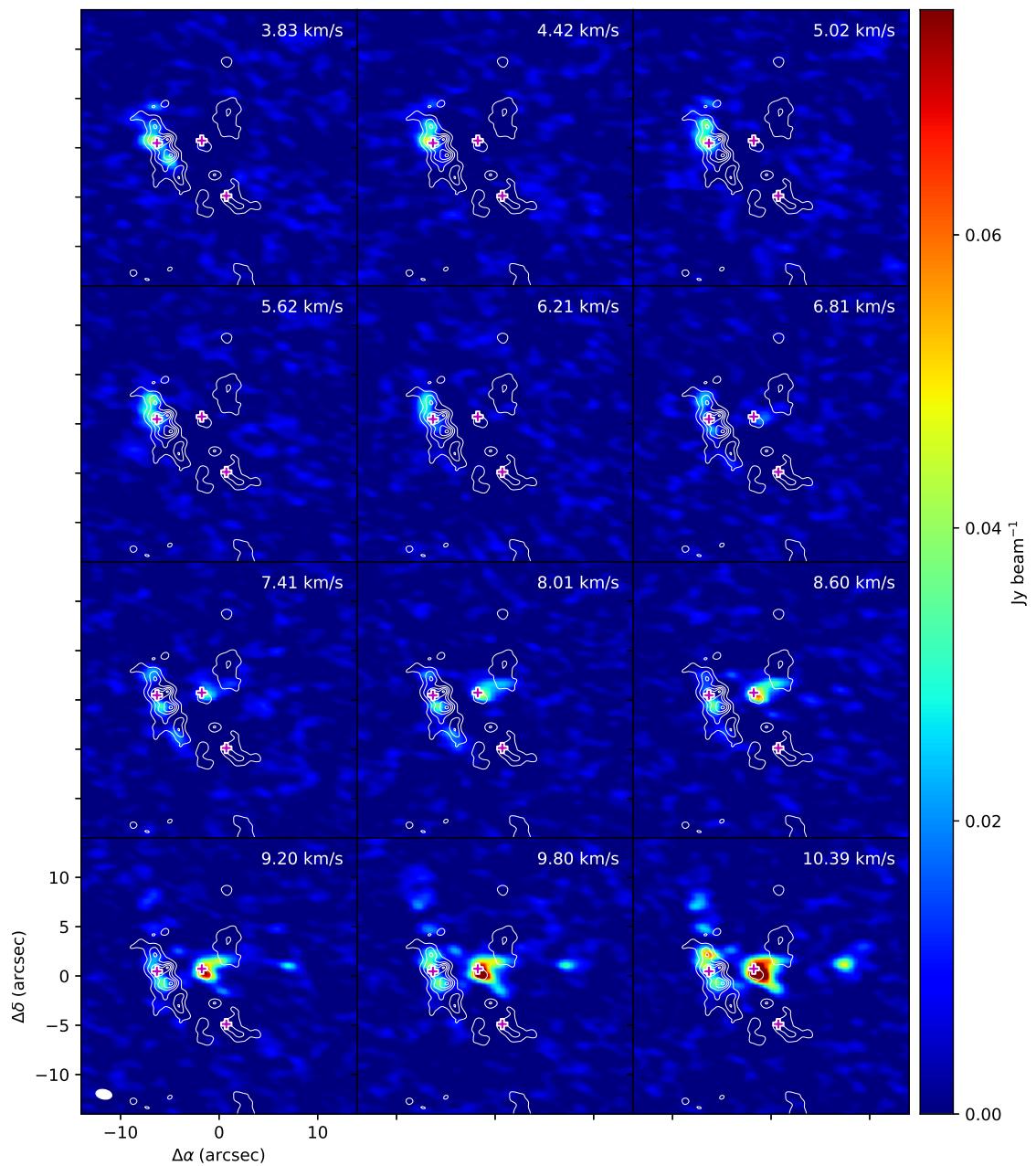


Figure 2.4: 245.202 GHz

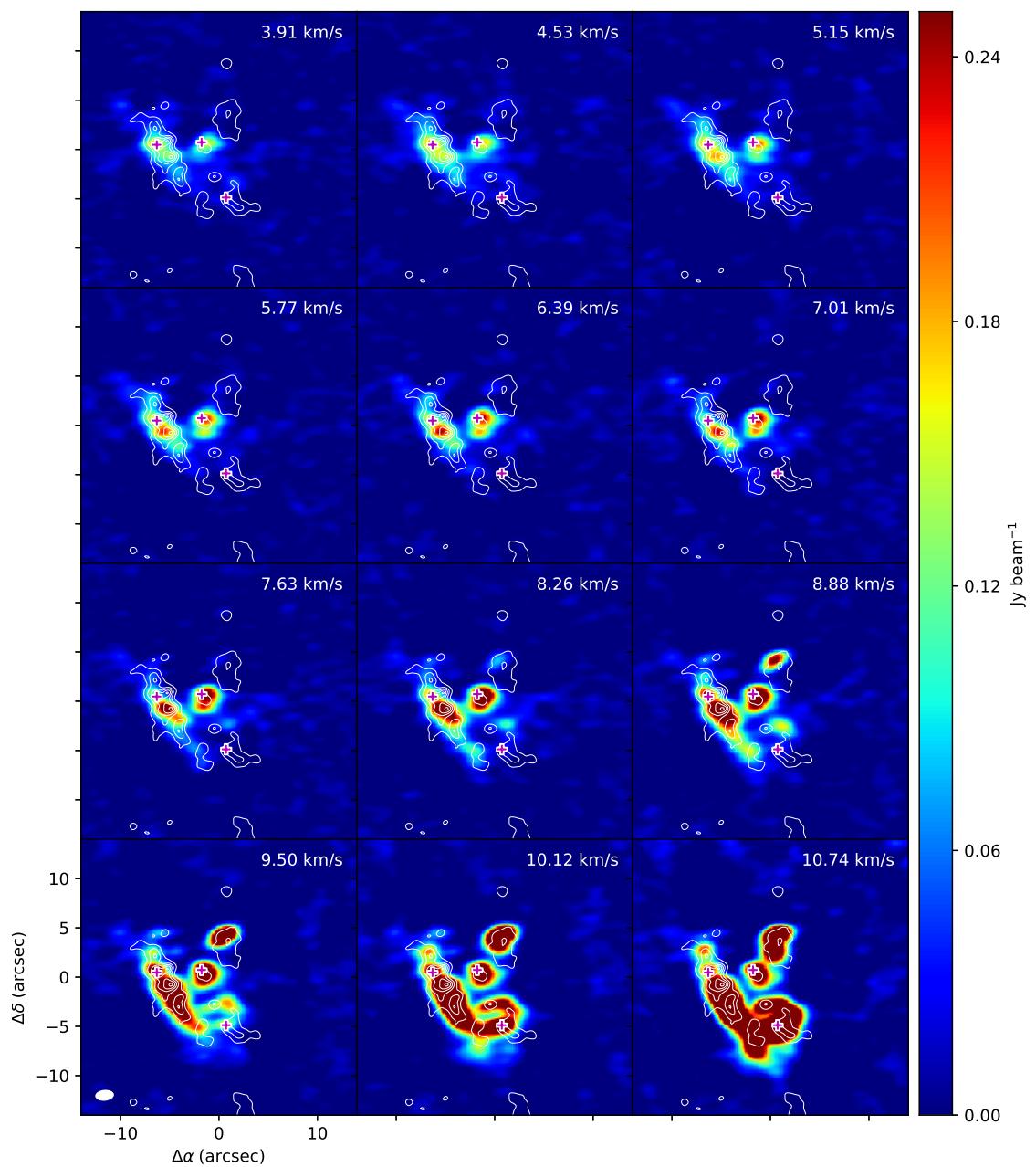


Figure 2.5: 235.735 GHz

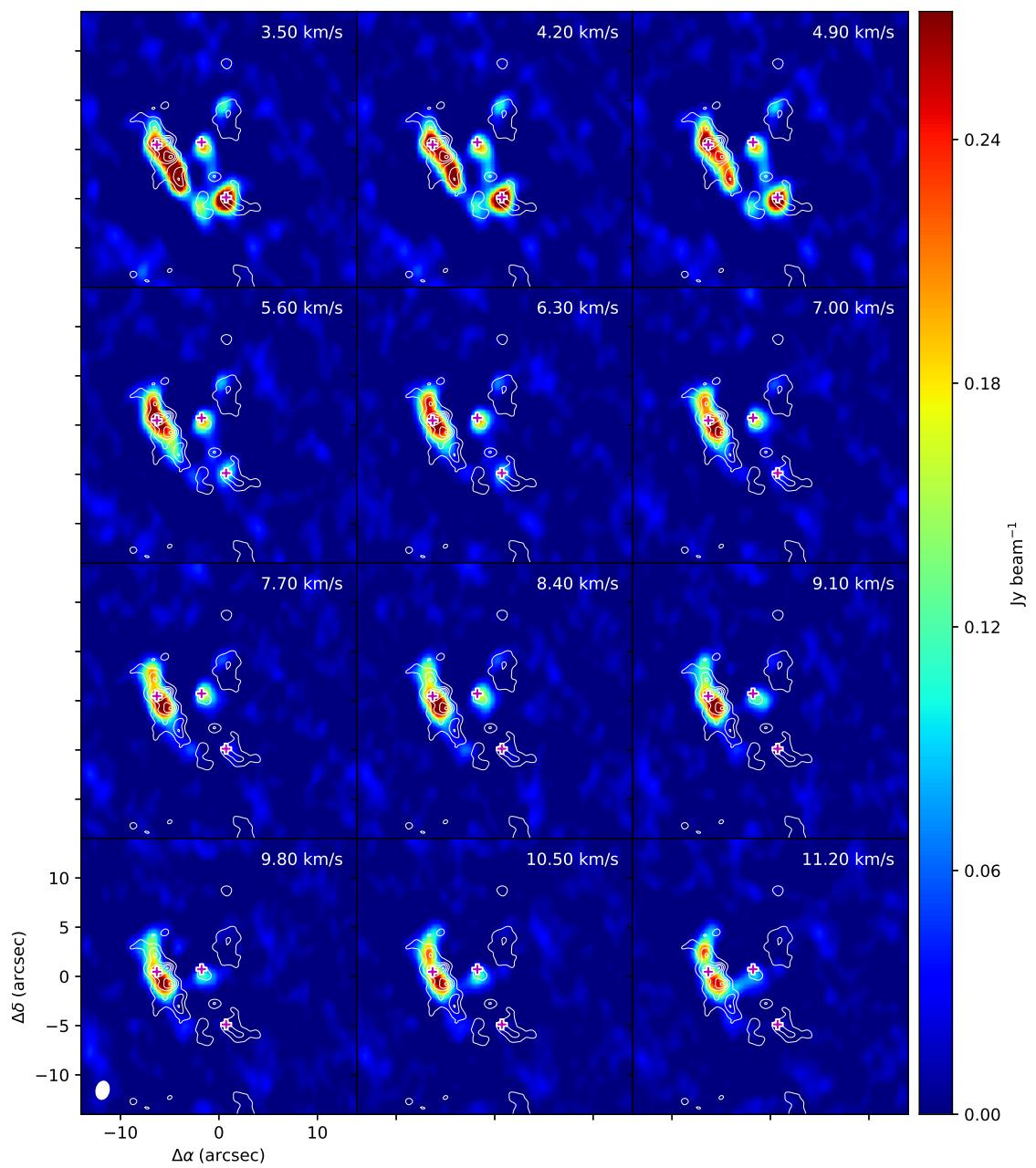


Figure 2.6: 242.262 GHz

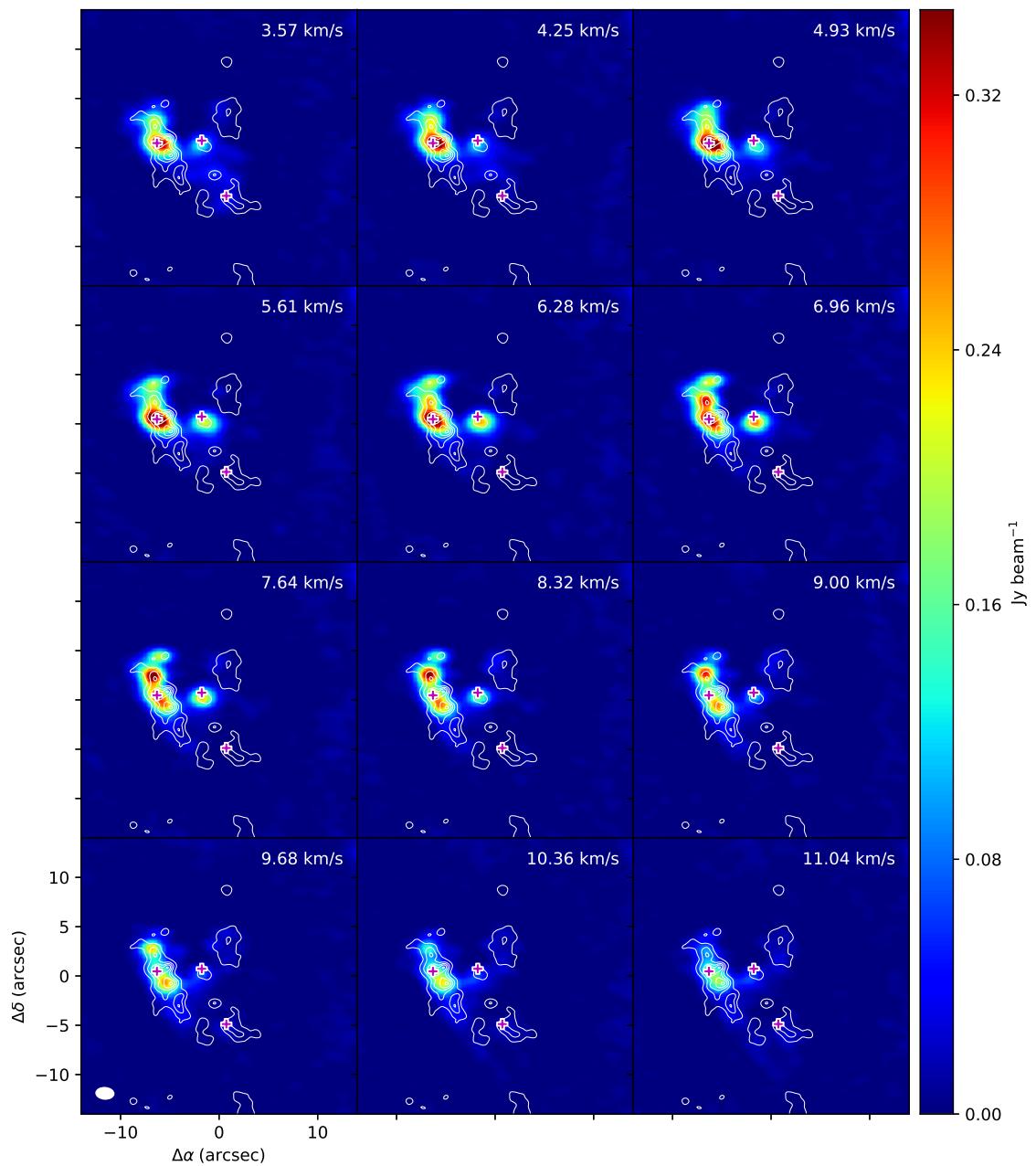


Figure 2.7: 215.670 GHz

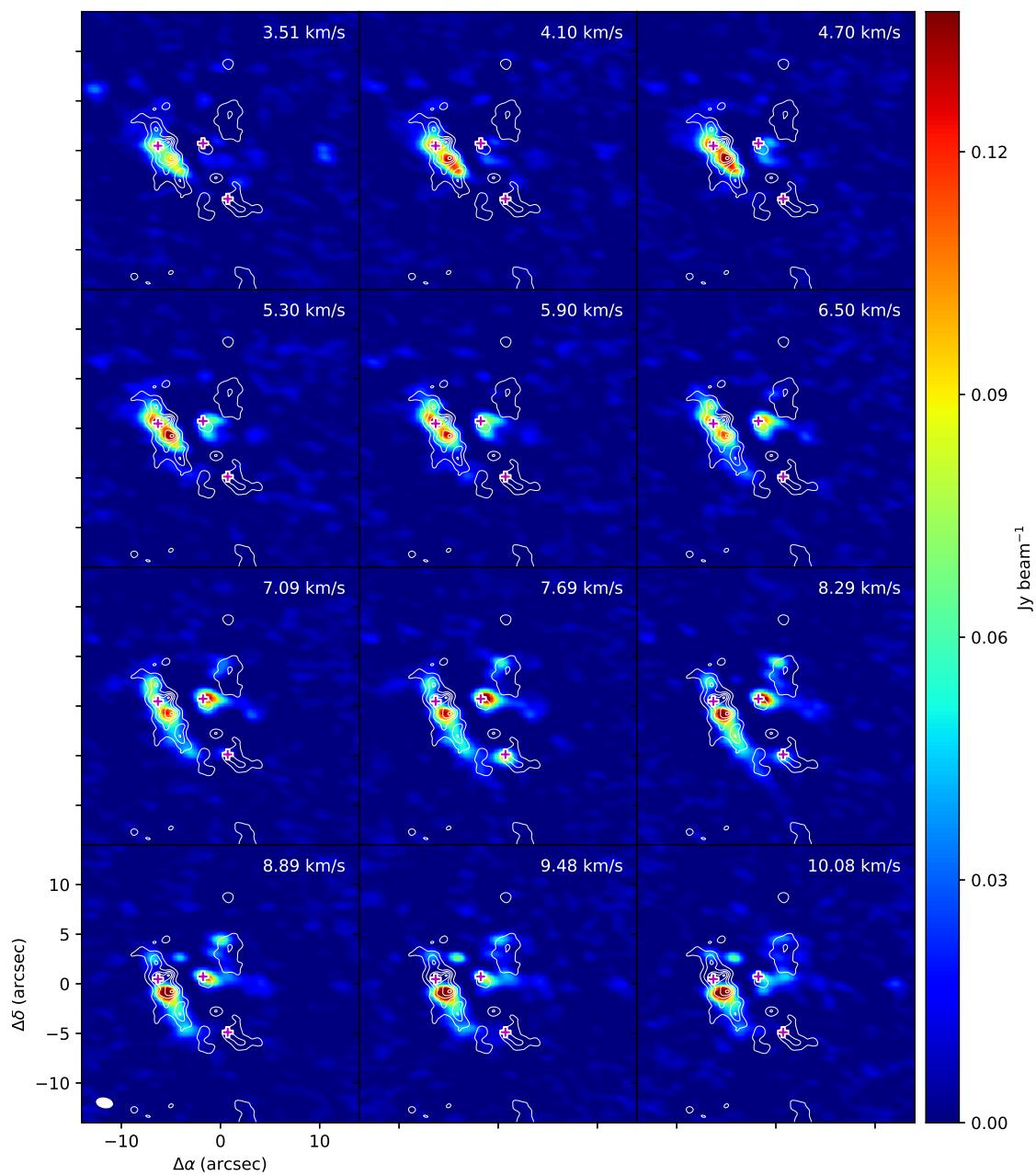


Figure 2.8: 244.887 GHz

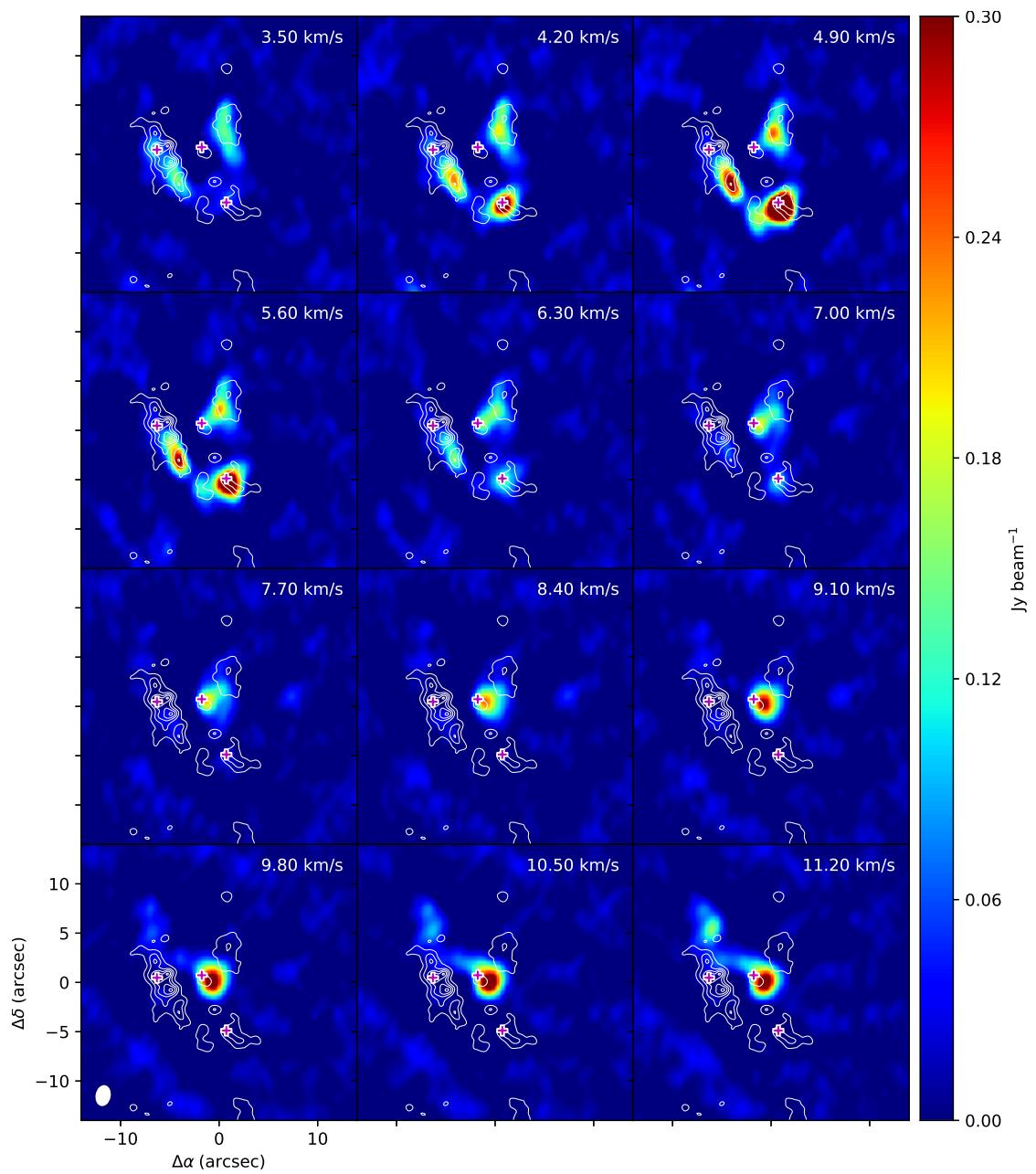


Figure 2.9: 221.755 GHz

