

2023 年度 卒業論文

12.2 GHz 及び 6.7 GHz メタノールレーザー放射の
検出による大質量星形成領域の物理状態の推量

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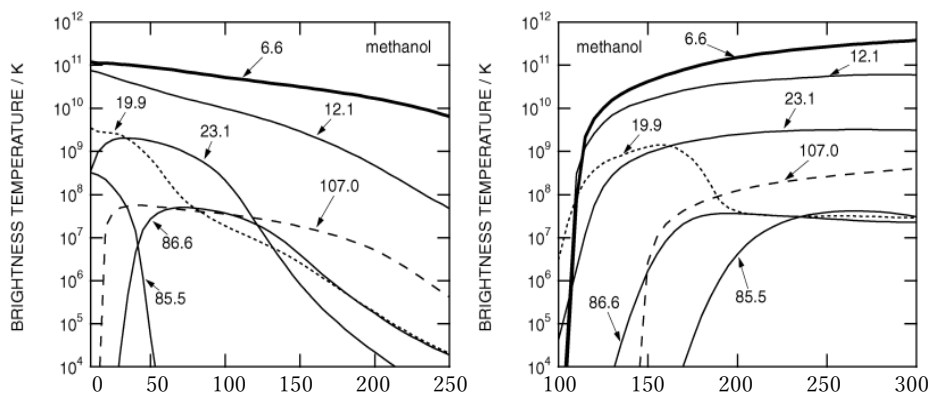
要旨

大質量星形成領域の物理状態（ガス温度、ダスト温度、ガス密度）を推量するため、茨城大学が運用している日立 32m アンテナを用いて、6.7 GHz 及び 12.2 GHz メタノールメーザーの観測を行った。観測された 433 天体において、それぞれ 6.7 GHz 及び 12.2 GHz のデータの平均化スペクトルを作成し、メーザー放射の検出を比較したところ、6.7 GHz メーザー放射が検出された天体は 400 天体であった。そのうち 12.2 GHz でもメーザー放射が検出された天体は 119 天体であった。6.7 GHz、12.2 GHz とともにメーザー放射が検出された 119 天体では、ピーク velocity 成分が同じ天体が 60 天体、異なる天体が 51 天体であった。6.7 GHz、12.2 GHz それぞれの強度を見ると、物理状態の理論値と矛盾はなく、これらの天体の物理状態（ガス温度、ダスト温度、ガス密度）の推量が可能だと考えた。

1 序論

1.1 研究背景

大質量星形成領域は中小質量星形成領域に比べ、高密度なガスで覆われており、また形成に要する時間も短いことから物理状態（ガス温度、ダスト温度、ガス密度）の推量が難しいとされている。メタノールメーザーは輝度が非常に高く、また高密度ガスによる吸収をほとんど受けないため、大質量形成領域の観測の最も有効な手段の 1 つである。6.7 GHz メタノールメーザーは広い範囲の物理状態（ガス温度、ダスト温度、ガス密度）で強く検出される。一方 12.2 GHz メタノールメーザーは 6.7 GHz と比べ狭い範囲の物理状態（ガス温度、ダスト温度、ガス密度）で強く検出される（図 1）。したがって 6.7 GHz 及び 12.2 GHz メタノールメーザー放射の強度や検出の有無を比較することは、天体の物理状態（ガス温度、ダスト温度、ガス密度）の推量に役立つと考えられる。



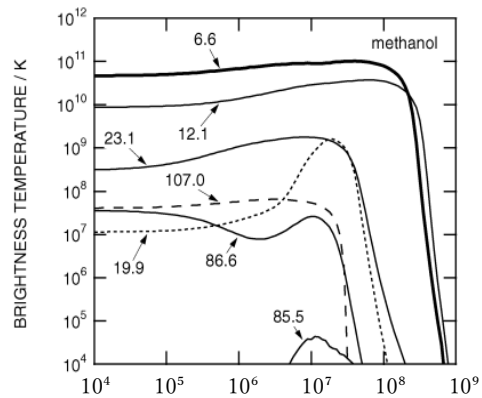


図 1：さまざまなメタノールメーザーにおける、物理状態と観測される輝度温度の関係[1]

1.2 先行研究

Breen ら[2]は、6.7 GHz でメーザー放射が検出された 580 天体に対して、メタノールマルチビーム探査 (MMB survey) を行い、12.2 GHz でメーザー放射が検出された天体は 250 天体であった。そのうち 80% の天体は 6.7 GHz、12.2 GHz とともに速度成分が一致していた。検出された 6.7 GHz の強度は 12.2 GHz の強度よりも大きく検出された。

2 観測

2.1 観測方法

茨城大学が運用している日立 32m アンテナでは 2023 年 3 月に新しい受信機を搭載し、6.5 GHz から 12.5 GHz の観測が可能となった。そこで、12.2 GHz の観測を開始した。観測諸元を次に記す。

2.2 観測諸元

6.7 GHz : 2012 年 12 月 30 日から 2024 年 1 月 22 日までのデータを使用

12.2 GHz : 2023 年 2 月 26 日から 2023 年 11 月 21 日までのデータを使用

天体数 : 433 天体 (6.7 GHz の観測を開始した時点で 6.7 GHz メタノールメーザーの検出報告がされていた全ての天体と、水メーザーなどの観測結果に基づいて追加した天体)

観測時間 : 1 日あたり 15 時間程度の観測を毎日実施した。

観測周波数 : 6.669 GHz、12.178 GHz

周波数範囲及び帯域幅 :

6.664 GHz–6.672 GHz の 8 MHz

12.170 GHz–12.186 GHz の 16 MHz

分光点数 : 8192 点 (8192 点分光した後、3 点の移動平均を取った)

速度範囲及び速度分解能 :

速度幅は、 360 km s^{-1} (6.7 GHz)、 394 km s^{-1} (12.2 GHz)。帯域中心の速度は、ドップラー効果により天体や観測日によって異なるが、おおむね -30 – $+30 \text{ km s}^{-1}$ 程度である。速度分解能は、 0.13 km s^{-1} (6.7 GHz)、 0.14 km s^{-1} (12.2 GHz)。

積分時間 : 1 天体 1 回の観測につき、ON 点 5 分、OFF 点 5 分。

典型的な T_{sys} と τ :

6.7 GHz : $T_{\text{sys}} \sim 25 \text{ K}$ 、 $\tau \sim 0.010$

12.2 GHz : $T_{\text{sys}} \sim 26 \text{ K}$ 、 $\tau \sim 0.012$

3 解析

3.1 解析方法

米倉覚則氏作成のプログラム winteg.c を用いて、観測日ごとのデータを平均化し、python matplotlib を用いて天体ごとに平均化スペクトルを作成した。baseline range は $v1$ 、 $v2$ 、 $v3$ 、 $v4$ で定義され、ノイズを $v1$ - $v2$ 間及び $v3$ - $v4$ 間により、ピークにおける速度成分及び強度を $v2$ - $v3$ 間により求められる。

3.2 解析結果

6.7 GHz 及び 12.2 GHz のスペクトルの例を図 2 から図 5 に示す。また、6.7 GHz と 12.2 GHz の検出の有無による分類結果を表 1 に示す。

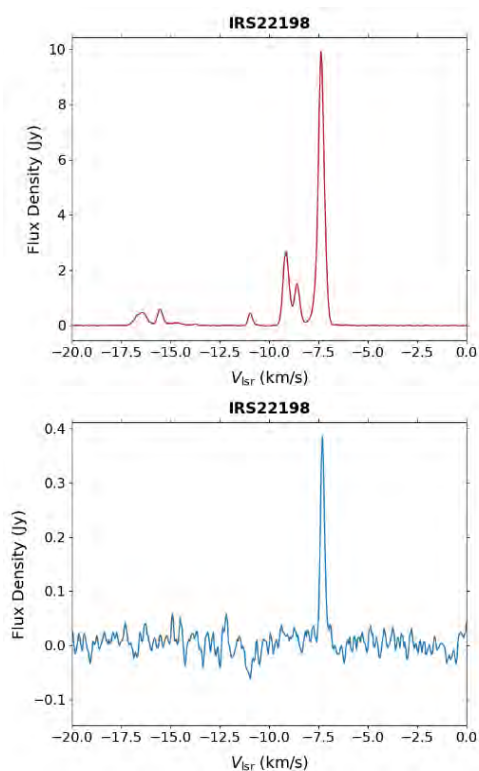


図 2 : 6.7 GHz、12.2 GHz の両方でメーザー放射が検出された天体
(ピークの速度成分同じ)

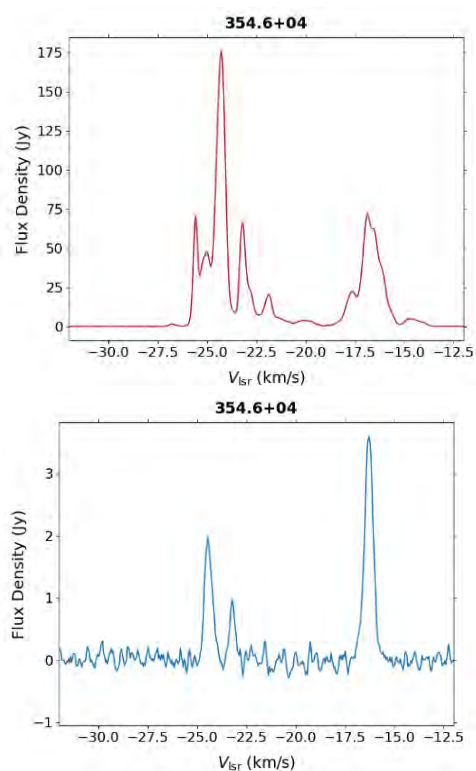


図 3 : 6.7 GHz、12.2 GHz の両方でメーザー放射が検出された天体
(ピークの速度成分異なる)

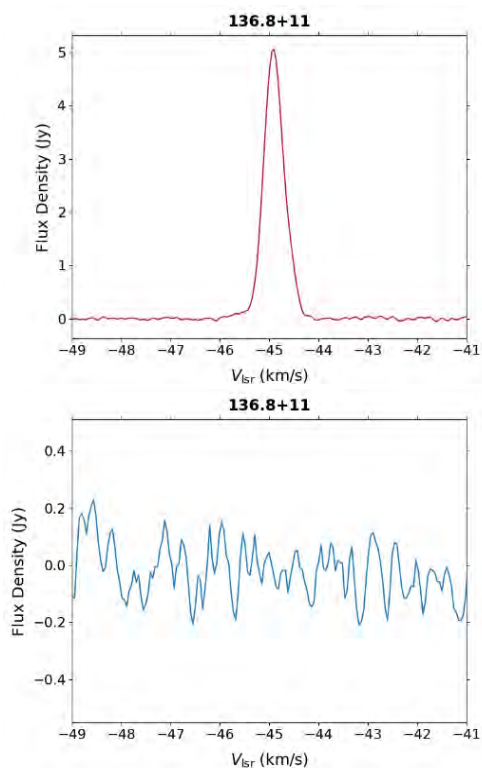


図 4：6.7 GHz のみメーザー放射が検出された天体(12.2 GHz ではメーザー放射が検出されなかった)

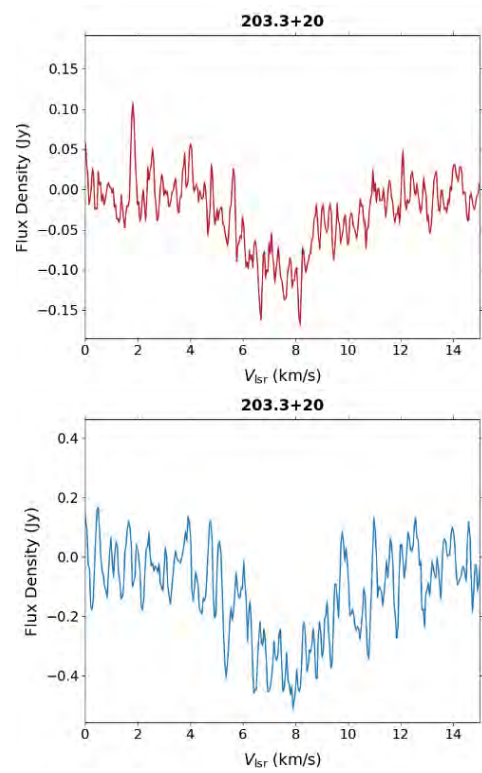


図 5：6.7 GHz、12.2 GHz とともにメーザー放射が検出されなかった天体

	6.7 GHz メーザー放射が検出された天体	6.7 GHz メーザー放射が検出されなかった天体	計
12.2 GHz メーザー放射が検出された天体	119 ピークの数成分 同：60、異：51	0	119
12.2 GHz メーザー放射が検出されなかった天体	281	33	314
計	400	33	433

表 1：6.7 GHz と 12.2 GHz の検出の有無による分類結果

4 考察

表 1 より、メーザー放射が 6.7 GHz では検出され 12.2 GHz では検出されなかった天体が存在すること、及びメーザー放射が 6.7 GHz では検出されず 12.2 GHz では検出された天体が存在しないことから、ガス温度と輝度温度の関係の図（図 1）と矛盾がないこと、つまり 6.7 GHz の方が広い物理状態の範囲で強いメーザー放射が検出されることが言える。

図 6 に 12.2 GHz メタノールメーザーの強度に対するヒストグラム、図 7 に 6.7 GHz メタノールメーザーと 12.2 GHz メタノールメーザーの強度比のヒストグラムを示す。図 7 より、(1)6.7 GHz の強度の方が 12.2 GHz の強度より常に大きくなること、(2)6.7 GHz と 12.2 GHz の強度比が大きくなるほど天体数は減少することがわかる。このことは 6.7 GHz の方が広い物理状態の範囲で強いメーザー放射が検出されることがと矛盾しない。

以上の結果から、6.7 GHz と 12.2 GHz メタノールメーザーの観測結果を組み合わせることにより、天体の物理状態（ガス温度、ダスト温度、ガス密度）の推量が可能だと考える。

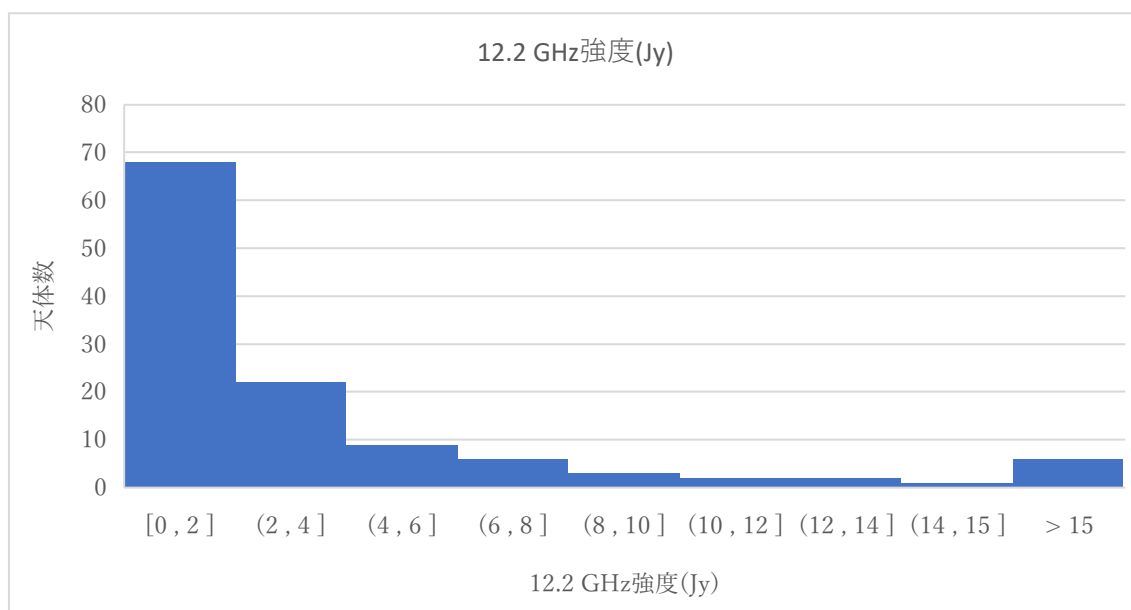


図 6：12.2 GHz メタノールメーザーの強度のヒストグラム

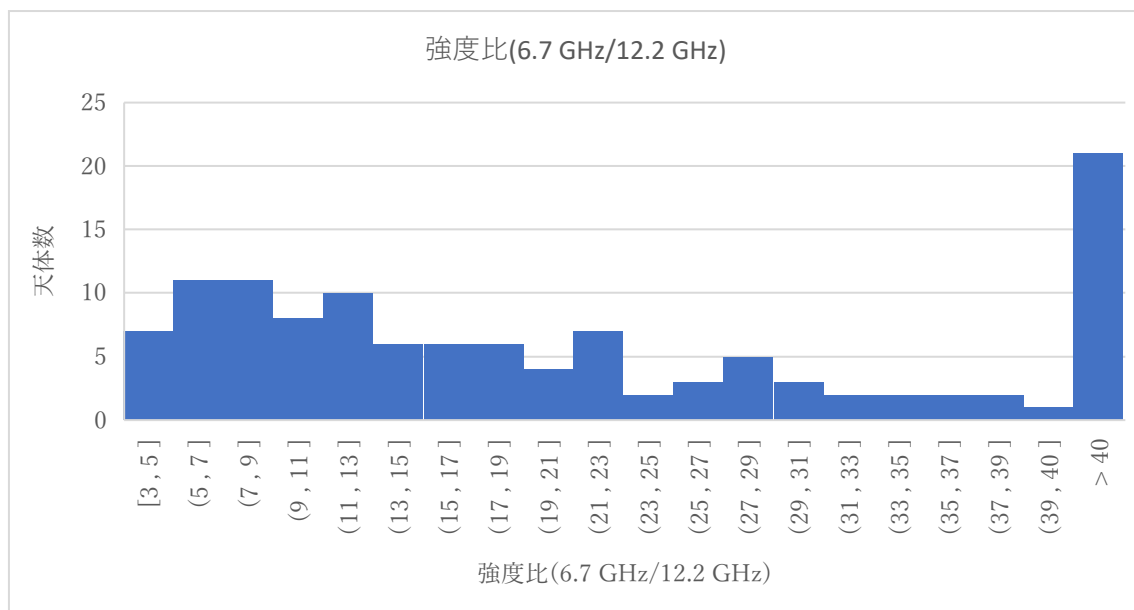


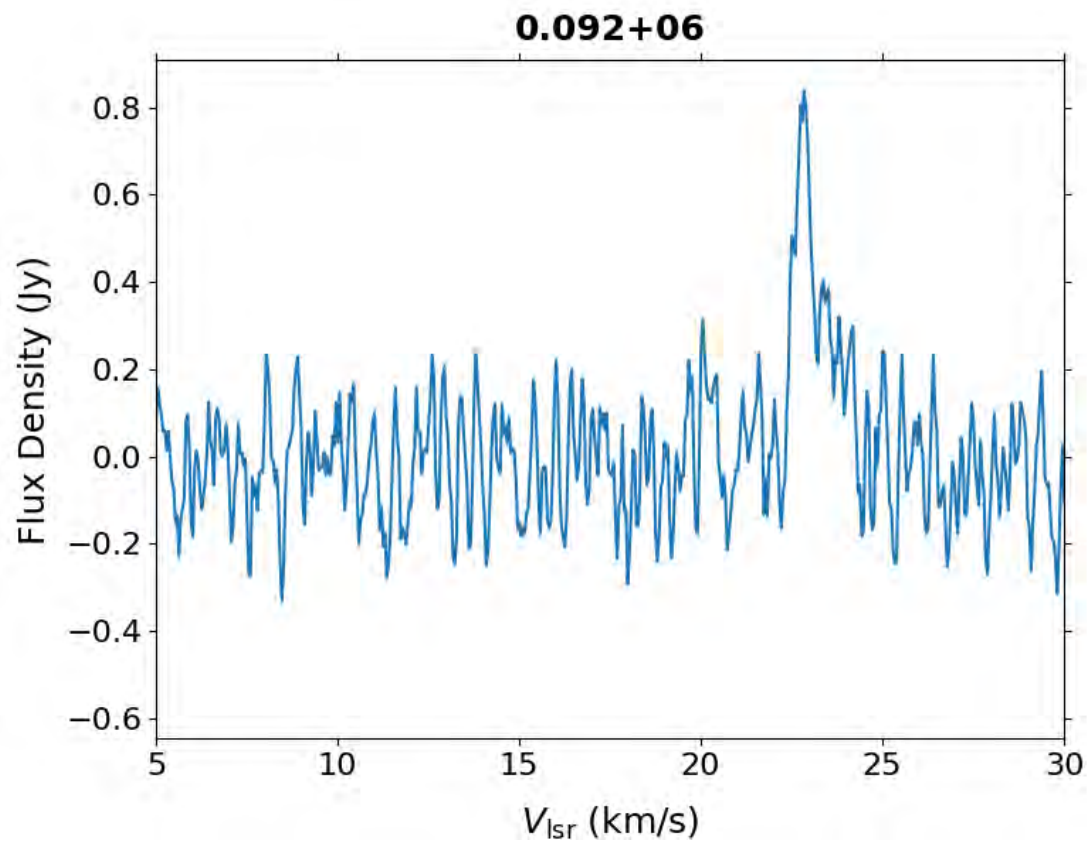
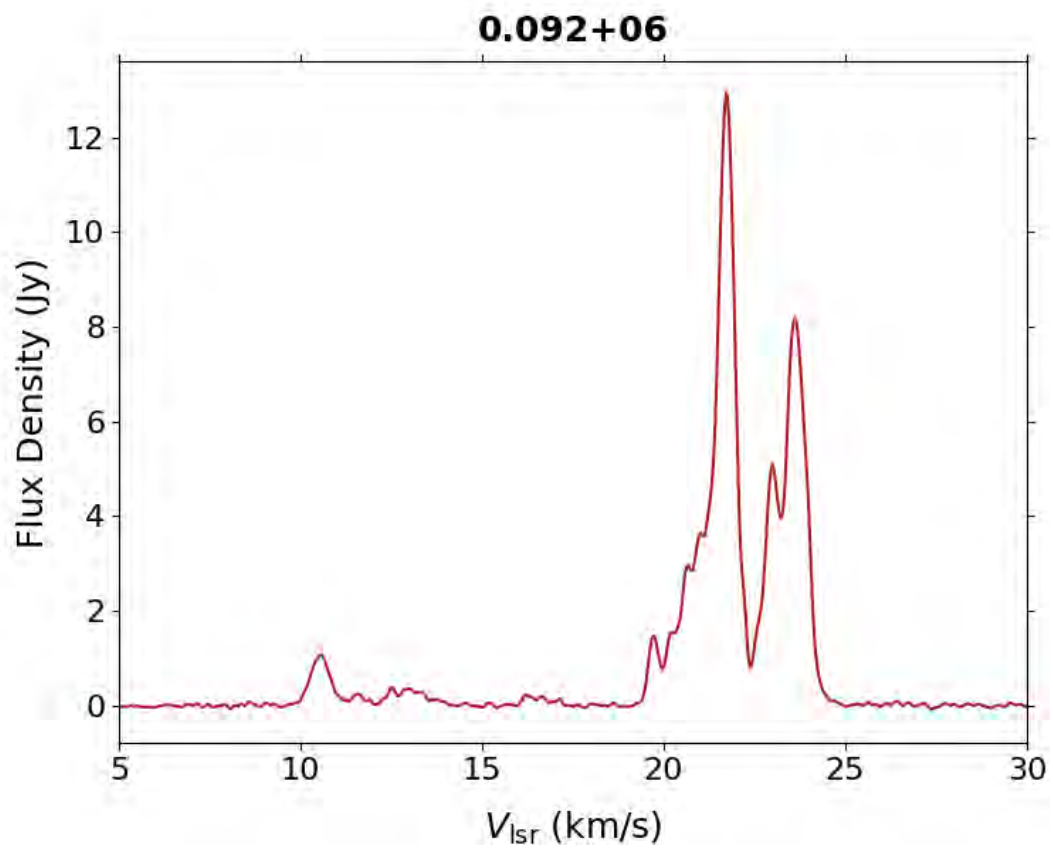
図 7 : 6.7 GHz 及び 12.2 GHz メタノールメーザーの強度比のヒストグラム

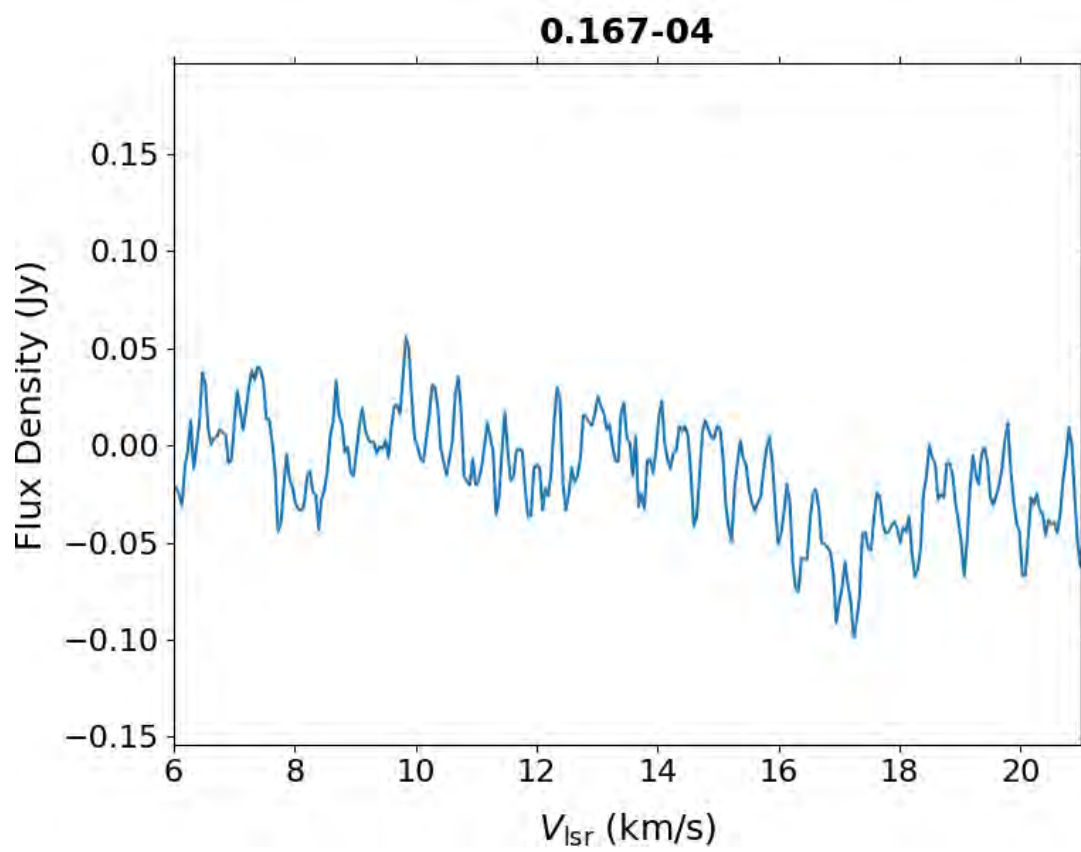
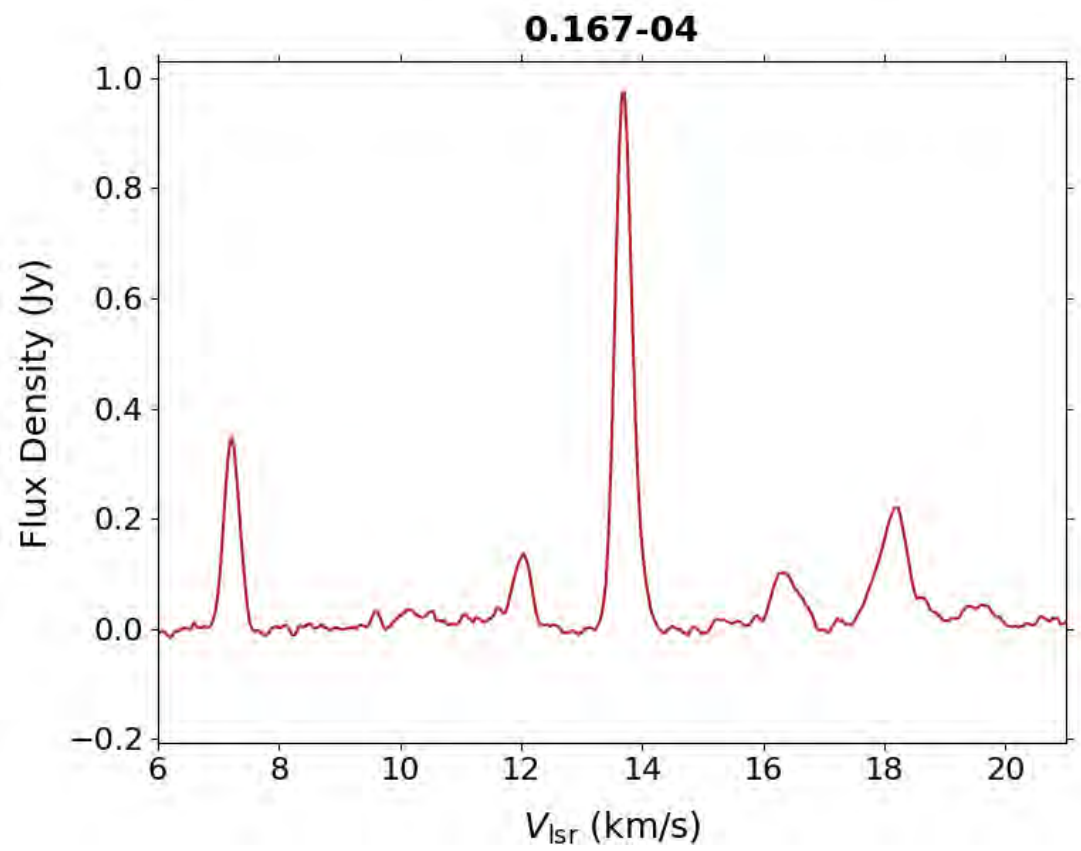
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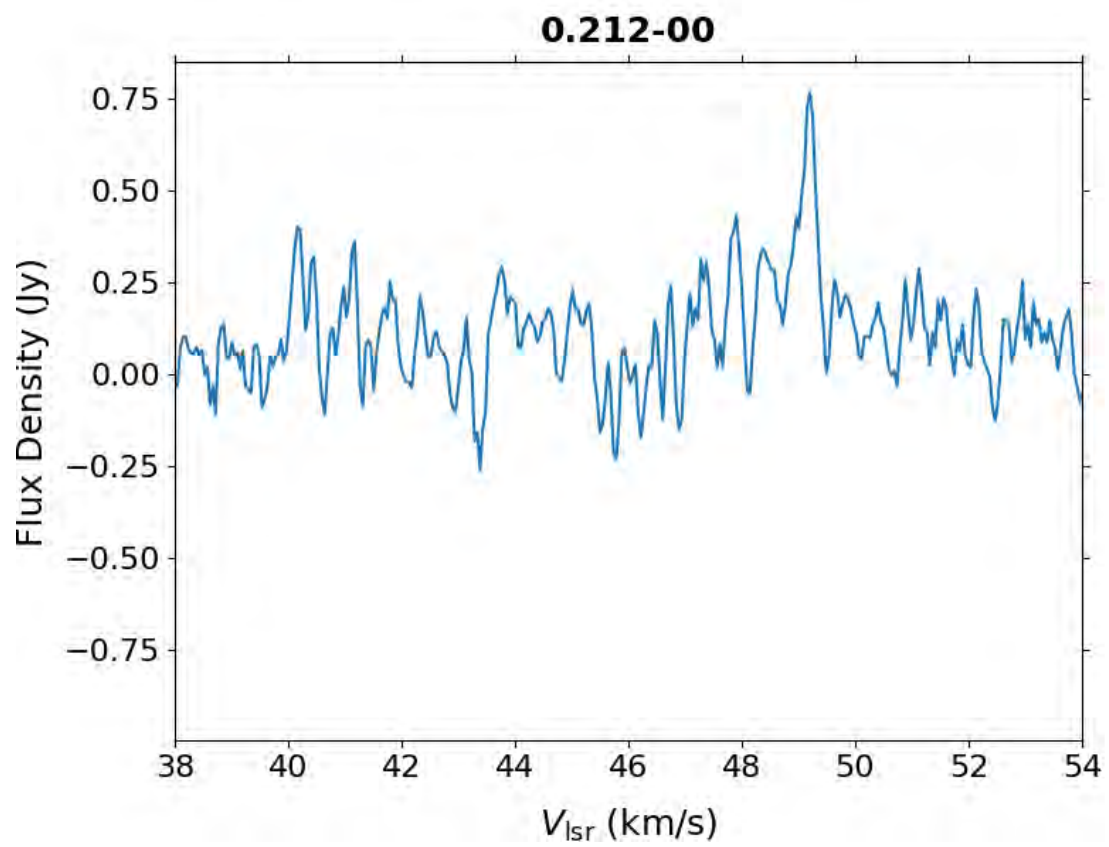
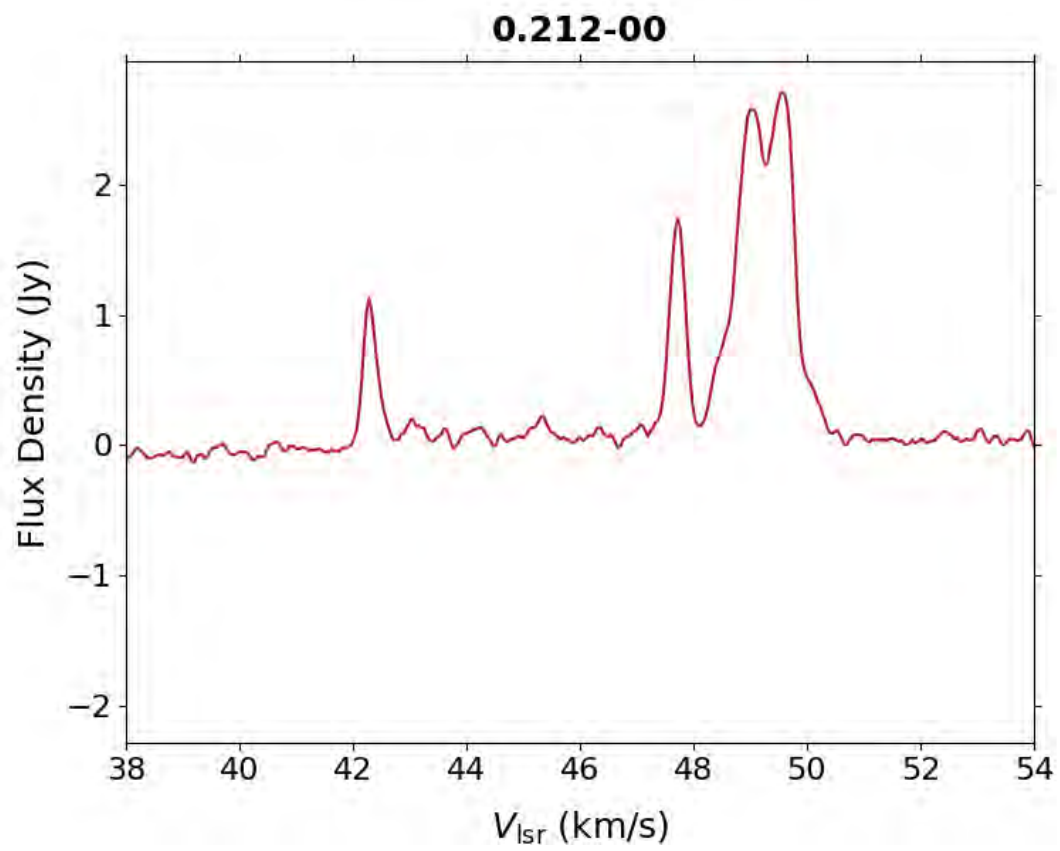
6.7 GHz メタノールメーザーではメーザー放射が検出されたが、12.2 GHz メタノールメーザーではメーザー放射が検出されなかった天体が 28 天体存在することを踏まえ、それがなぜかを調査していく。また、6.7 GHz メタノールメーザーは約 11 年観測を行っているのに対し 12.2 GHz メタノールメーザーの観測は約 1 年であるため、12.2 GHz メタノールメーザーは 6.7 GHz メタノールメーザーに比べてノイズが大きい。引き続き観測を行い、より多くのデータを得る必要がある。

参考文献

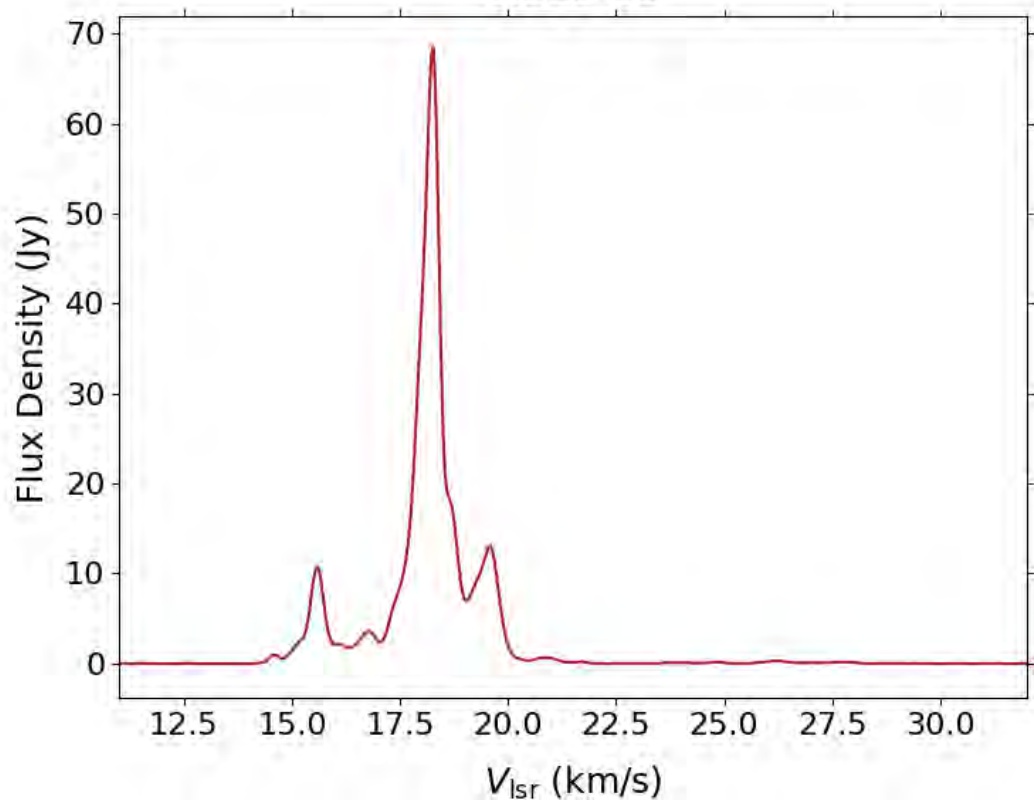
- [1] Ellingsen et al. MNRAS 354, 2, 401-413 (2004) Discovery of new 19.9 - GHz methanol masers in star - forming regions
- [2] Breen et al. 2011 STATISTICAL PROPERTIES OF 12.2 GHz METHANOL MASERS ASSOCIATED WITH A COMPLETE SAMPLE OF 6.7 GHz METHANOL MASERS



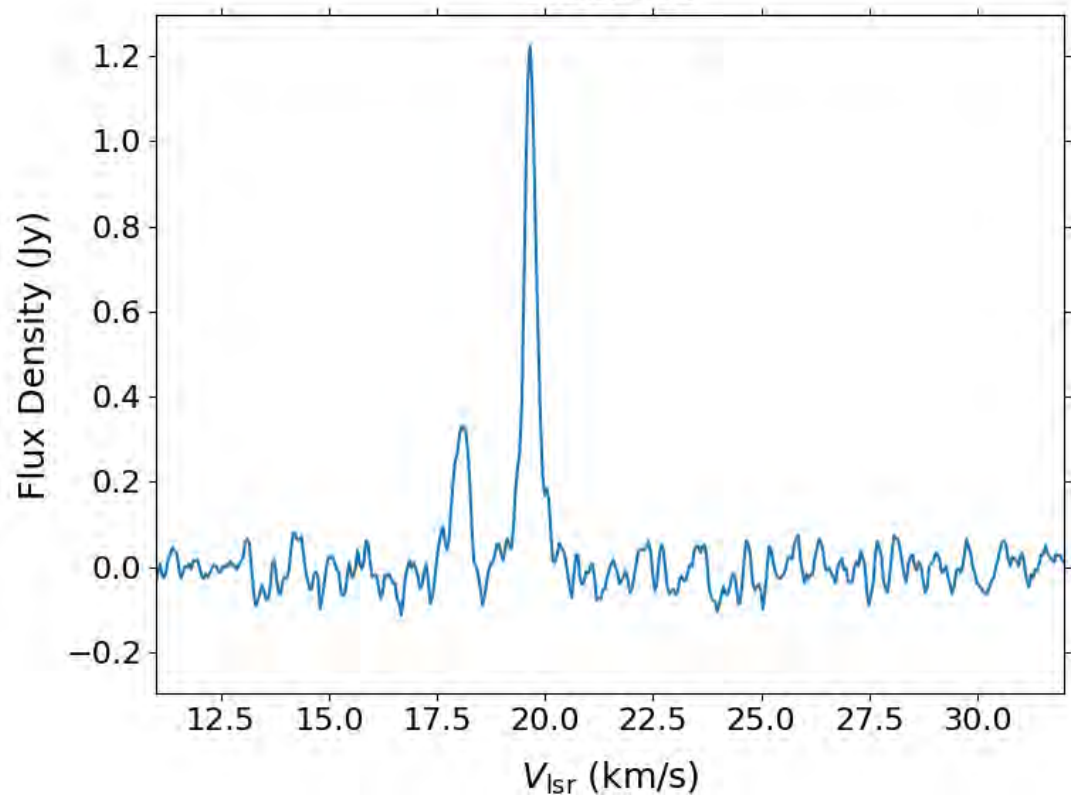


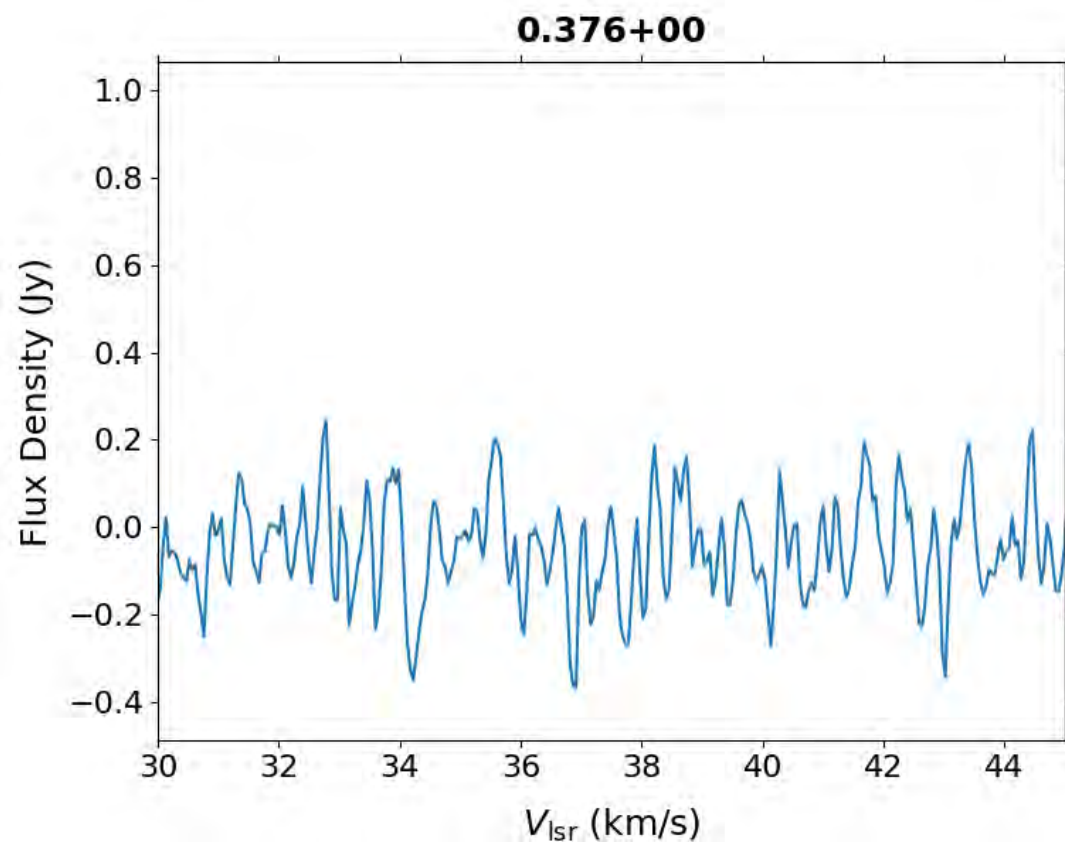
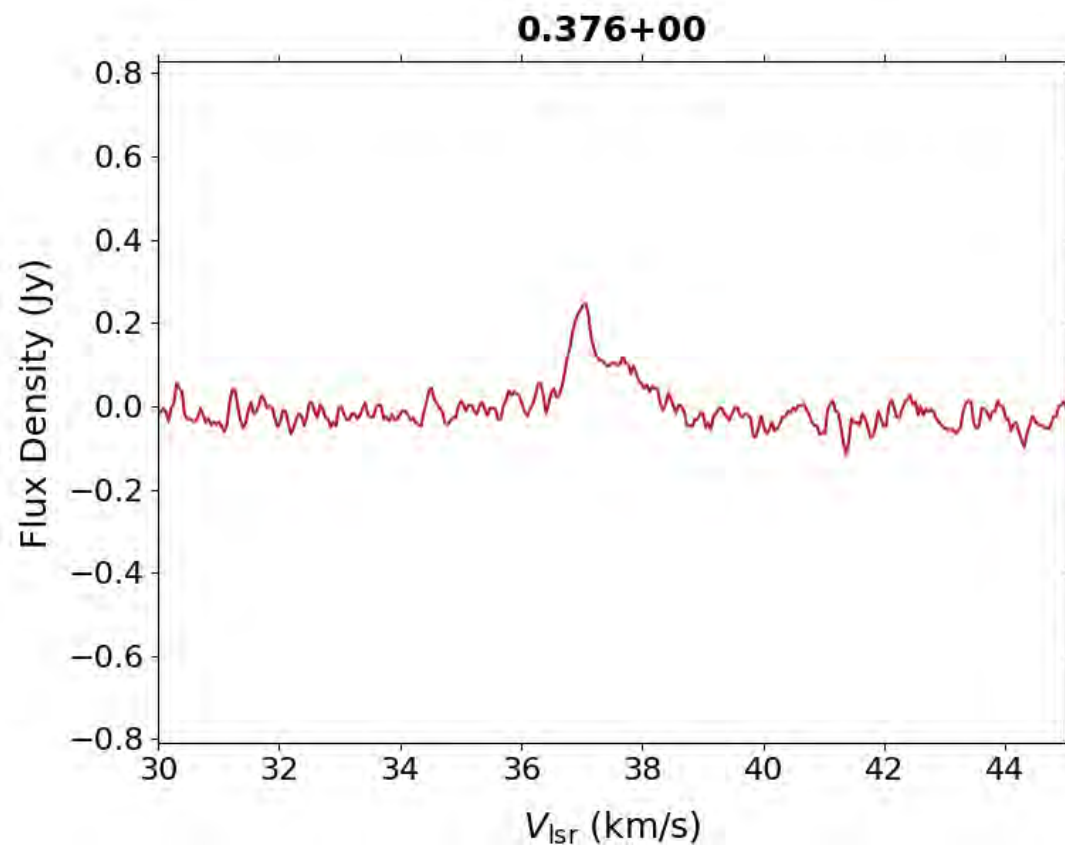


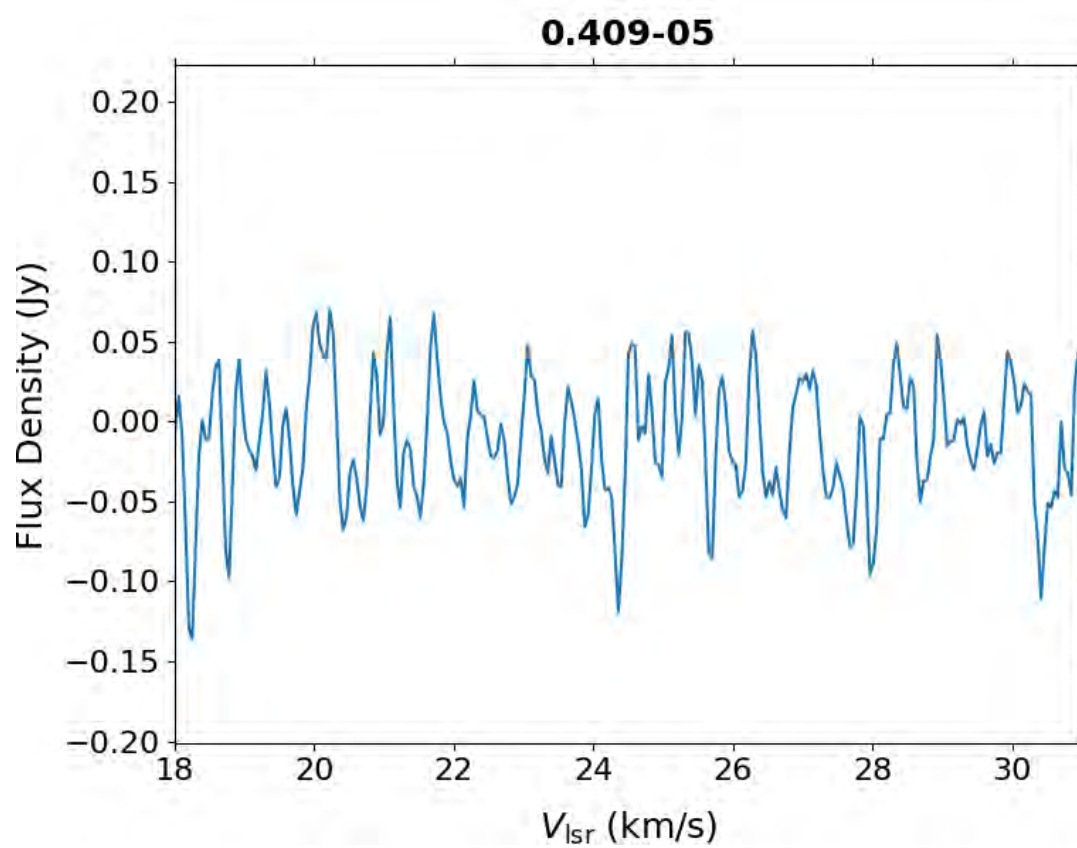
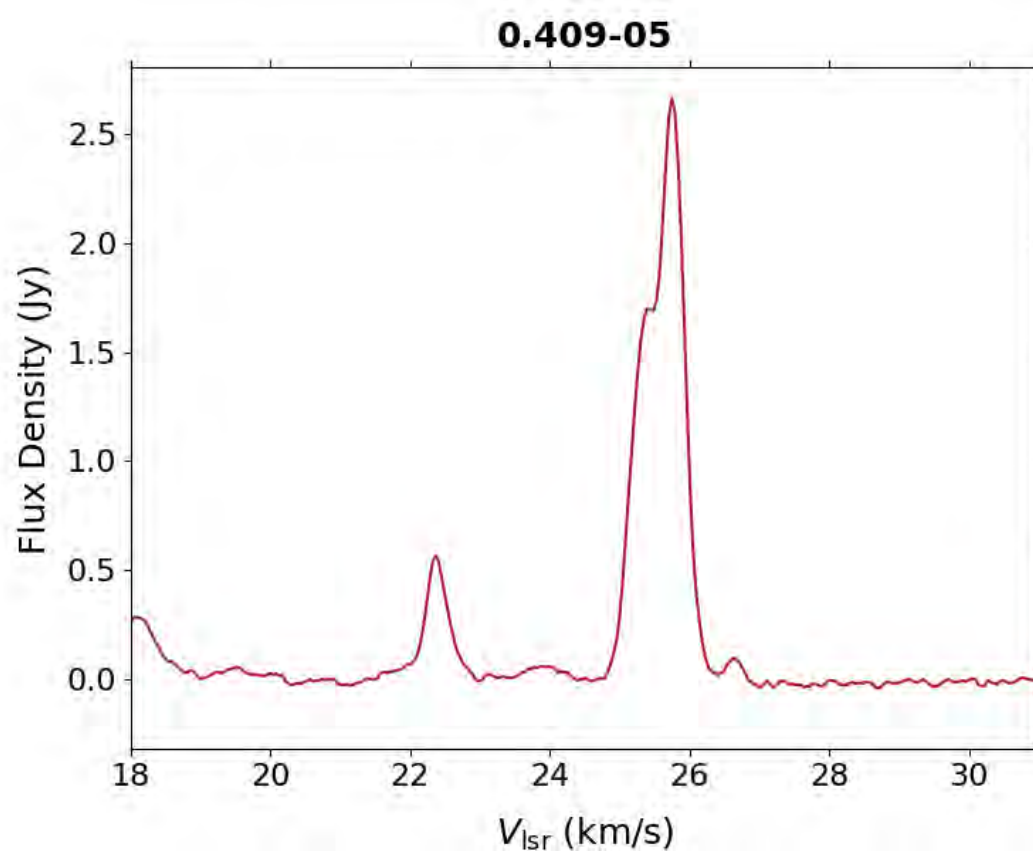
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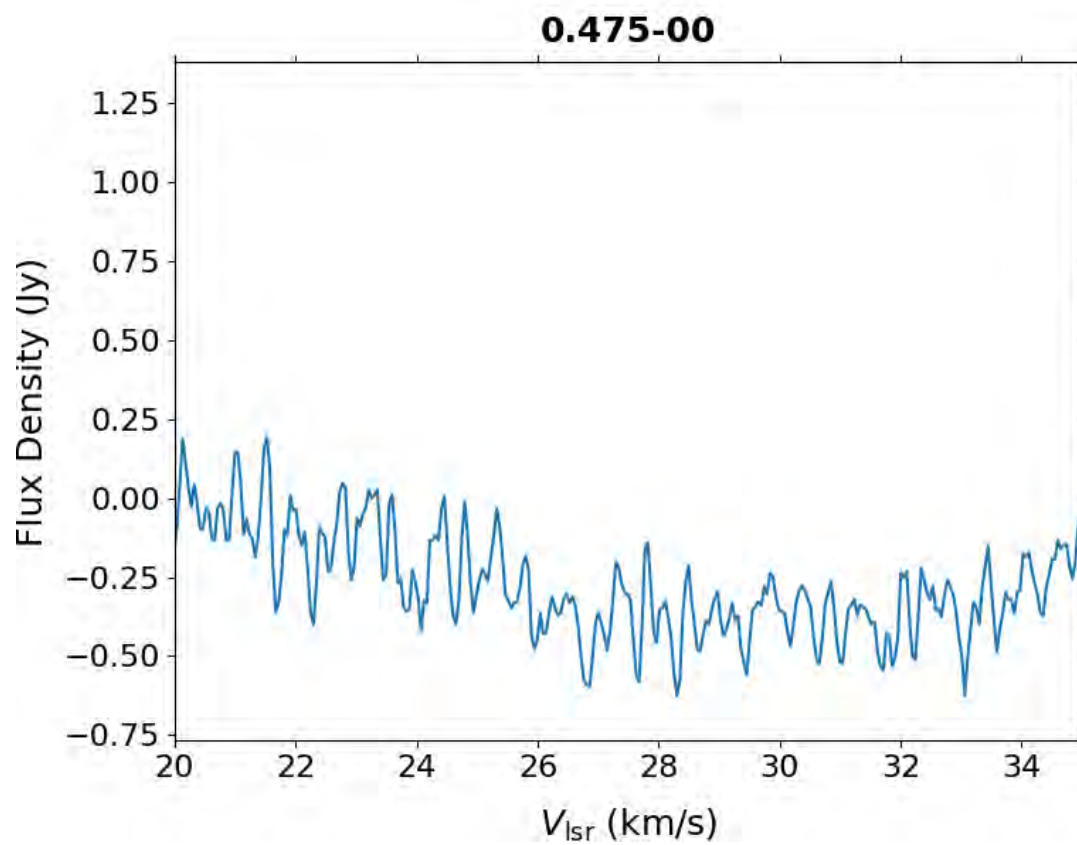
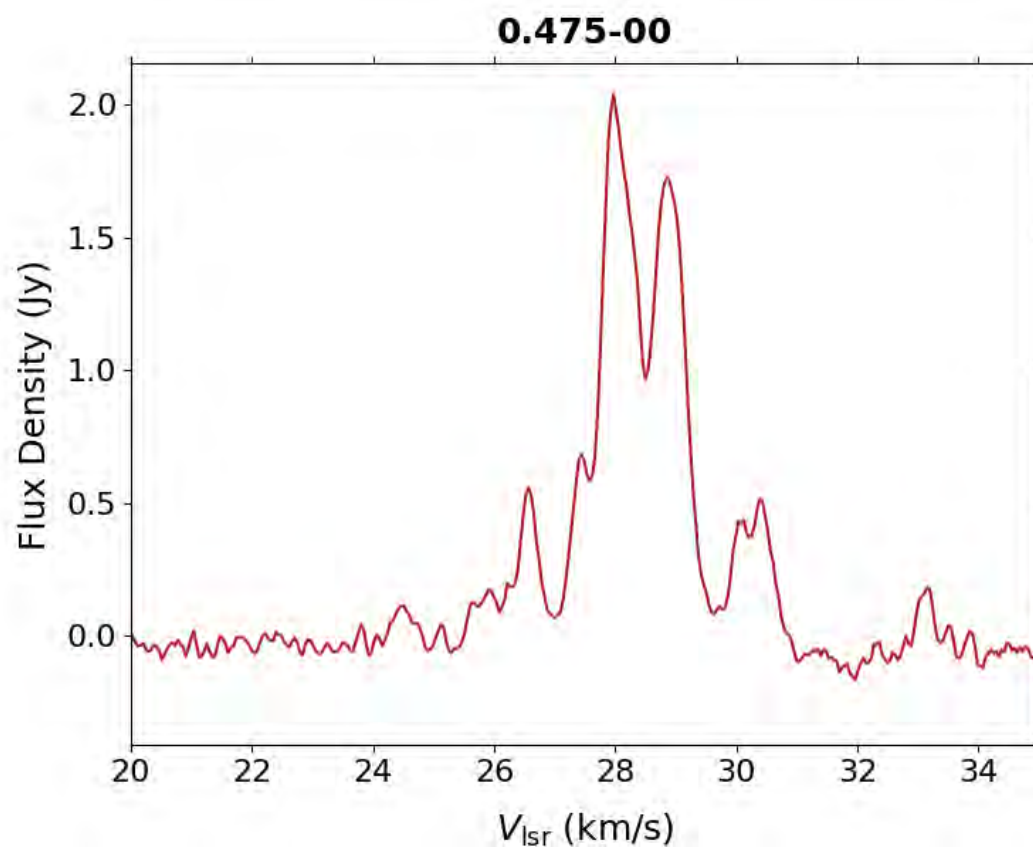


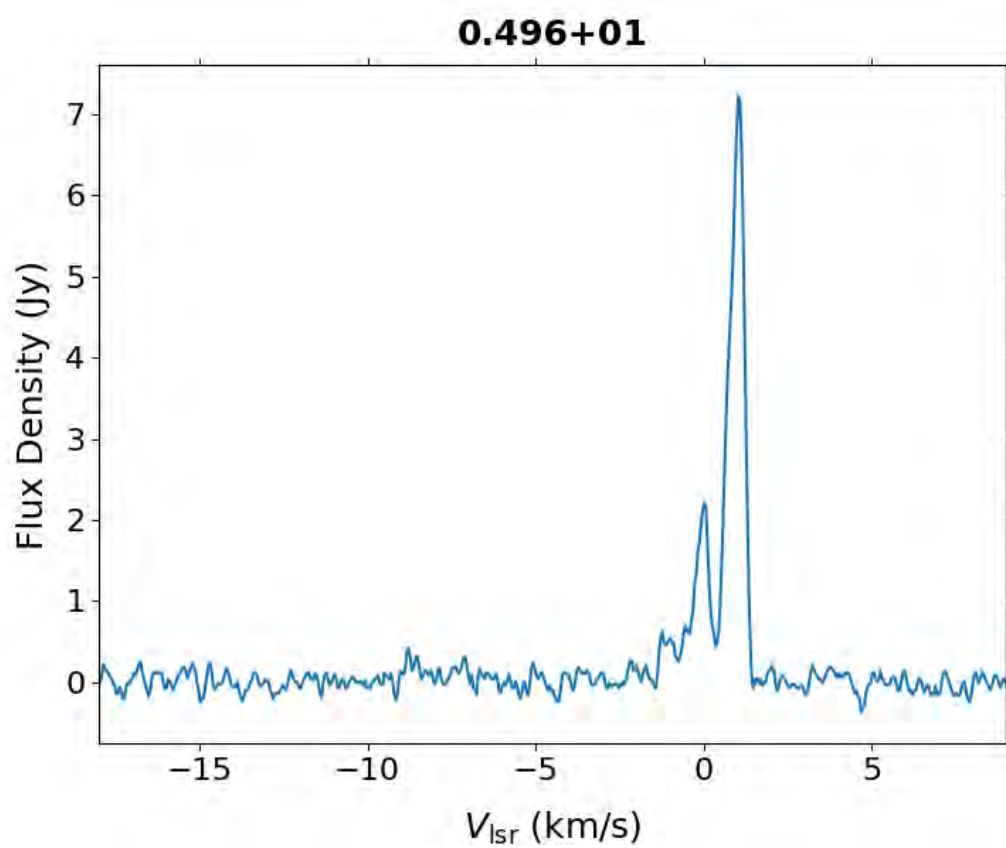
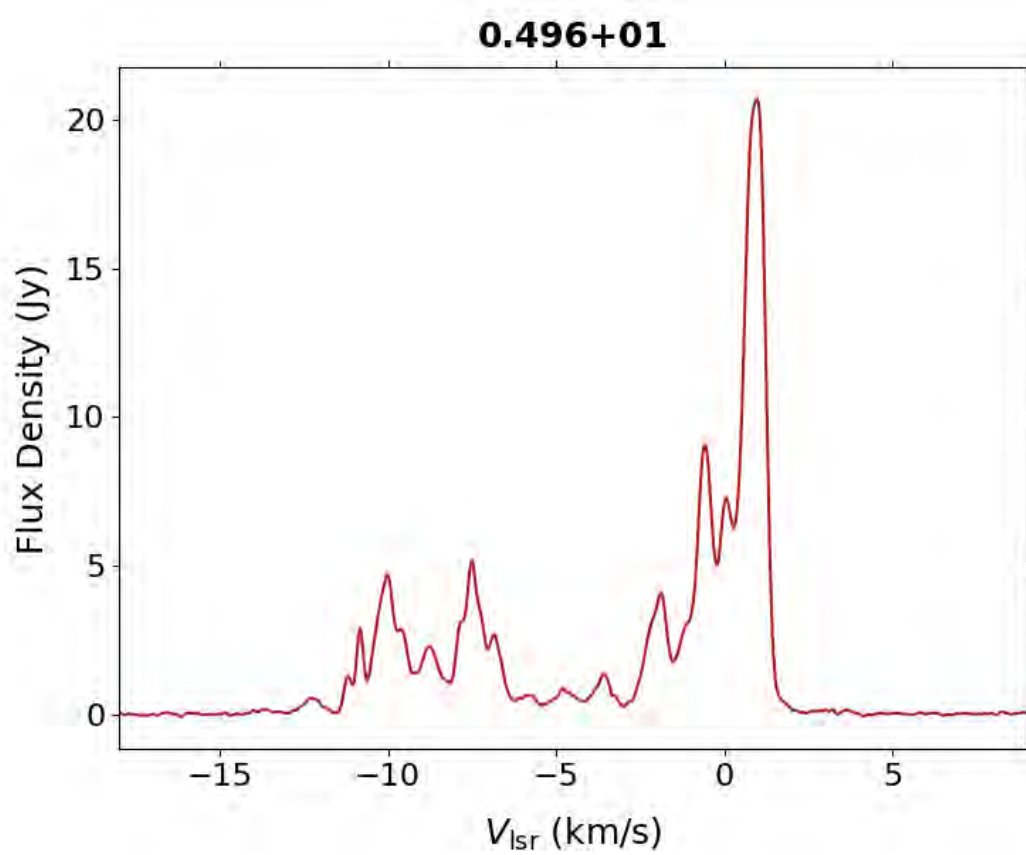
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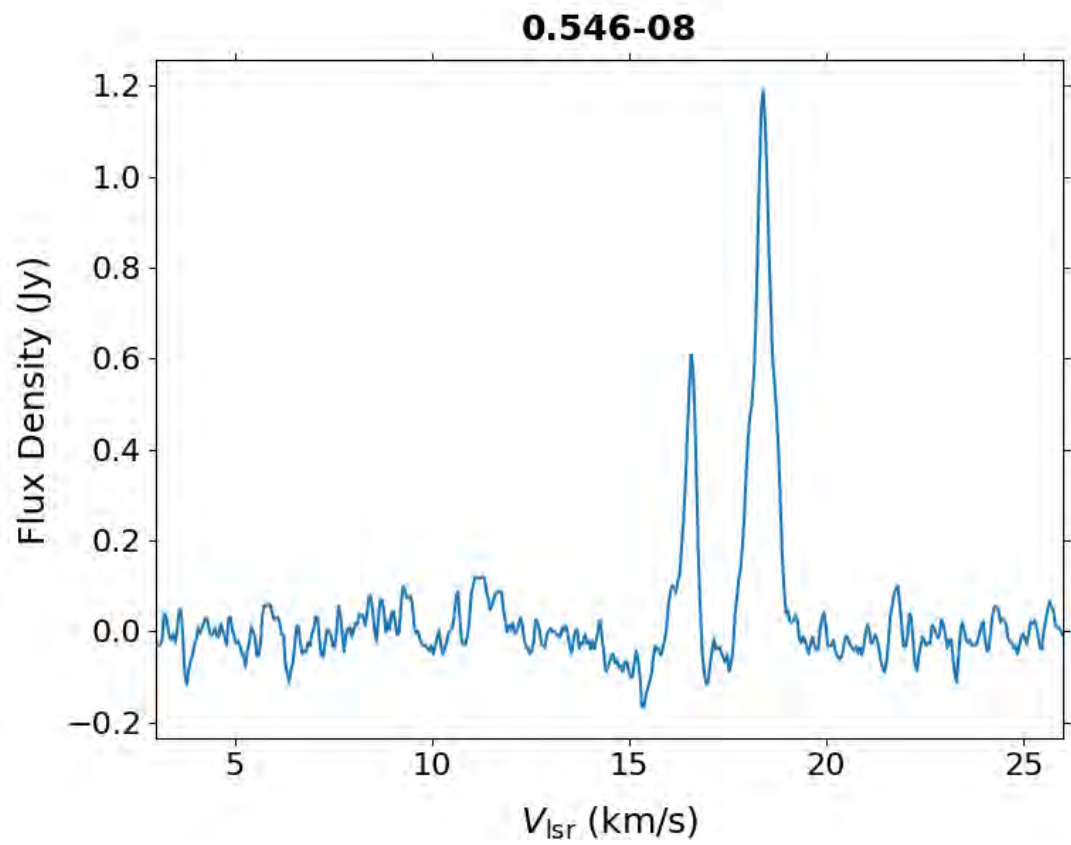
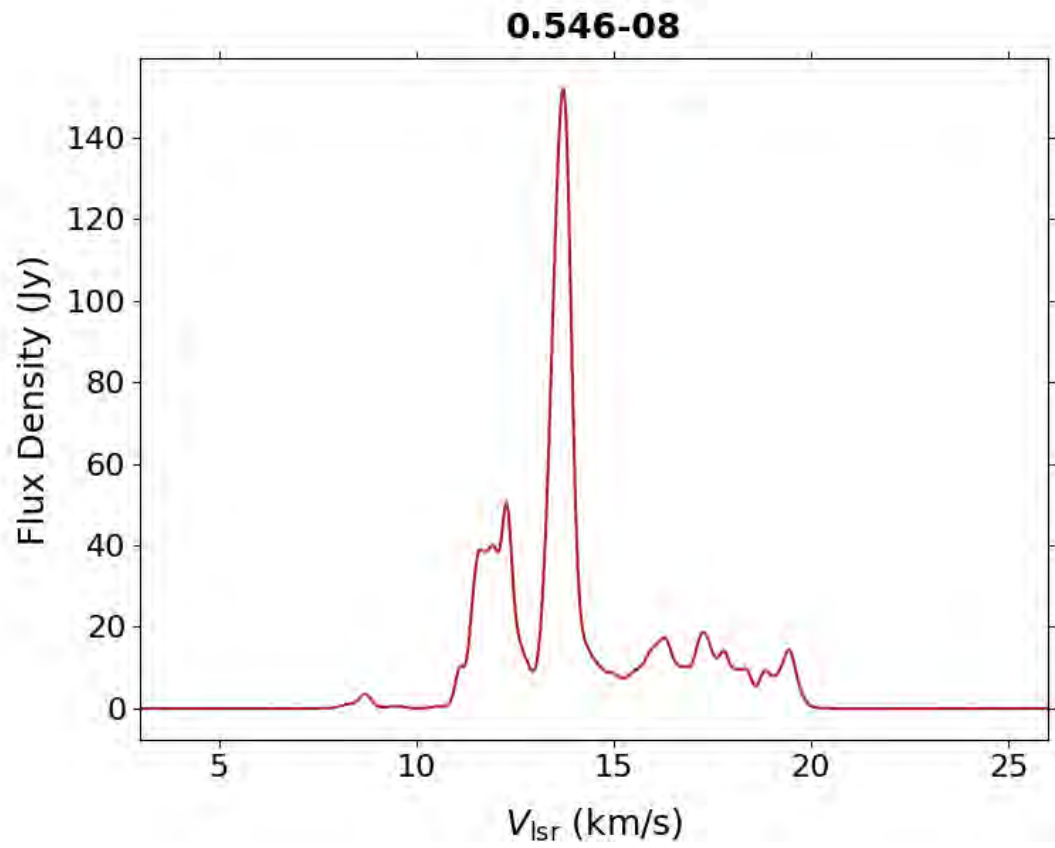




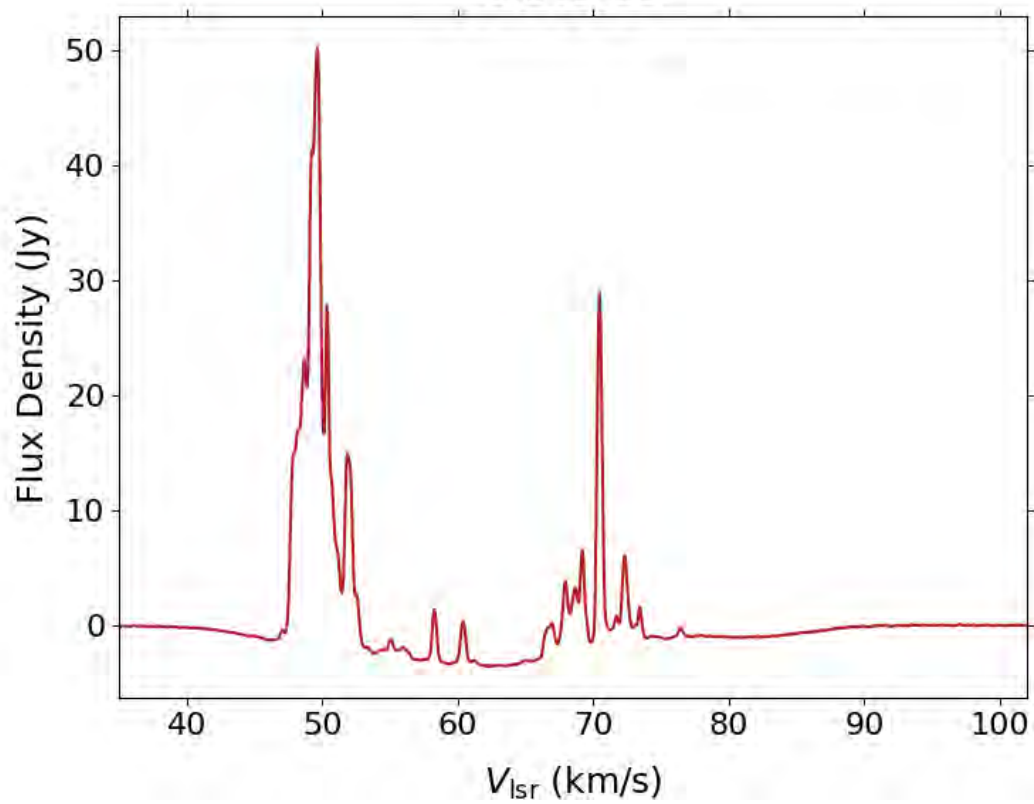




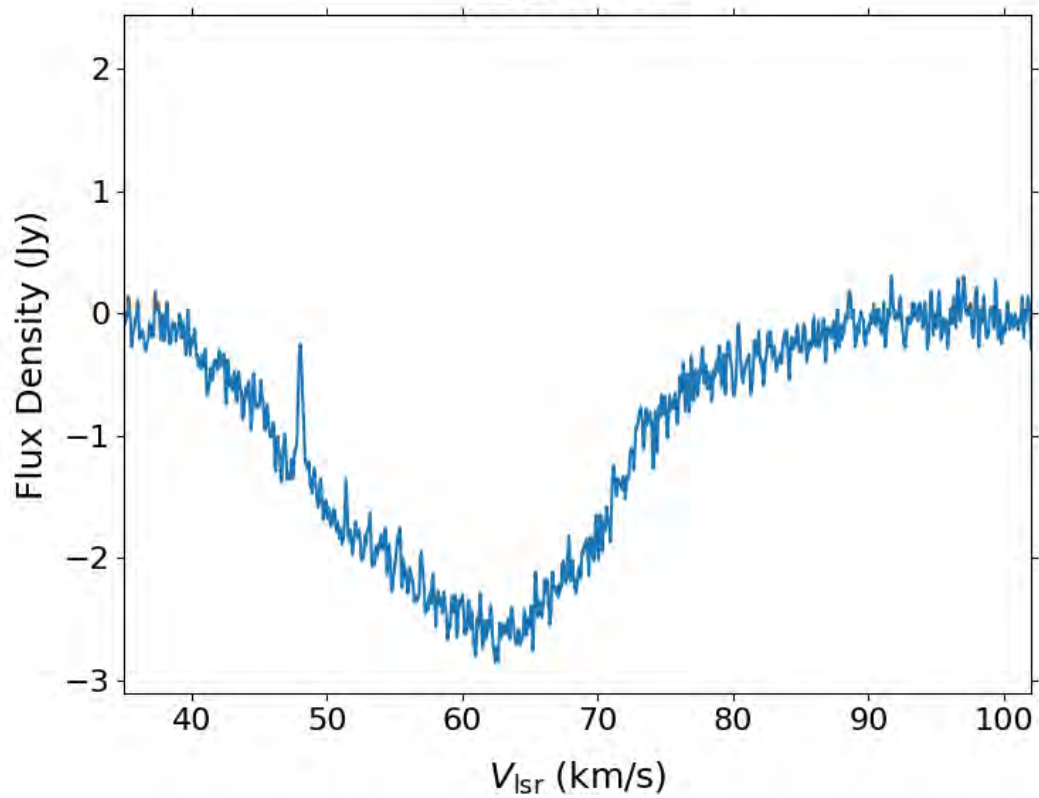


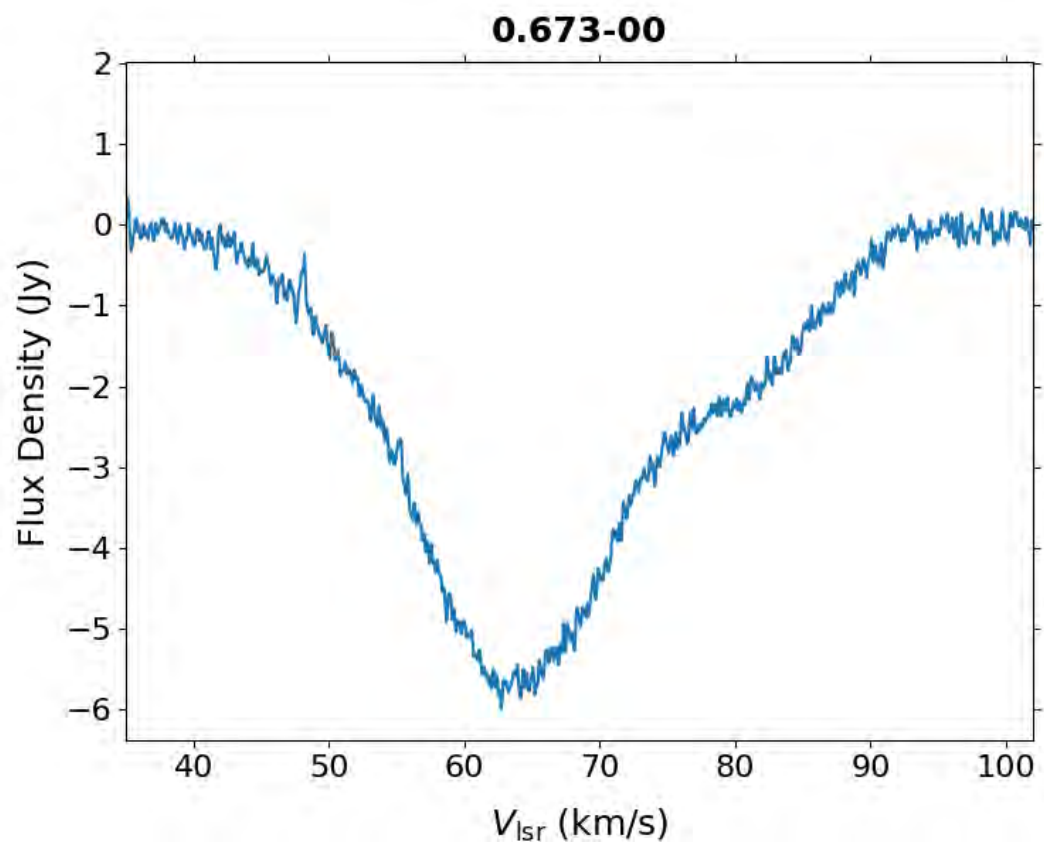
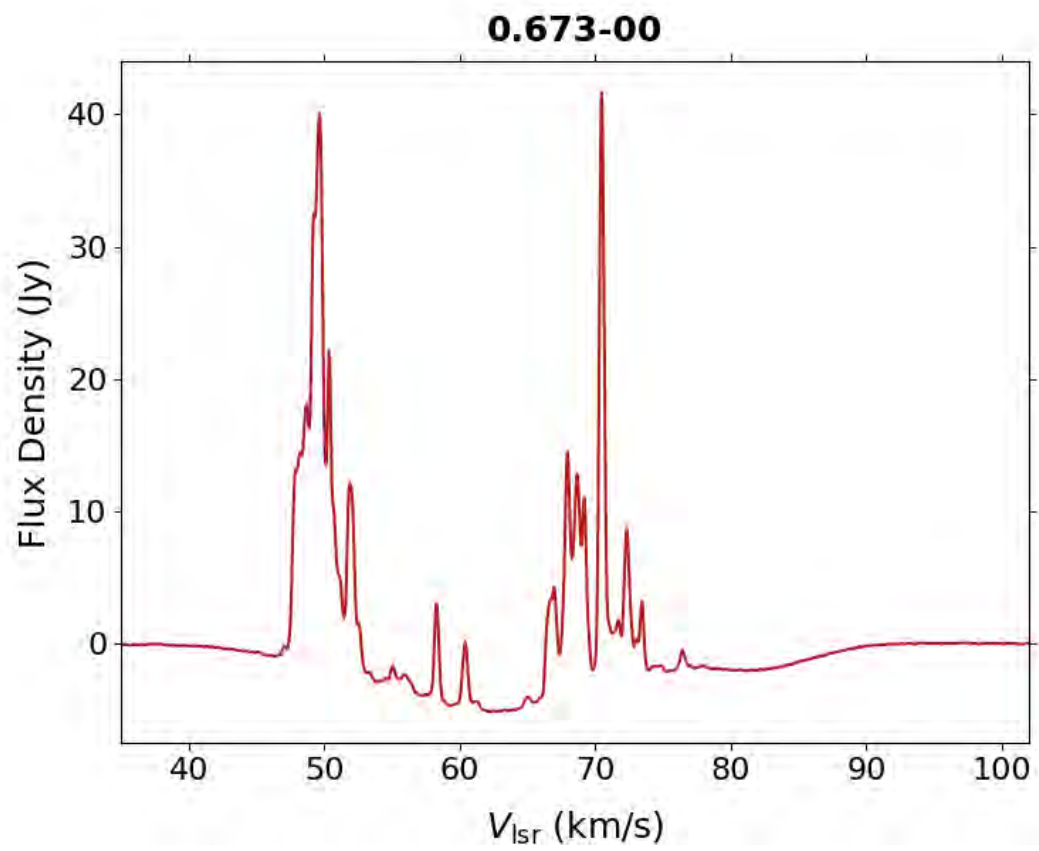


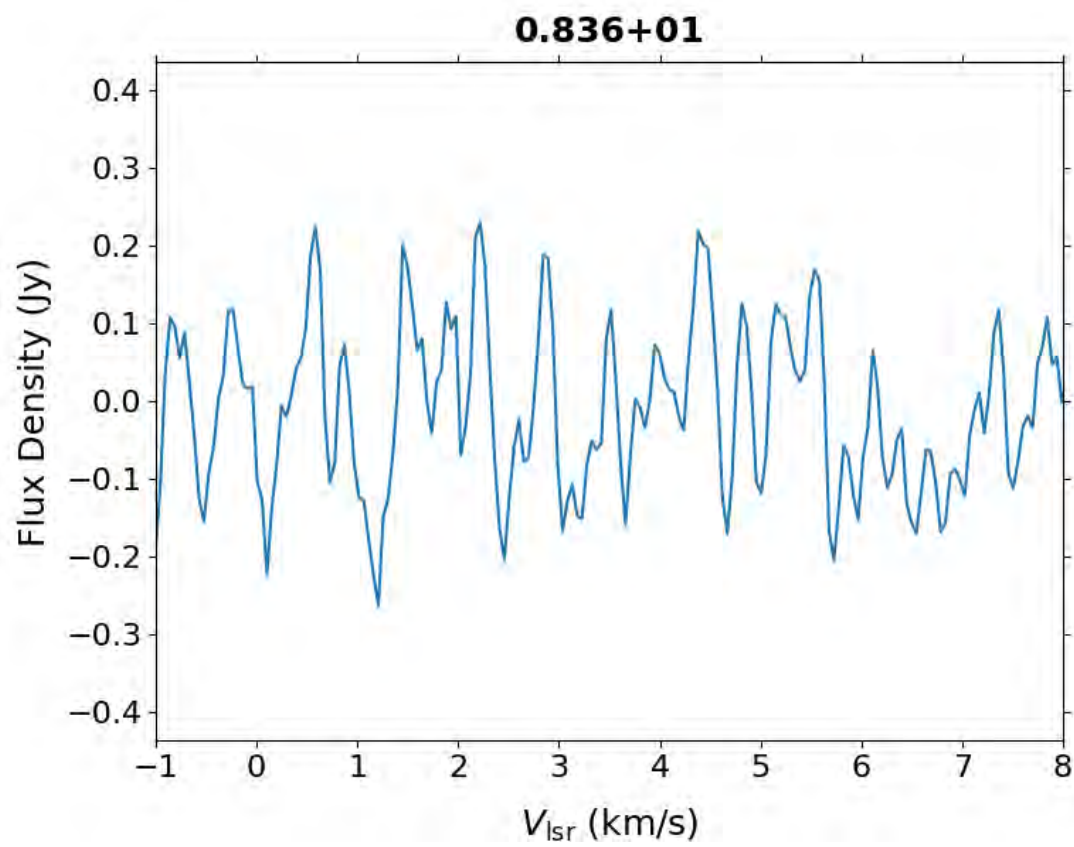
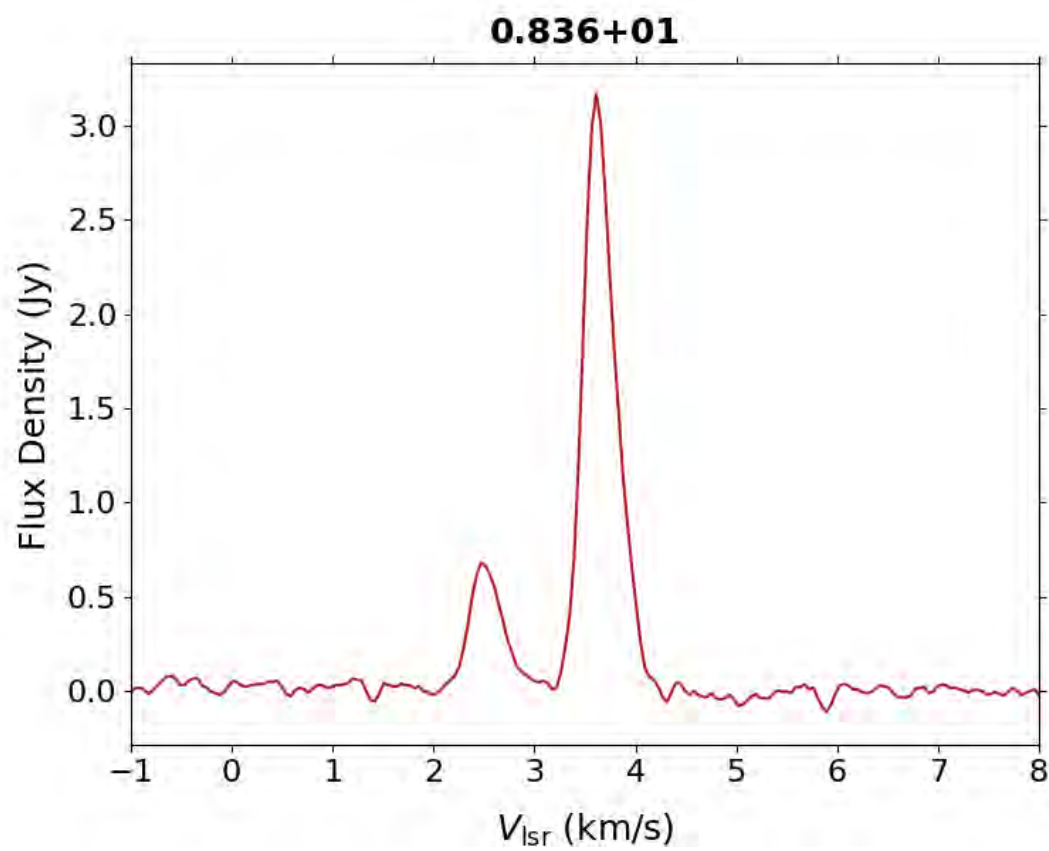
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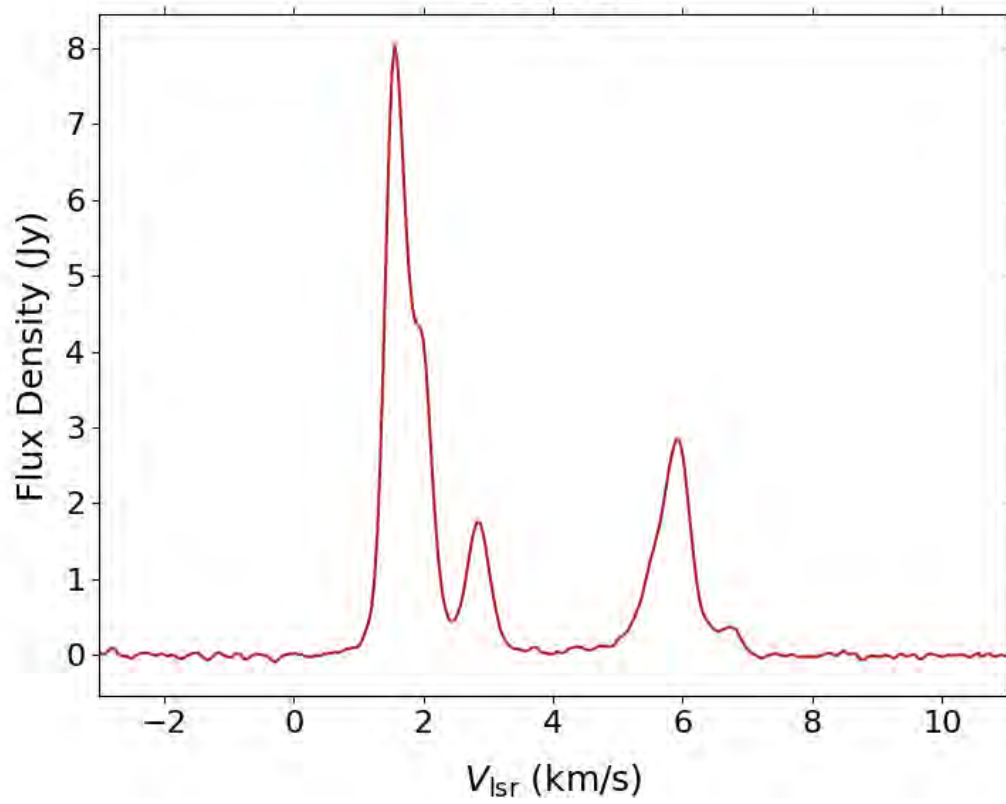
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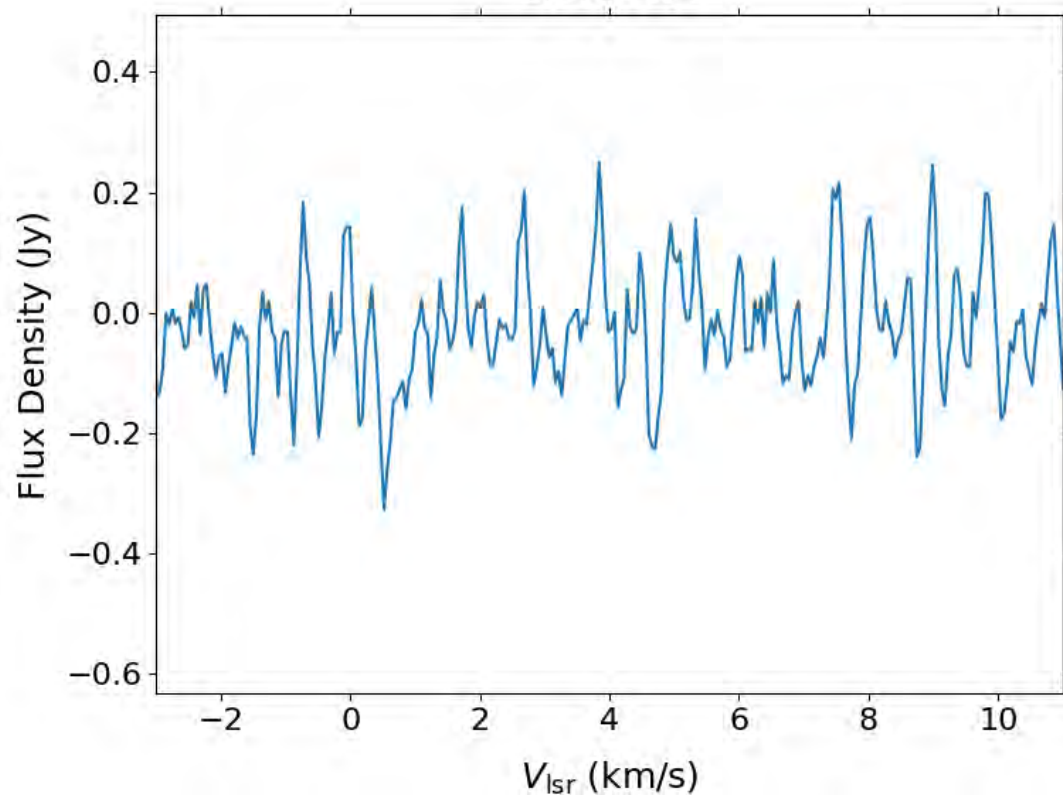


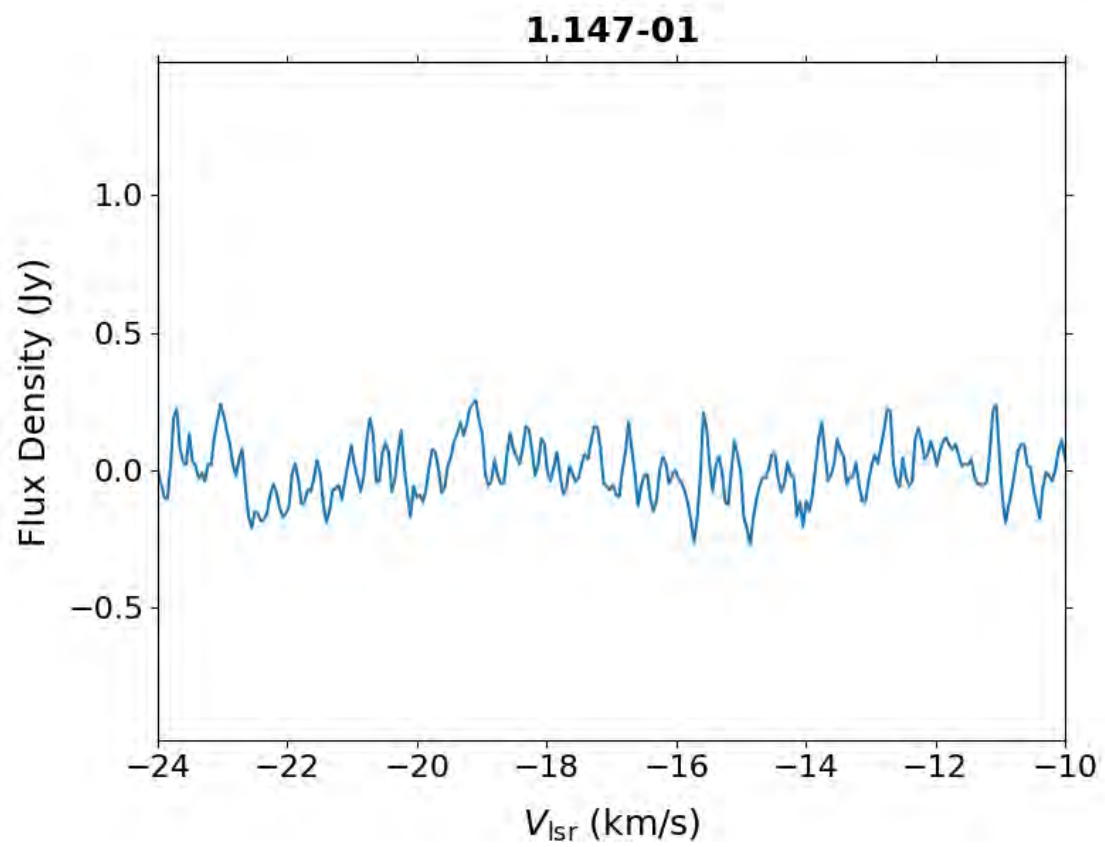
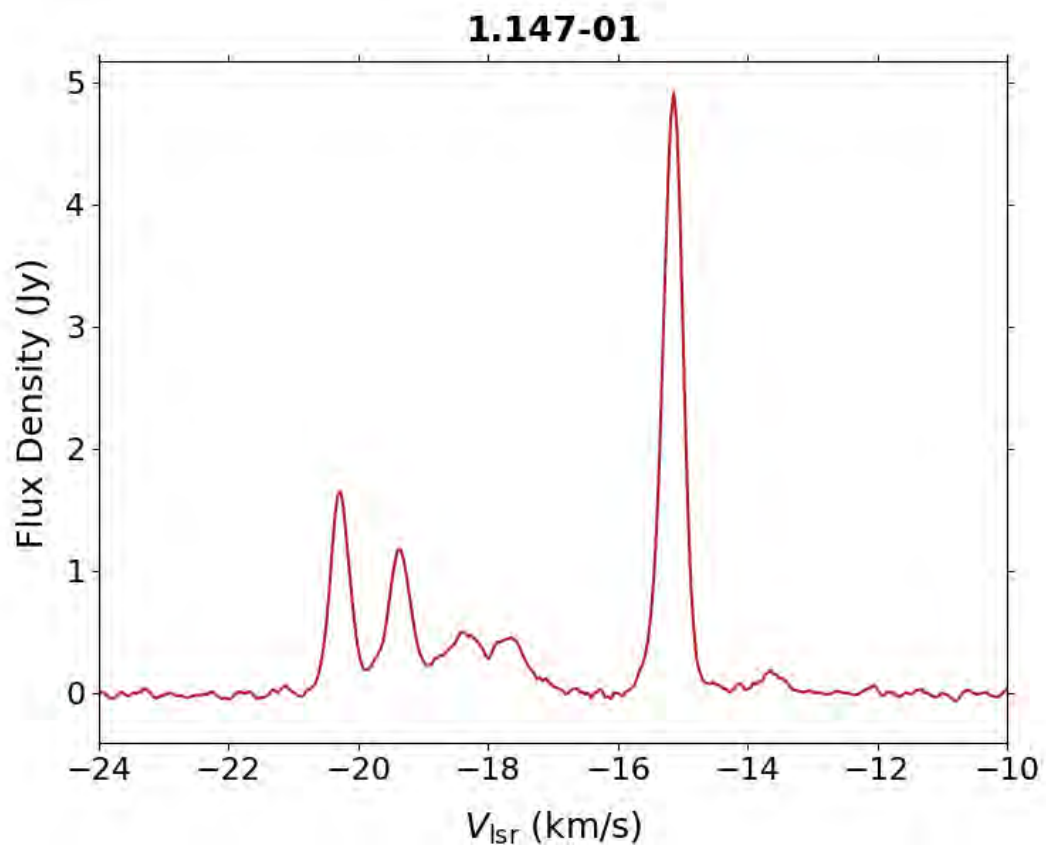


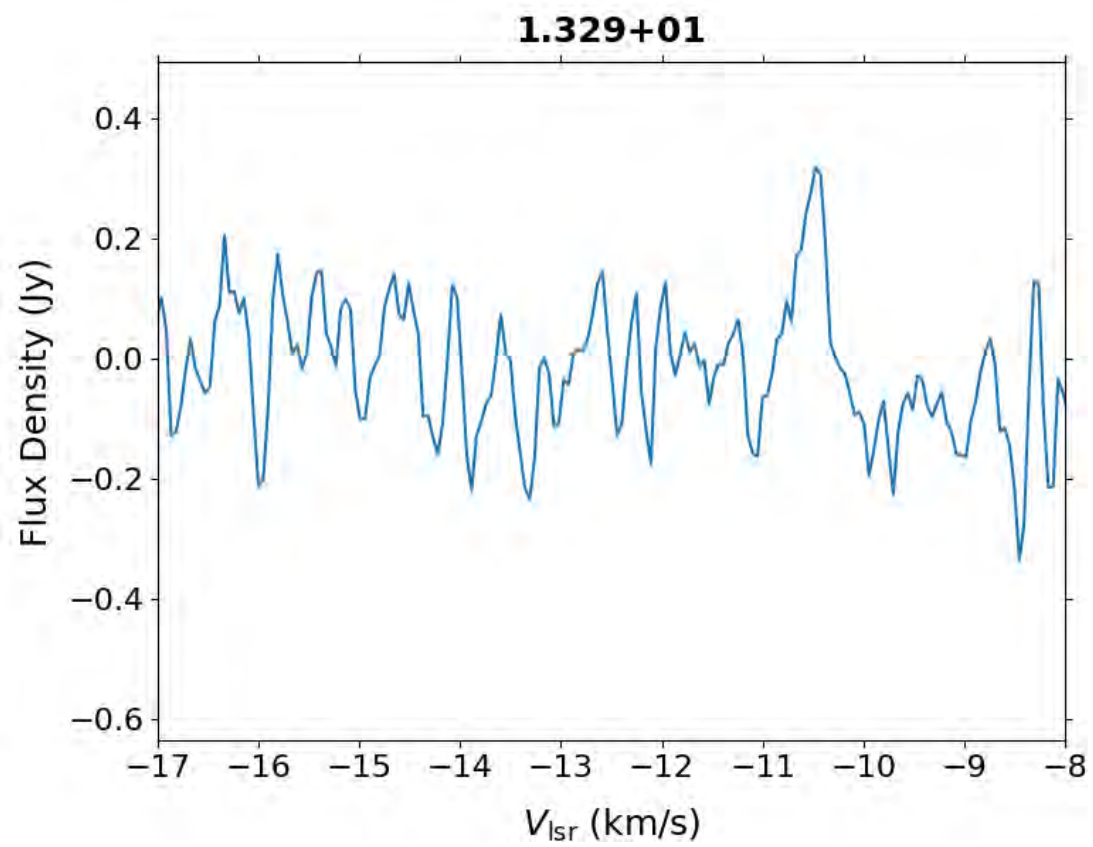
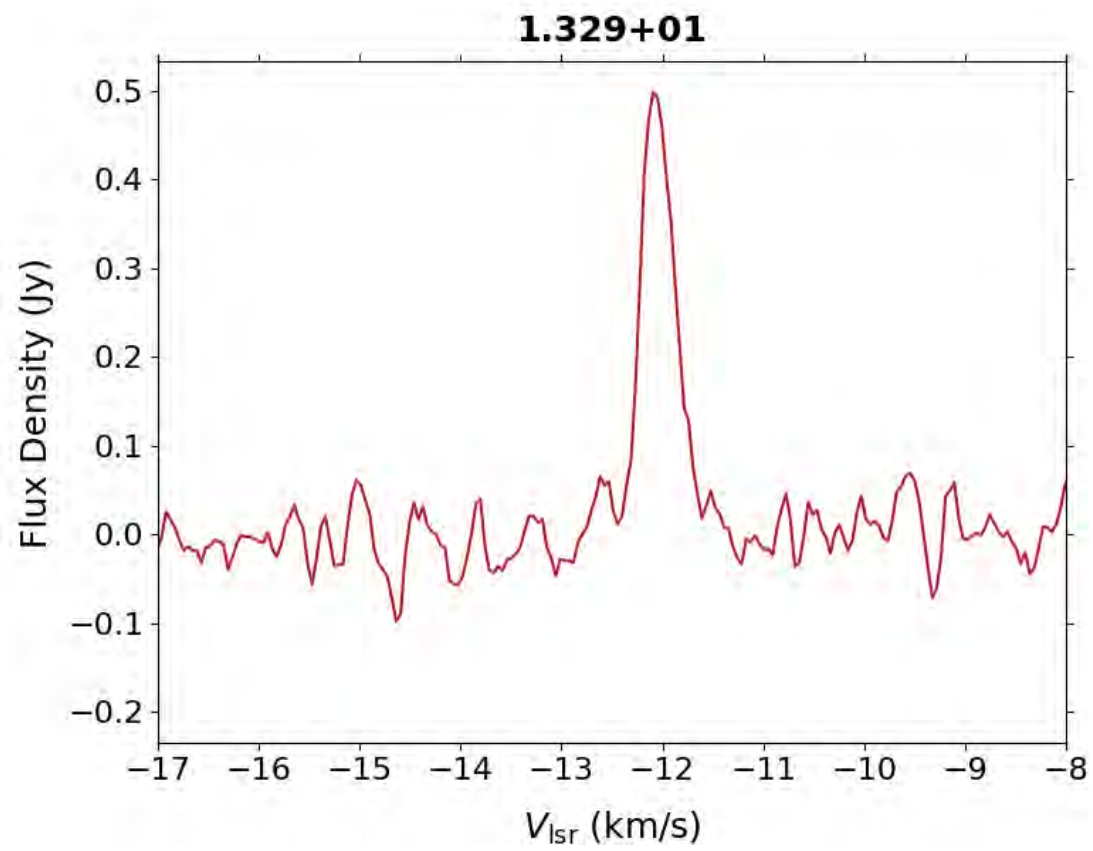
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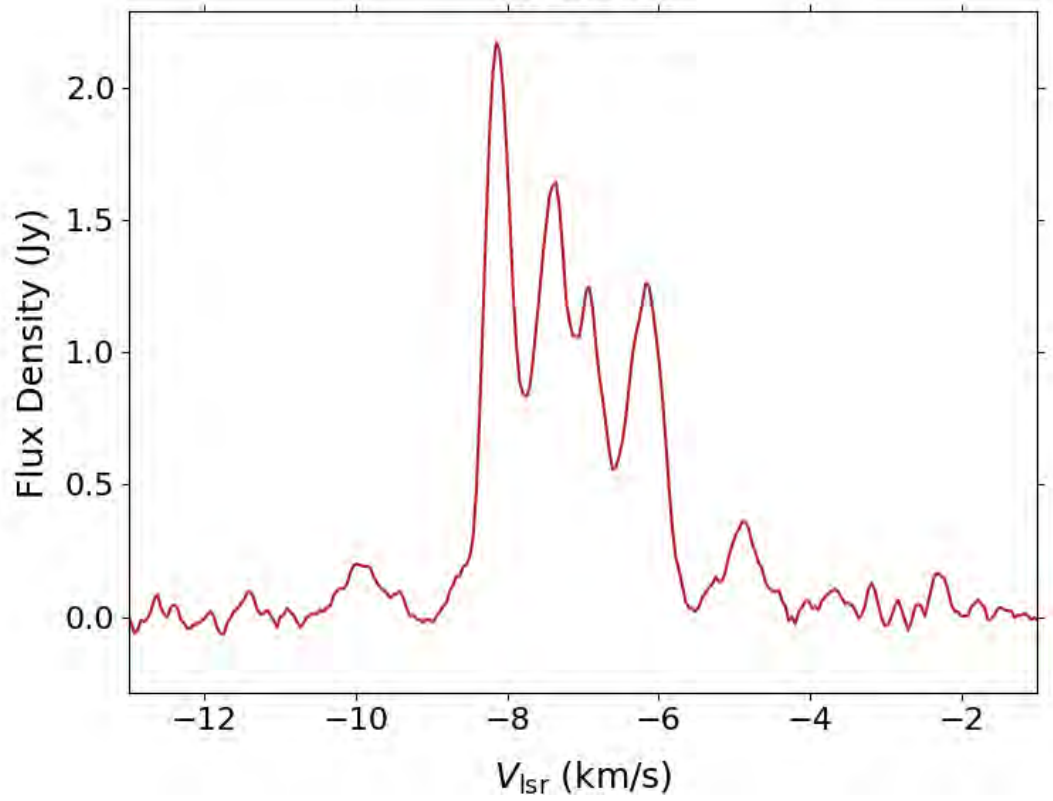
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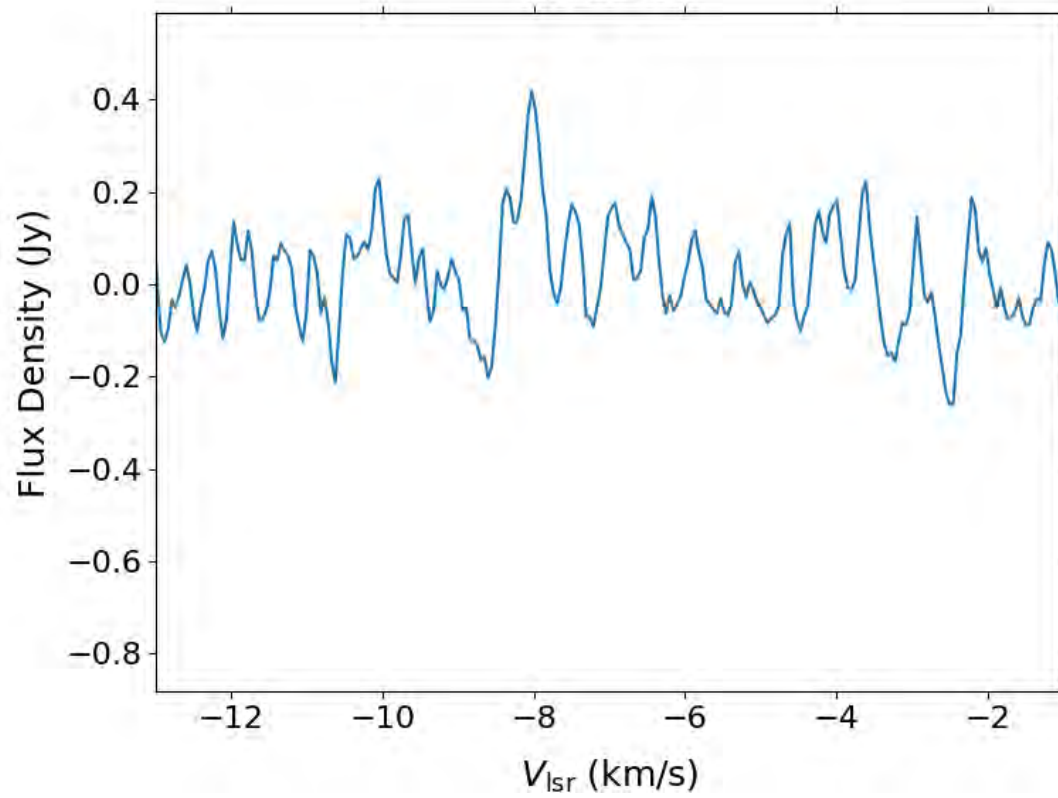




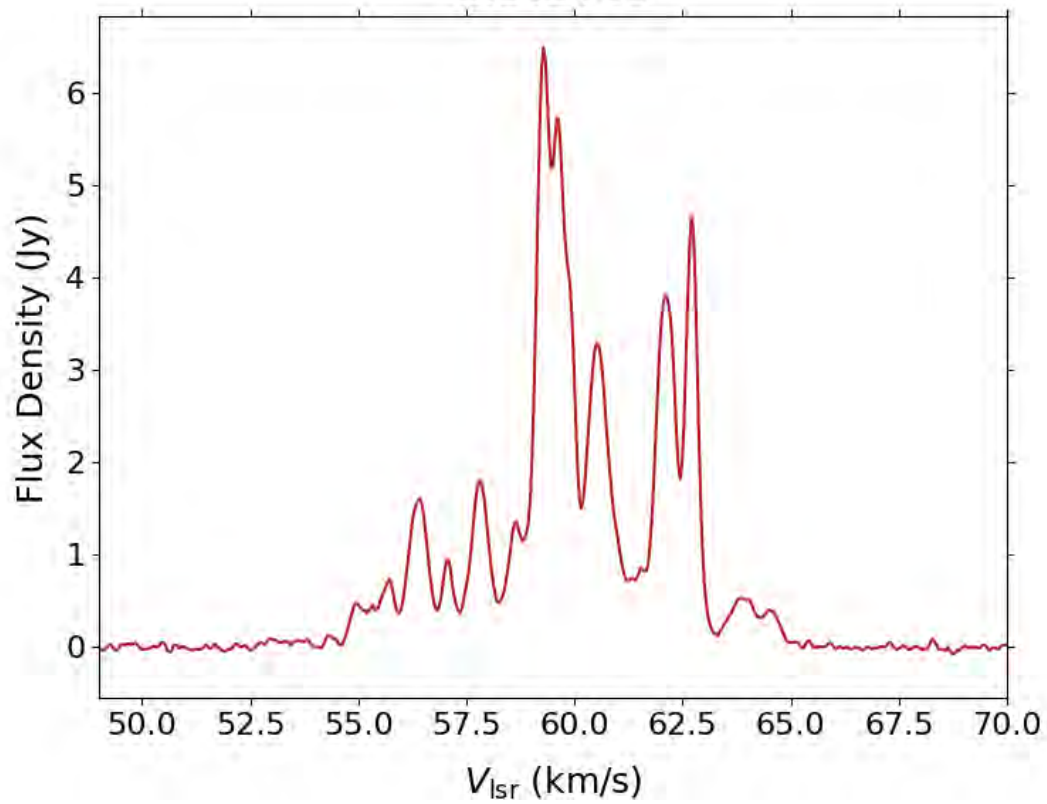
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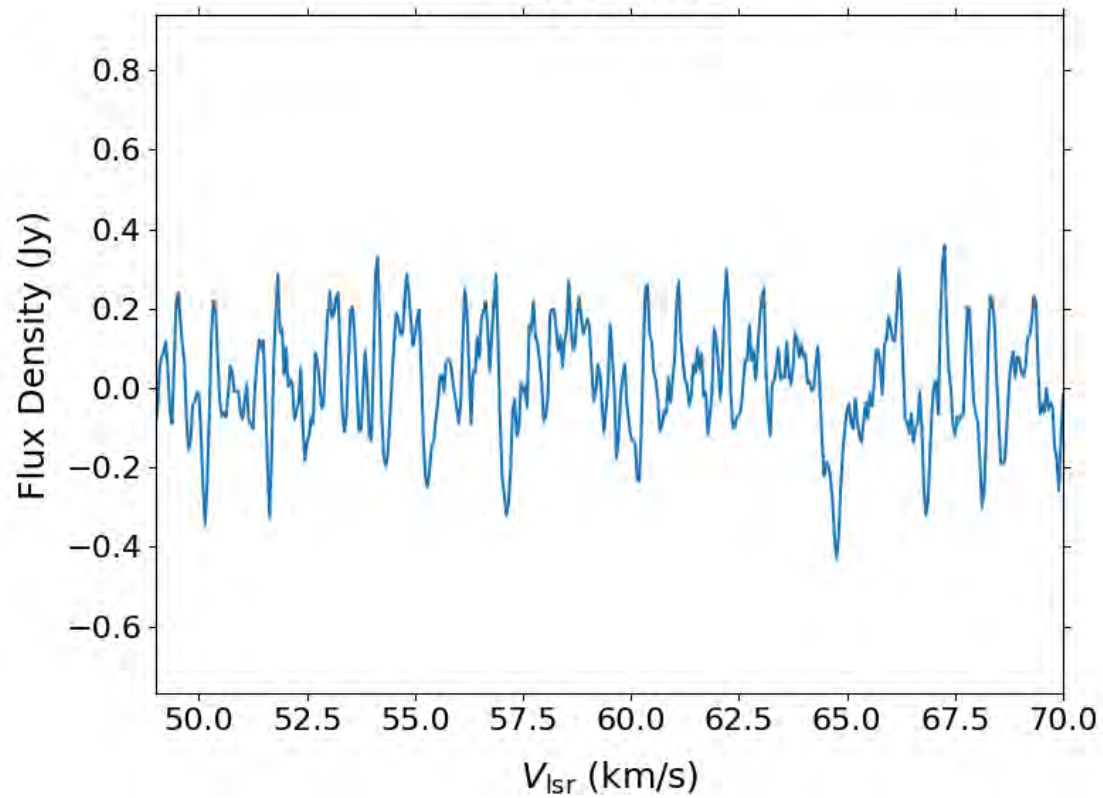
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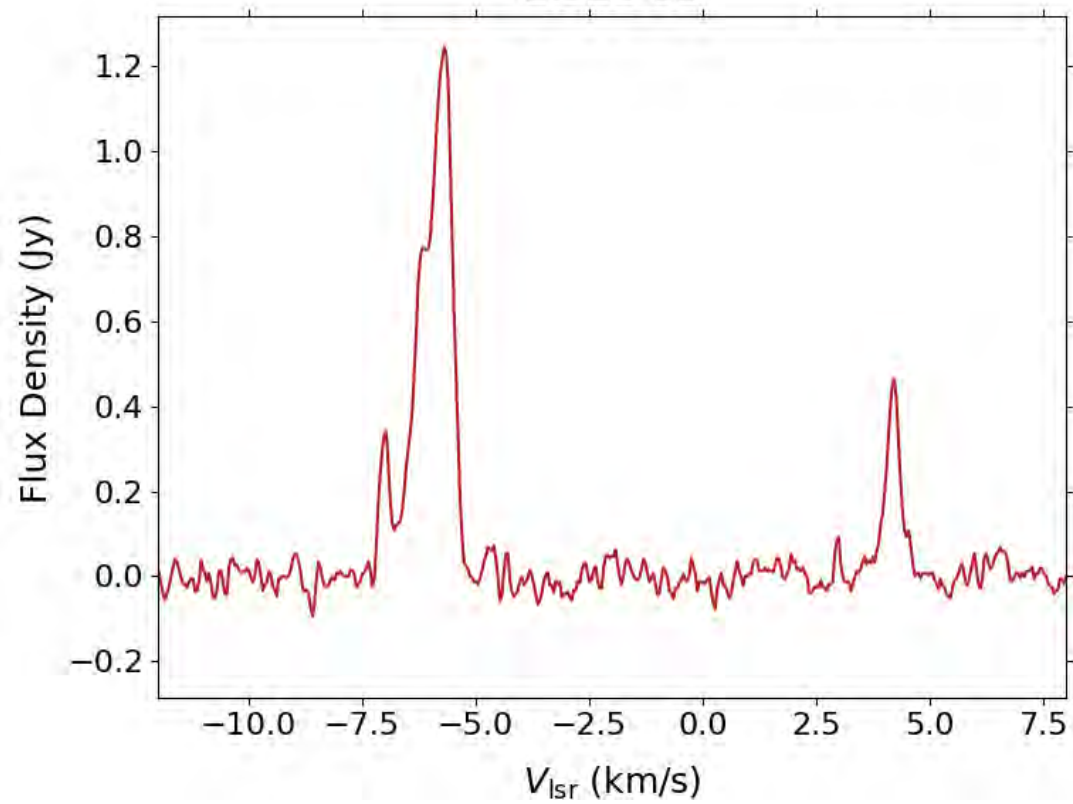
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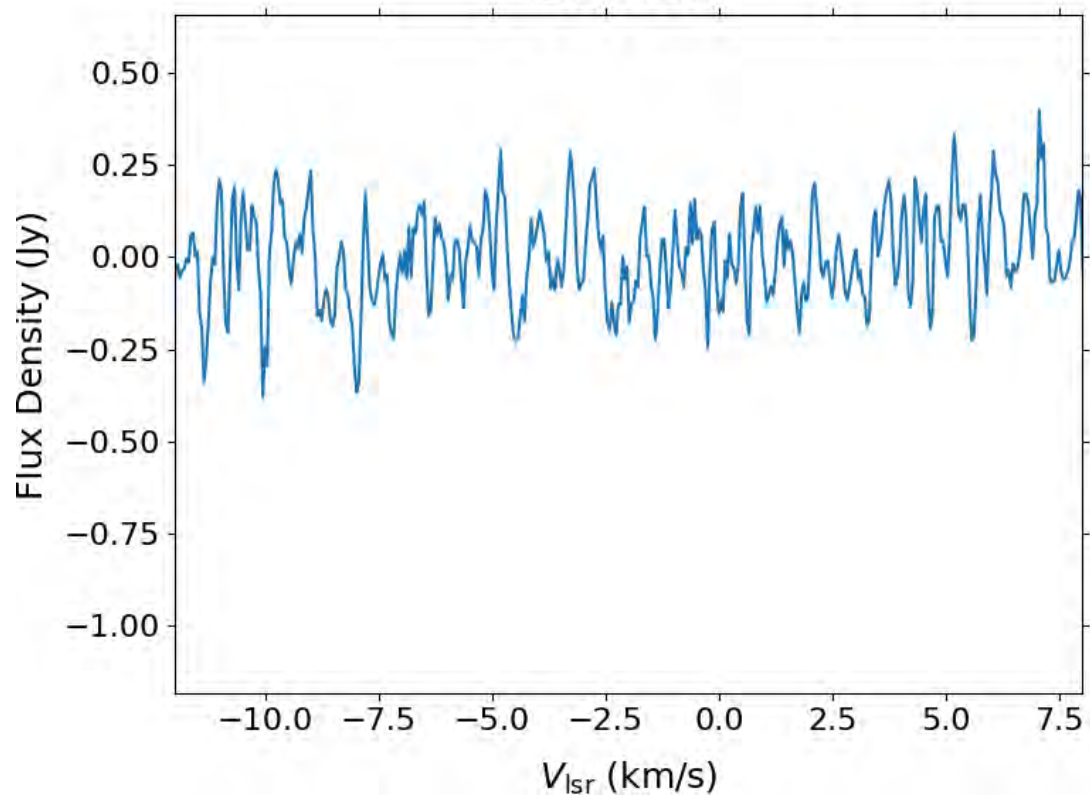
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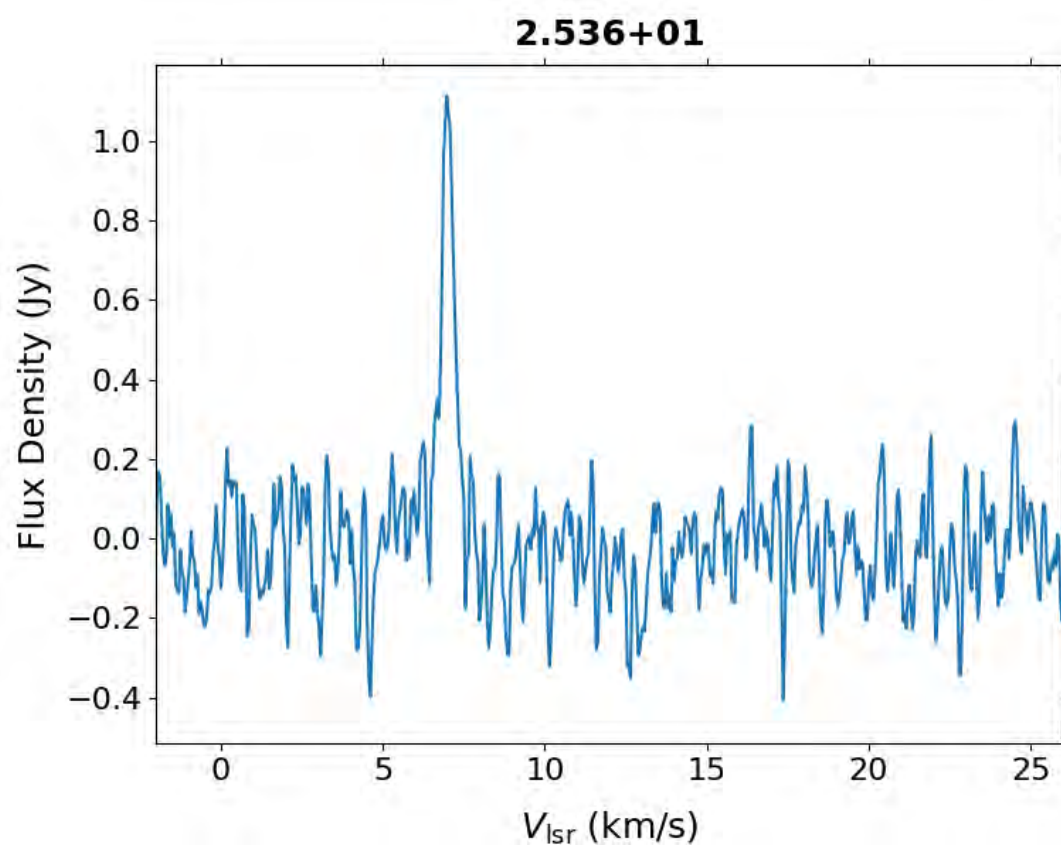
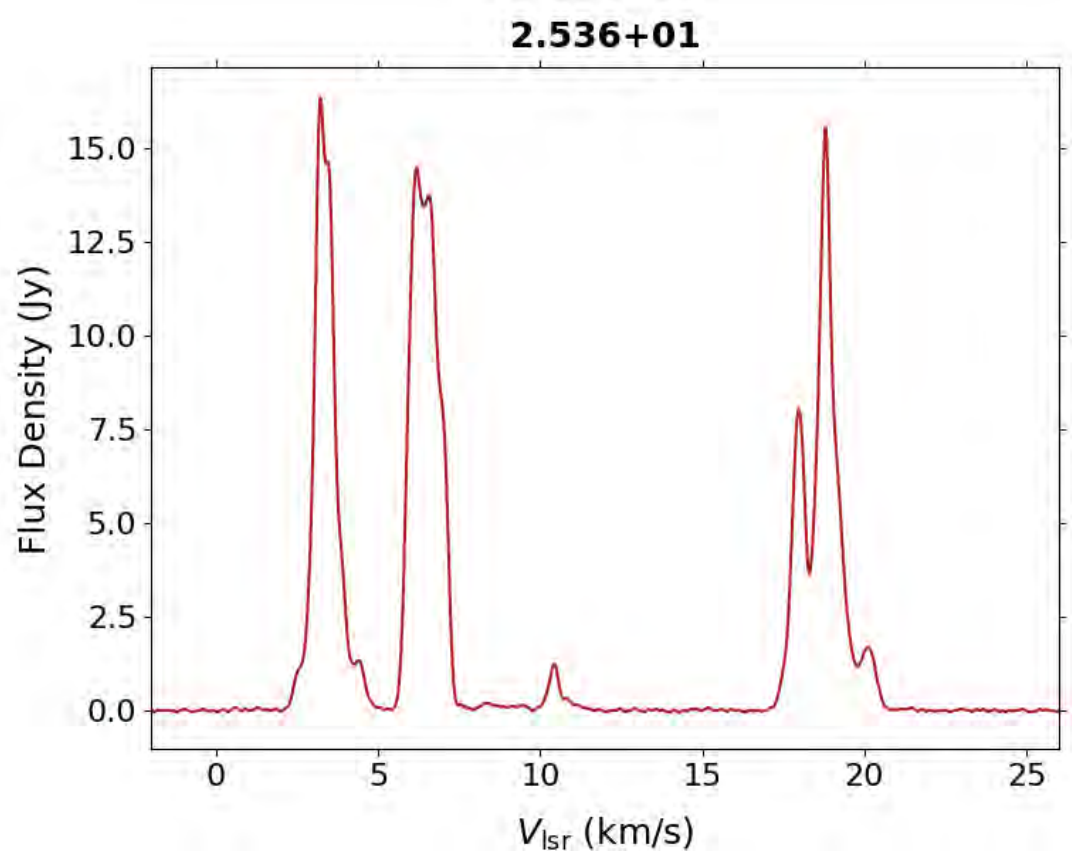


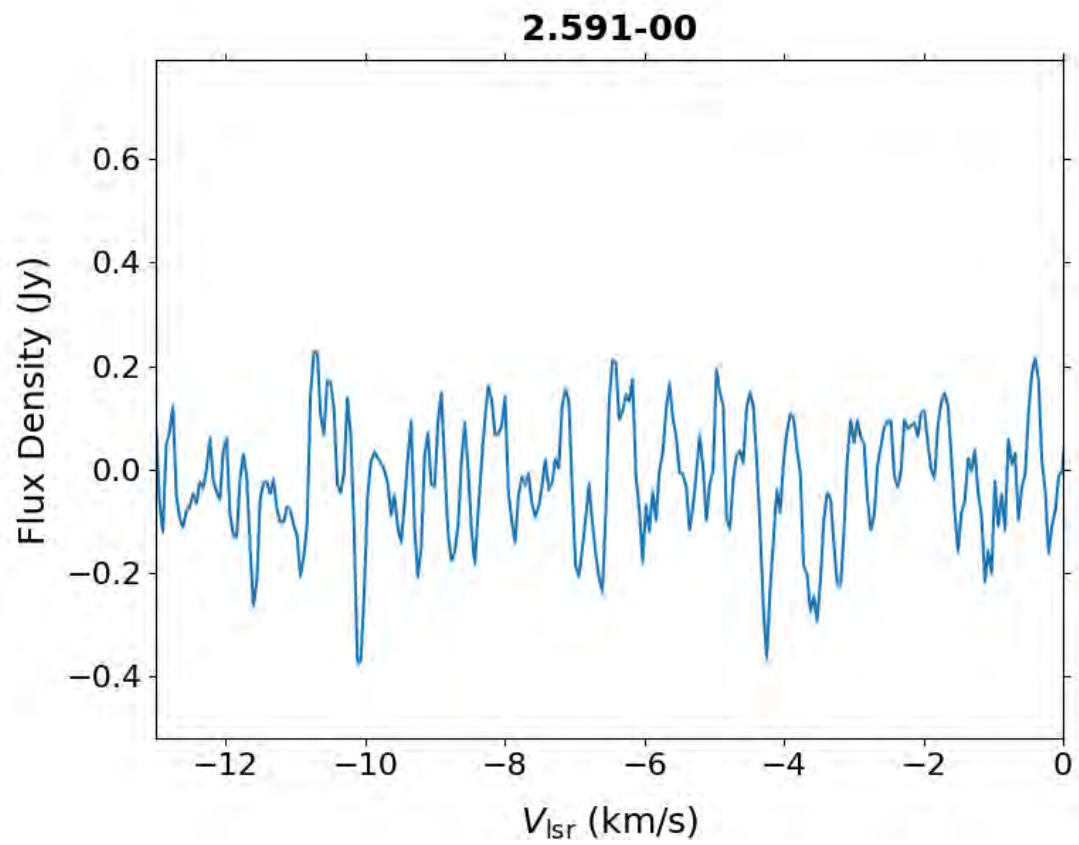
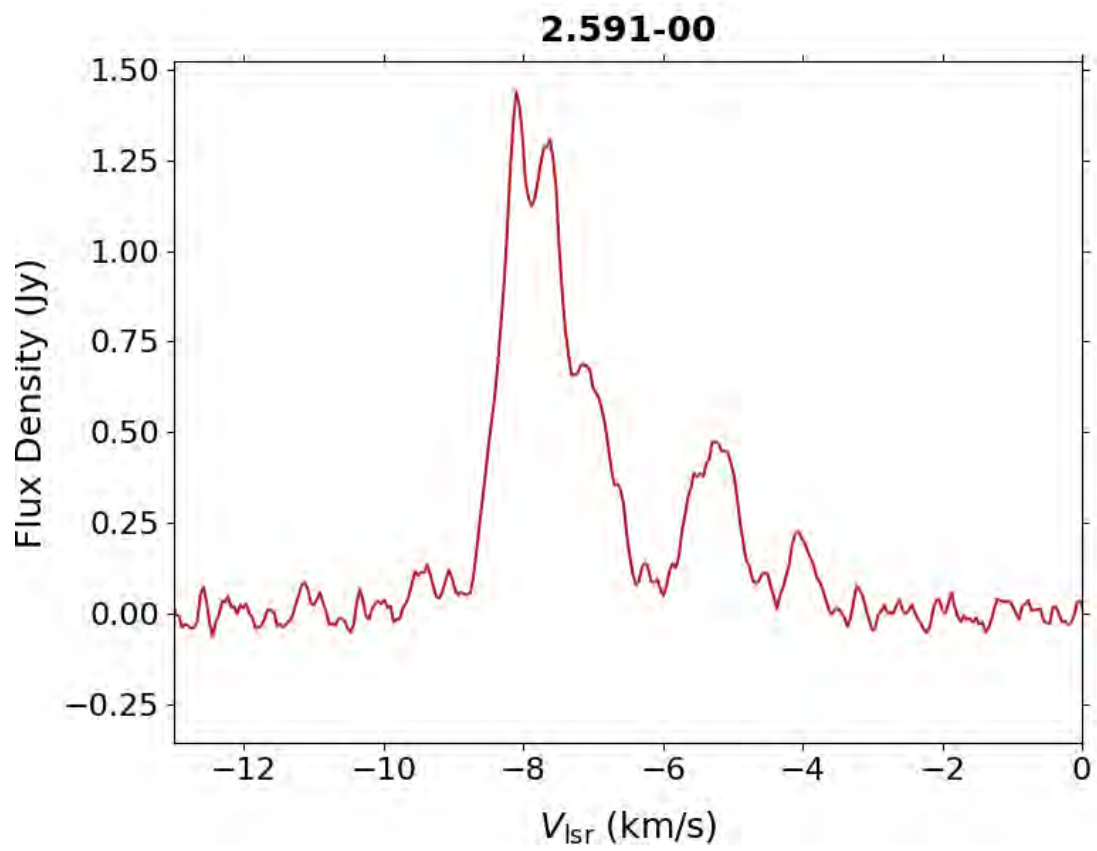
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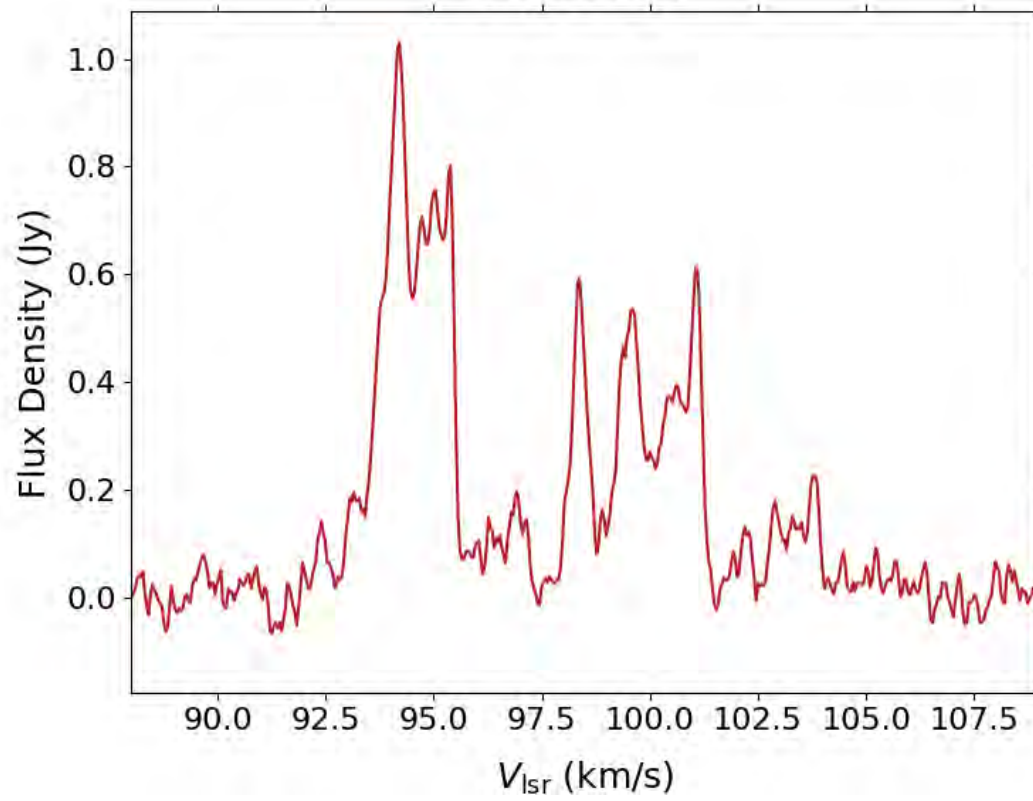
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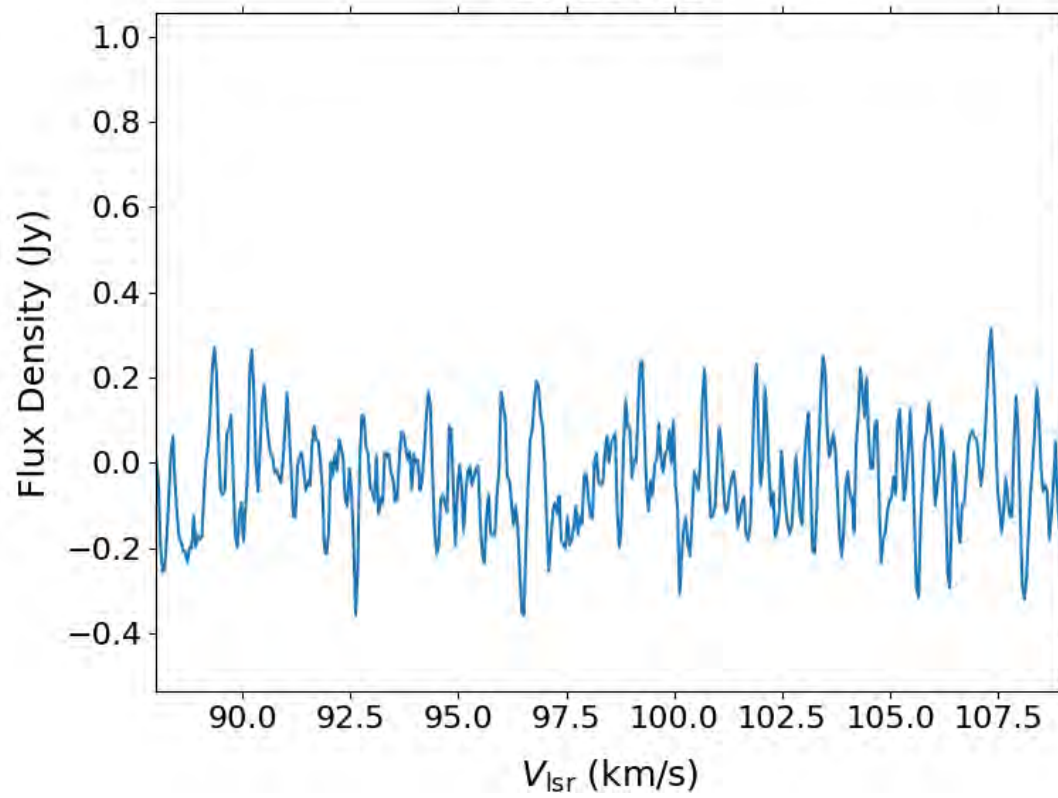


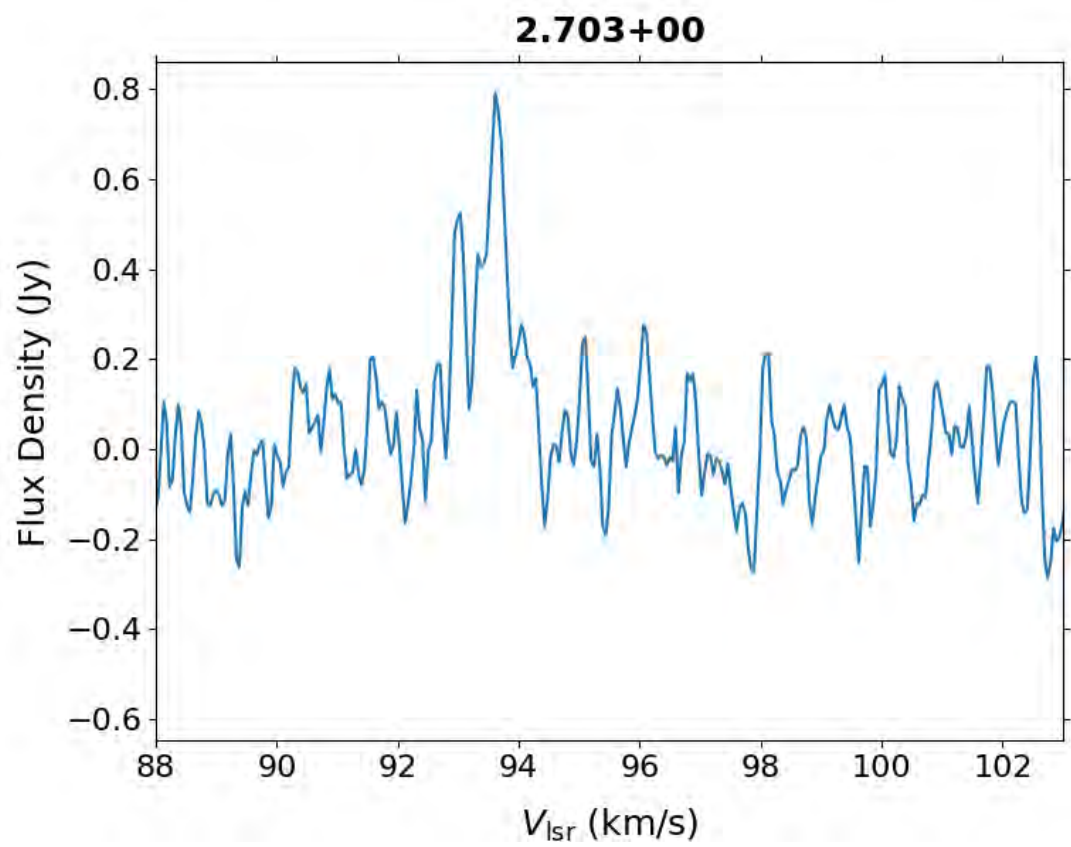
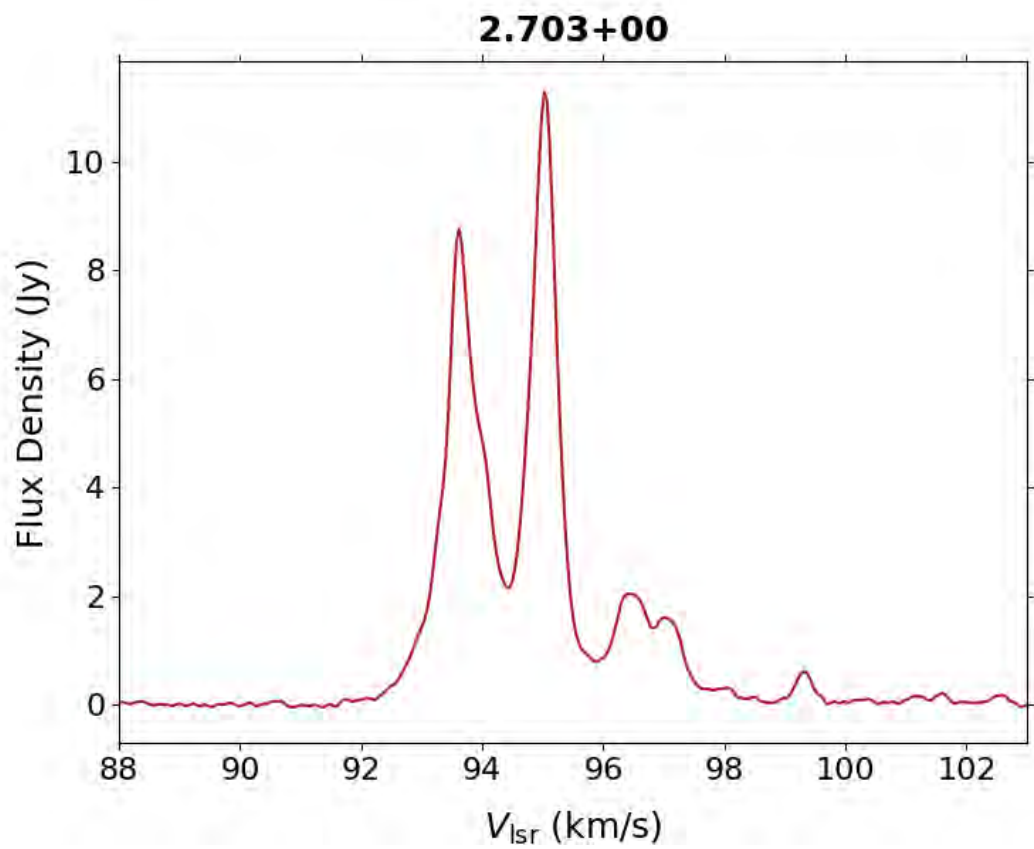


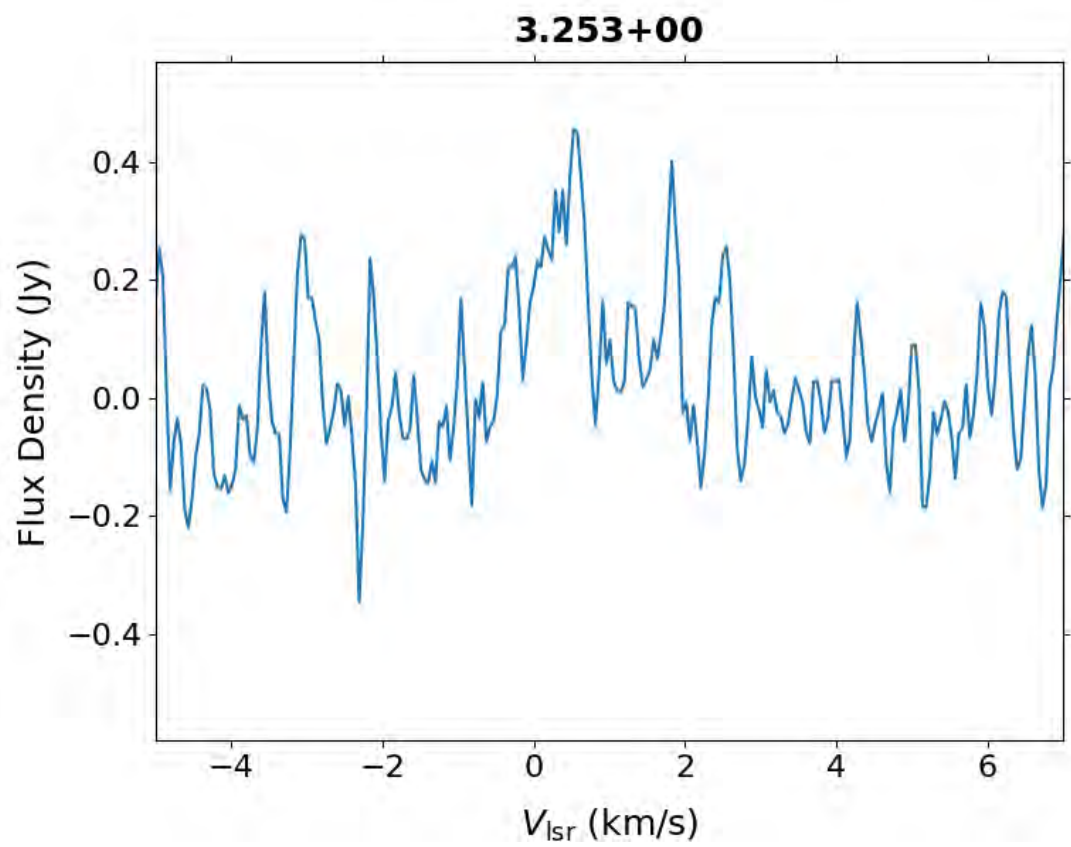
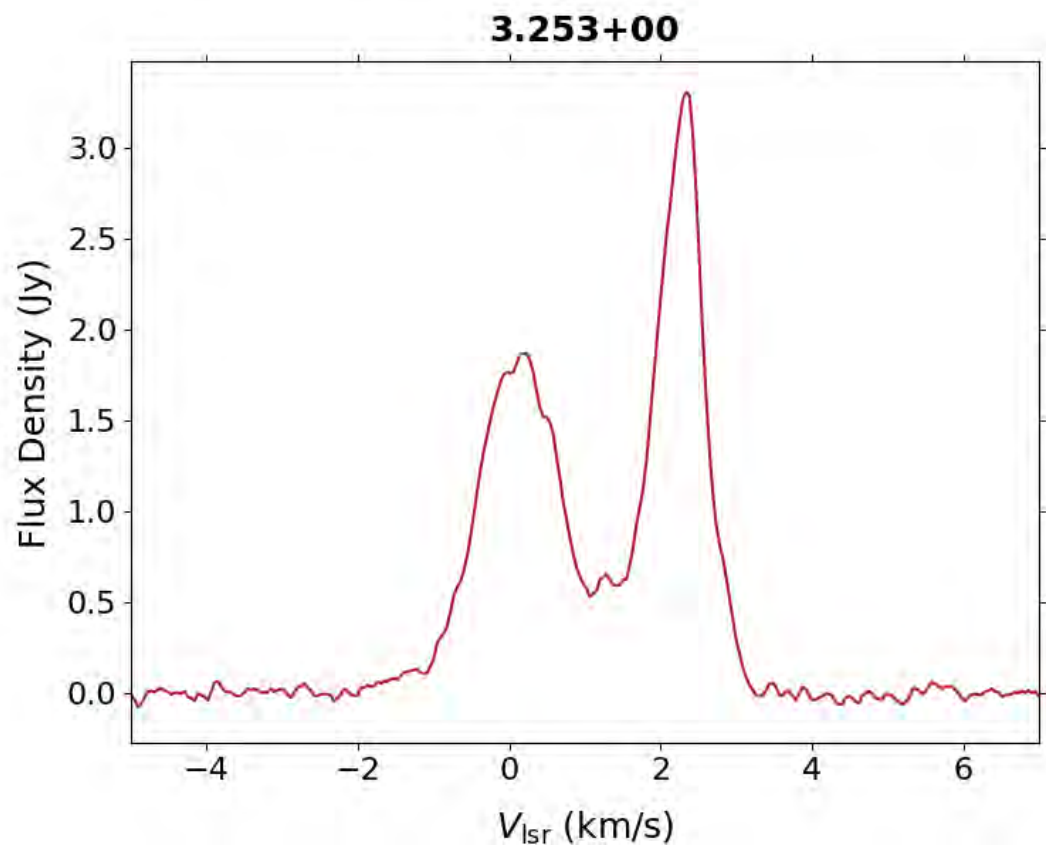
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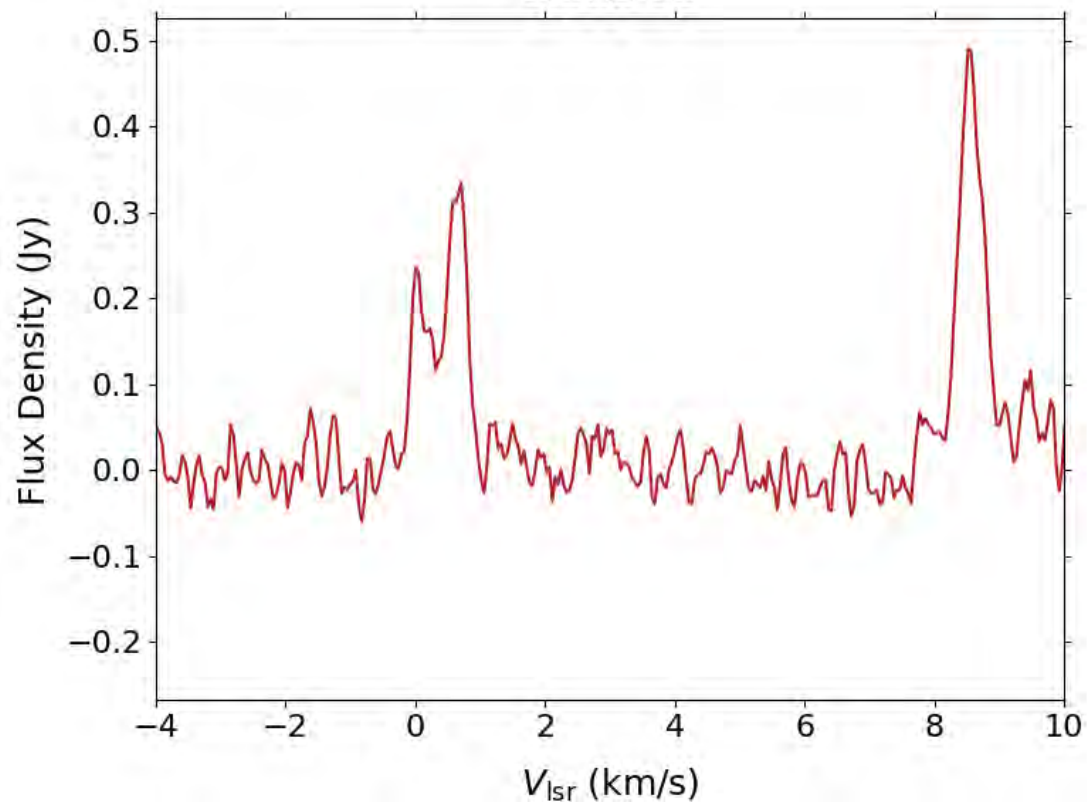
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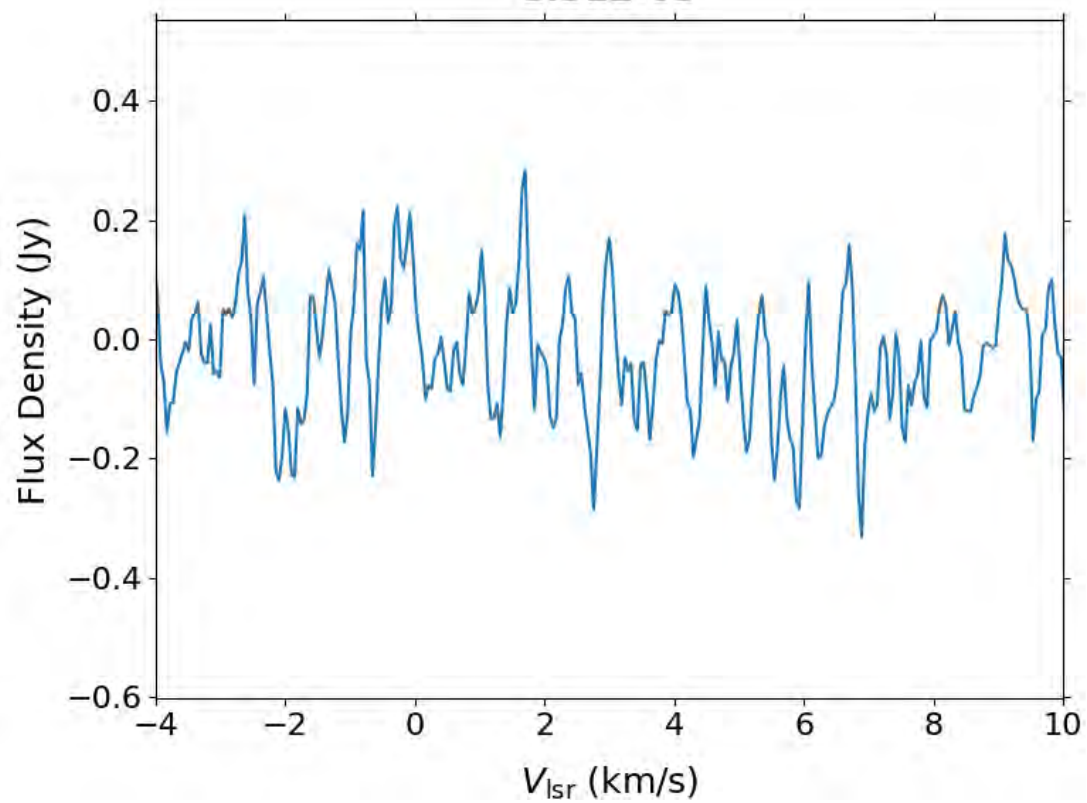


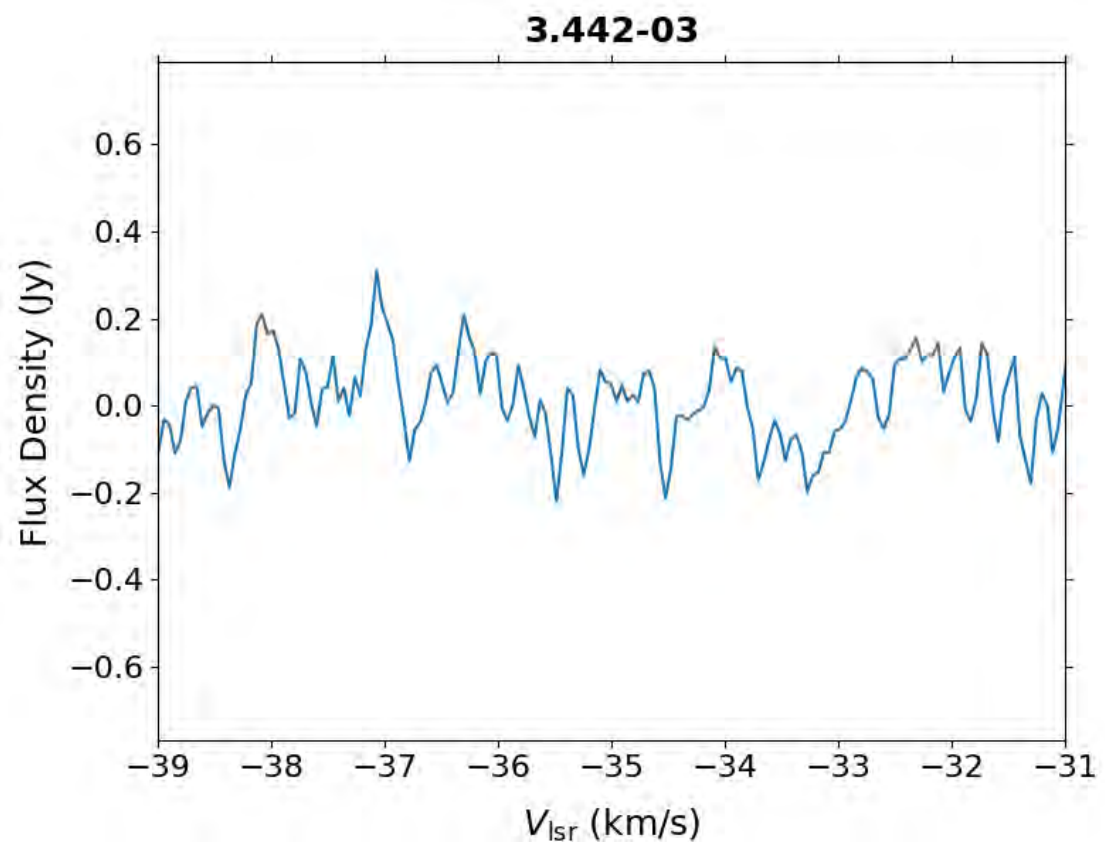
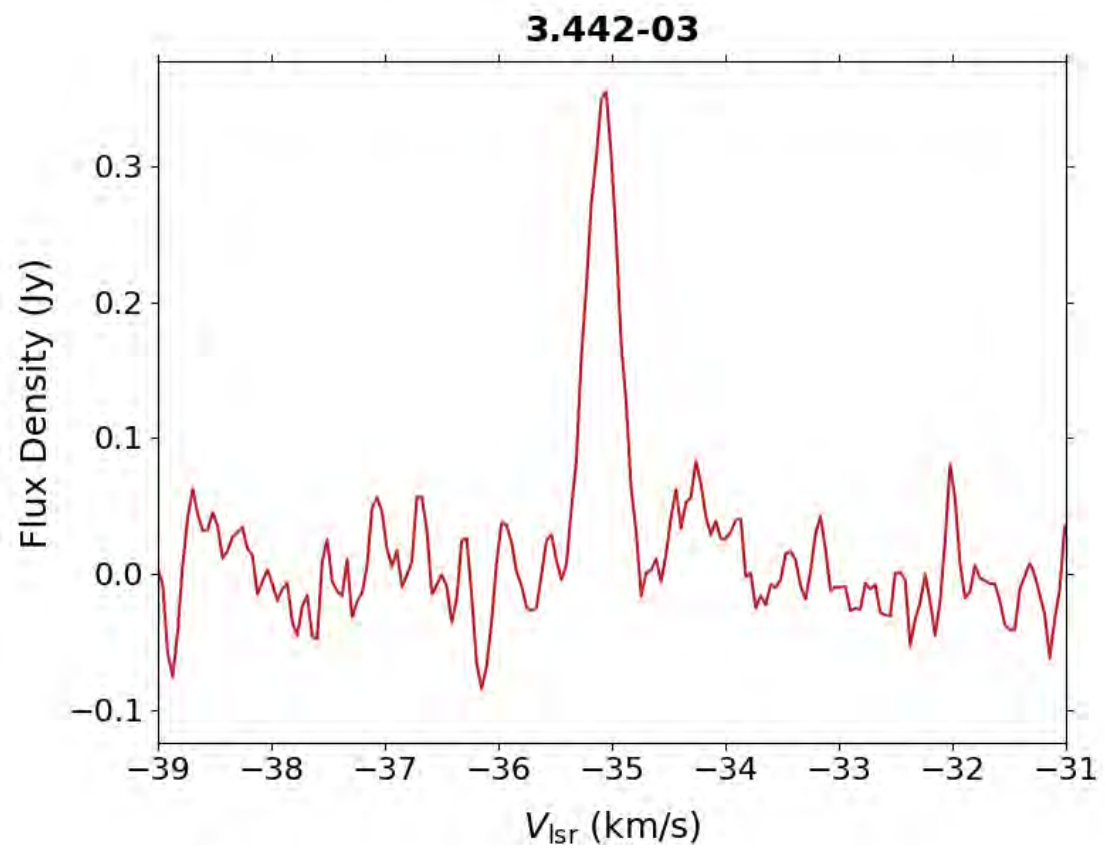


3.312-03

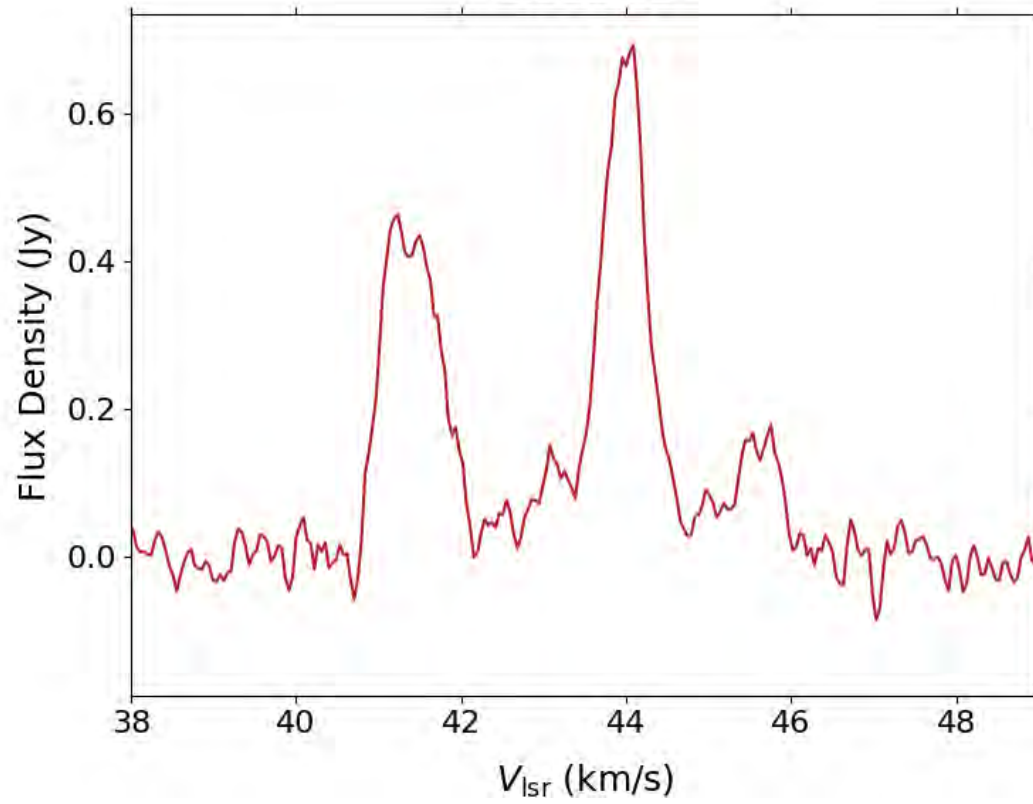


3.312-03

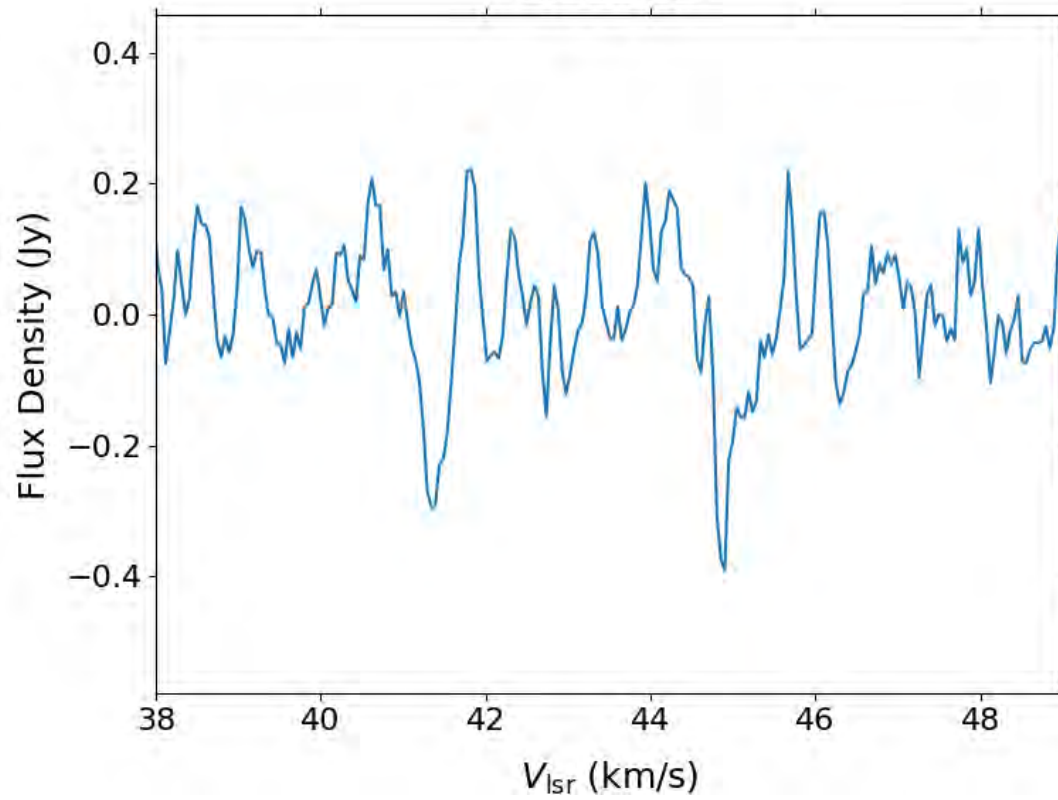


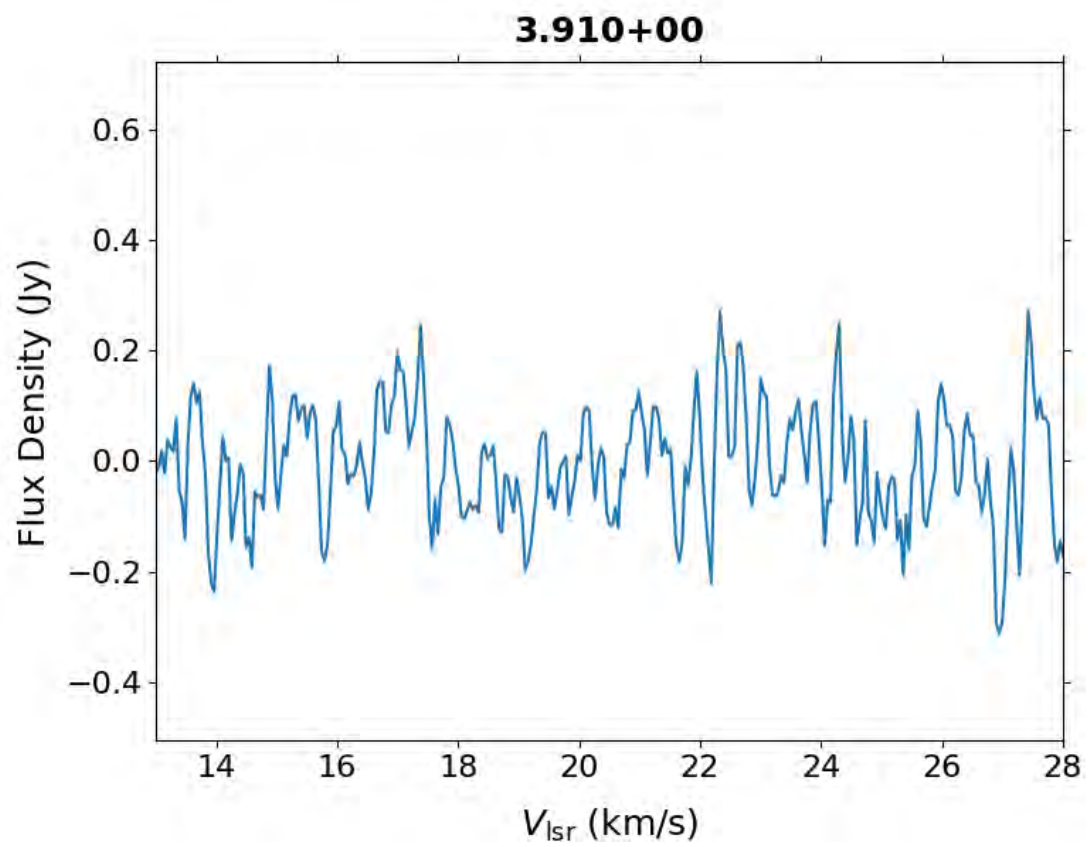
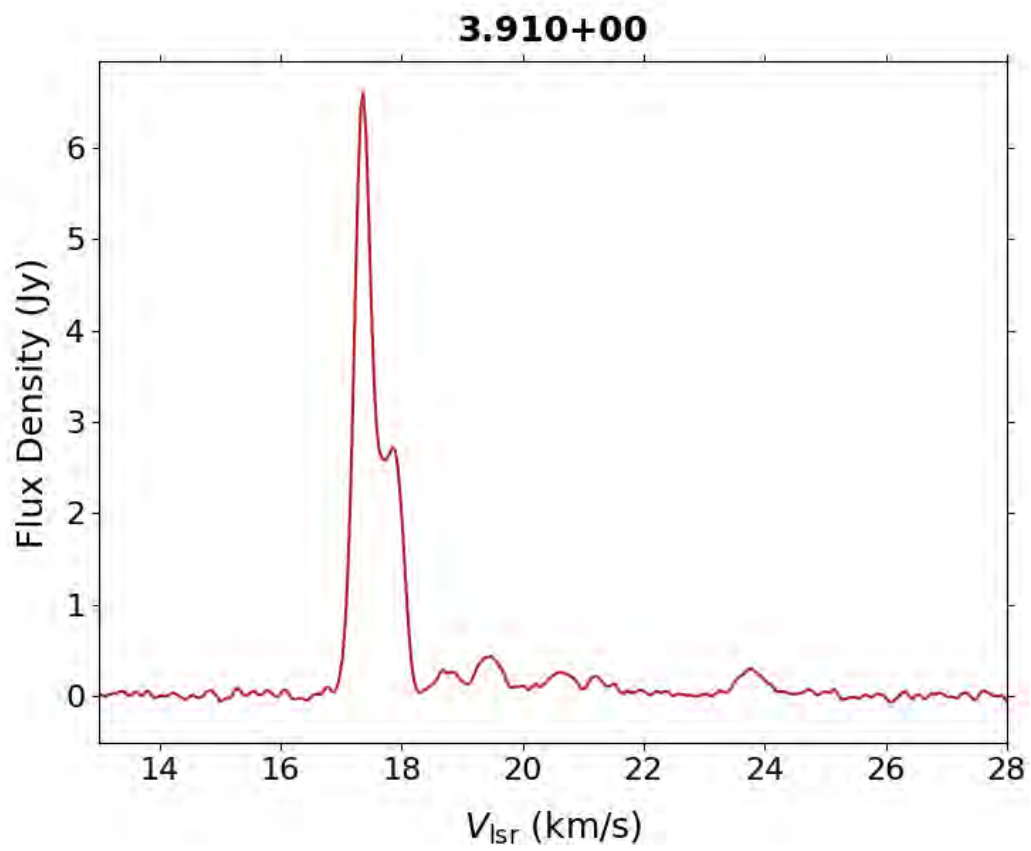


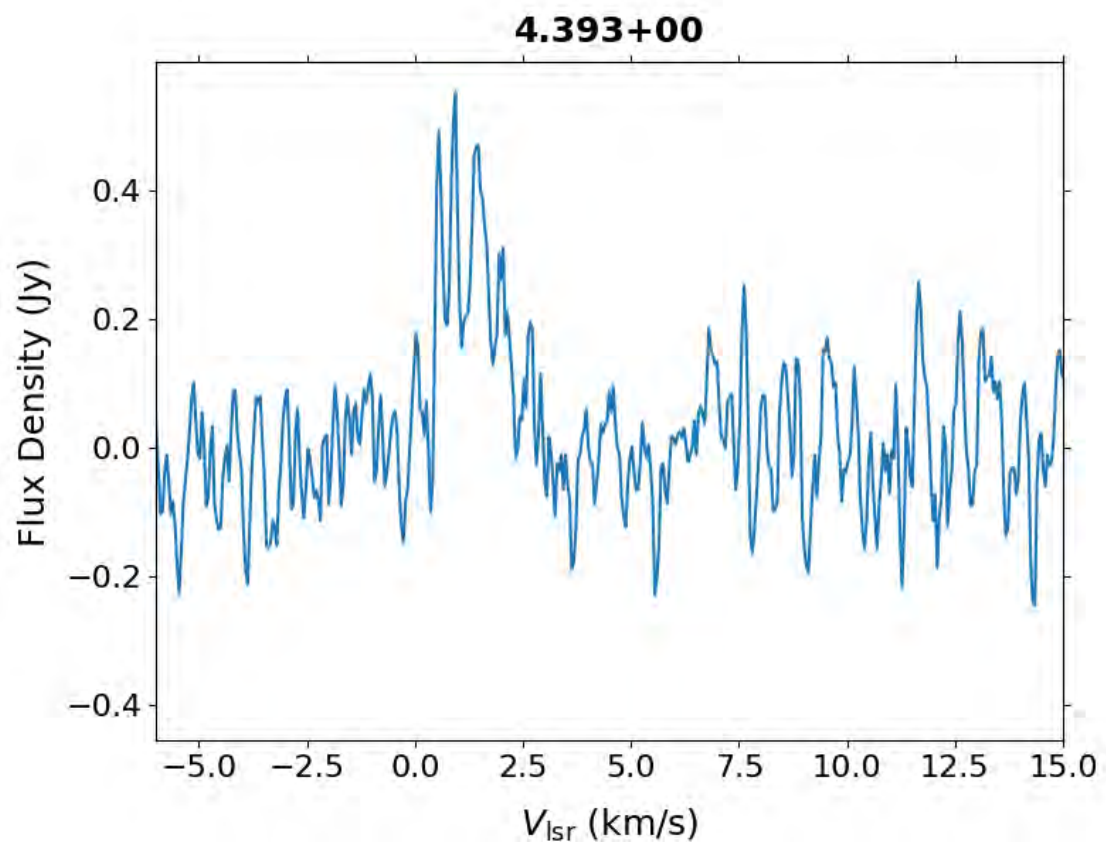
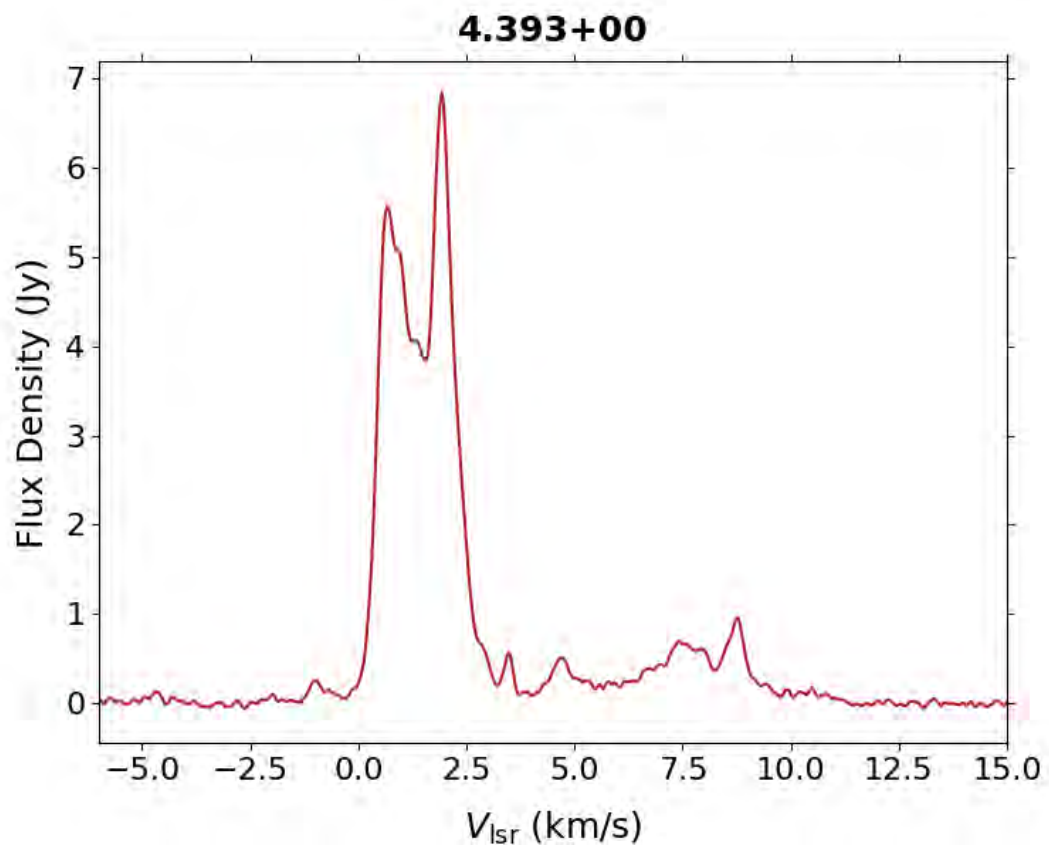
3.502-02

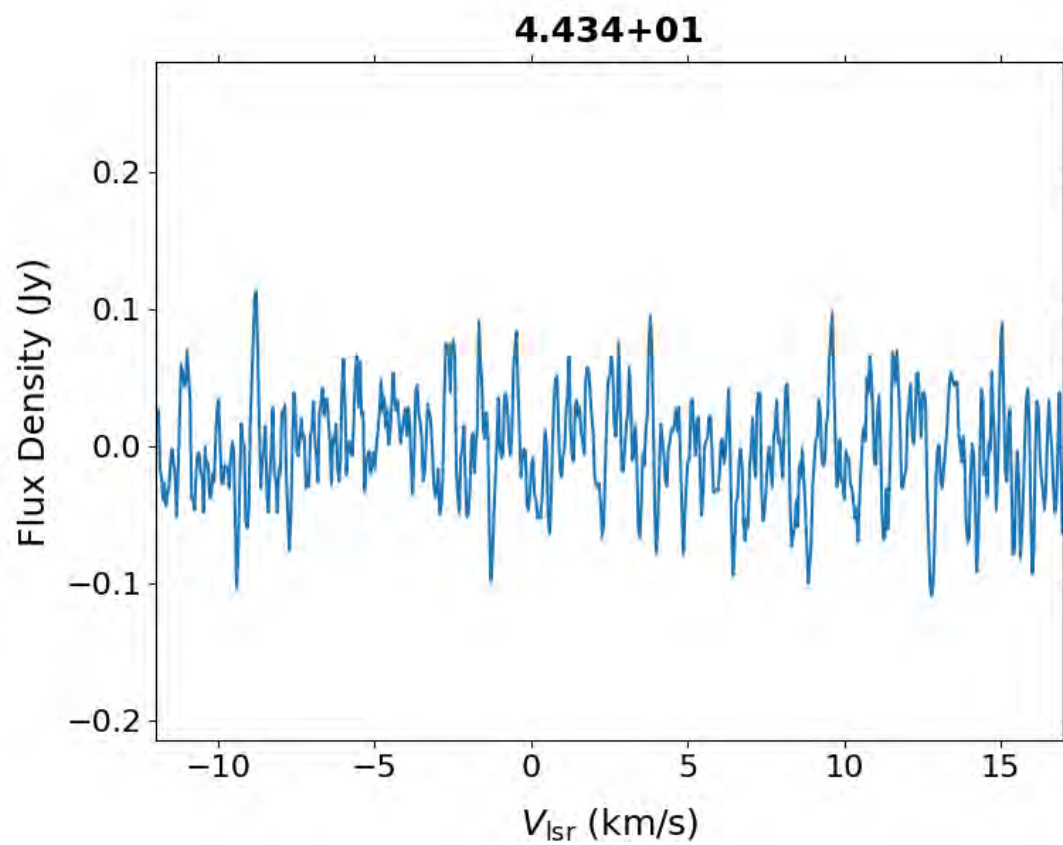
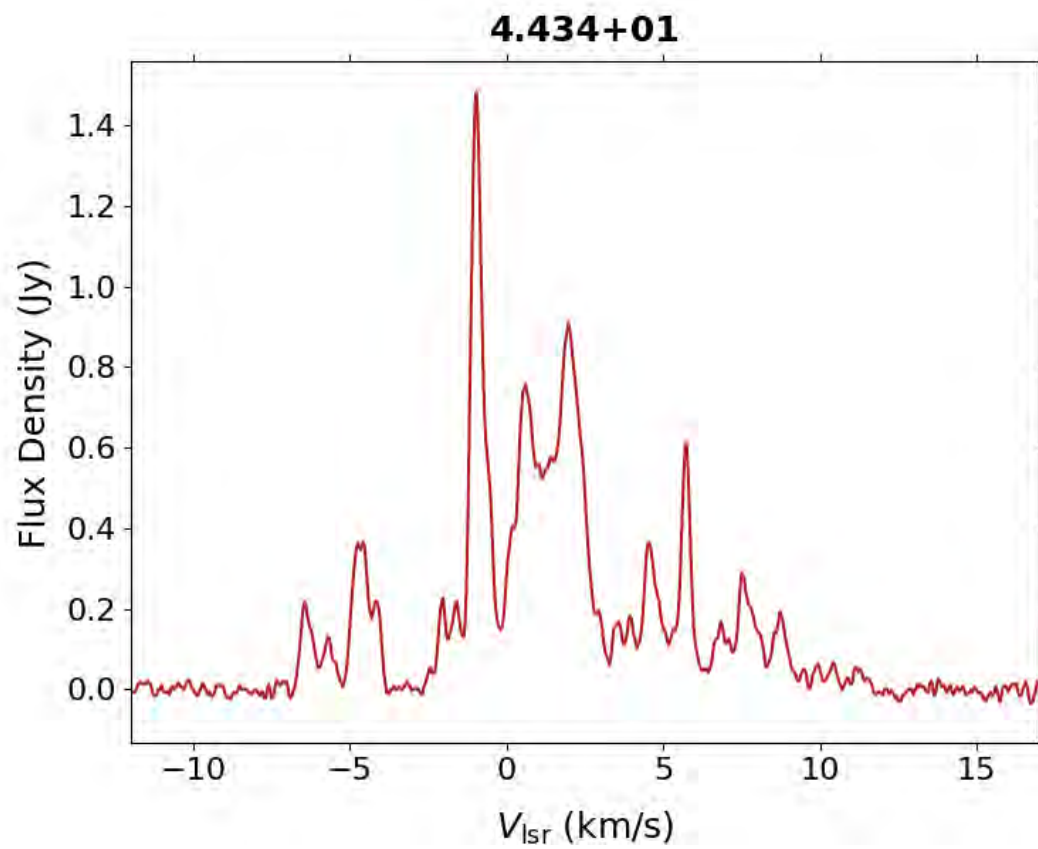


3.502-02

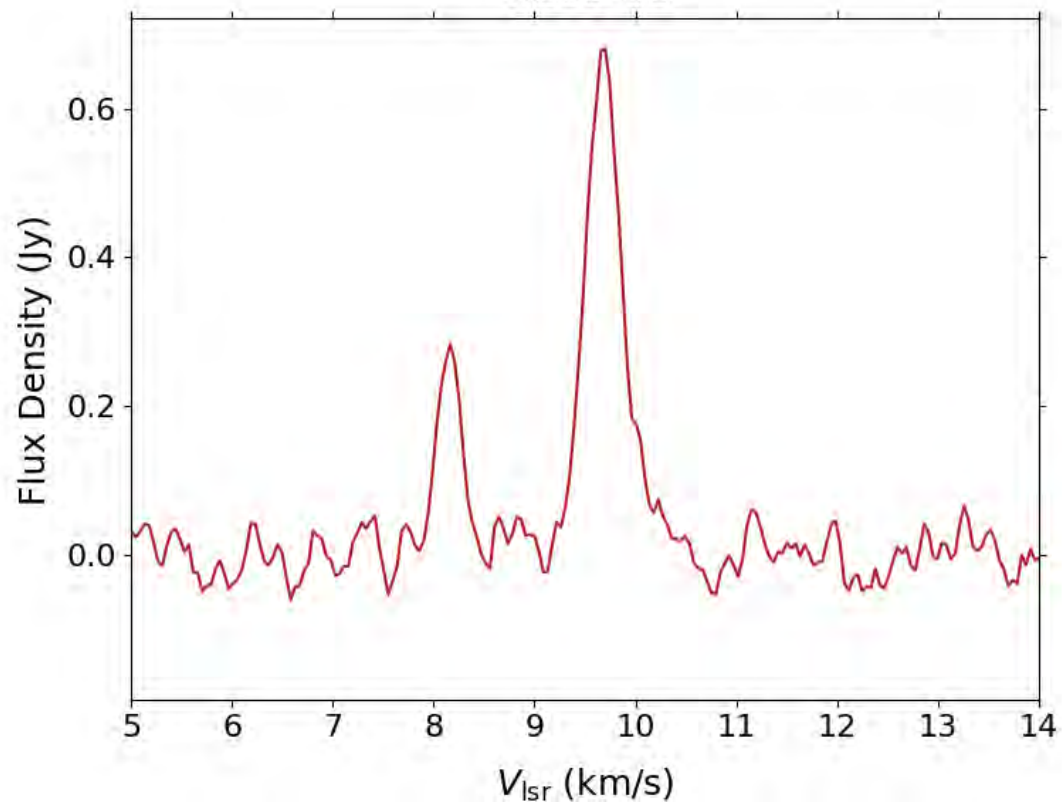




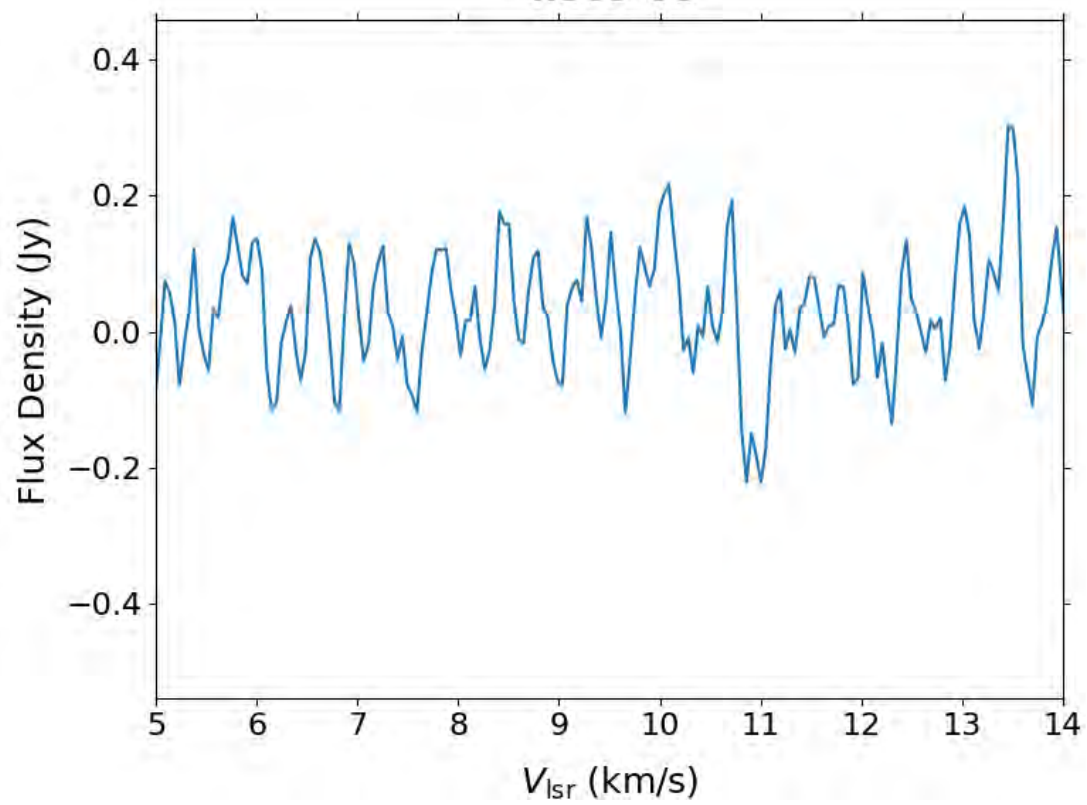


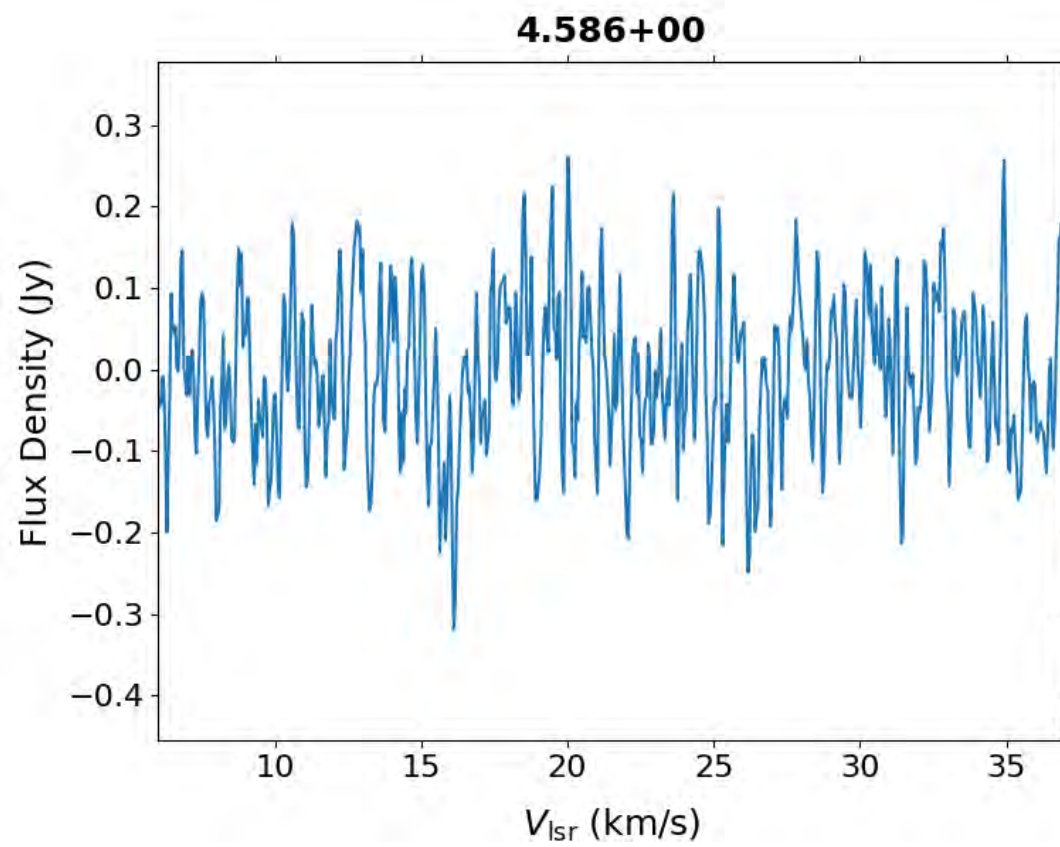
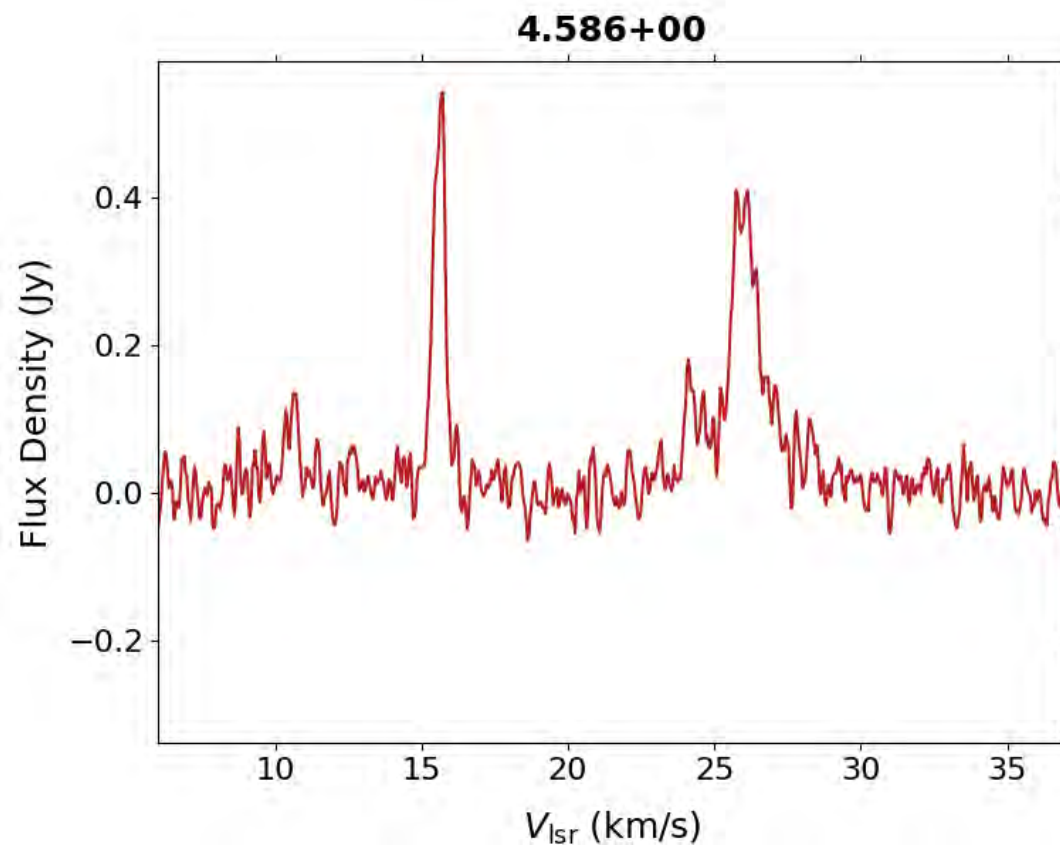


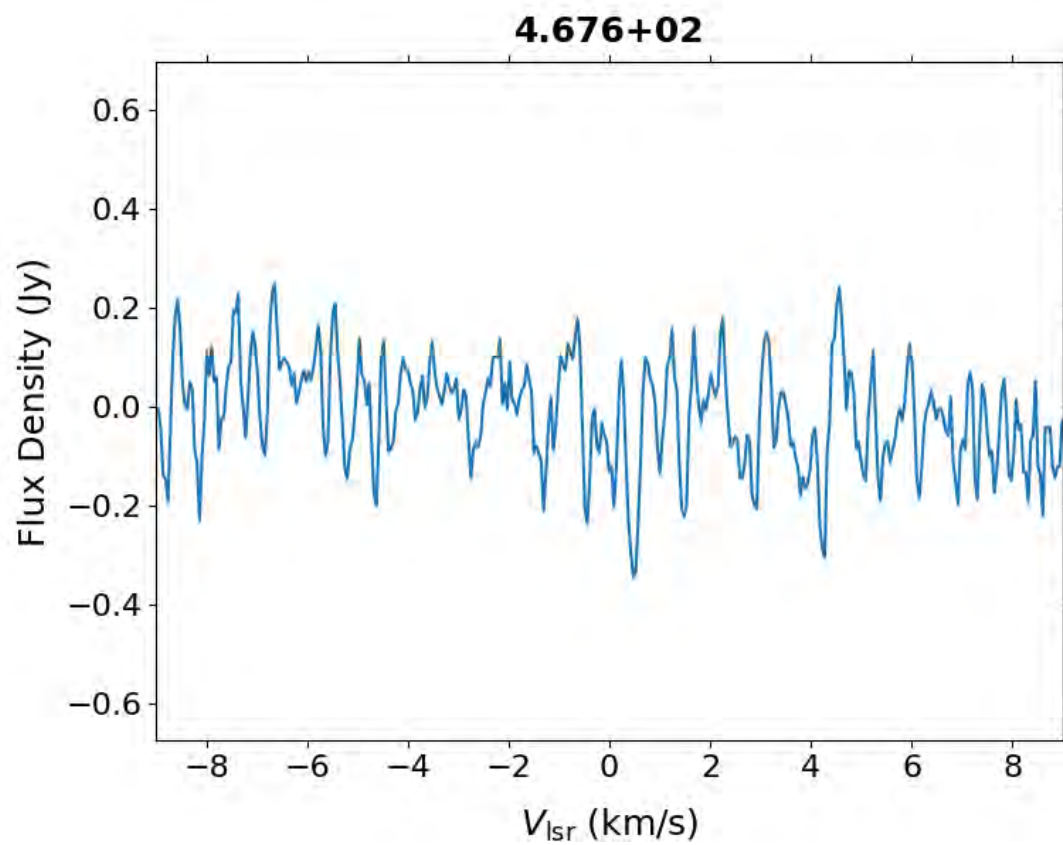
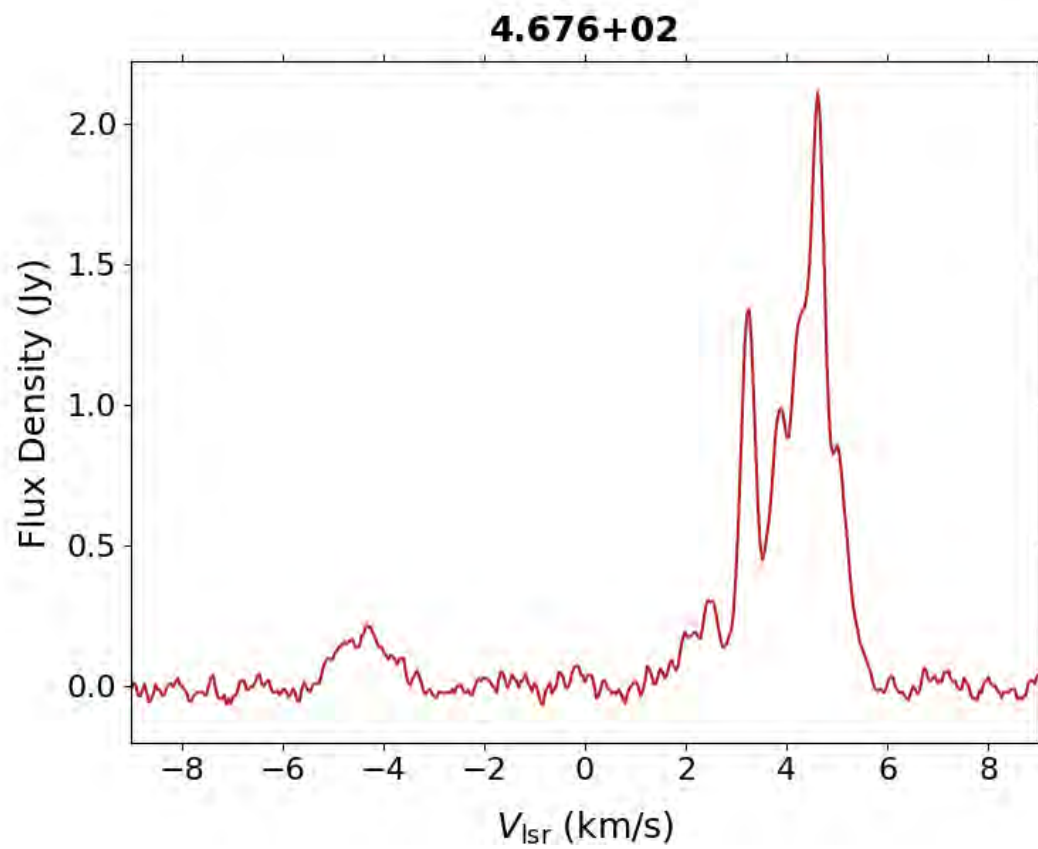
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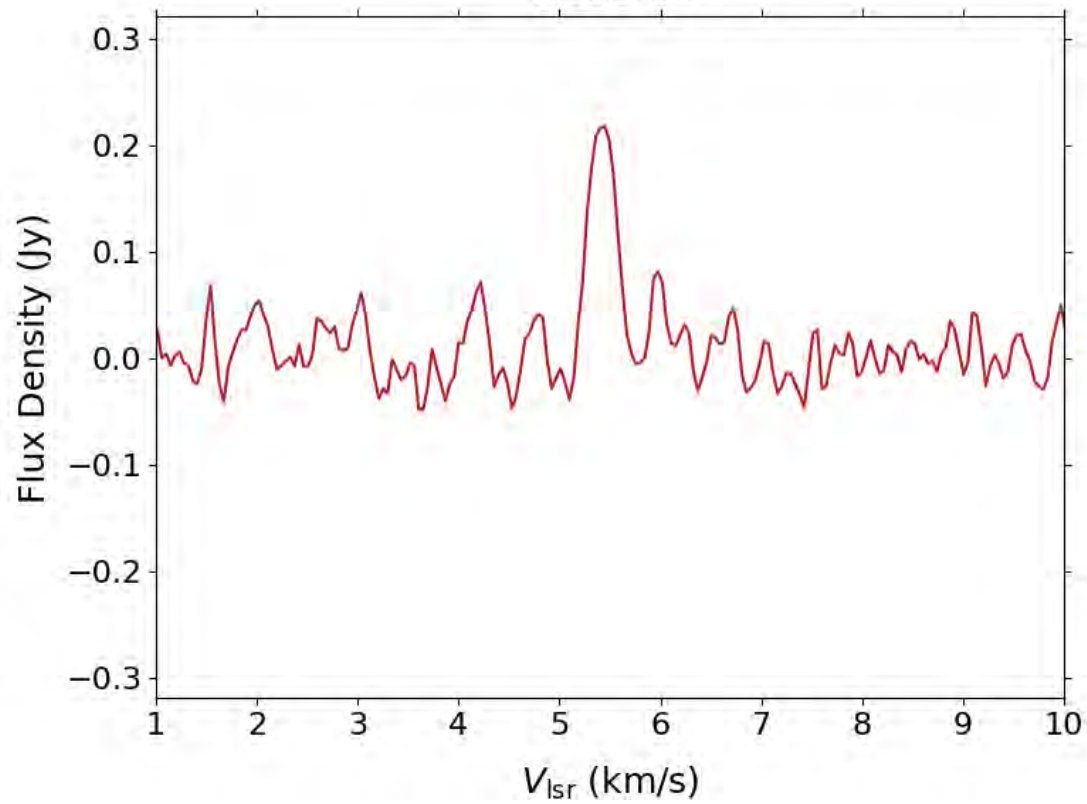
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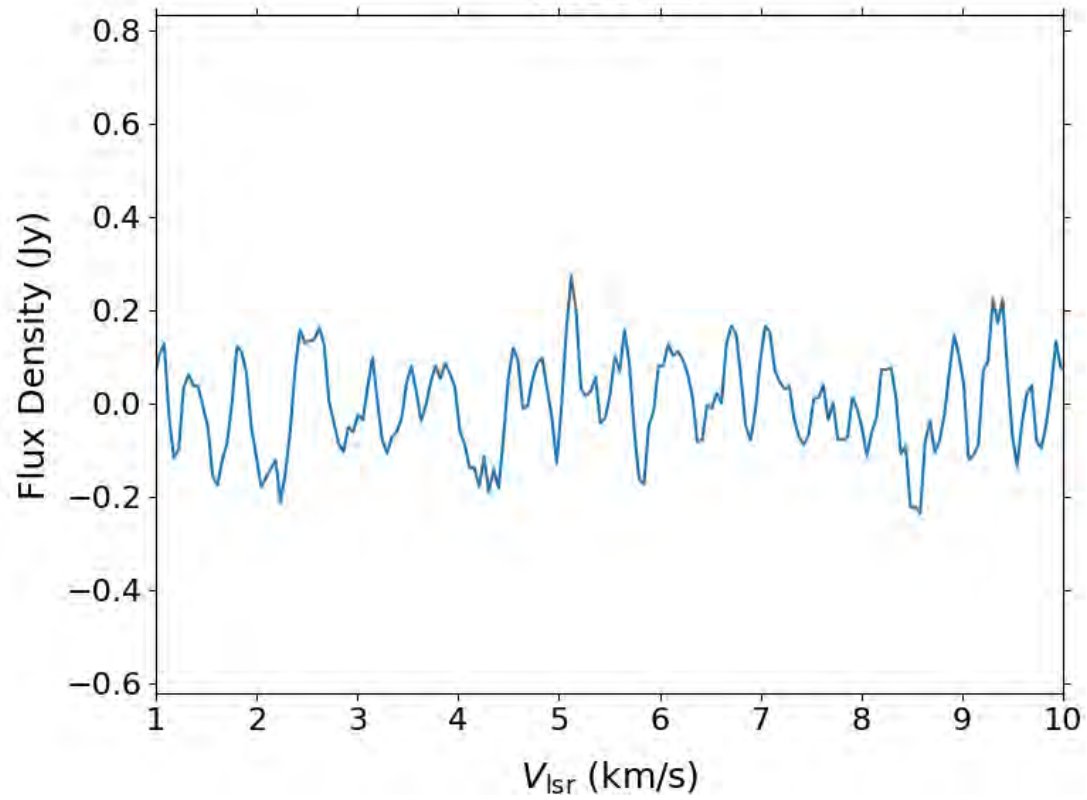


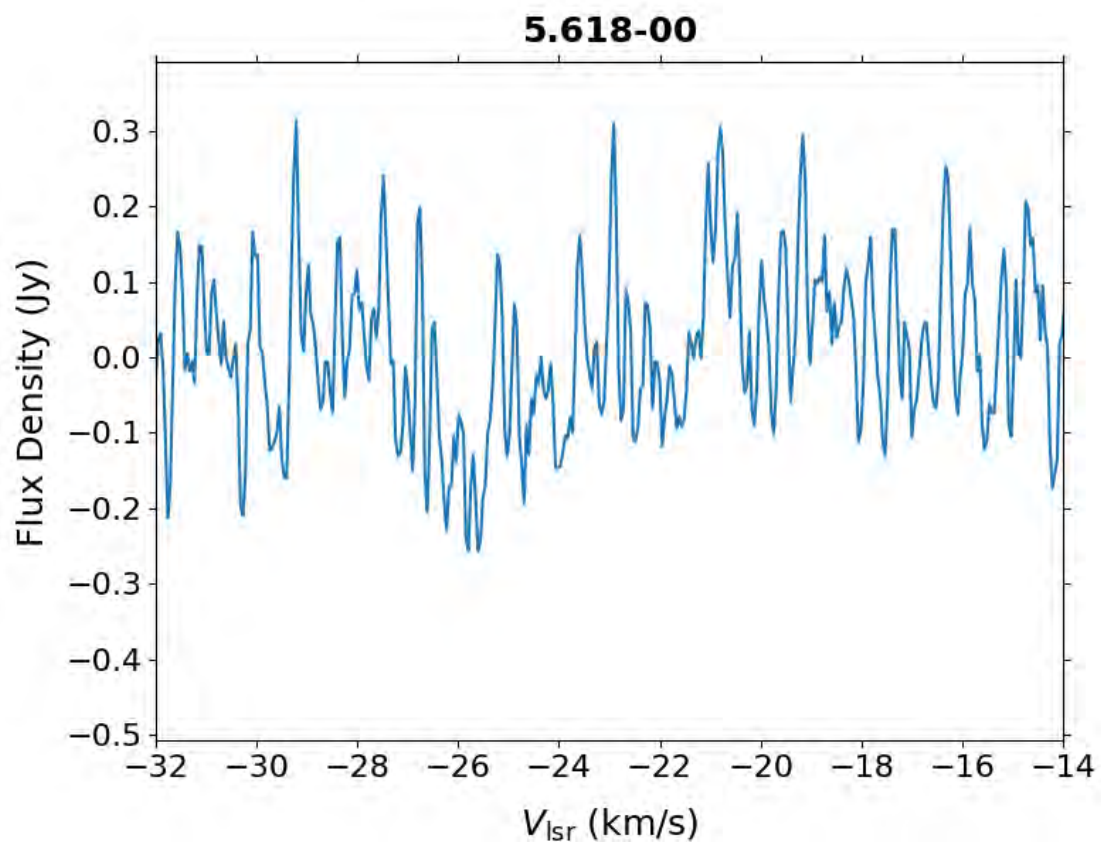
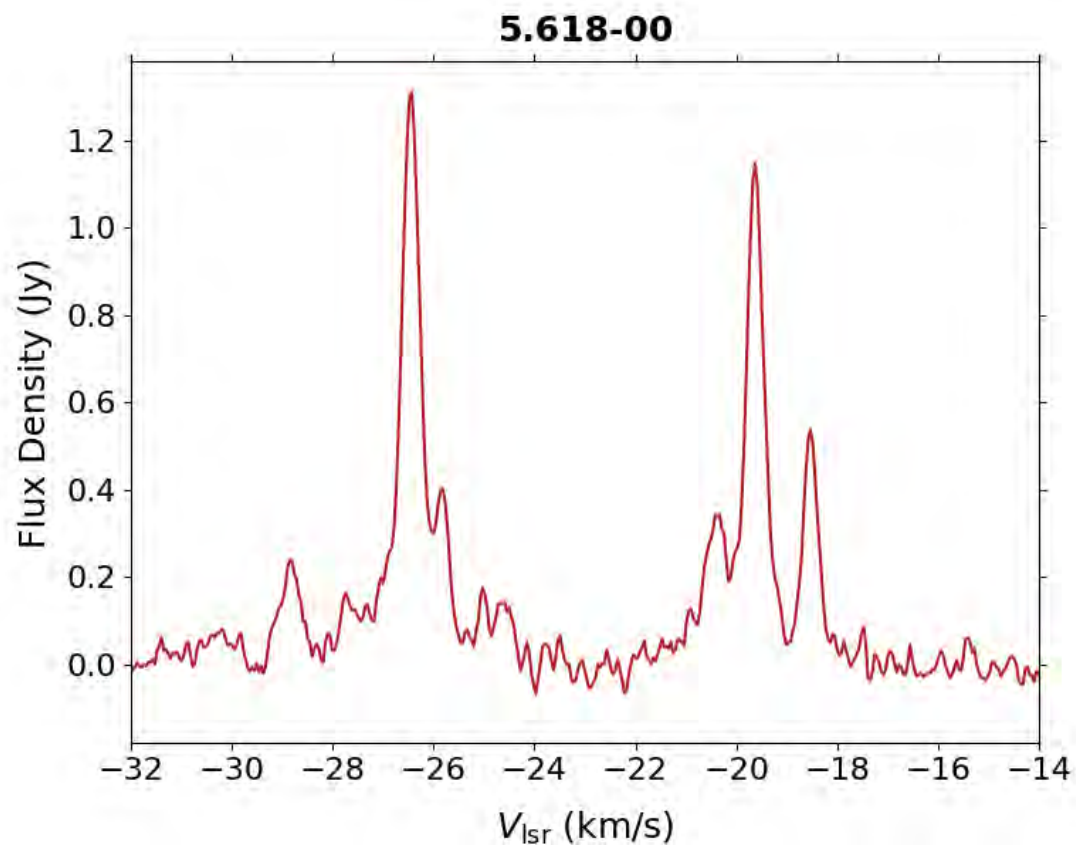