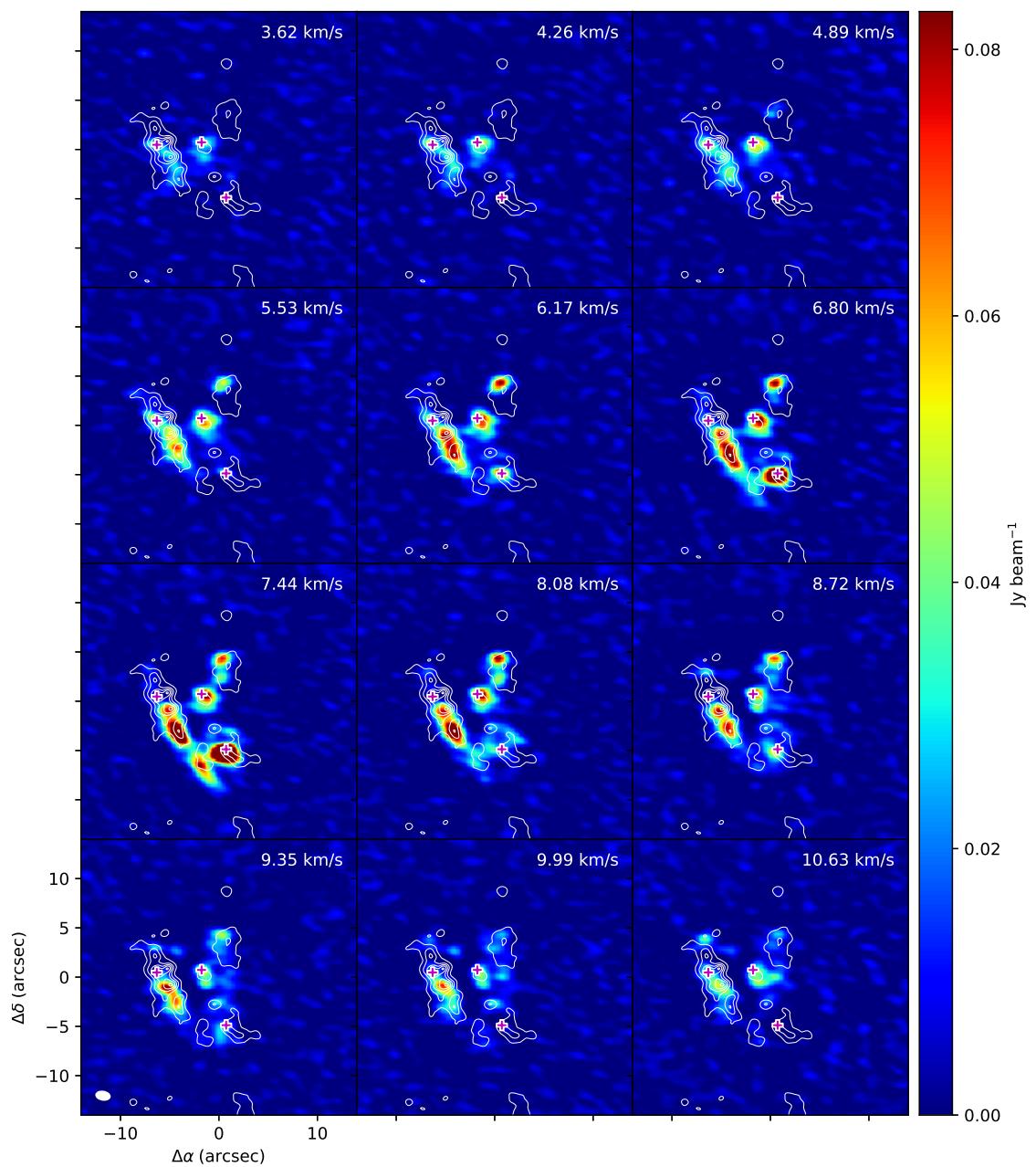


Figure 2.10: 229.908 GHz

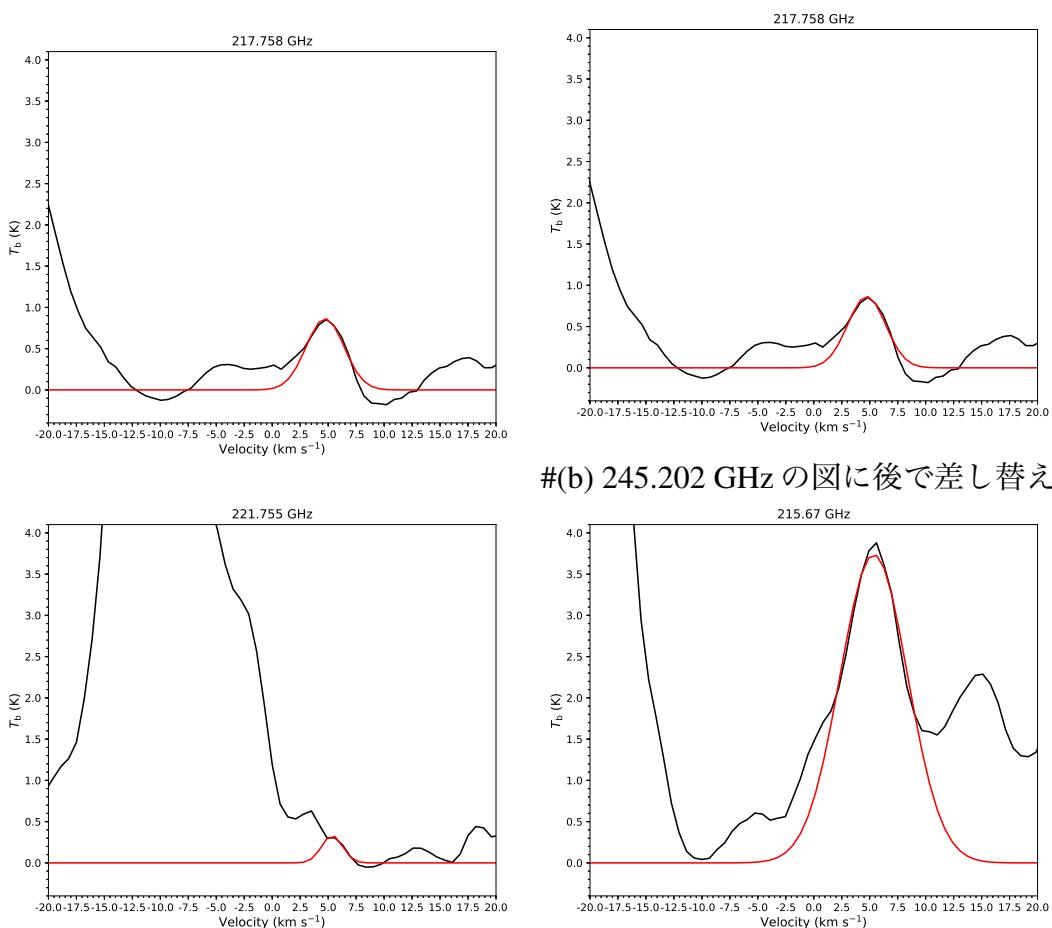


Figure 2.11: Spectrum

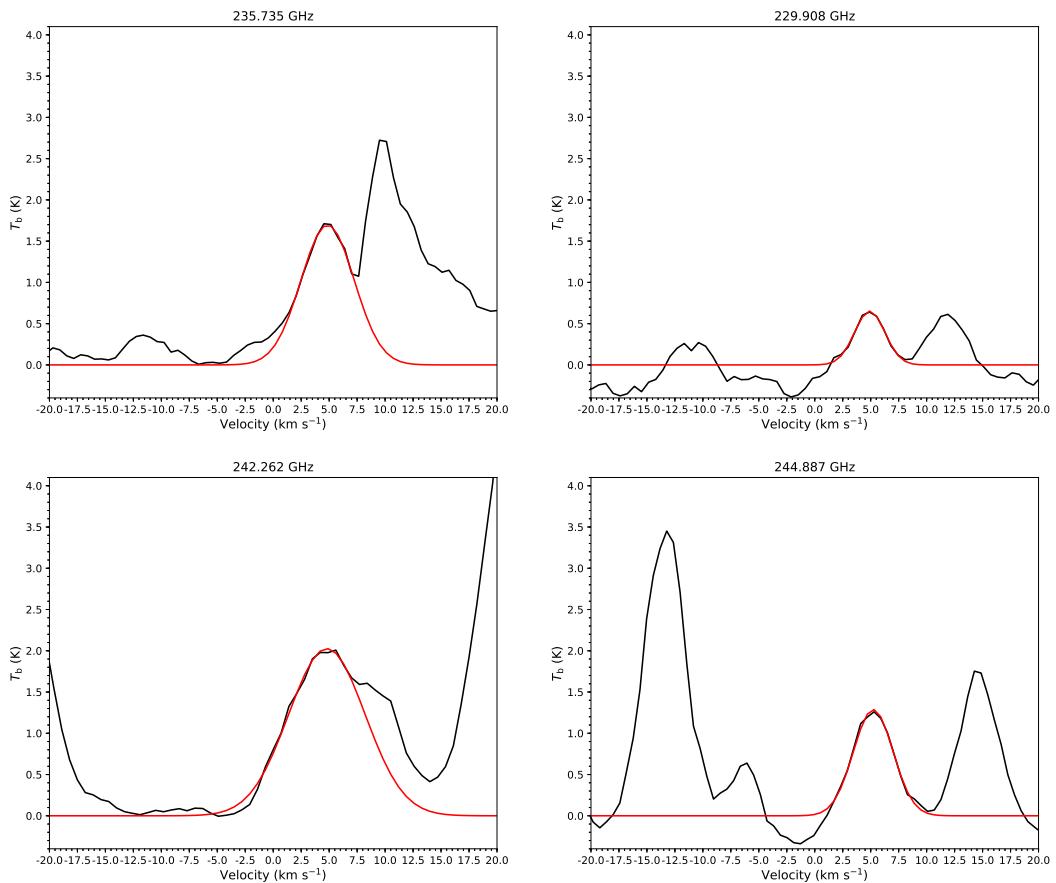


Figure 2.12: (Continued)

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

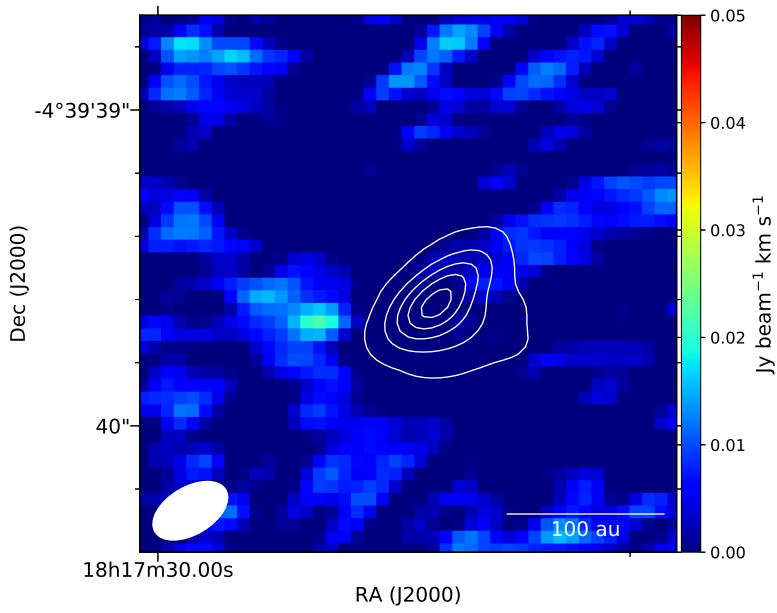


Figure 3.1: Integrated intensity map around 217.079 GHz. The white contours represent the 1.3 mm continuum map, where the contour levels are 10 %, 30 %, 50 %, 70 %, 90 % of the peak intensity.

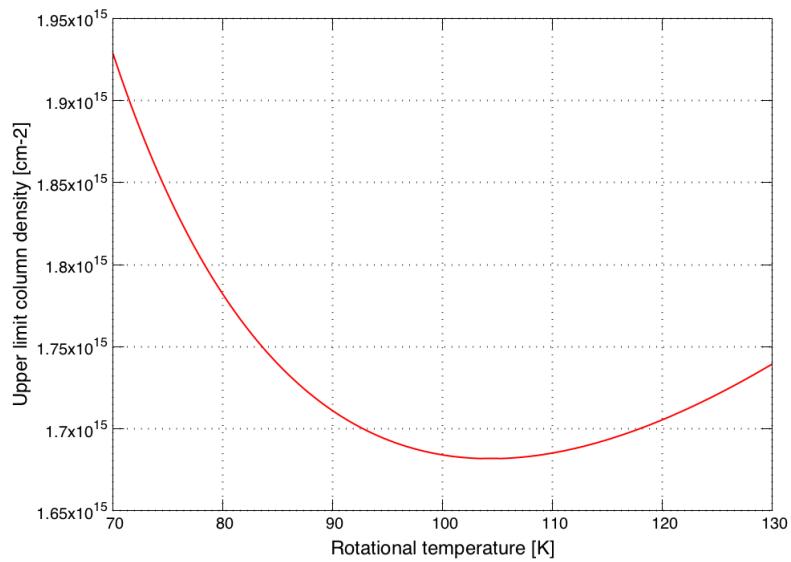


Figure 3.2: Upper limit column density for the strongest CH₃NH₂ transition ($11_2A_1 \rightarrow 11_2A_2$) as function of T_{rot} . A 3σ value of 75 Jy km s⁻¹ is used.

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

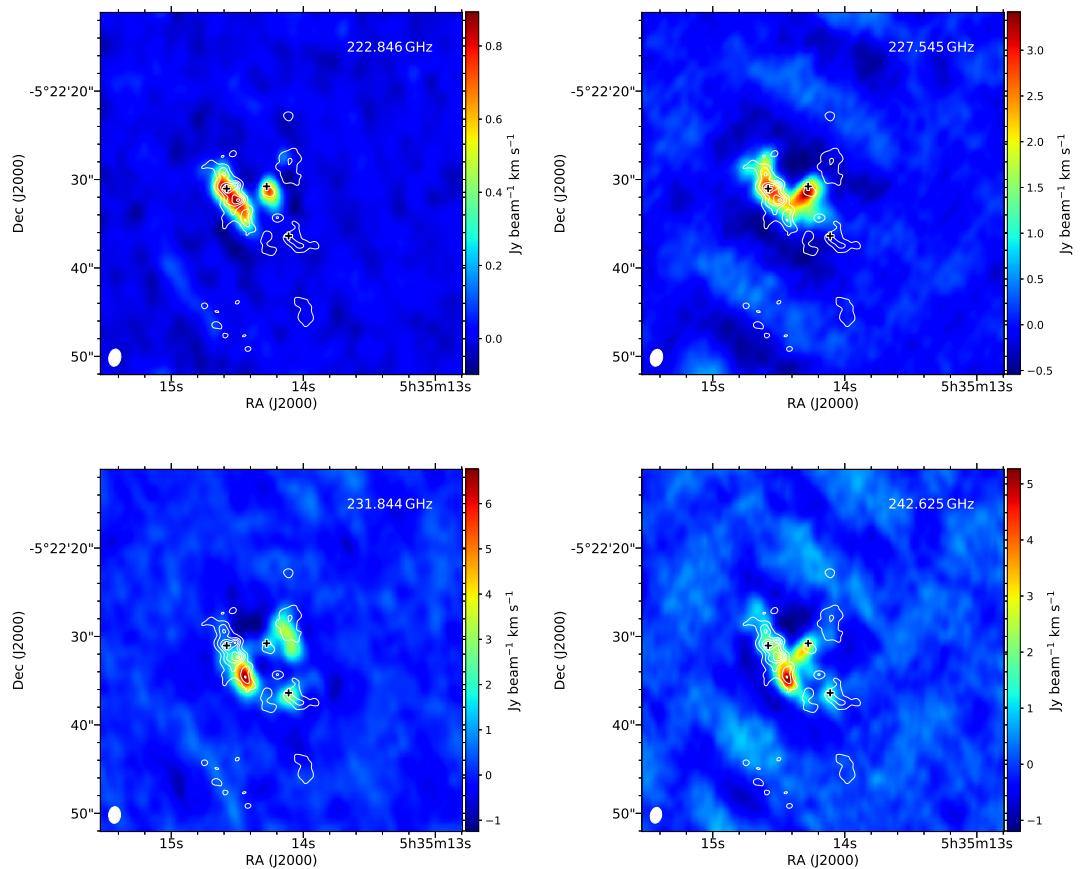


Figure A.1: Integrated intensity maps around methylamine line.