4.866-01

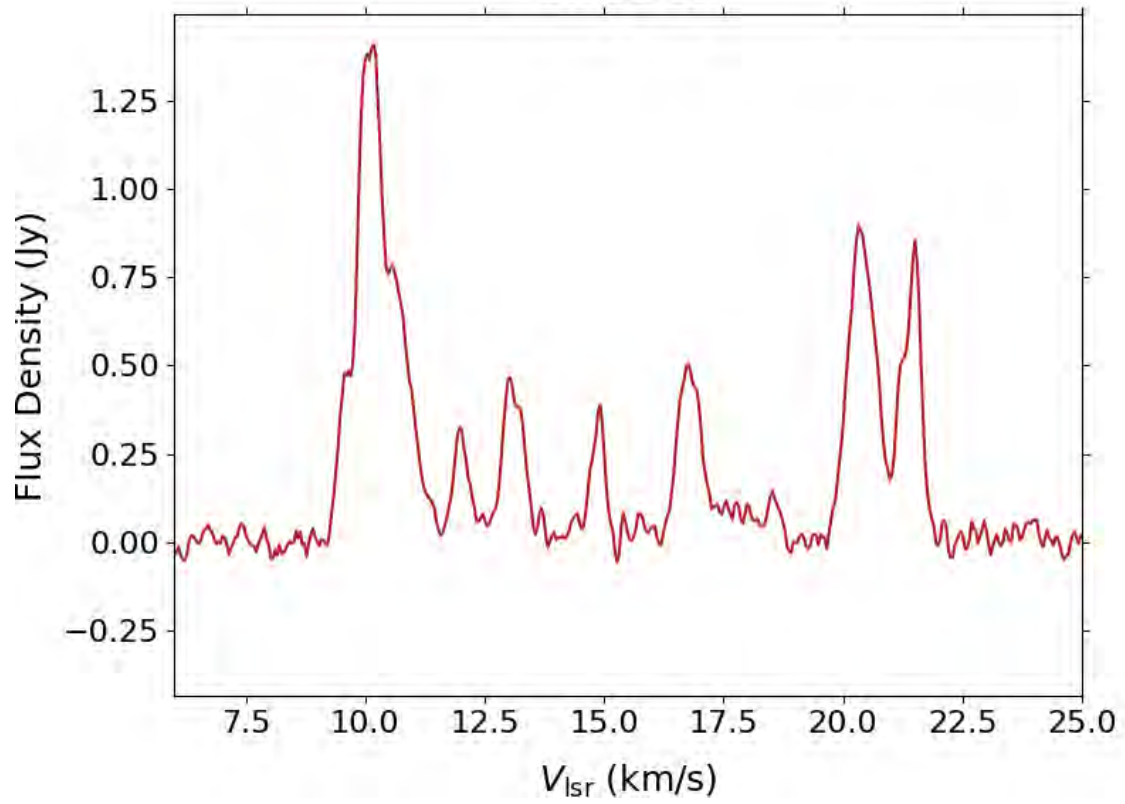


4.866-01

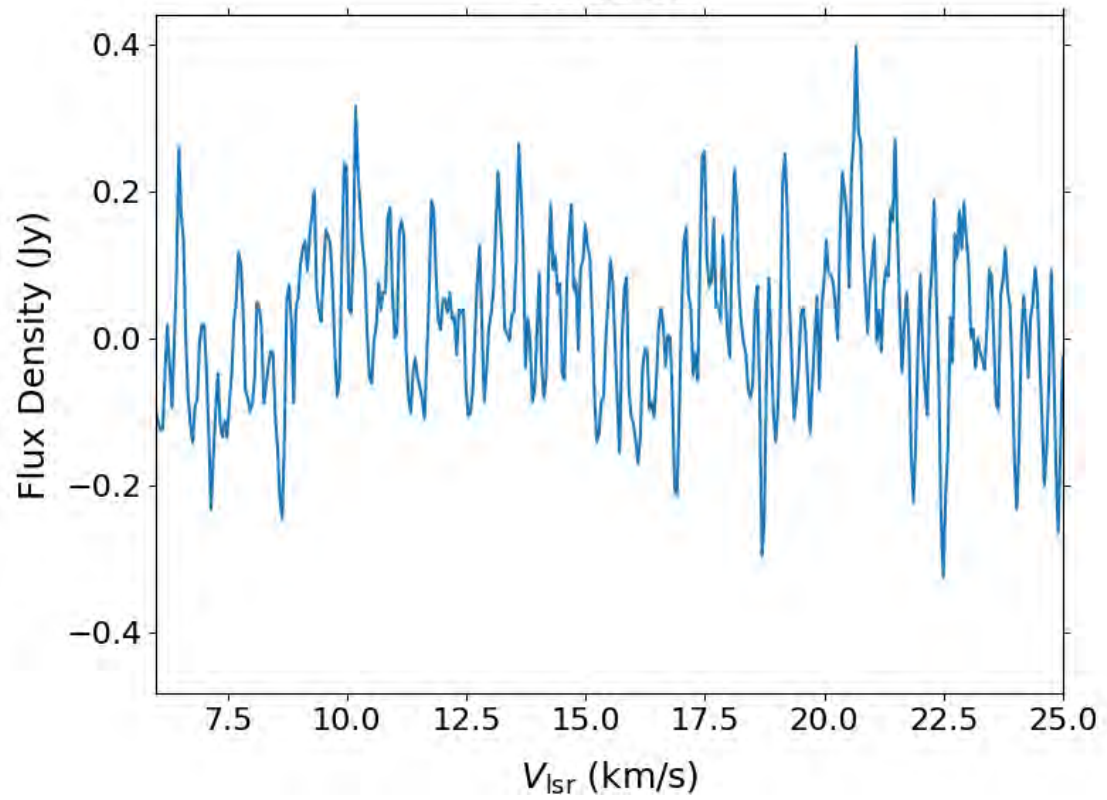


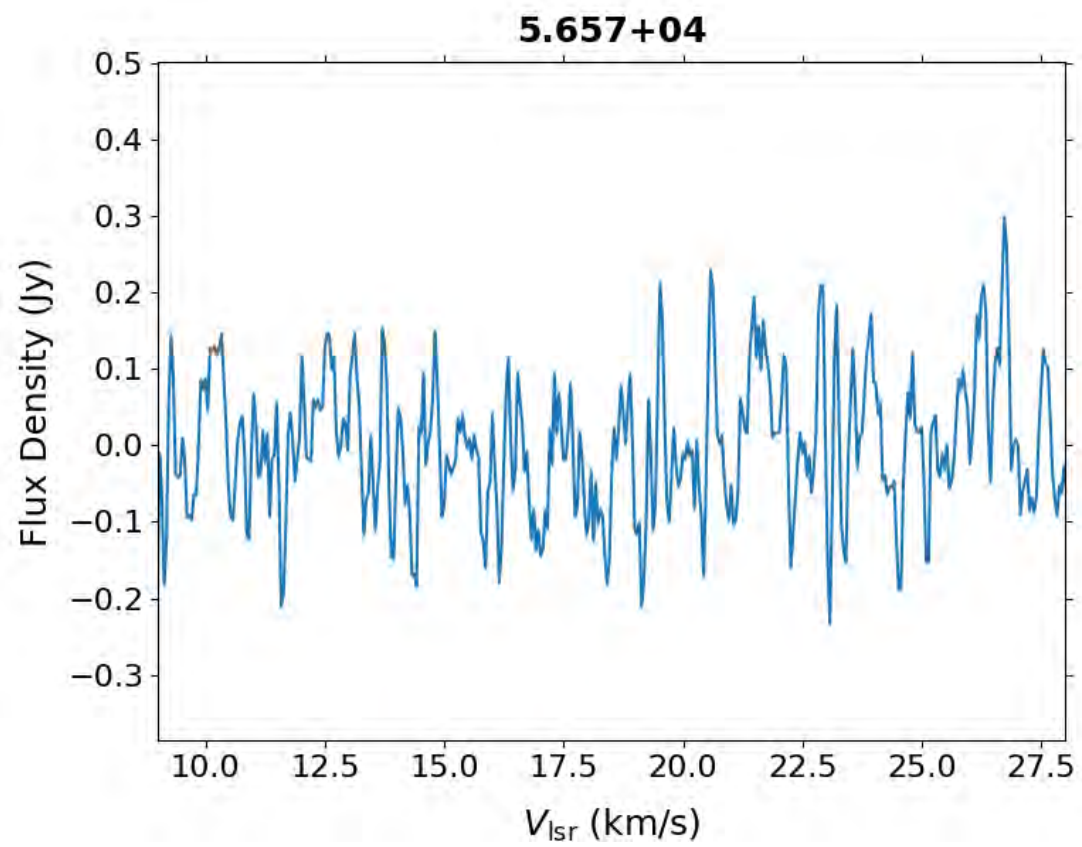
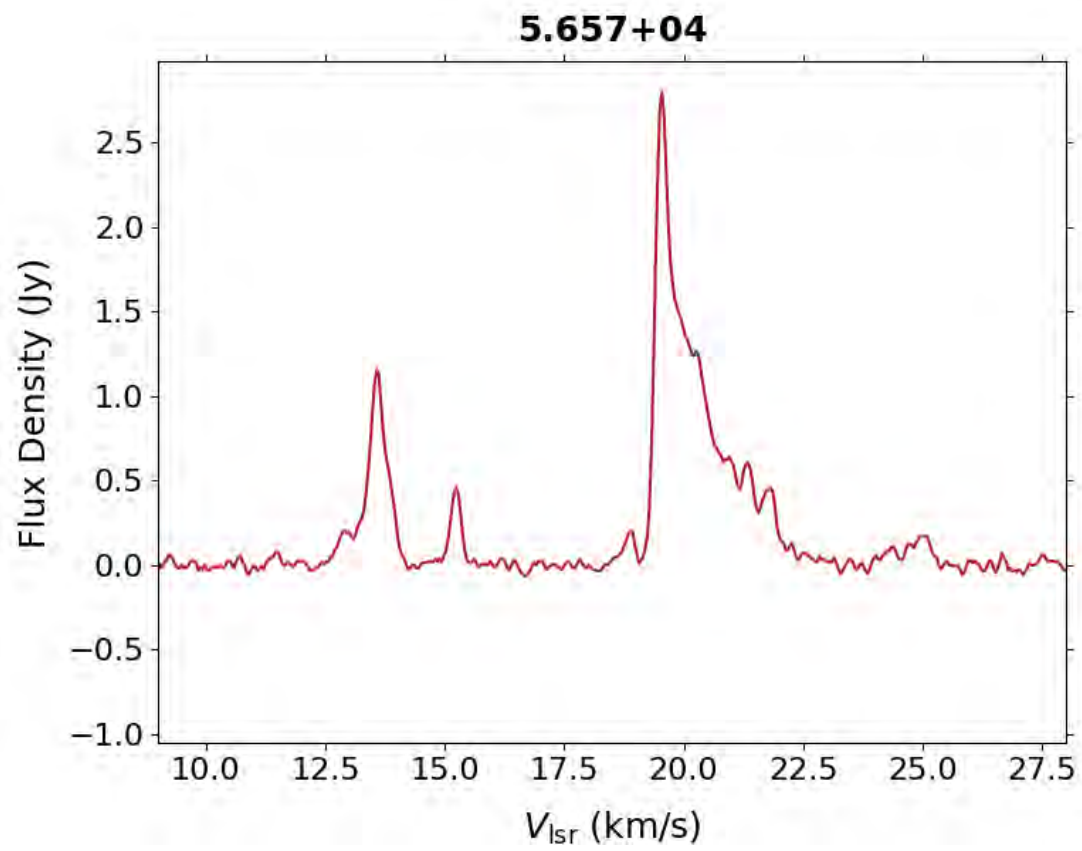


5.630-02

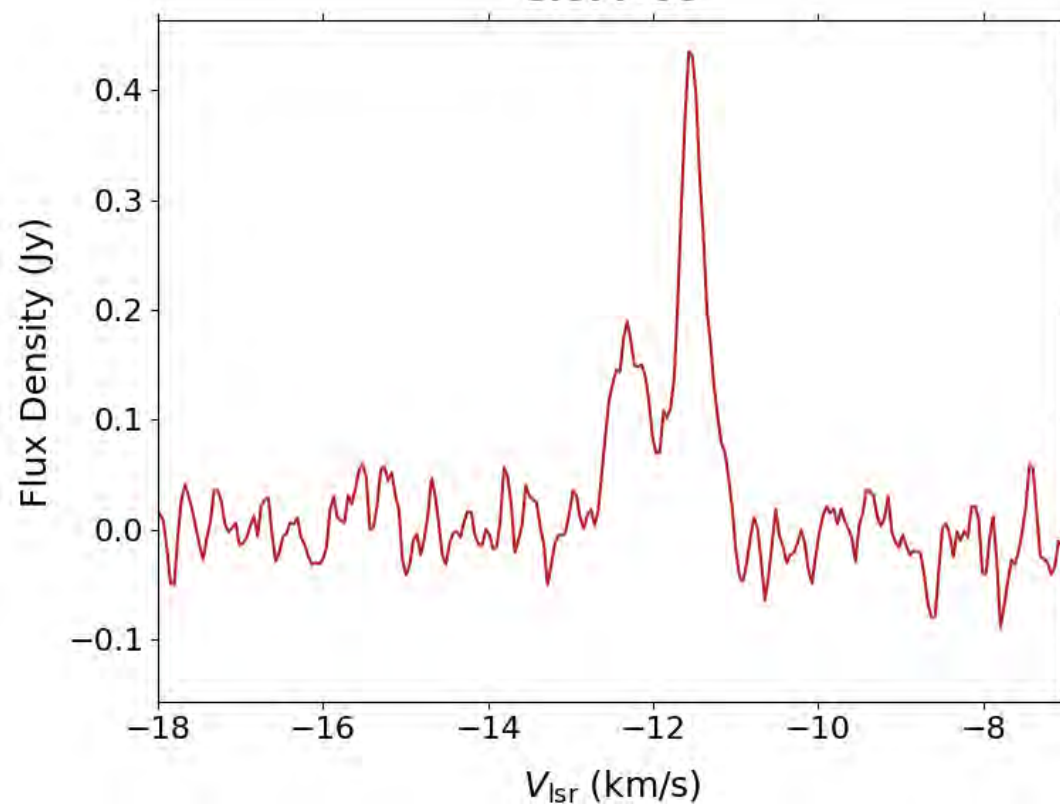


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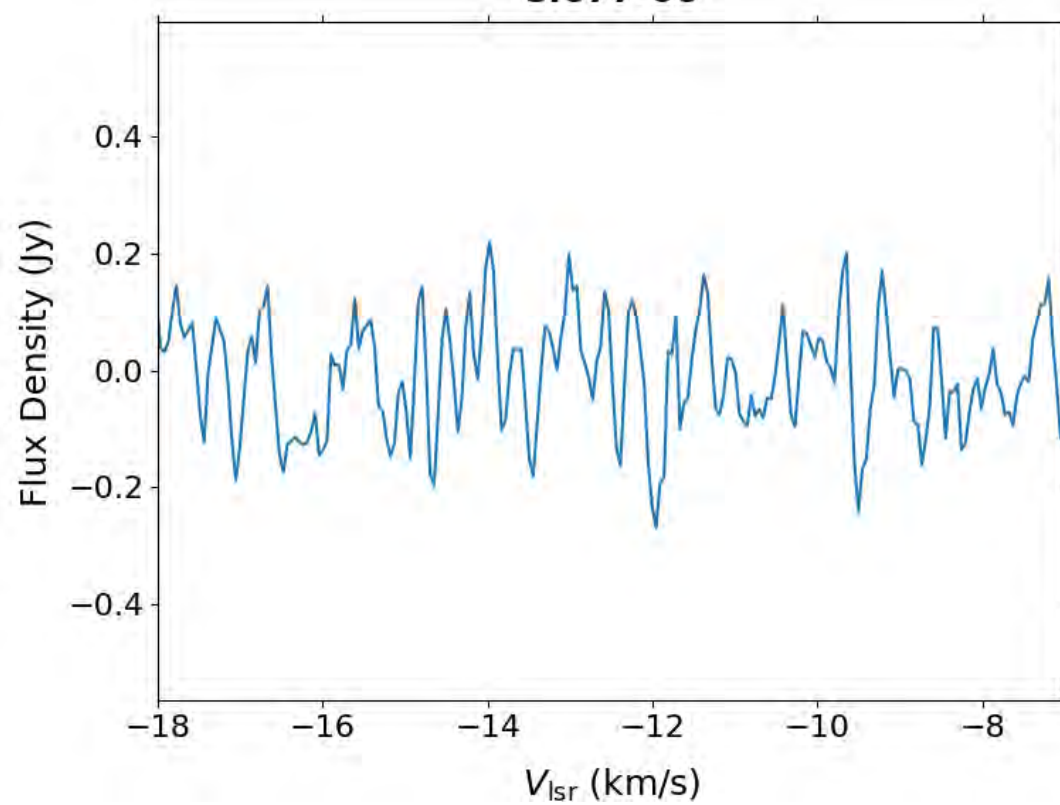




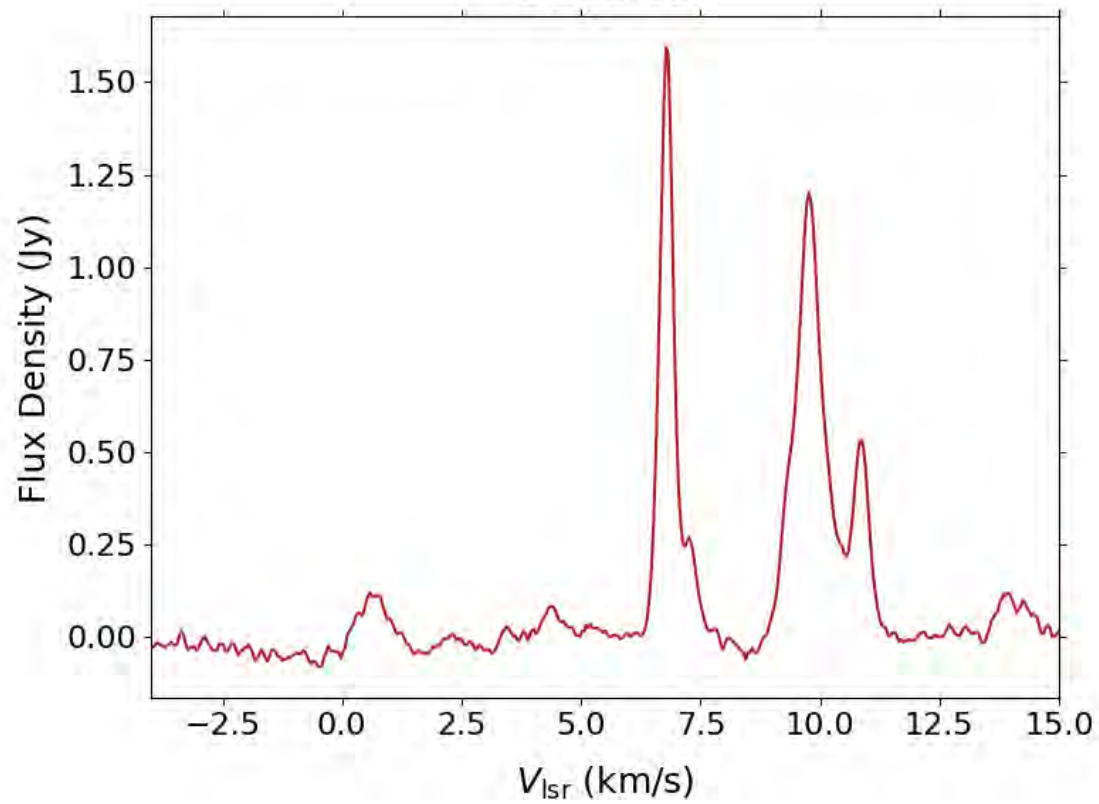
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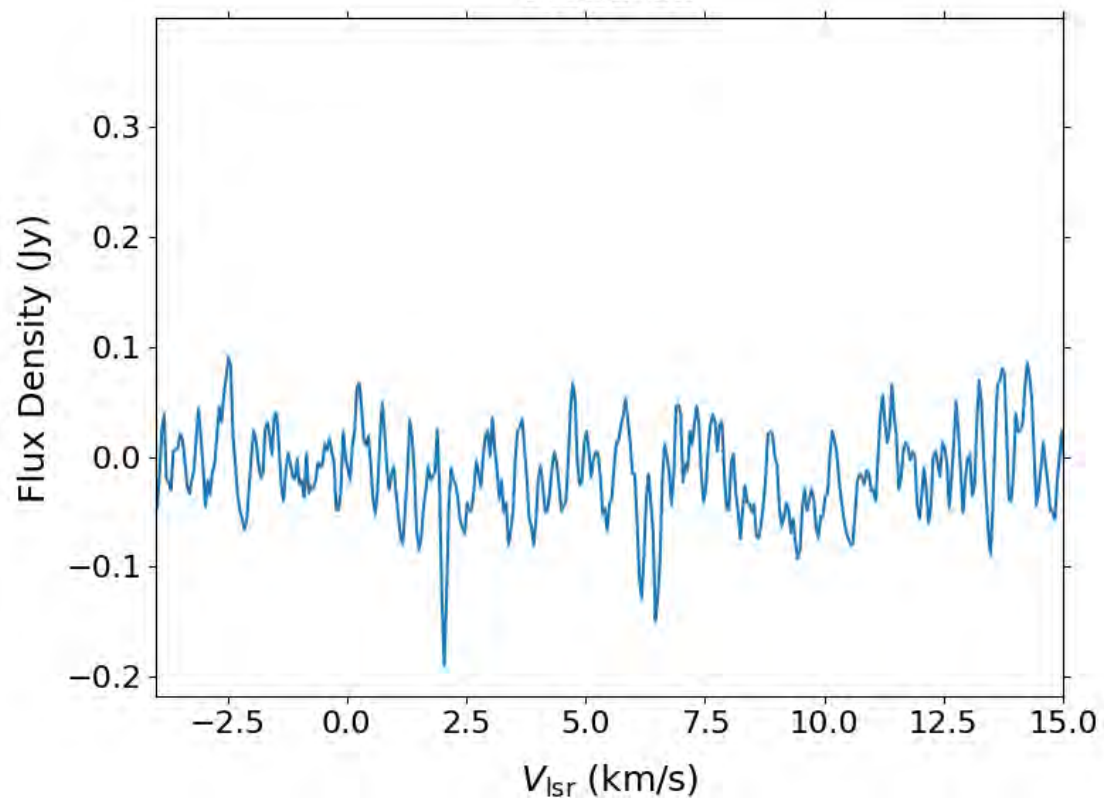
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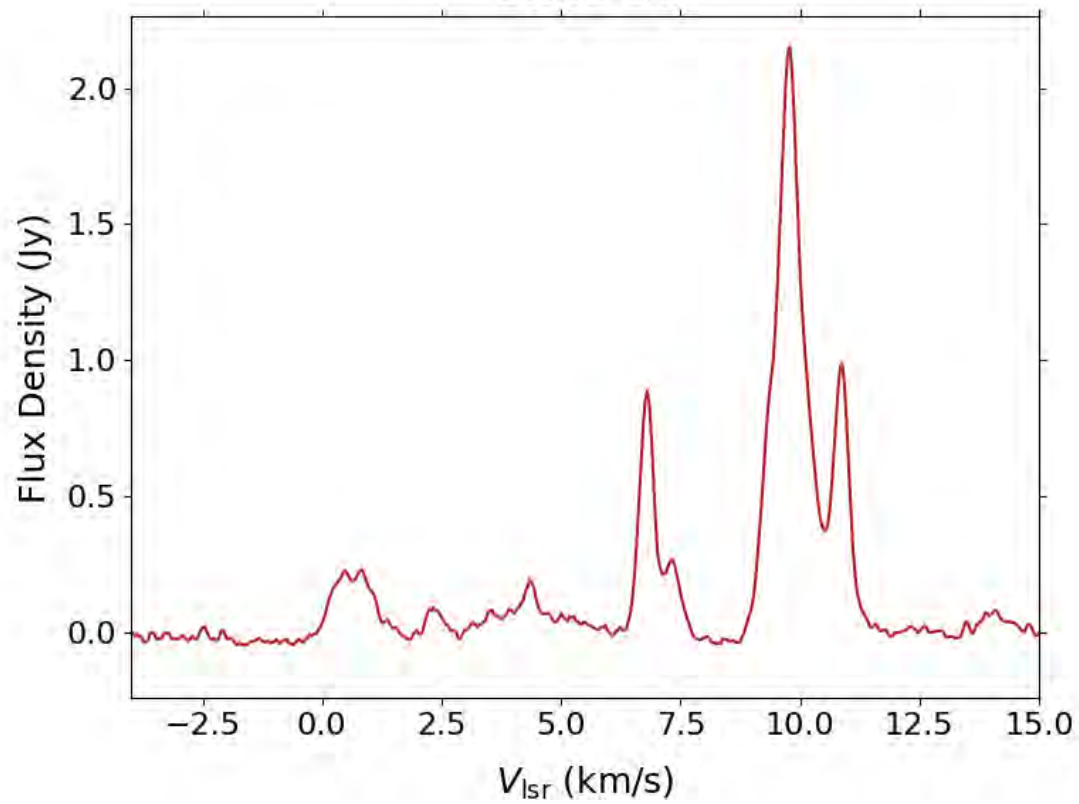
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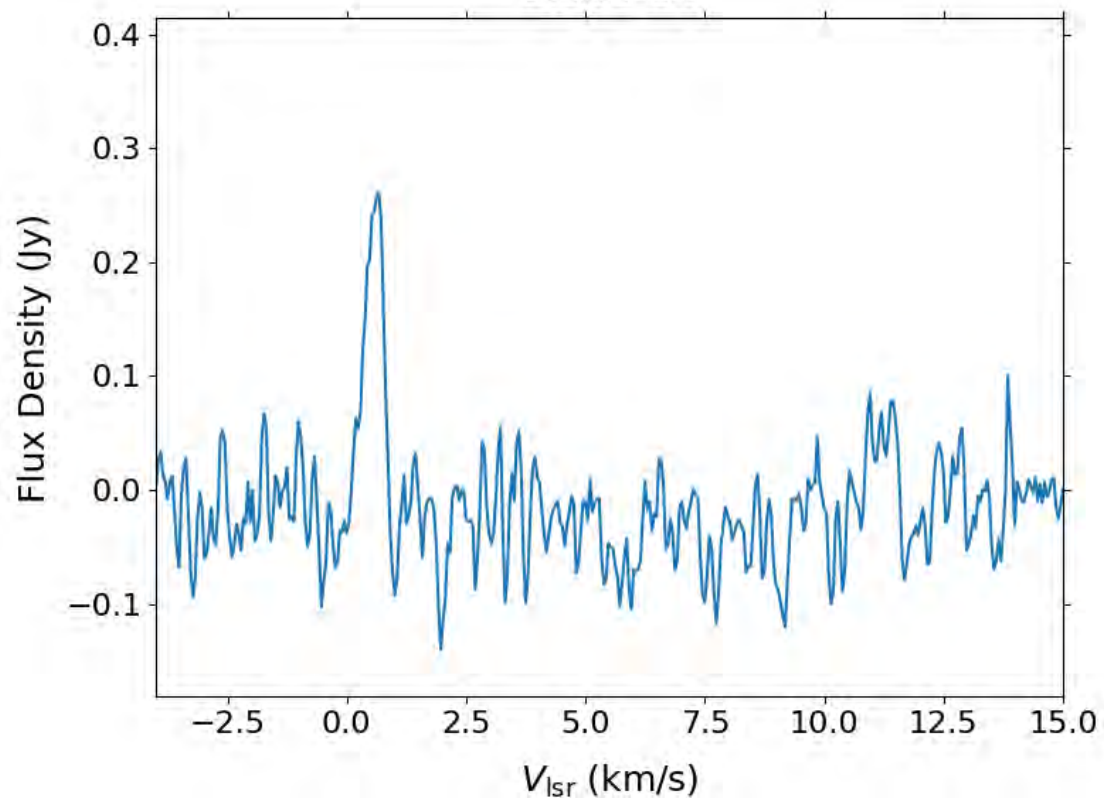
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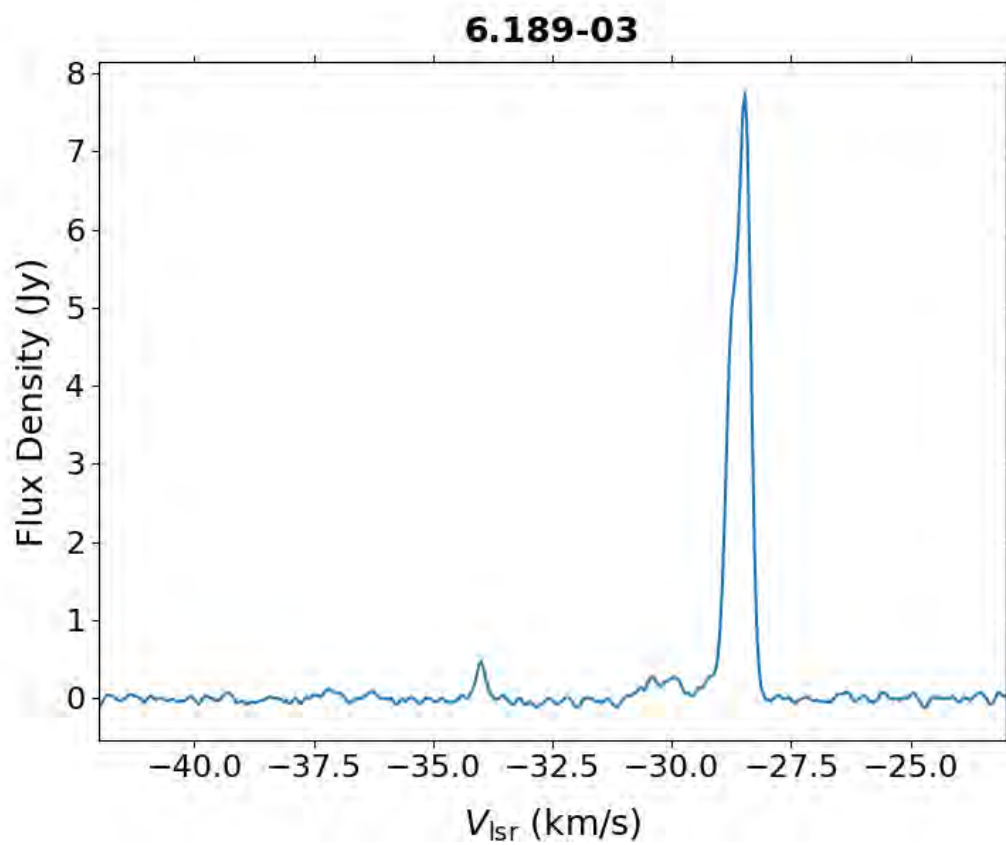
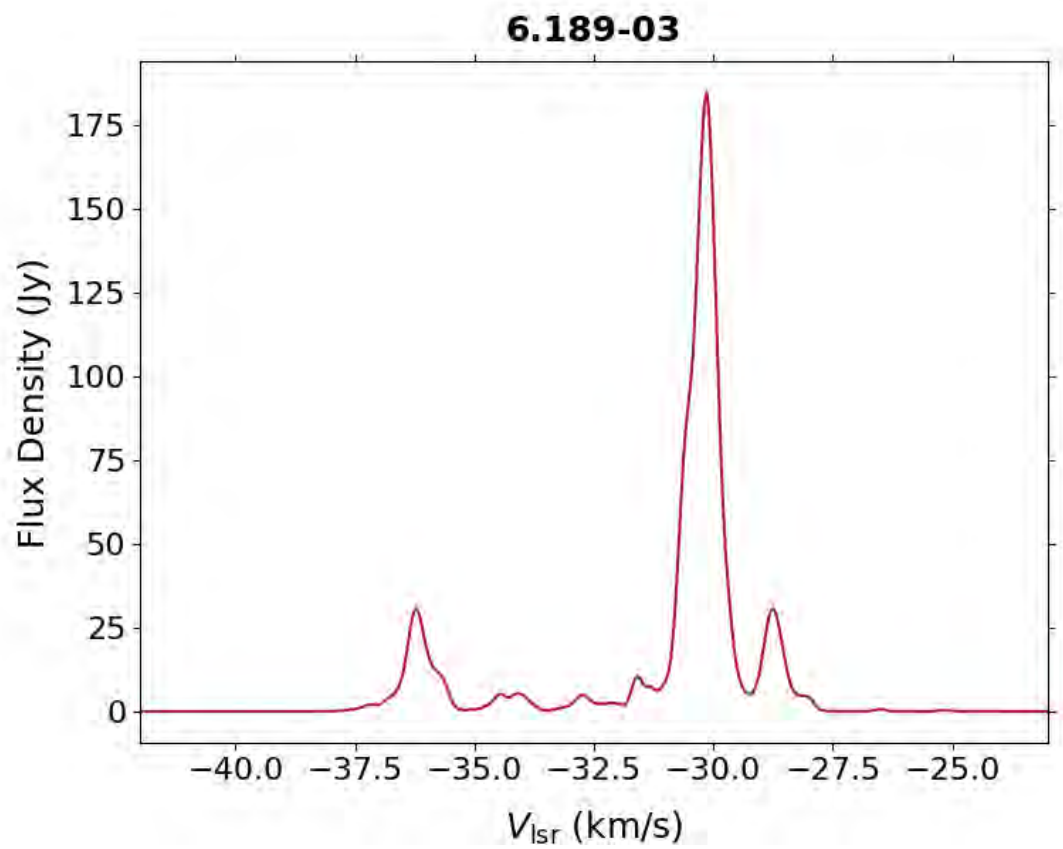


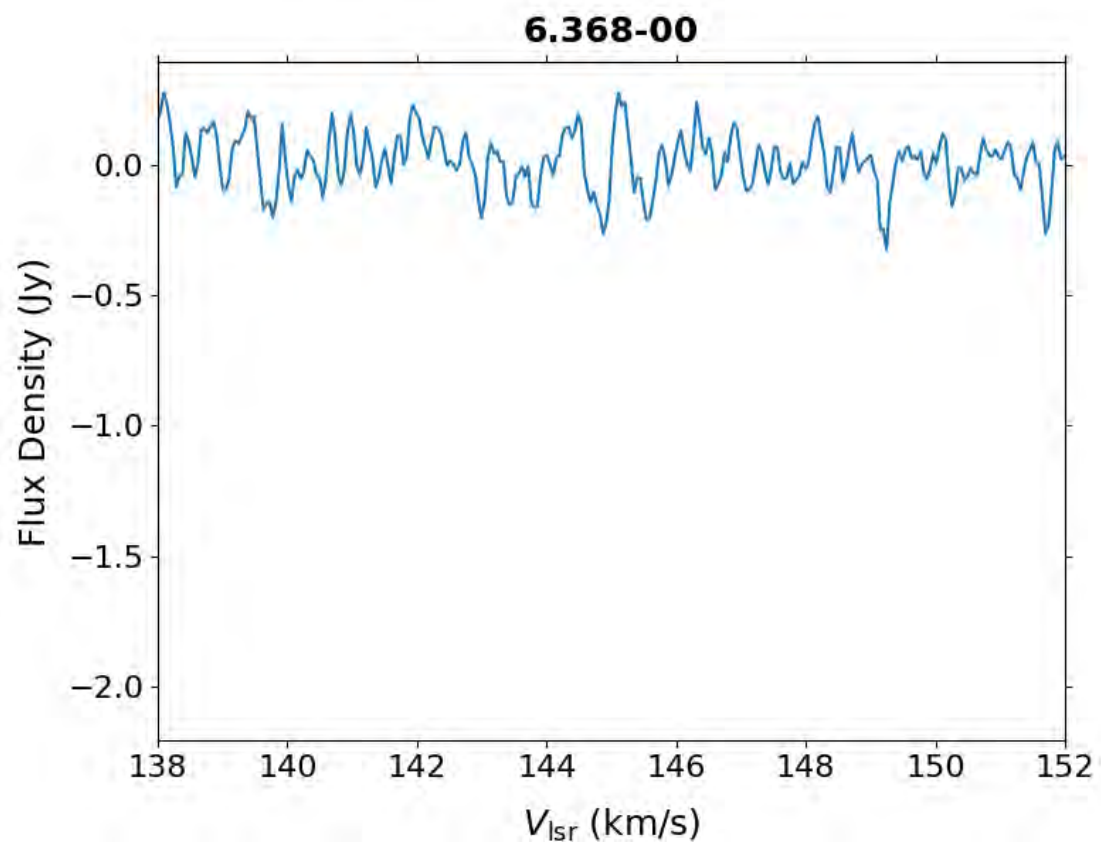
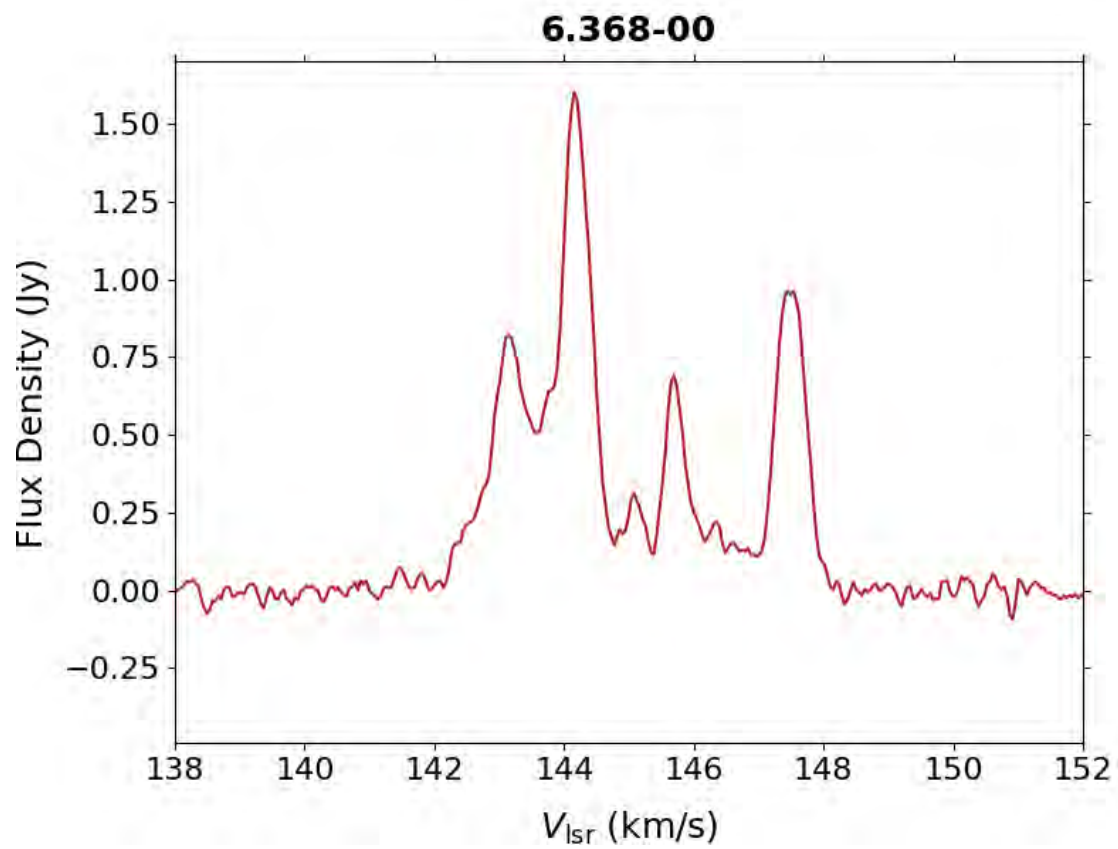
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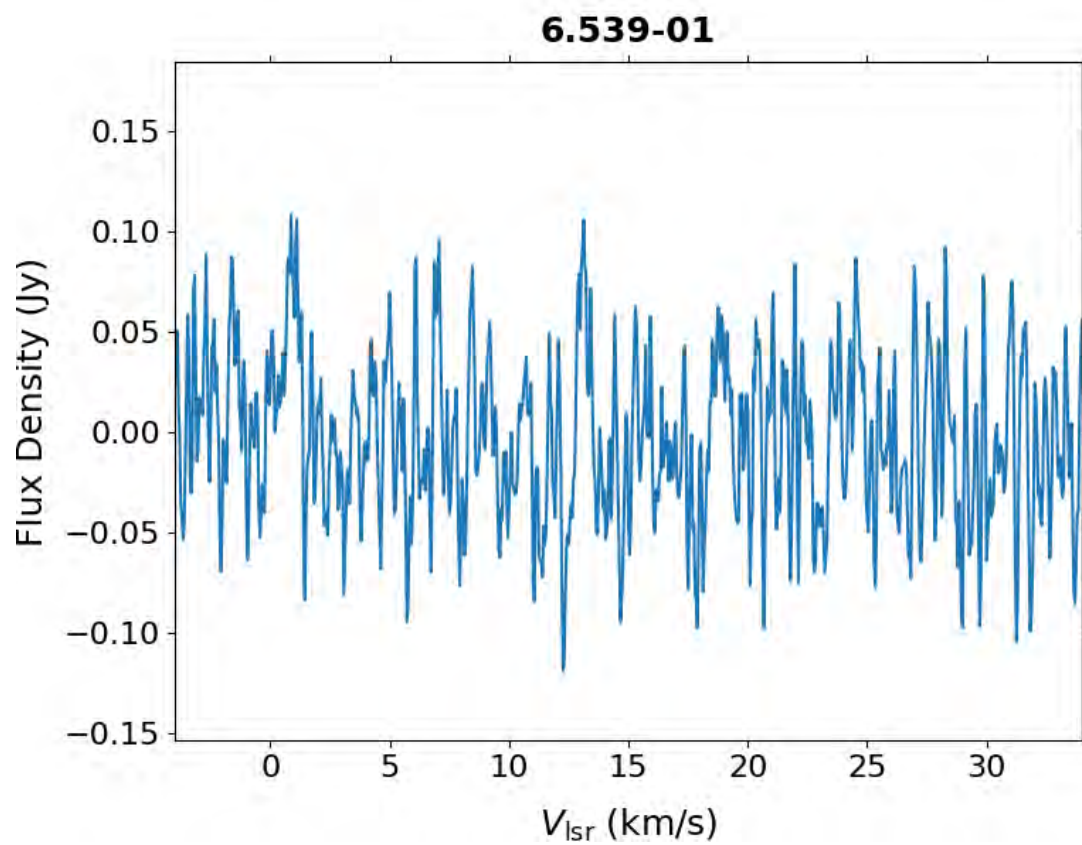
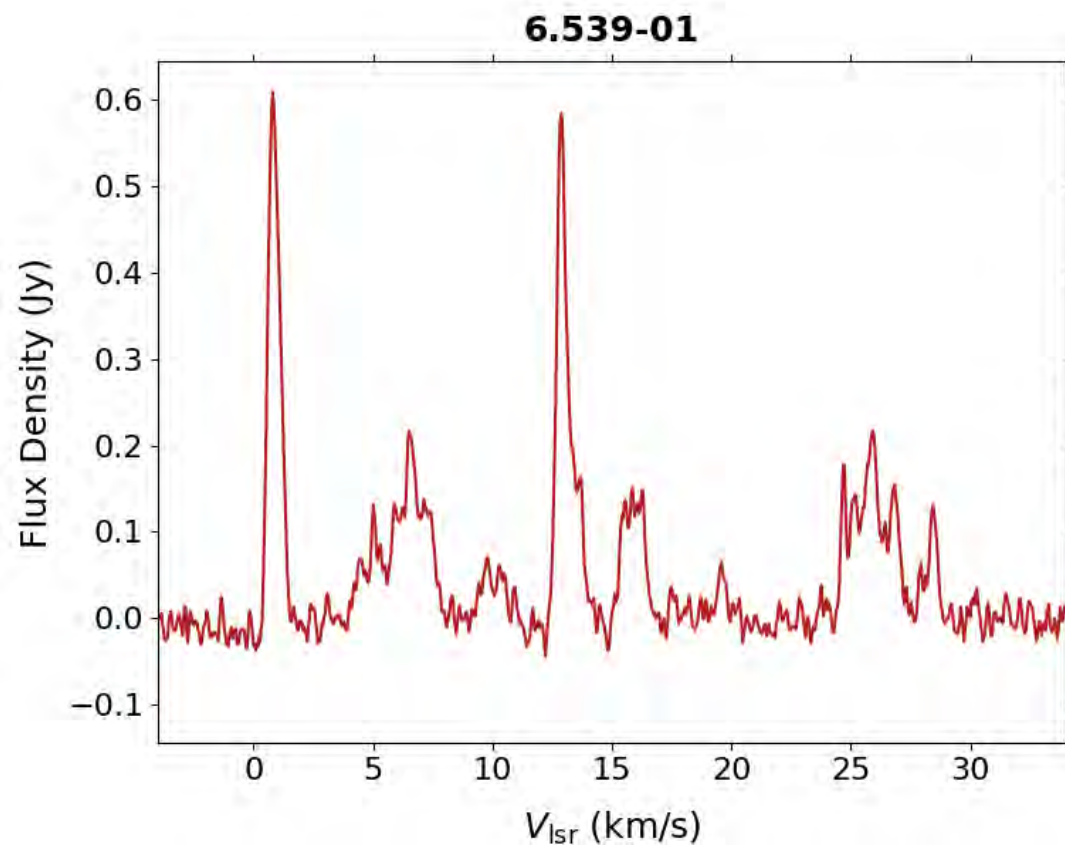


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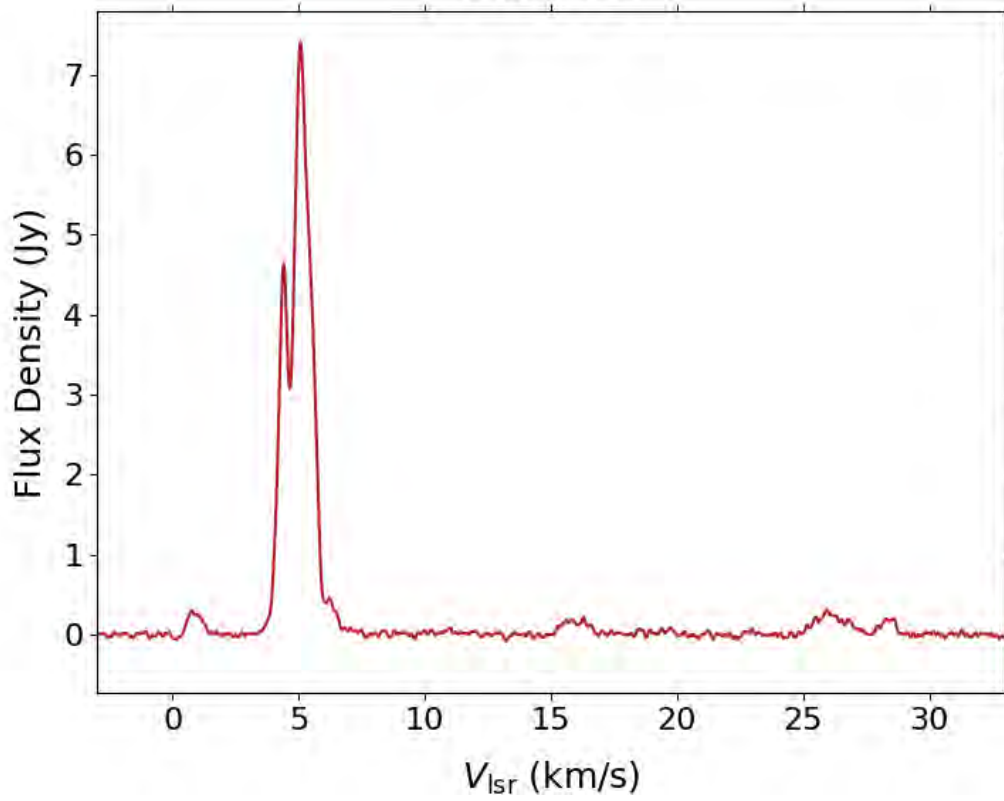




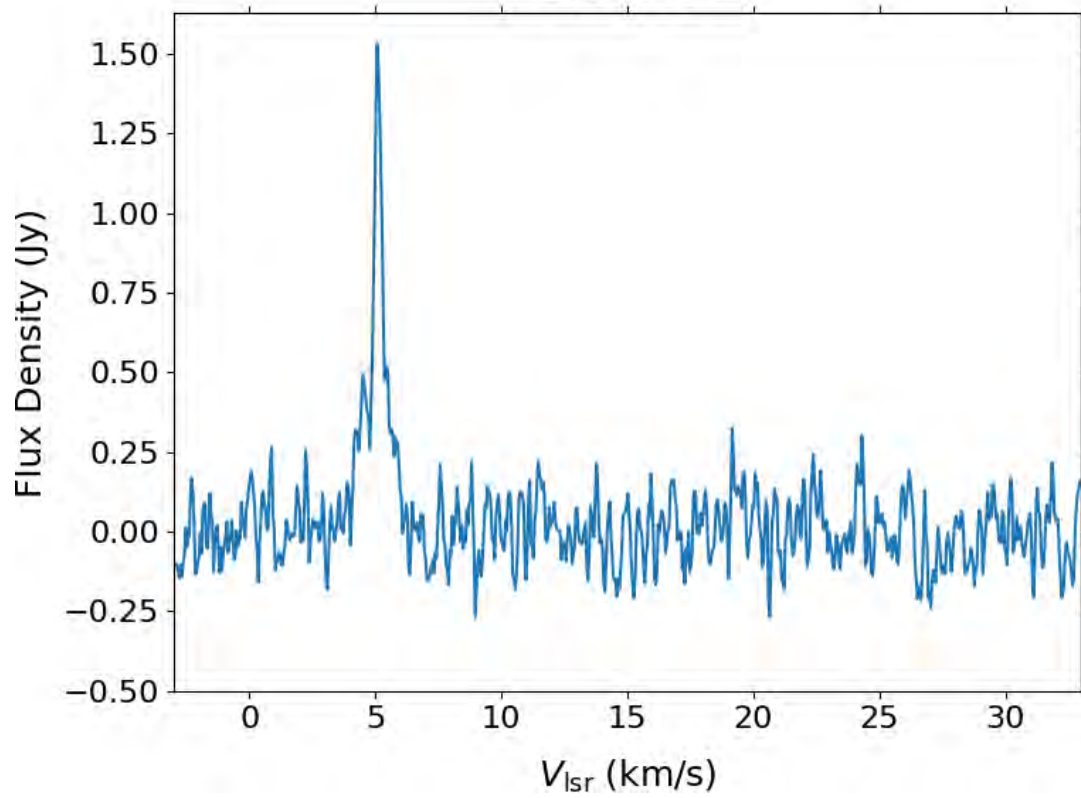


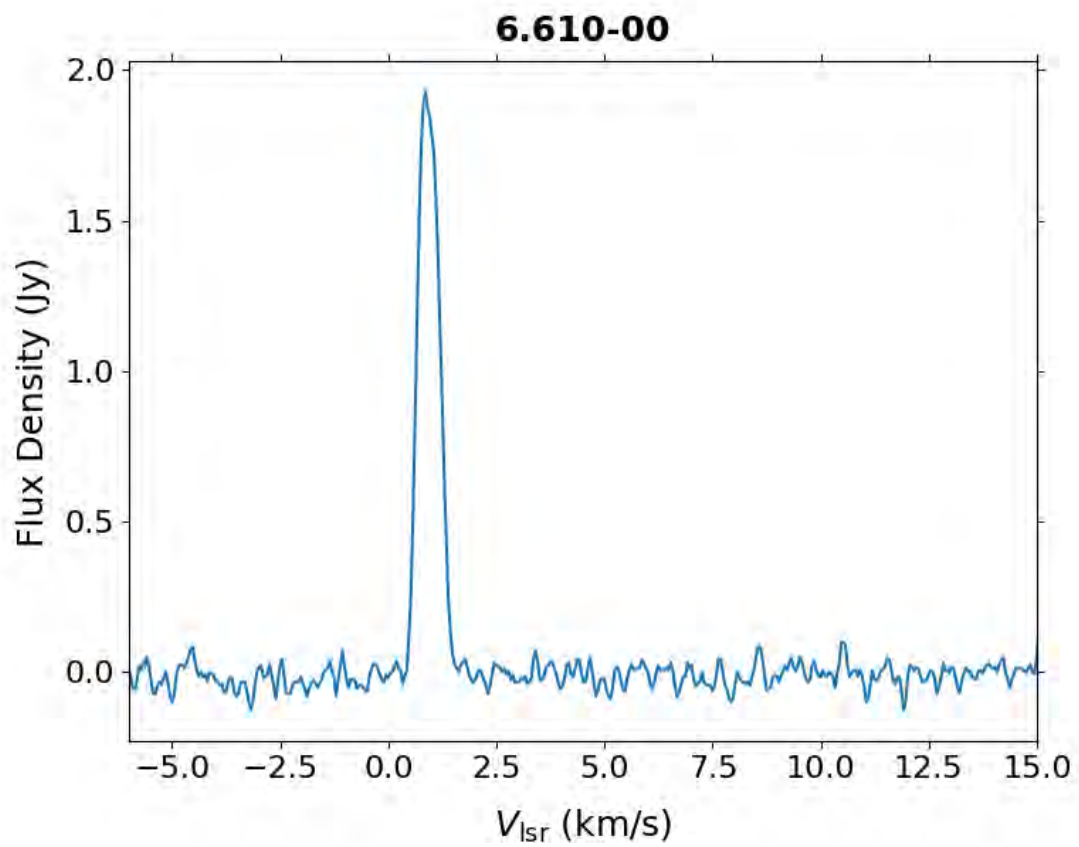
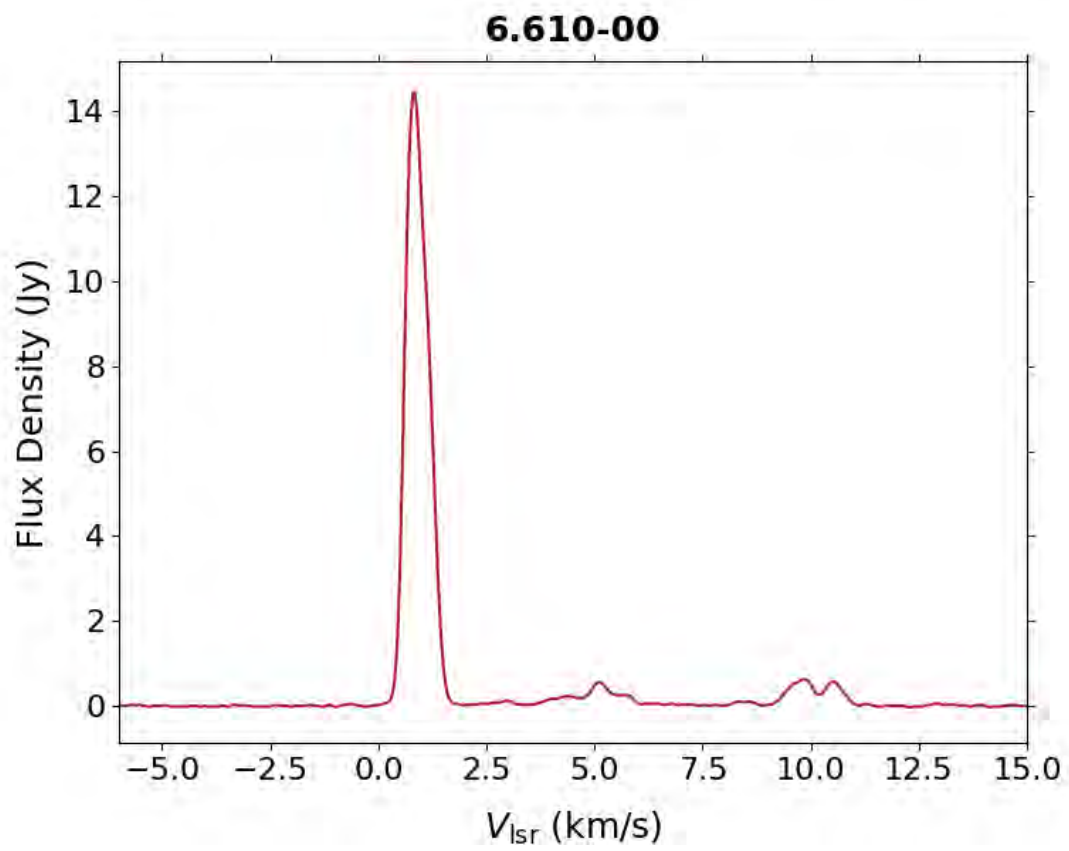


6.588-01

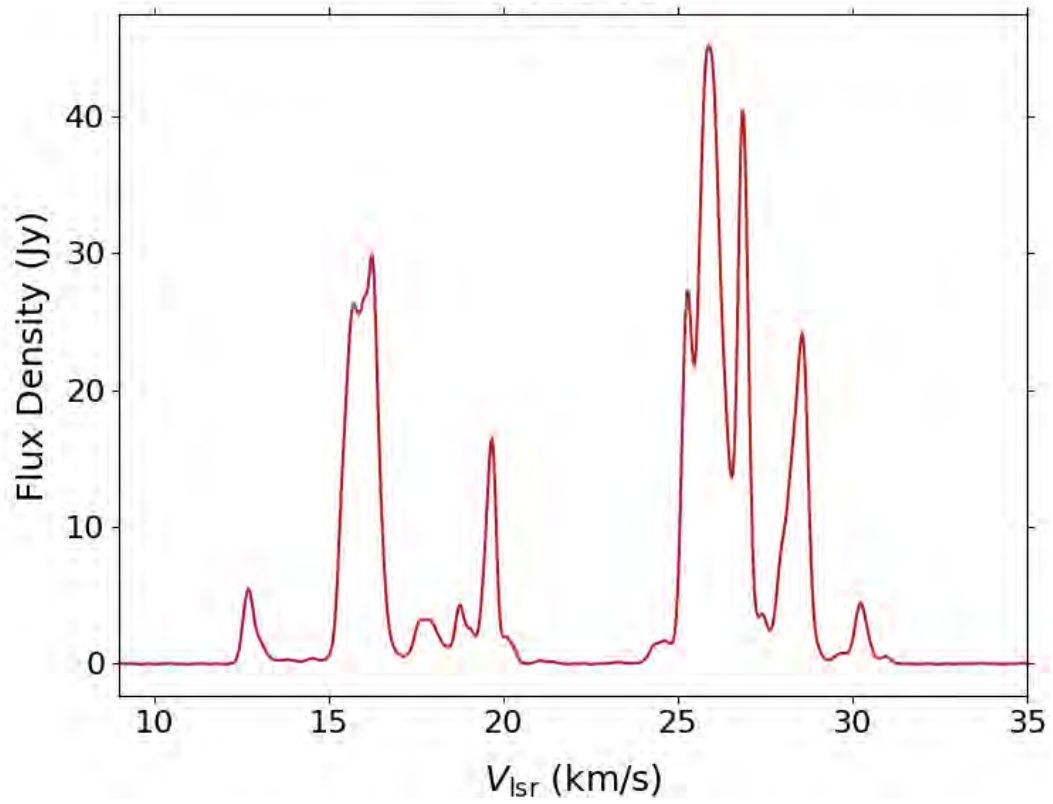


6.588-01

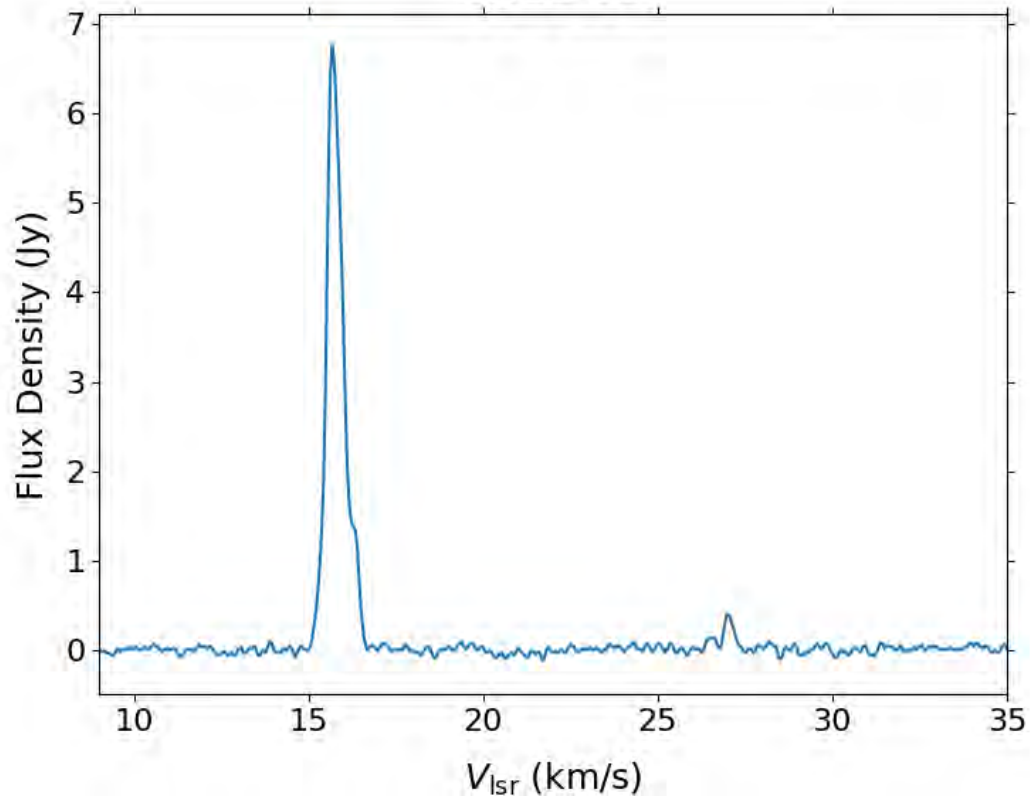


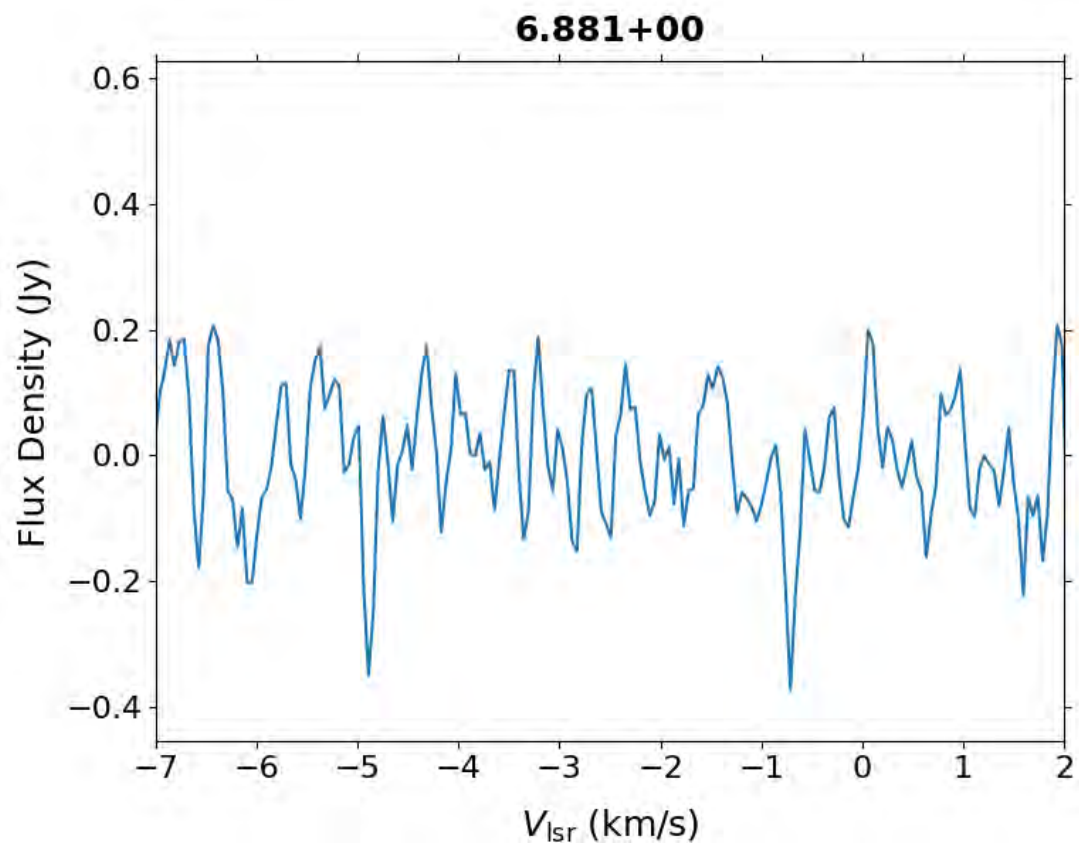
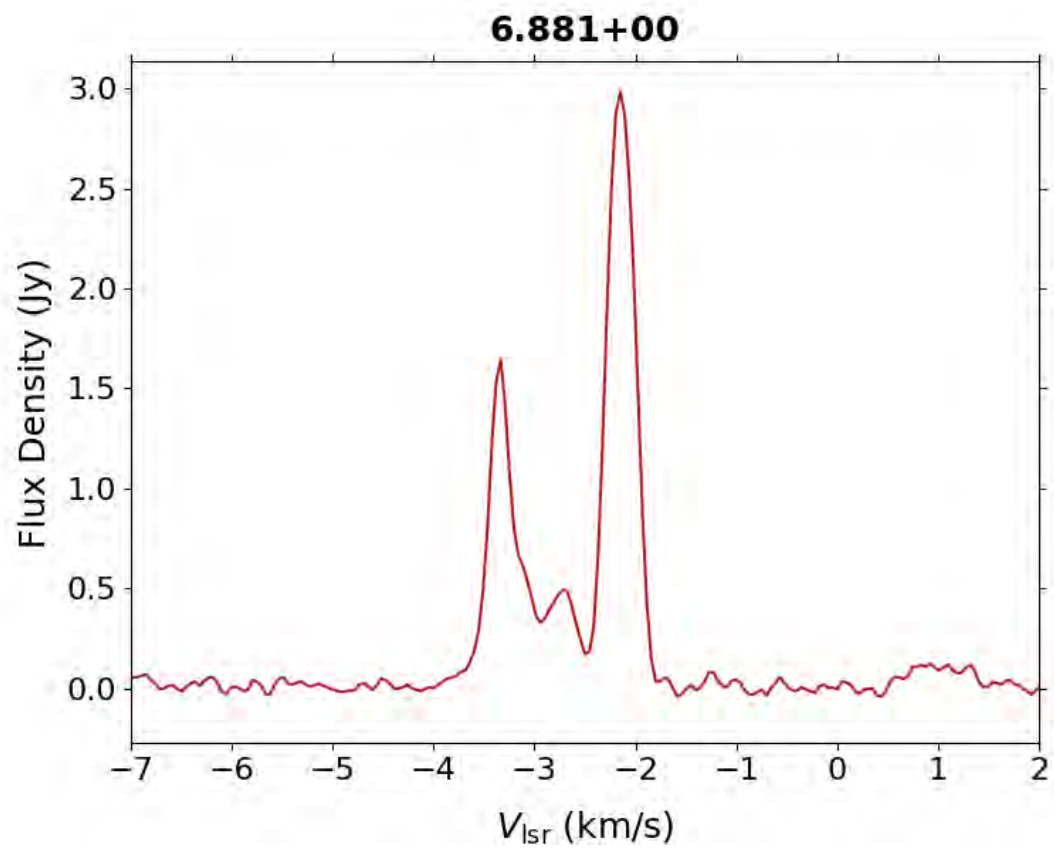


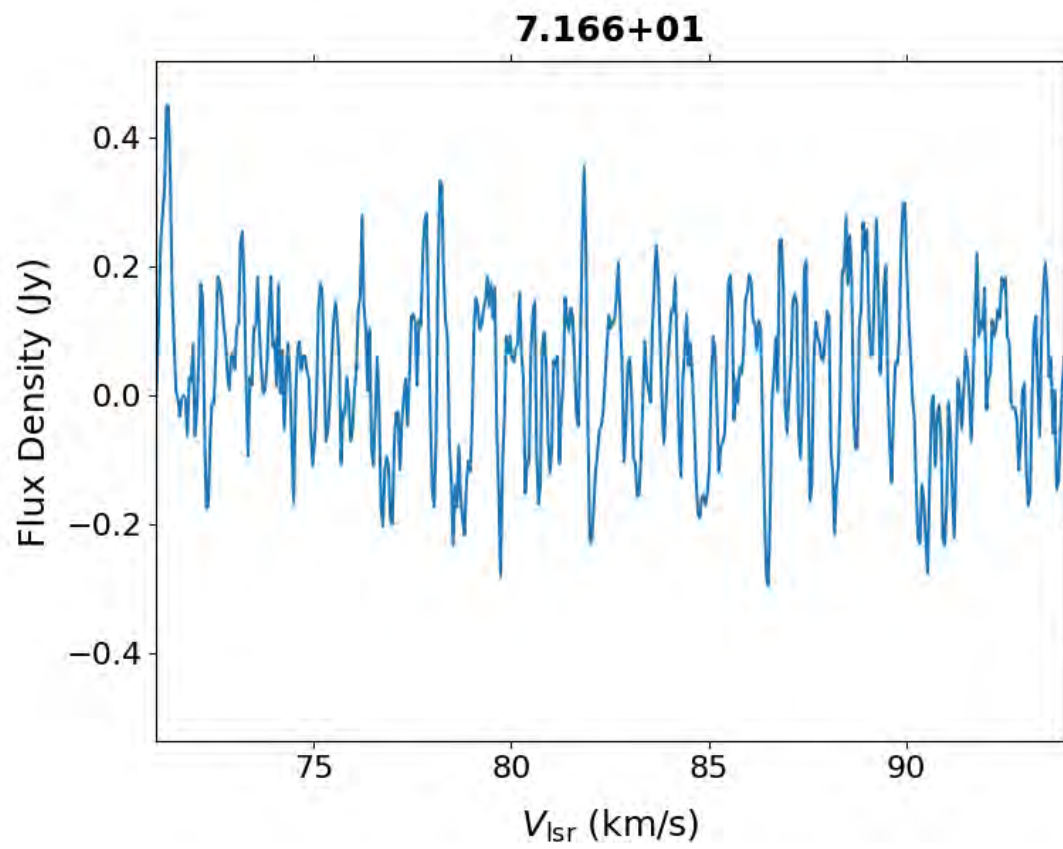
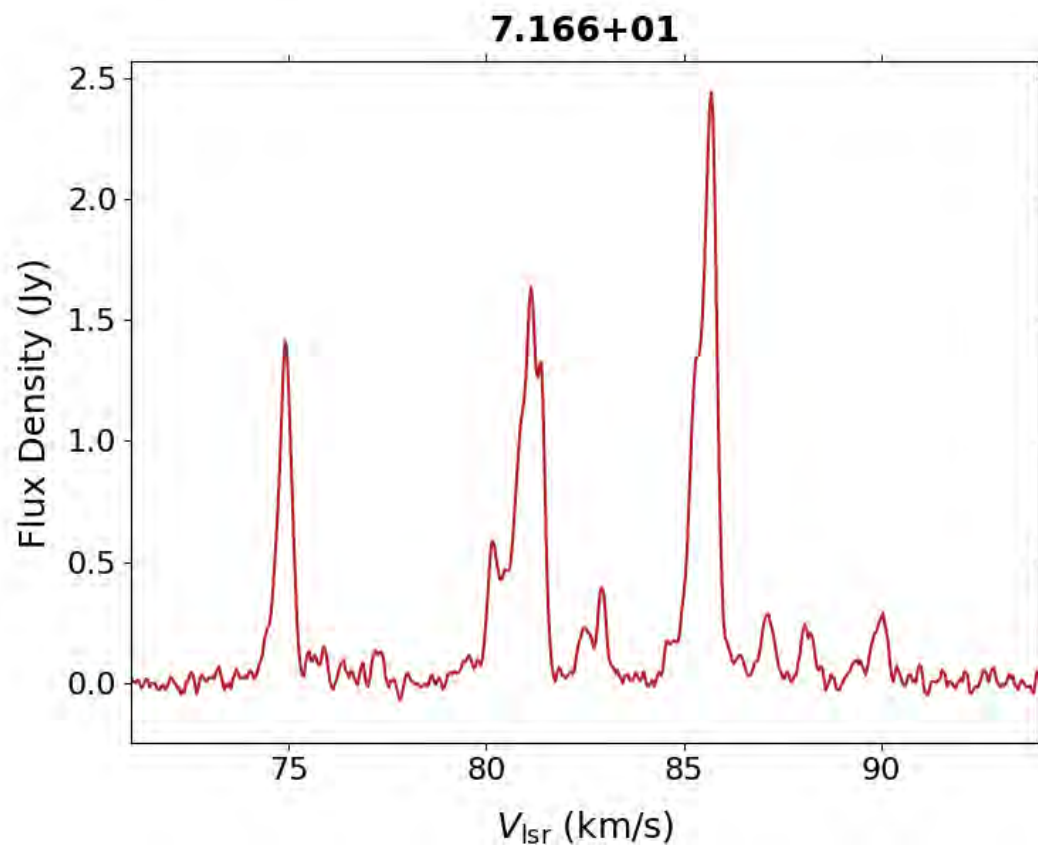
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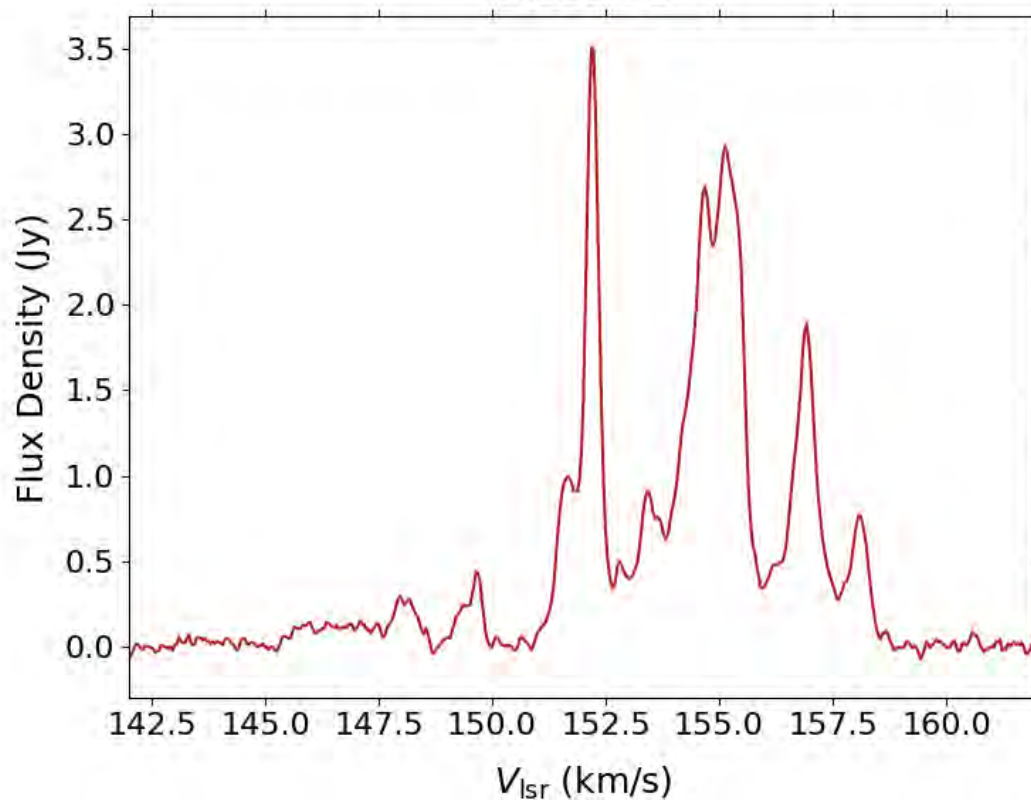
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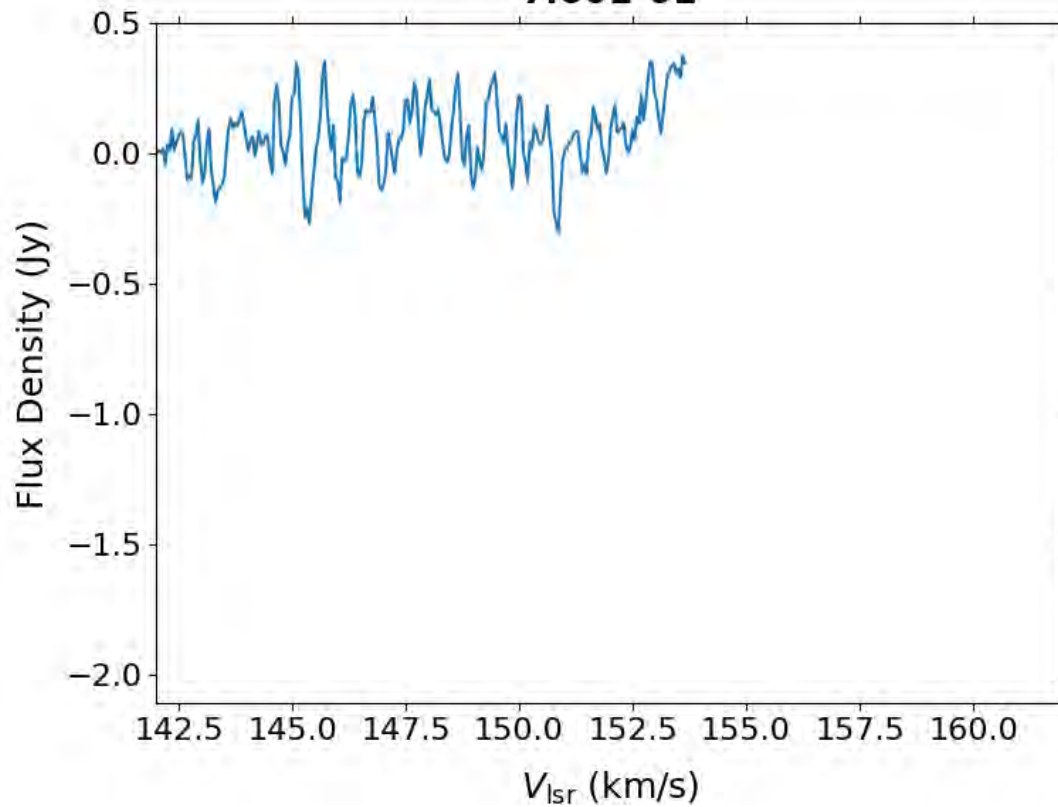




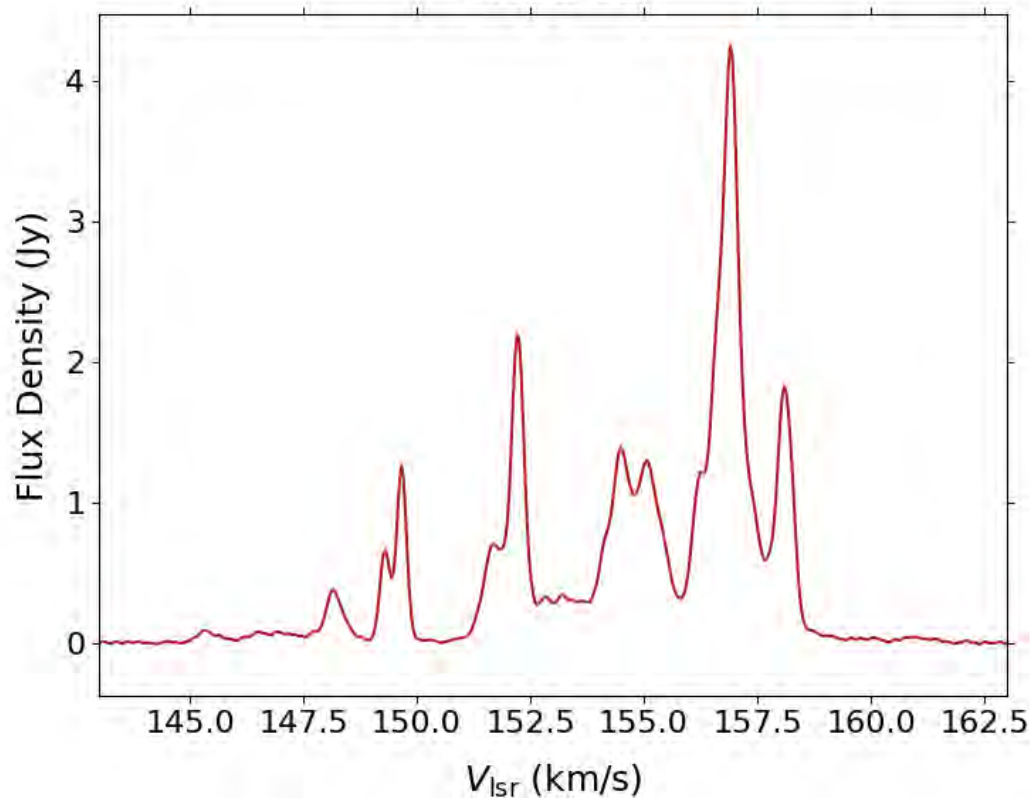
7.601-01



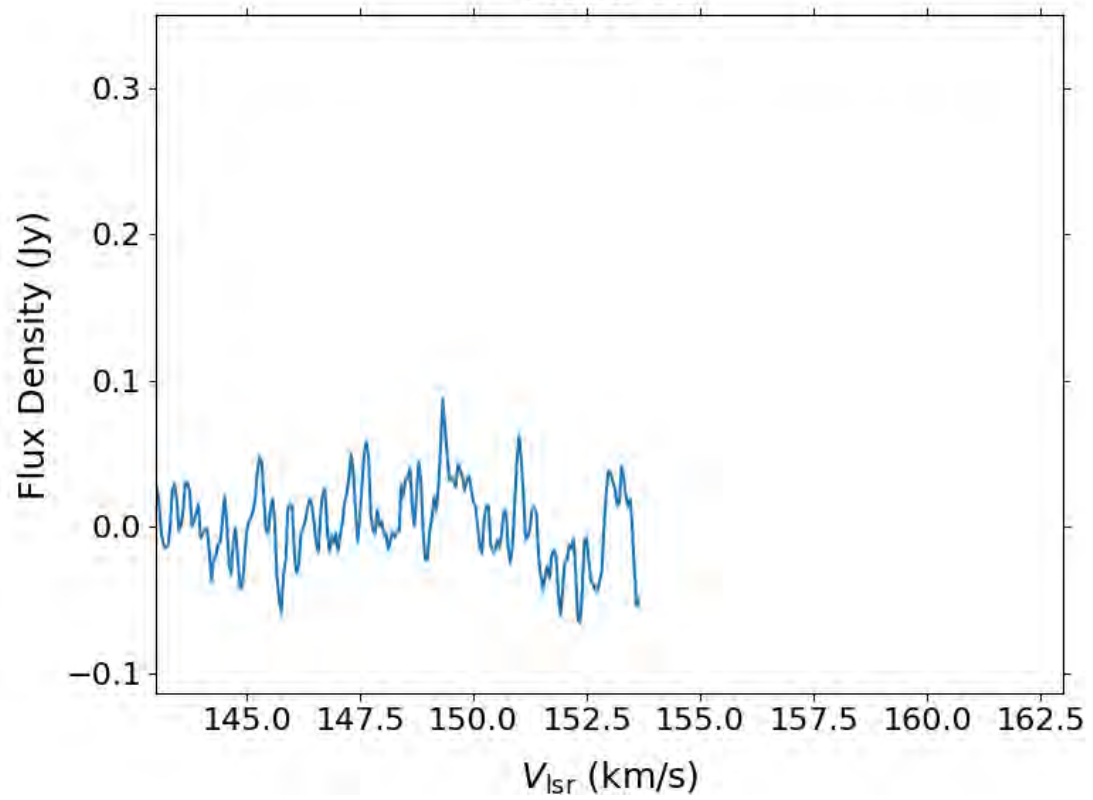
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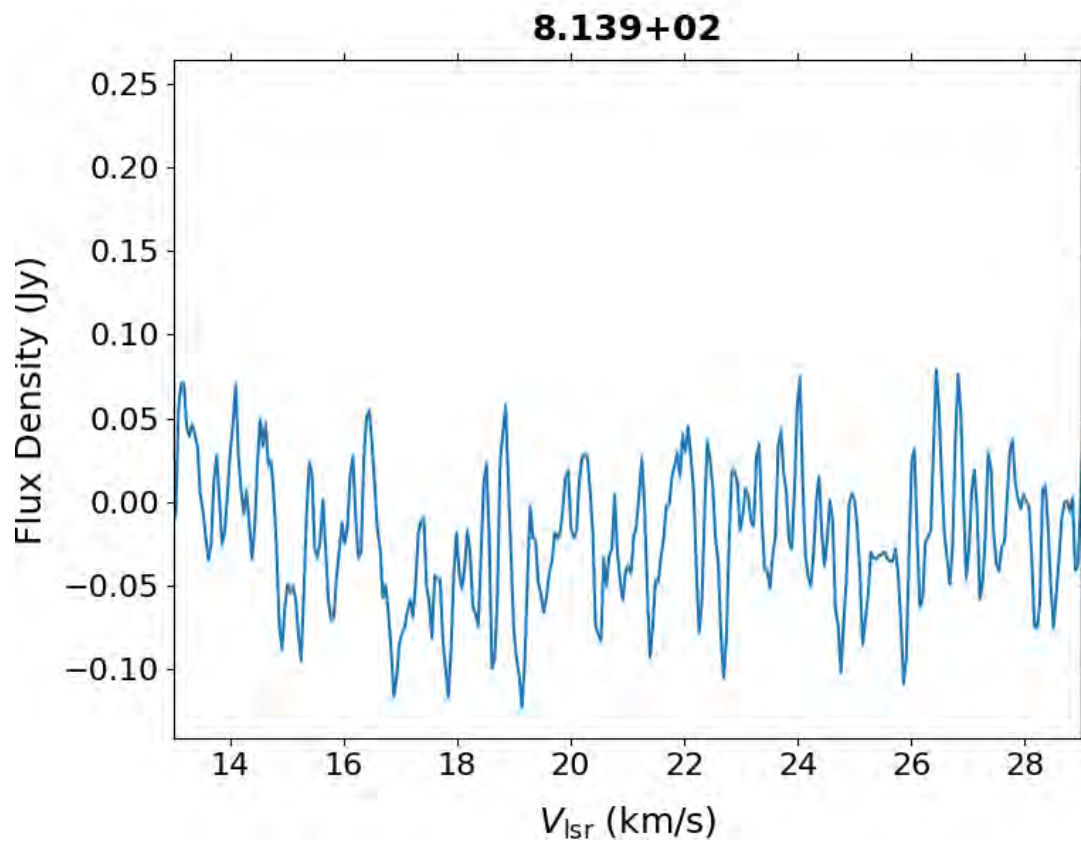
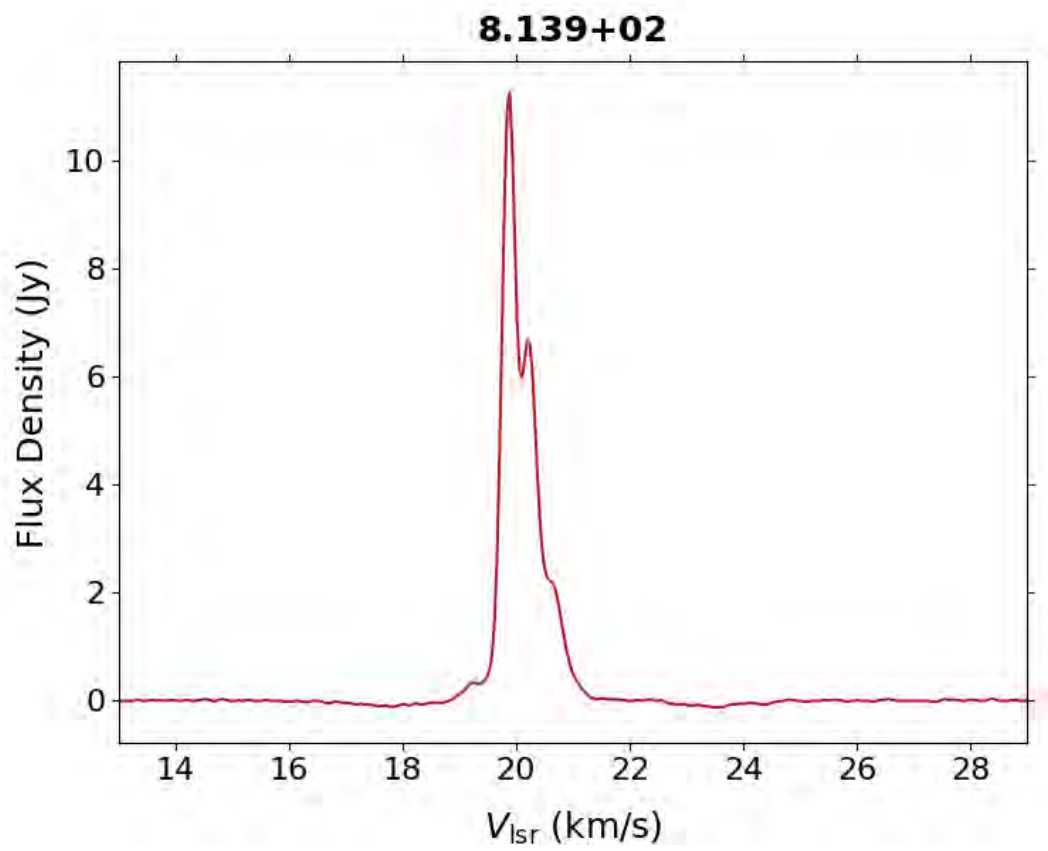


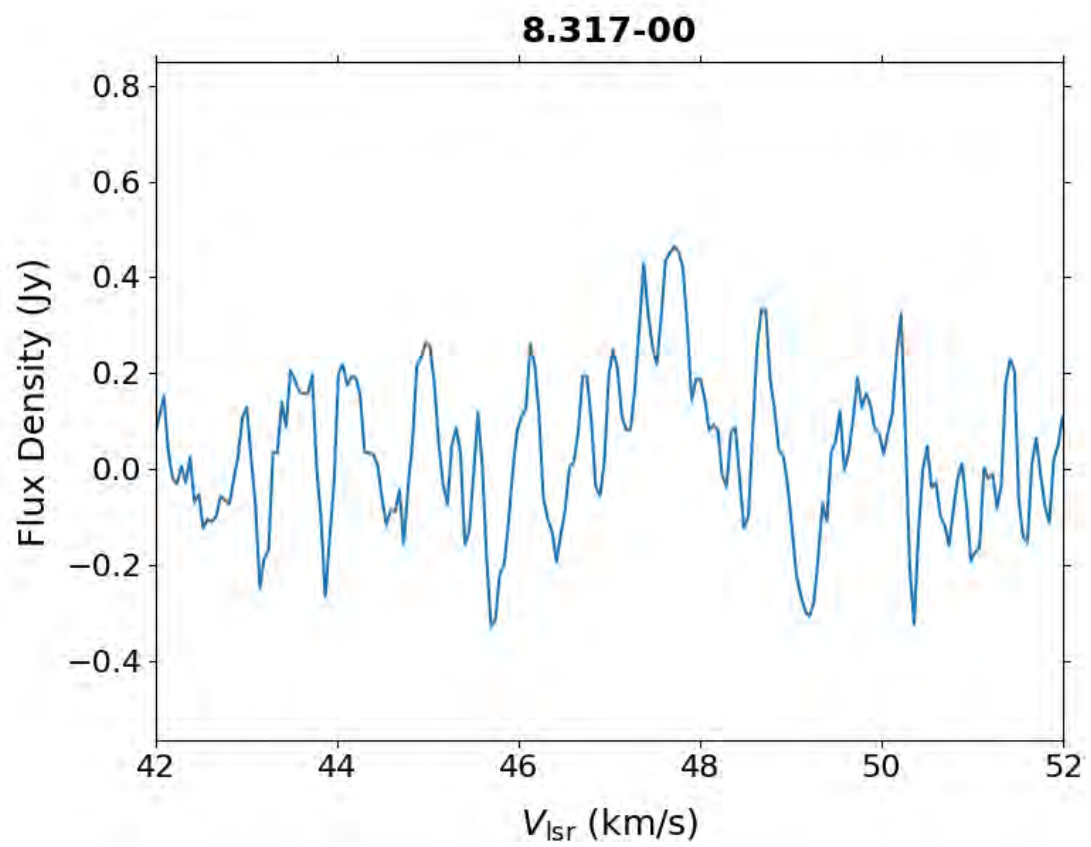
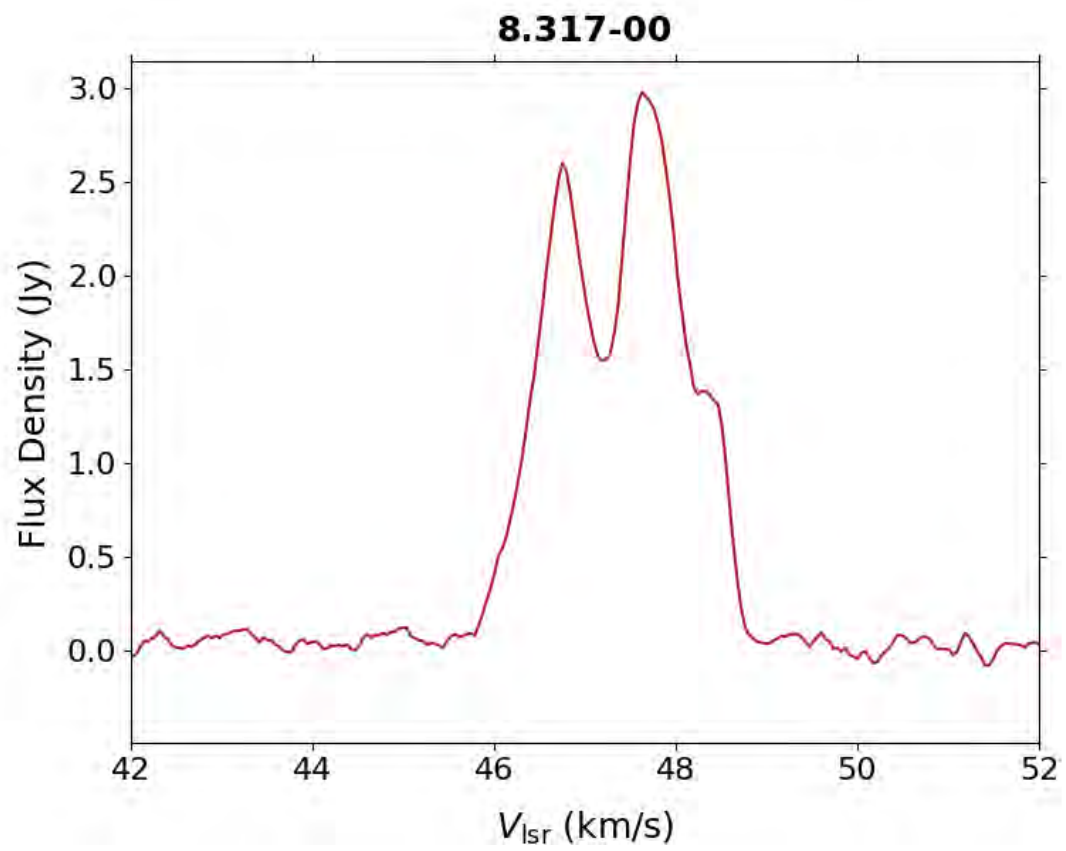
7.632-01

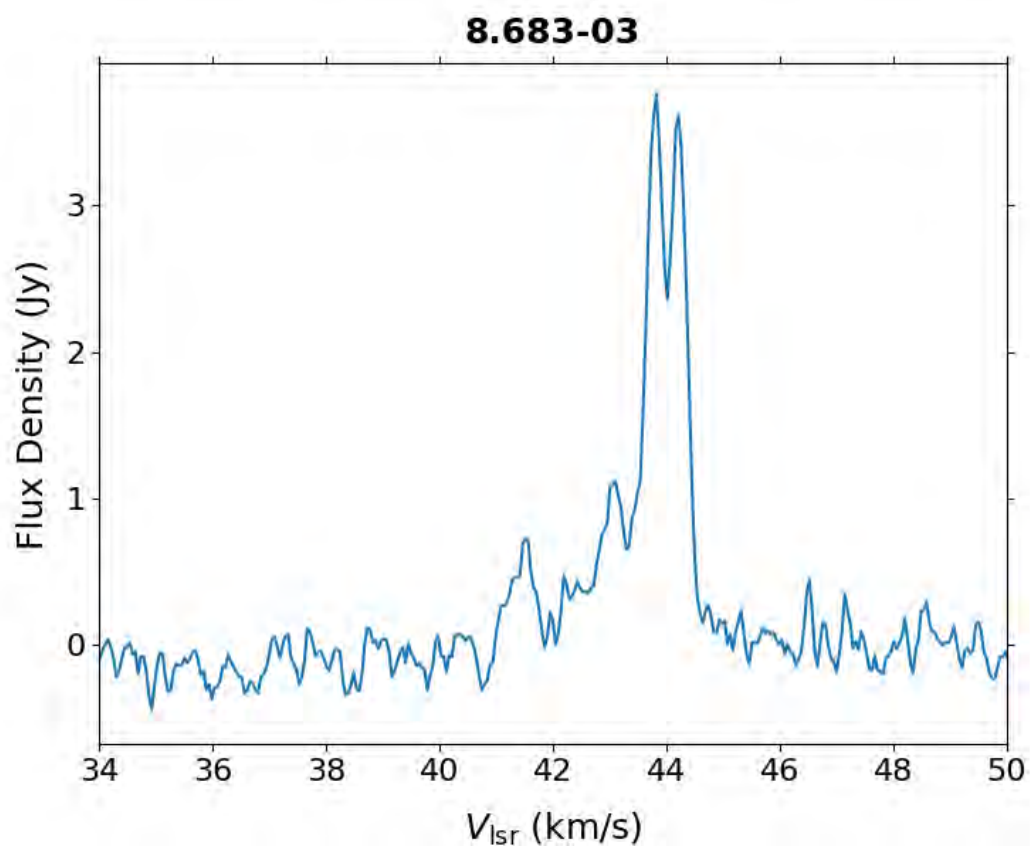
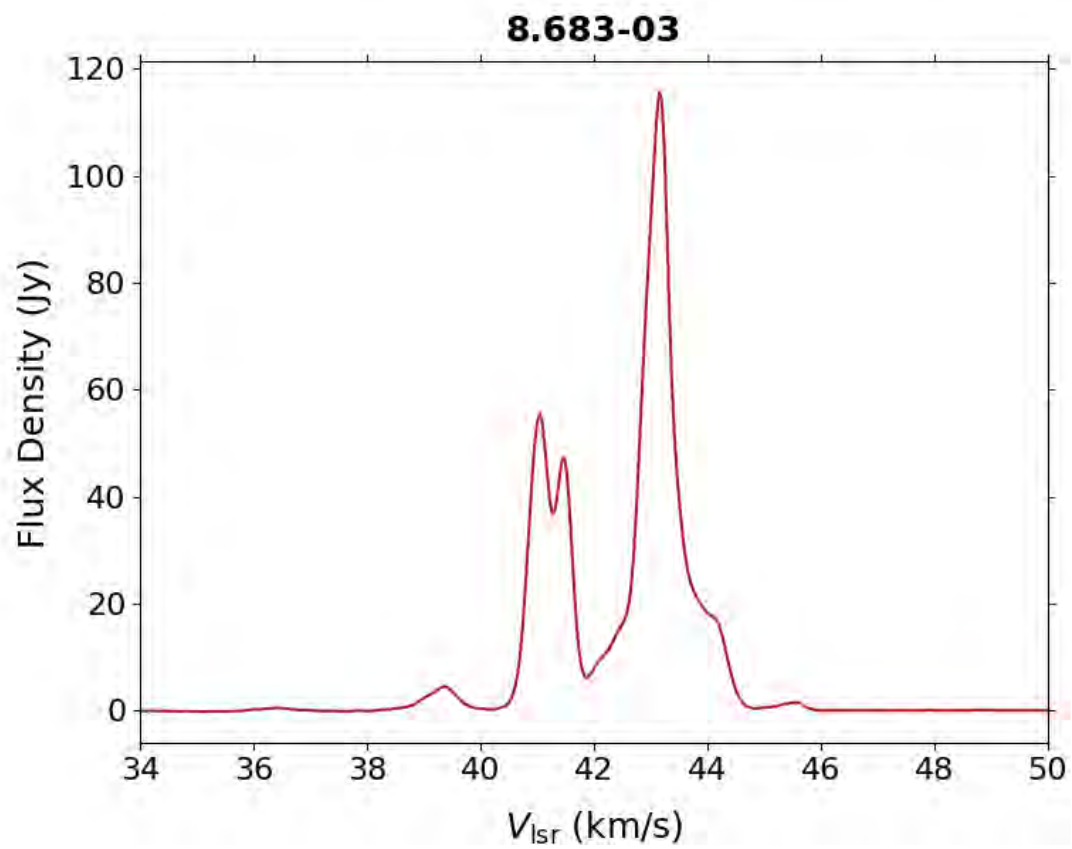


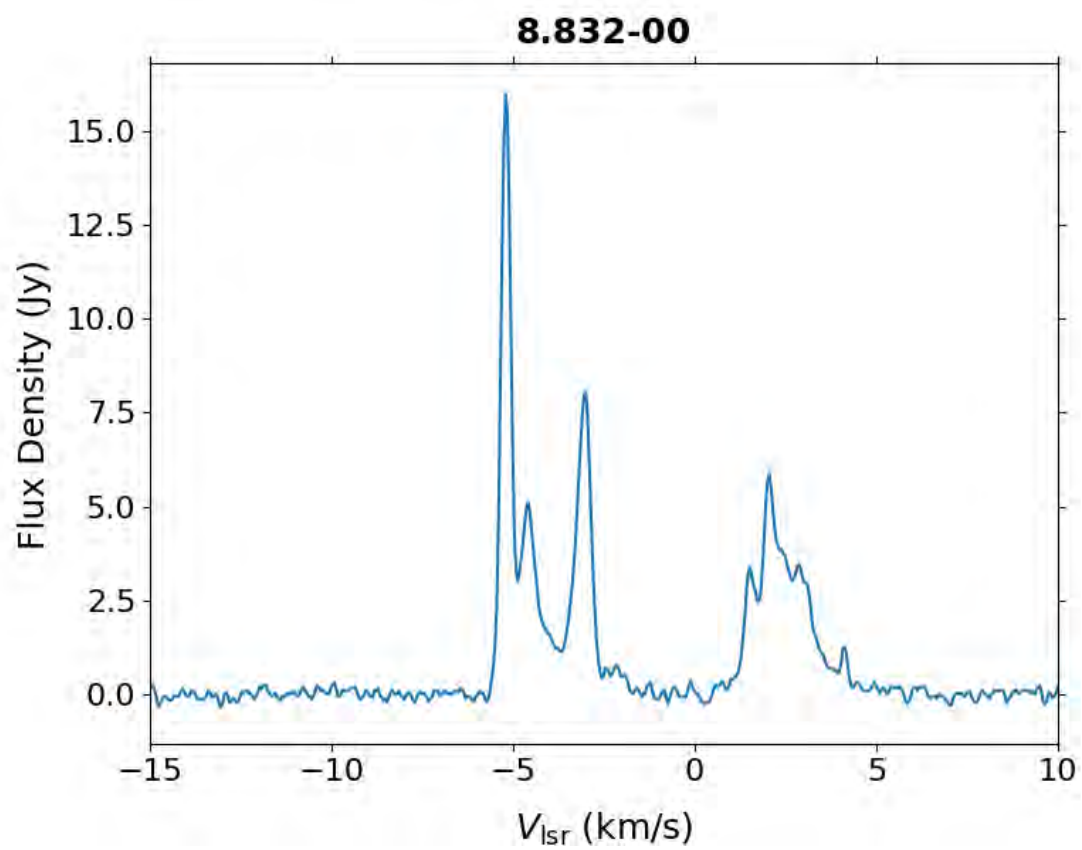
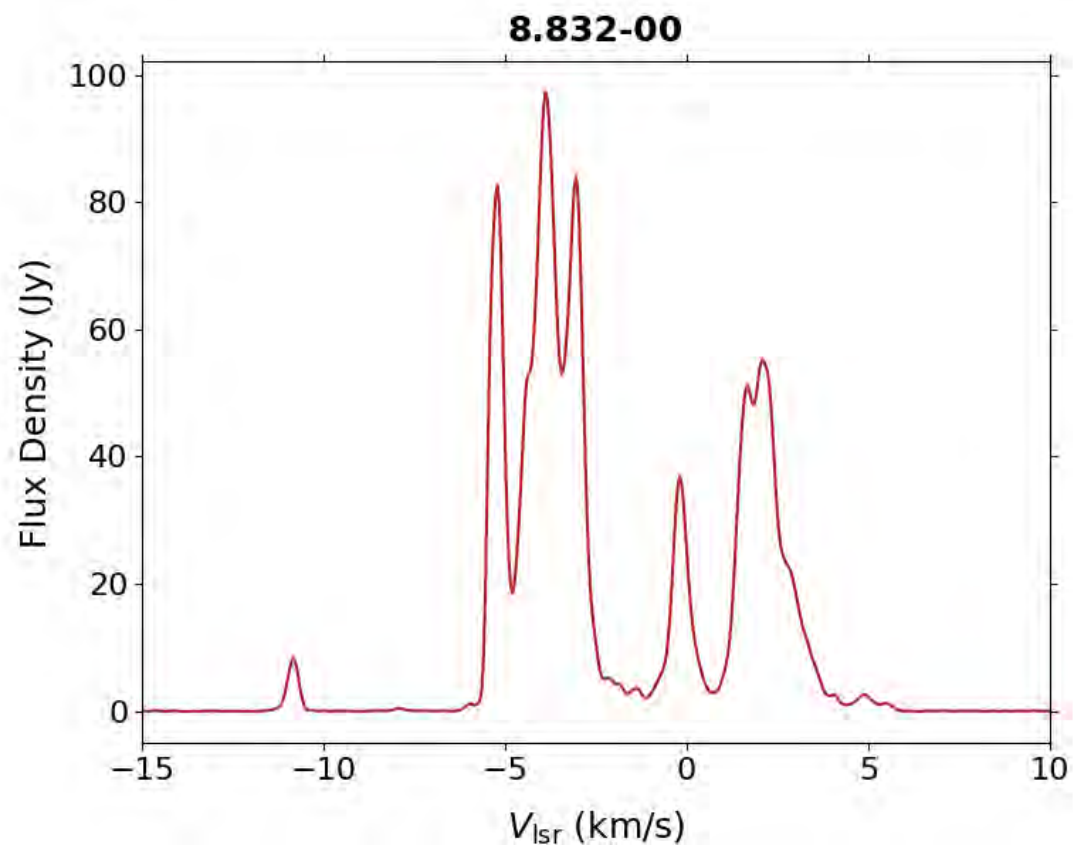
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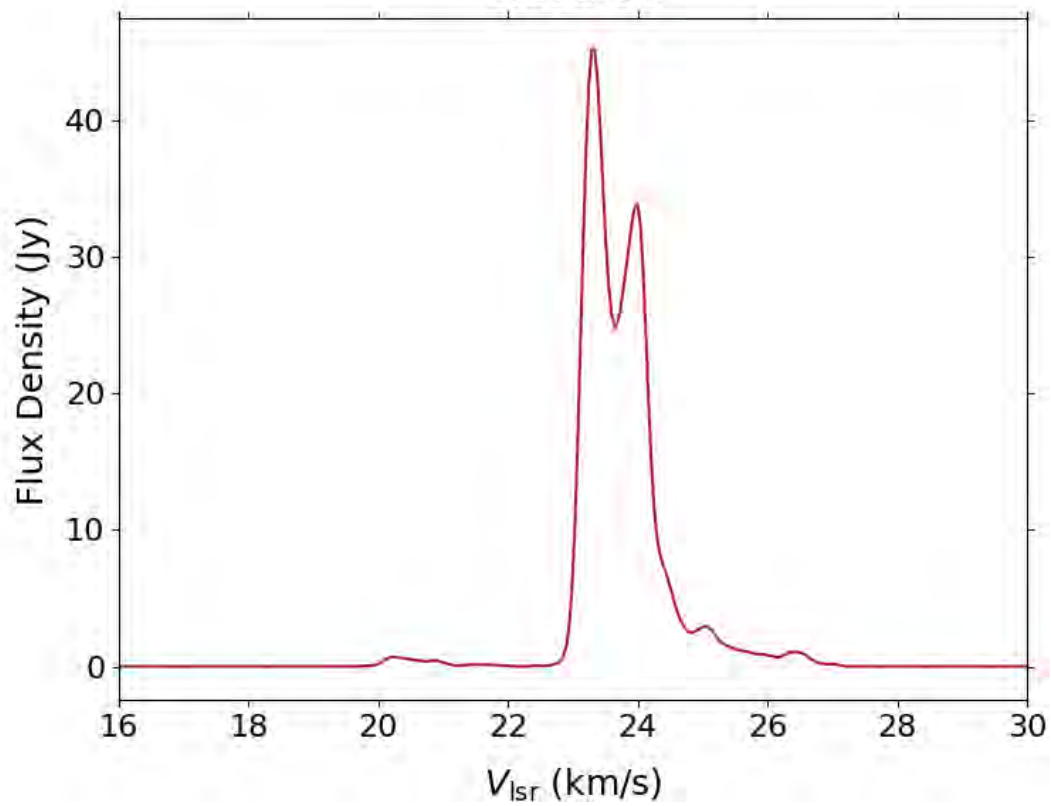




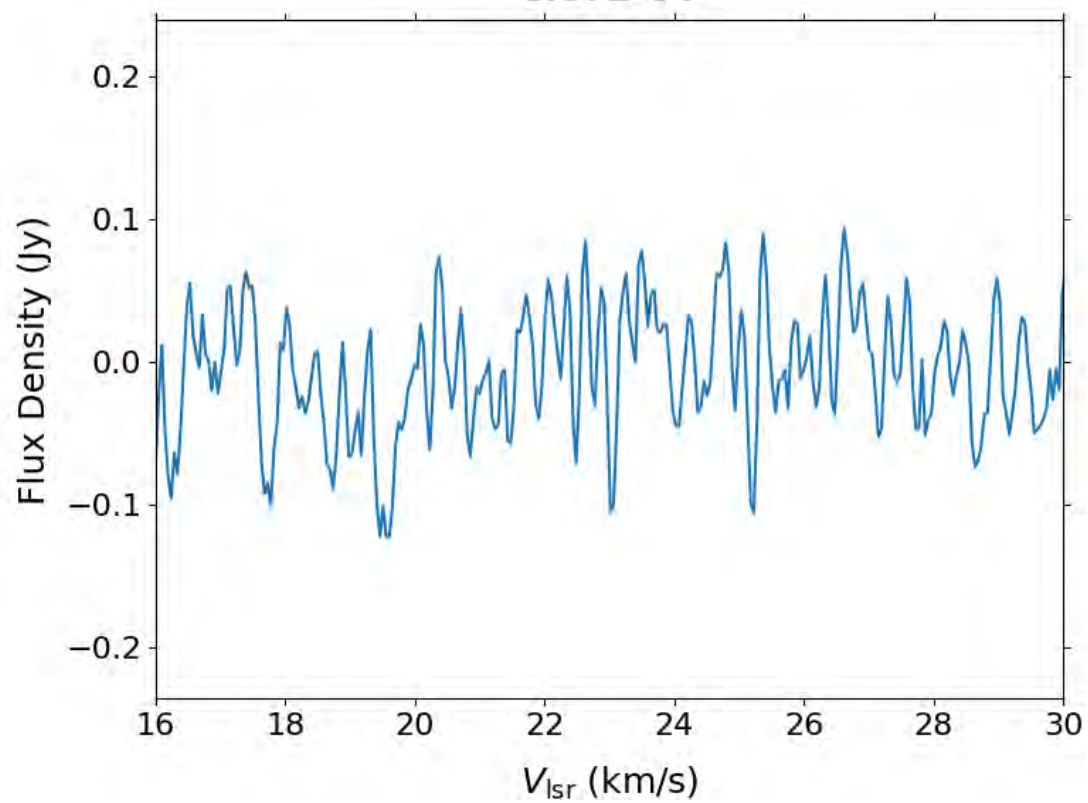




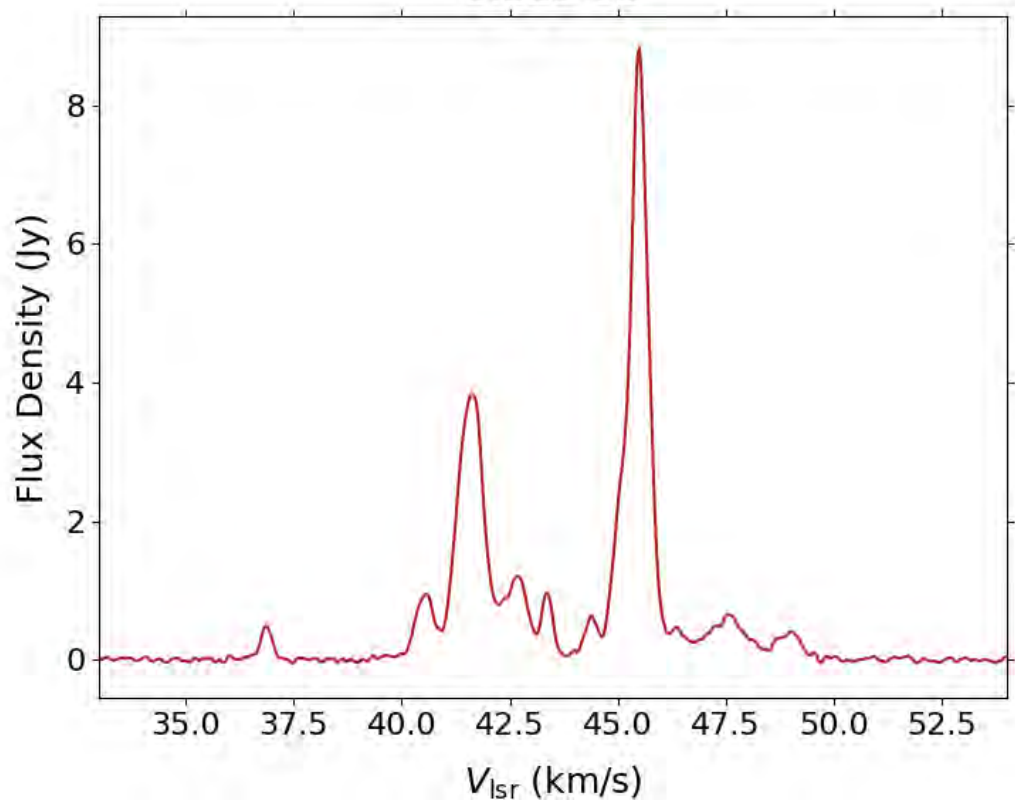
8.872-04



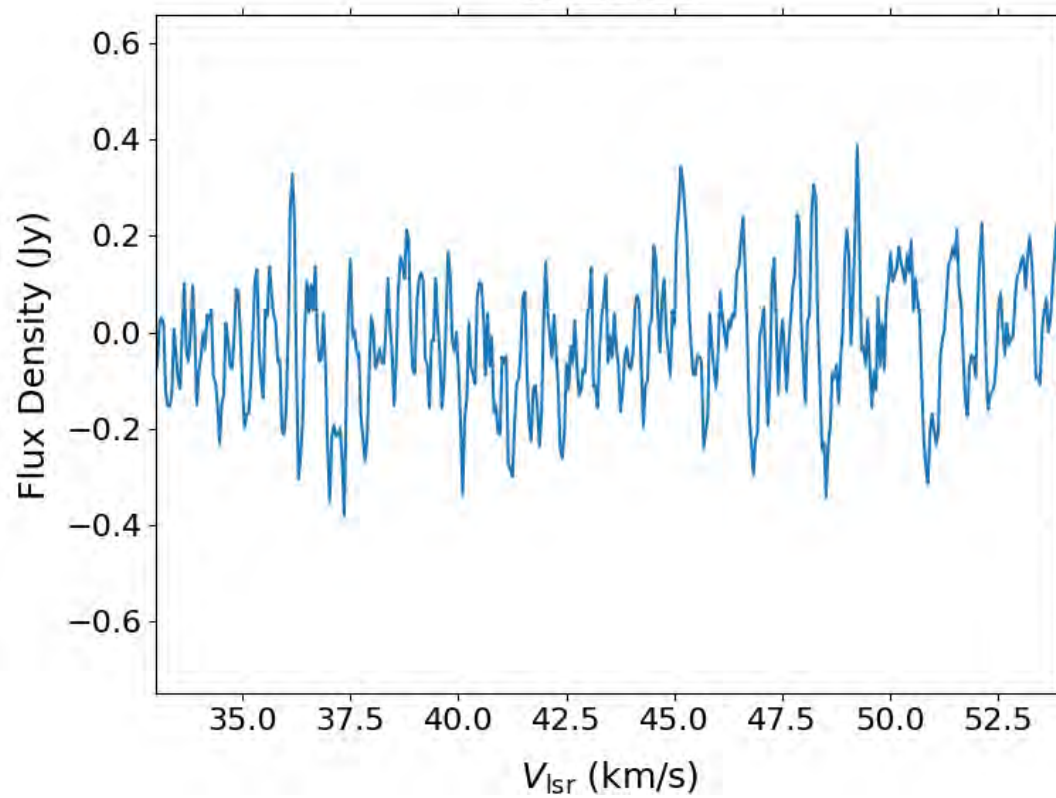
8.872-04

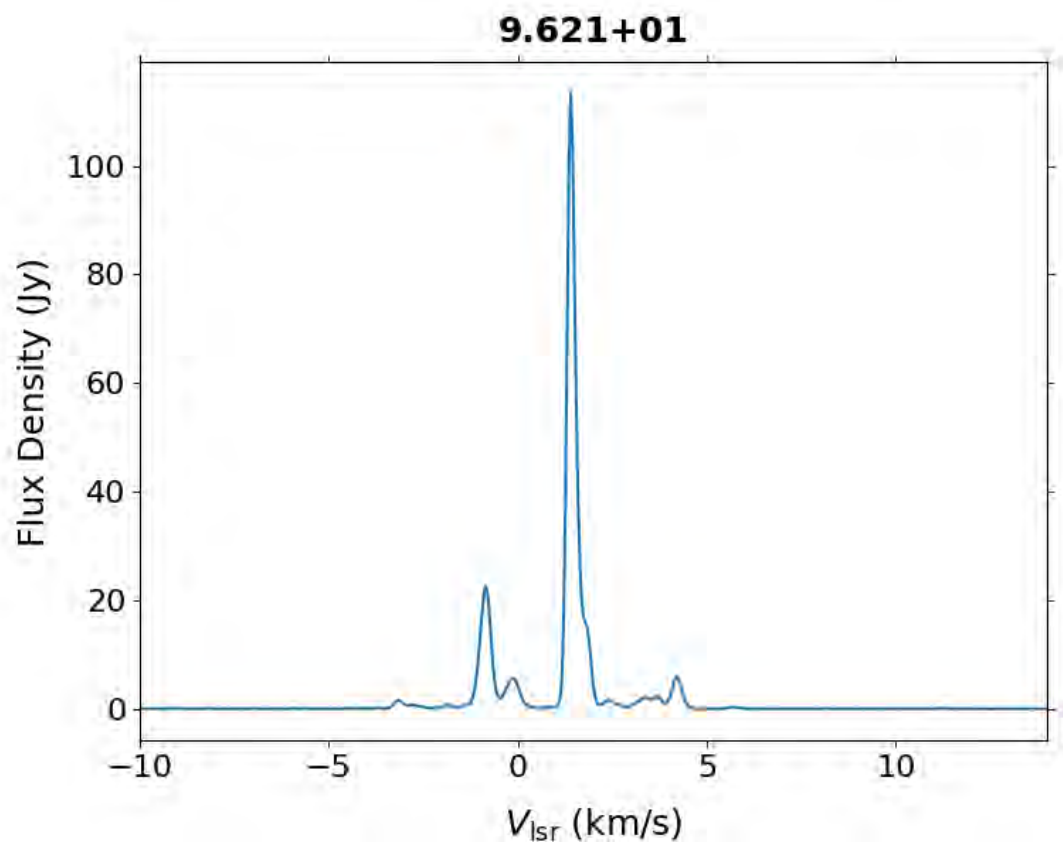
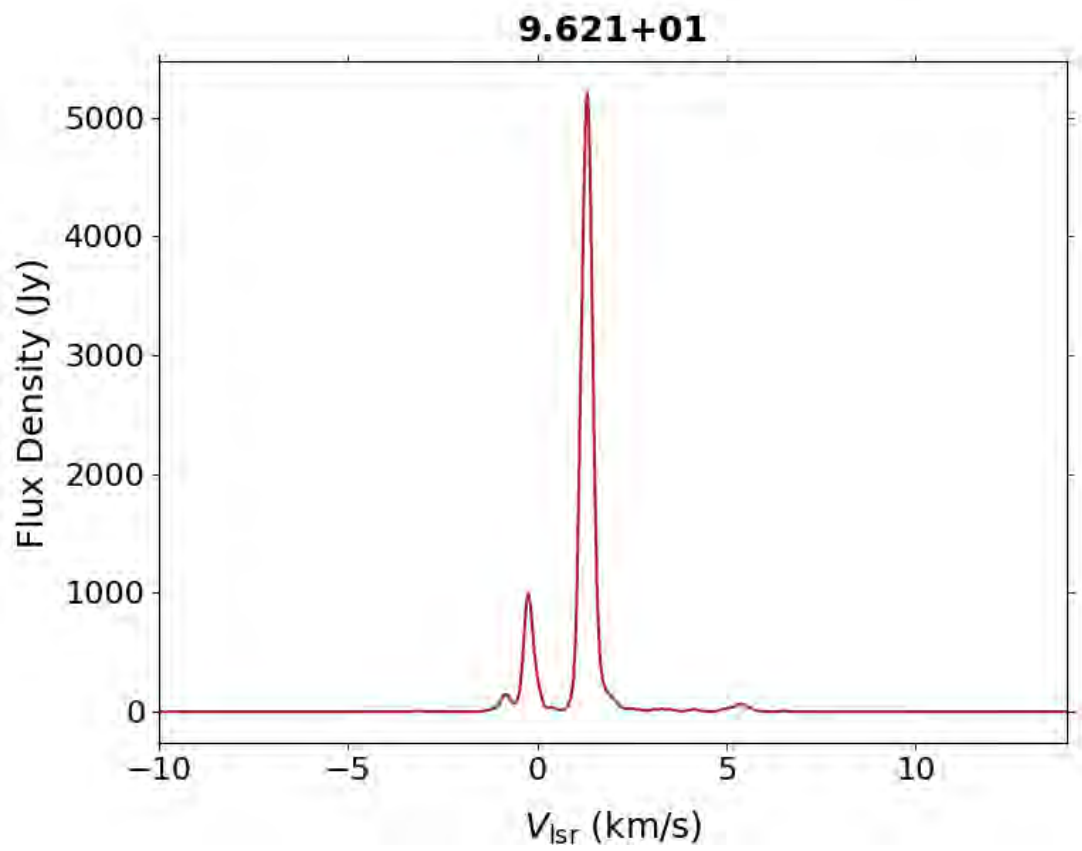


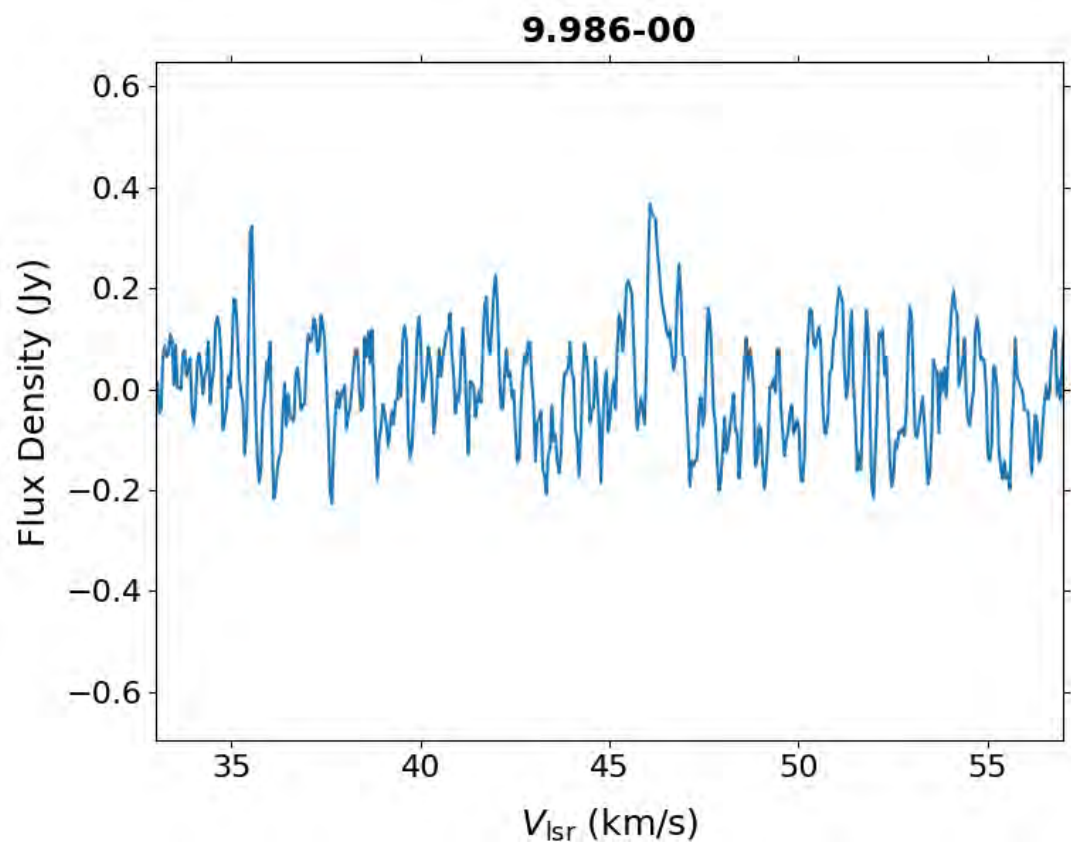
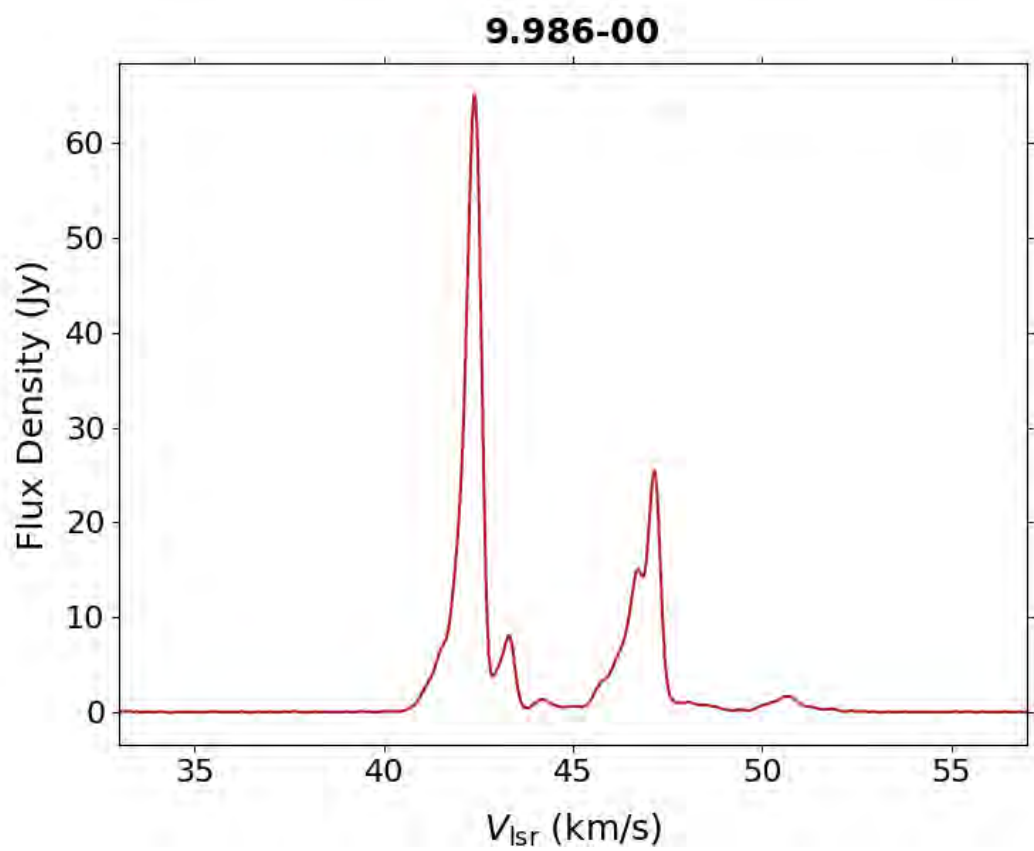
9.215-02

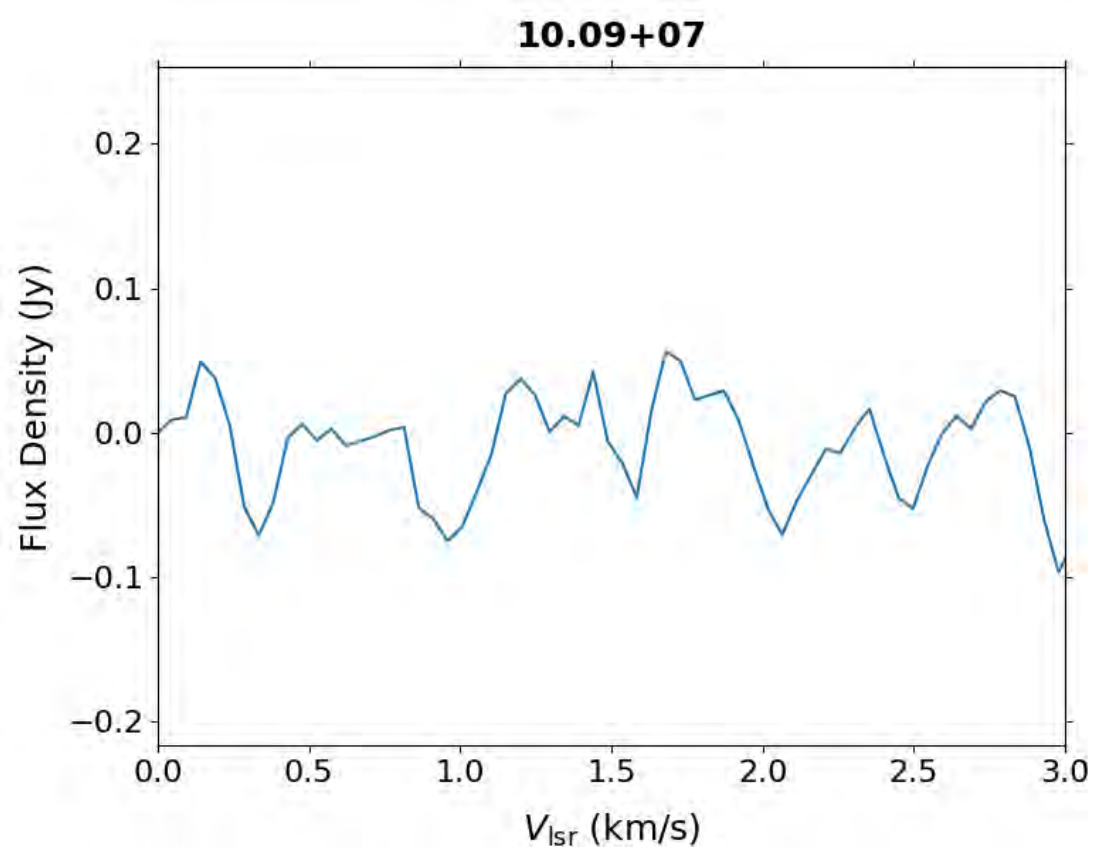
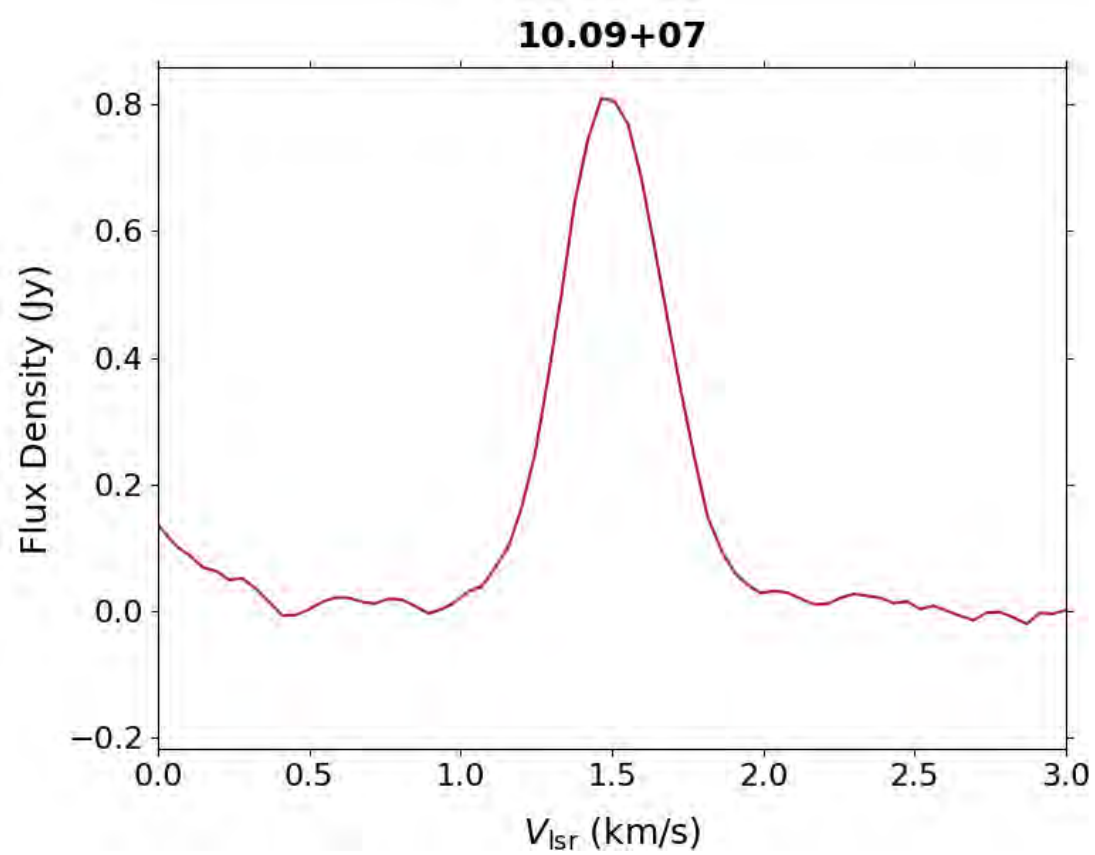


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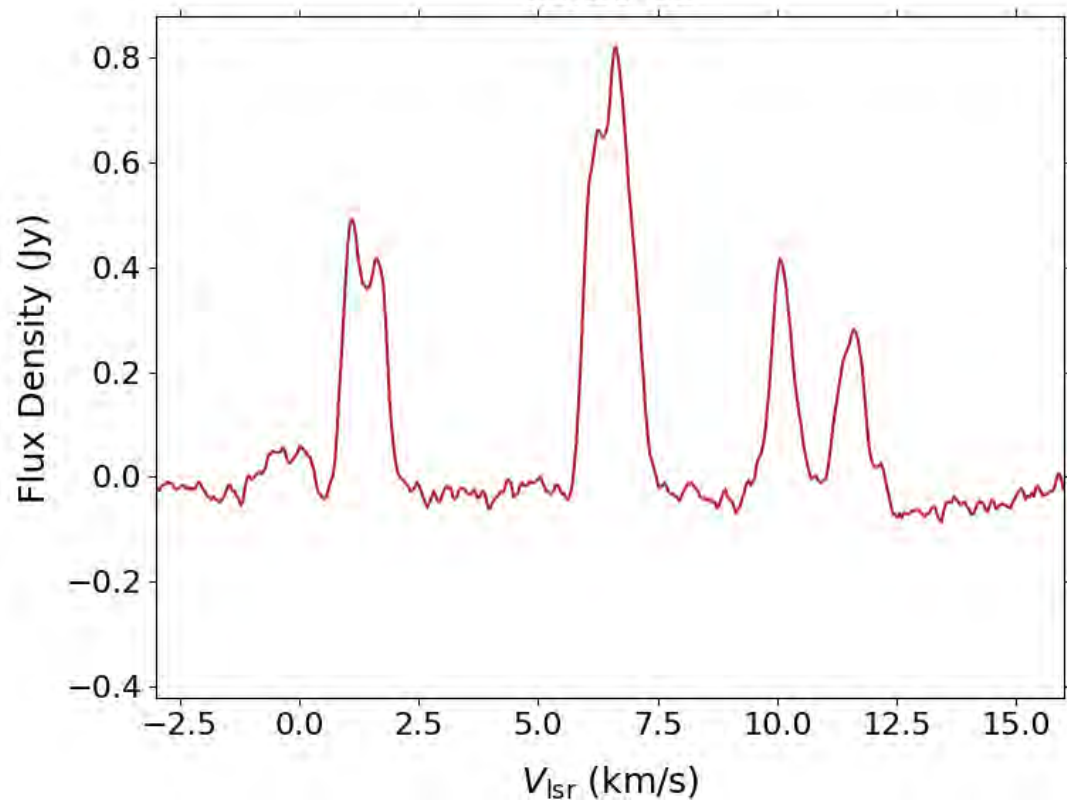




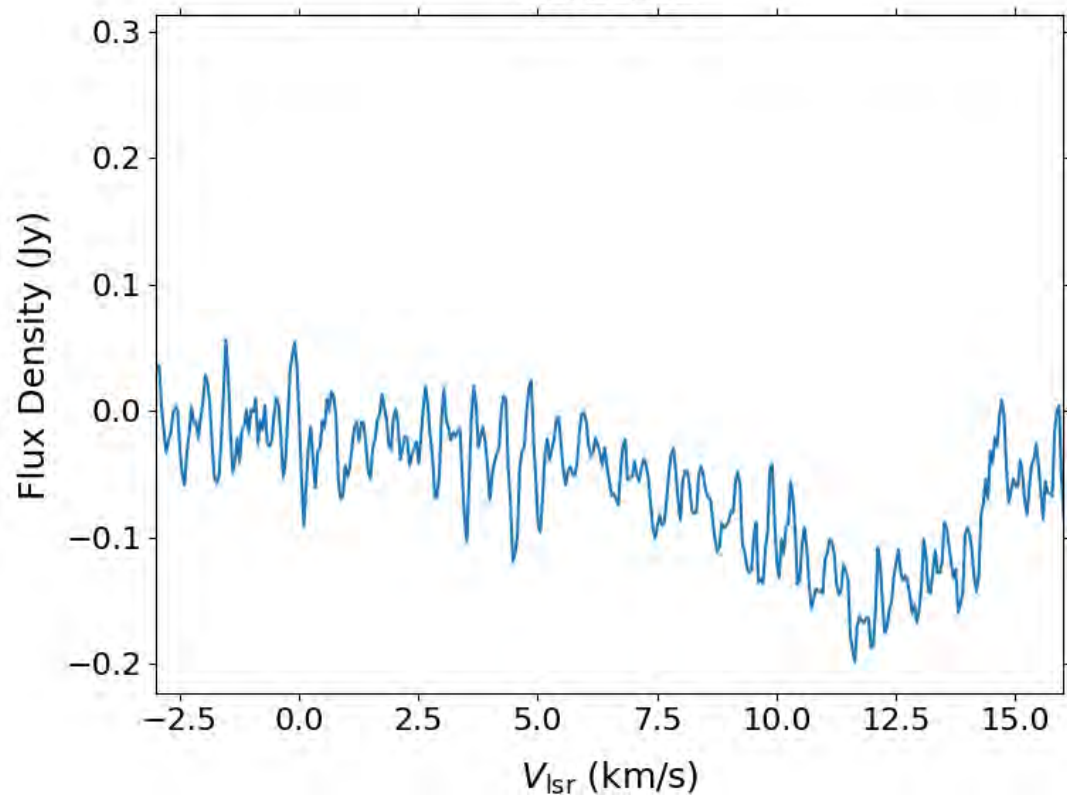


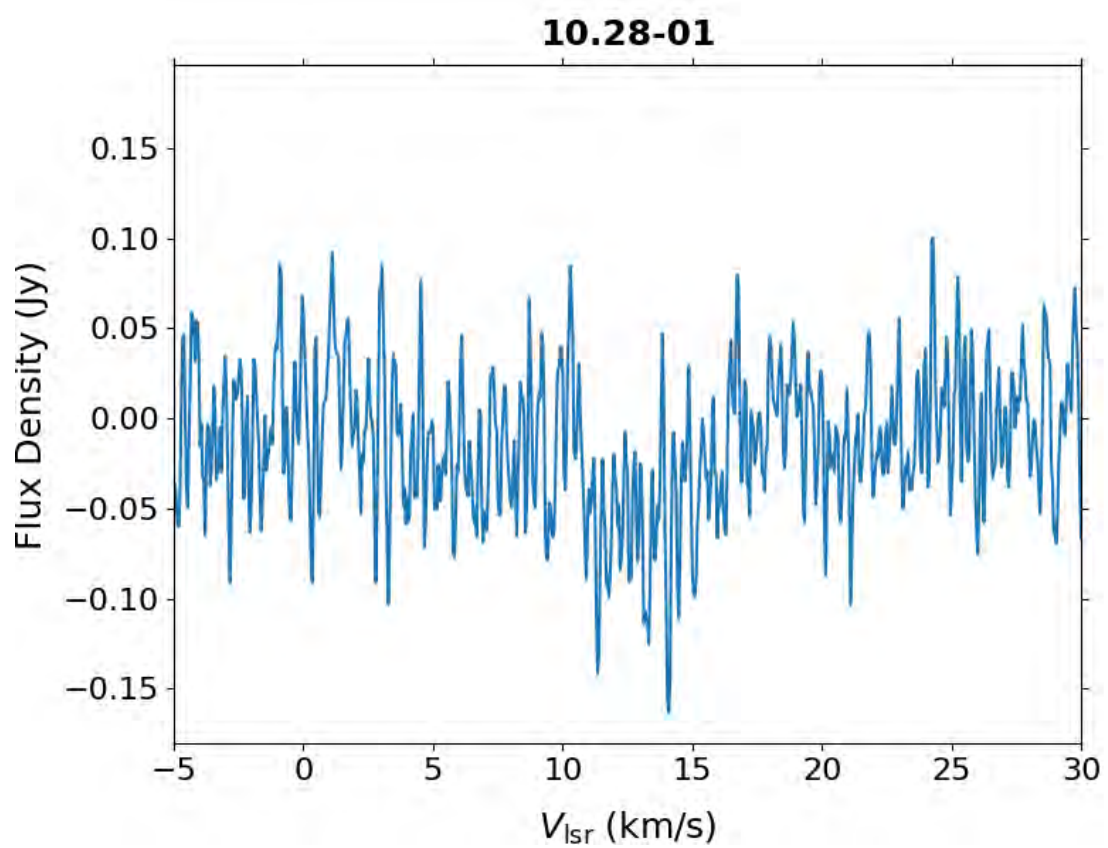
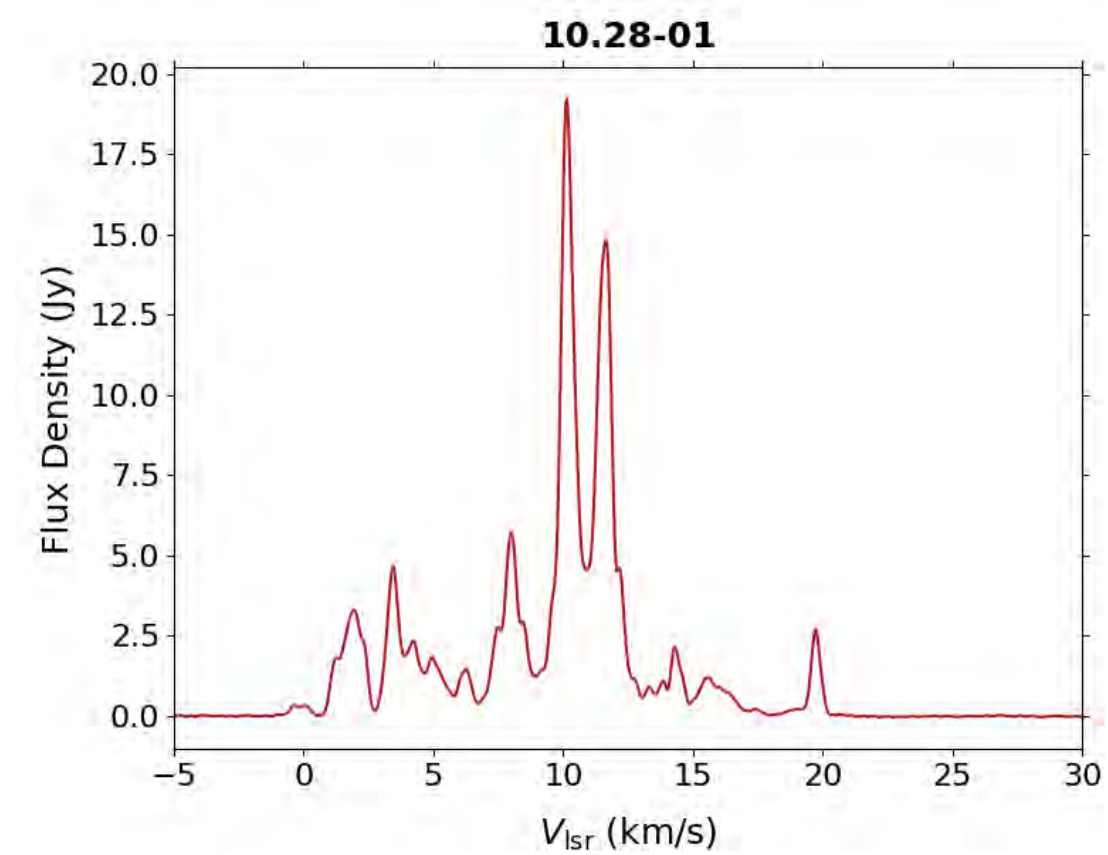


10.20-03

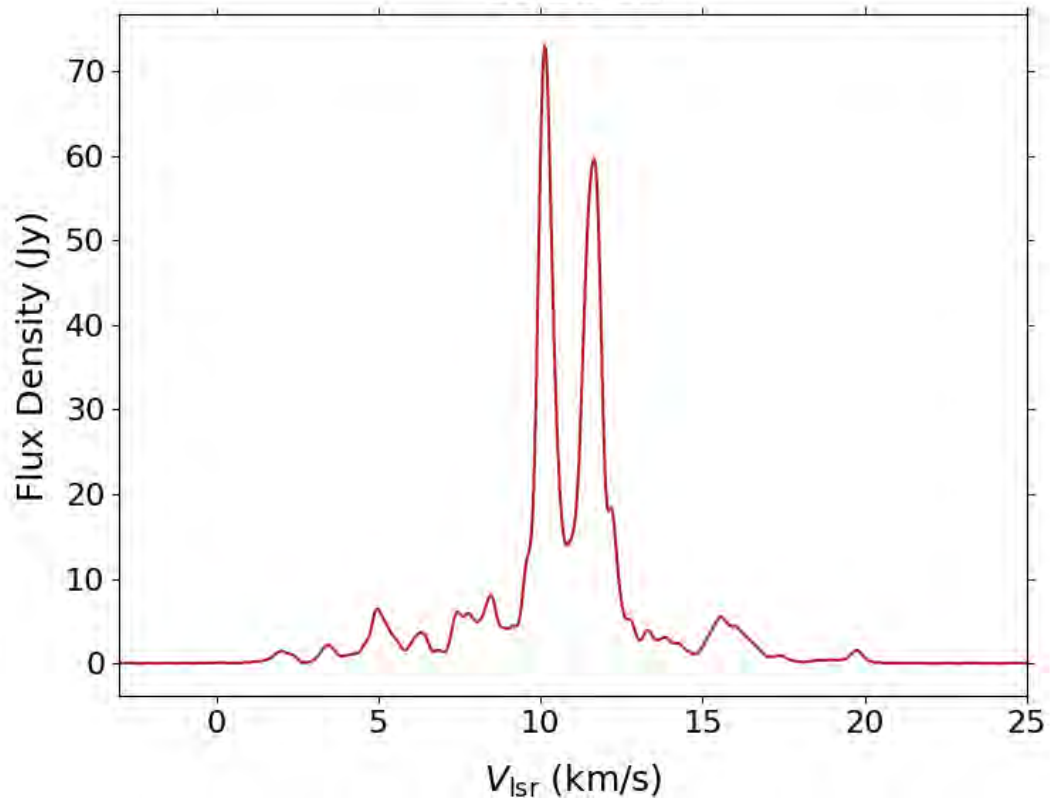


10.20-03

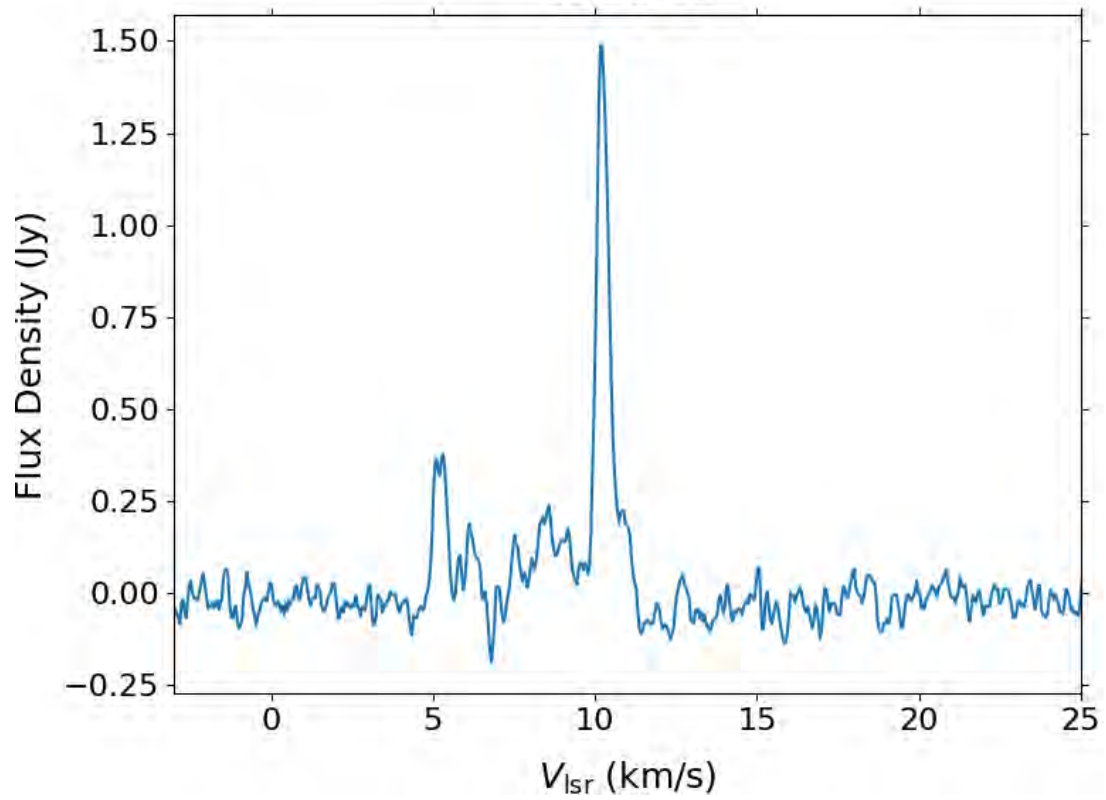




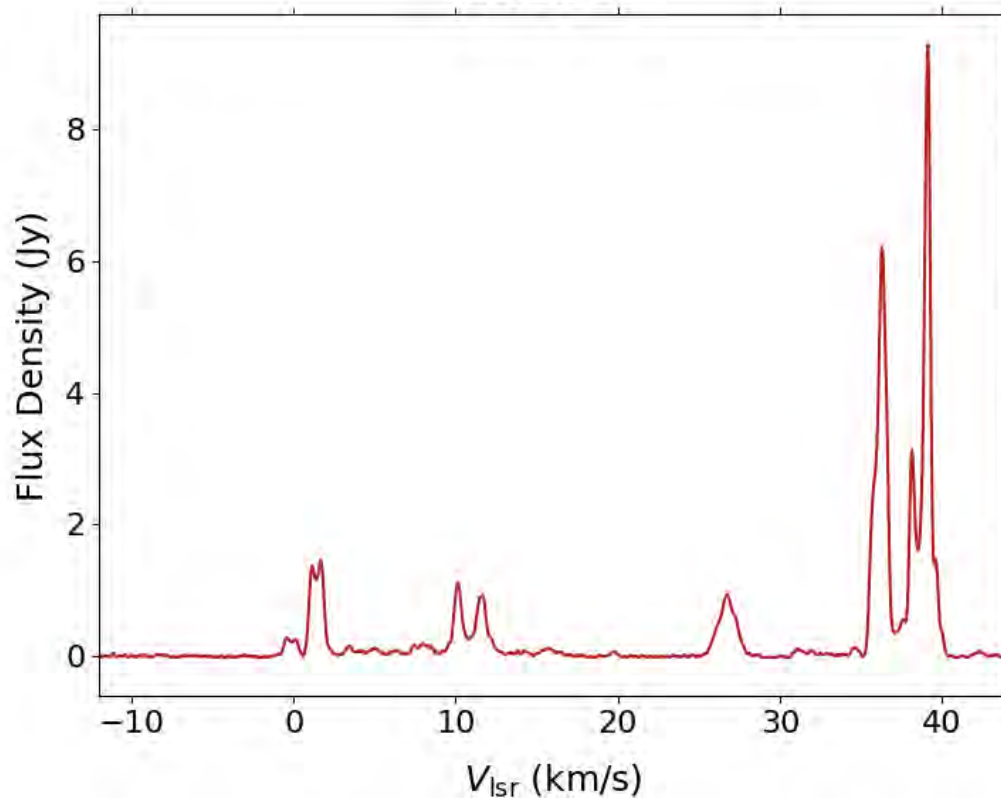
10.32-01



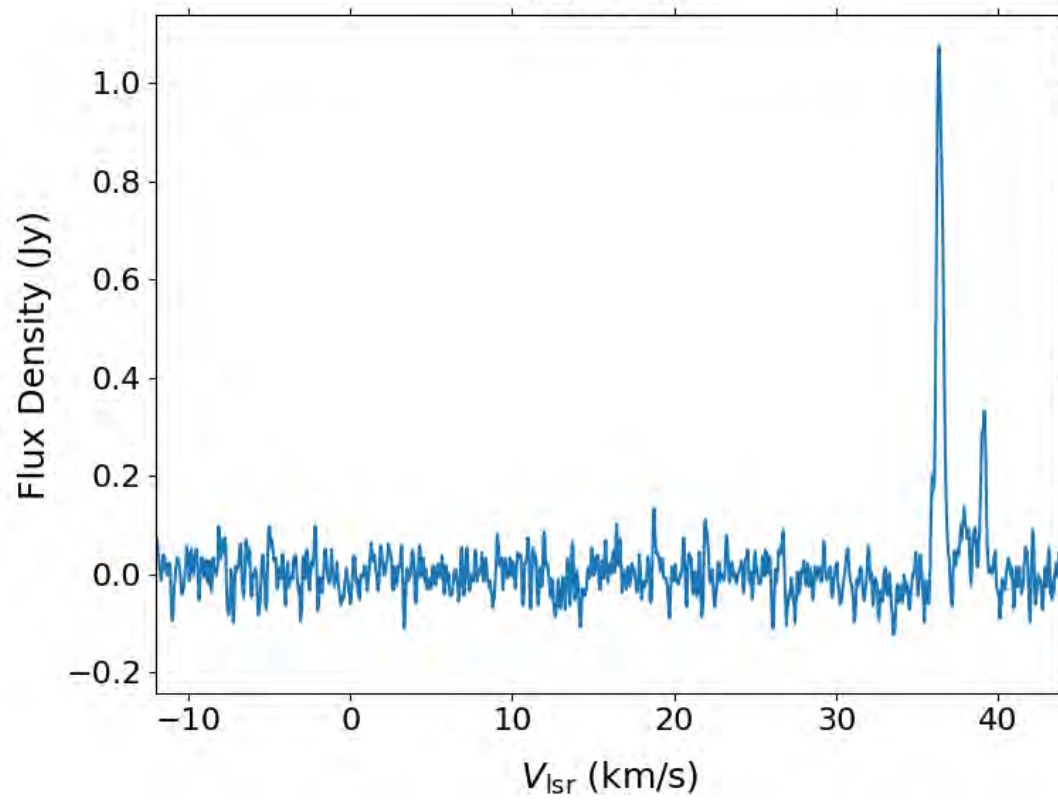
10.32-01



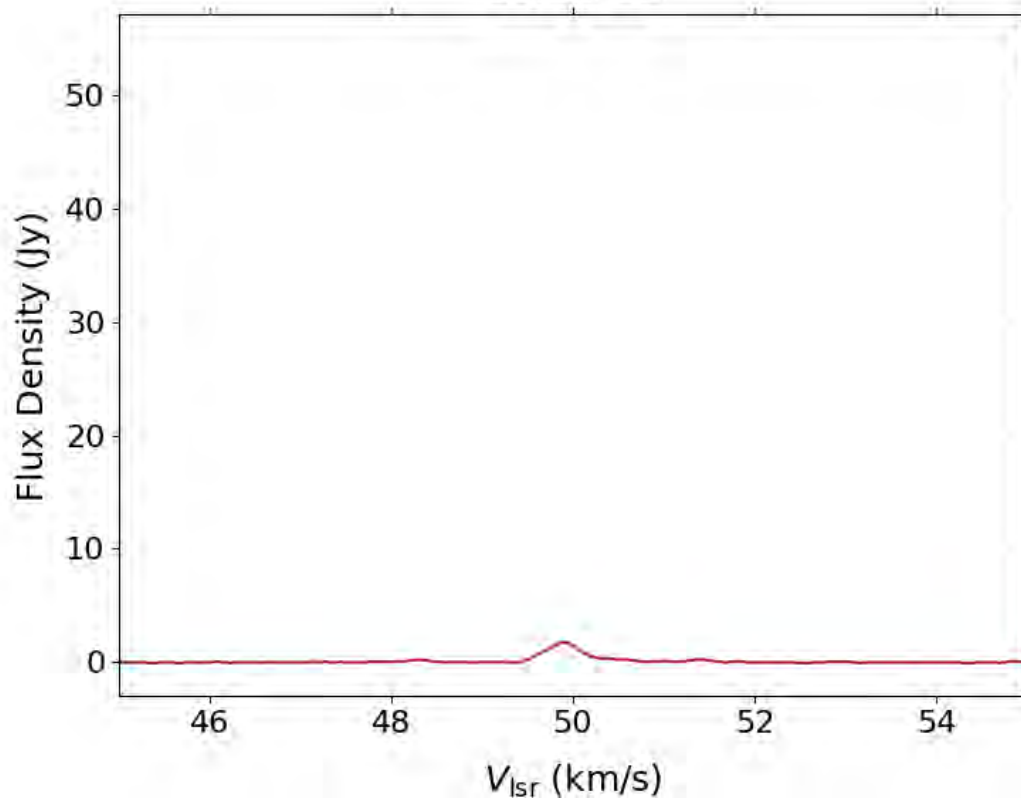
10.32-02



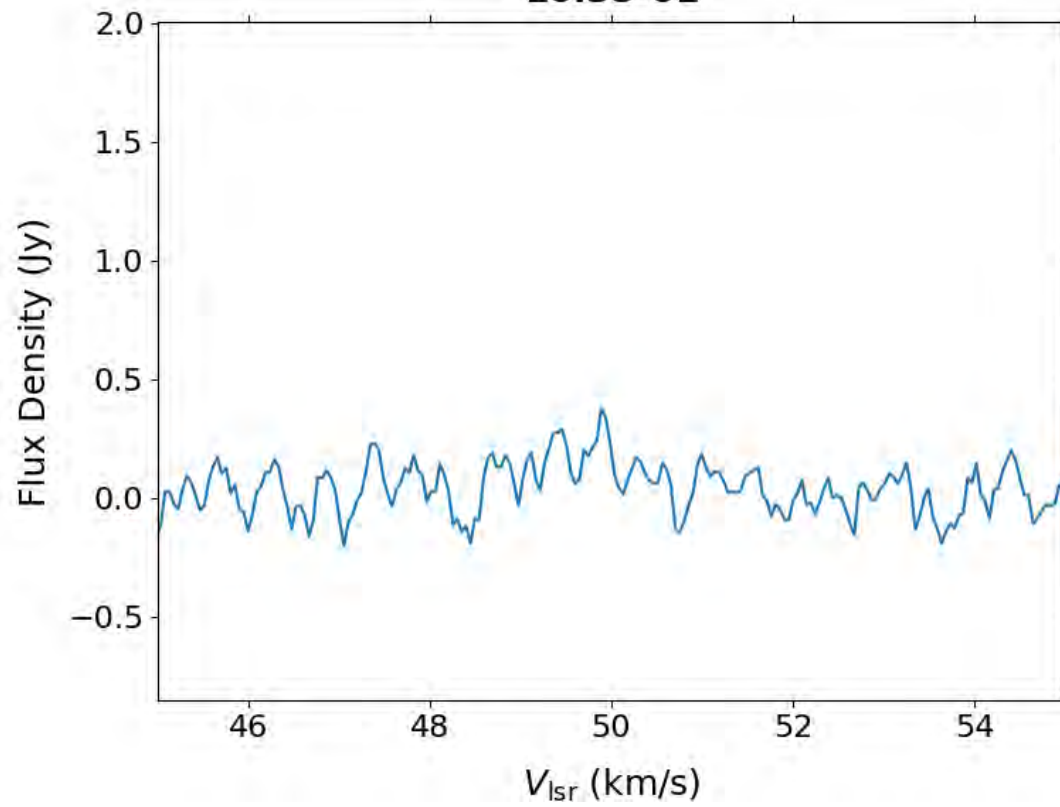
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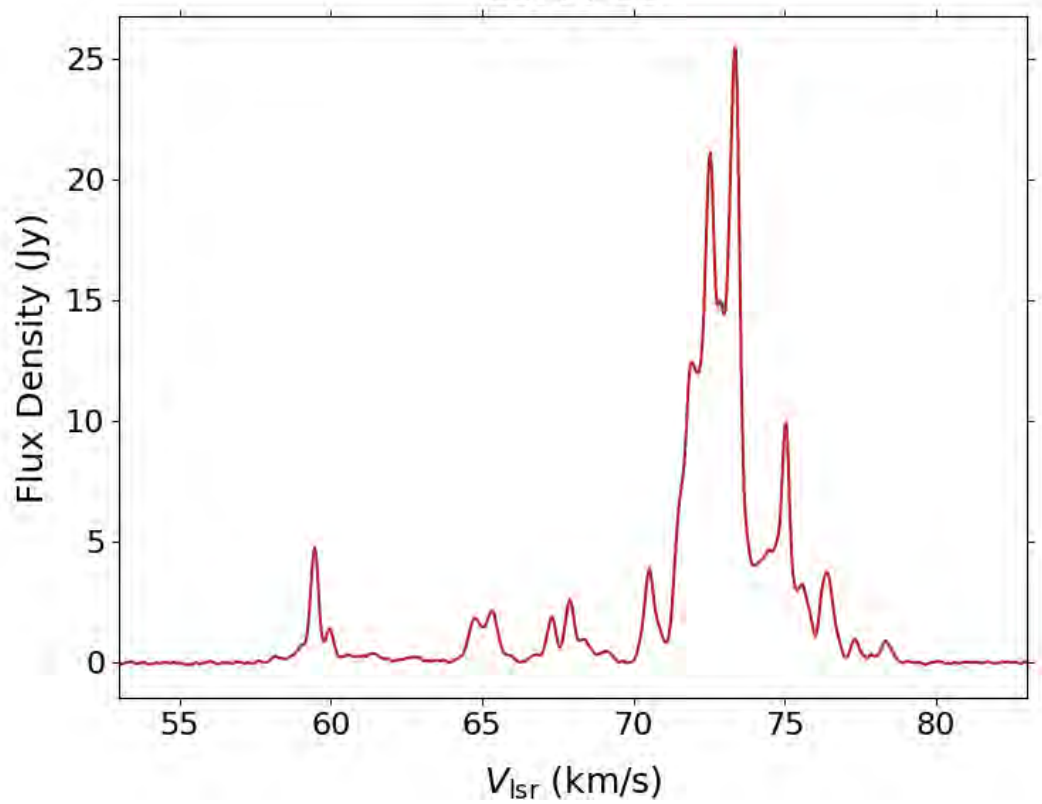
10.35-01



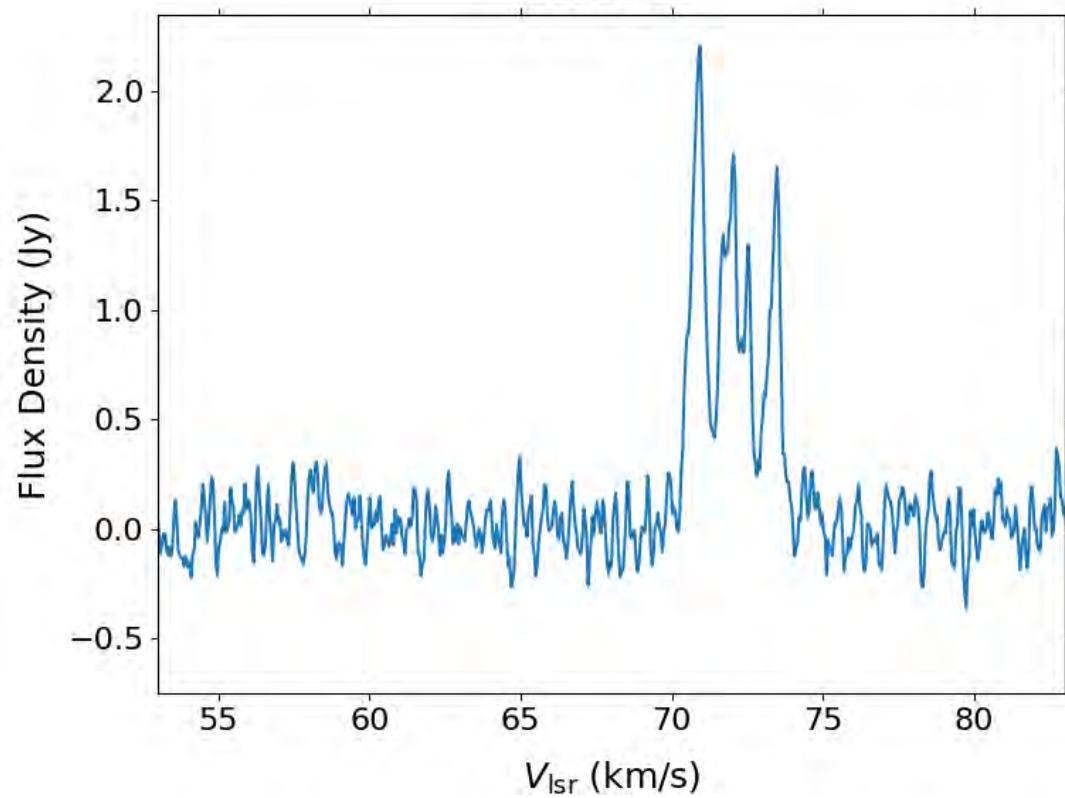
10.35-01

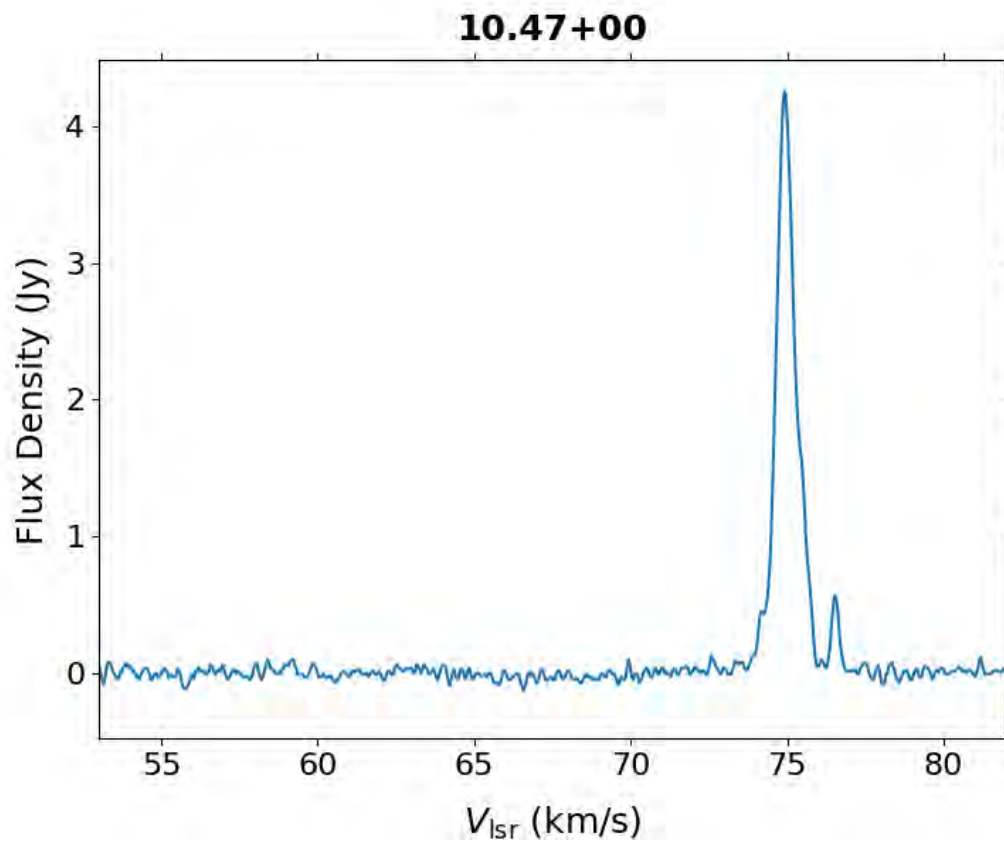
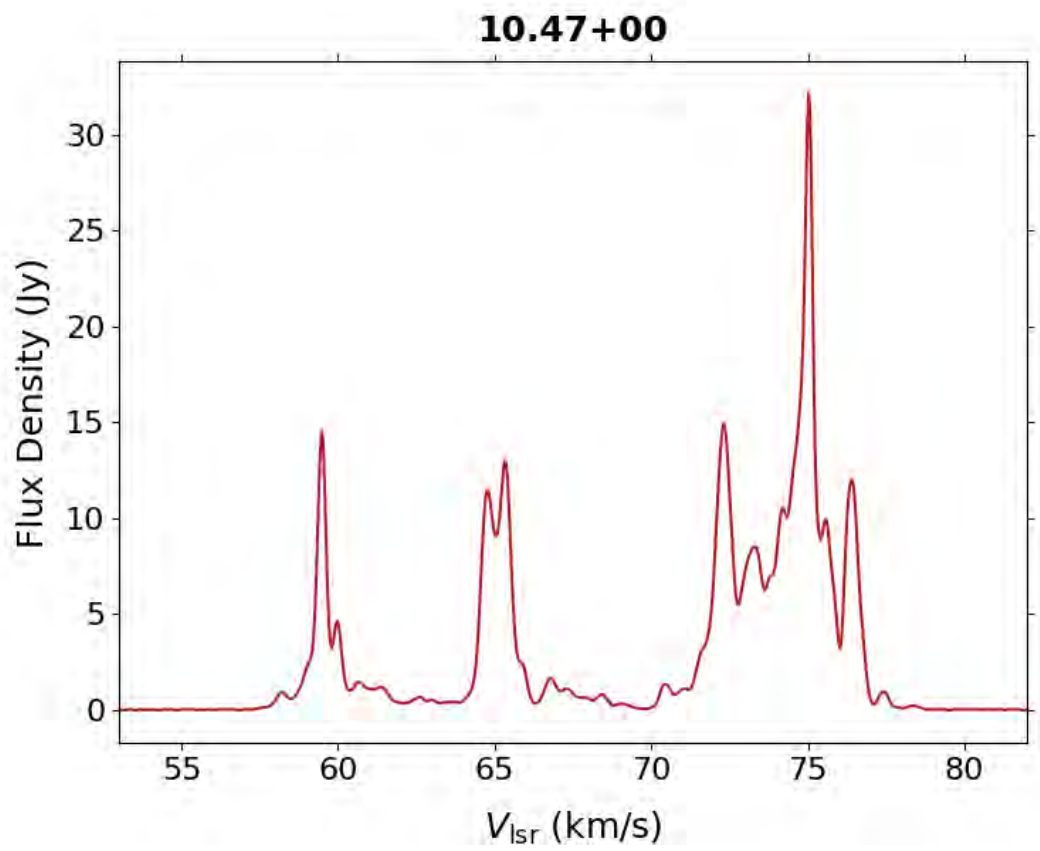


10.44-00

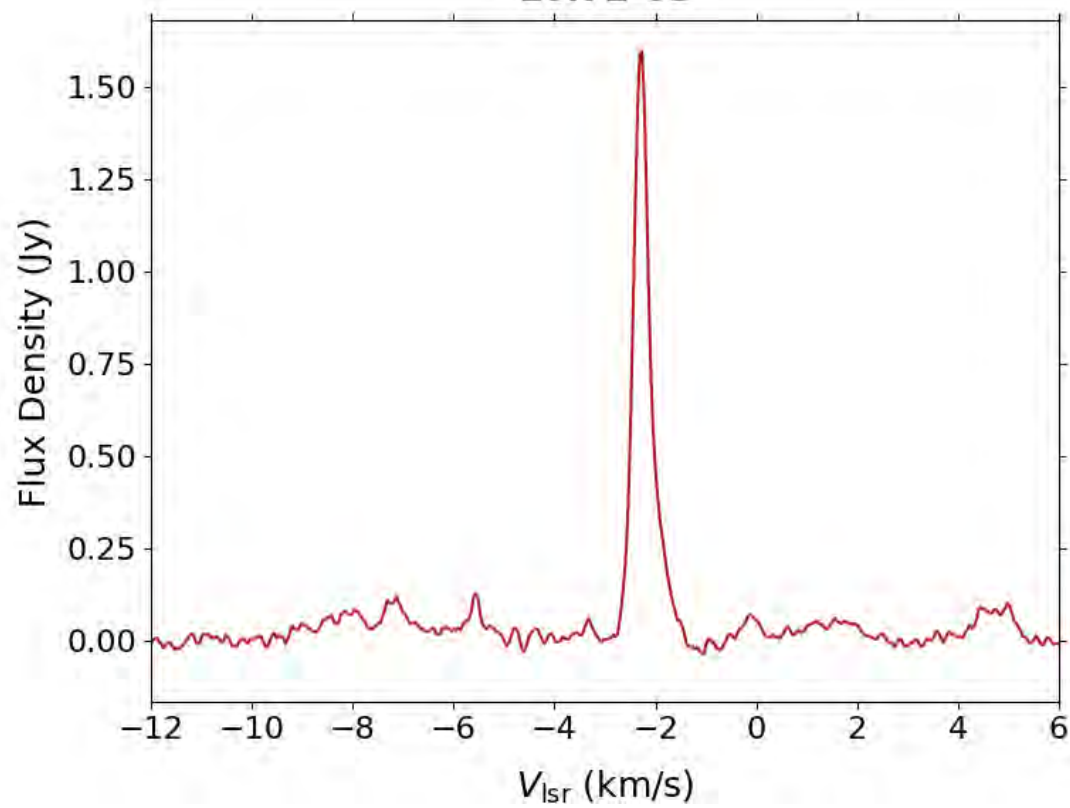


10.44-00

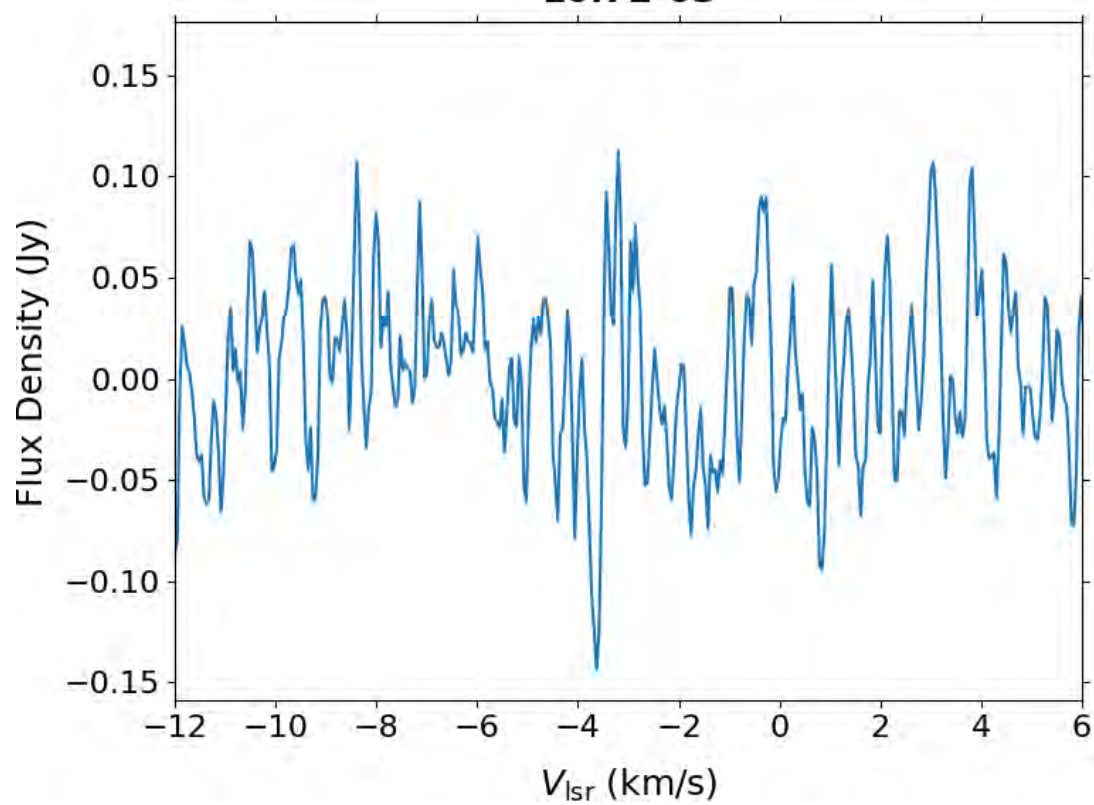




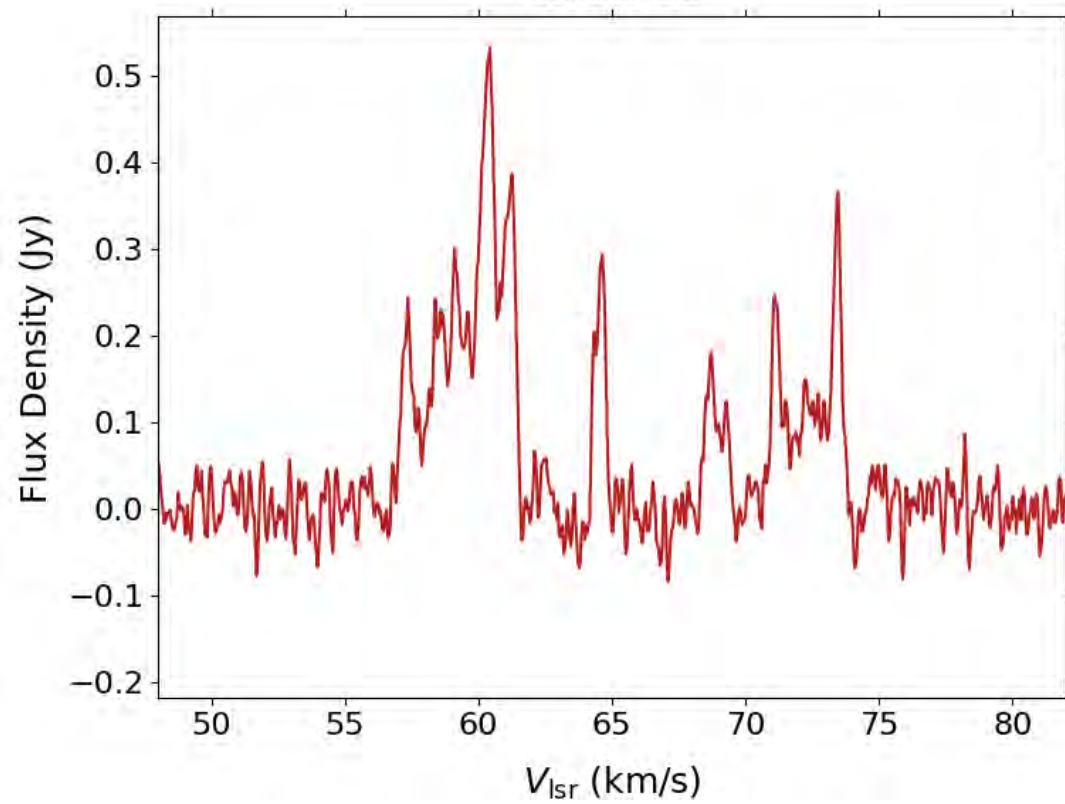
10.72-03



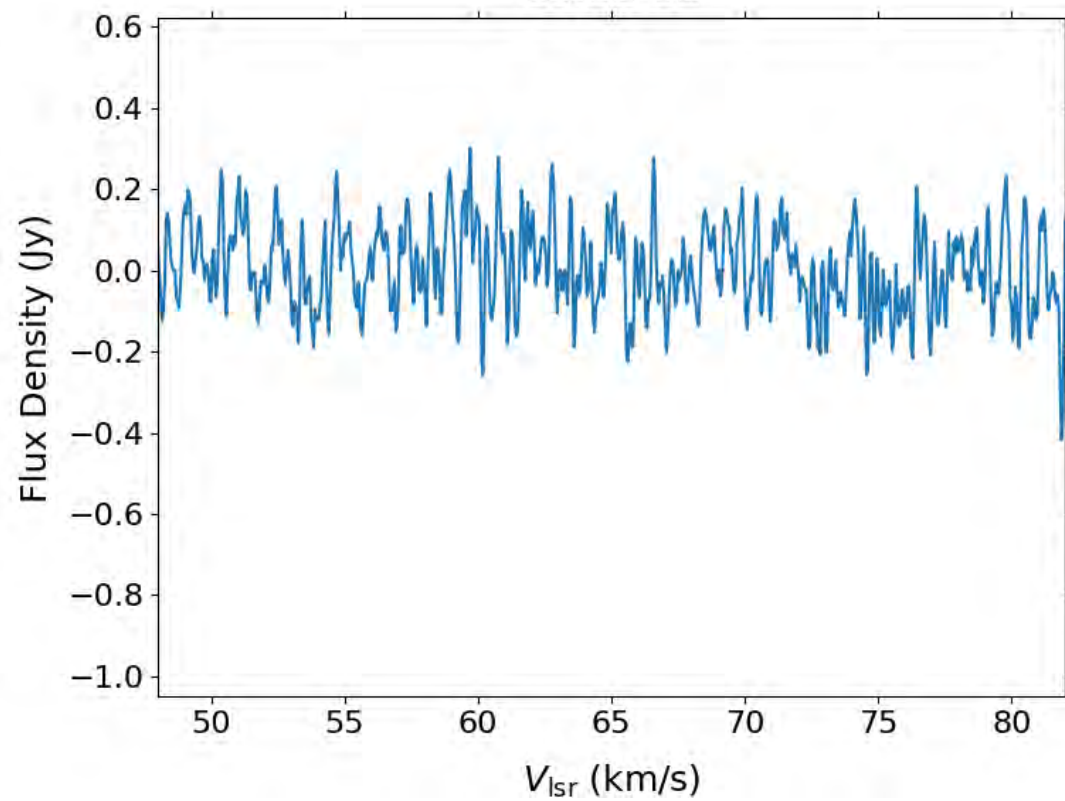
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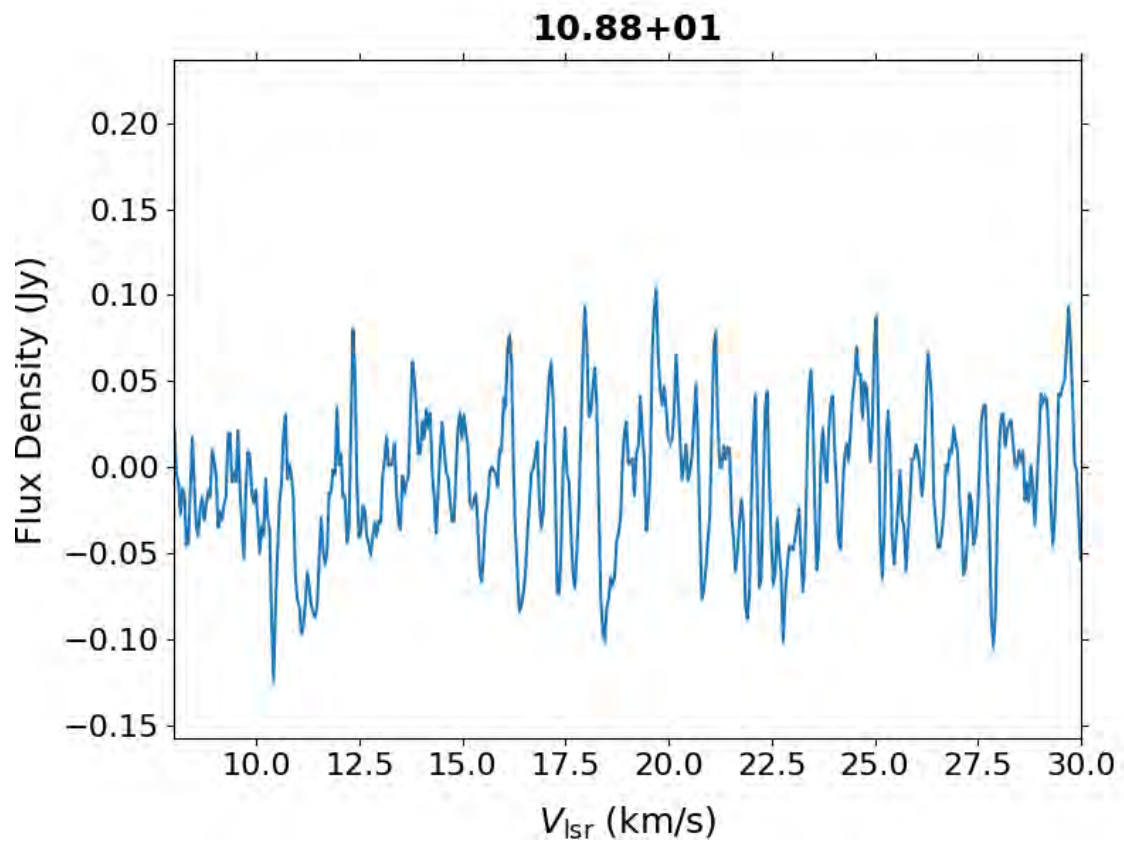
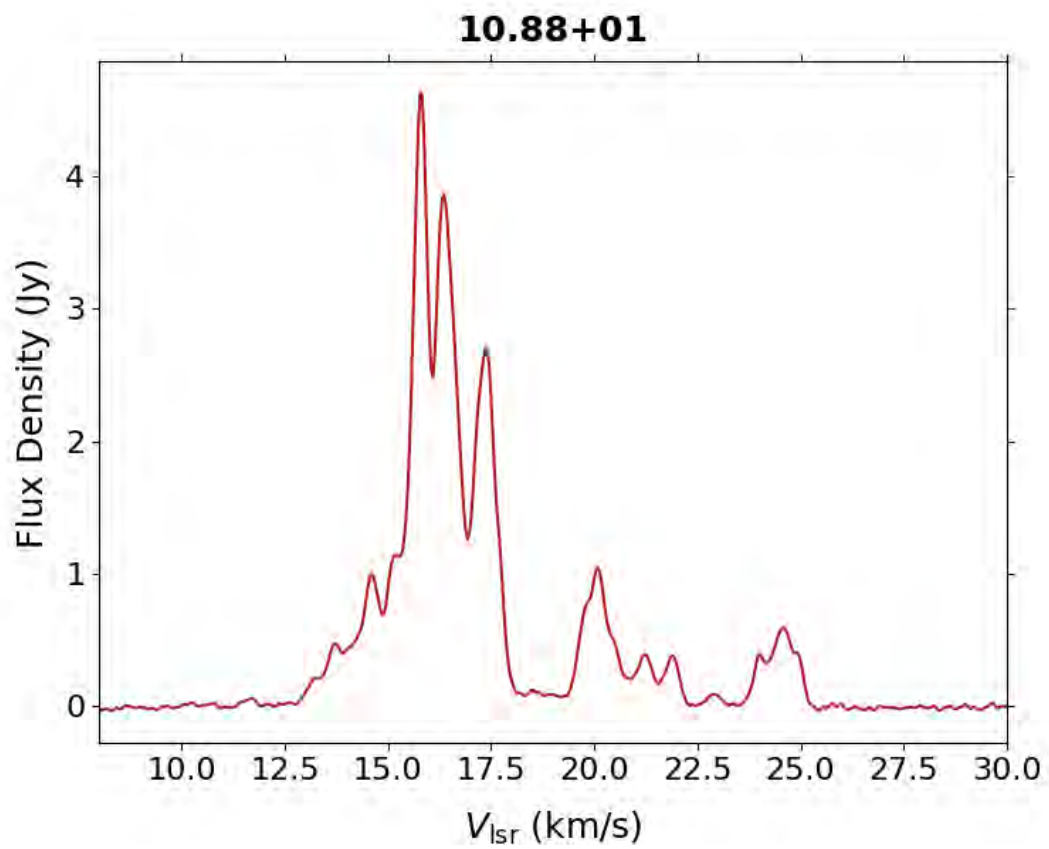


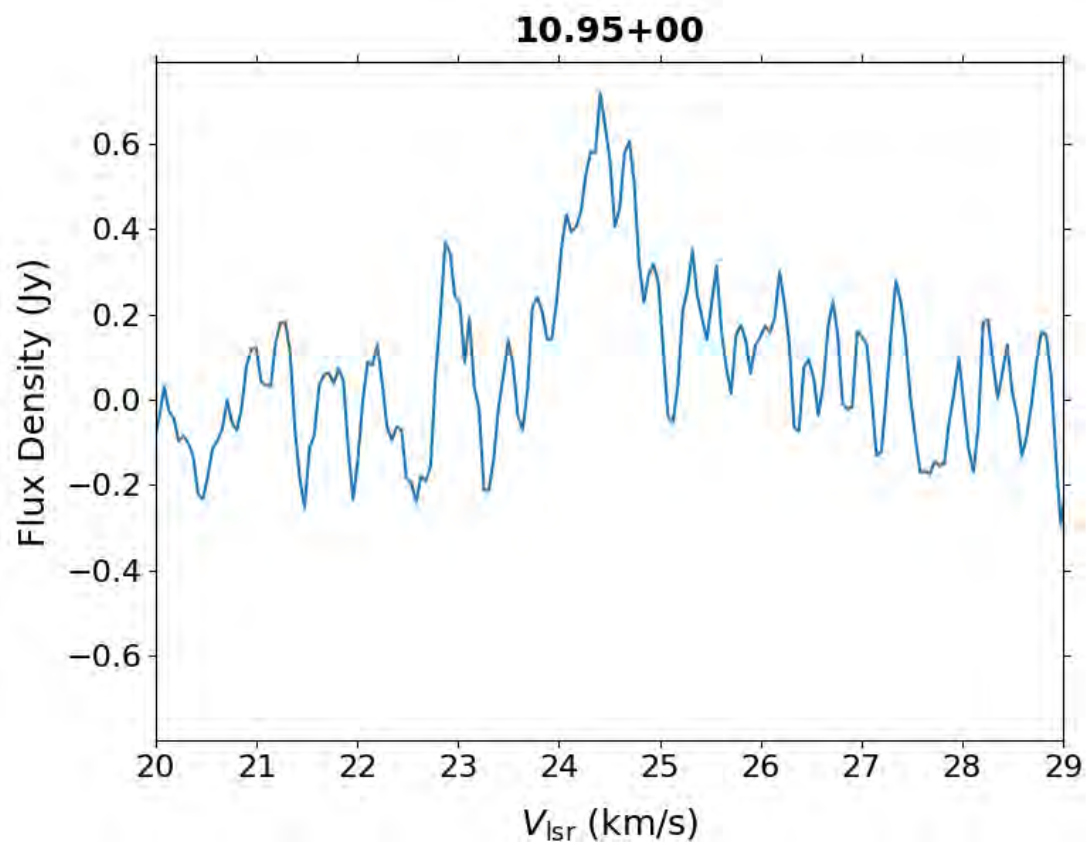
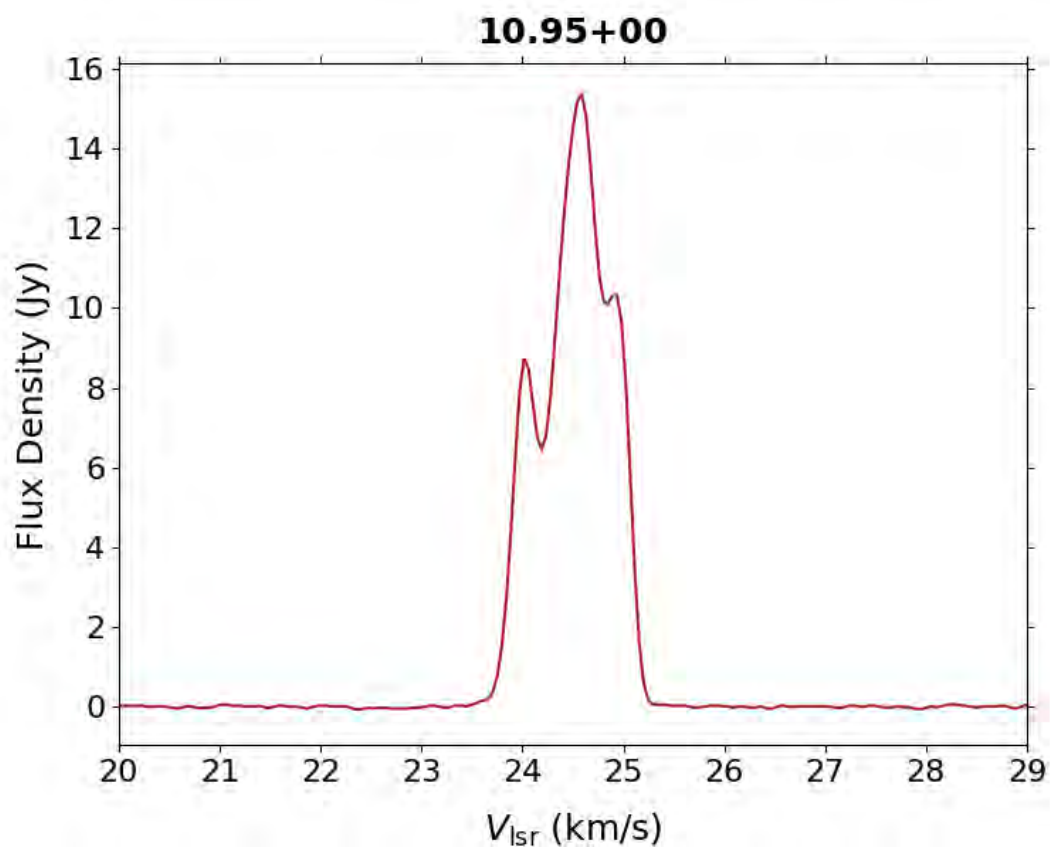
10.82-01

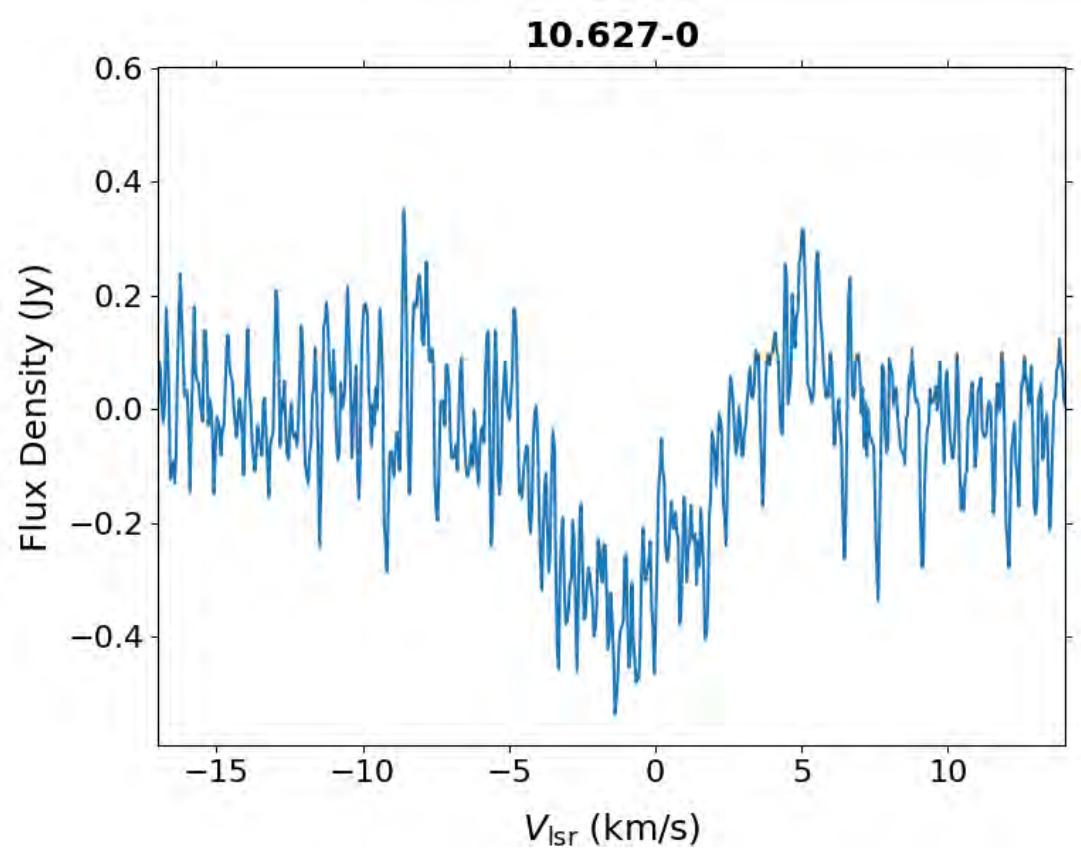
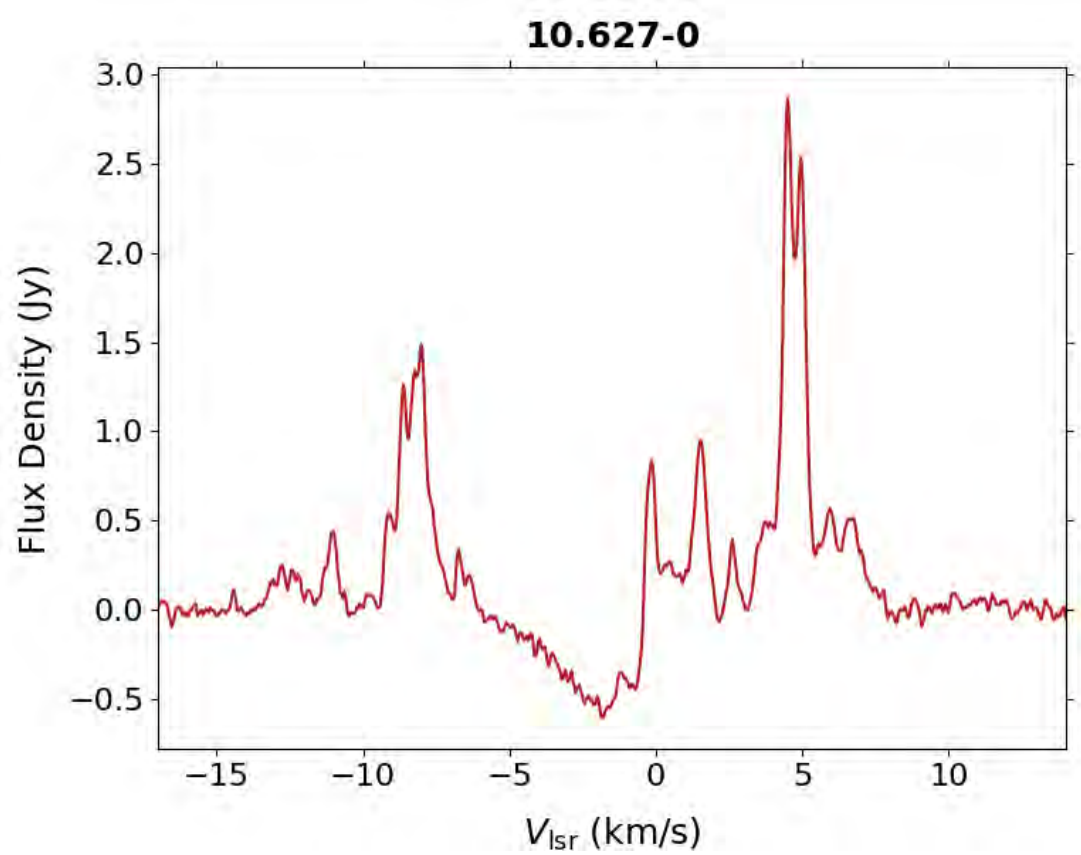


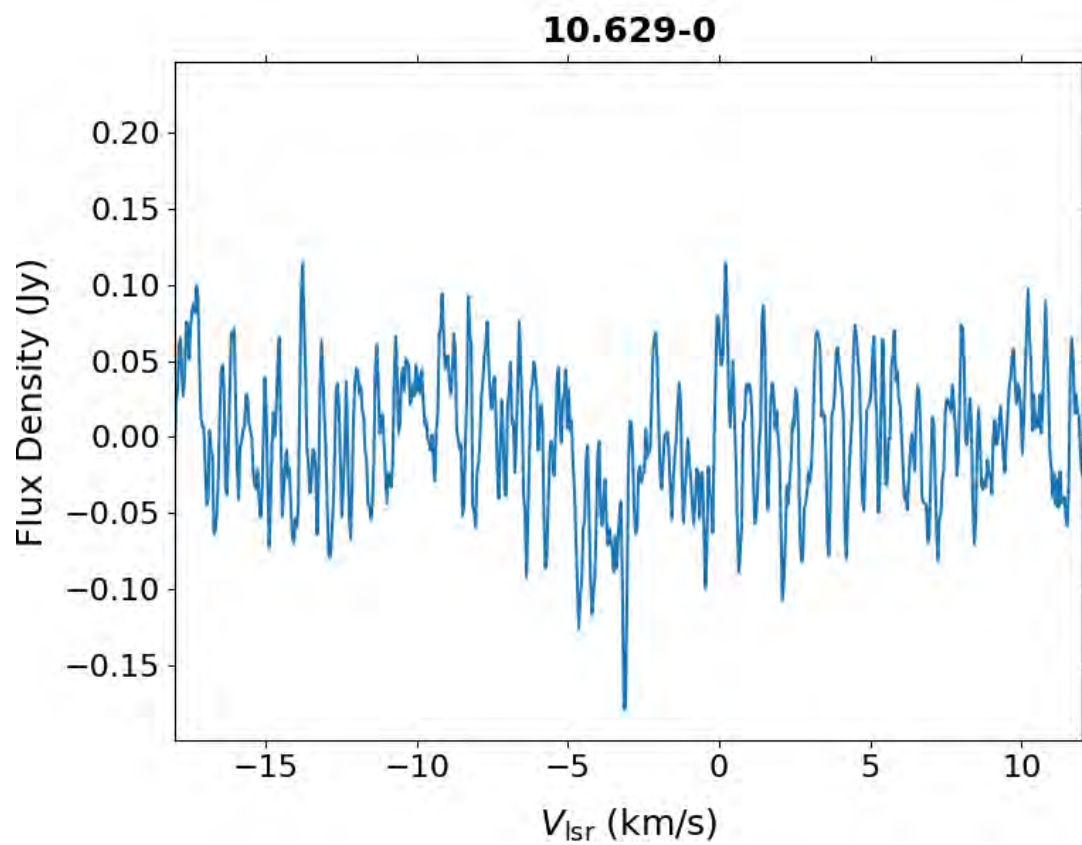
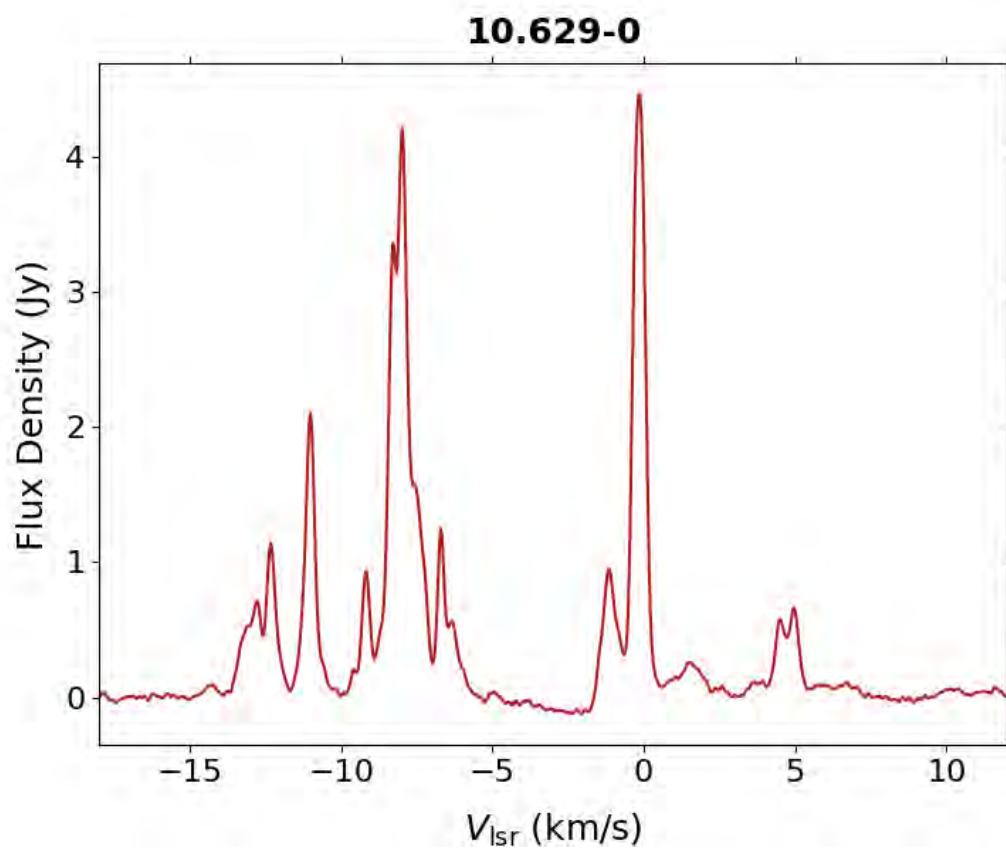
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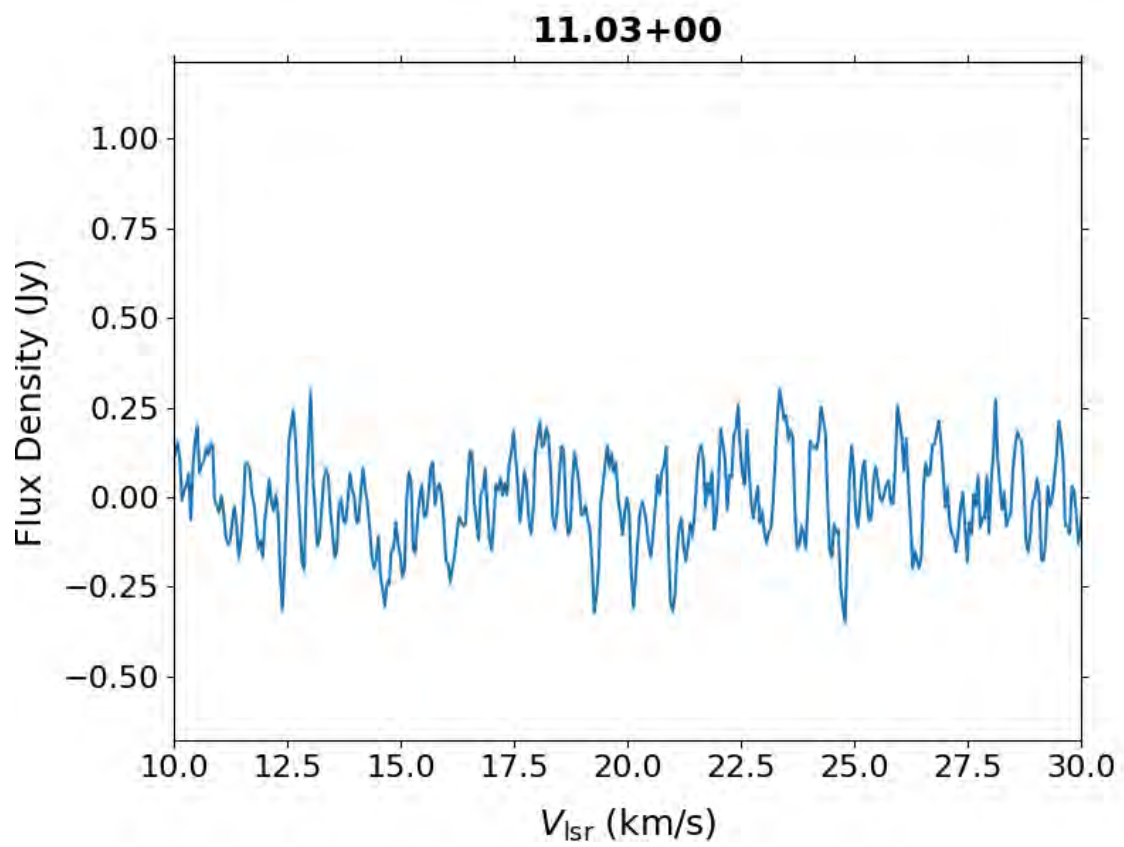
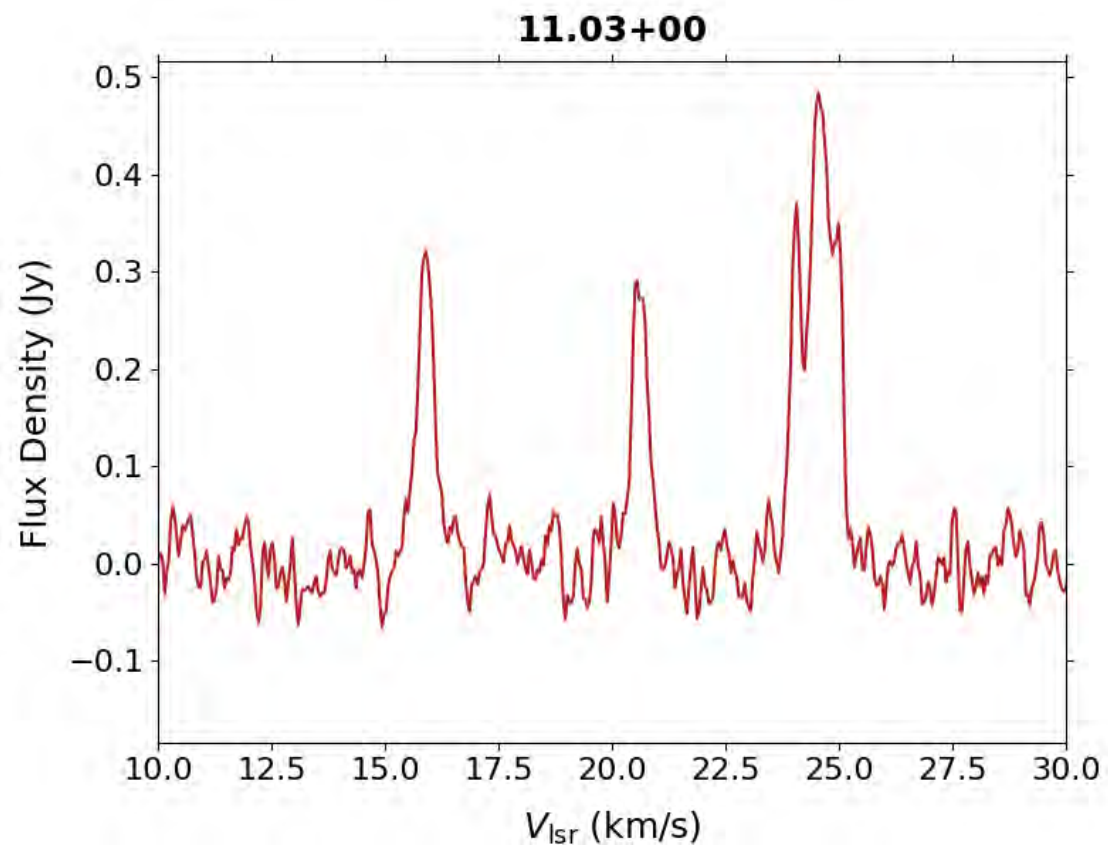