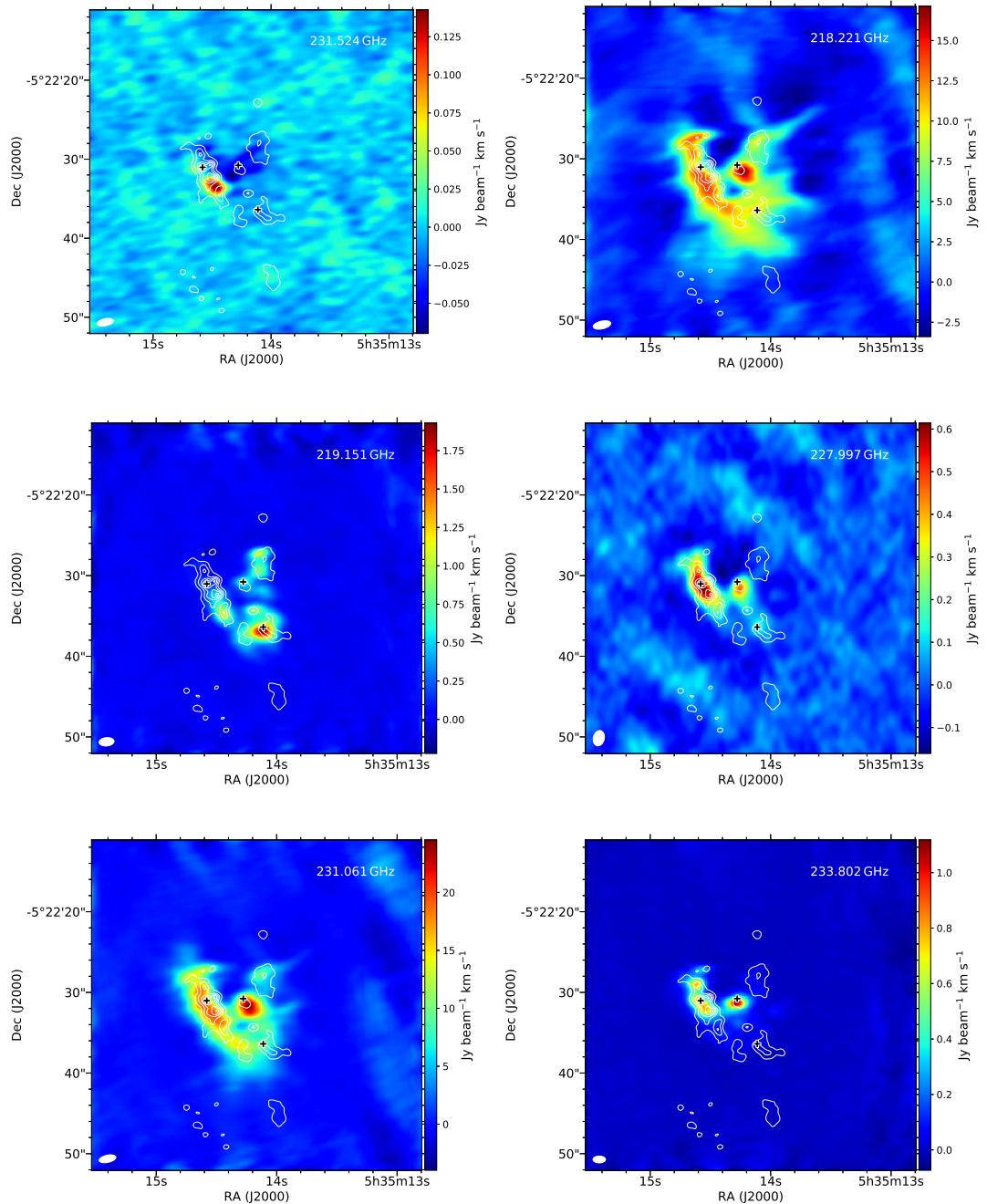


Figure A.2: (Continued)

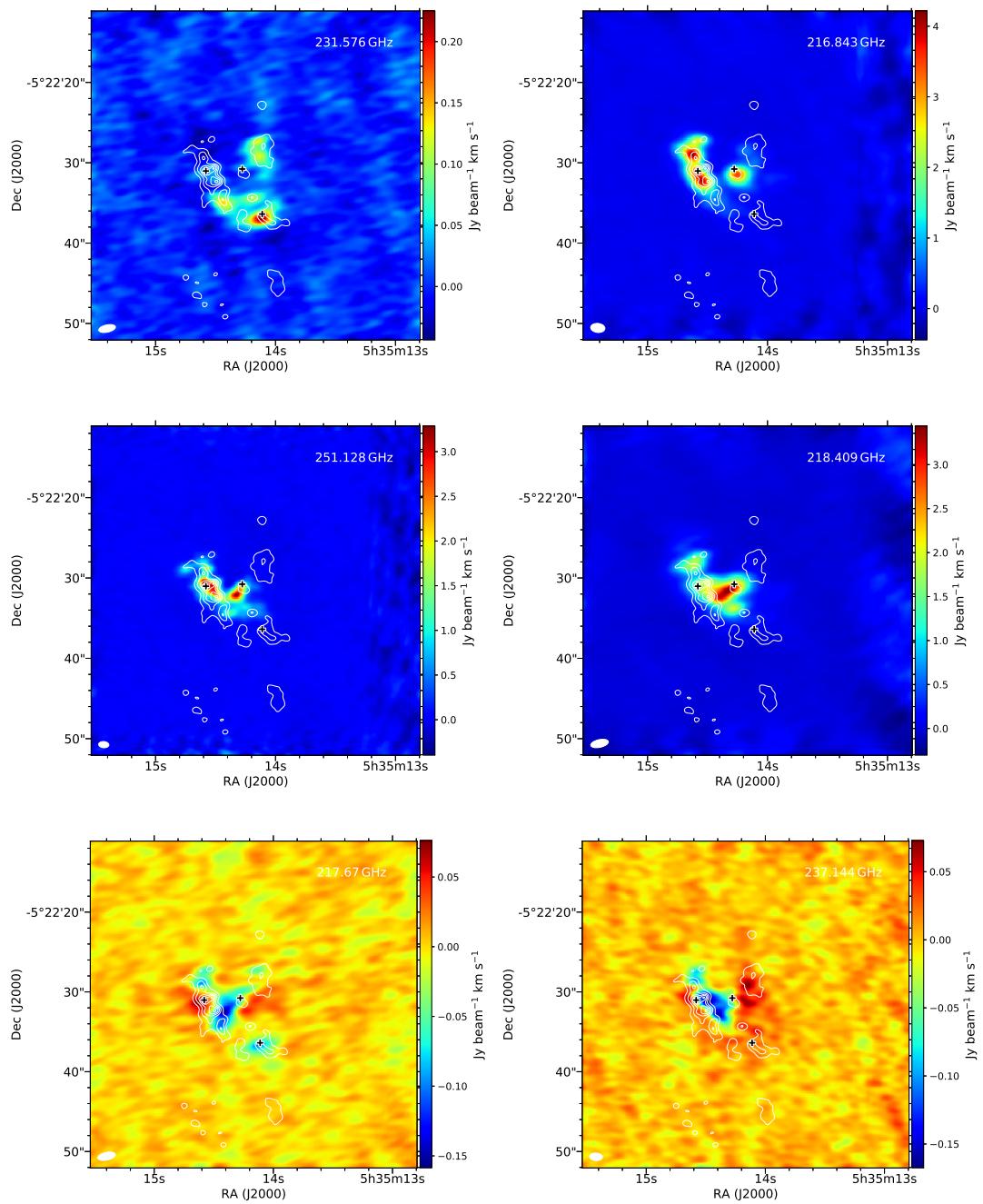


Figure A.3: (Continued)

A.2 Channel maps

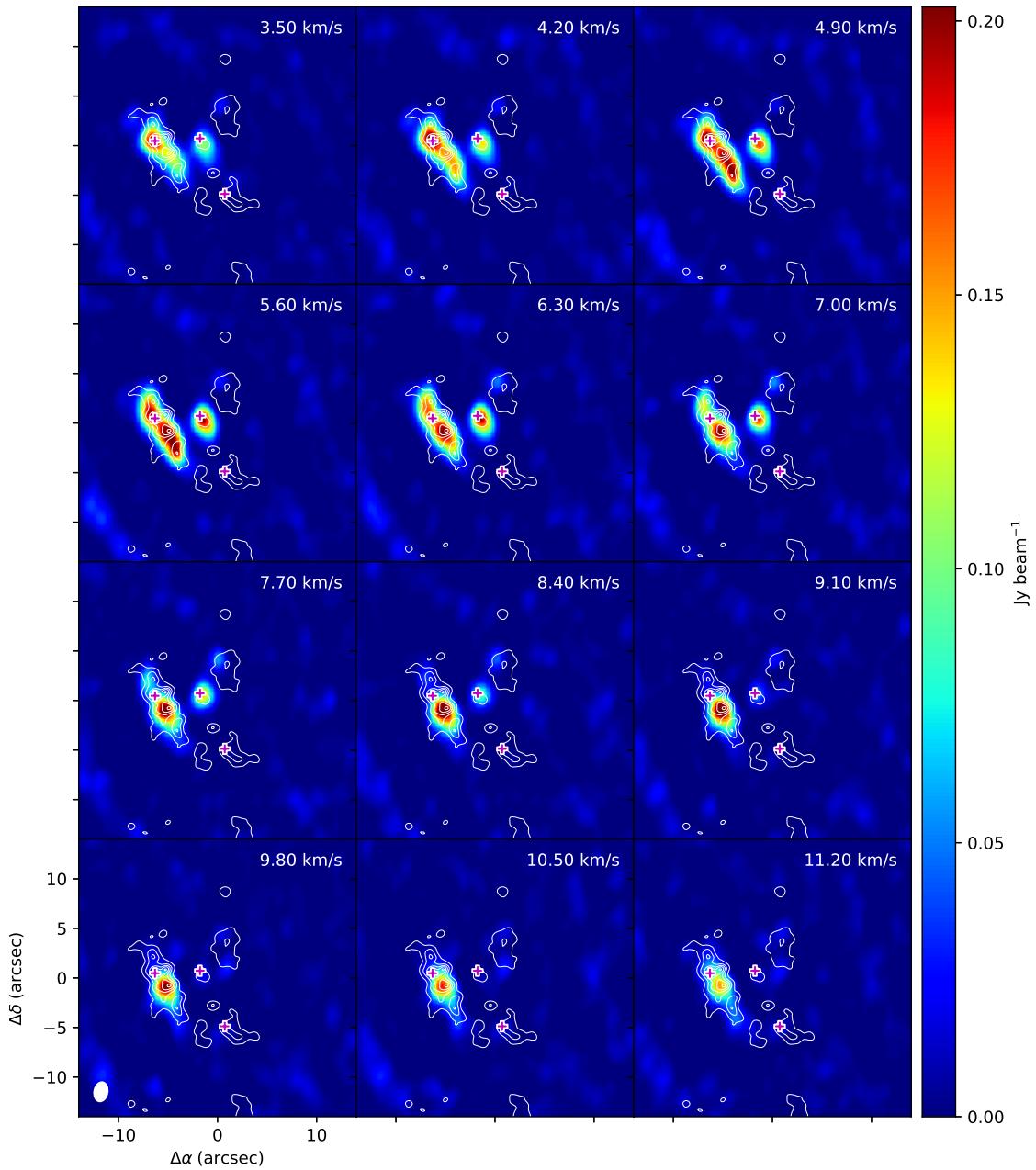


Figure A.4: 222.846GHz

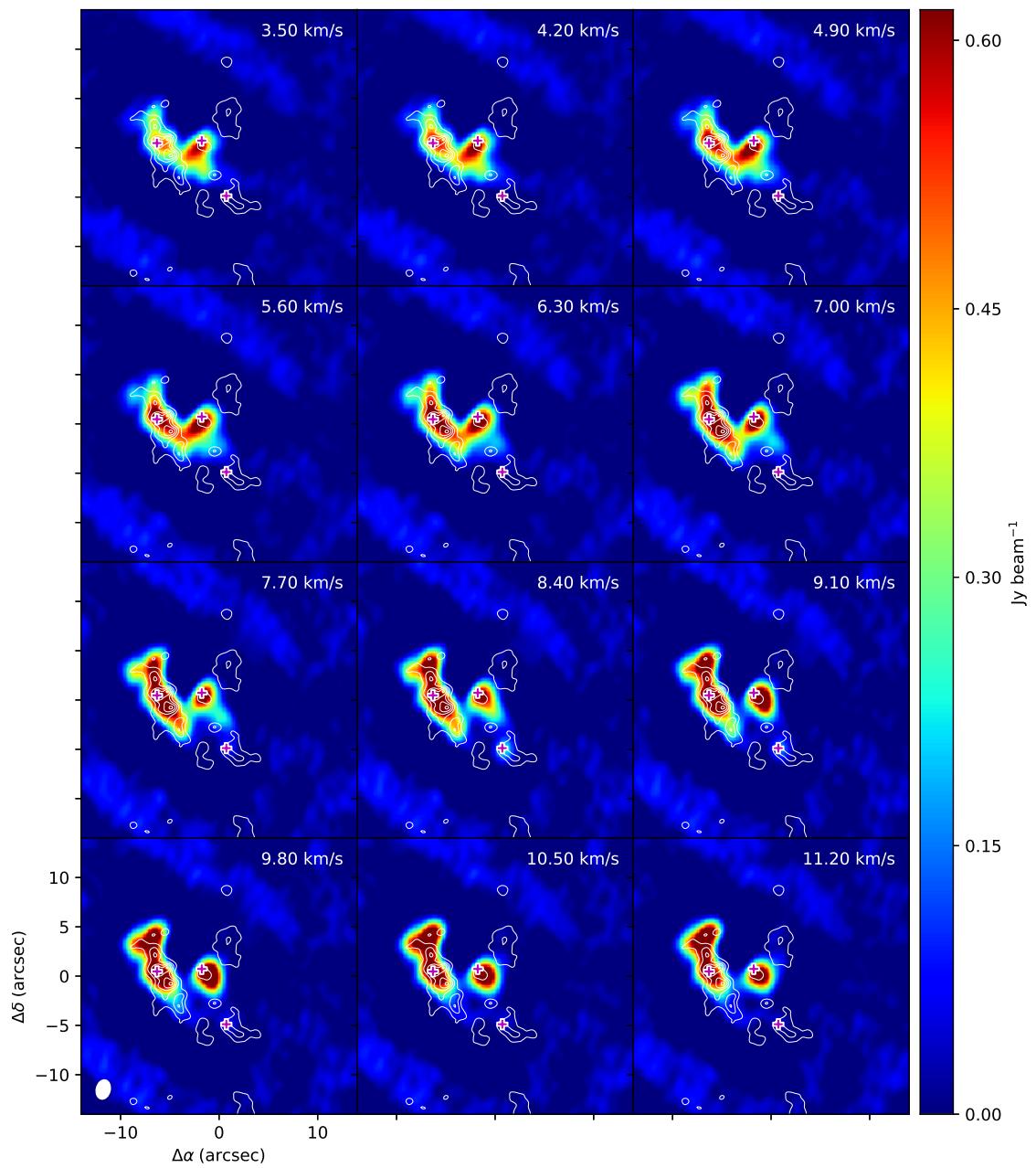


Figure A.5: 227.545GHz

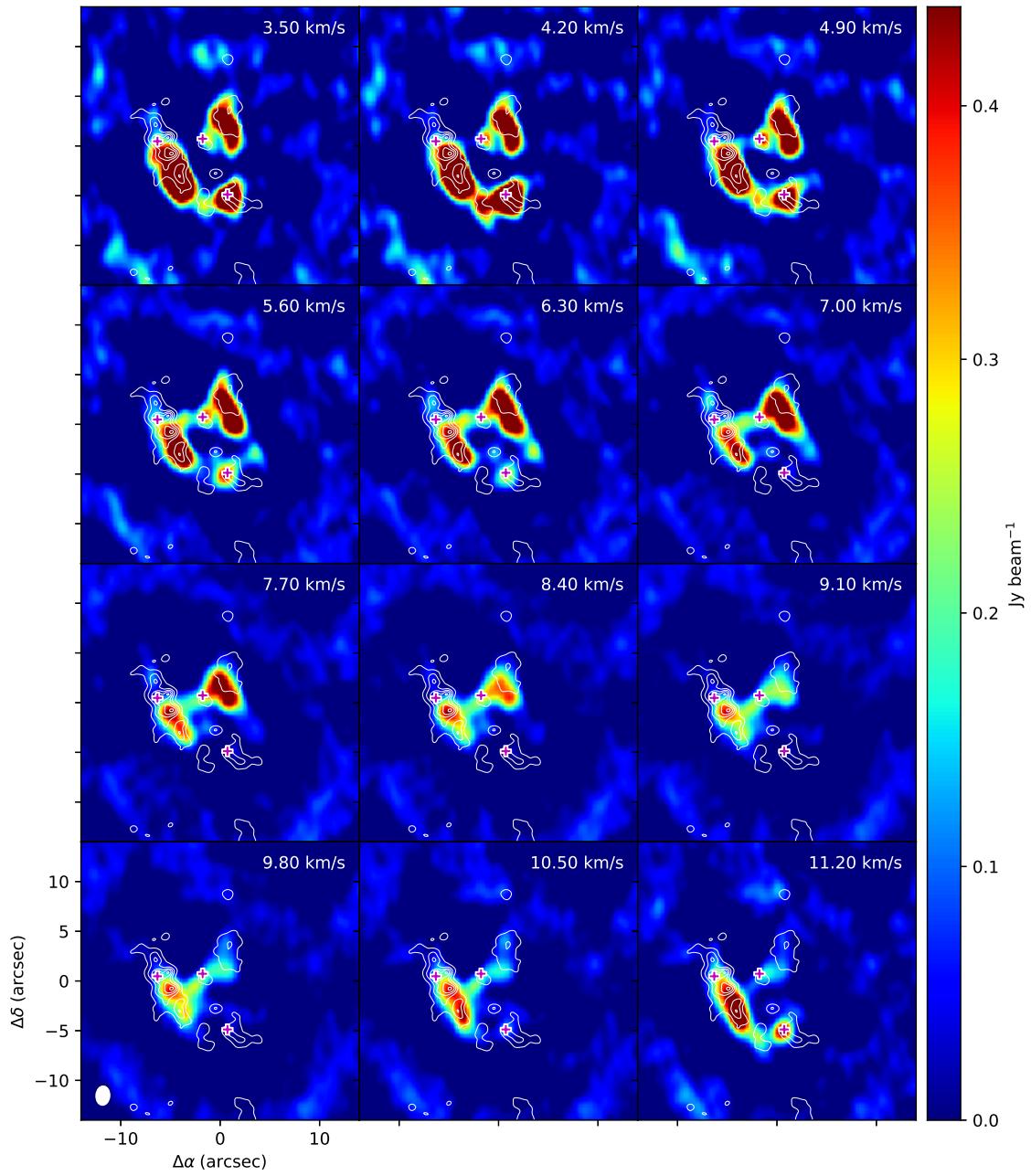


Figure A.6: 231.844GHz

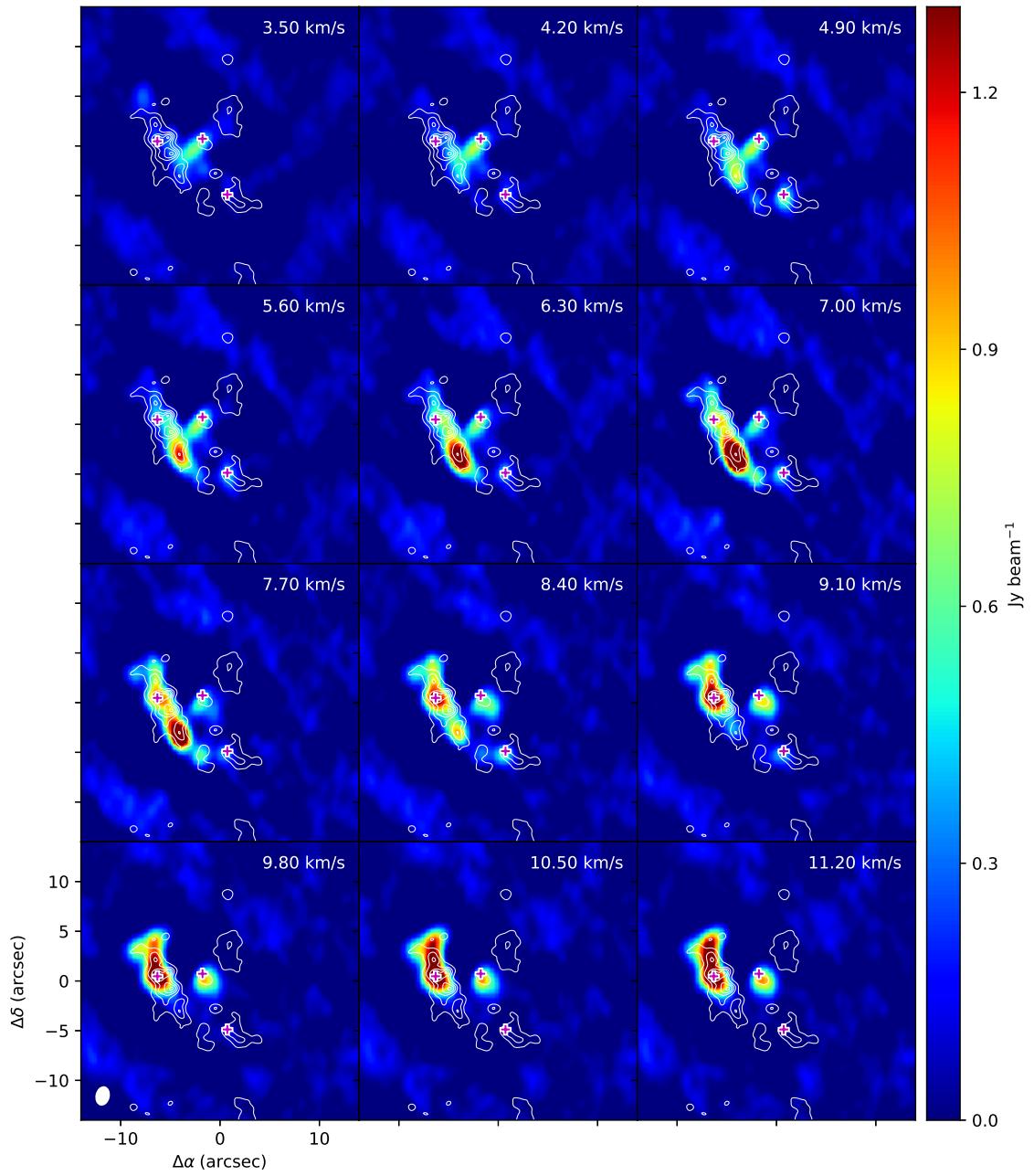


Figure A.7: 242.625GHz