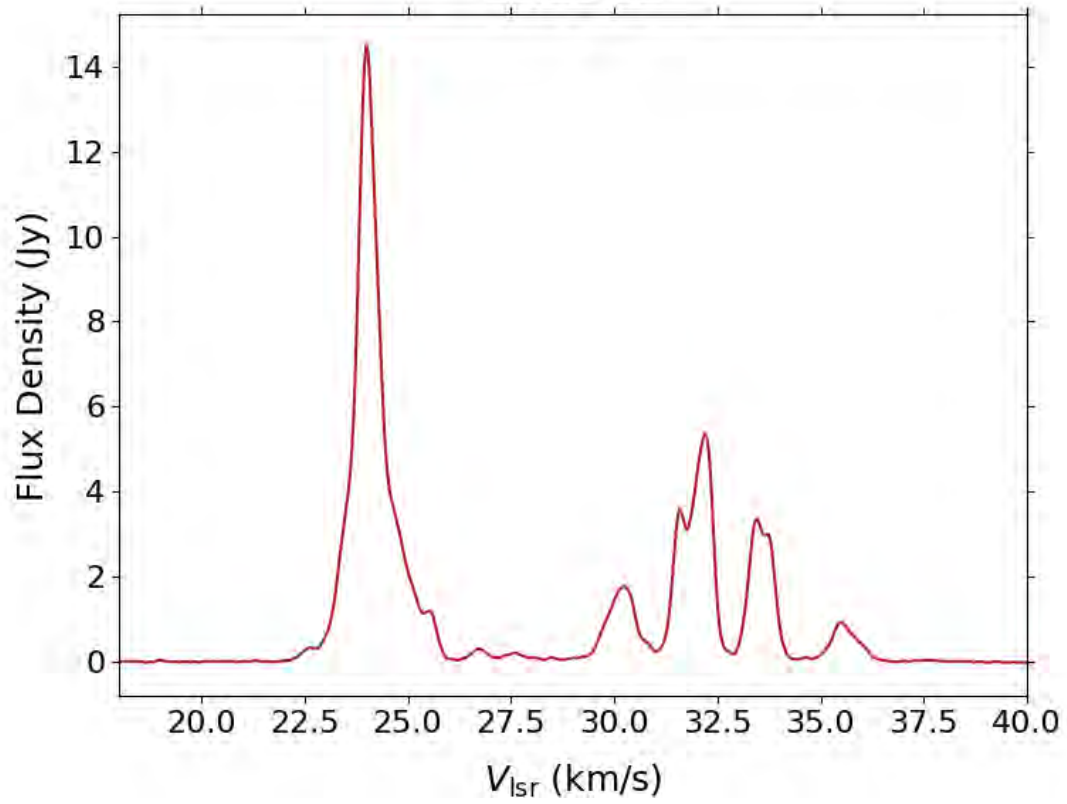




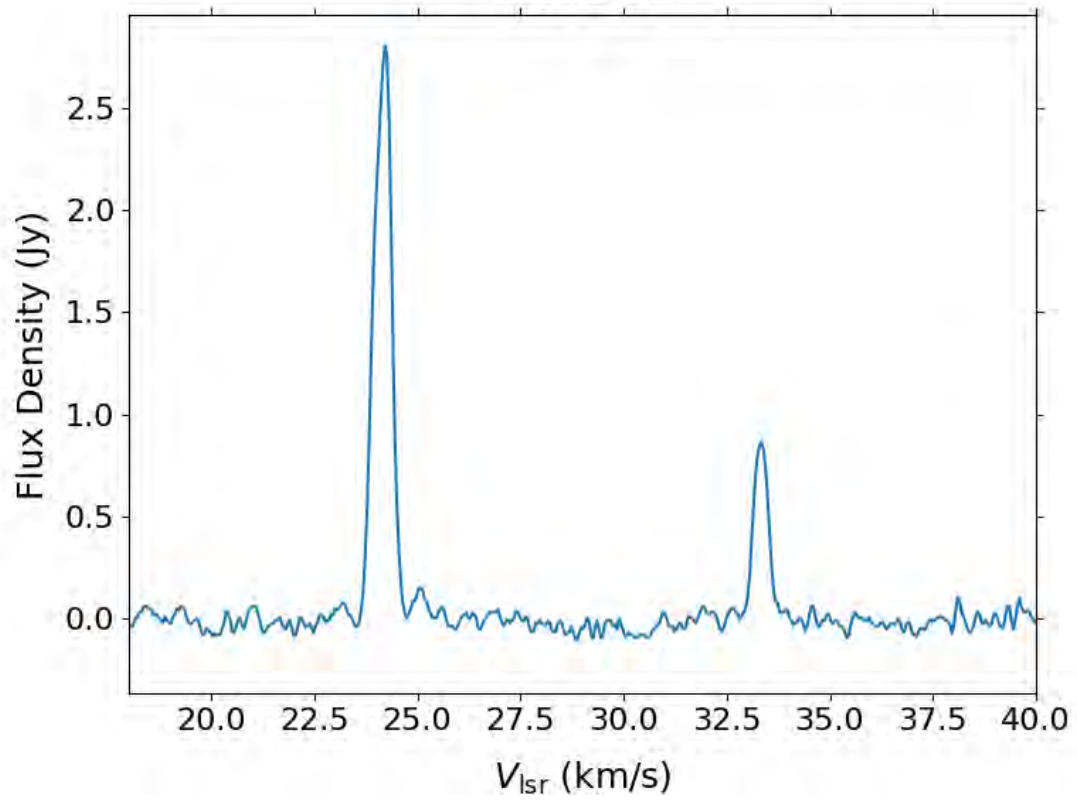




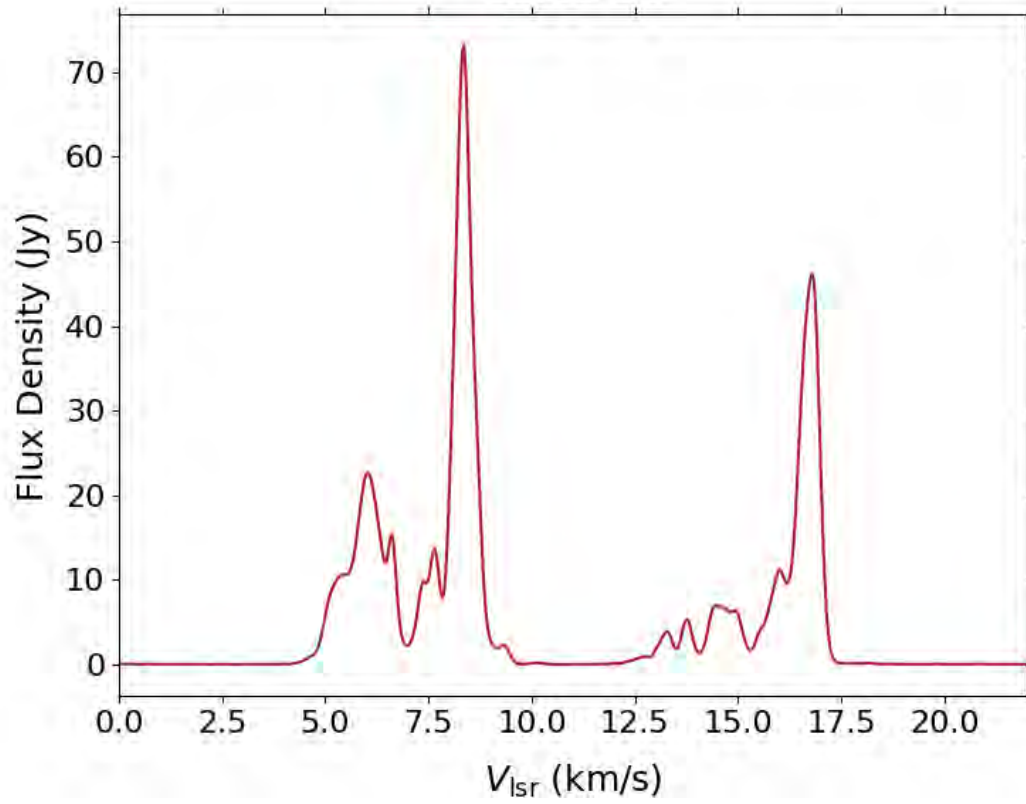
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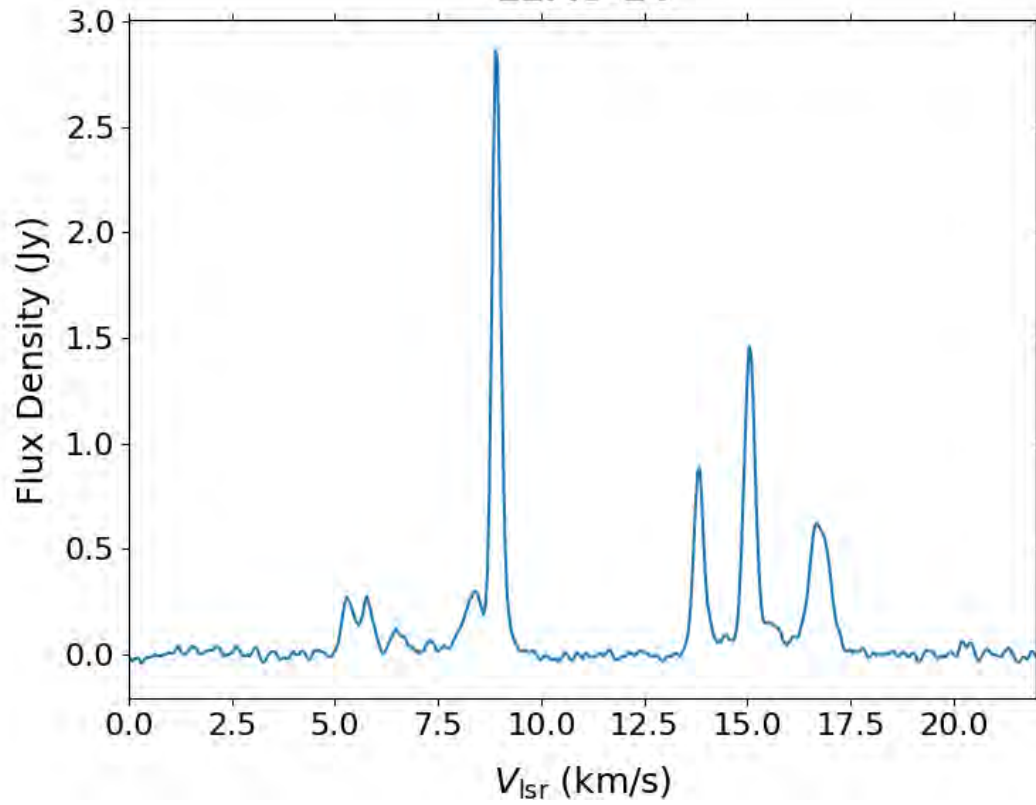
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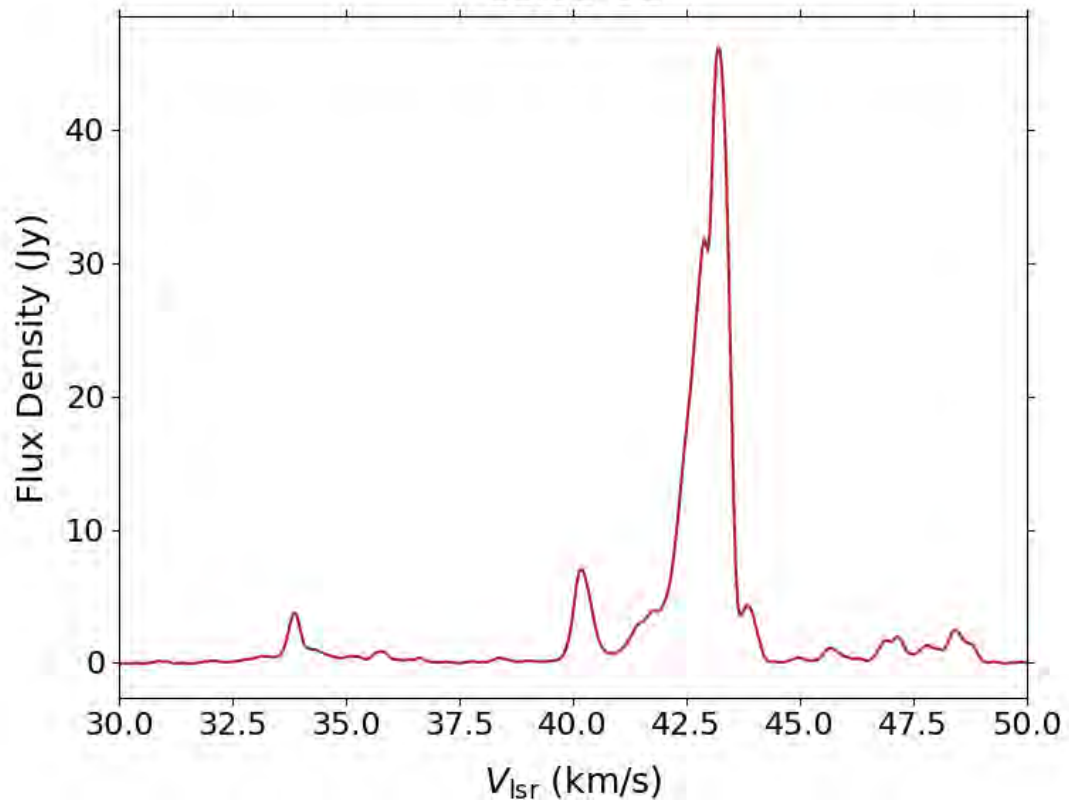
11.49-14



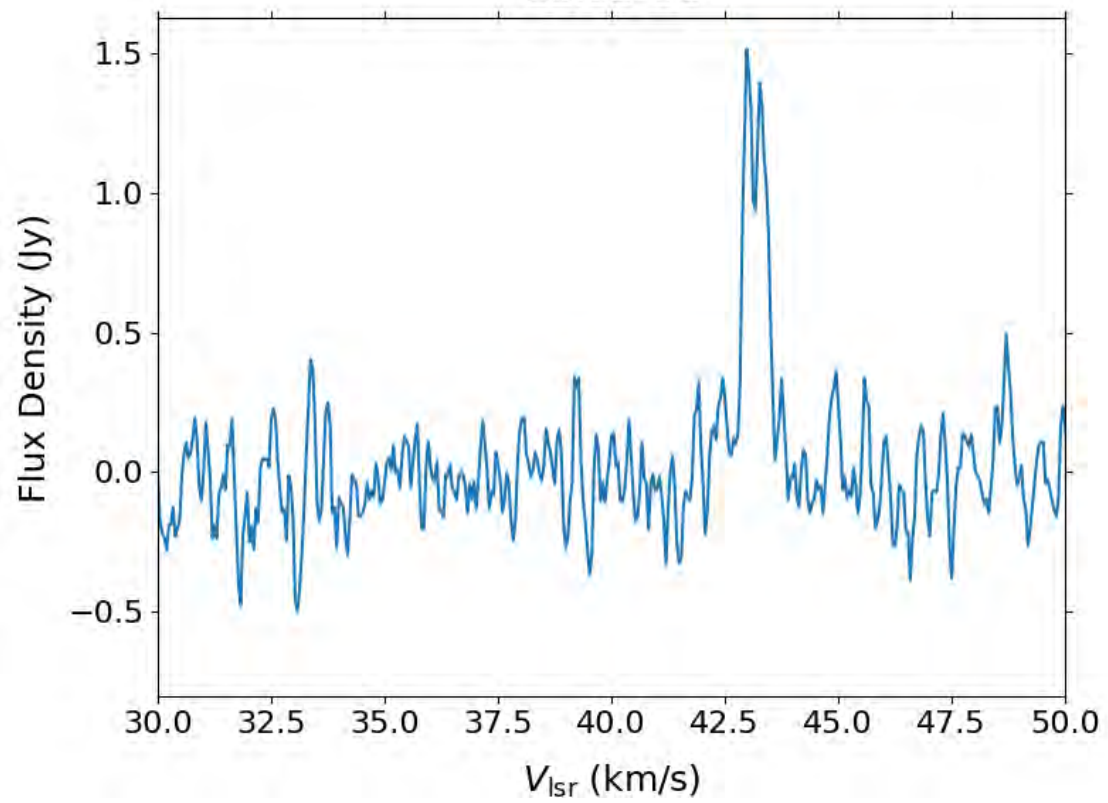
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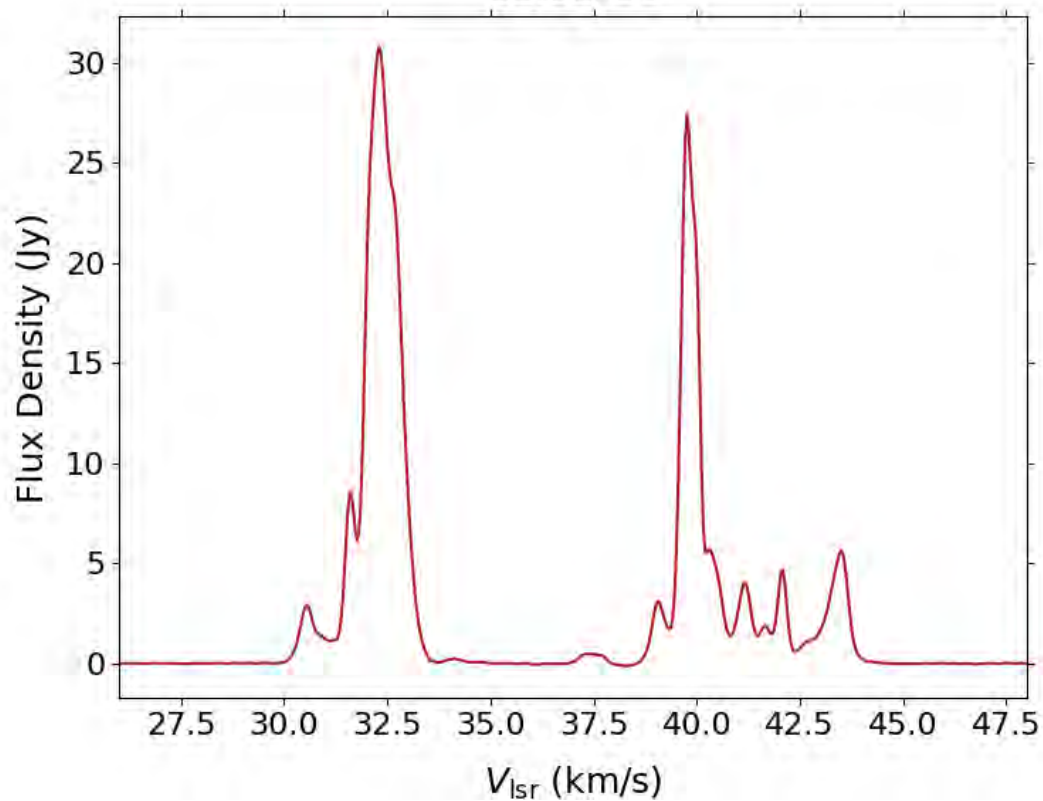
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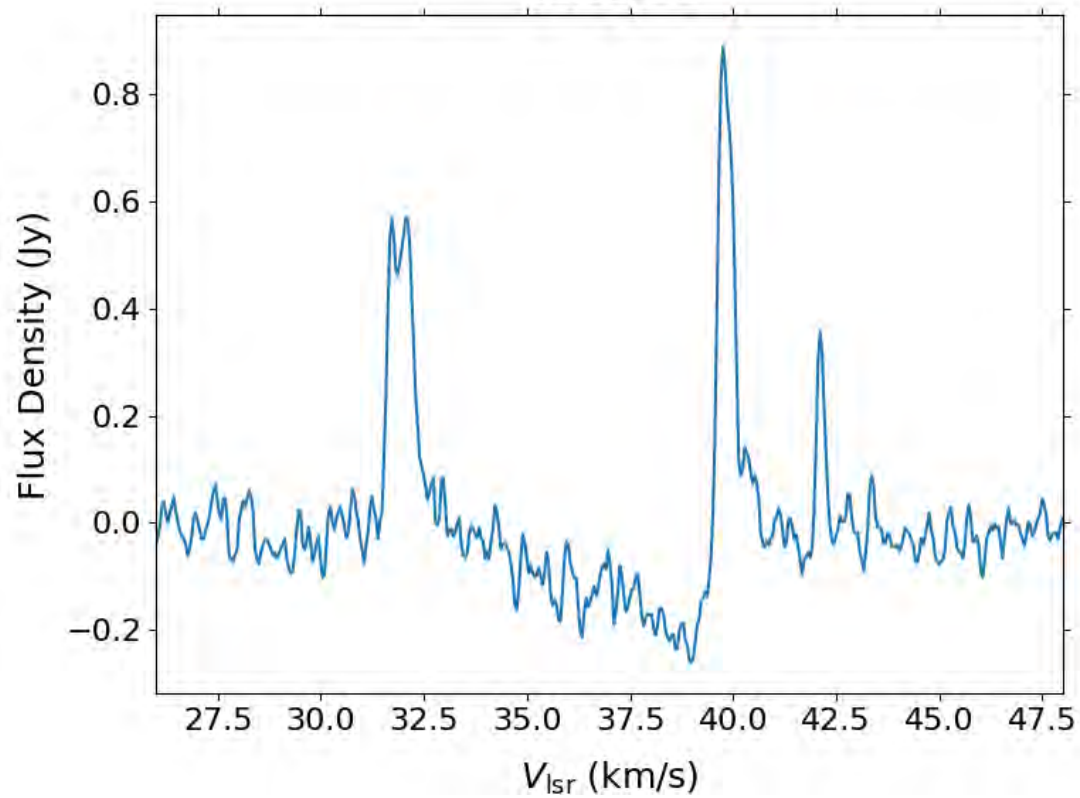
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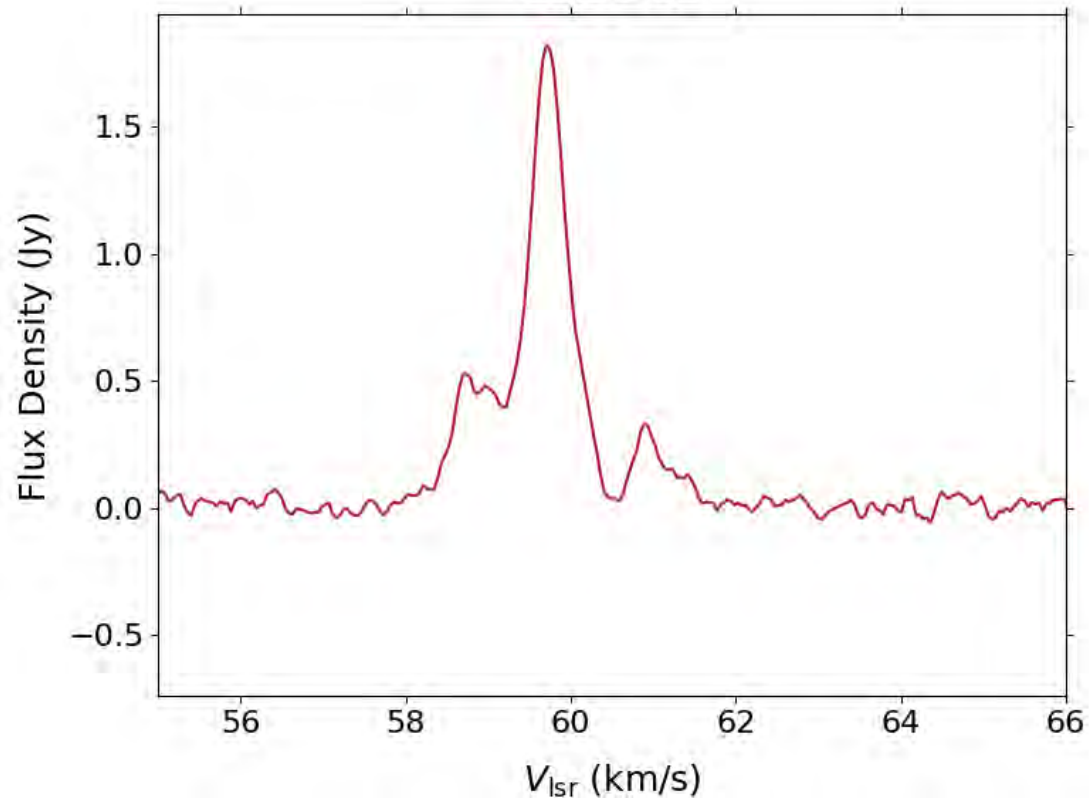
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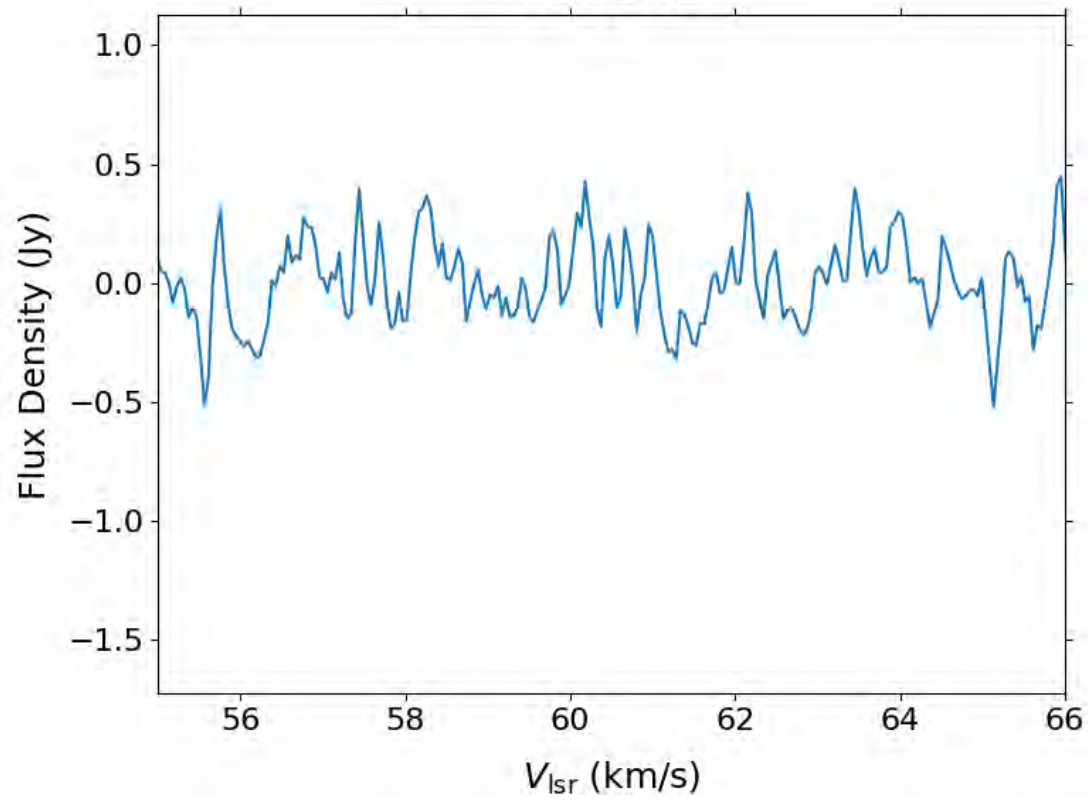
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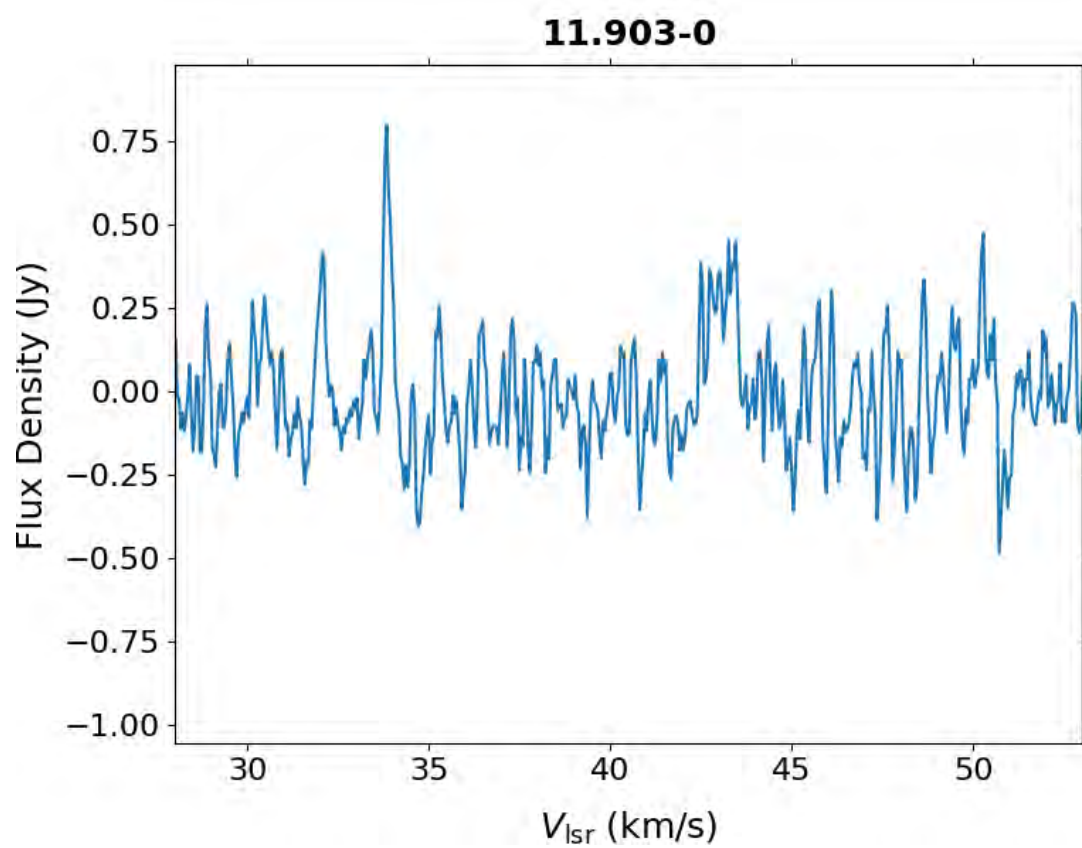
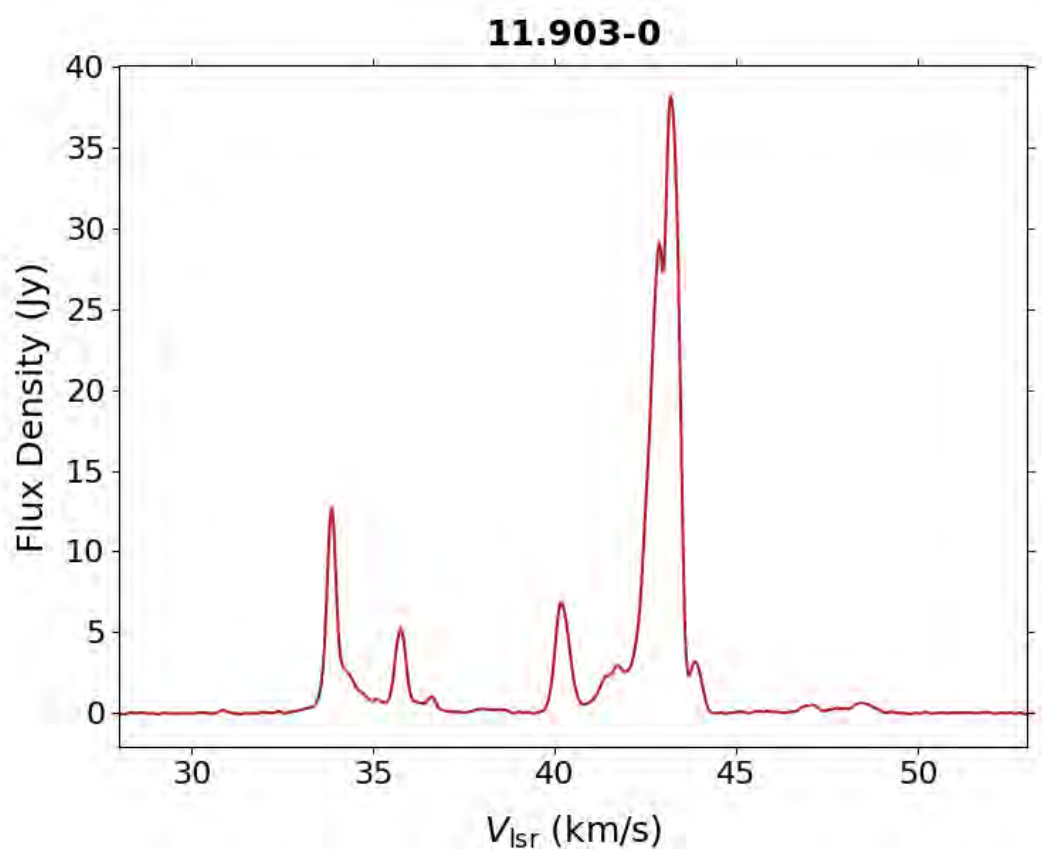


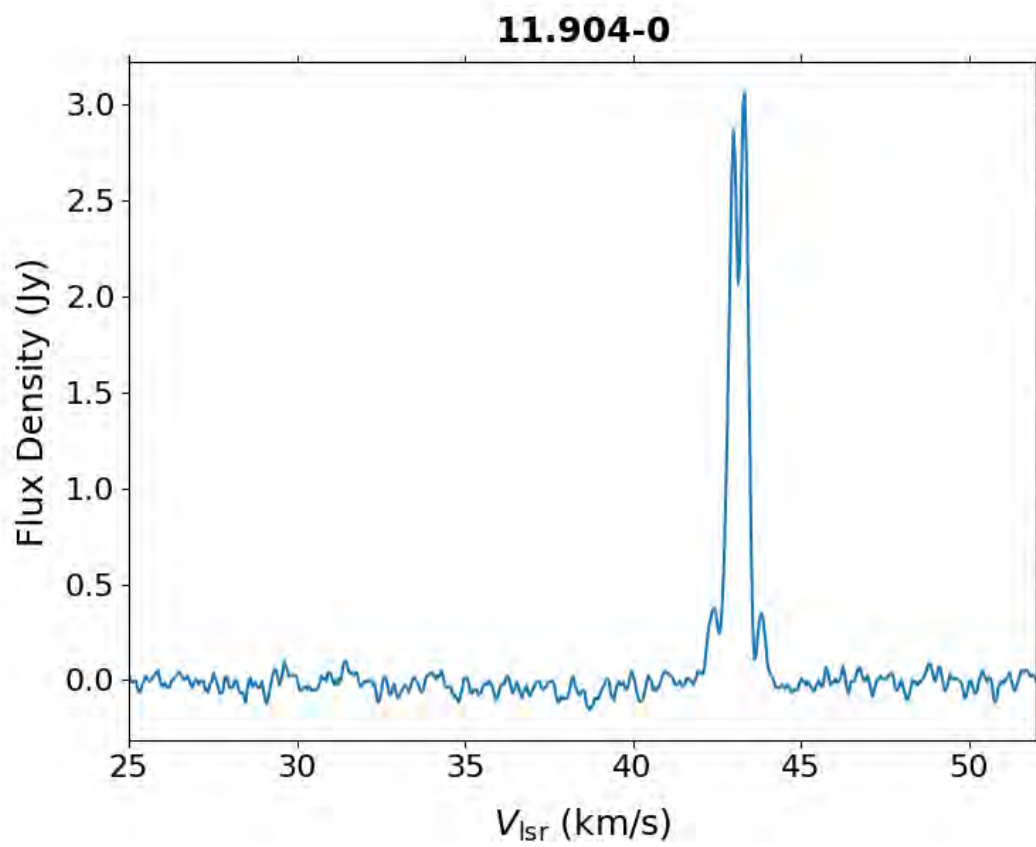
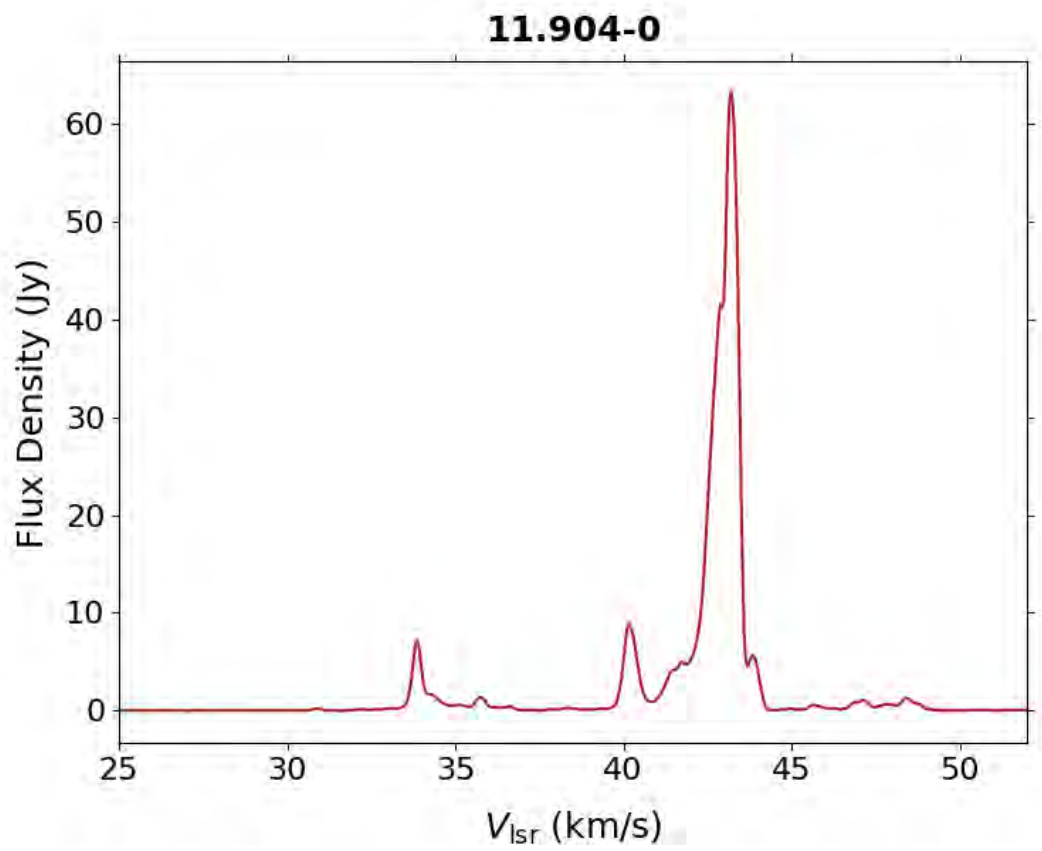
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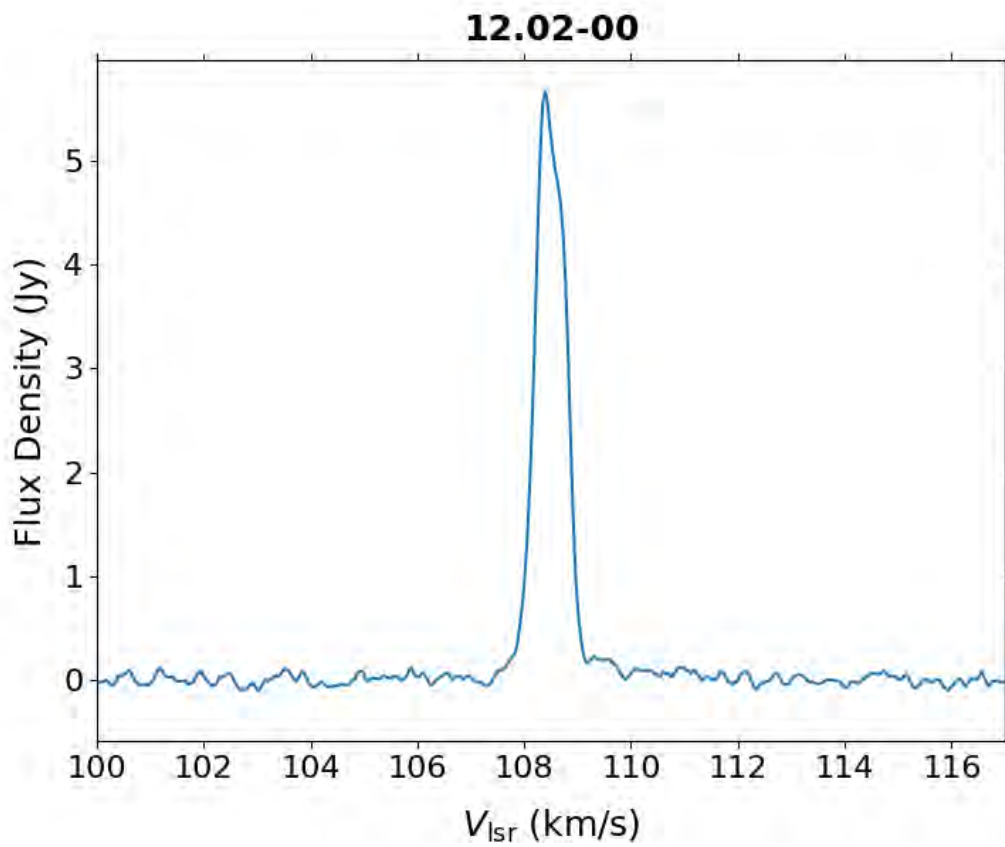
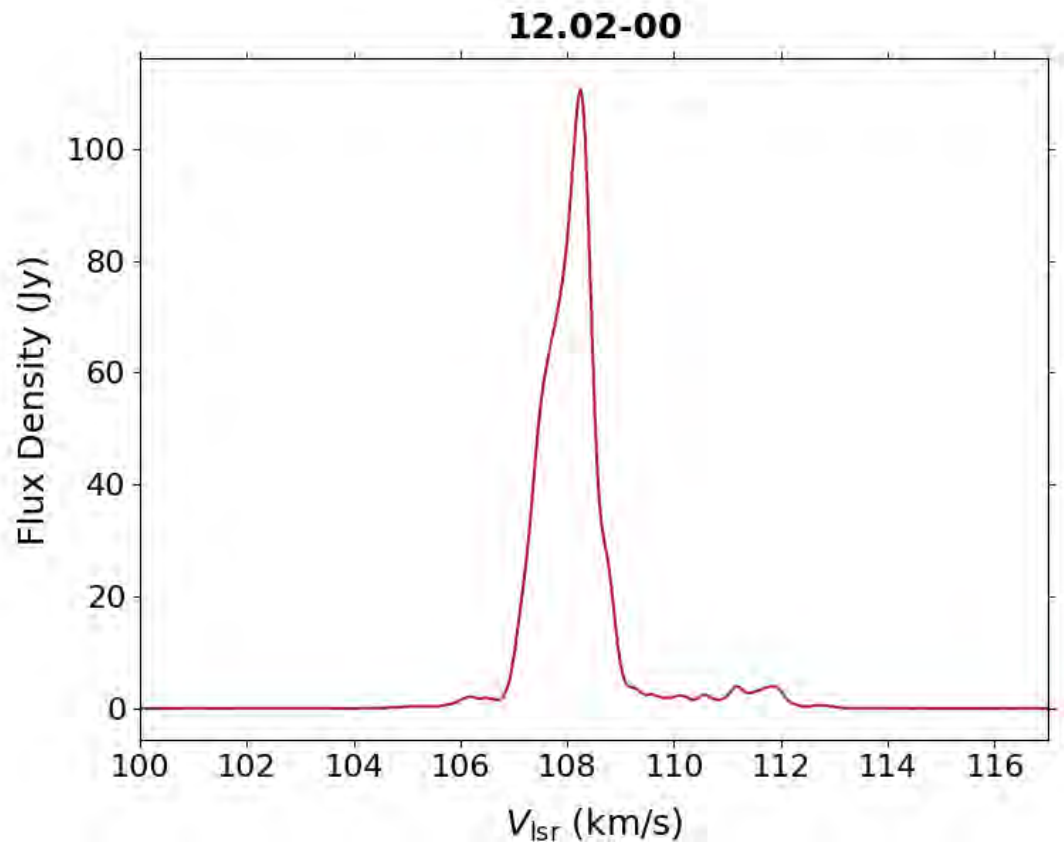


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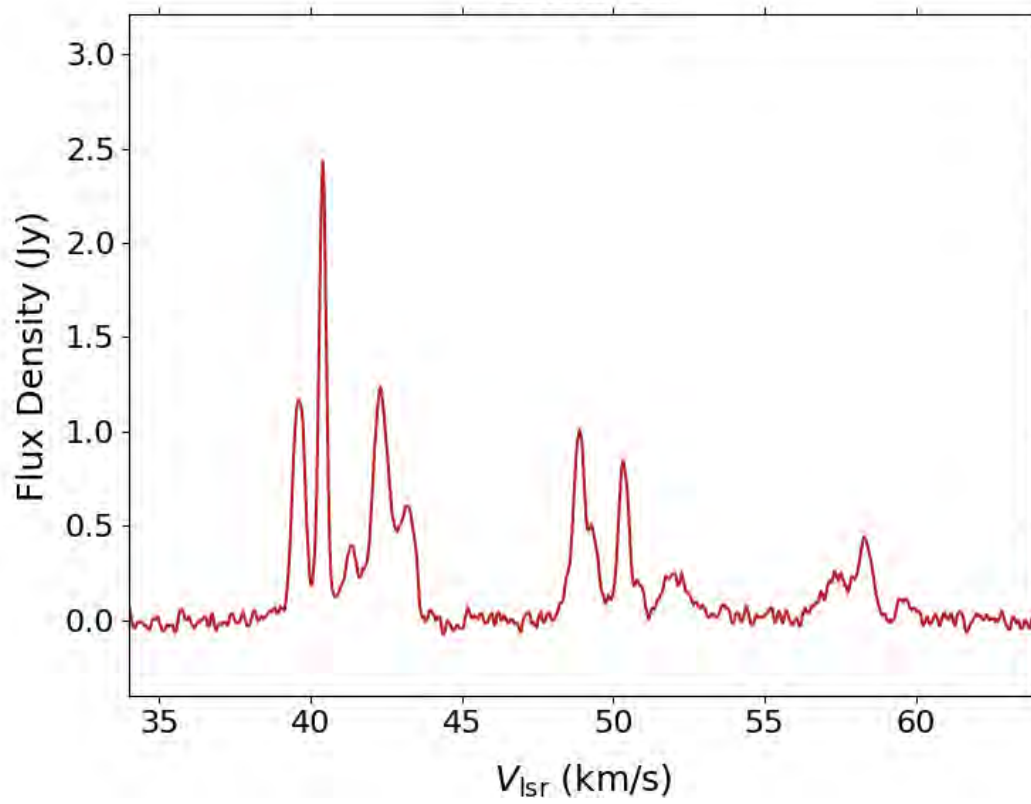




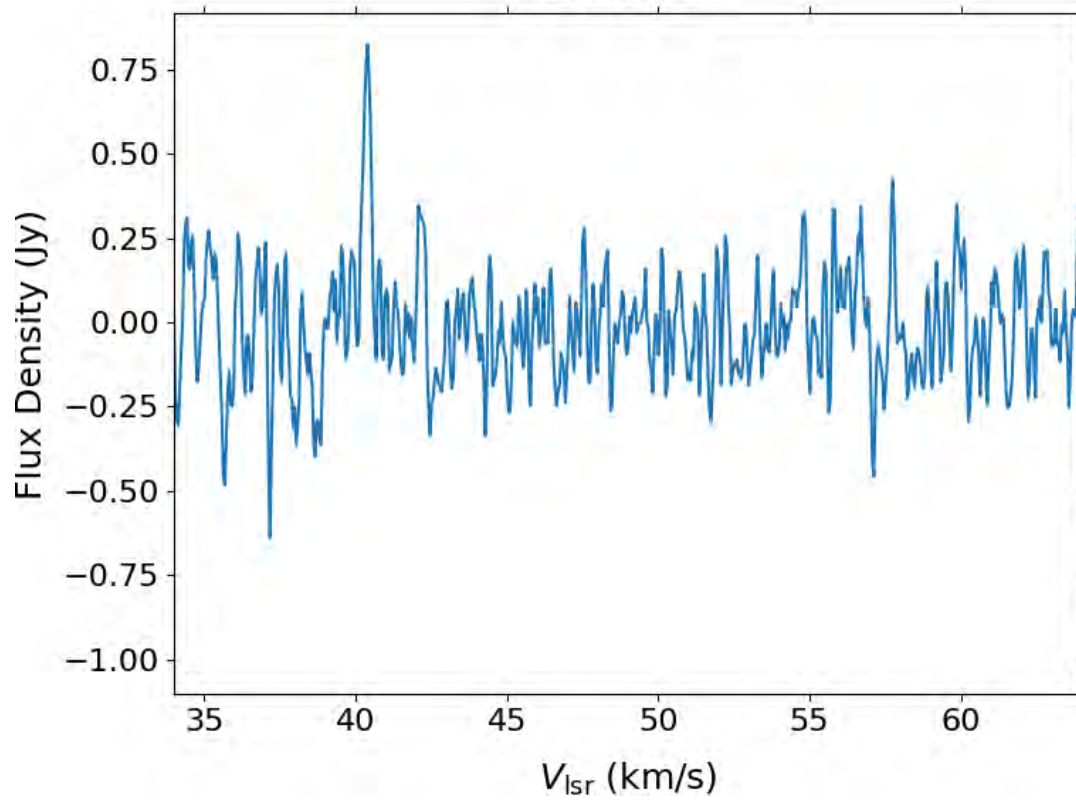




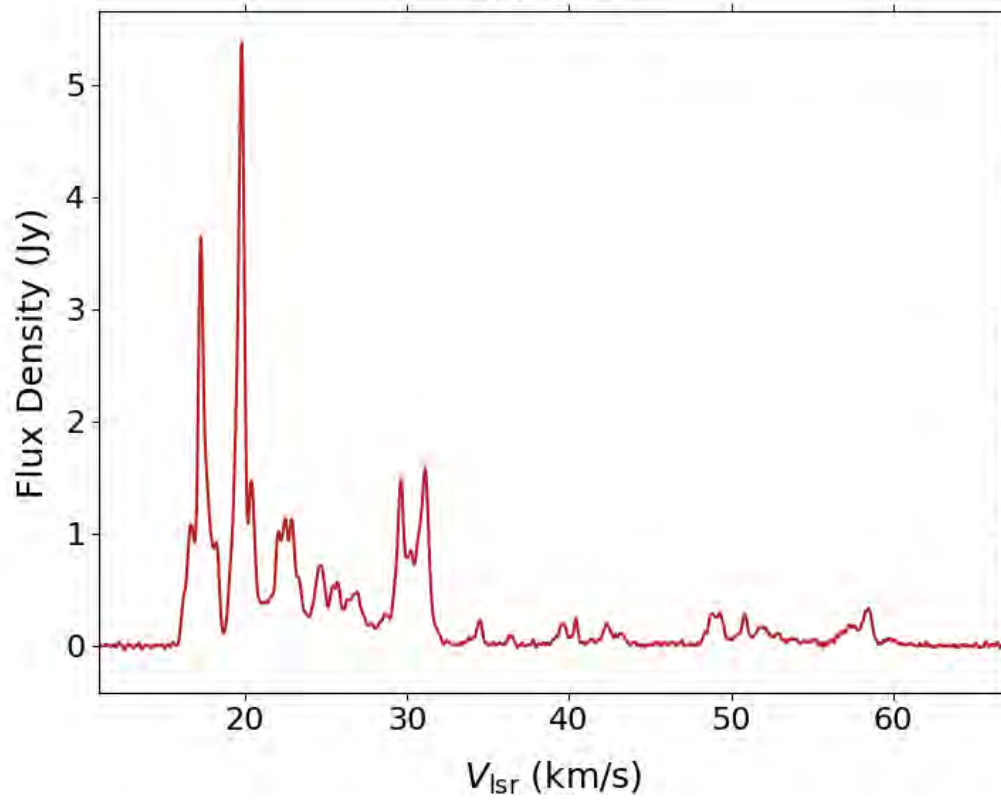
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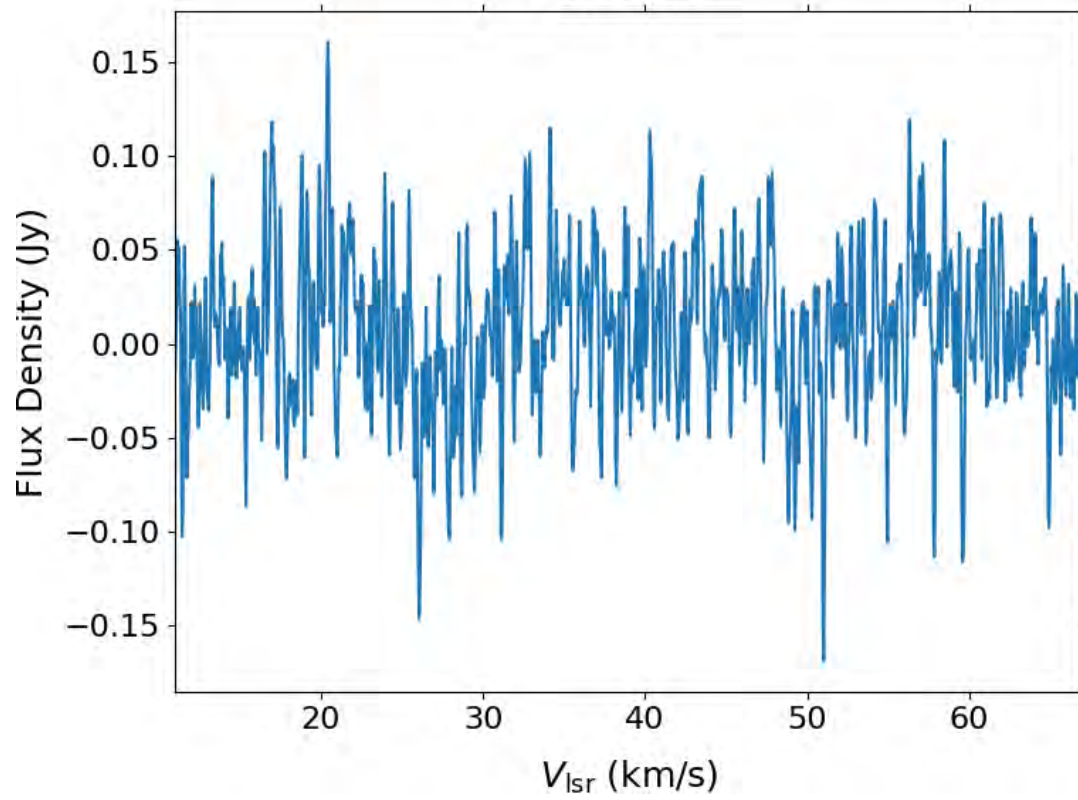
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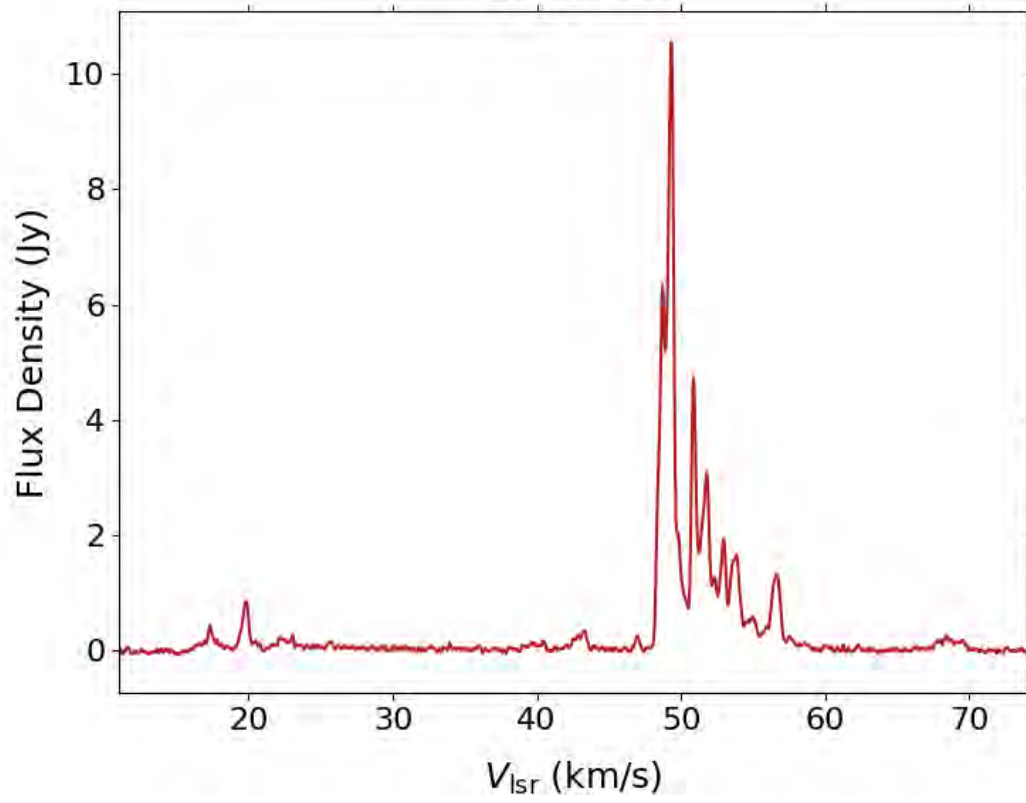
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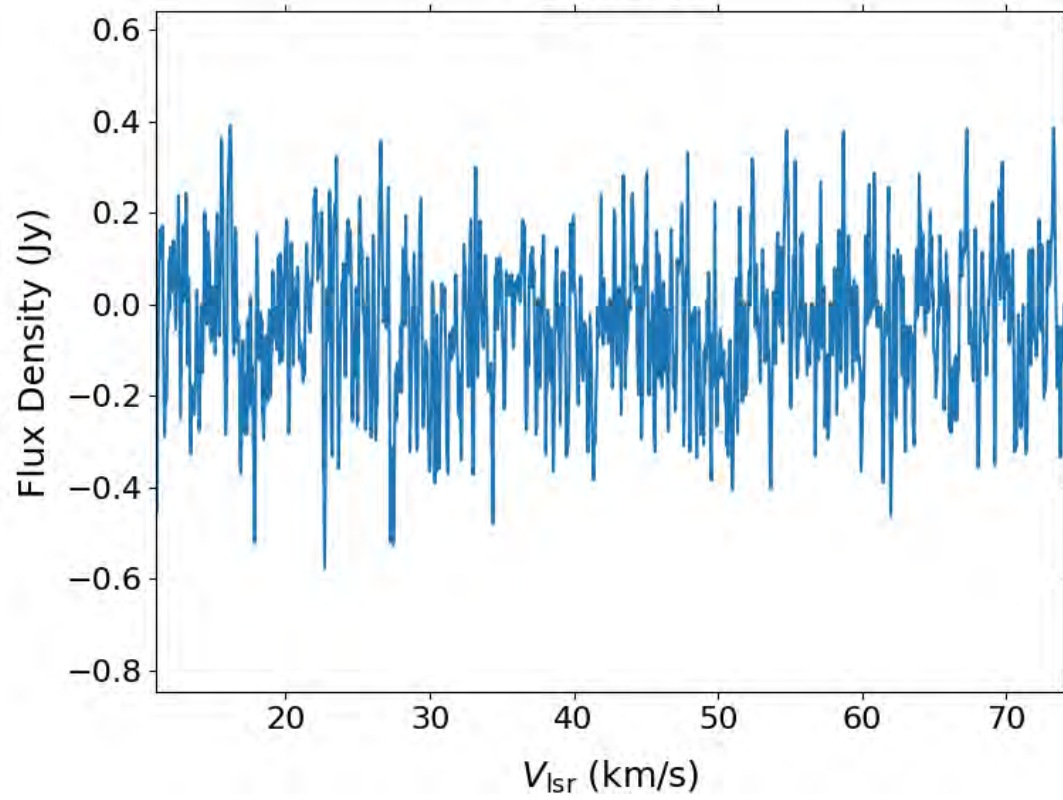
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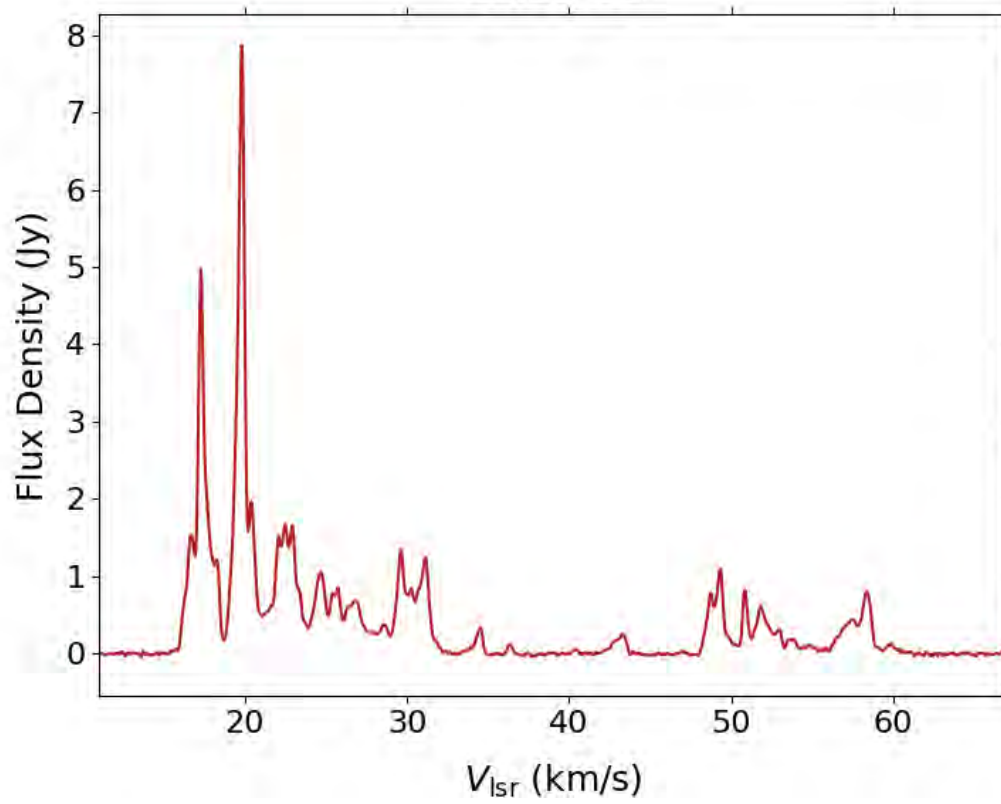
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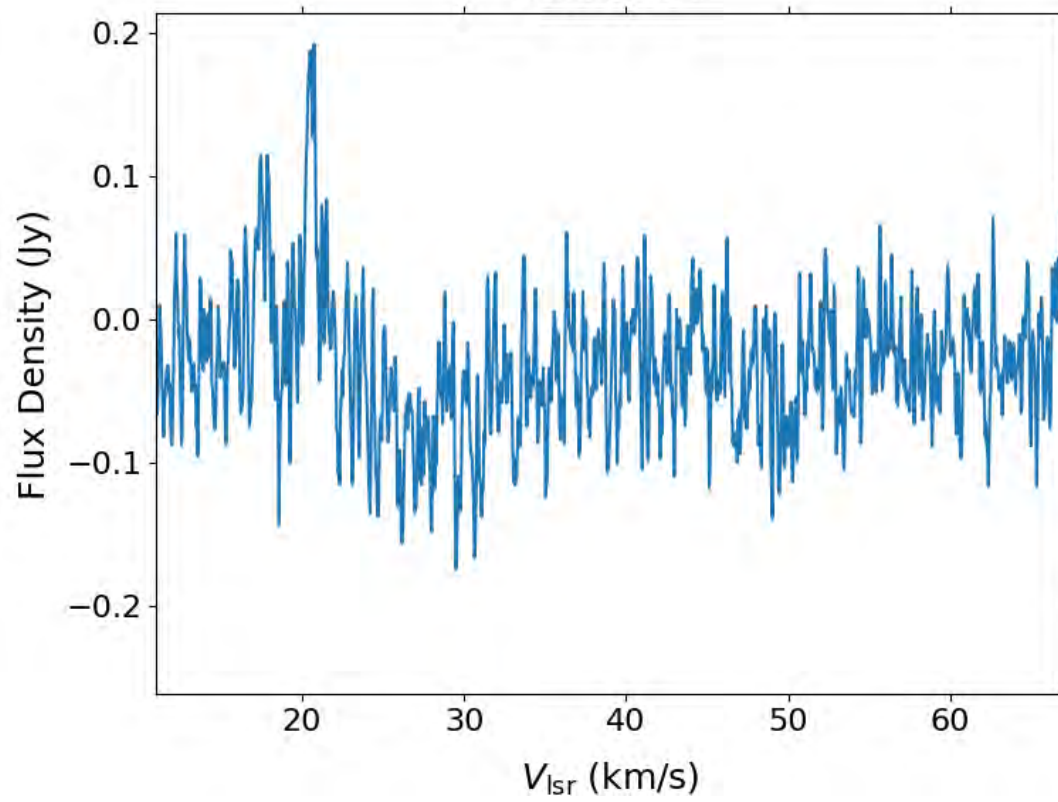
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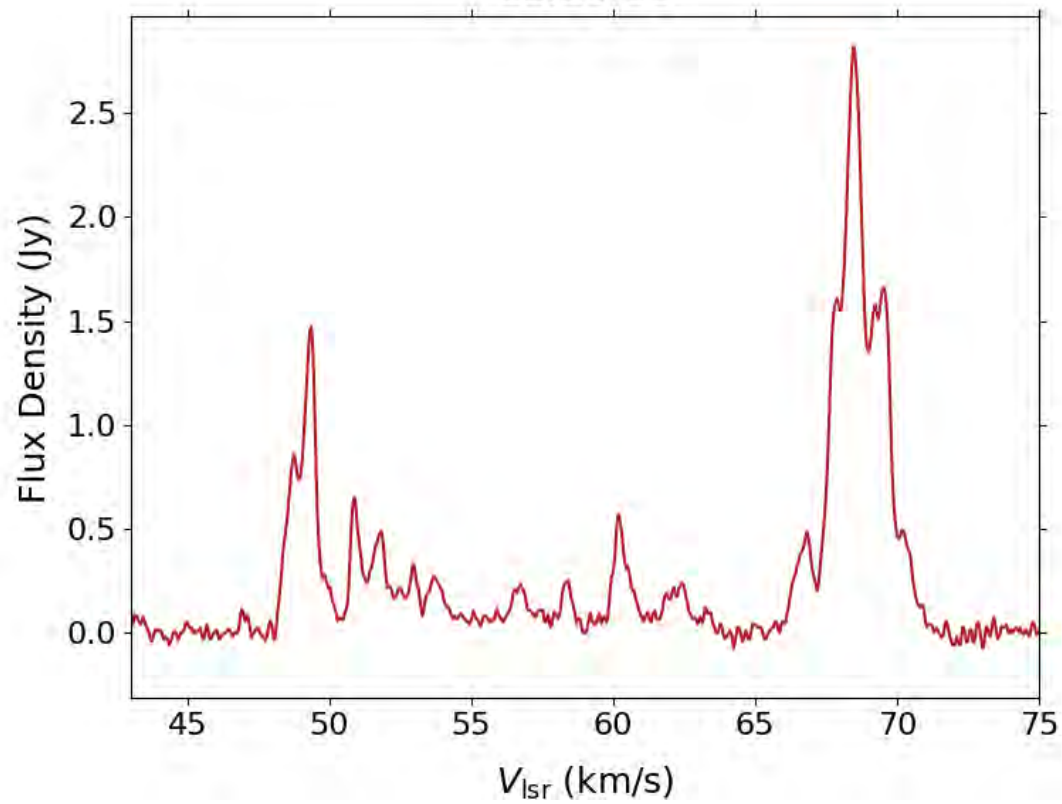
12.20-01



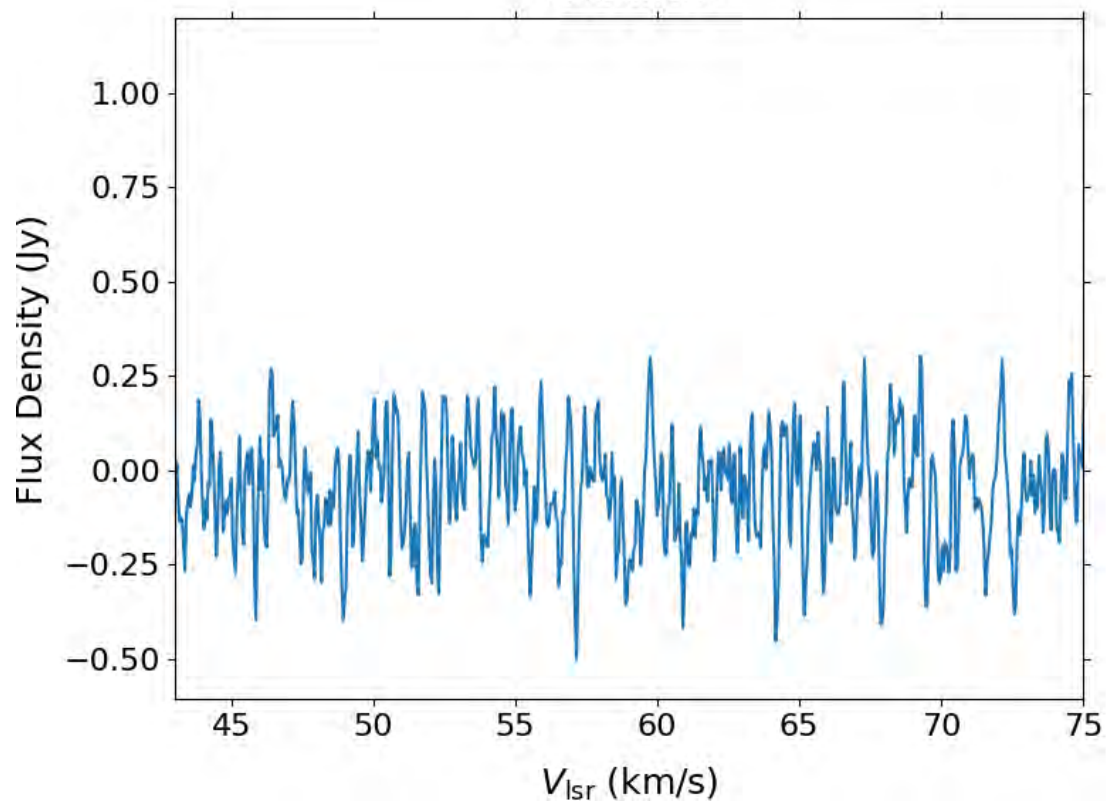
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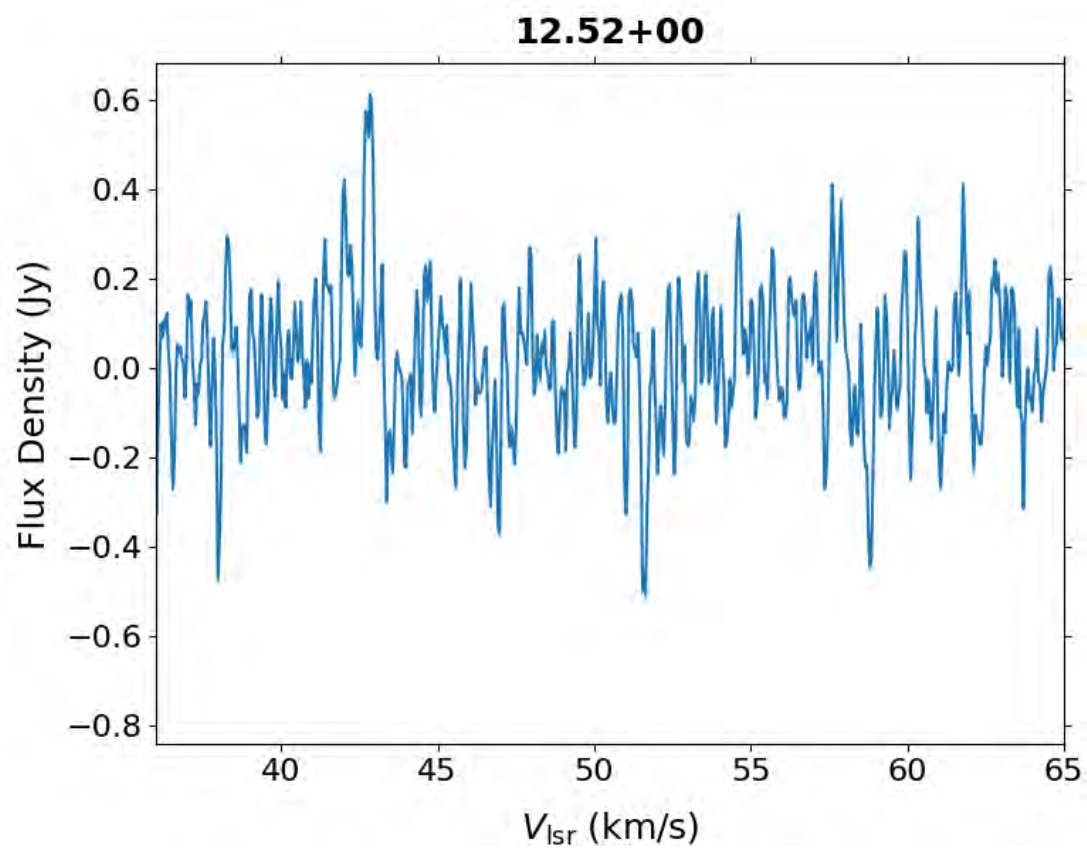
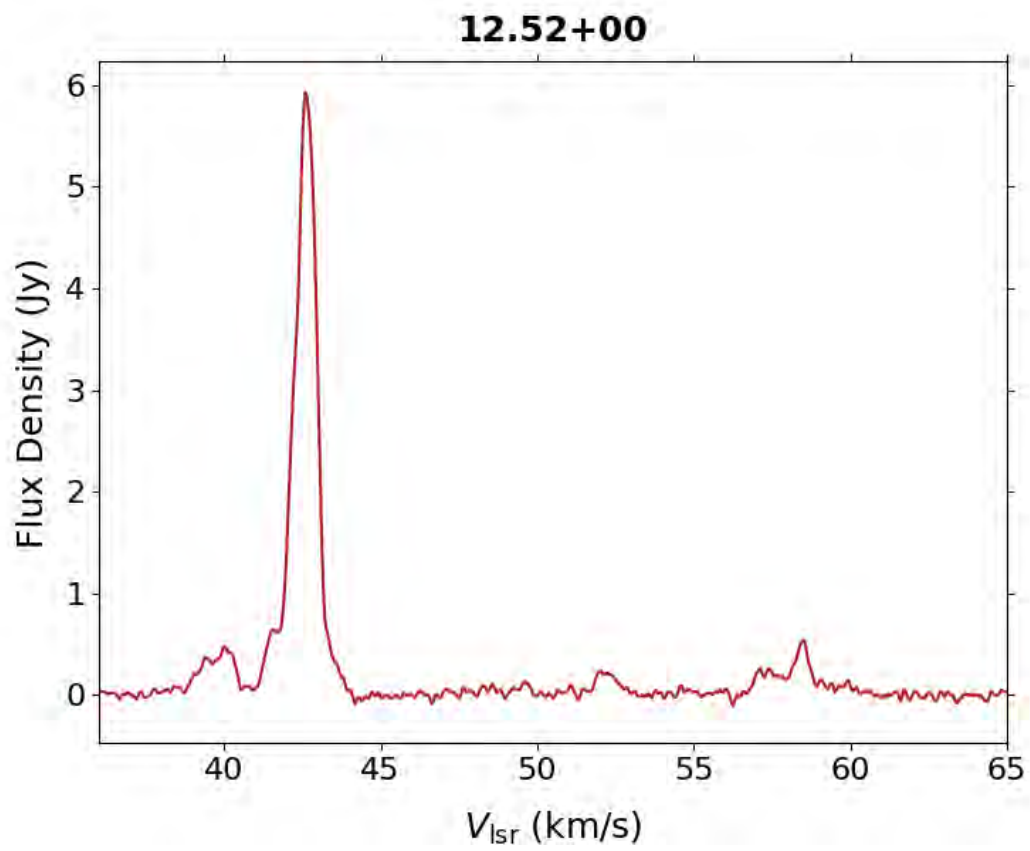


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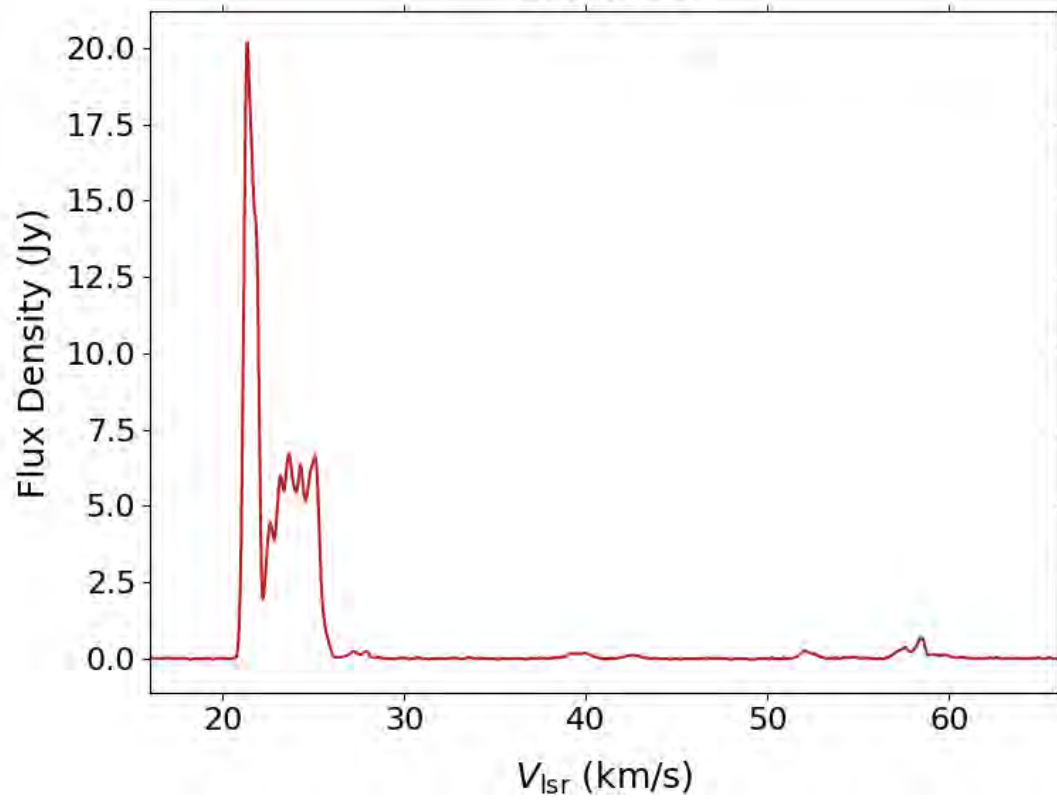


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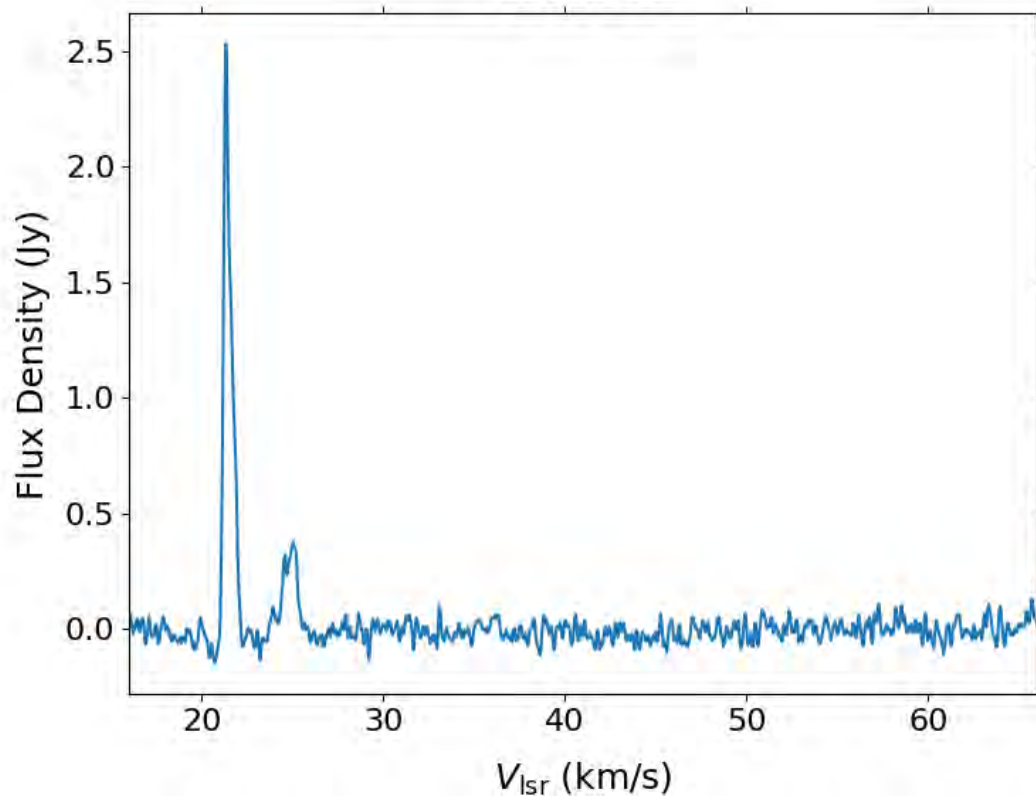




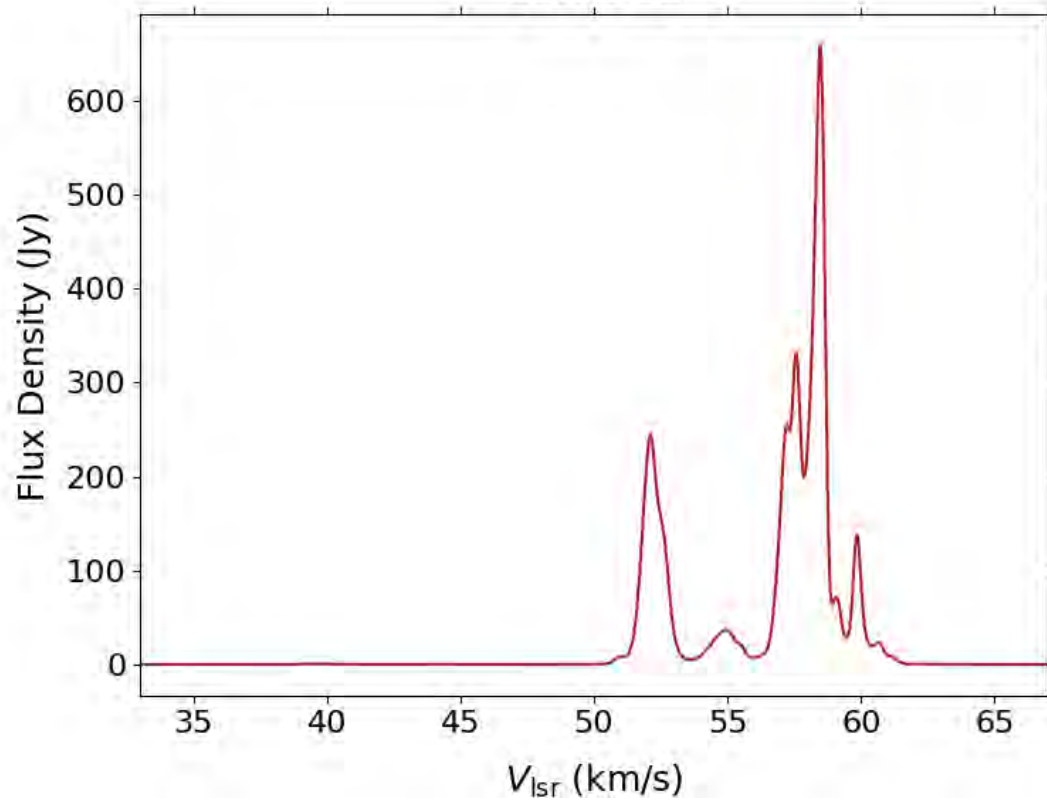
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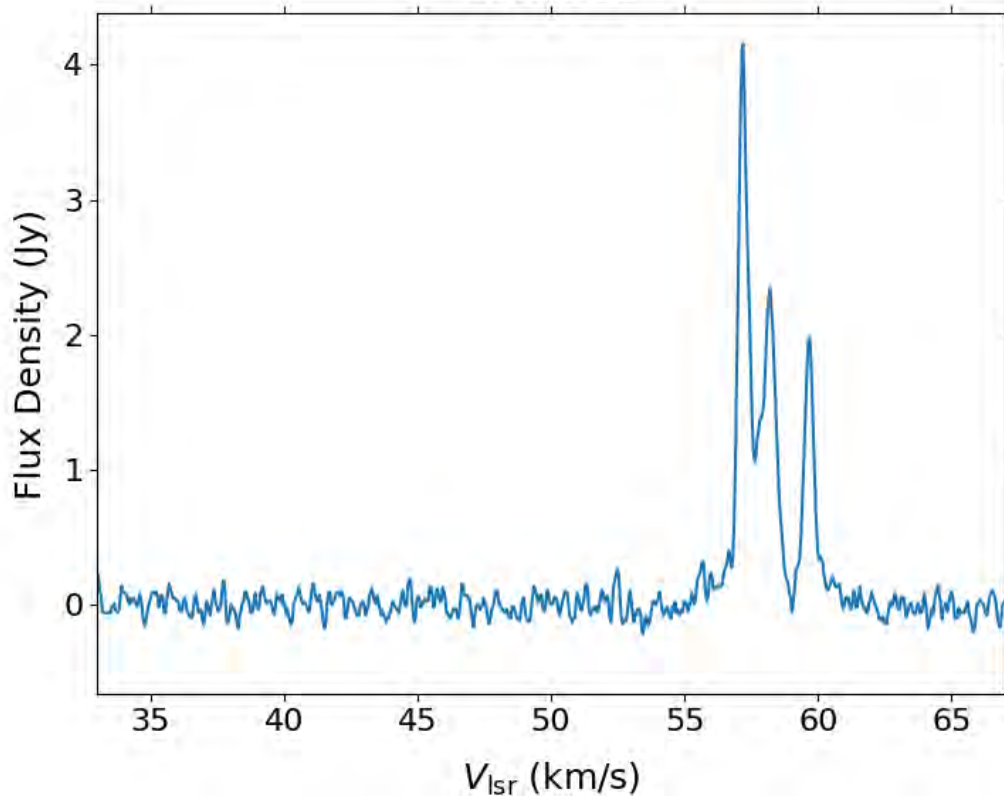
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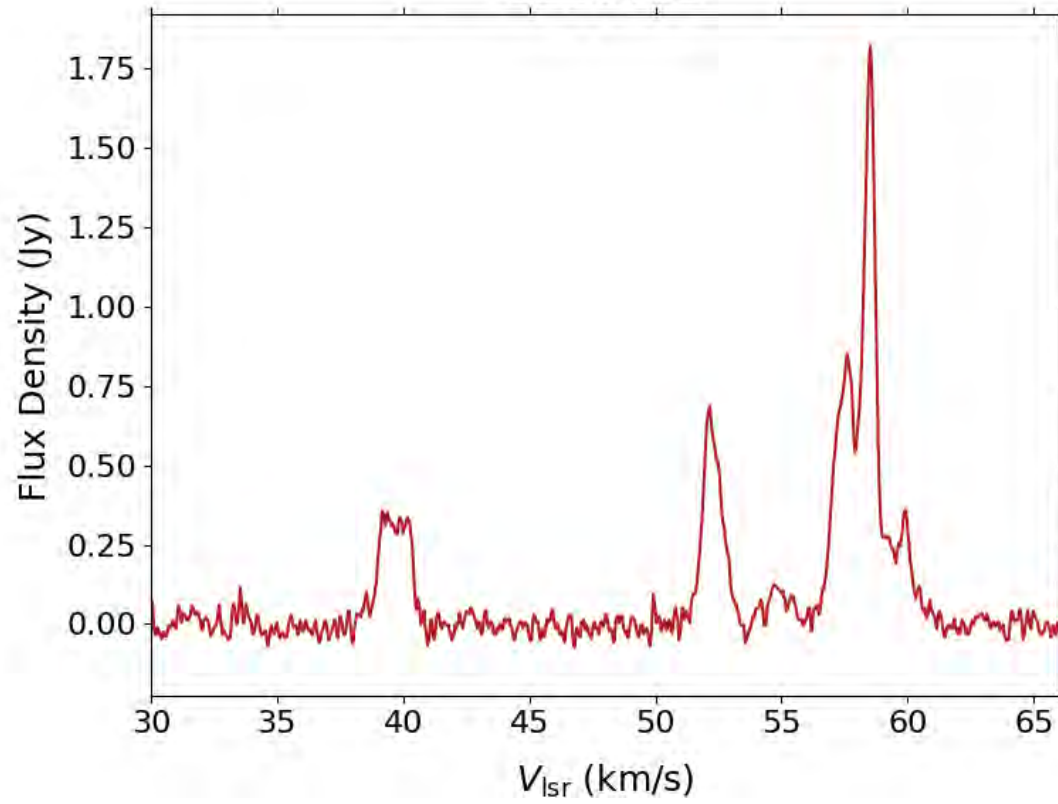
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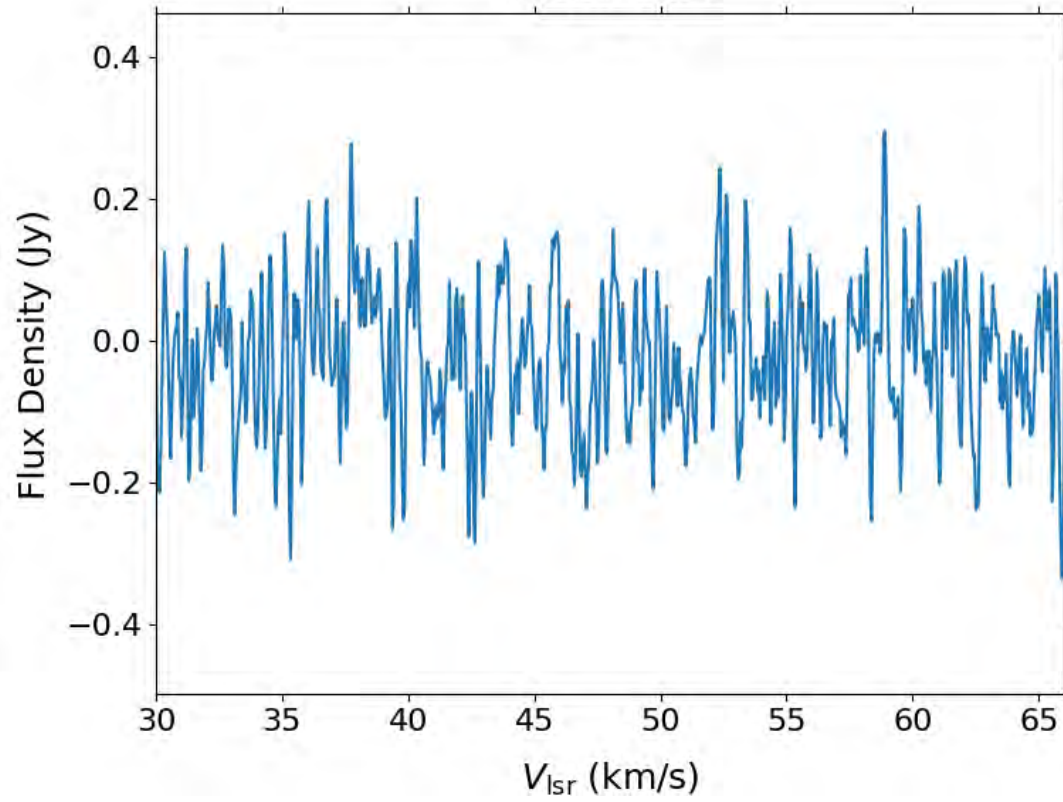
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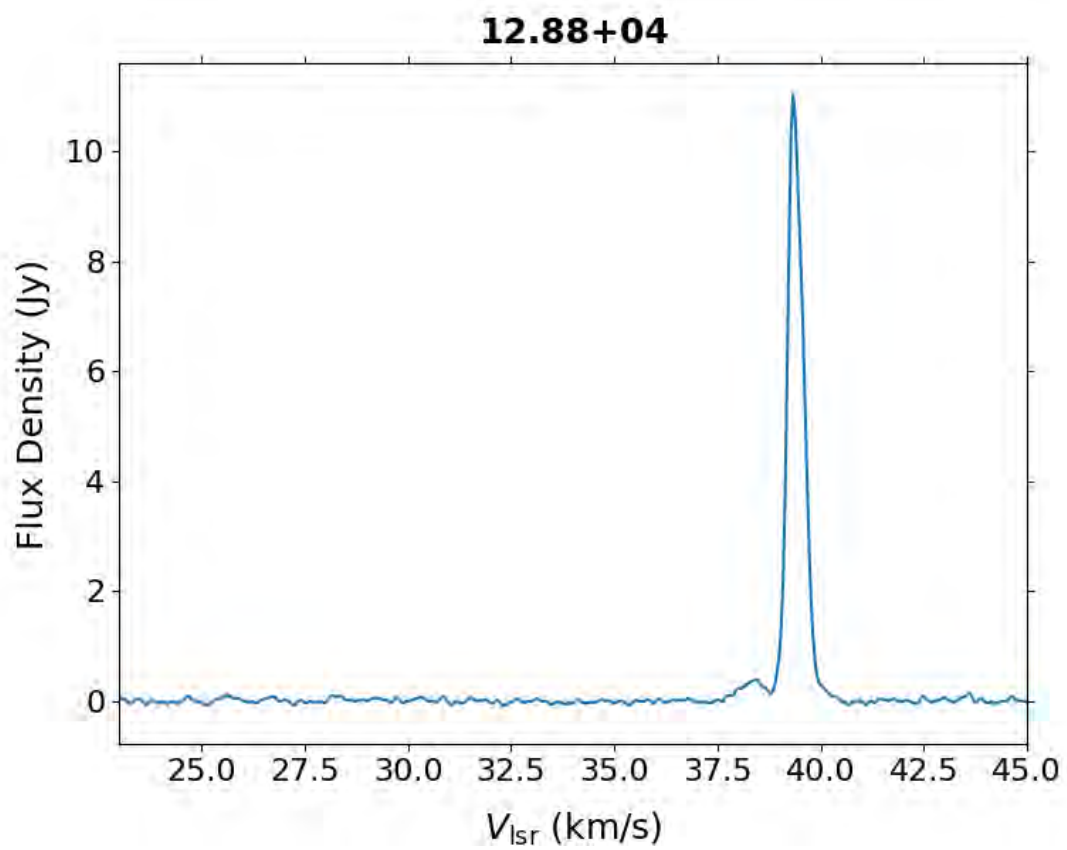
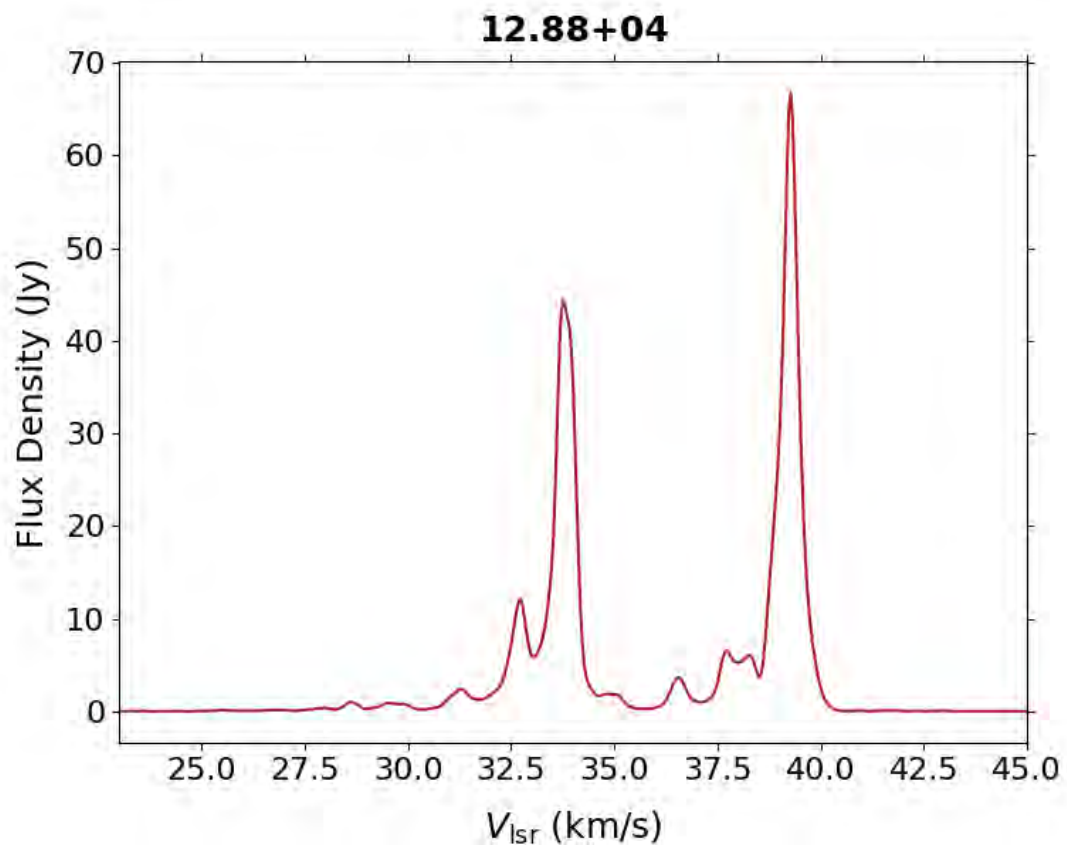


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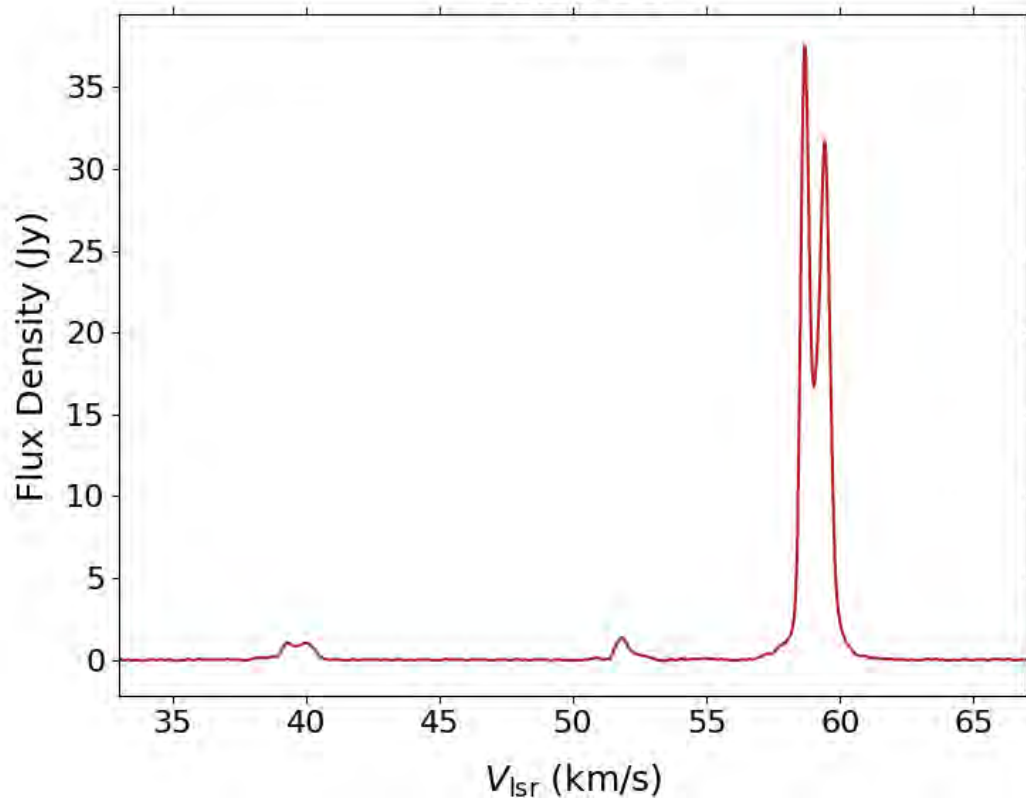


12.77+01

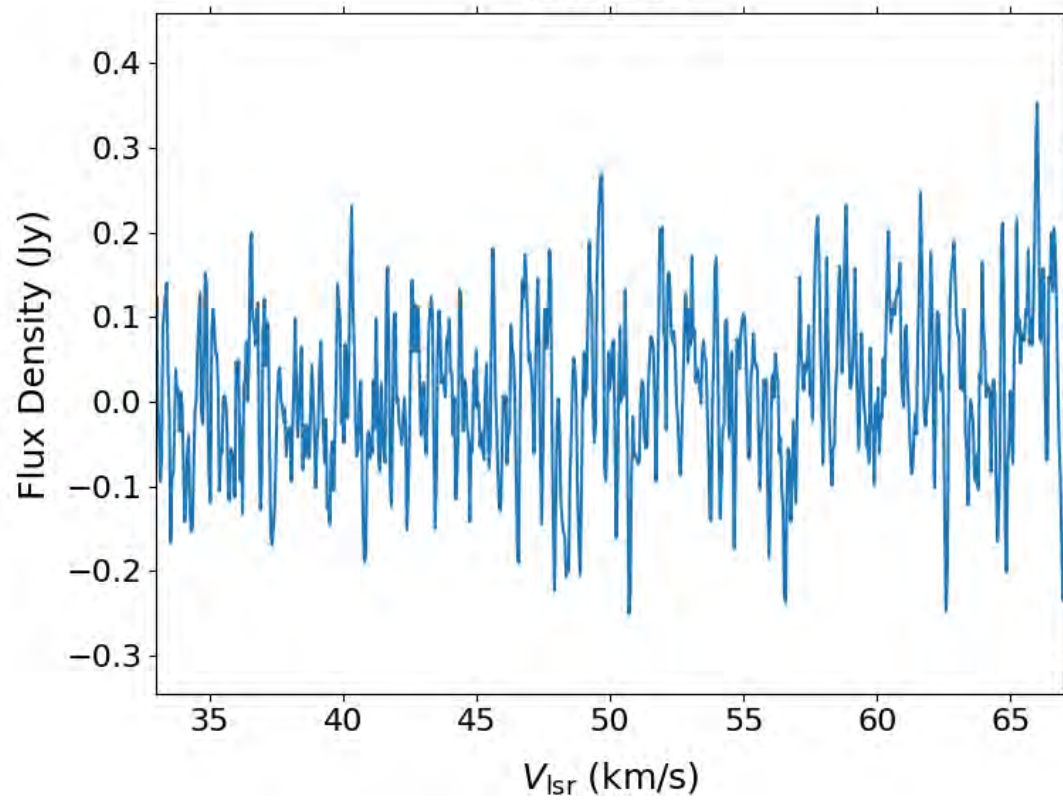




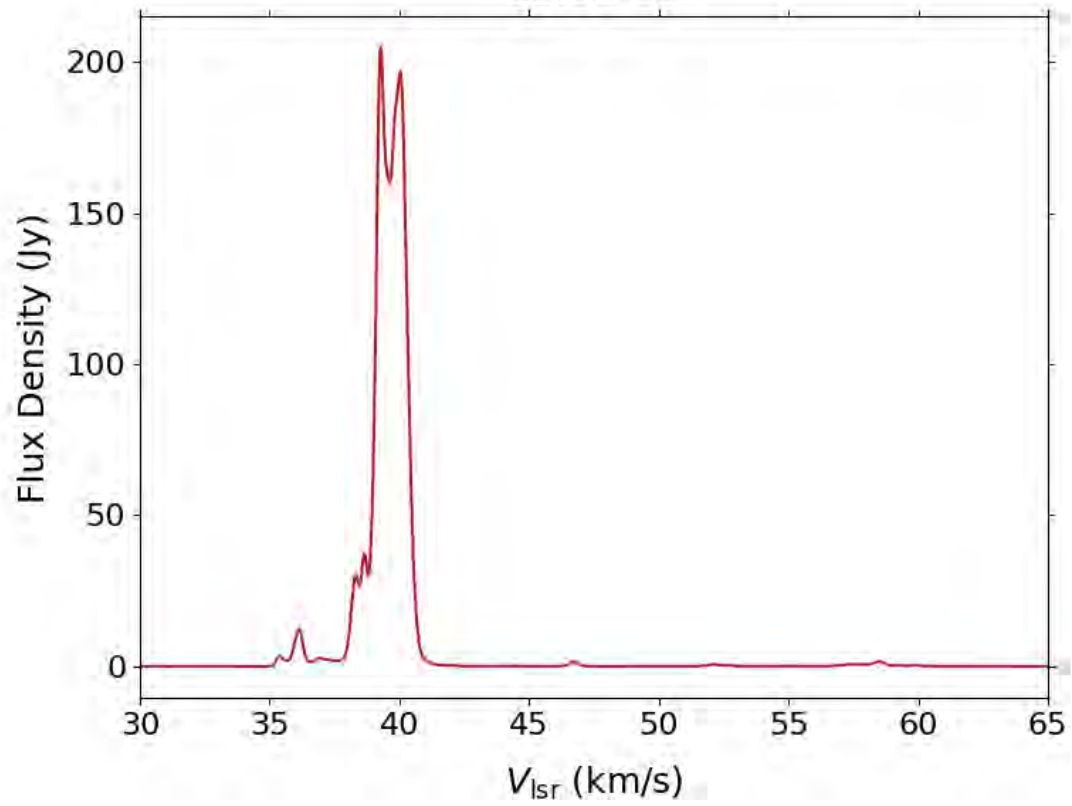
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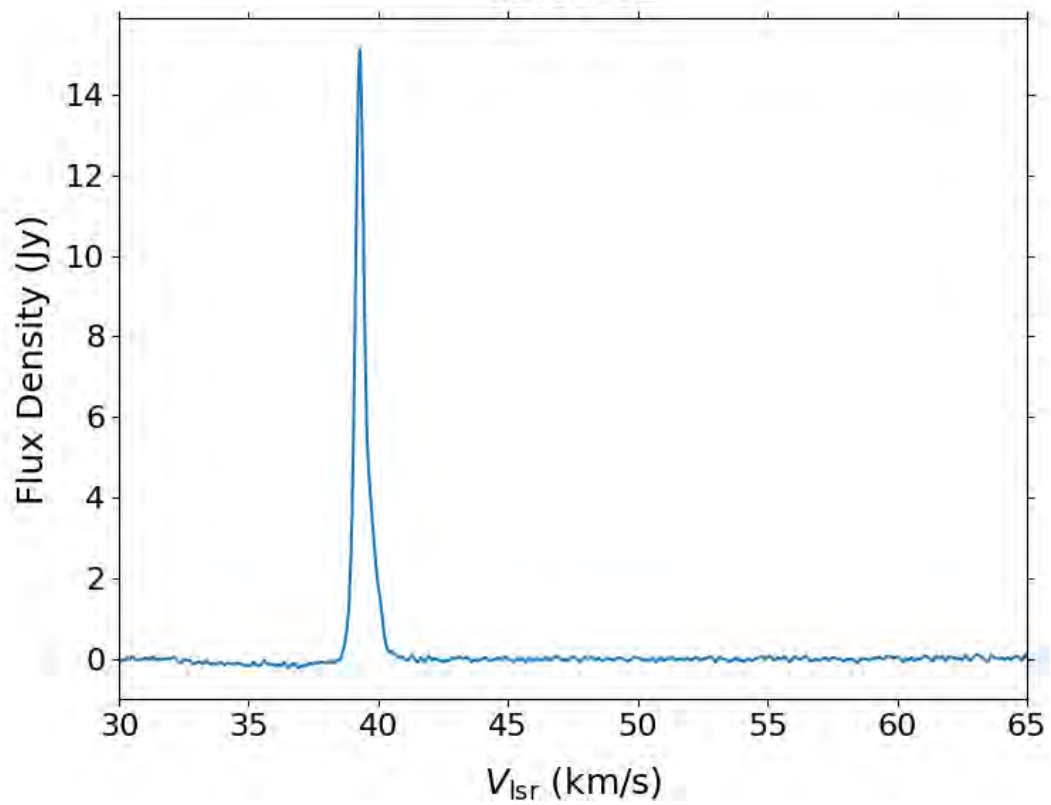
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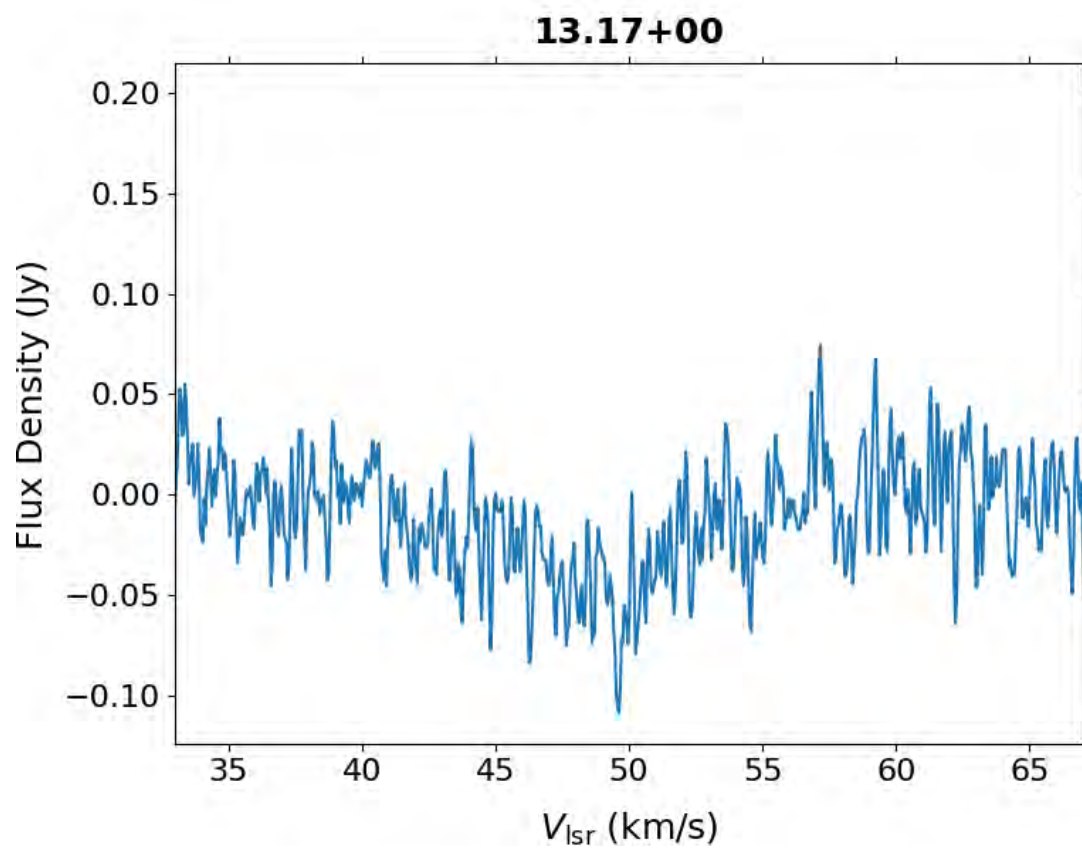
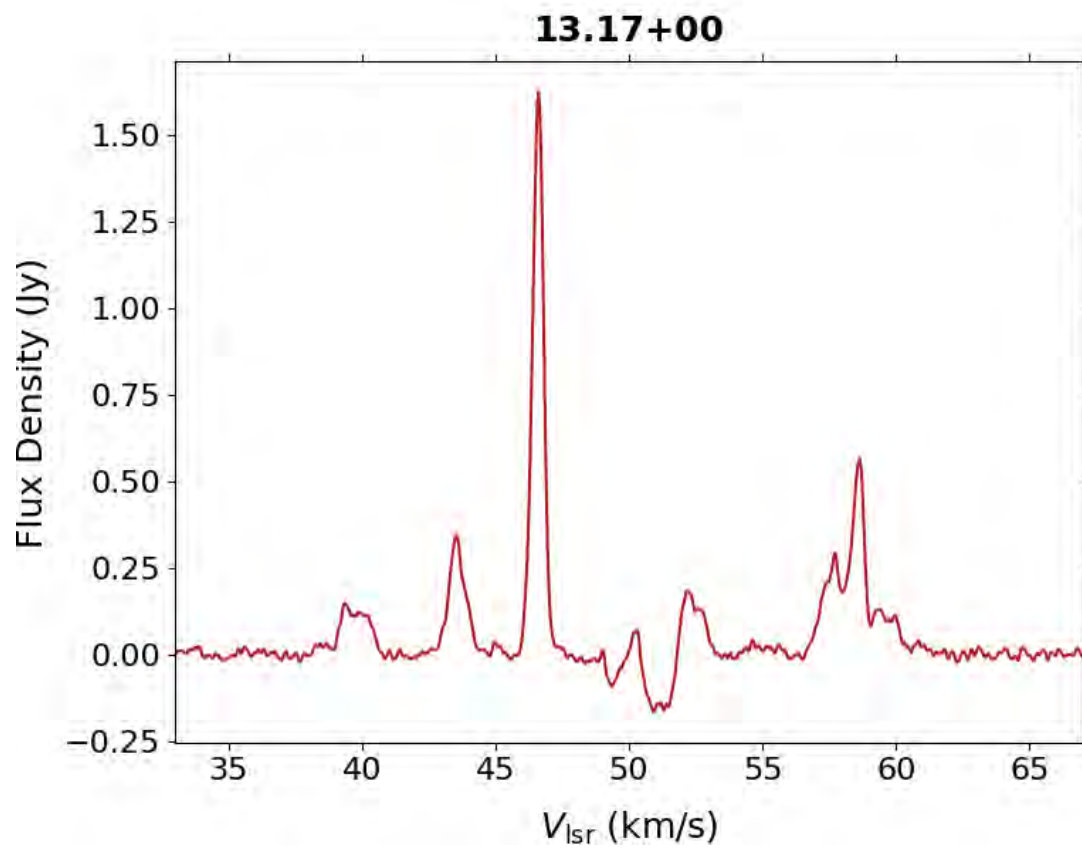


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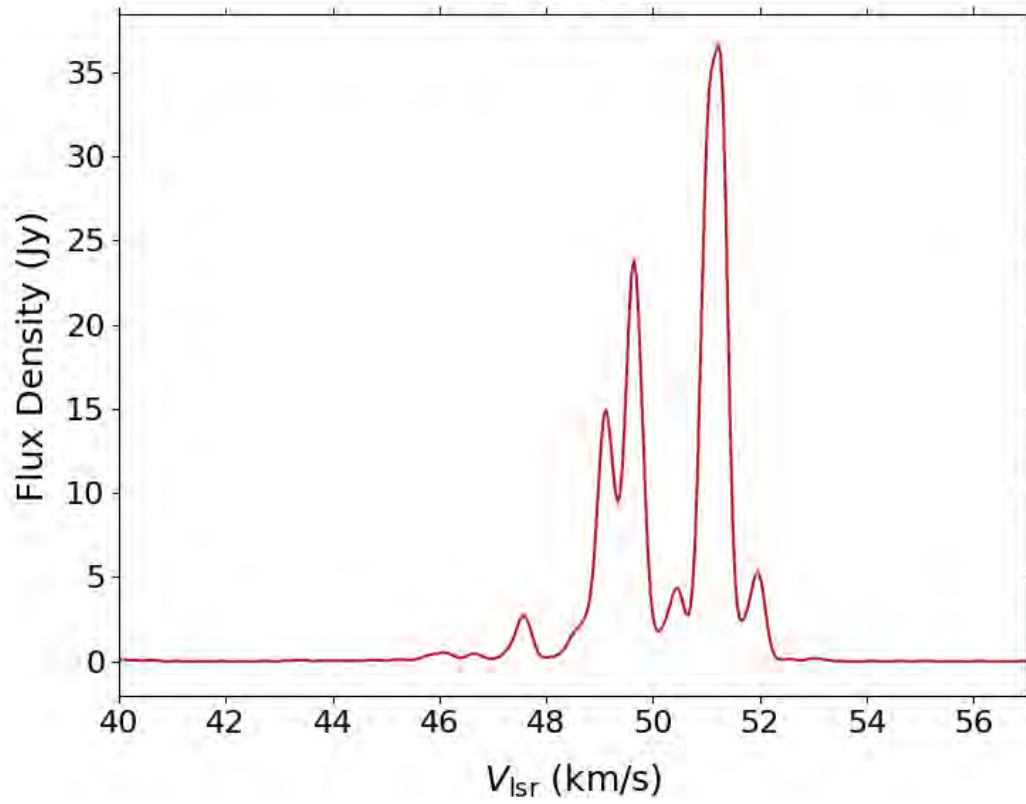


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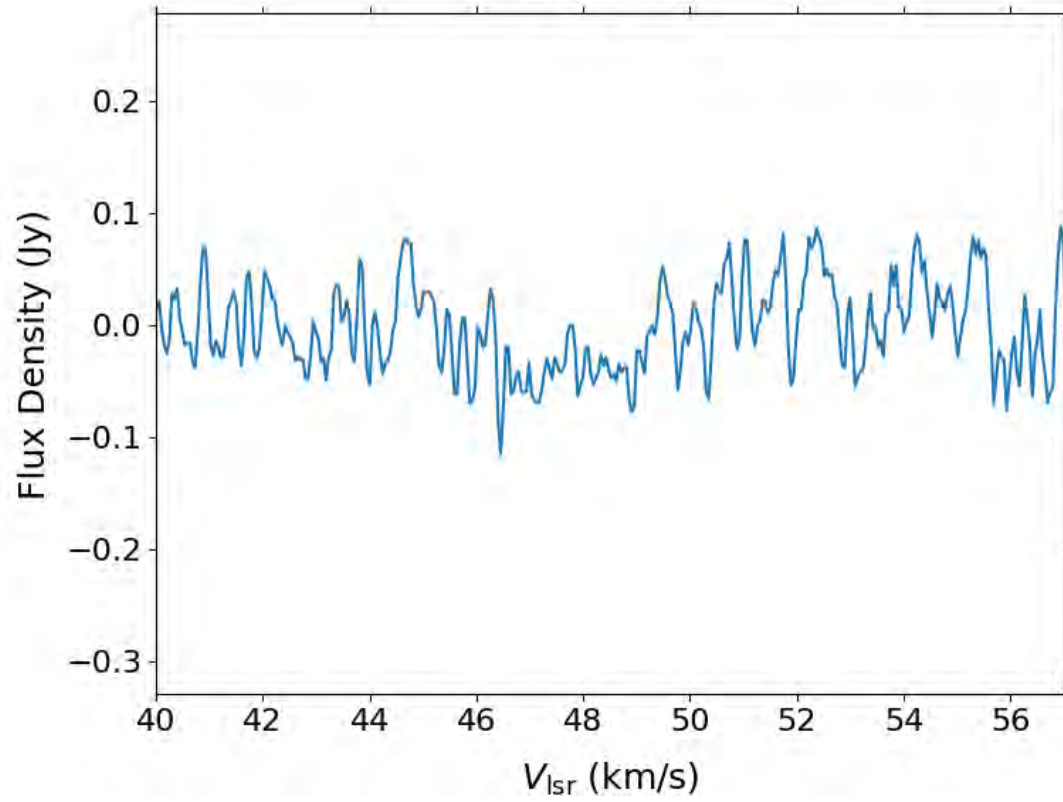


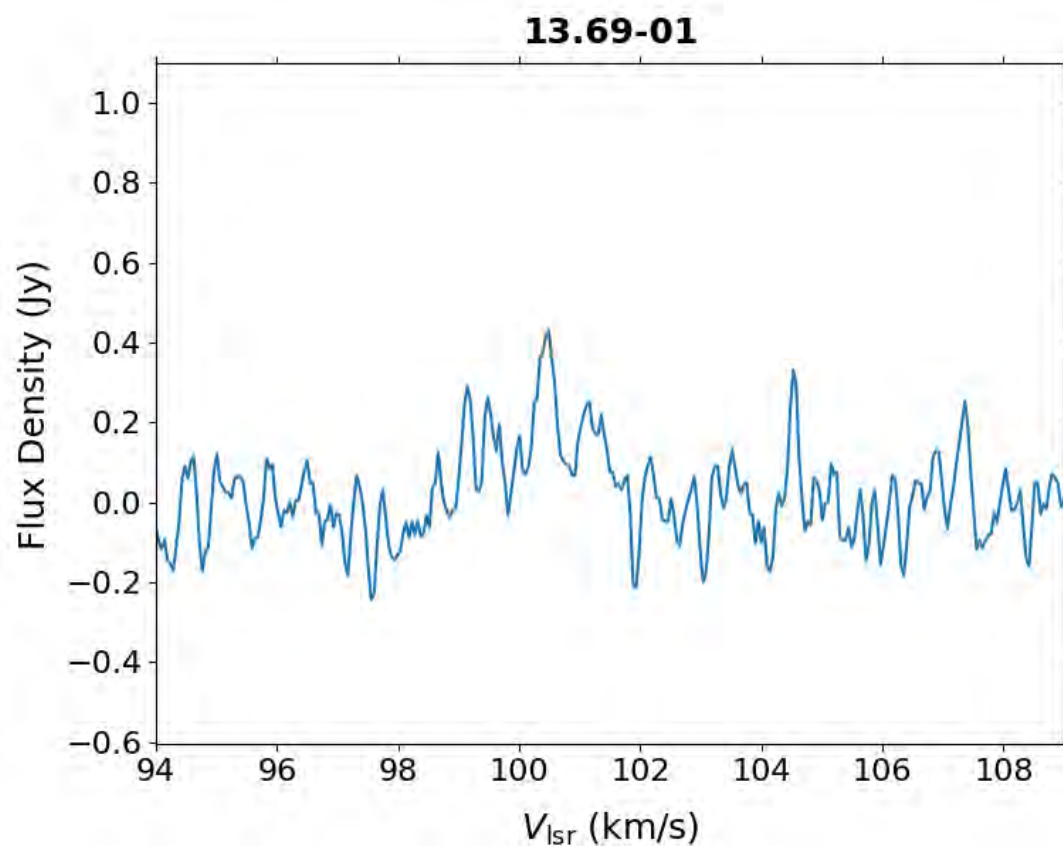
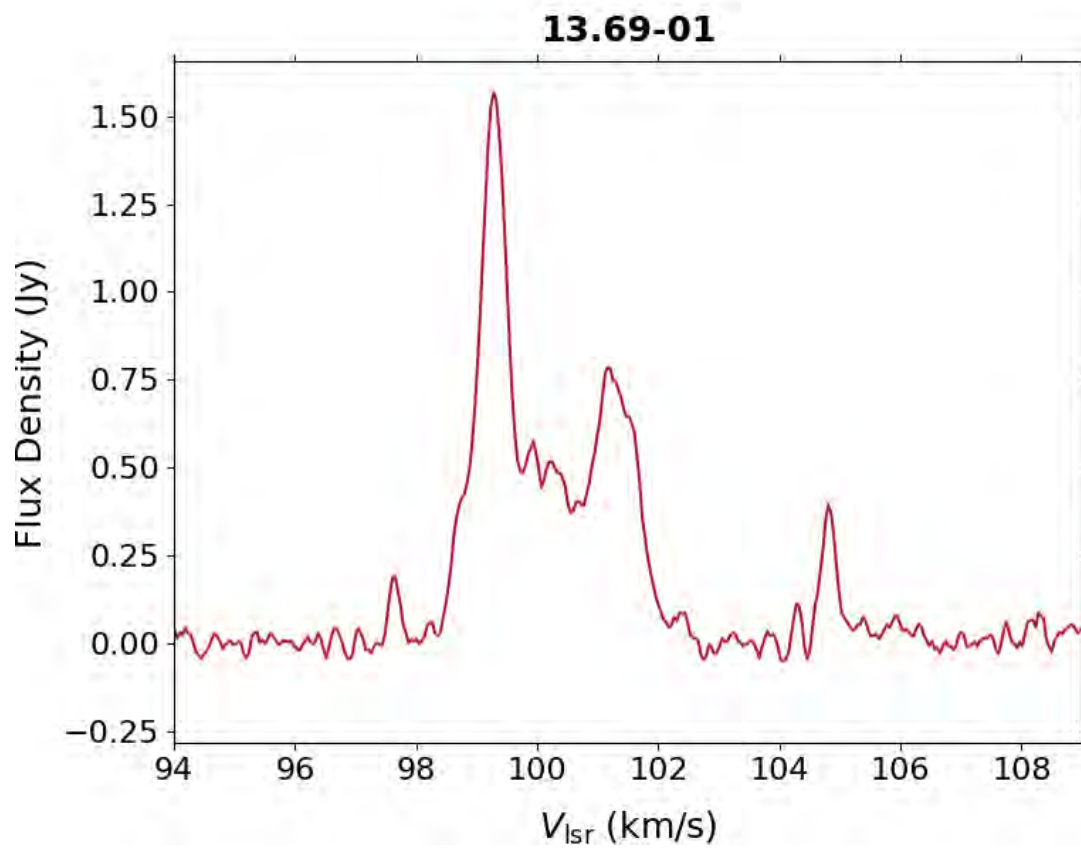


13.65-05

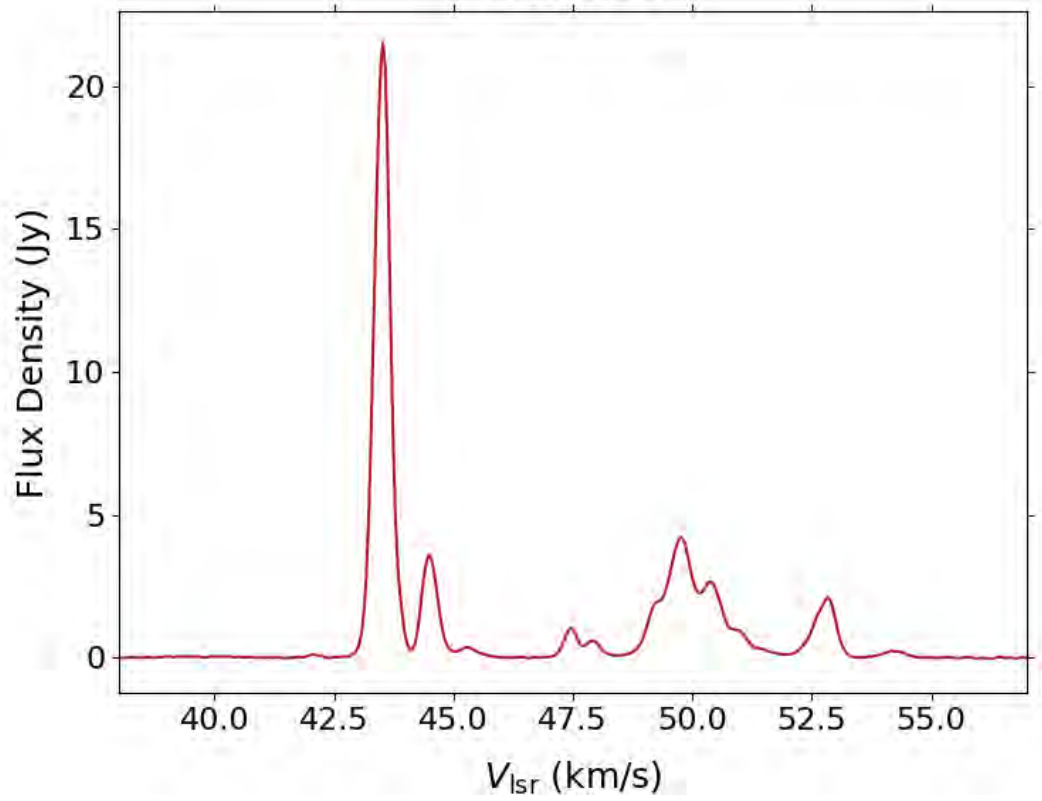


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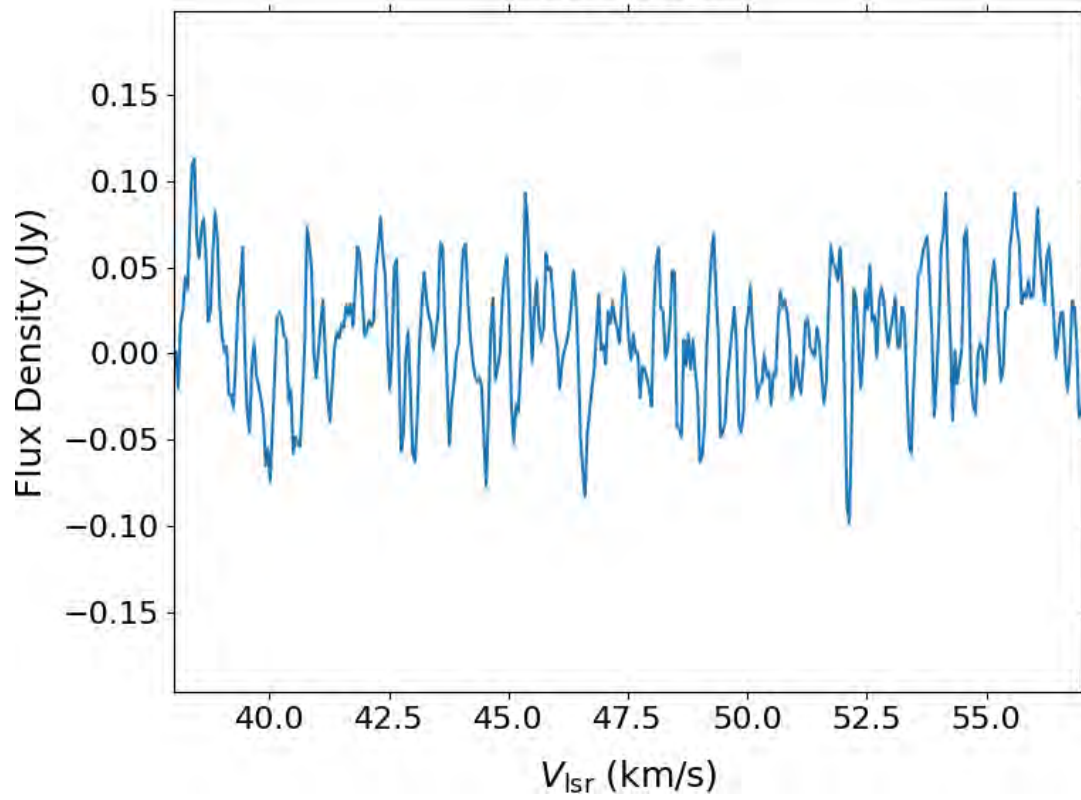


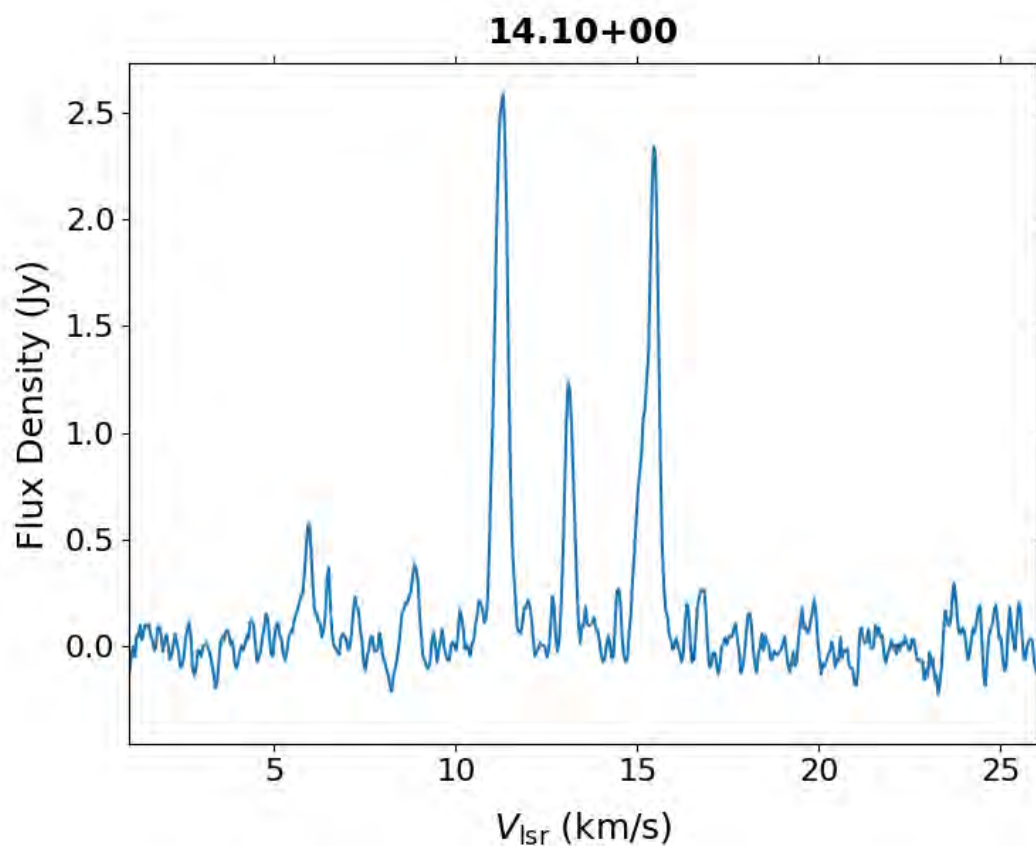
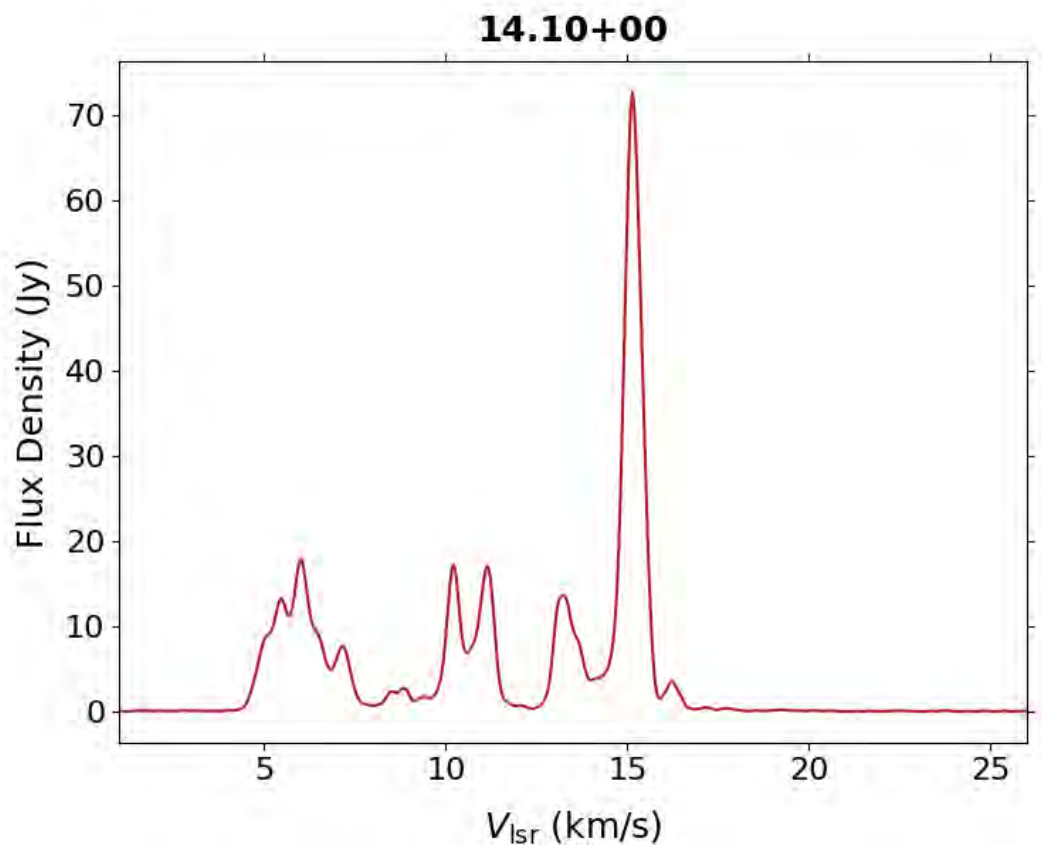


13.71-00

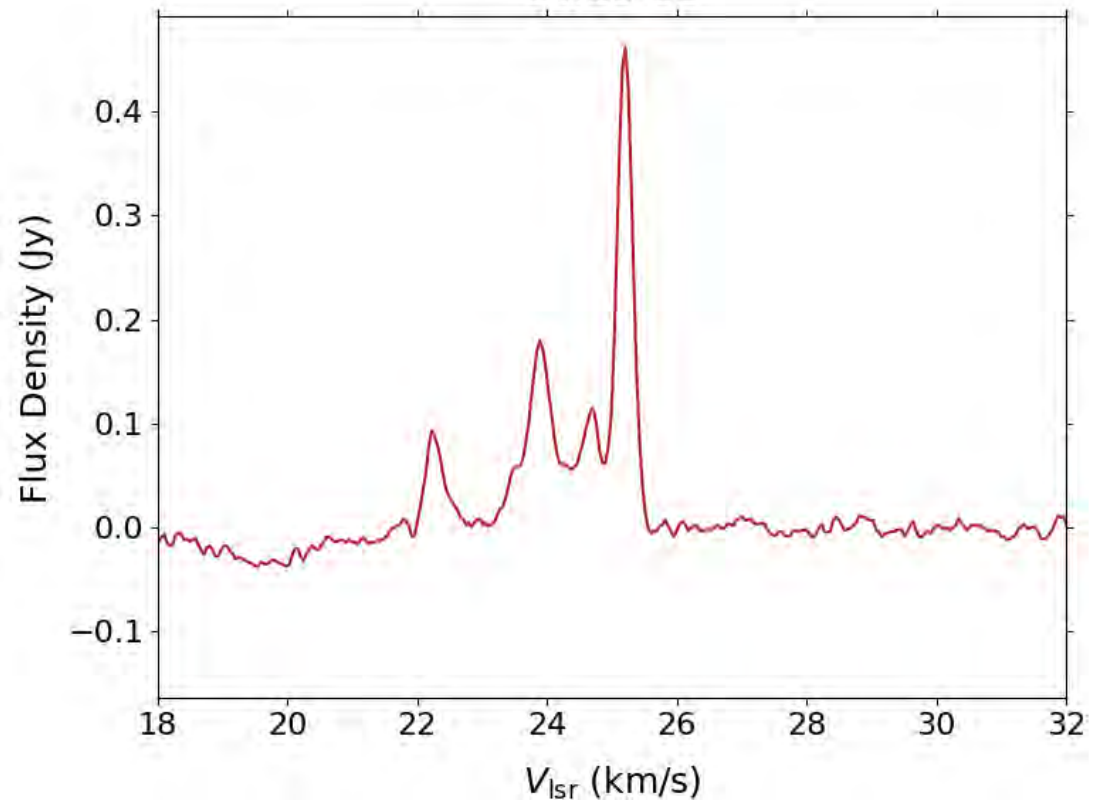


13.71-00

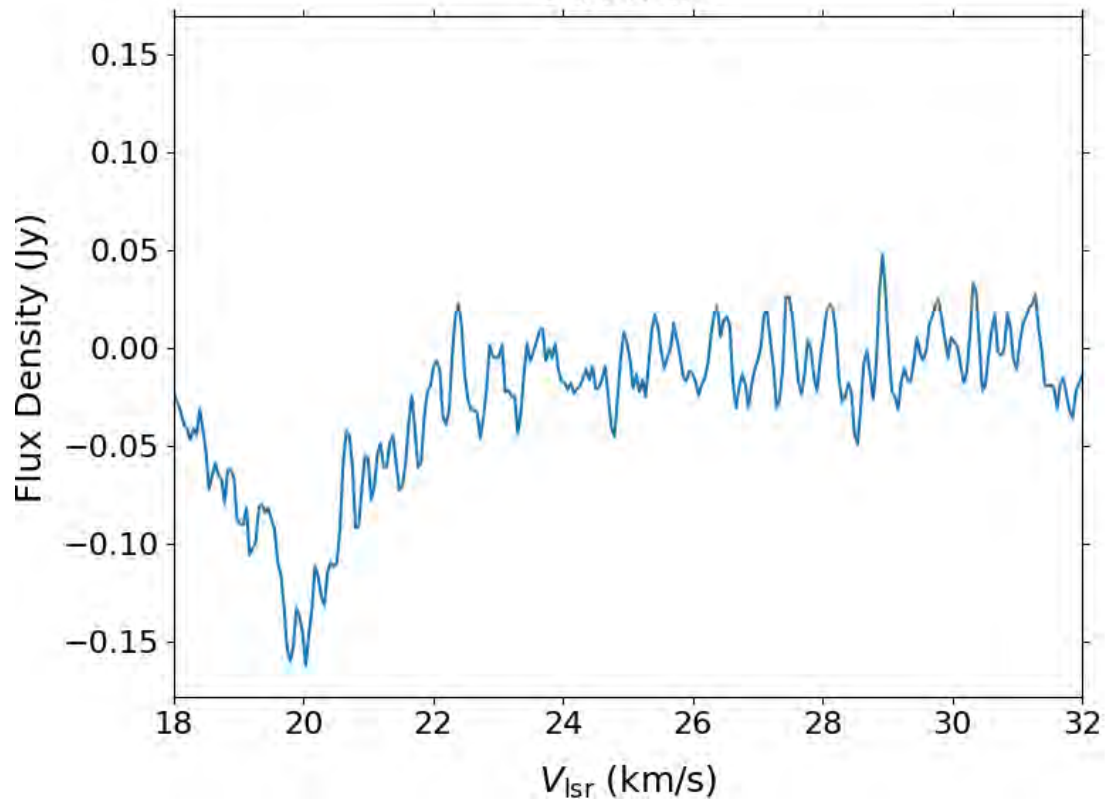




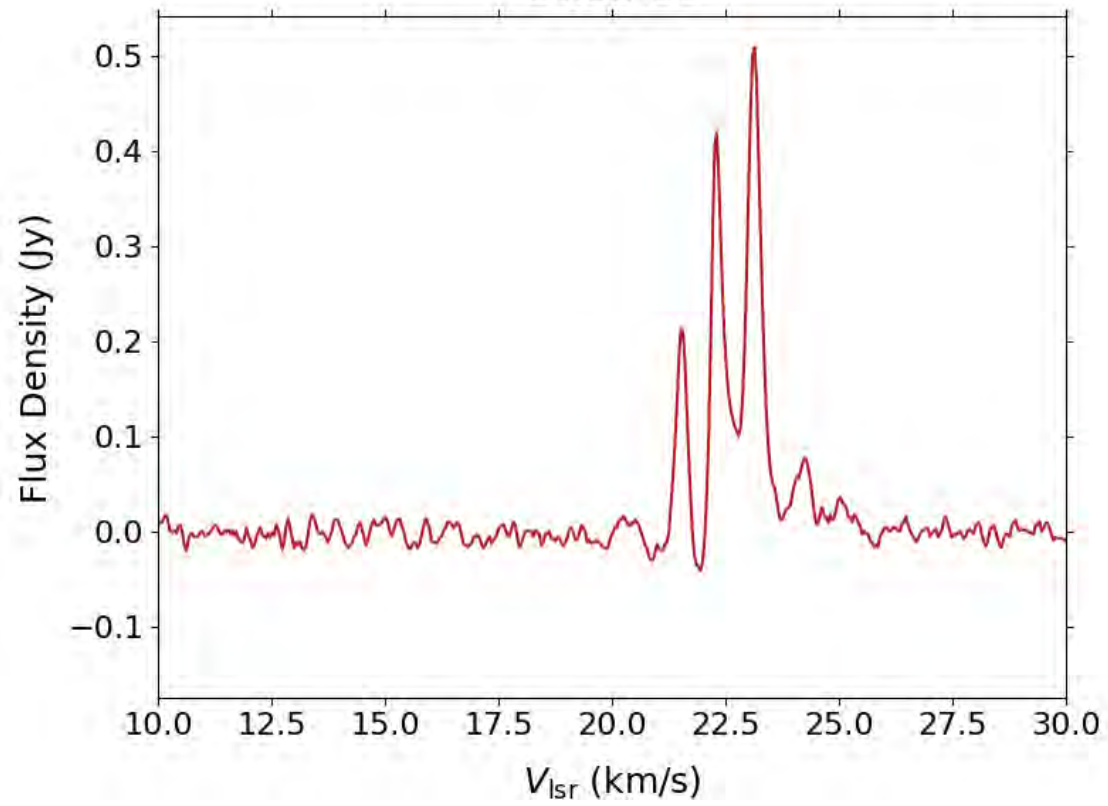
14.23-05



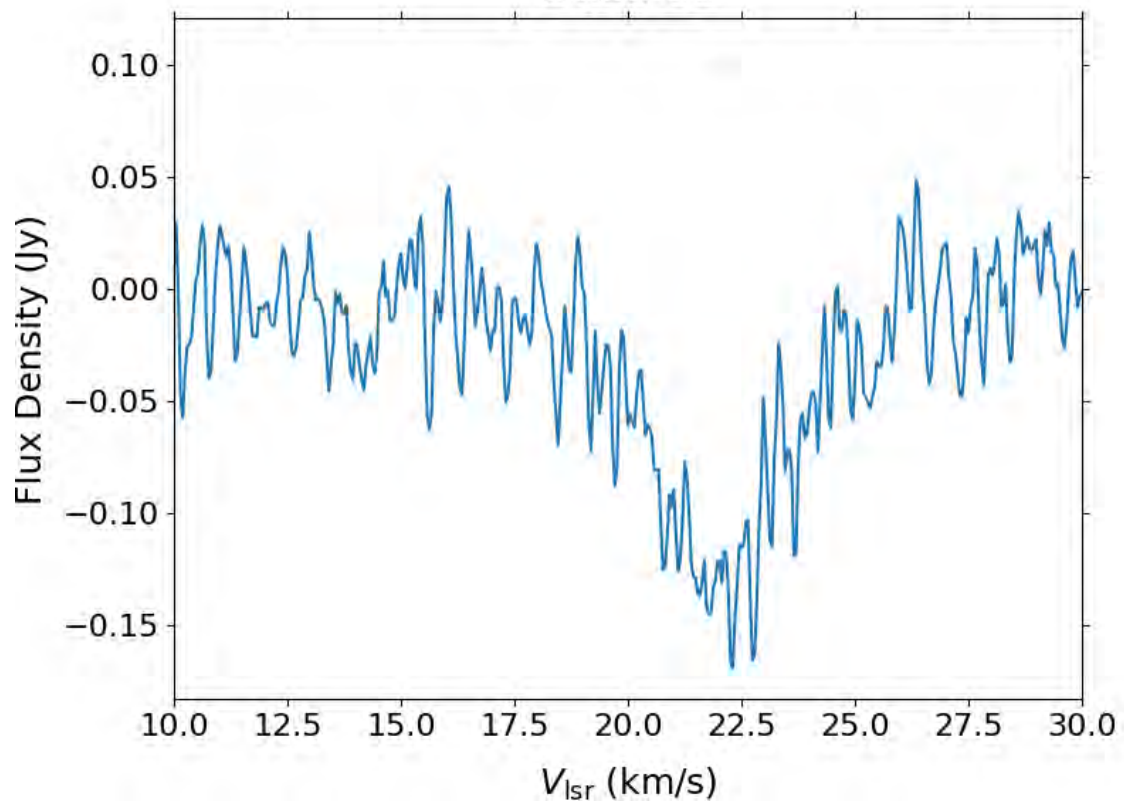
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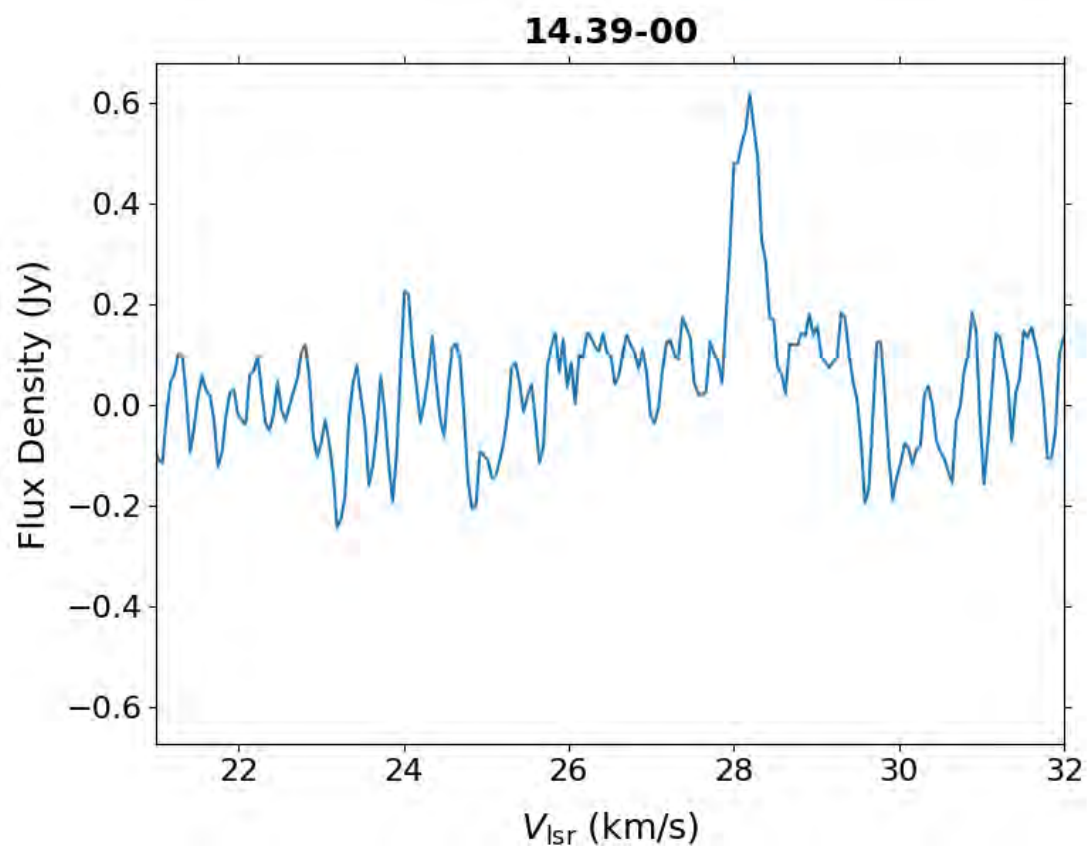
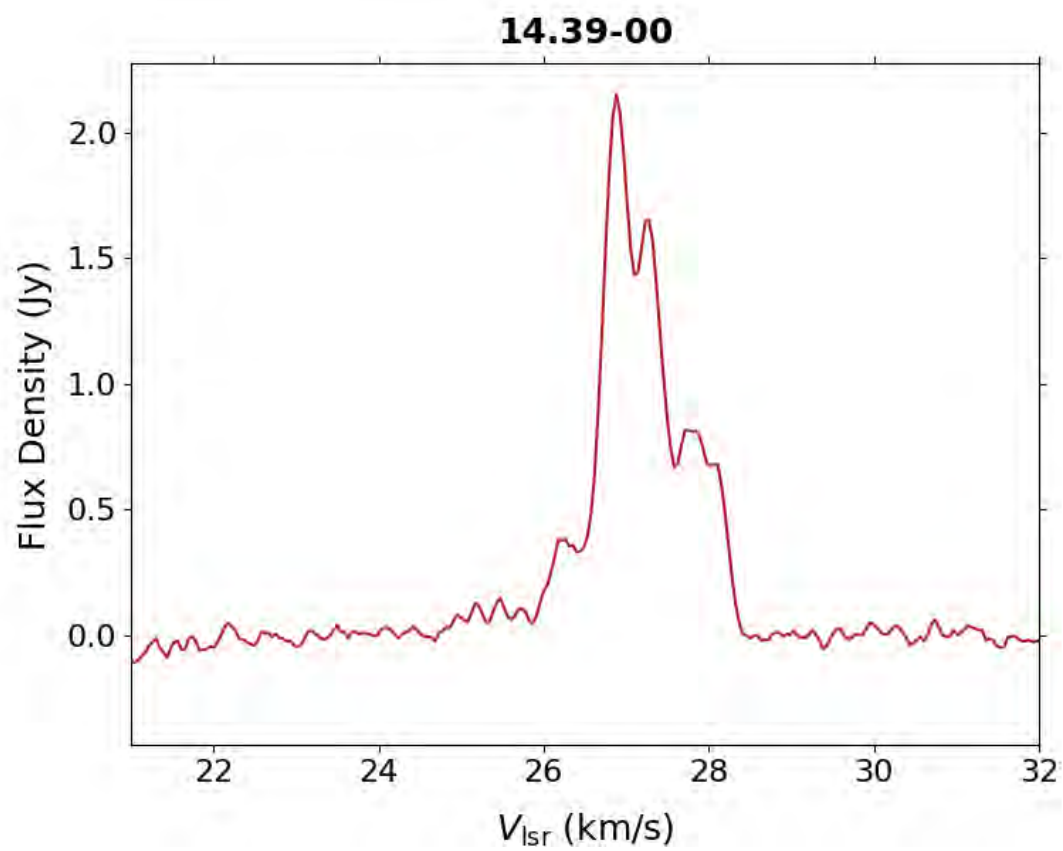


14.33-06

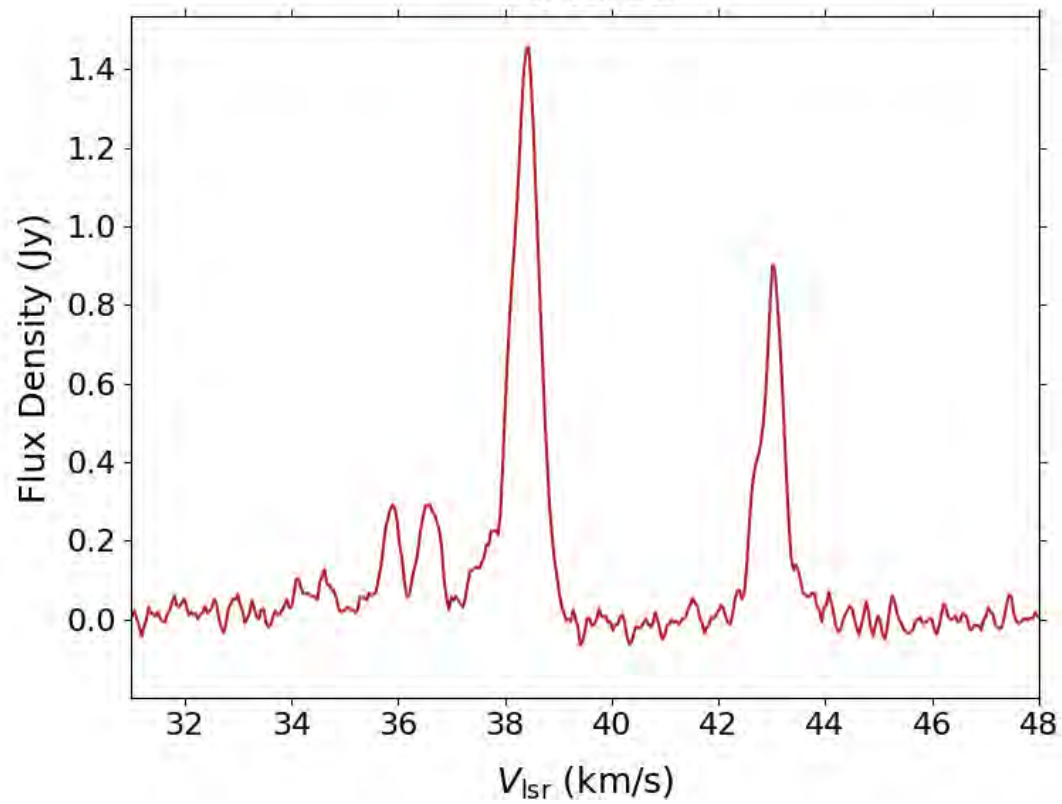


14.33-06

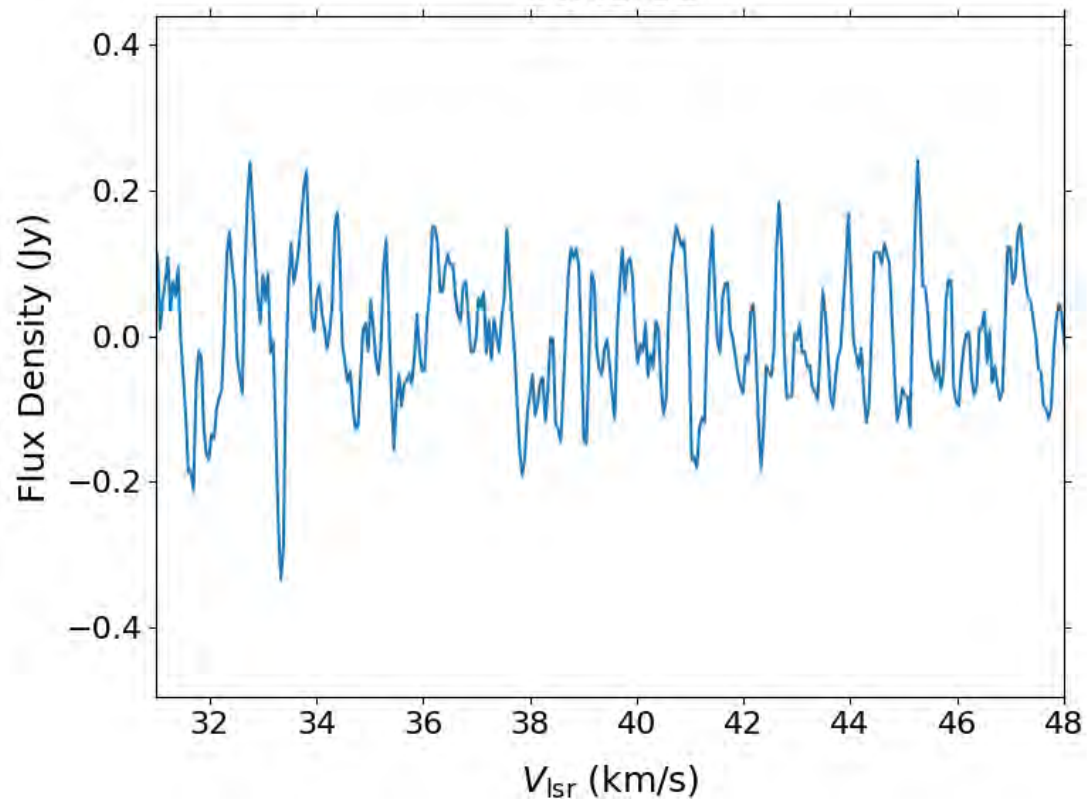


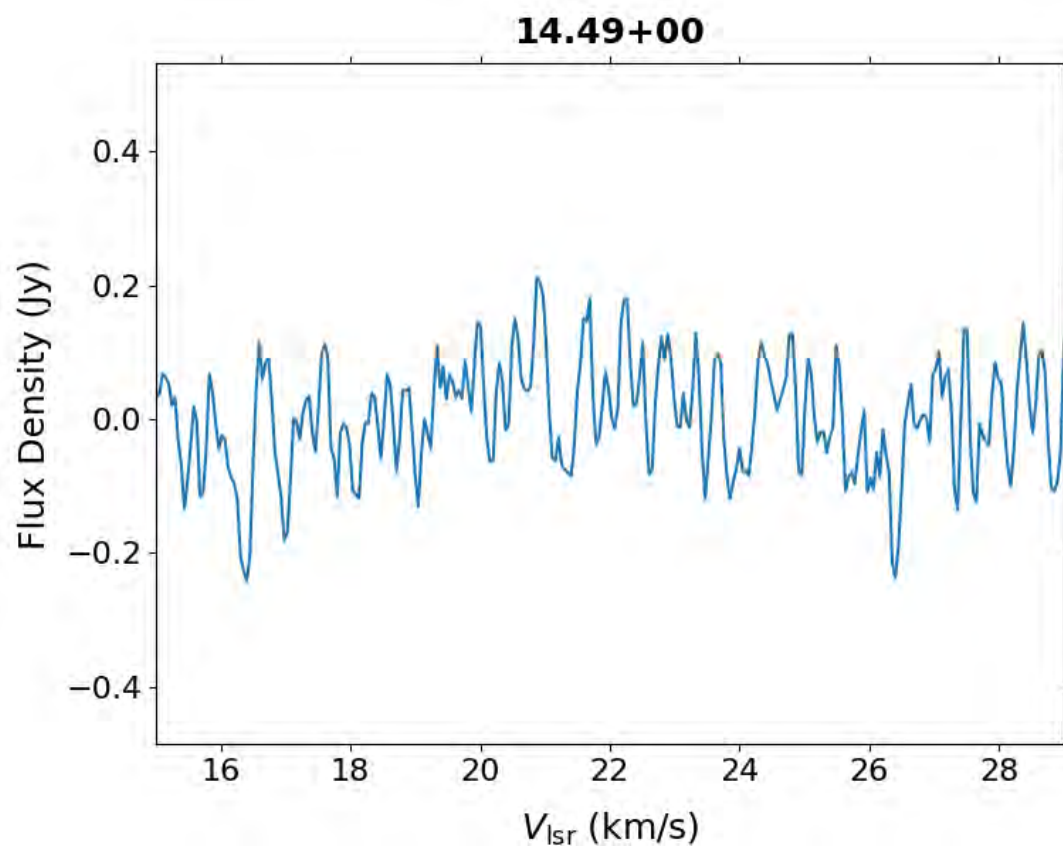
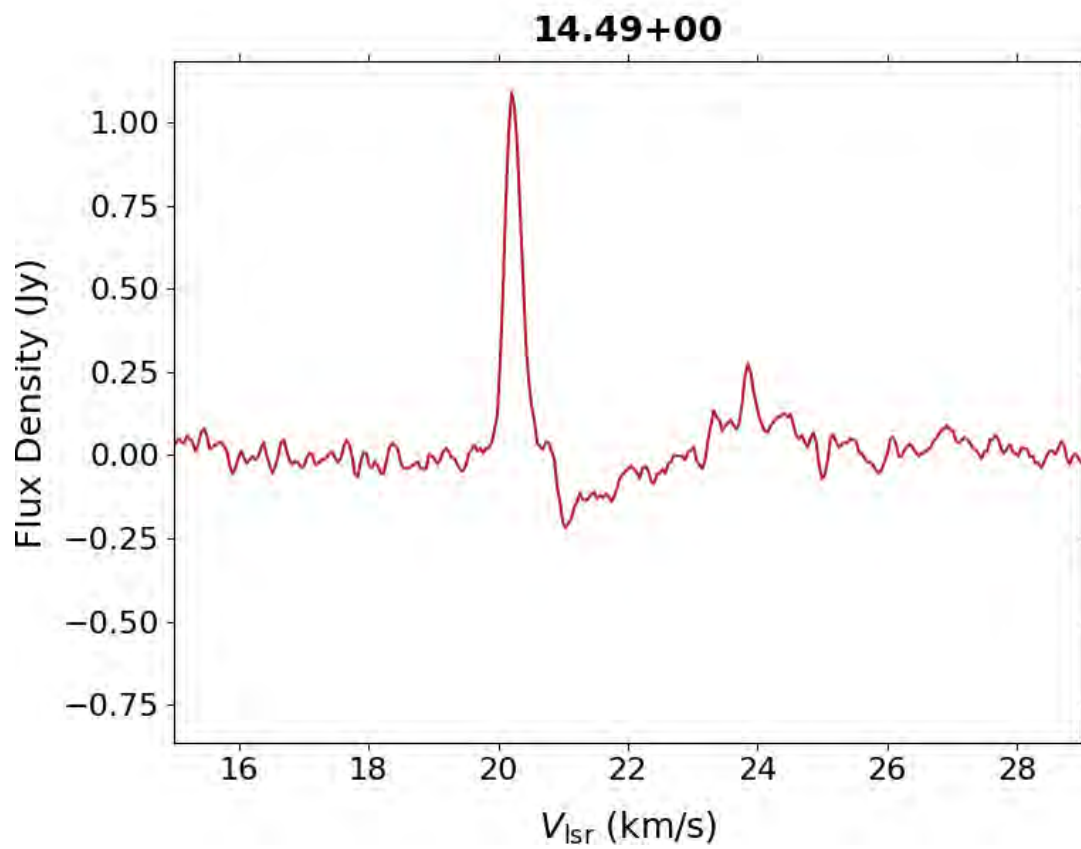


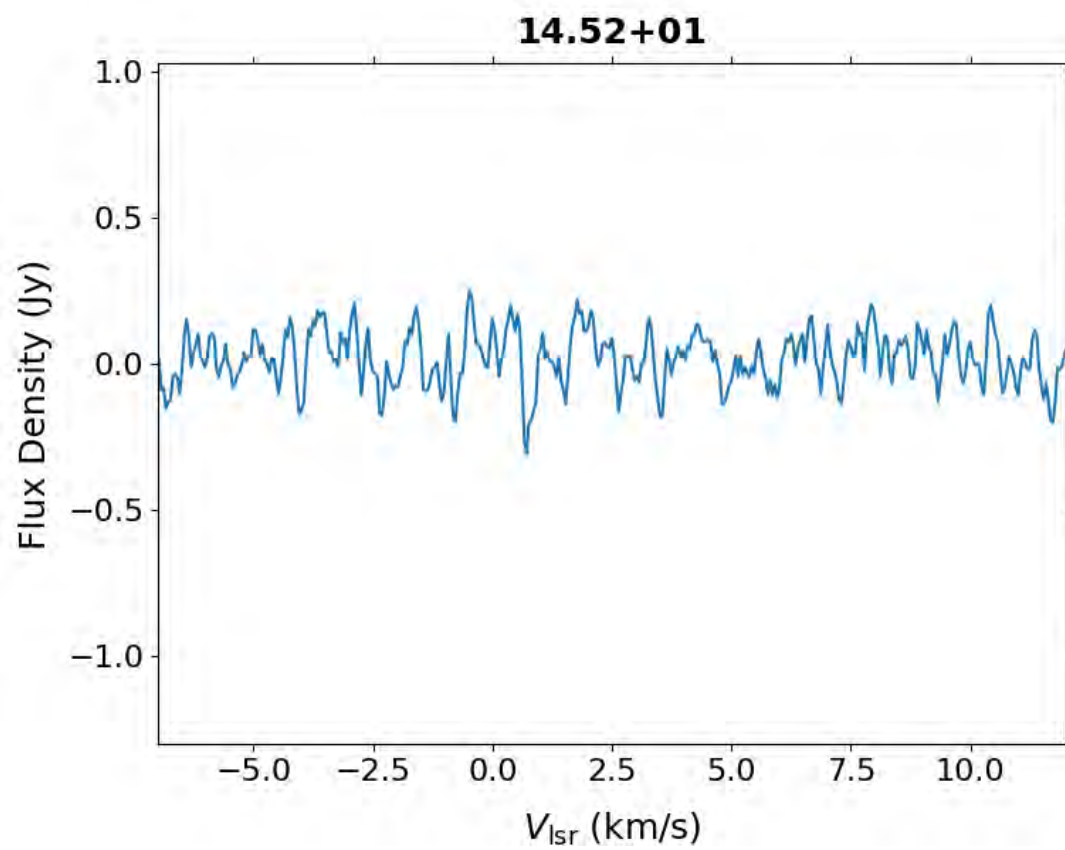
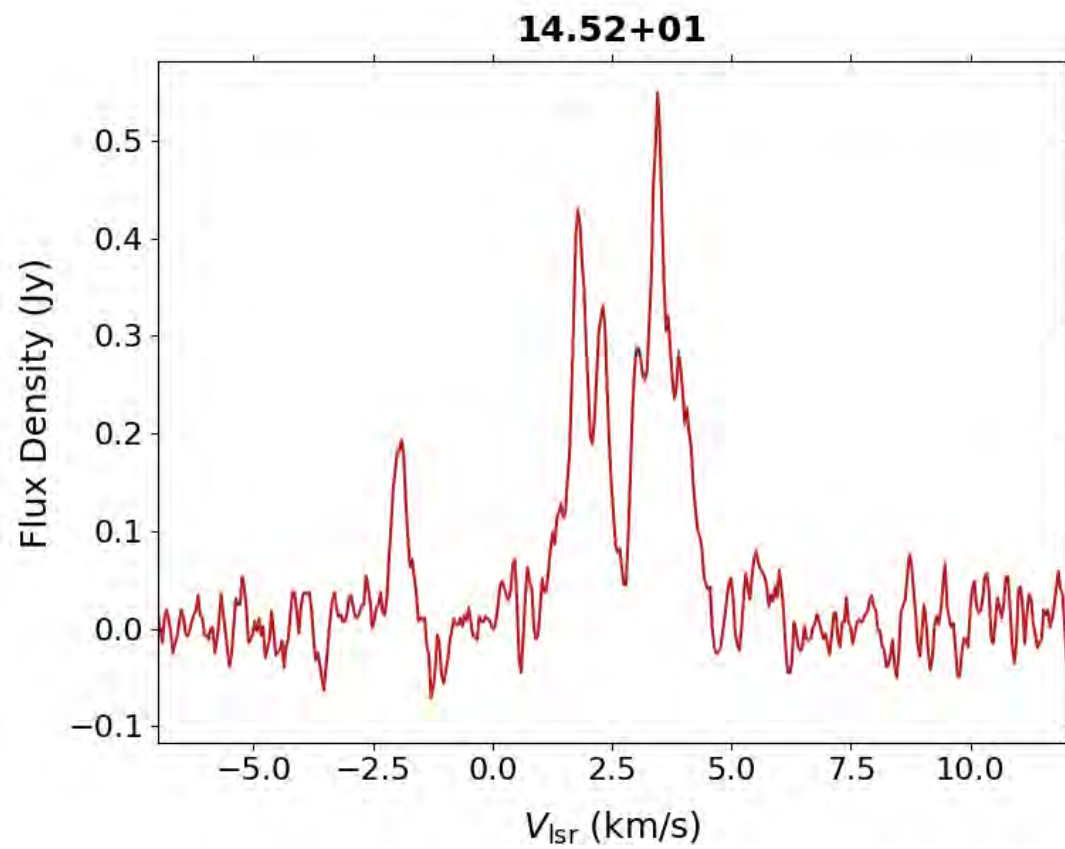
14.45-01

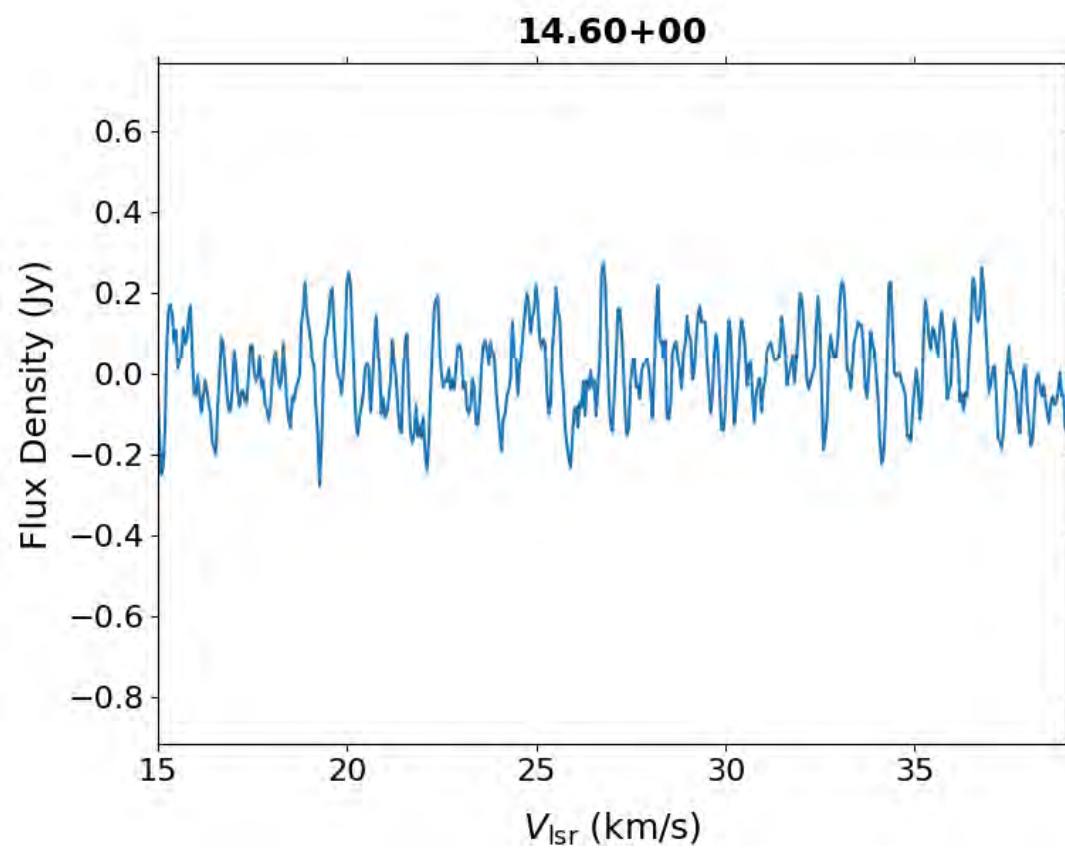
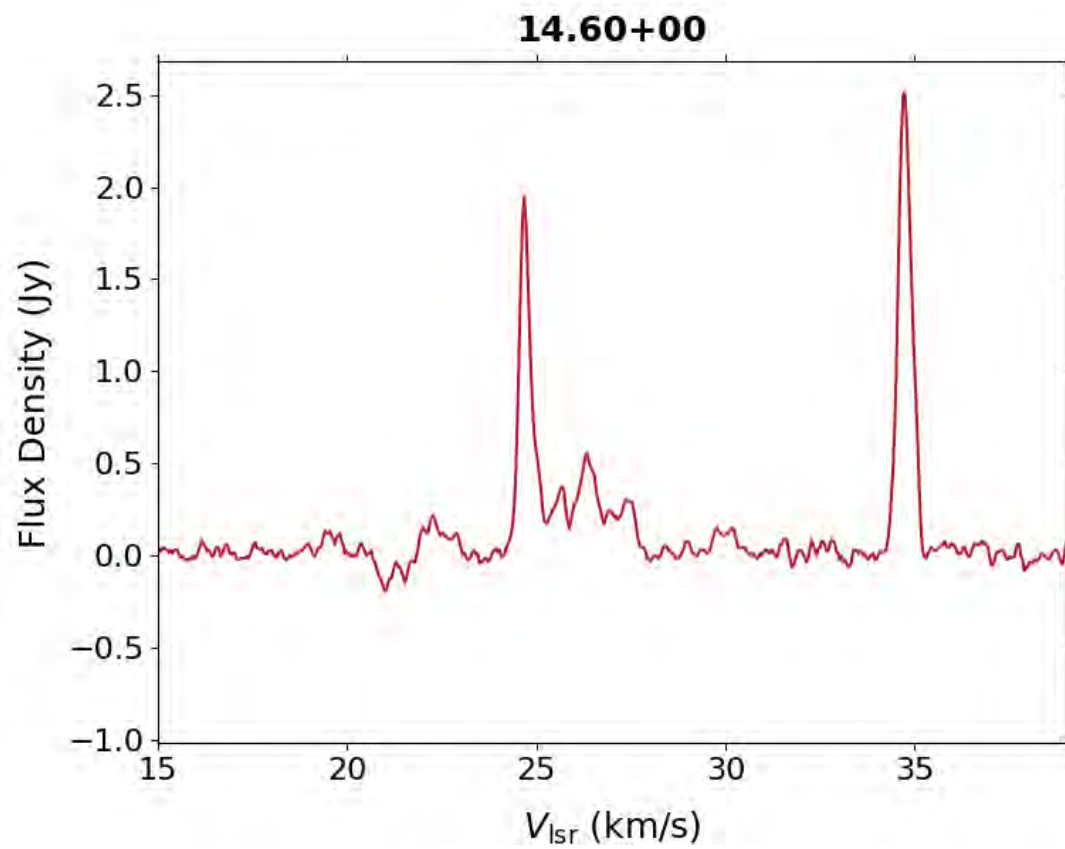


14.45-01

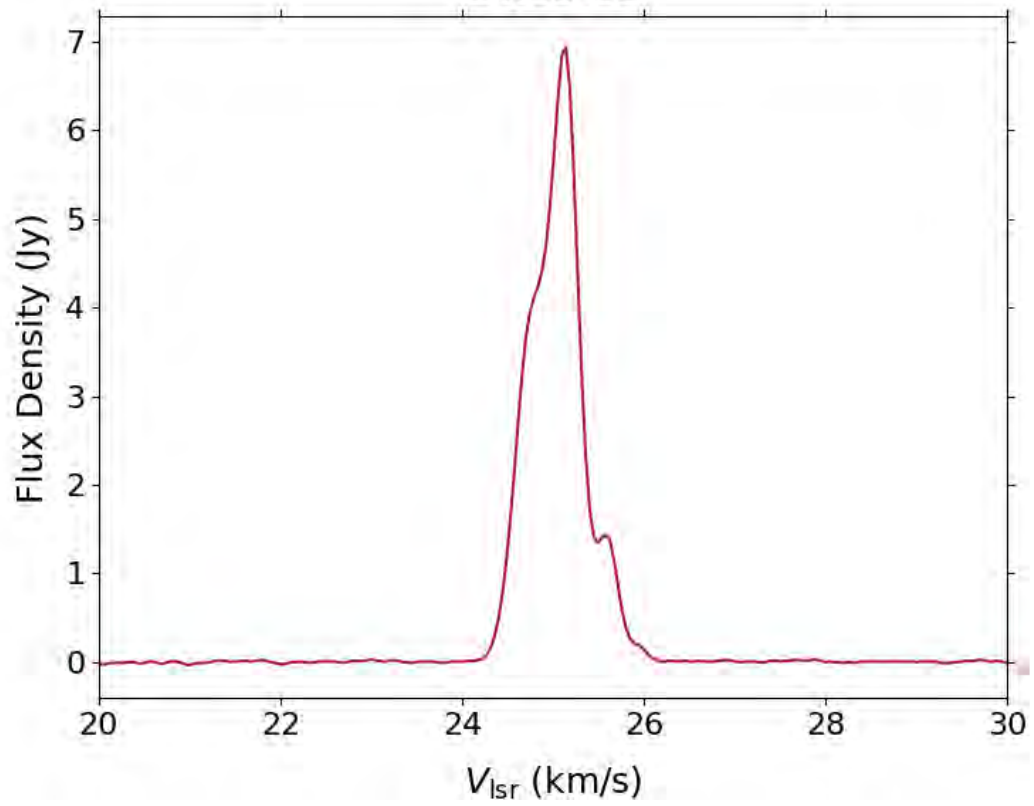




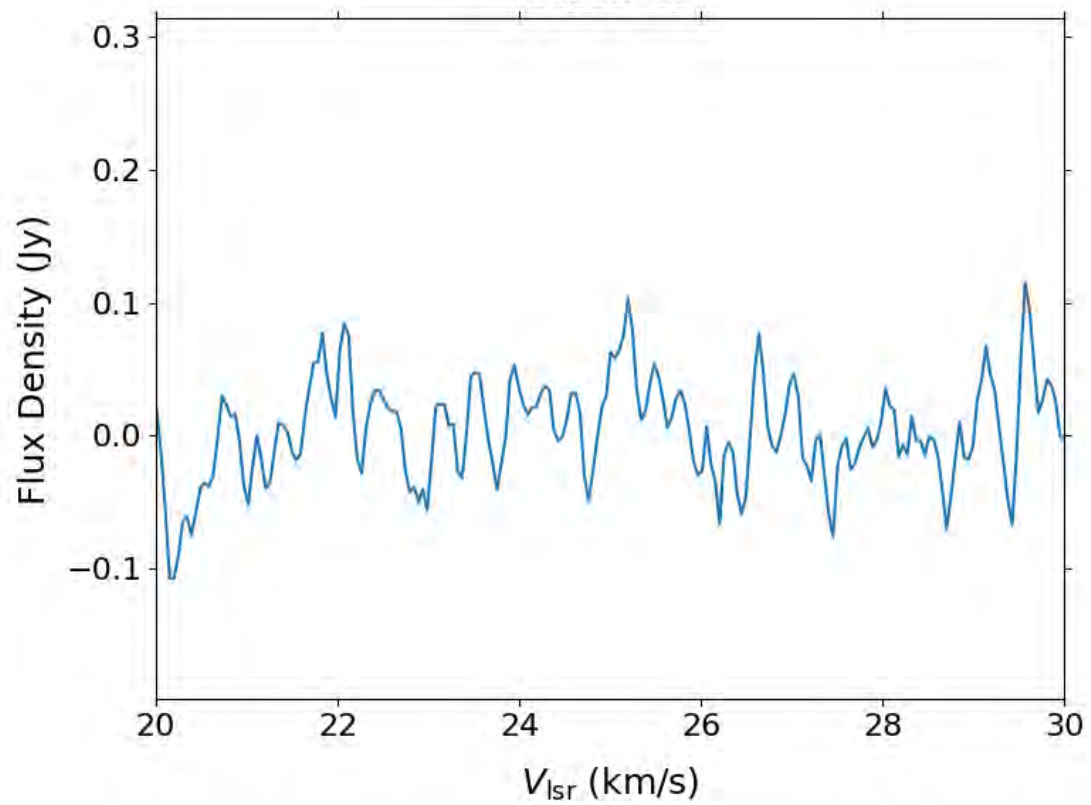




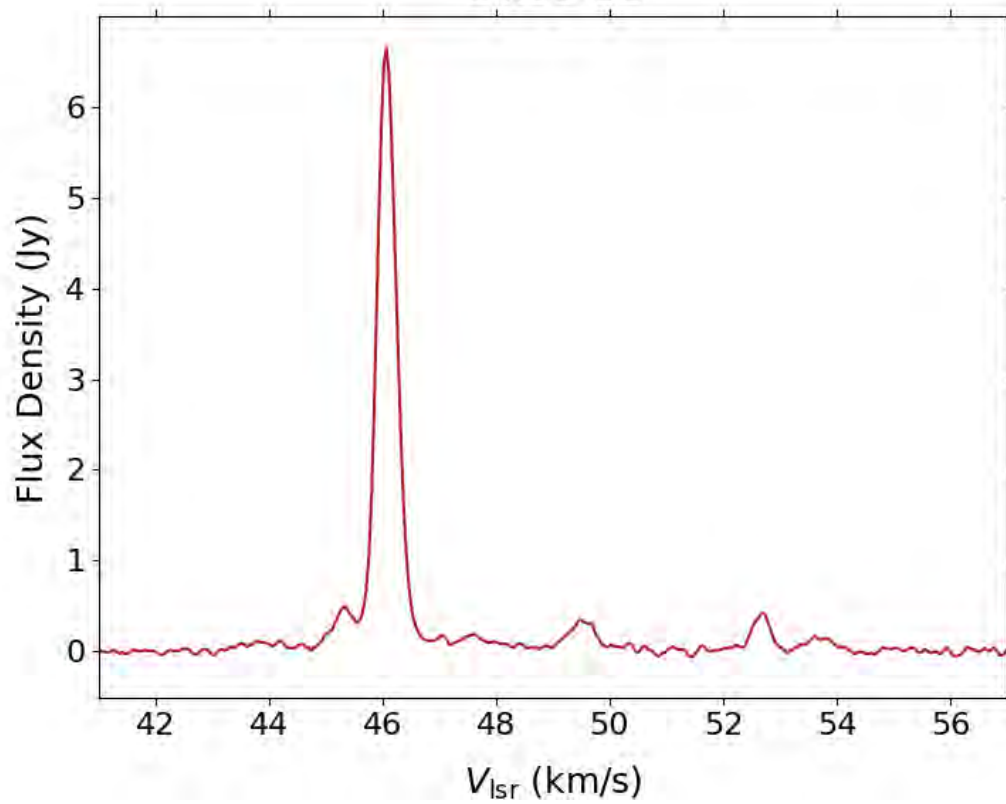
14.63-05



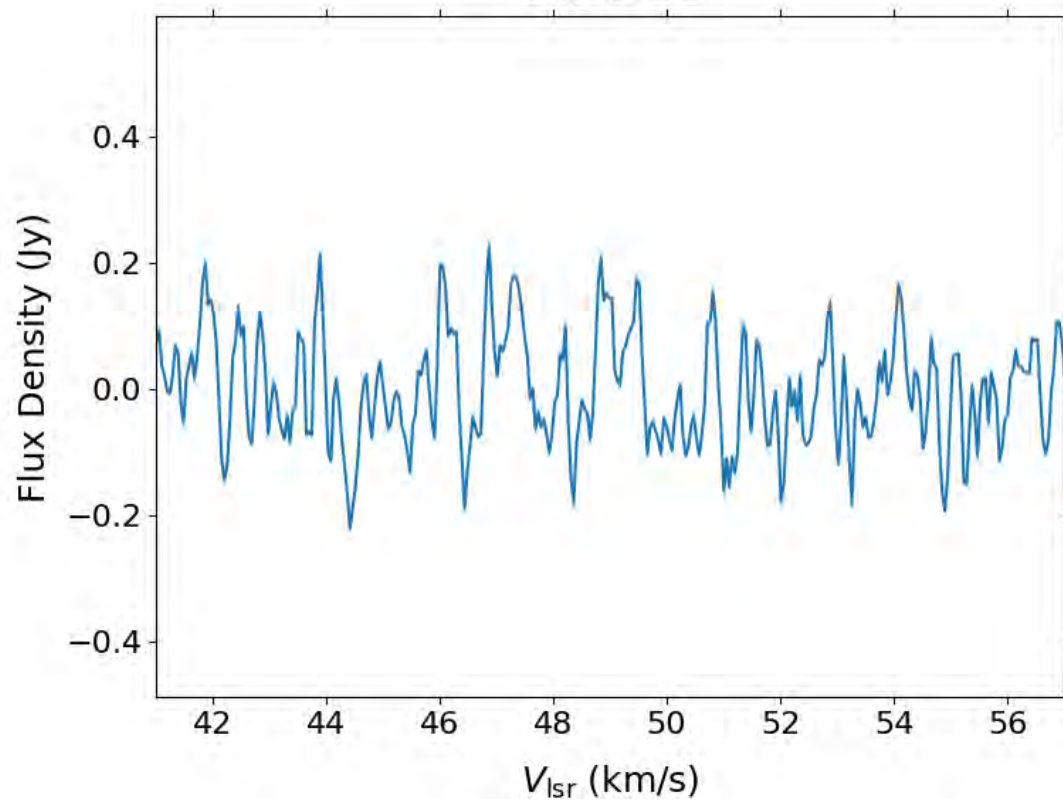
14.63-05



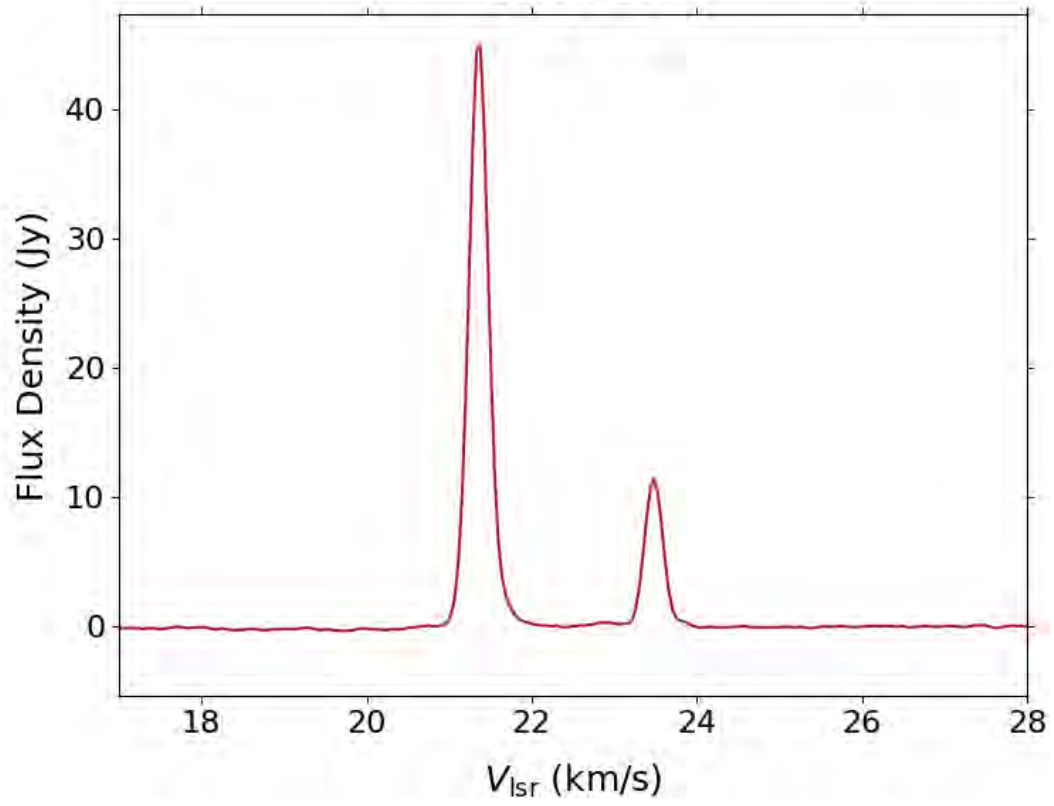
14.99-01



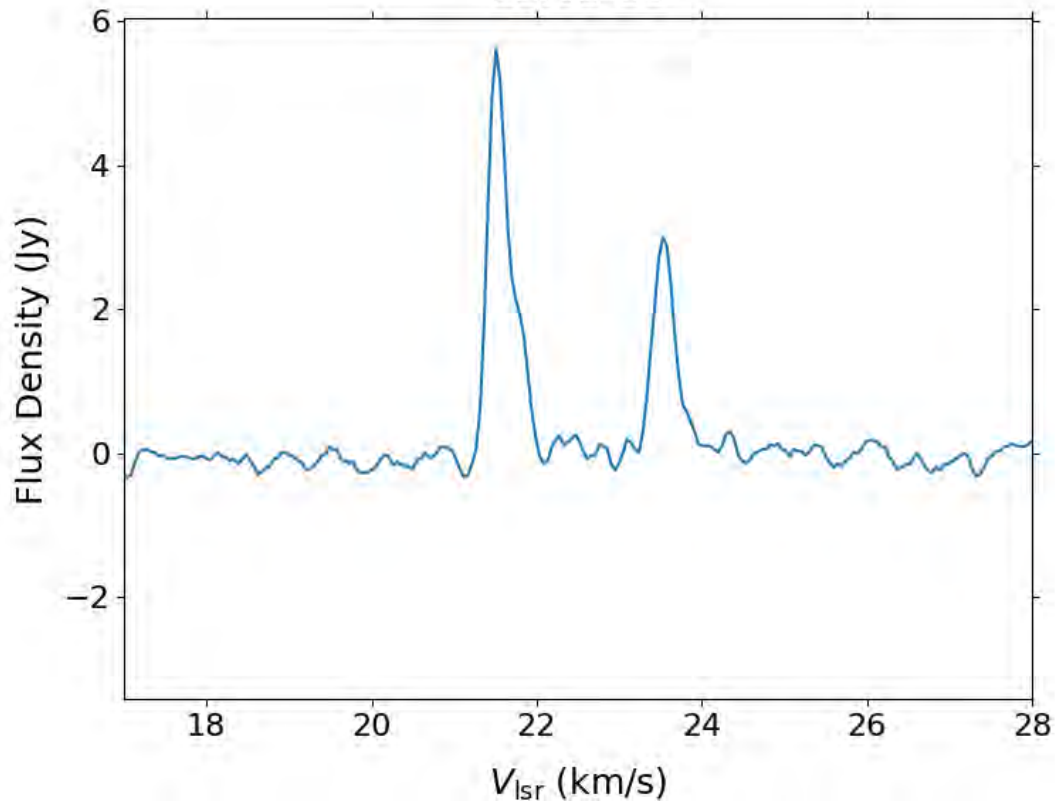
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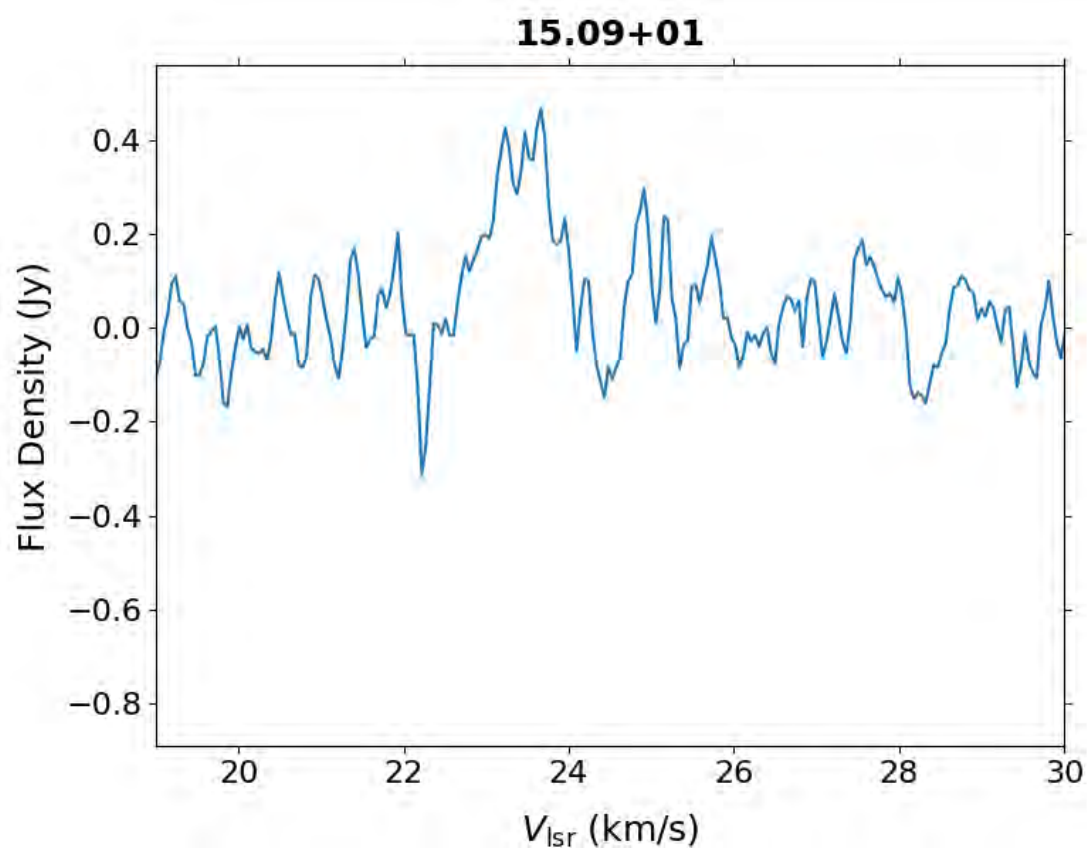
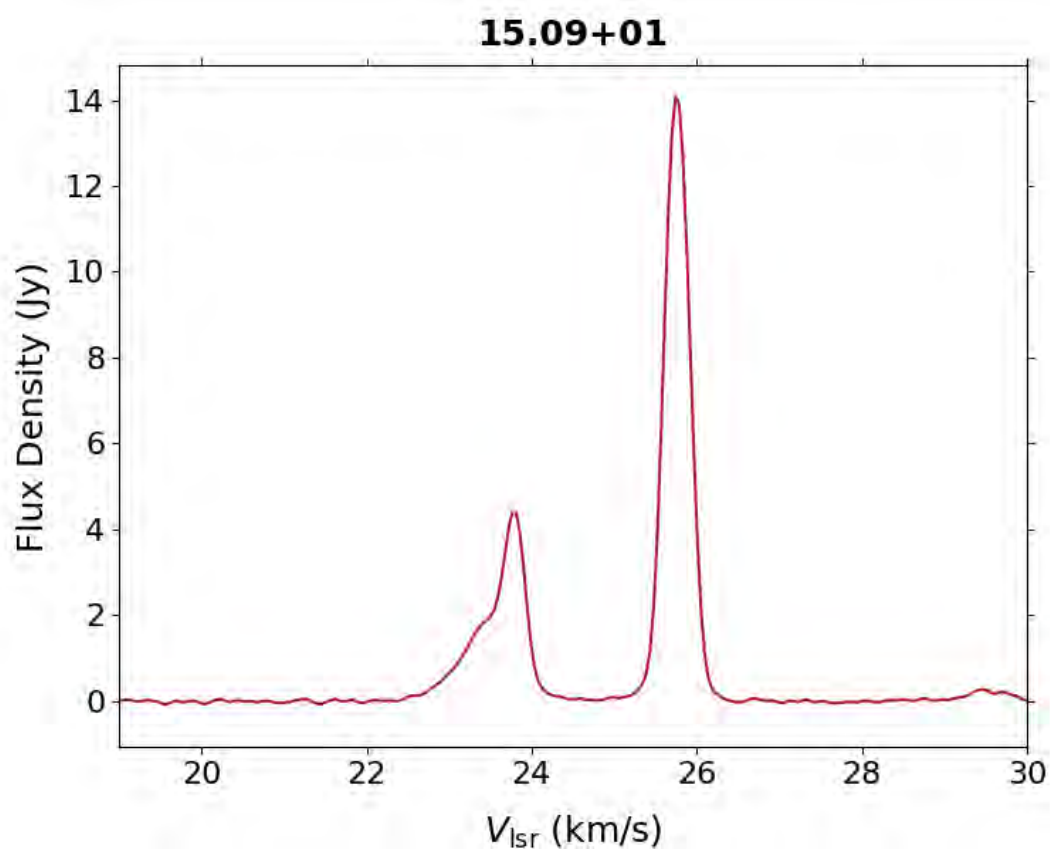


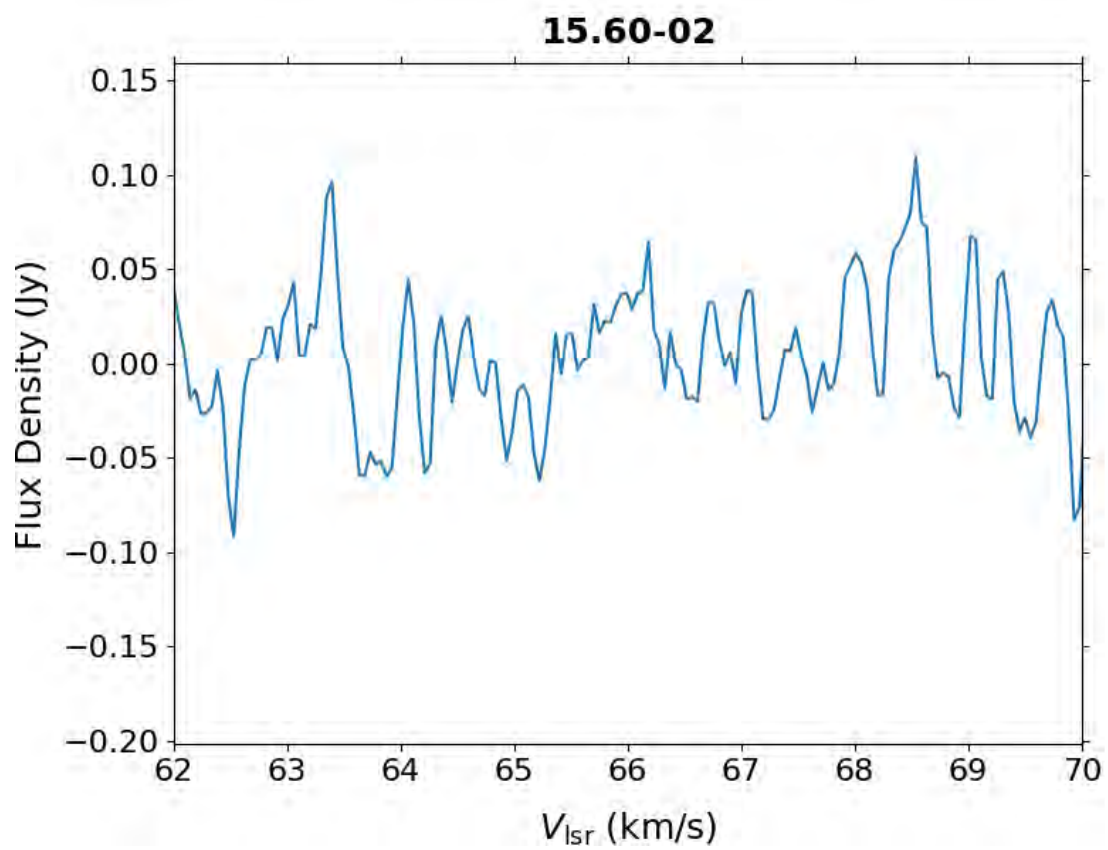
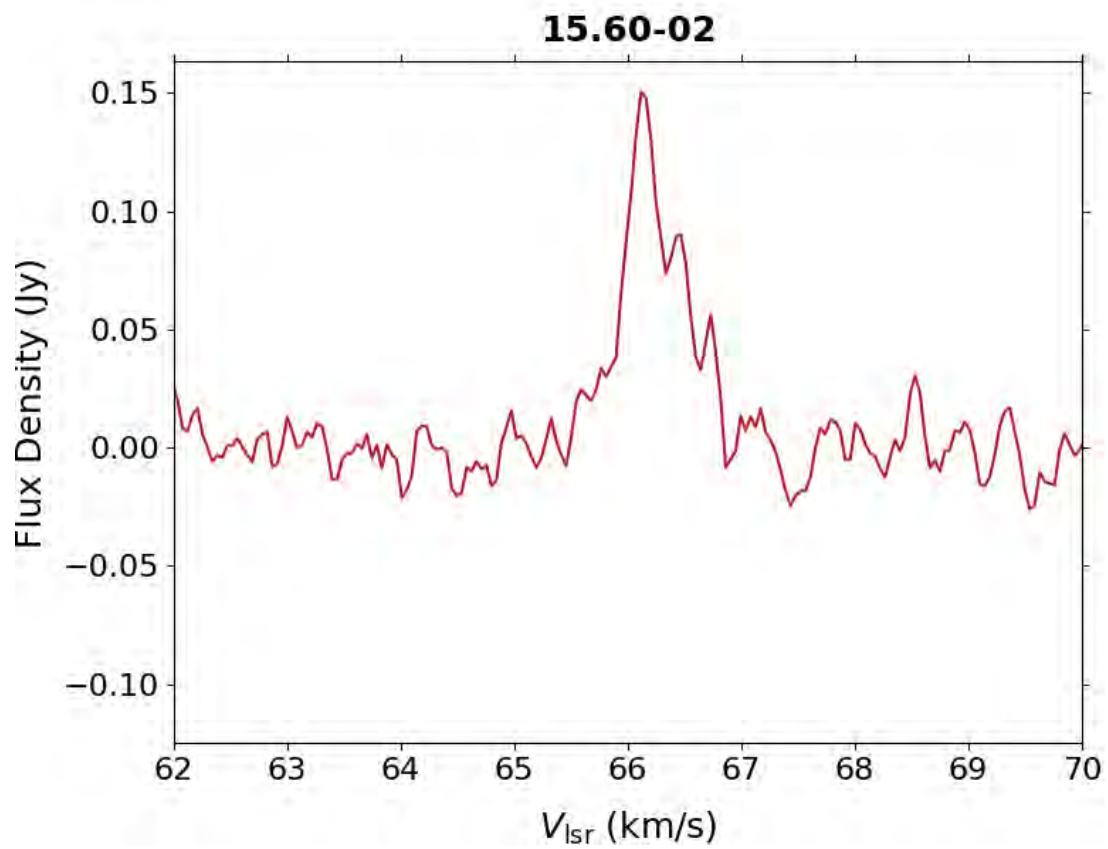
15.03-06