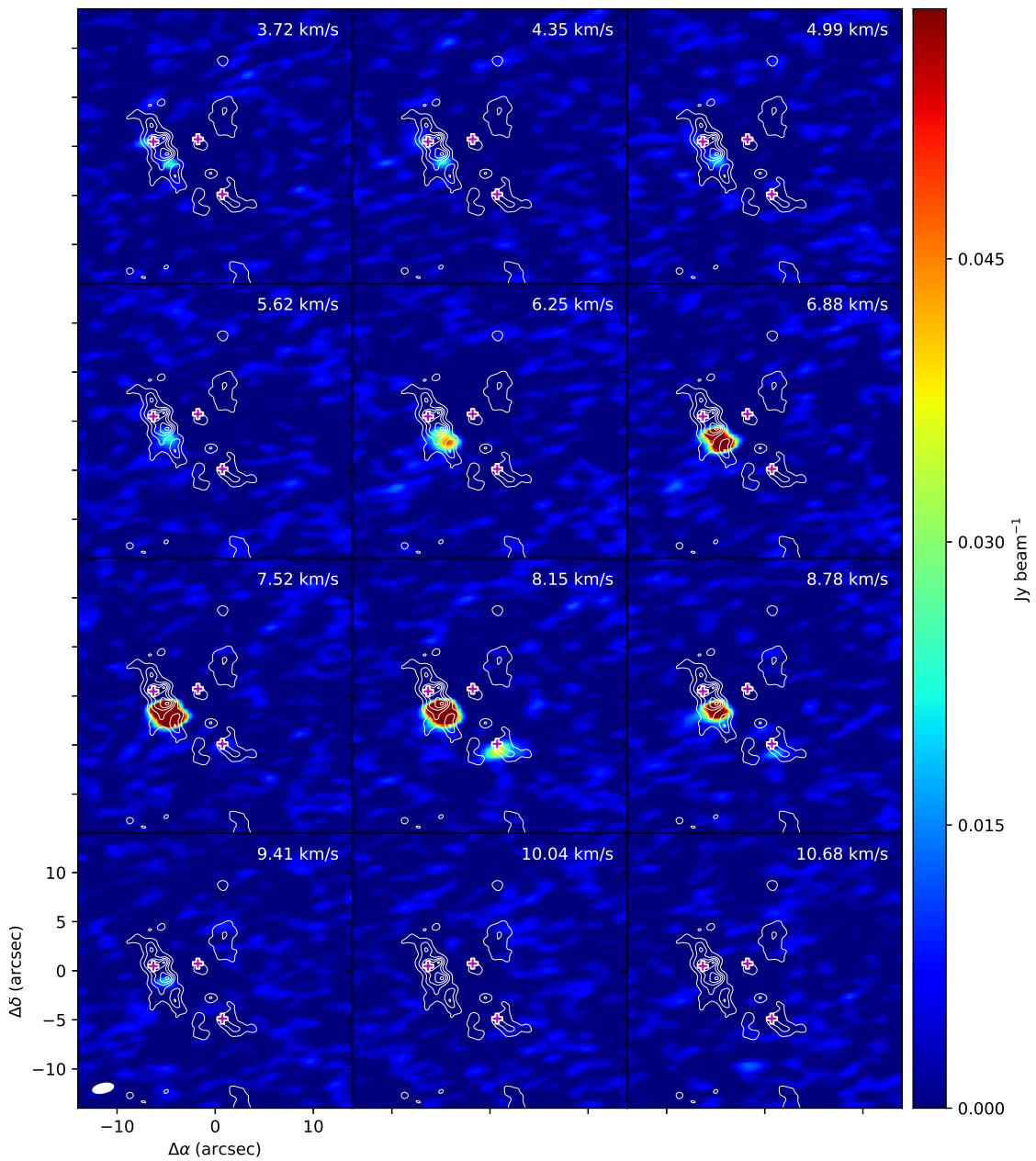


Figure A.8: 231.524GHz

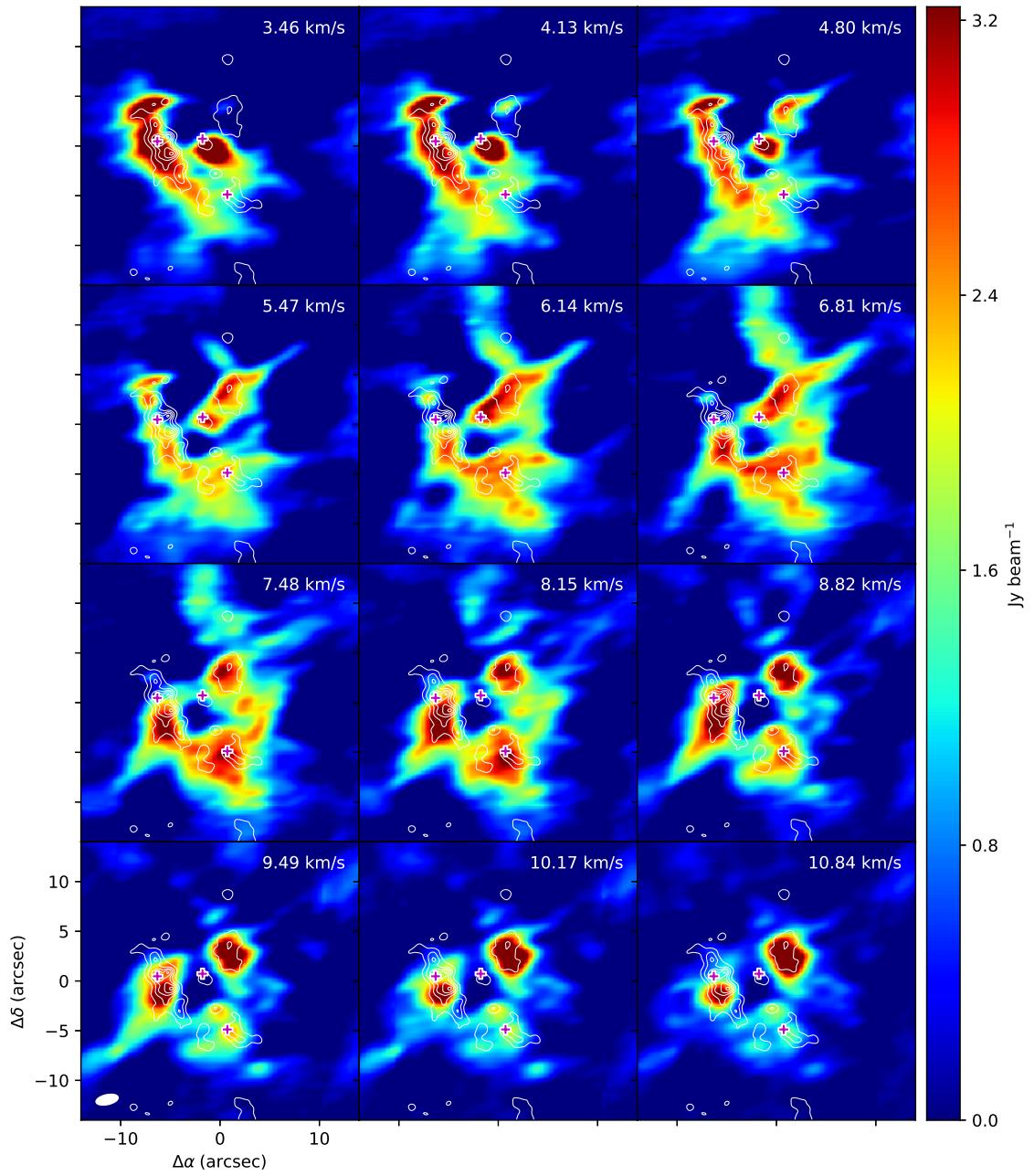


Figure A.9: 218.221GHz

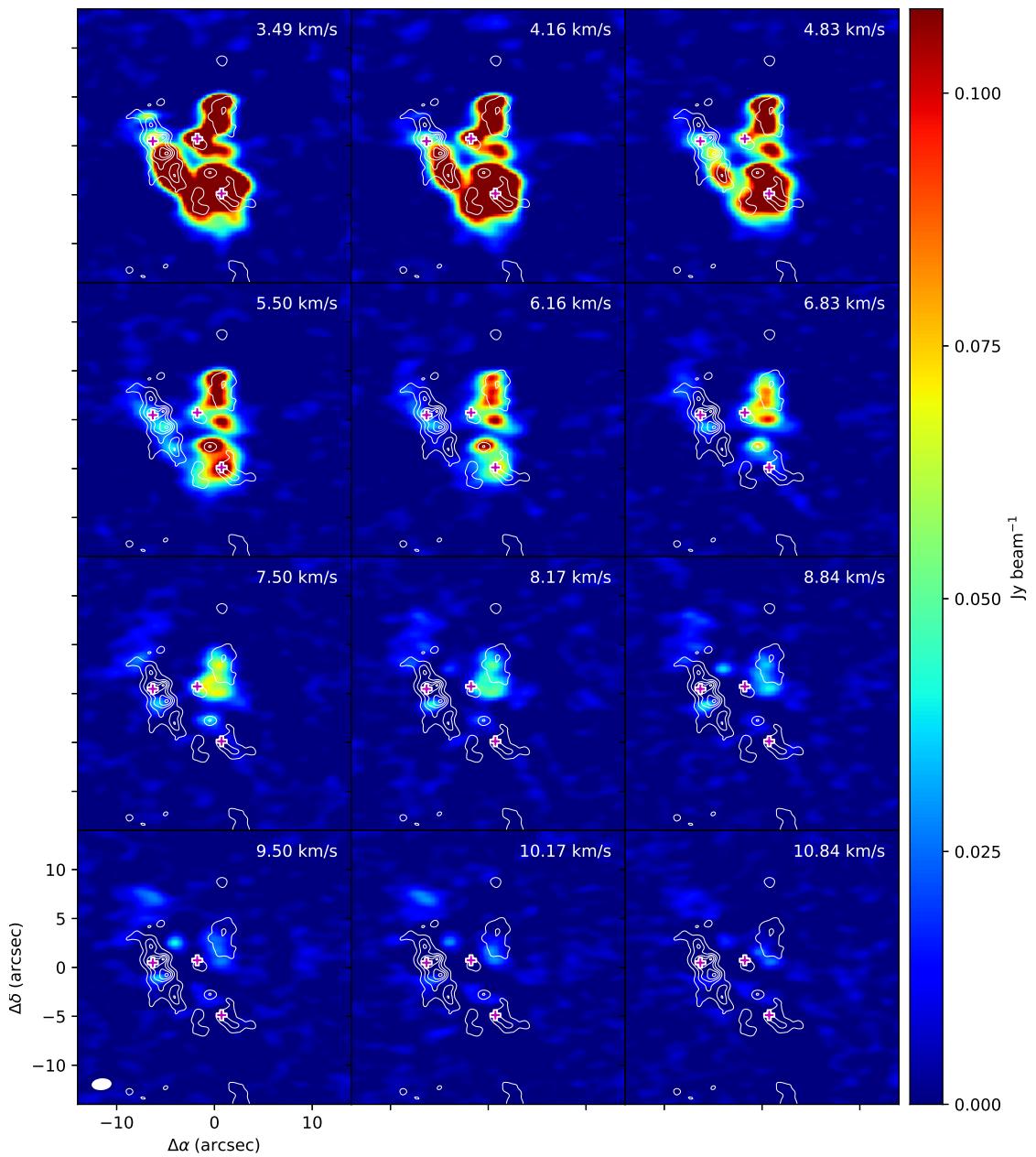


Figure A.10: 219.151GHz

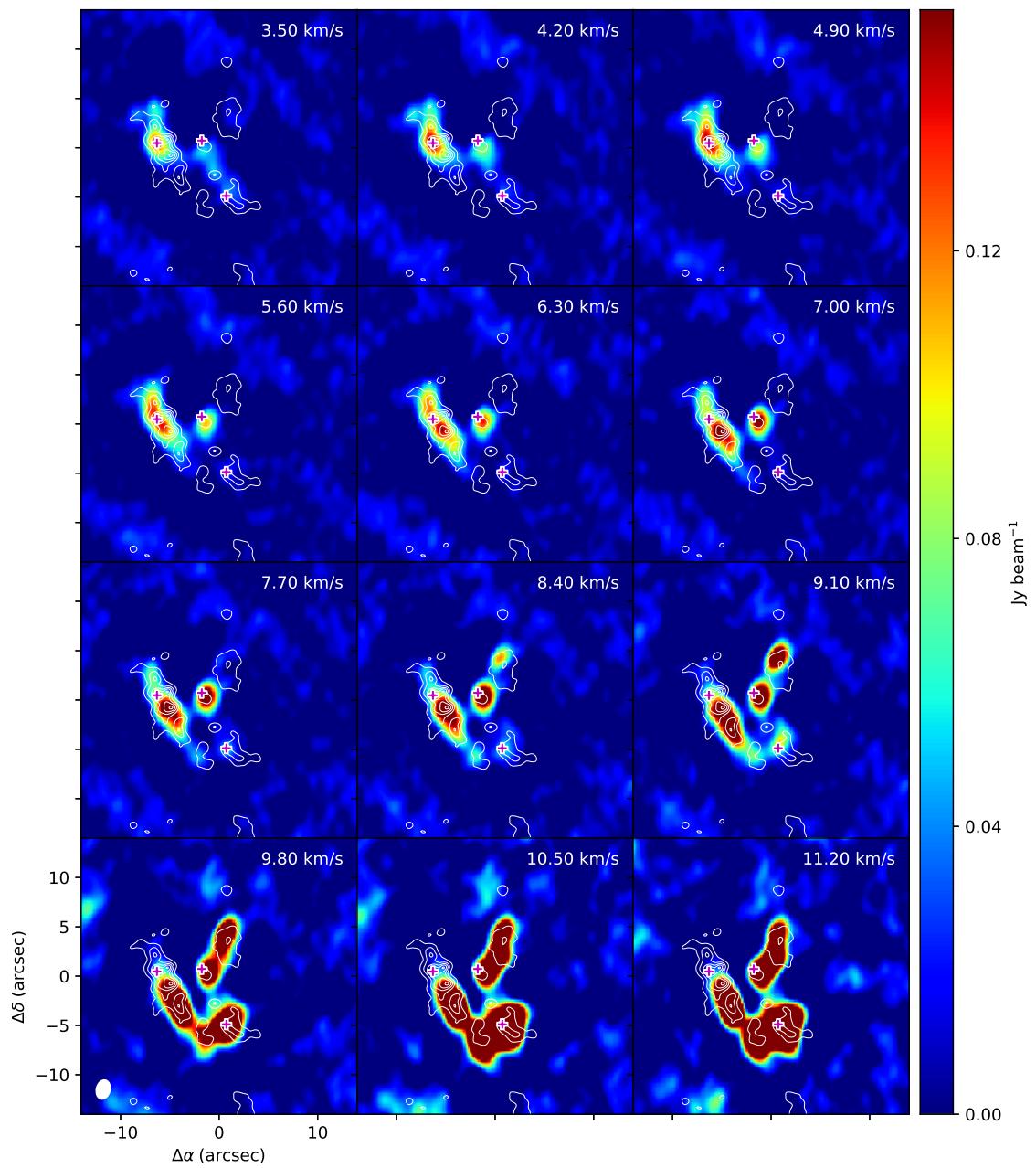


Figure A.11: 227.997GHz