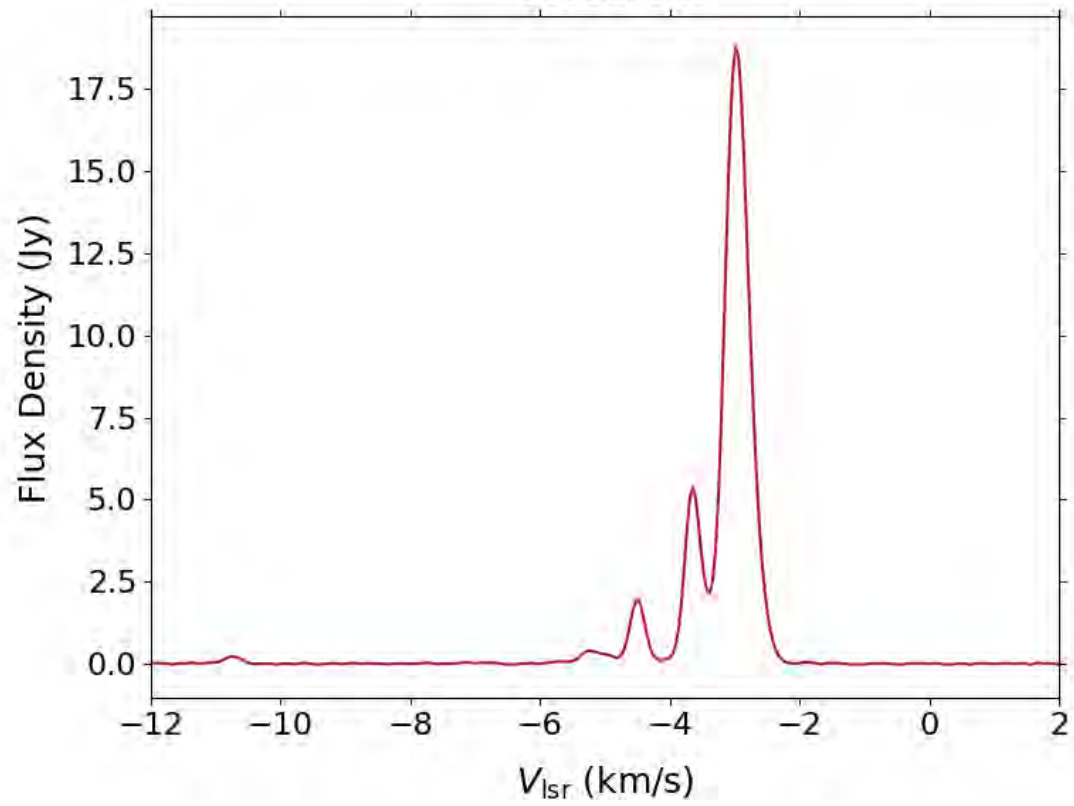
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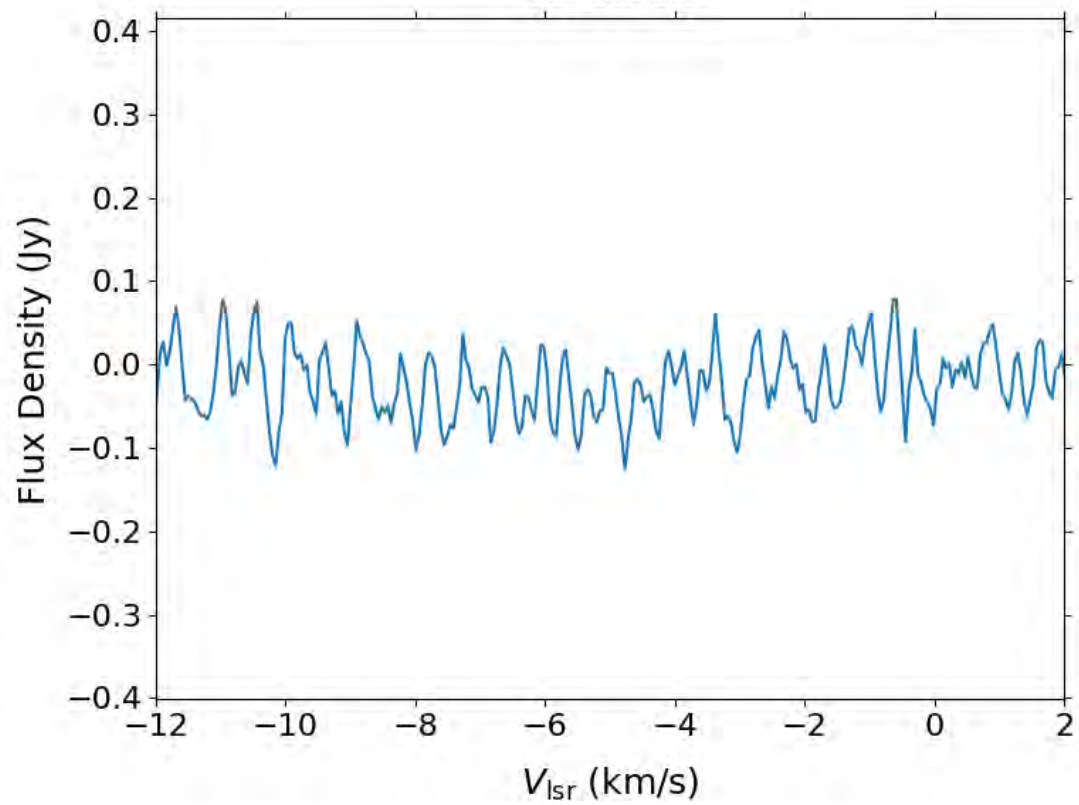


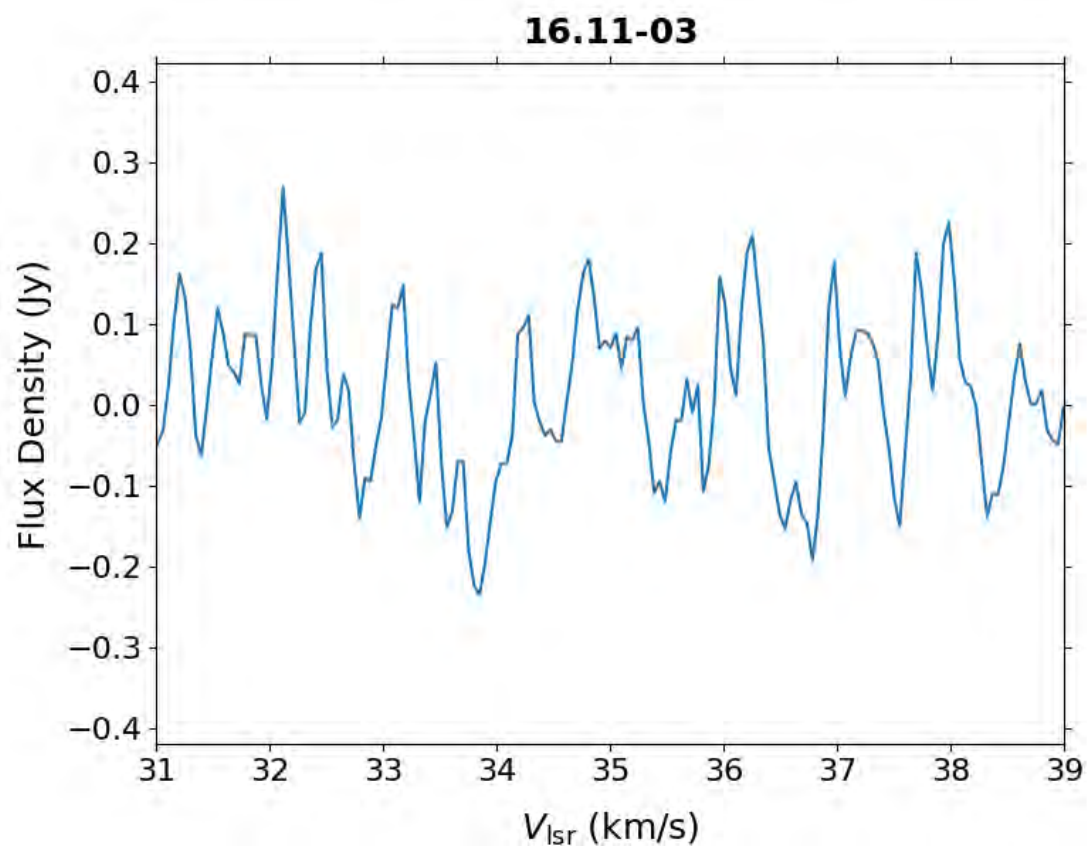
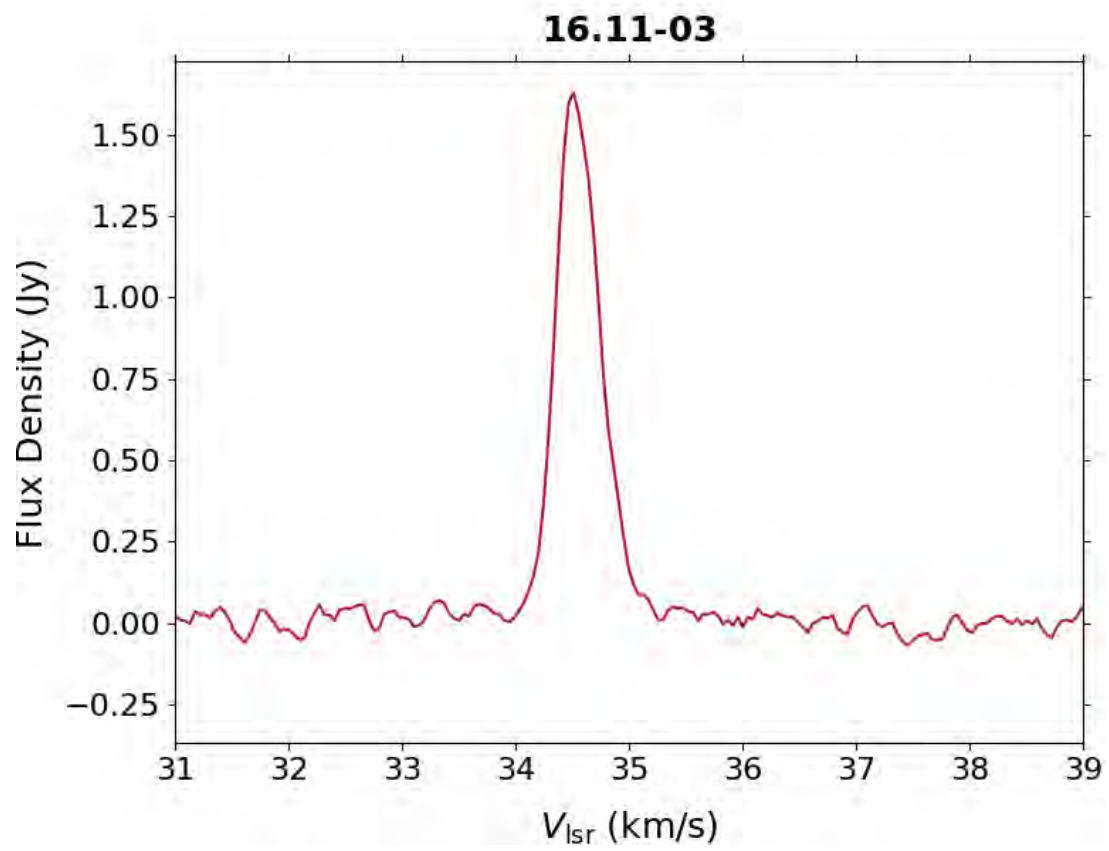


15.66-04

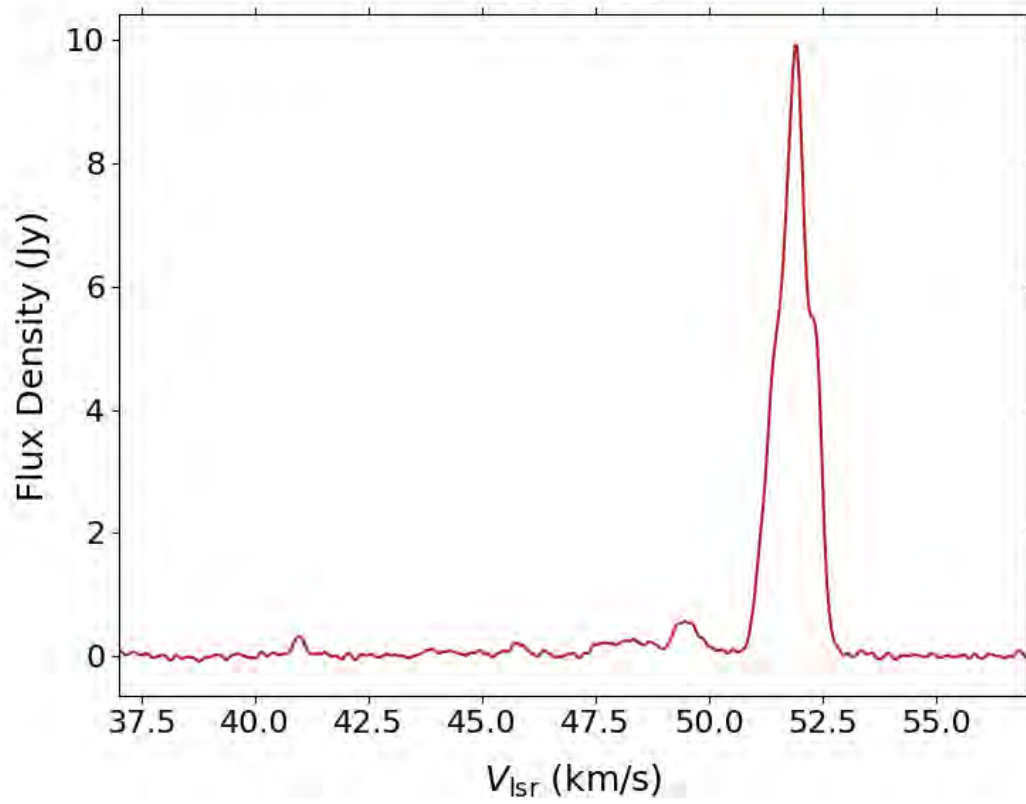


15.66-04

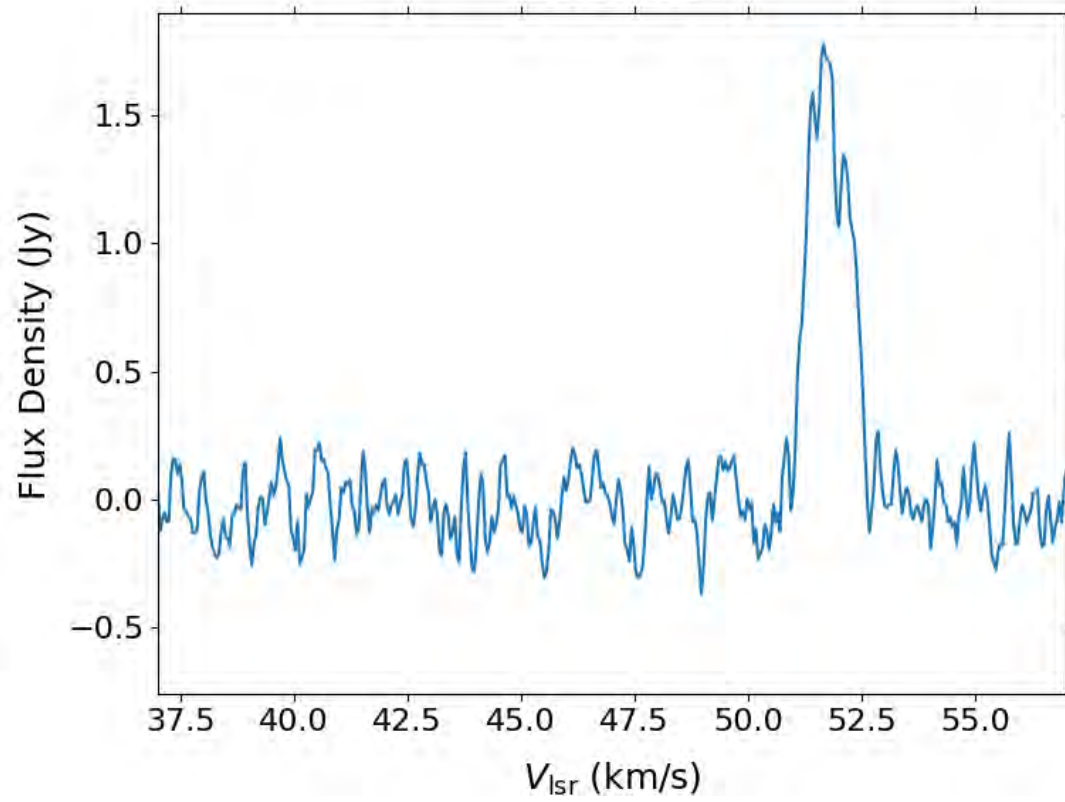


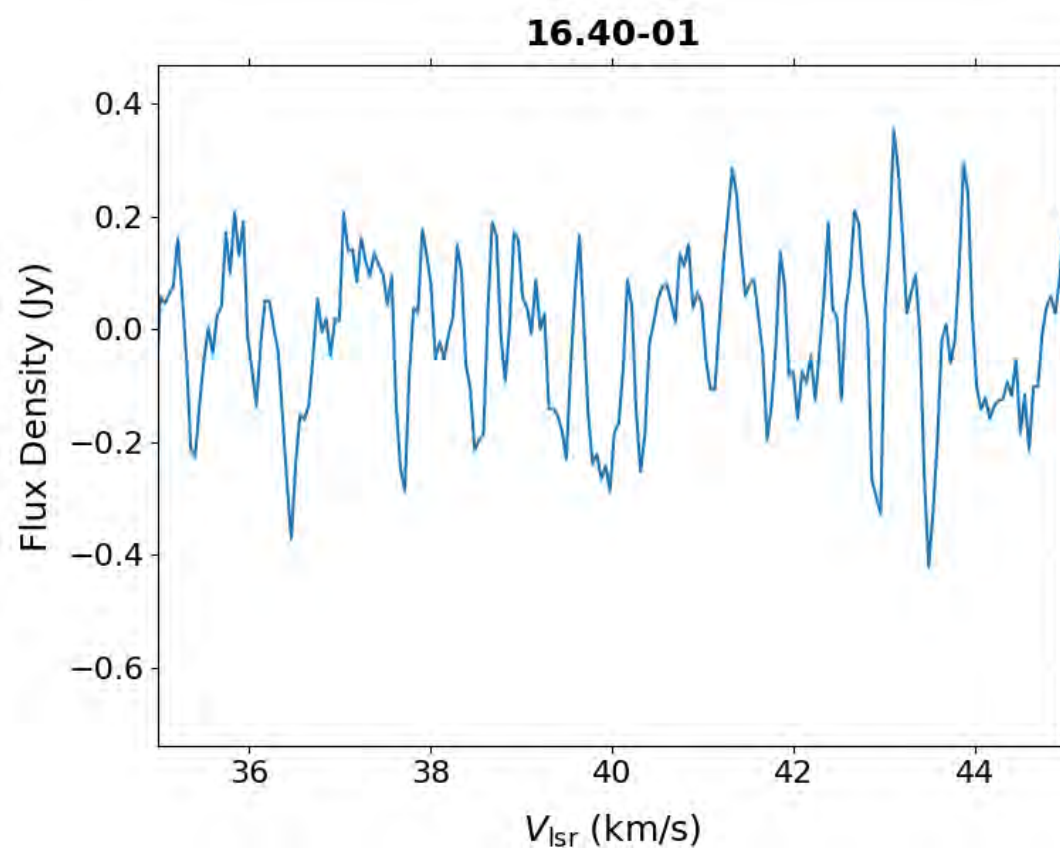
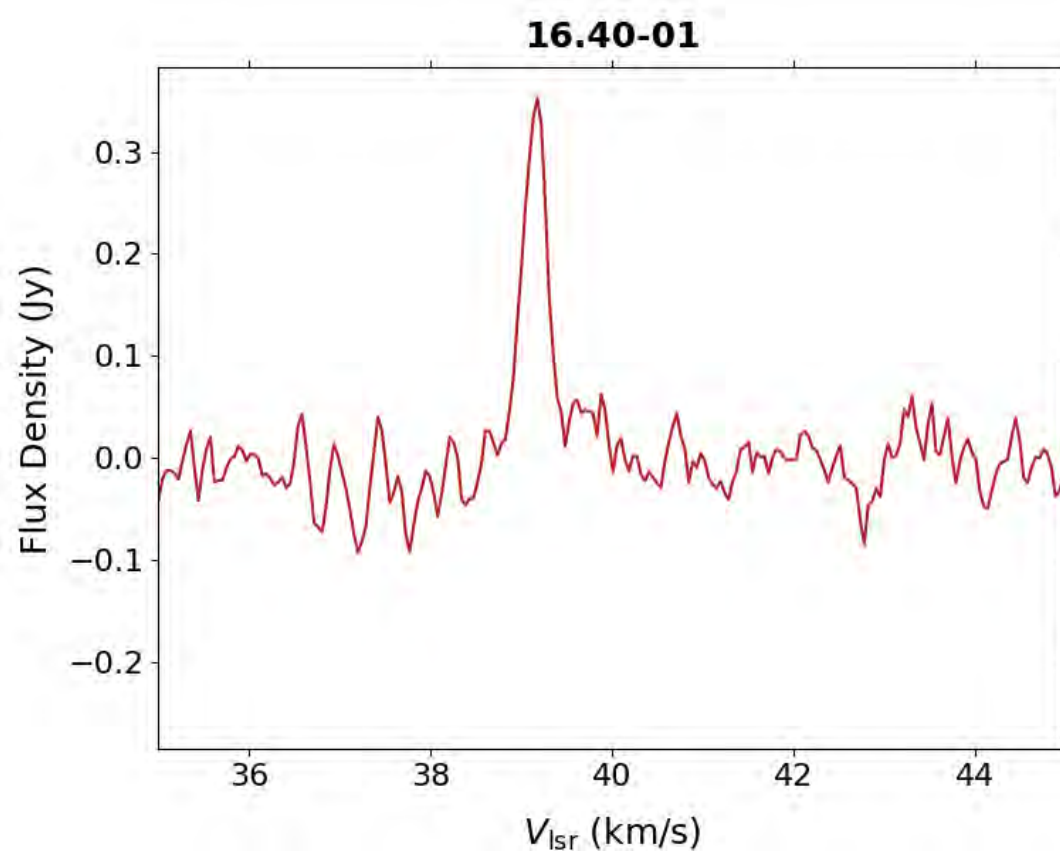


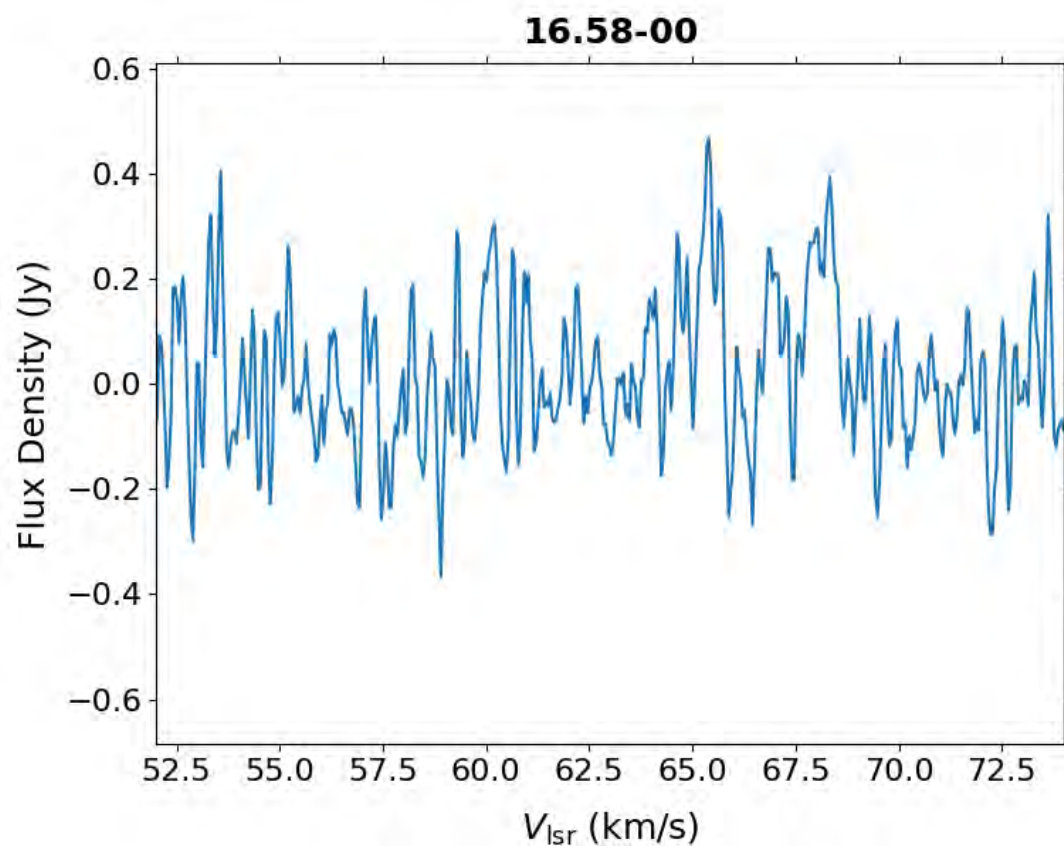
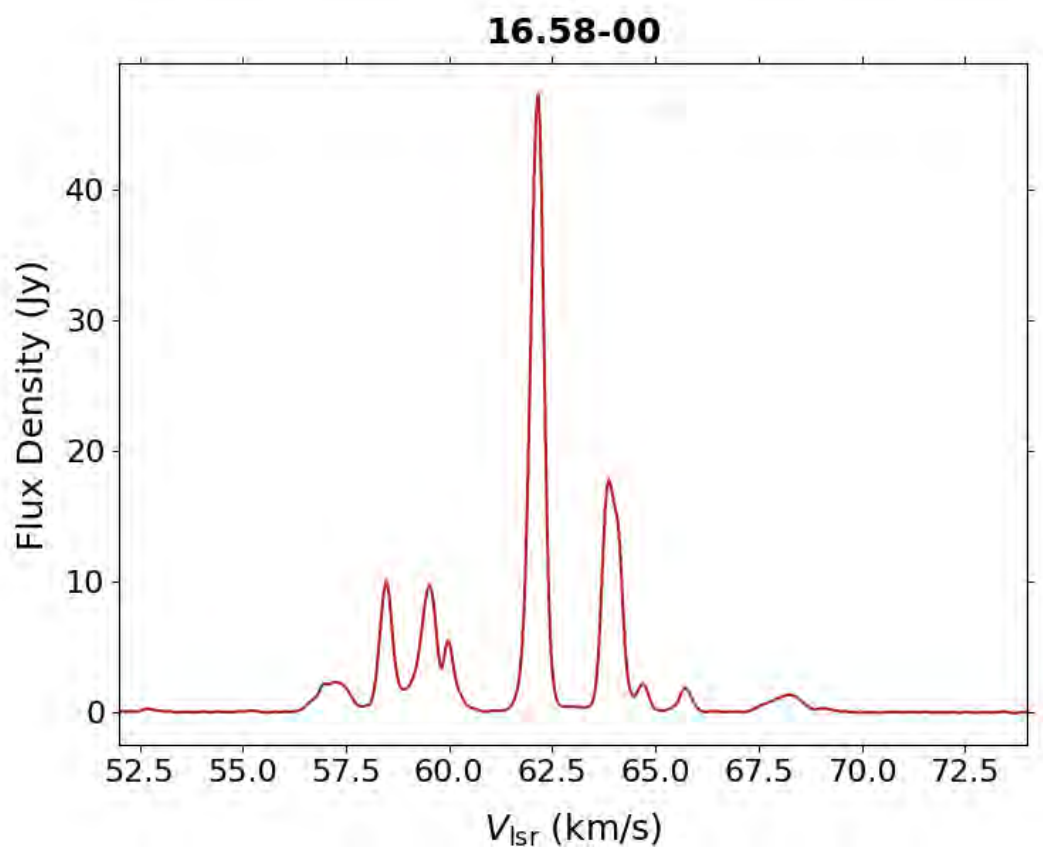
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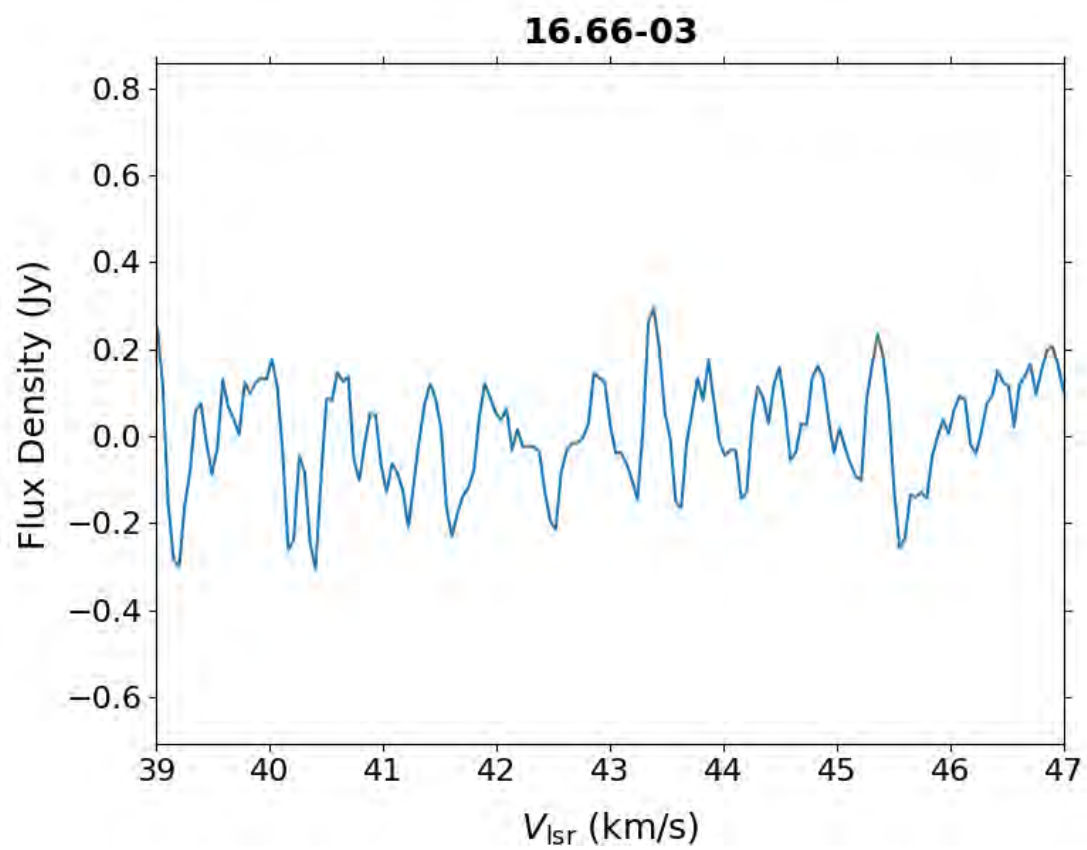
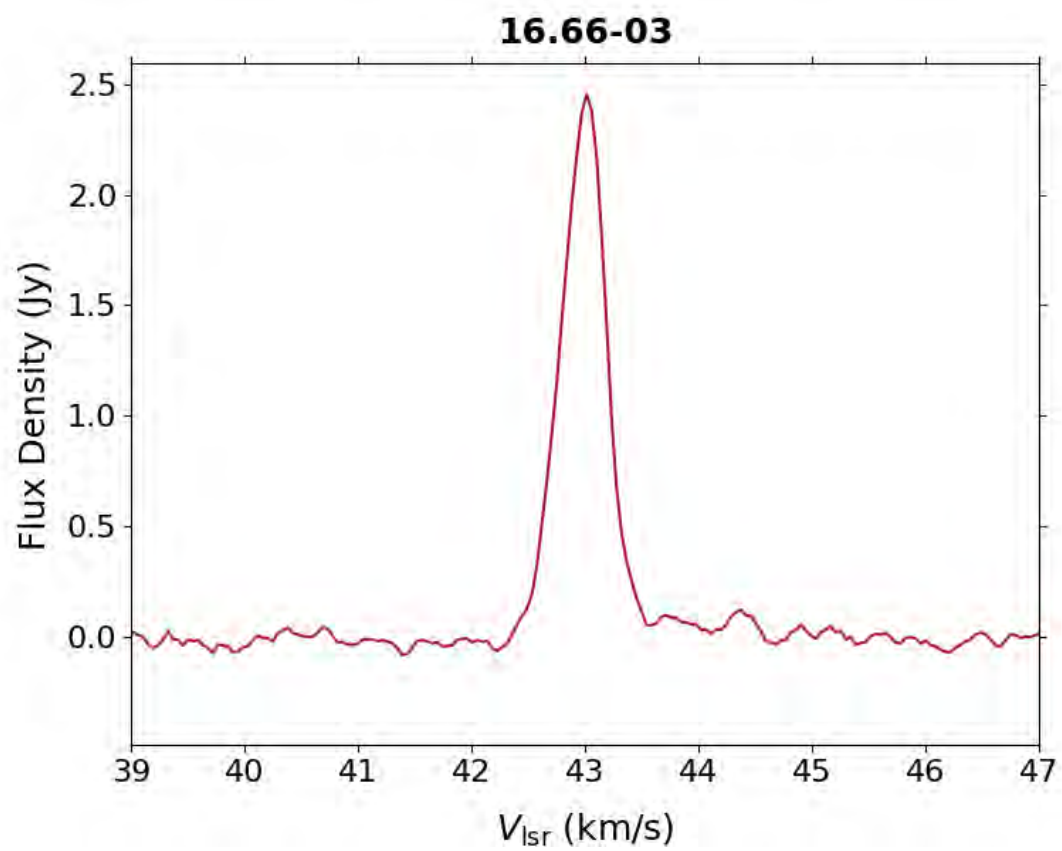


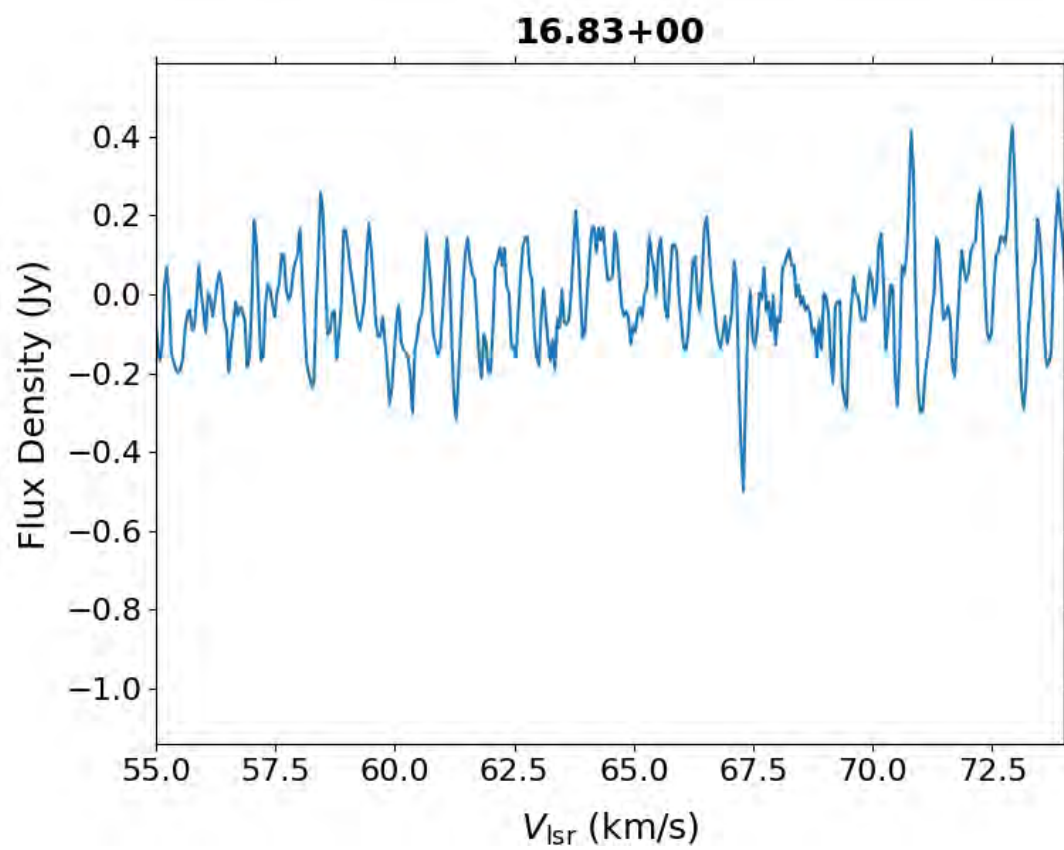
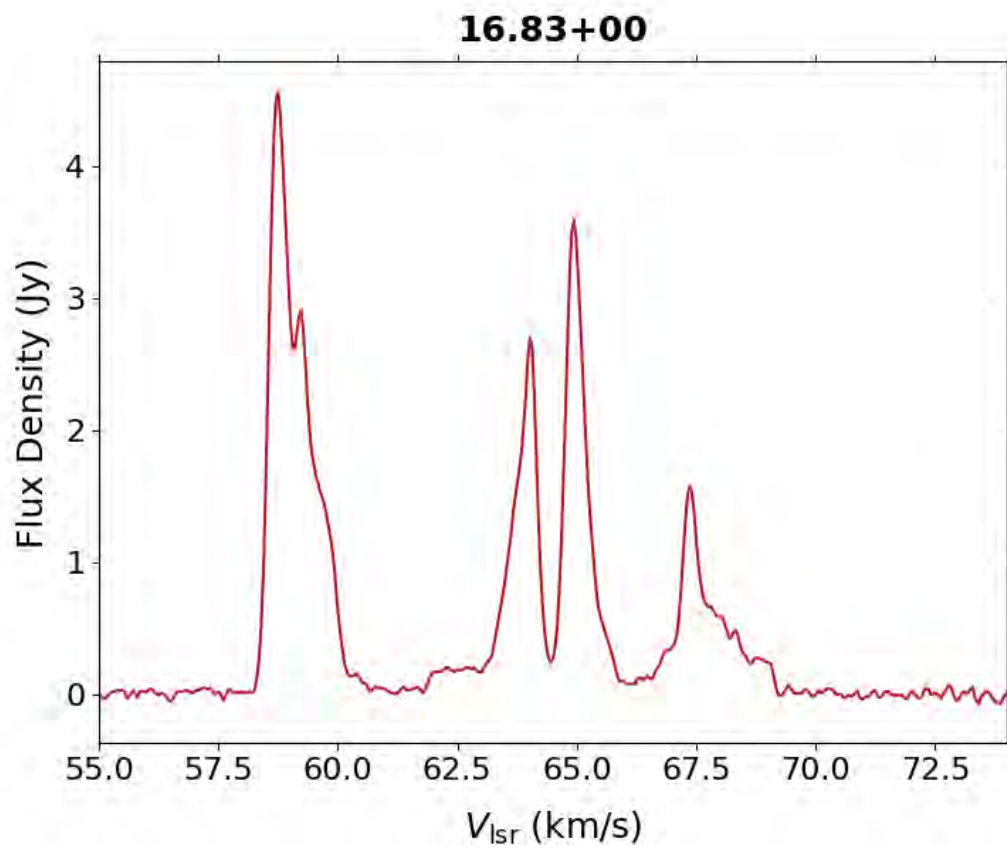
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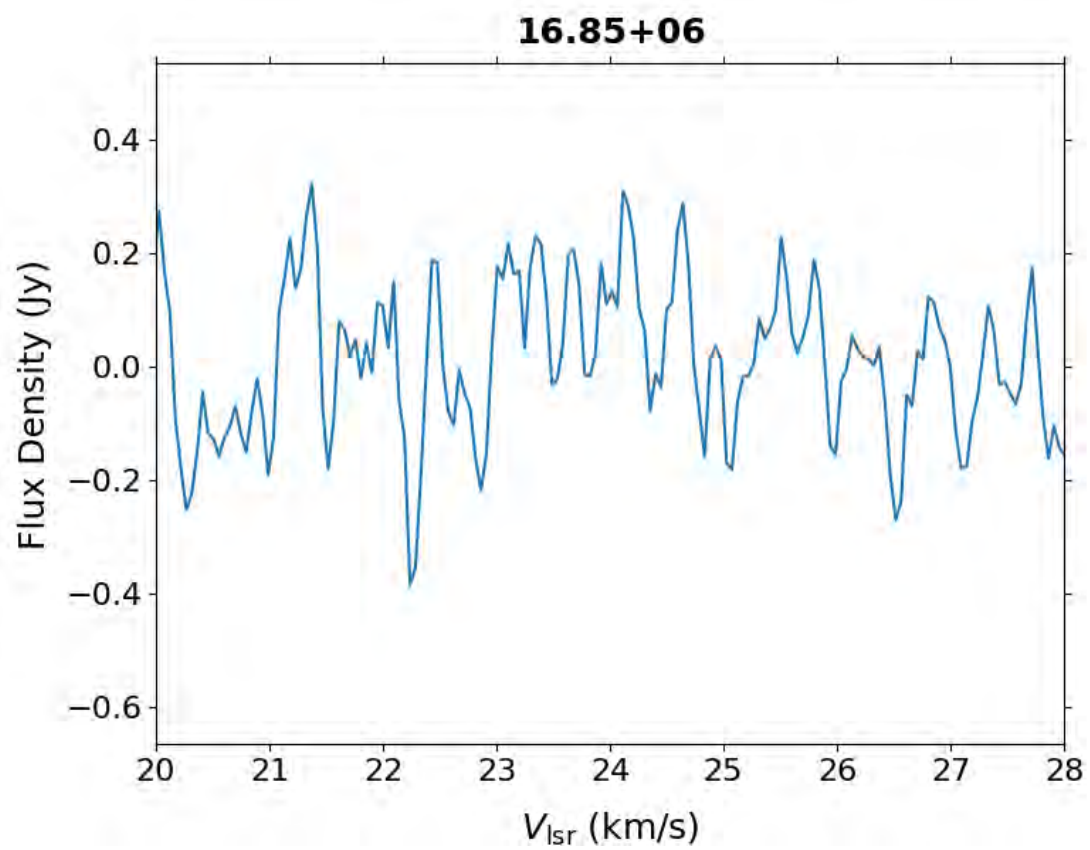
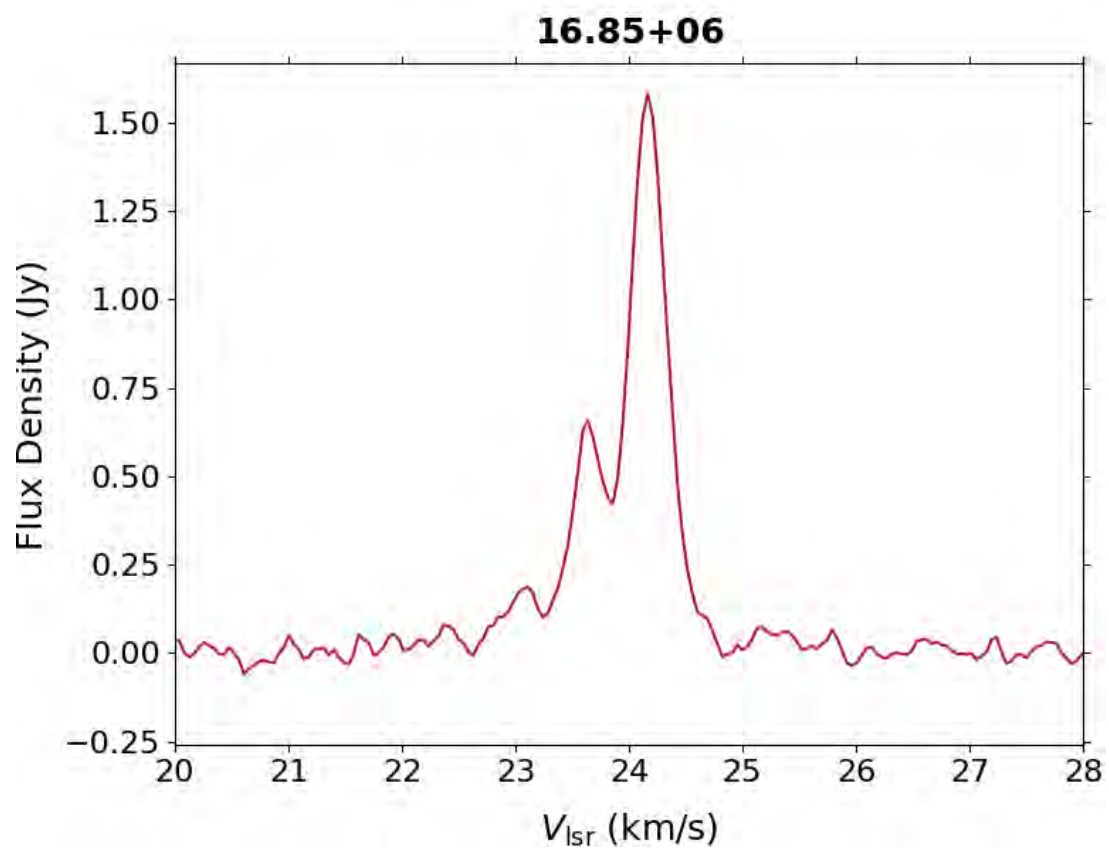


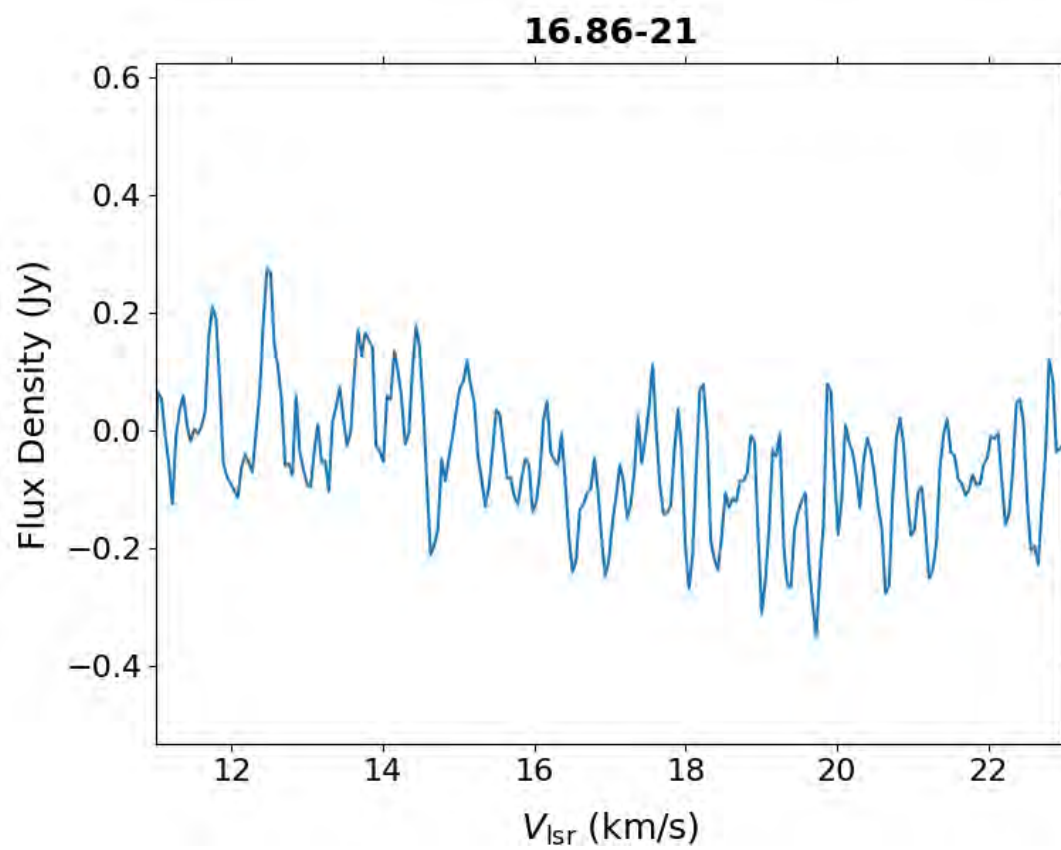
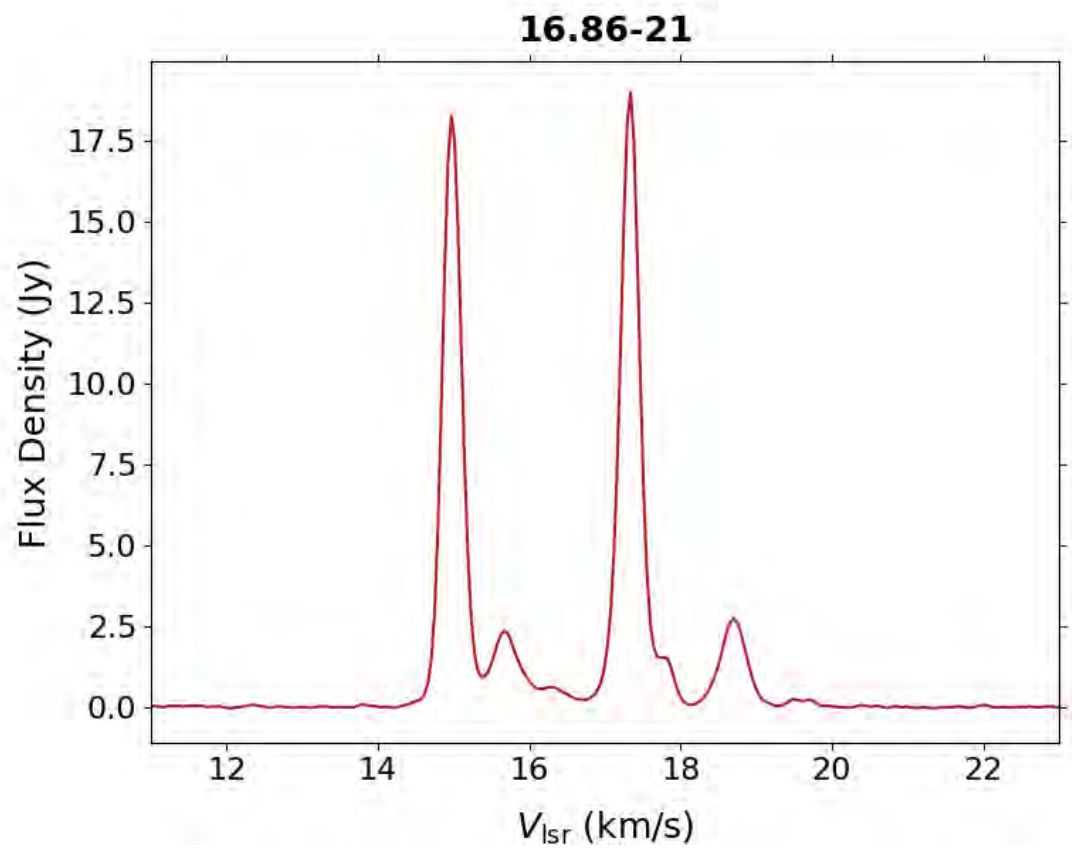


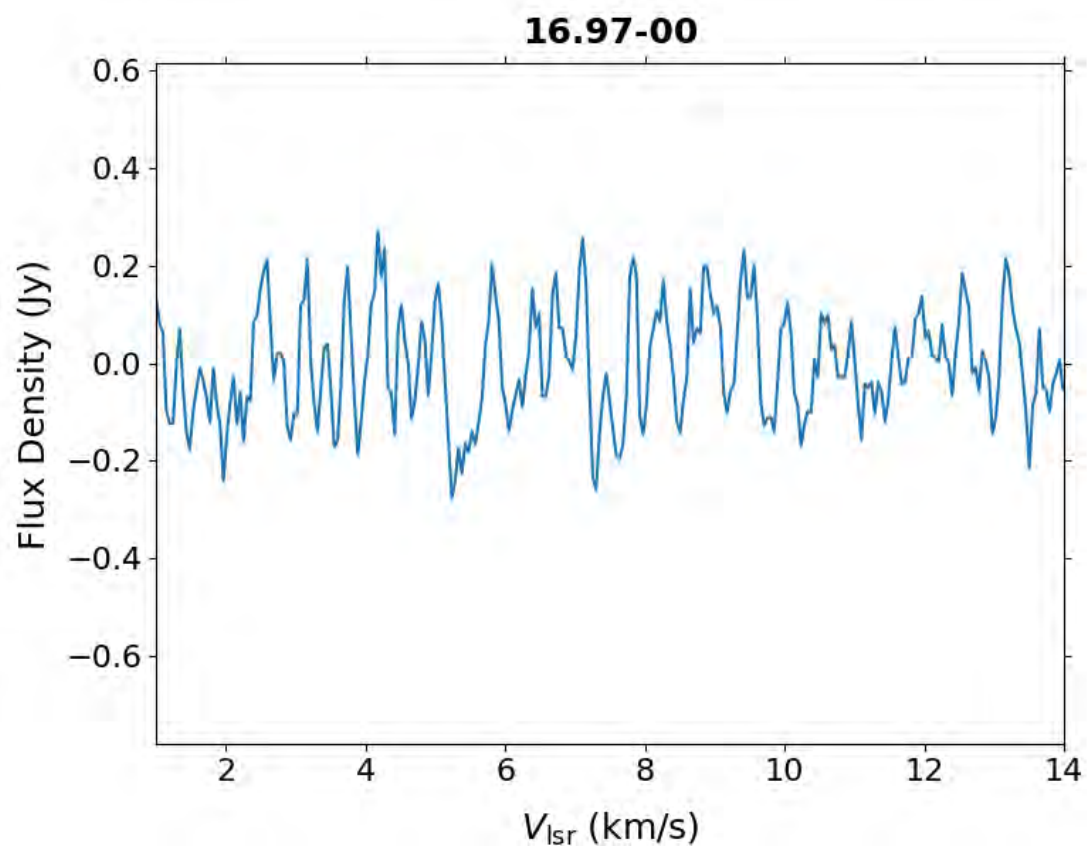
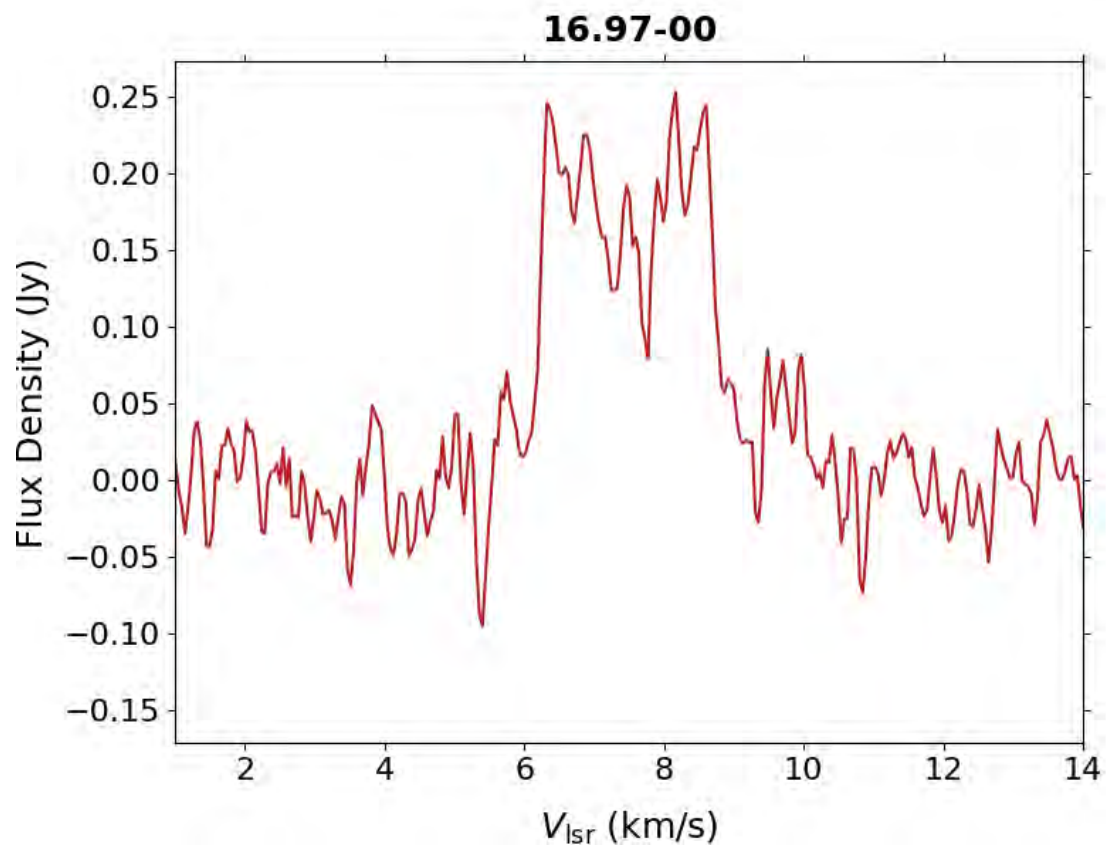


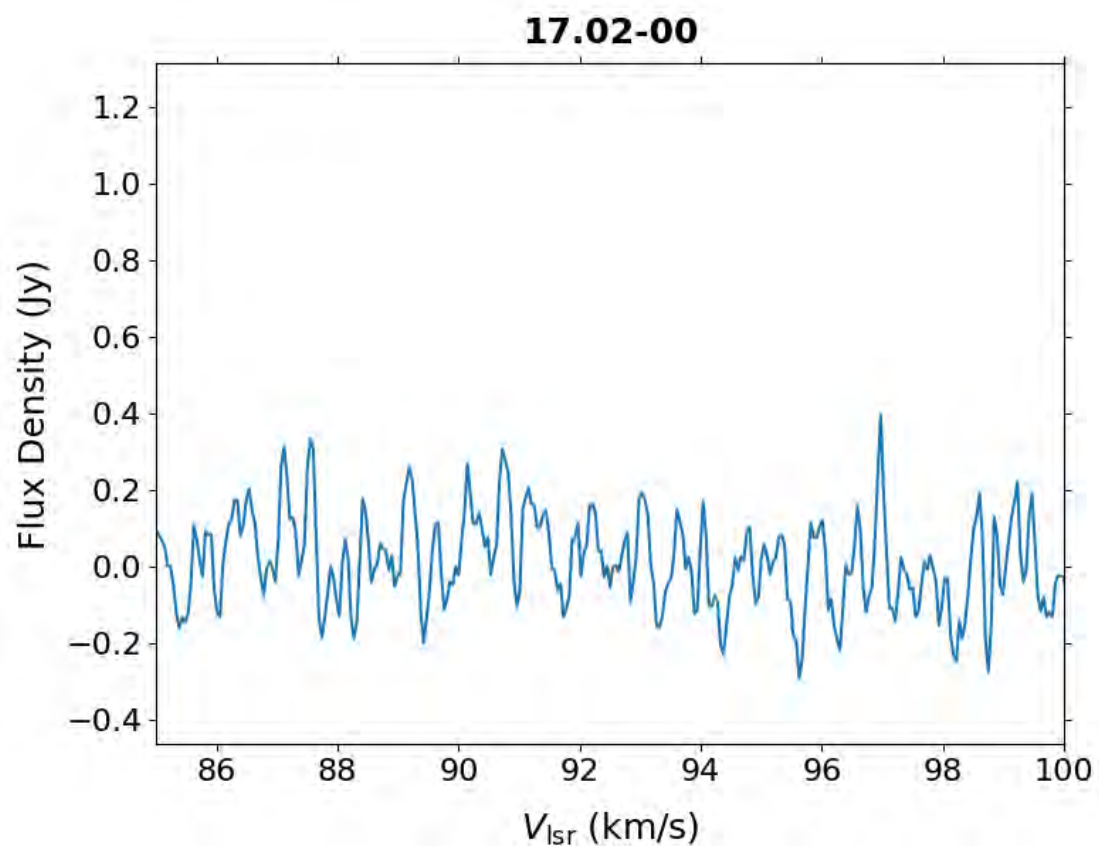
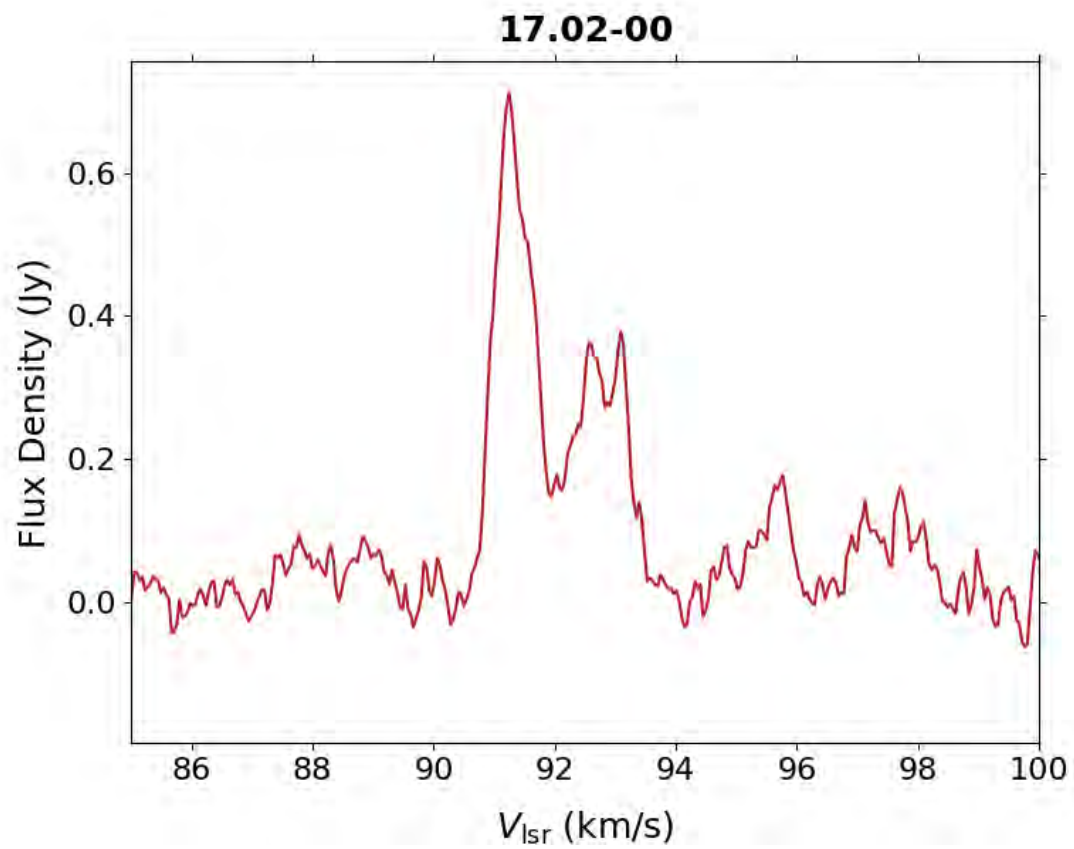




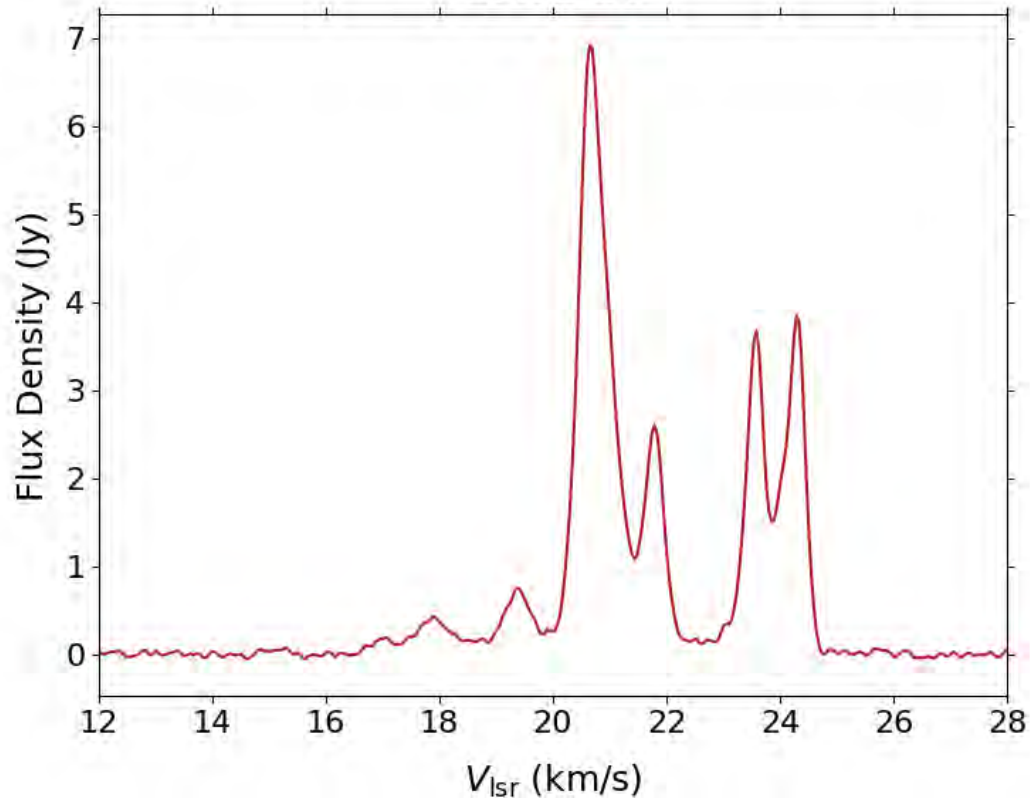




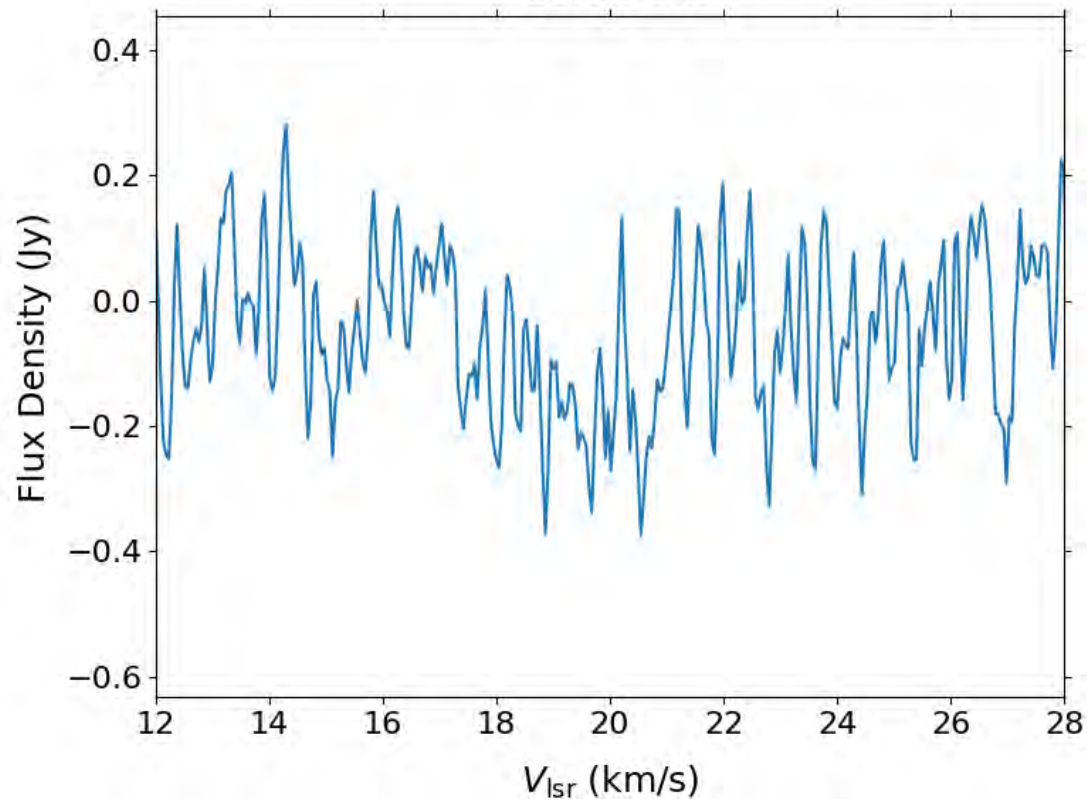


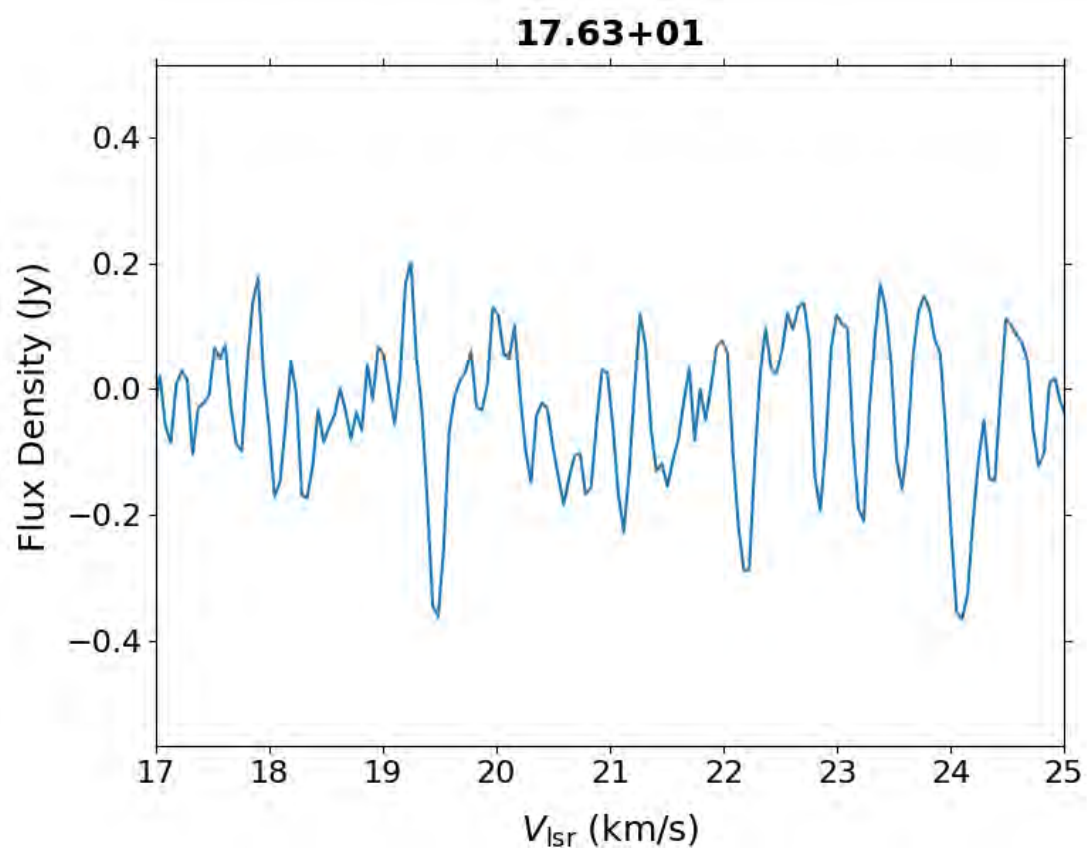
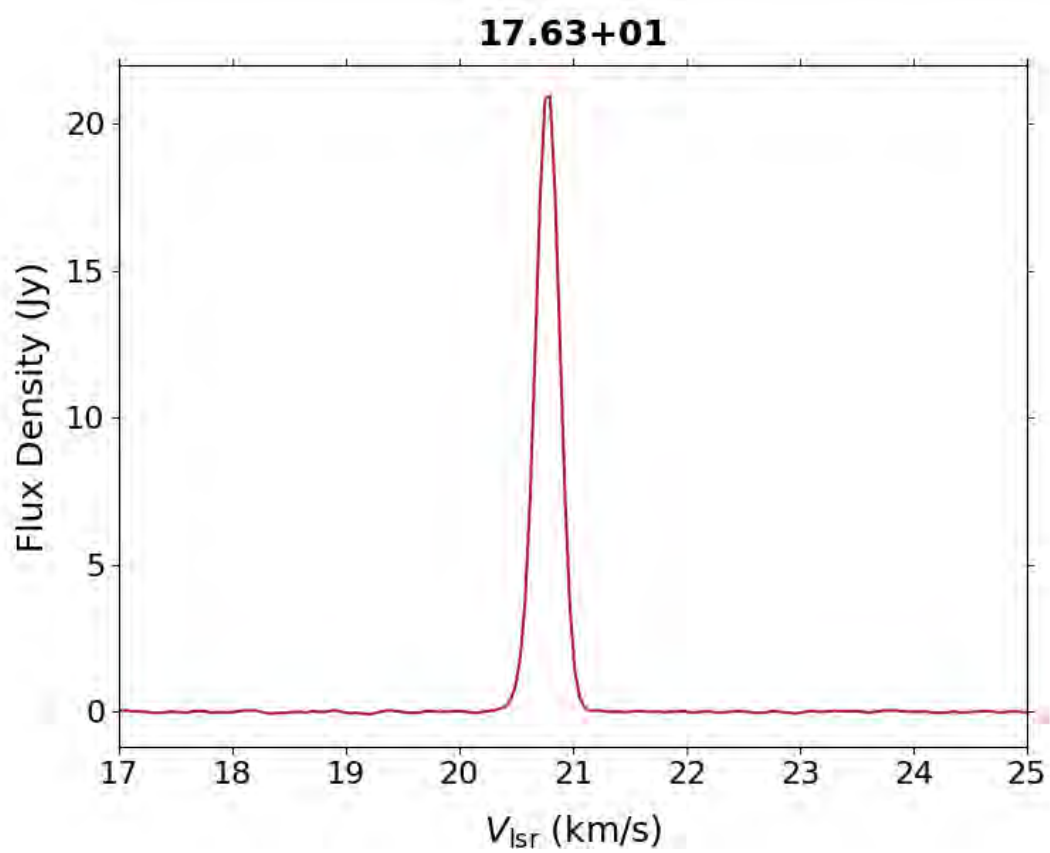


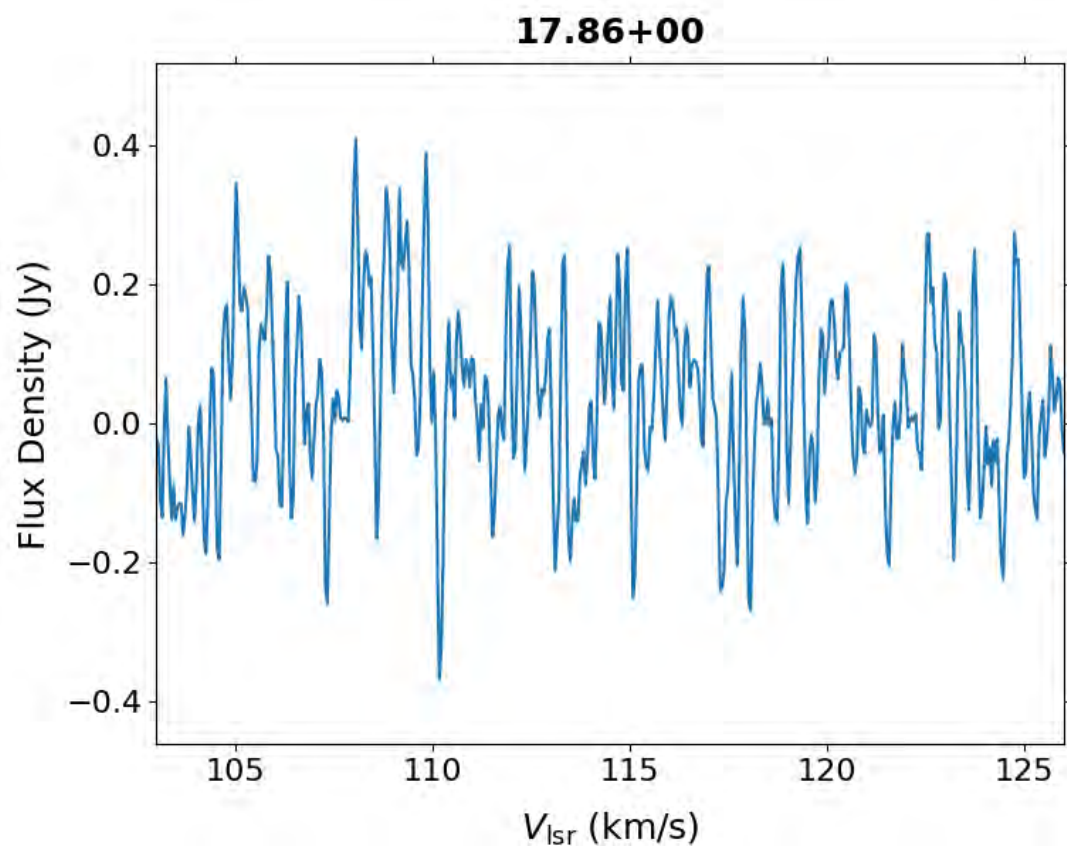
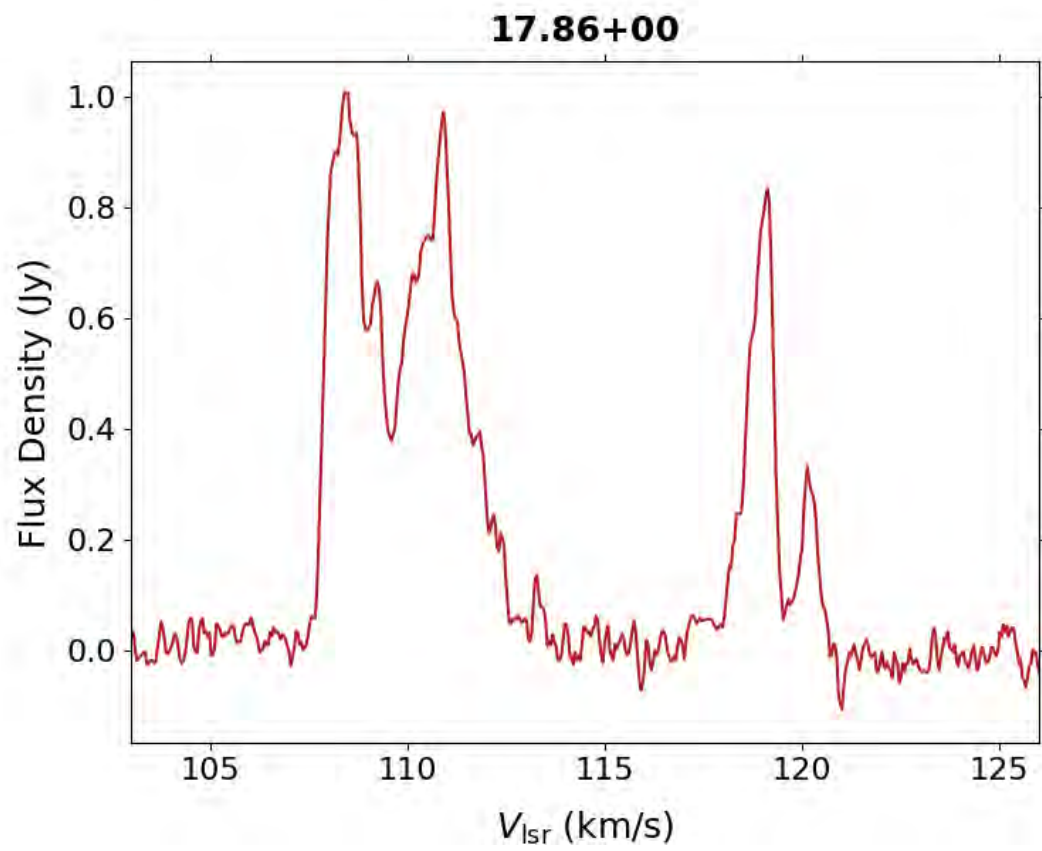
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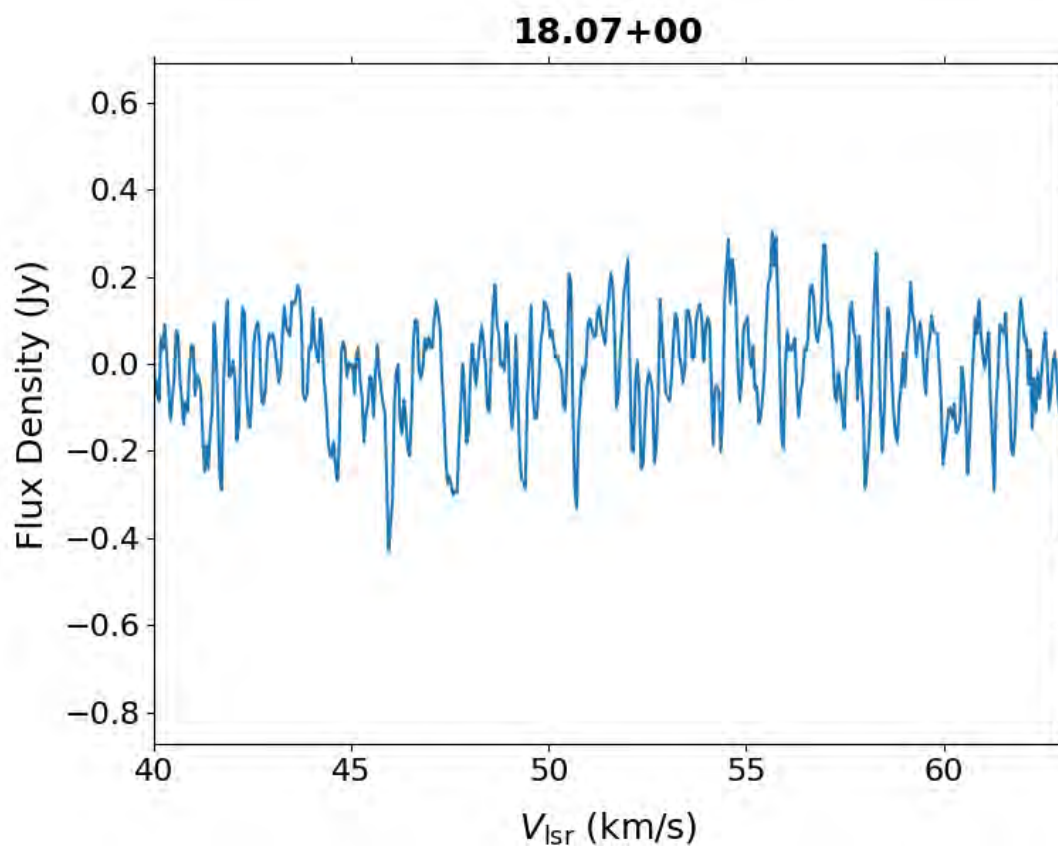
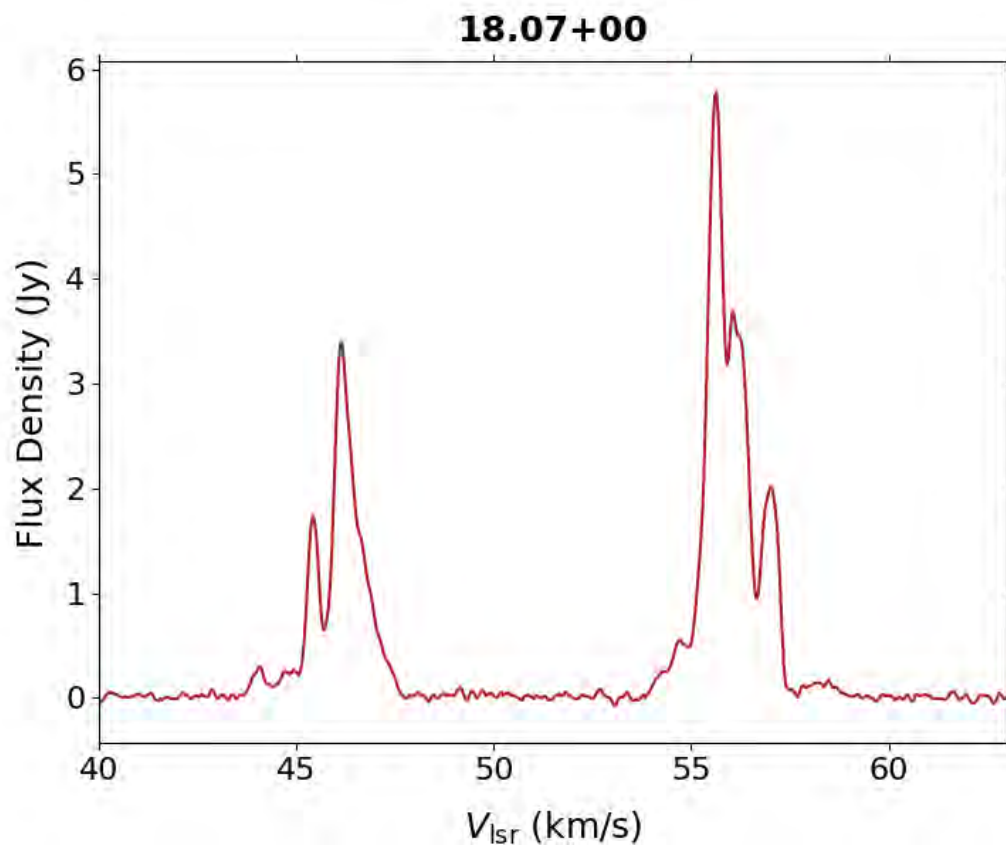


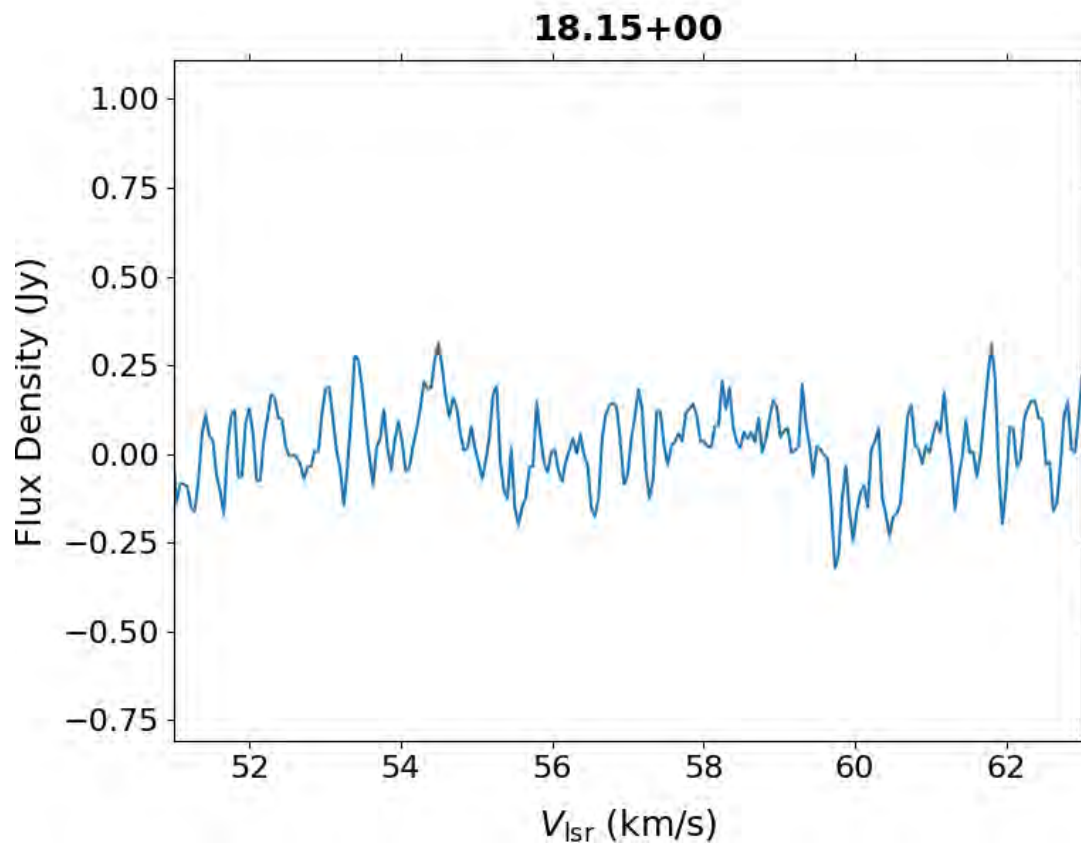
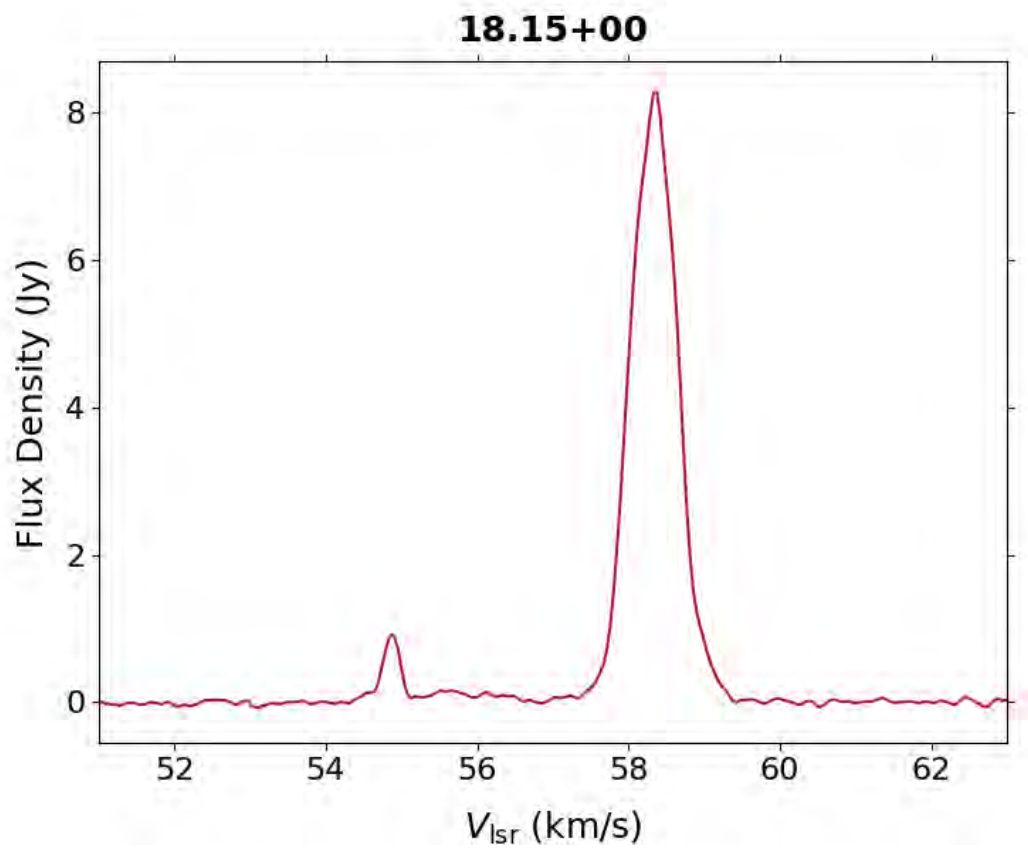
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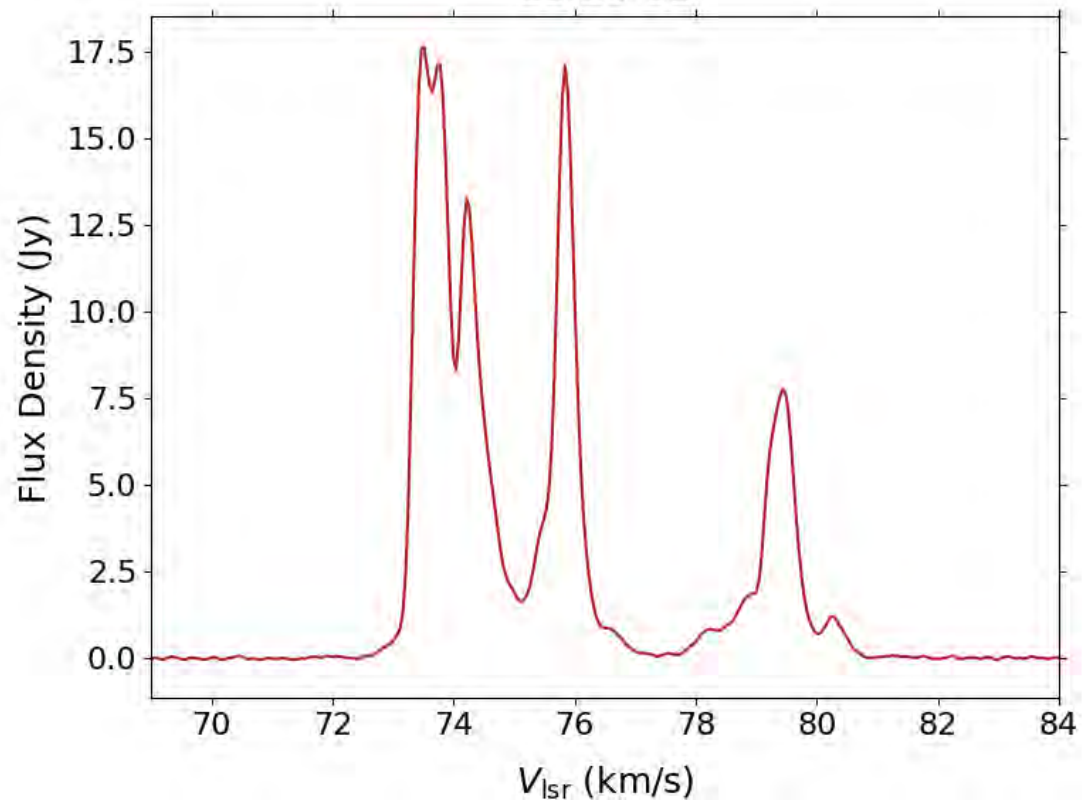




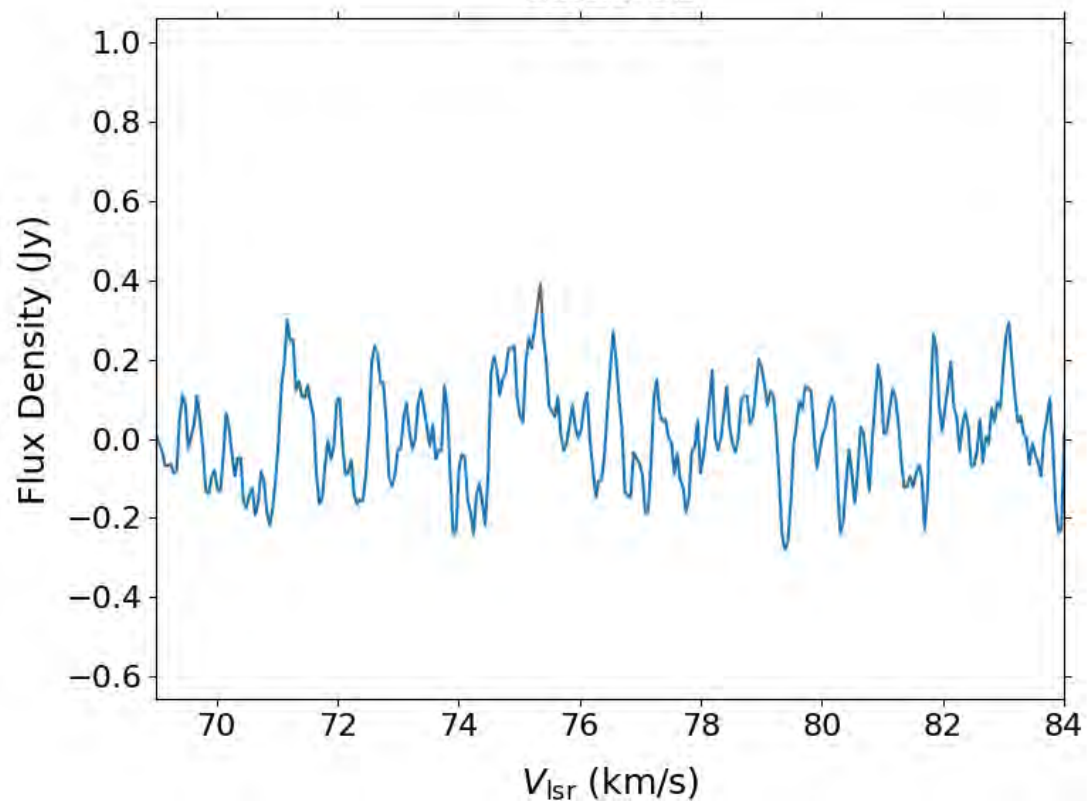


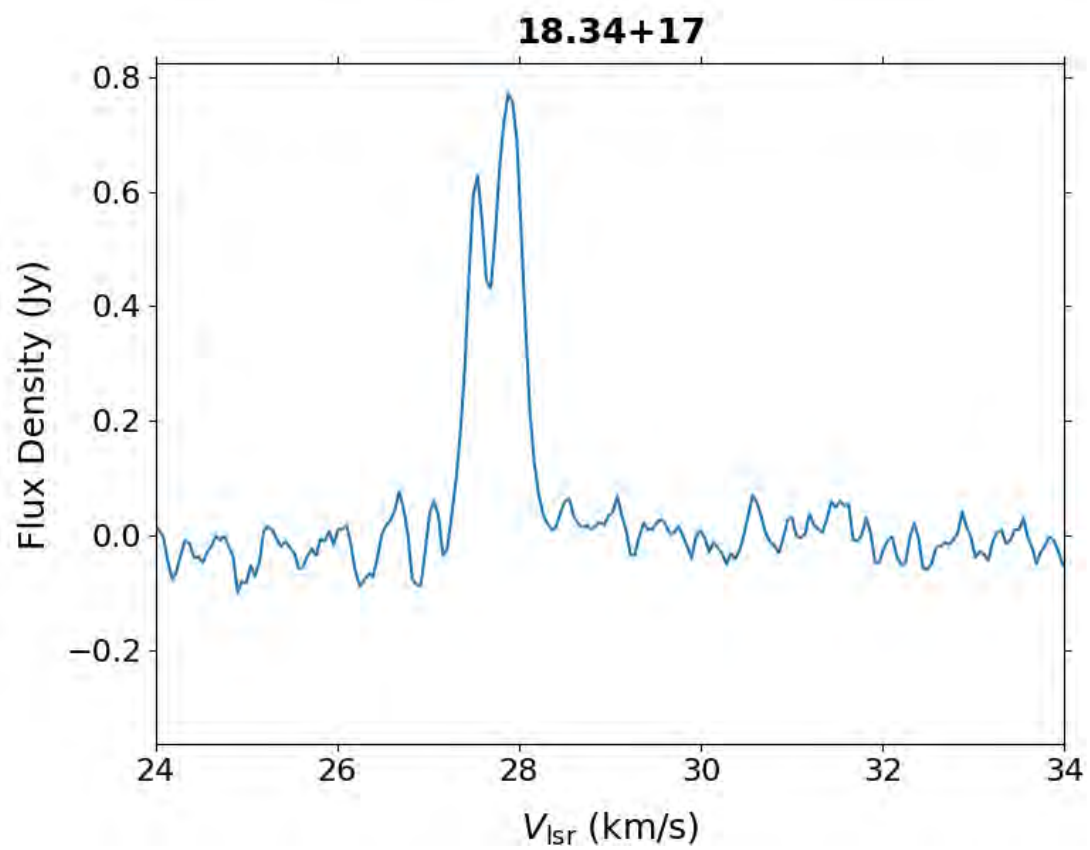
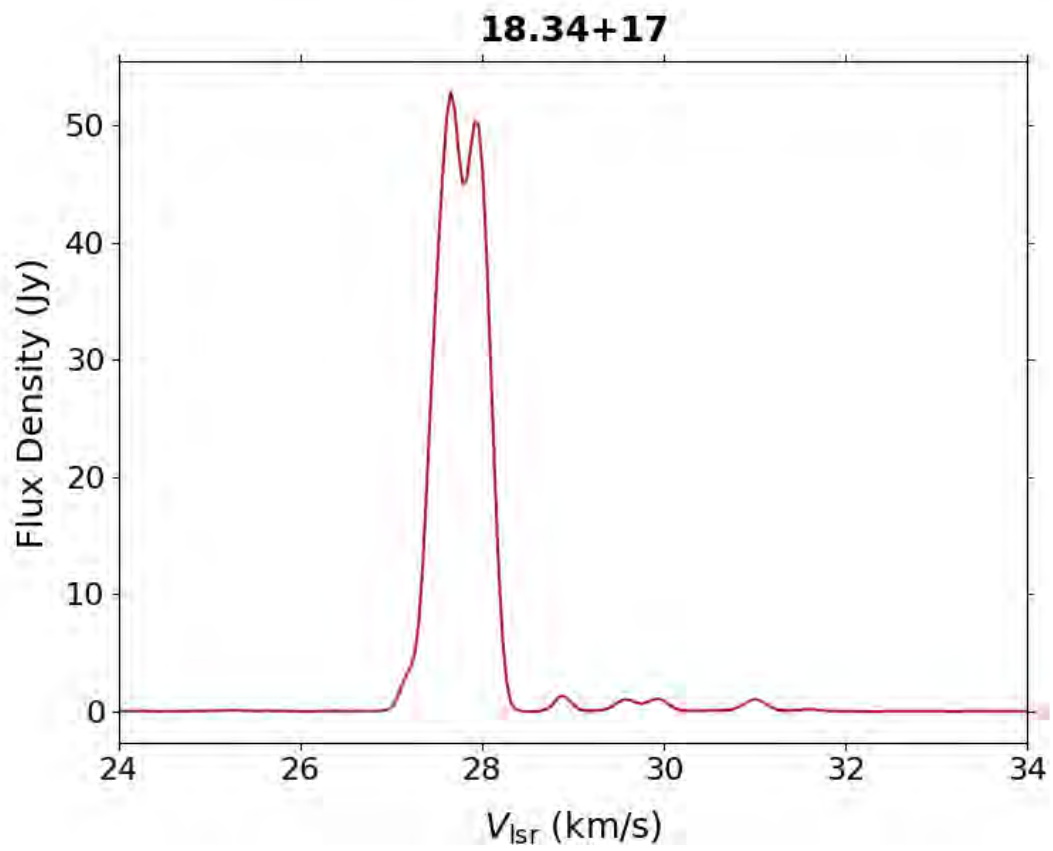


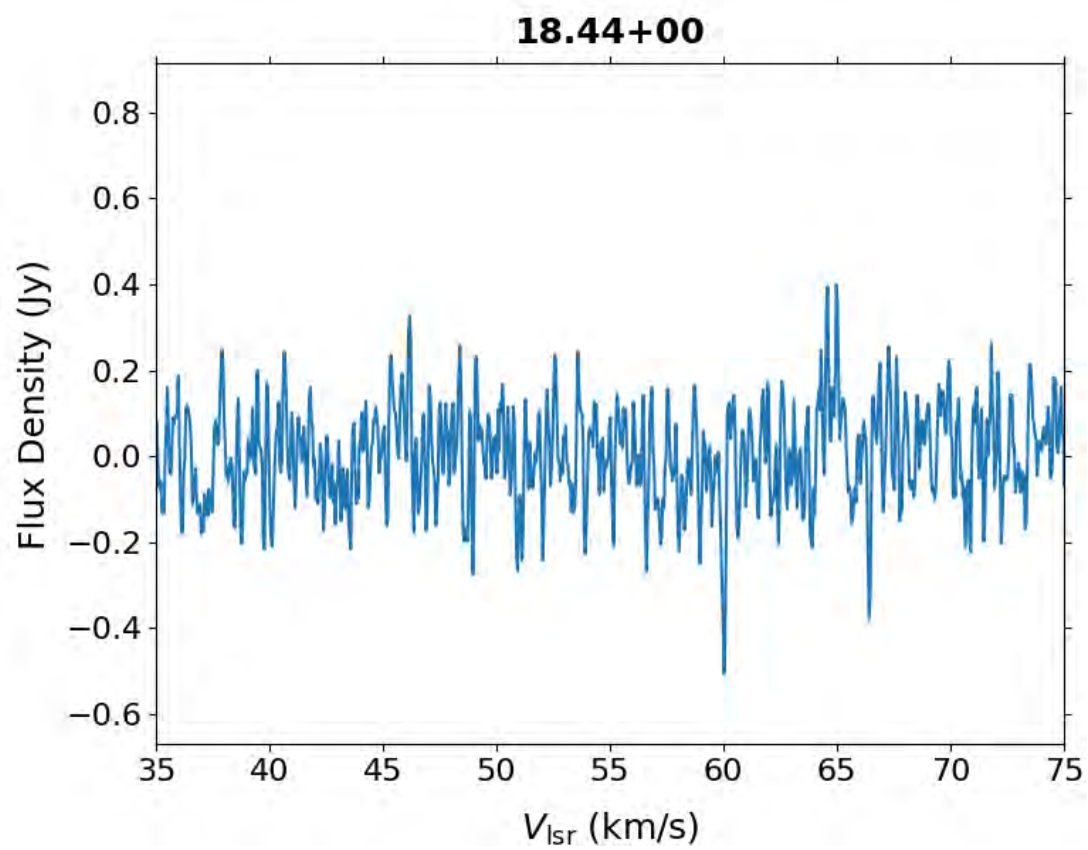
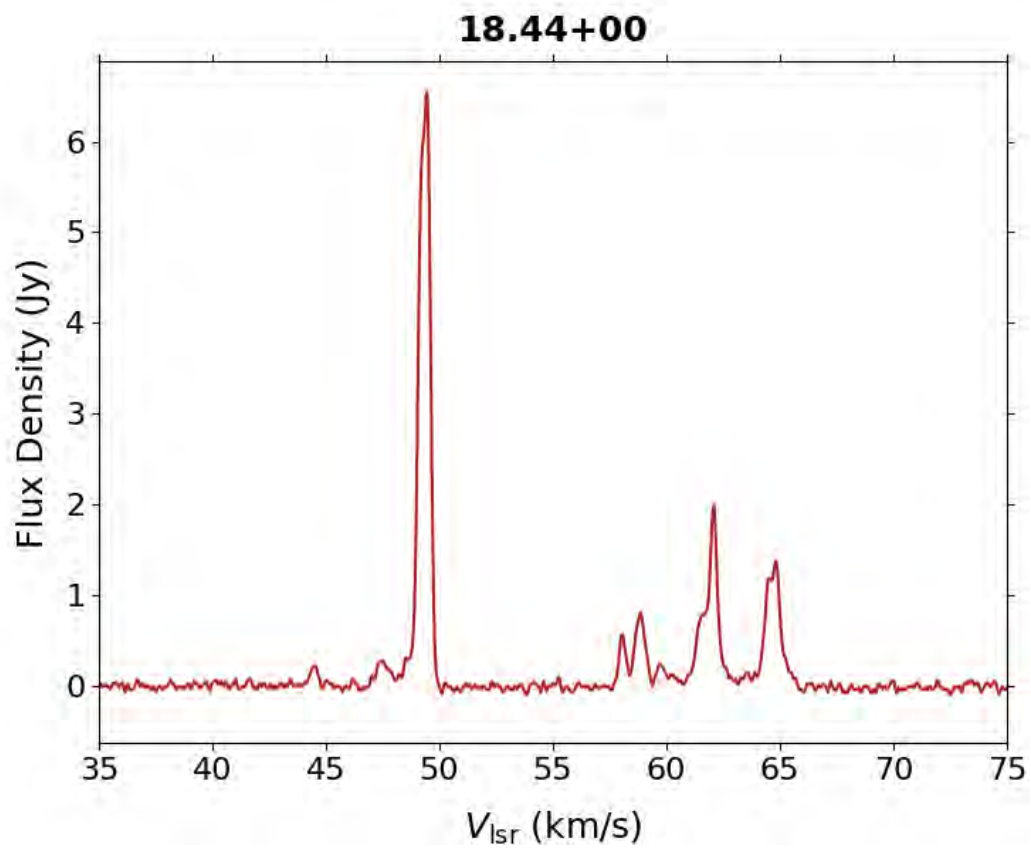
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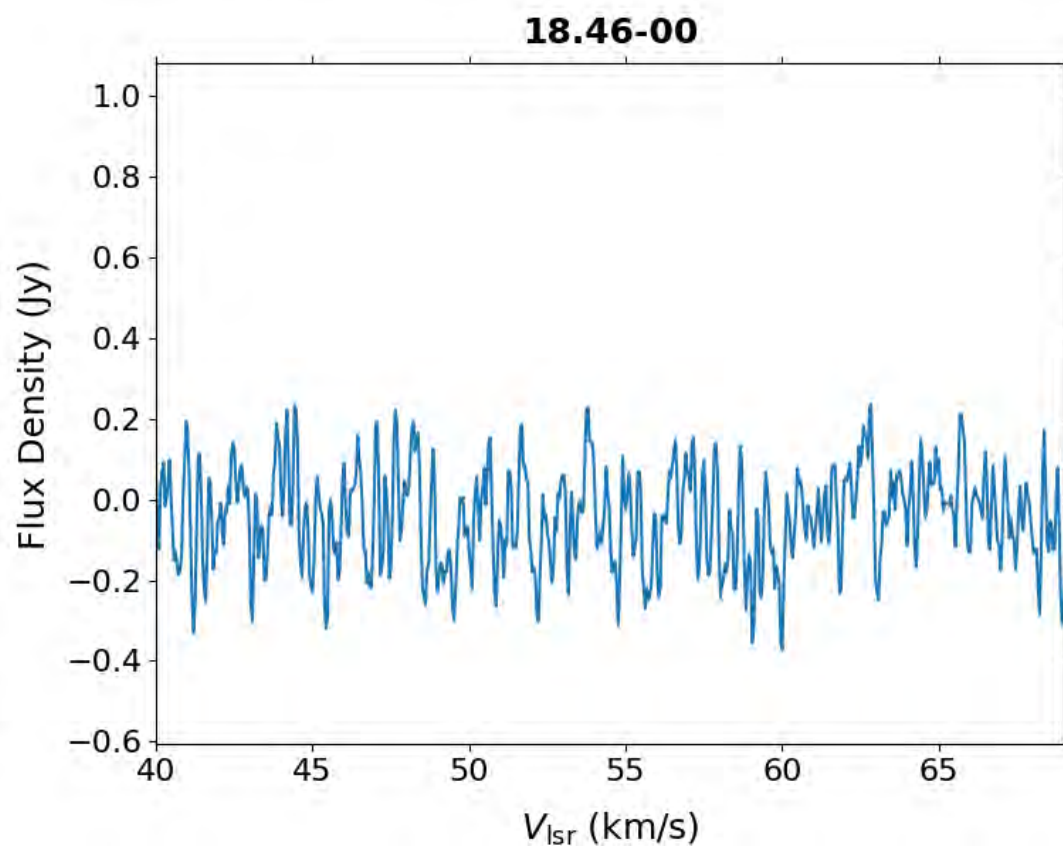
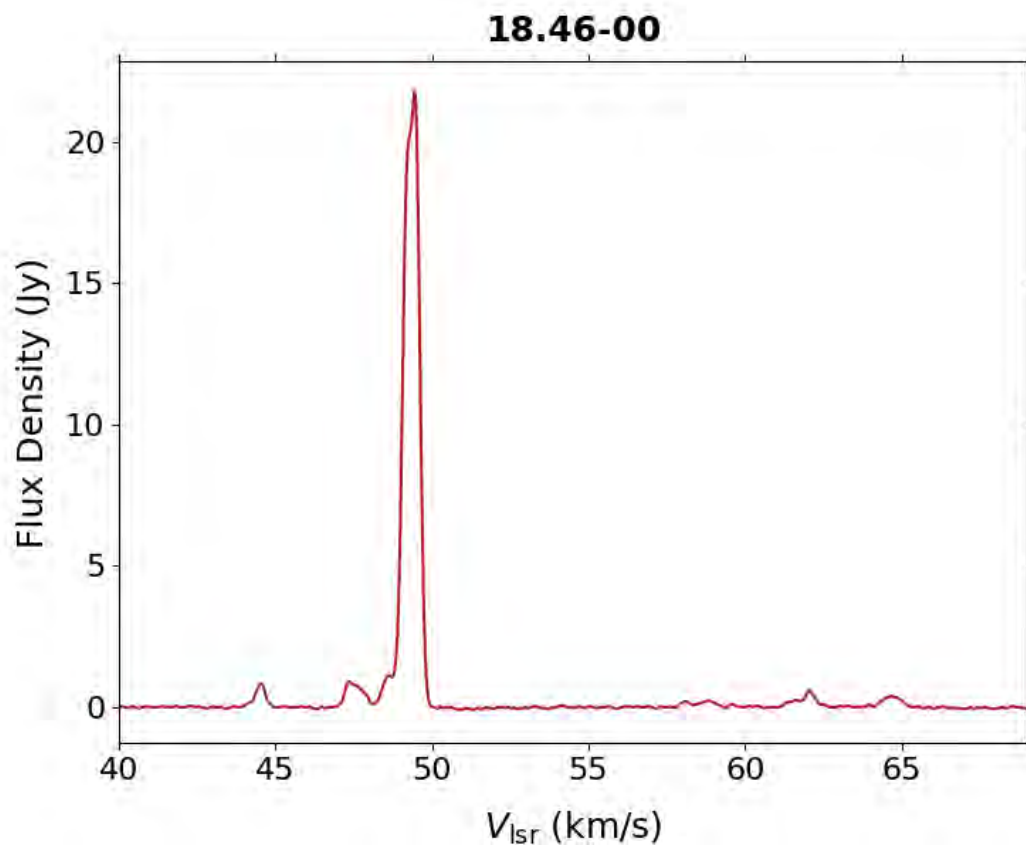


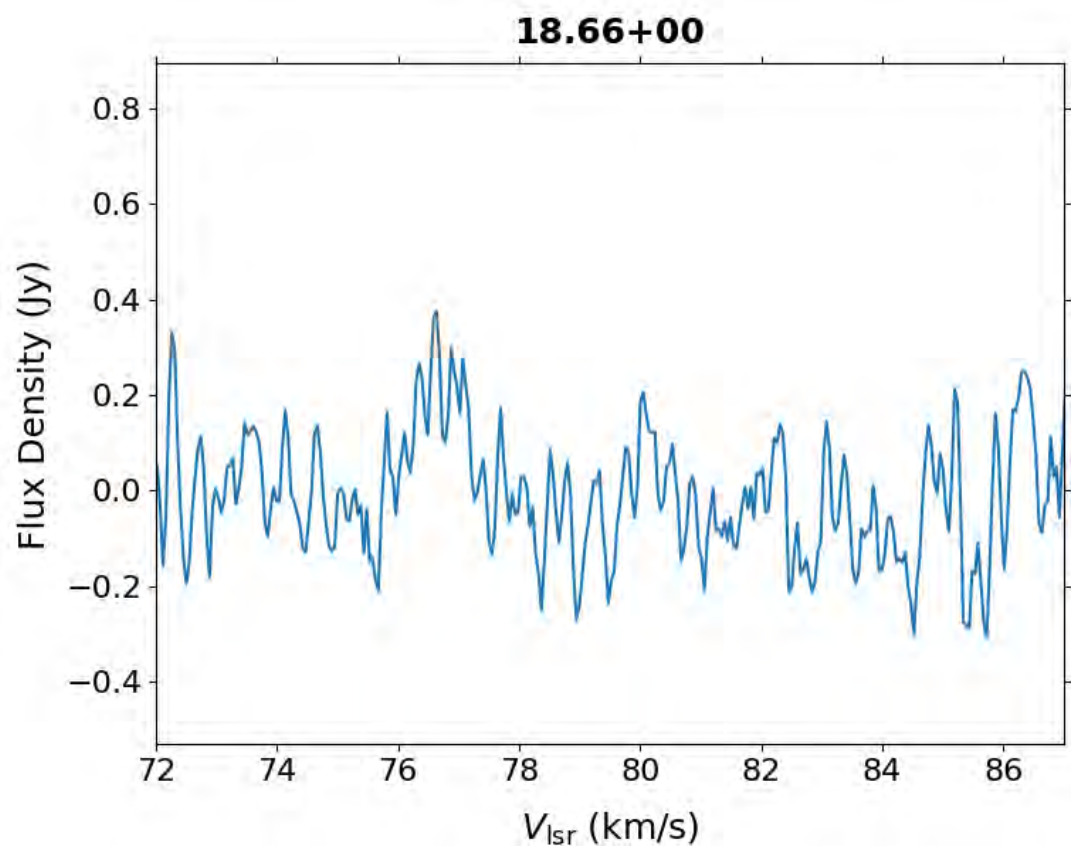
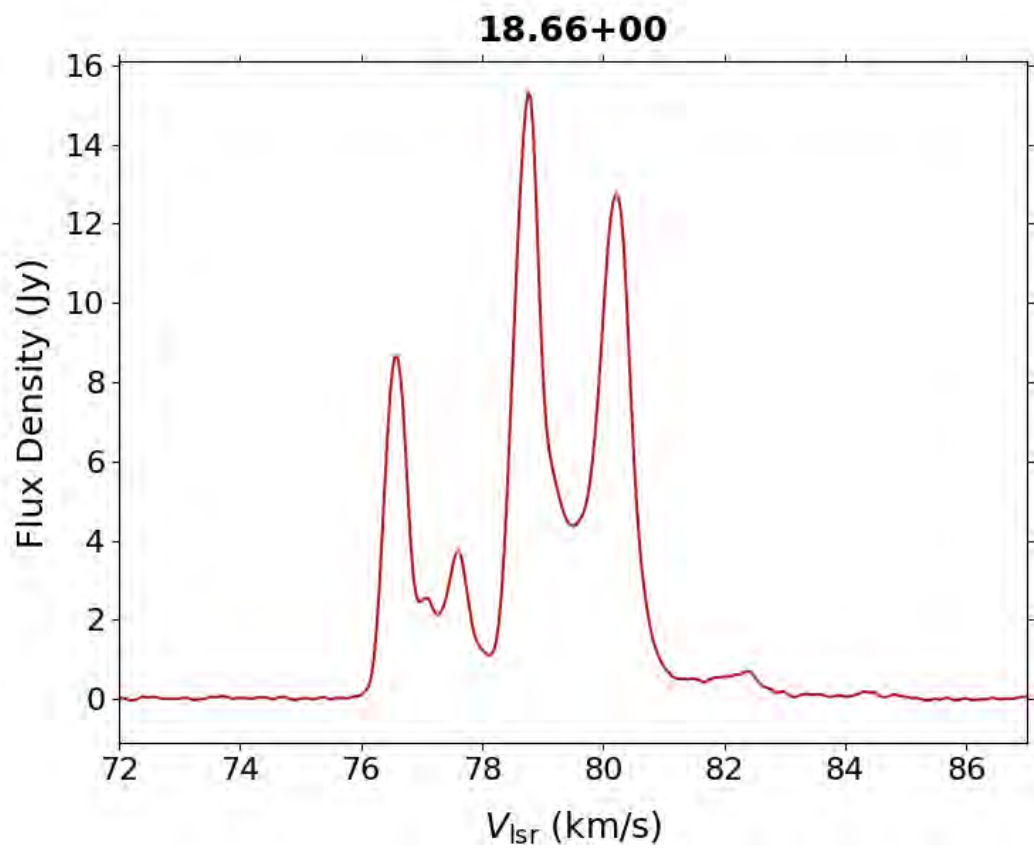
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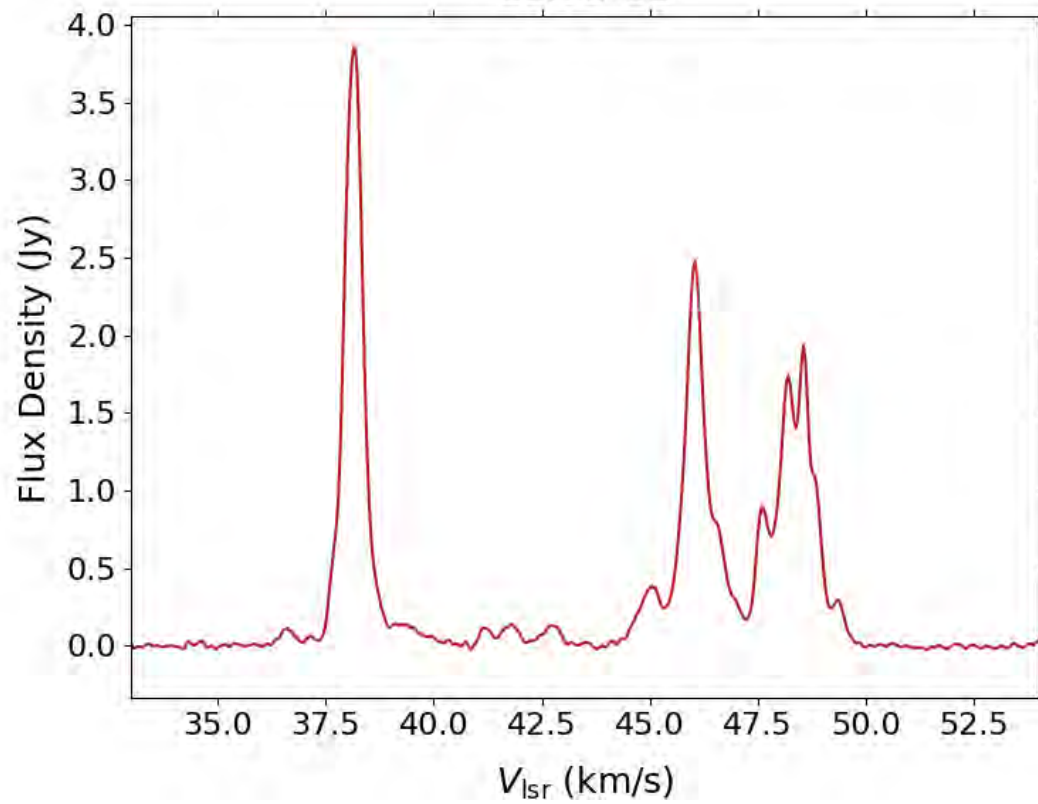




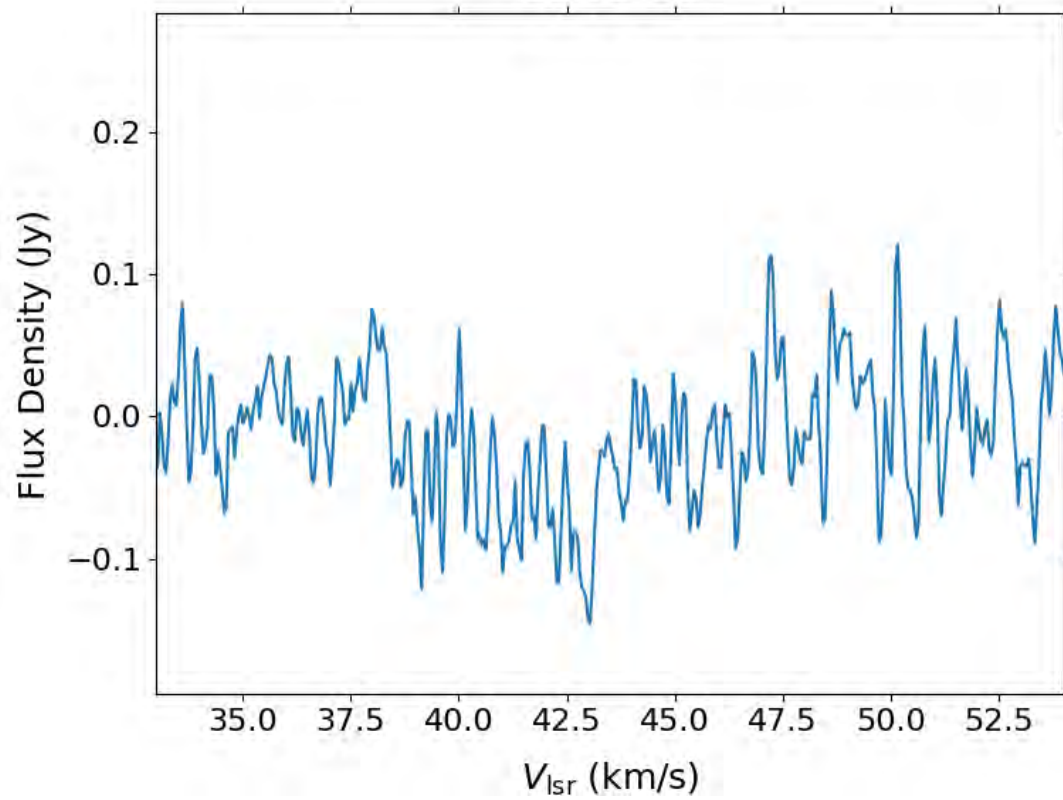




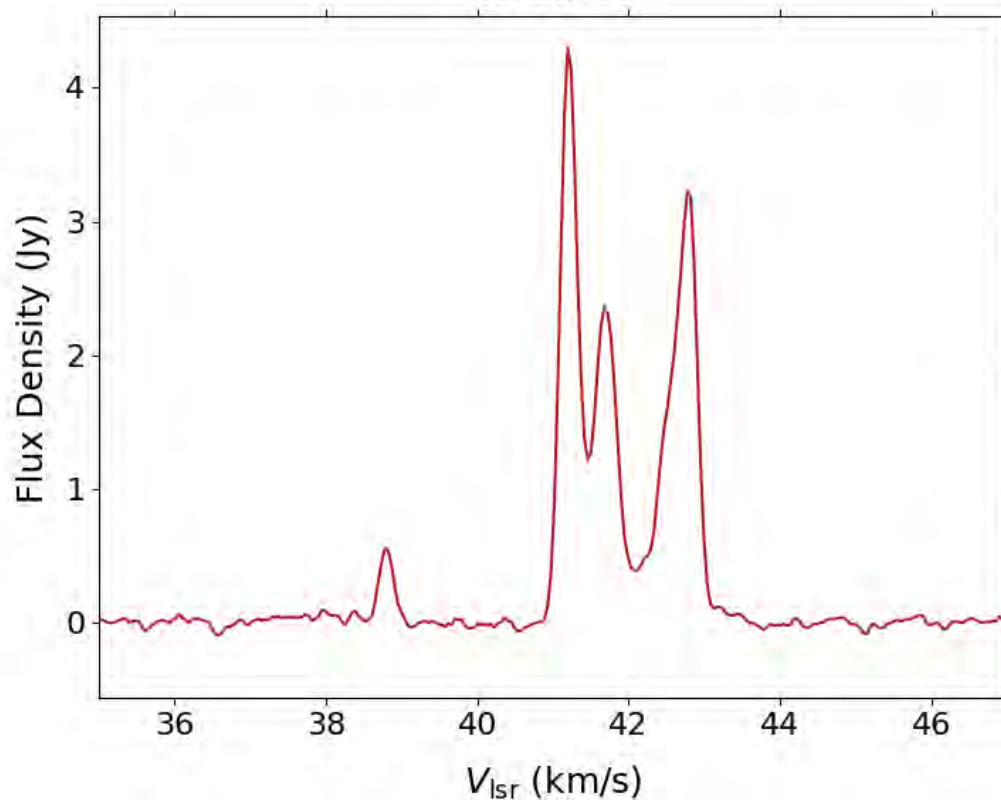
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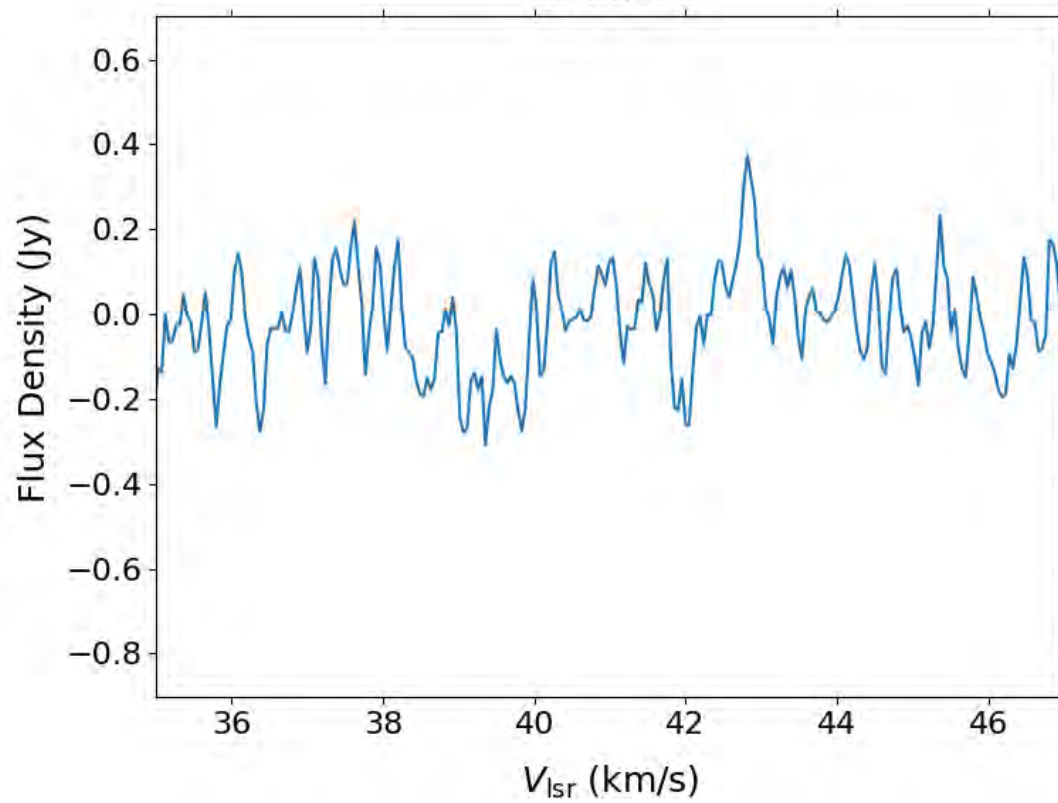
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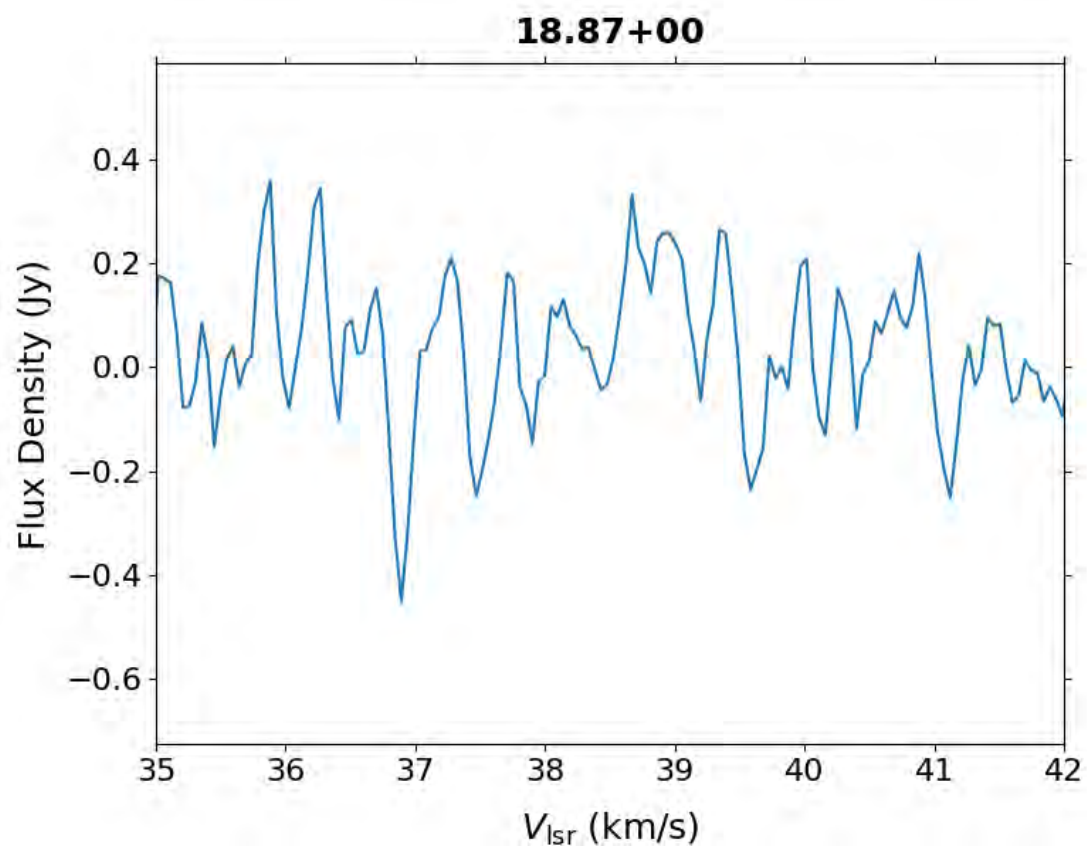
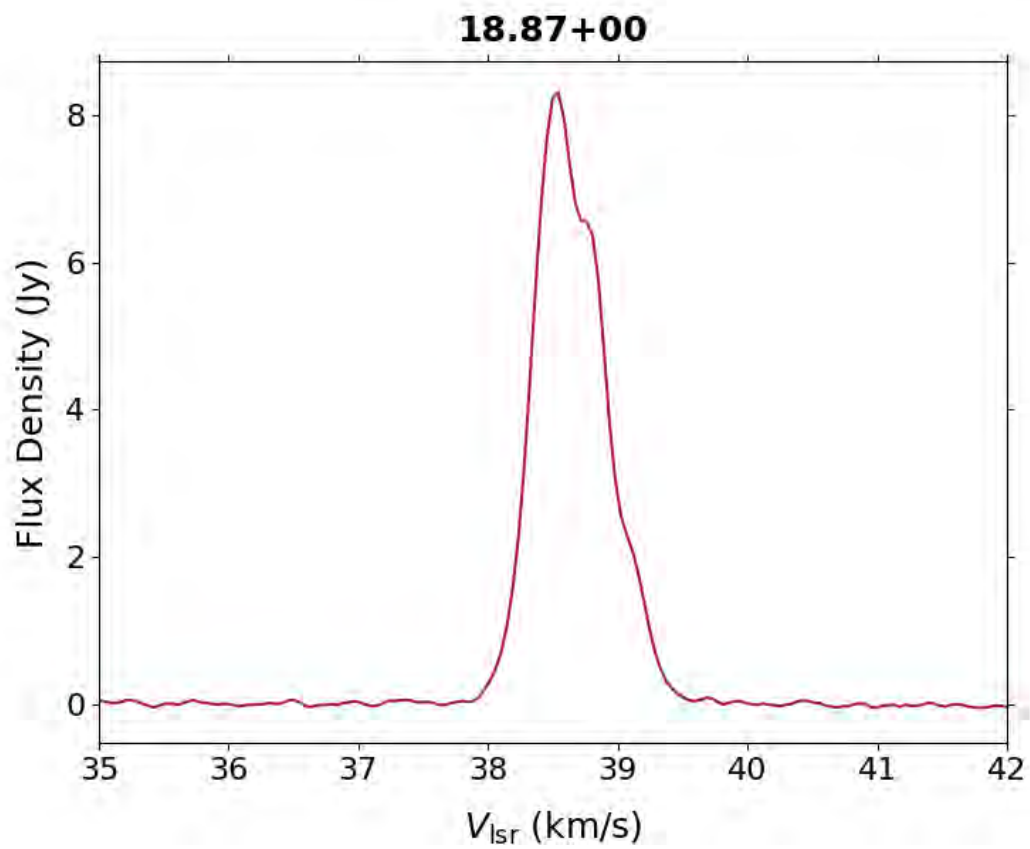


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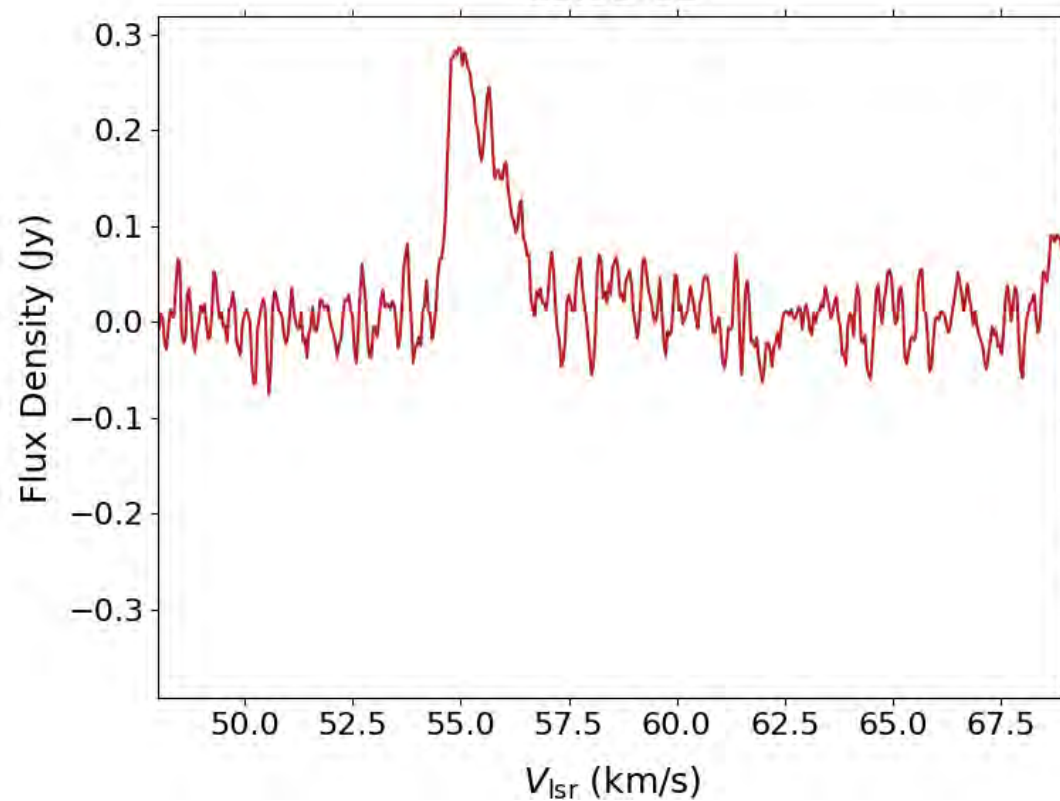


18.83-03

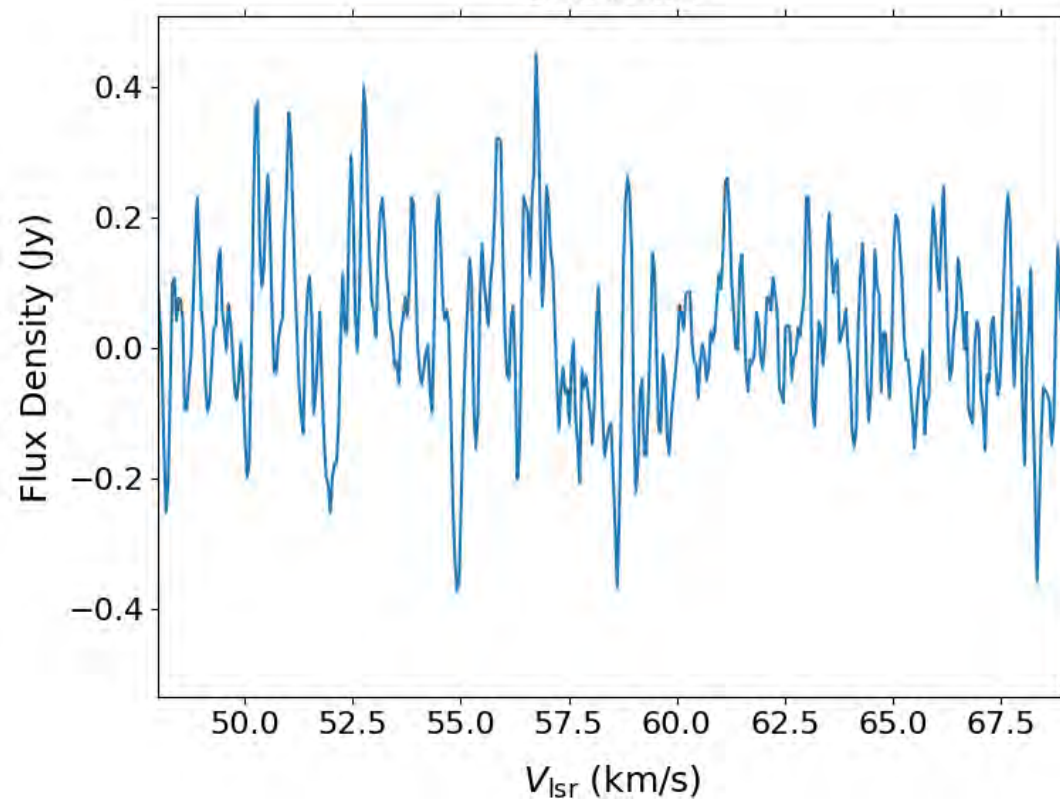


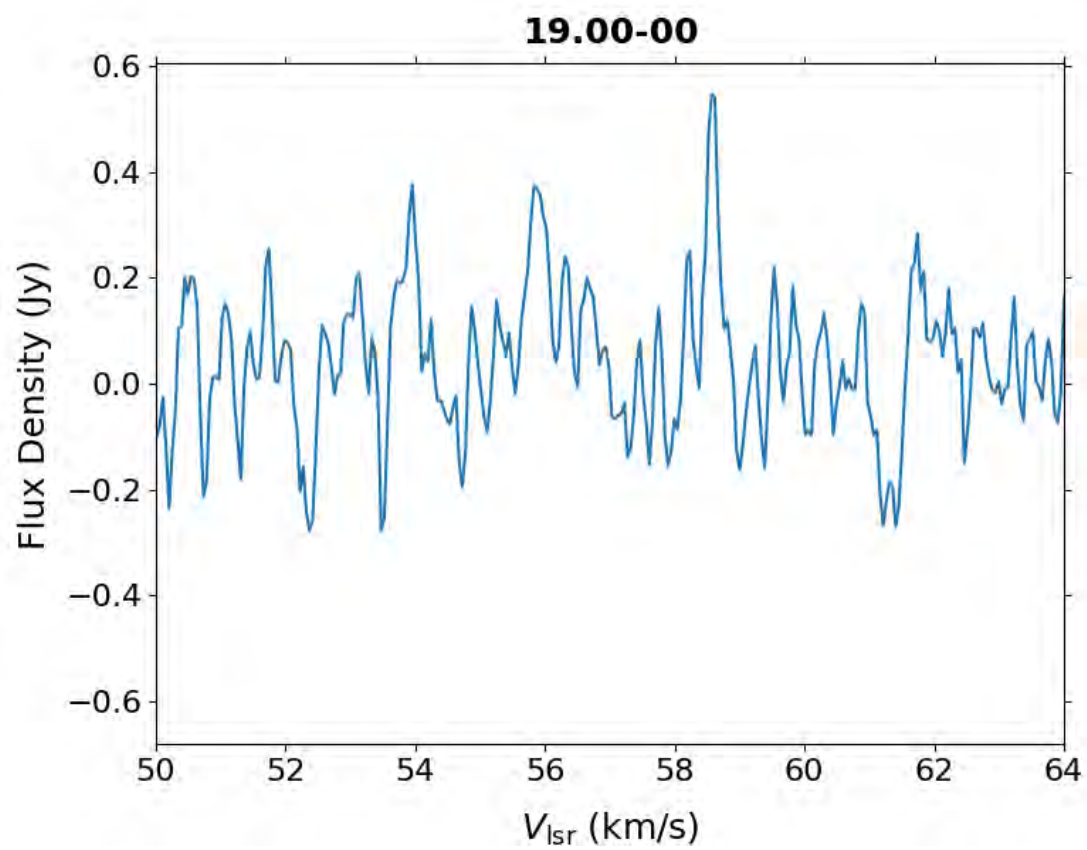
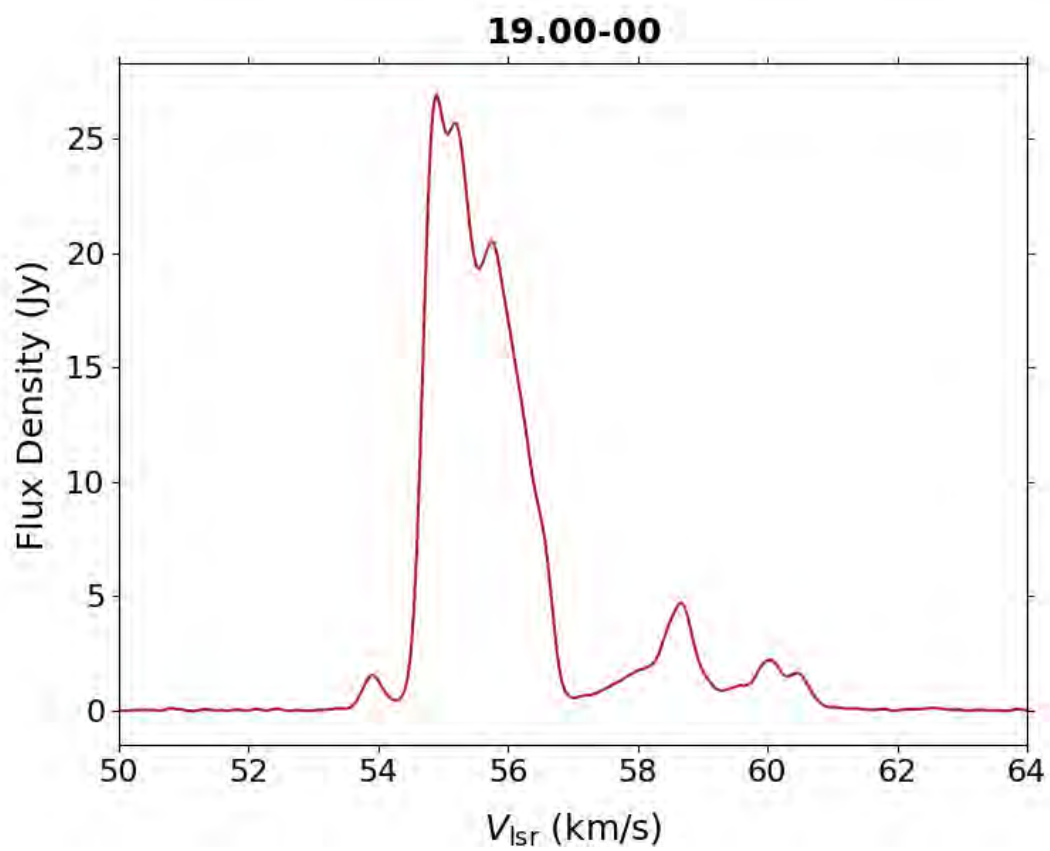


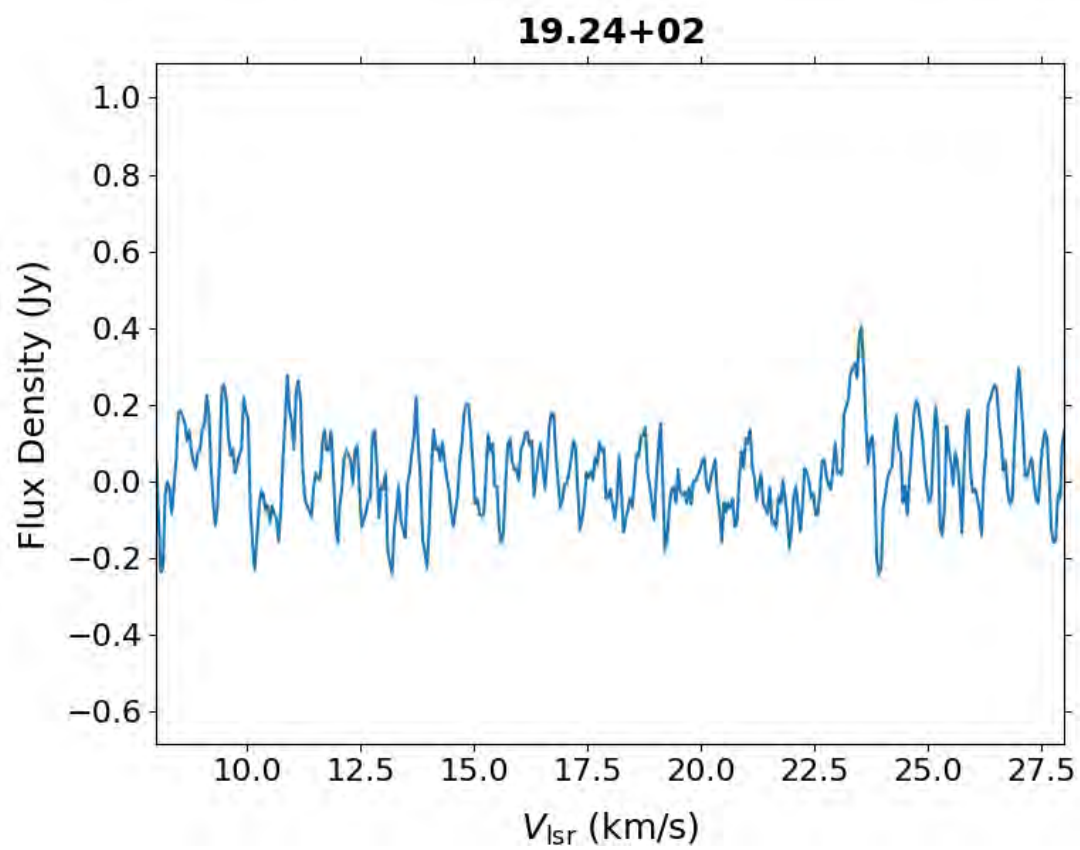
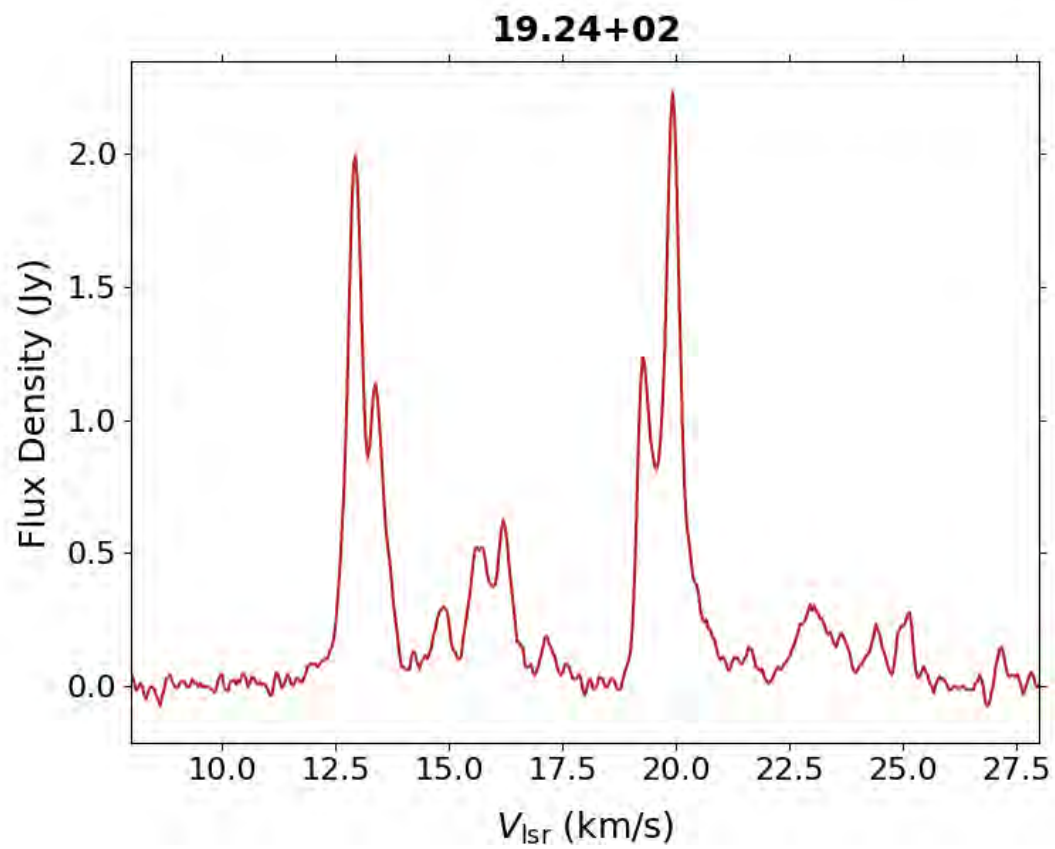
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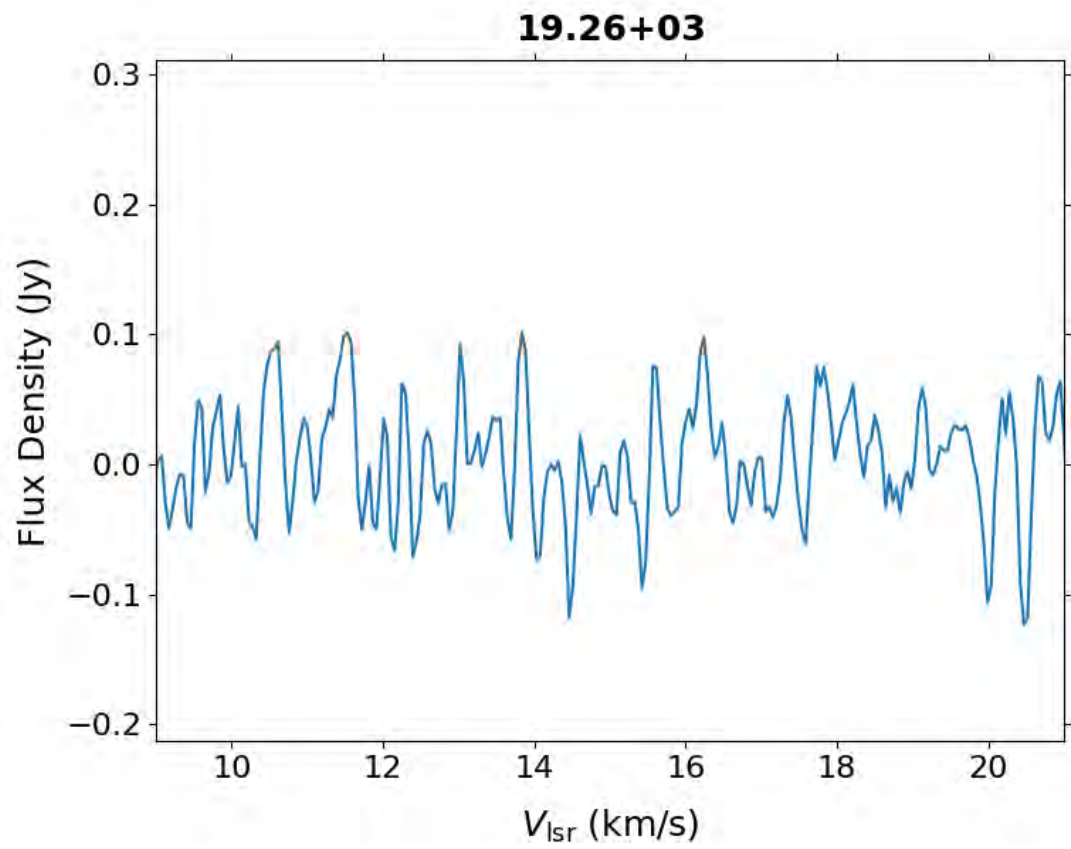
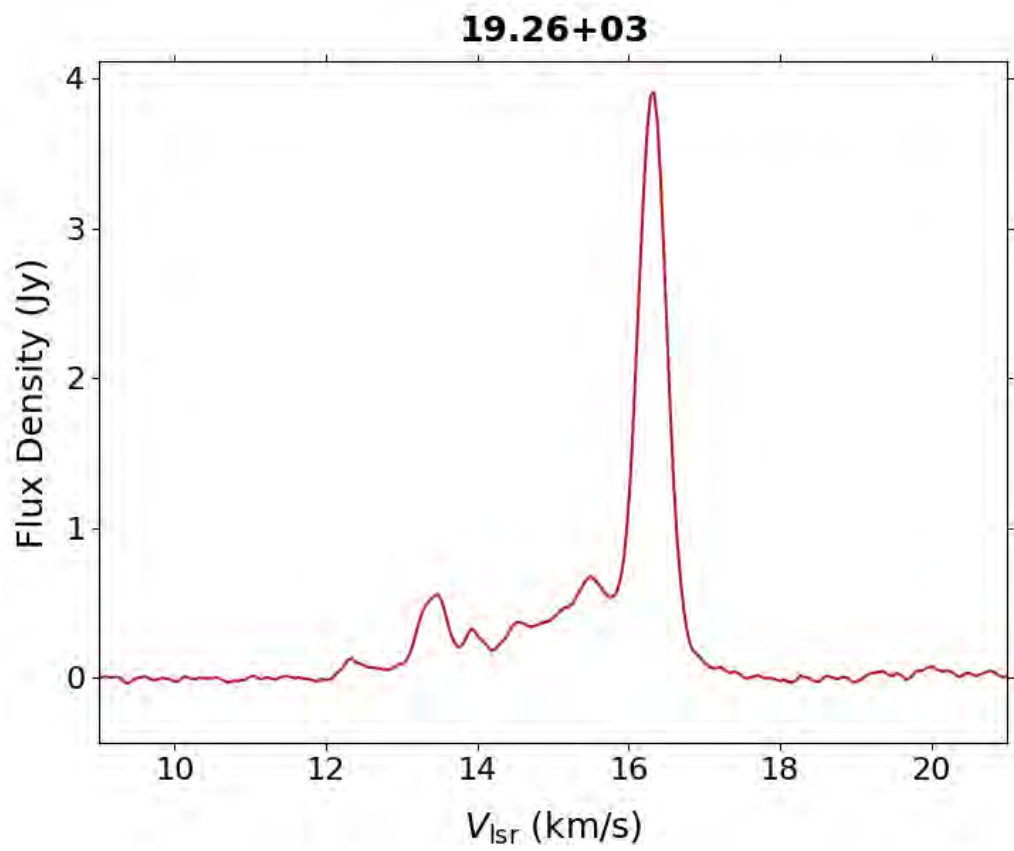


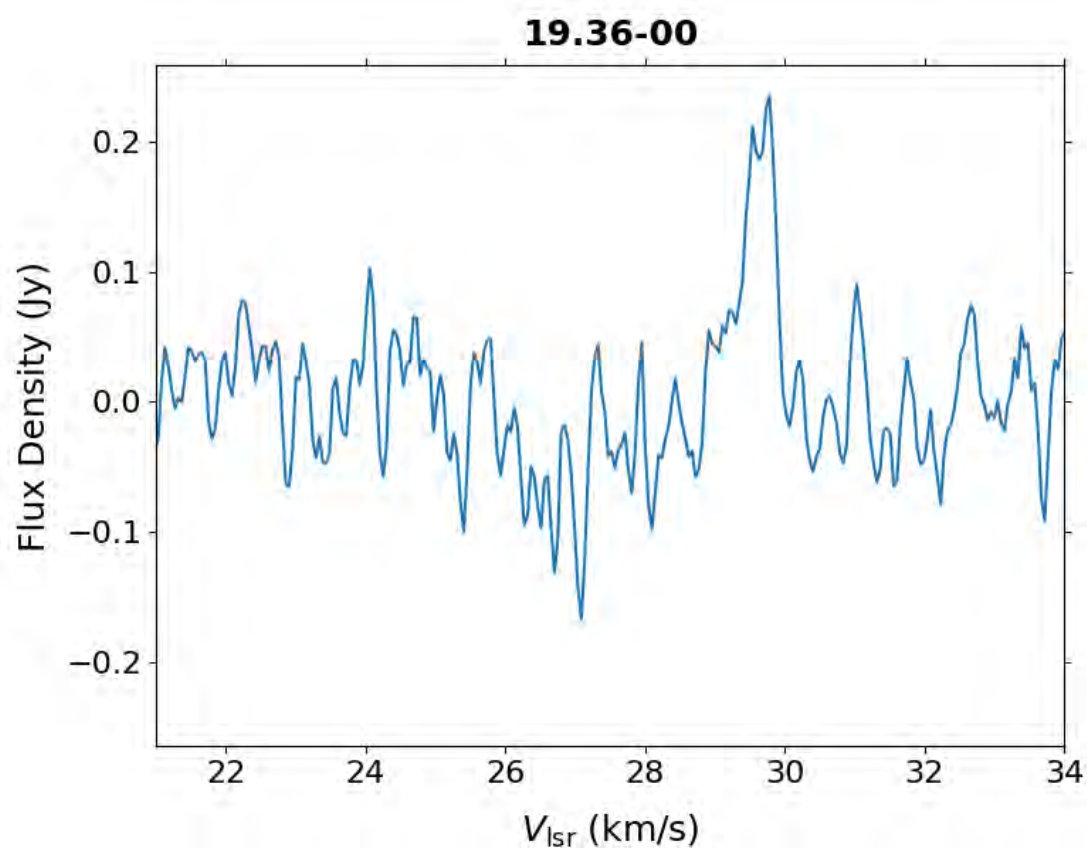
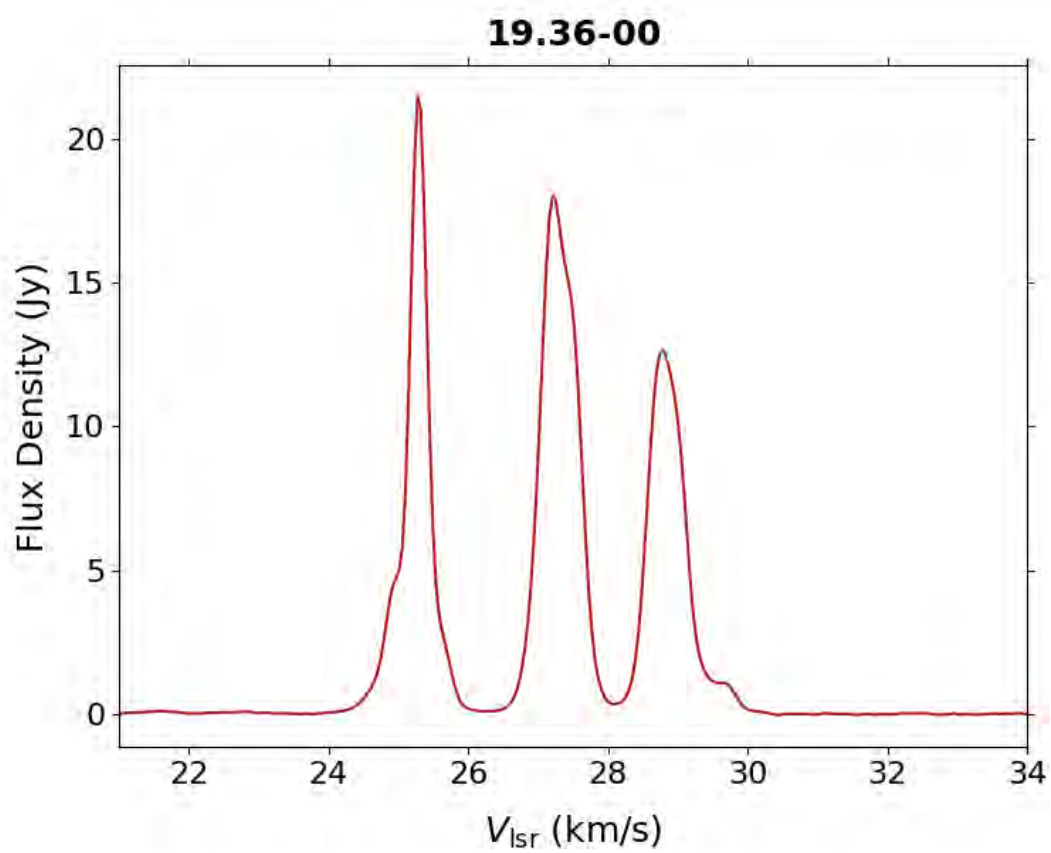
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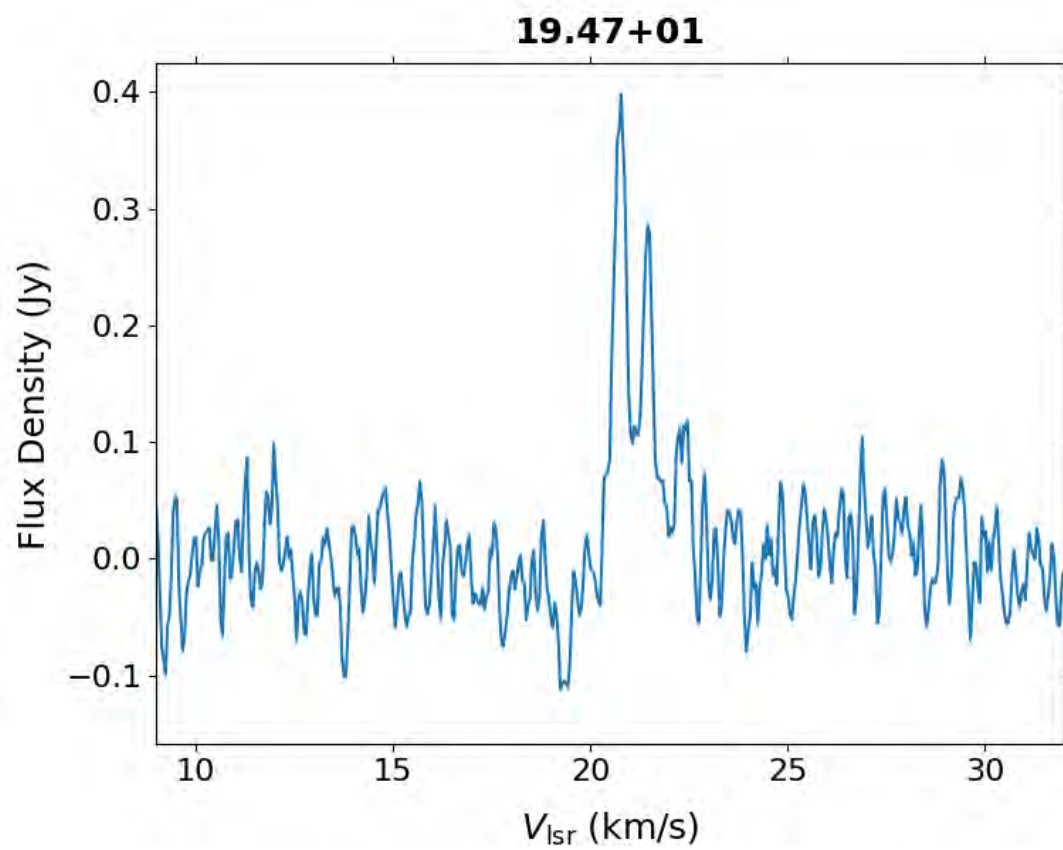
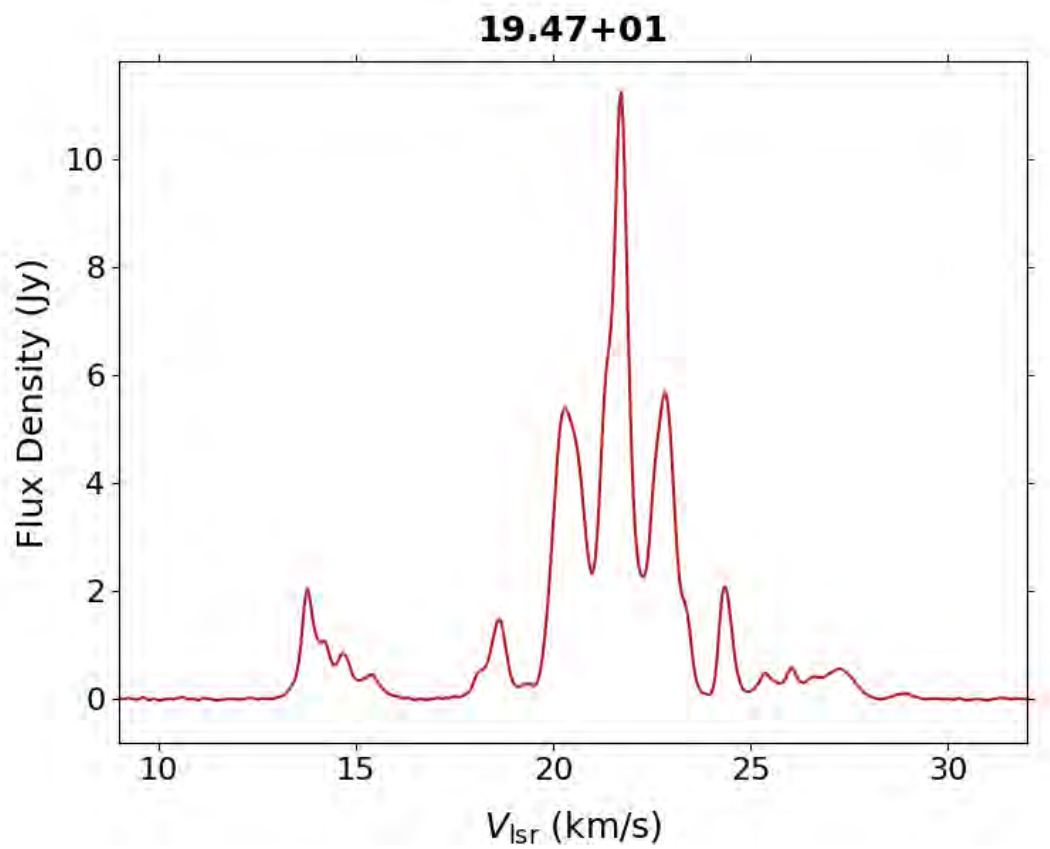


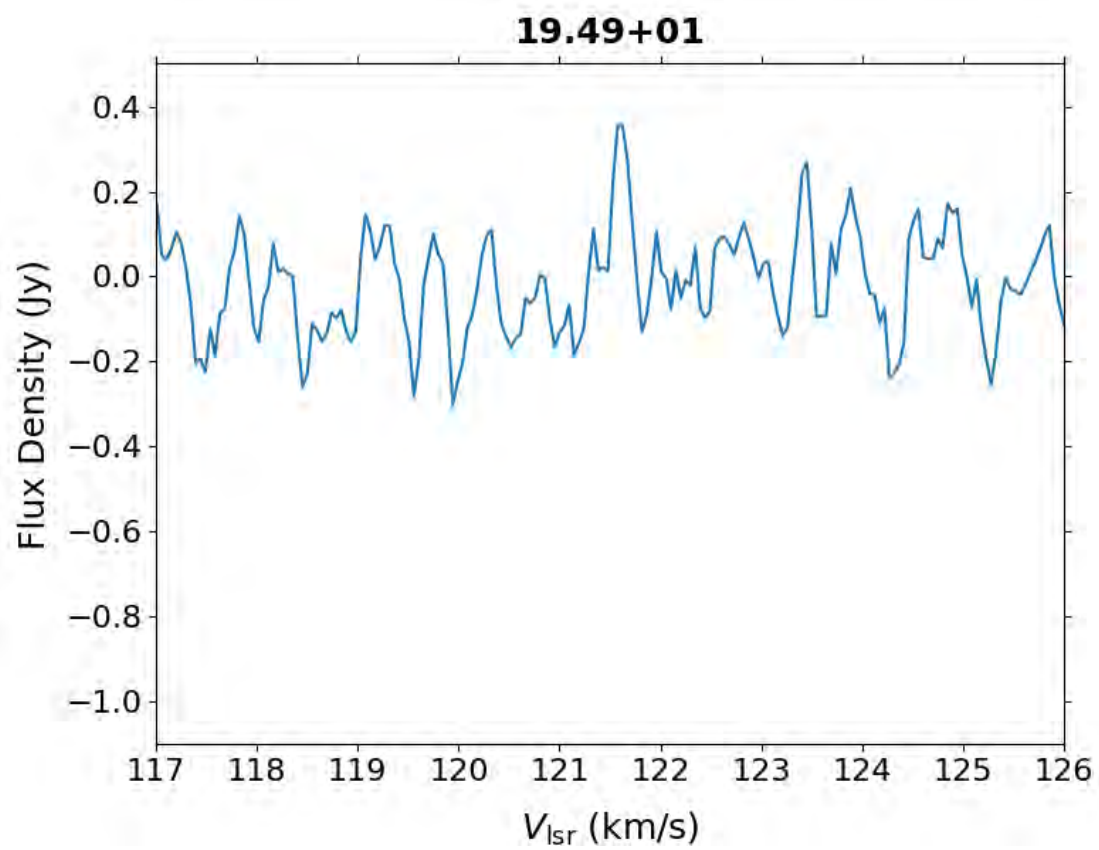
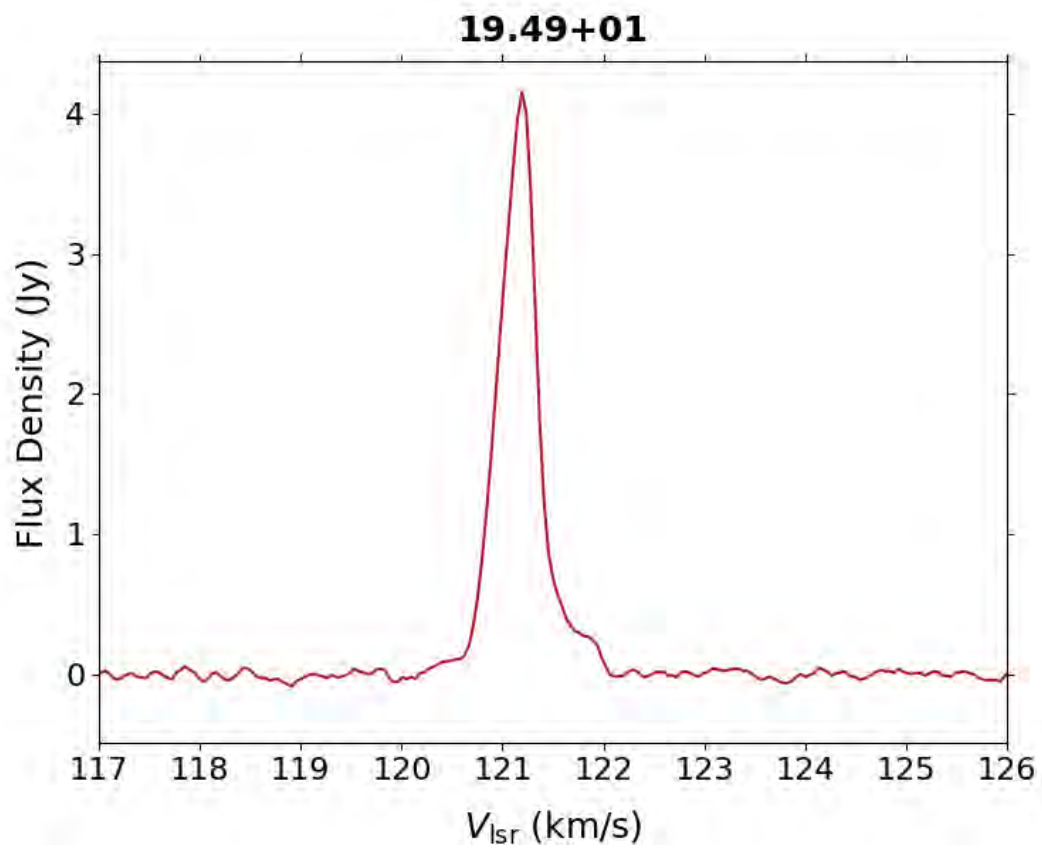




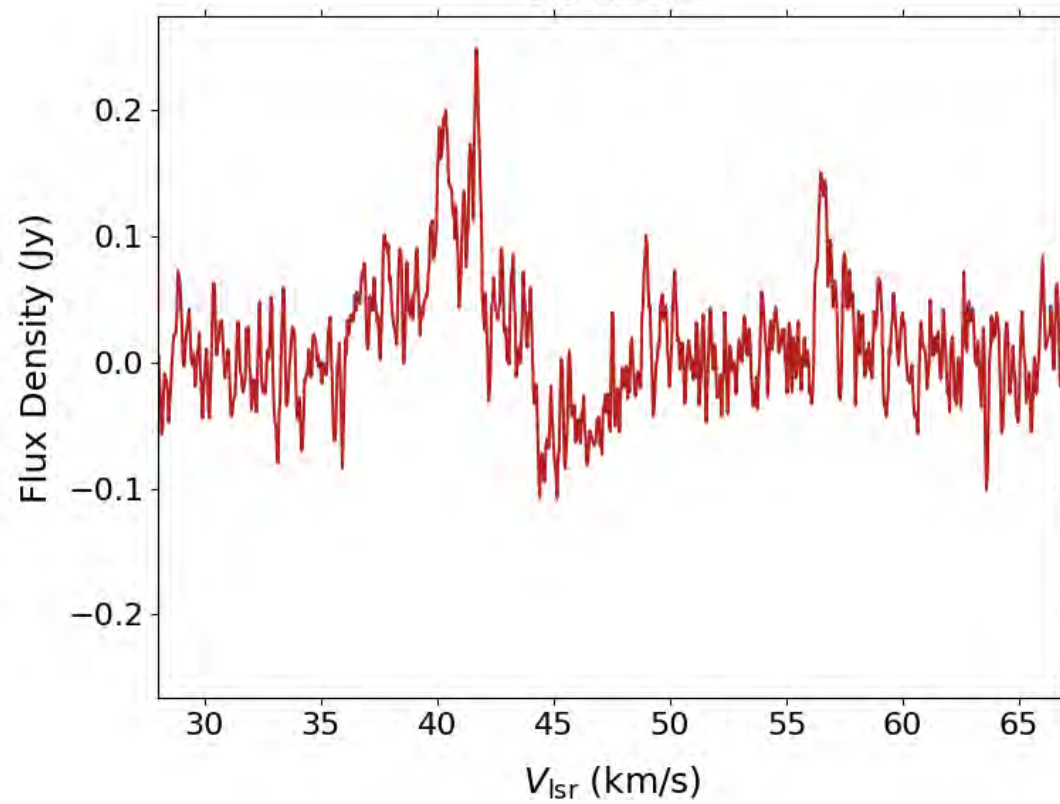




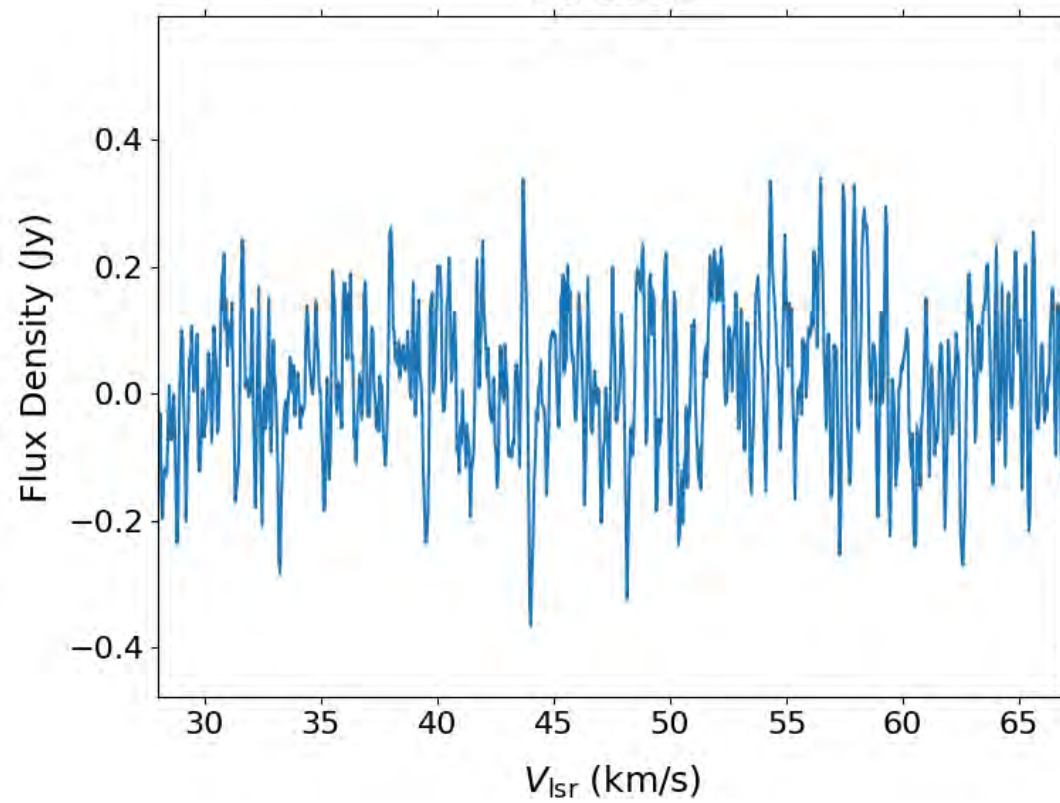


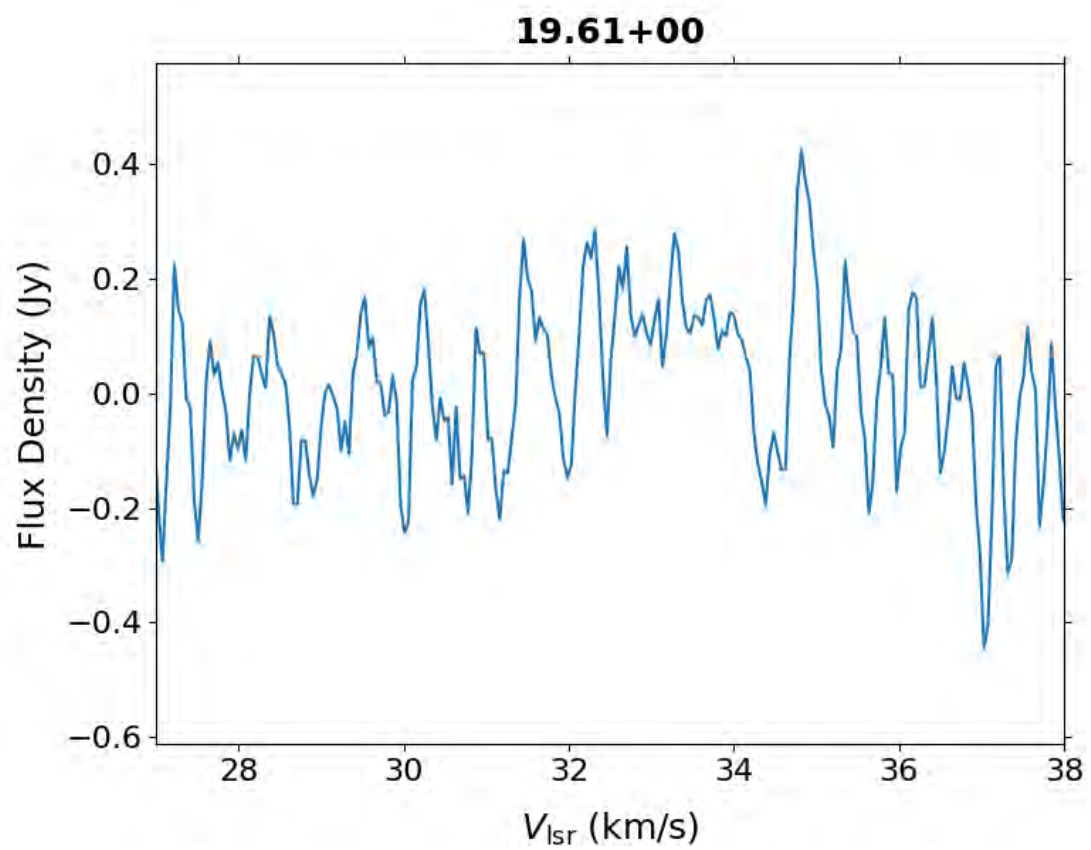
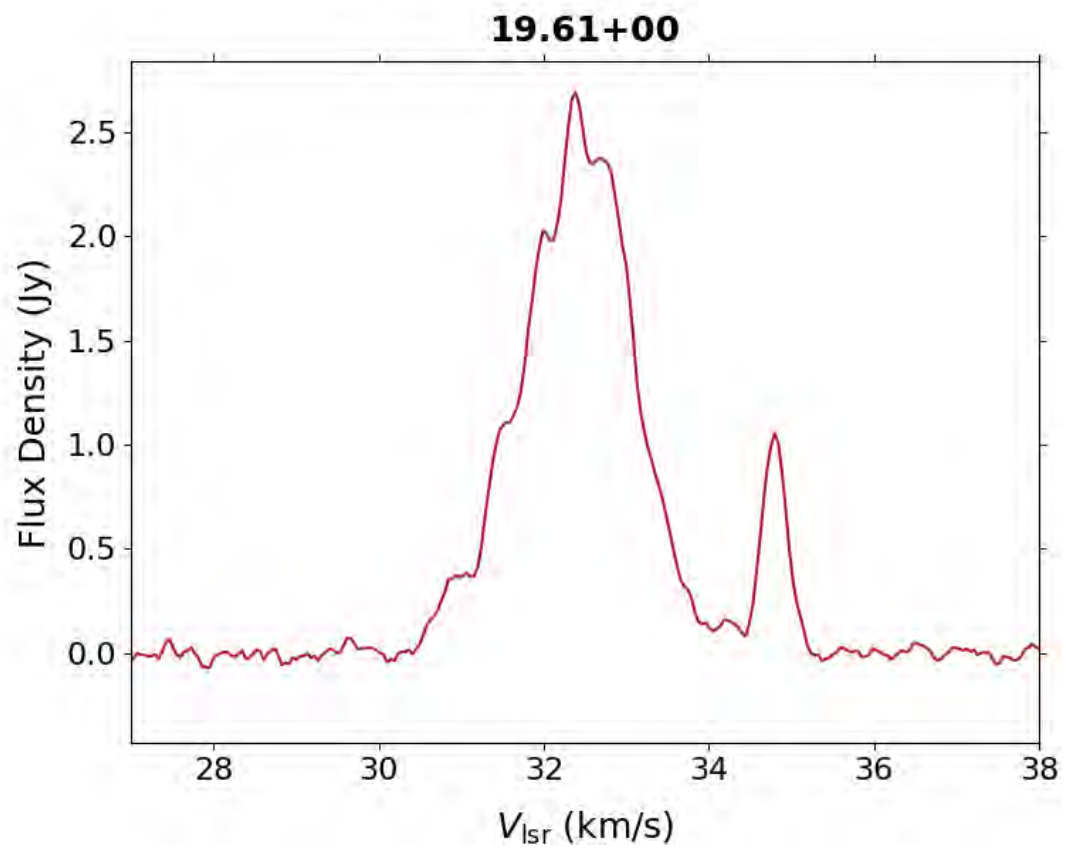


19.60-02

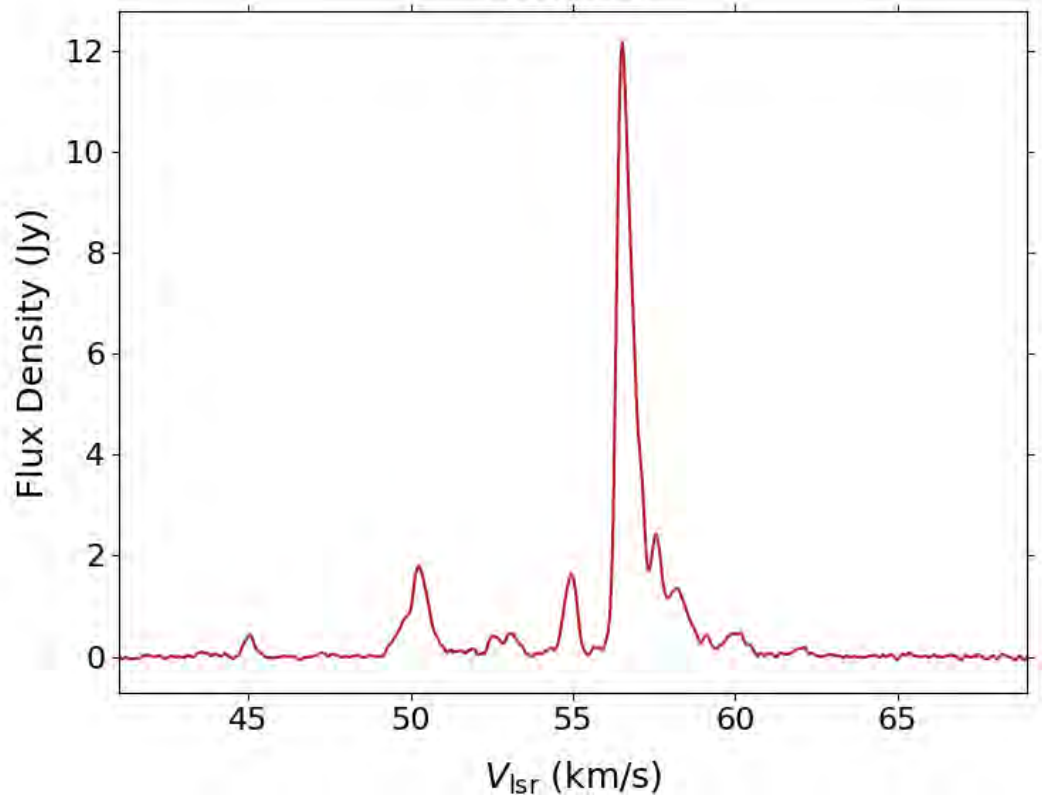


19.60-02

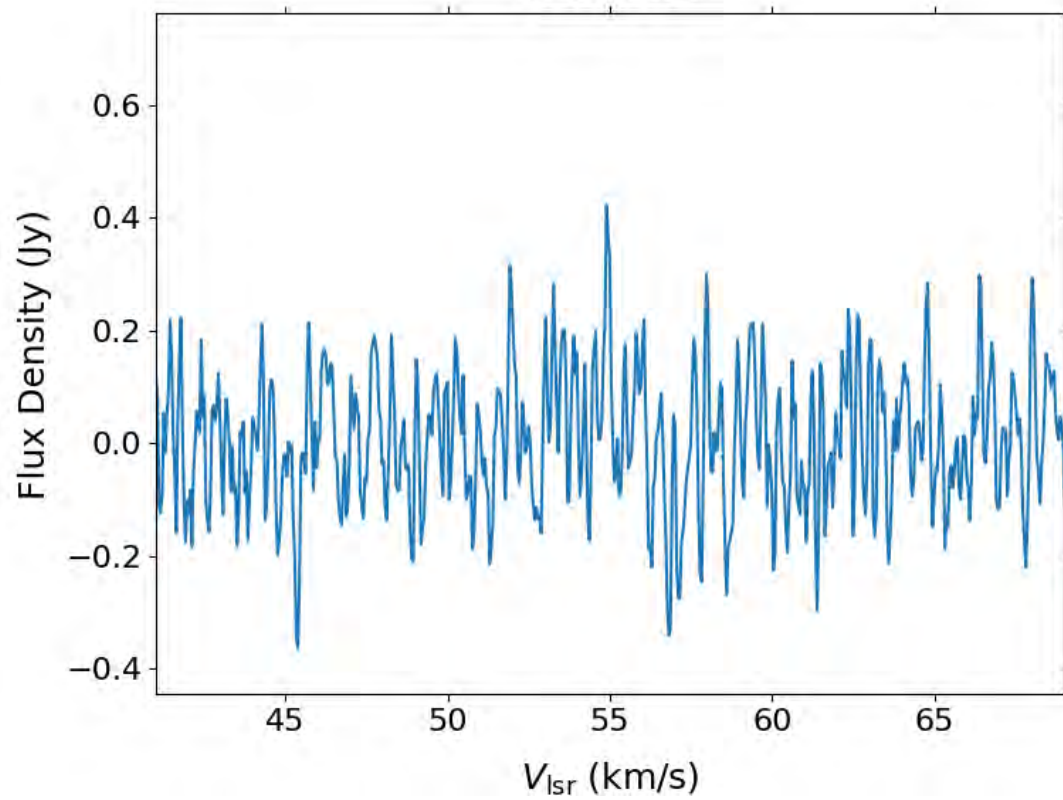


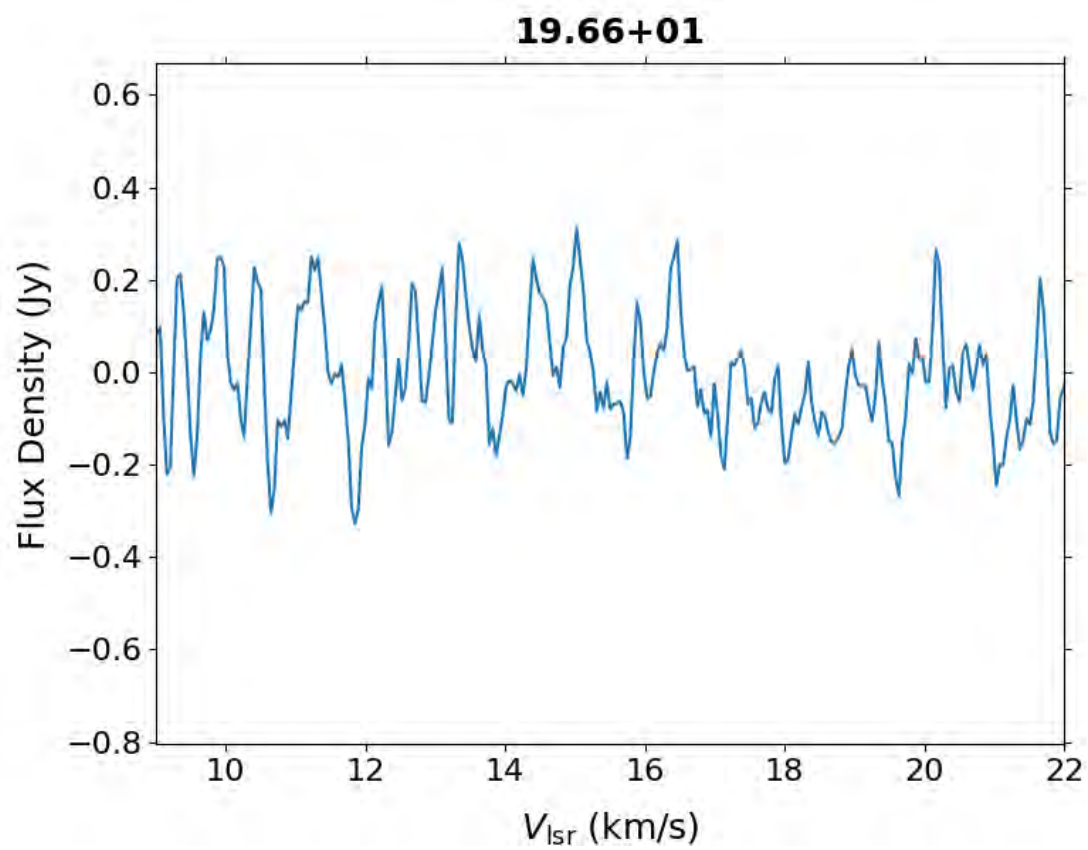
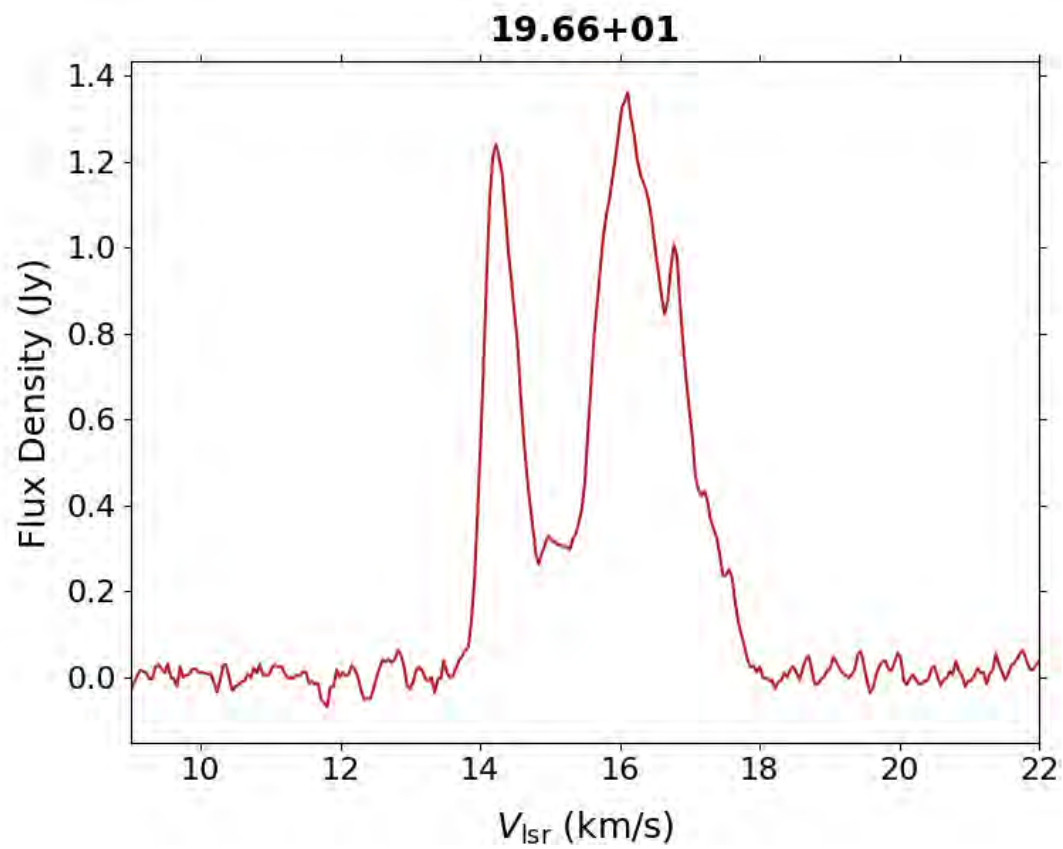


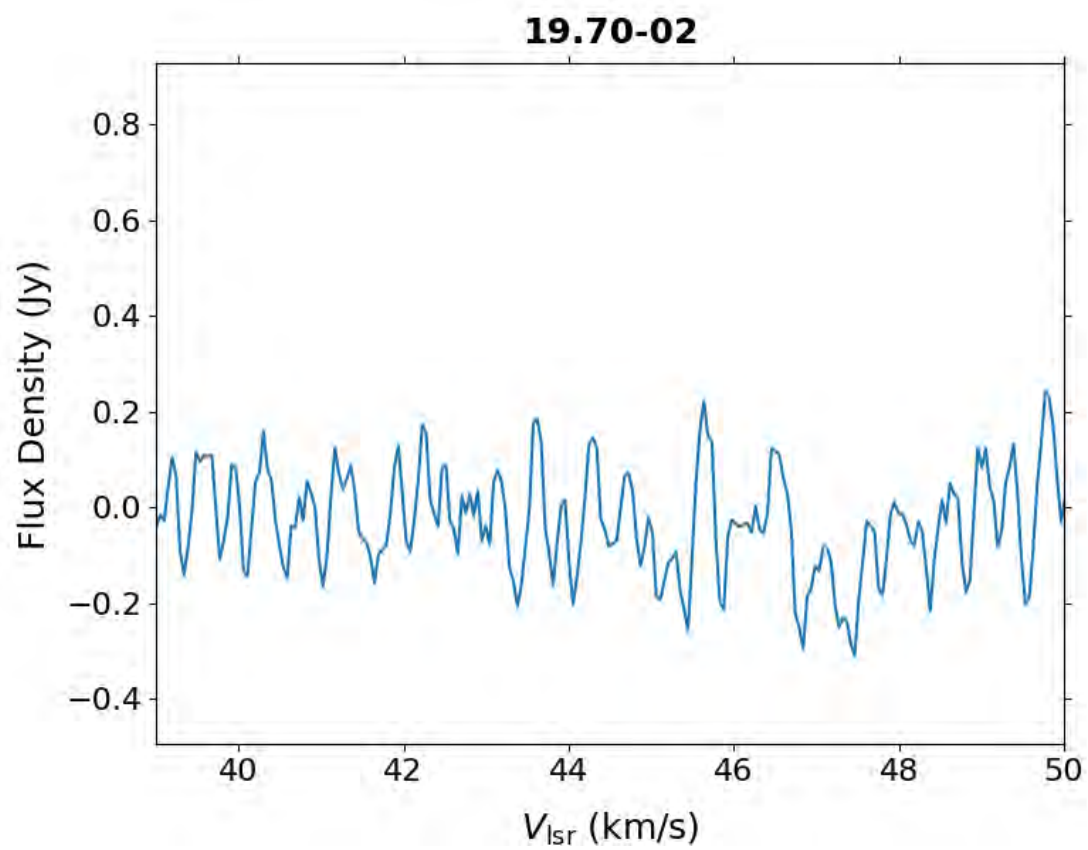
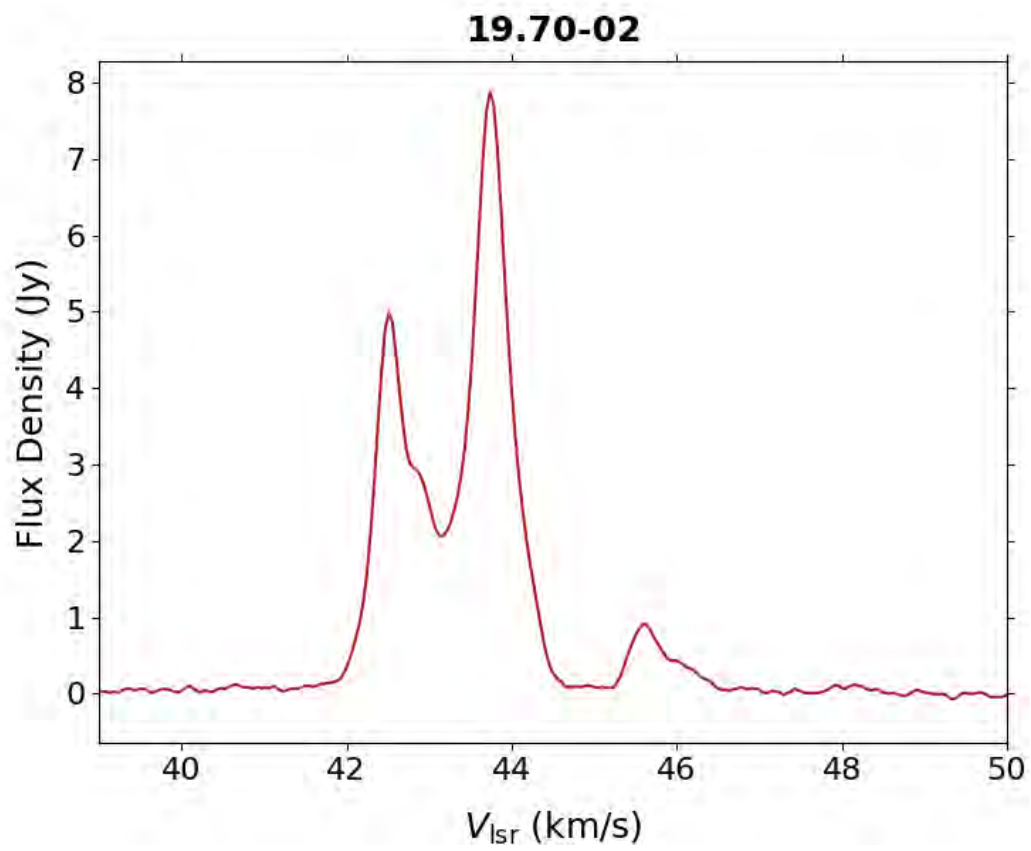
19.61-01



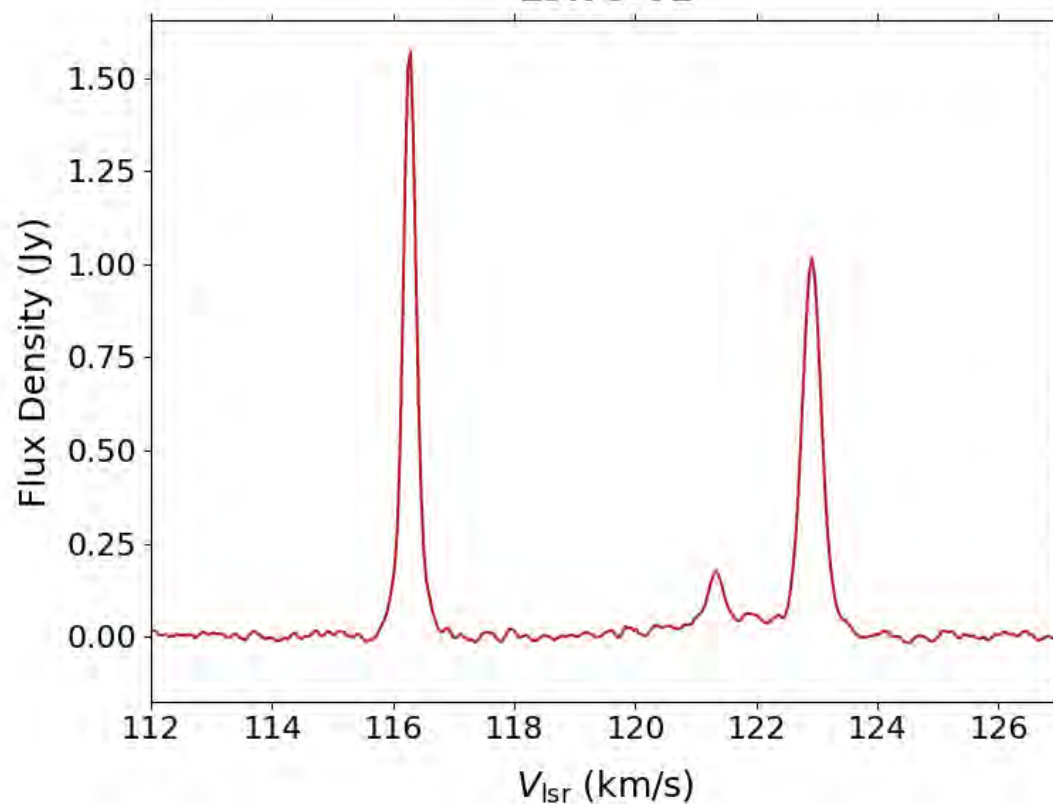
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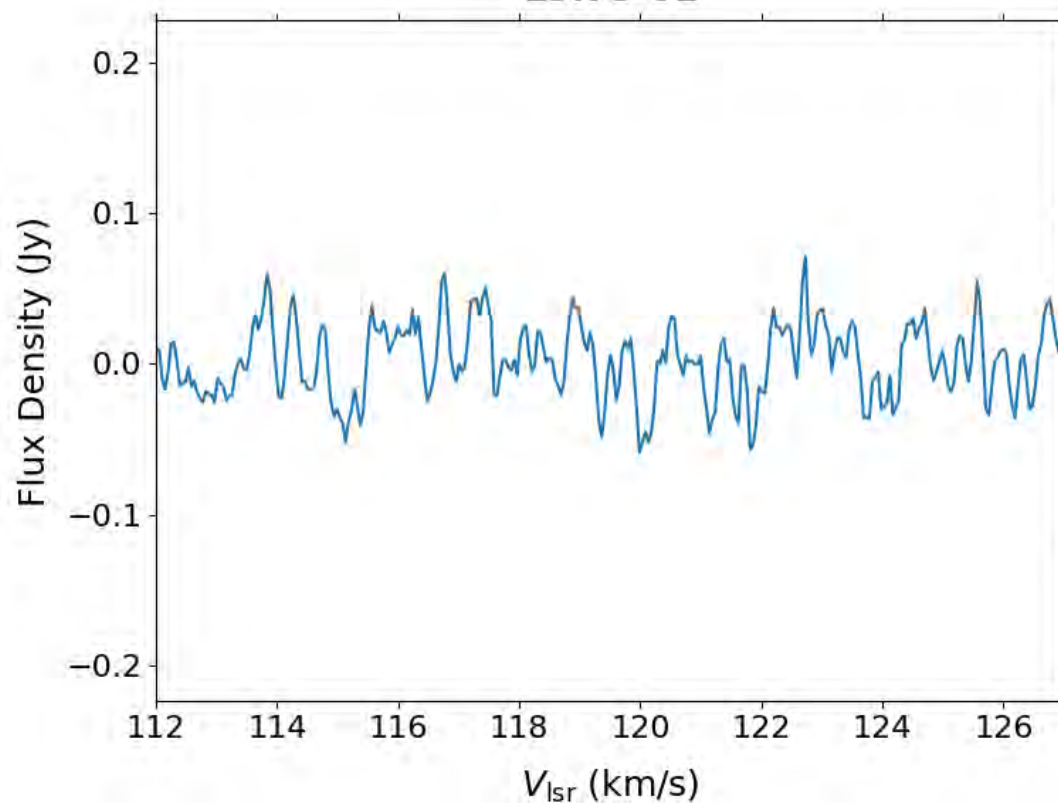




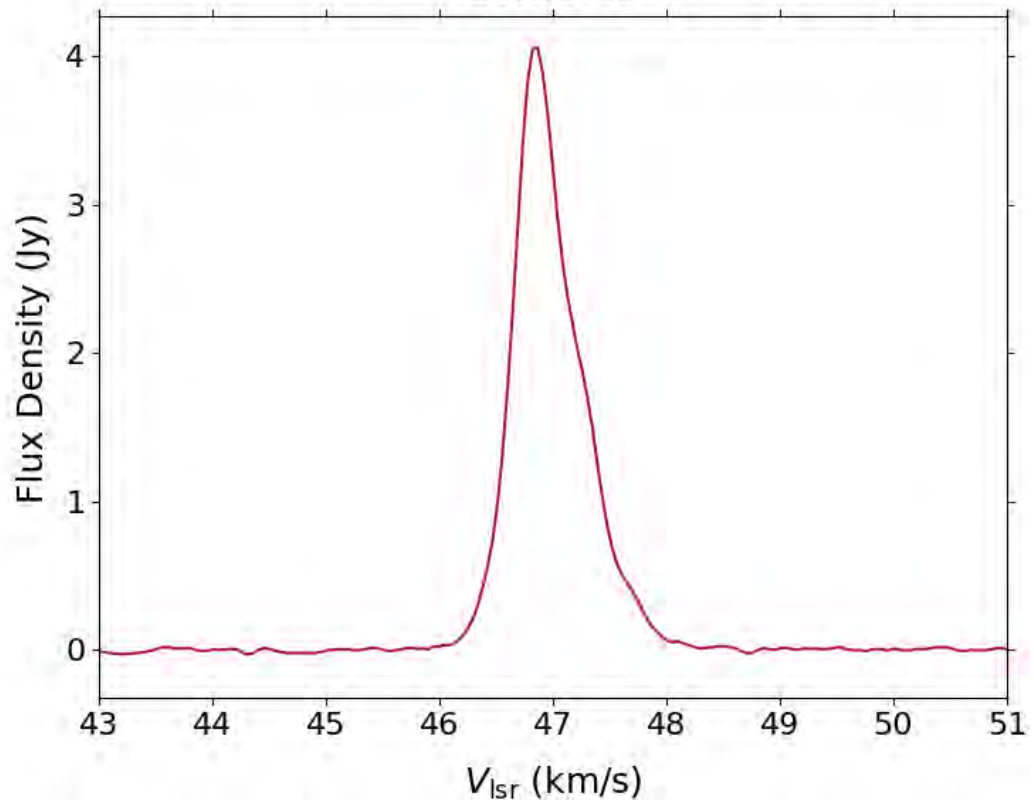
19.75-01



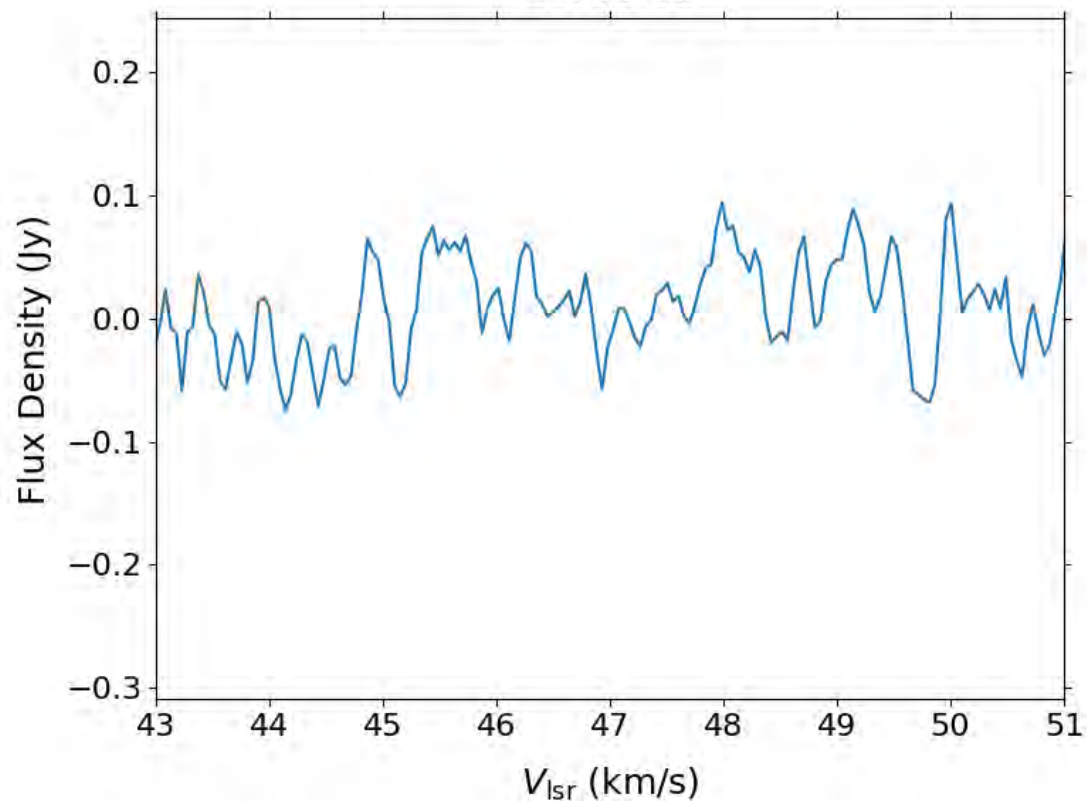
19.75-01



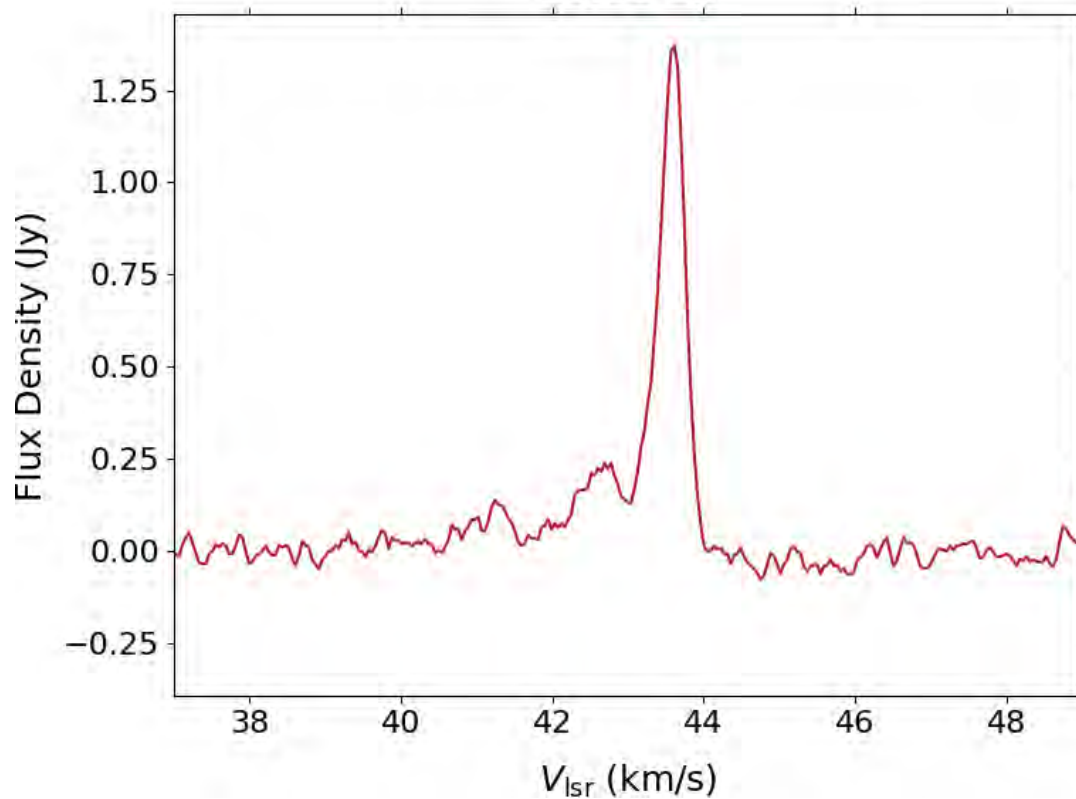
19.88-05



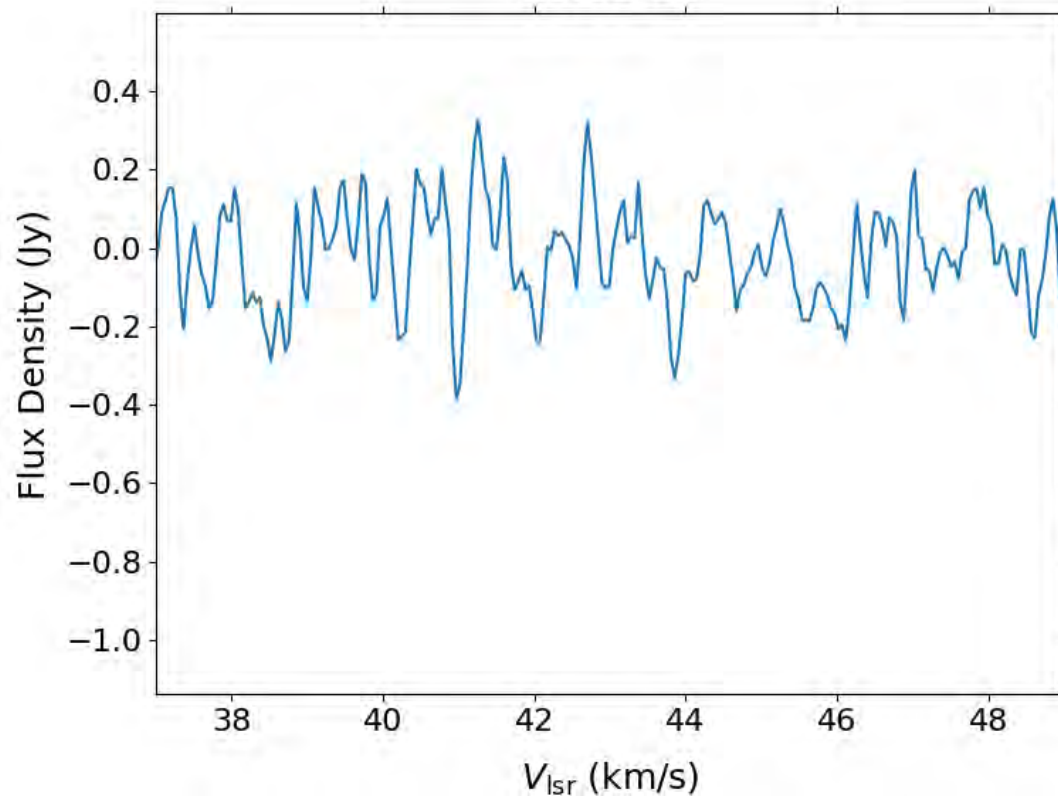
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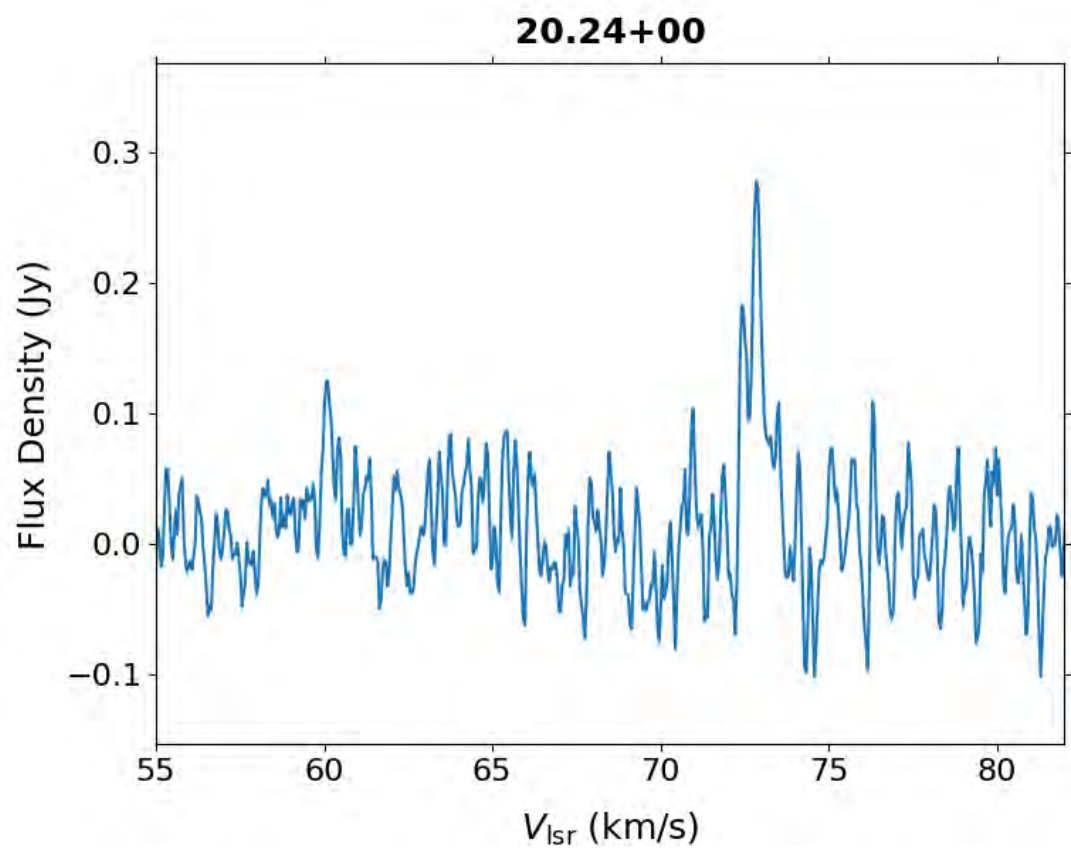
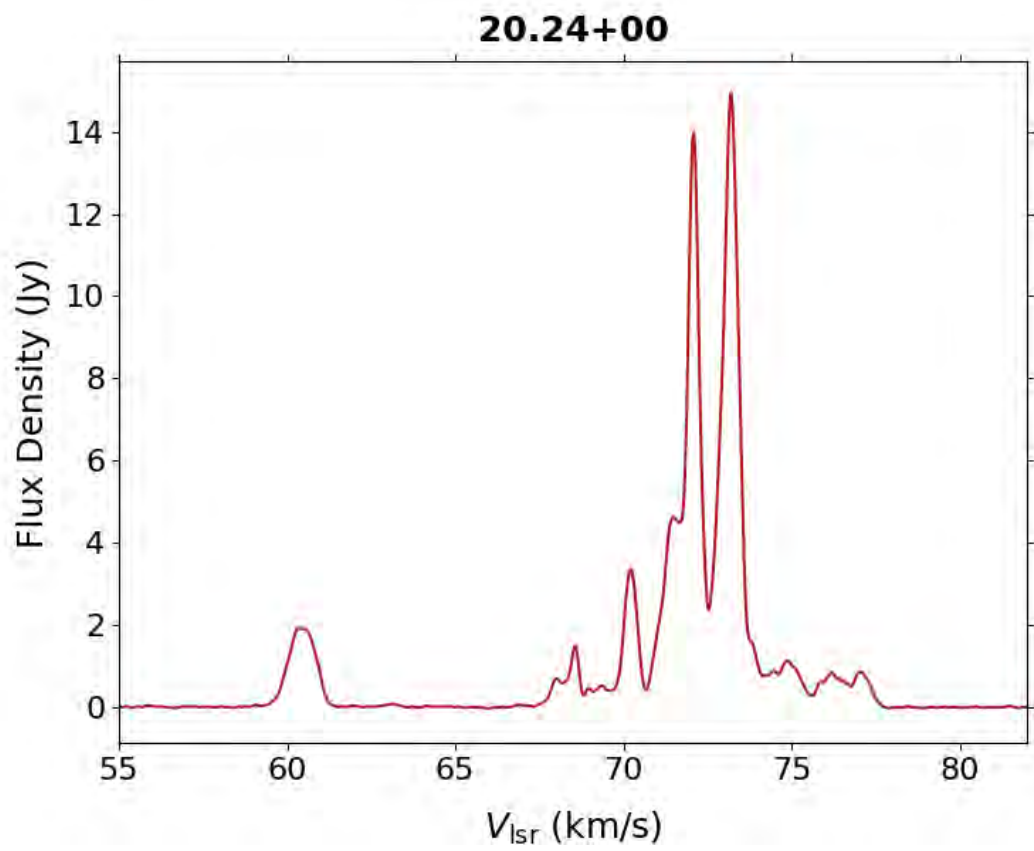


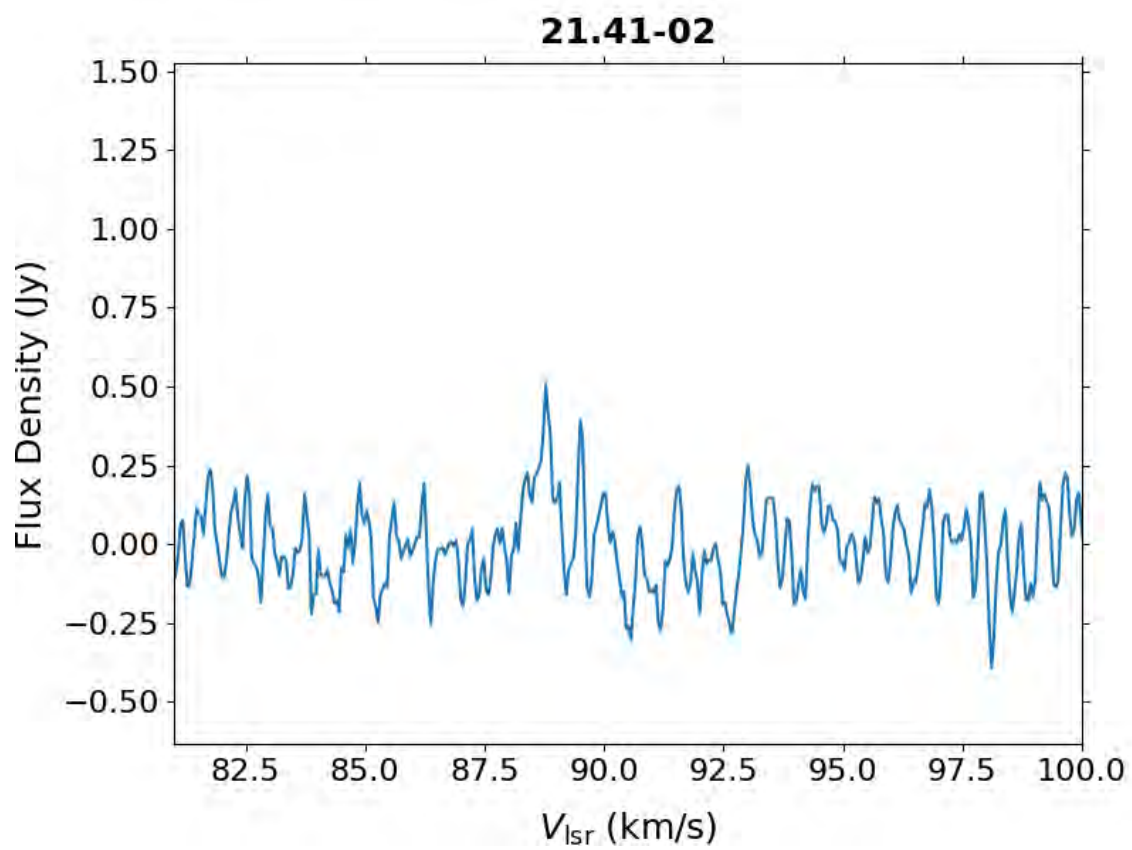
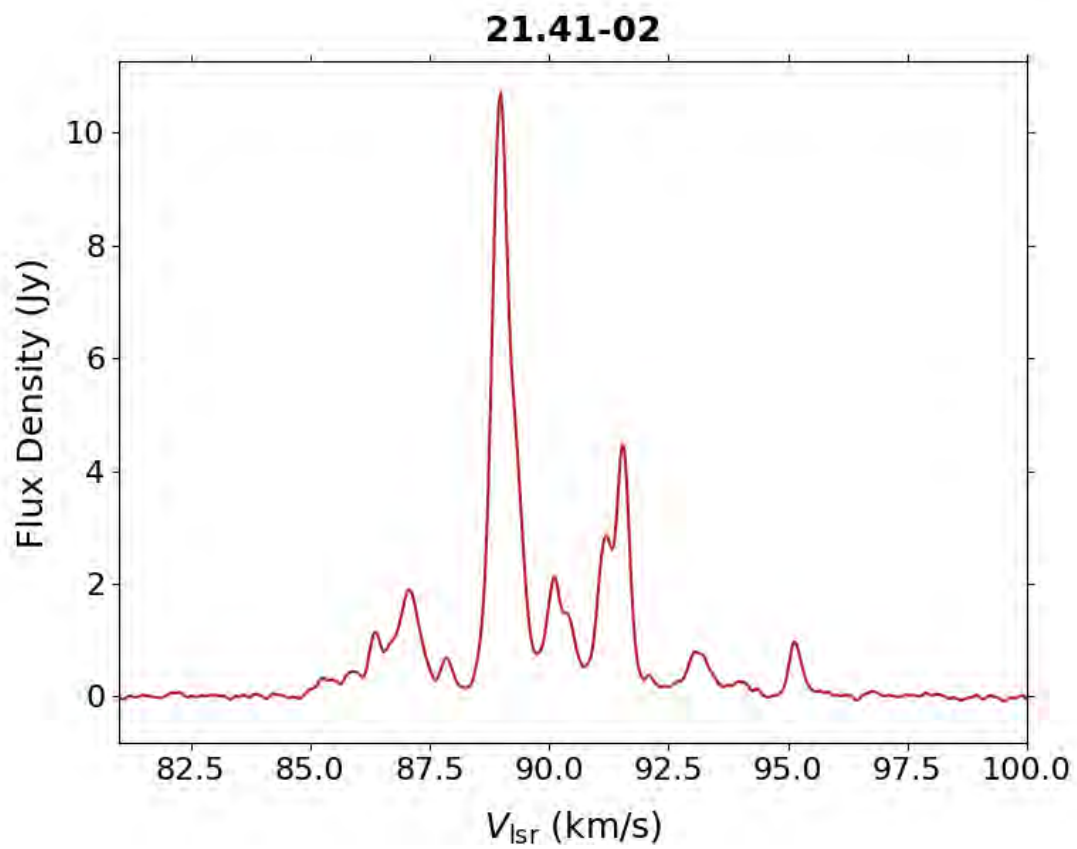
20.08-01



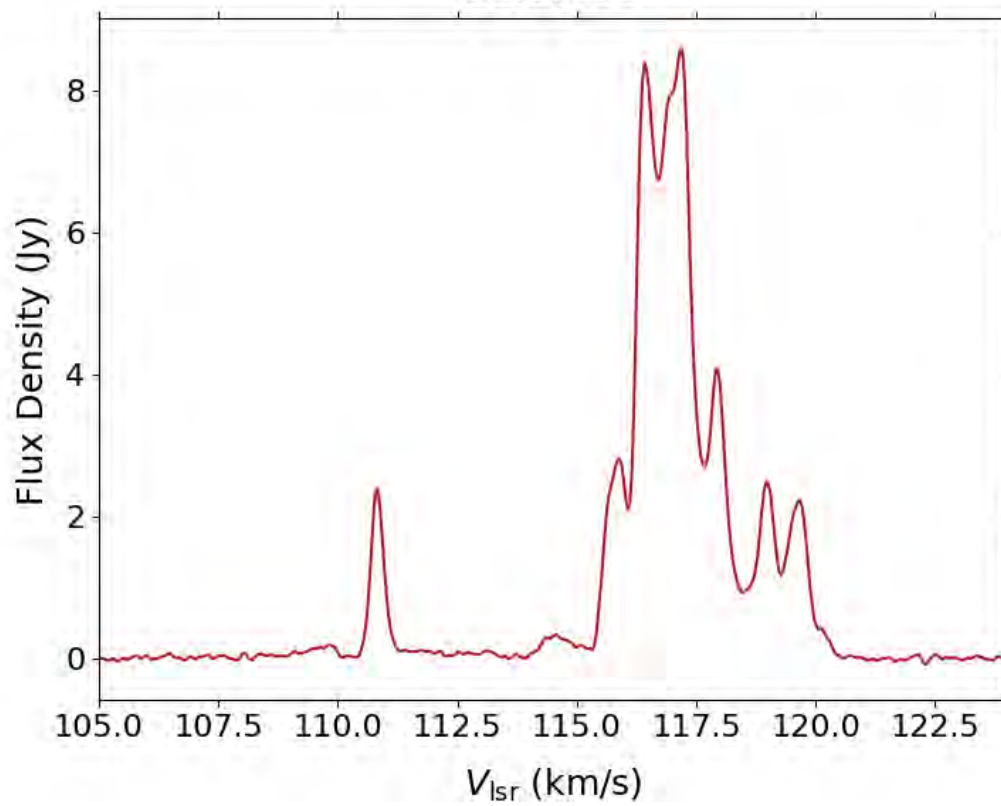
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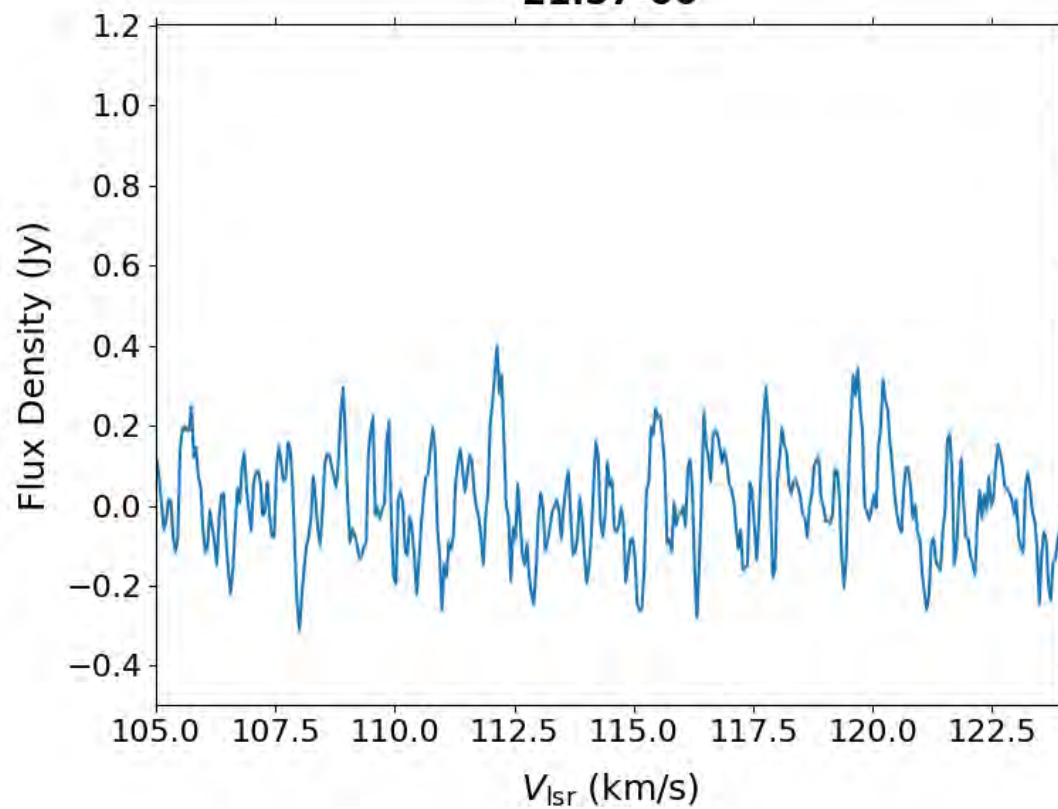


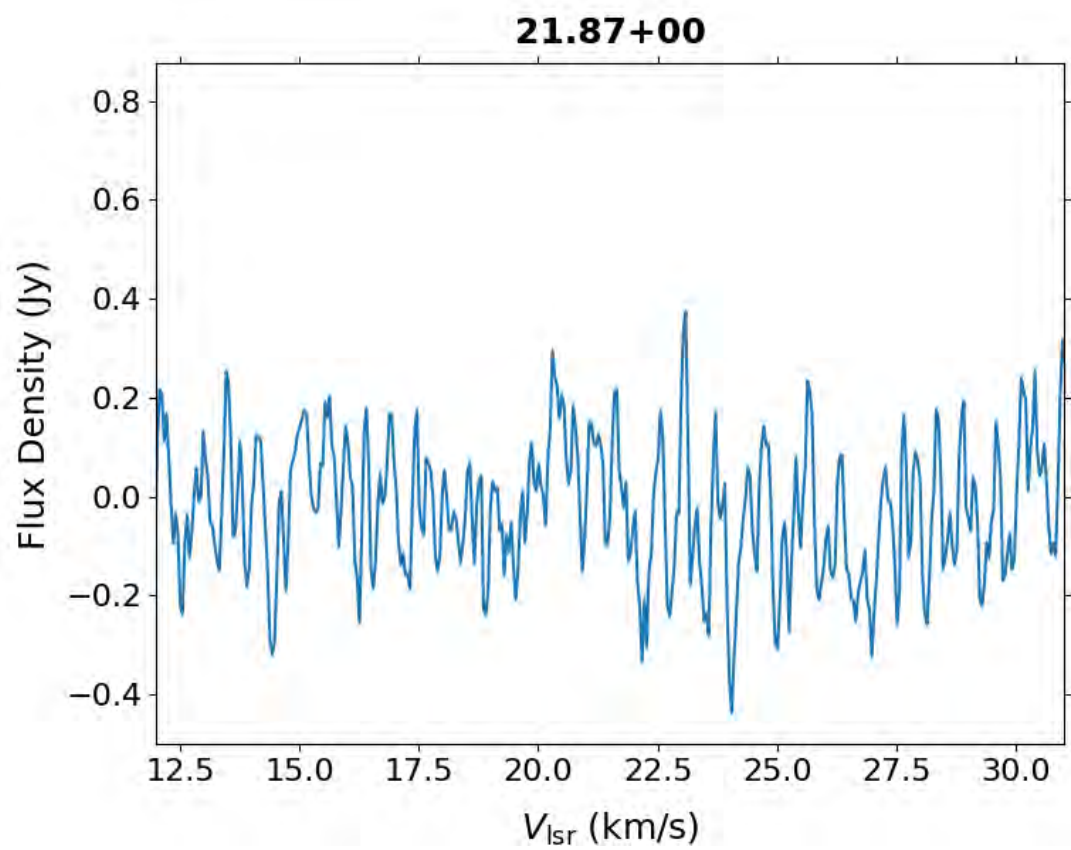
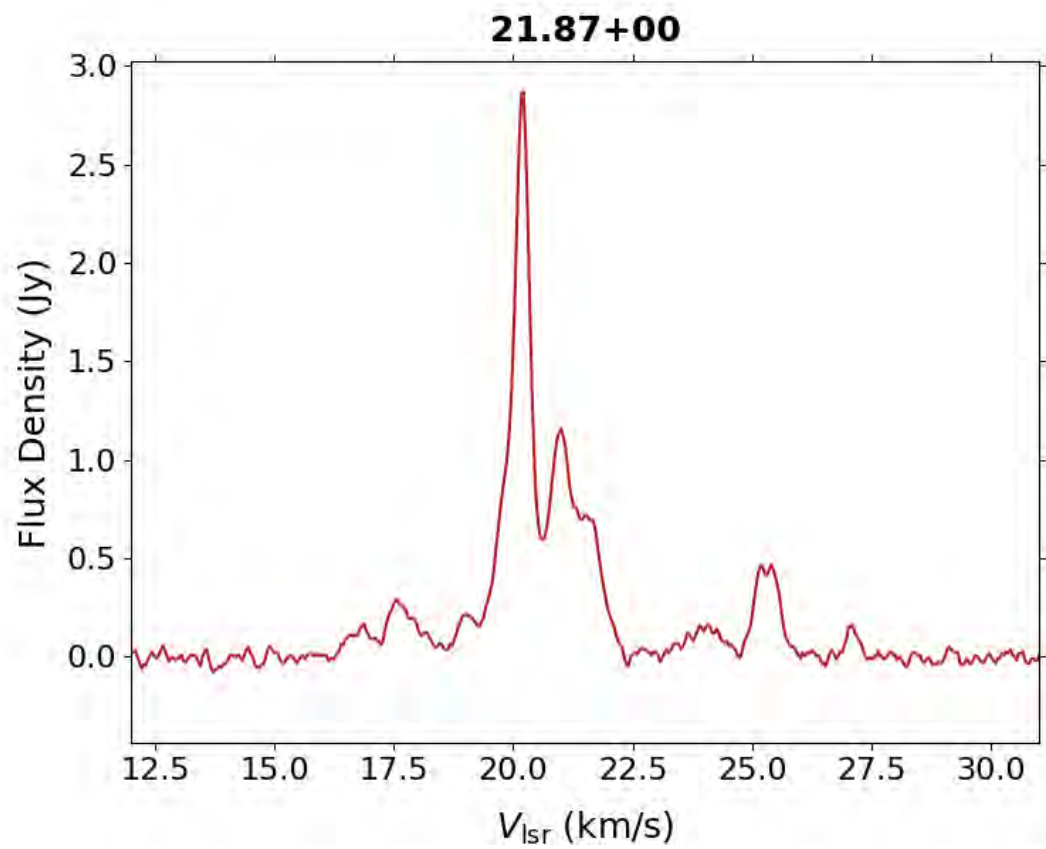


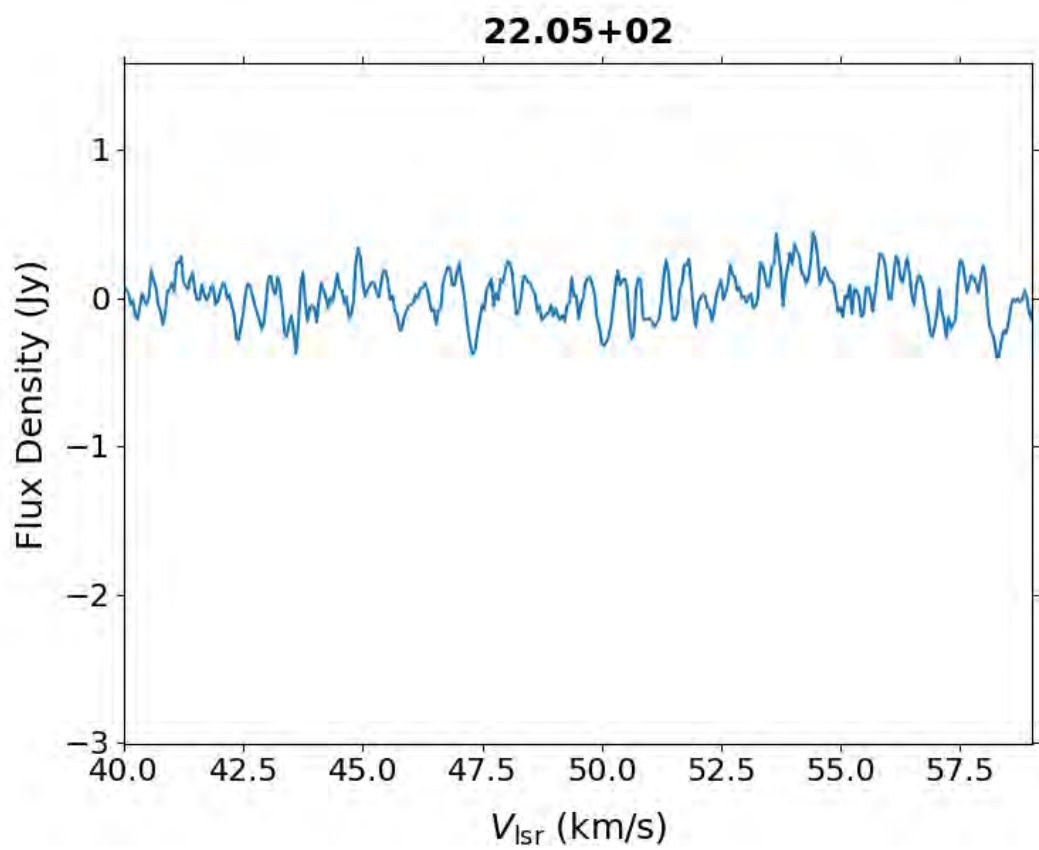
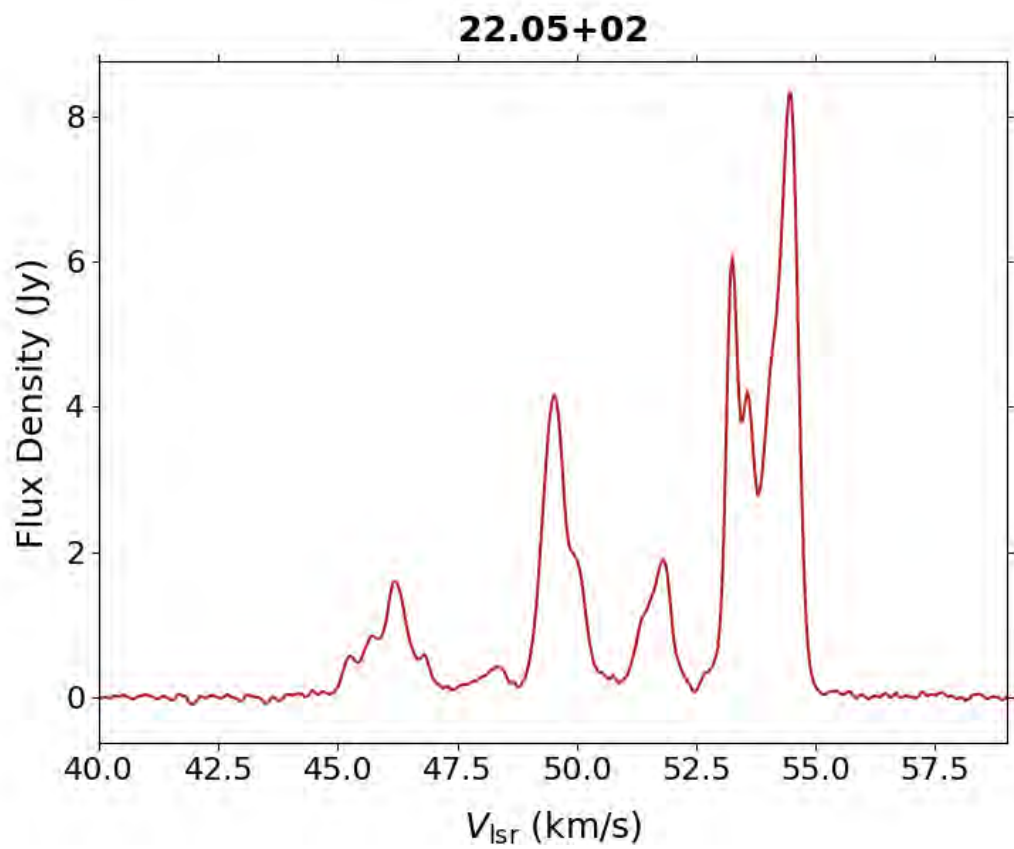
21.57-00



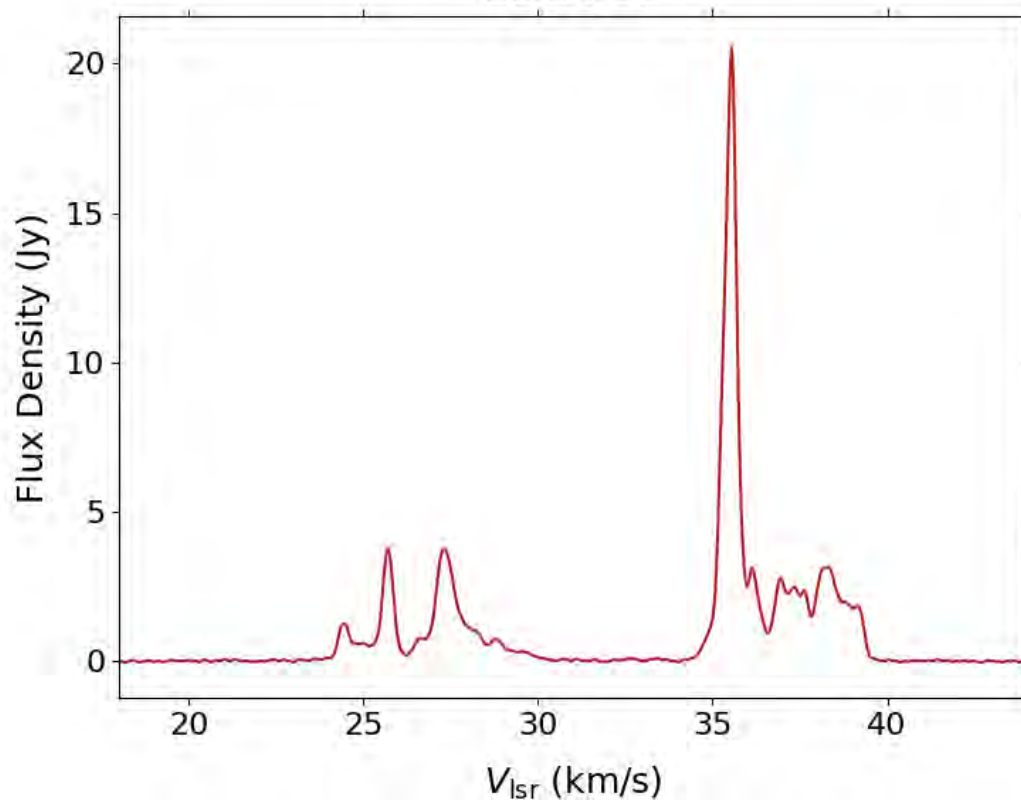
21.57-00



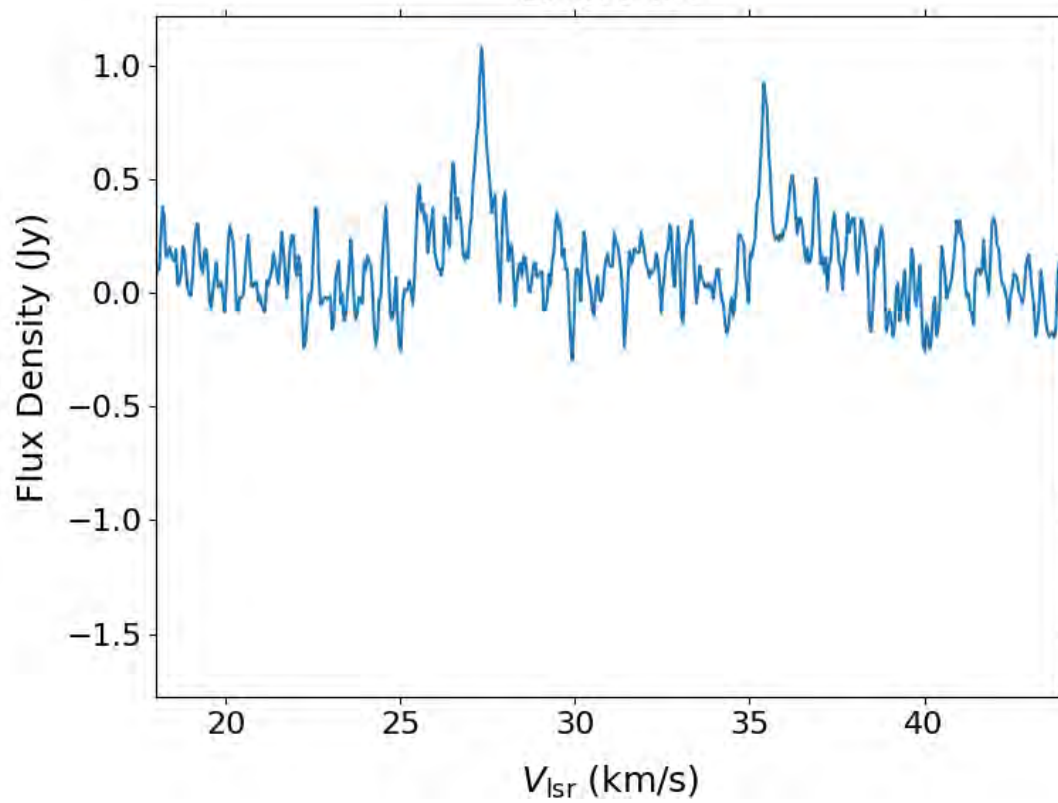


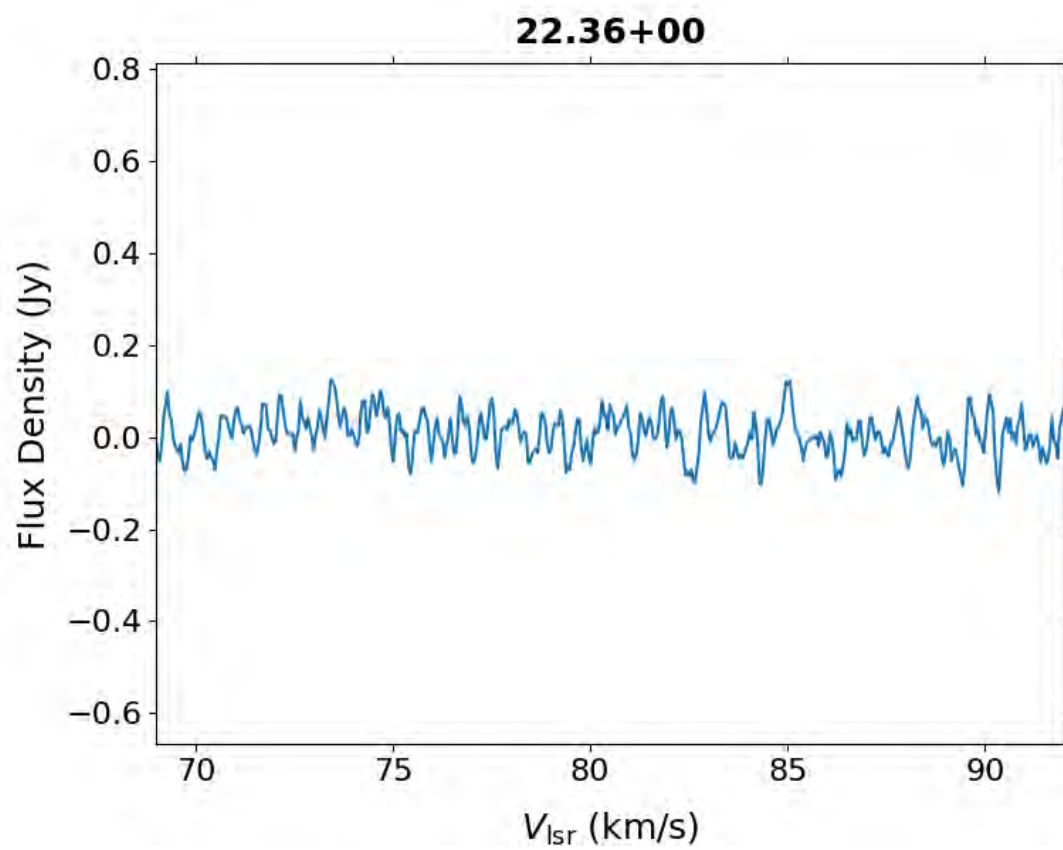
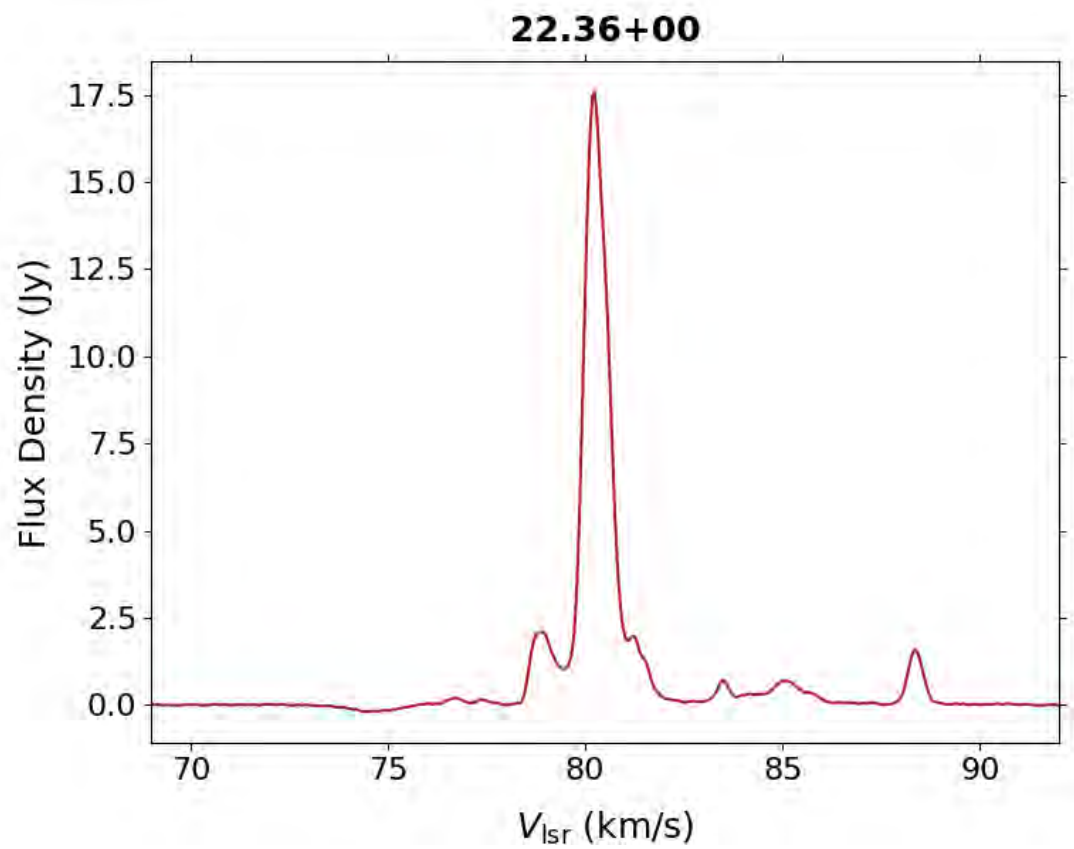


22.34-01

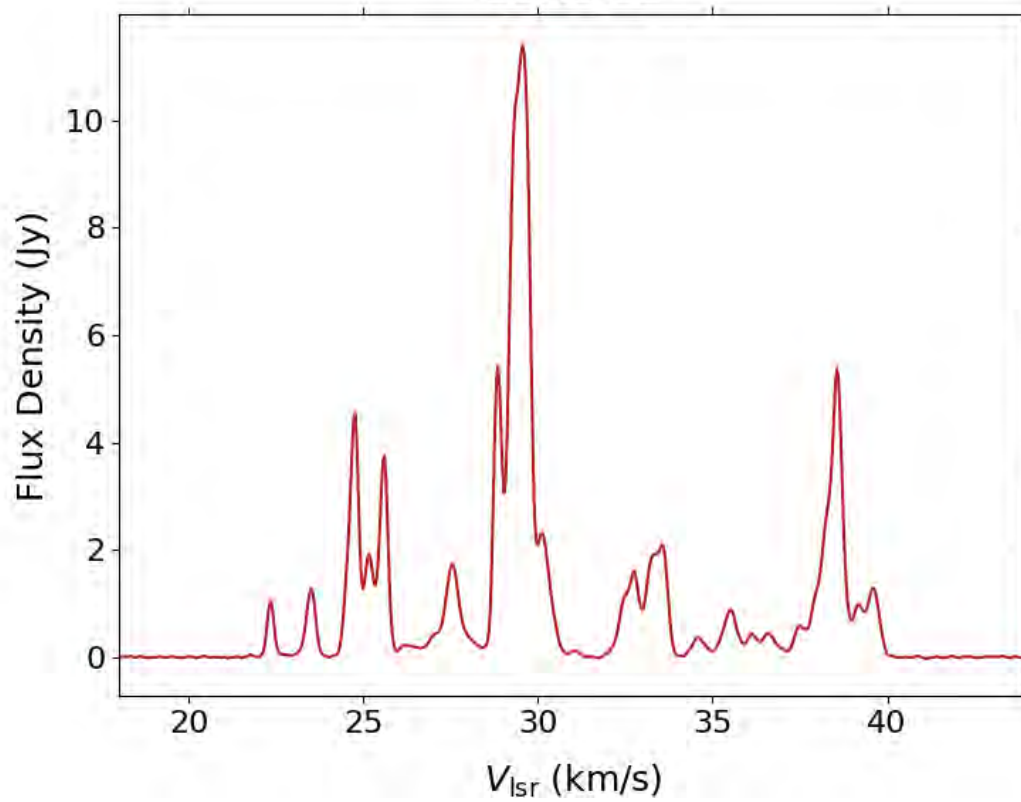


22.34-01

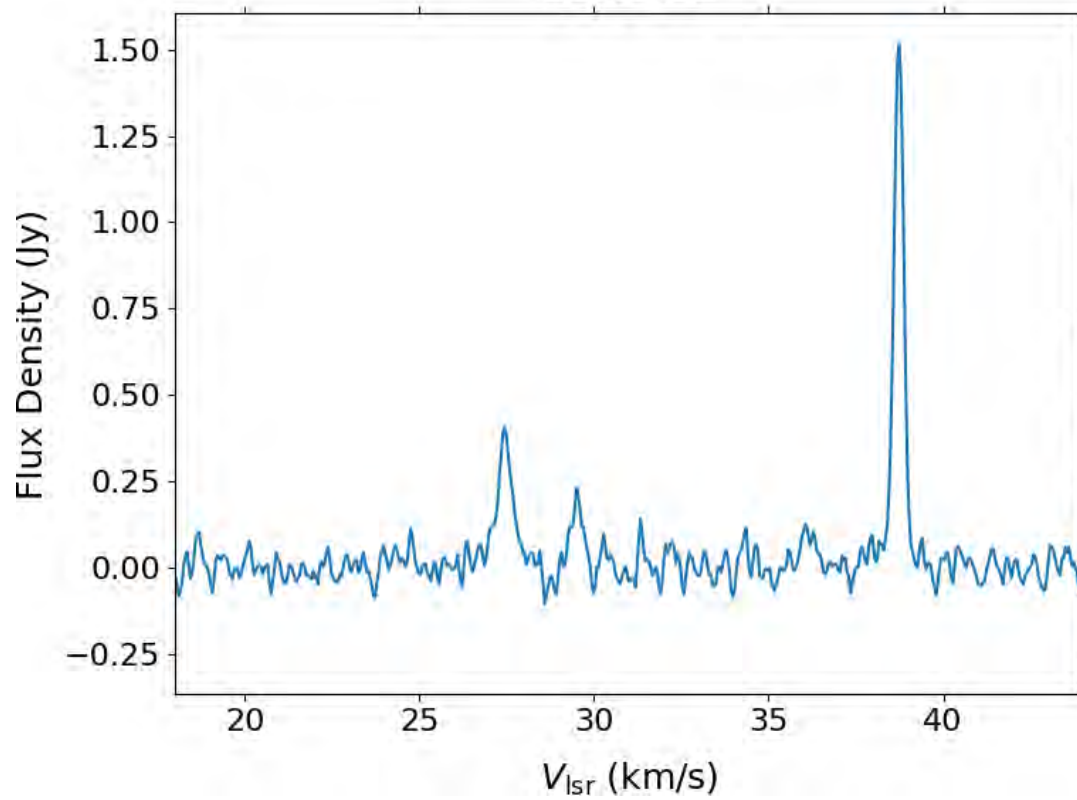


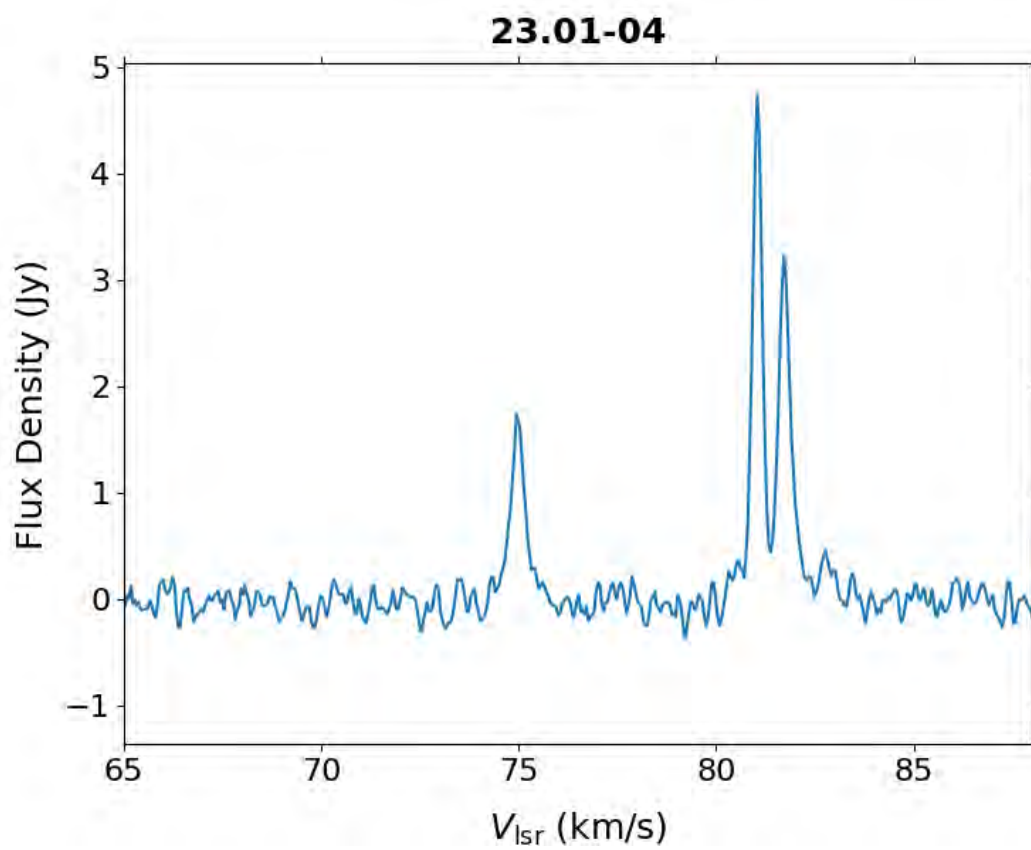
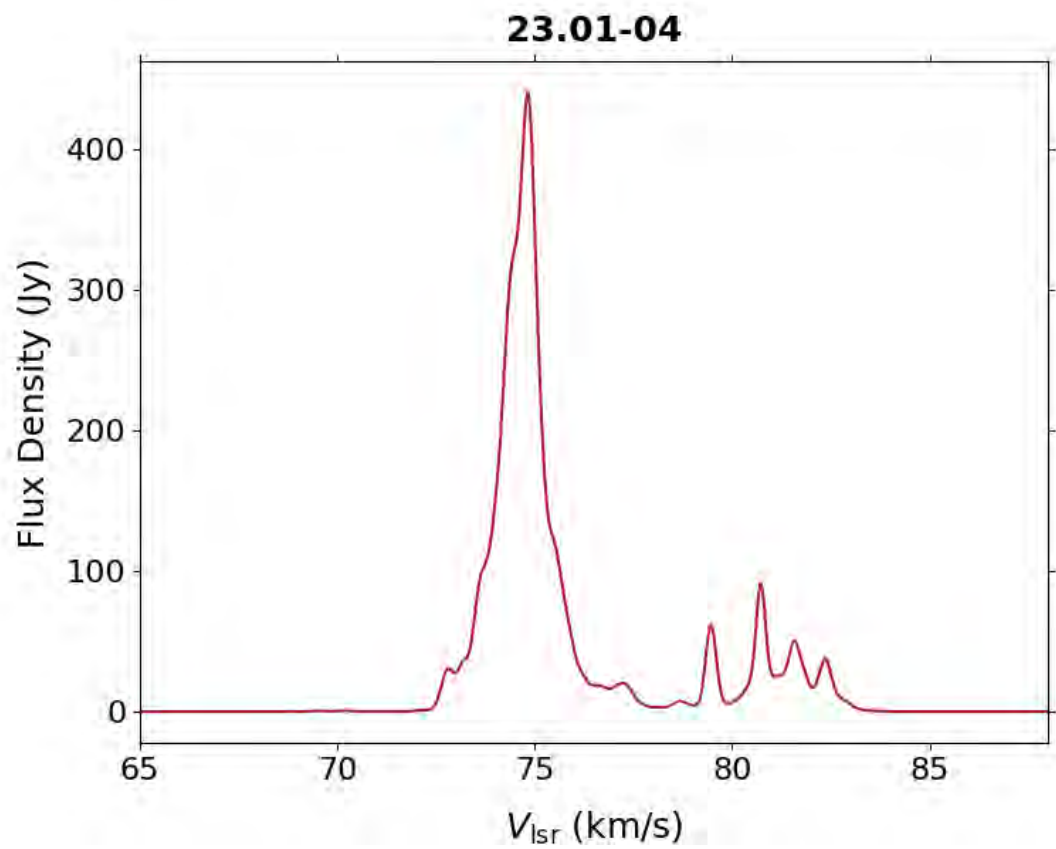


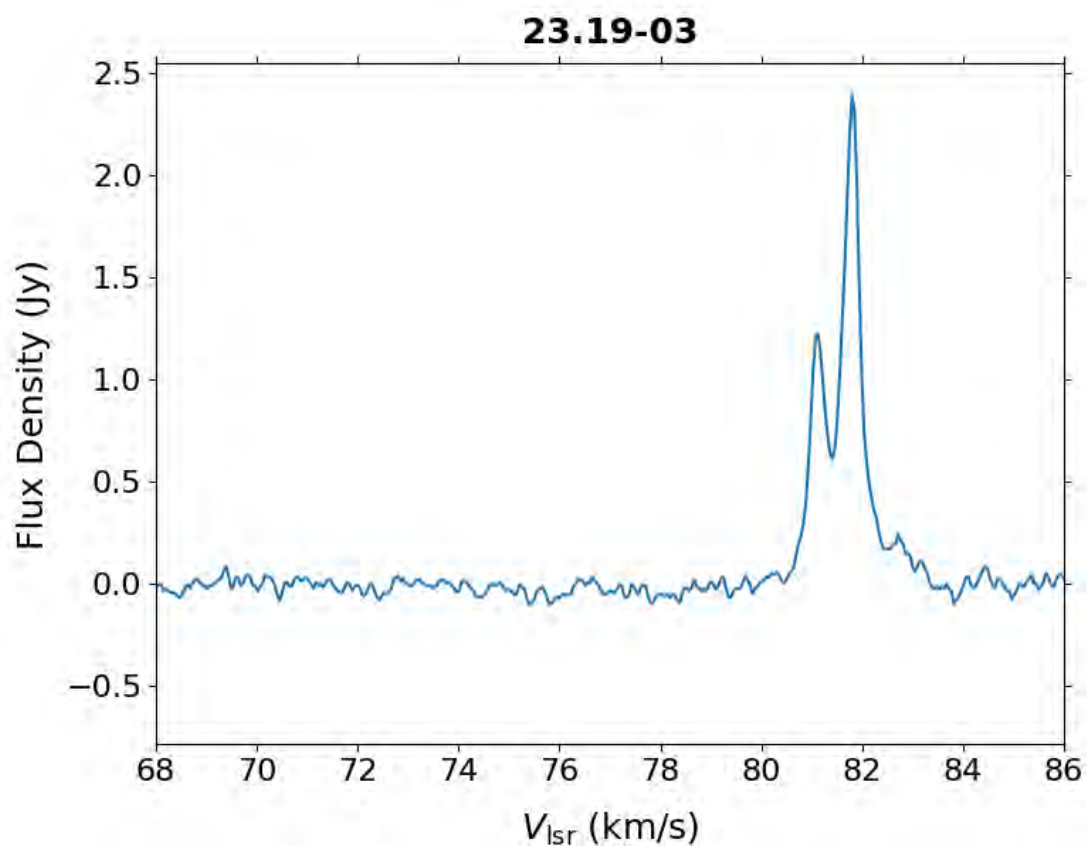
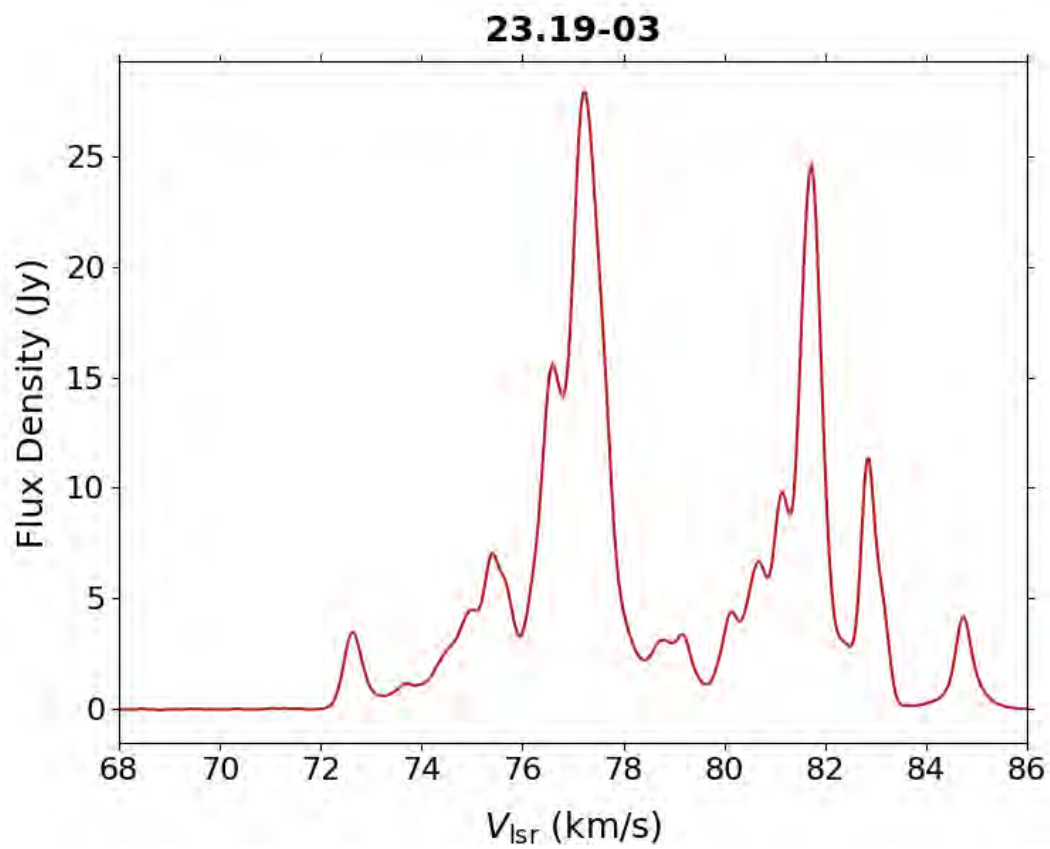
22.43-01



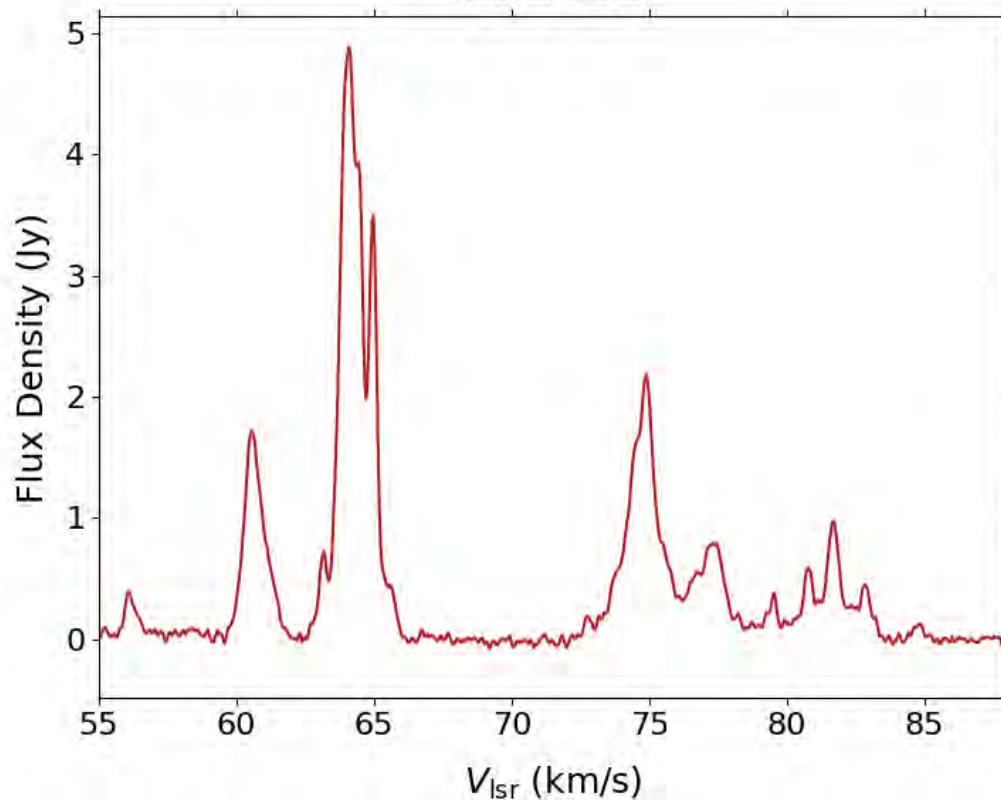
22.43-01



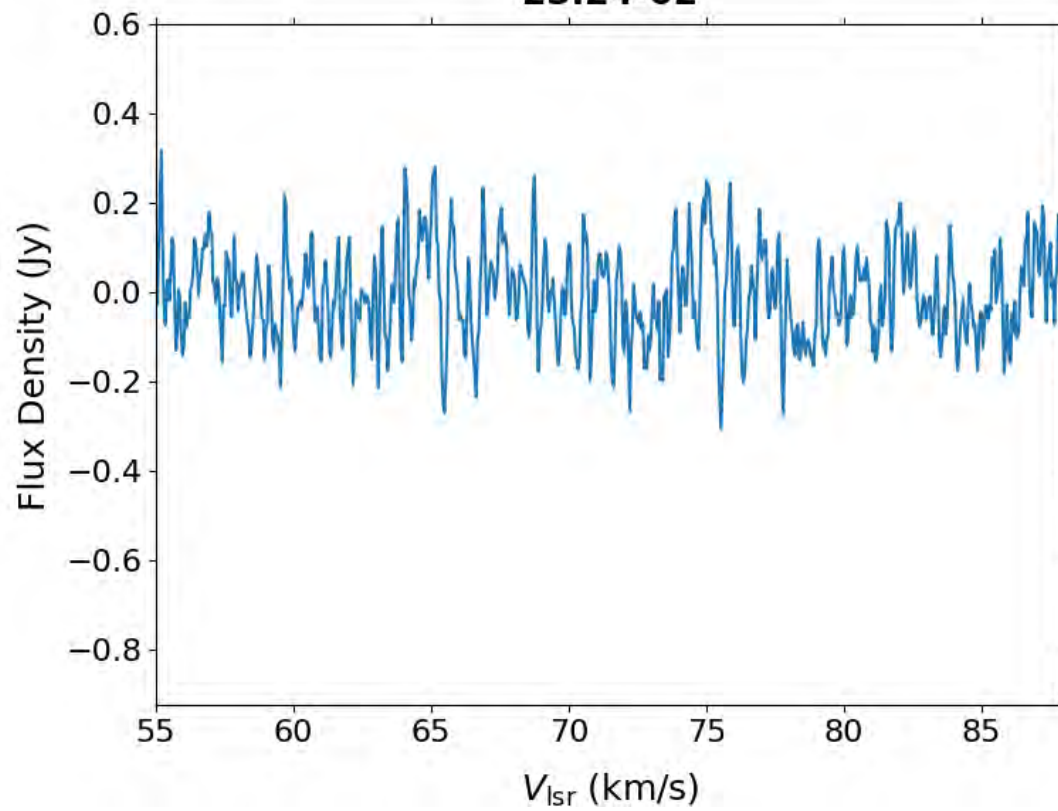




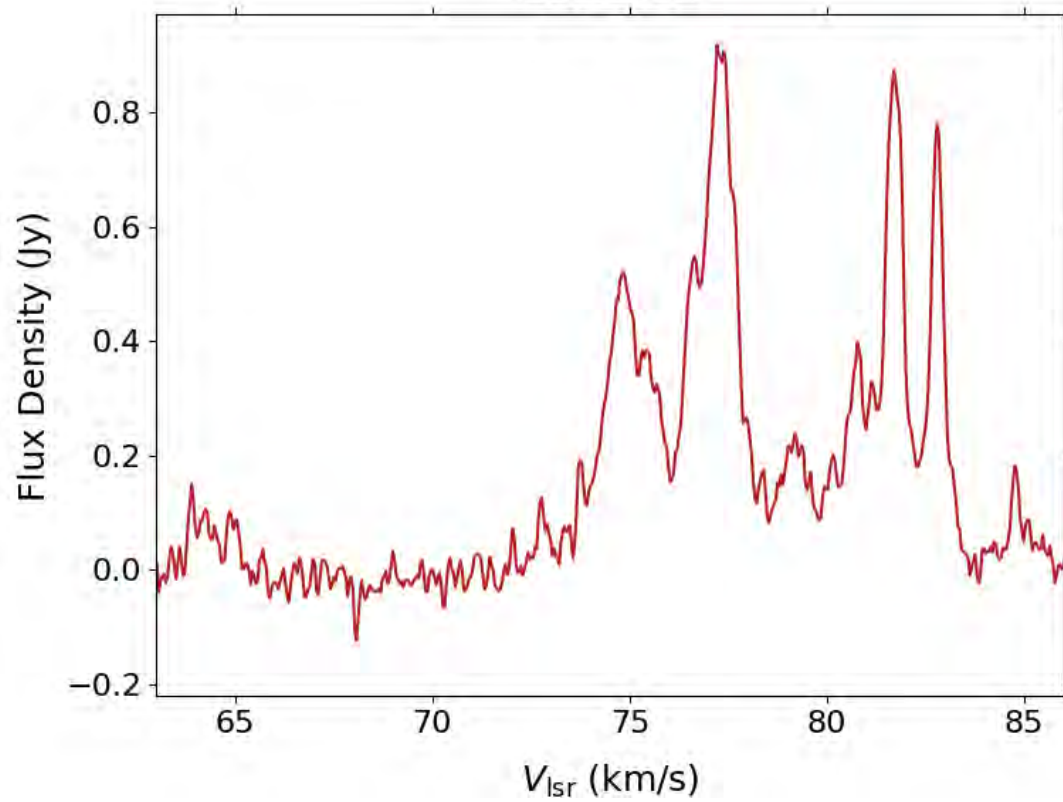
23.24-02



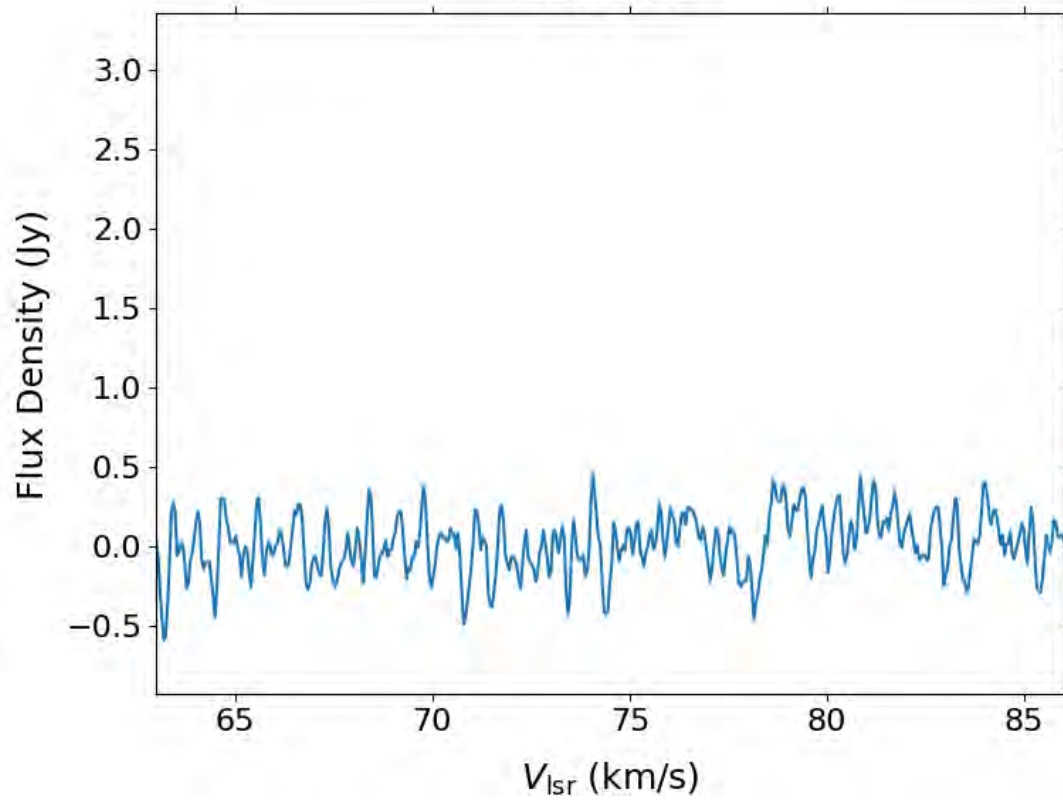
23.24-02

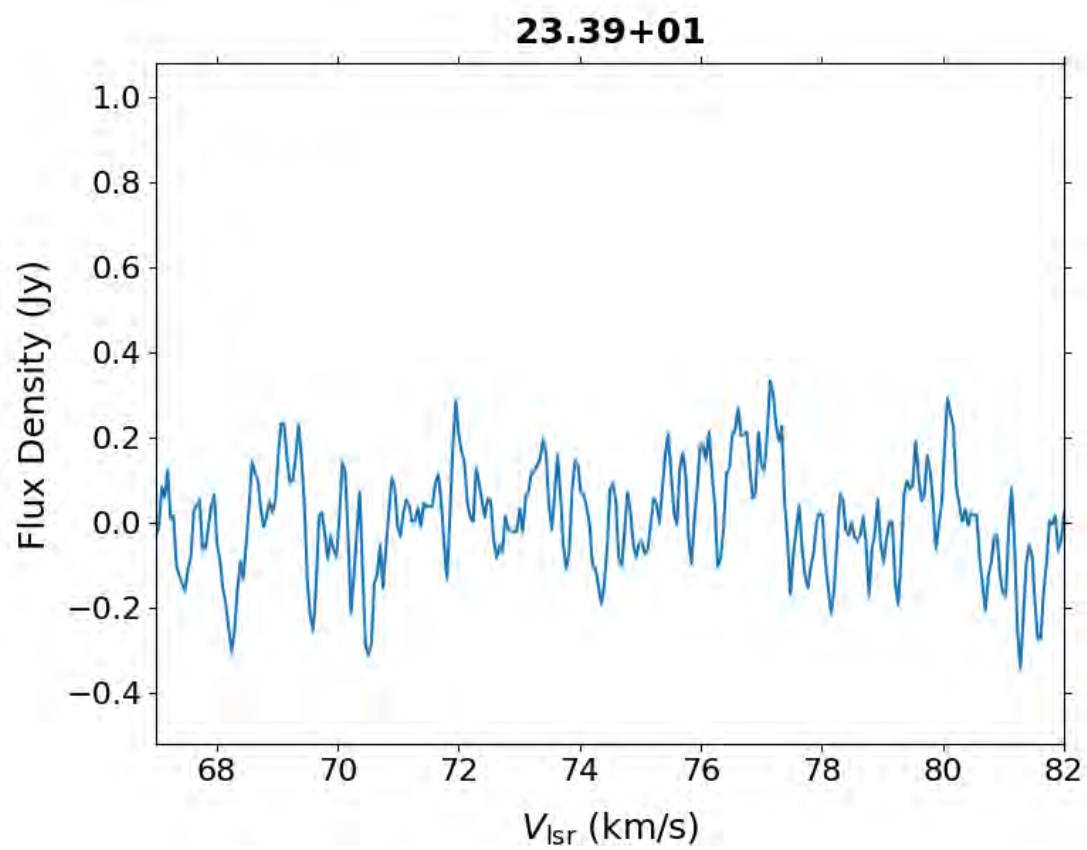
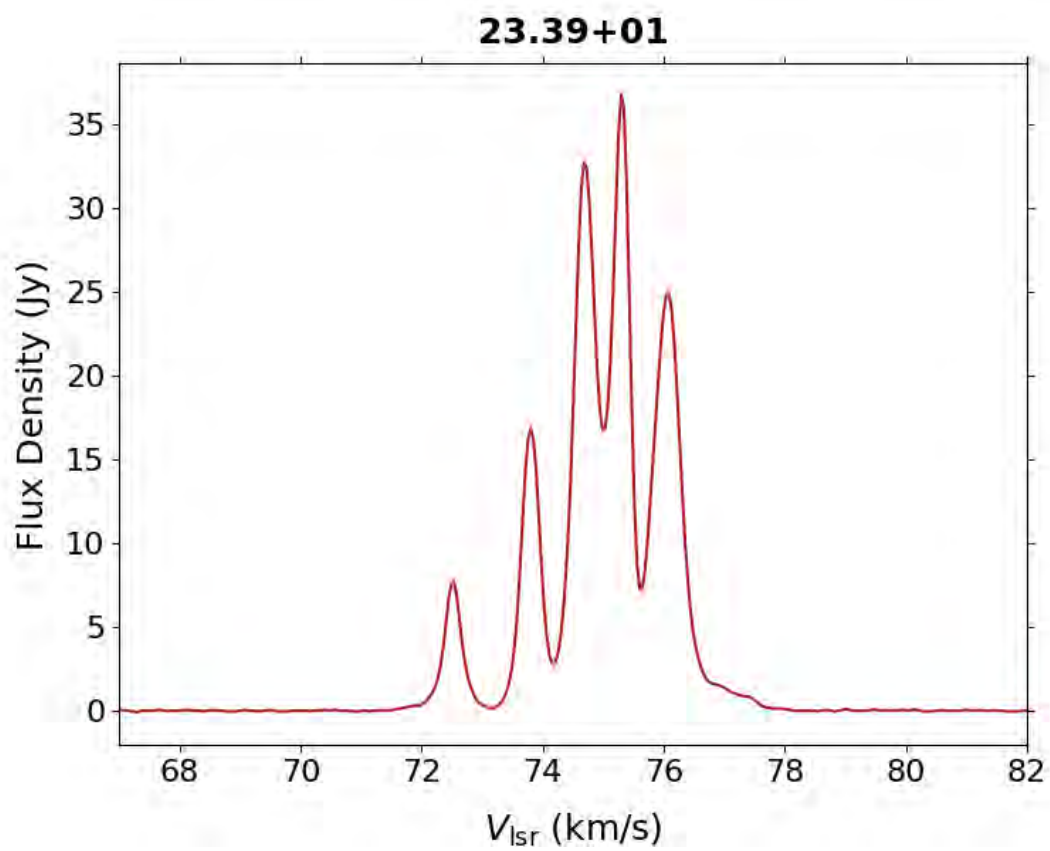


23.32-02

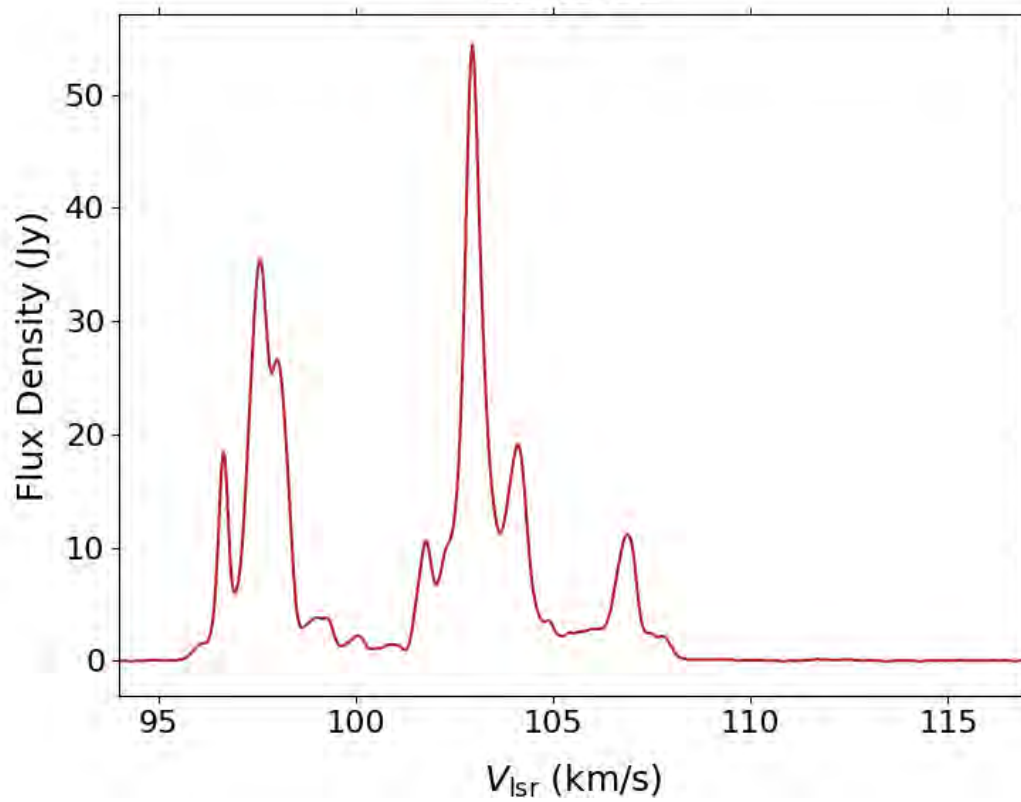


23.32-02

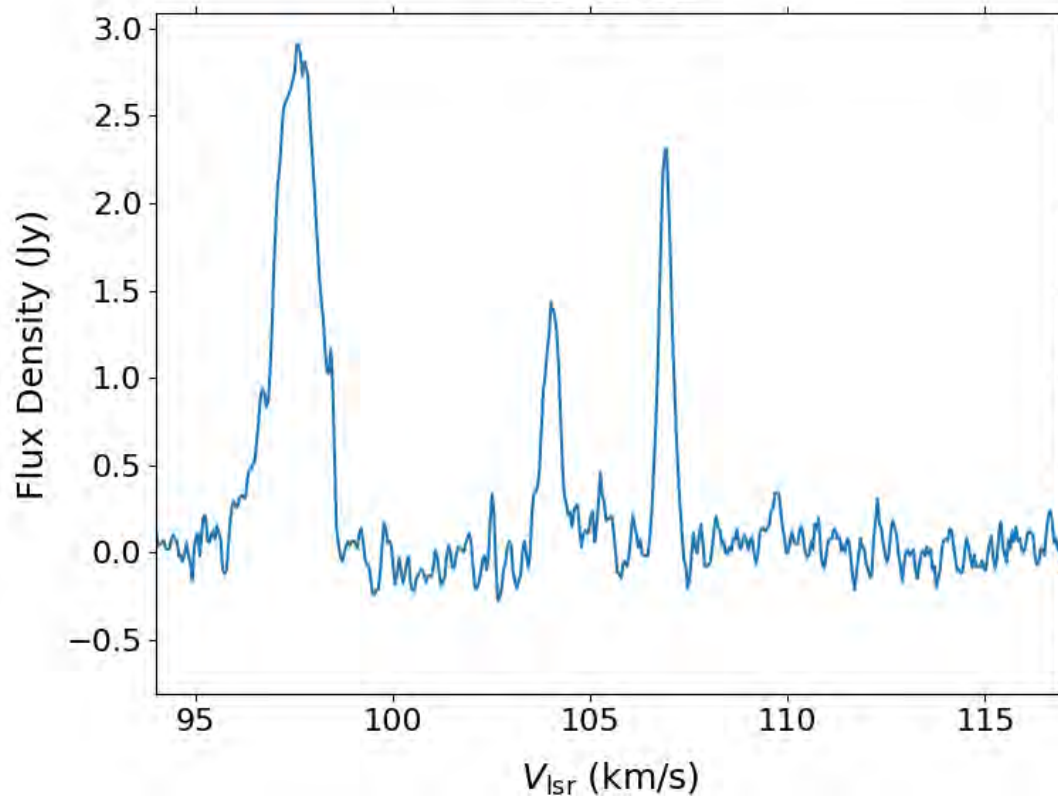




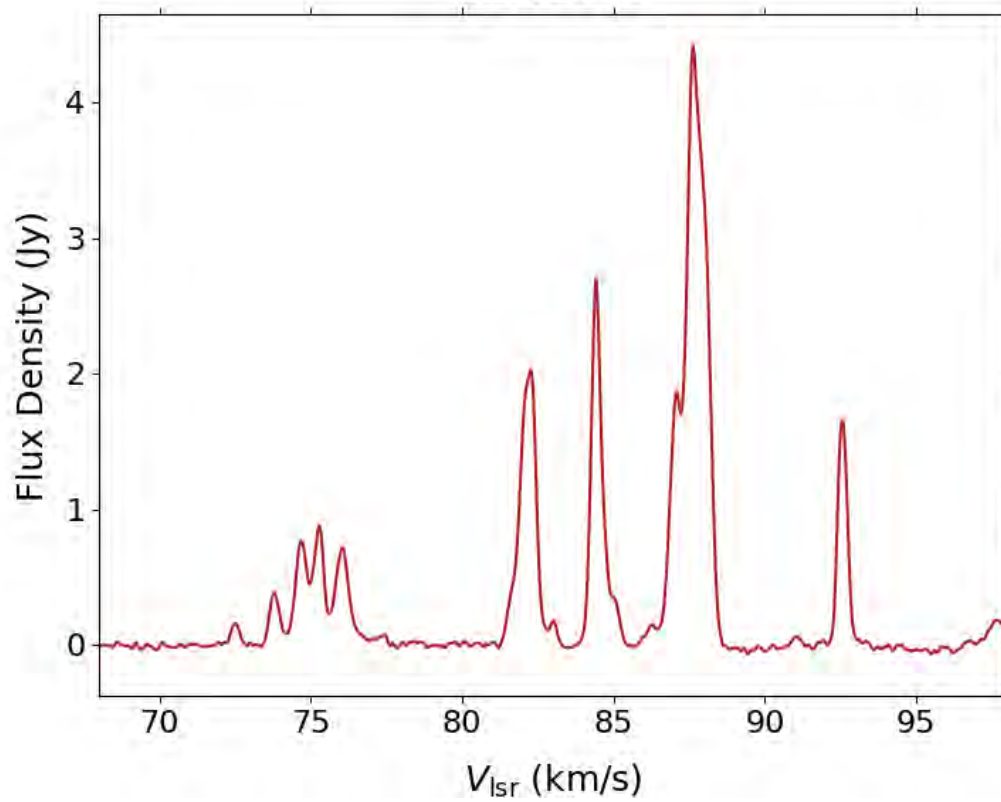
23.43-01



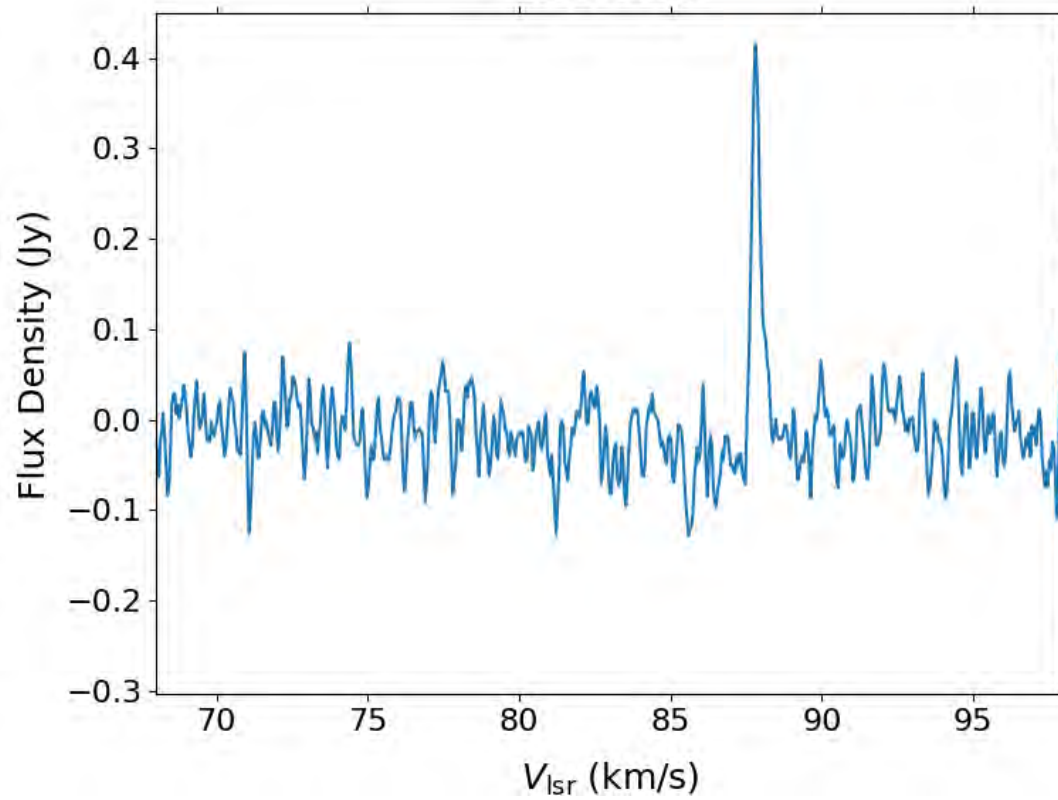
23.43-01



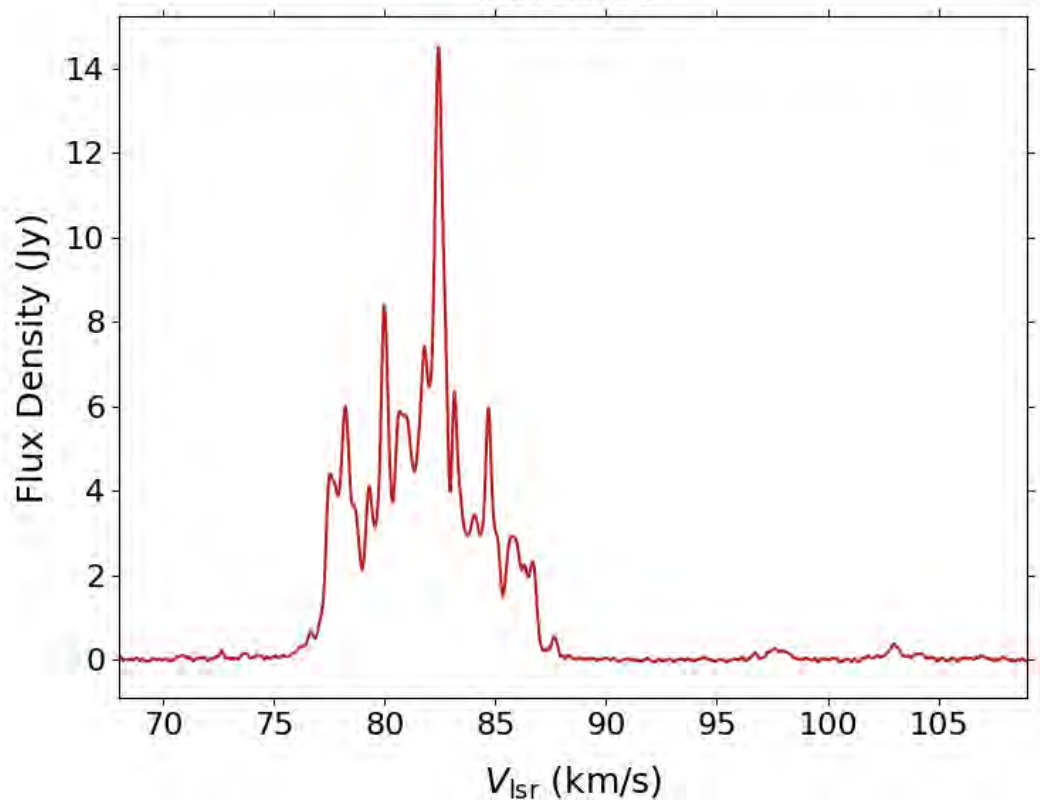
23.48+00



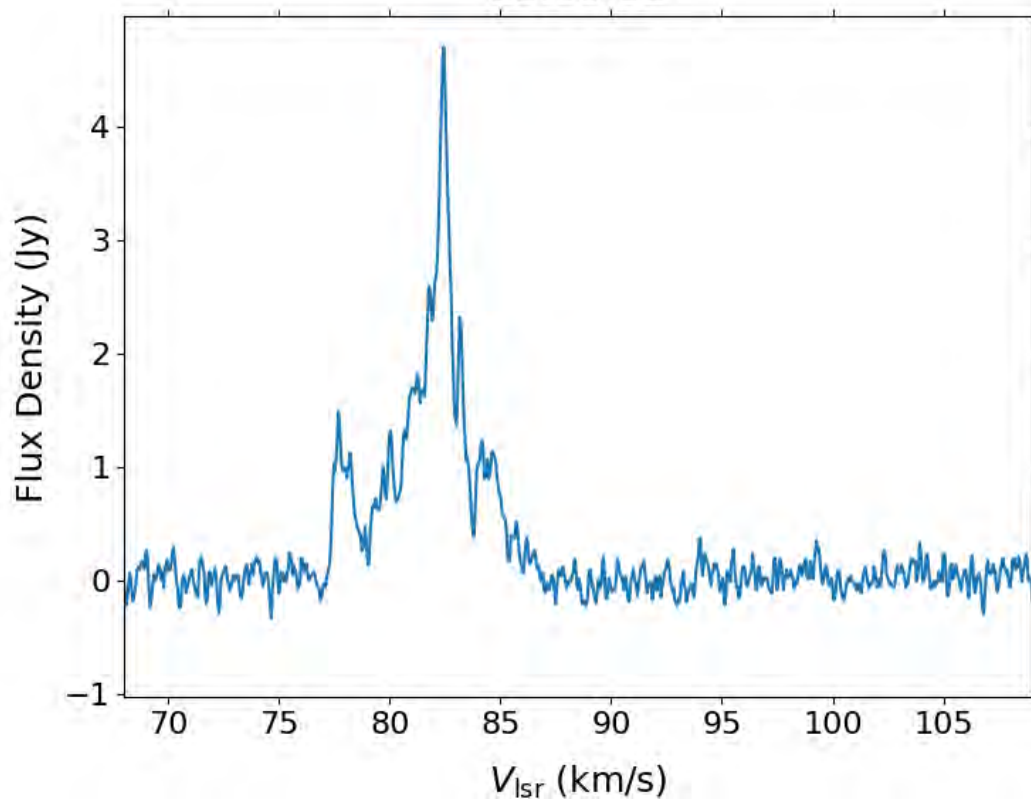
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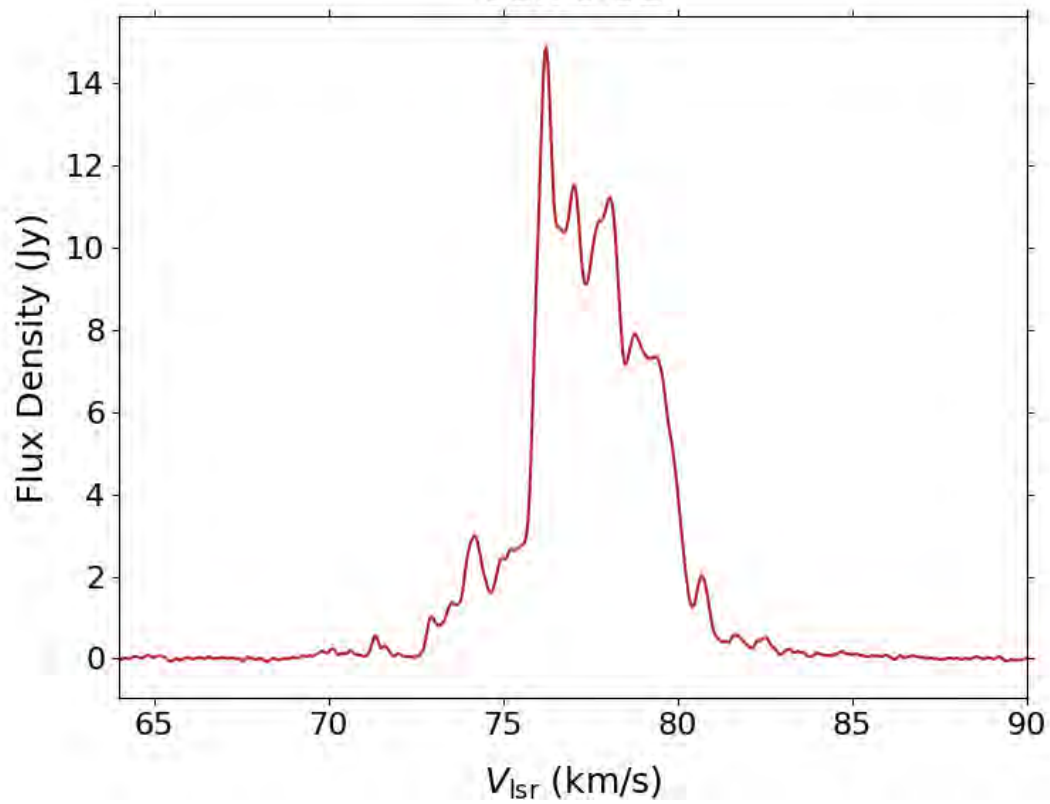
23.66-01



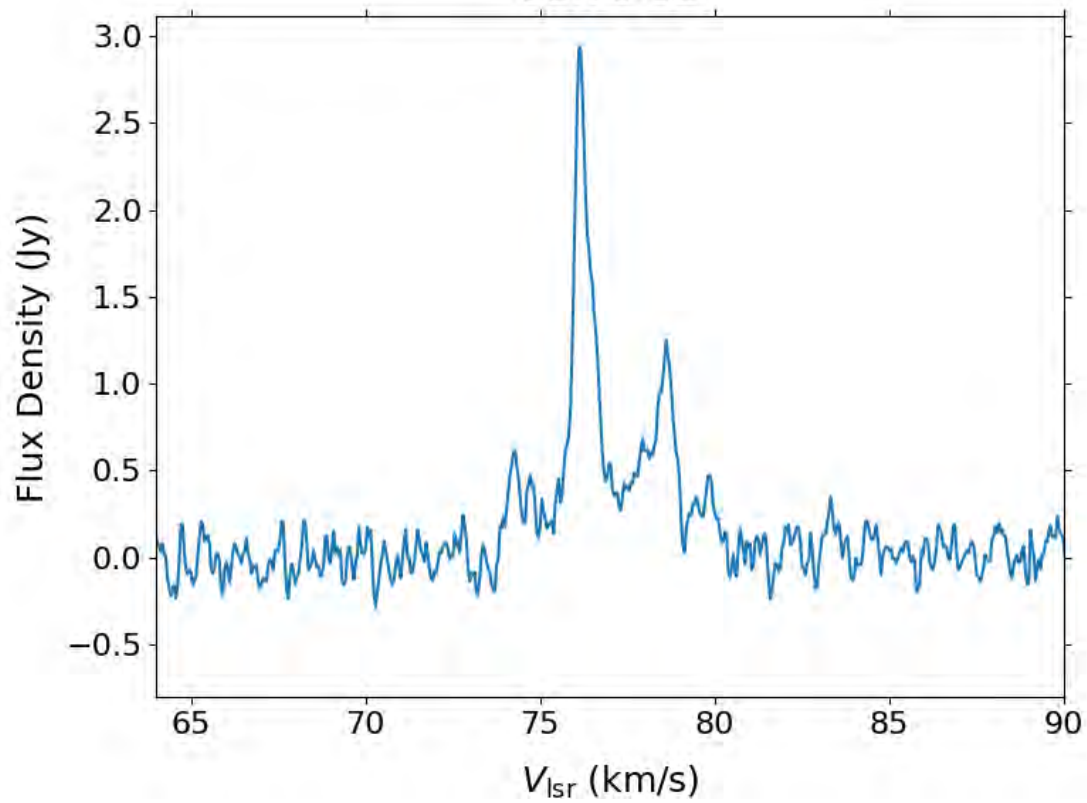
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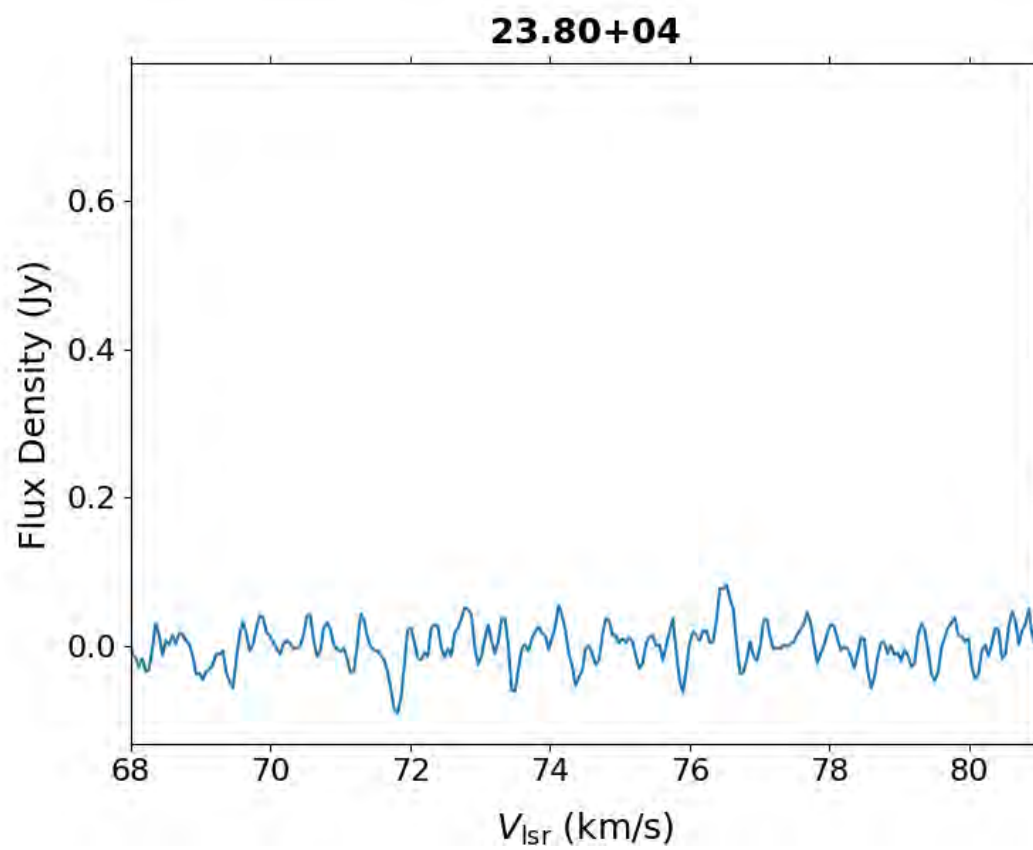
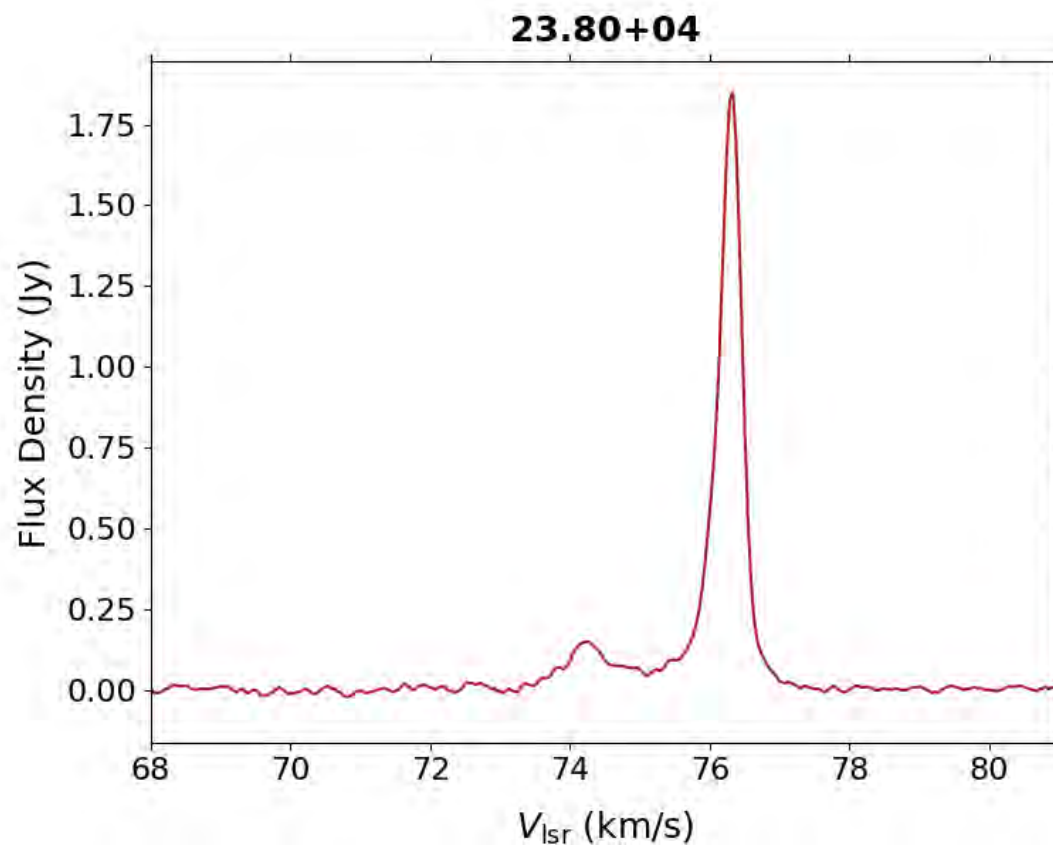


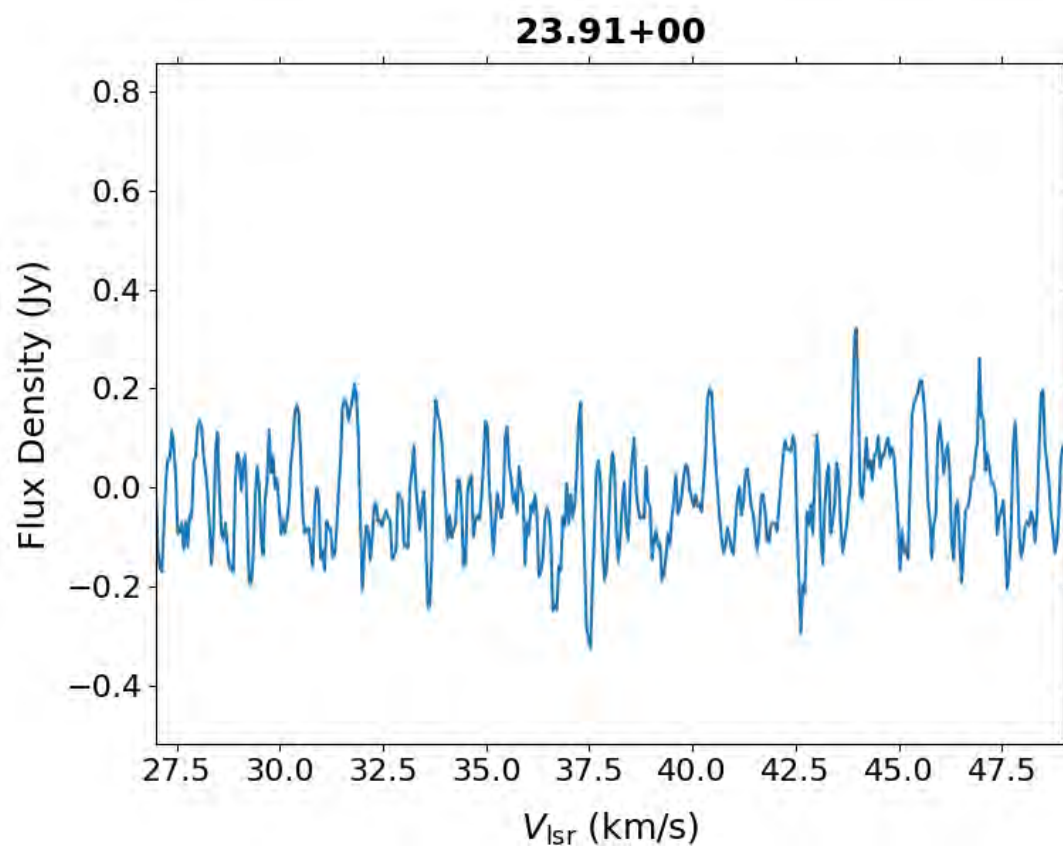
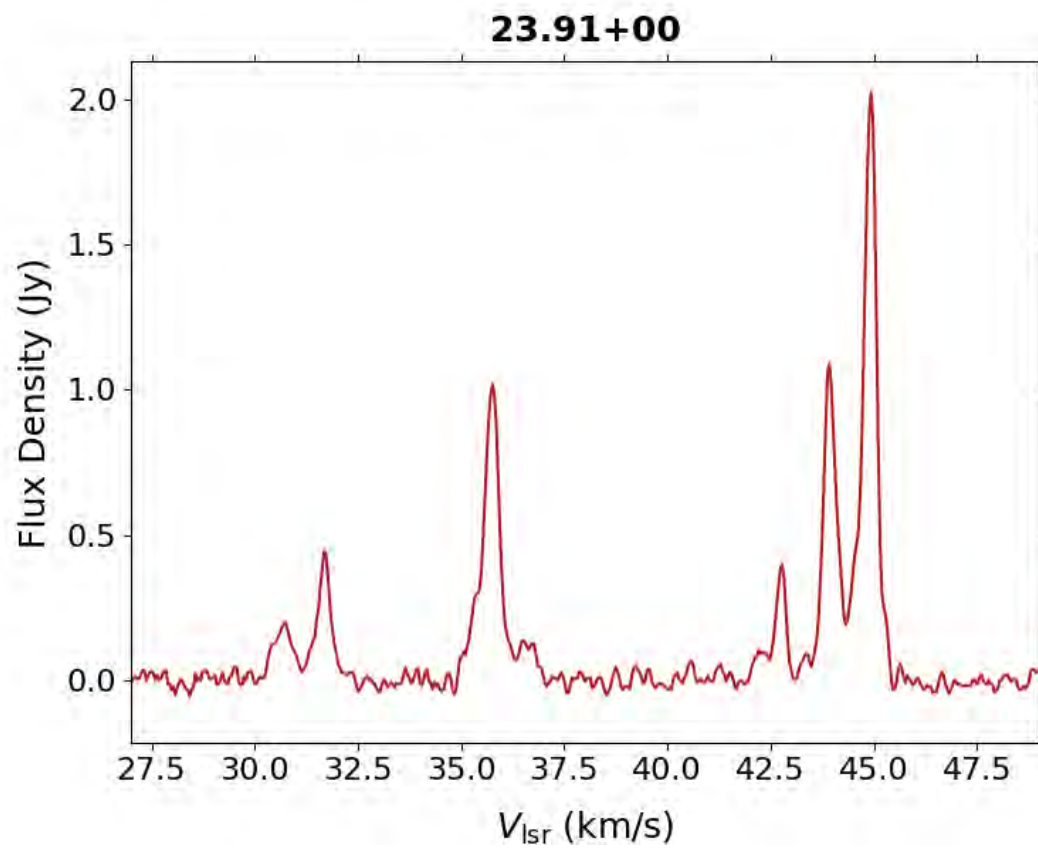
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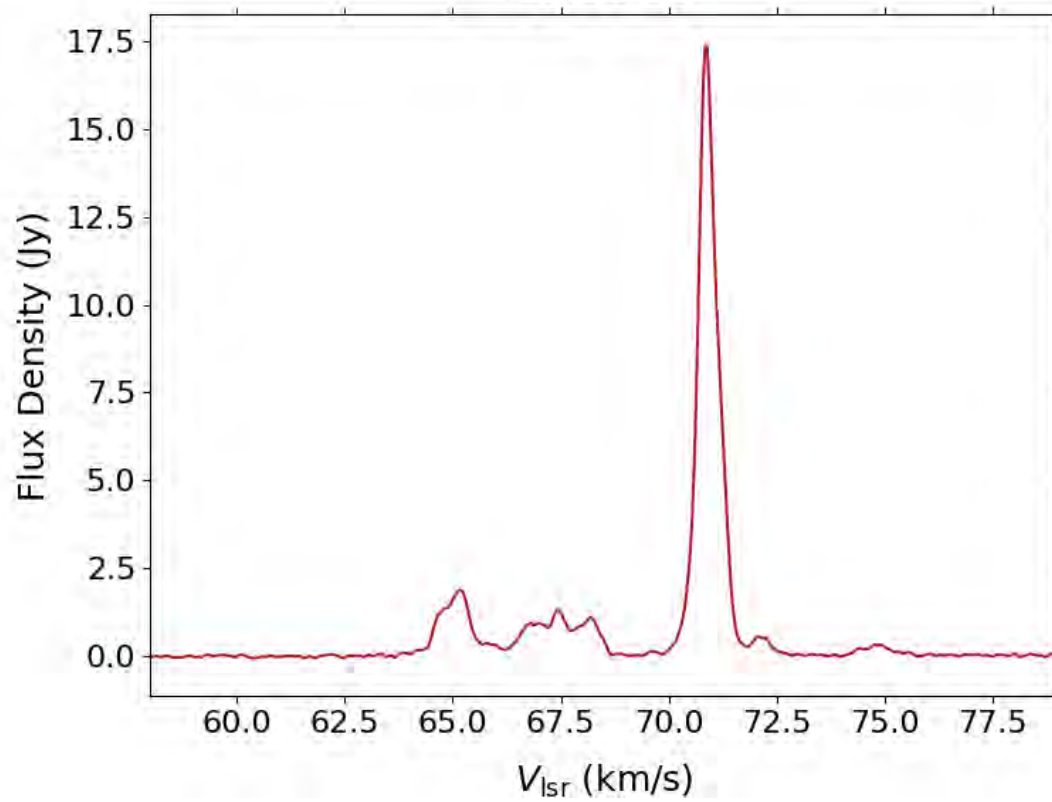
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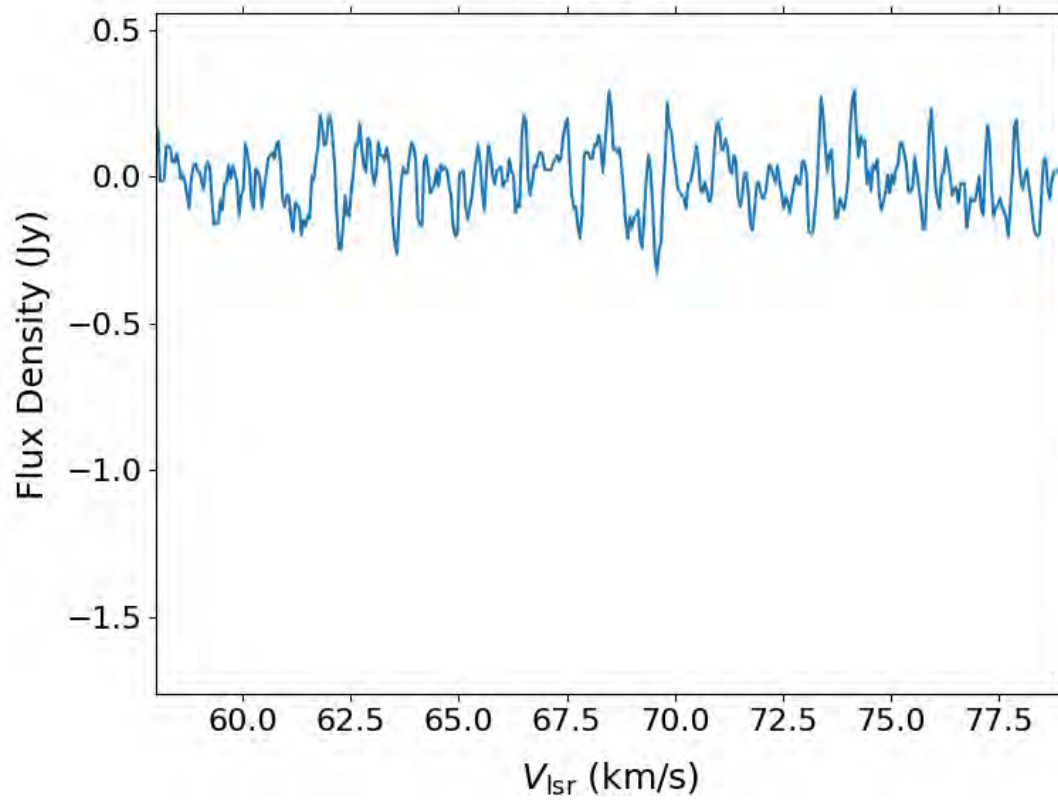




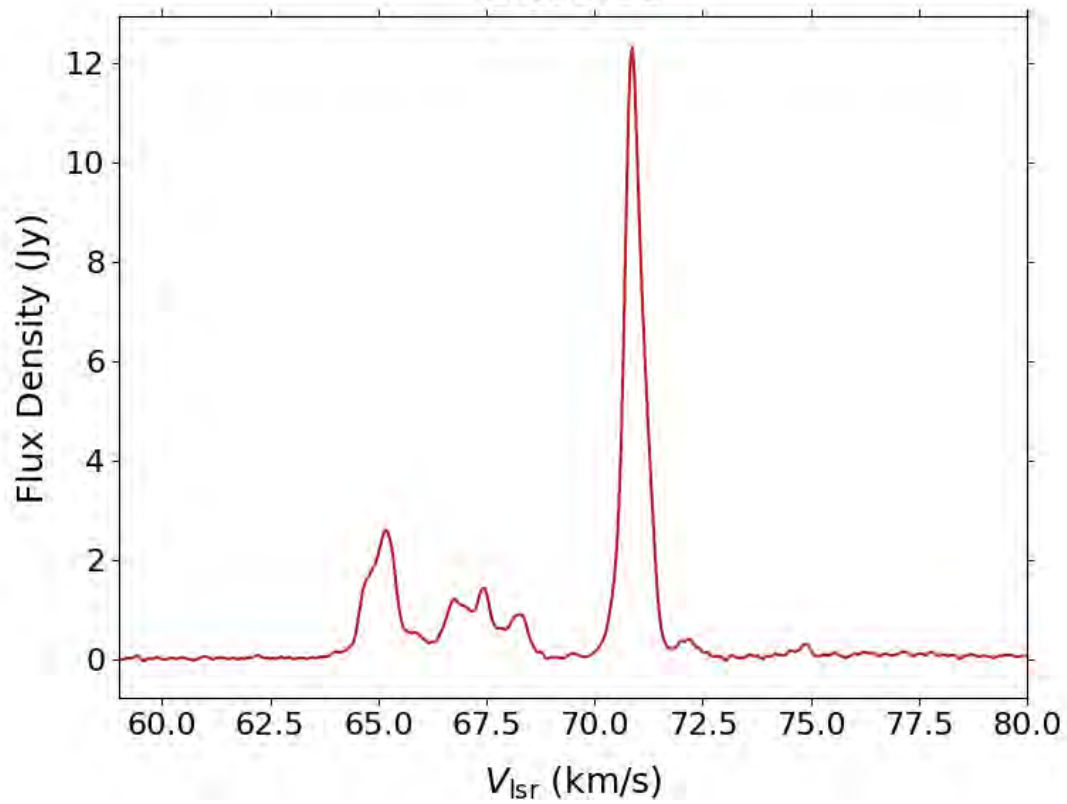
23.98-00



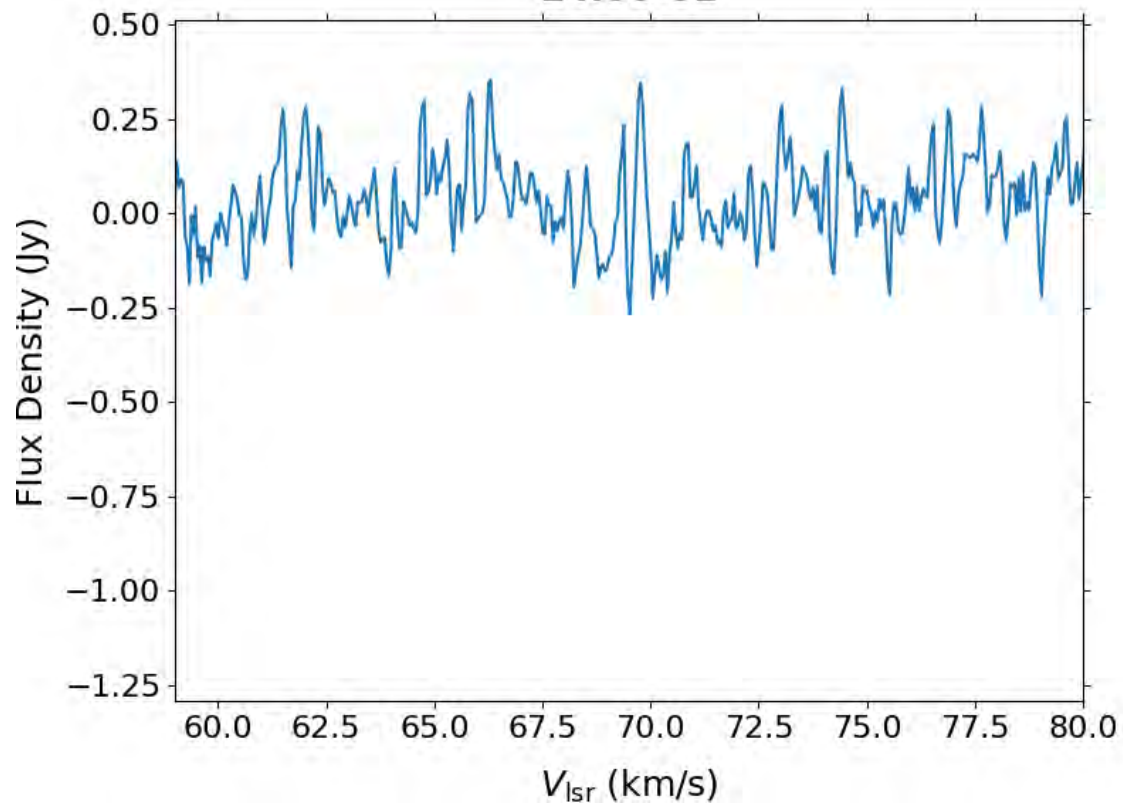
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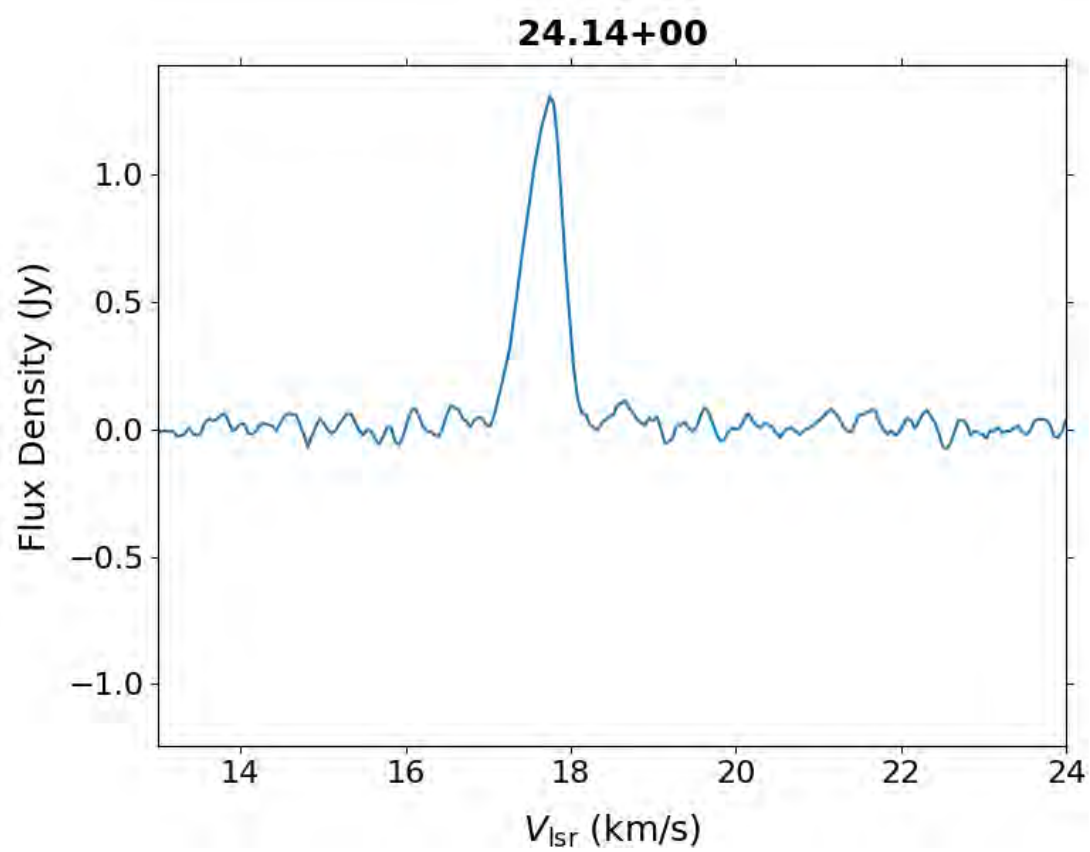
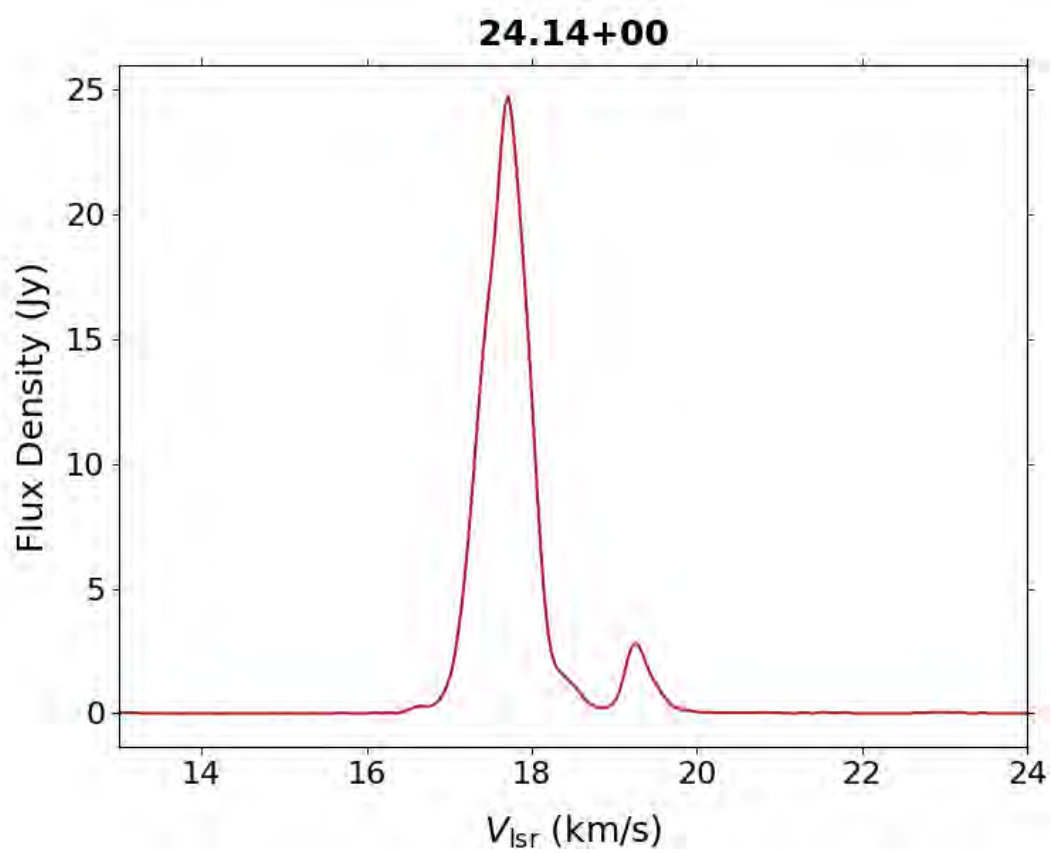


24.00-01

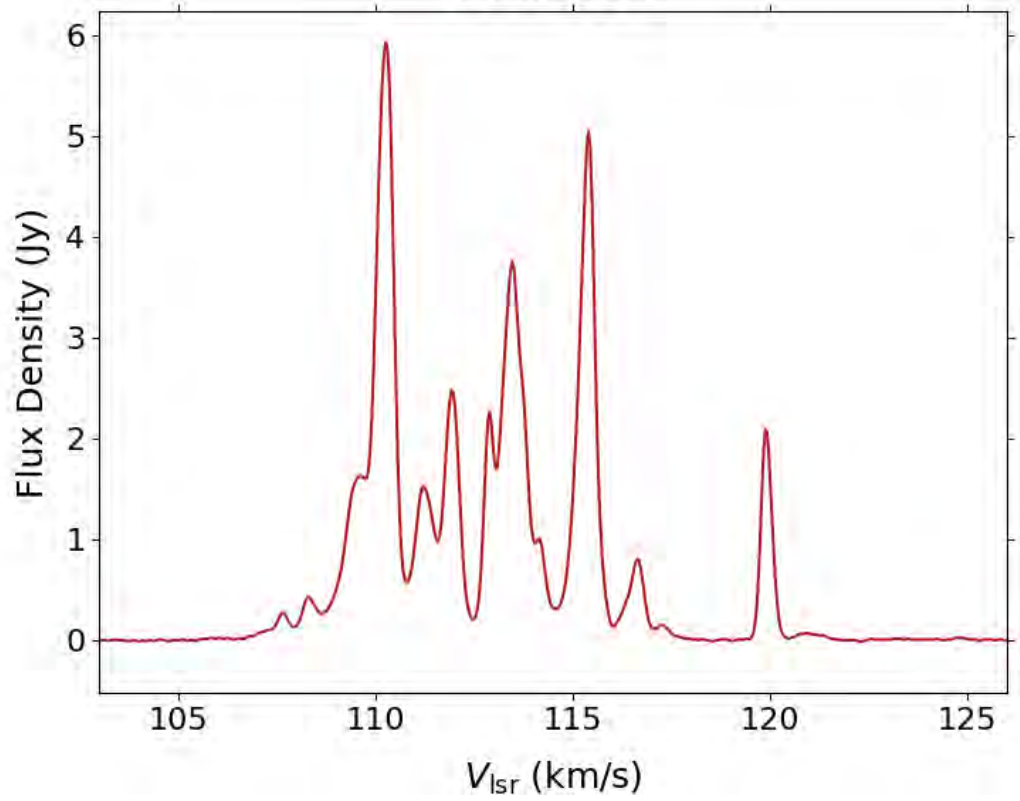


24.00-01

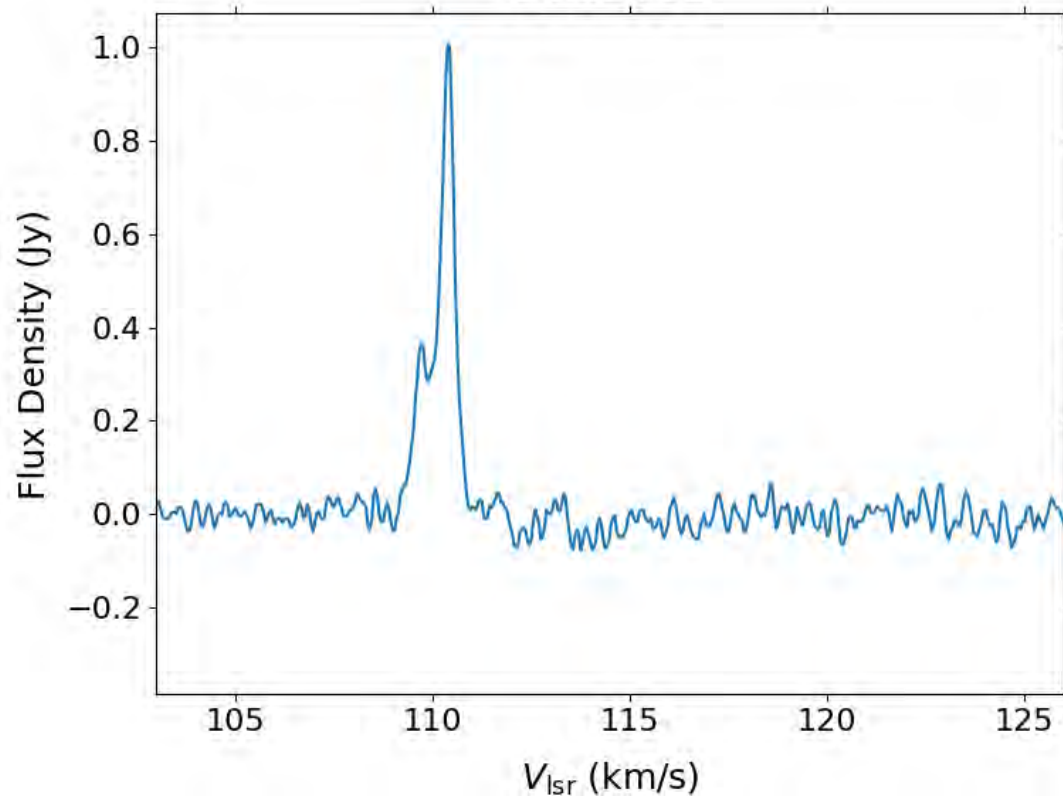




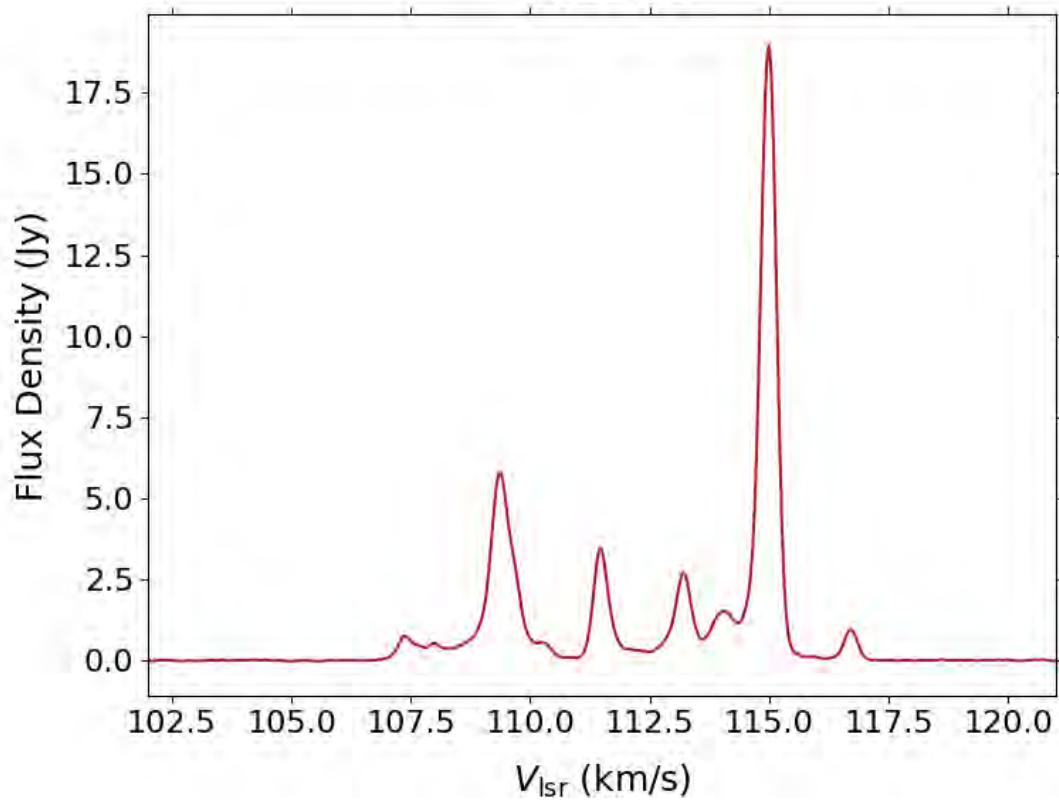
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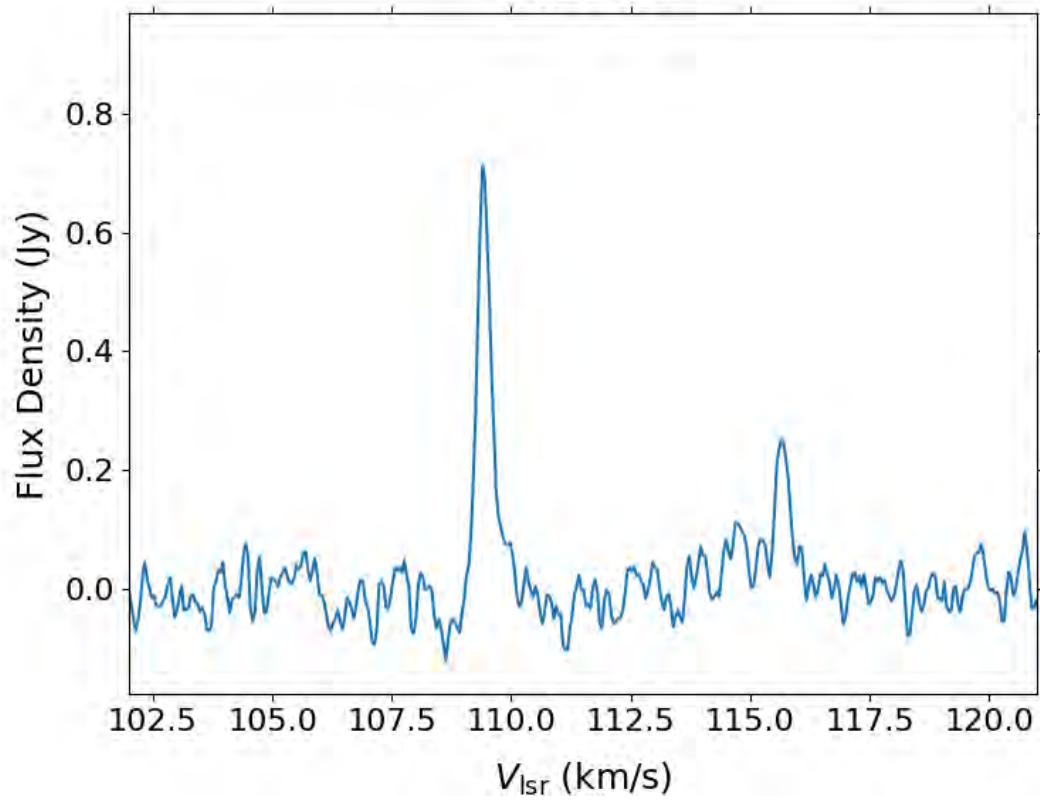
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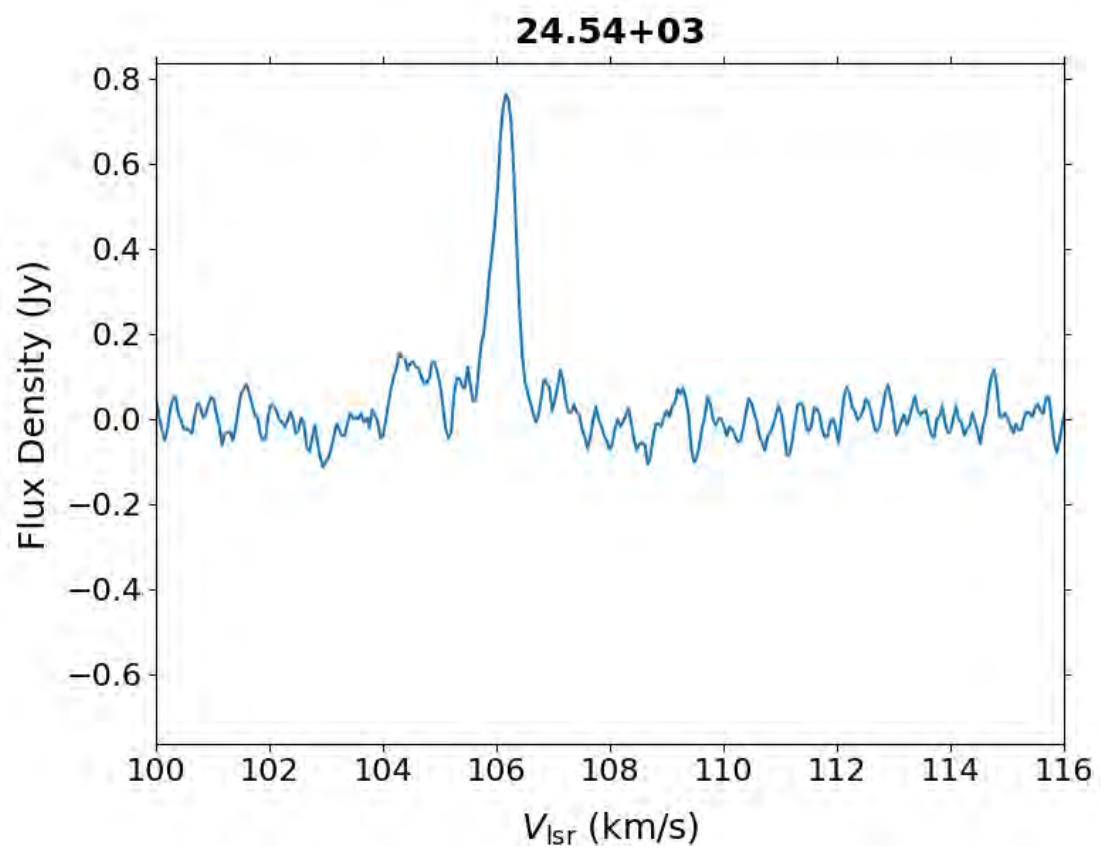
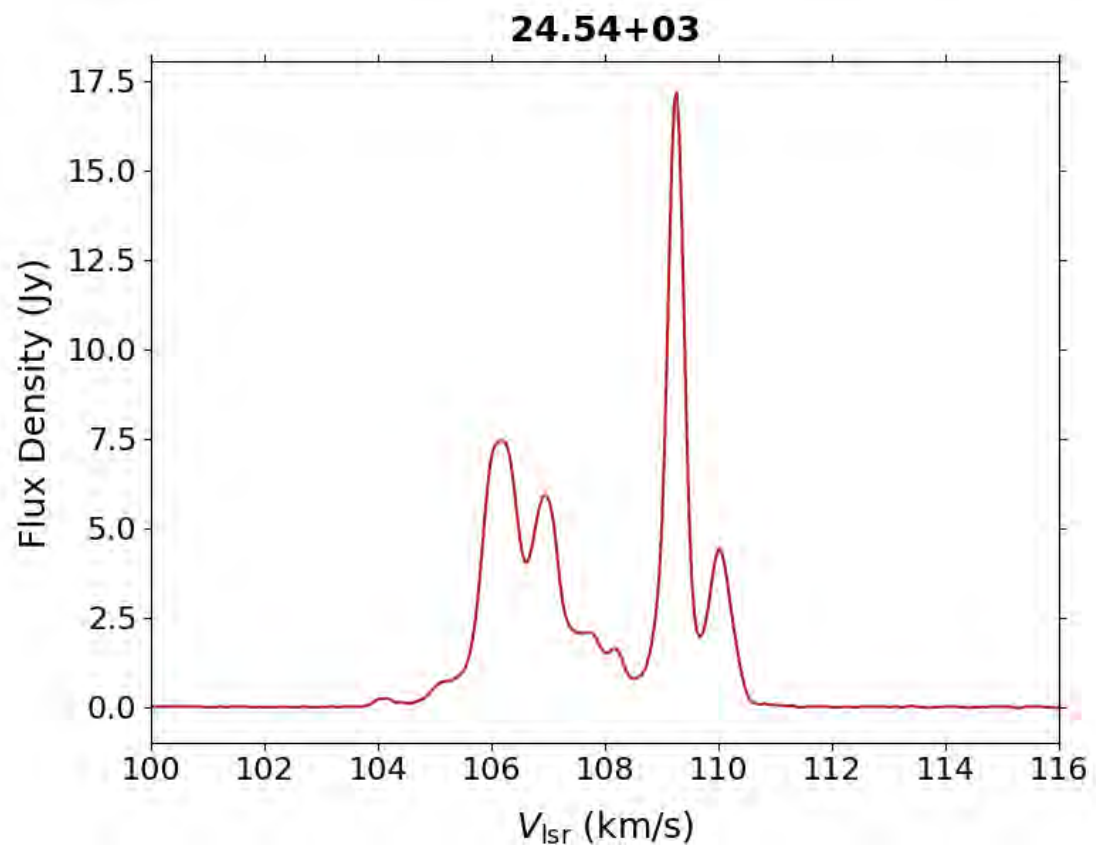


24.50-00

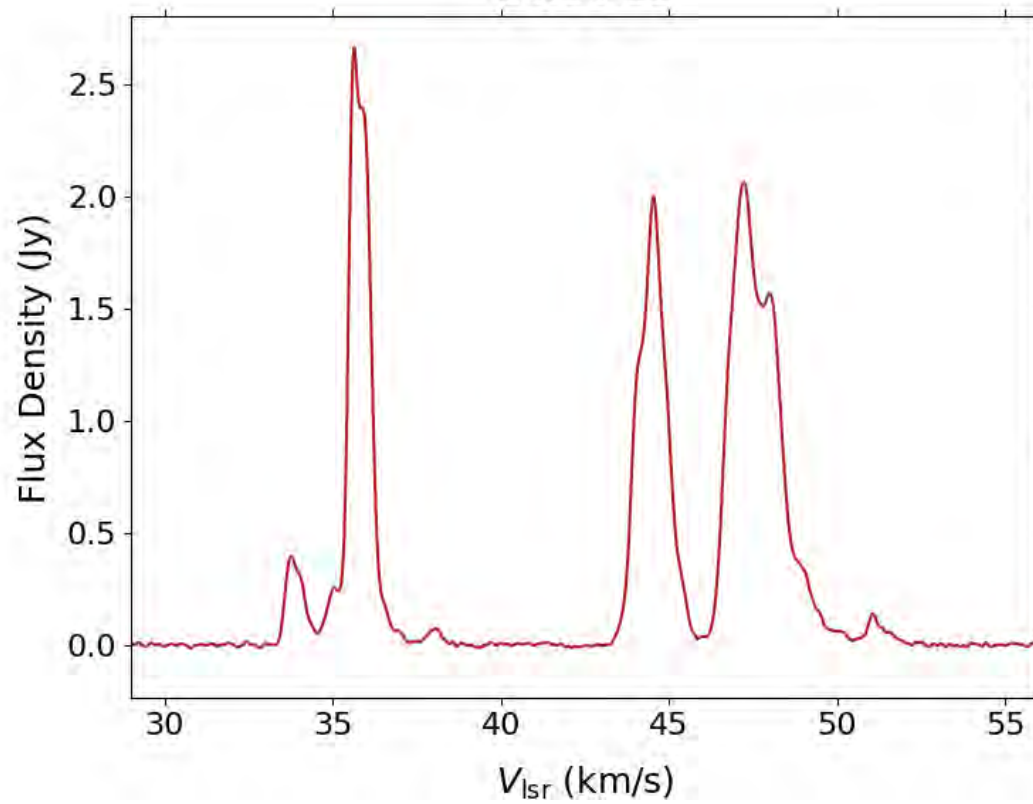


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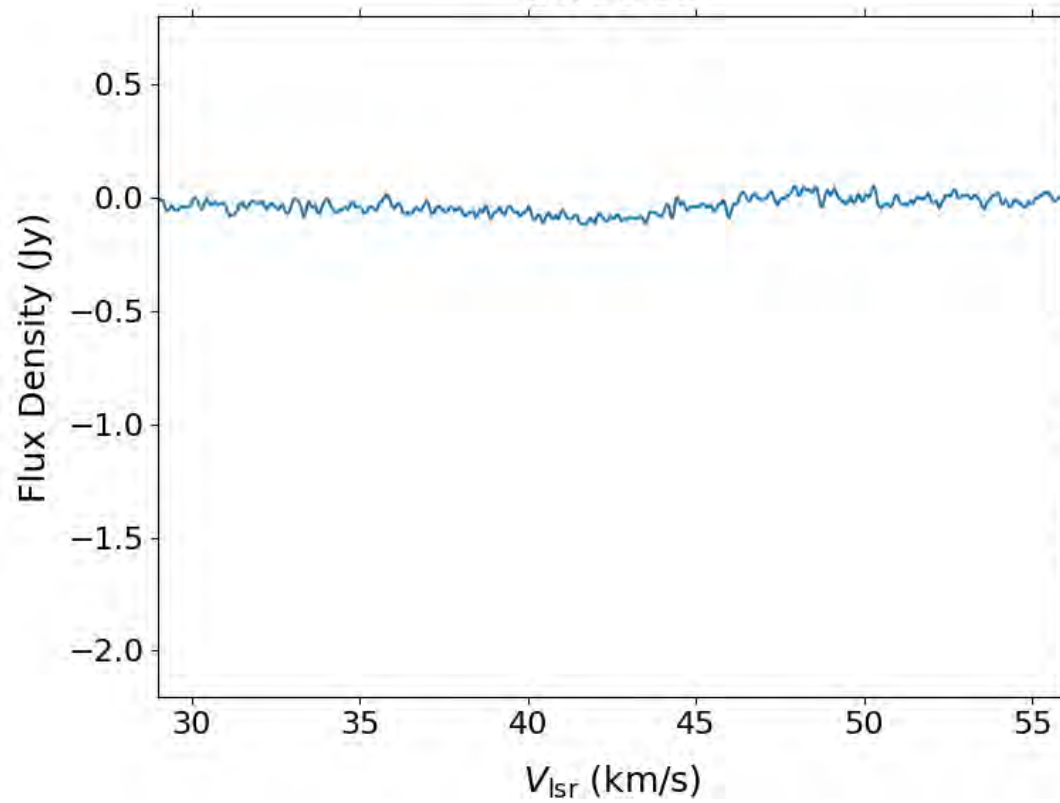


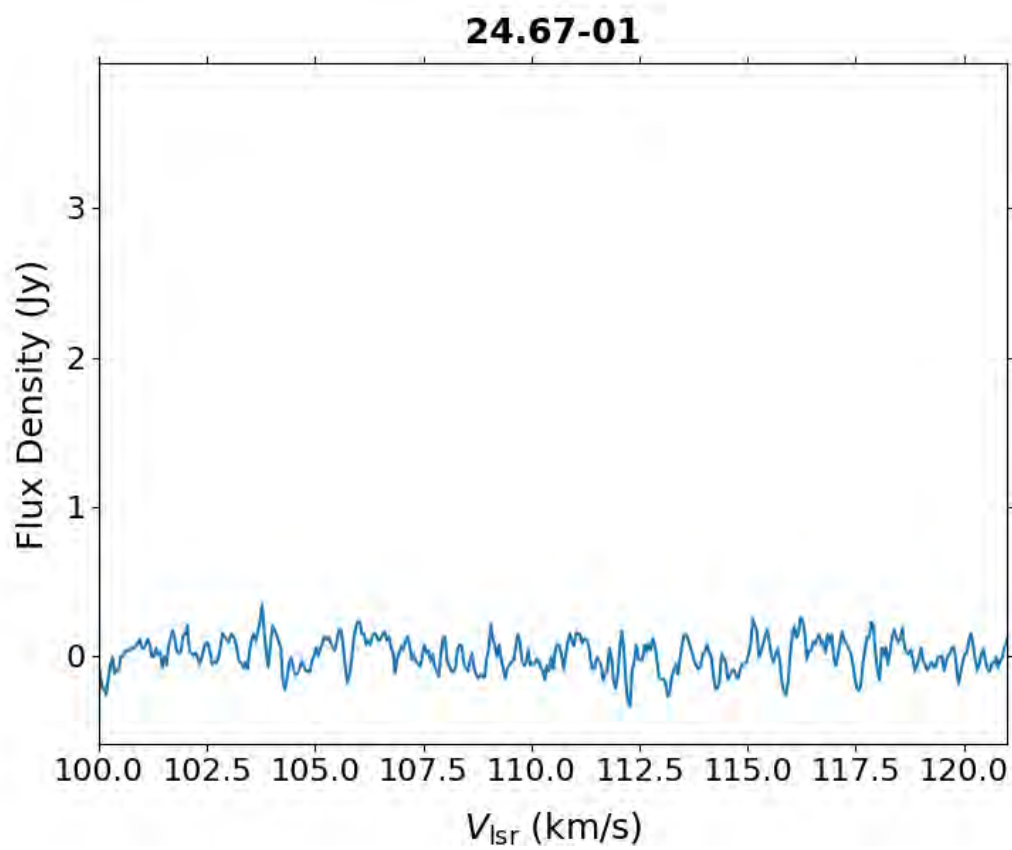
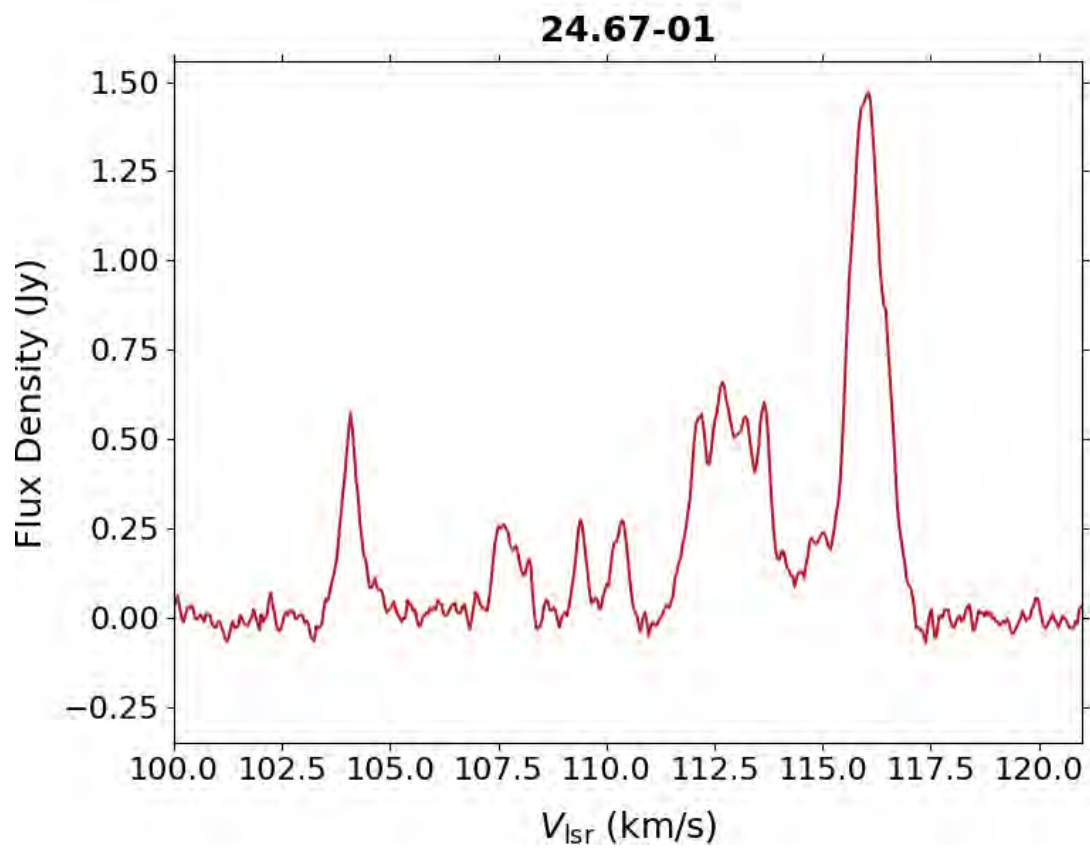


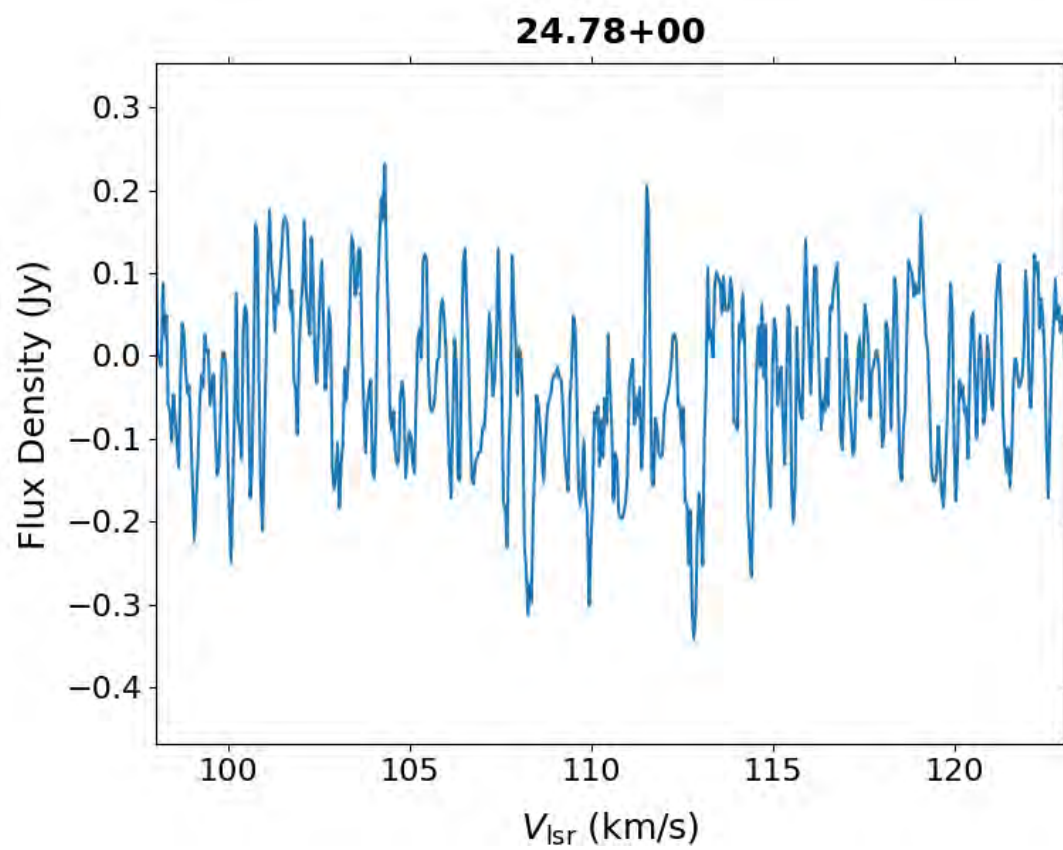
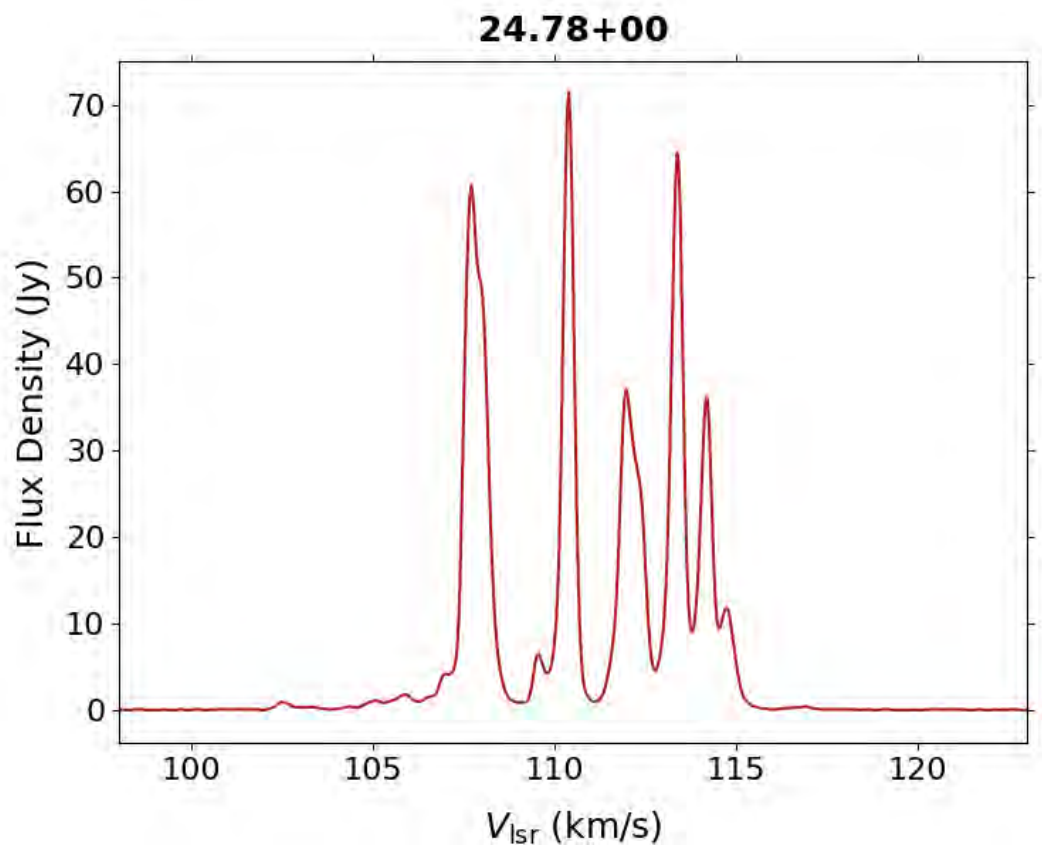
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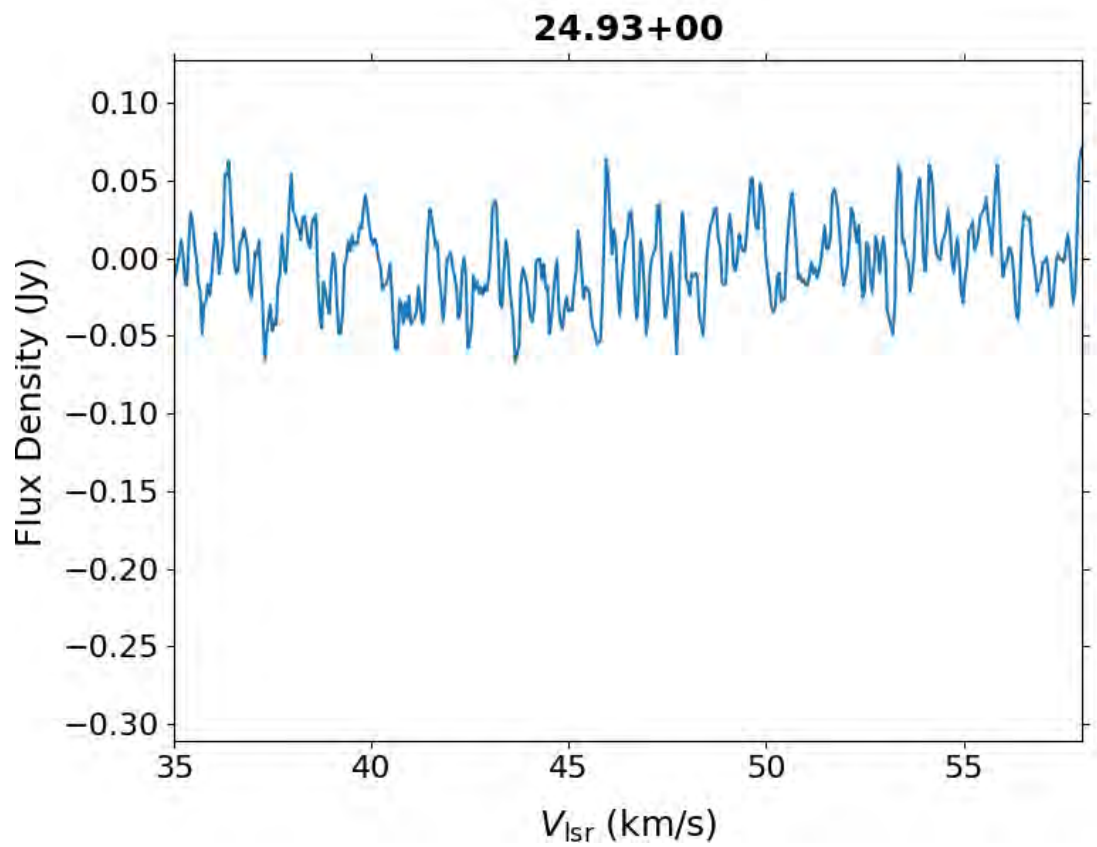
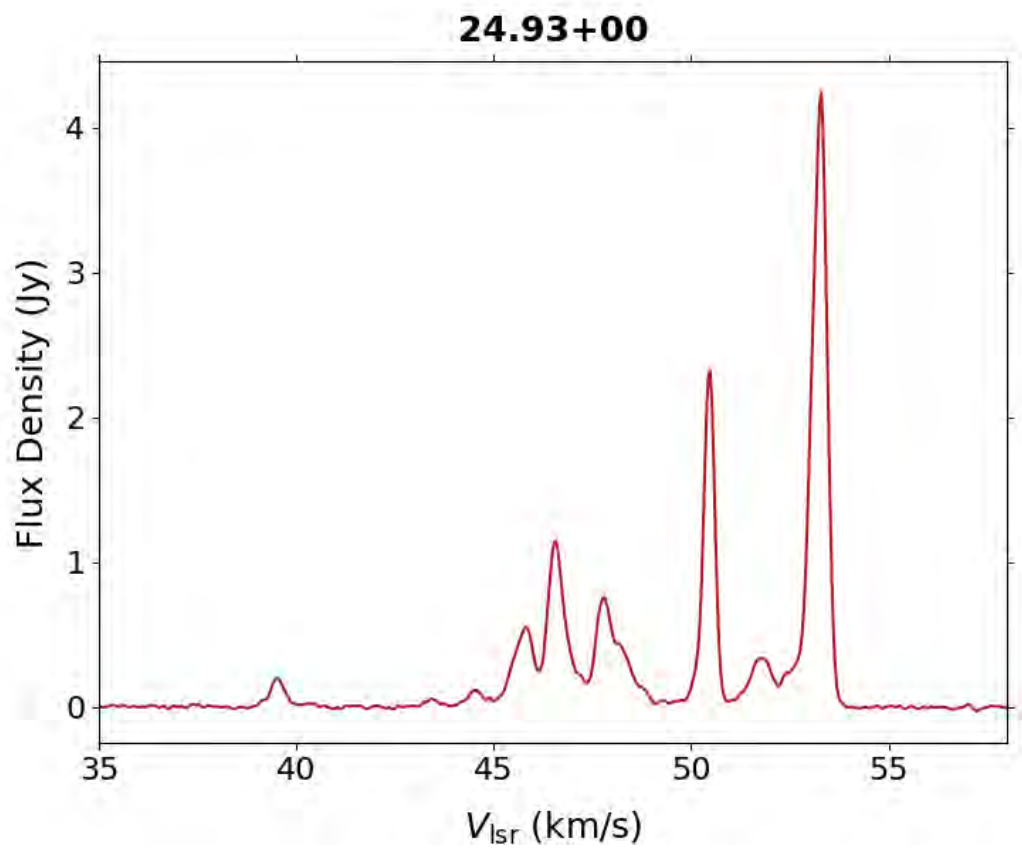


24.64-03

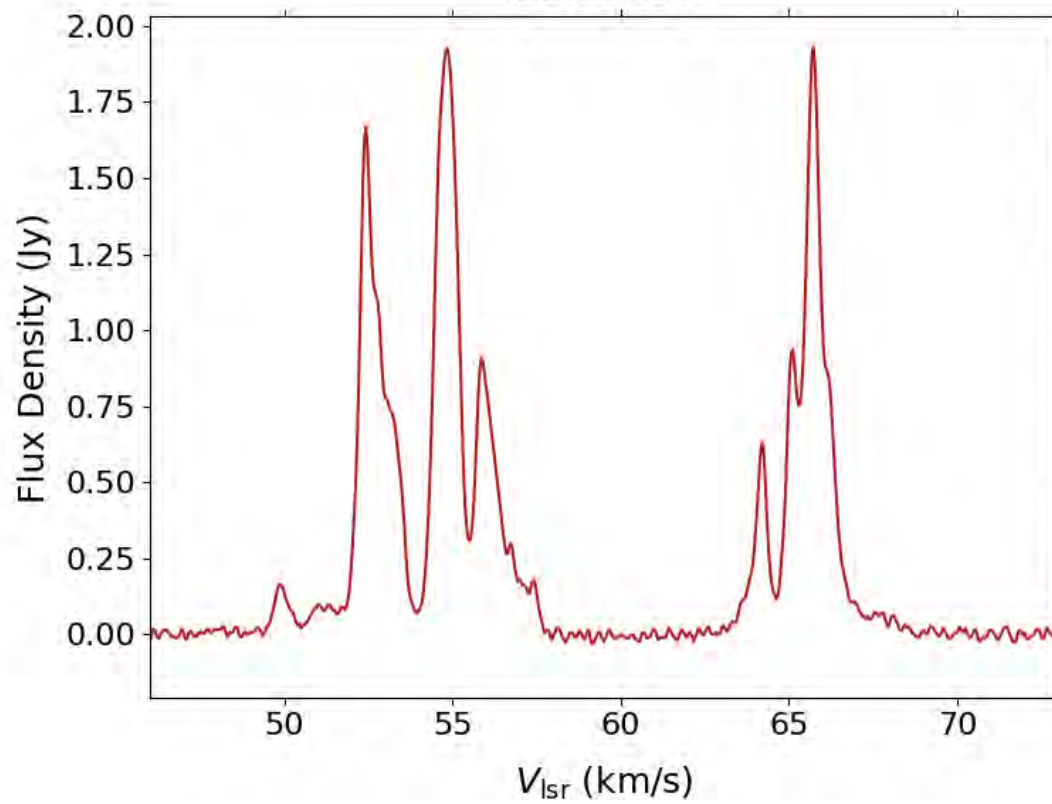




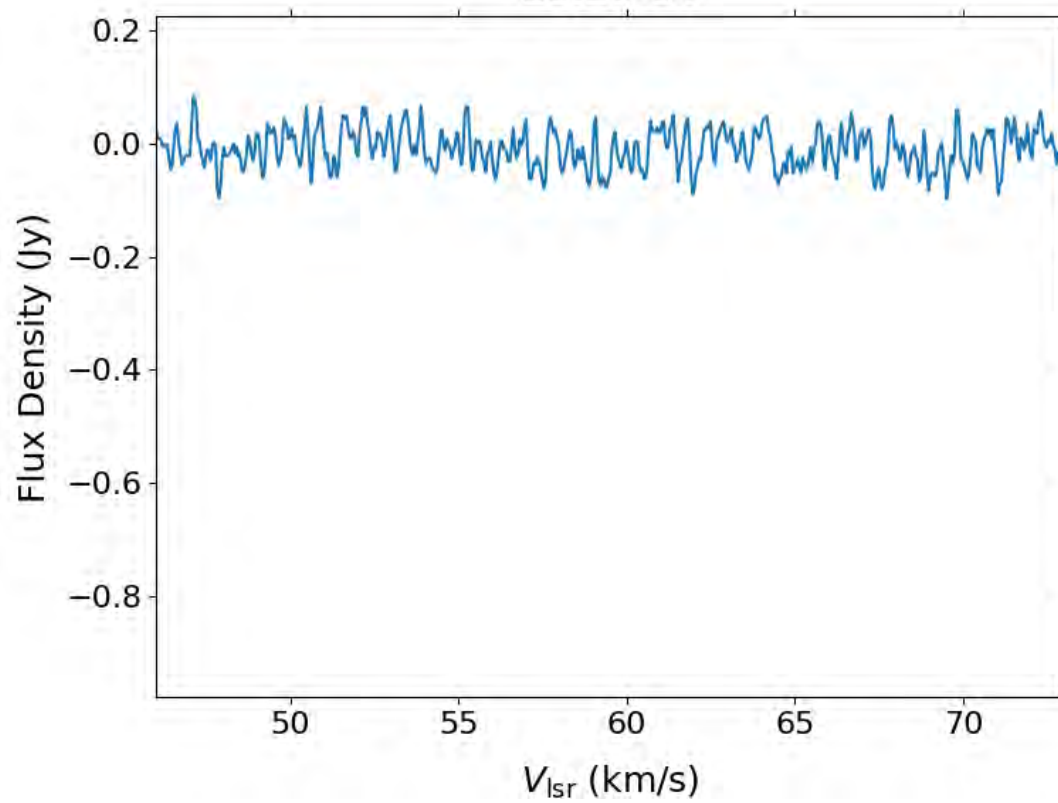


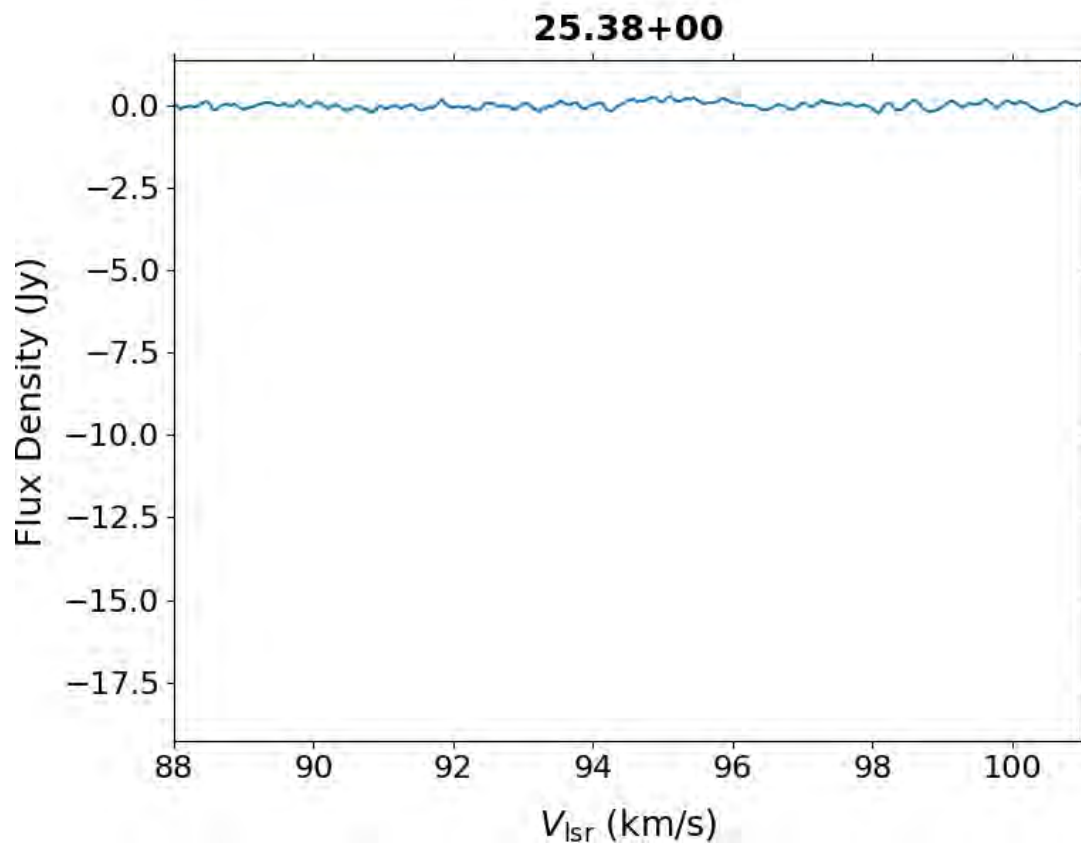
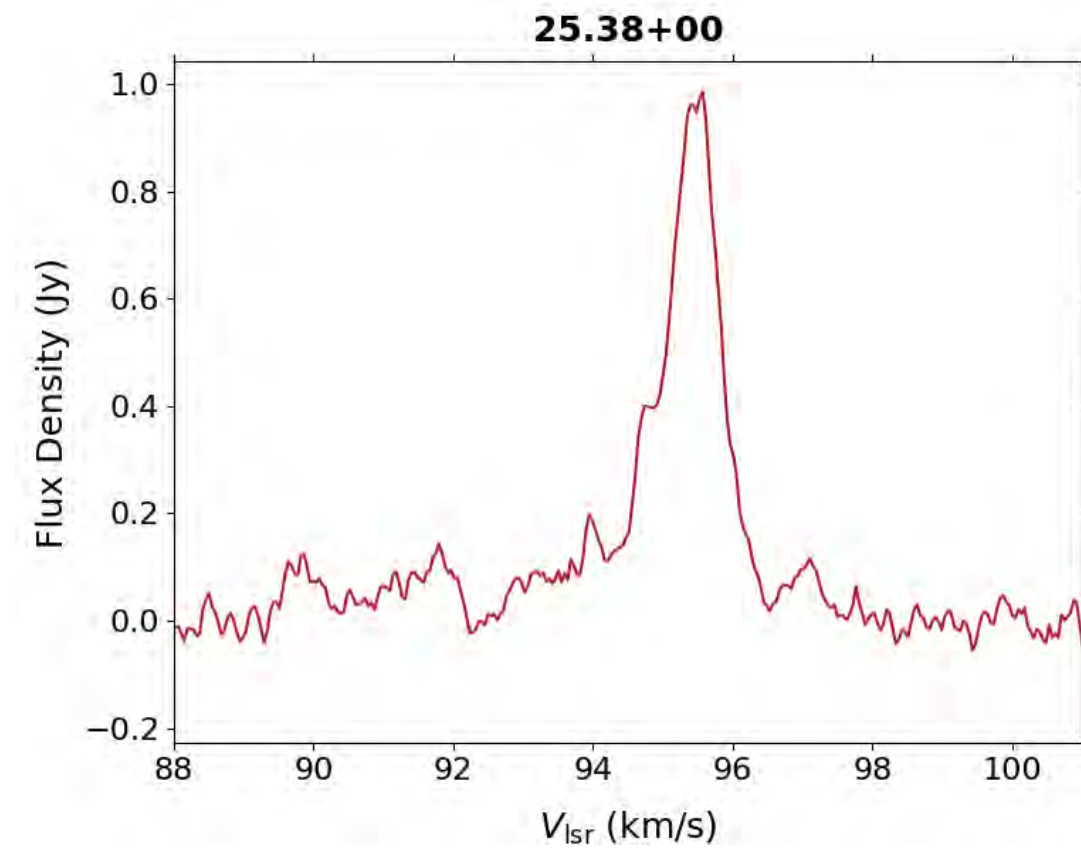


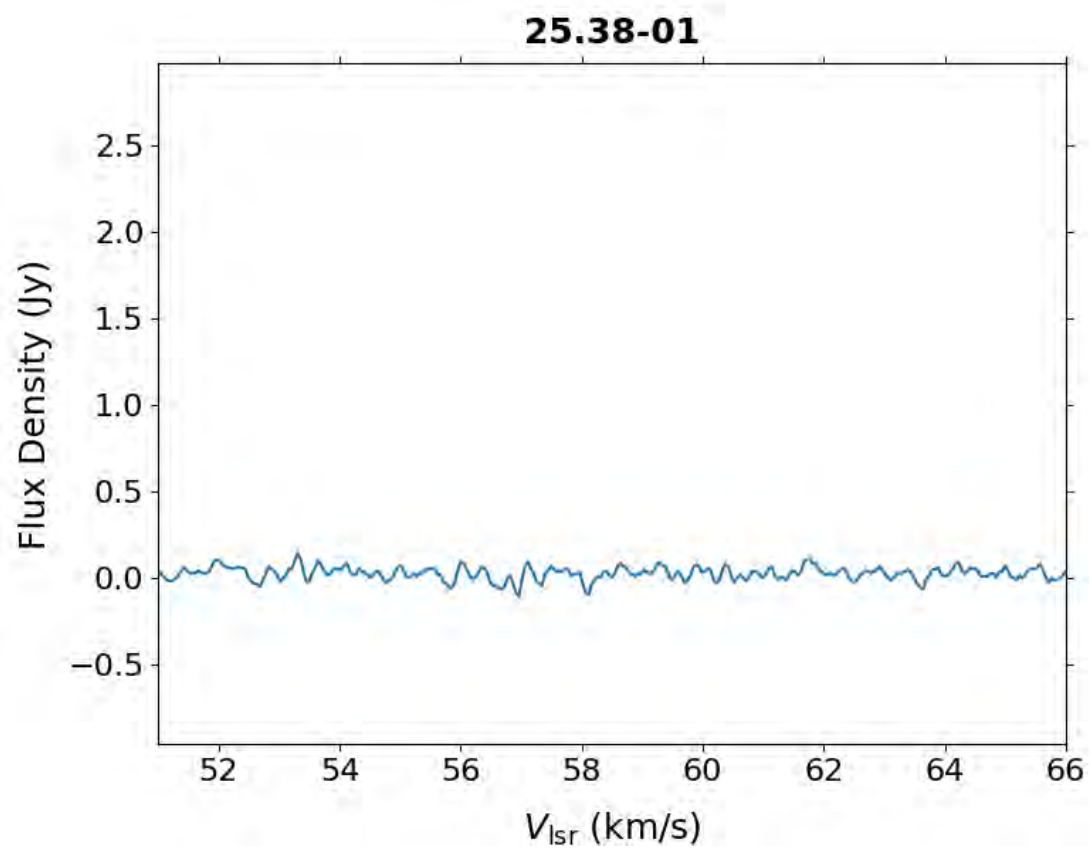
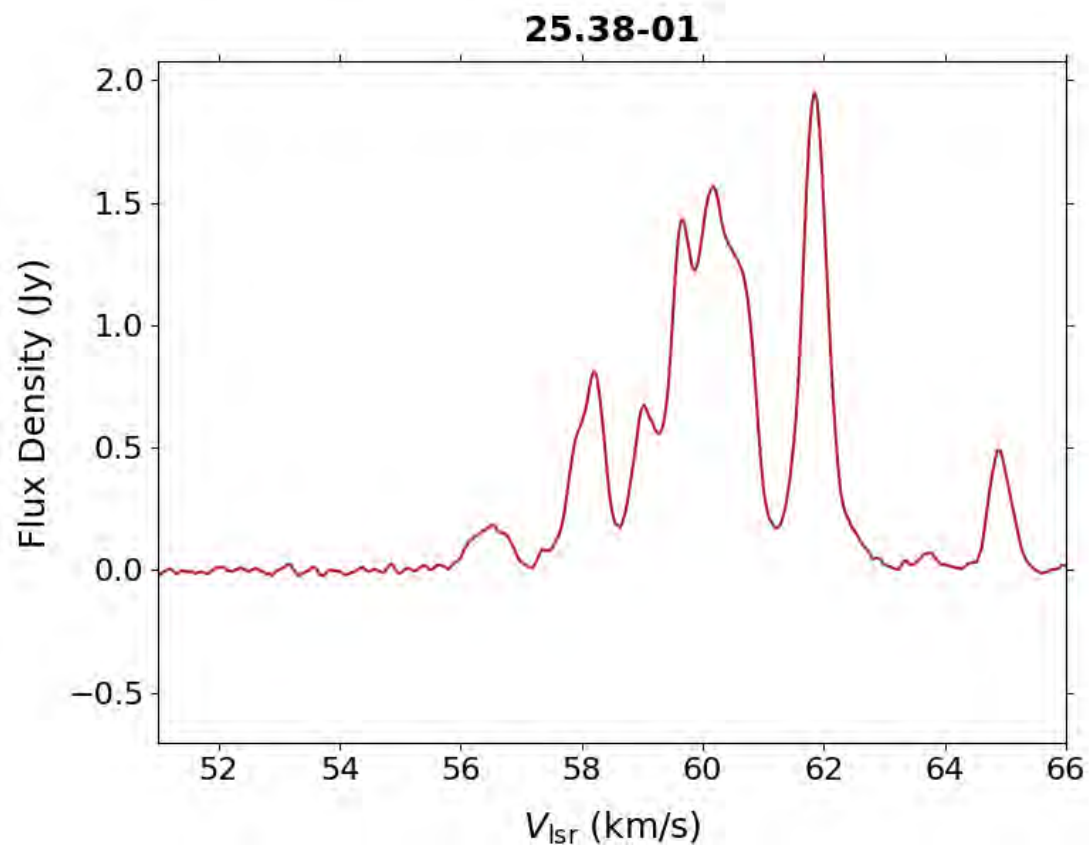
25.27-04

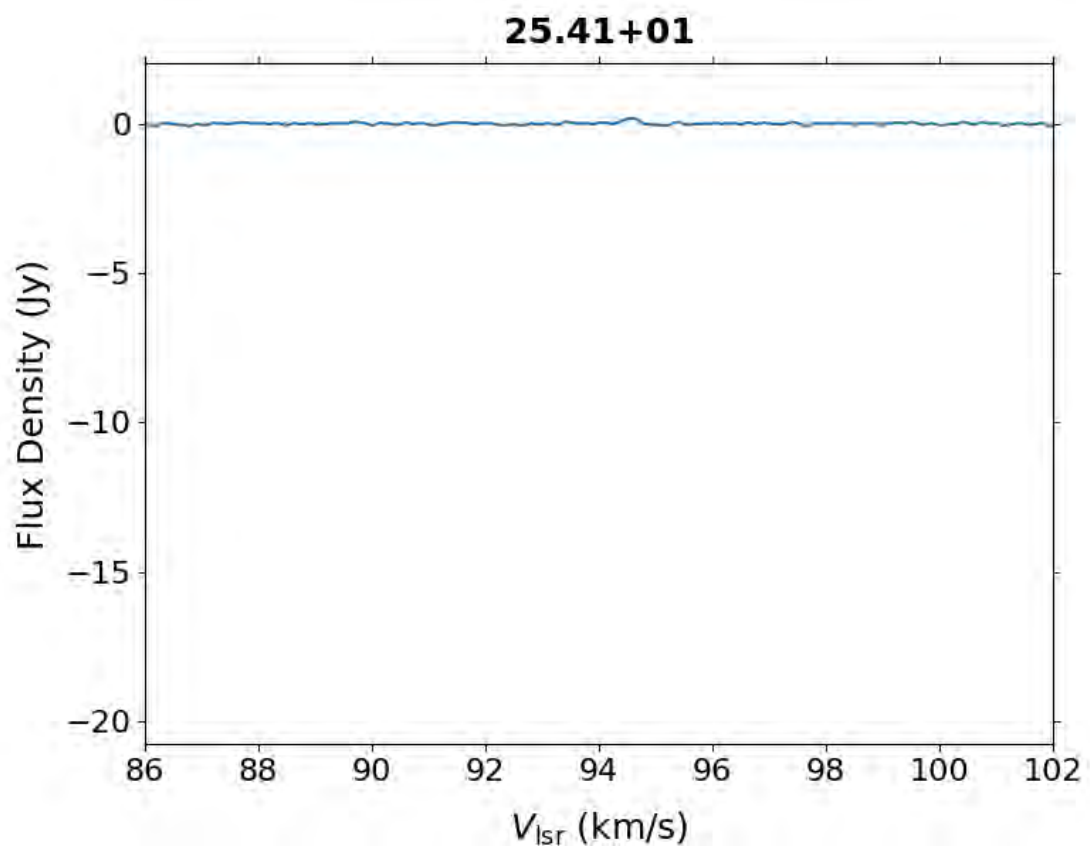
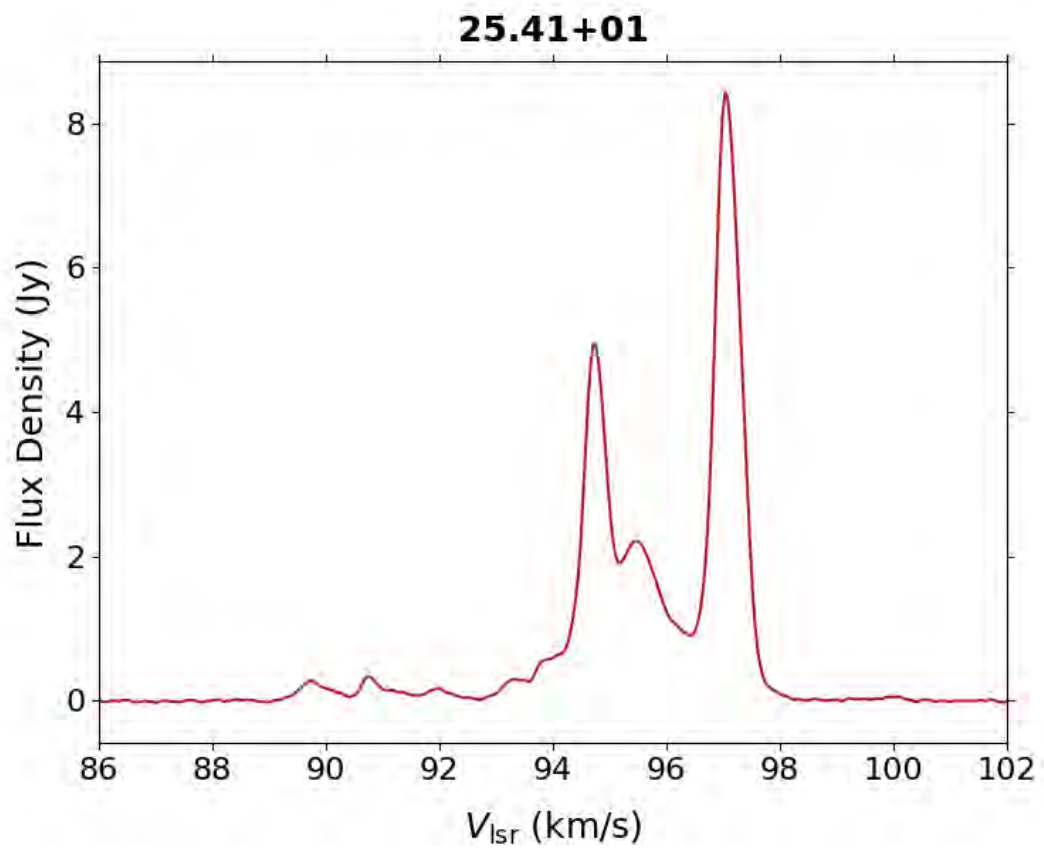


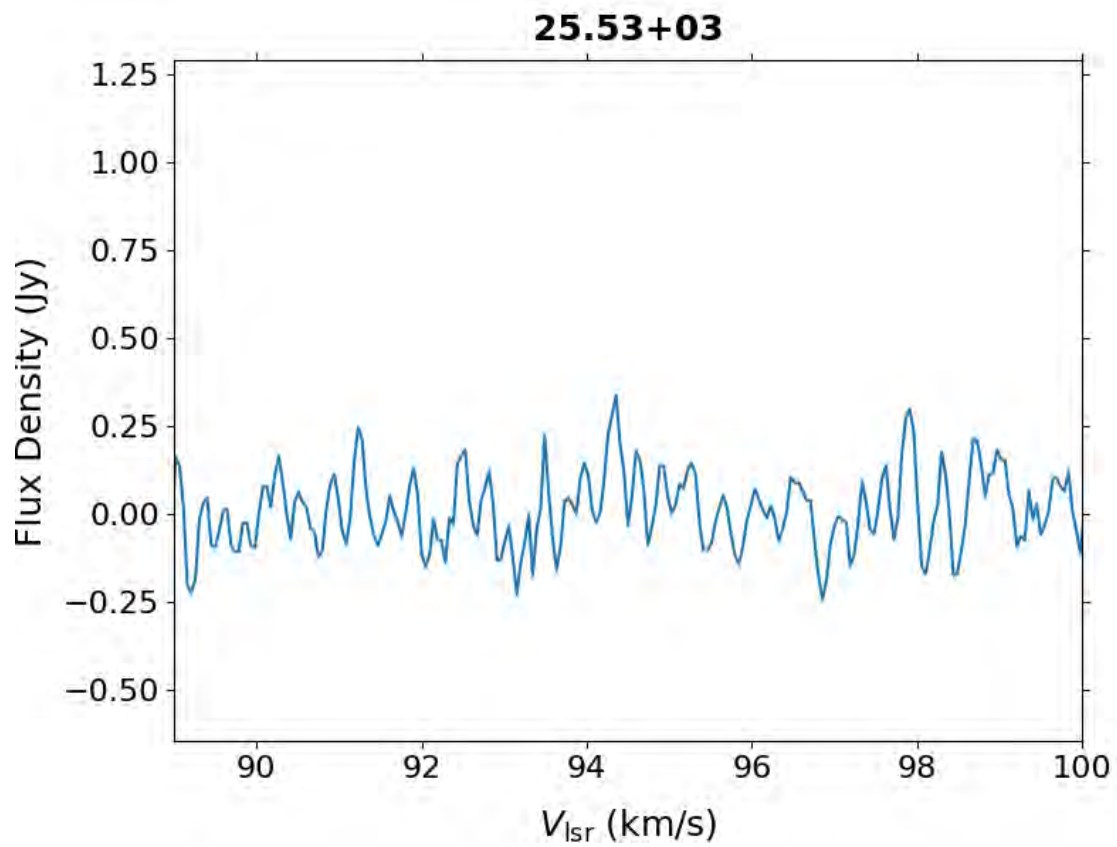
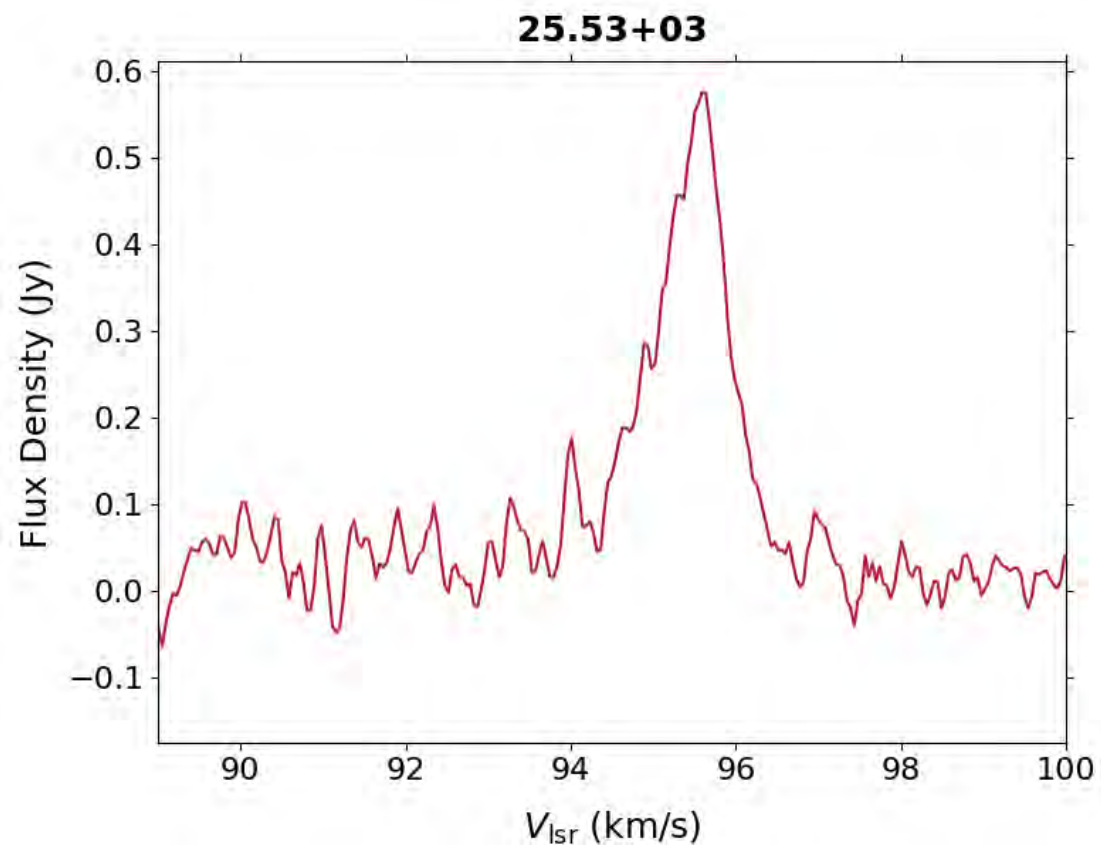
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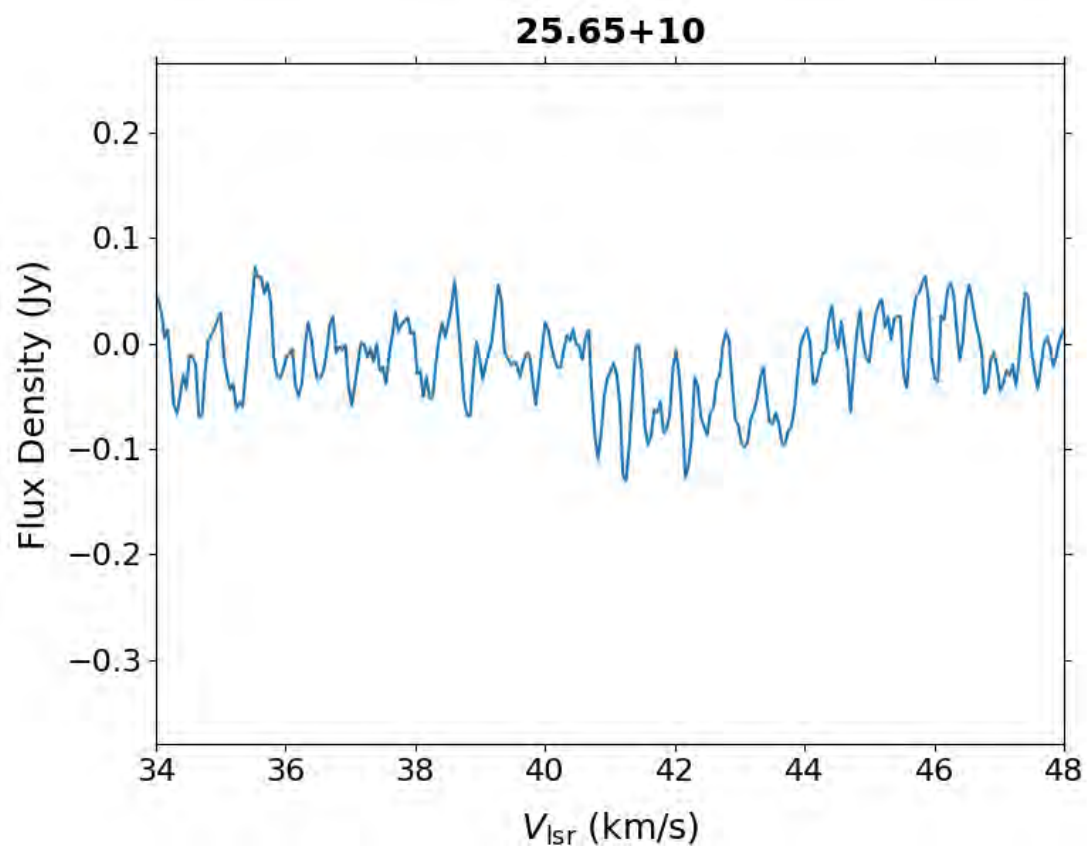
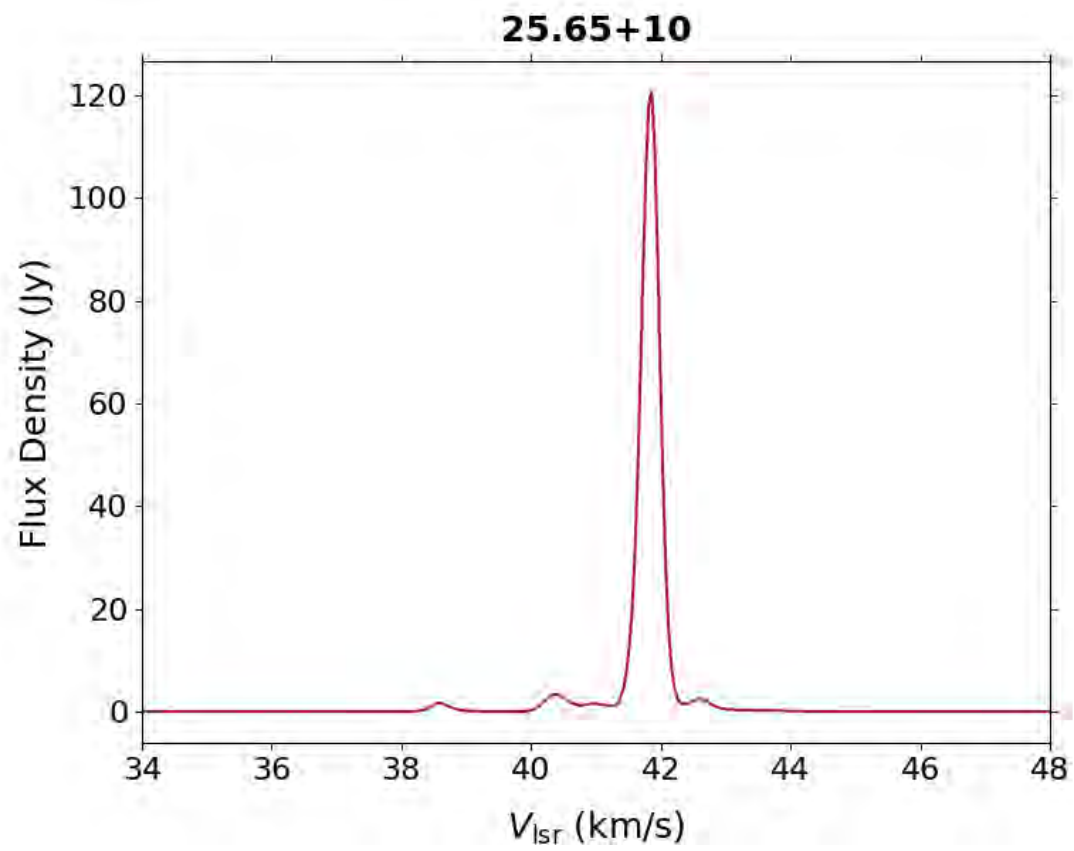


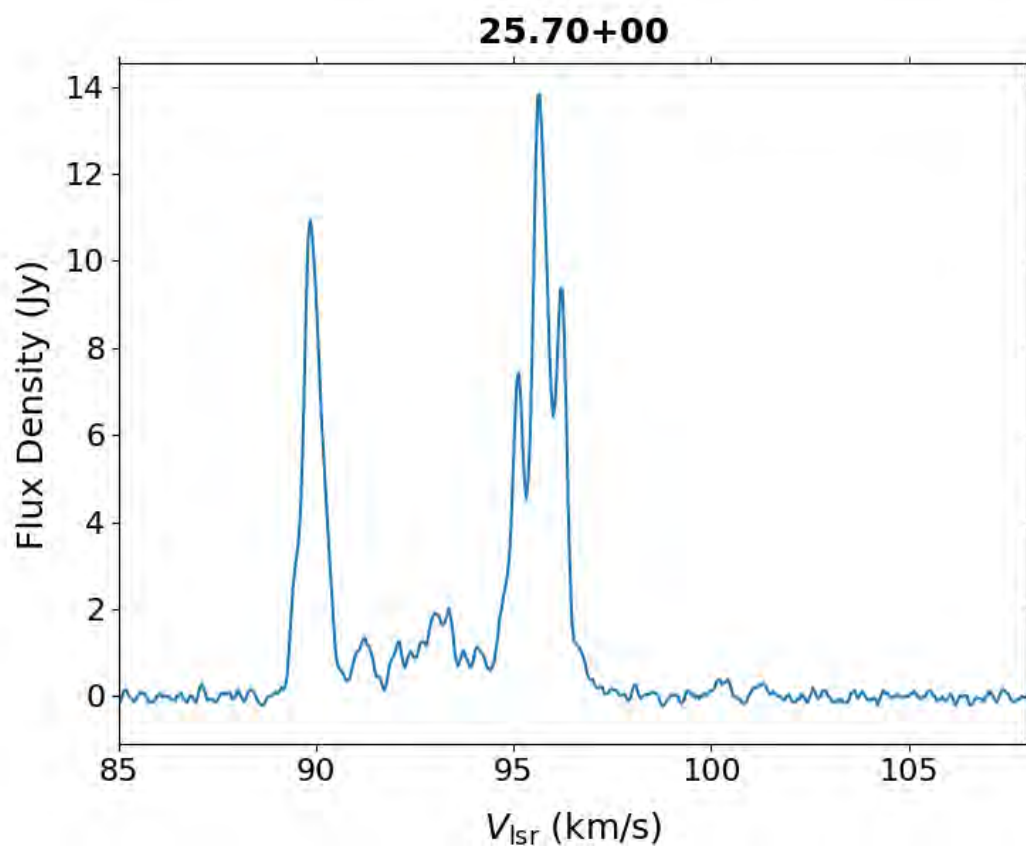
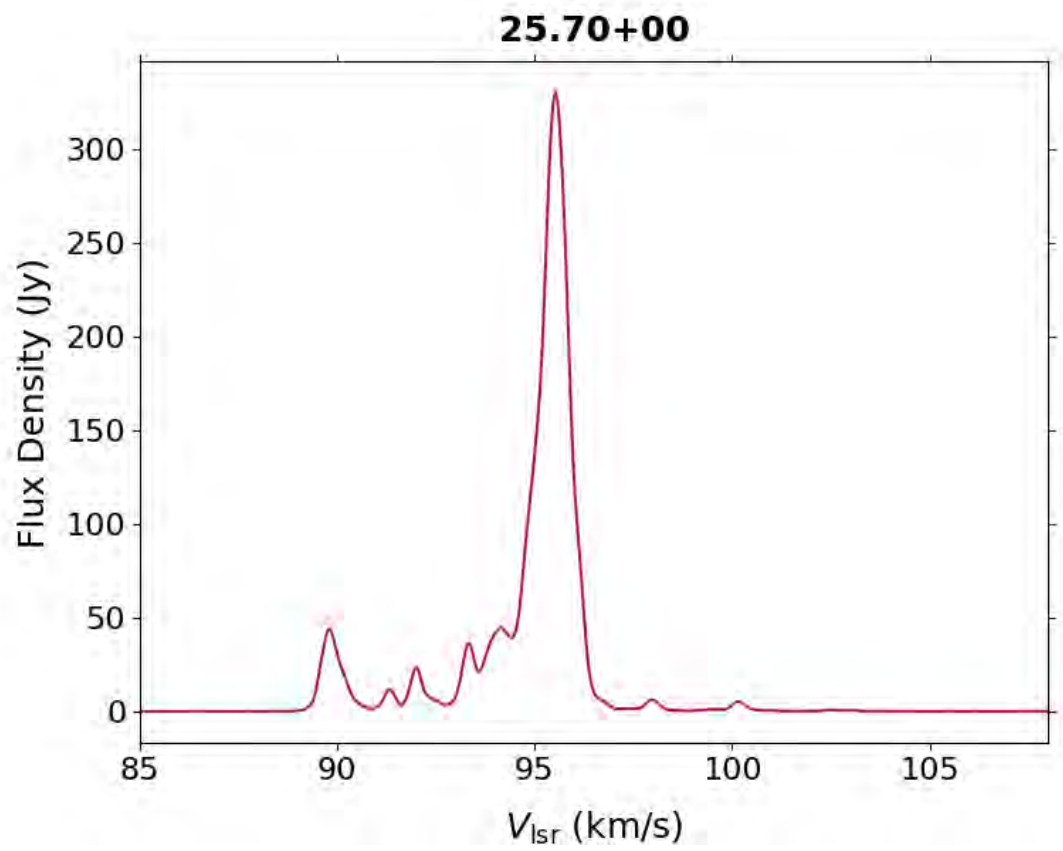