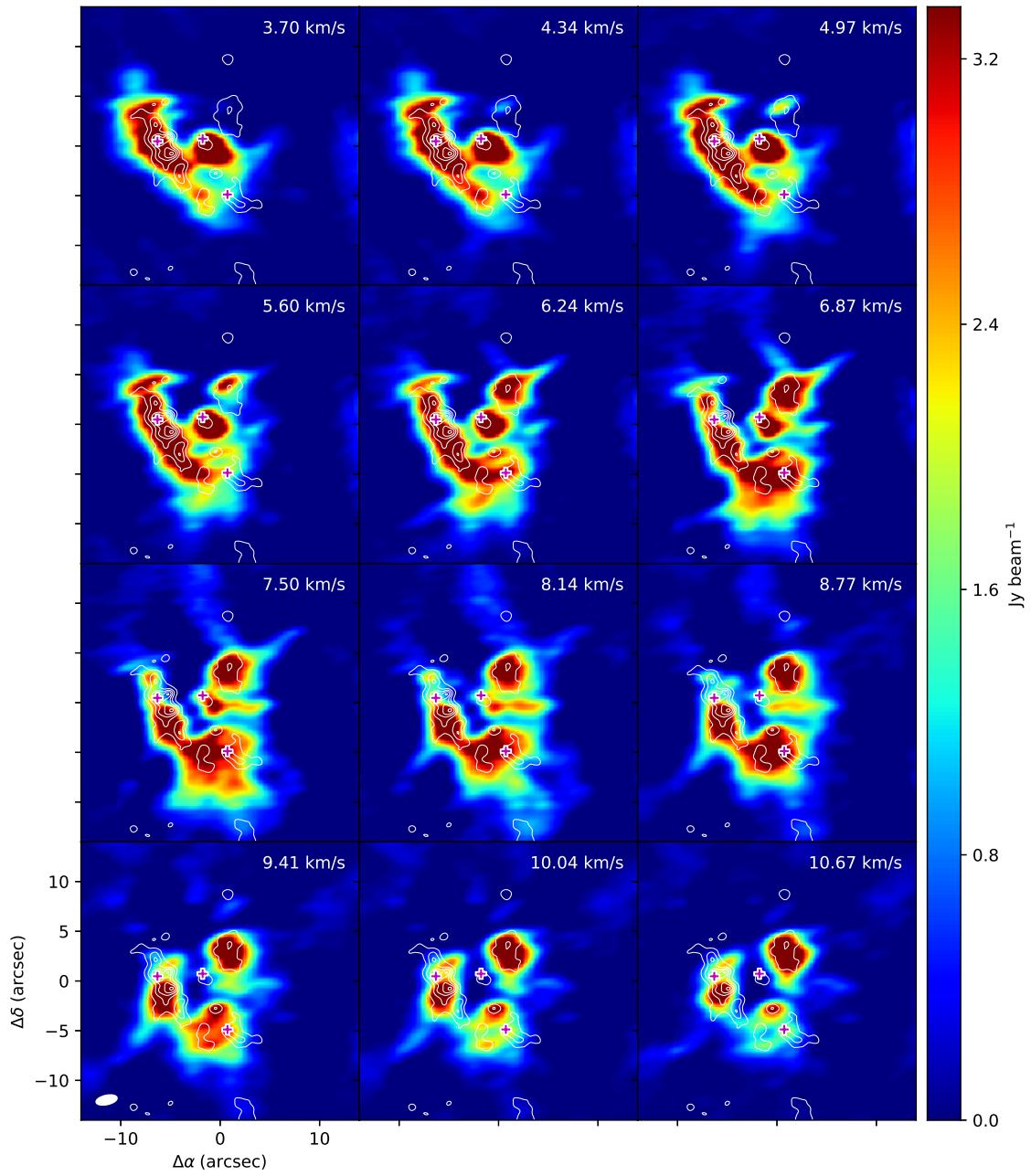


Figure A.12: 231.061GHz

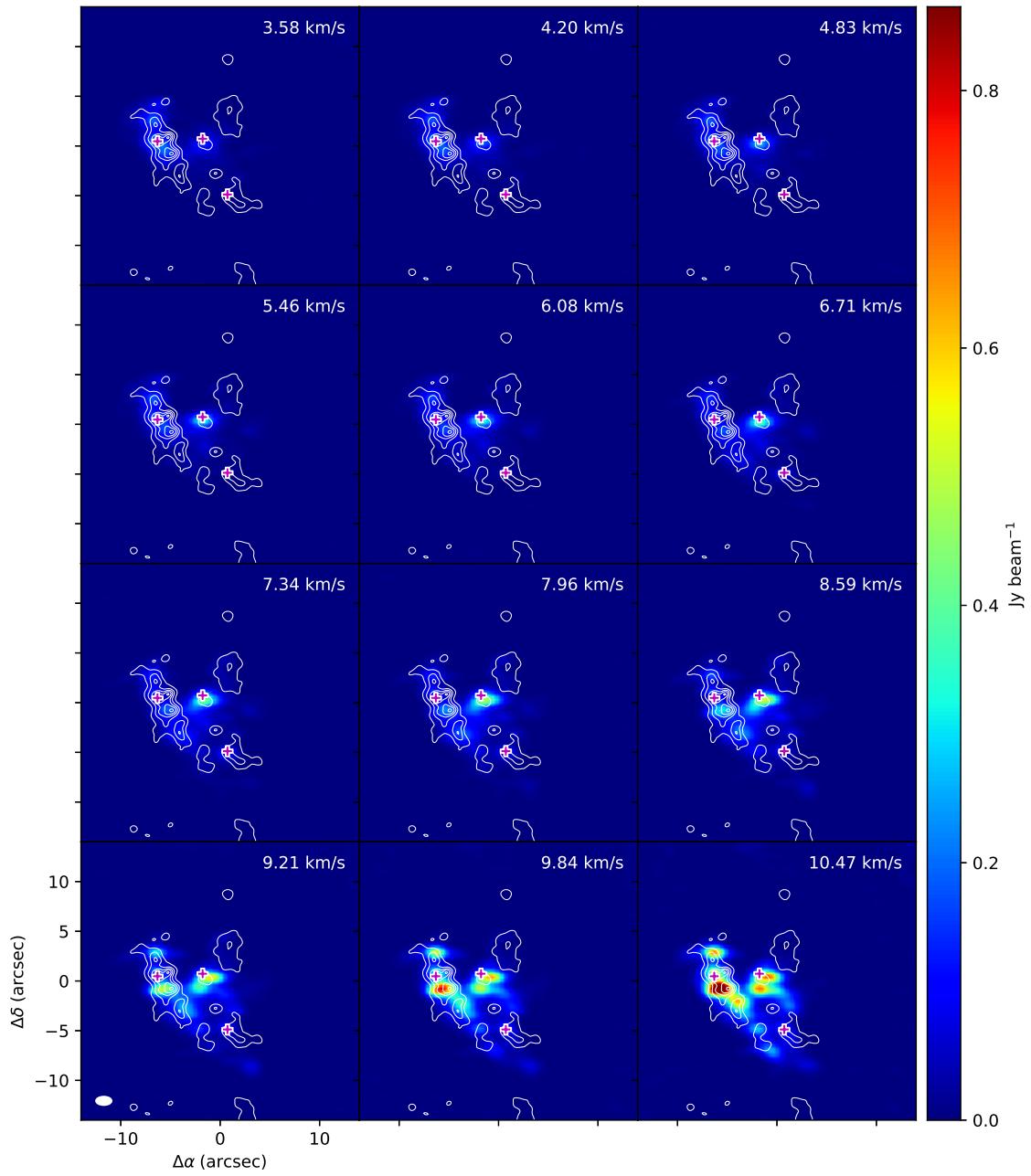


Figure A.13: 233.802GHz

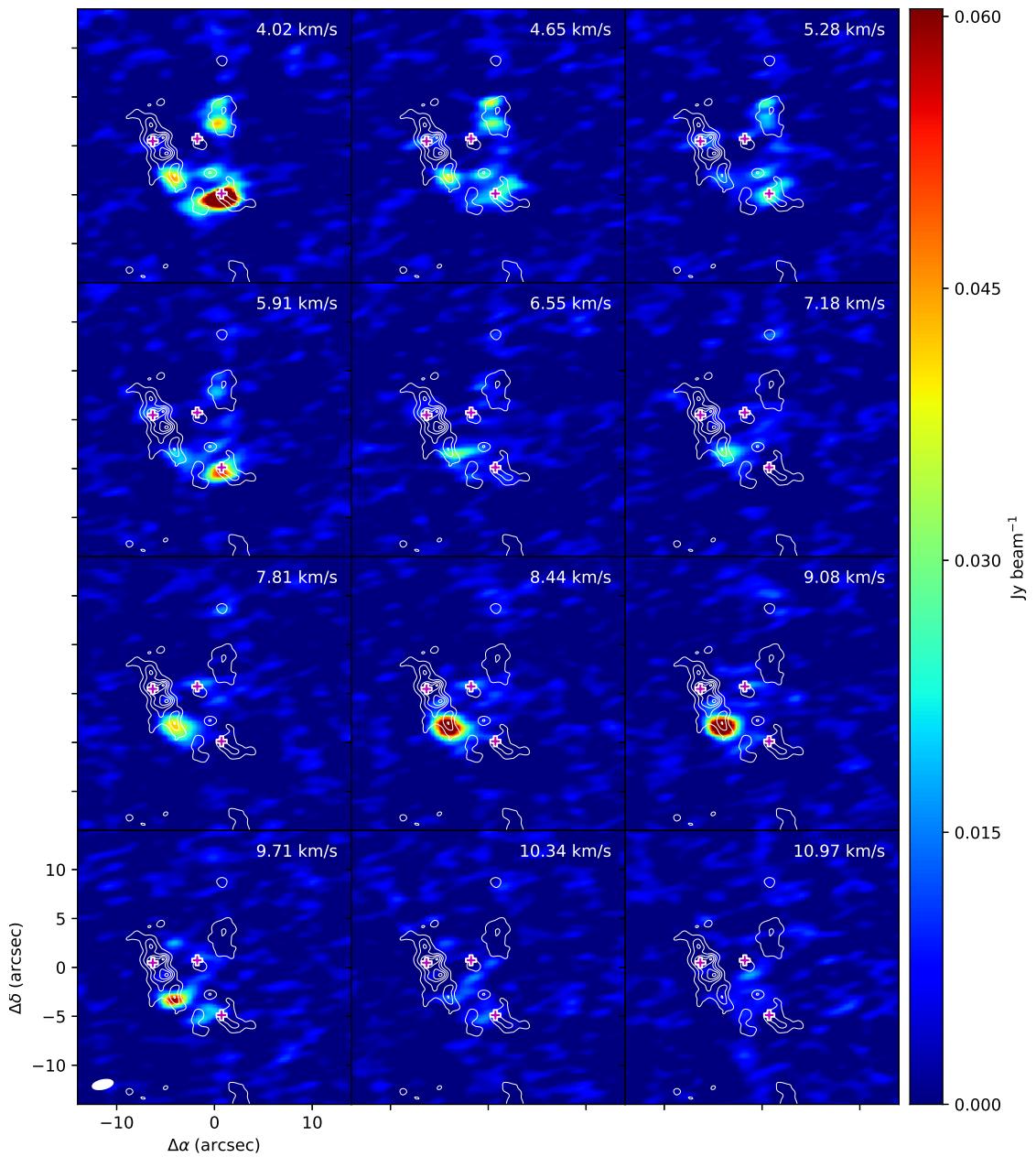


Figure A.14: 231.576GHz

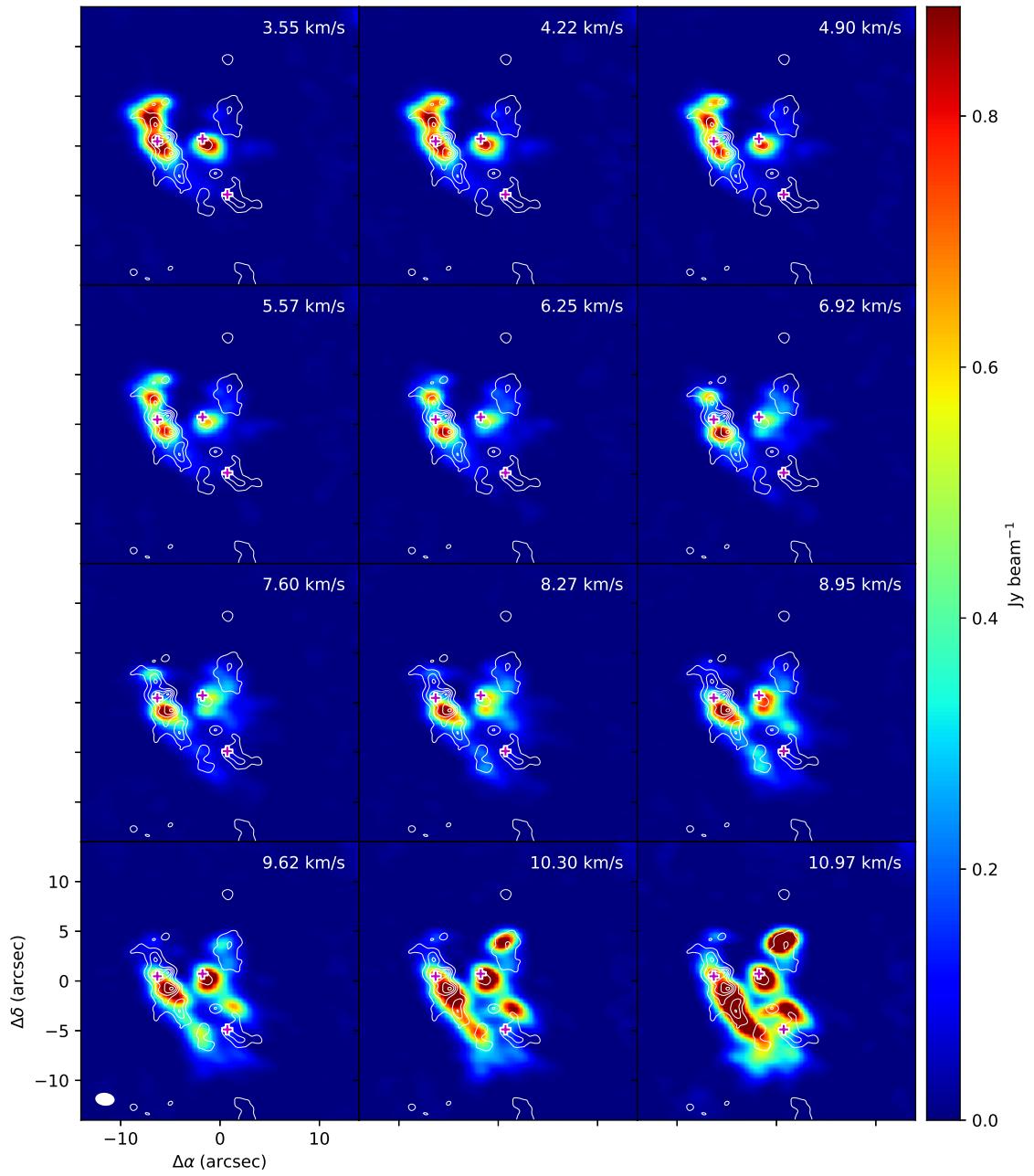


Figure A.15: 216.843GHz