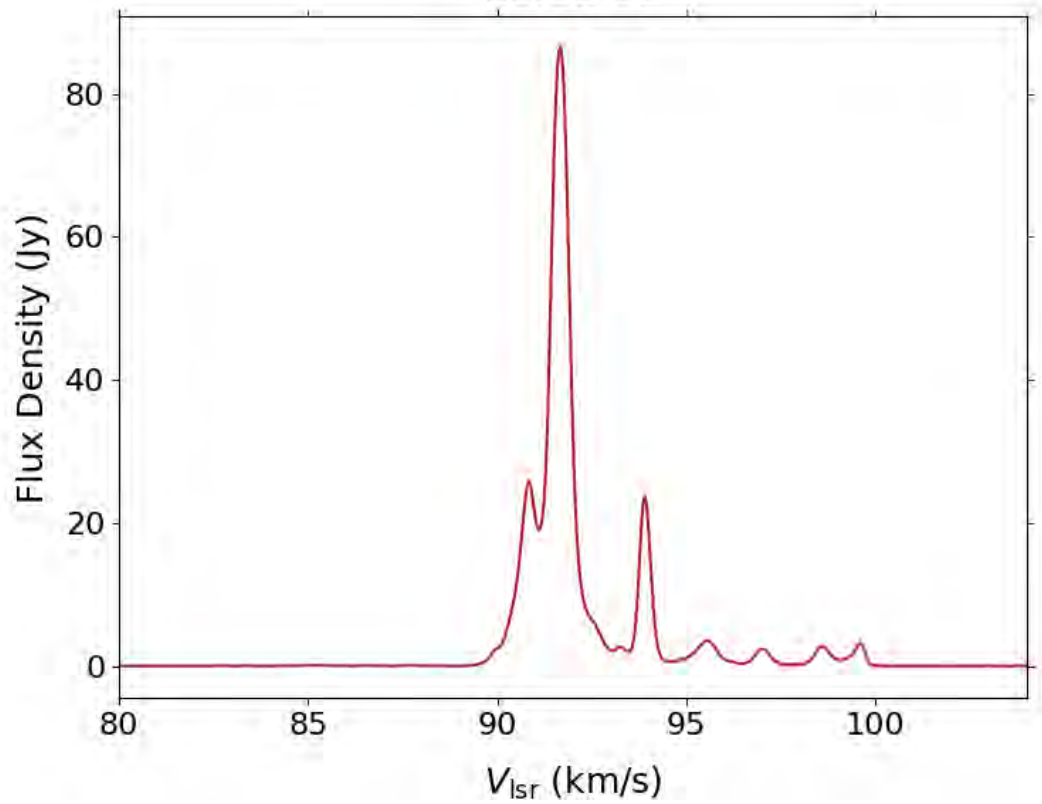




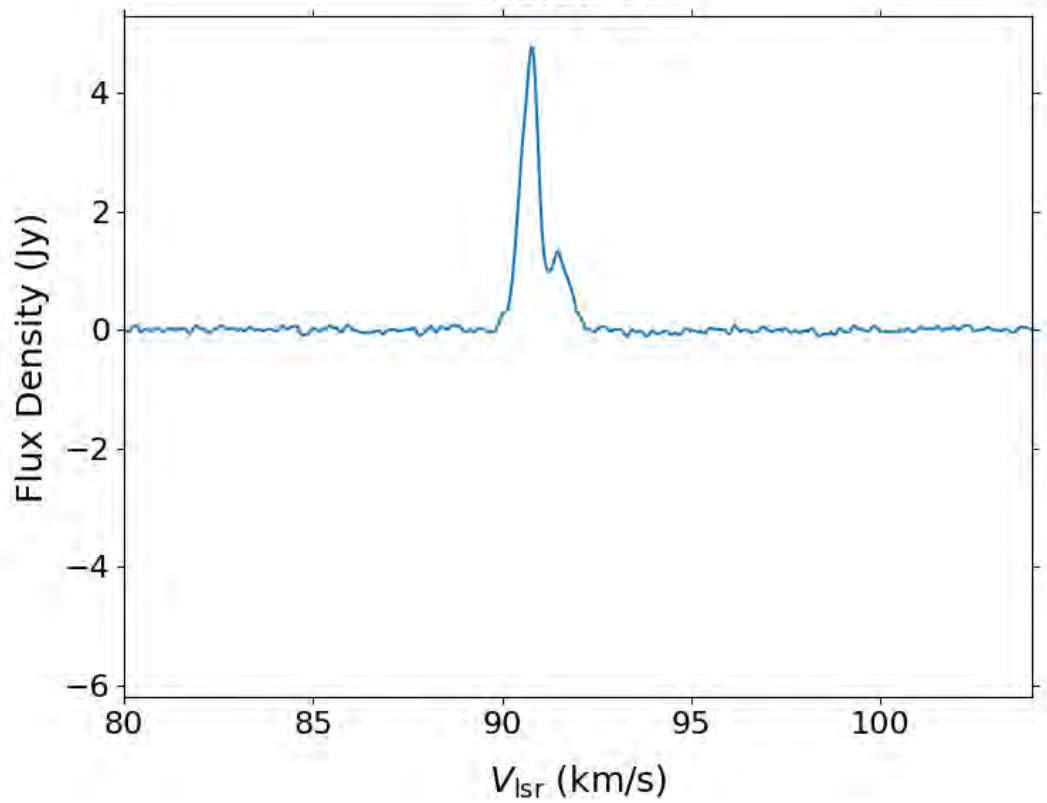


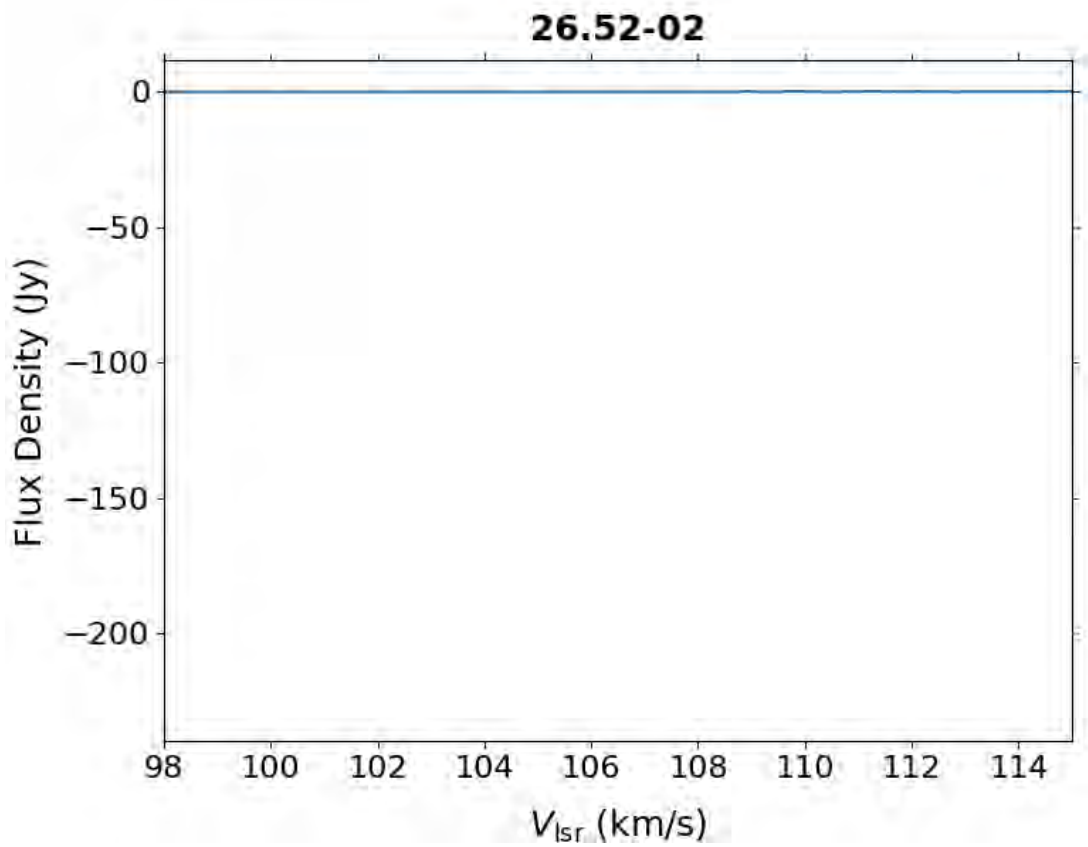
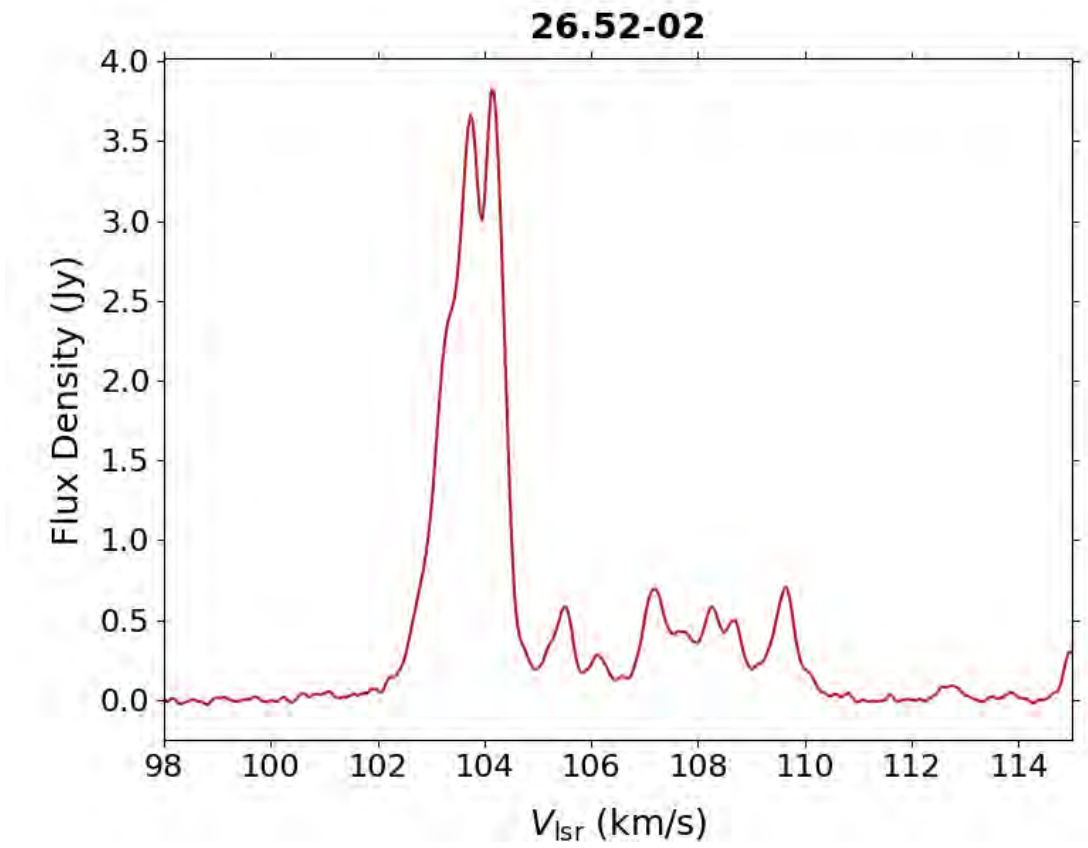


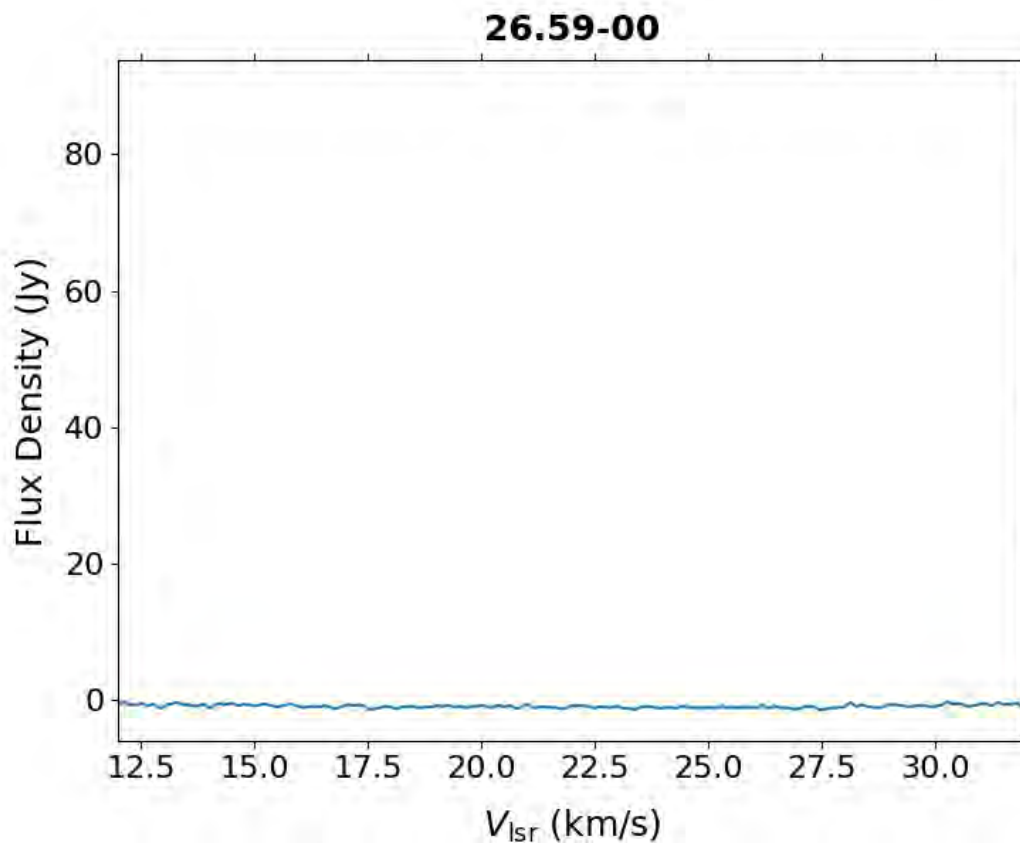
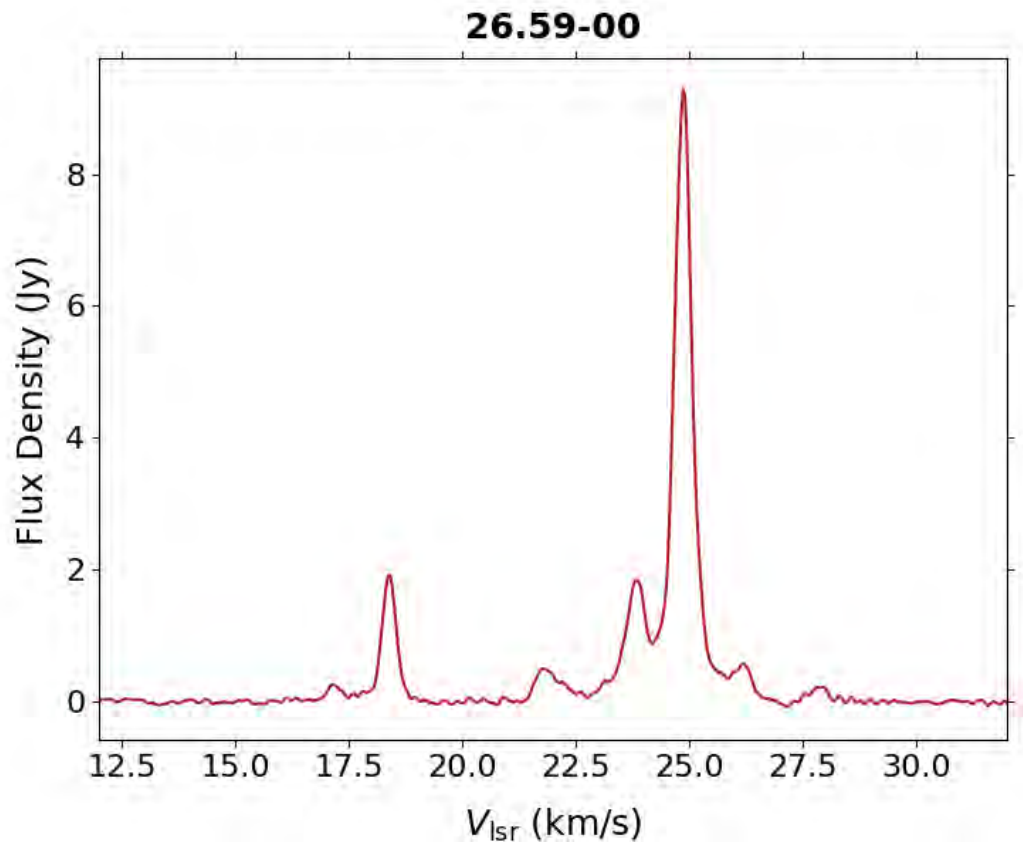
25.82-01



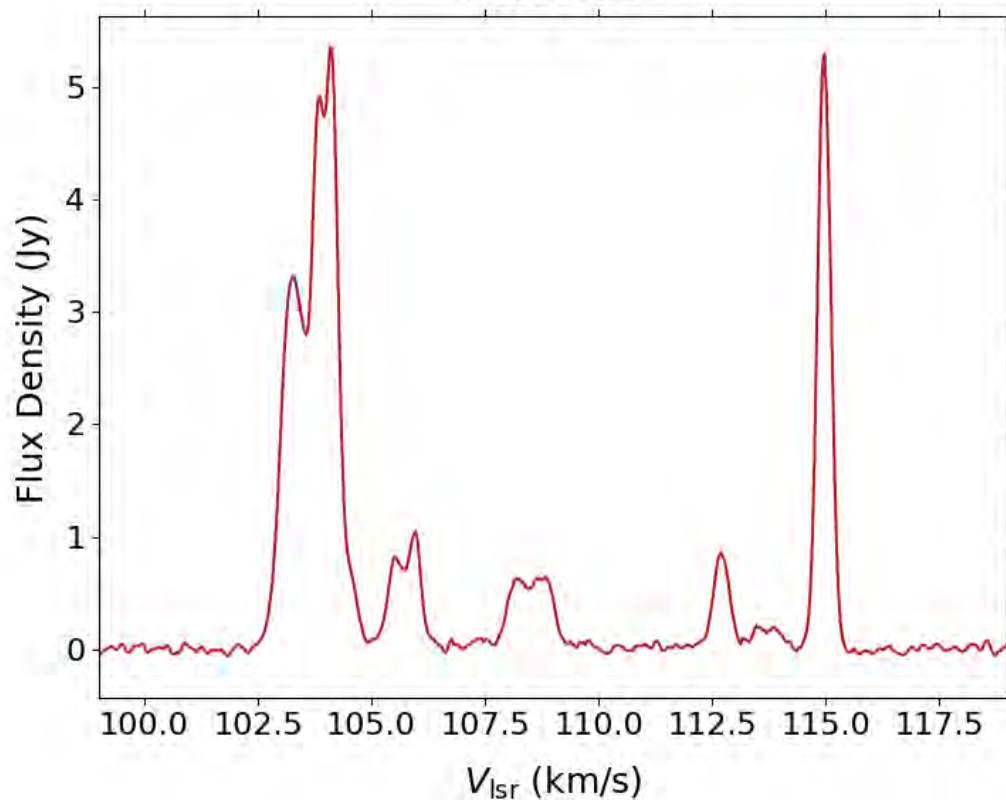
25.82-01



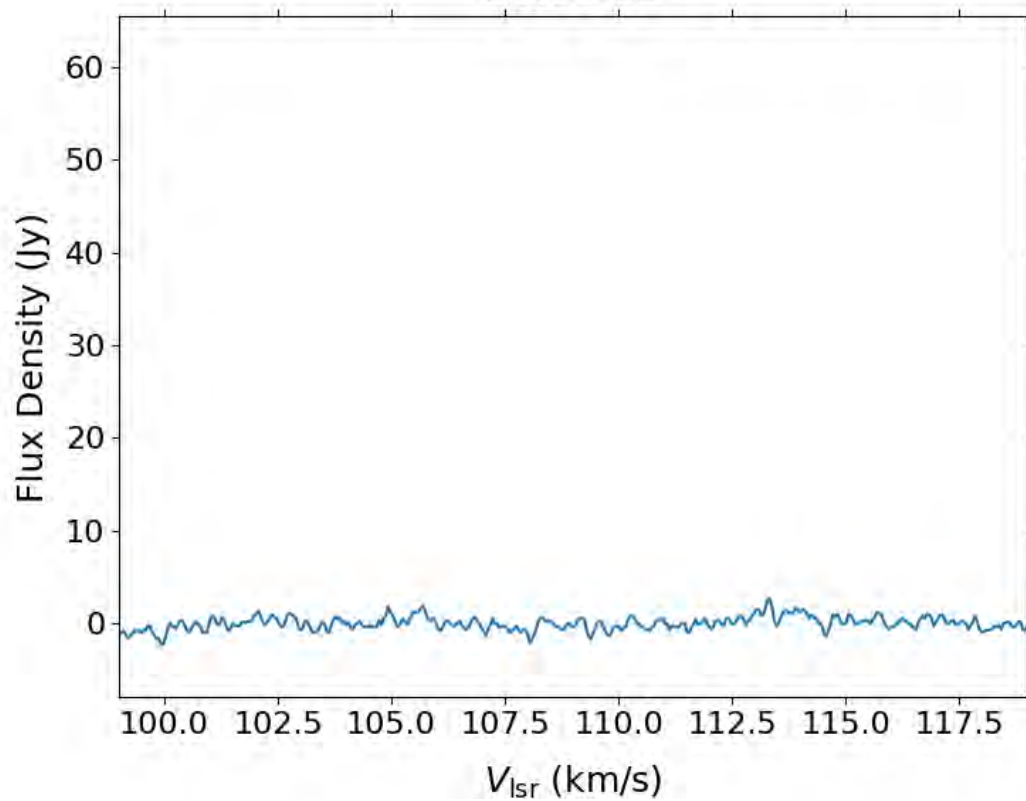


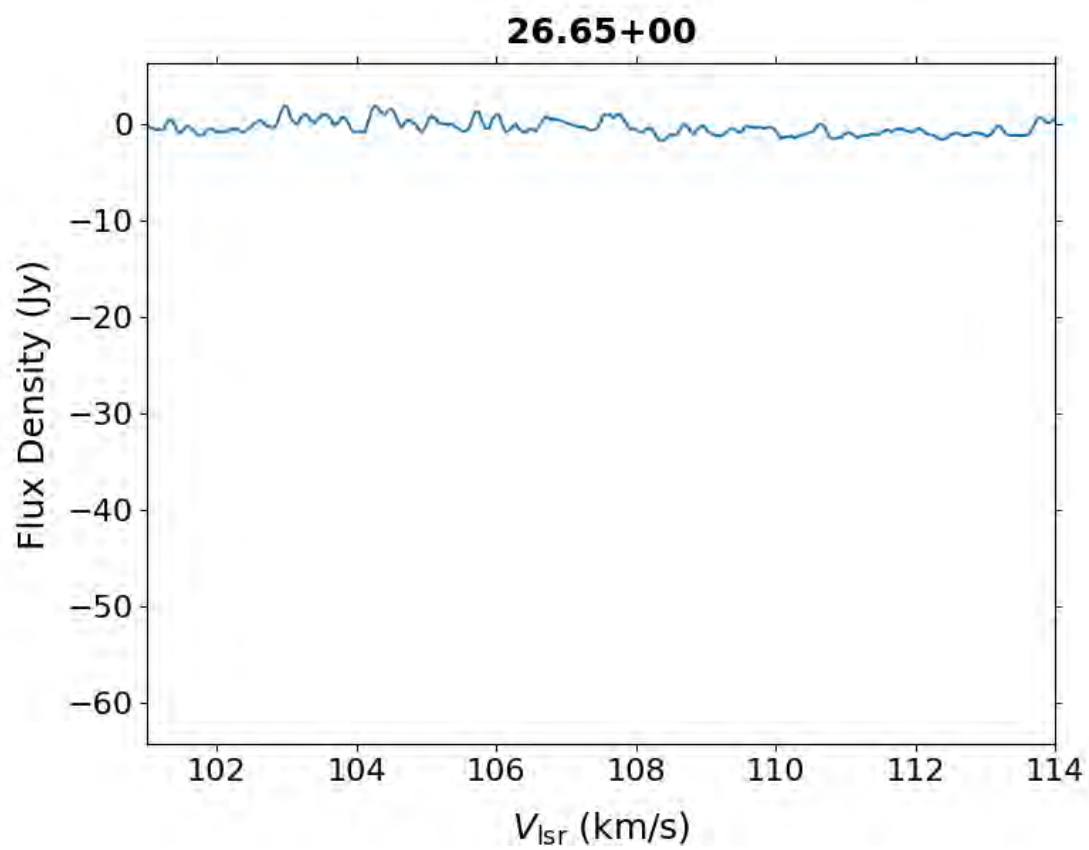
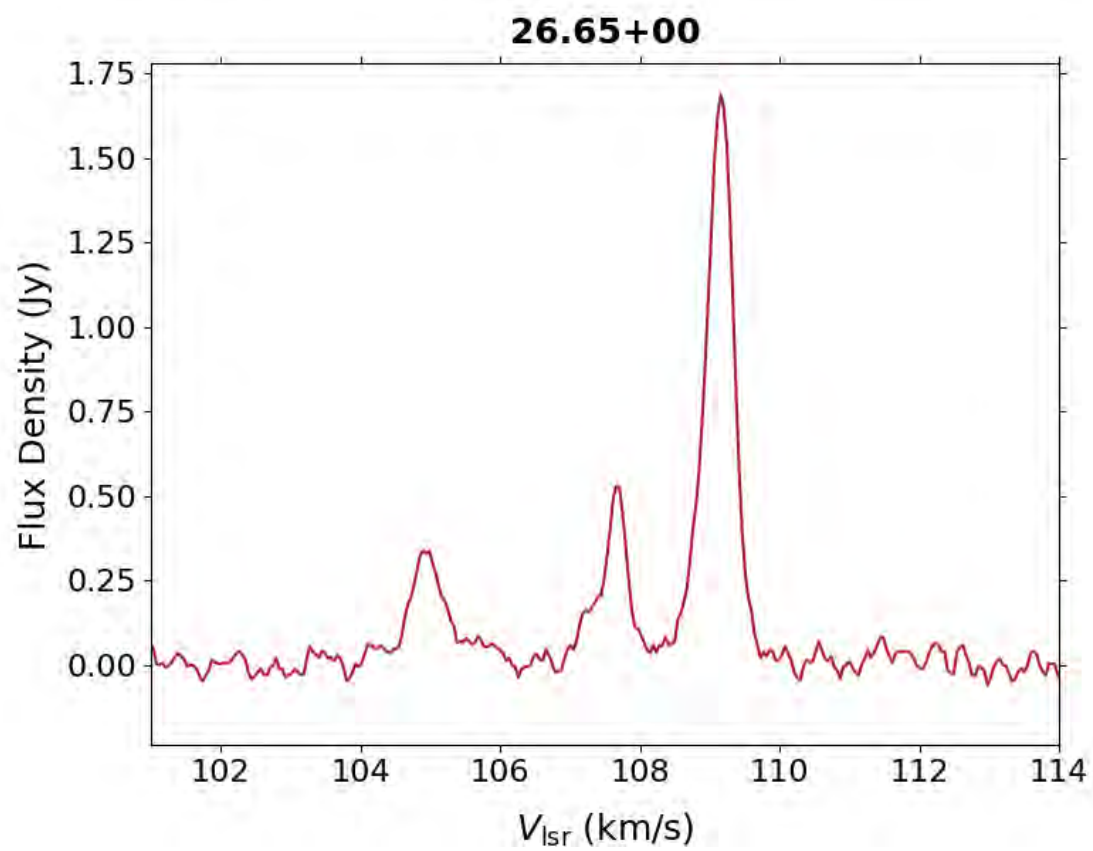


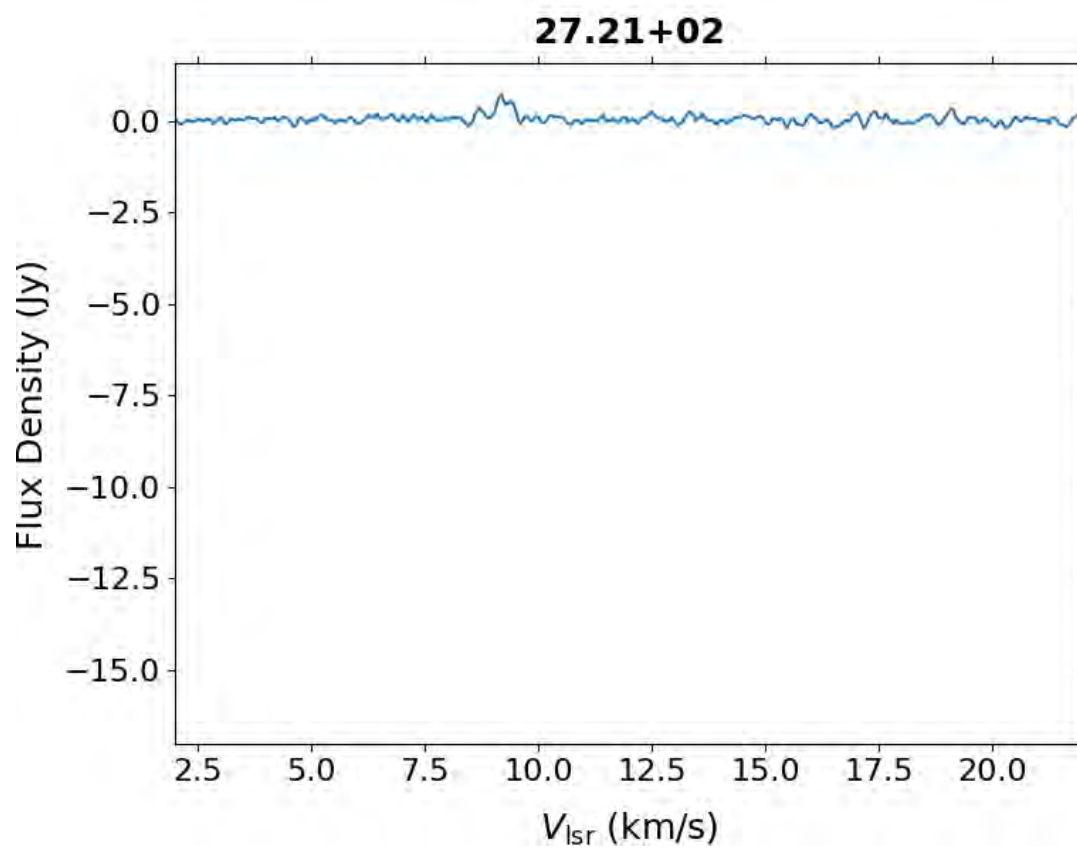
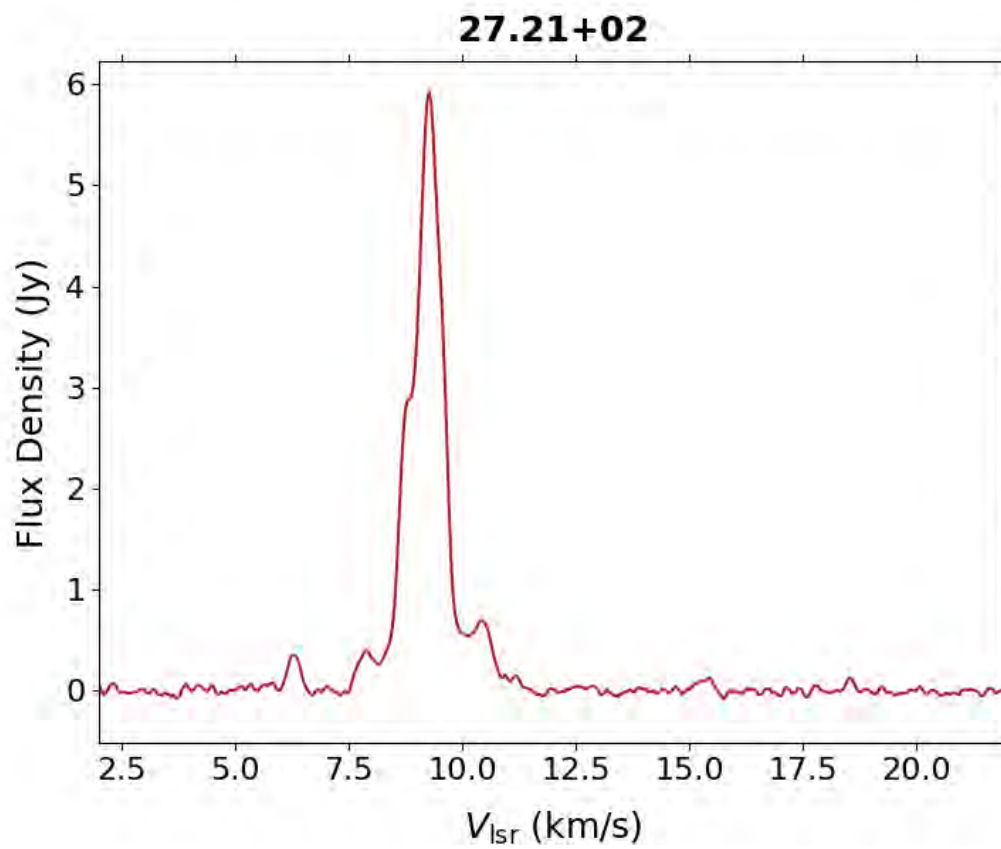
26.60-02

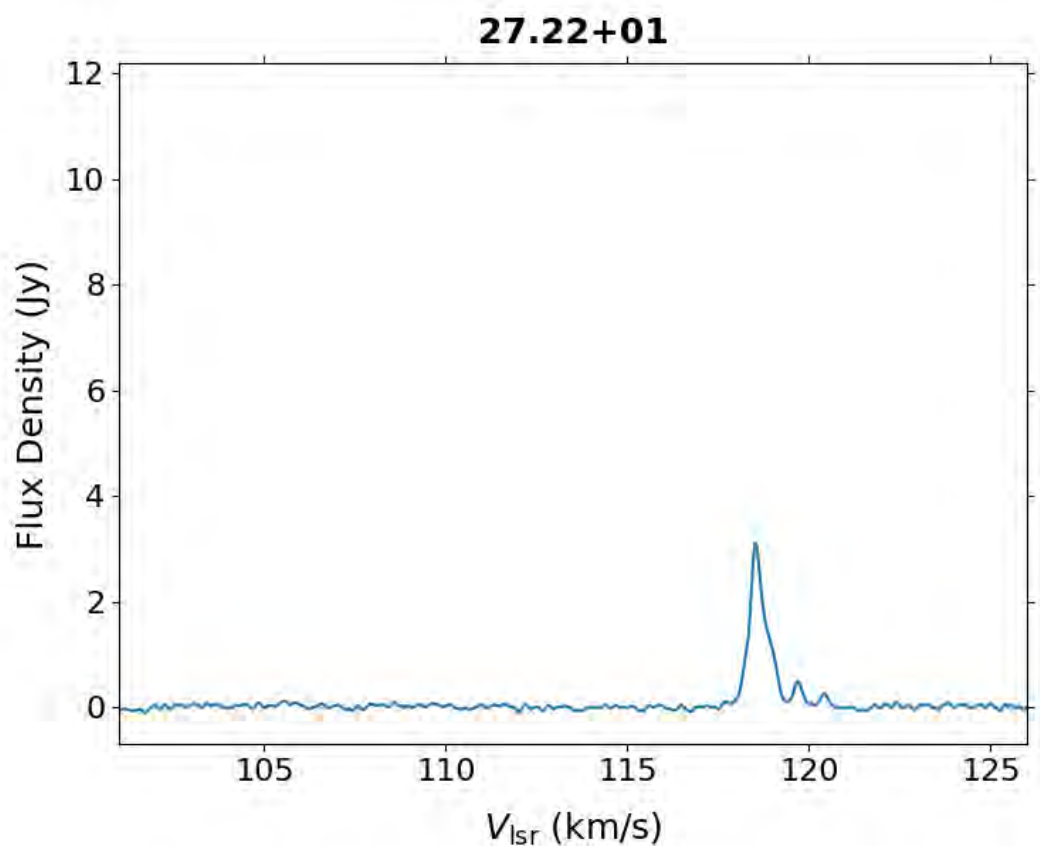
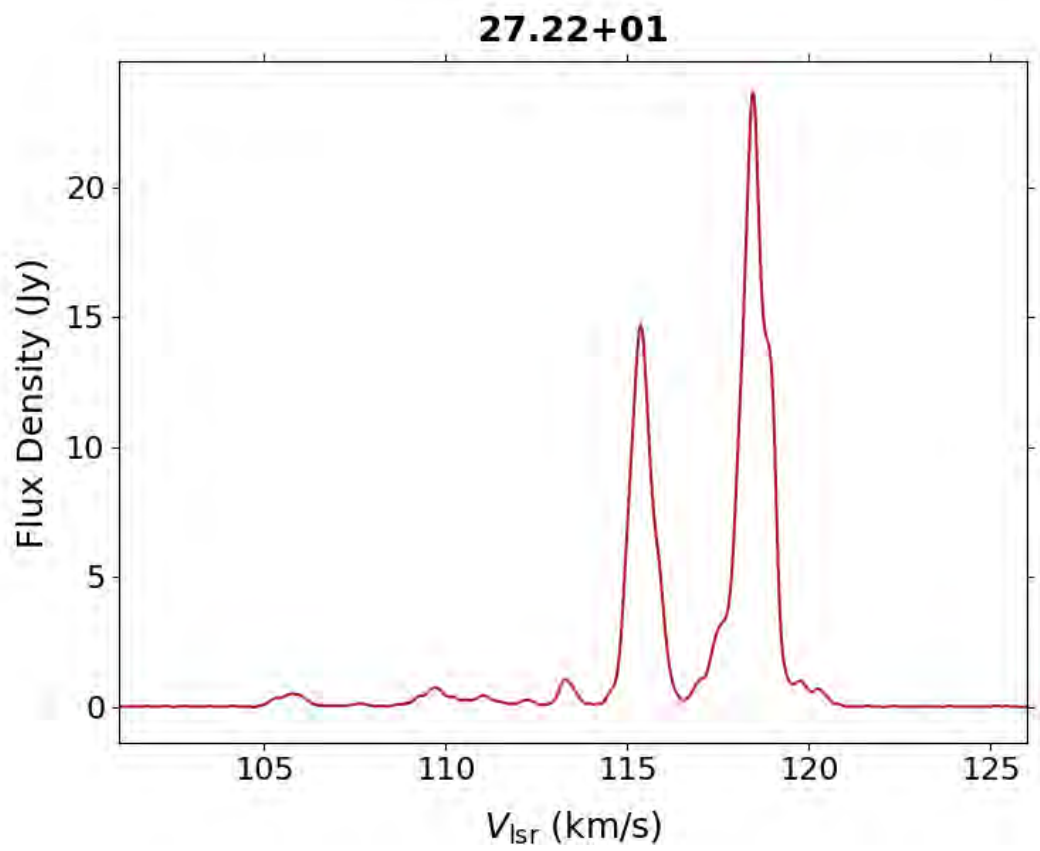


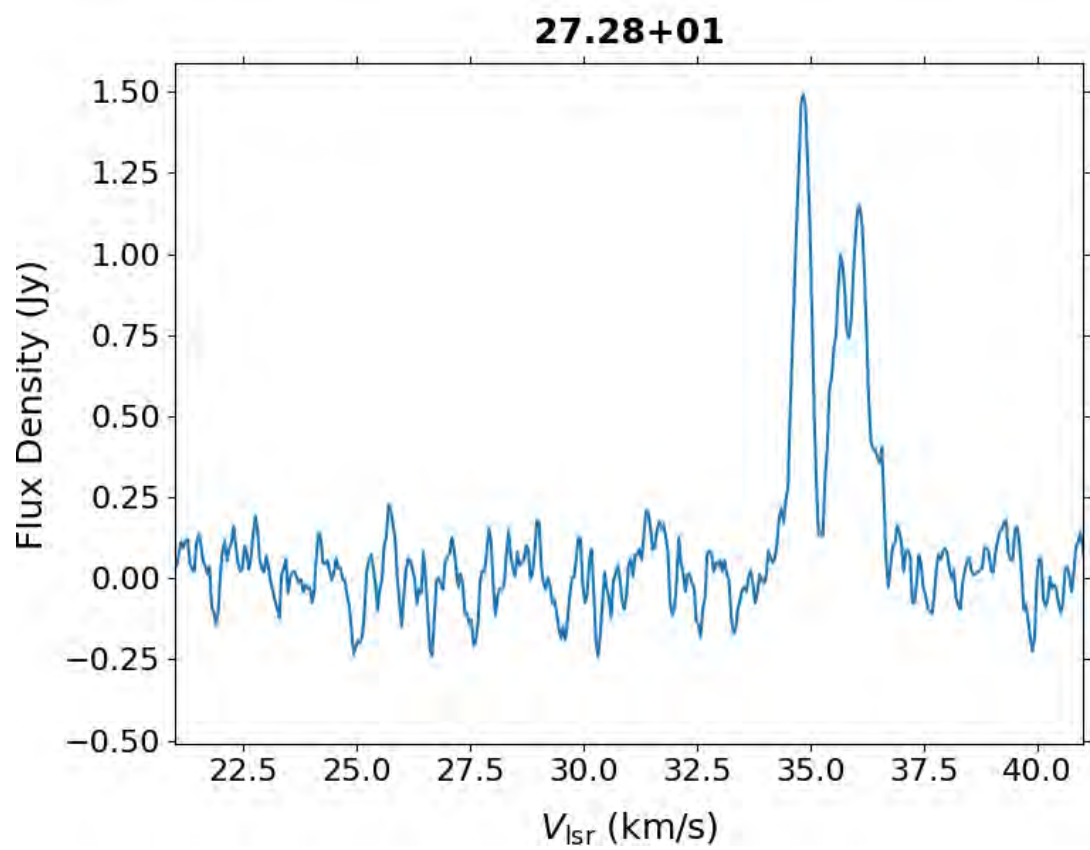
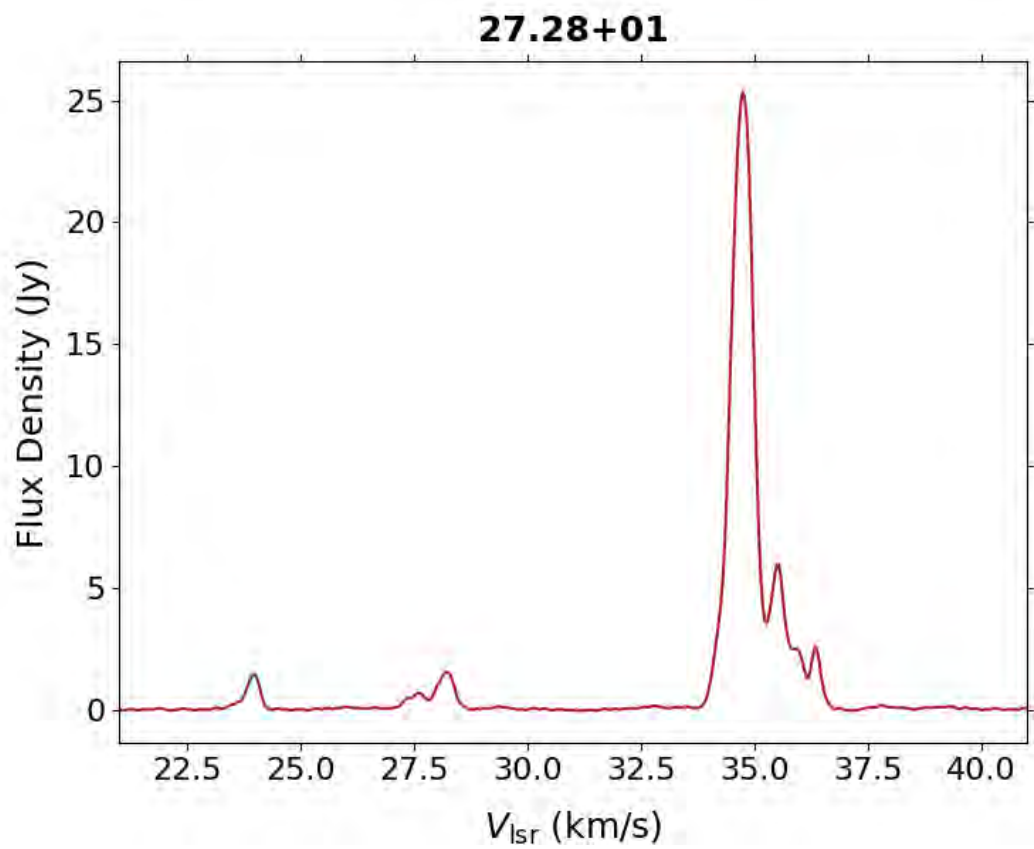
26.60-02



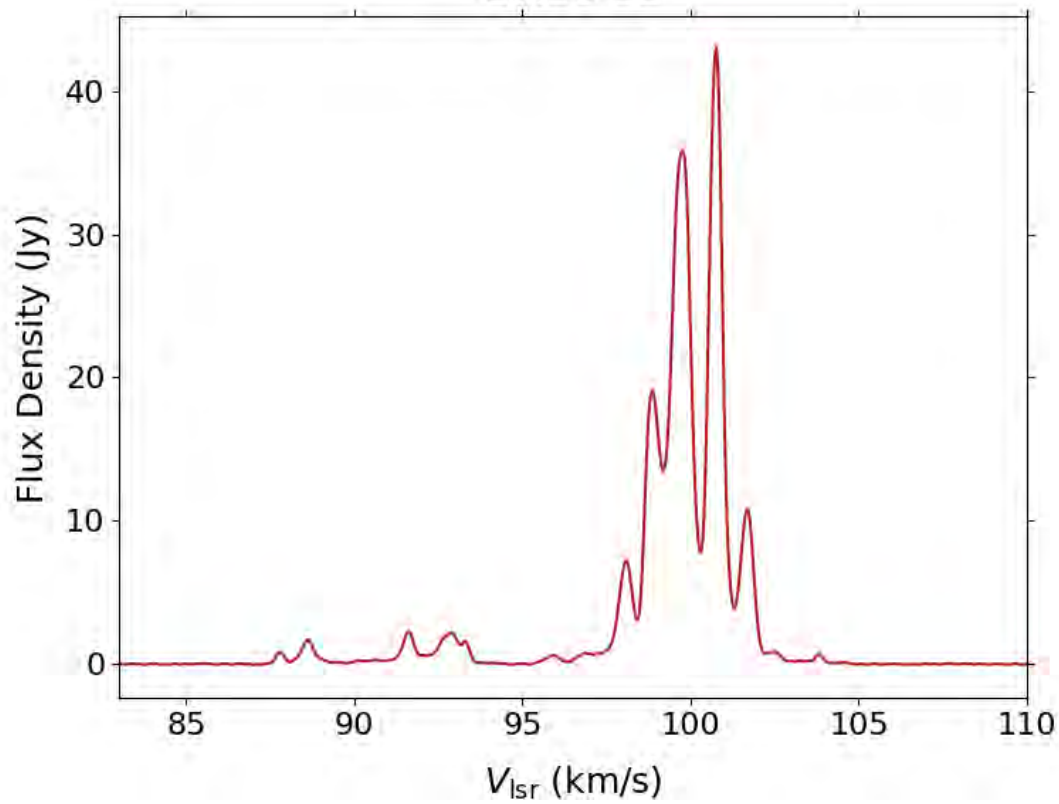




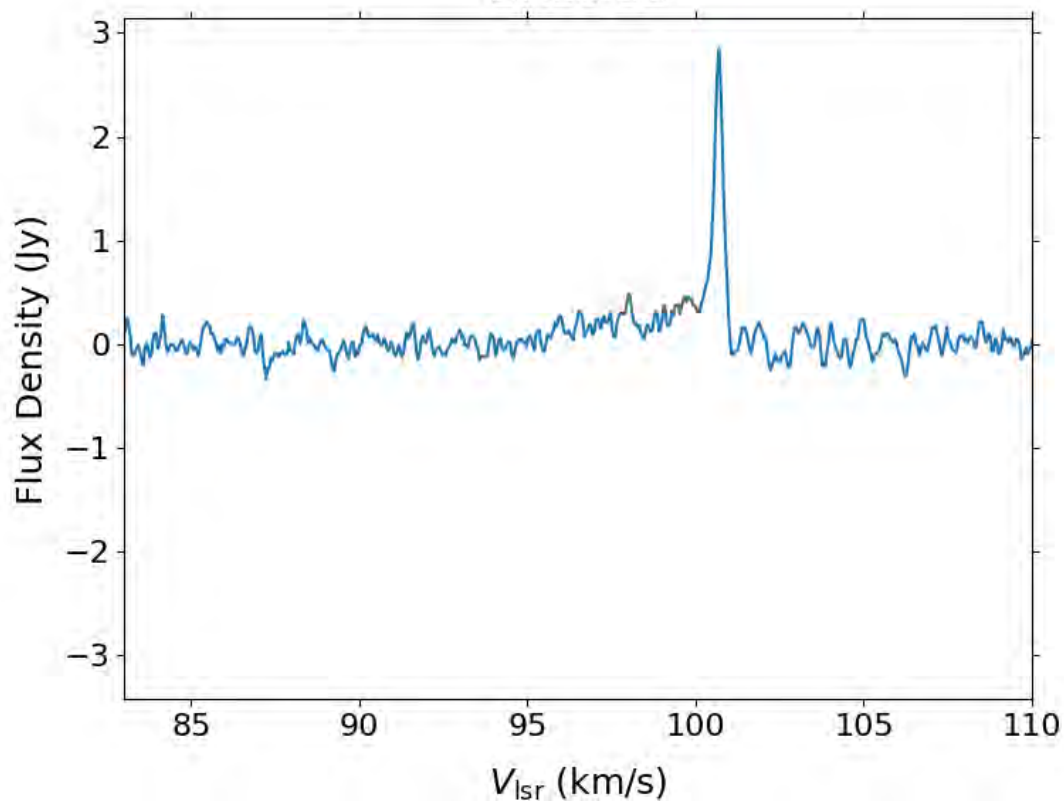


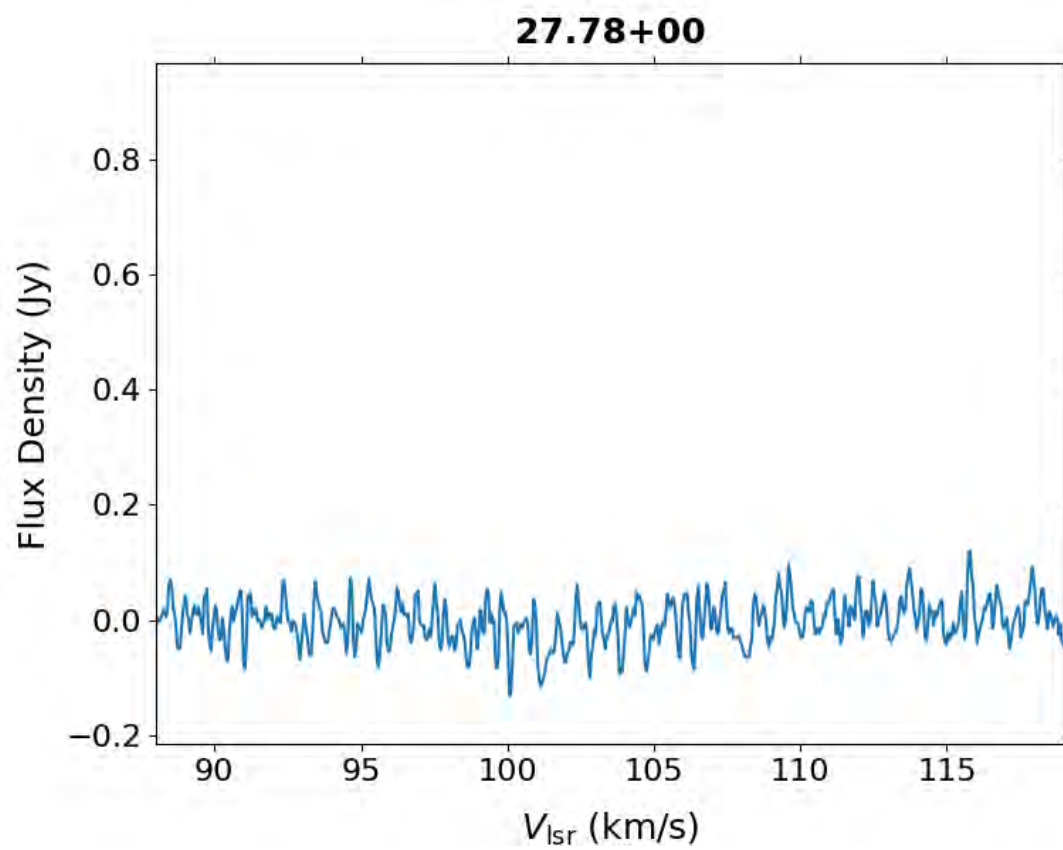
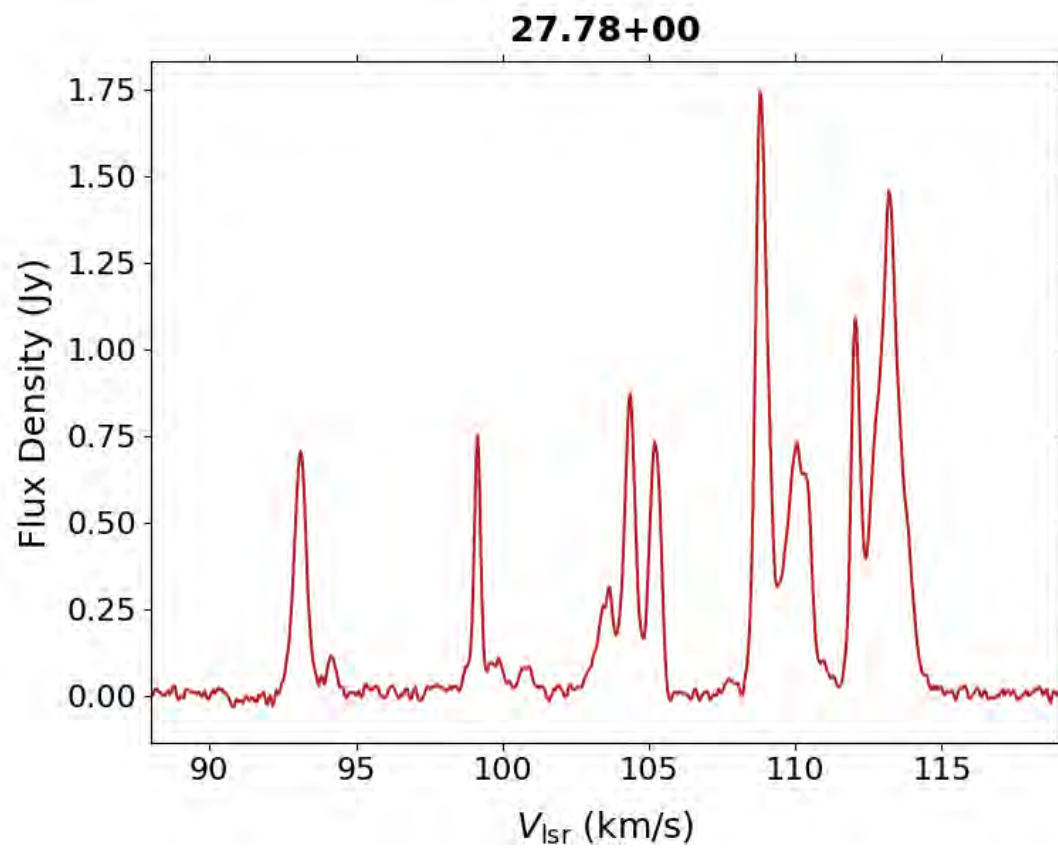


27.36-01

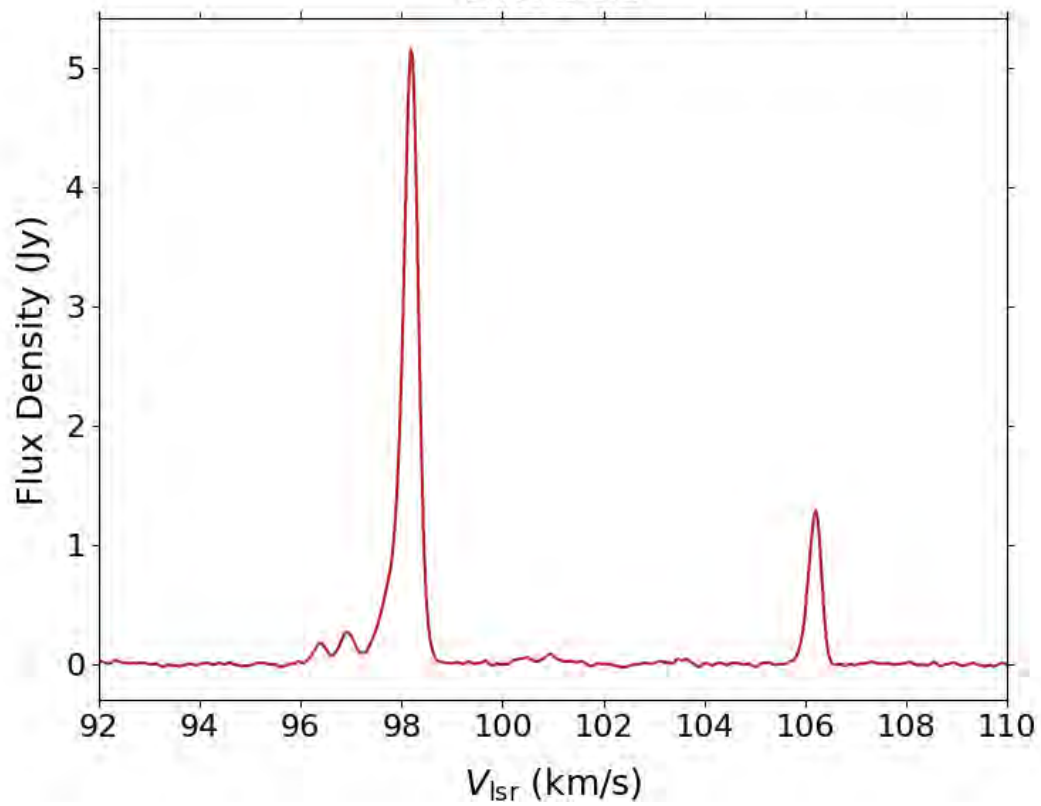


27.36-01

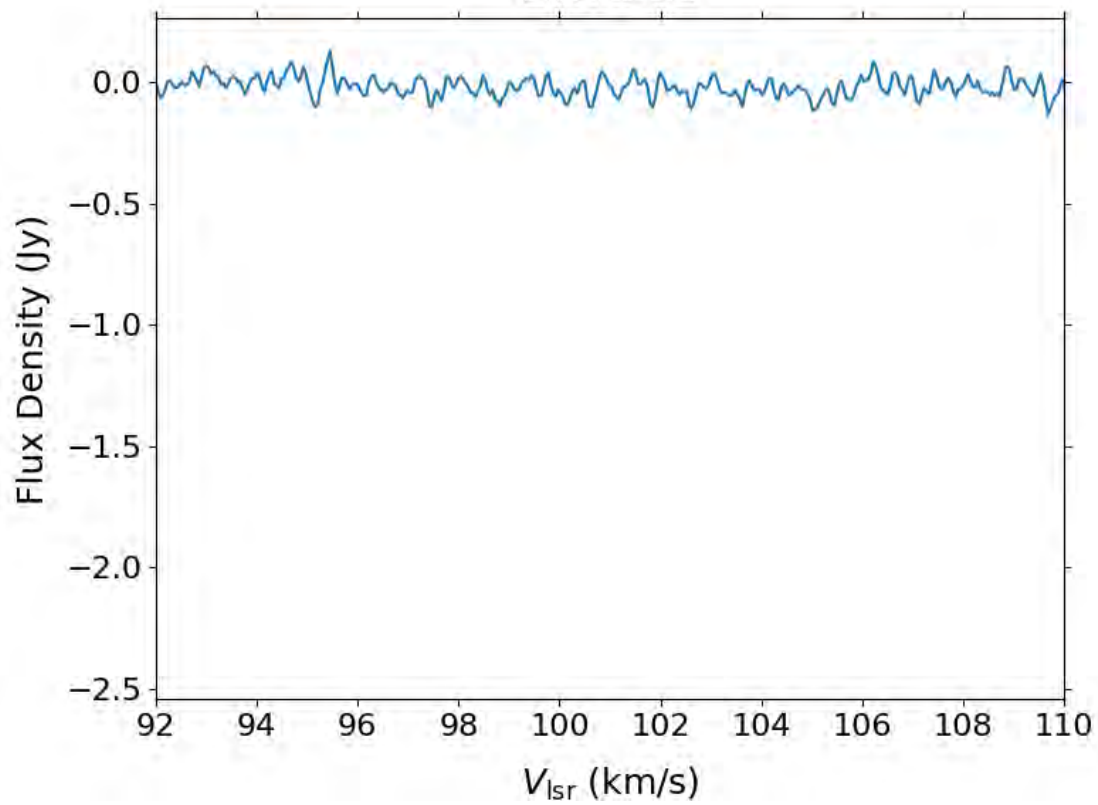


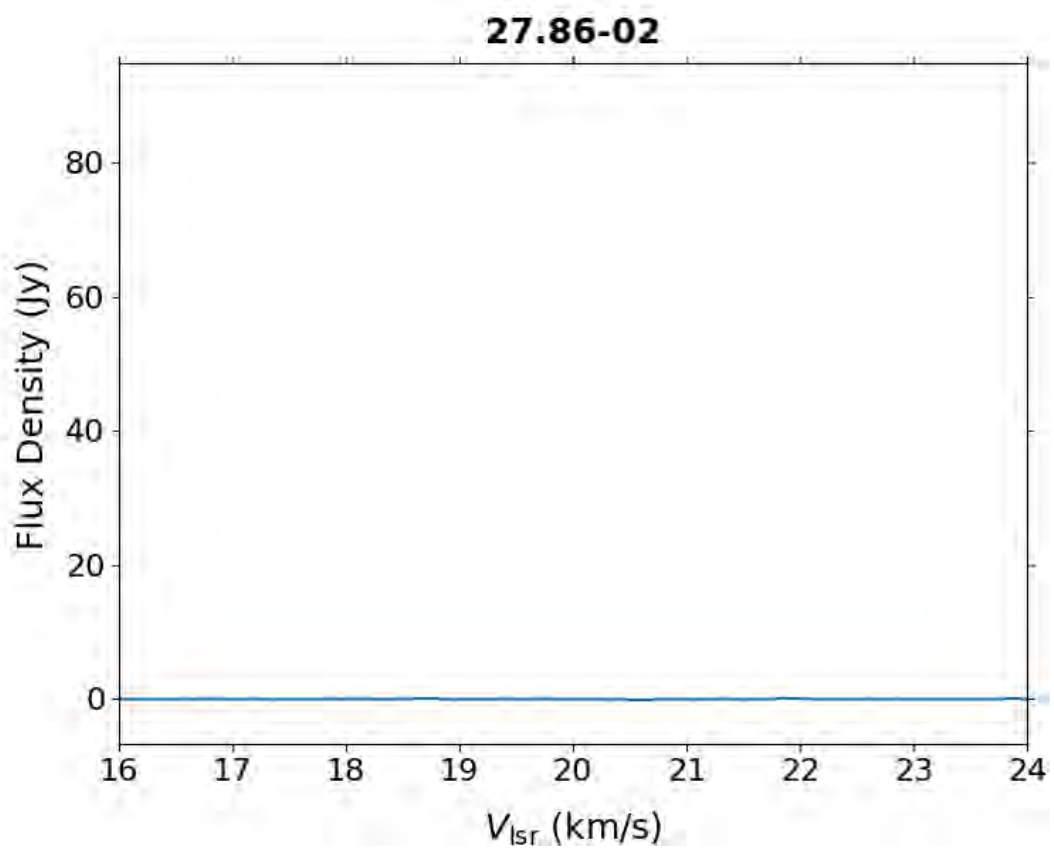
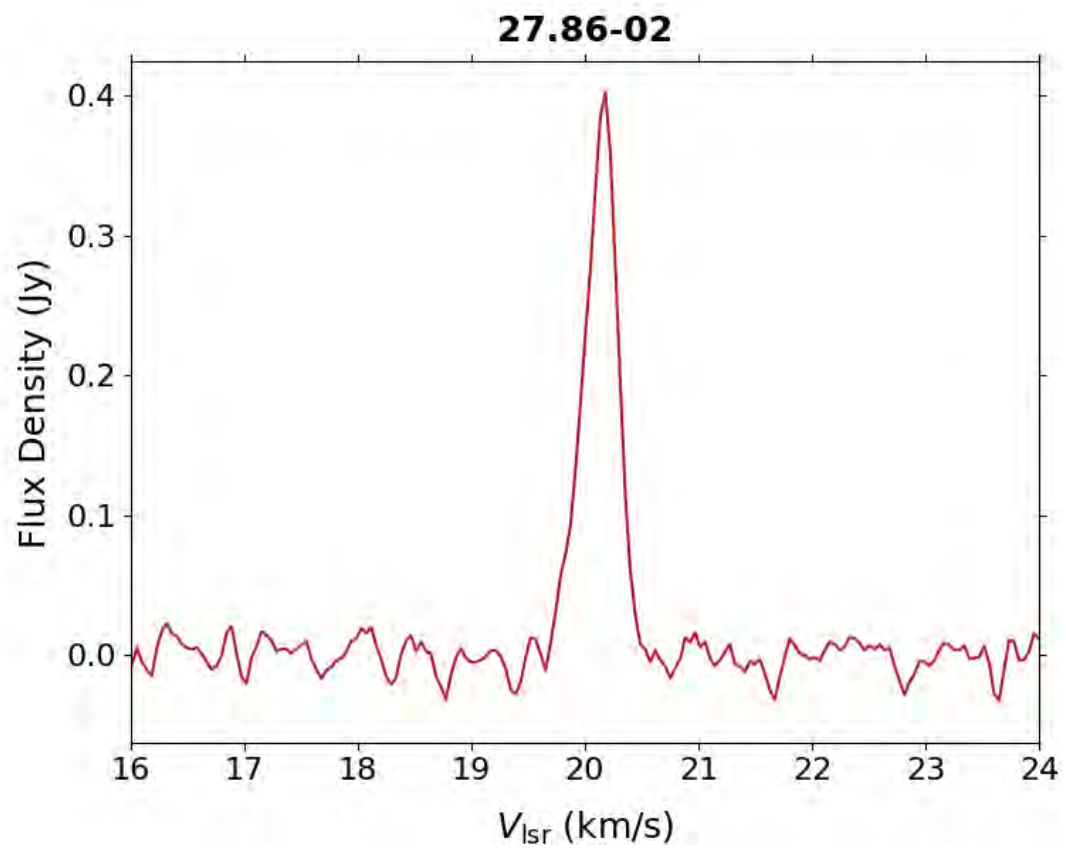


27.78-02

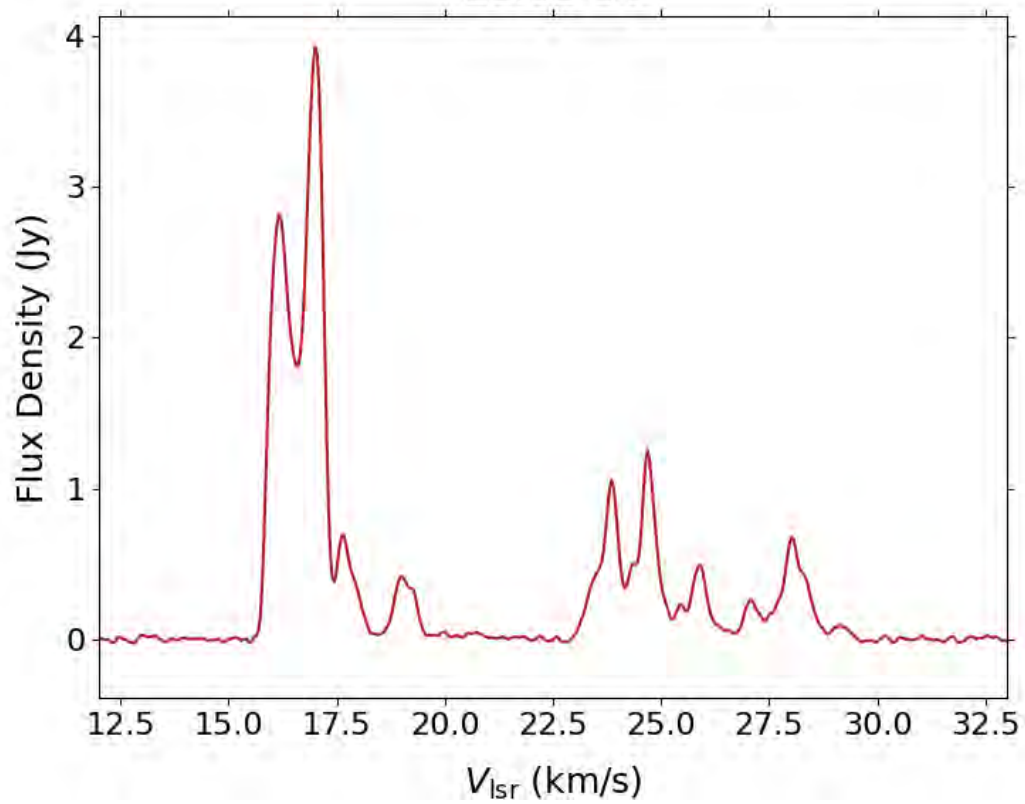


27.78-02

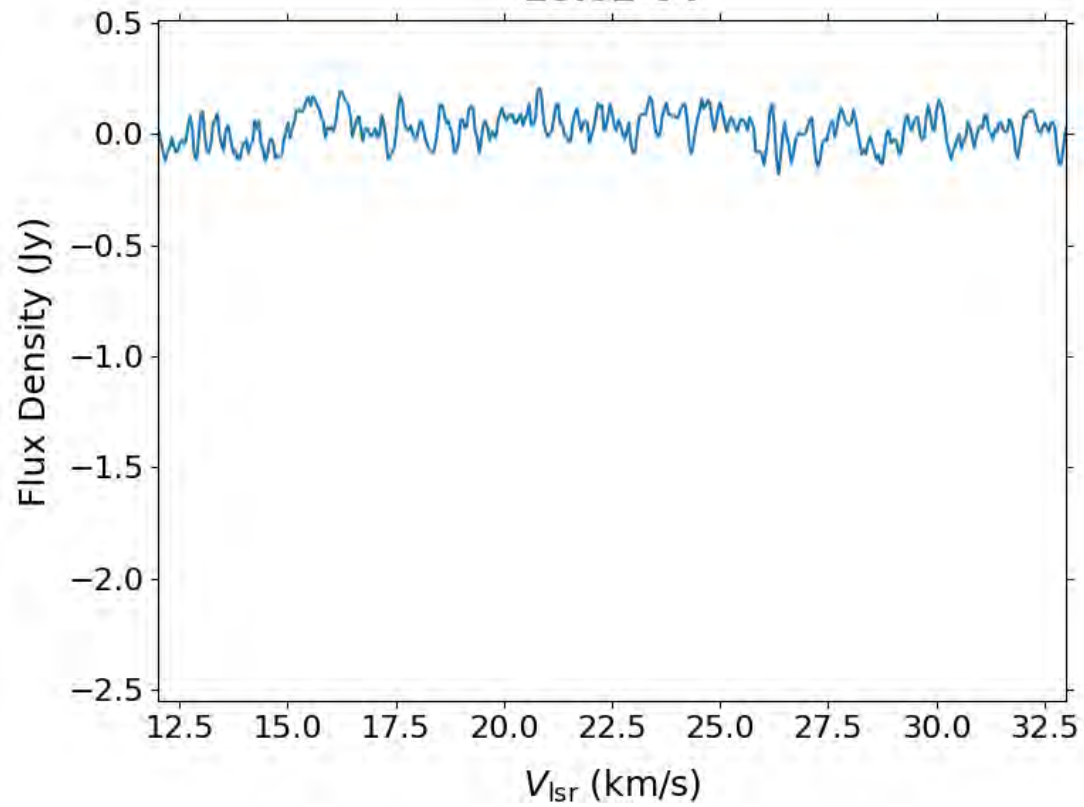


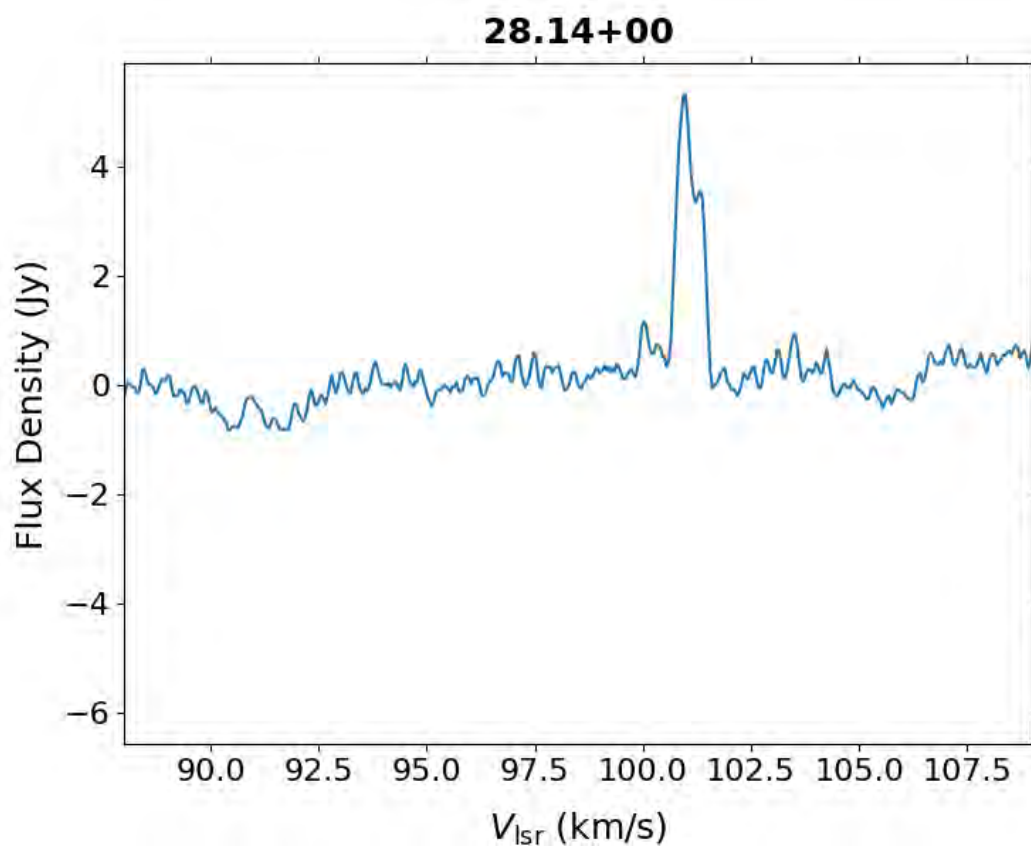
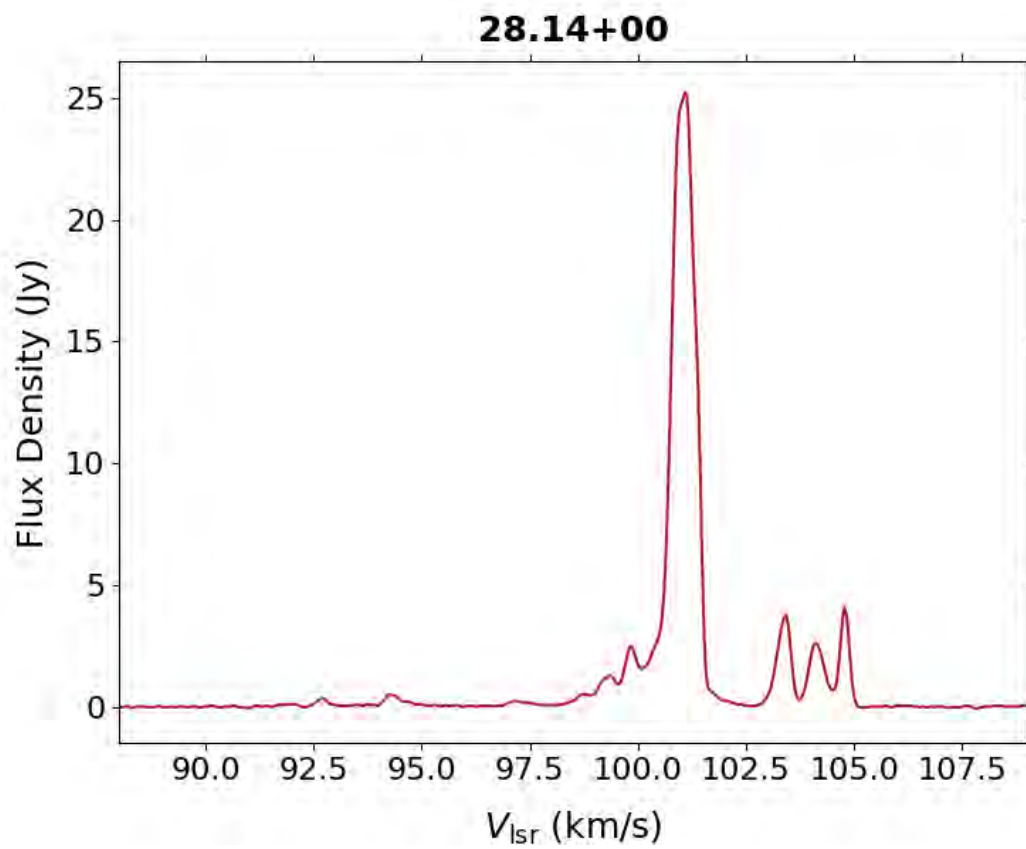


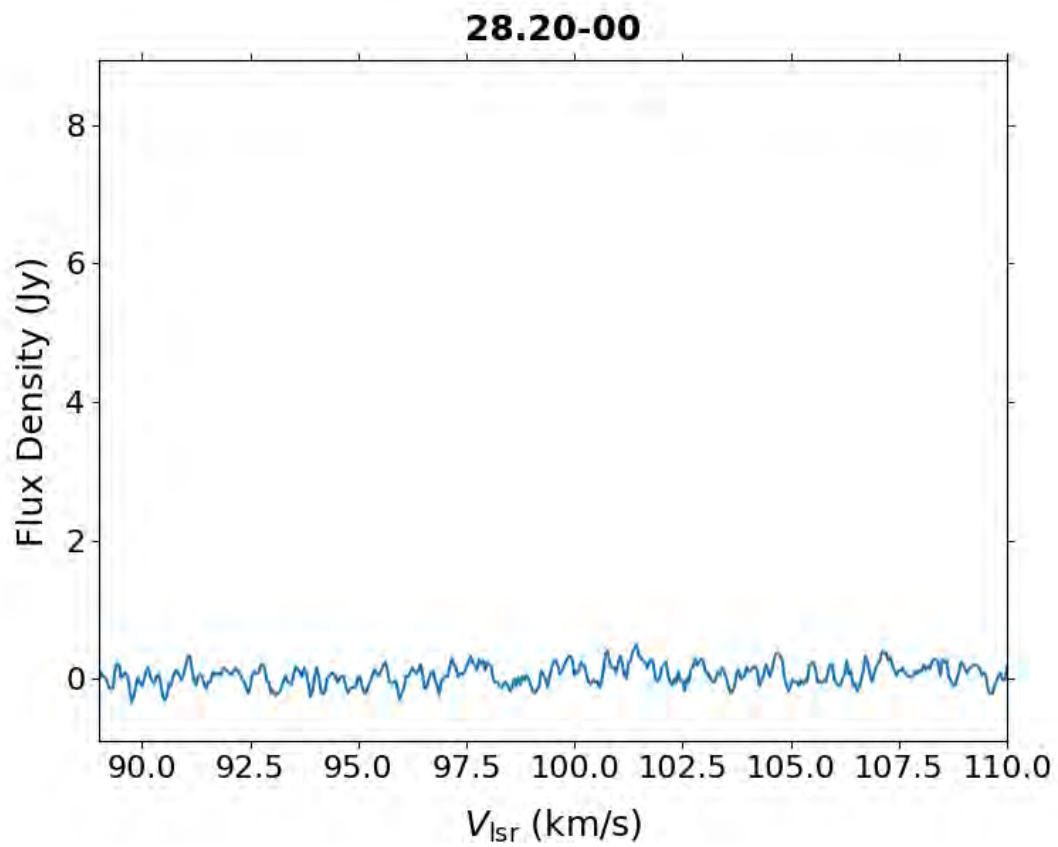
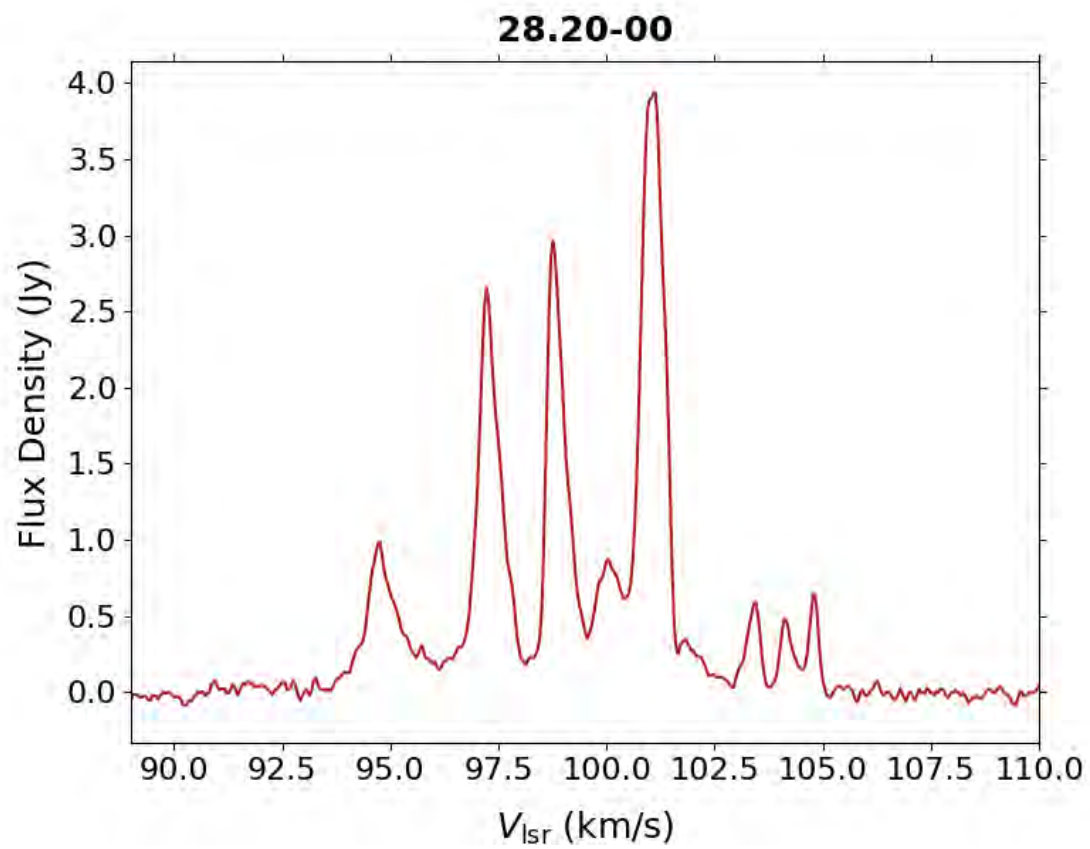
28.02-04



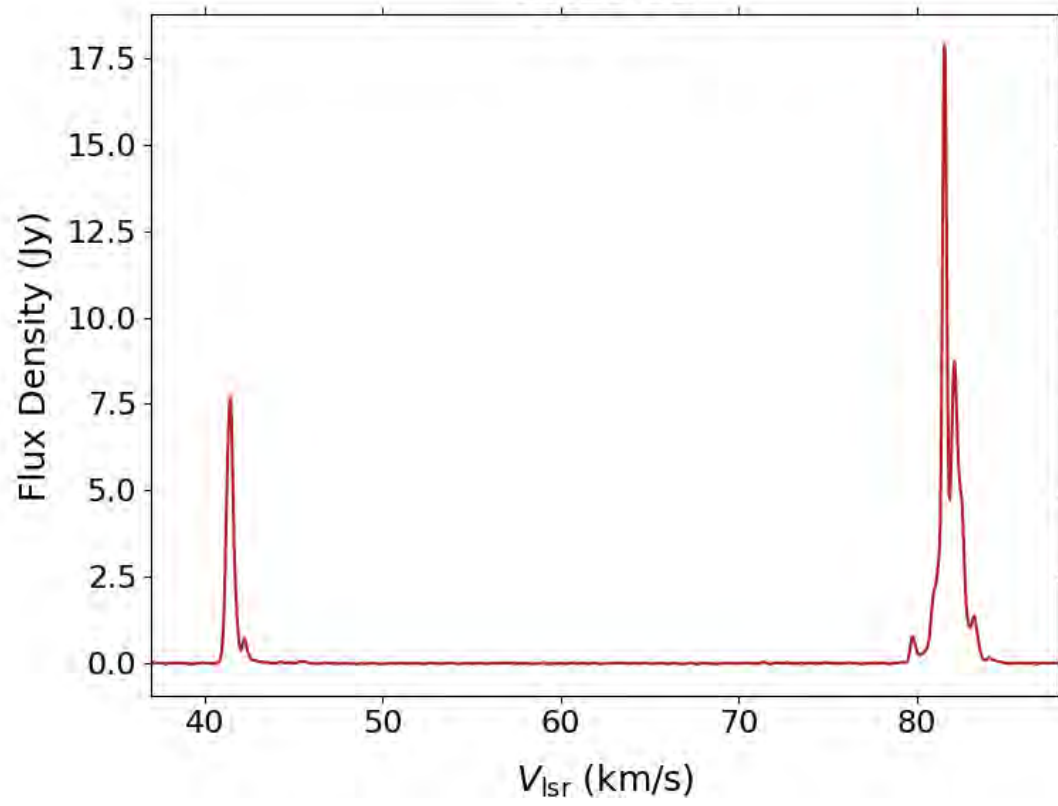
28.02-04



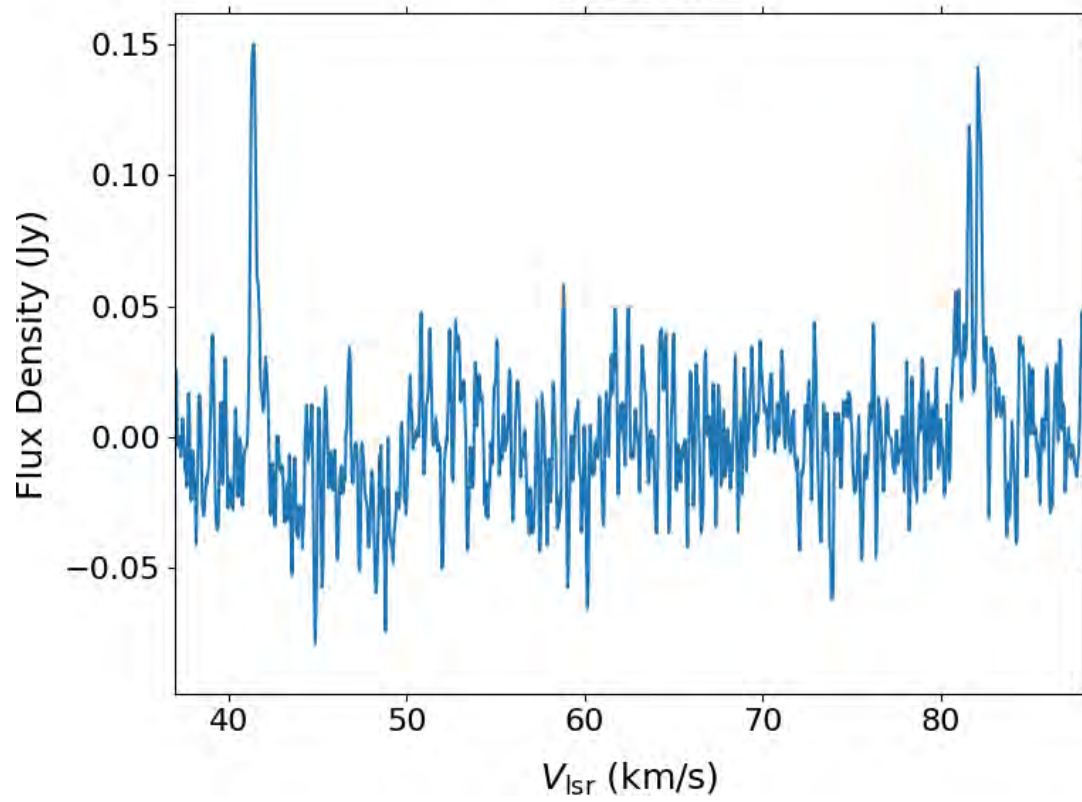




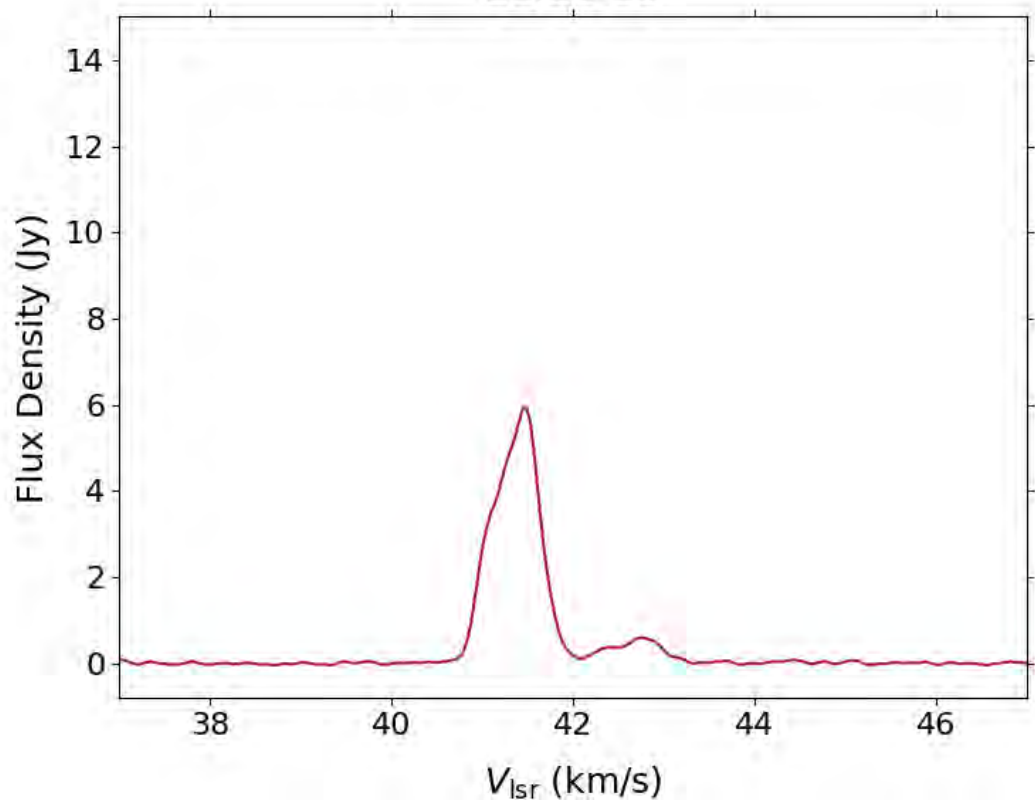
28.28-0B



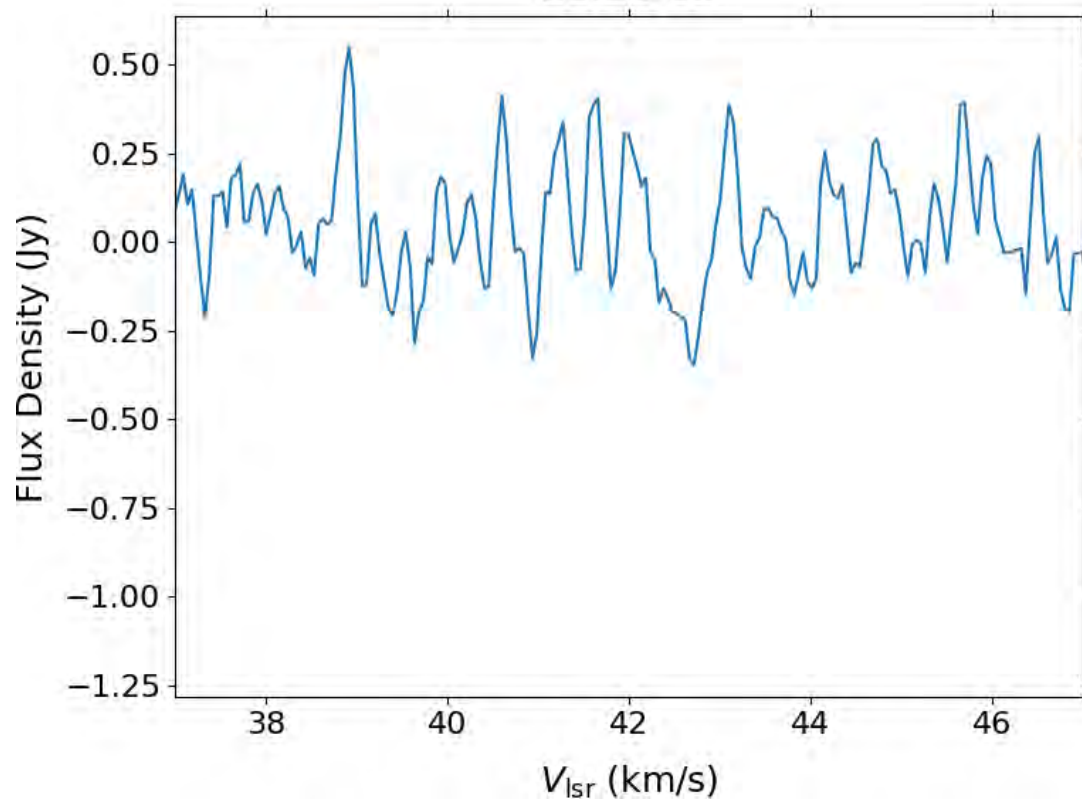
28.28-0B

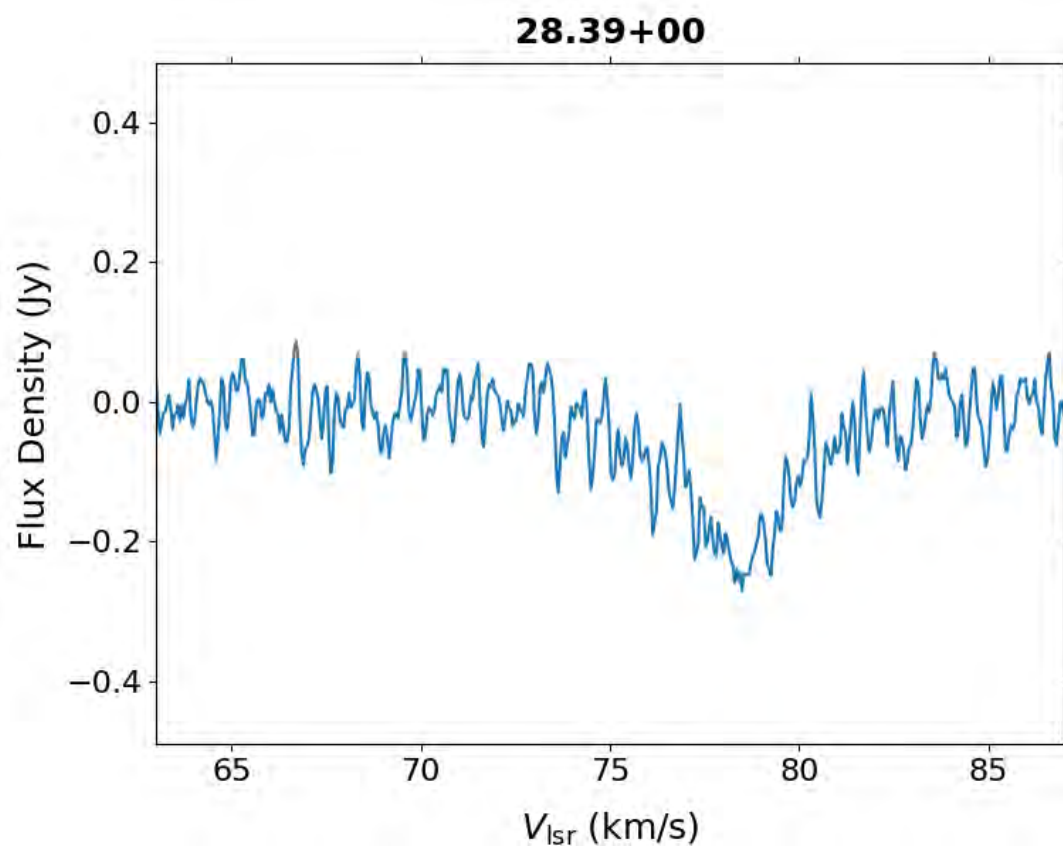
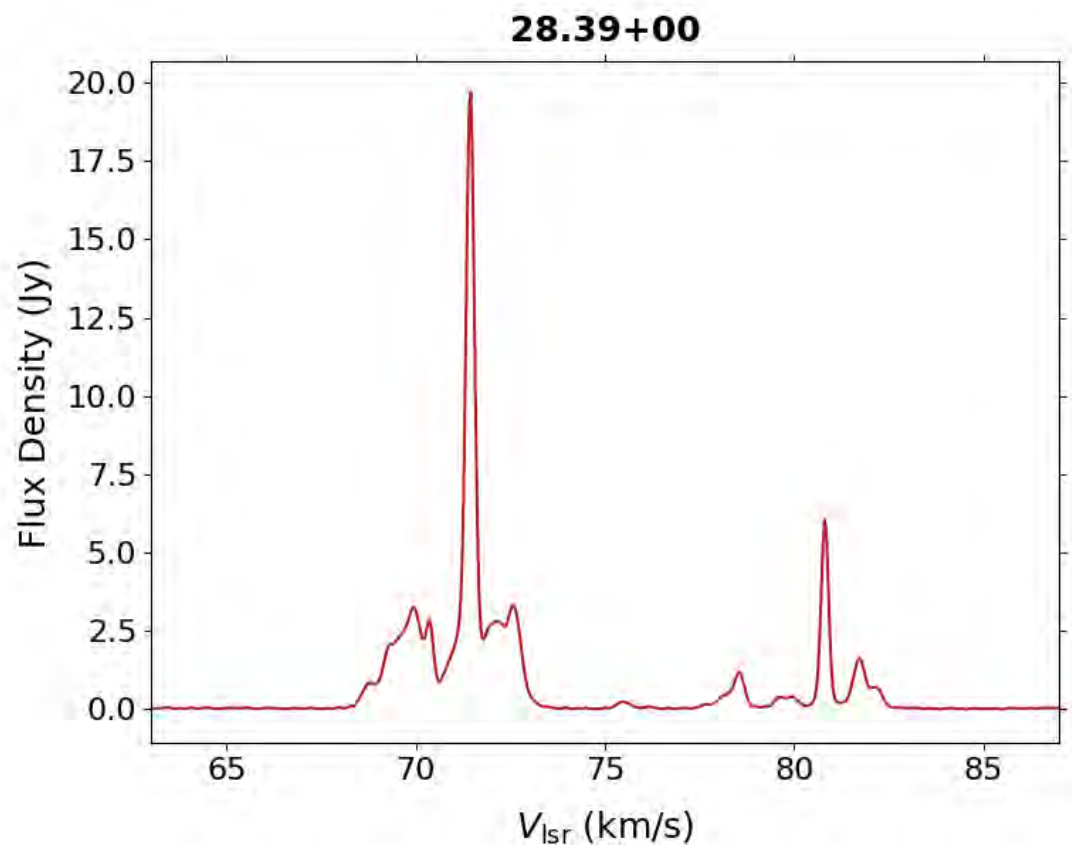


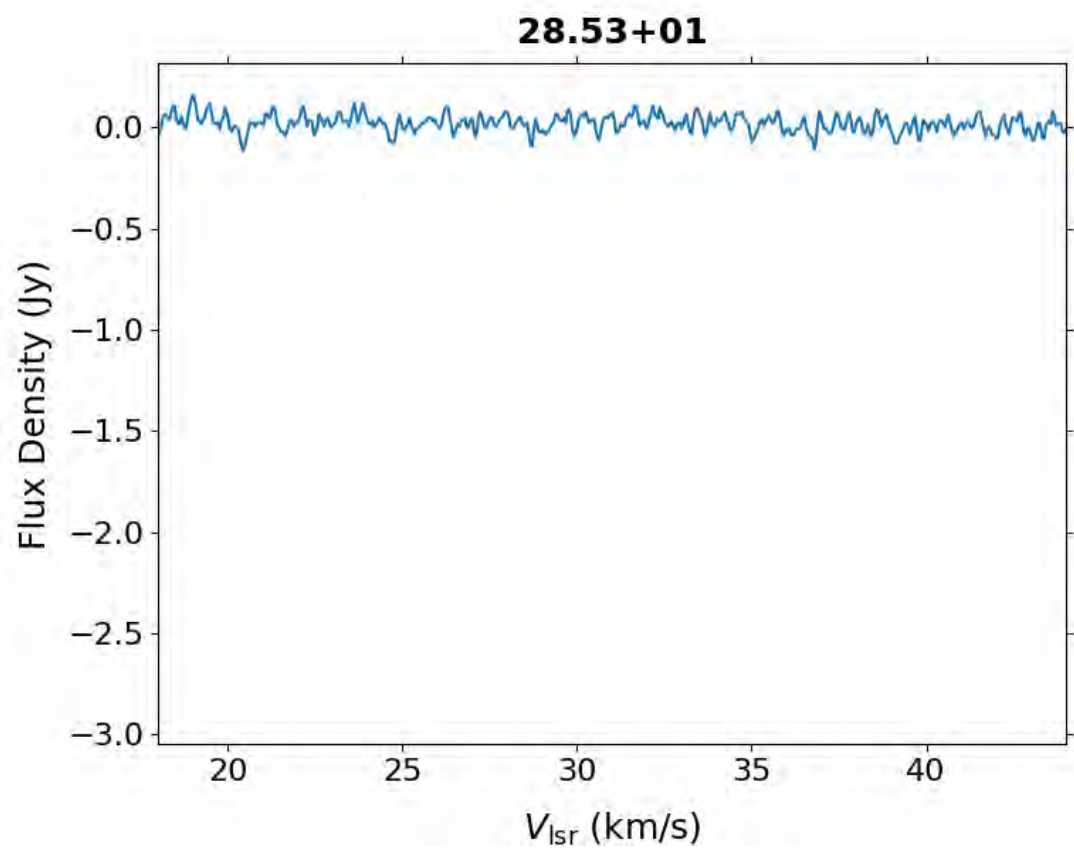
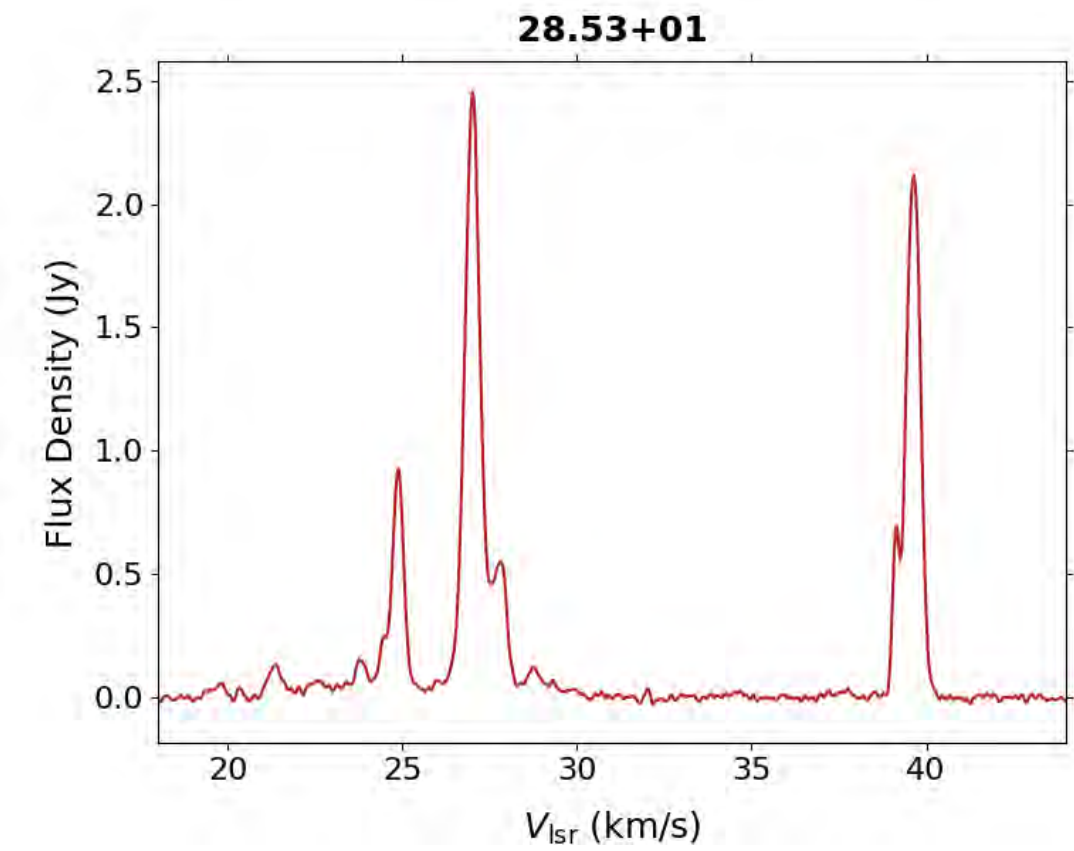
28.28-03

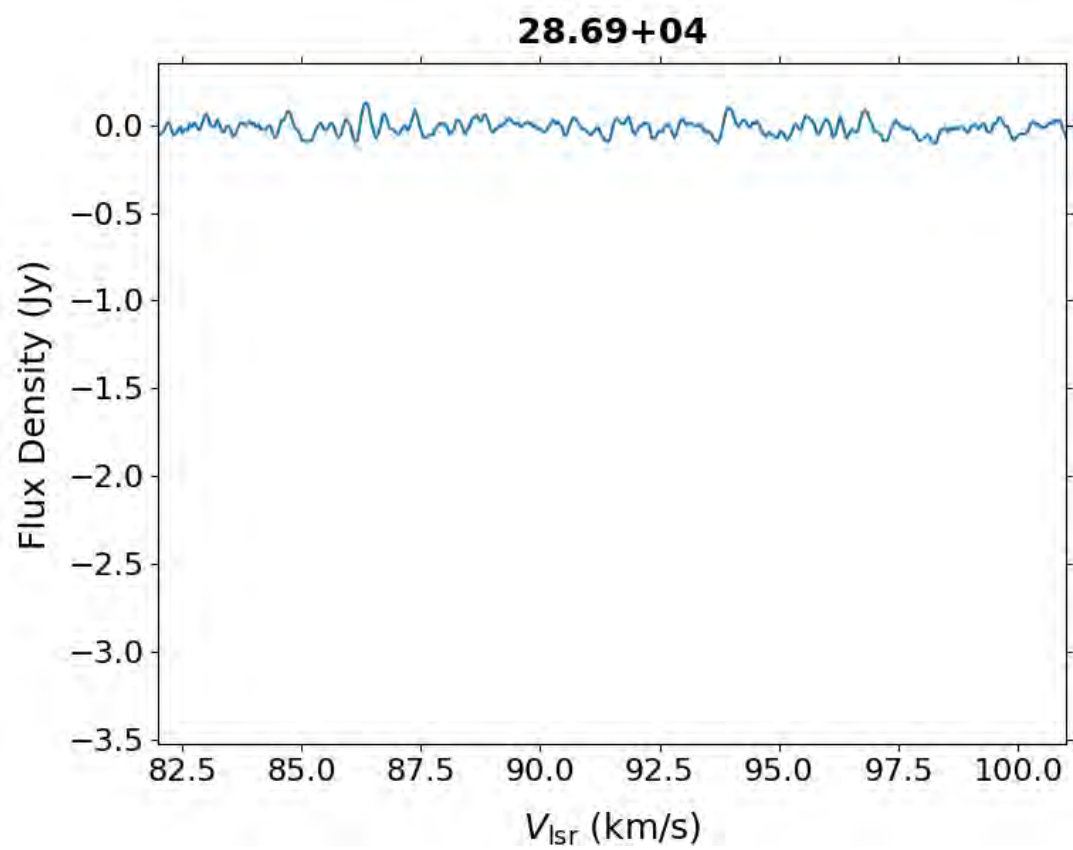
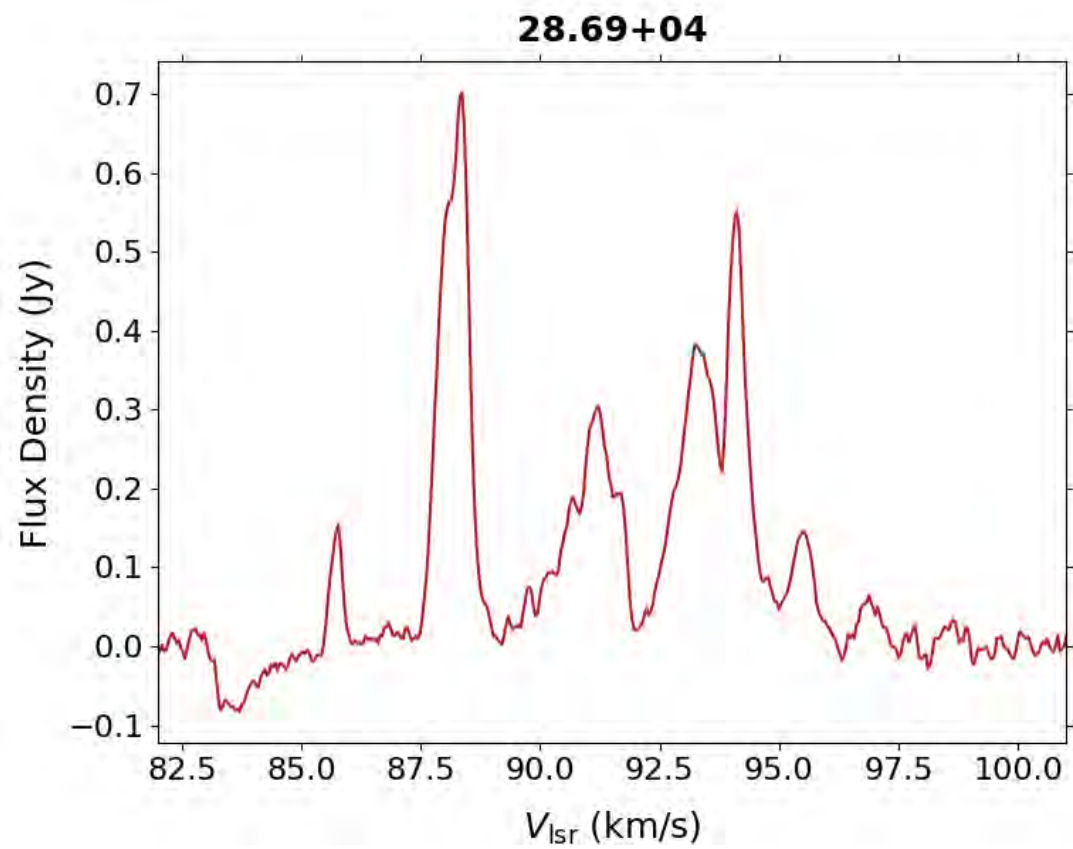


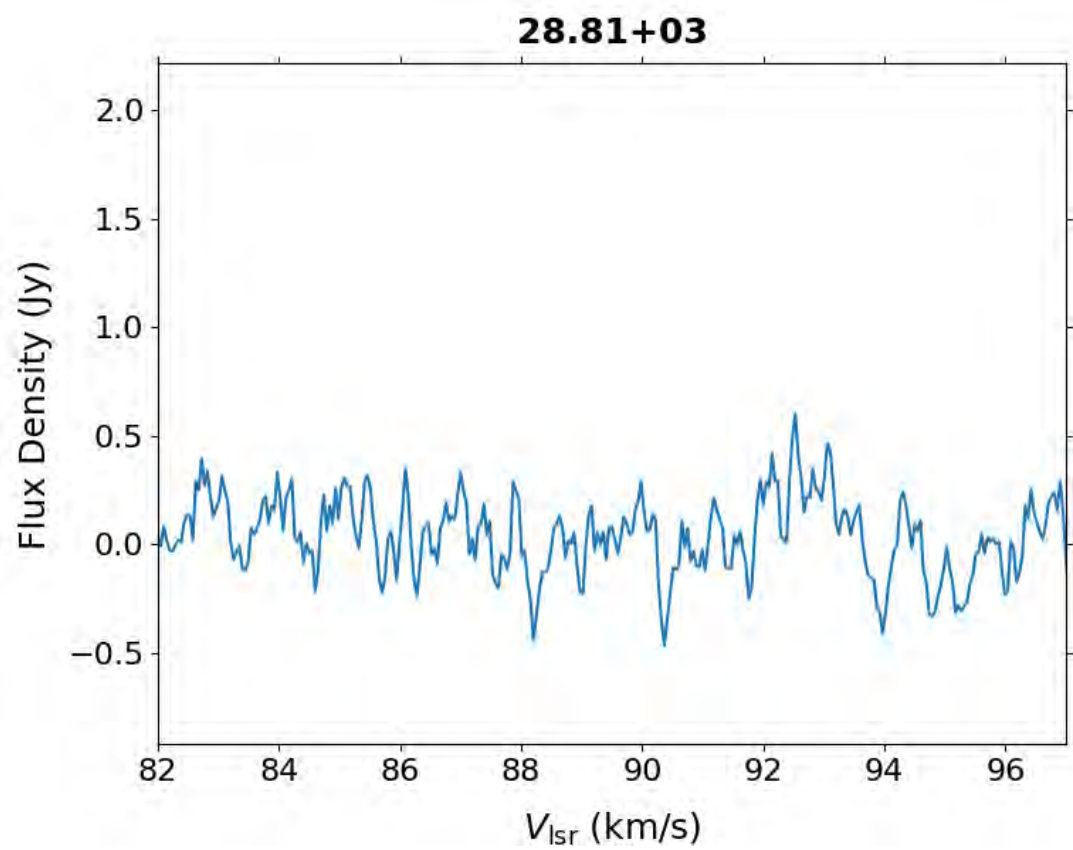
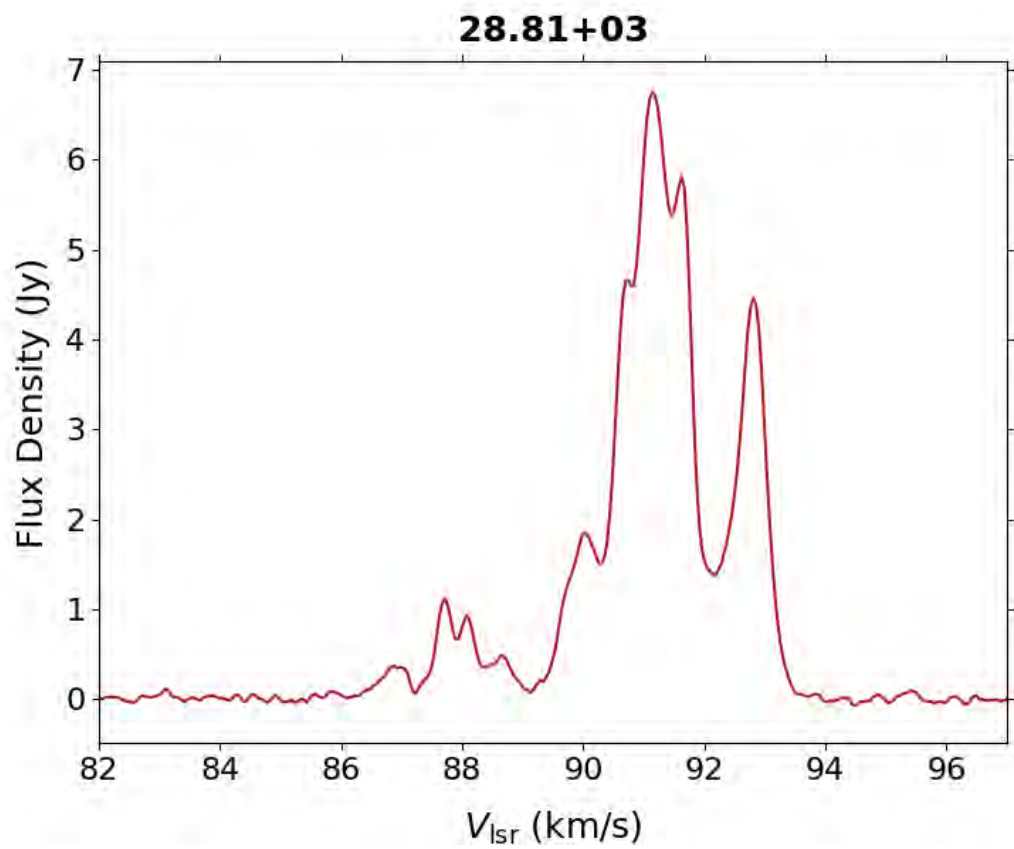
28.28-03

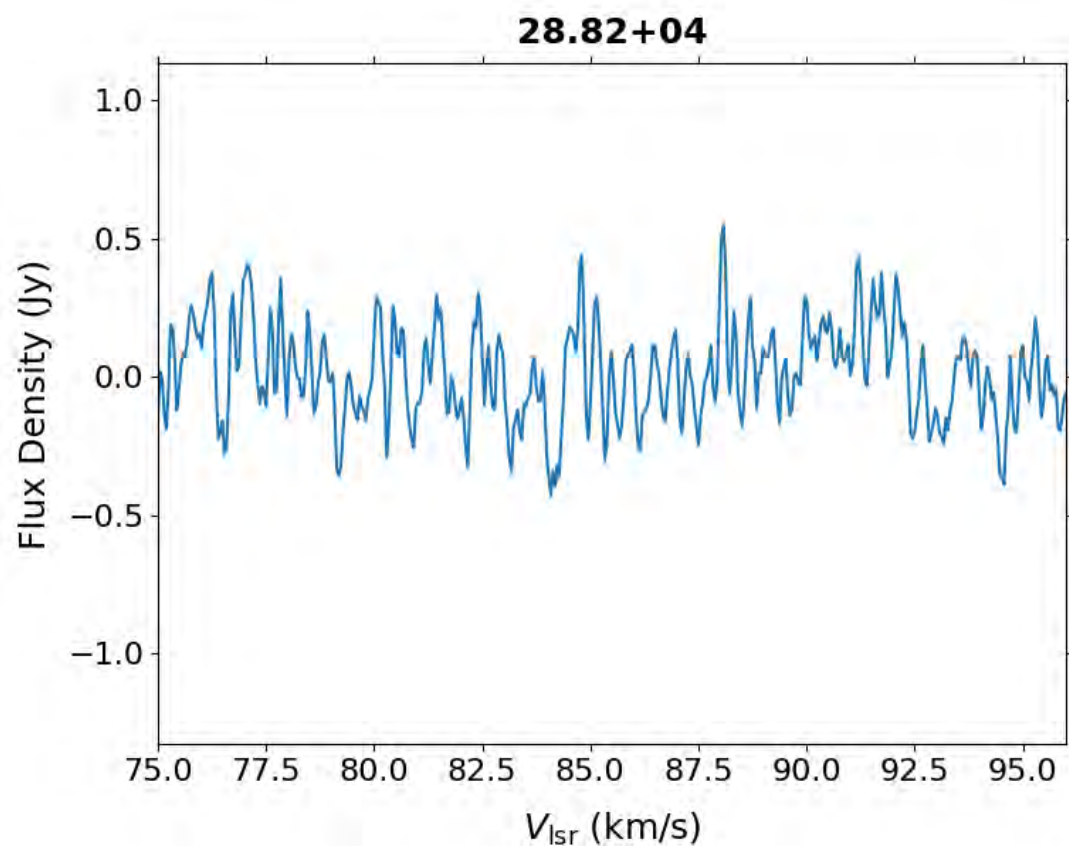
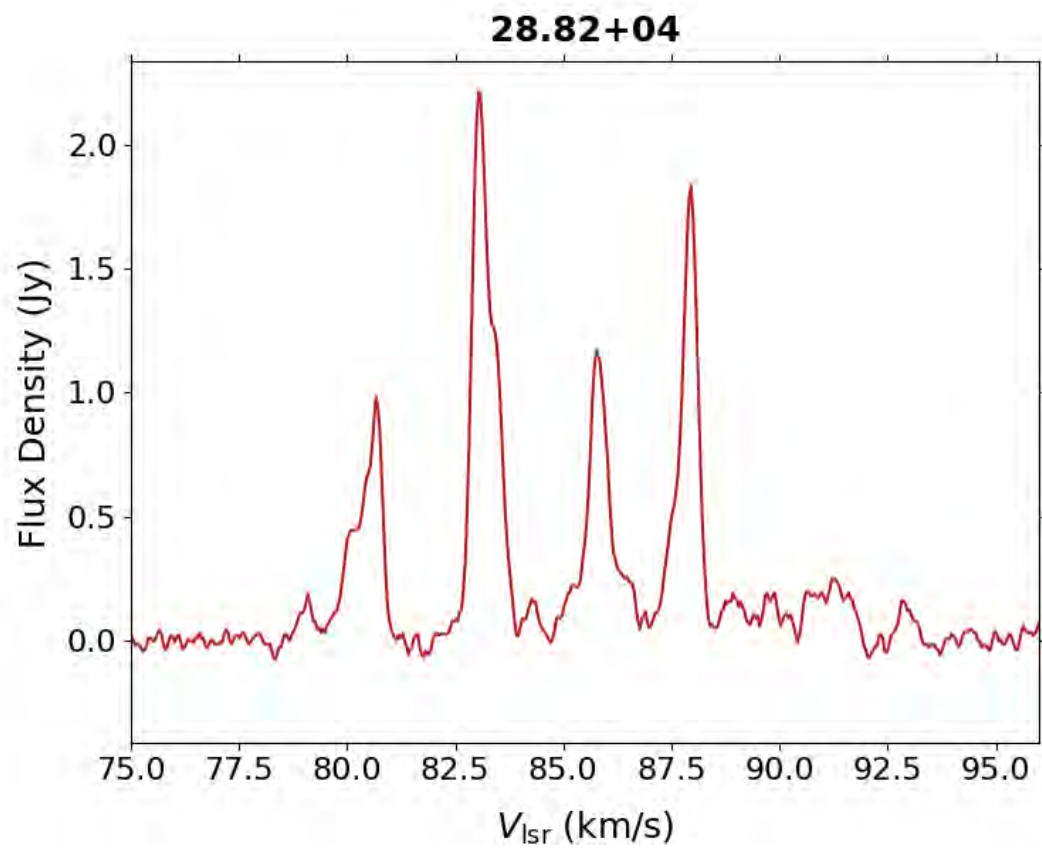




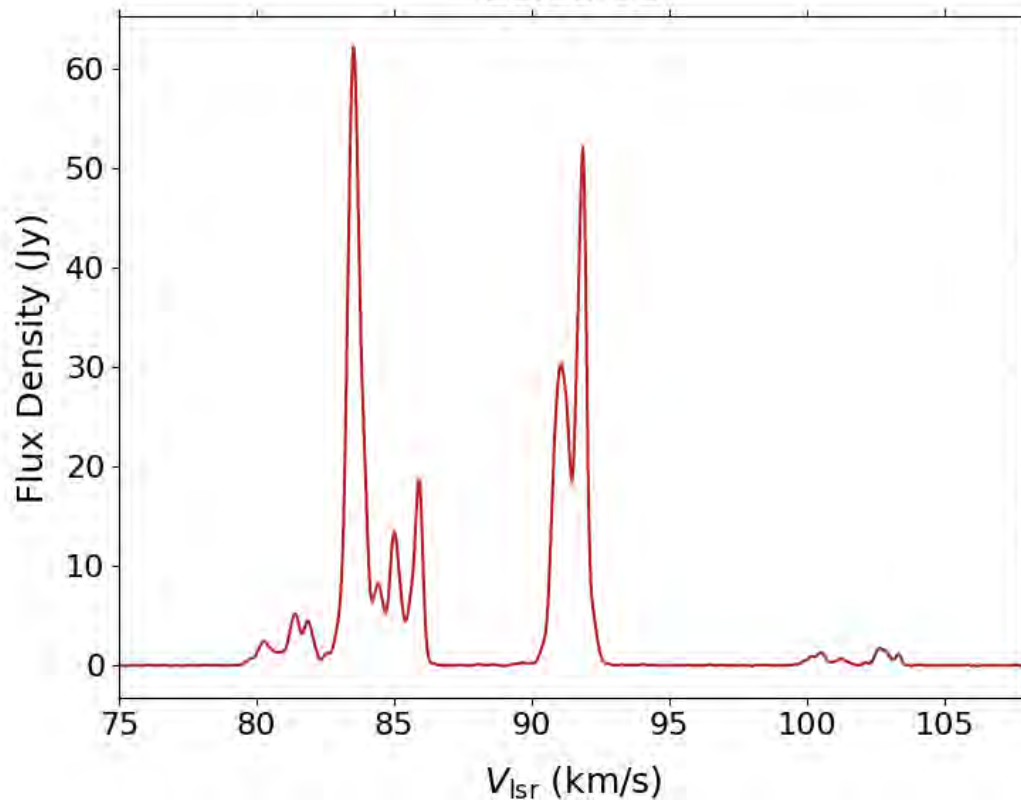




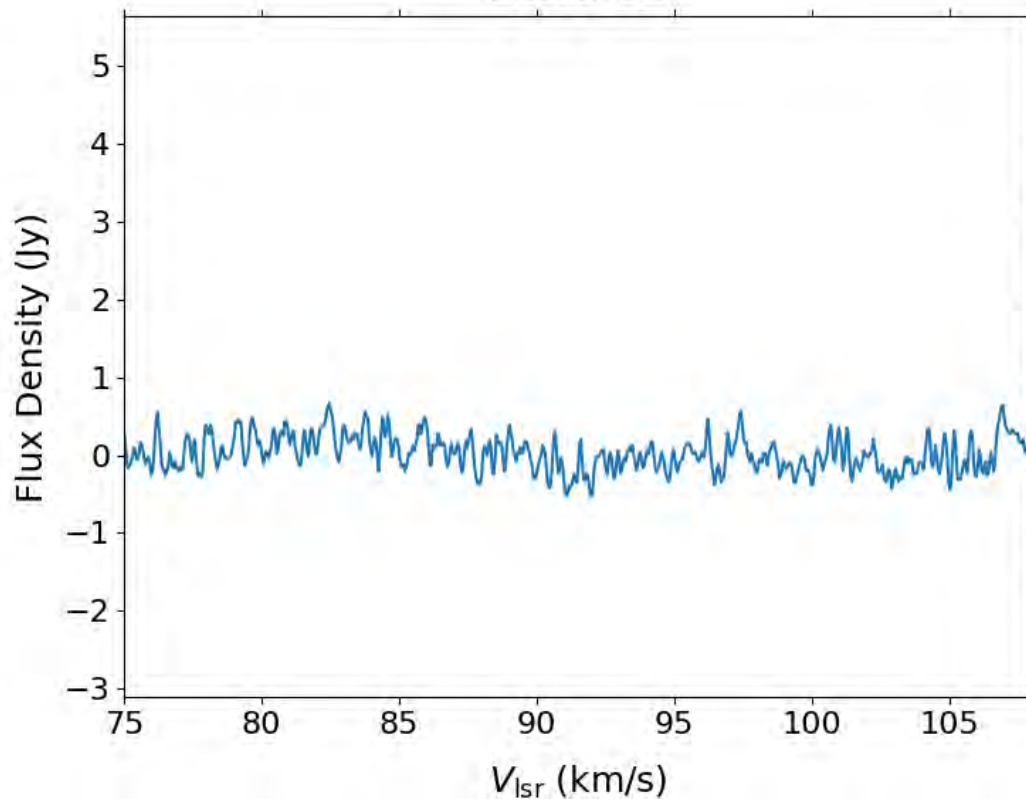


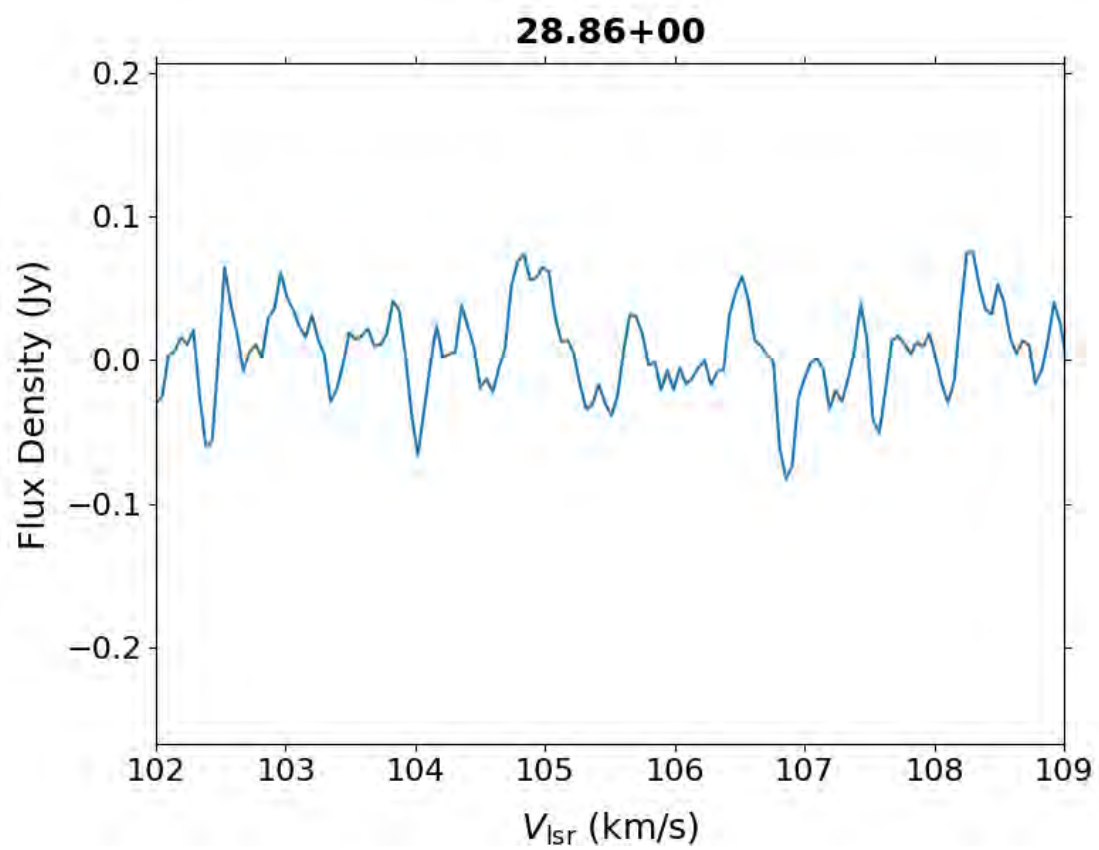
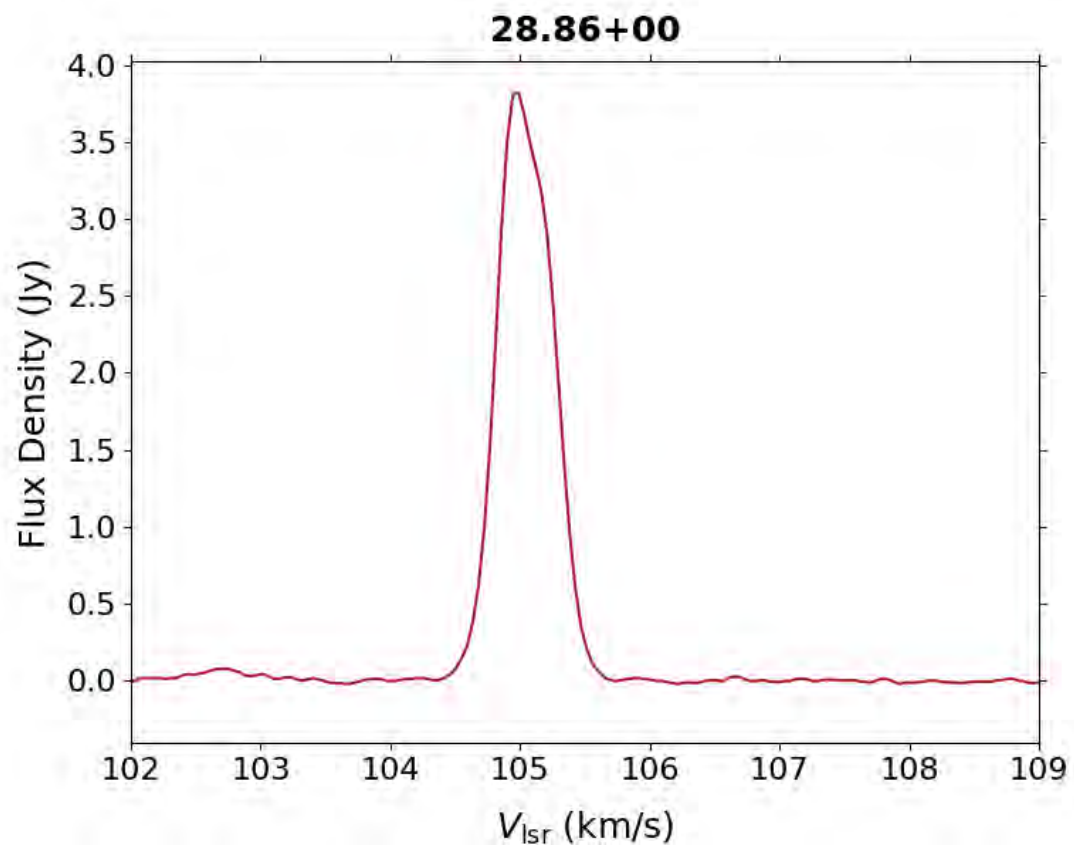


28.83-02

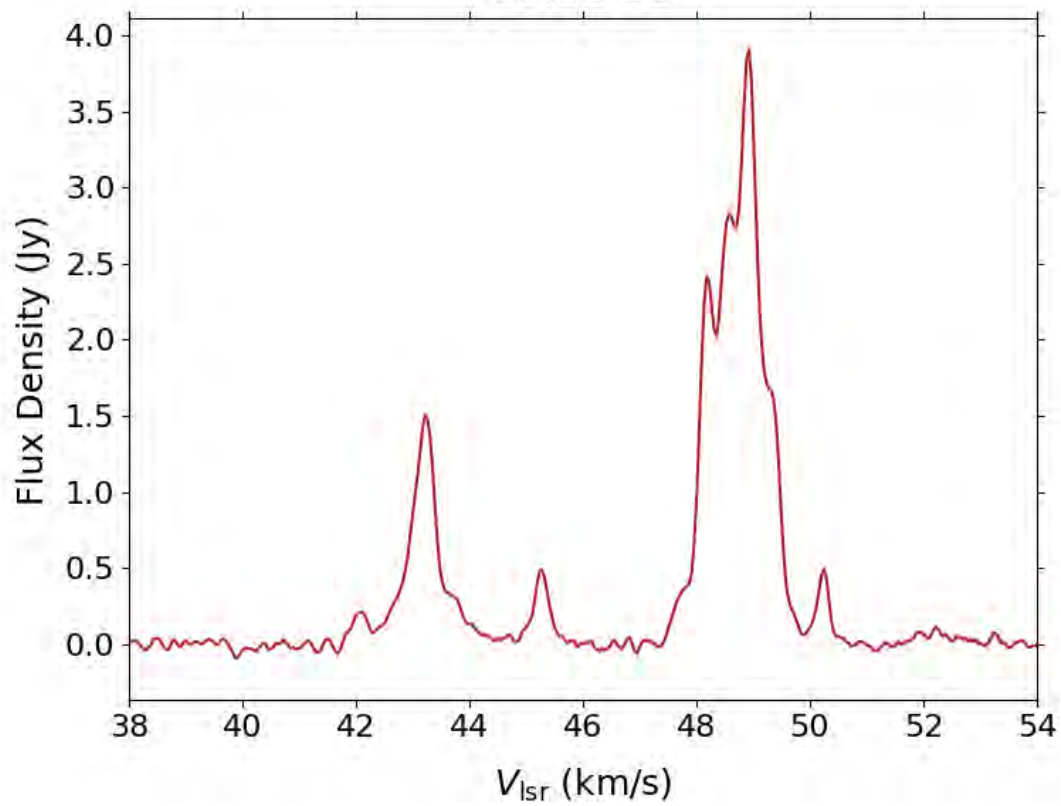


28.83-02

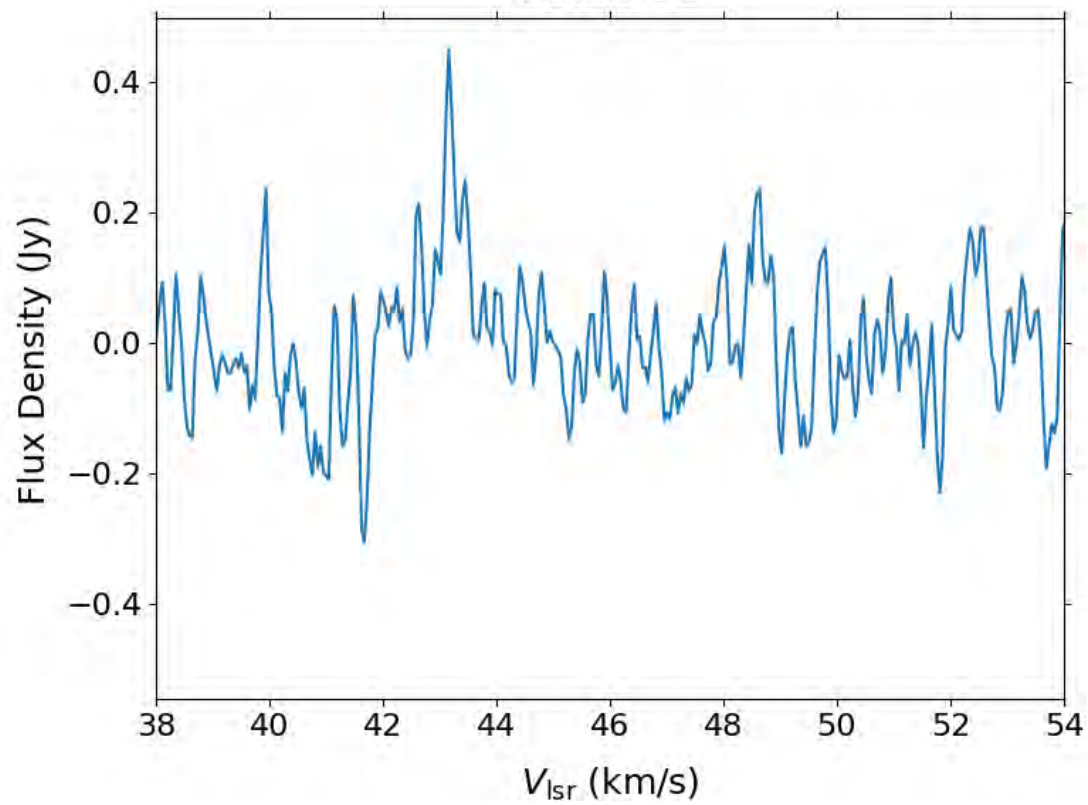




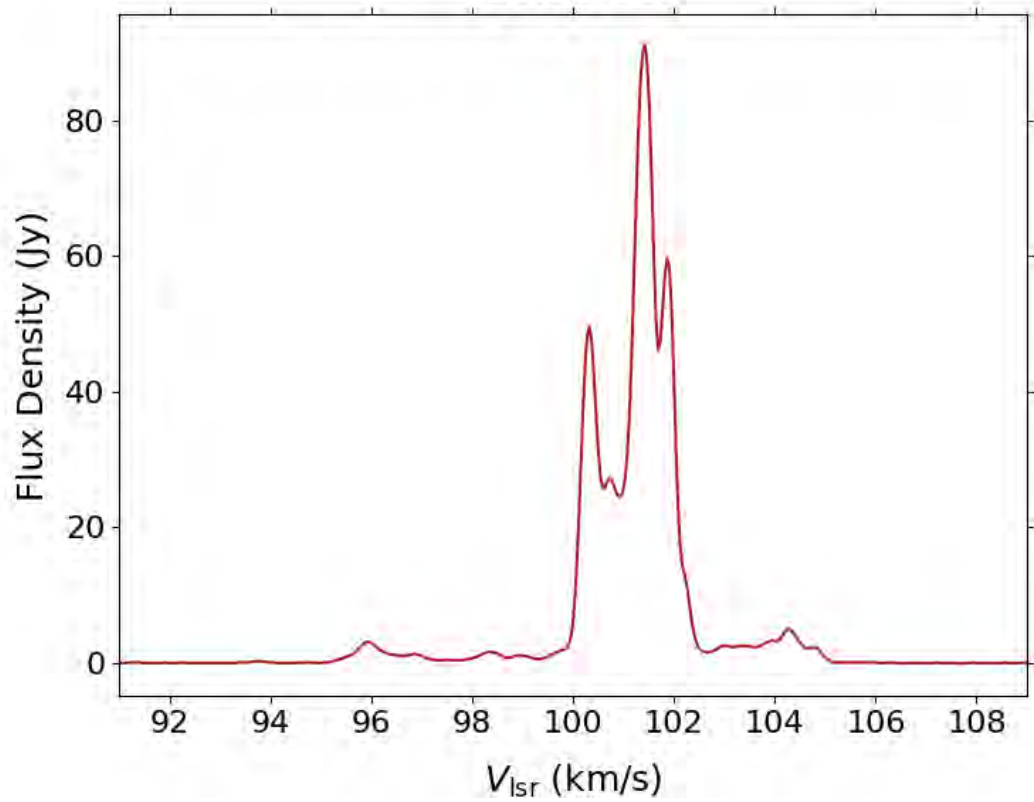
29.31-01



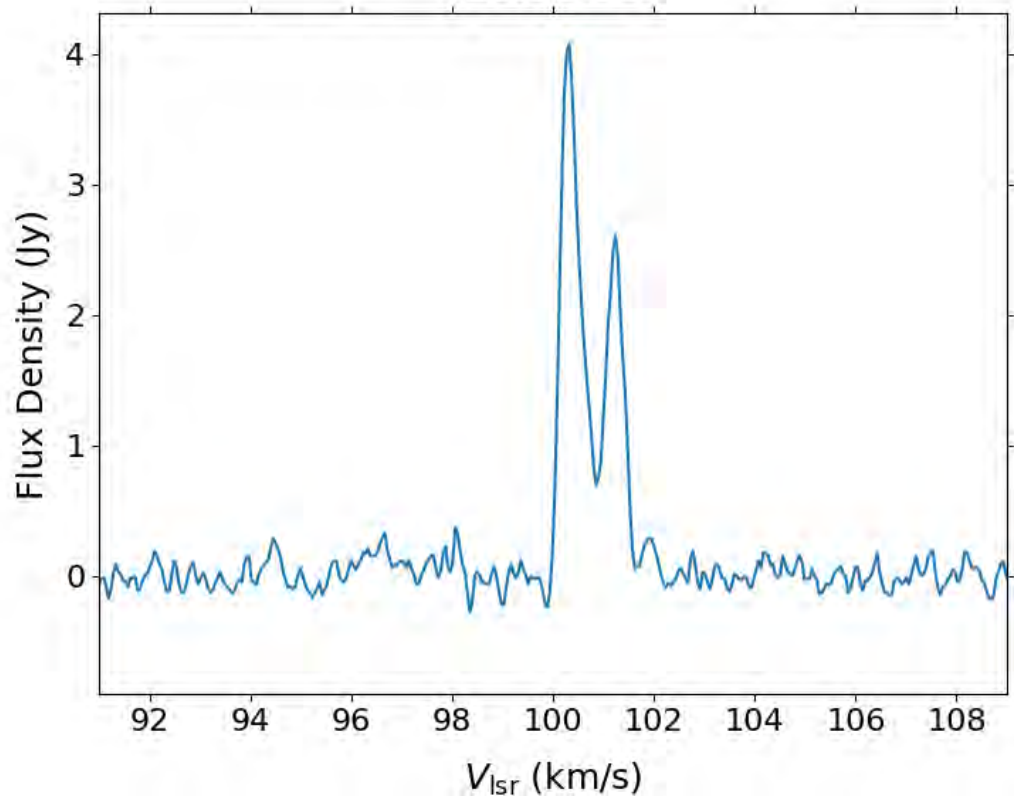
29.31-01

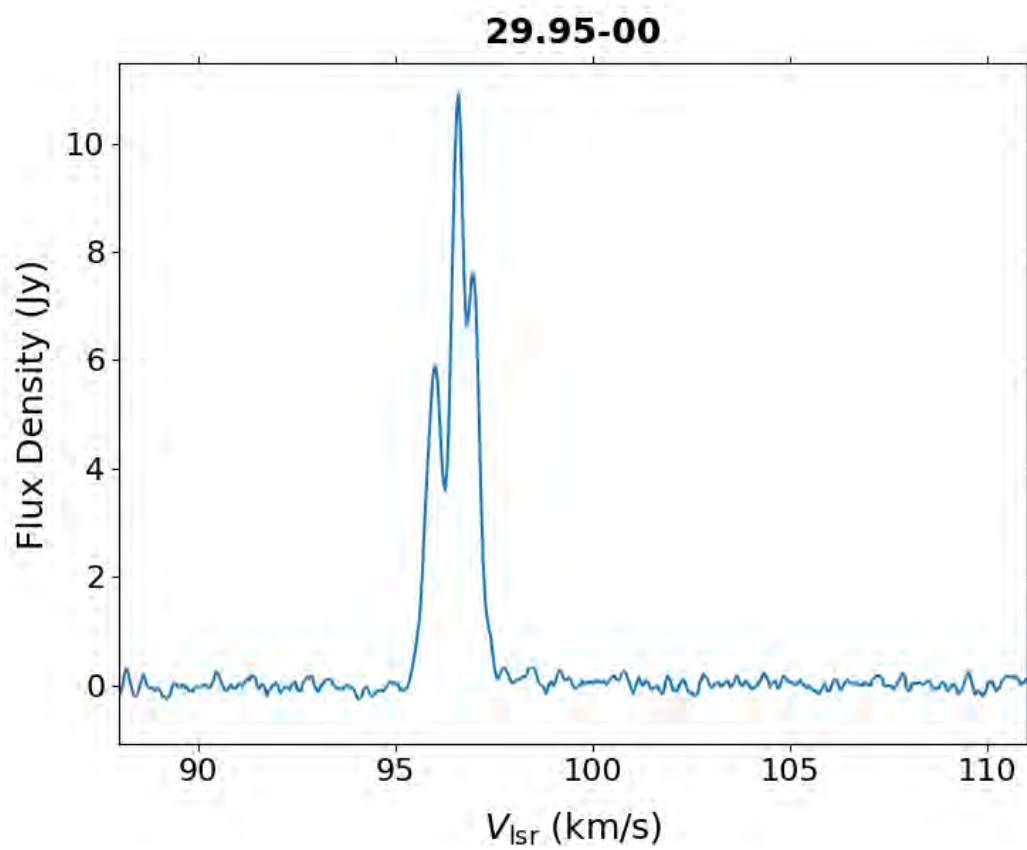
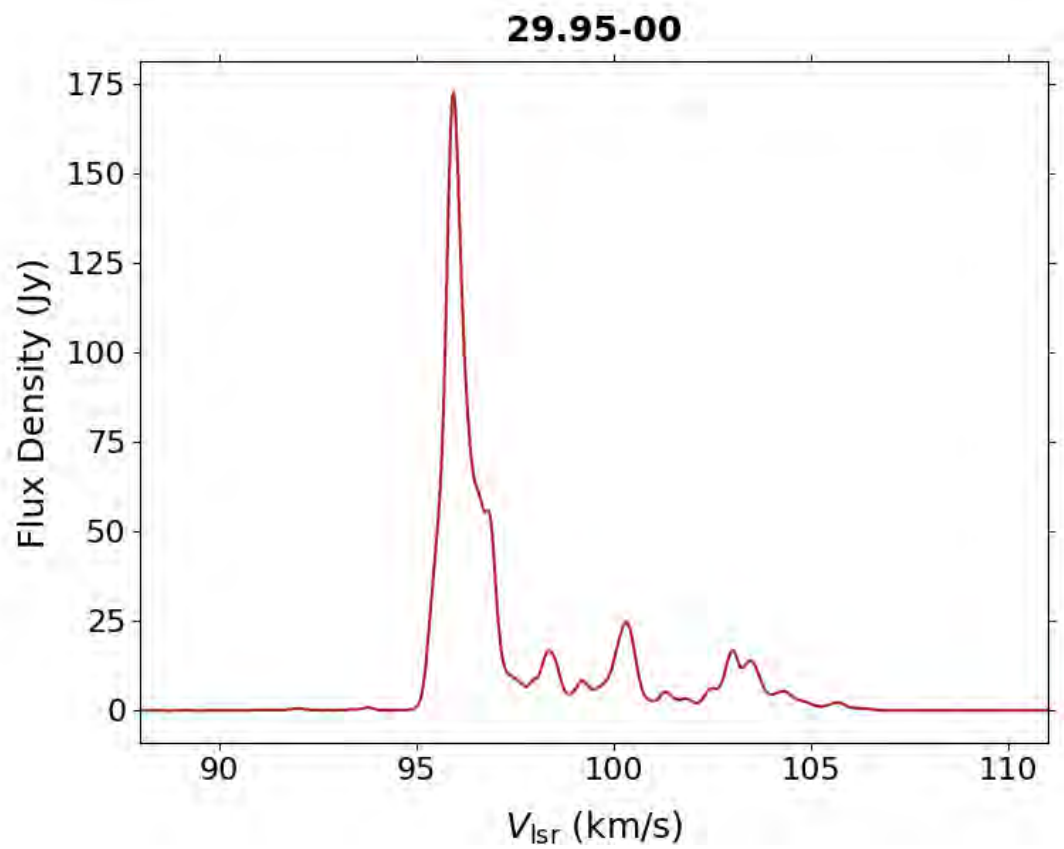


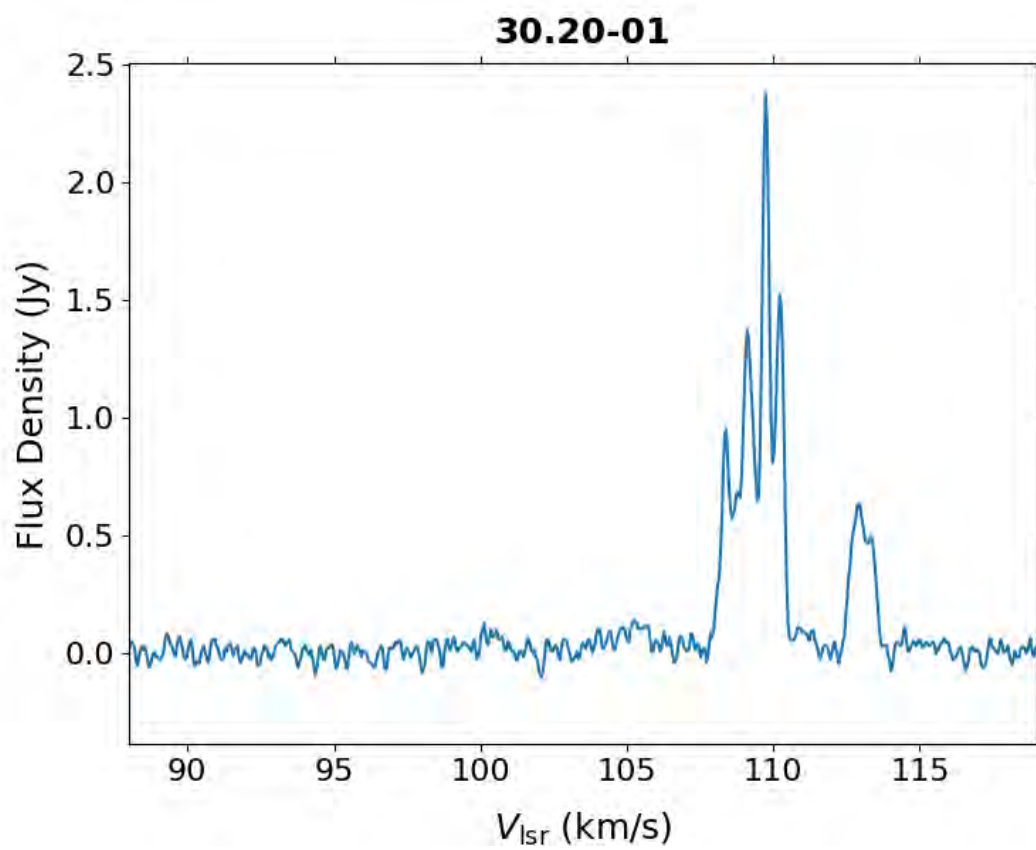
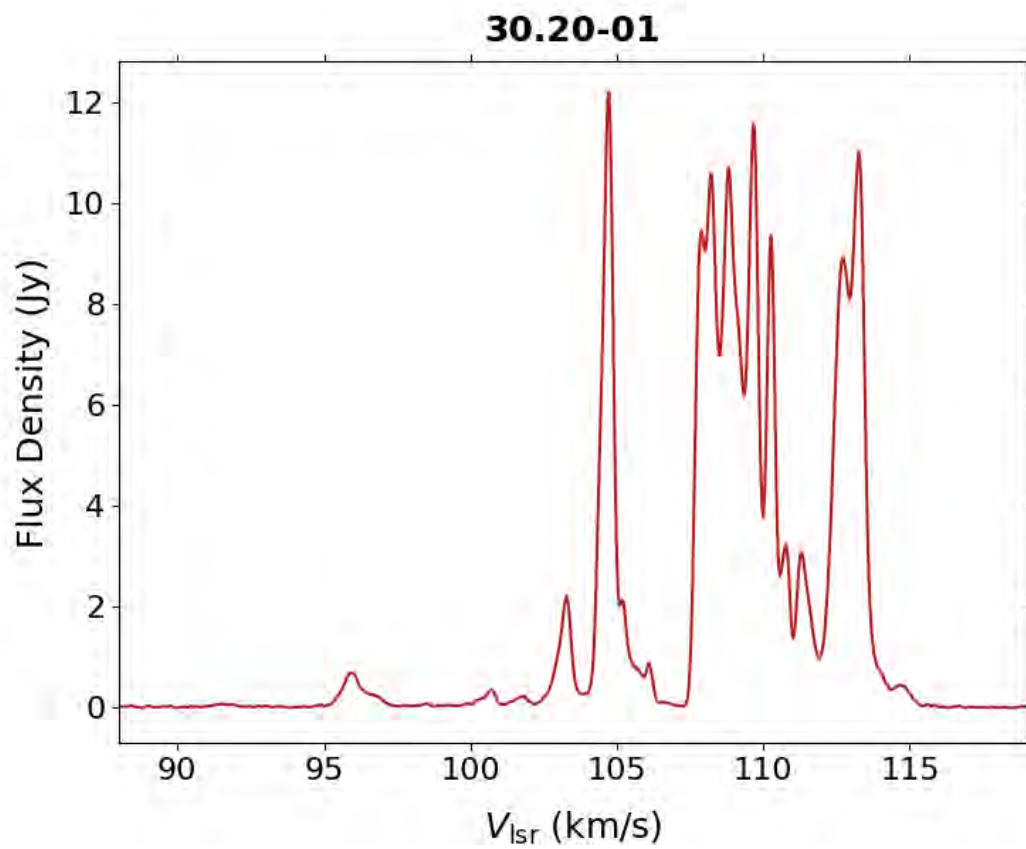
29.86-00

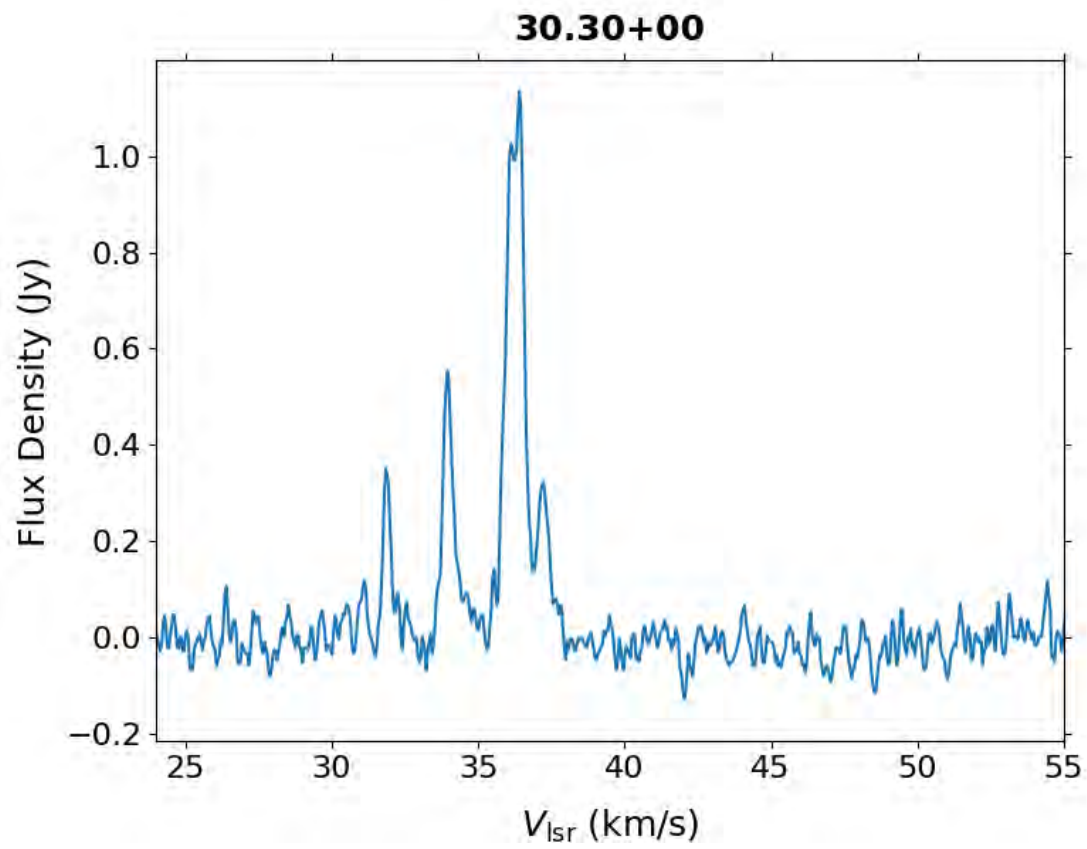
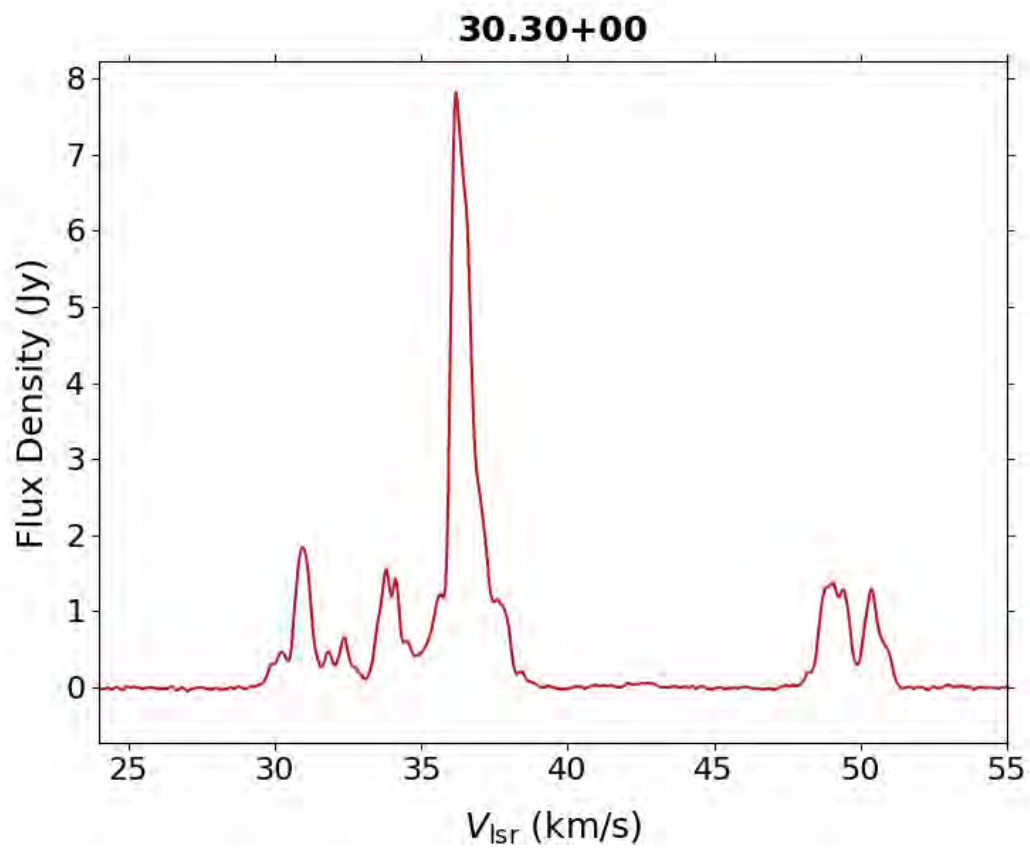


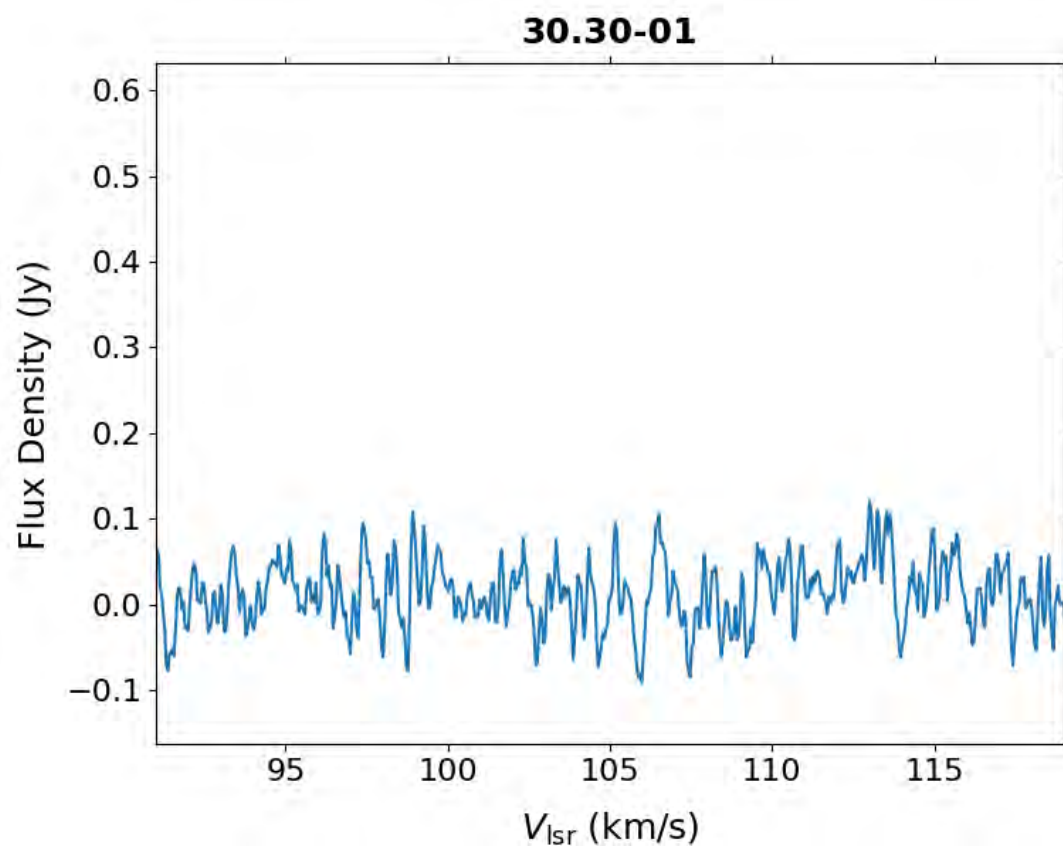
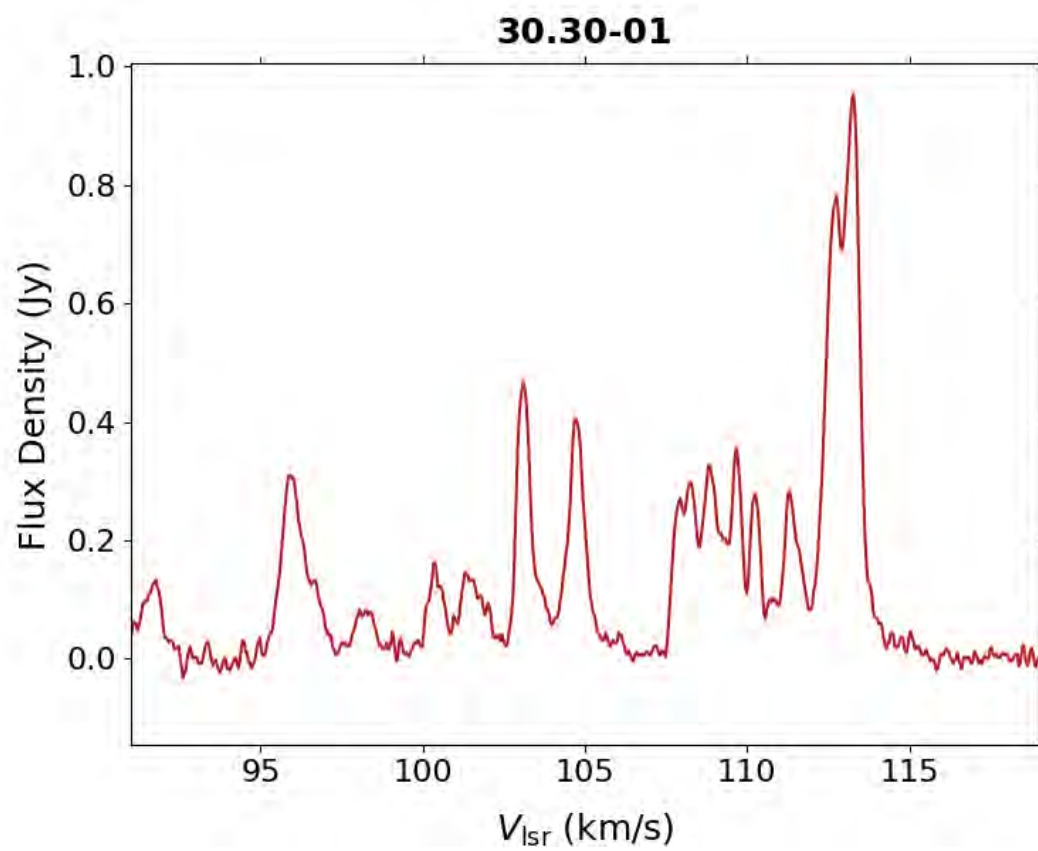
29.86-00



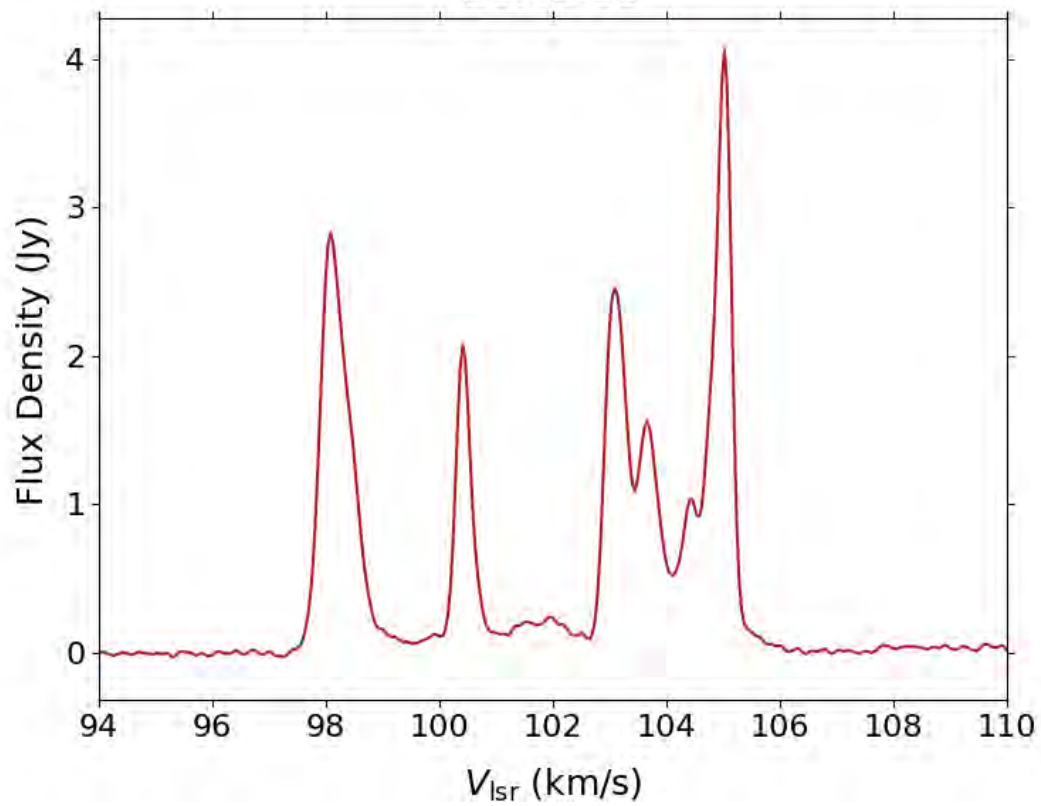




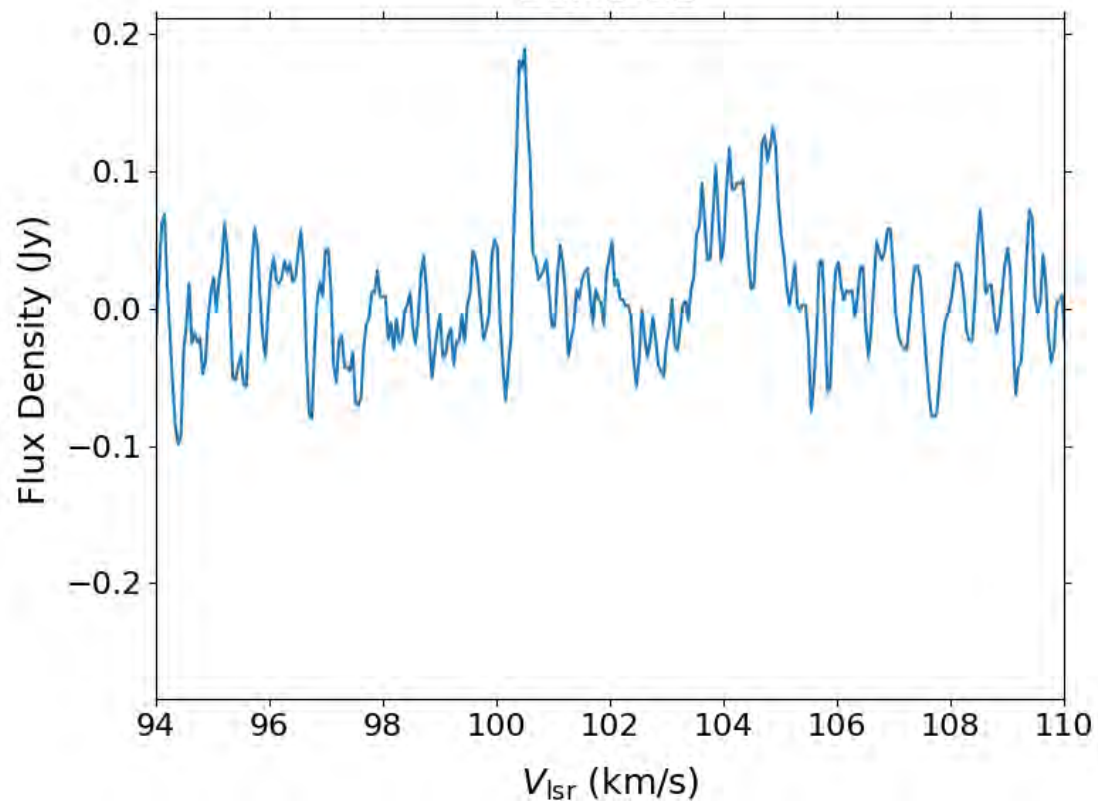


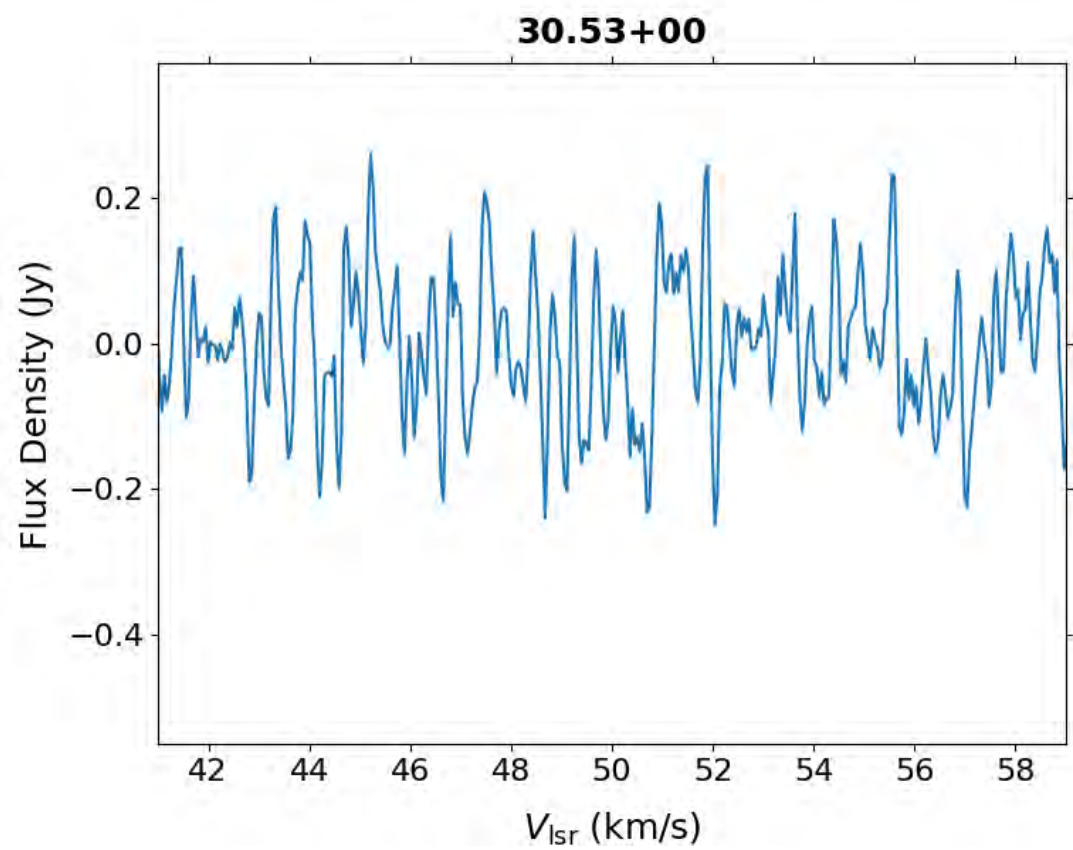
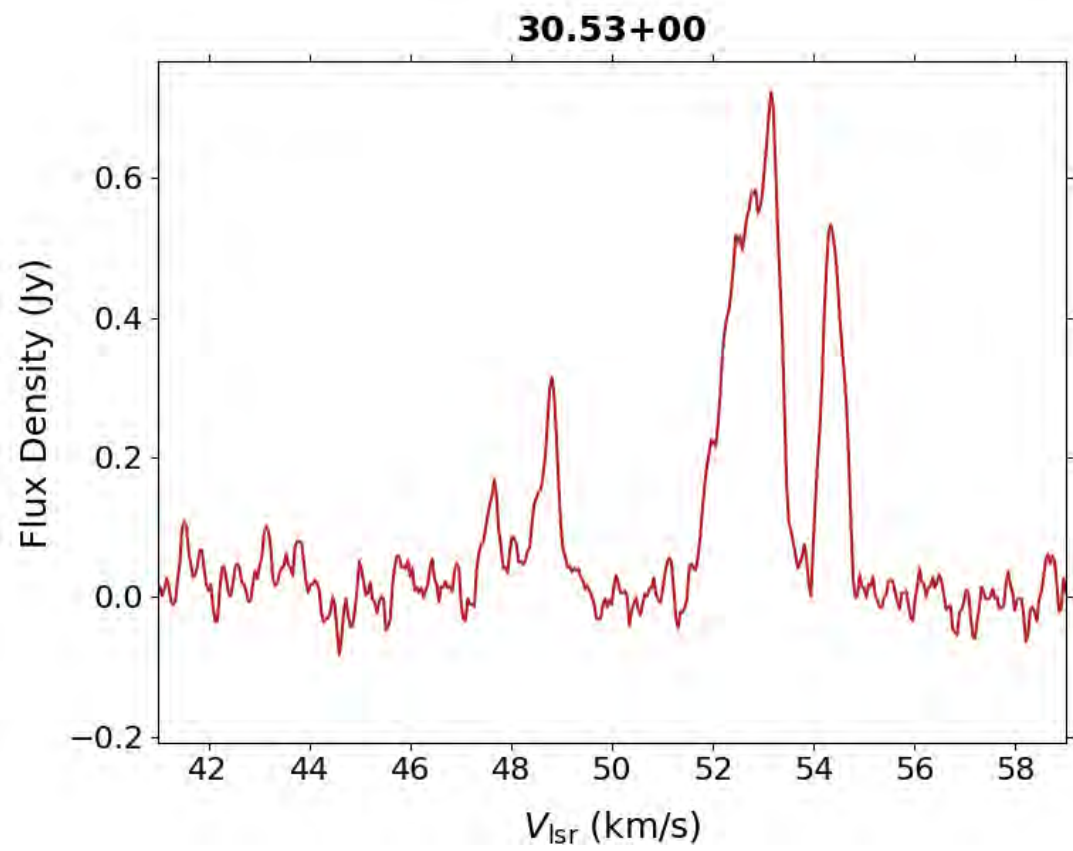


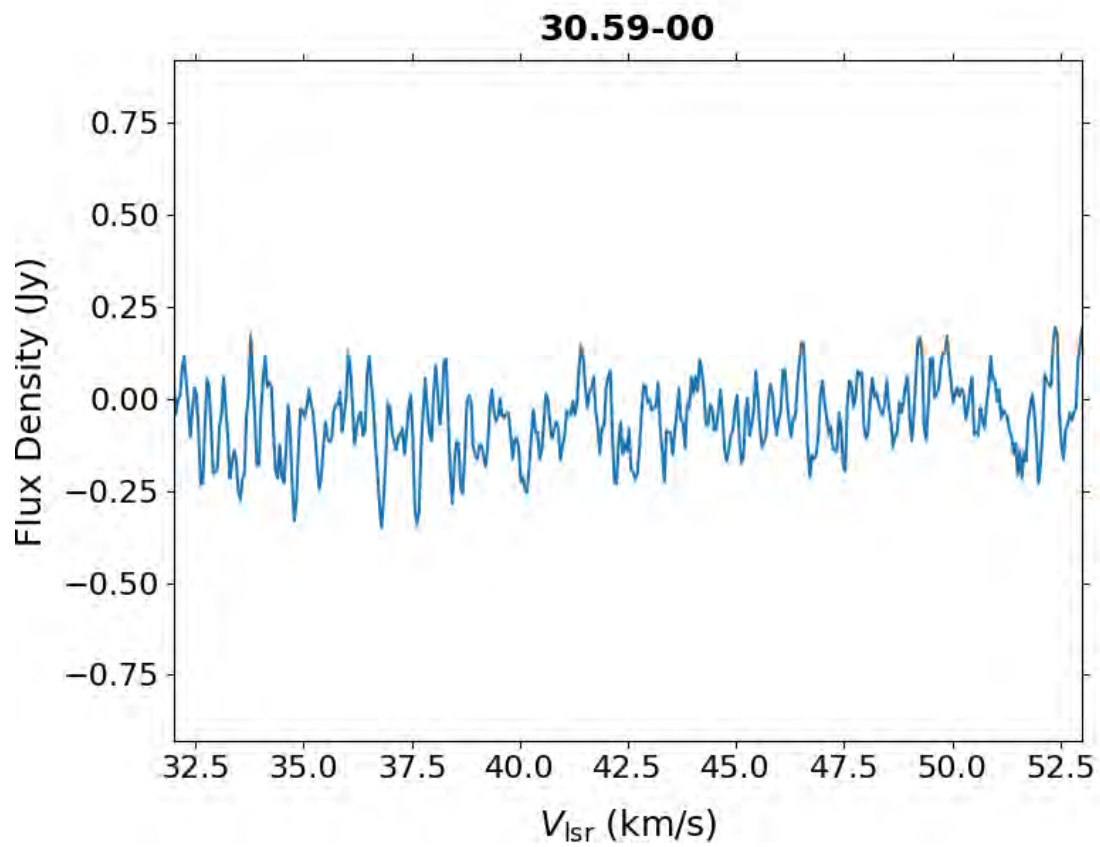
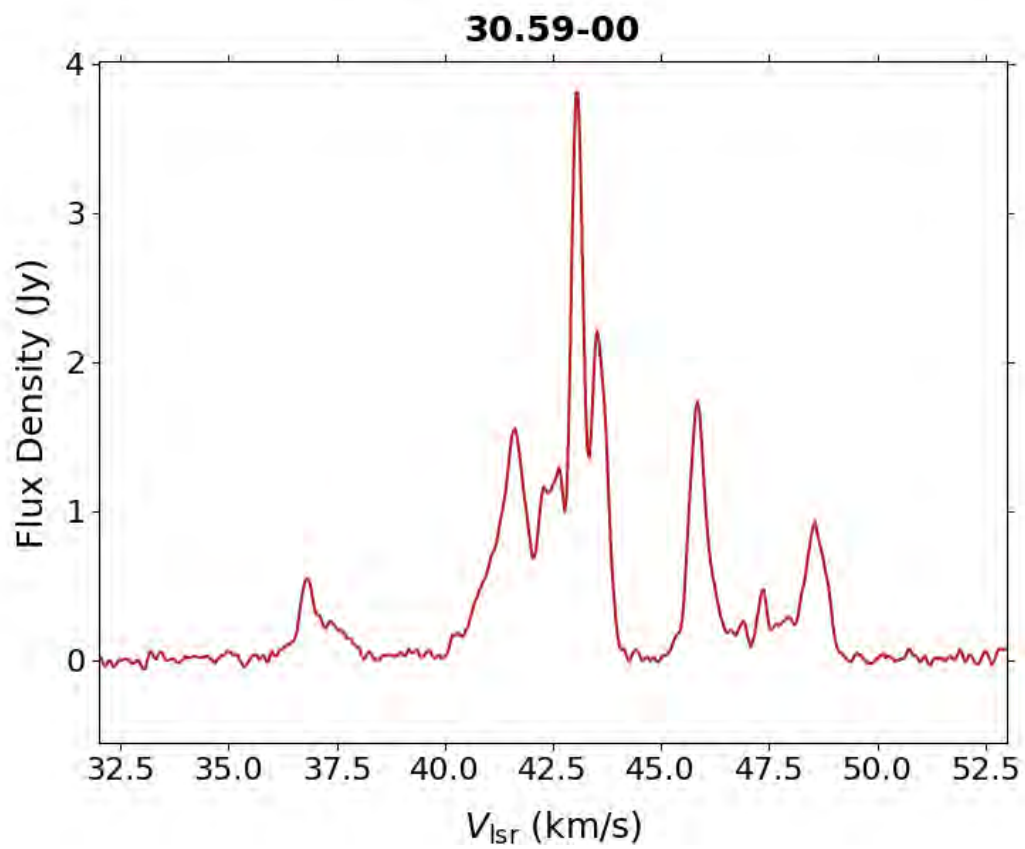
30.40-02

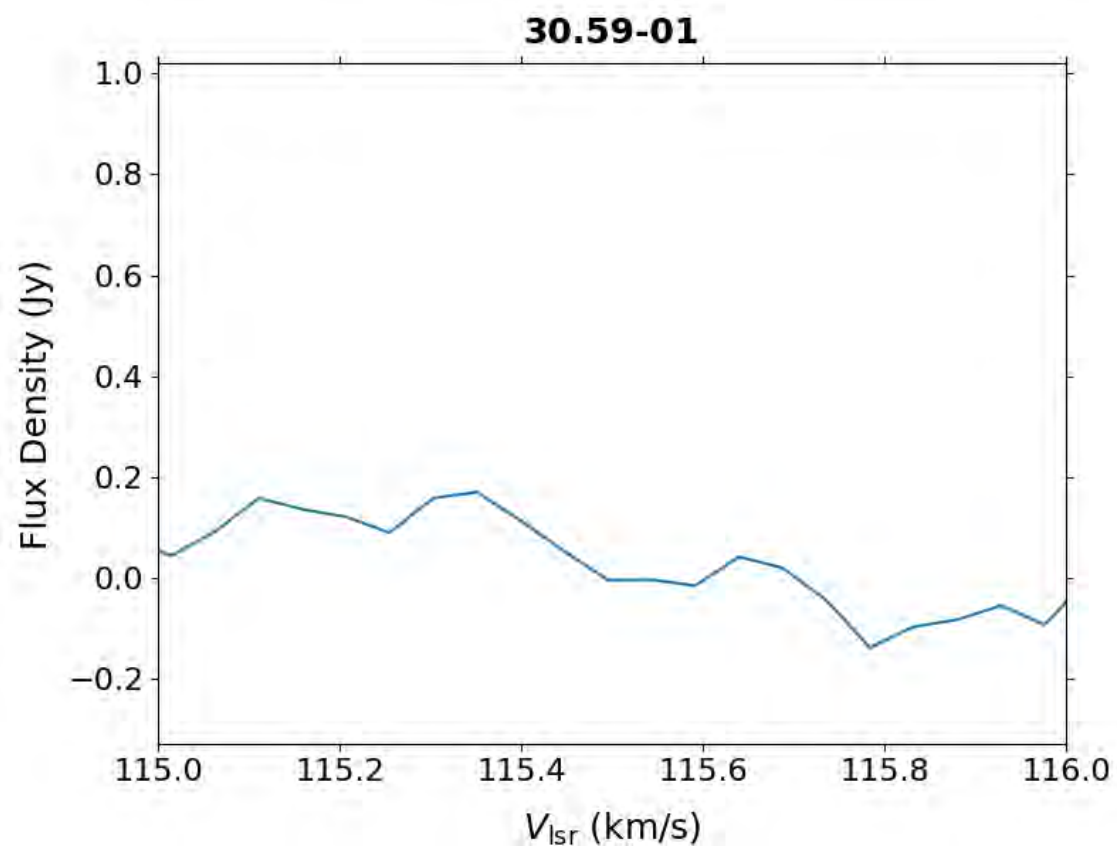
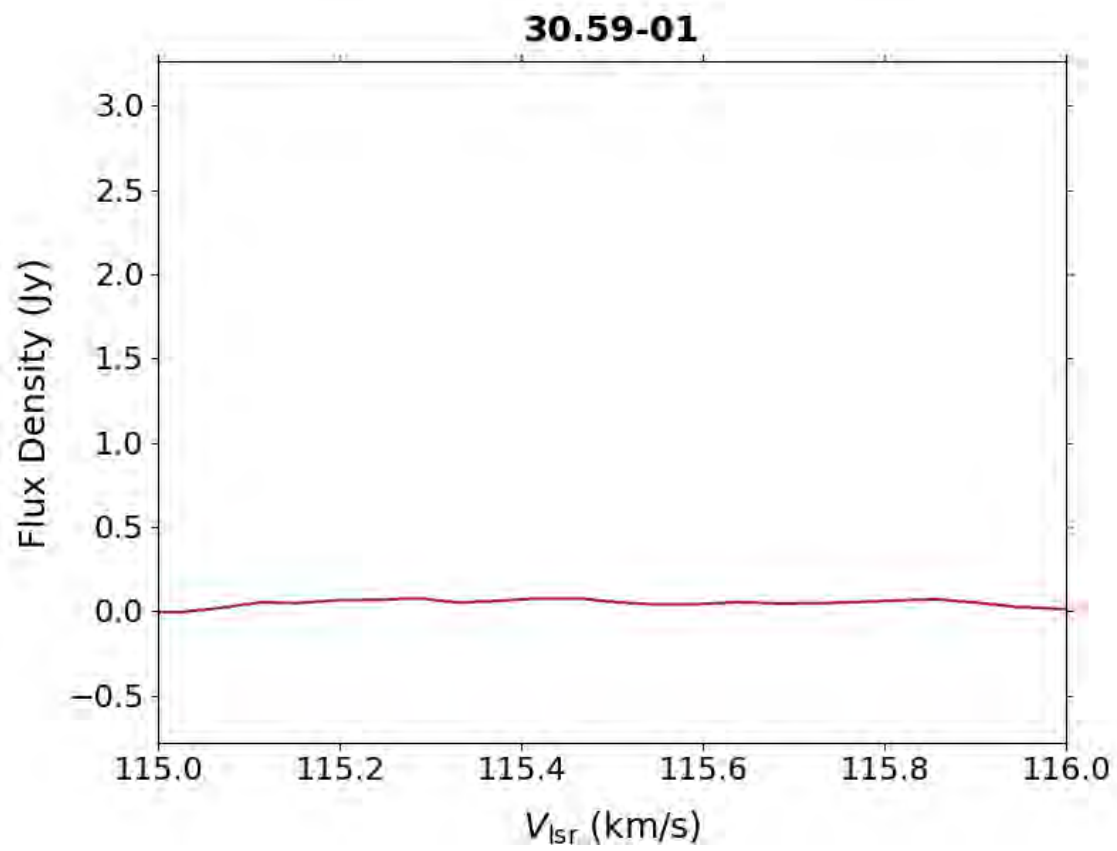


30.40-02

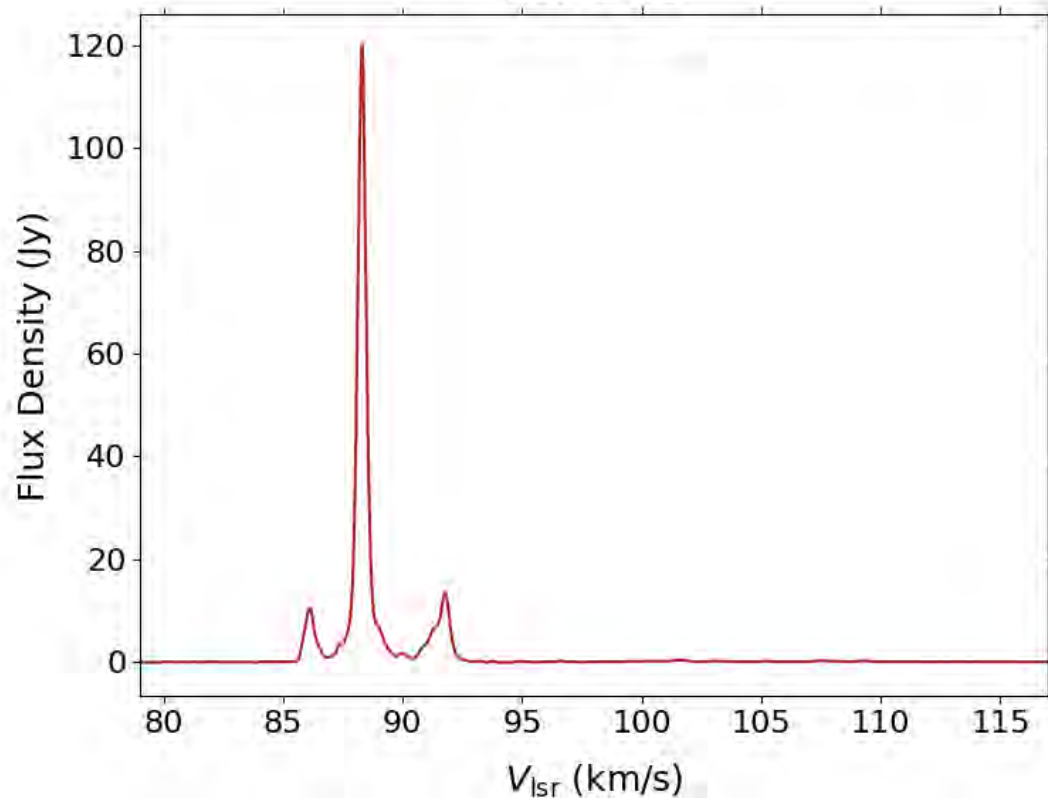




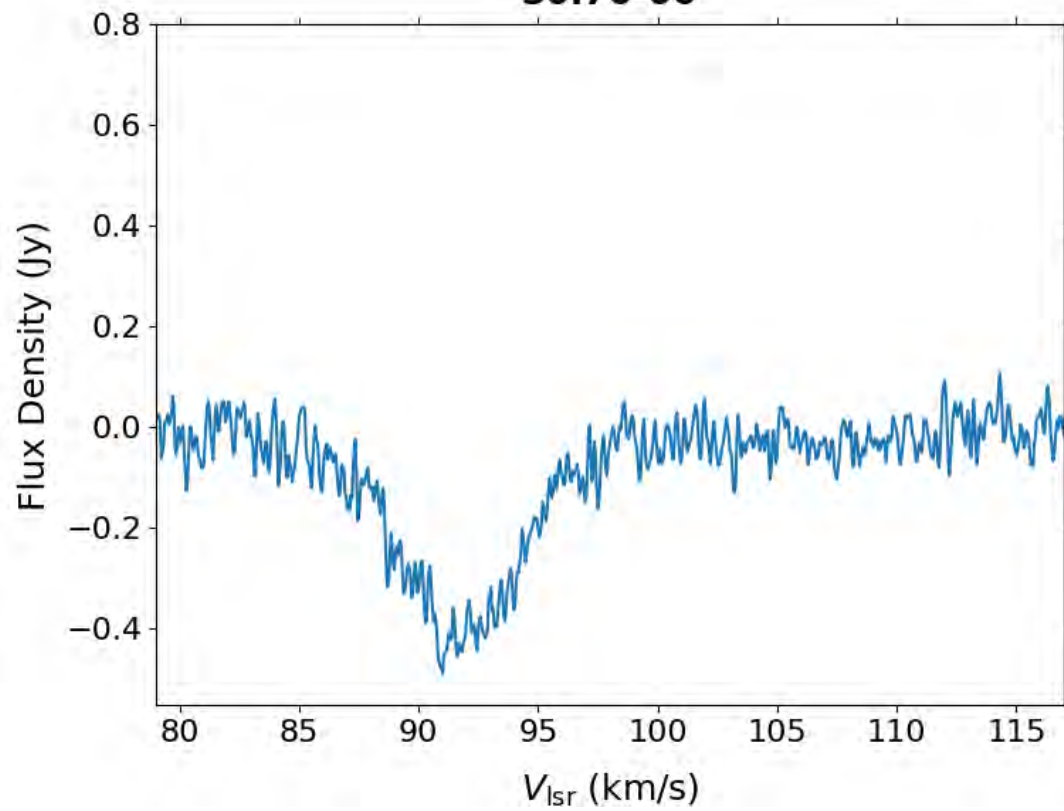


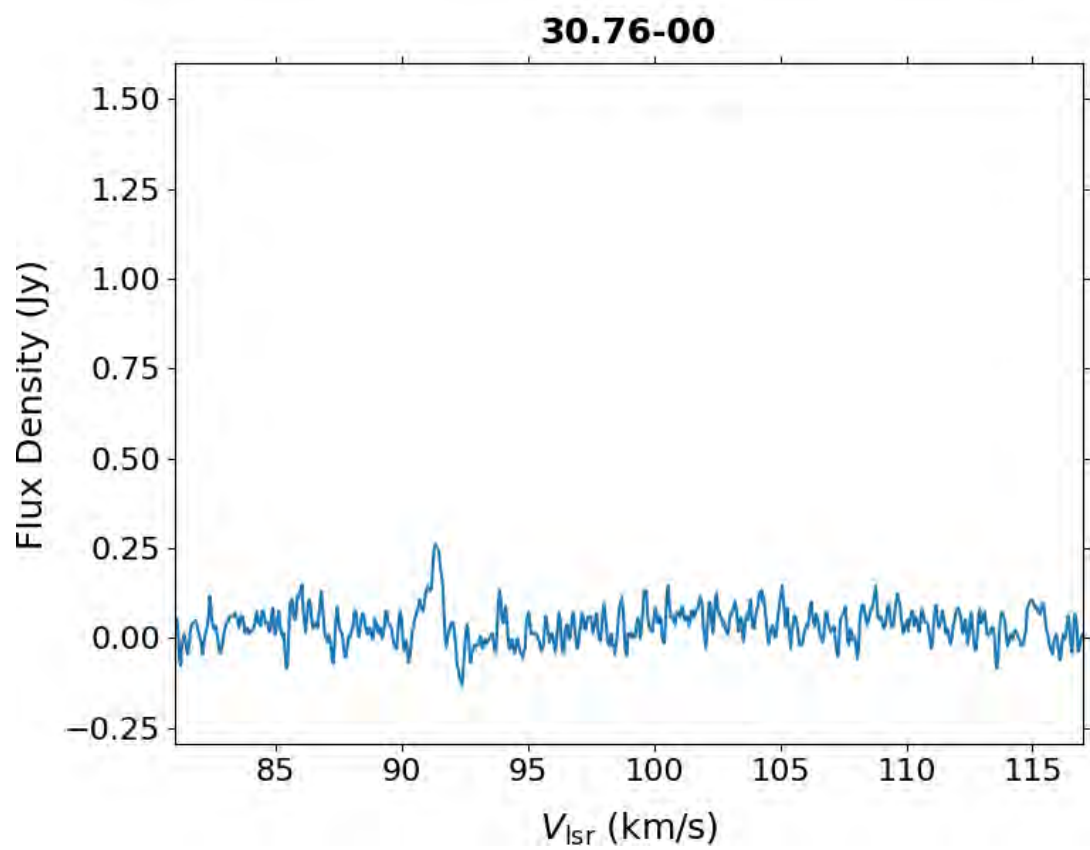
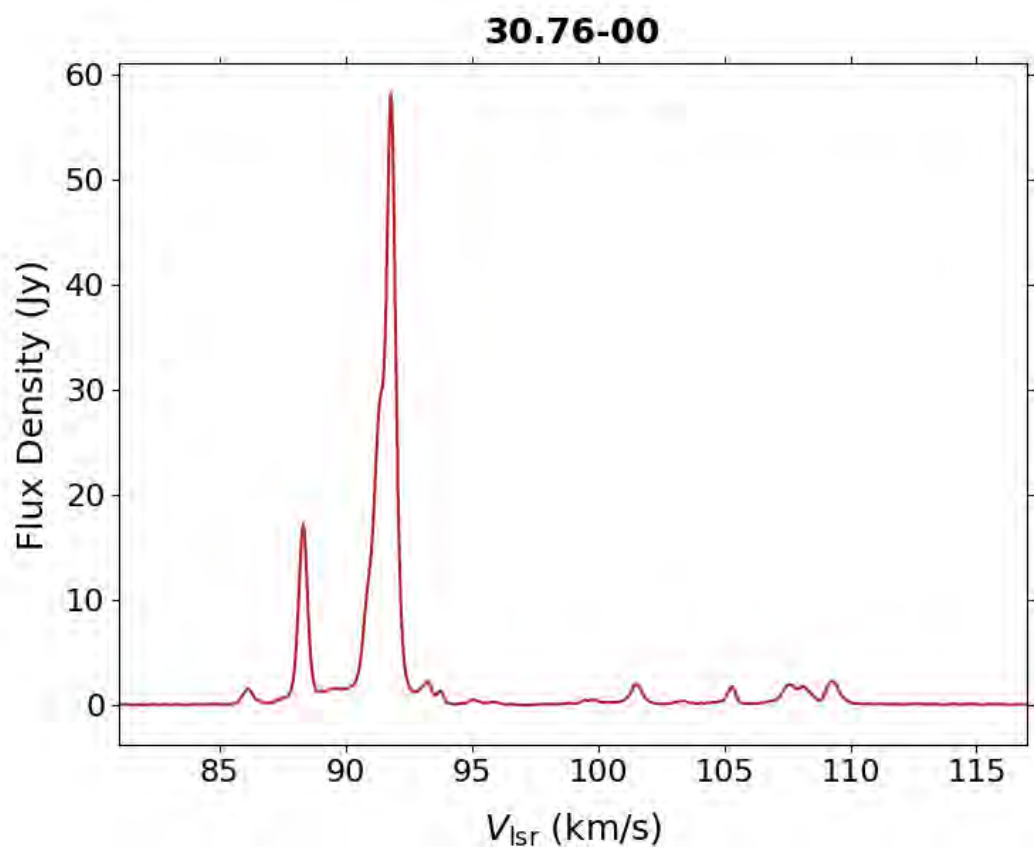


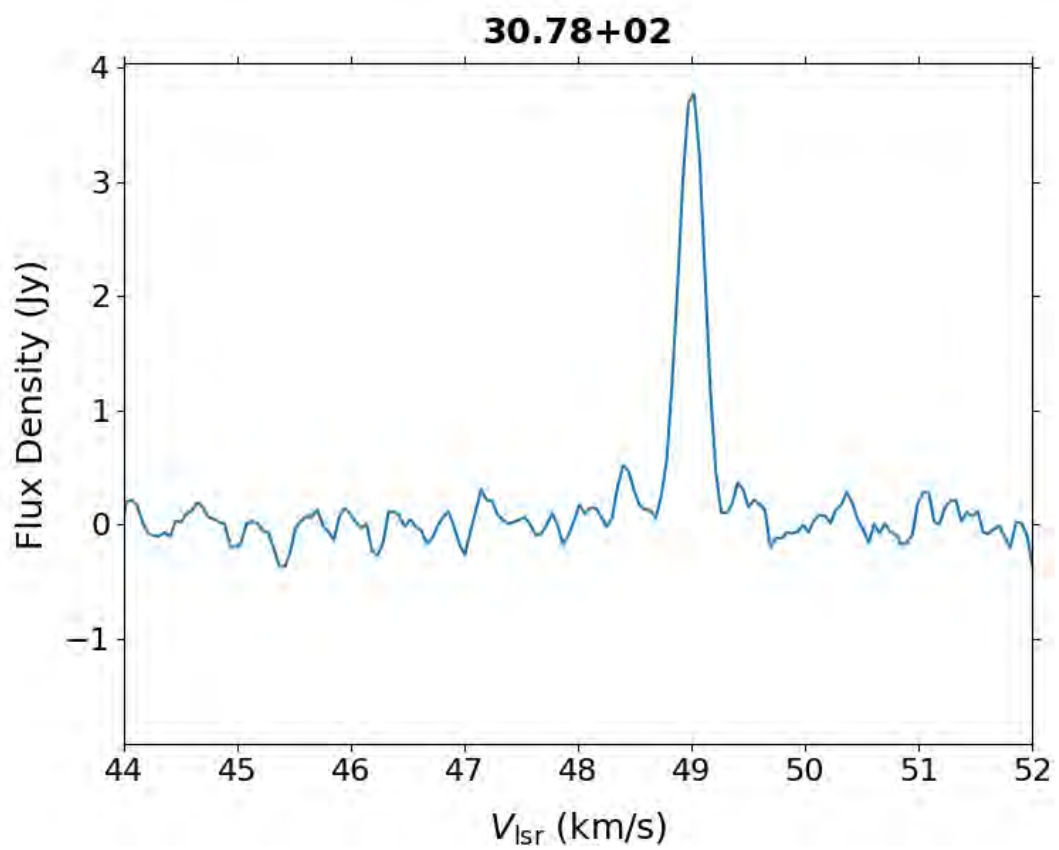
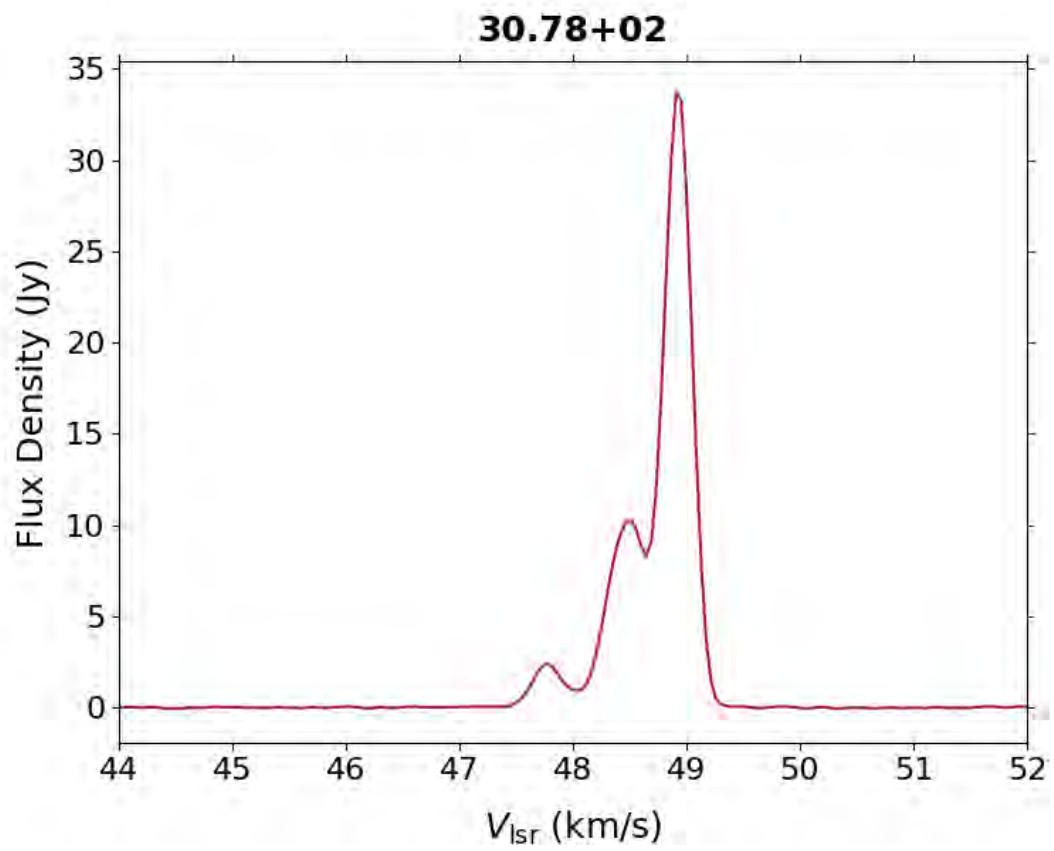
30.70-00



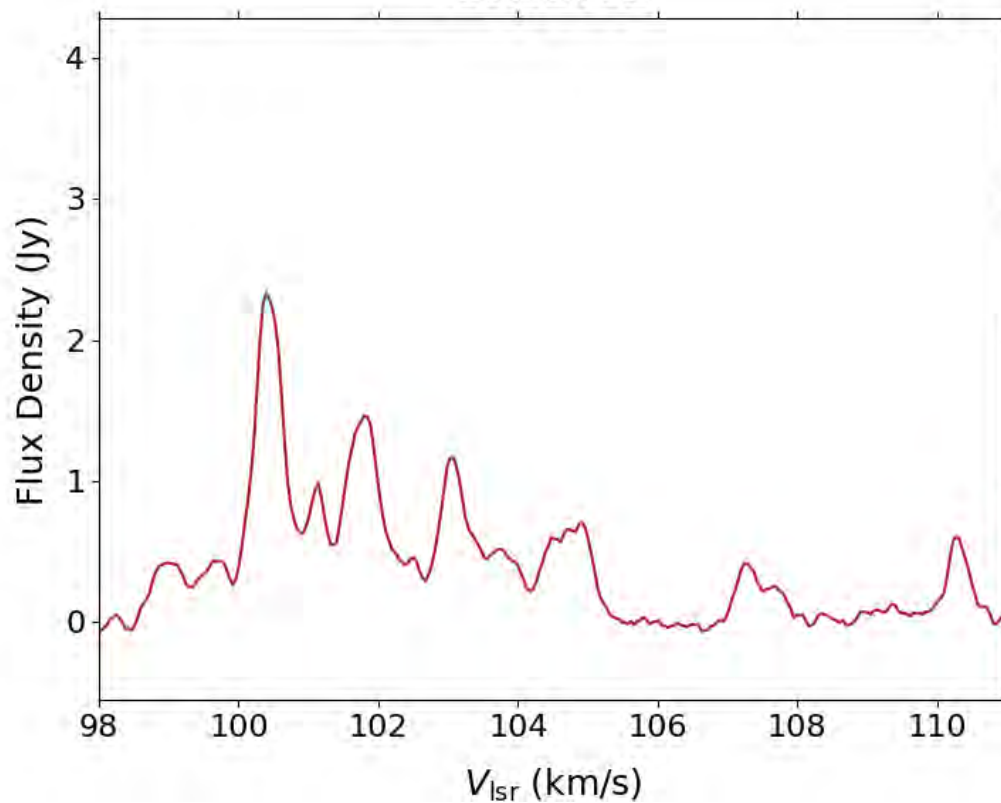
30.70-00



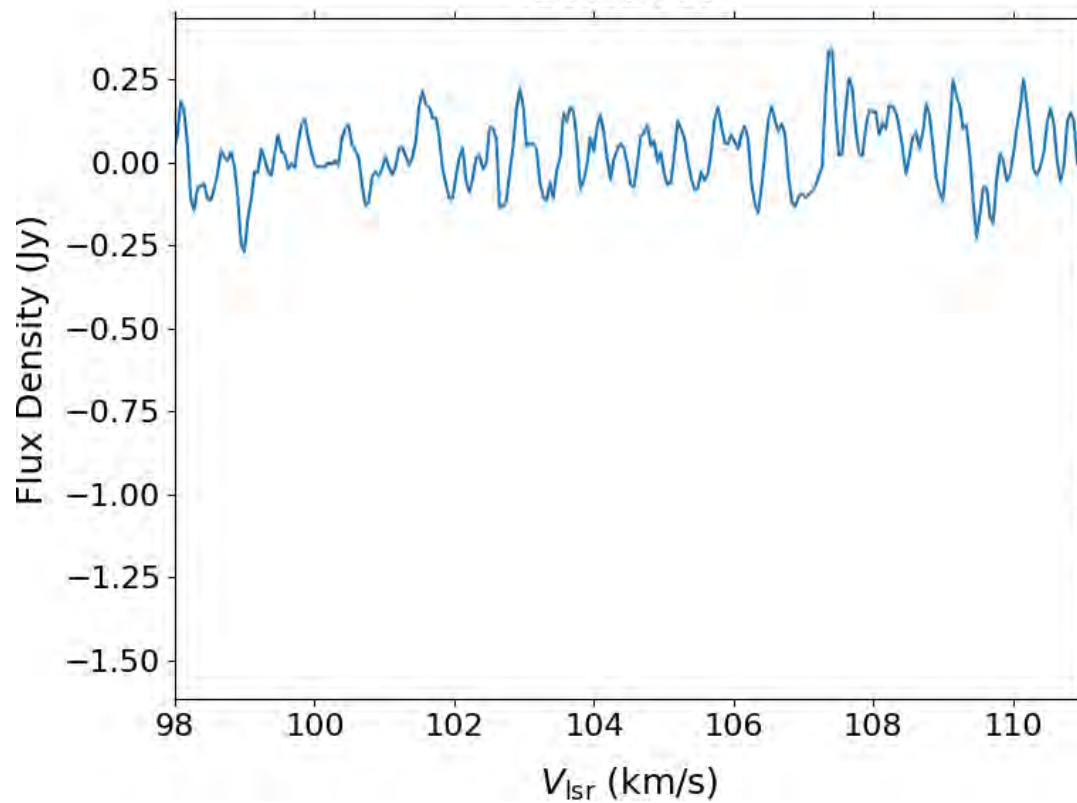


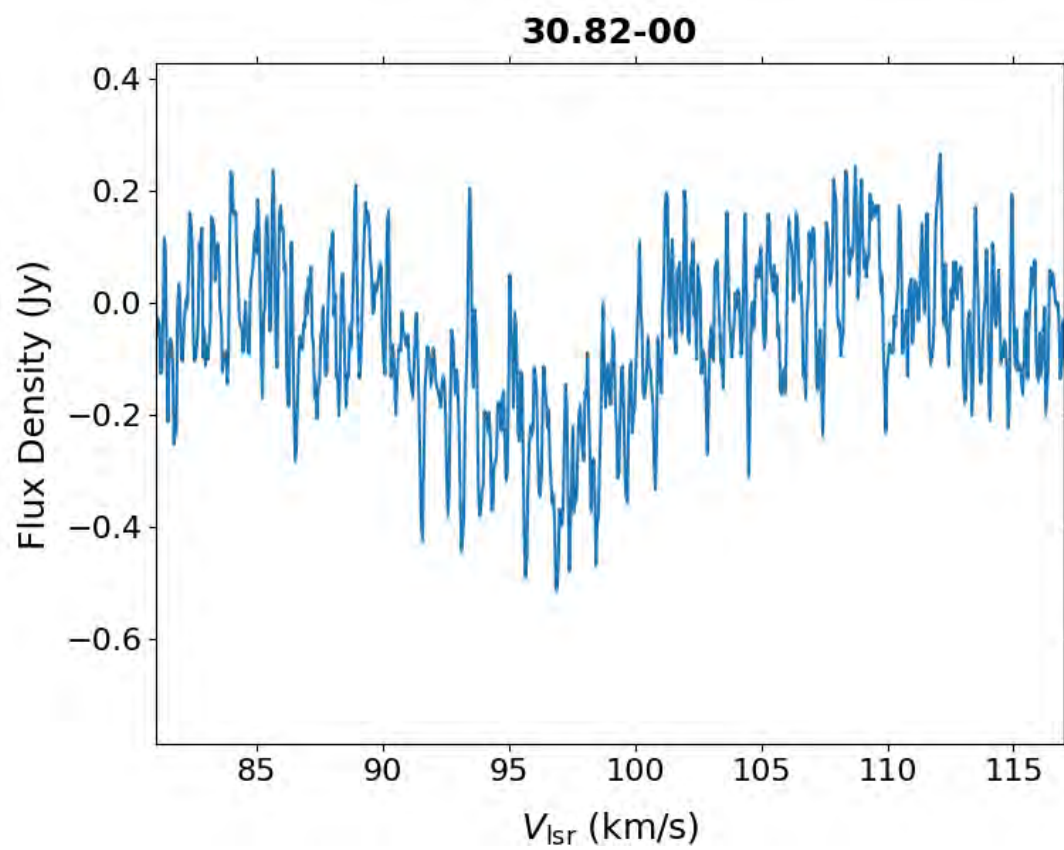
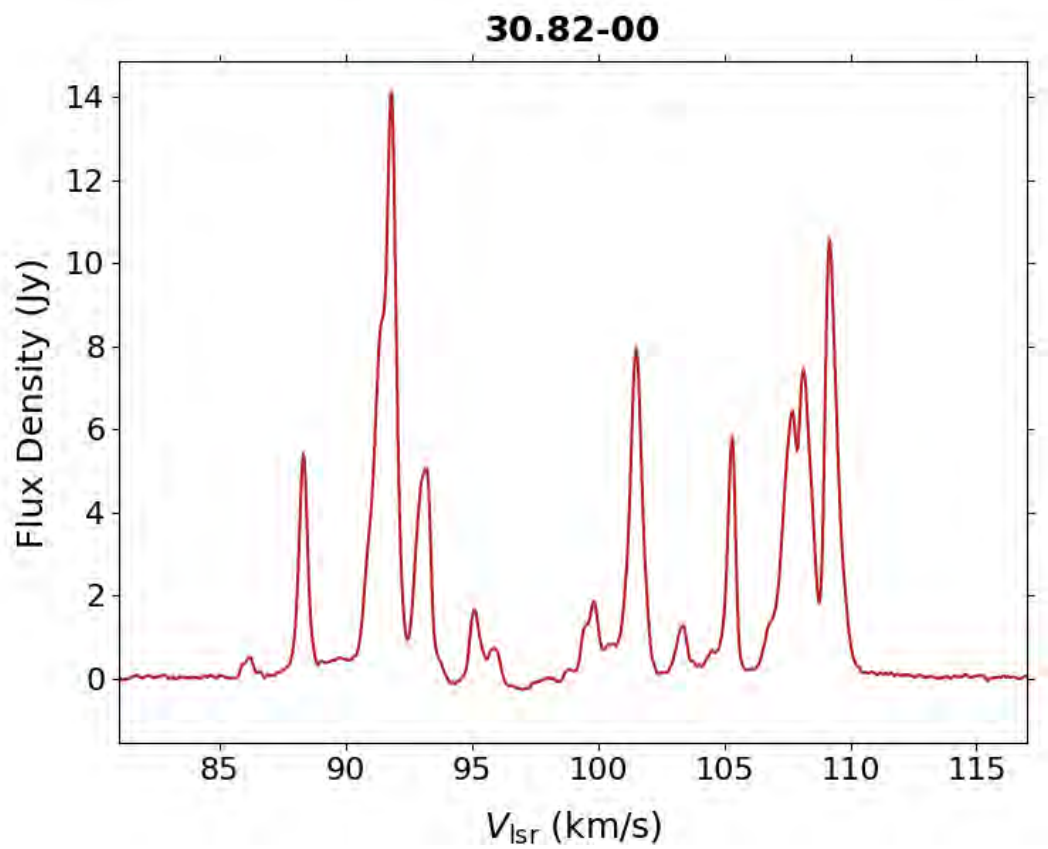


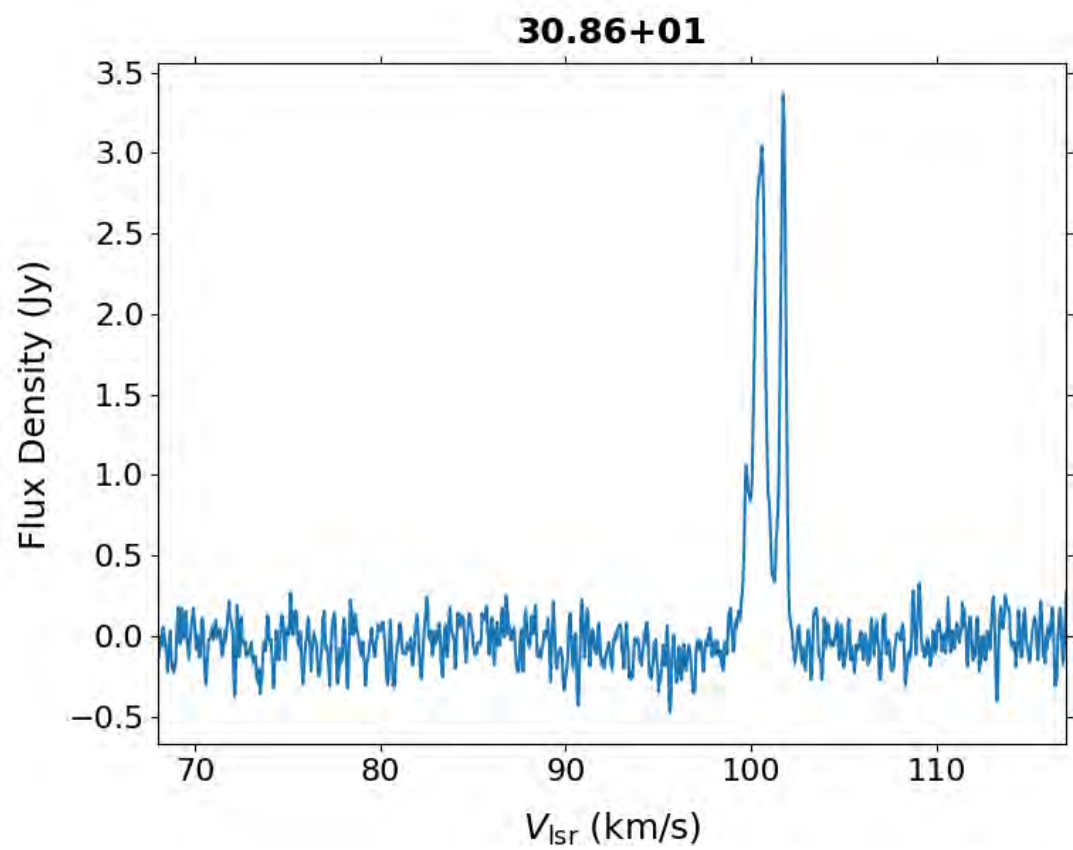
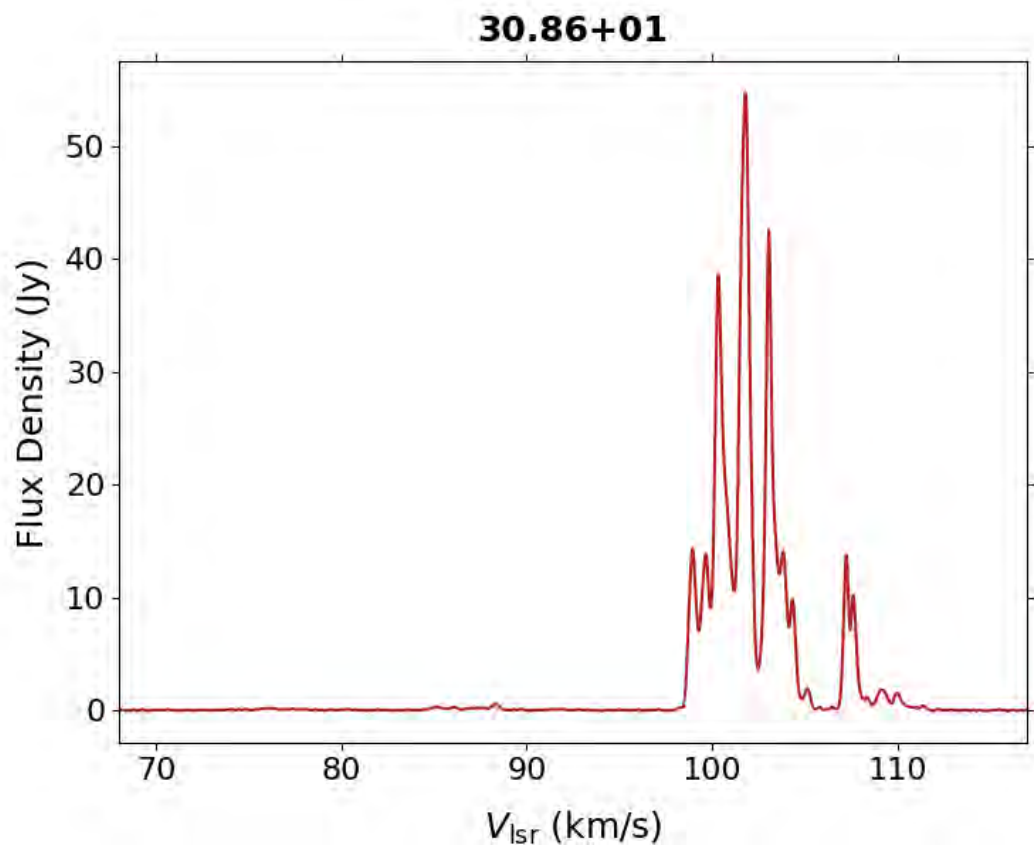
30.82+02



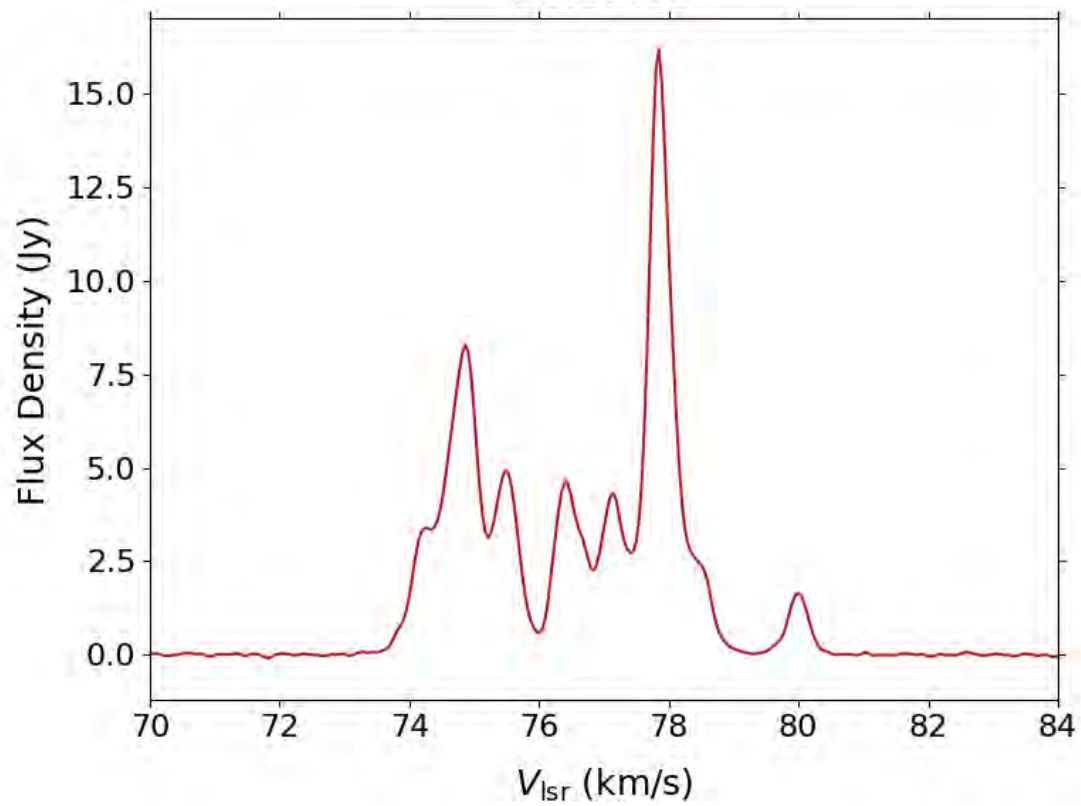
30.82+02



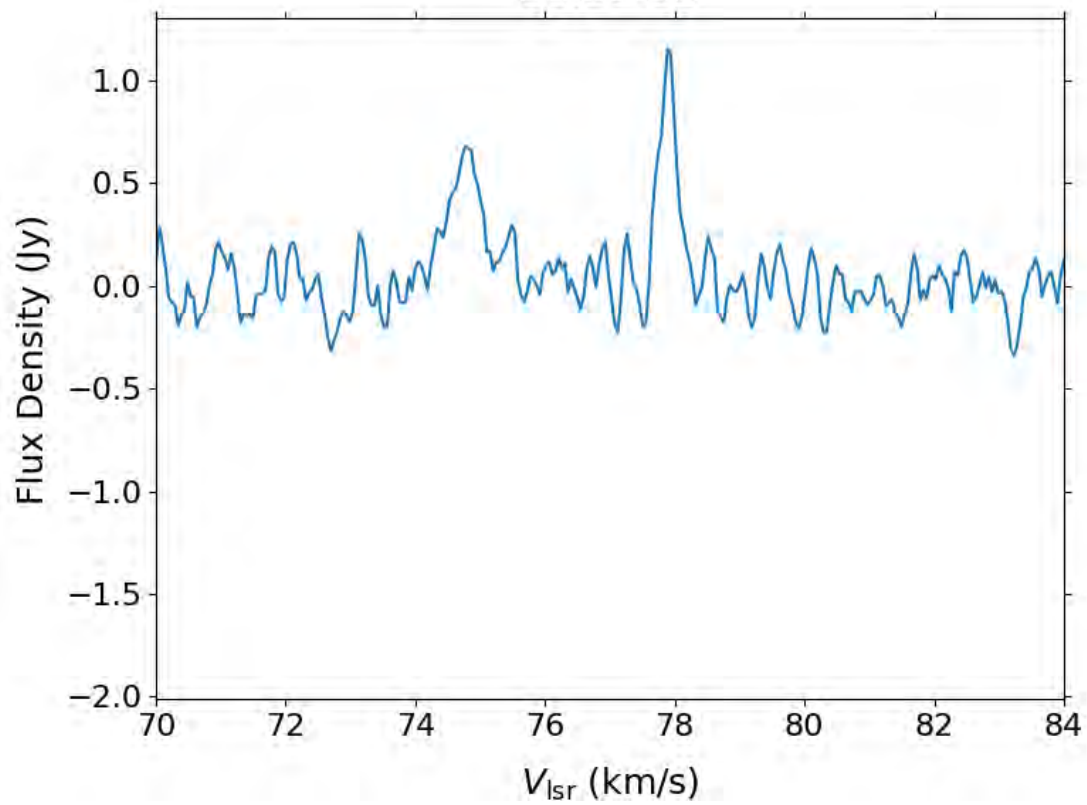


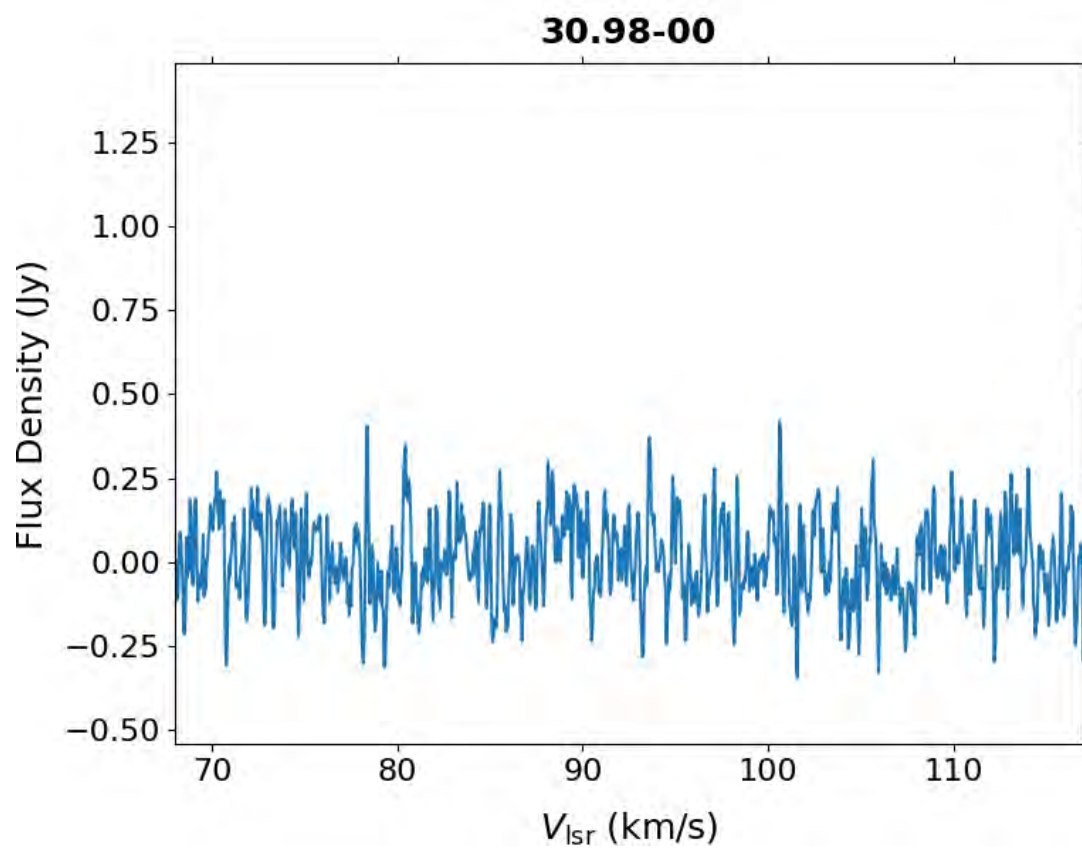
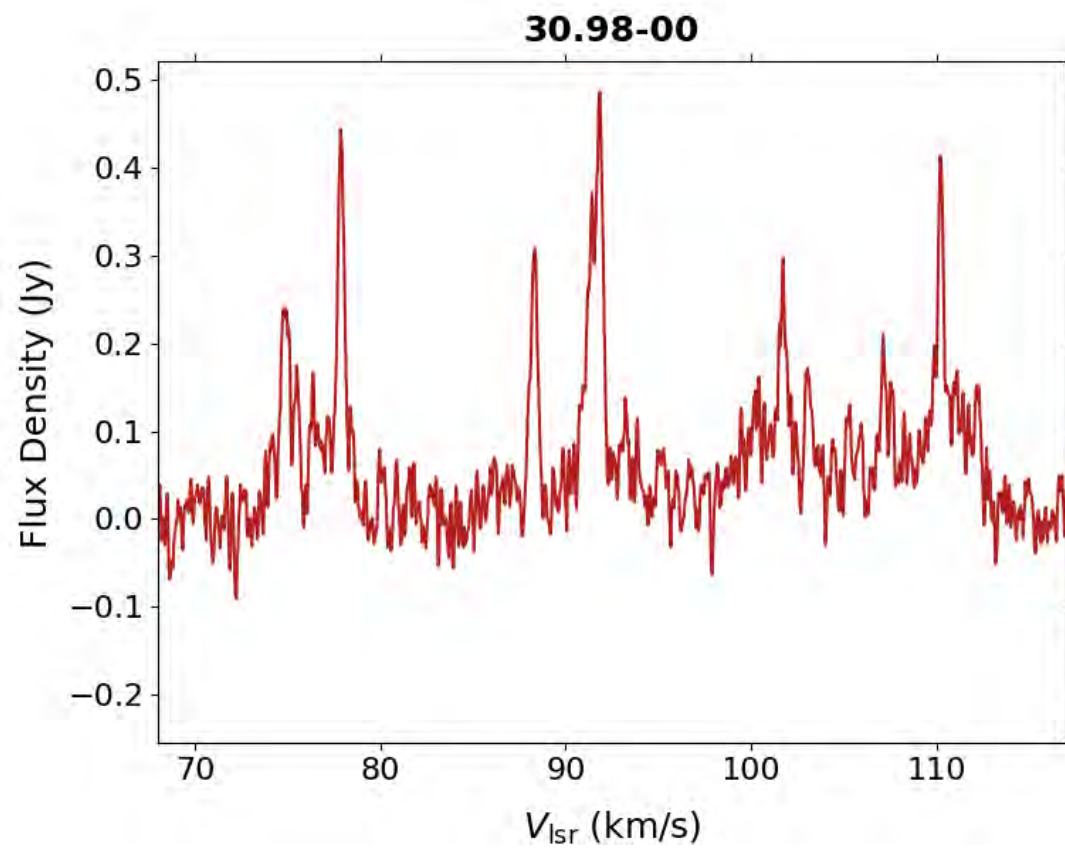


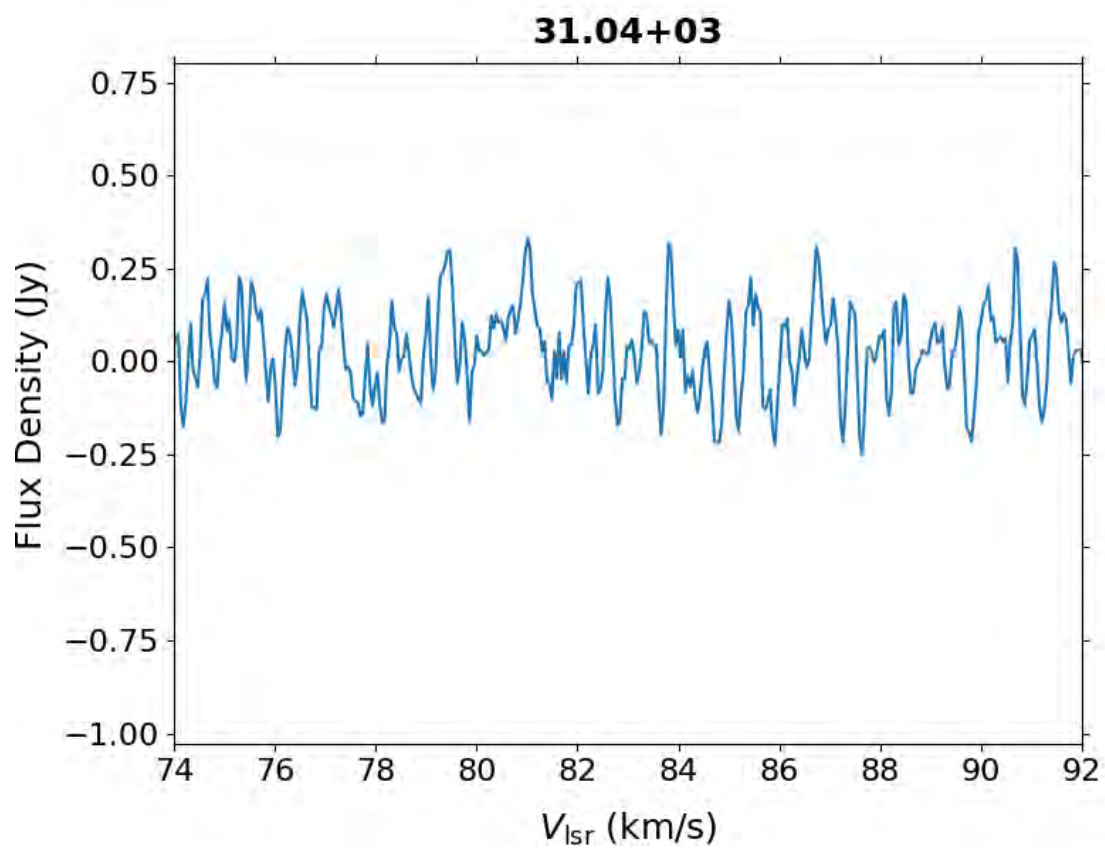
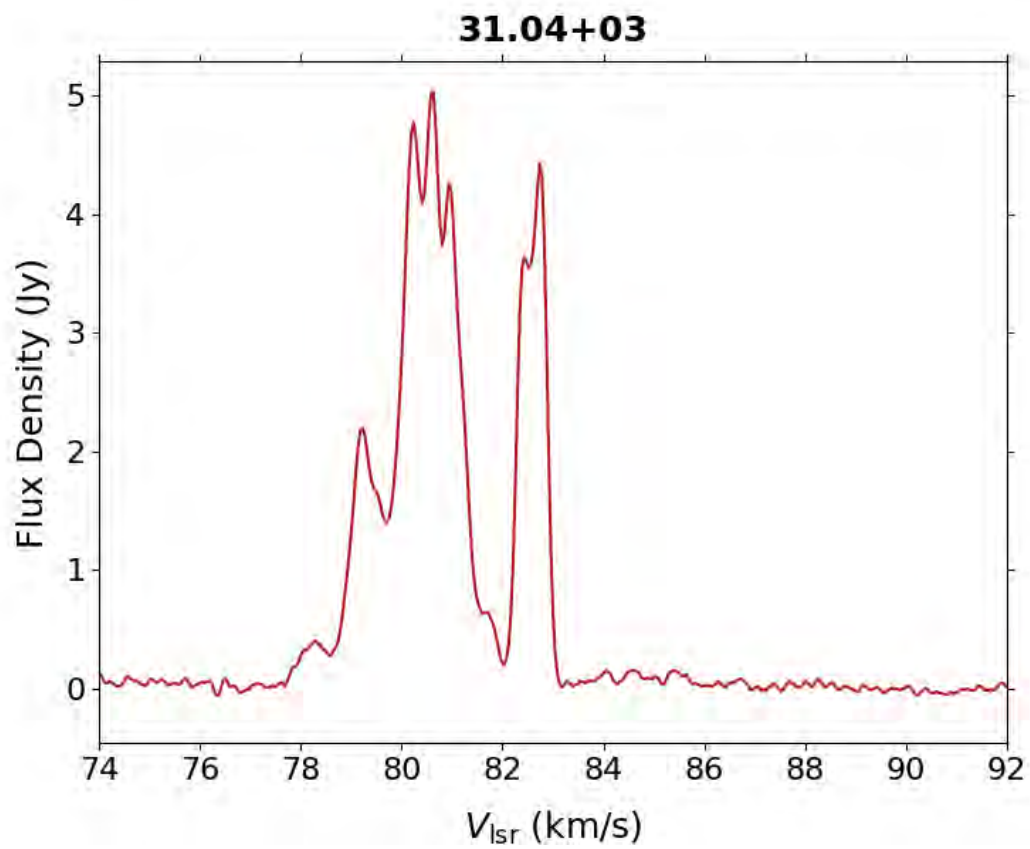
30.96-01

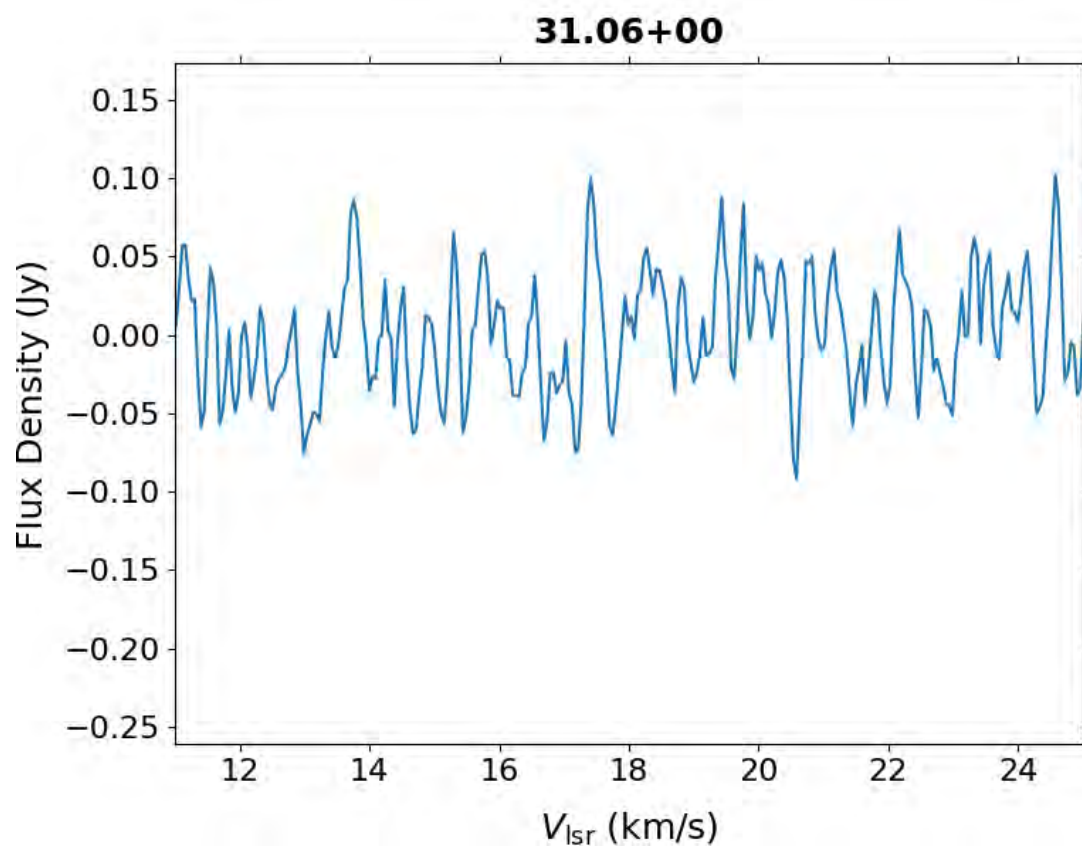
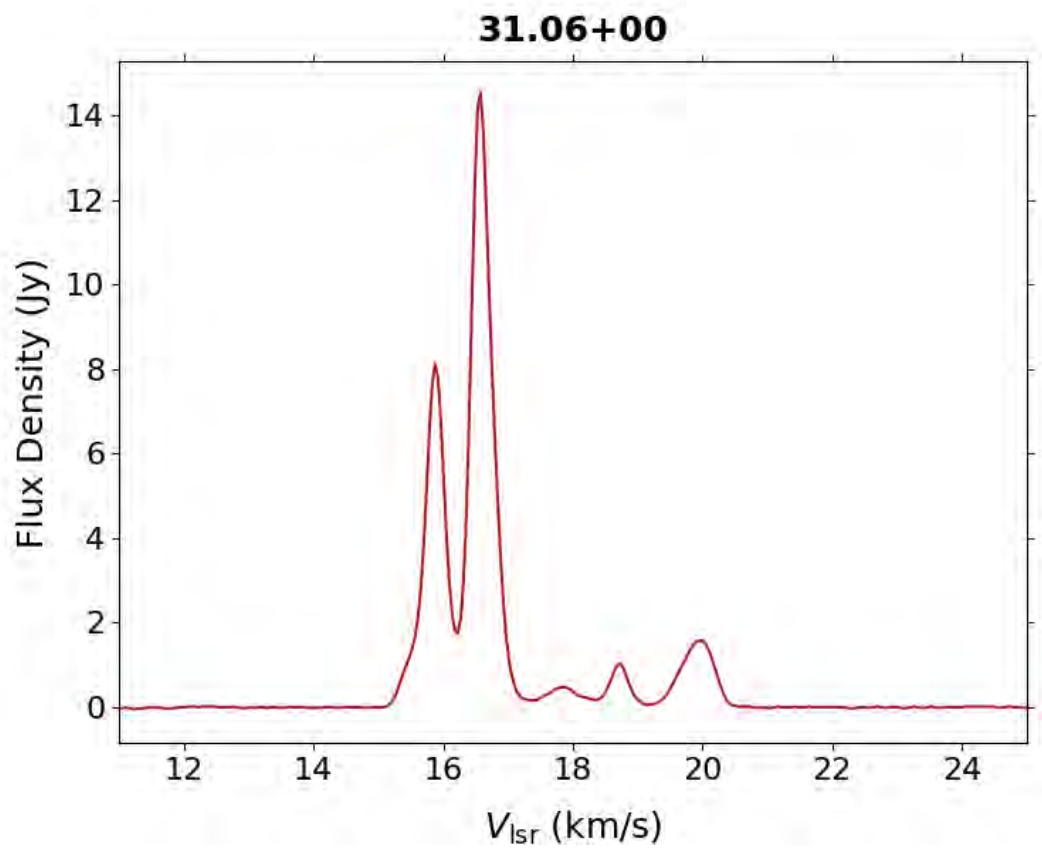


30.96-01

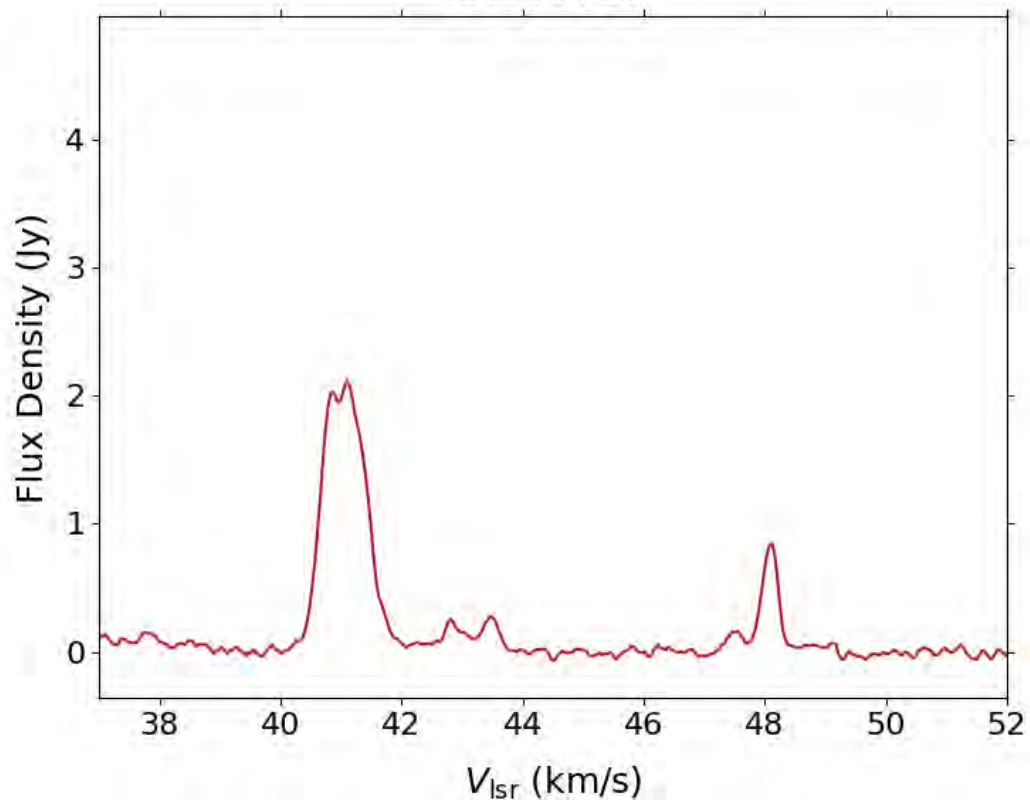




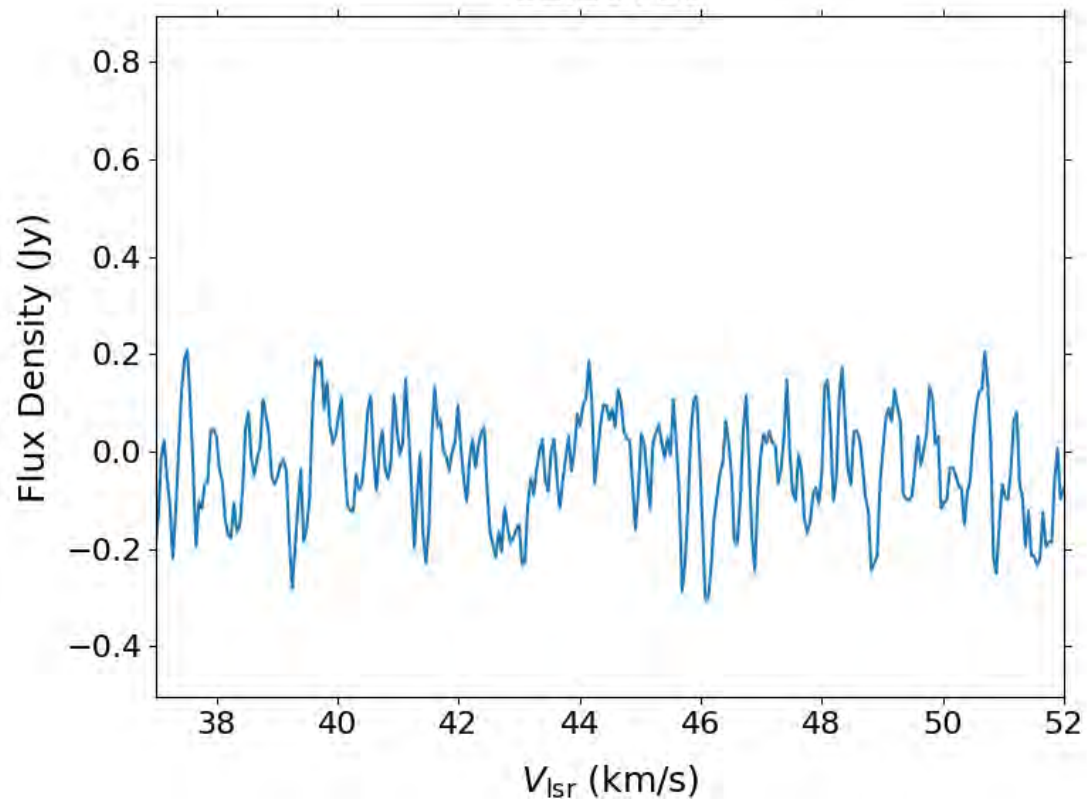


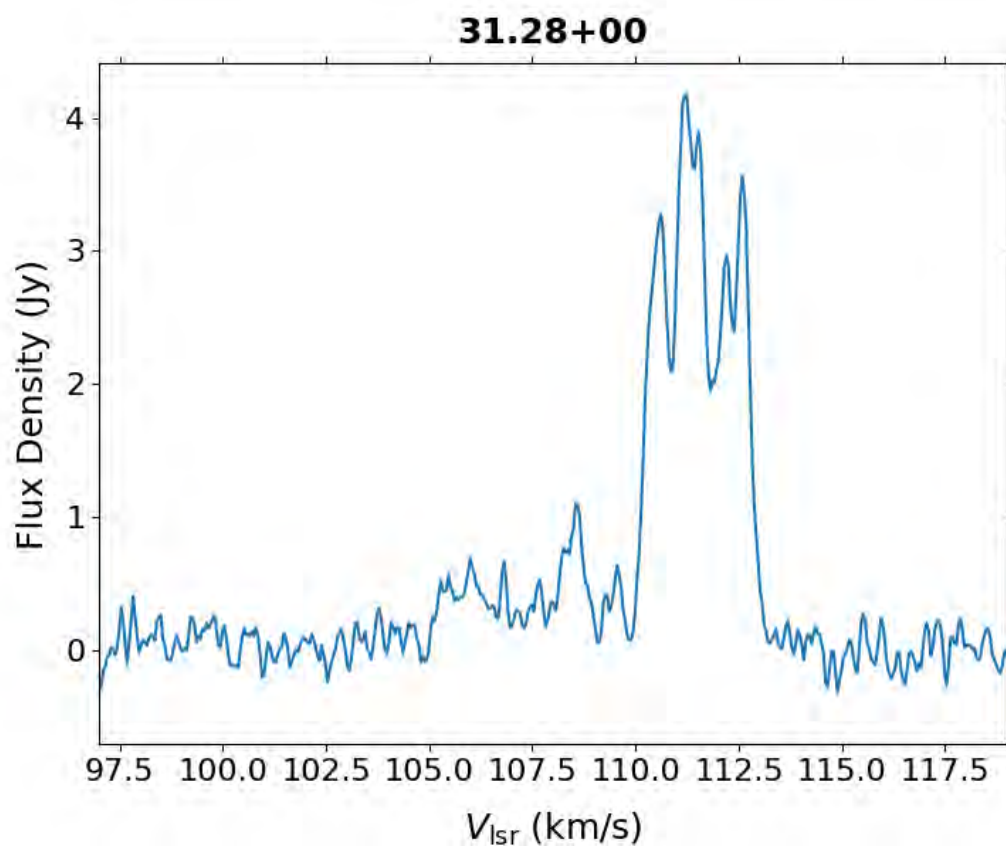
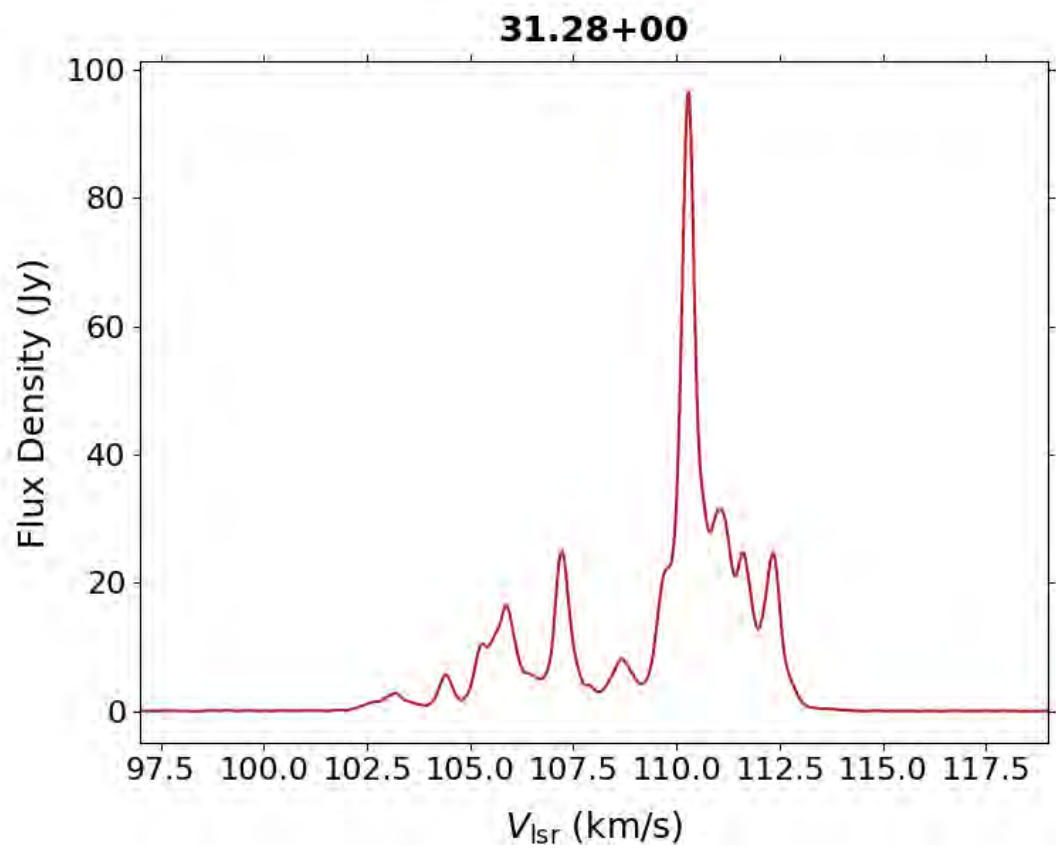


31.16+00

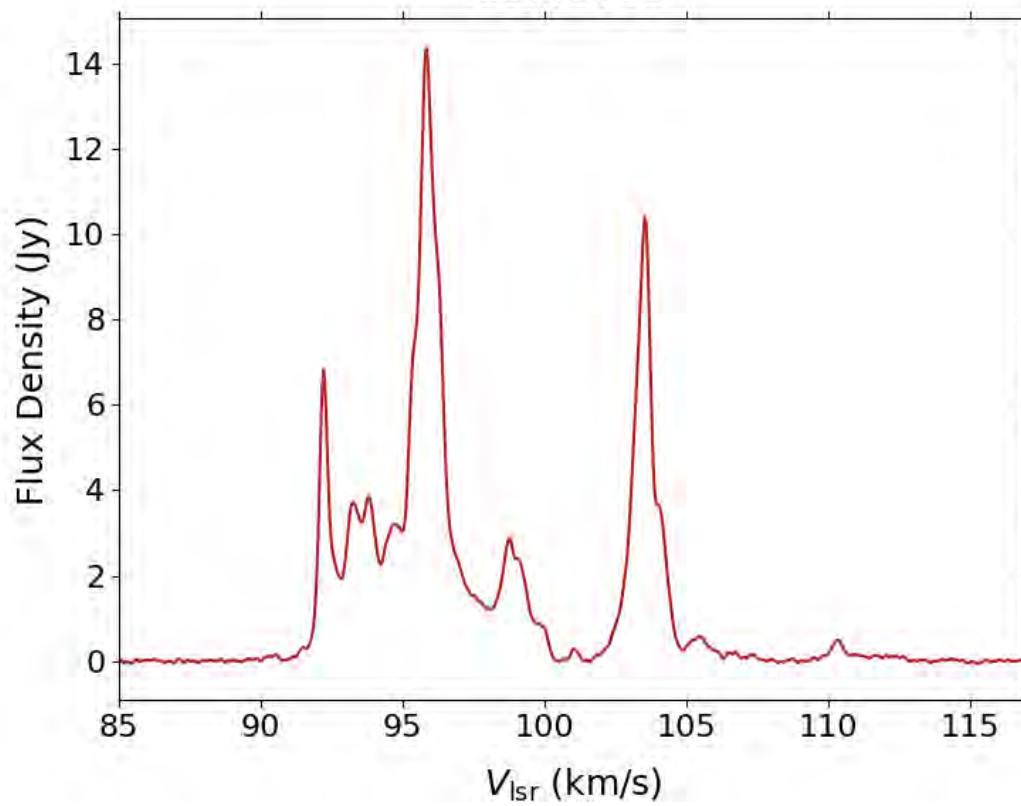


31.16+00

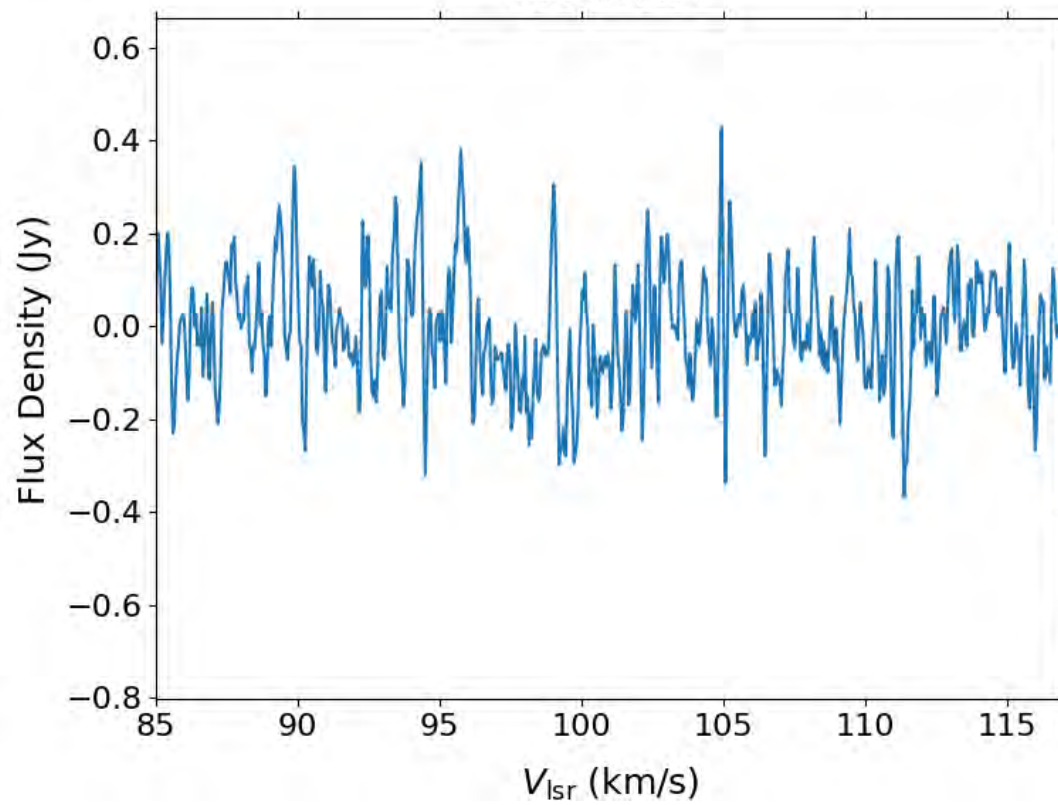


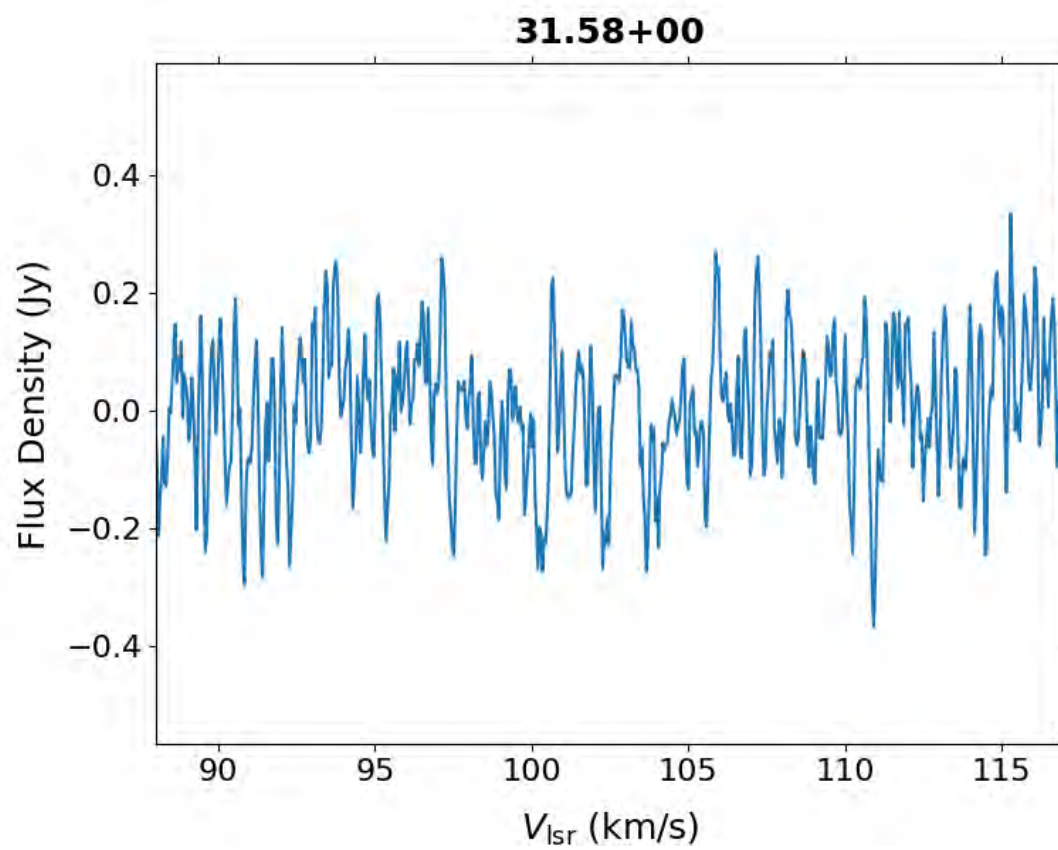
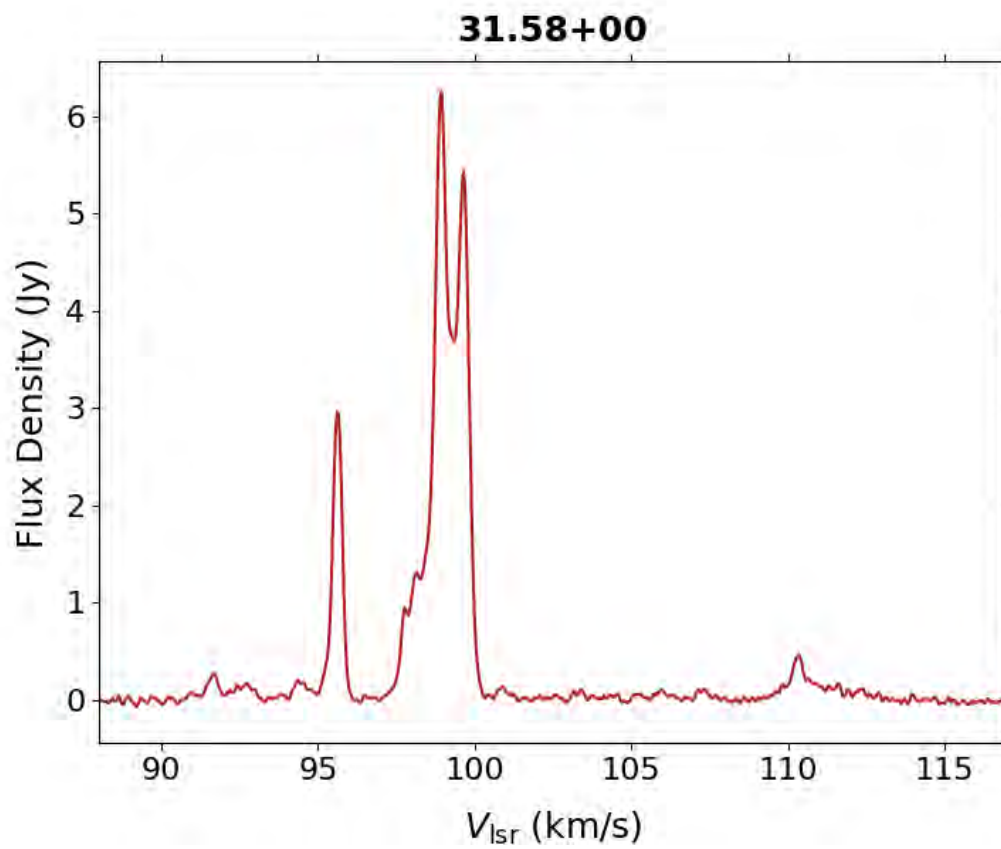


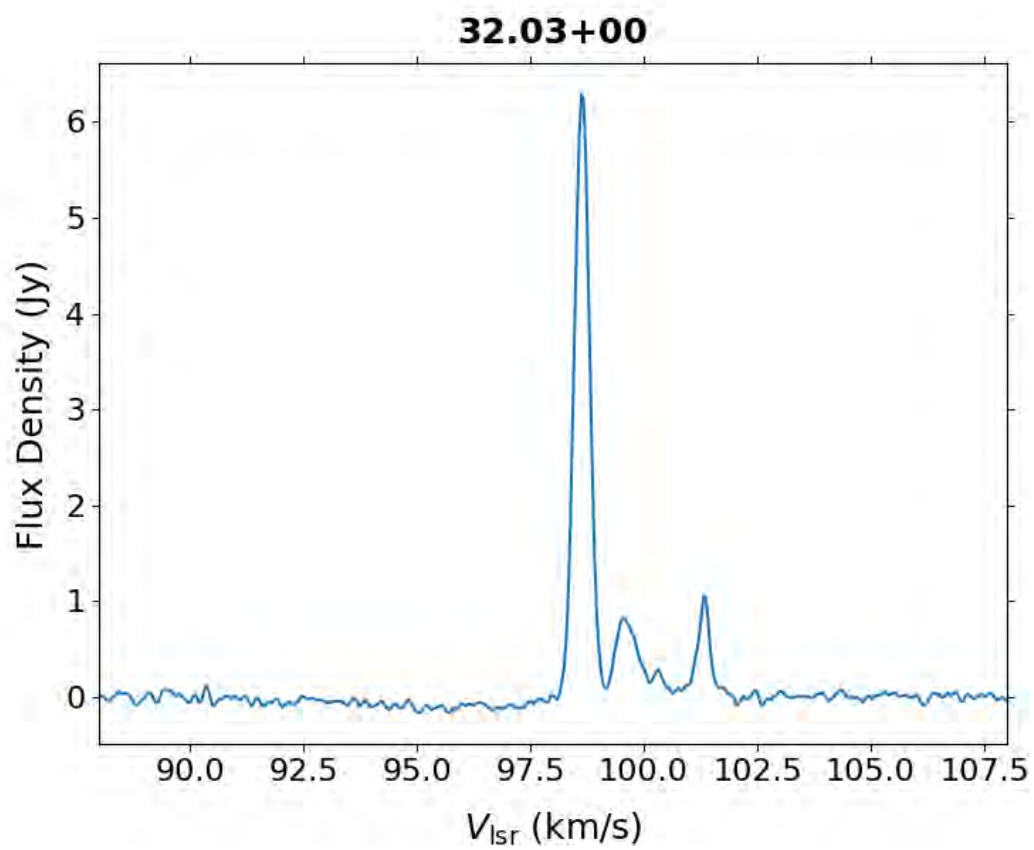
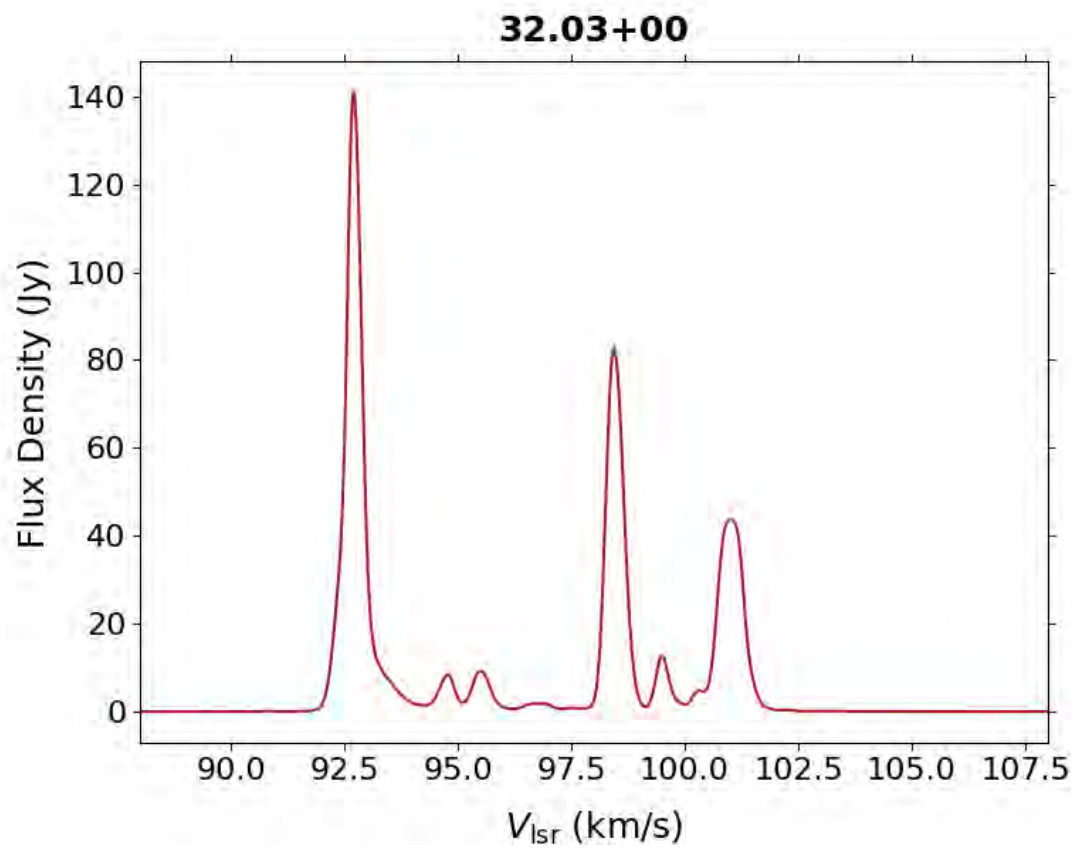
31.41+03

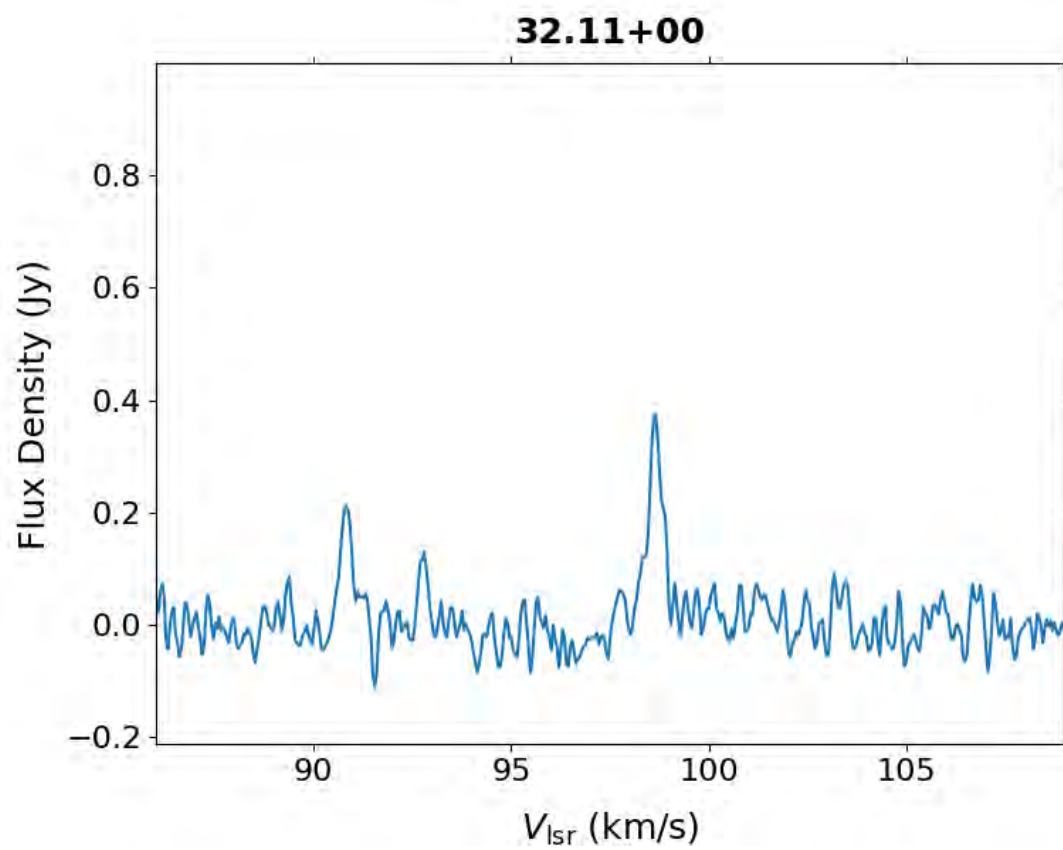
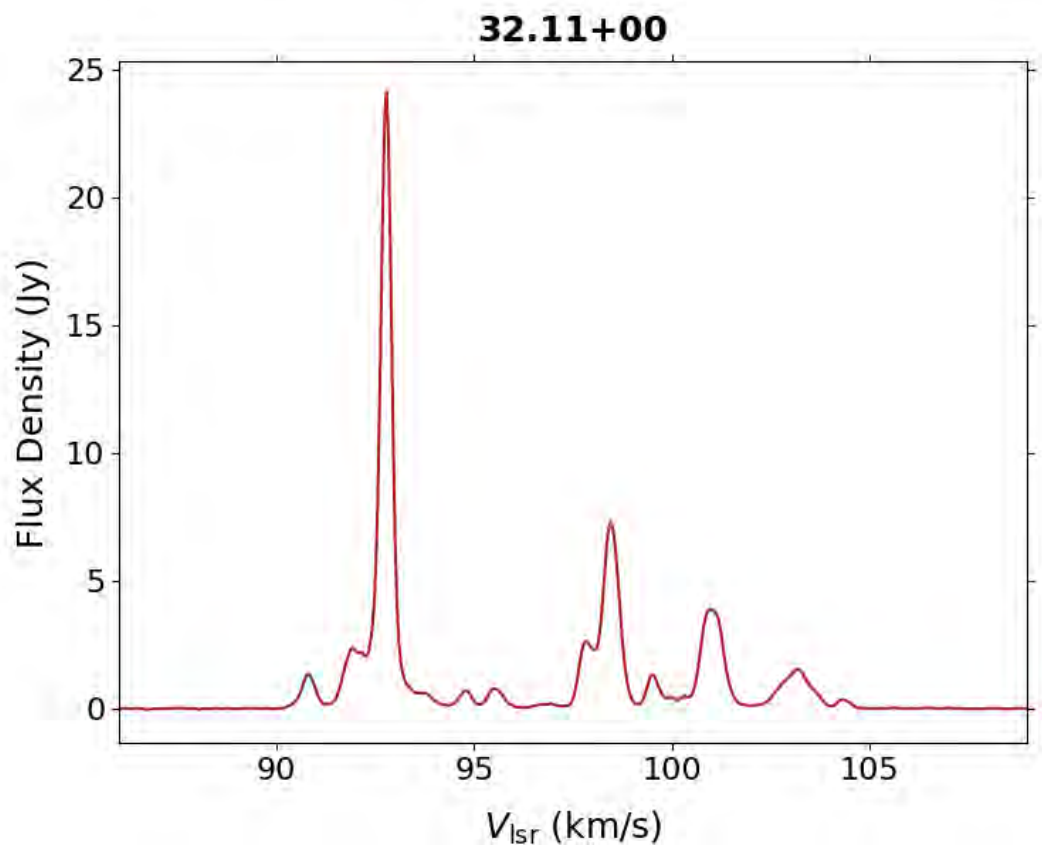


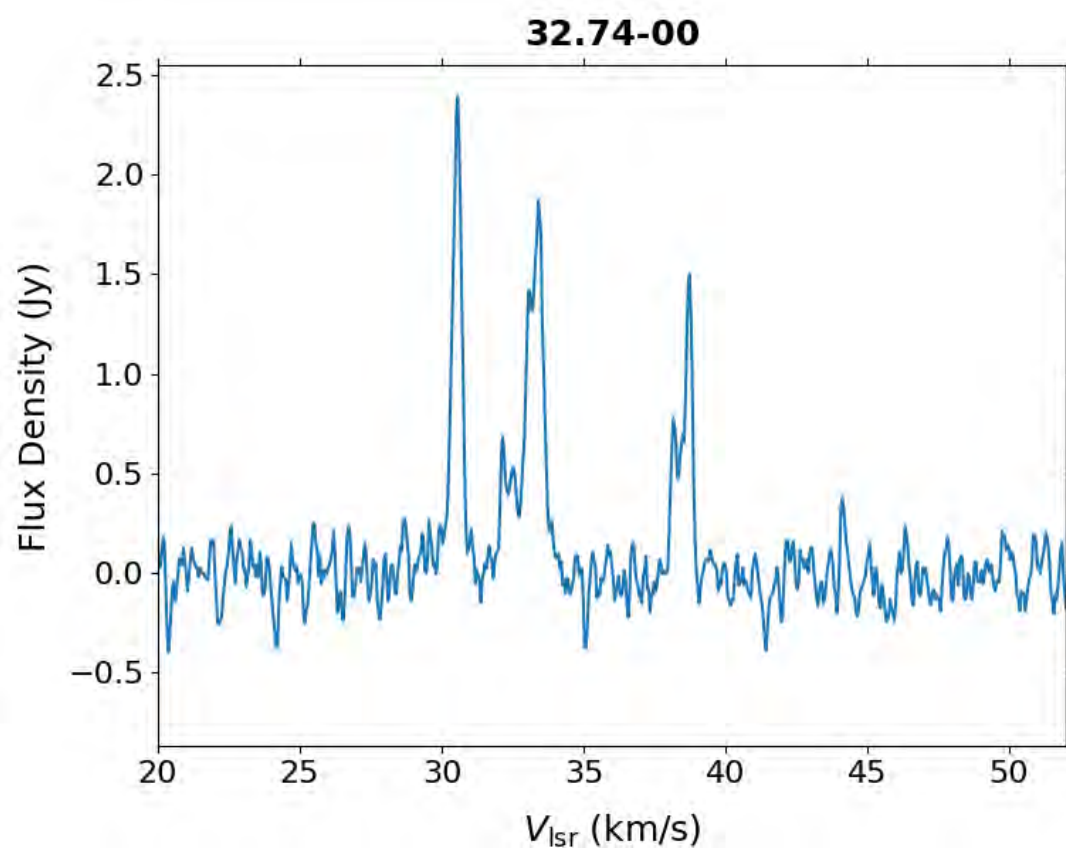
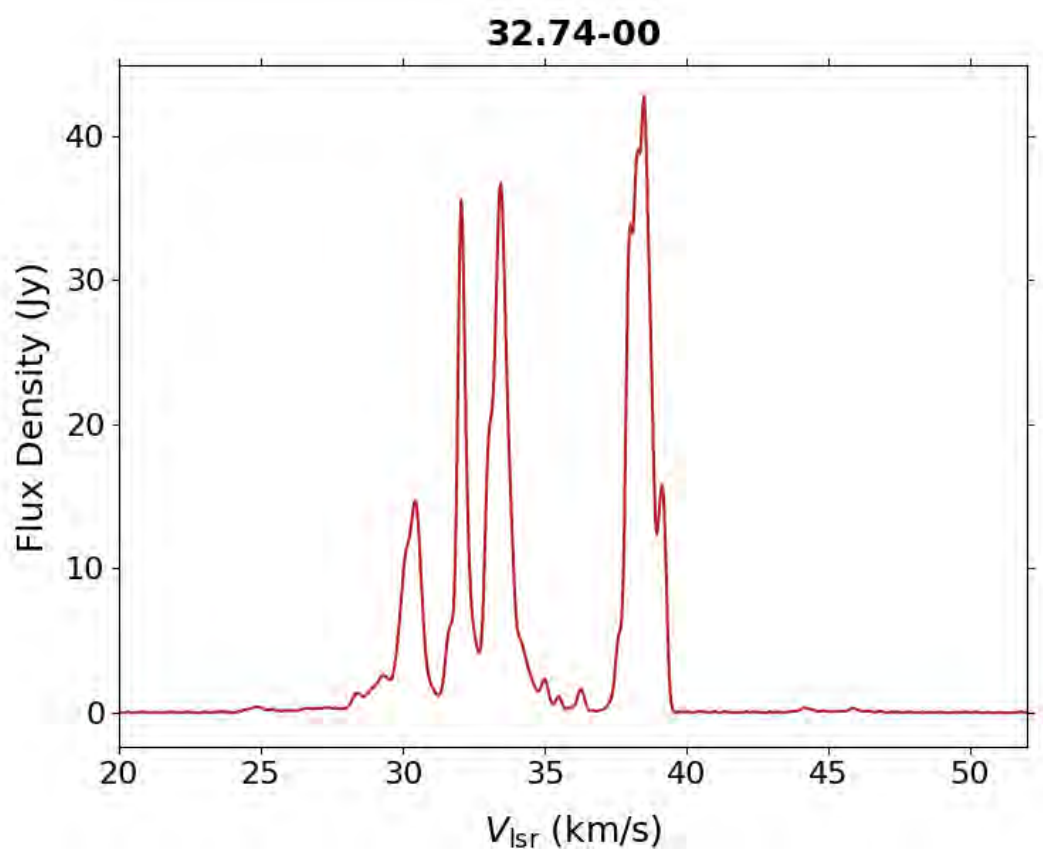
31.41+03



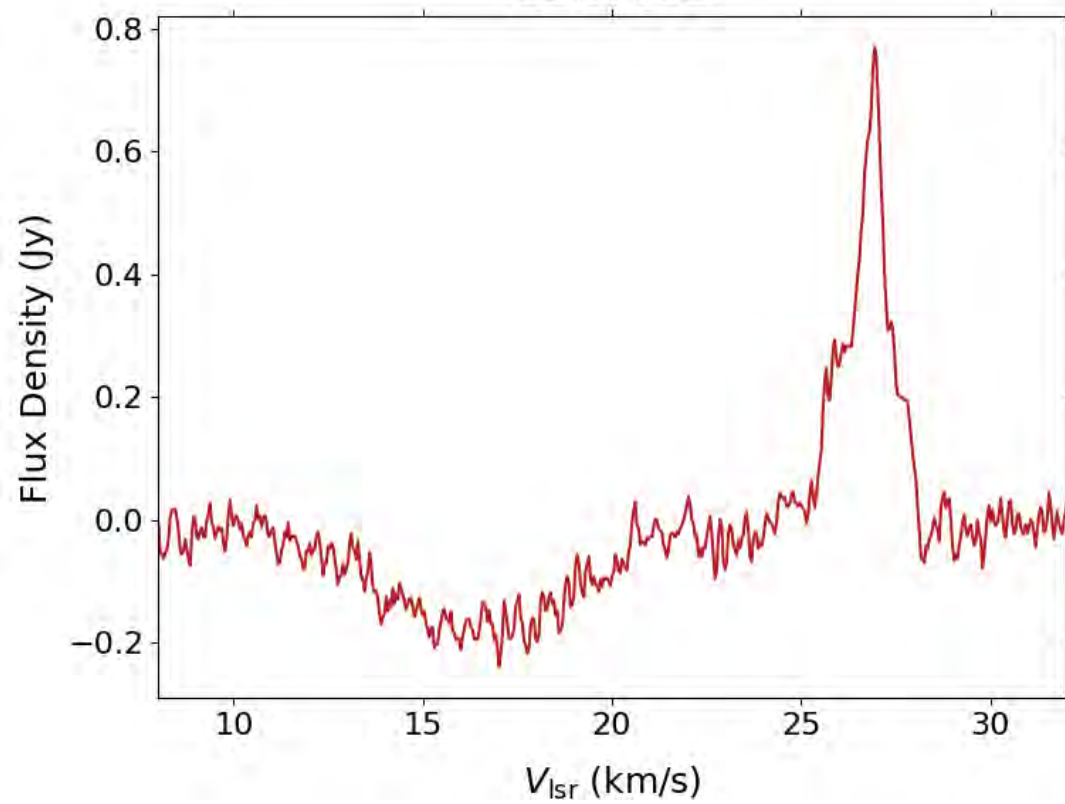




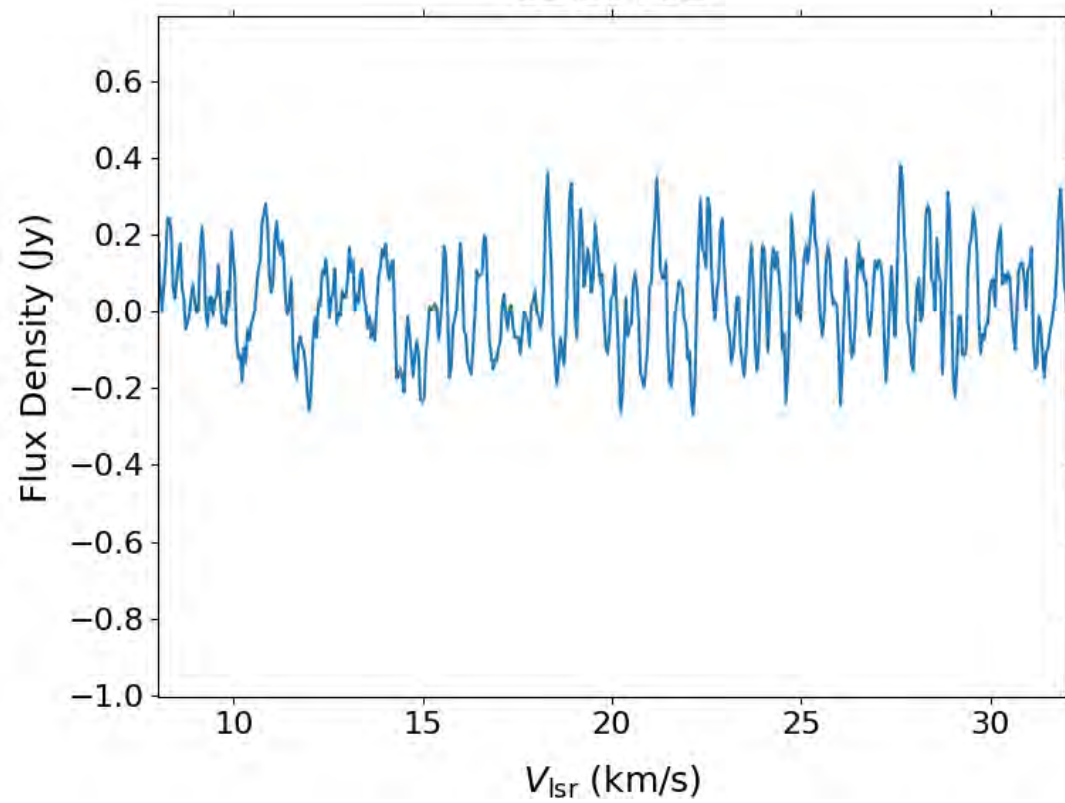


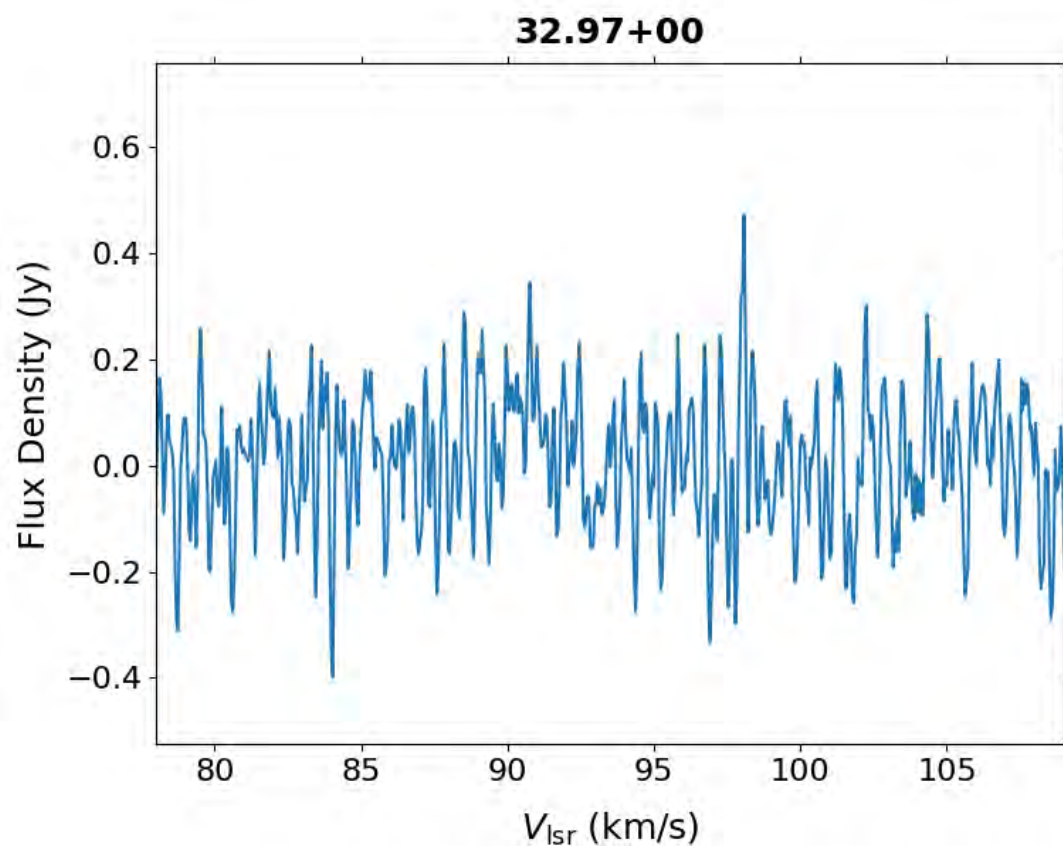
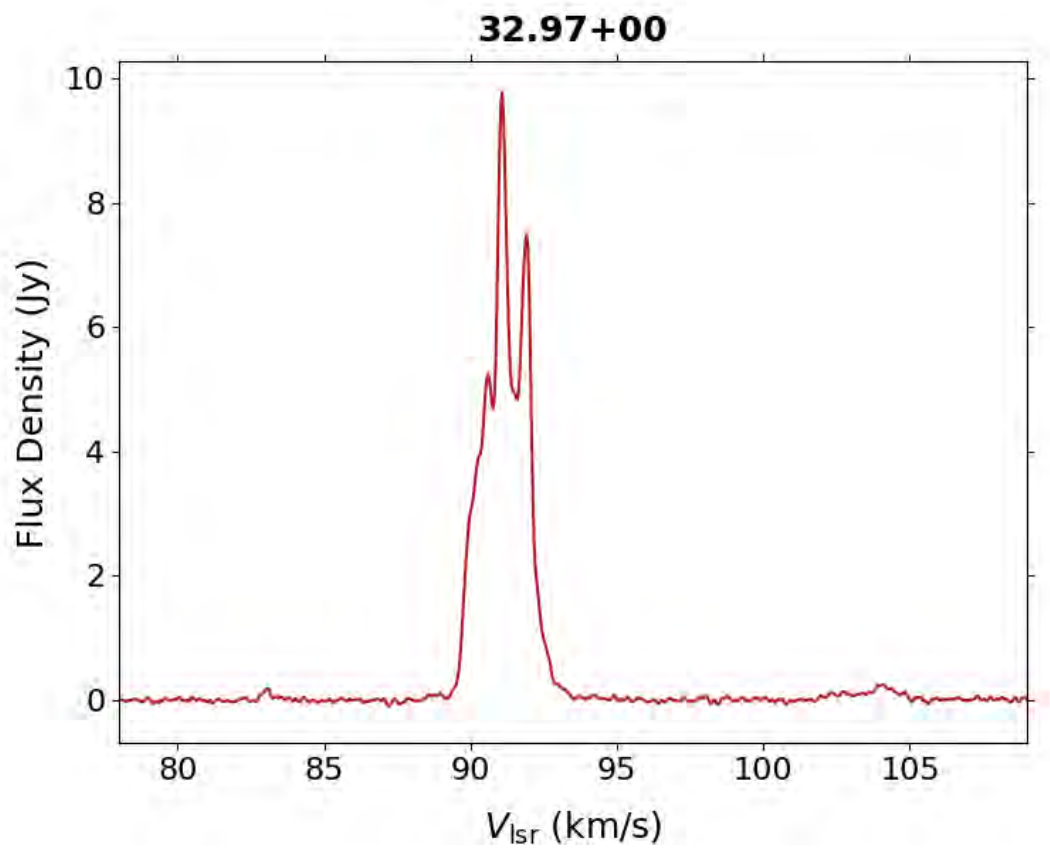


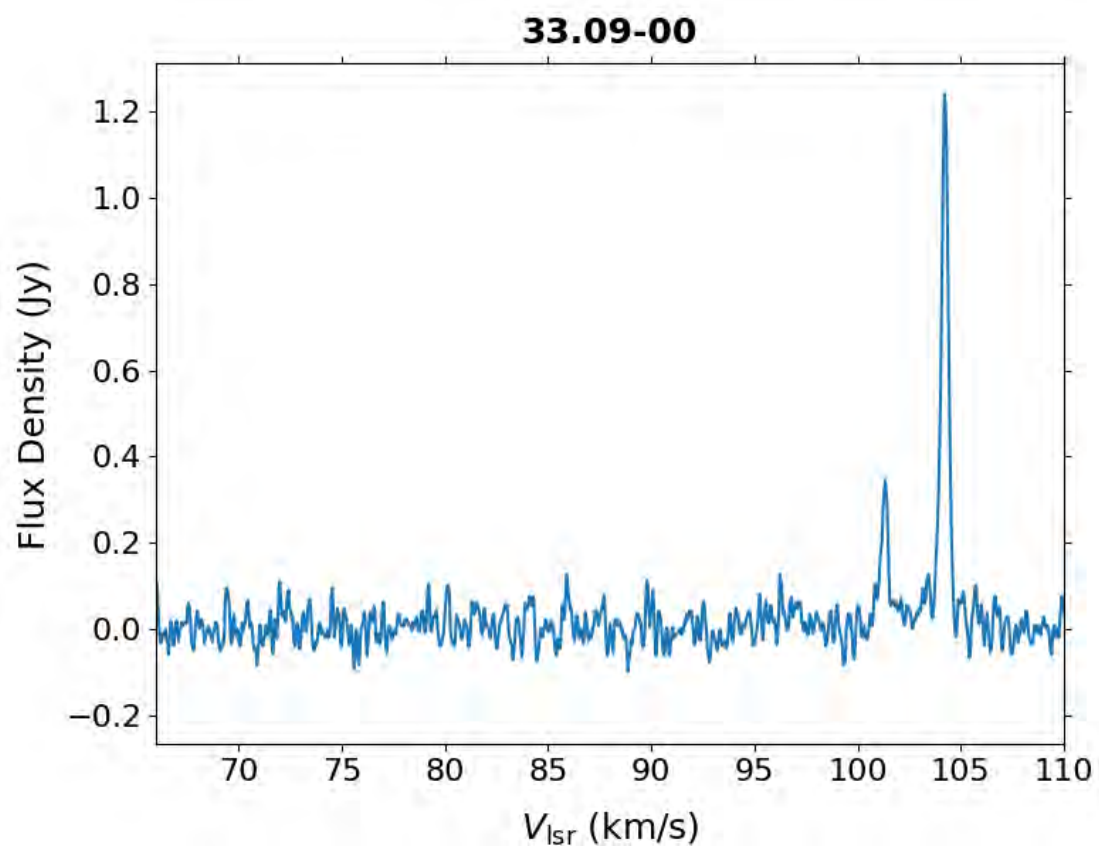
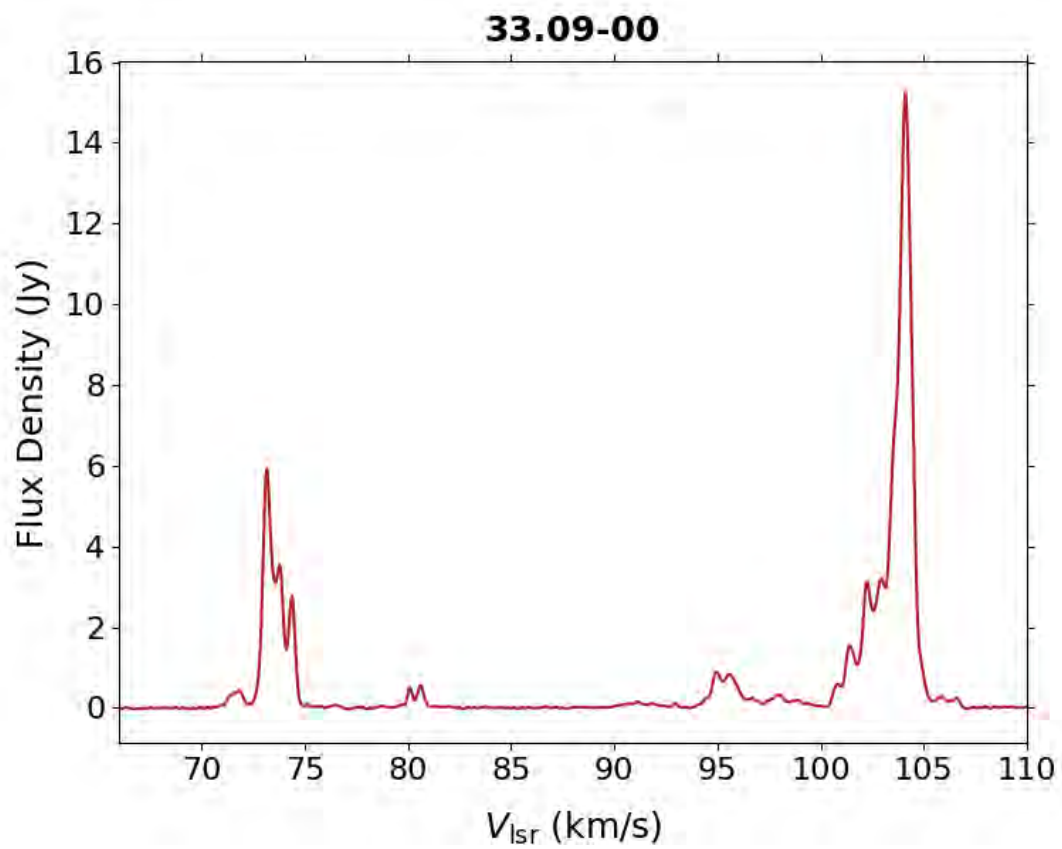
32.80+01

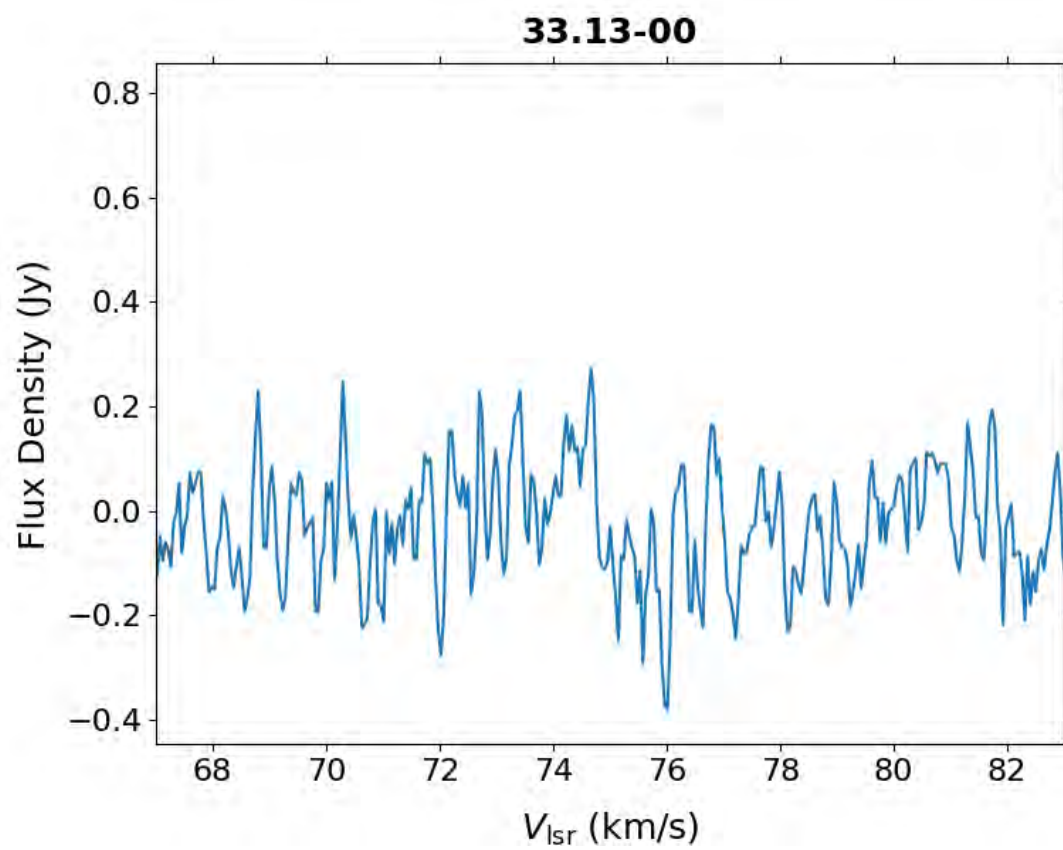
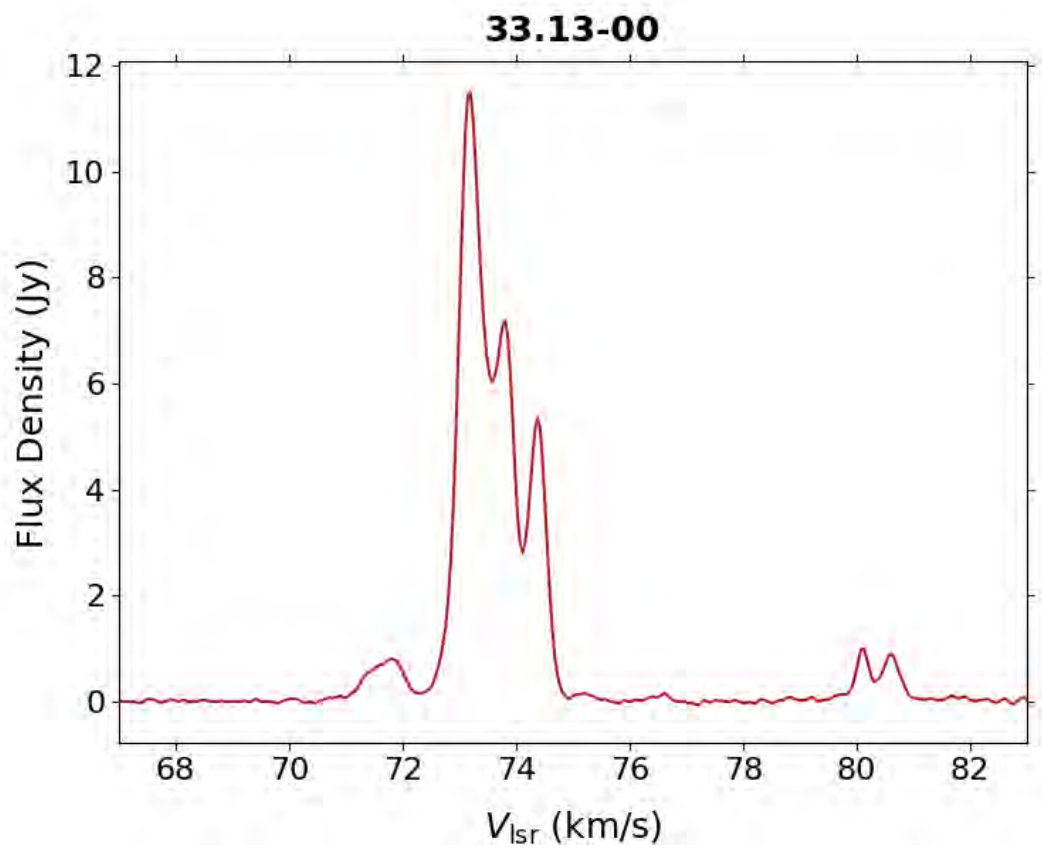


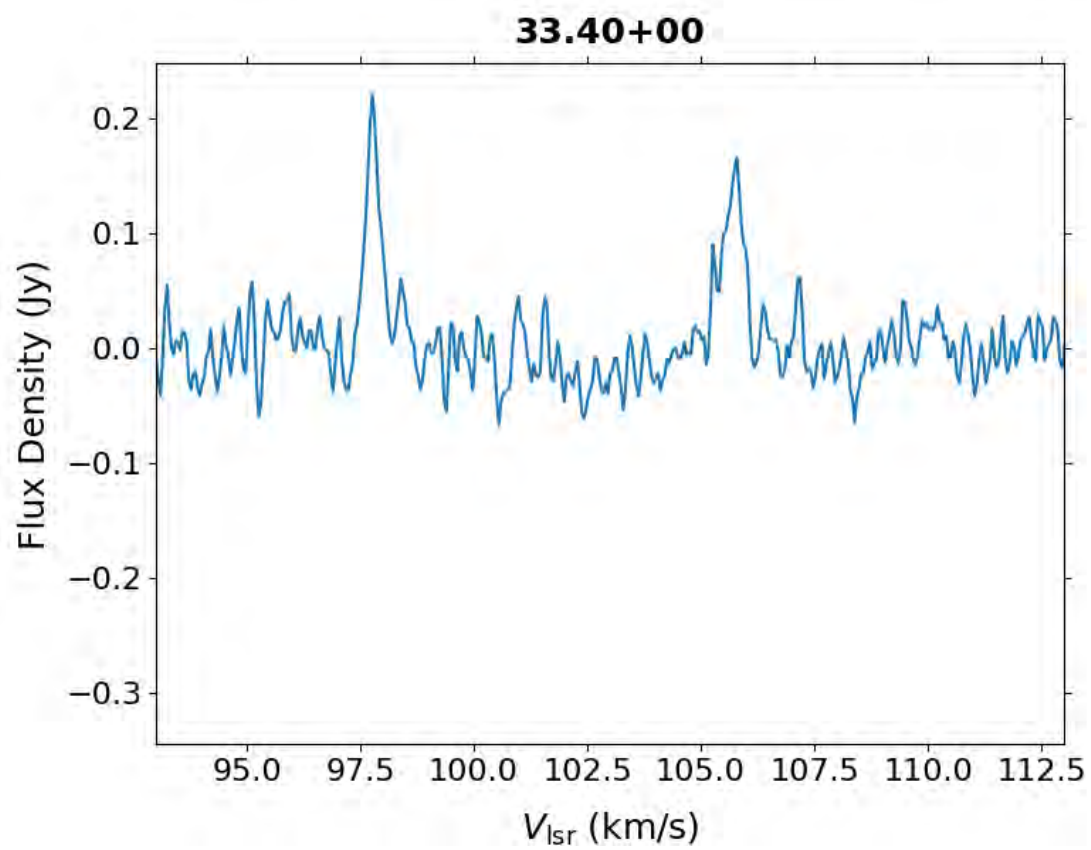
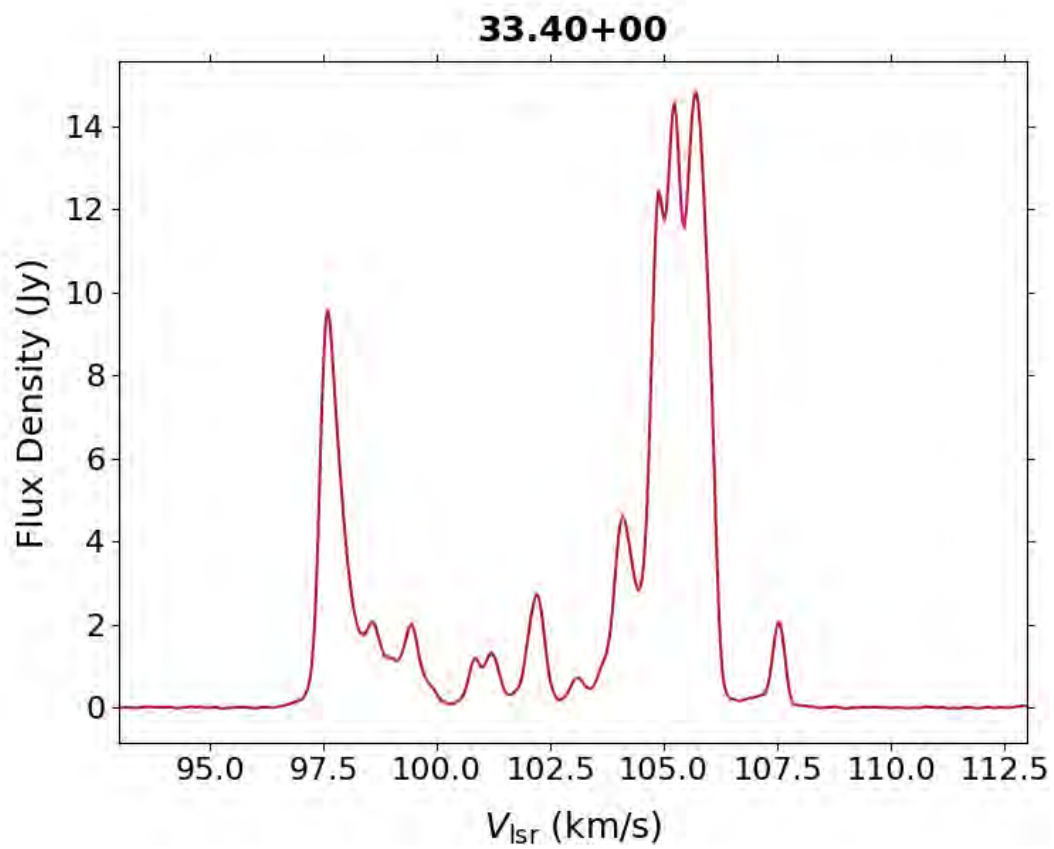
32.80+01



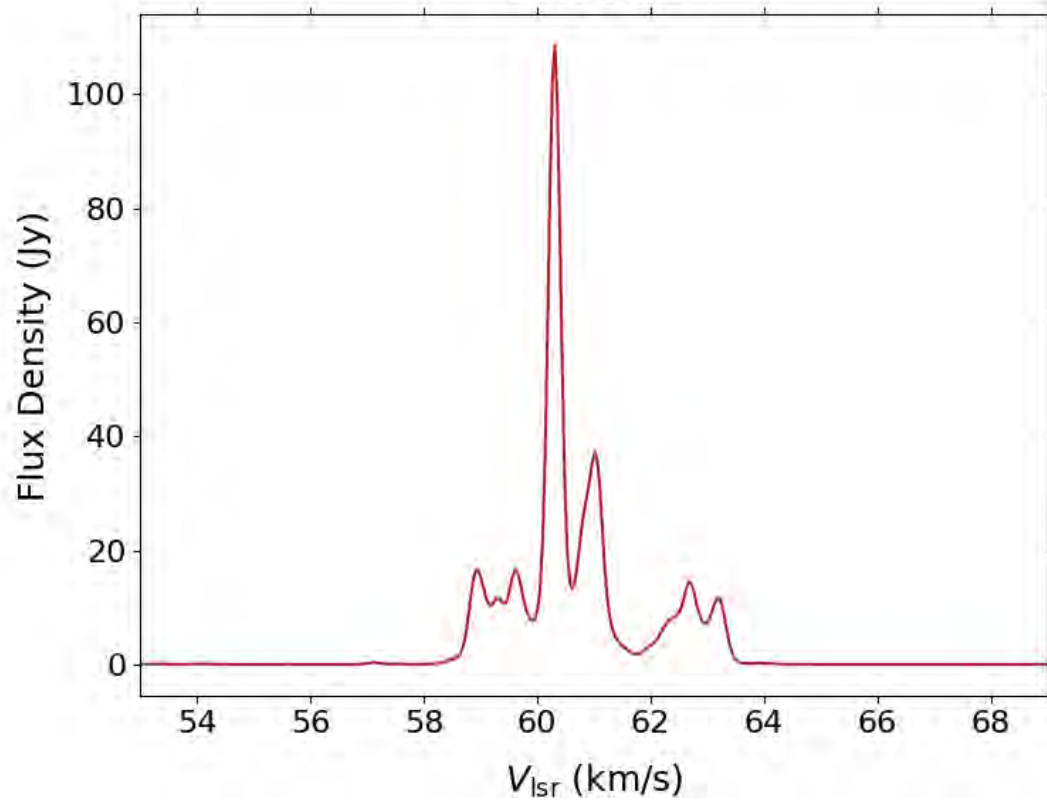




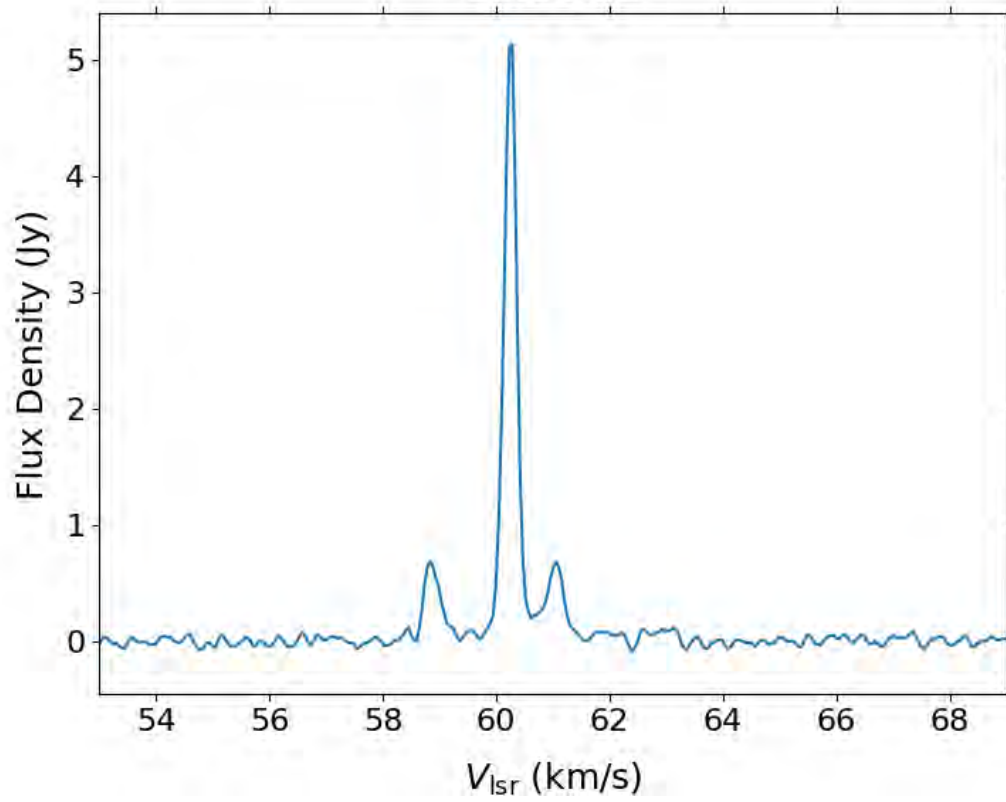




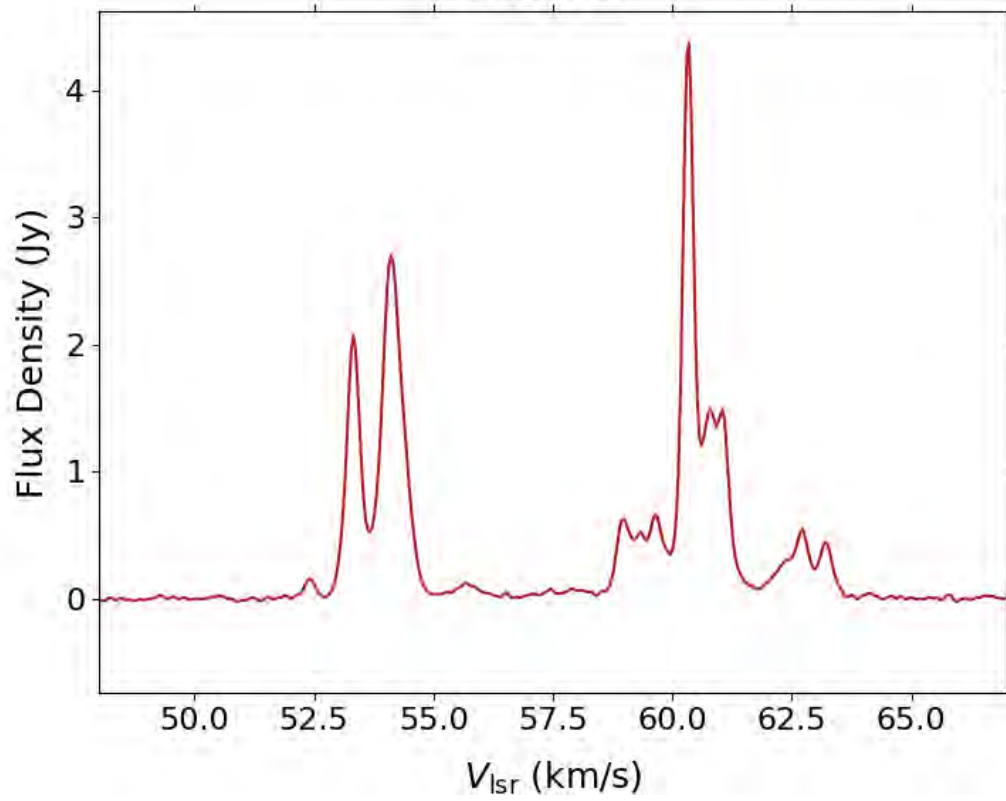
33.64-02



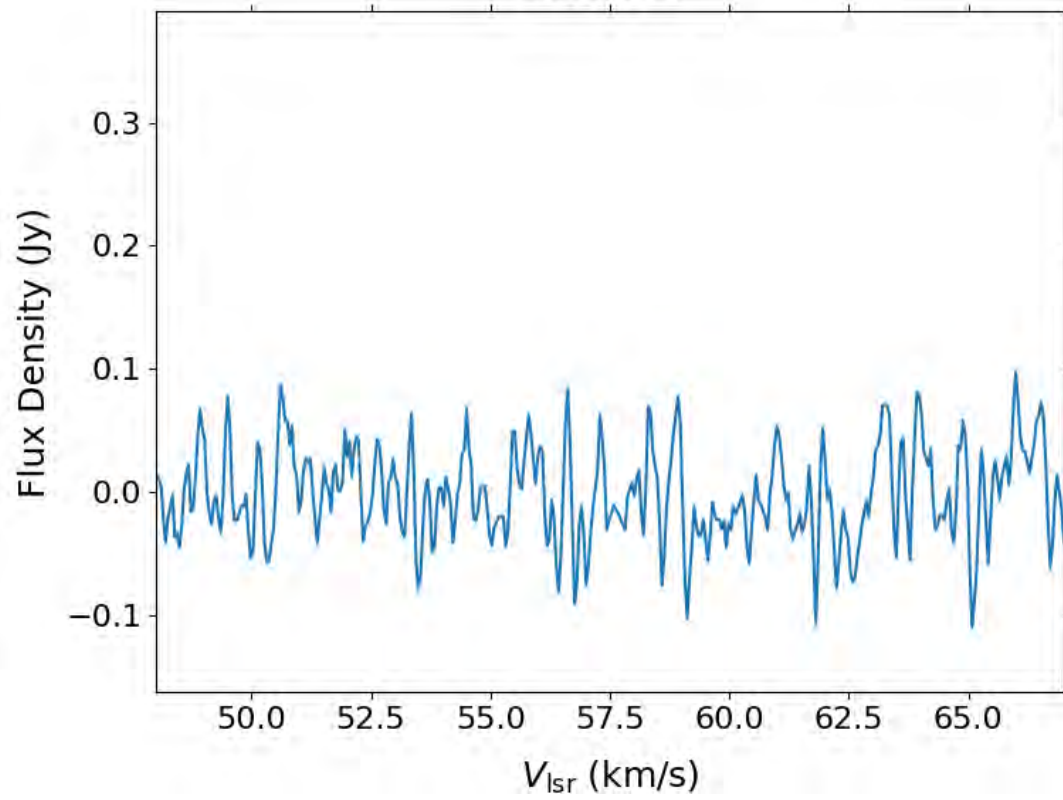
33.64-02

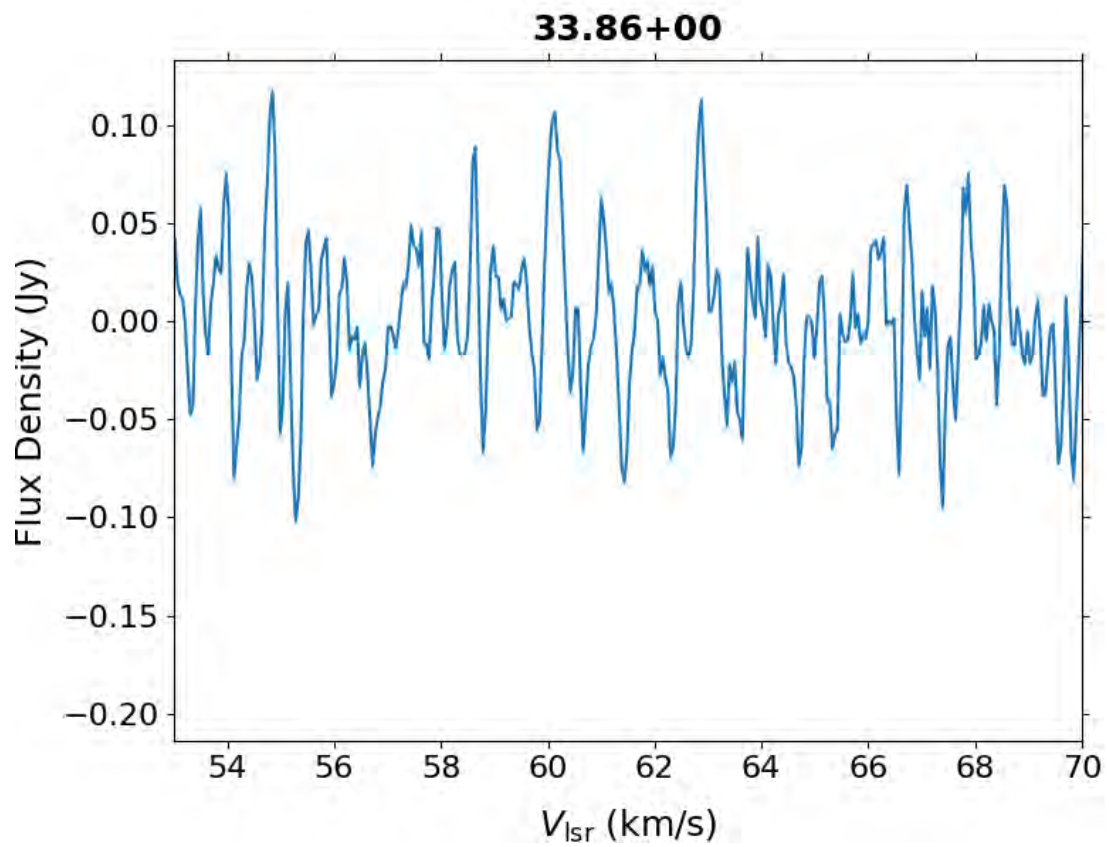
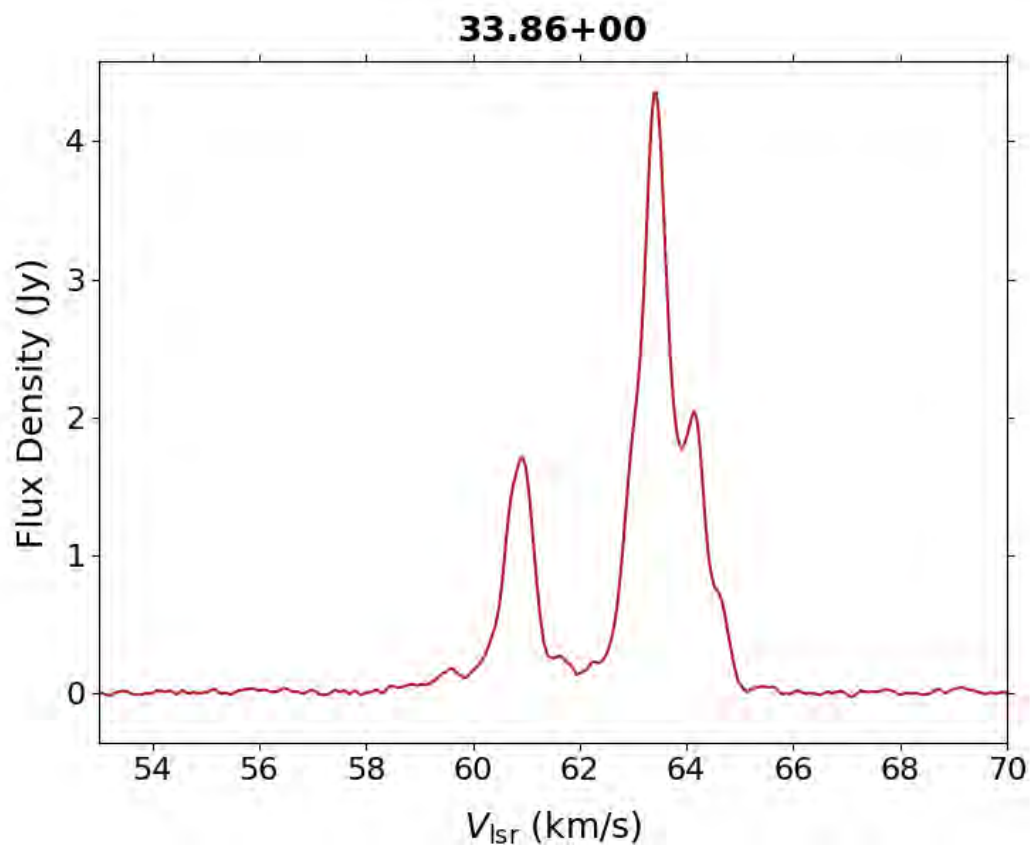


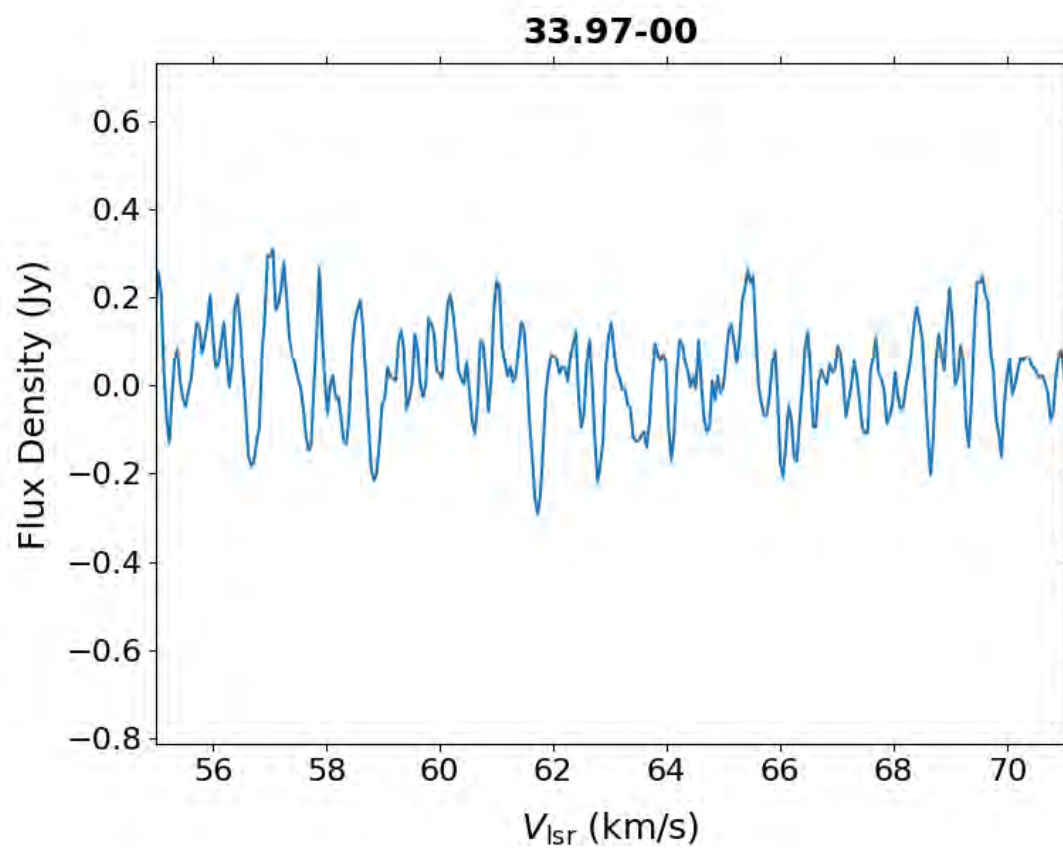
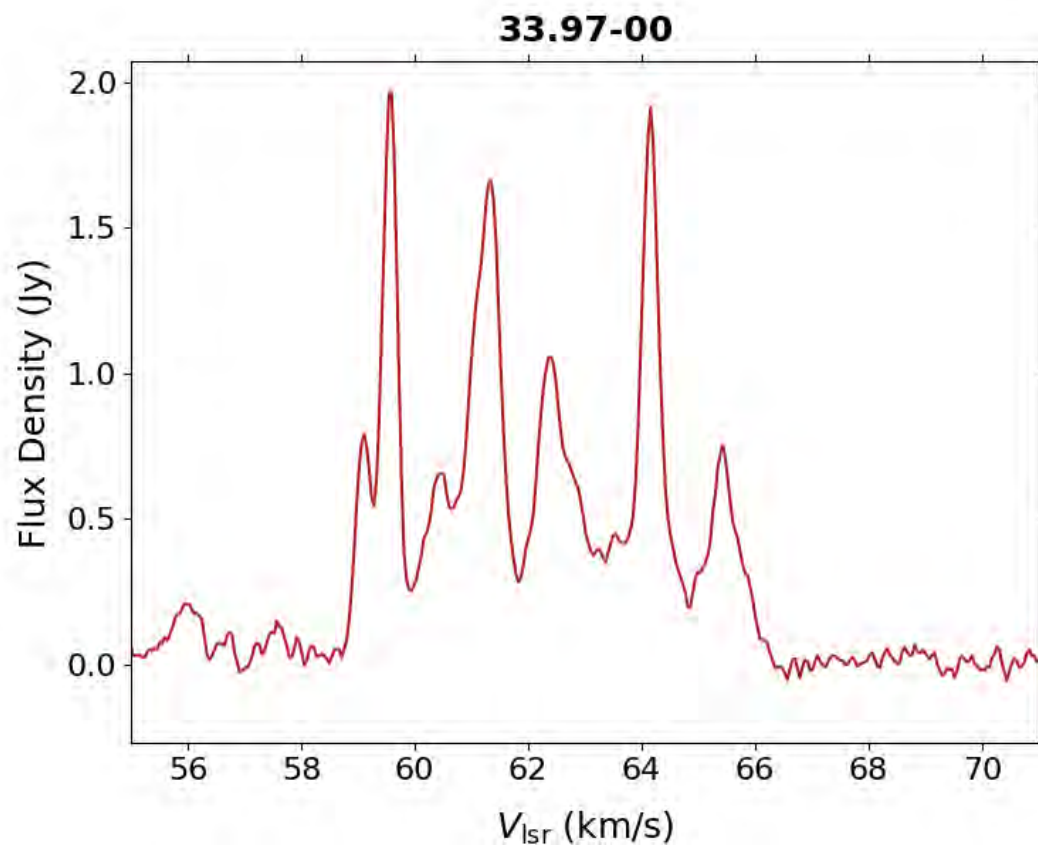
33.74-01

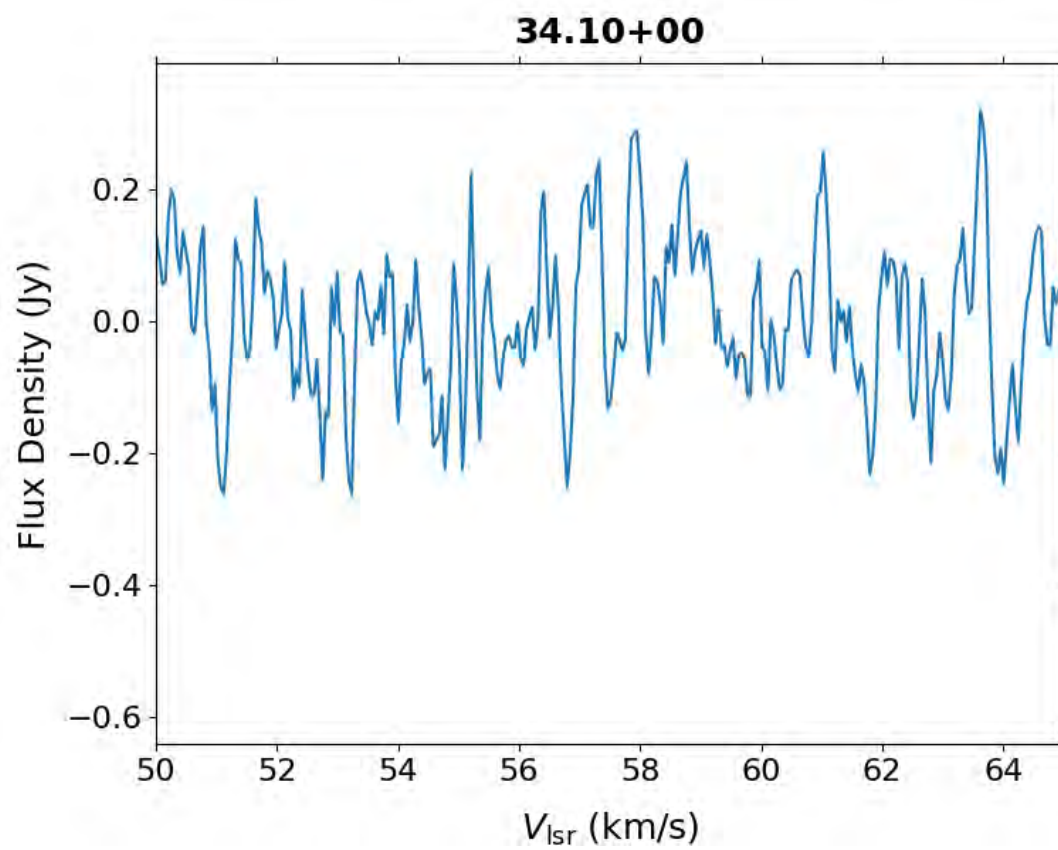
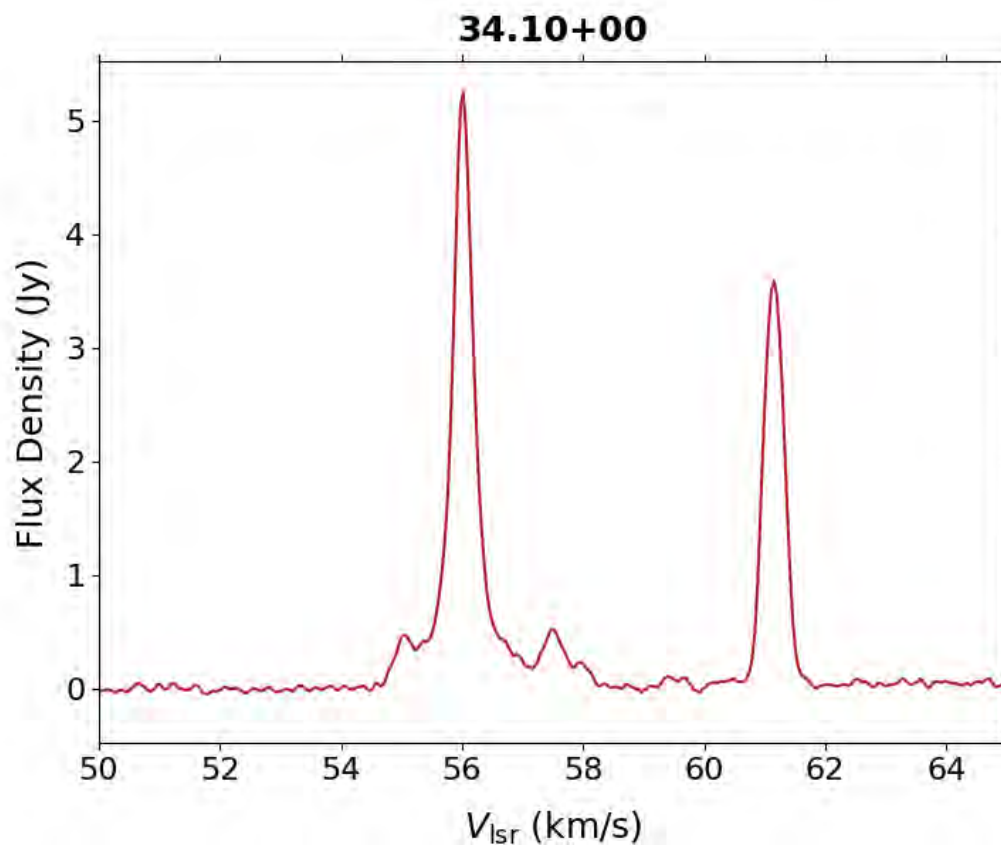


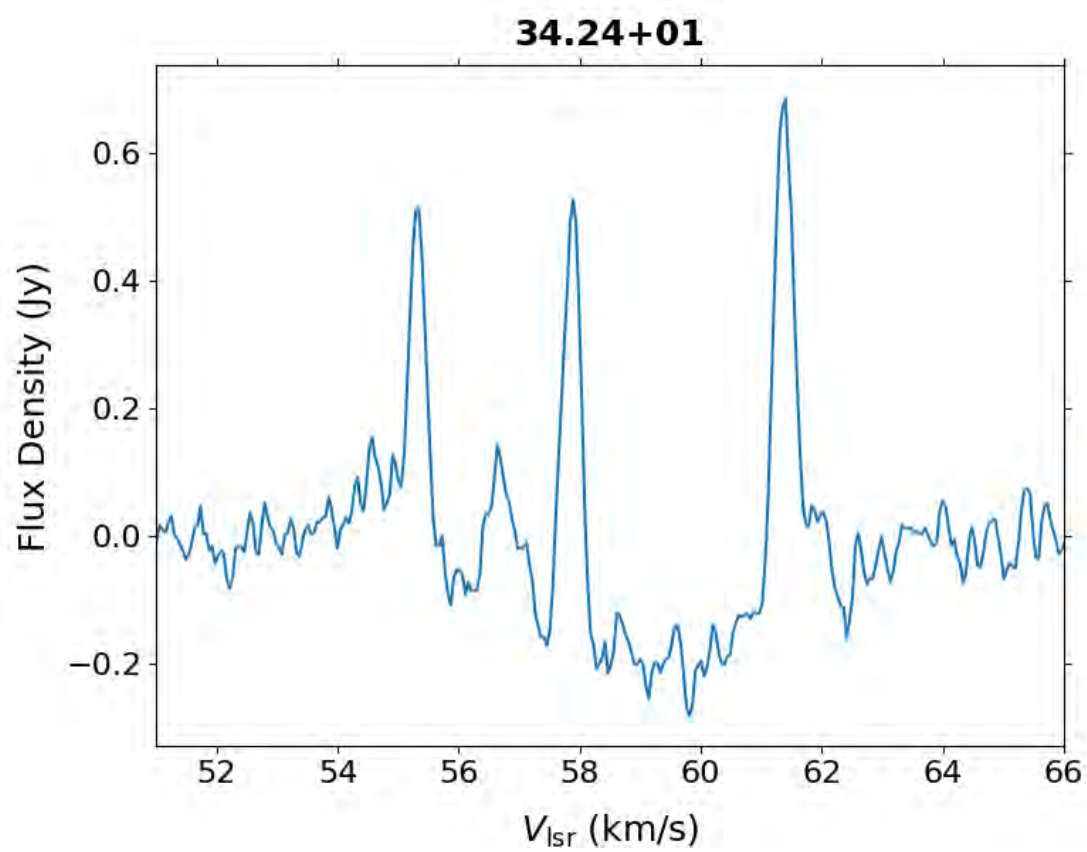
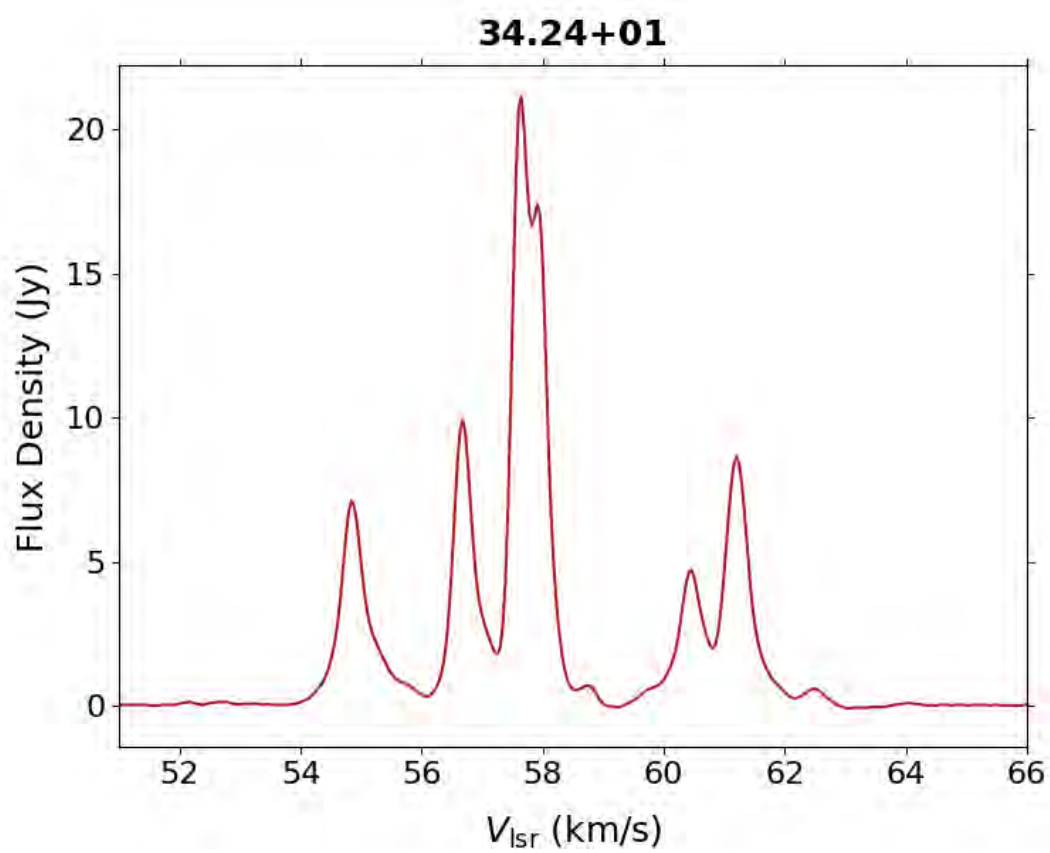
33.74-01

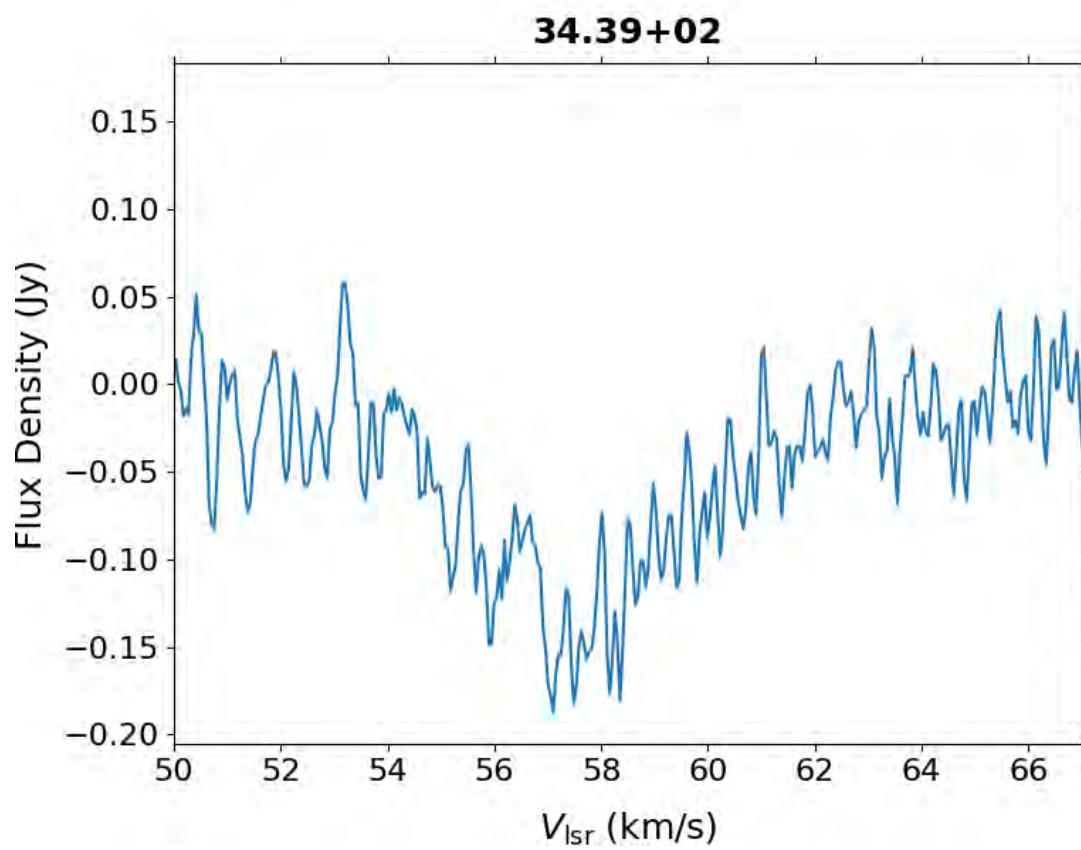
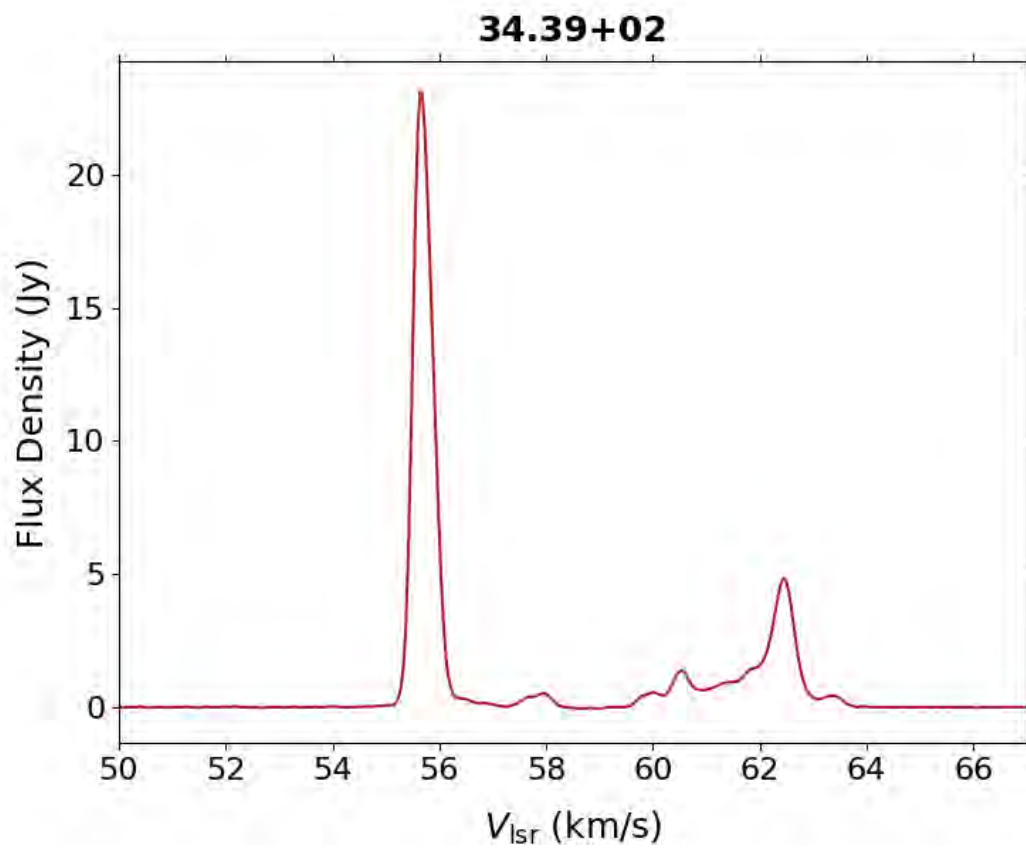




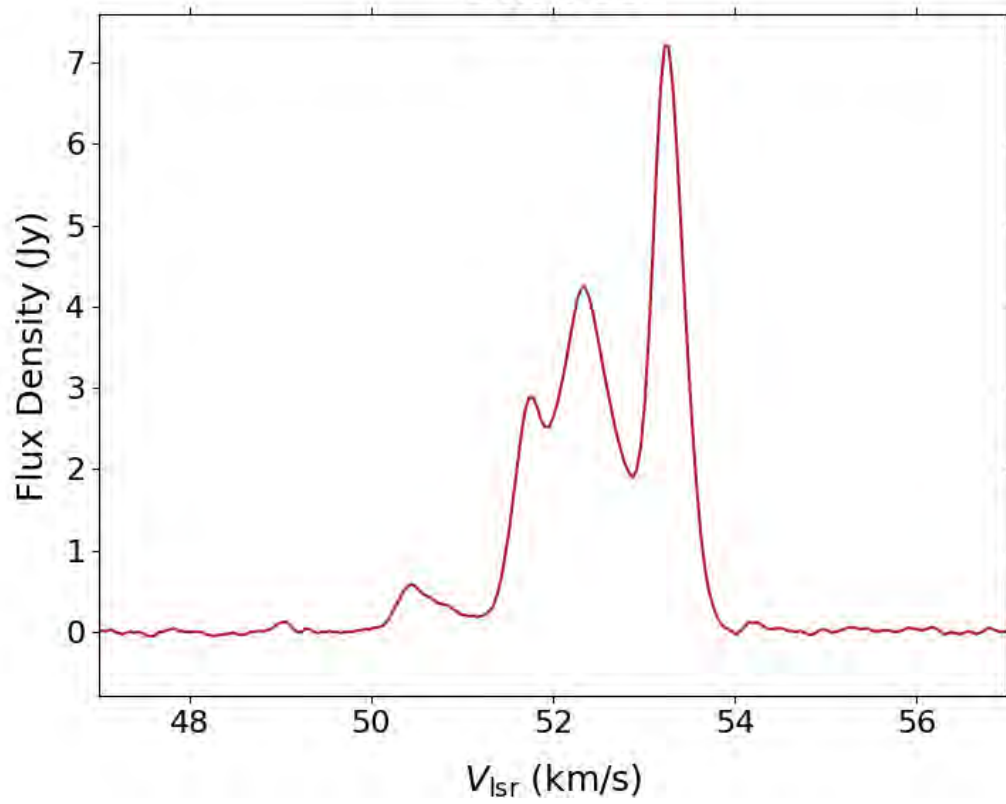




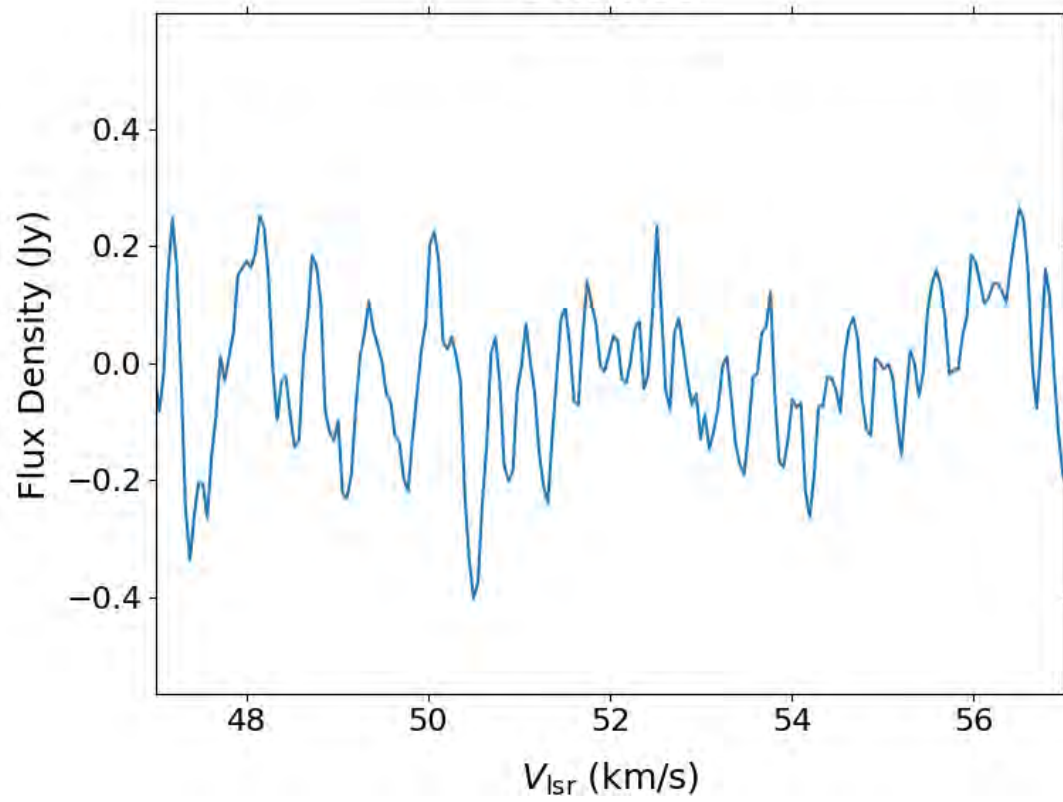




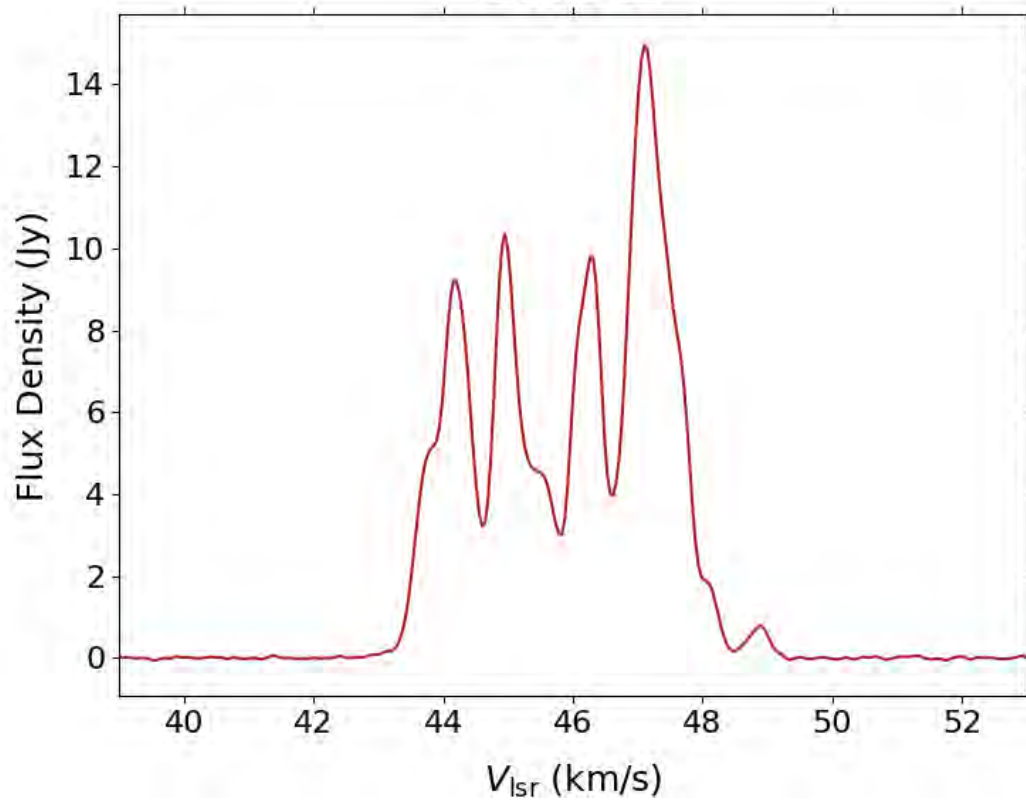
34.74-00



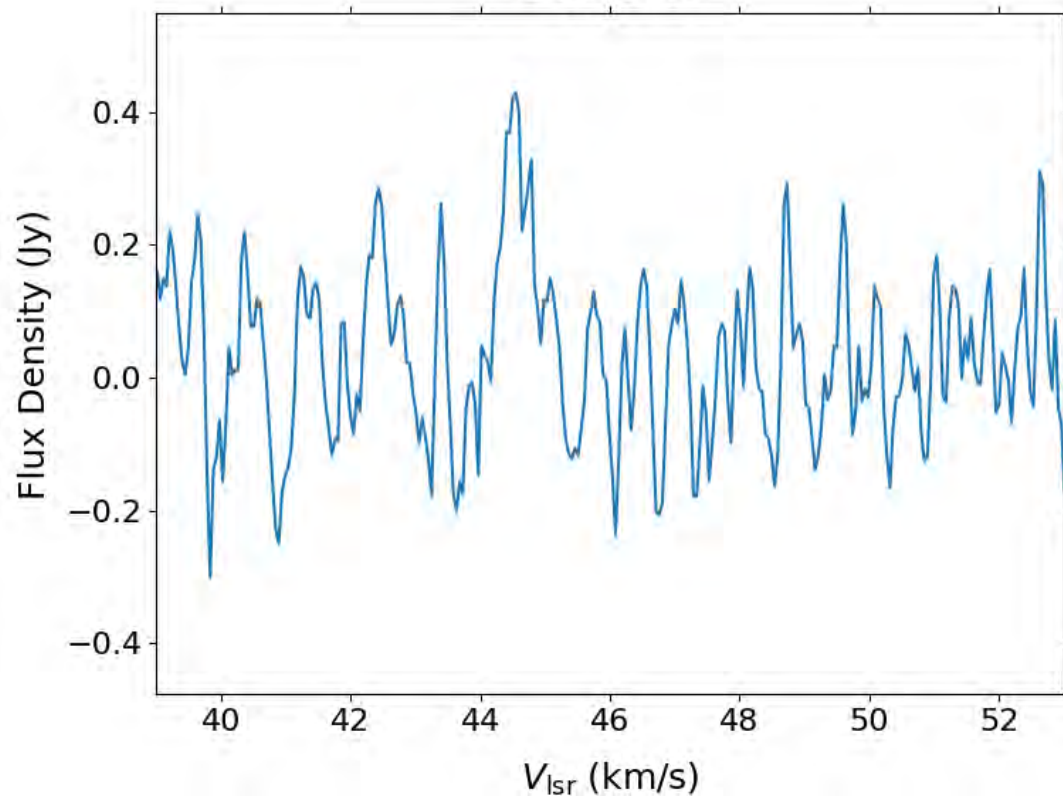
34.74-00

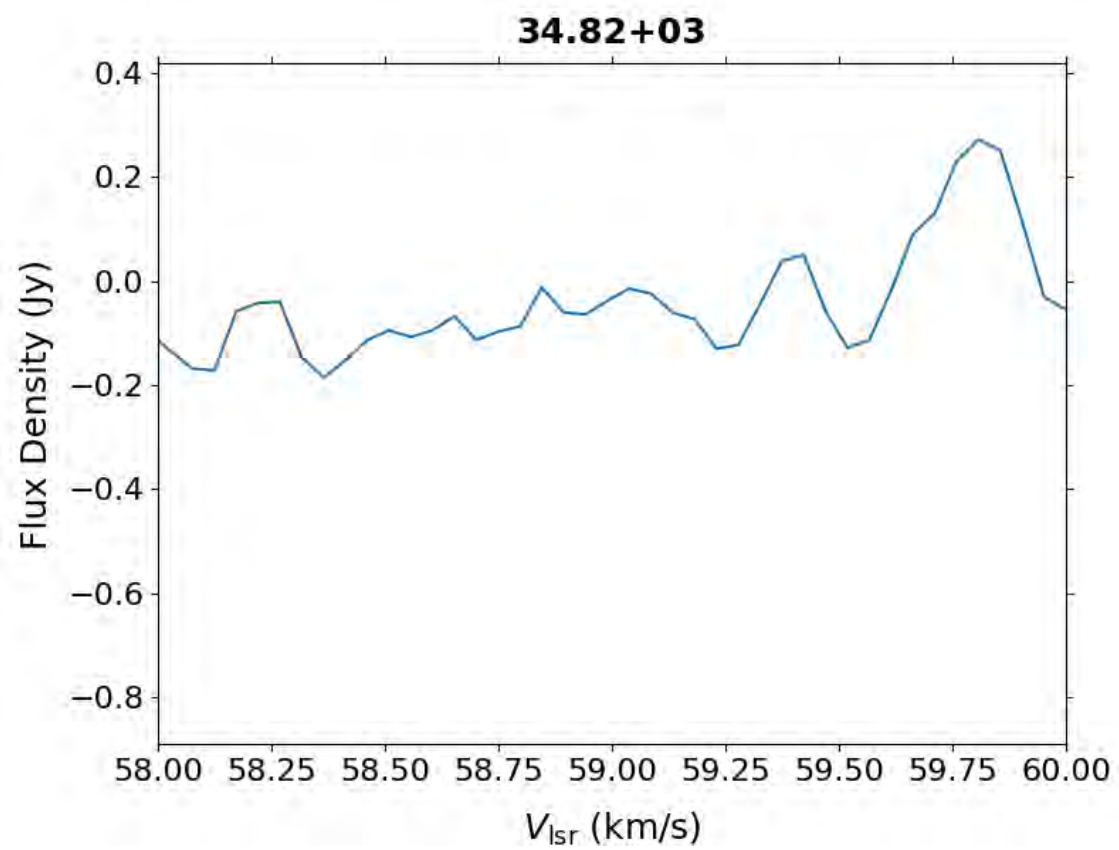
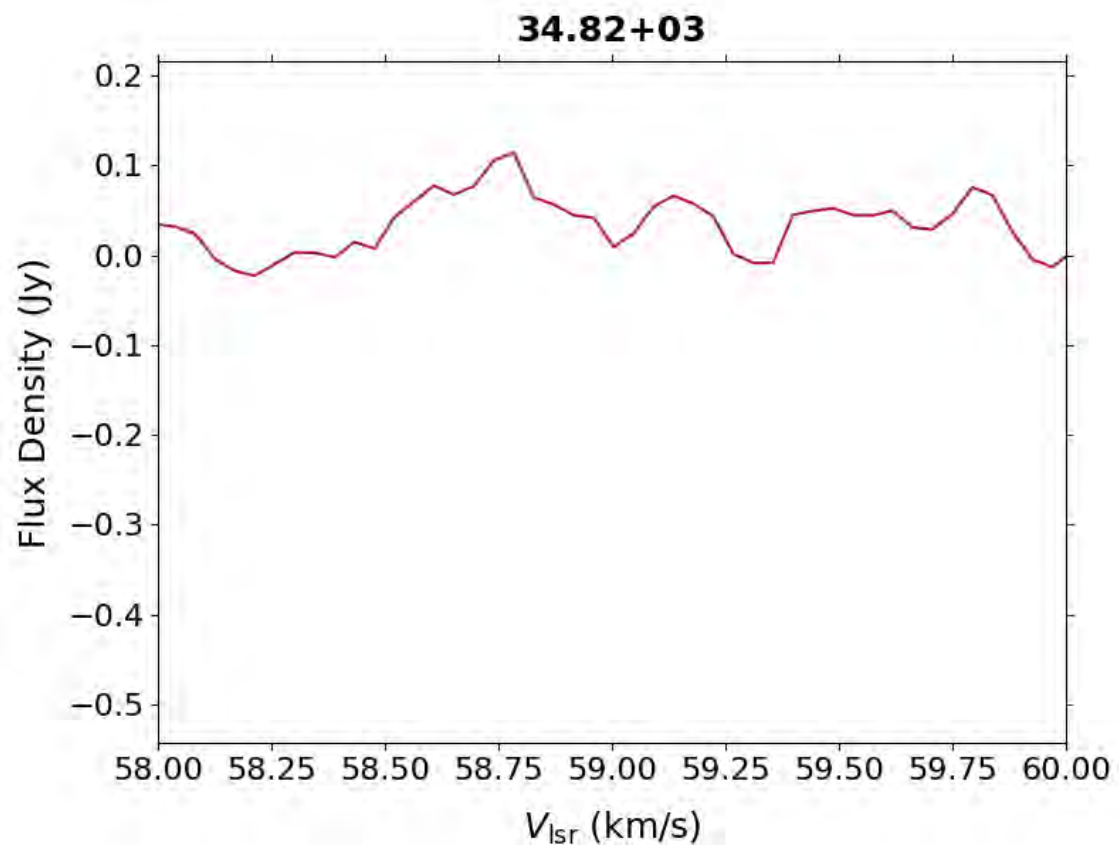


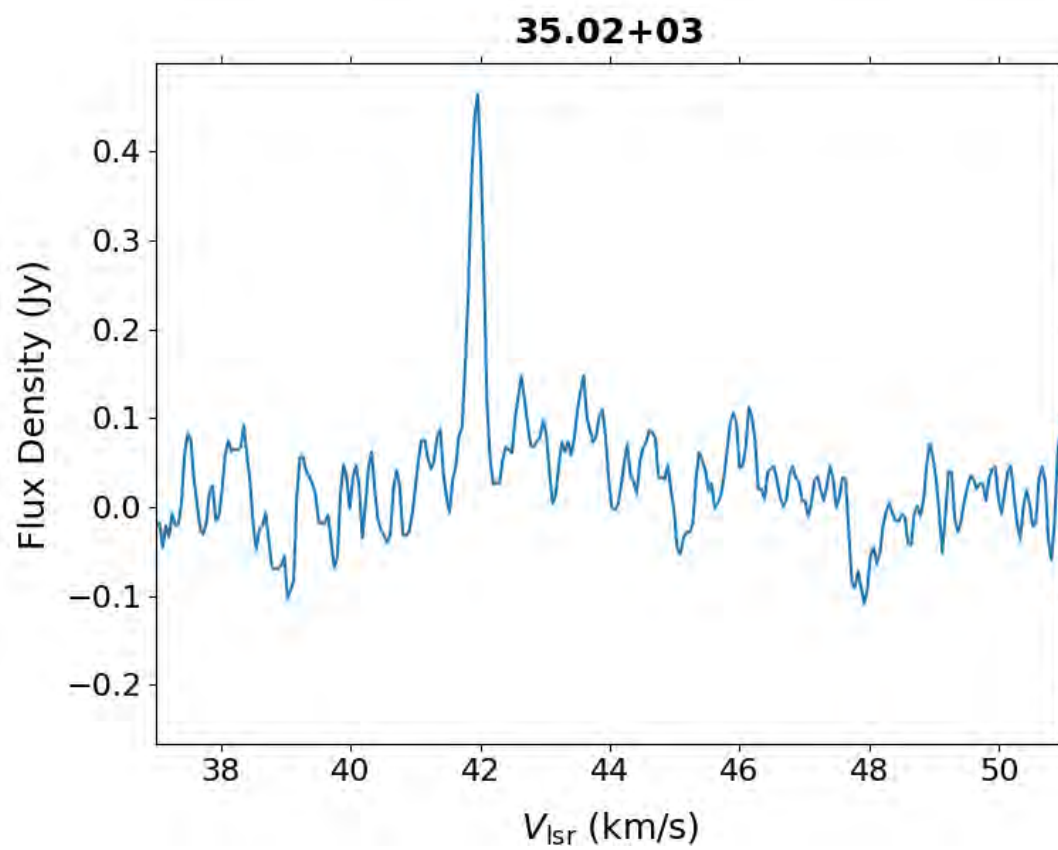
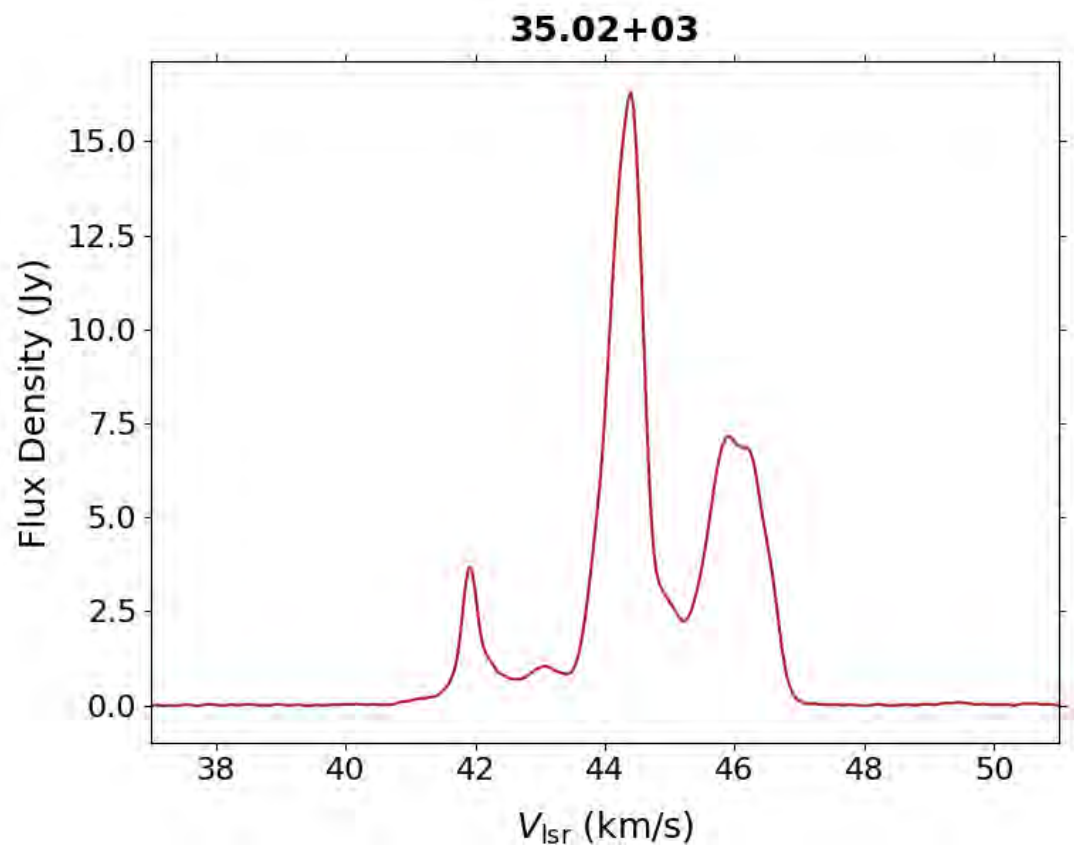
34.78-13



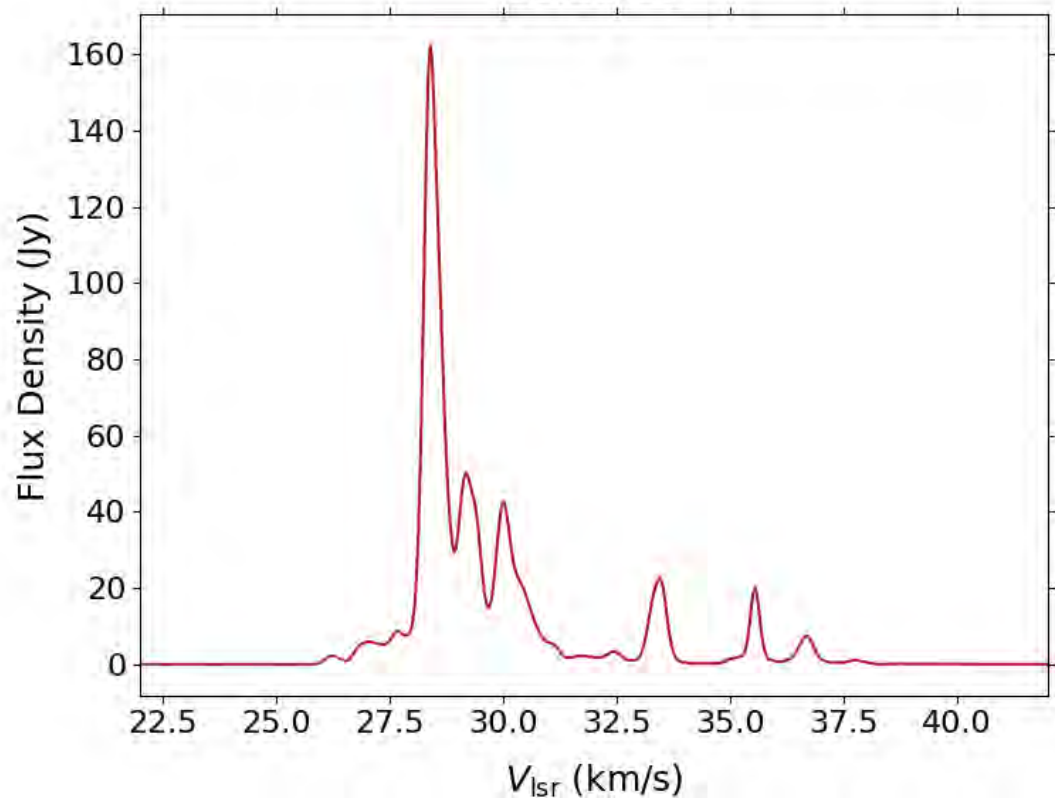
34.78-13



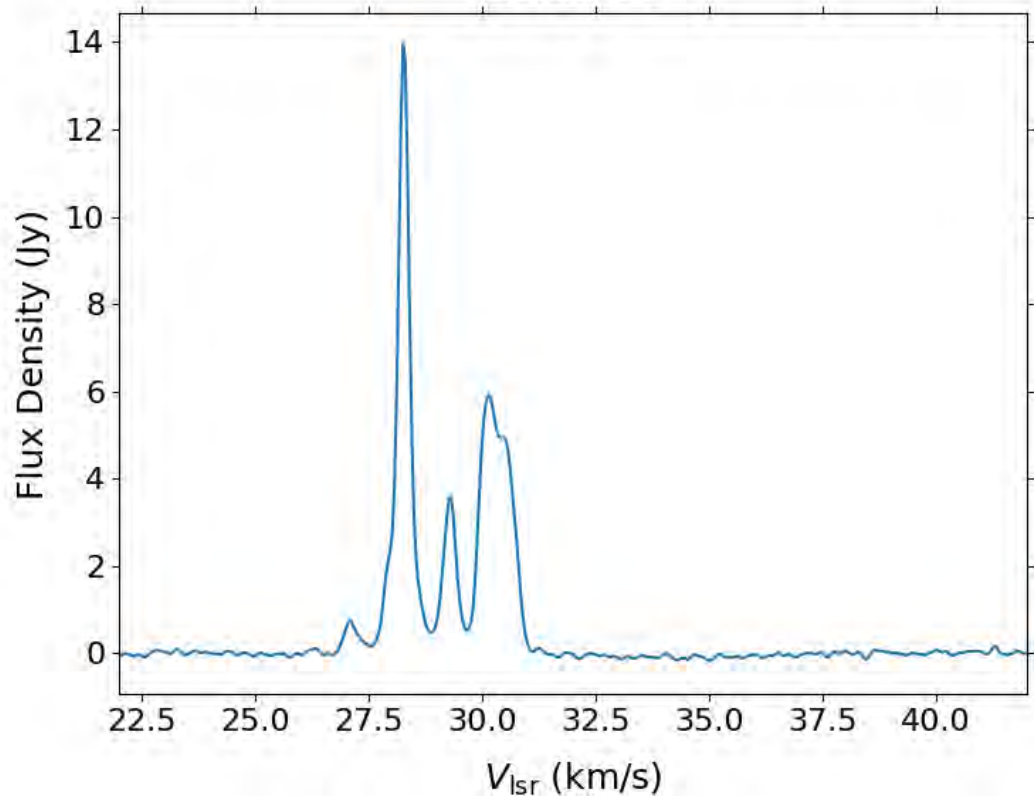




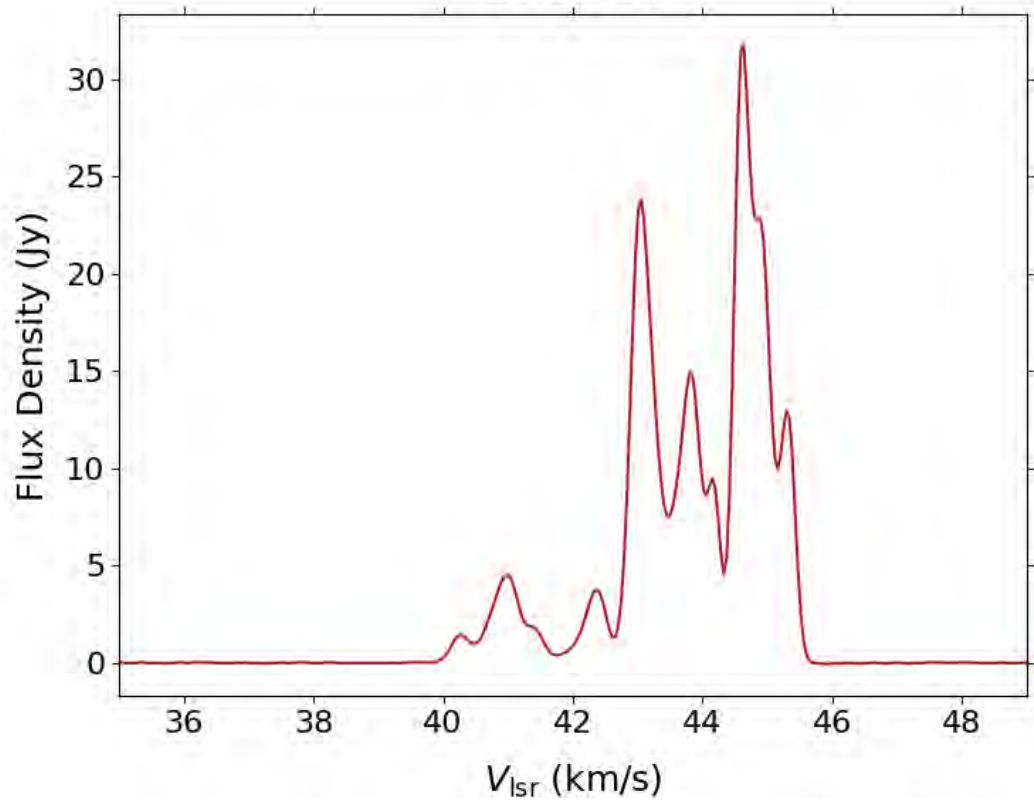
35.20-07



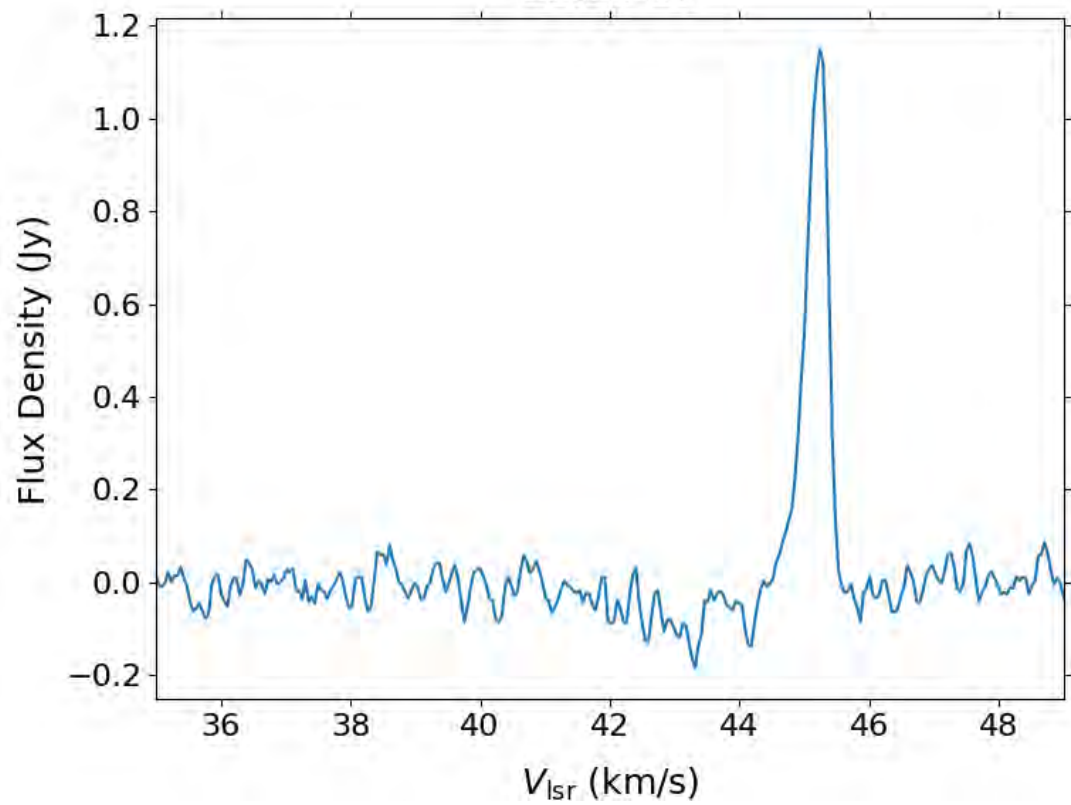
35.20-07



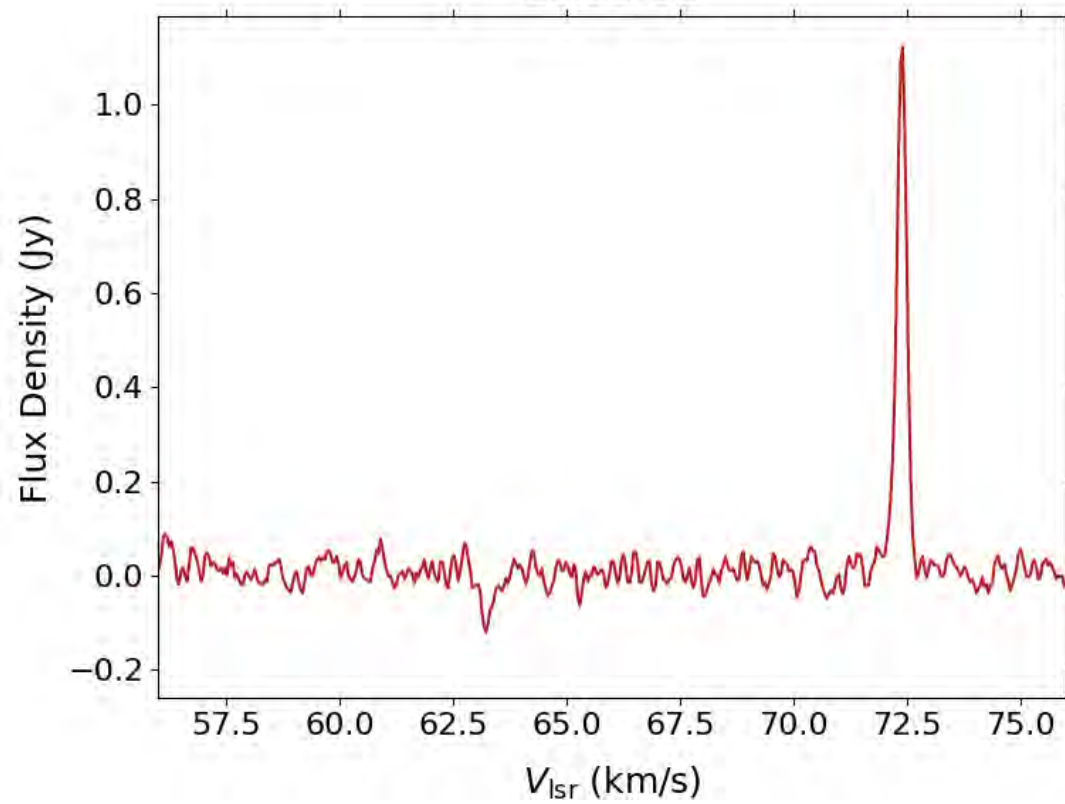
35.20-17



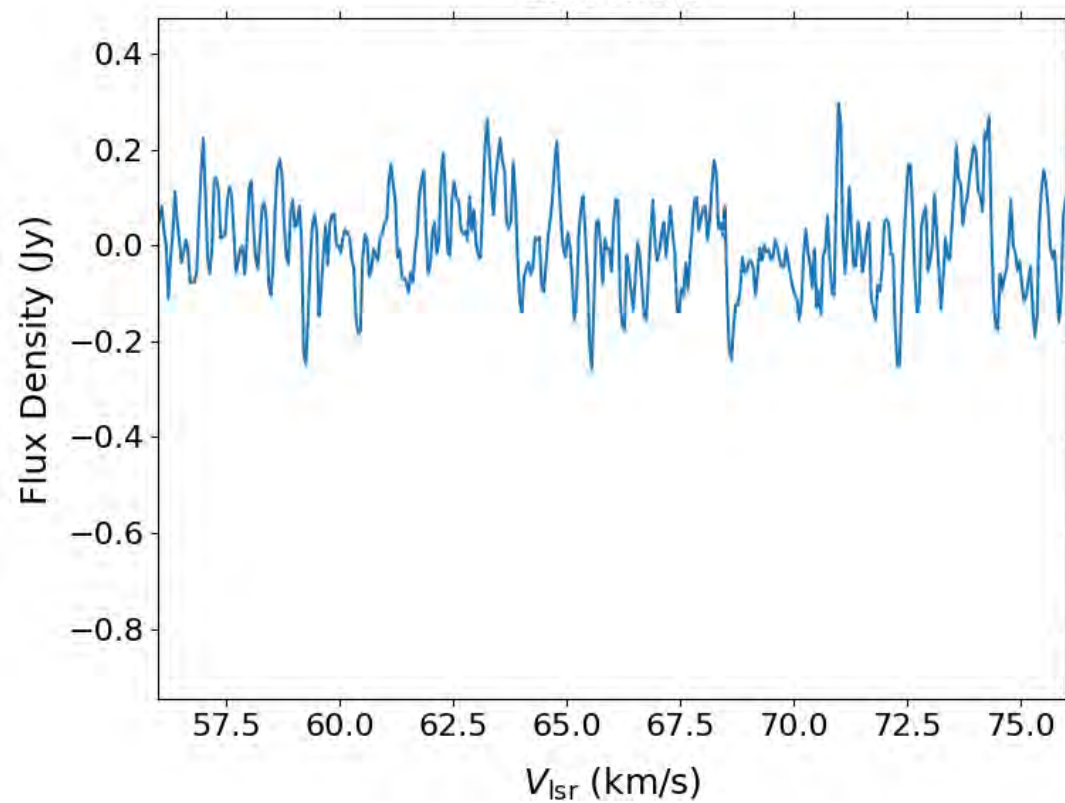
35.20-17

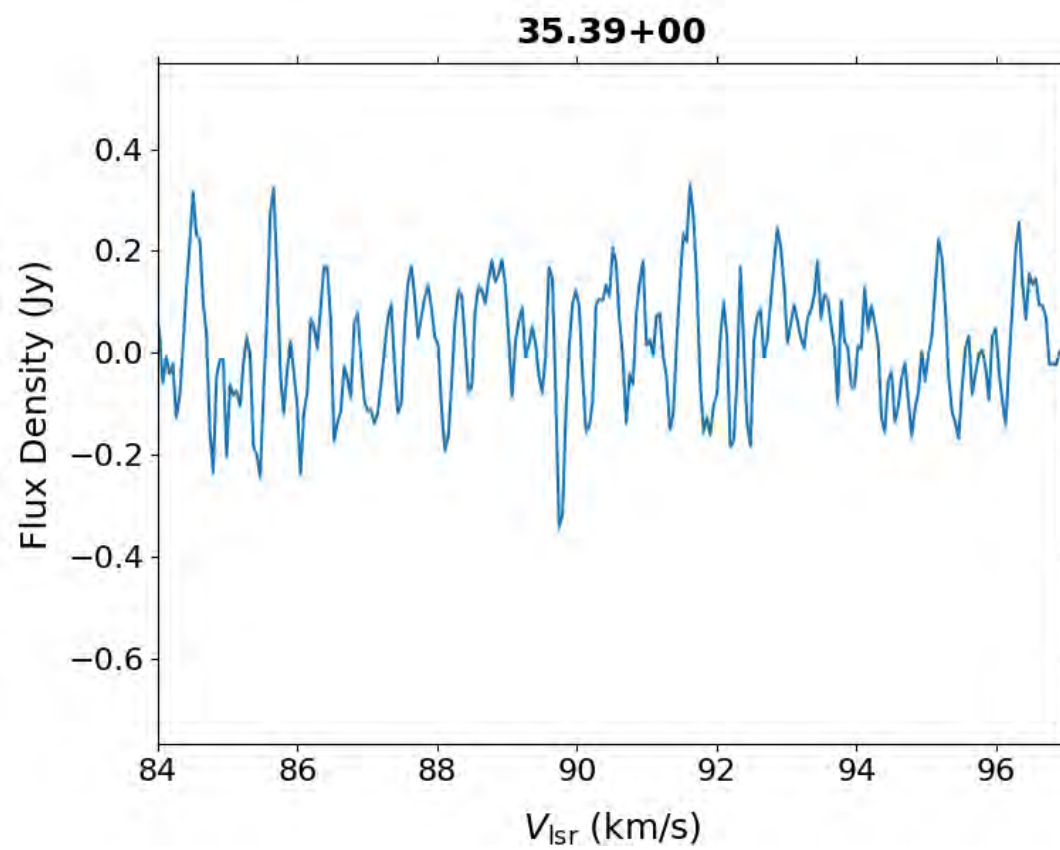
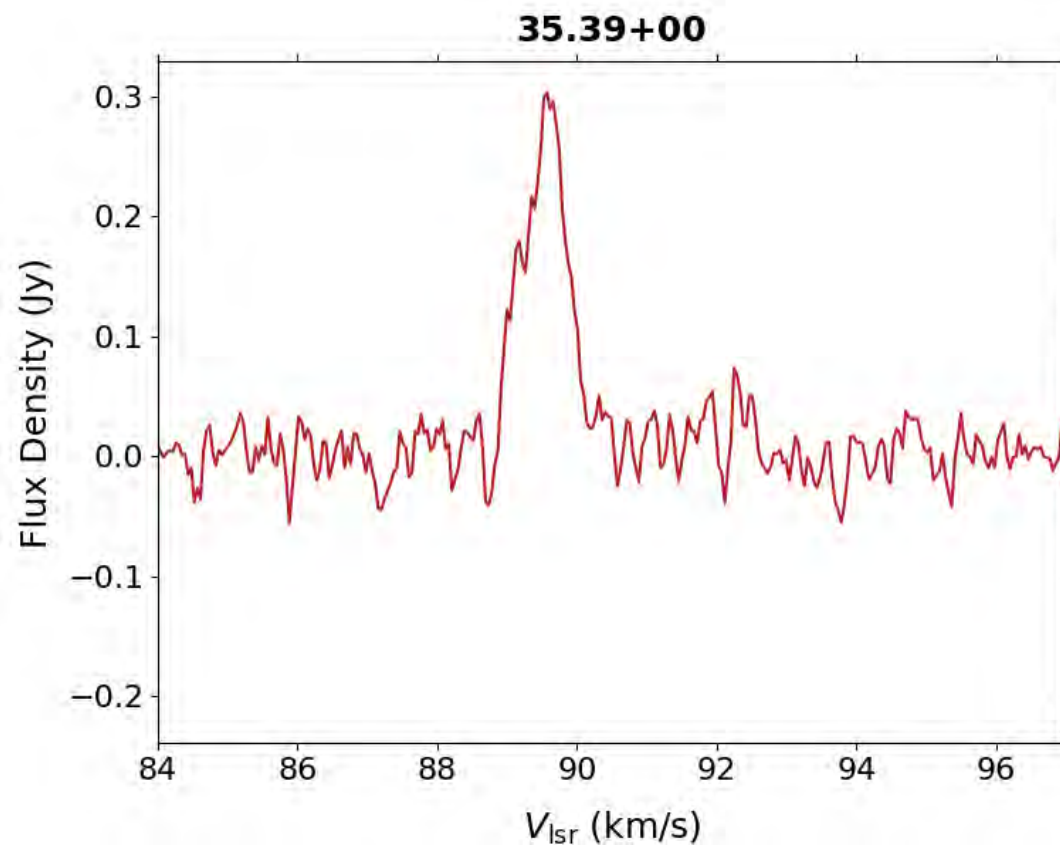


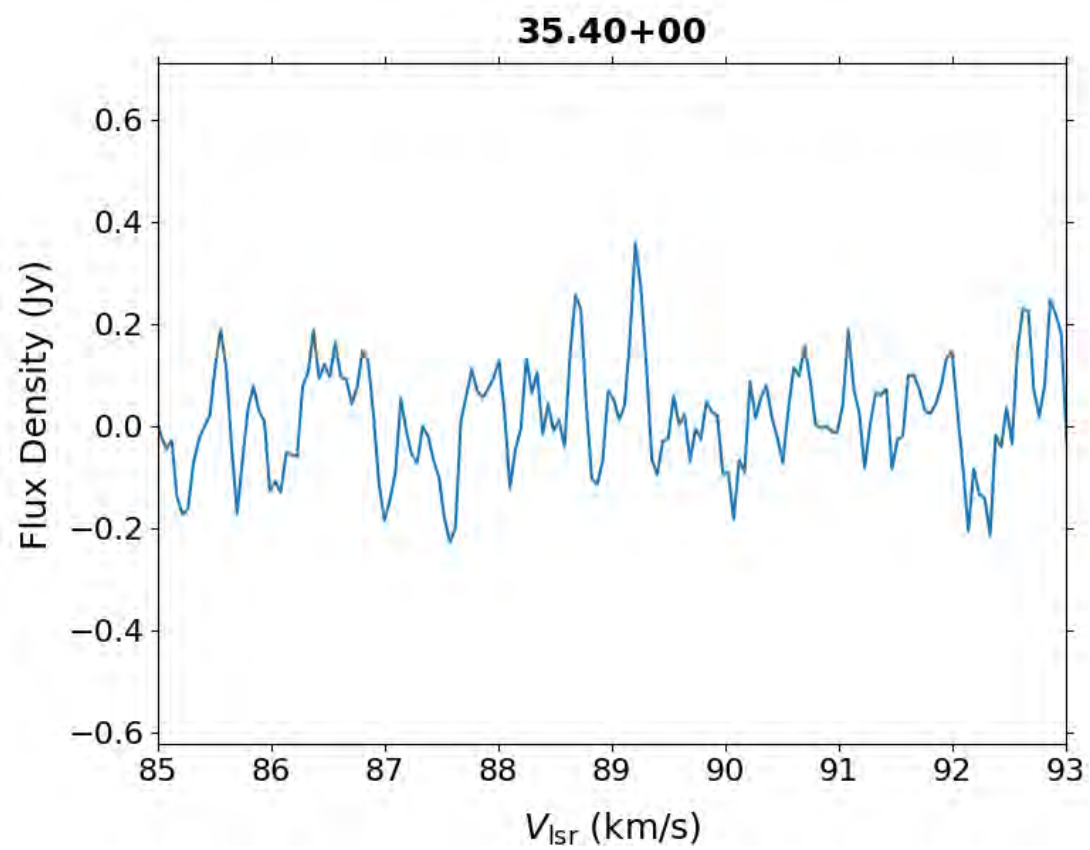
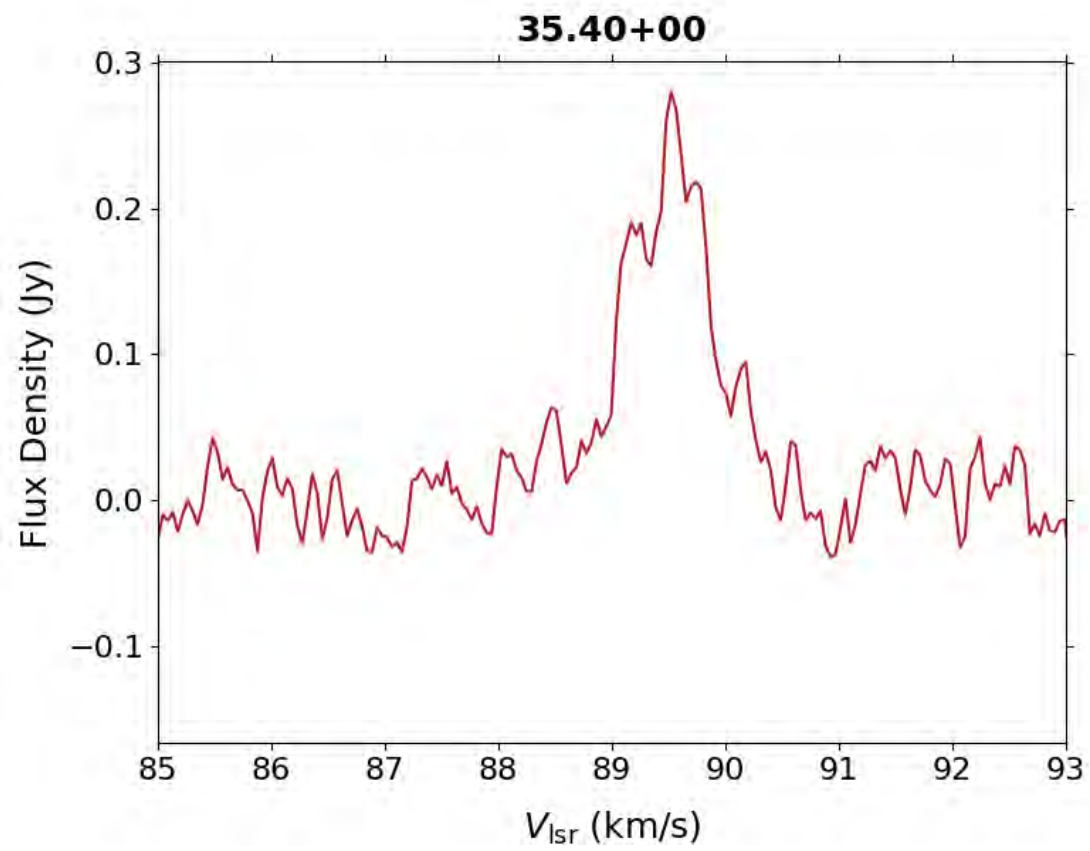
35.25-02

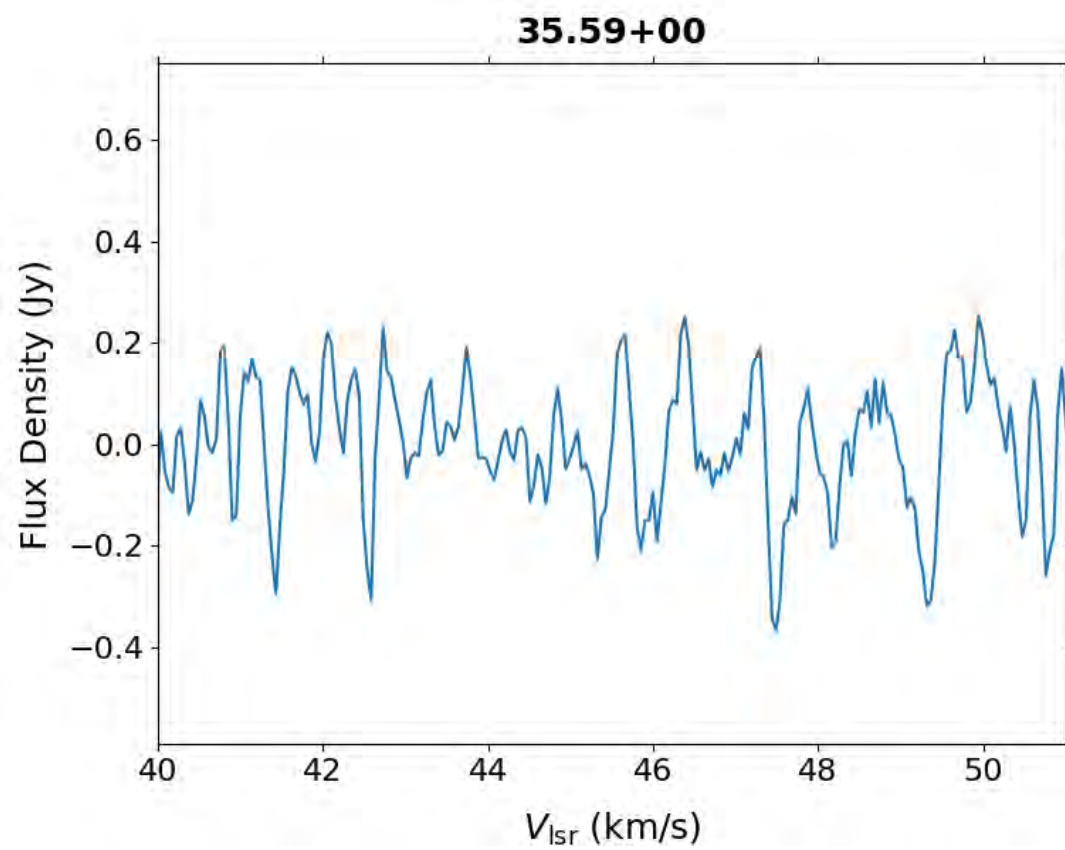
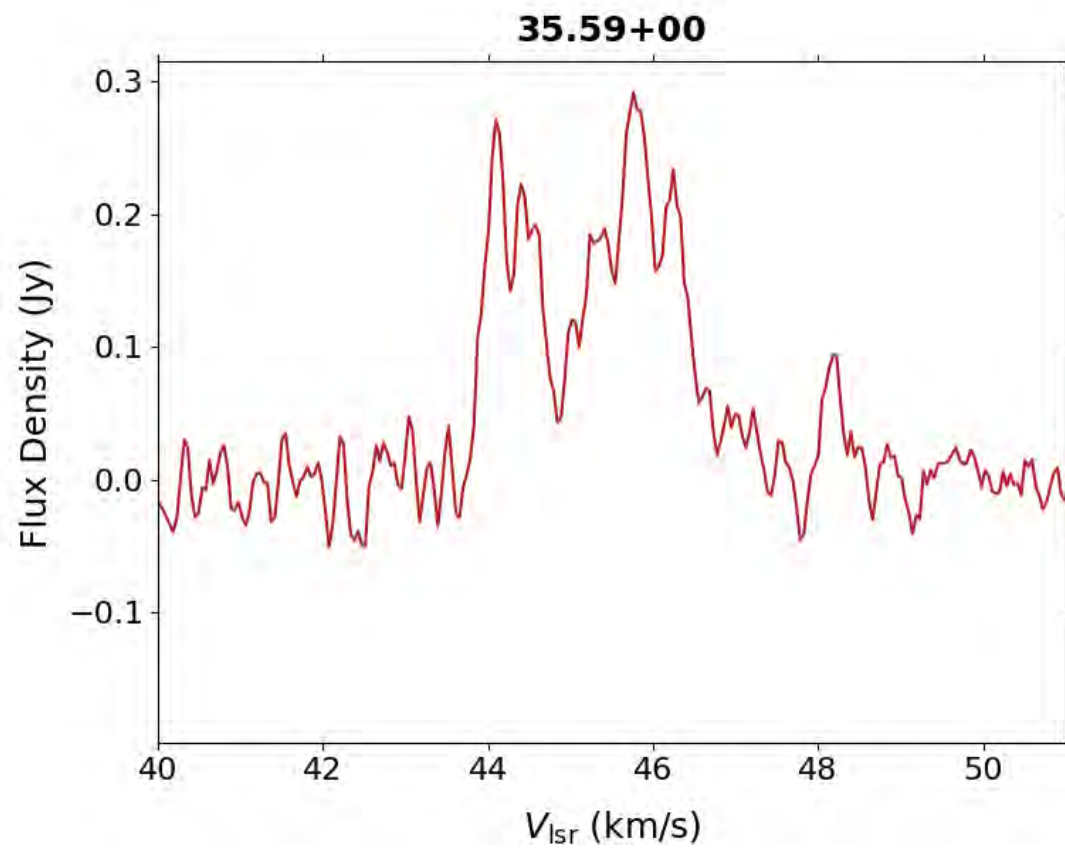


35.25-02

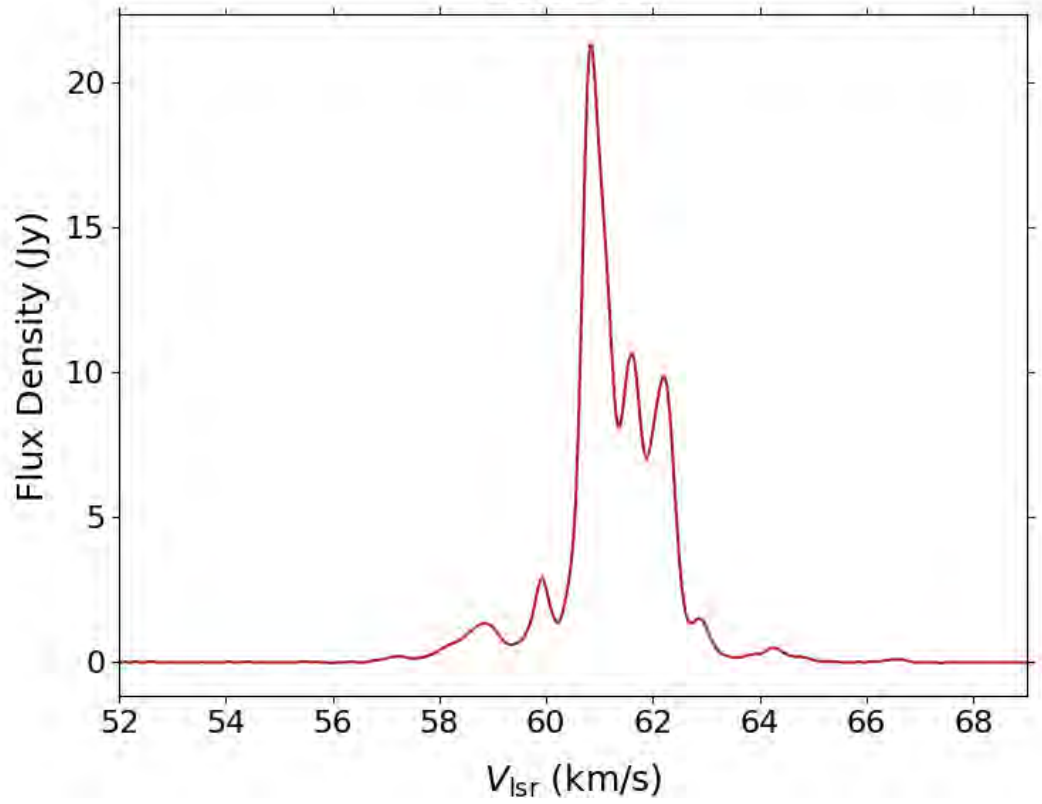




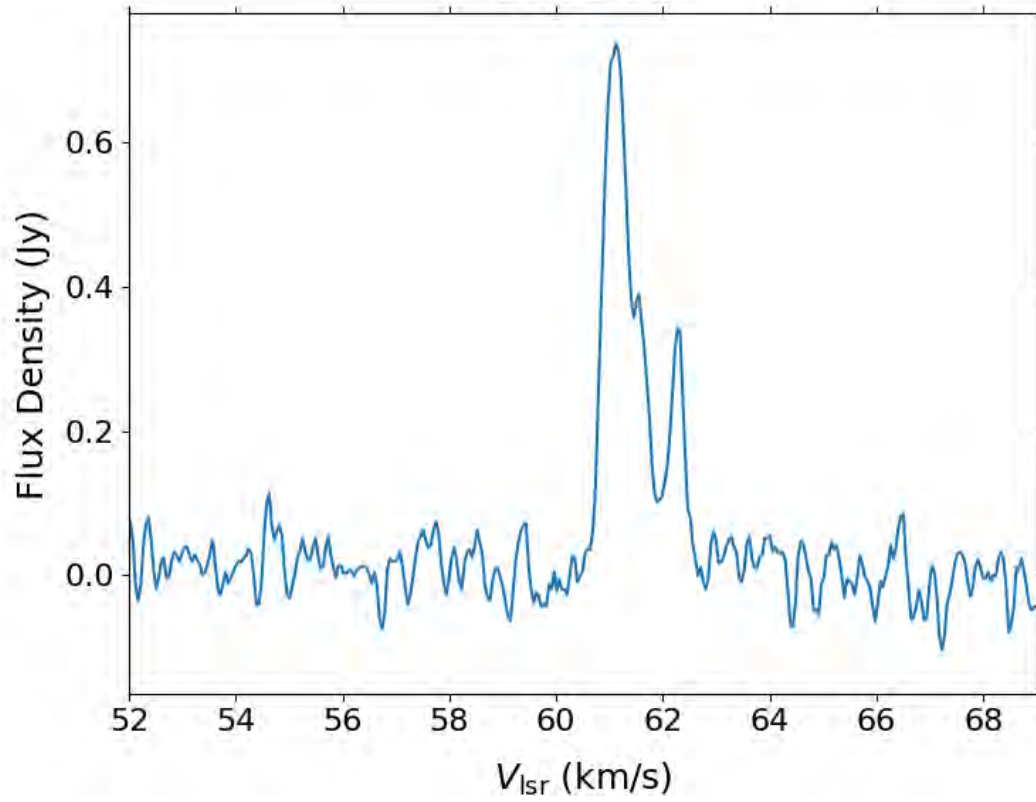


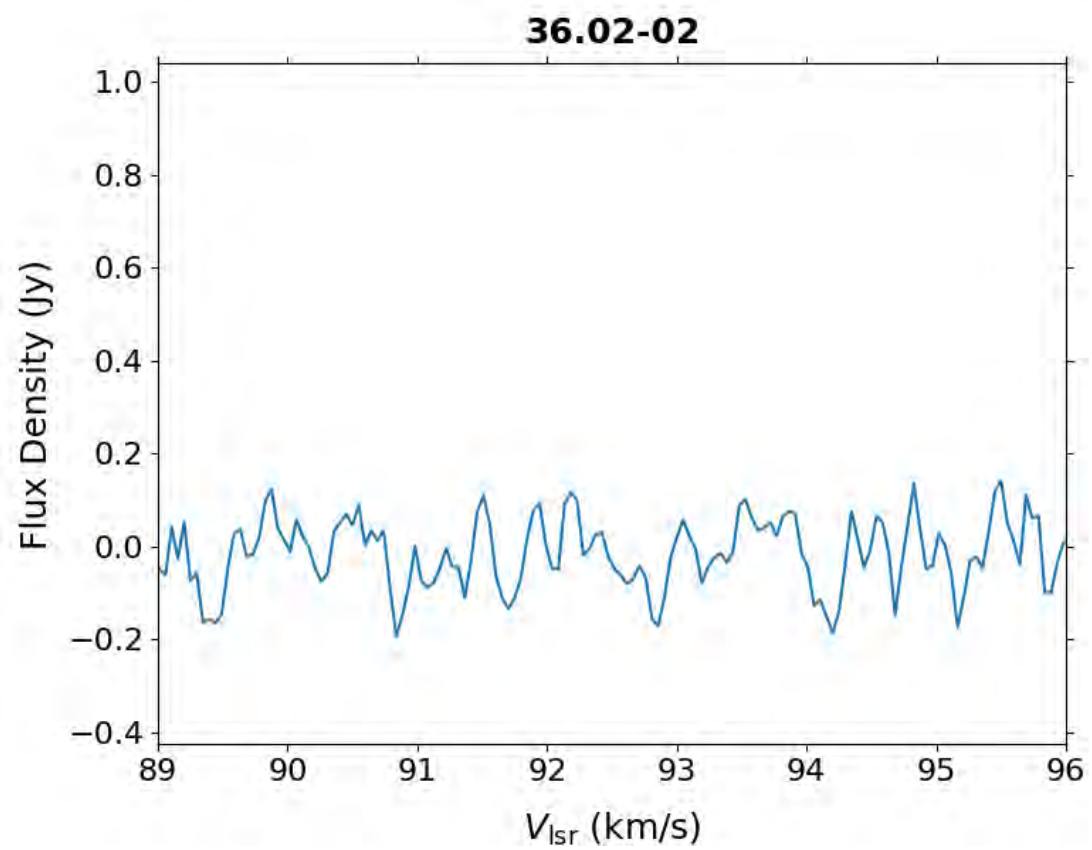
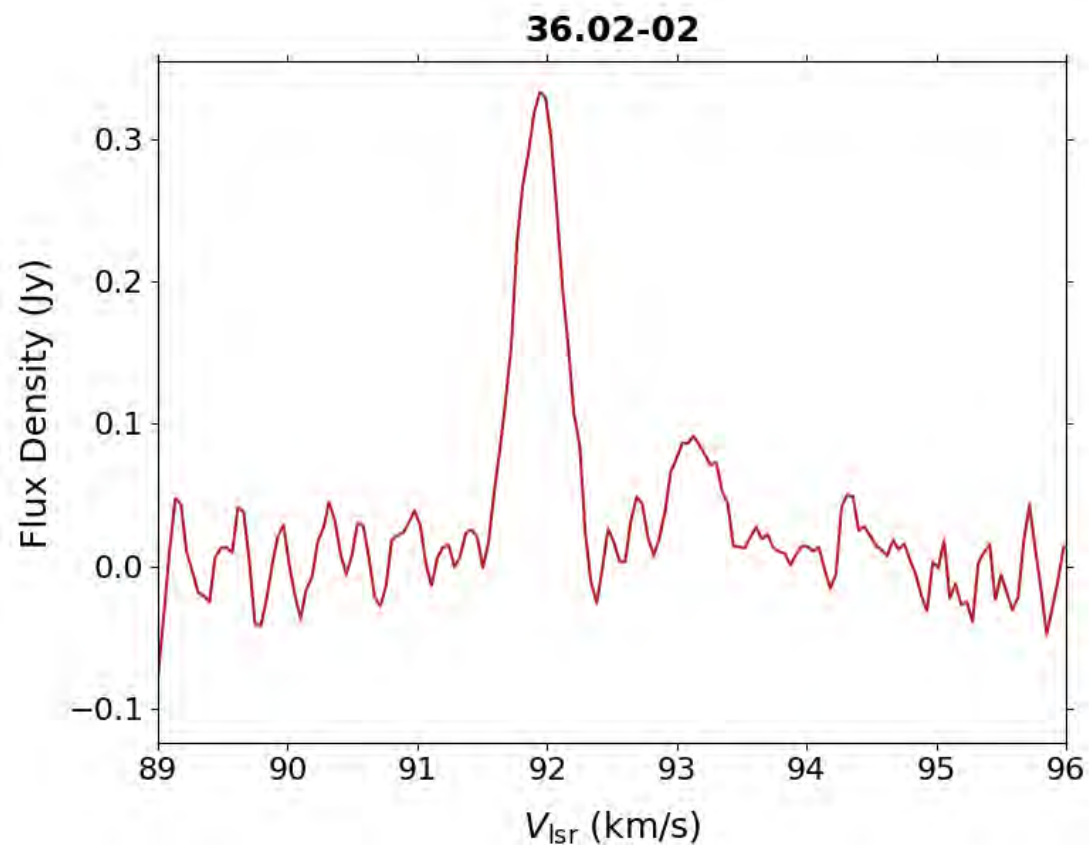


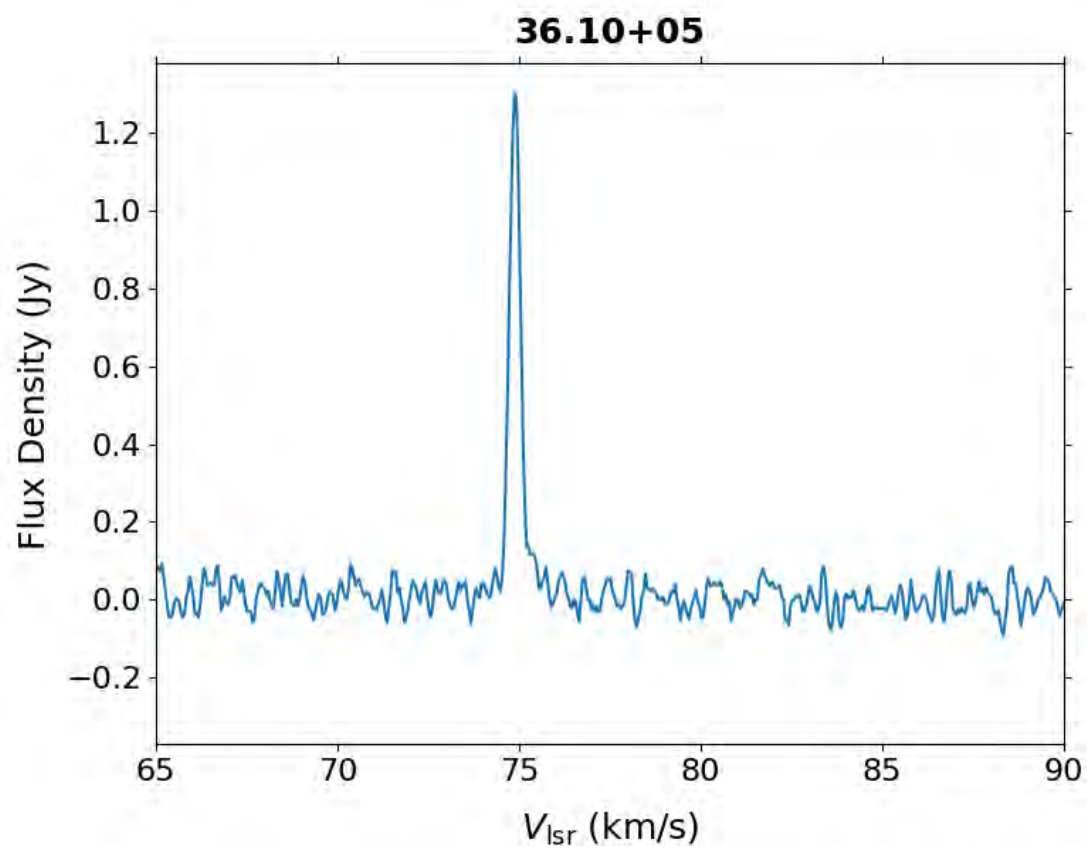
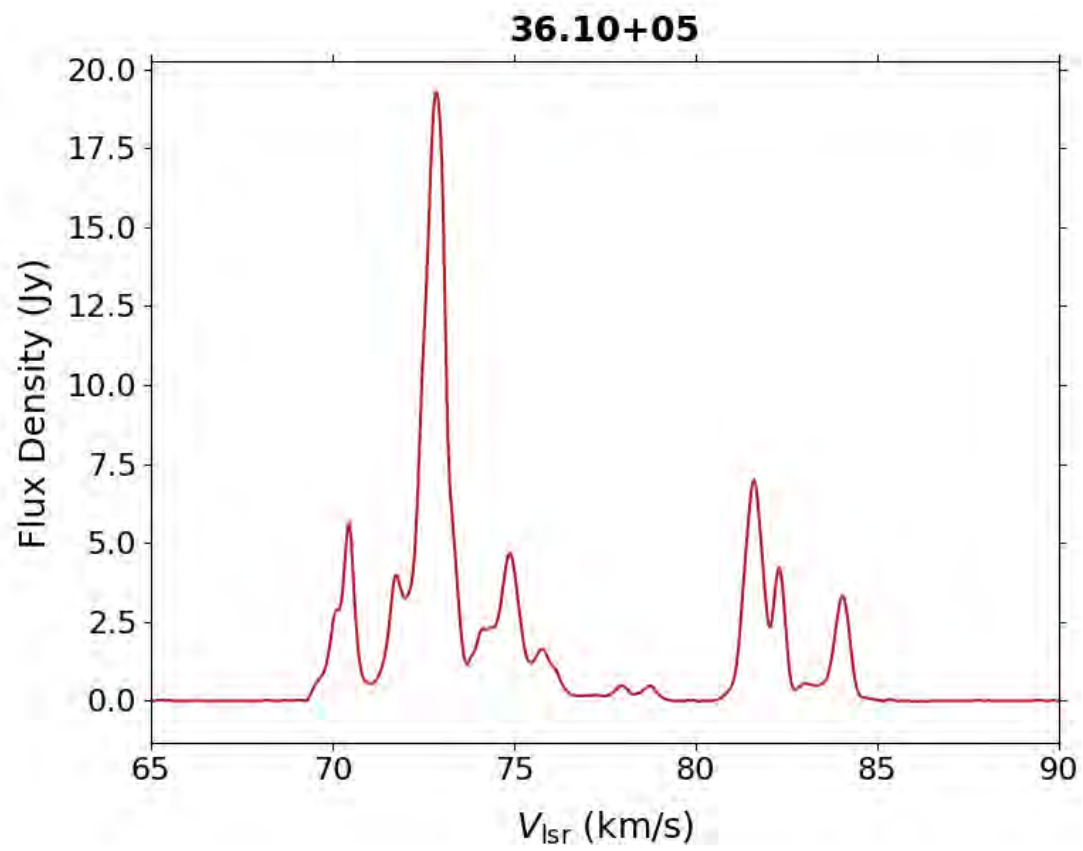
35.79-01