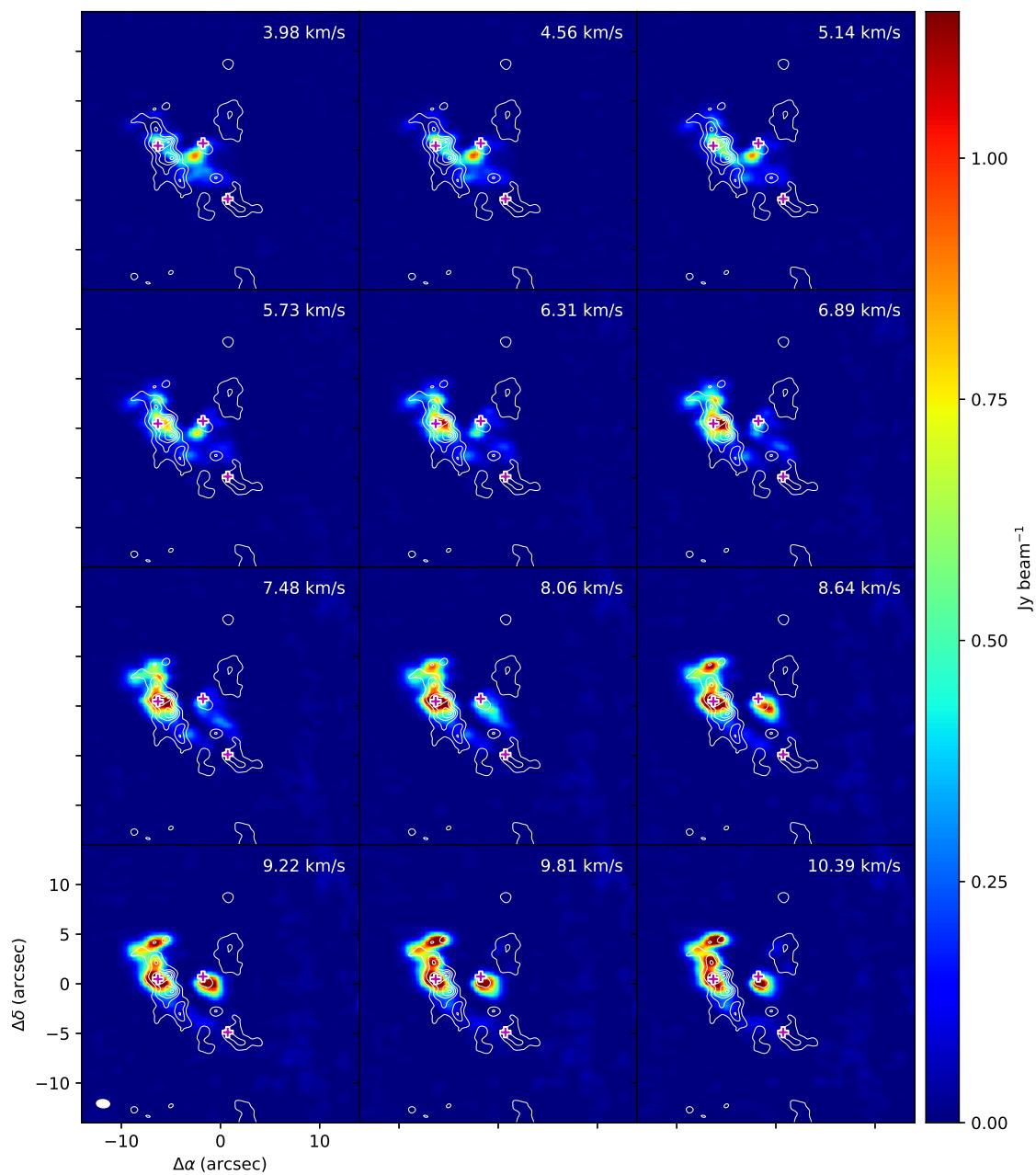


Figure A.16: 251.128GHz

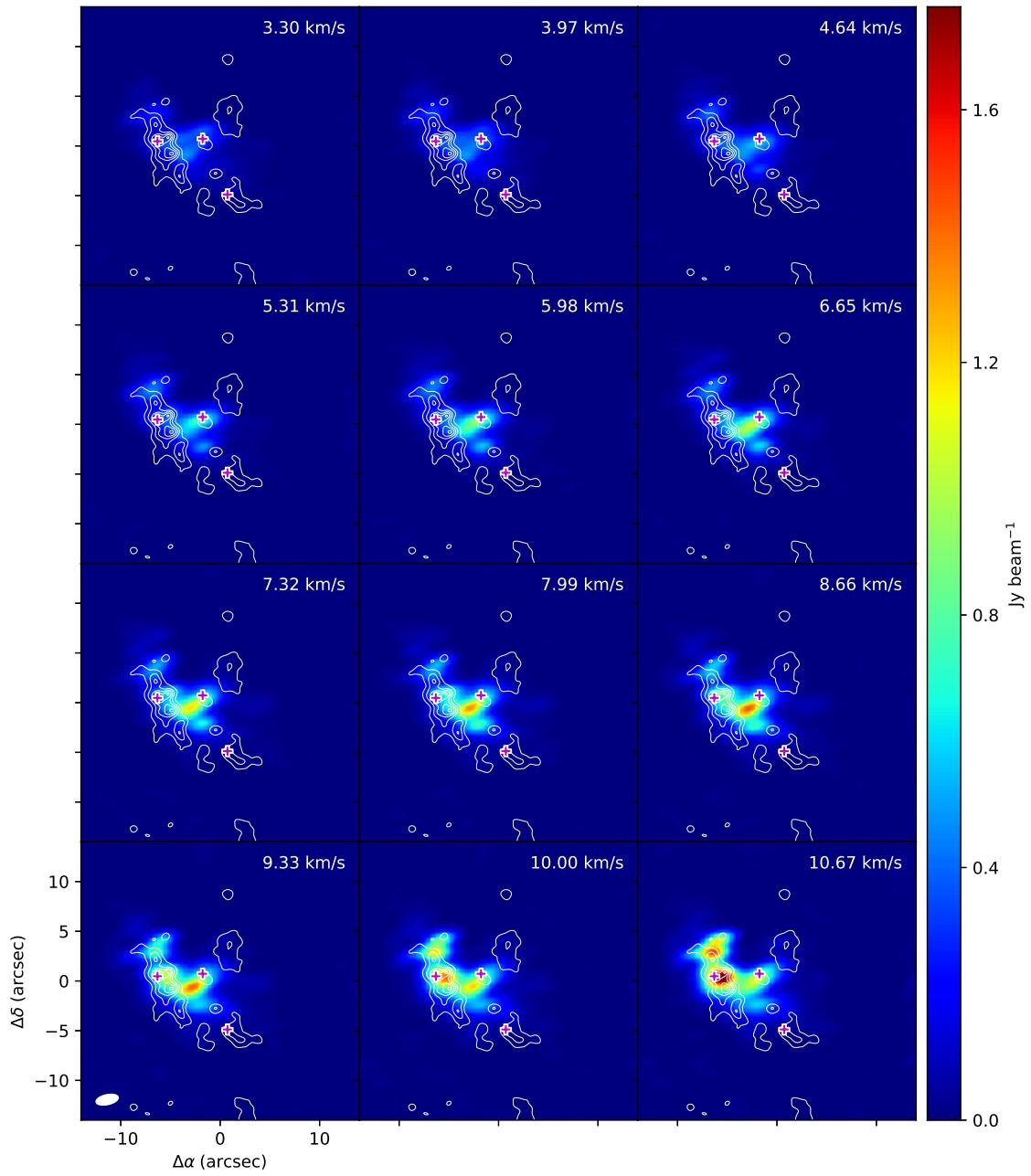


Figure A.17: 218.409GHz

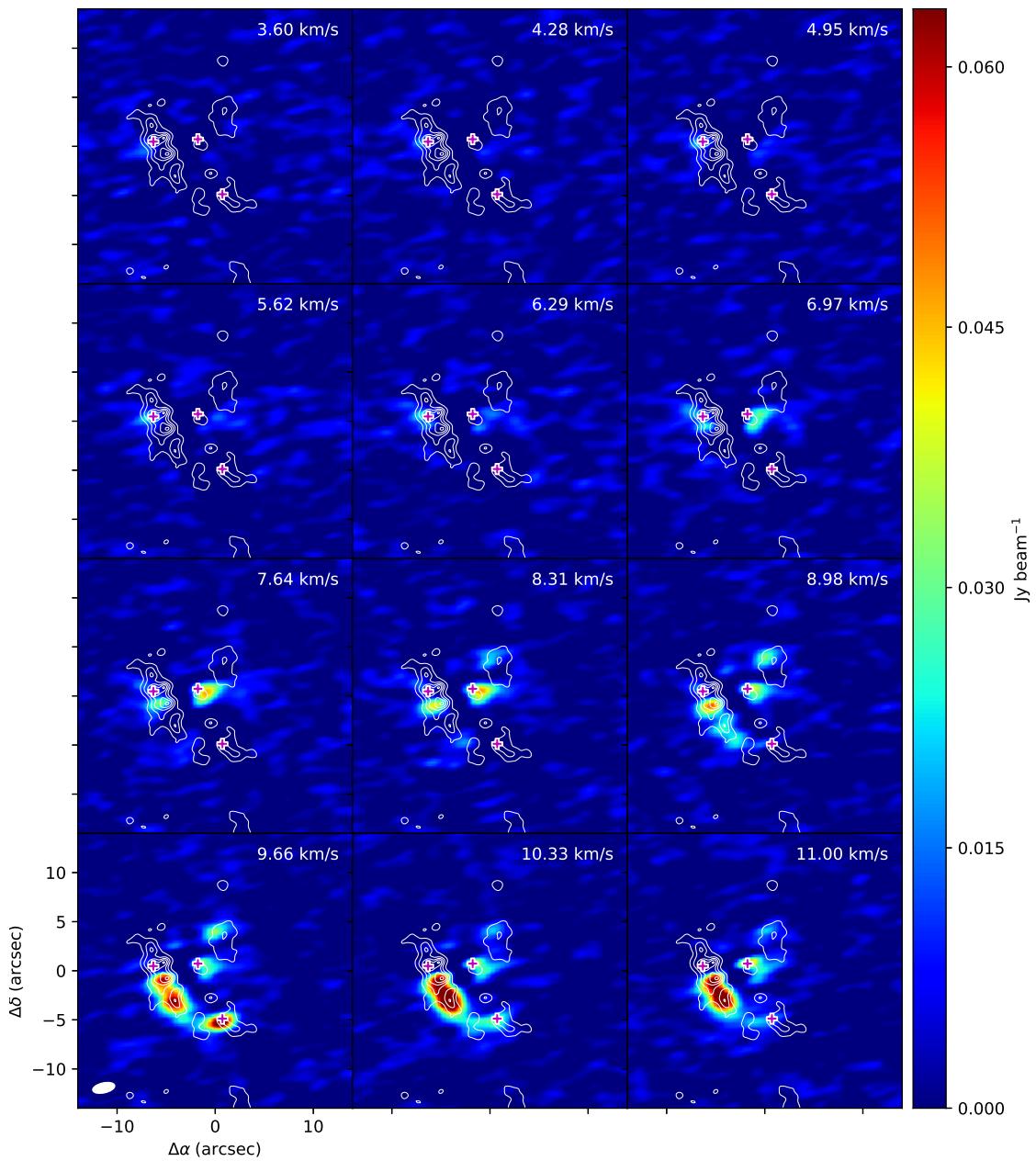


Figure A.18: 217.670GHz

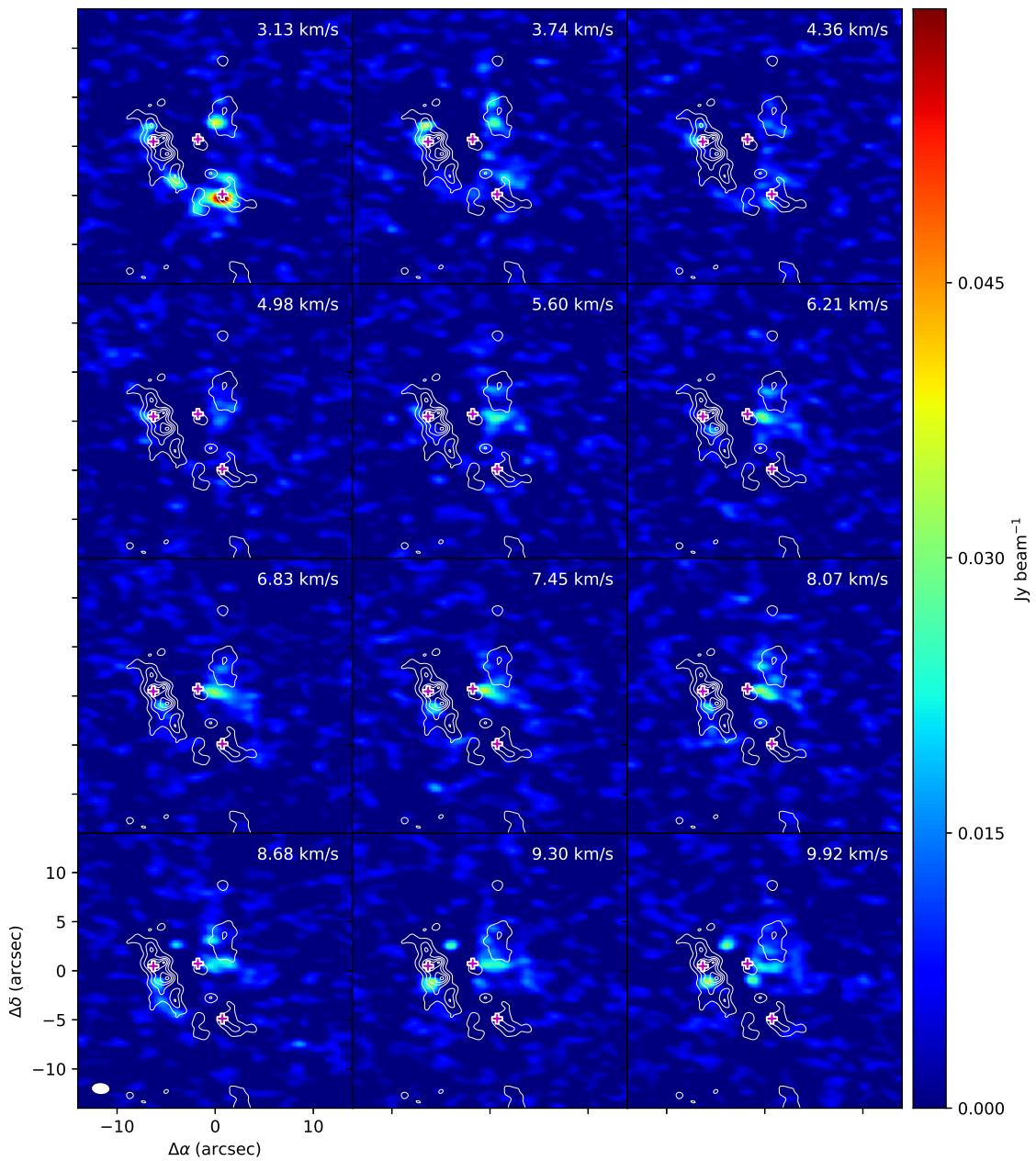


Figure A.19: 237.144GHz

Acknowledgments

References