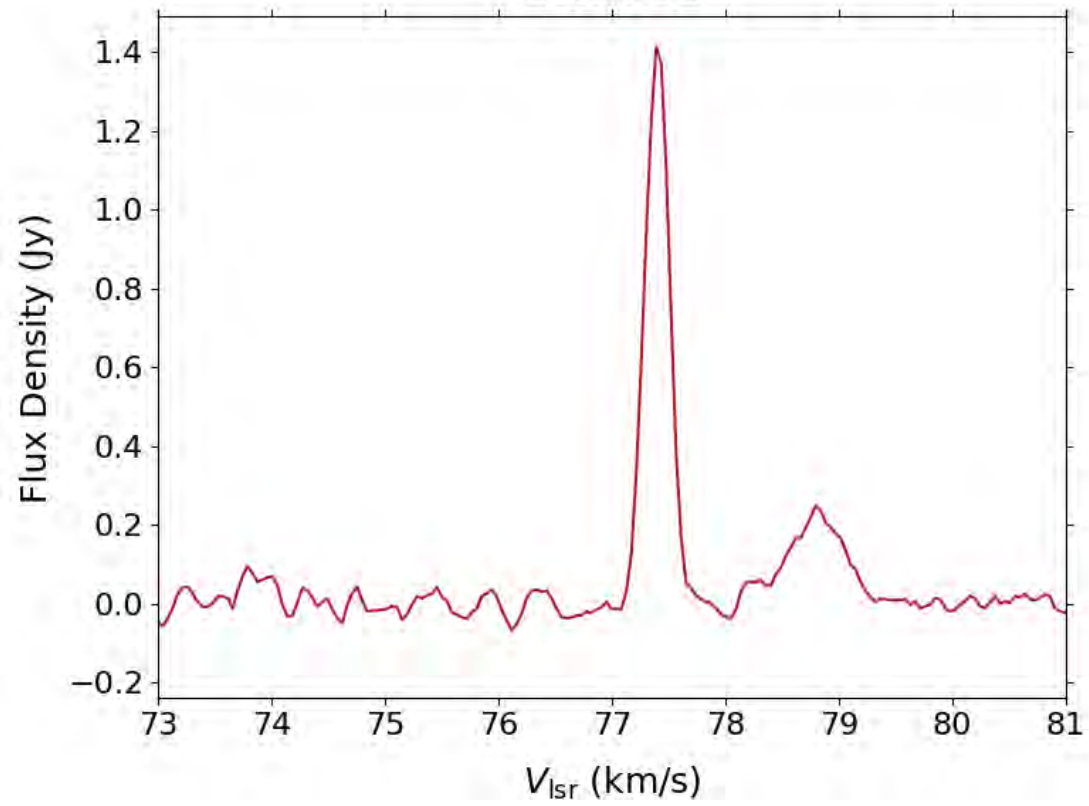
35.79-01



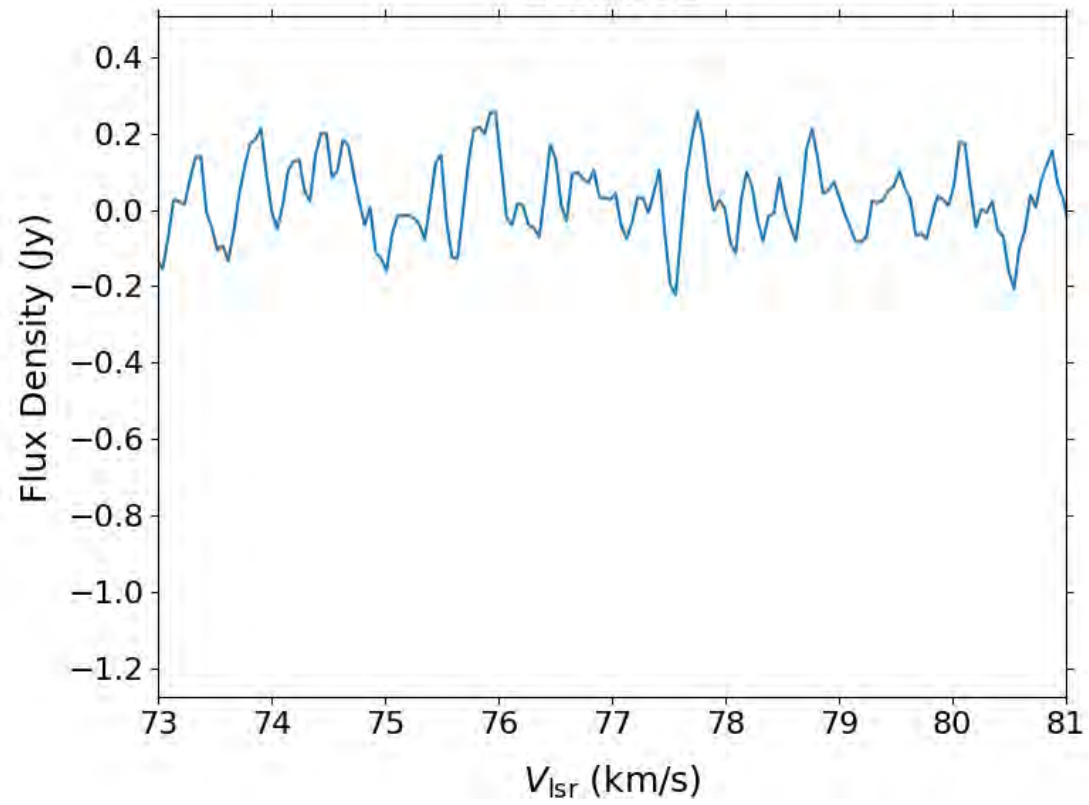


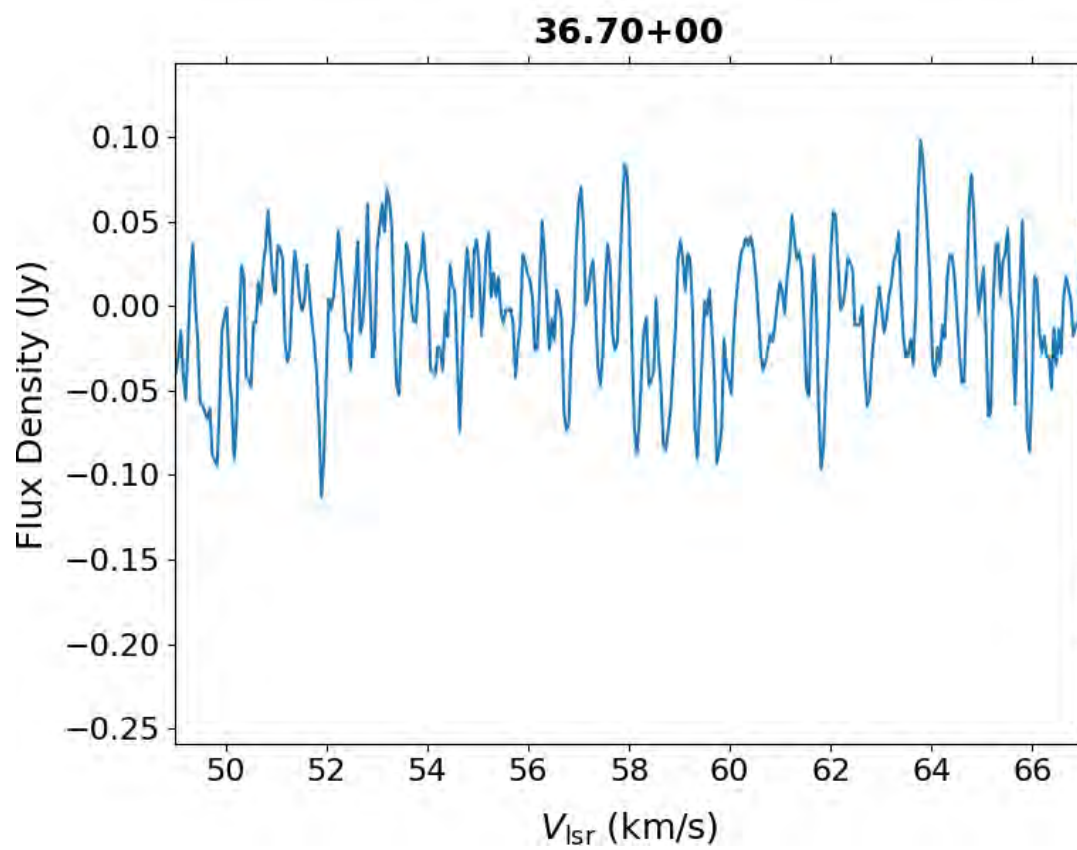
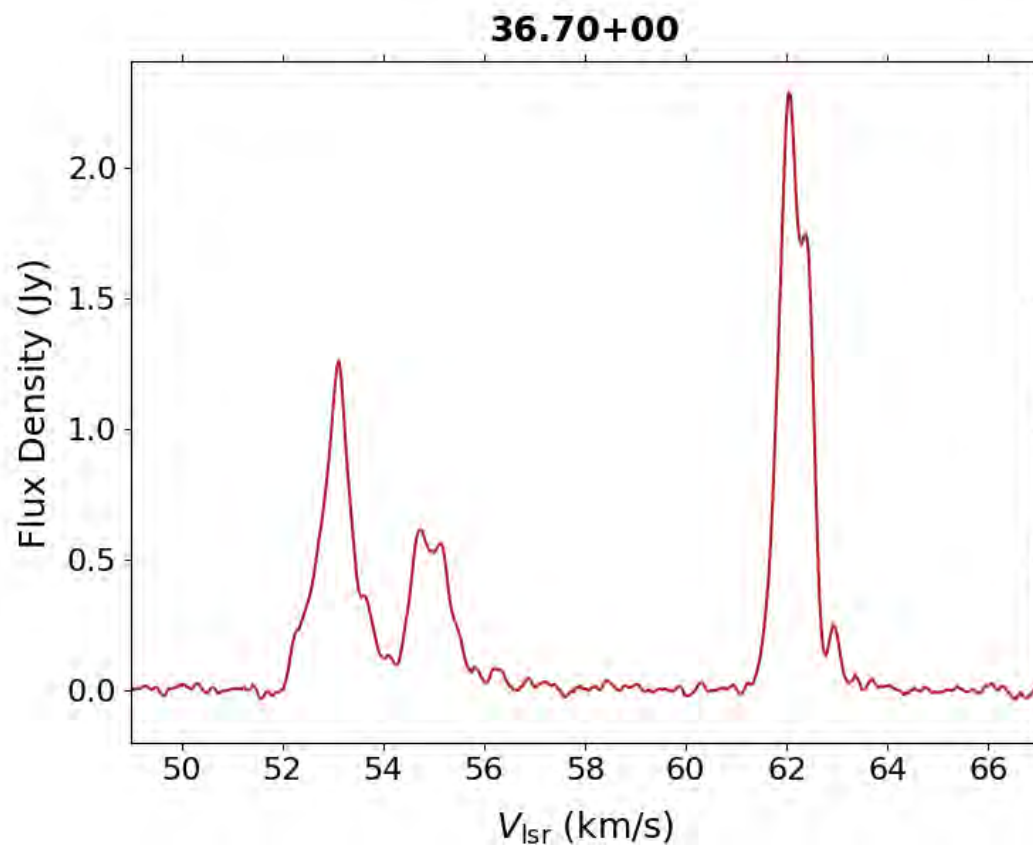


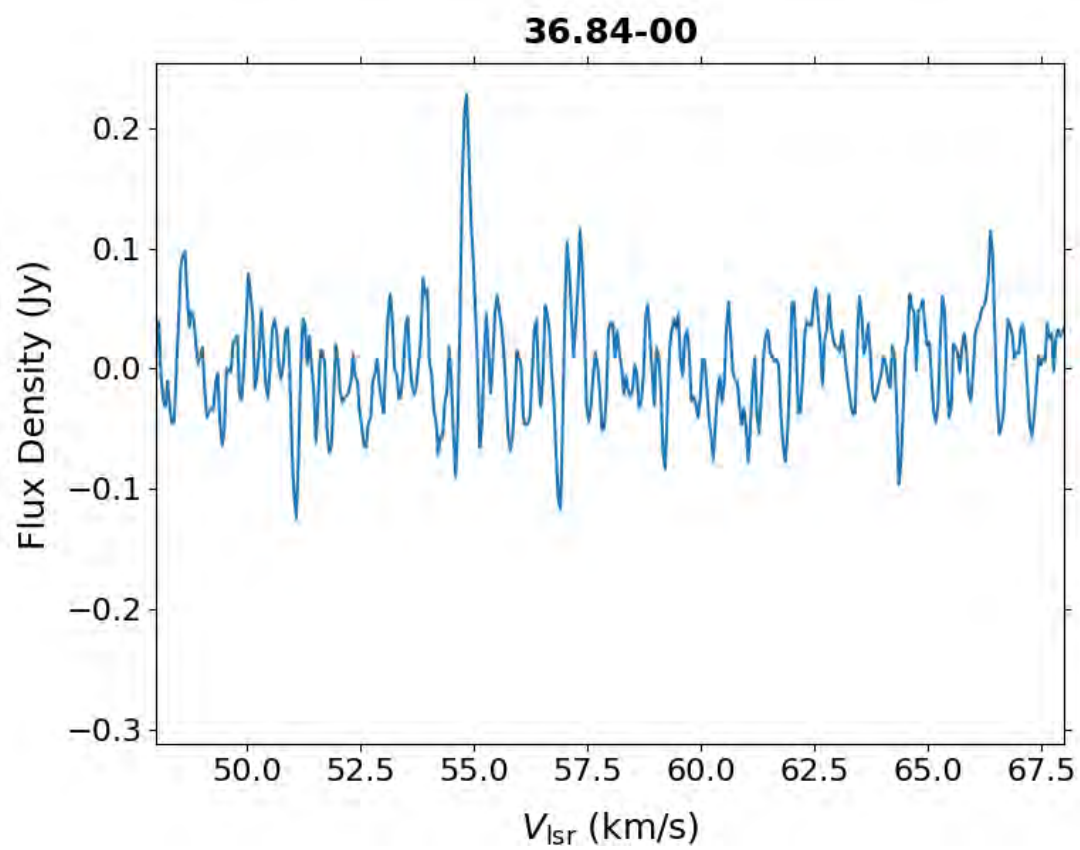
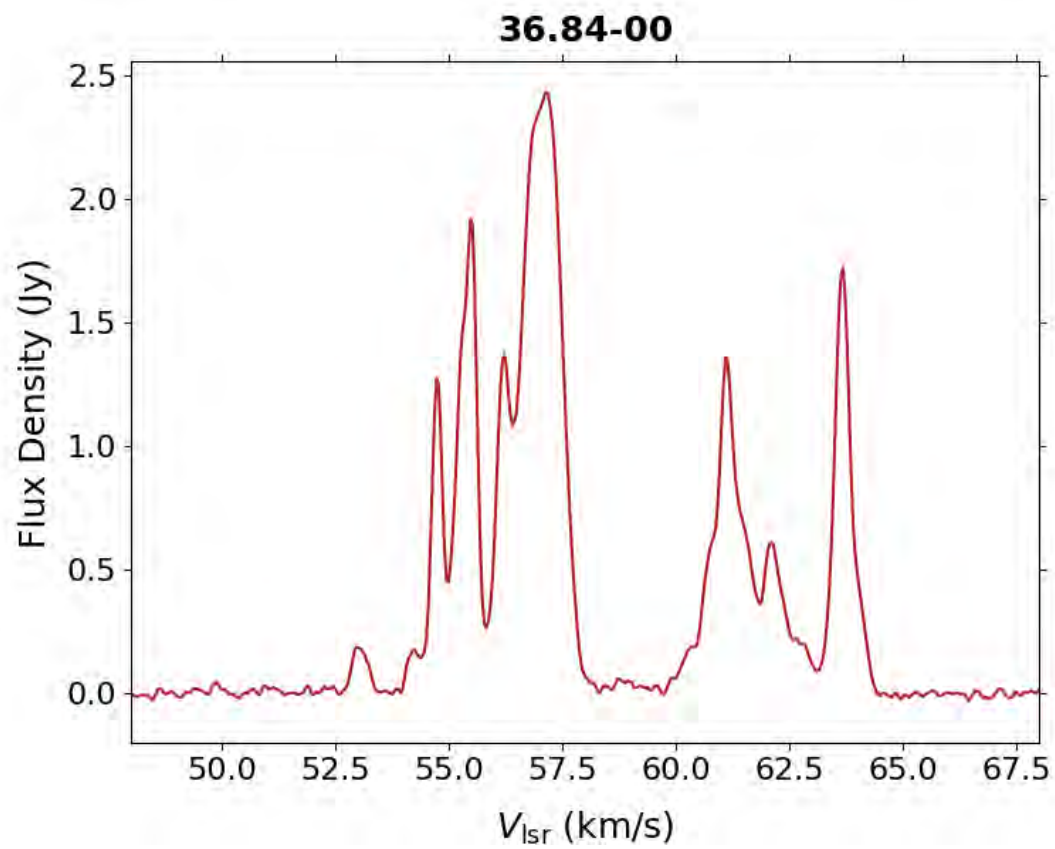
36.64-02

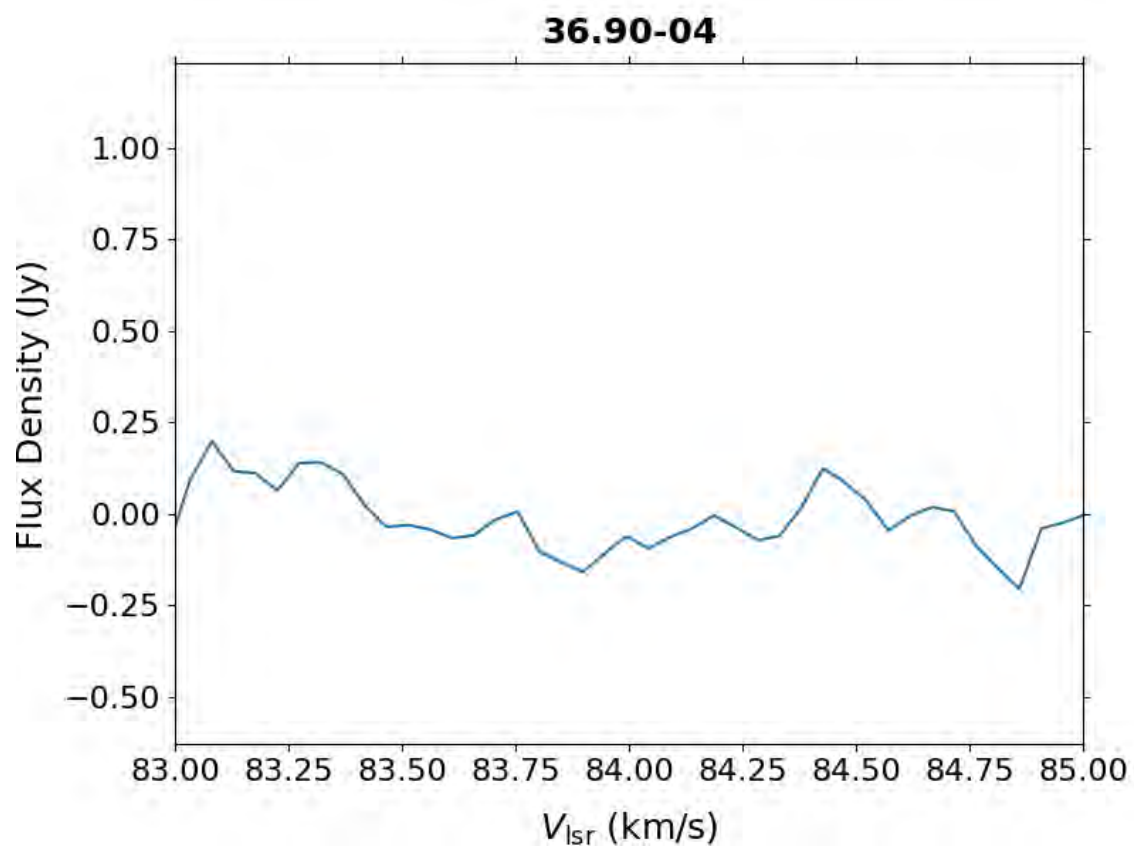
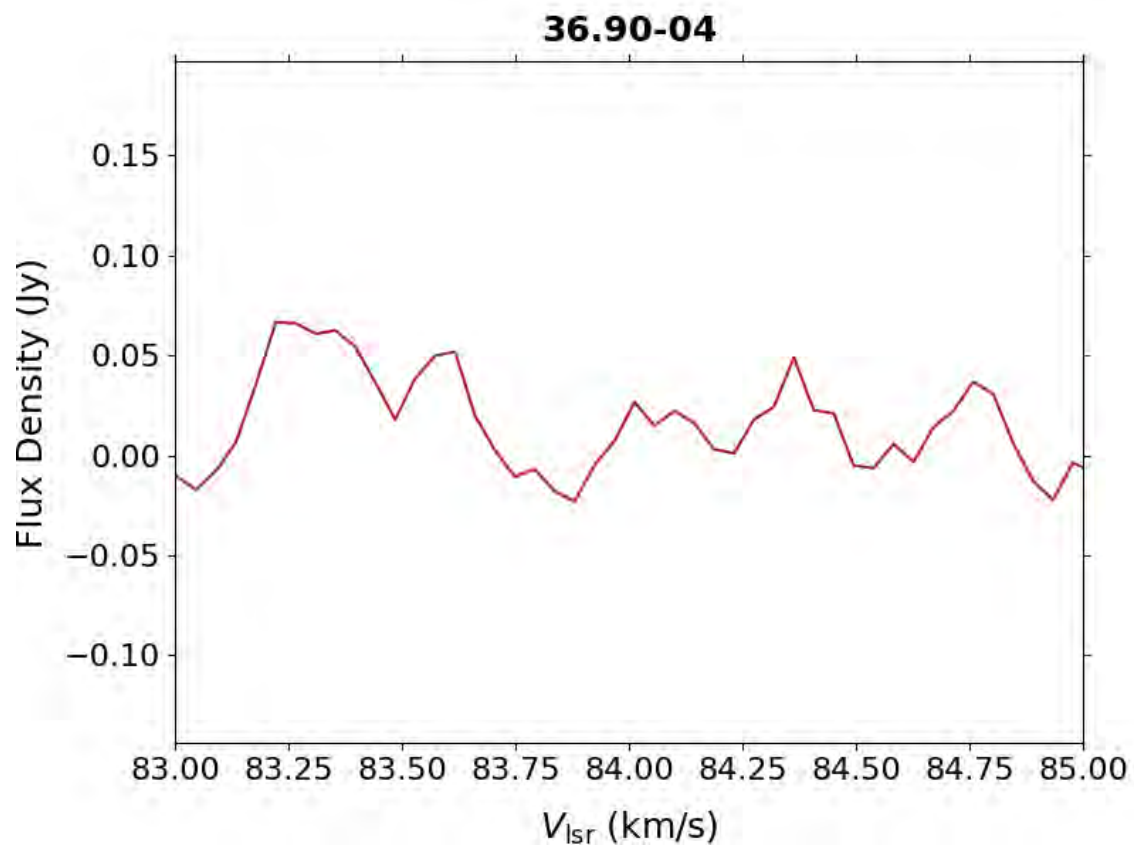


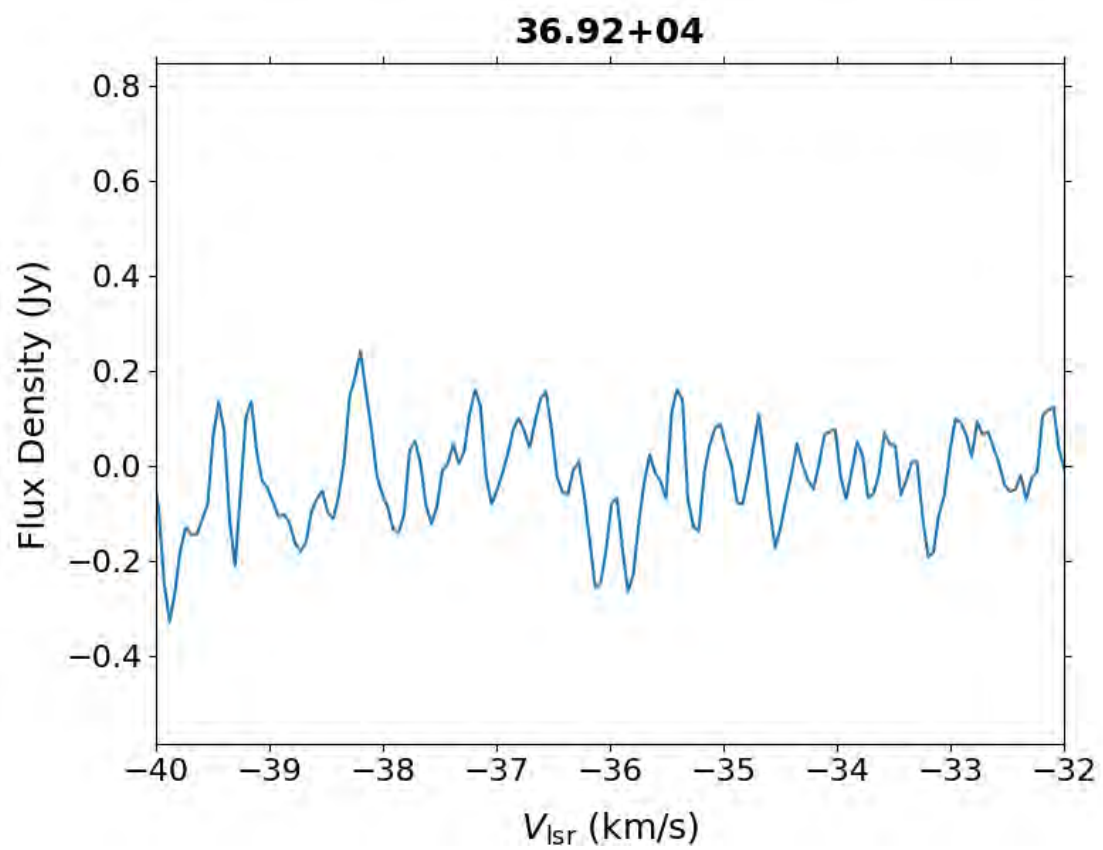
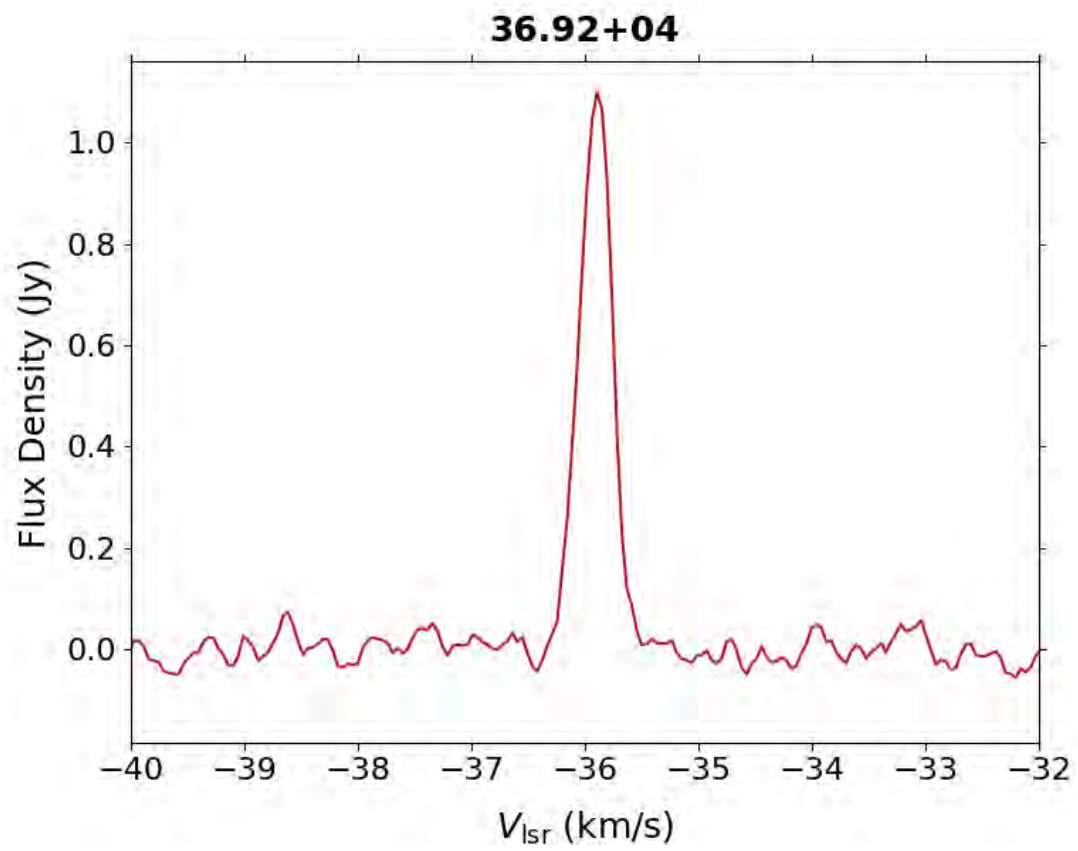
36.64-02

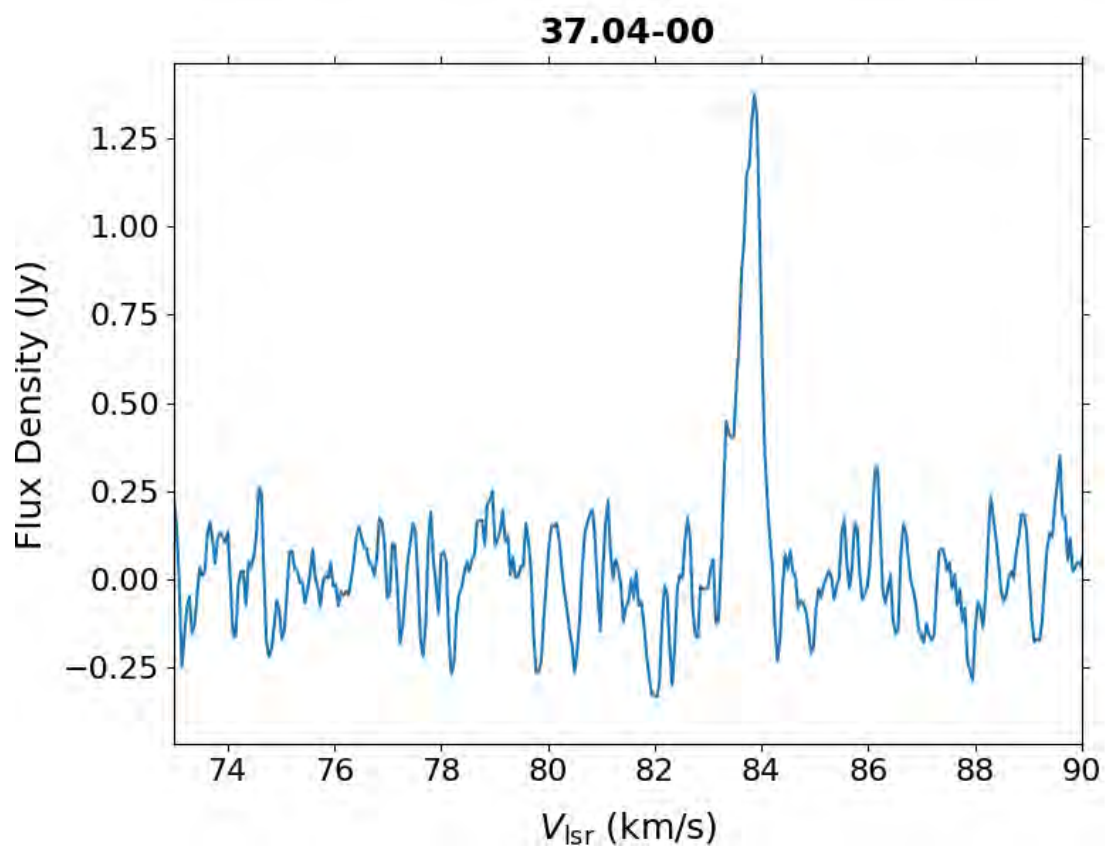
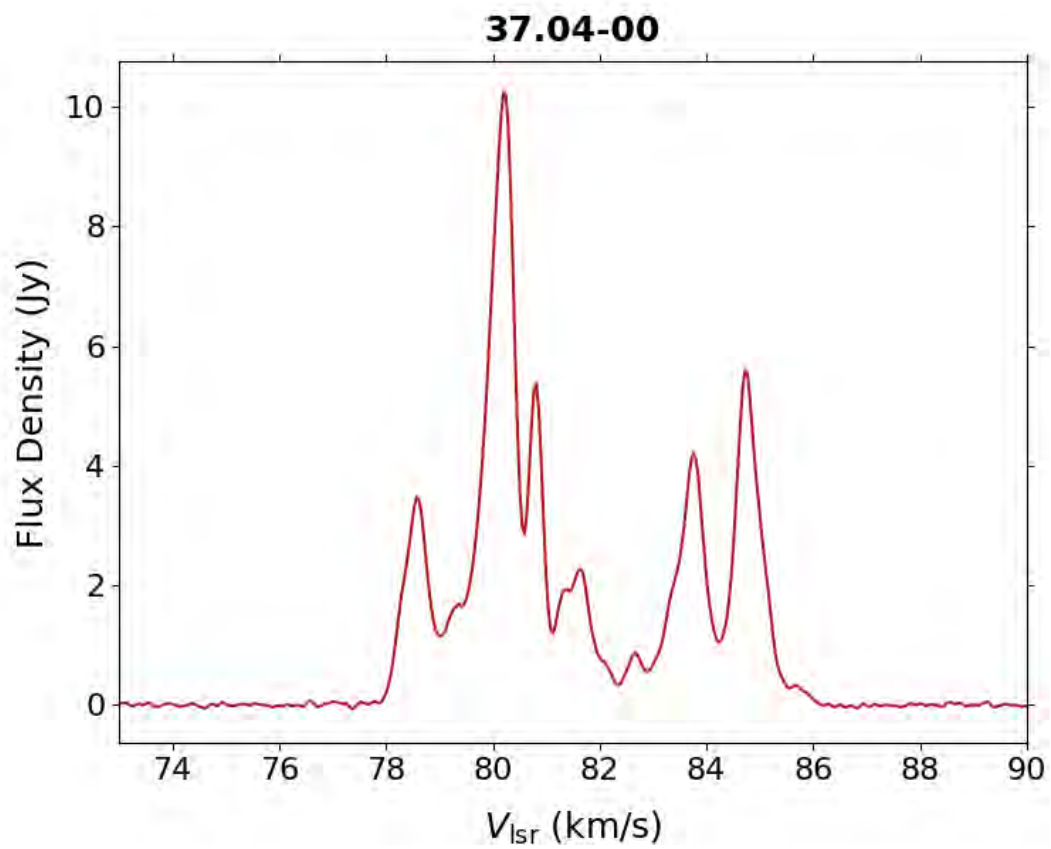


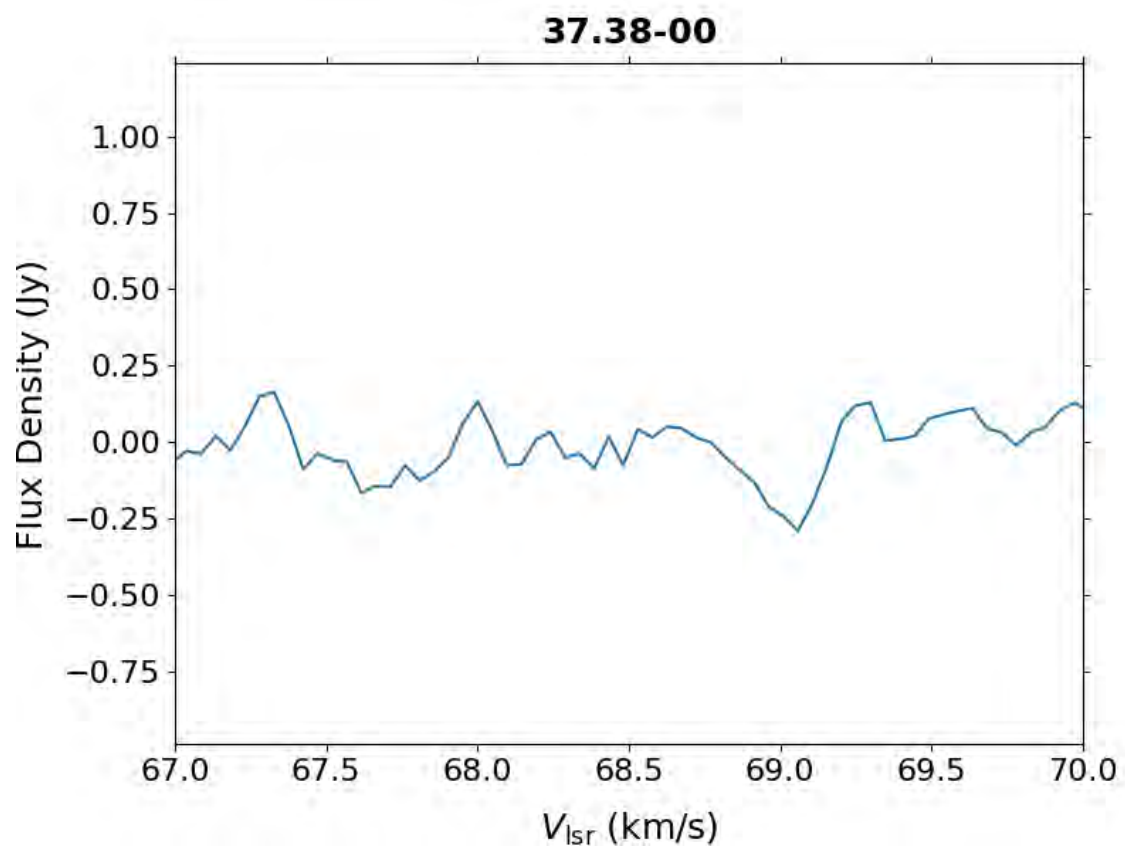
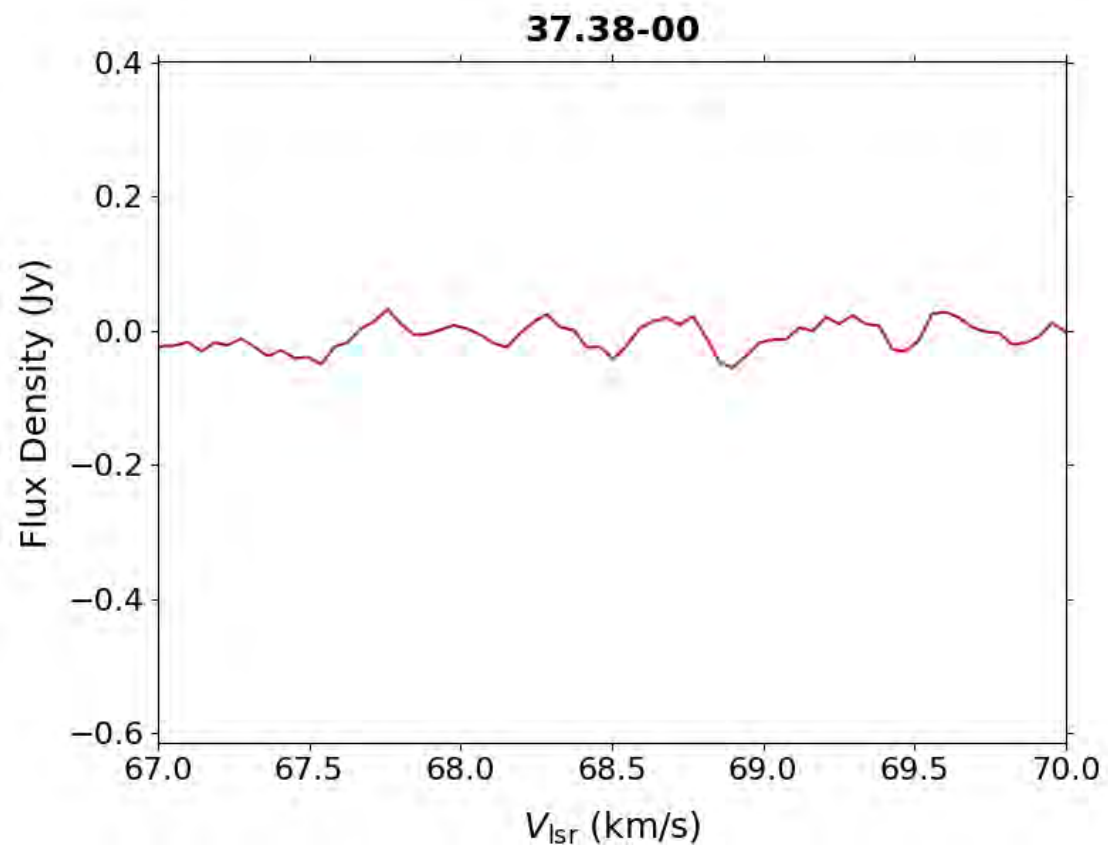


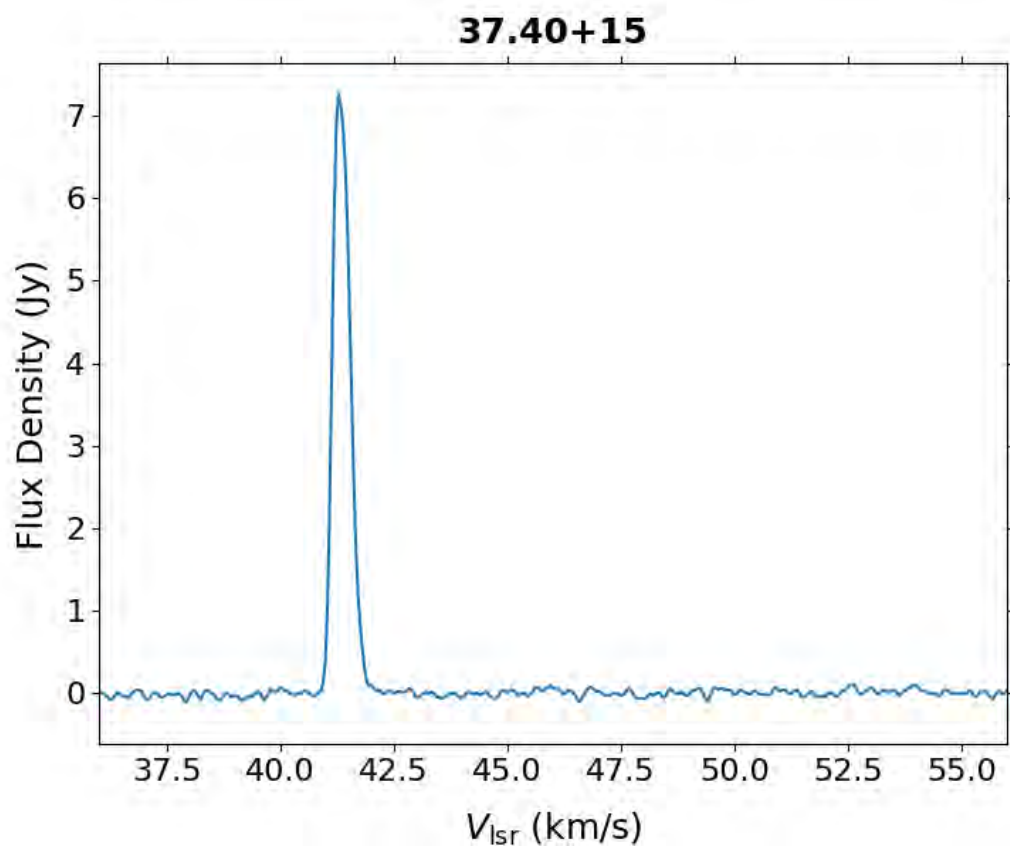
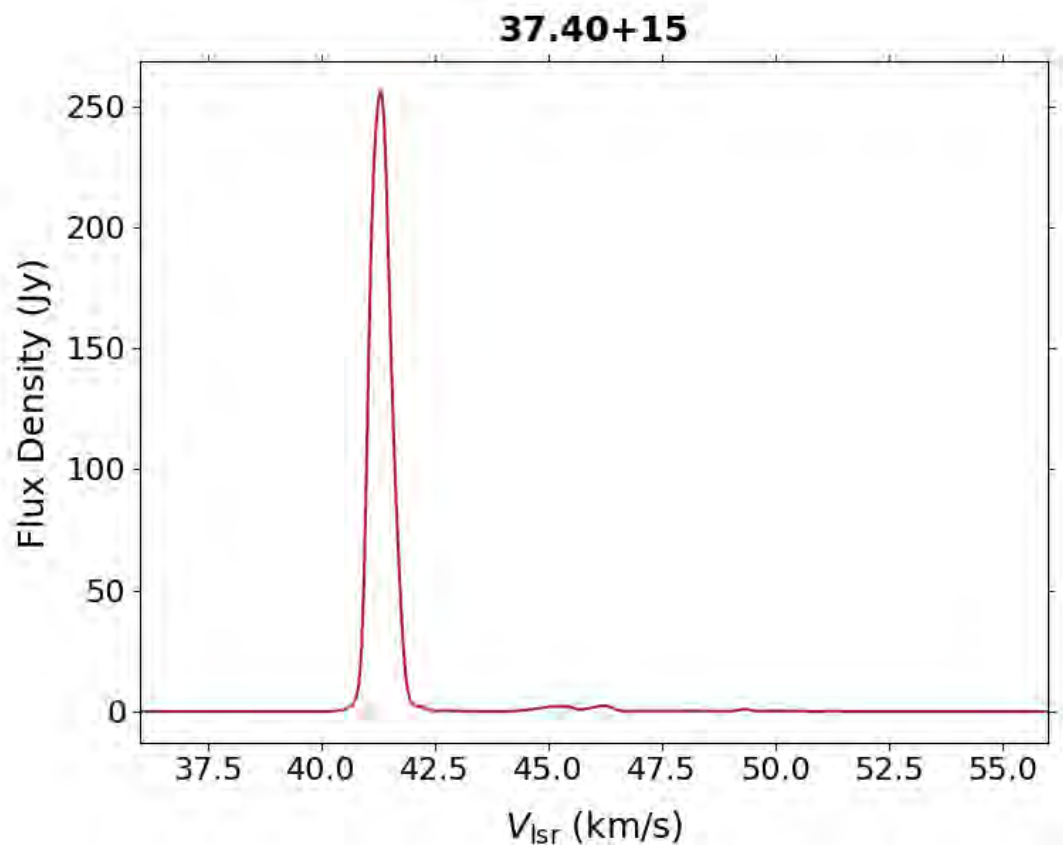




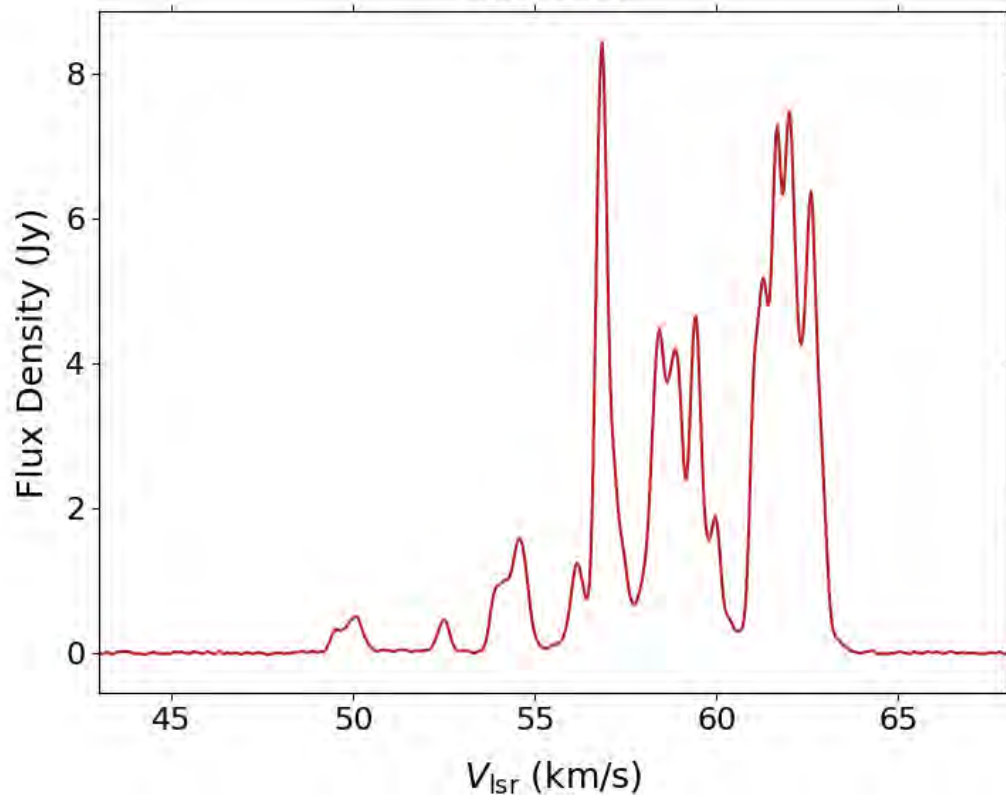




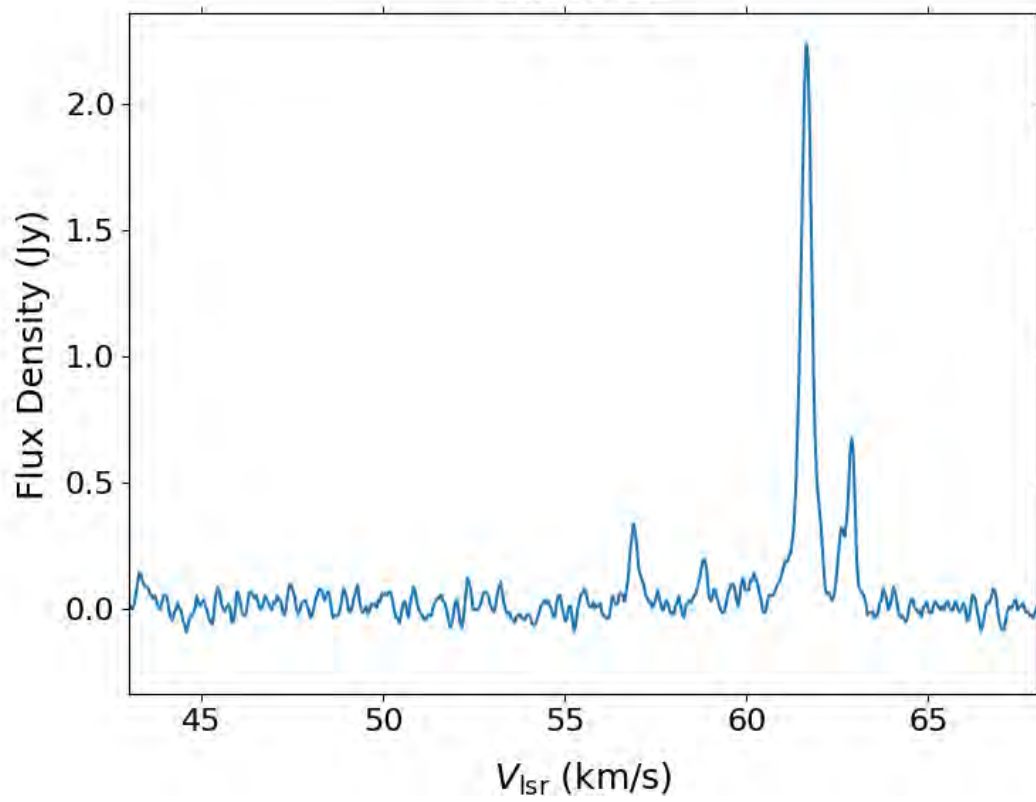




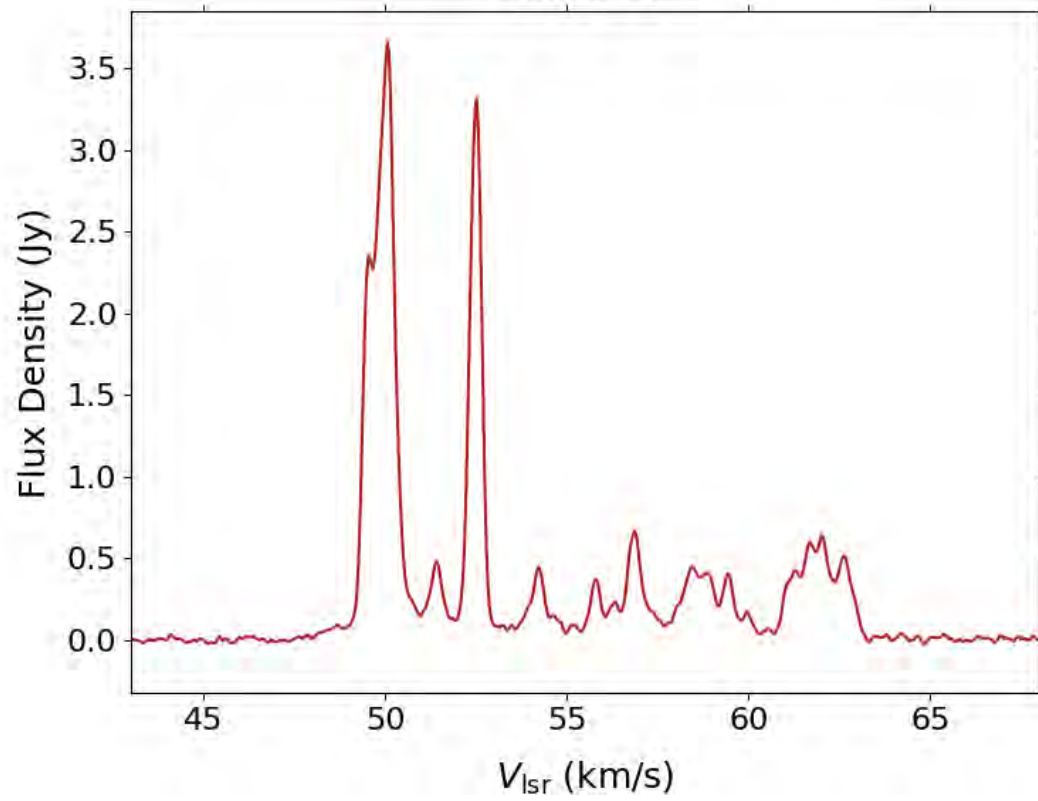
37.47-01



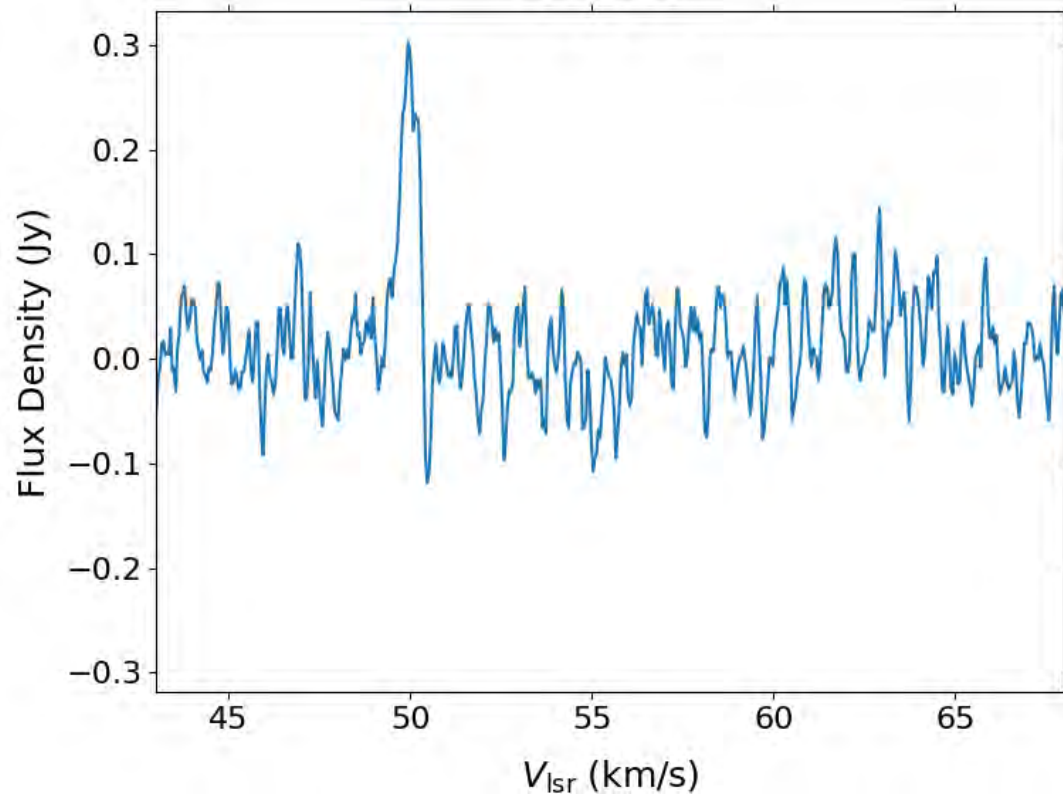
37.47-01

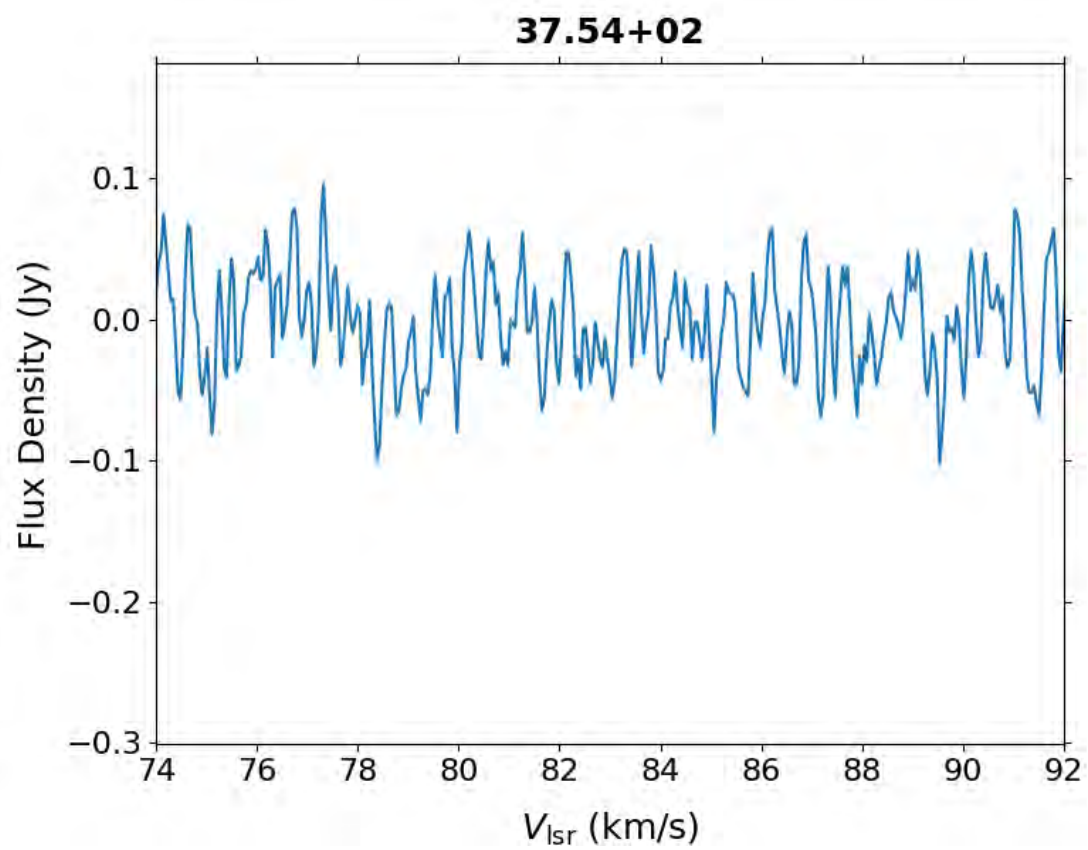
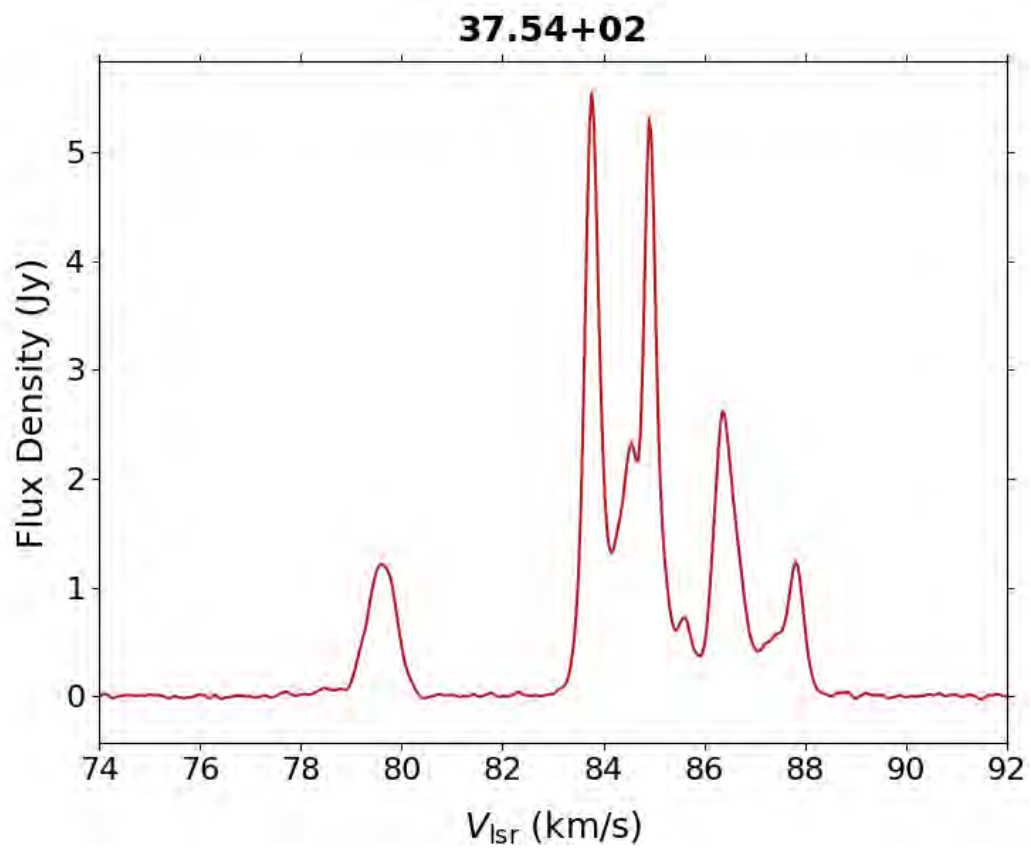


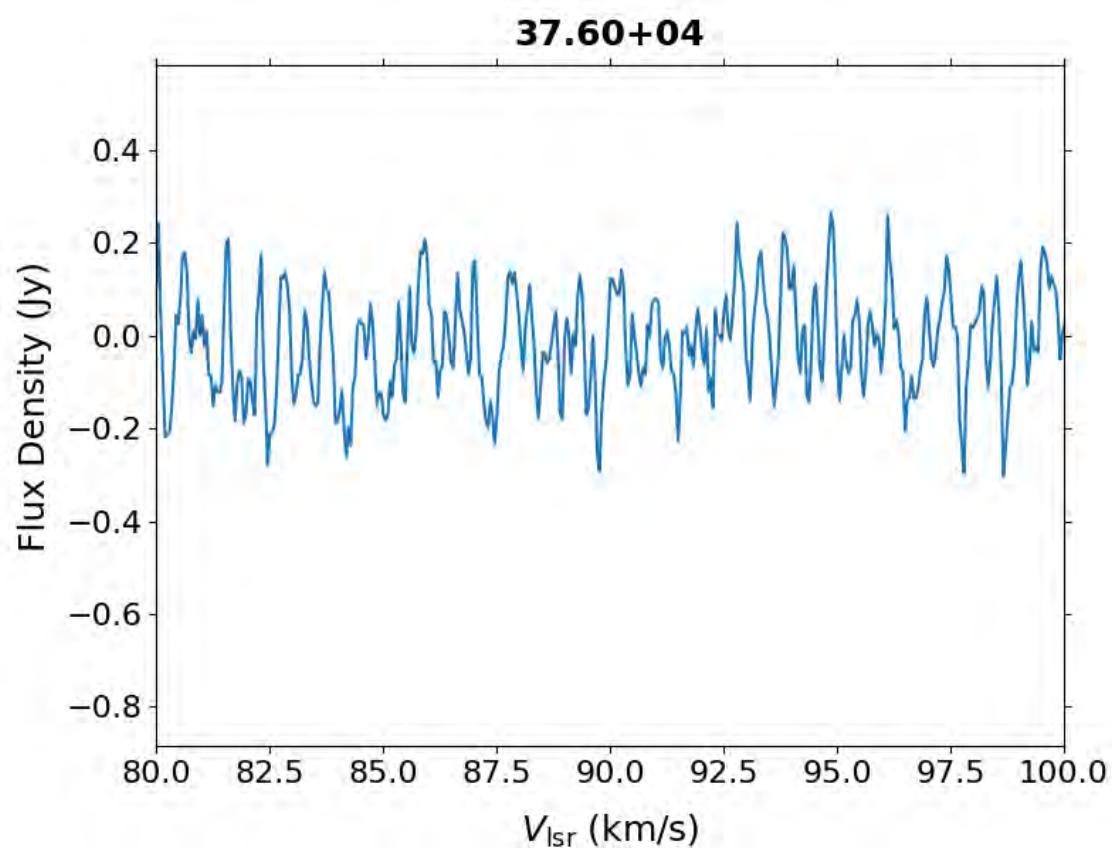
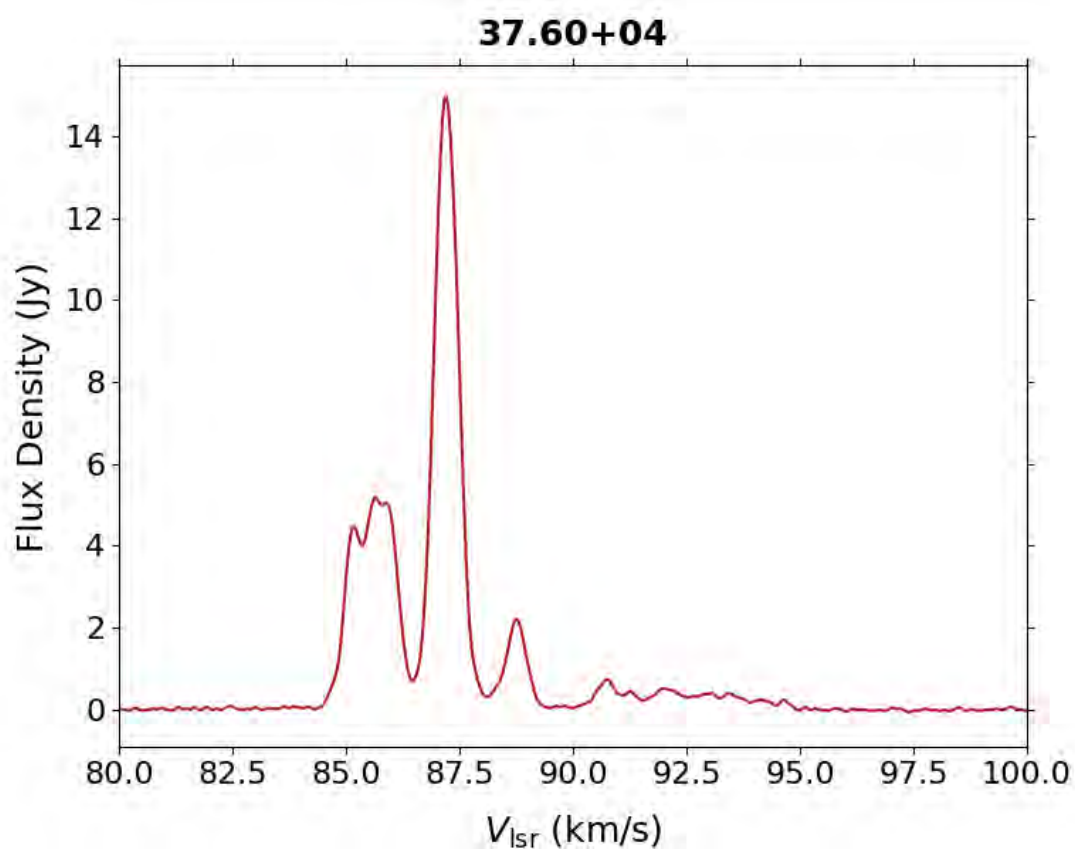
37.52-01



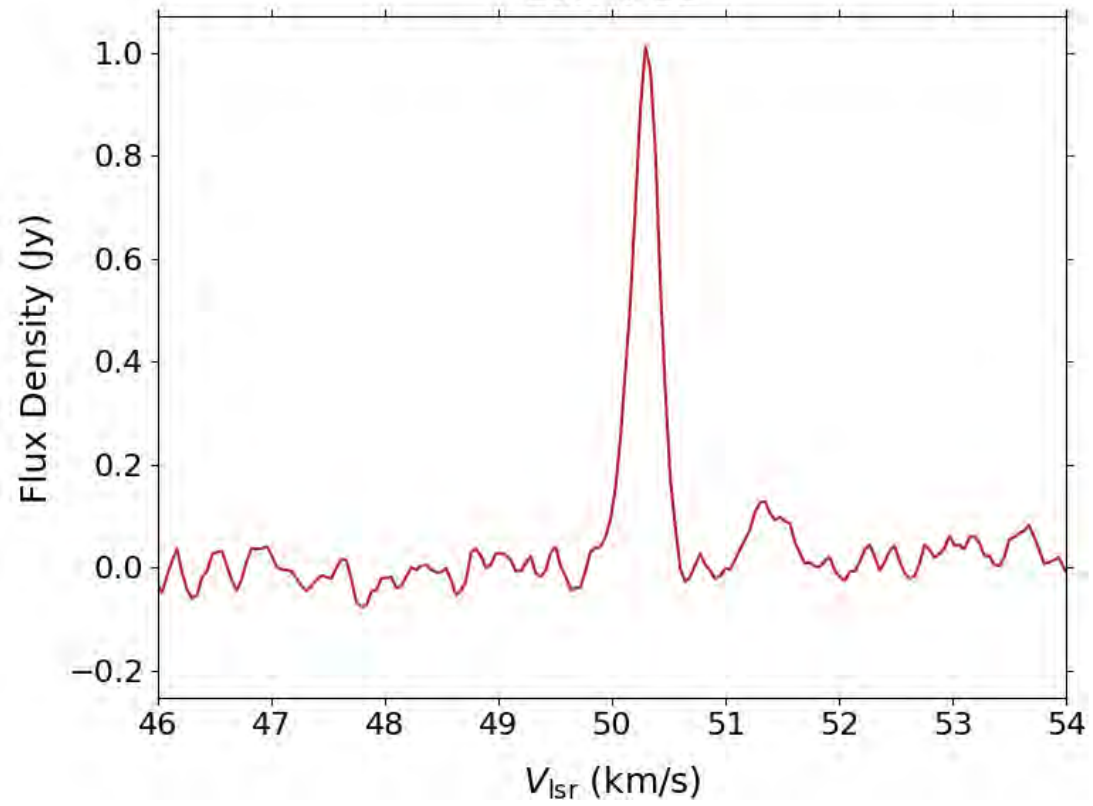
37.52-01



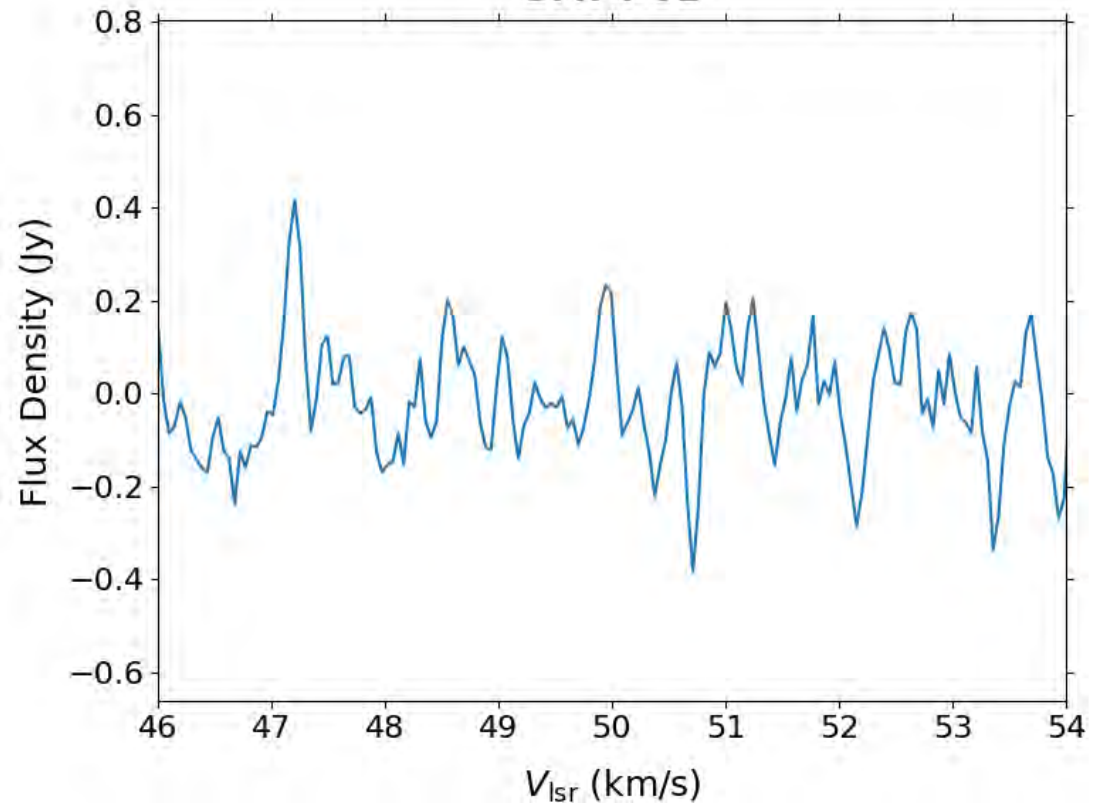




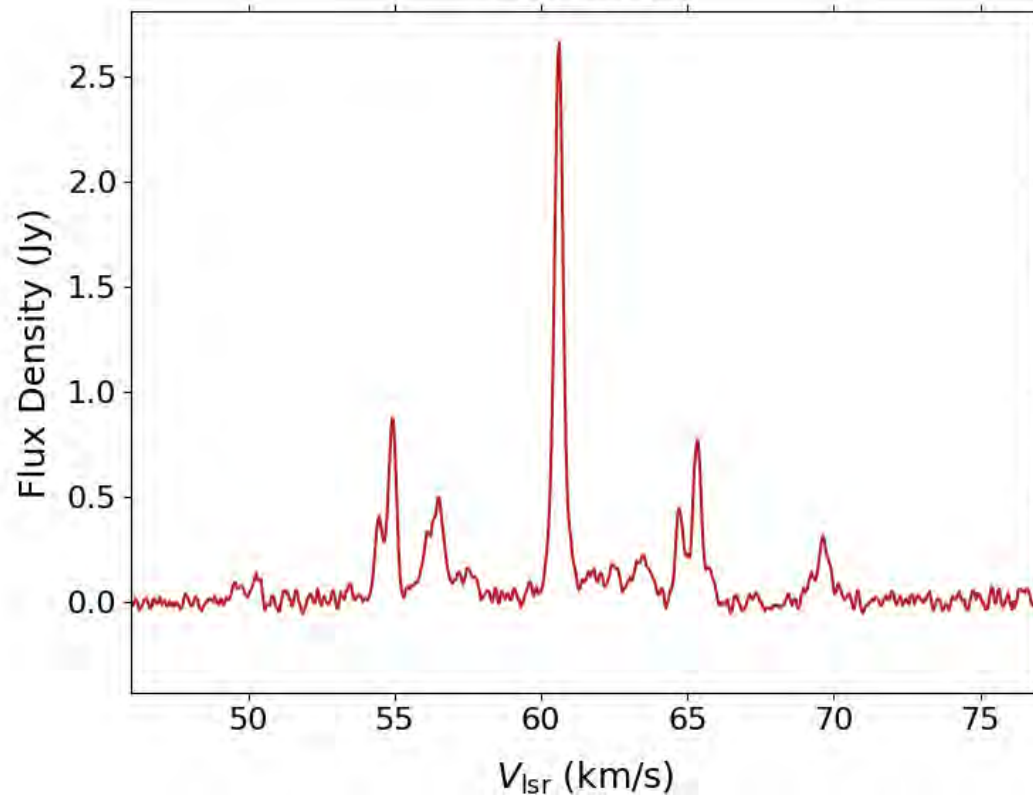
37.74-01



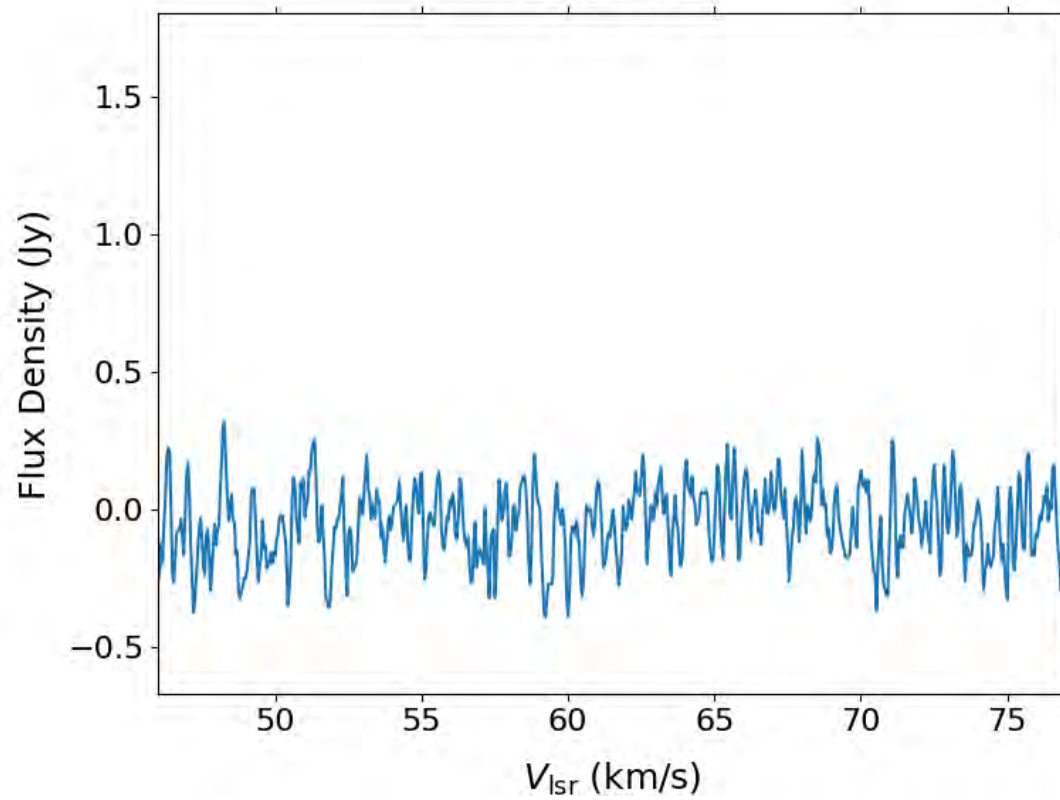
37.74-01

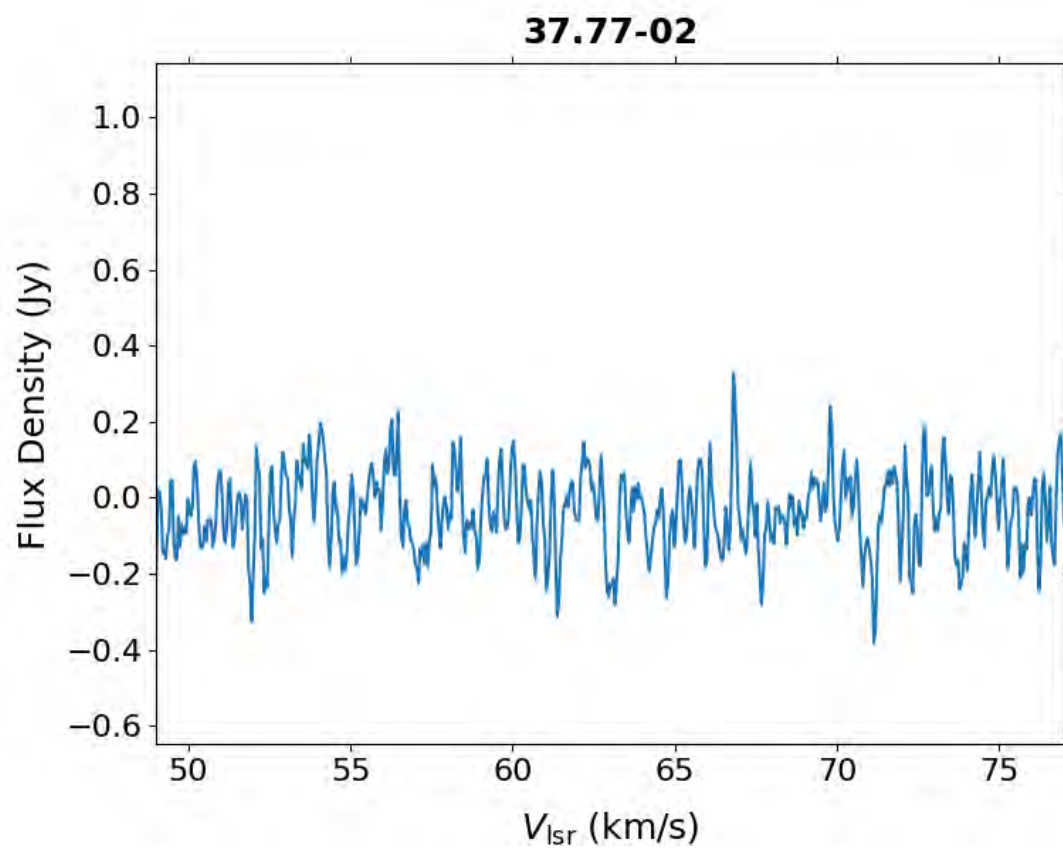
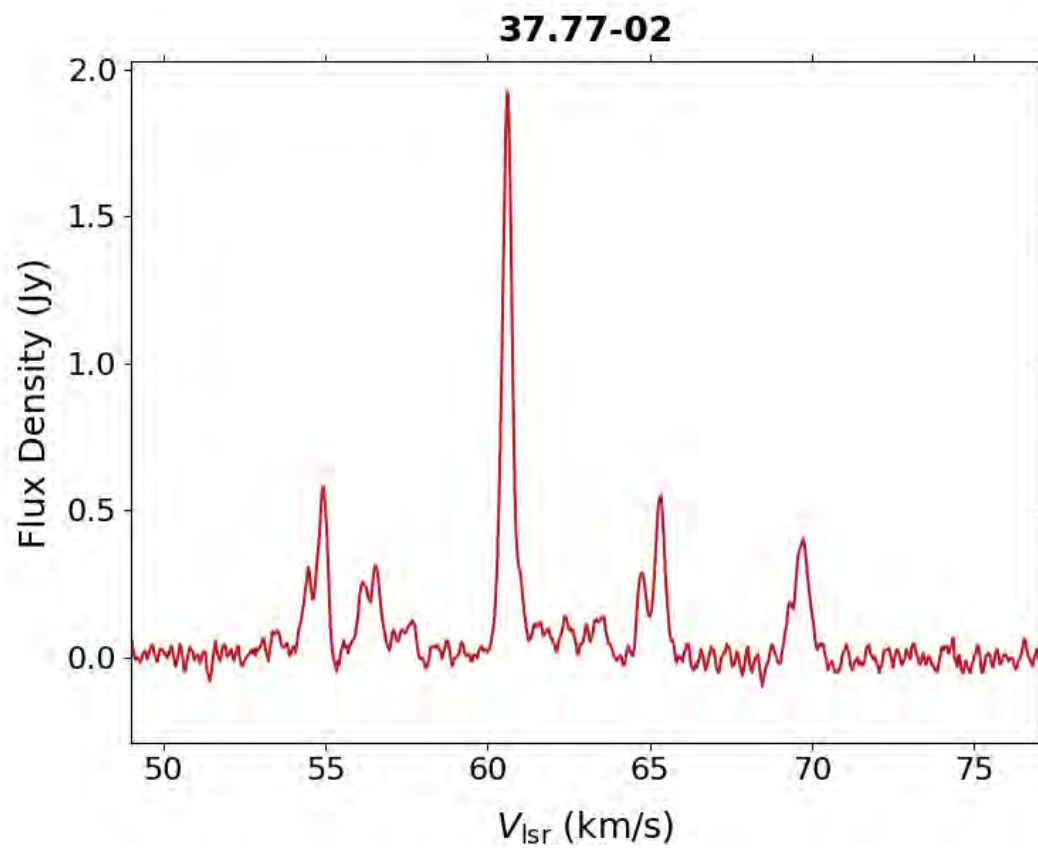


37.76-01

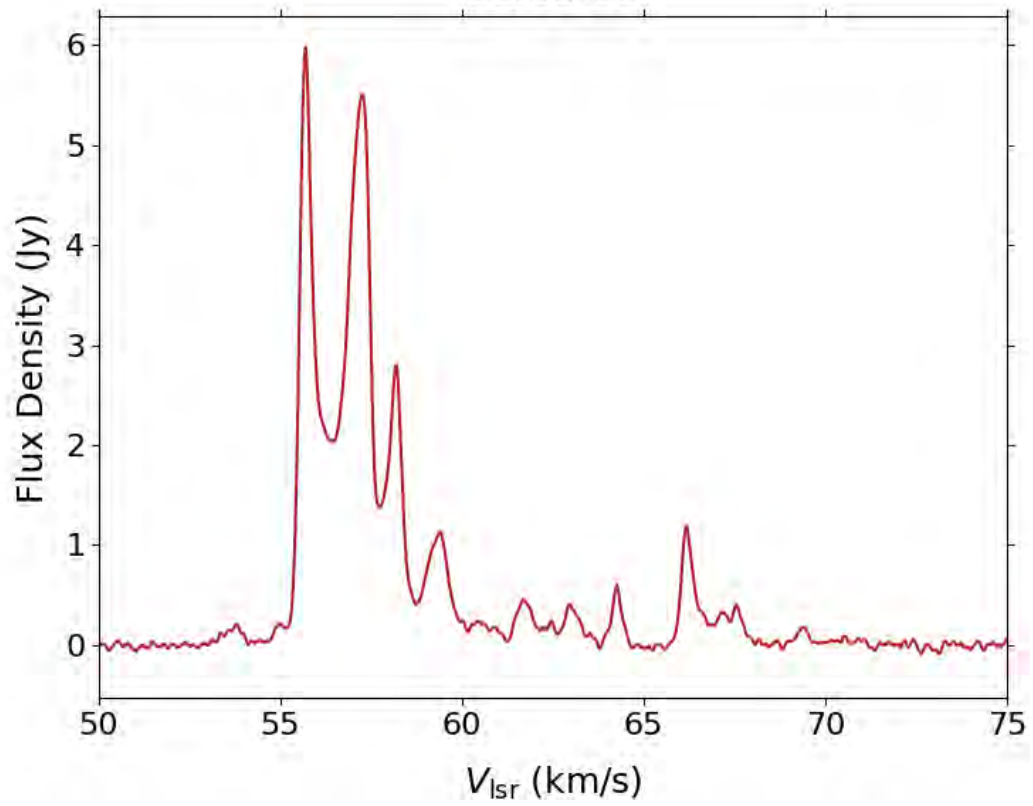


37.76-01

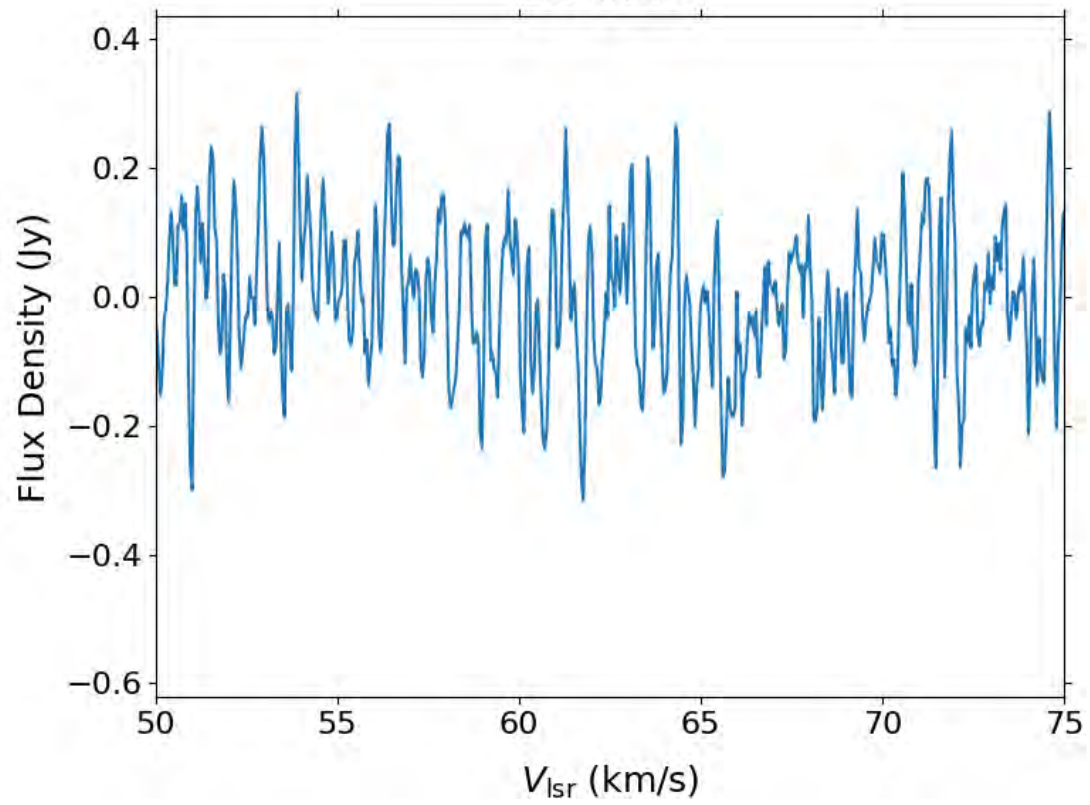




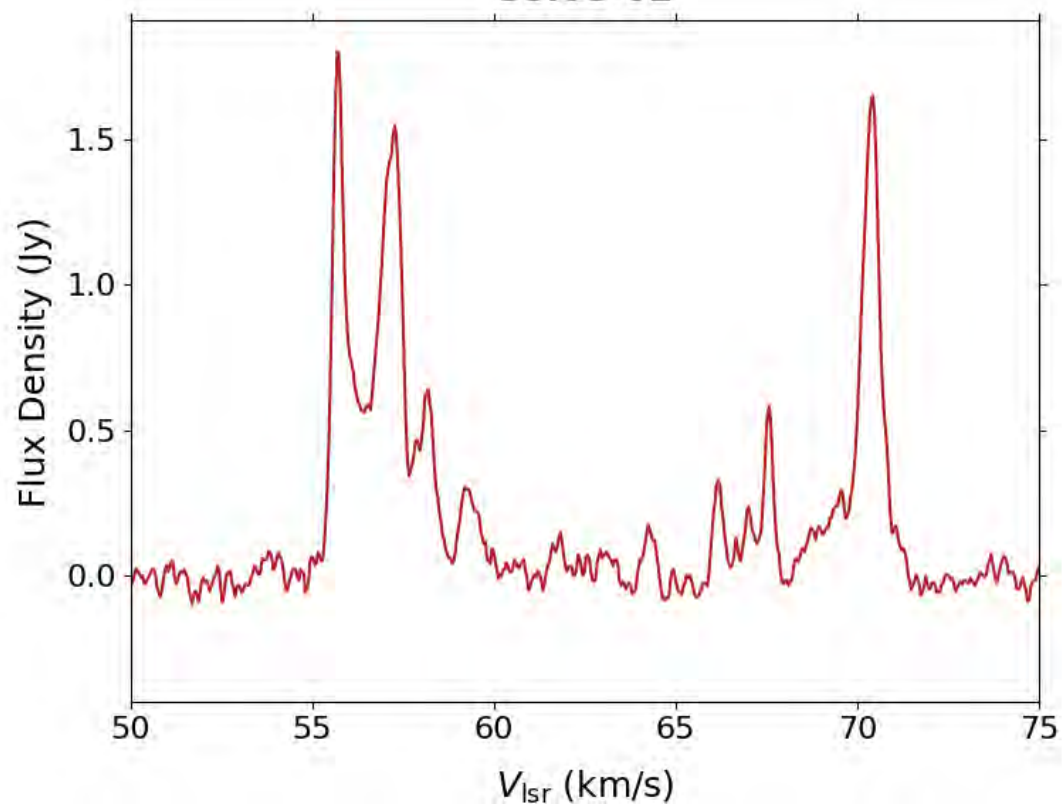
38.03-03



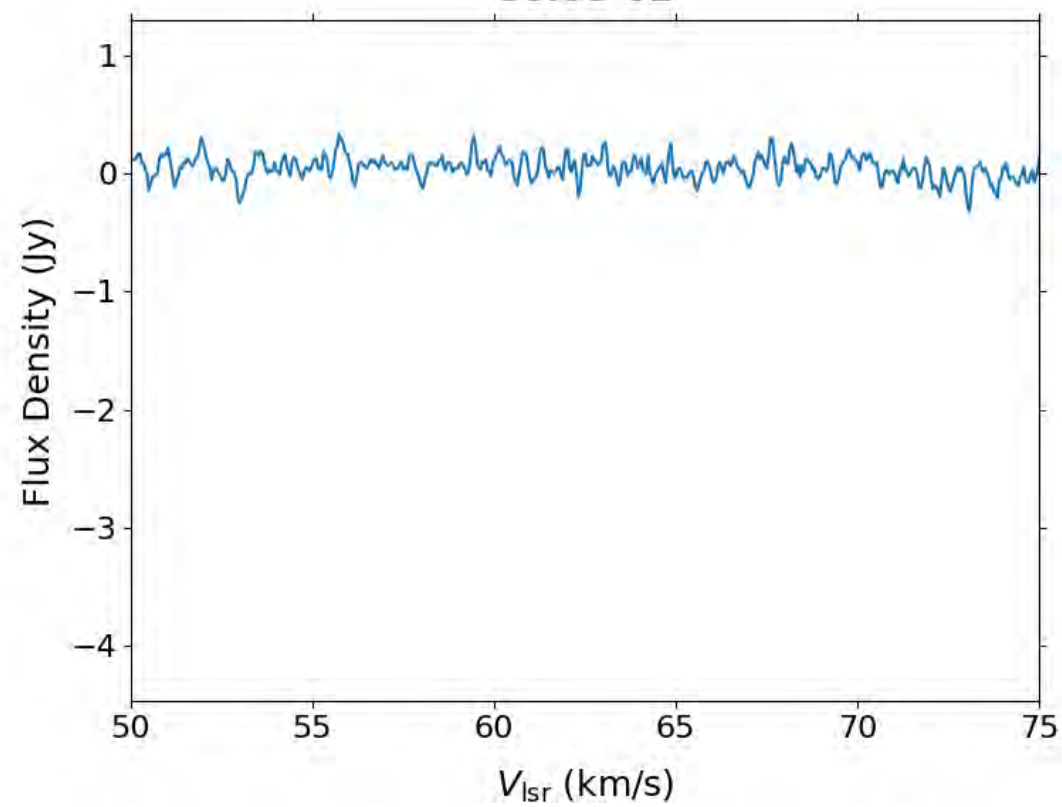
38.03-03



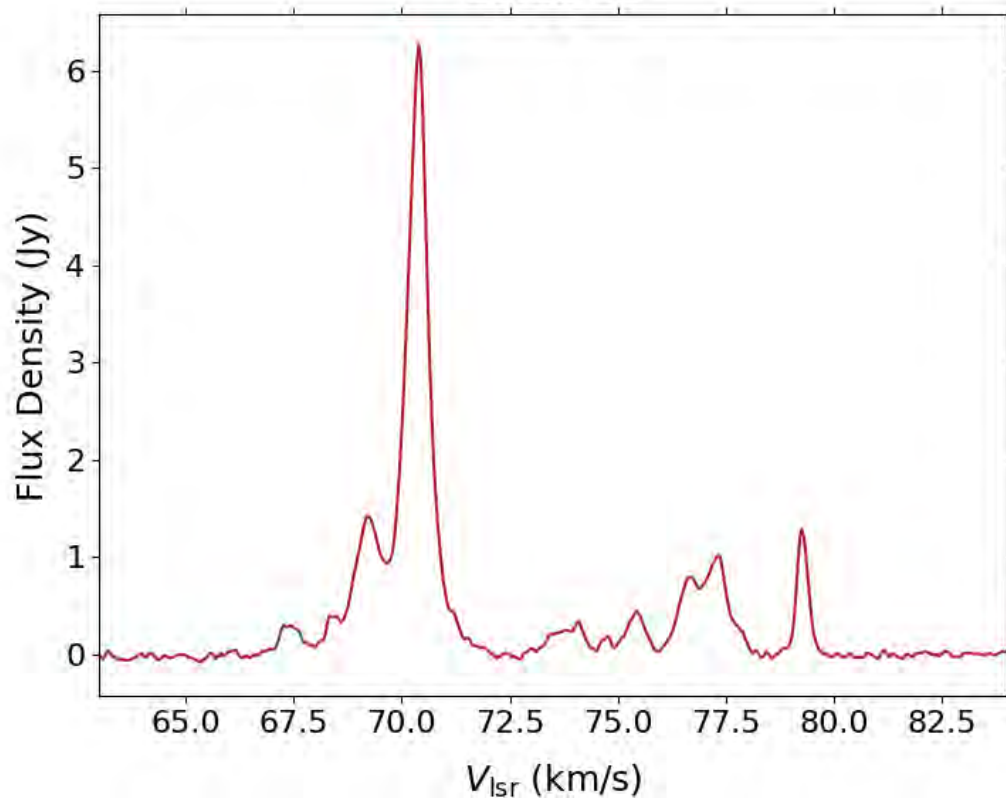
38.08-02



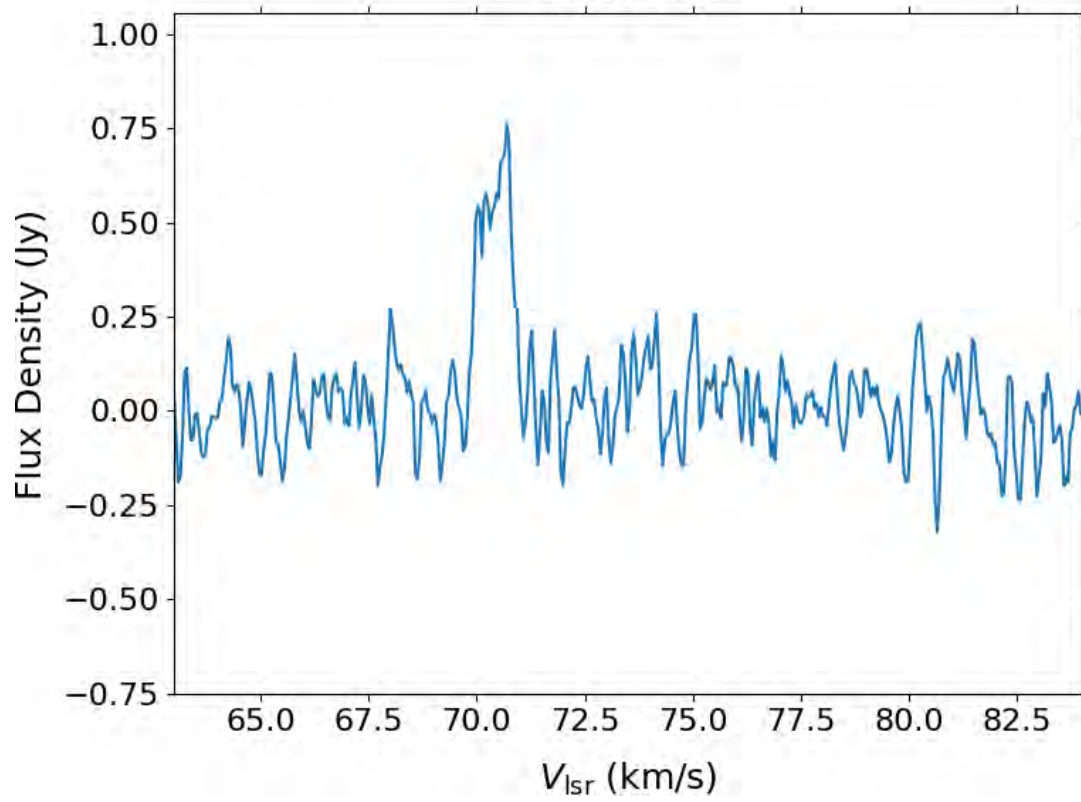
38.08-02

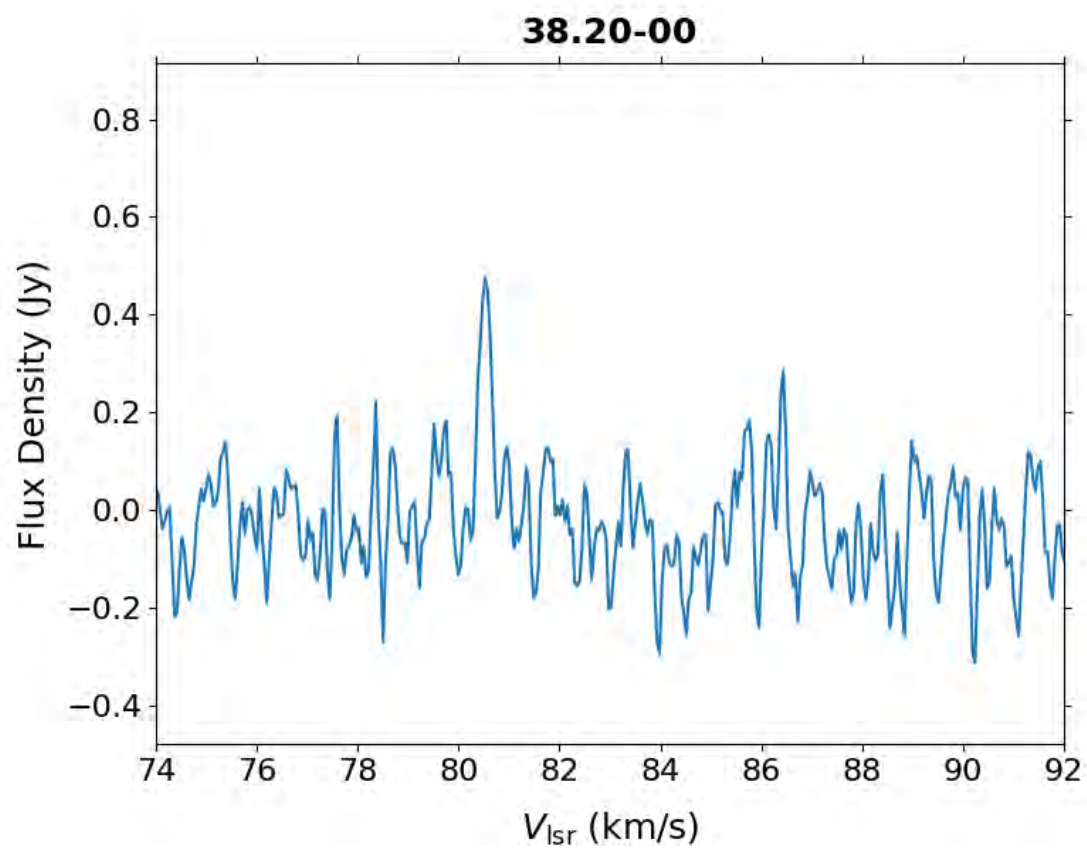
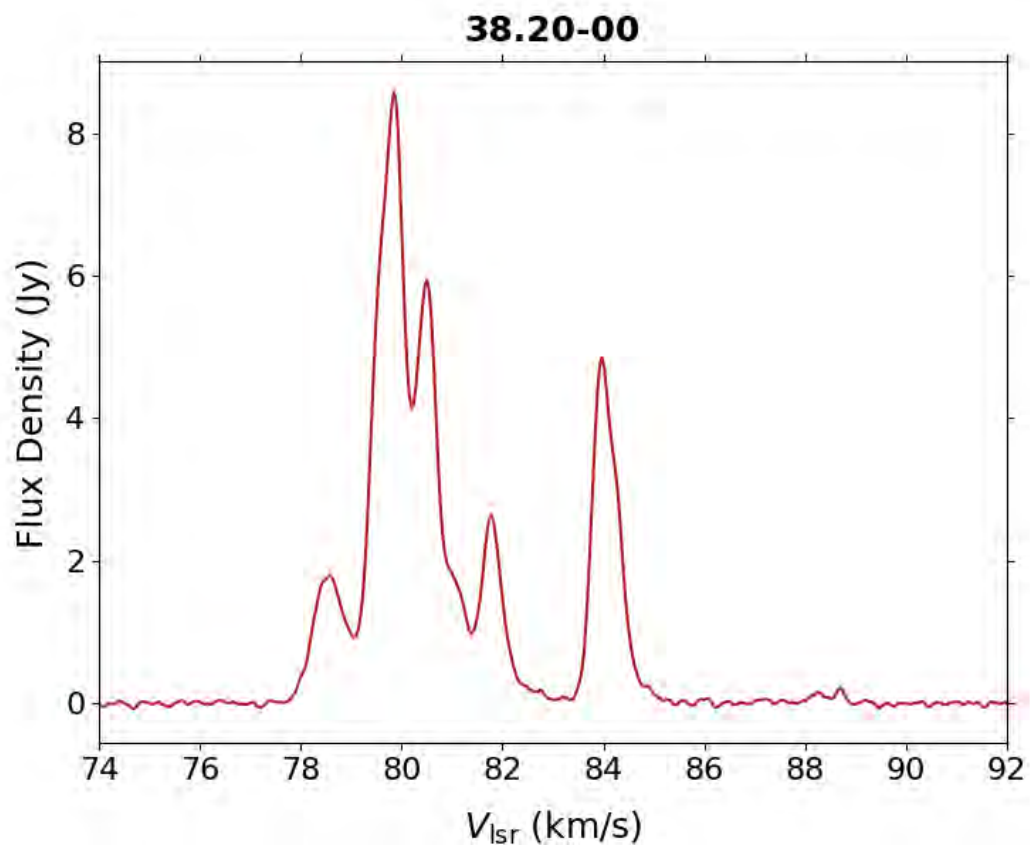


38.12-02

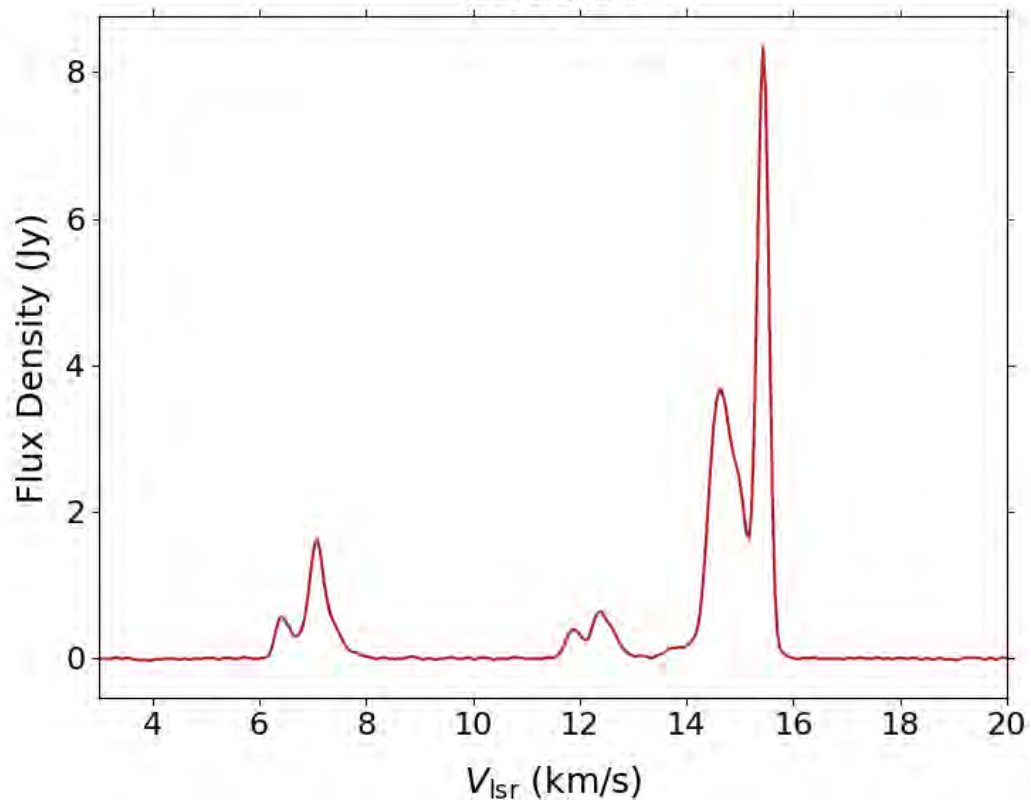


38.12-02

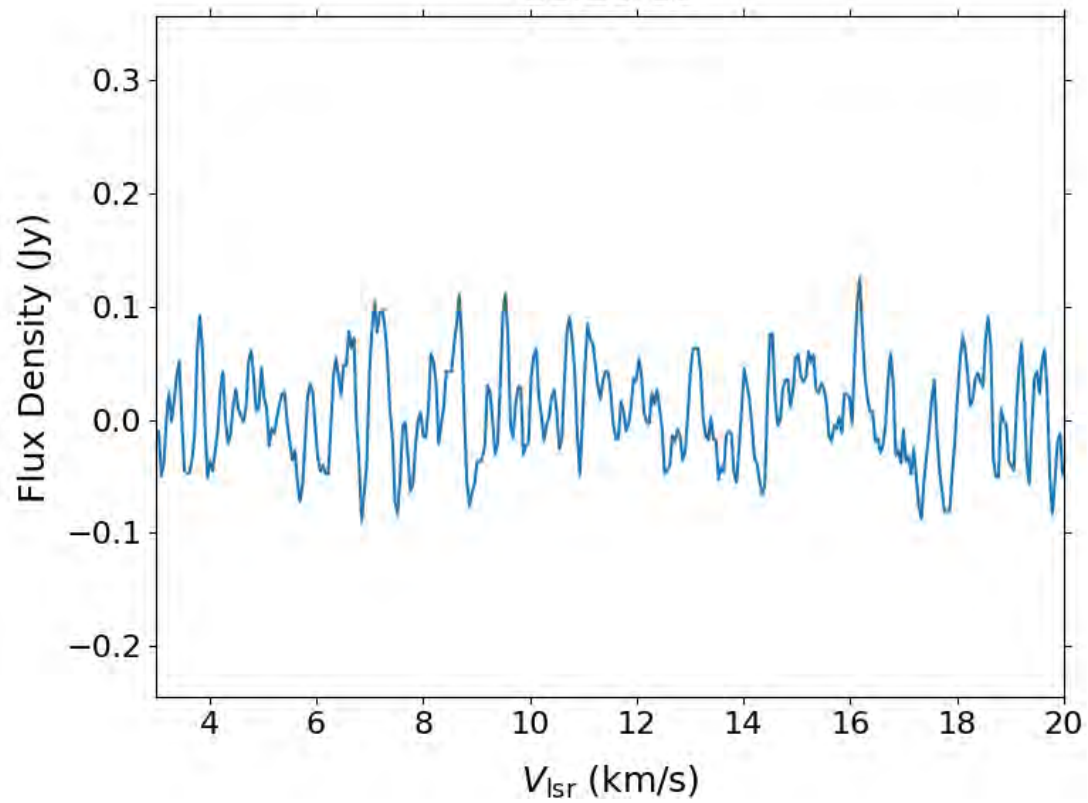




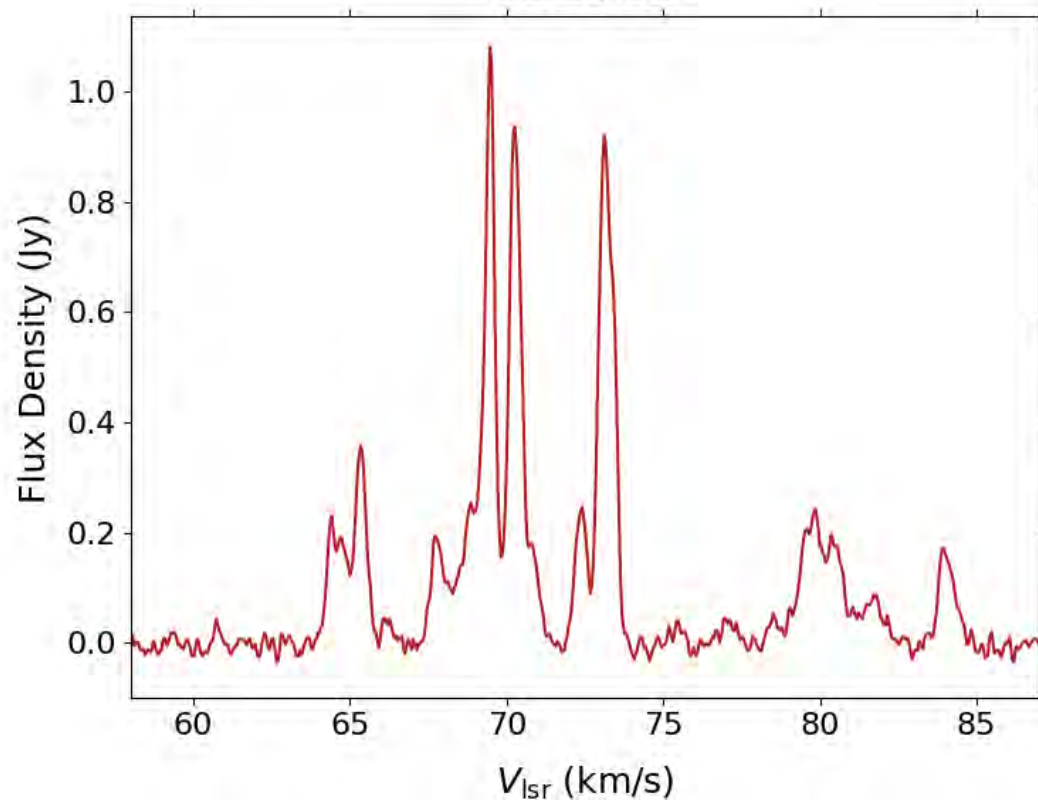
38.26-00



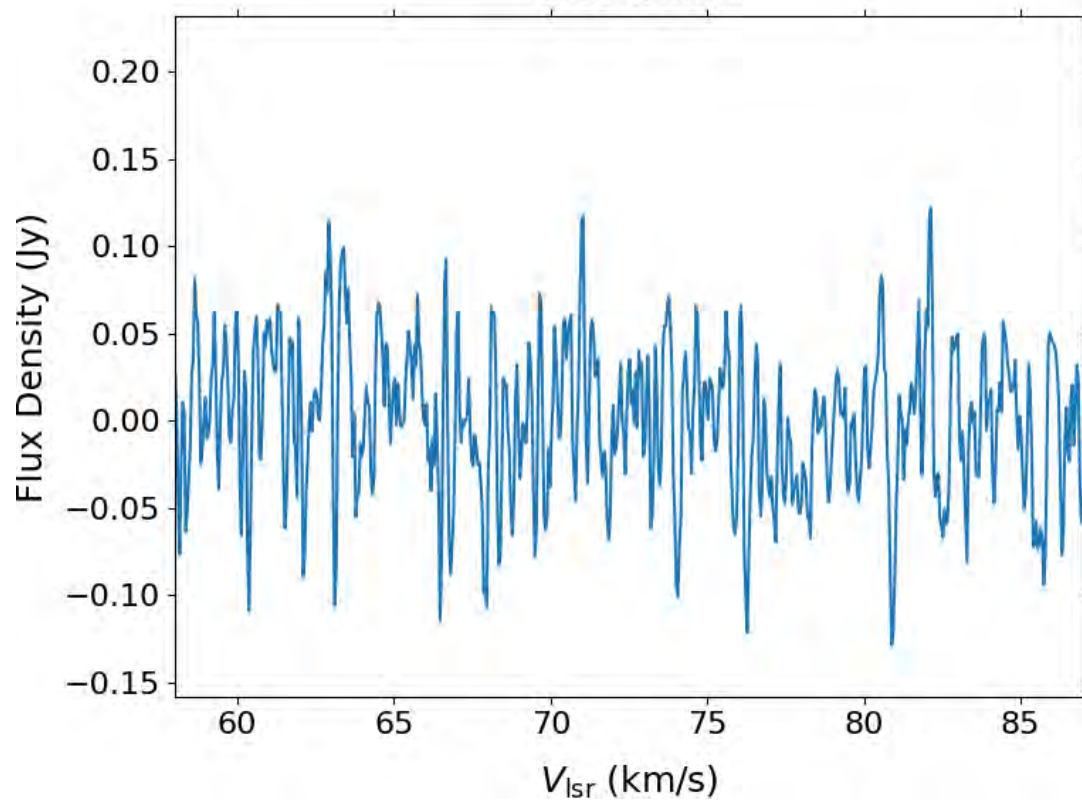
38.26-00

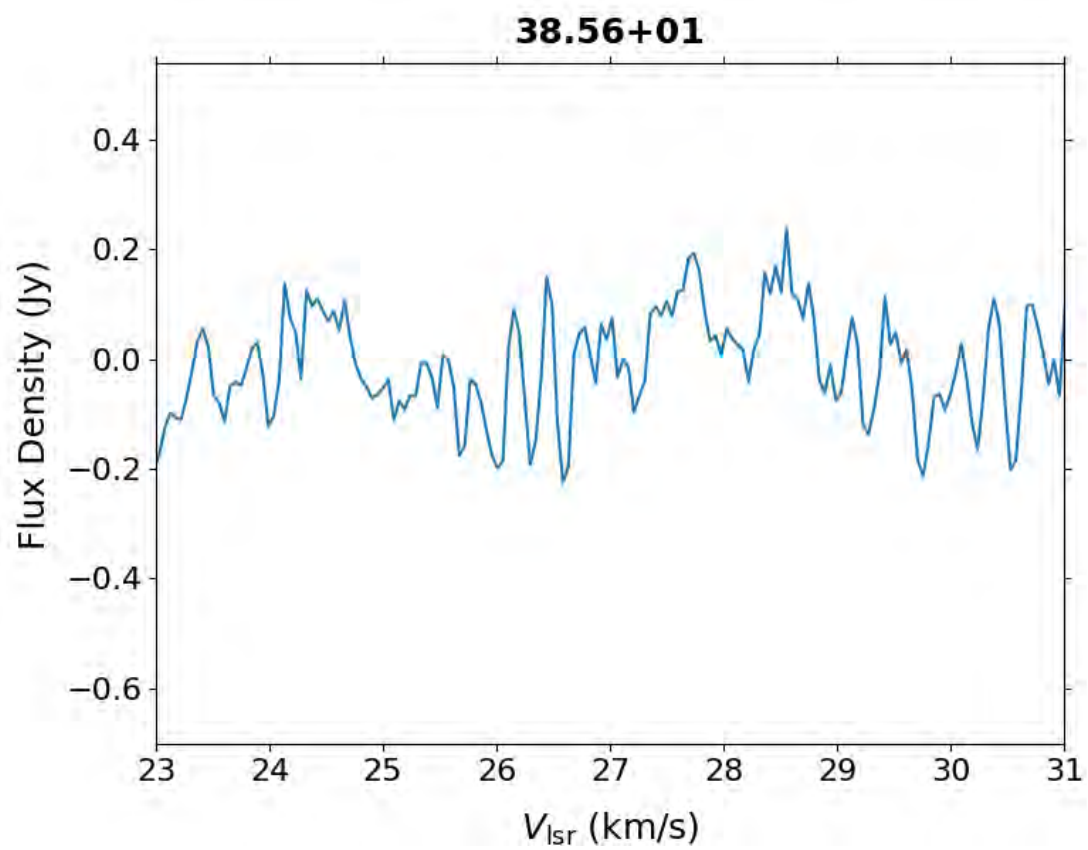
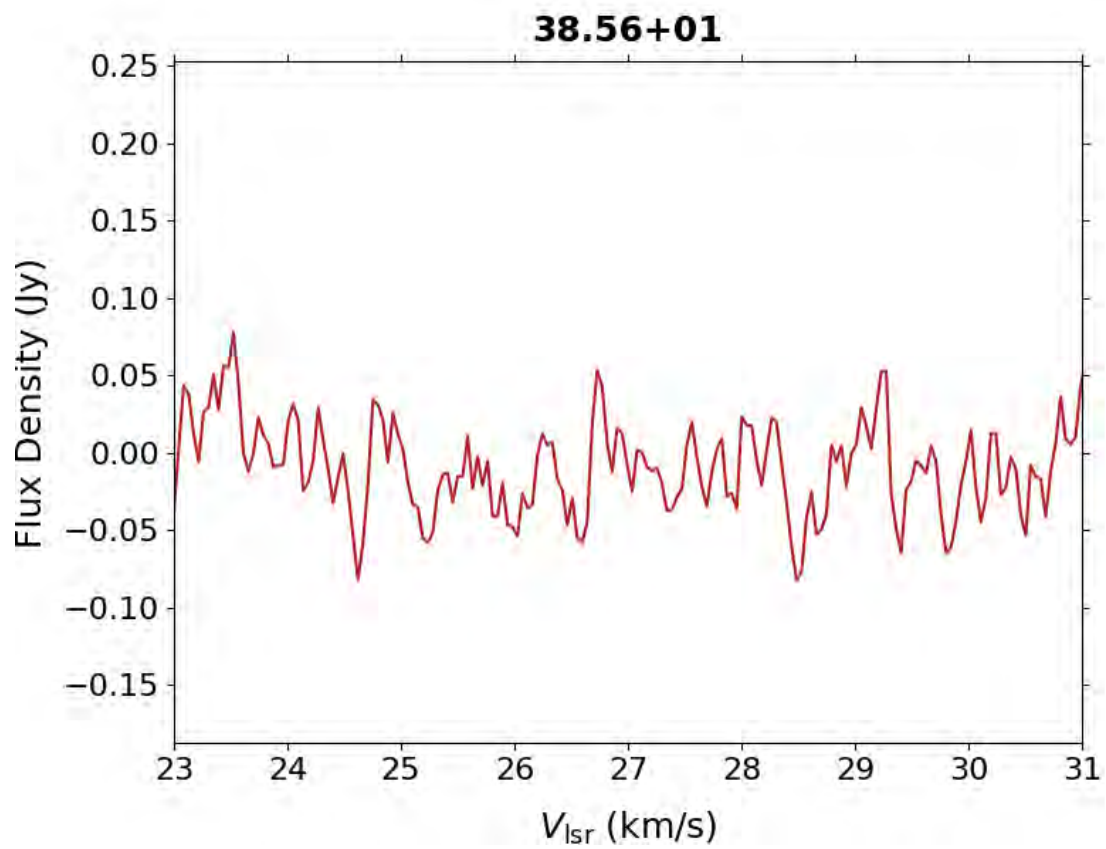


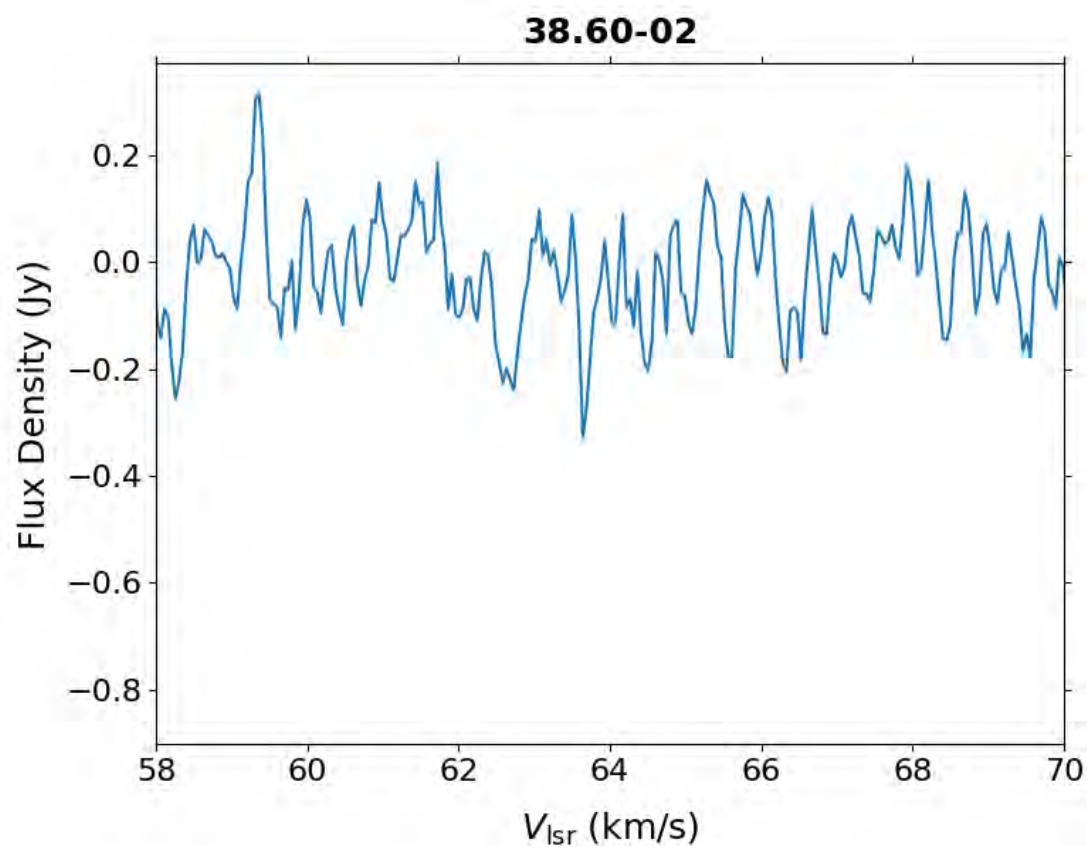
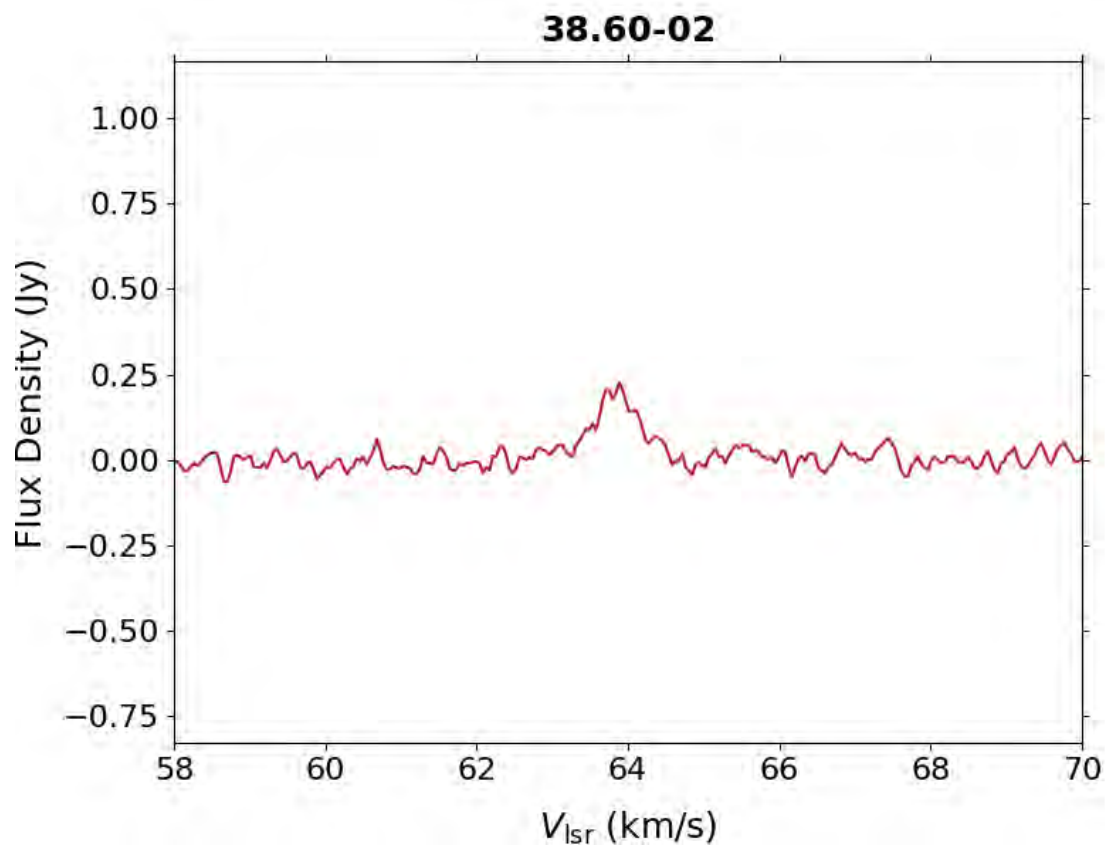
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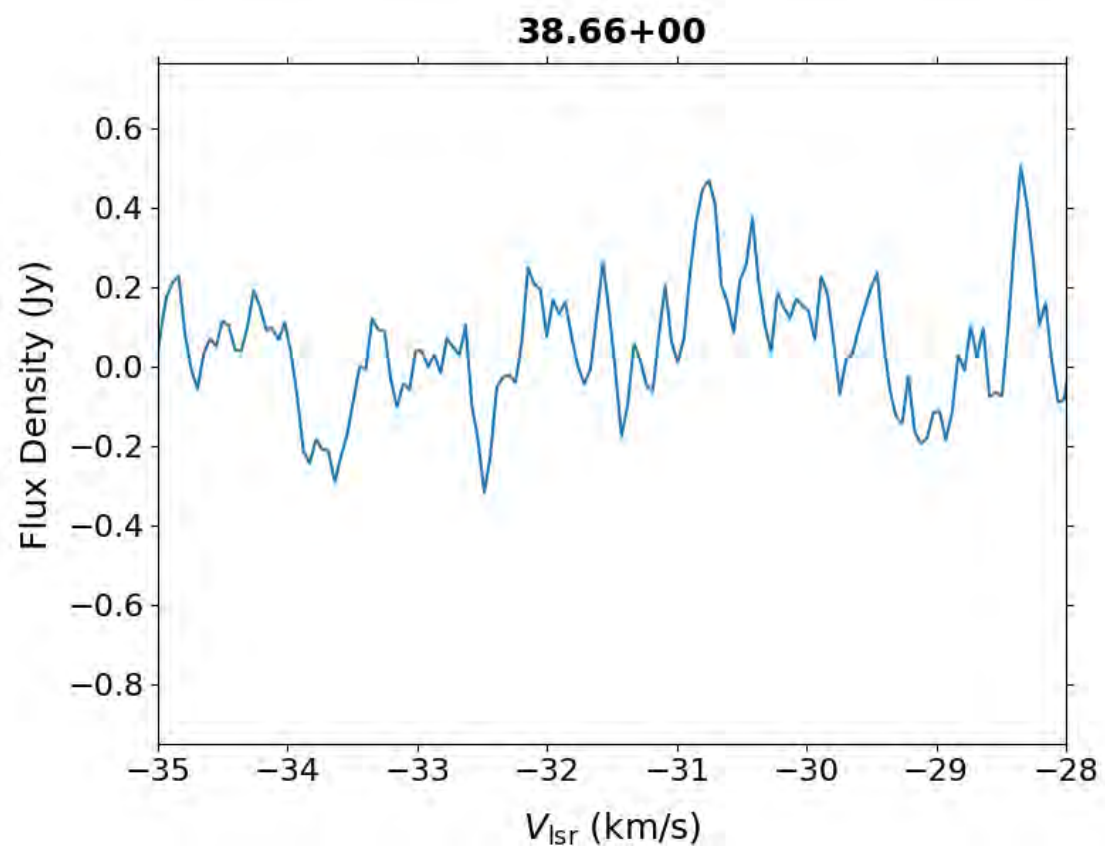
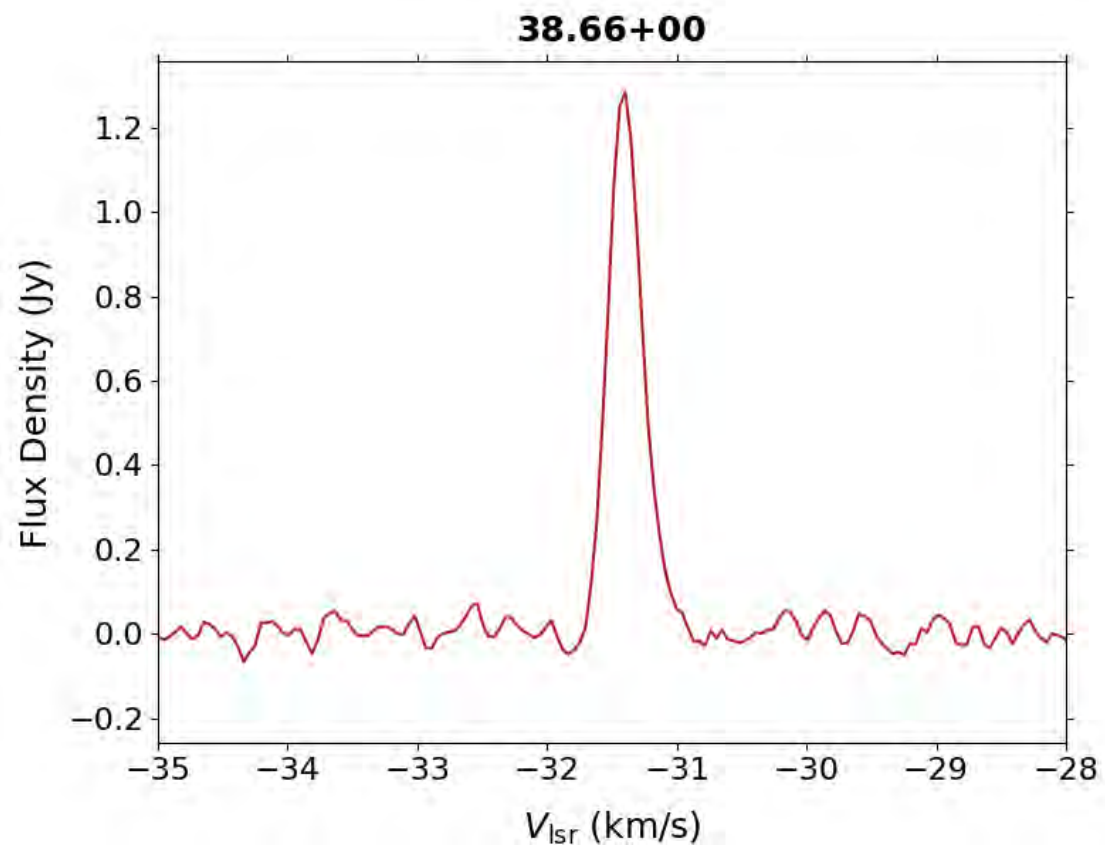


38.26-02

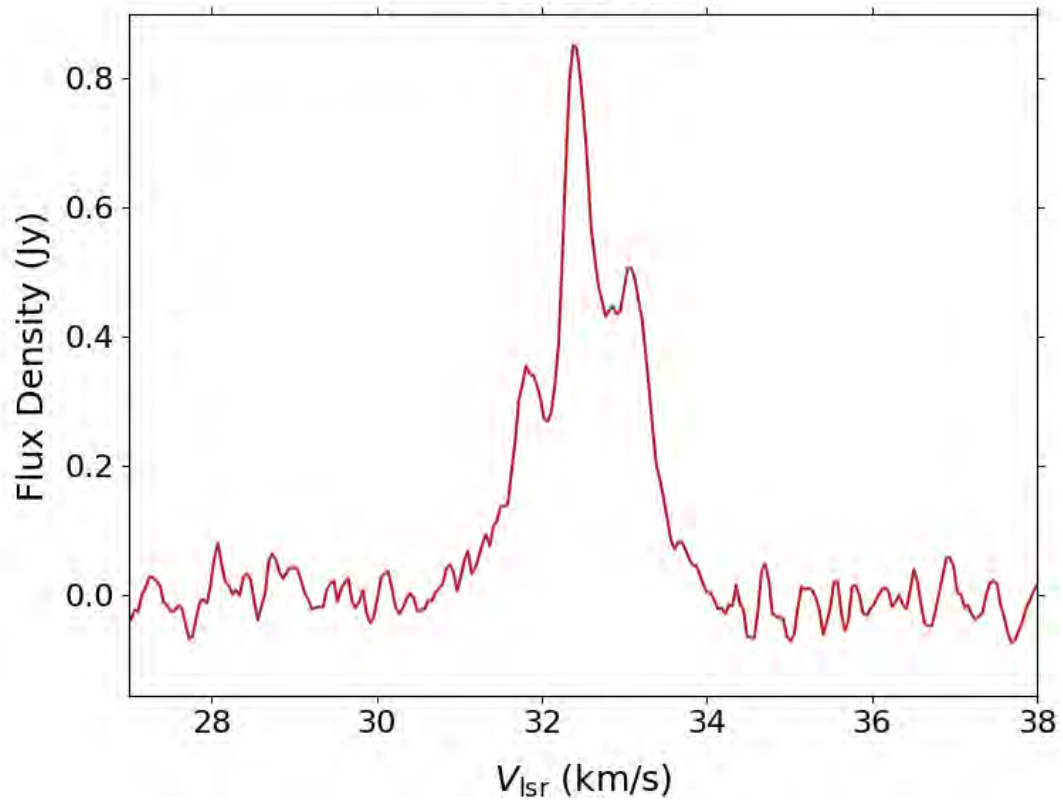




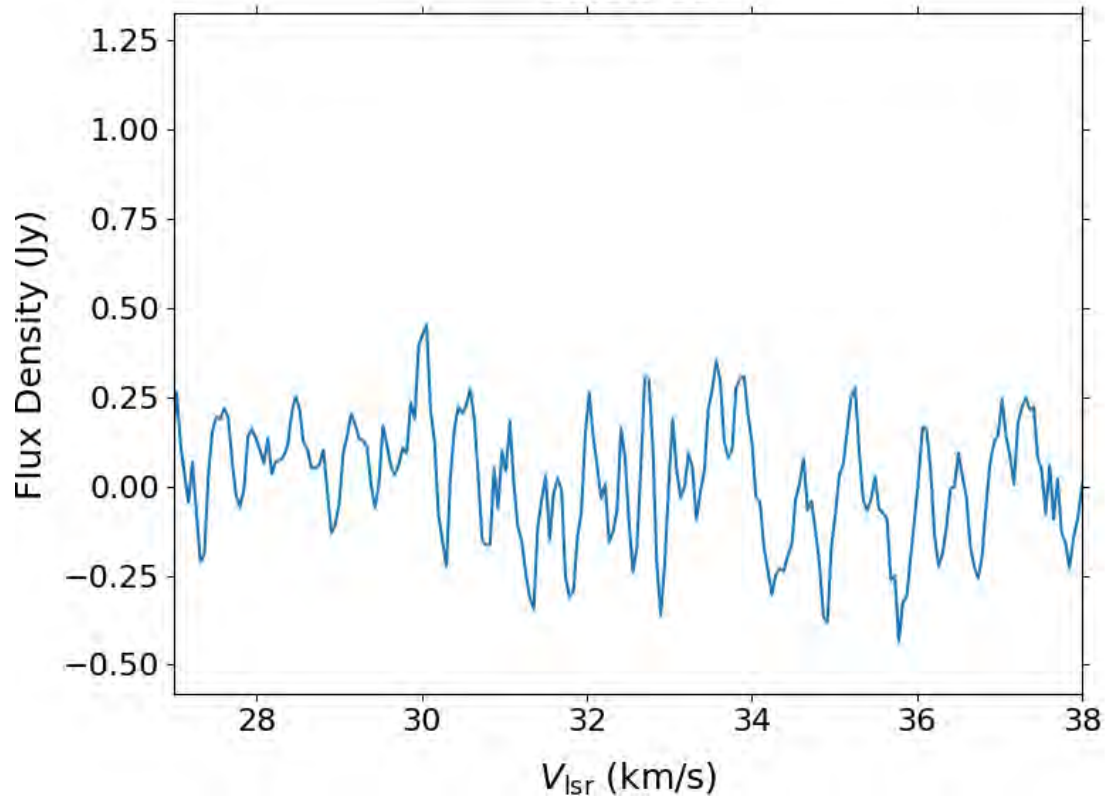


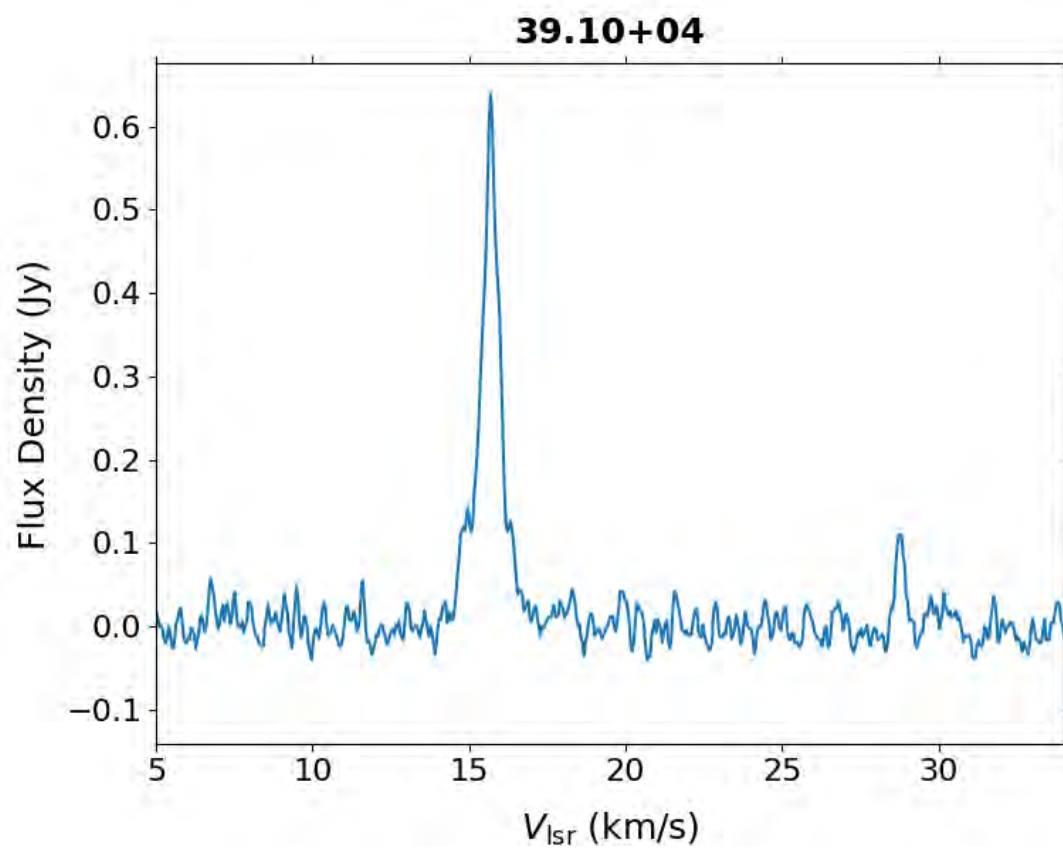
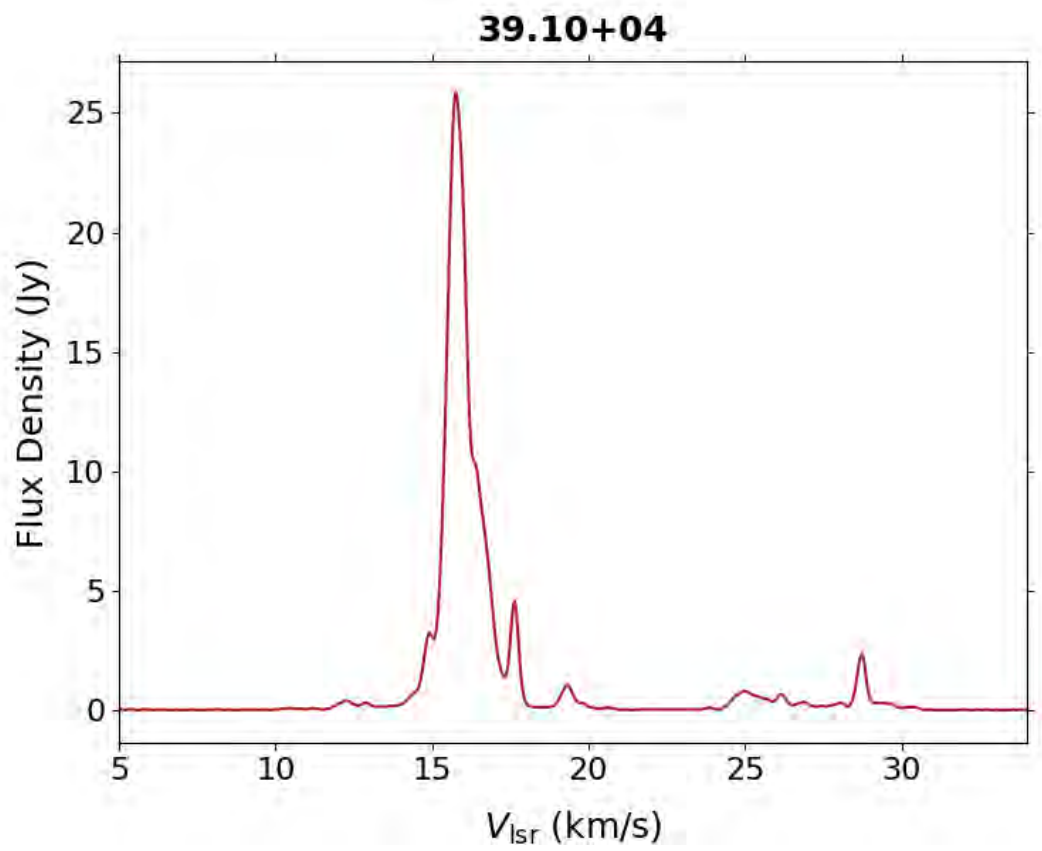


38.92-03

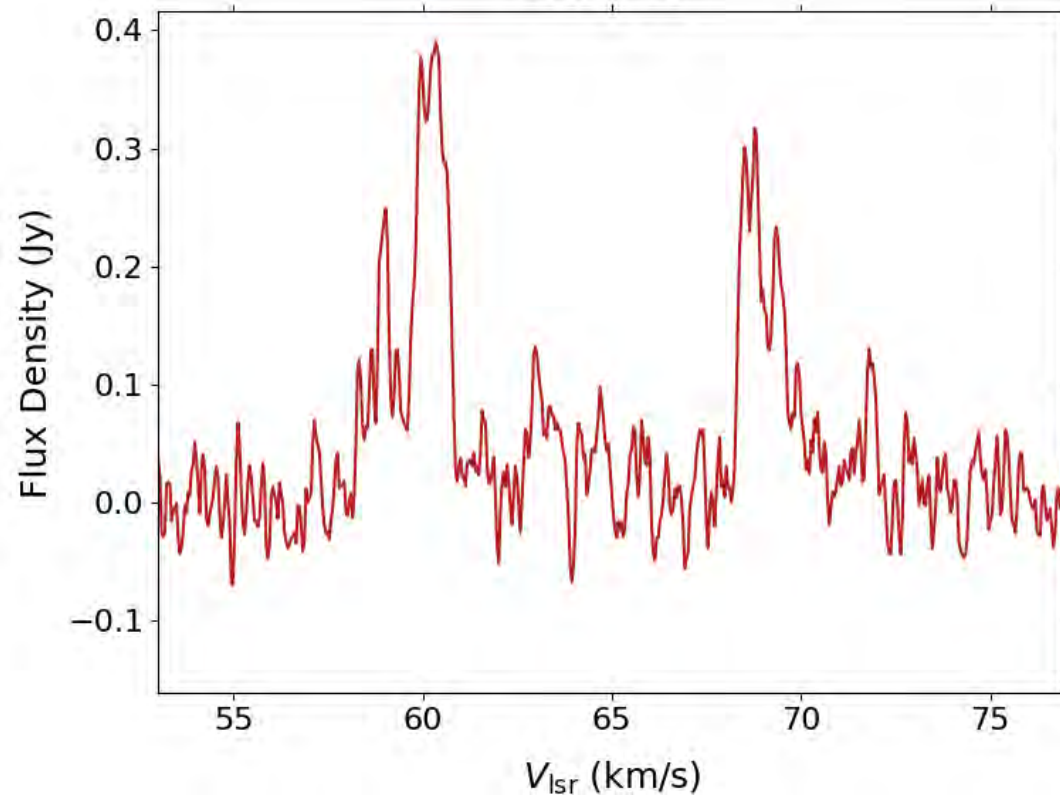


38.92-03

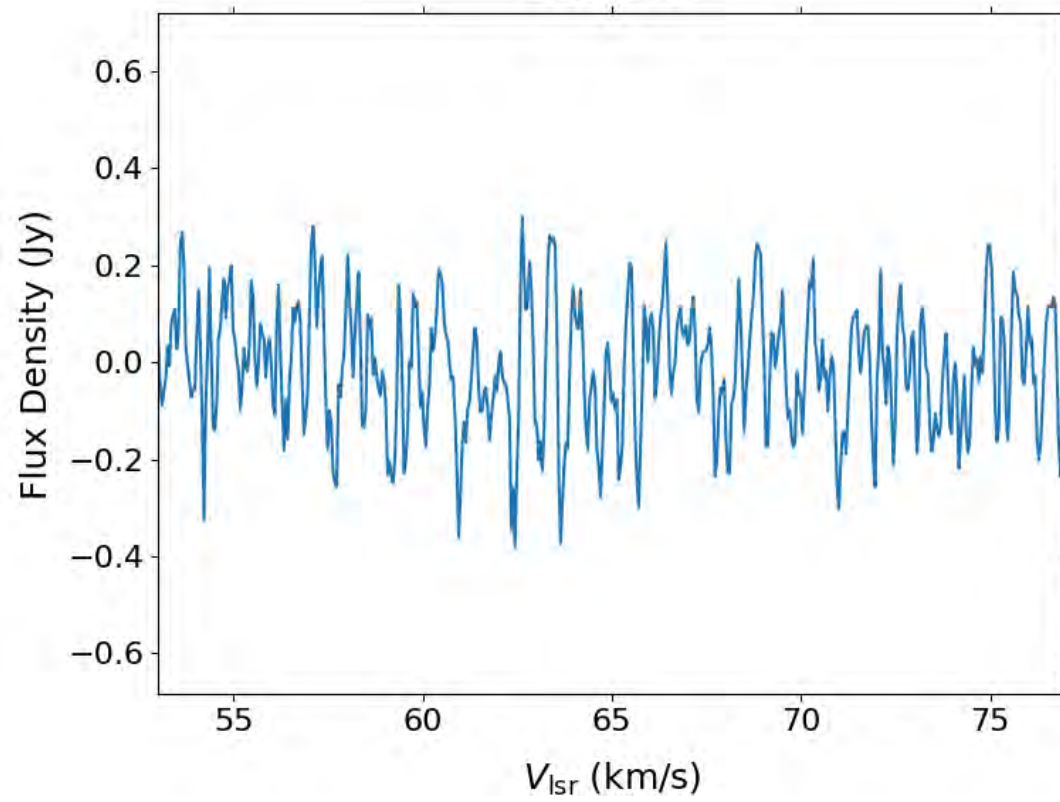


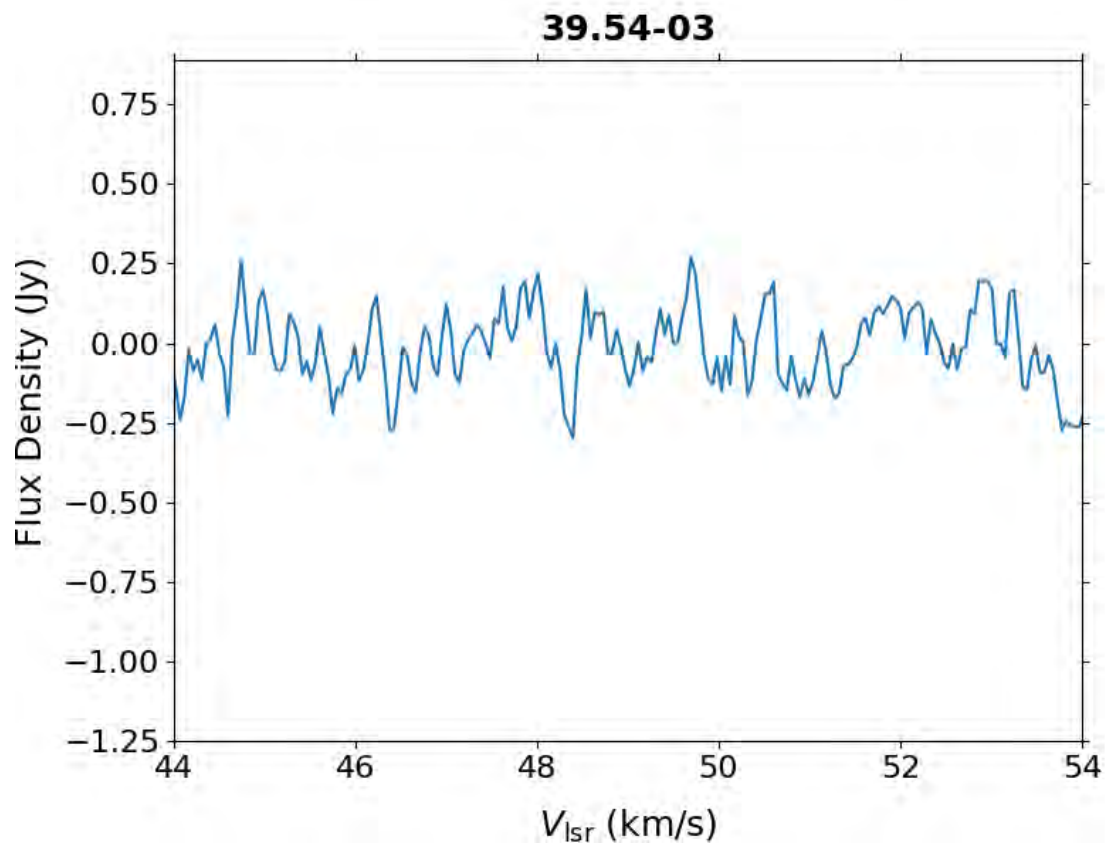
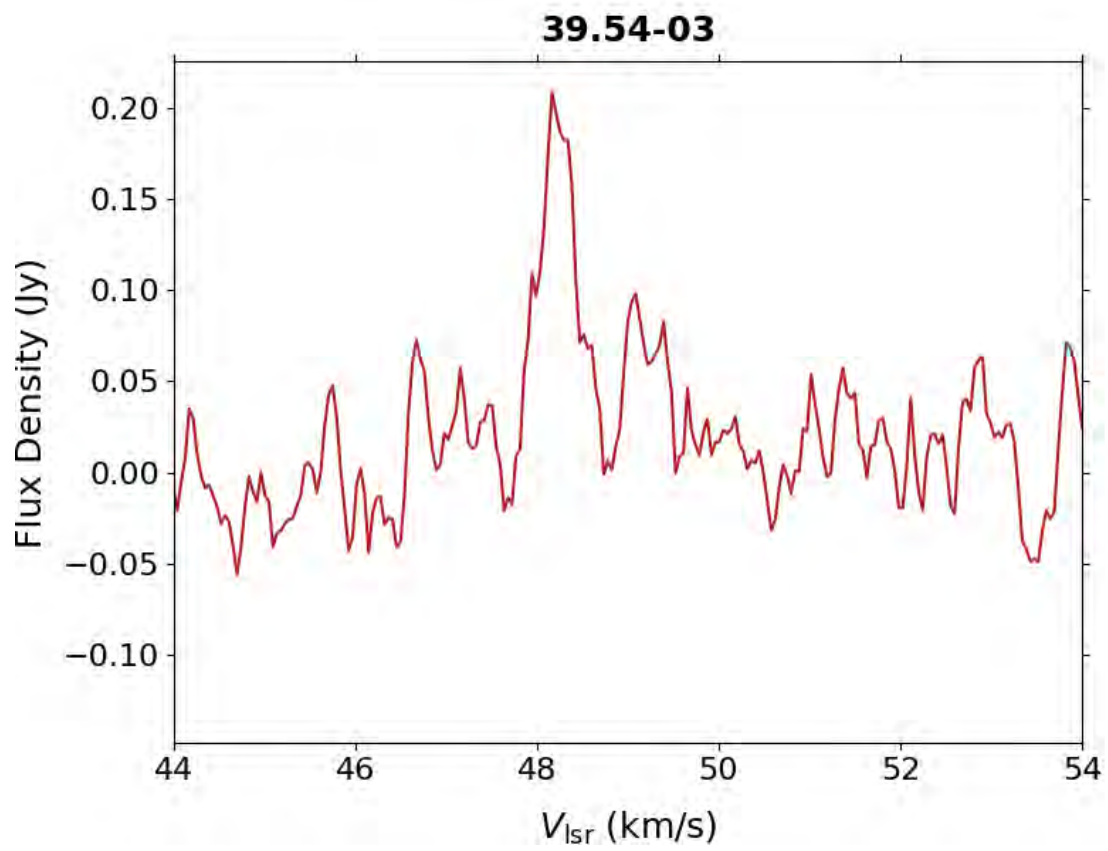


39.39-01

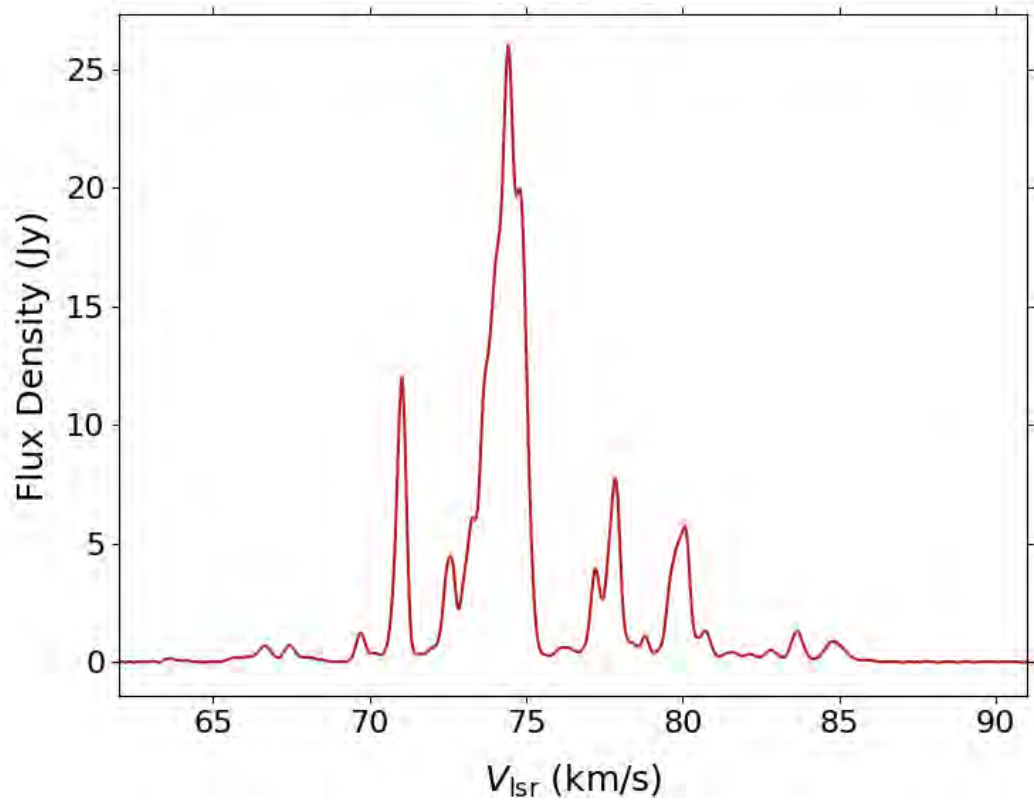


39.39-01

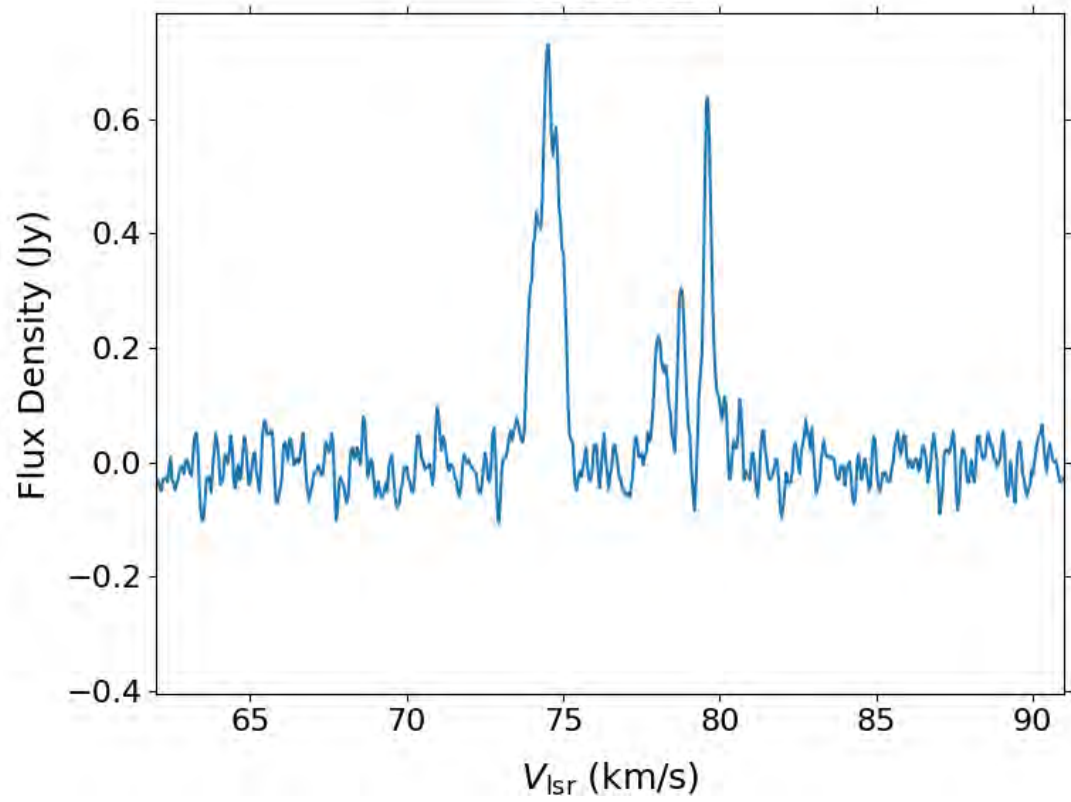


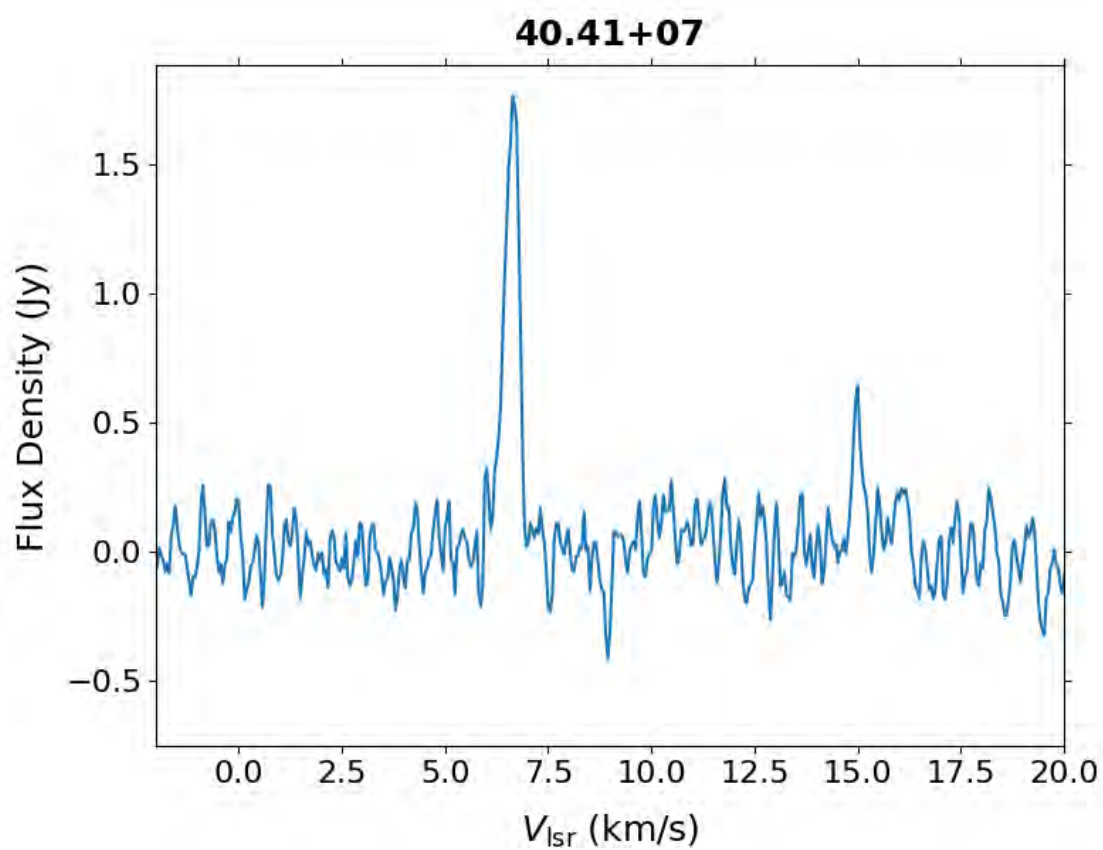
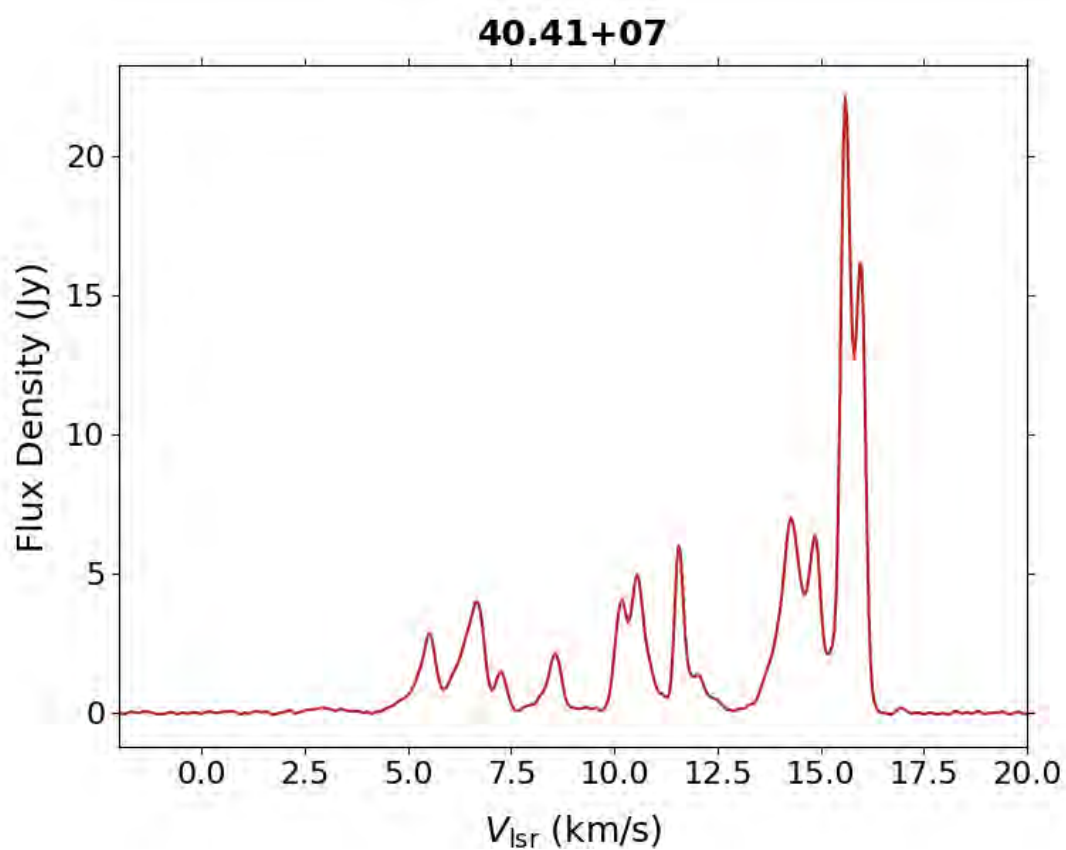


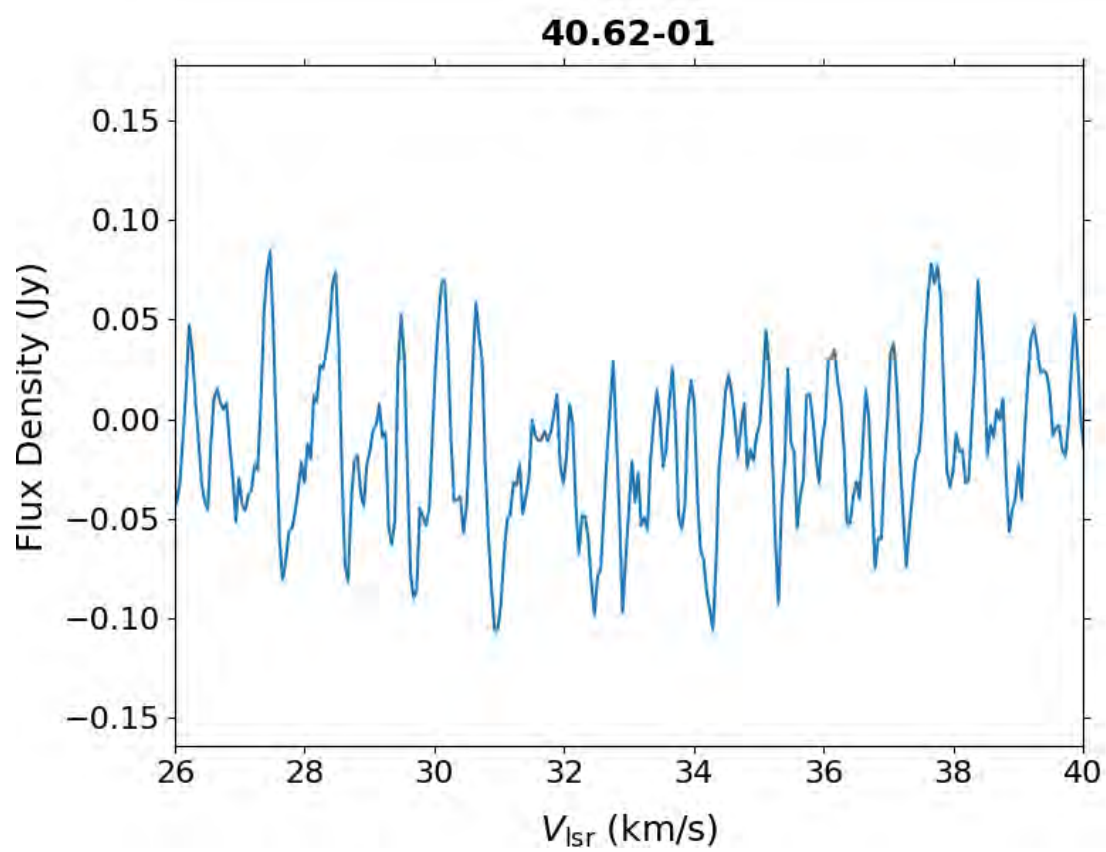
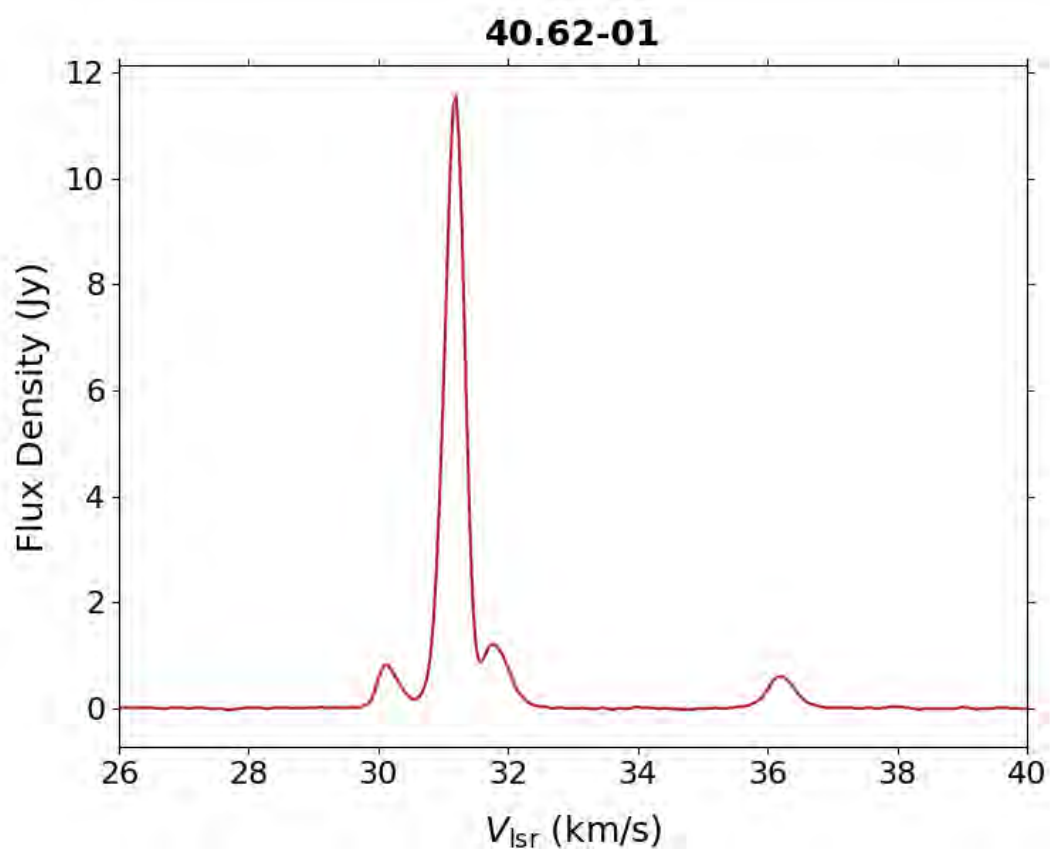
40.28-02



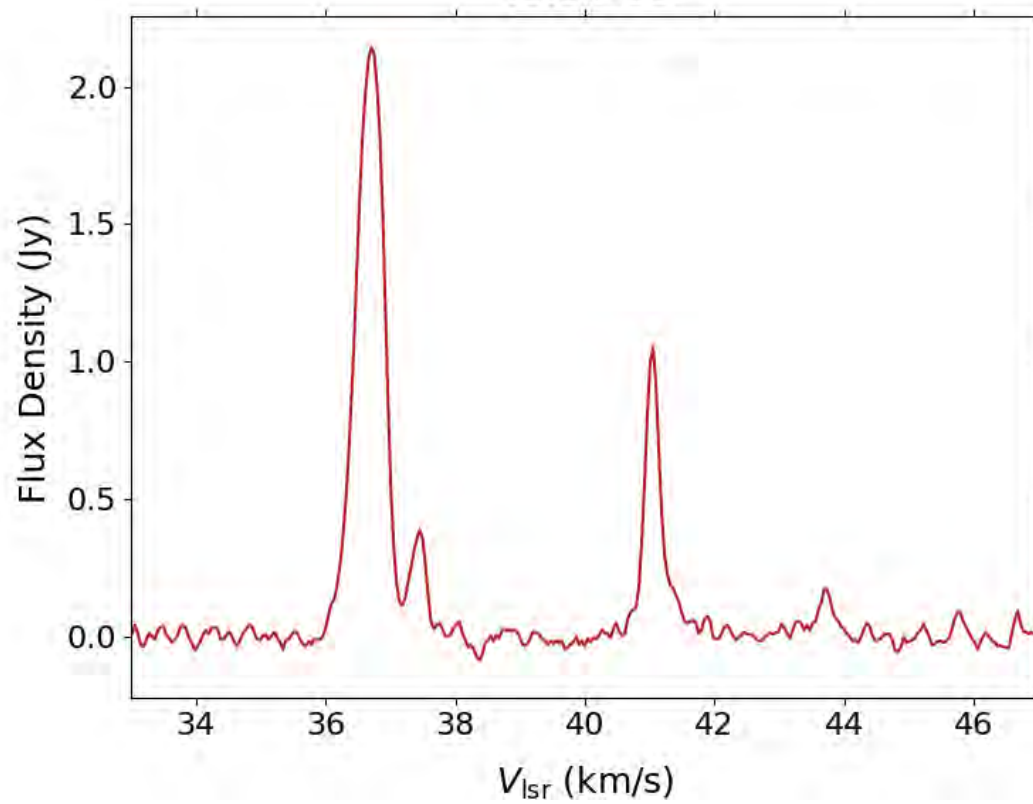
40.28-02



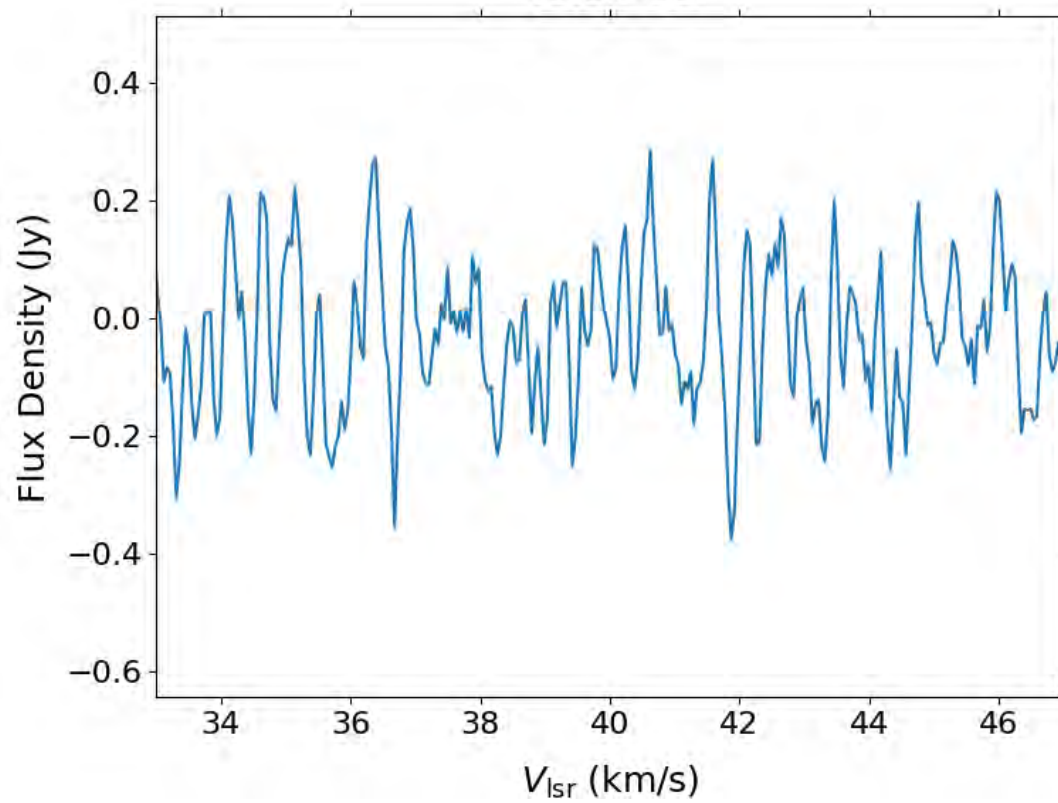




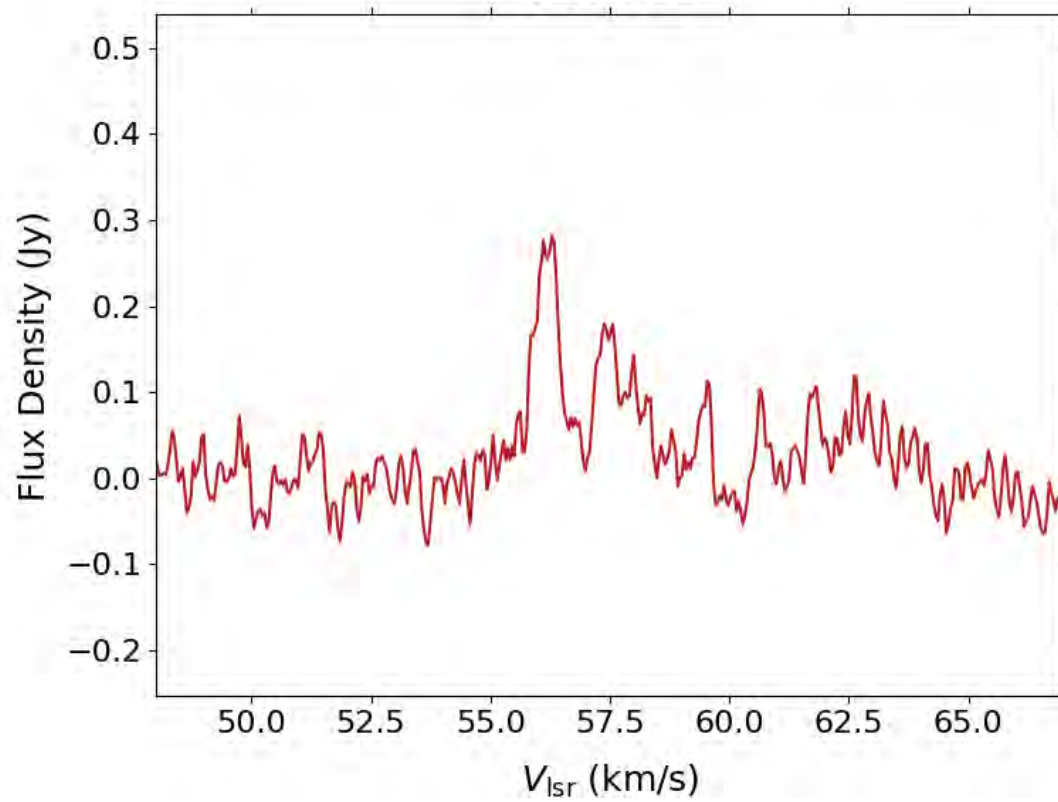
40.94-00



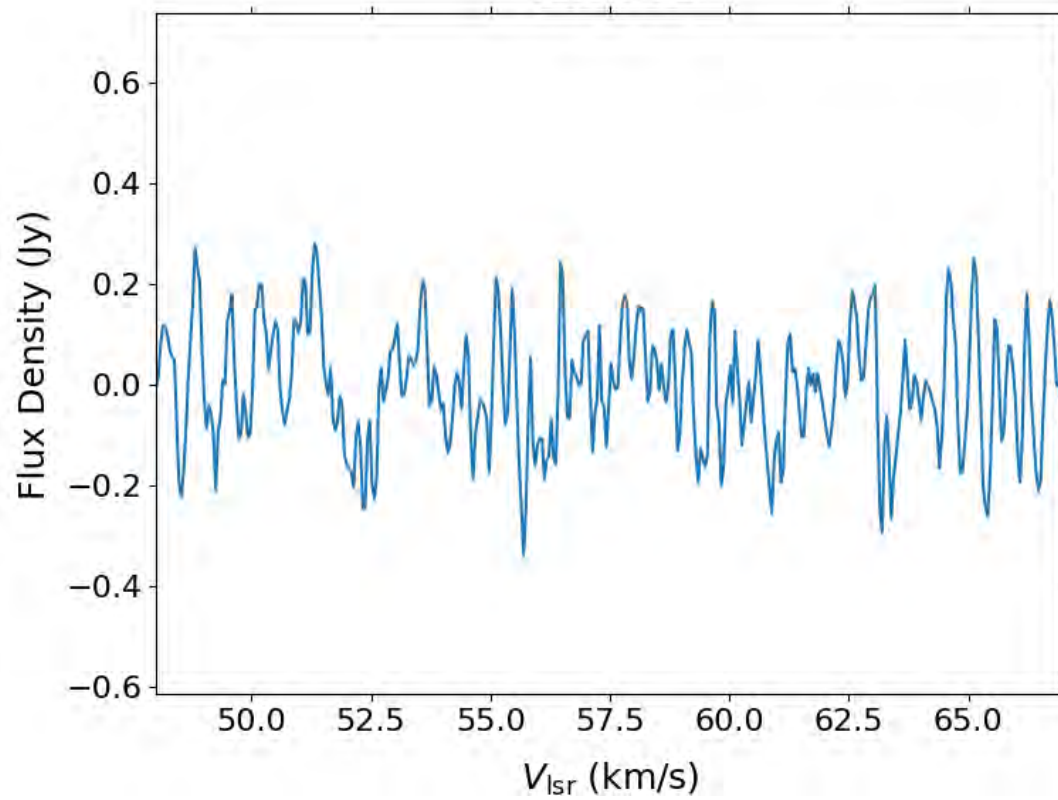
40.94-00

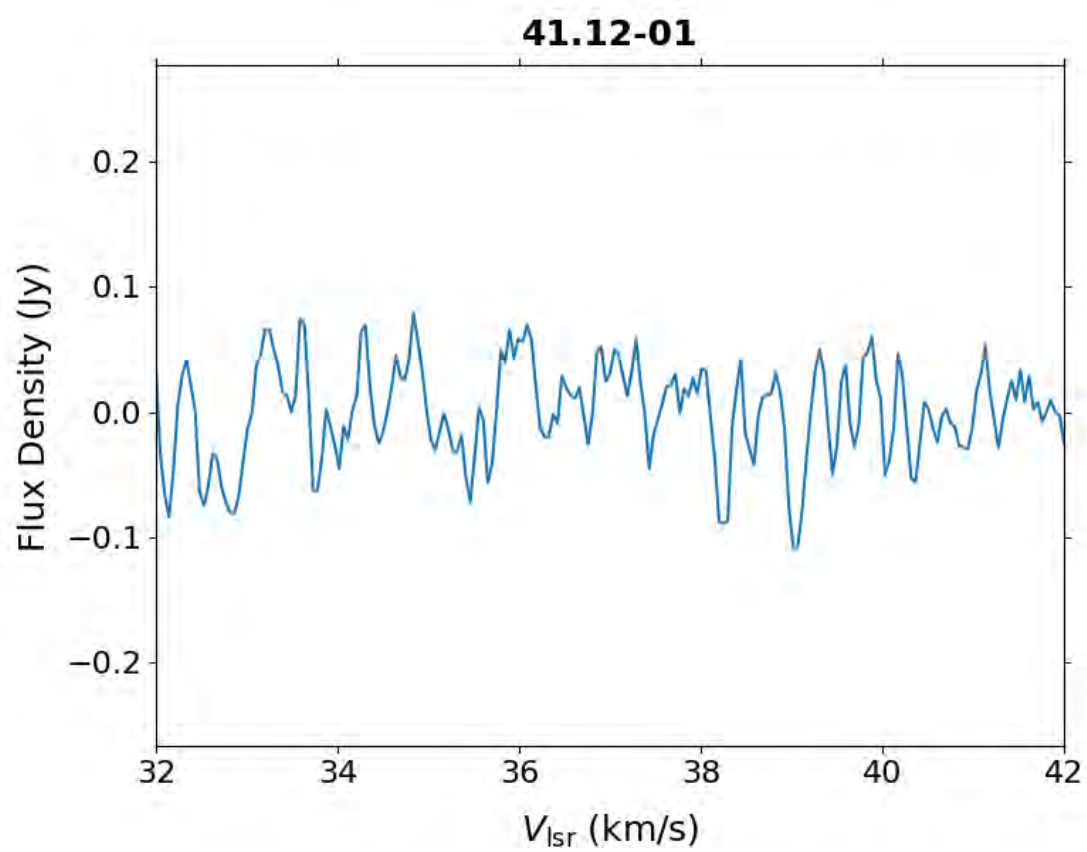
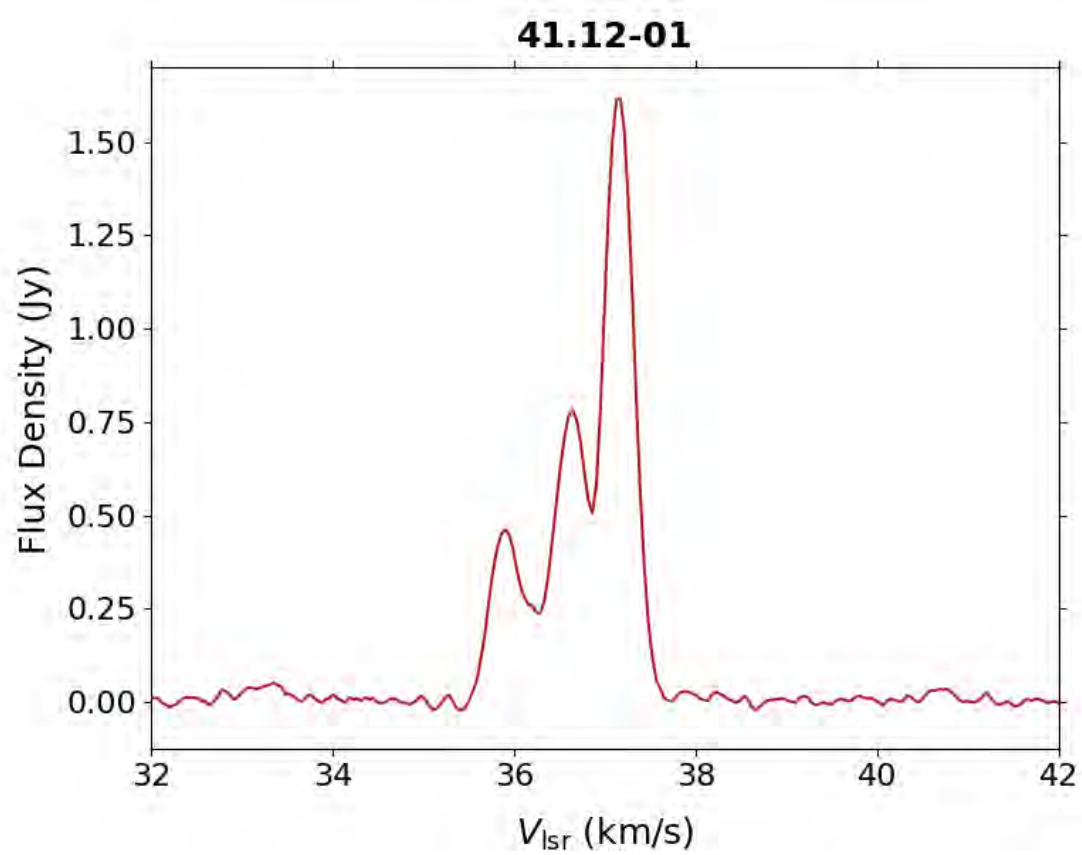


41.08-01

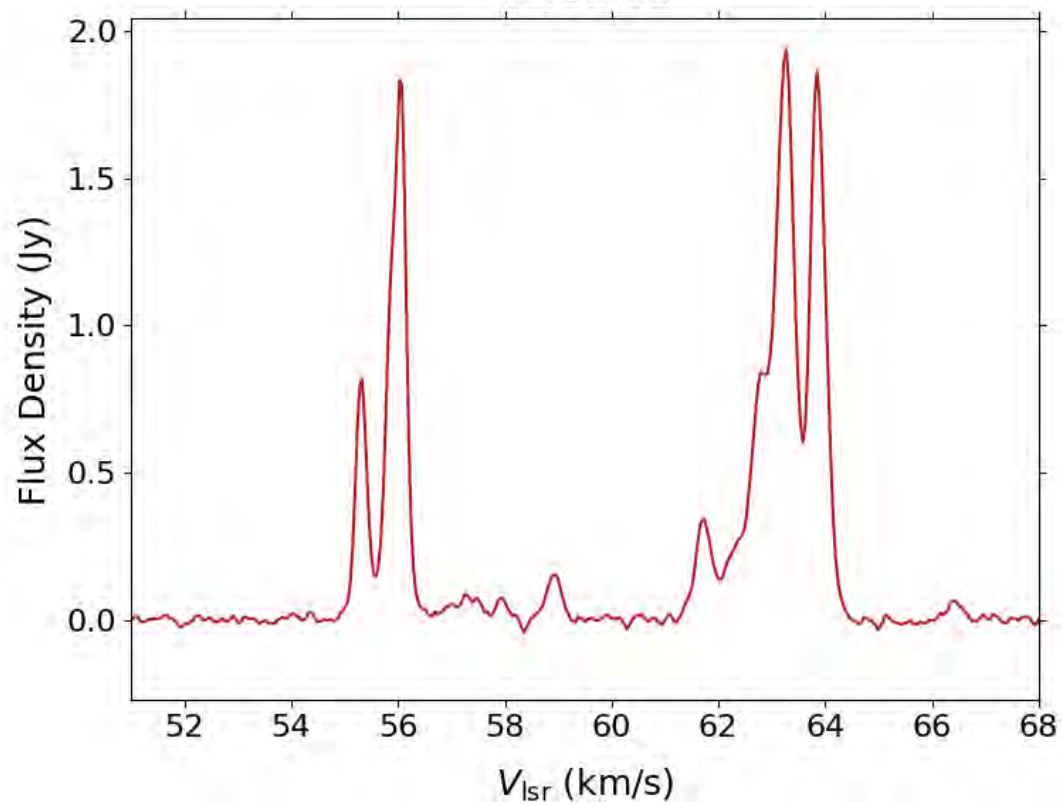


41.08-01

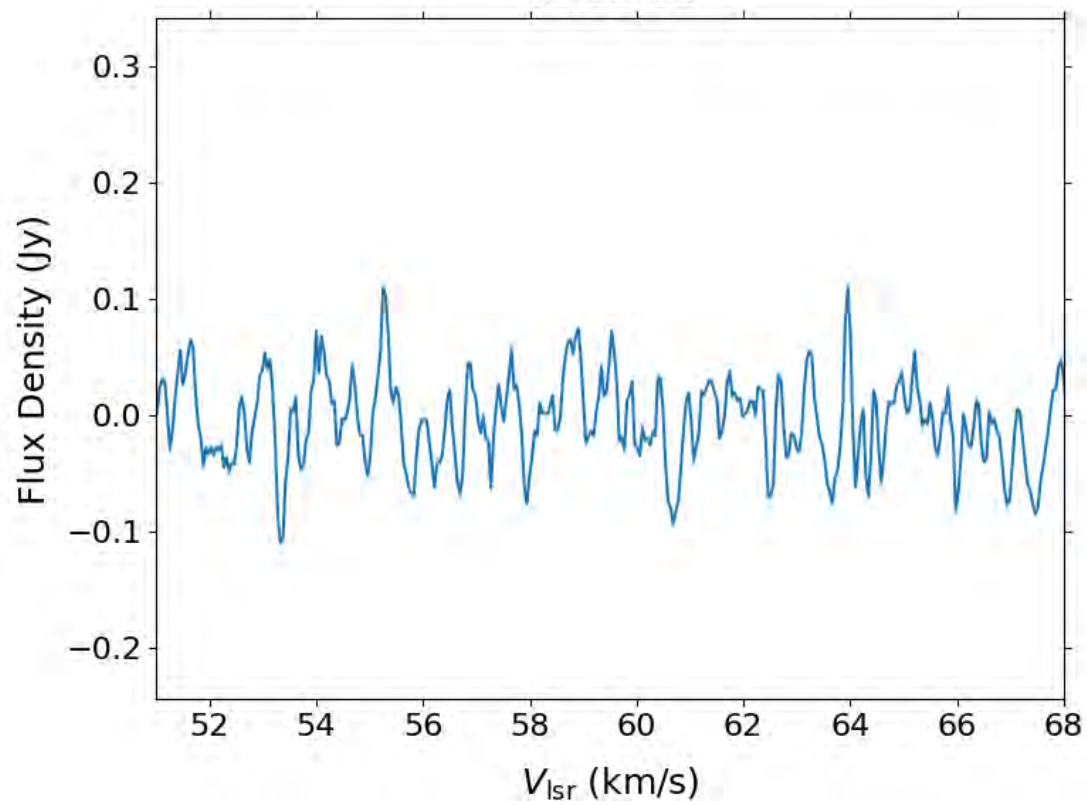




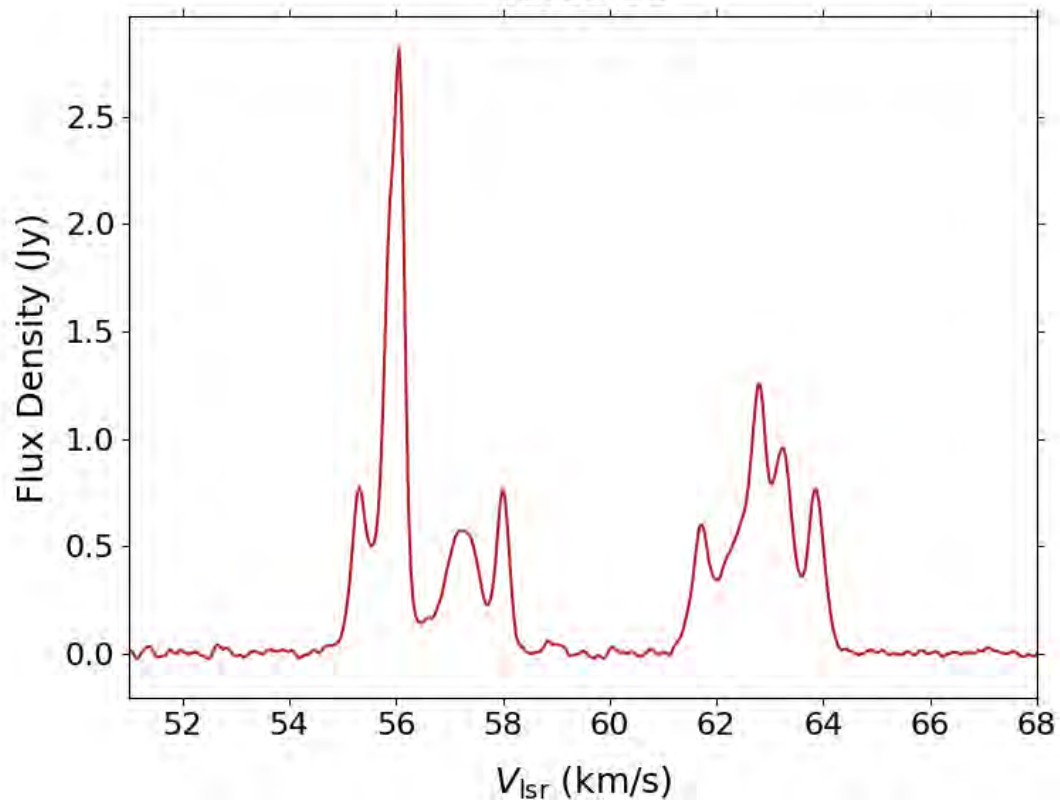
41.12-02



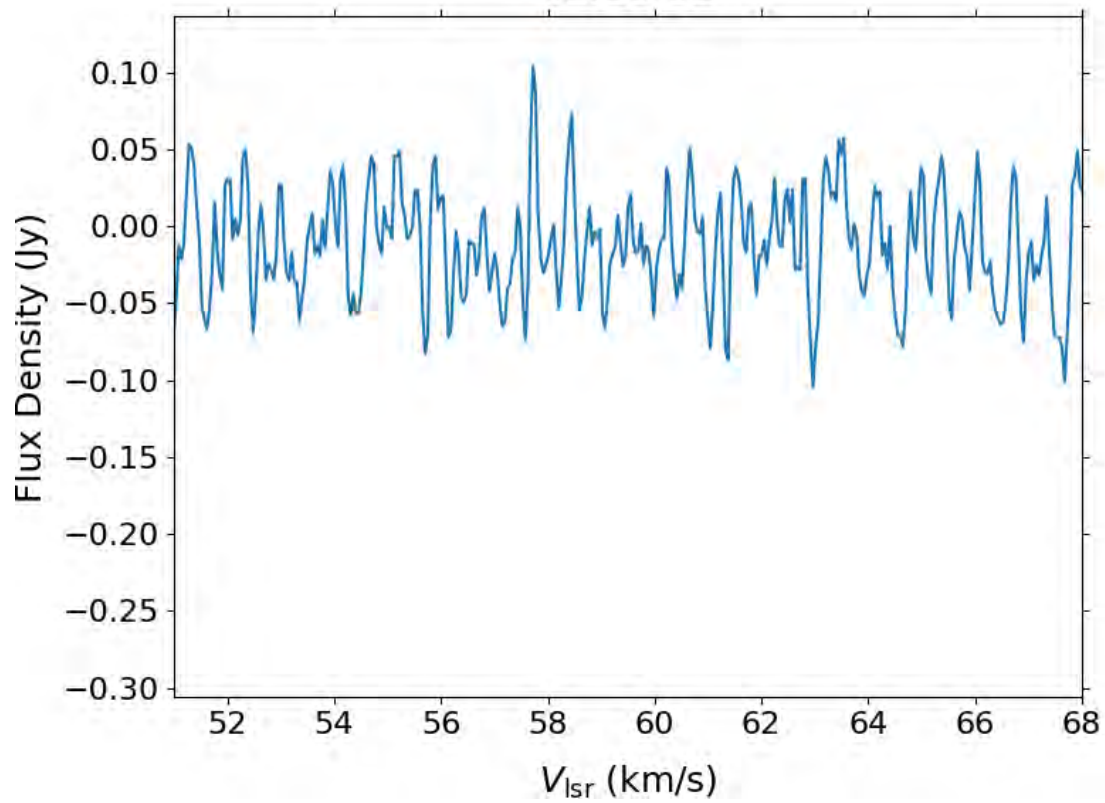
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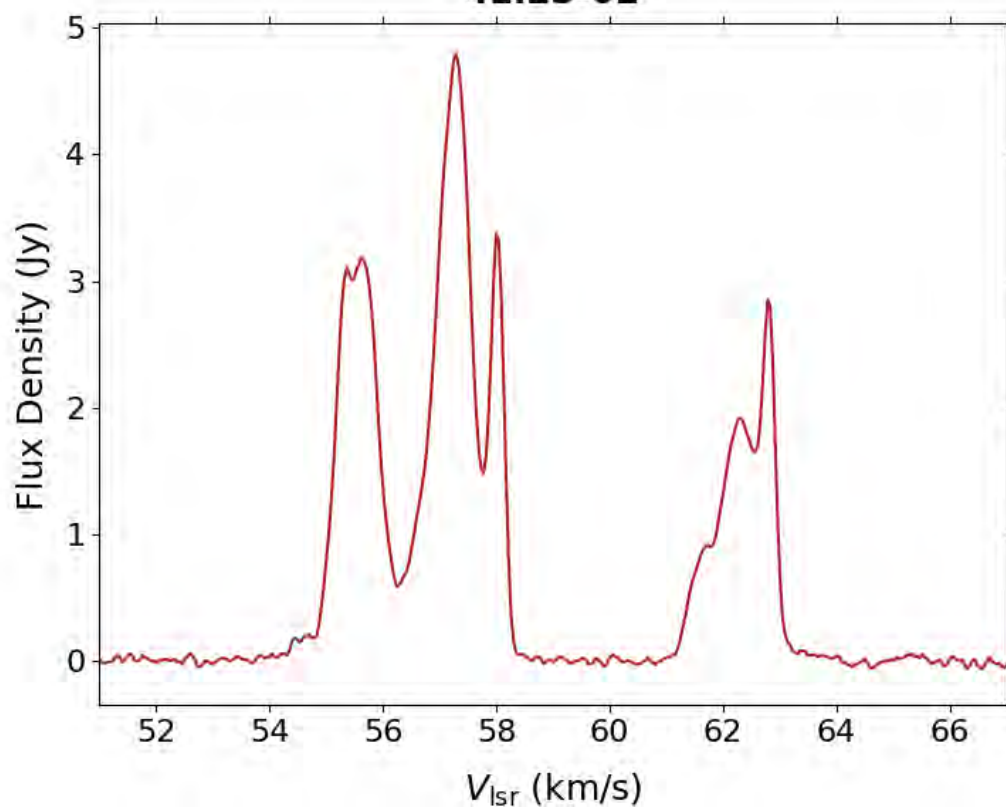
41.16-02



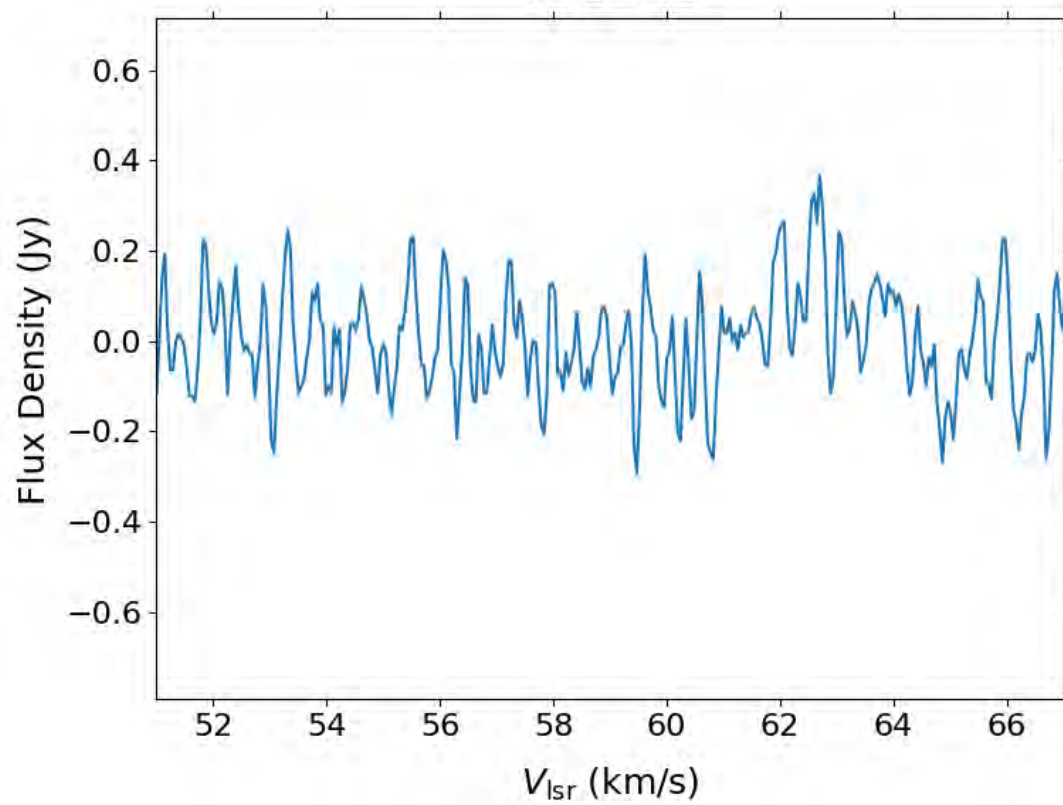
41.16-02

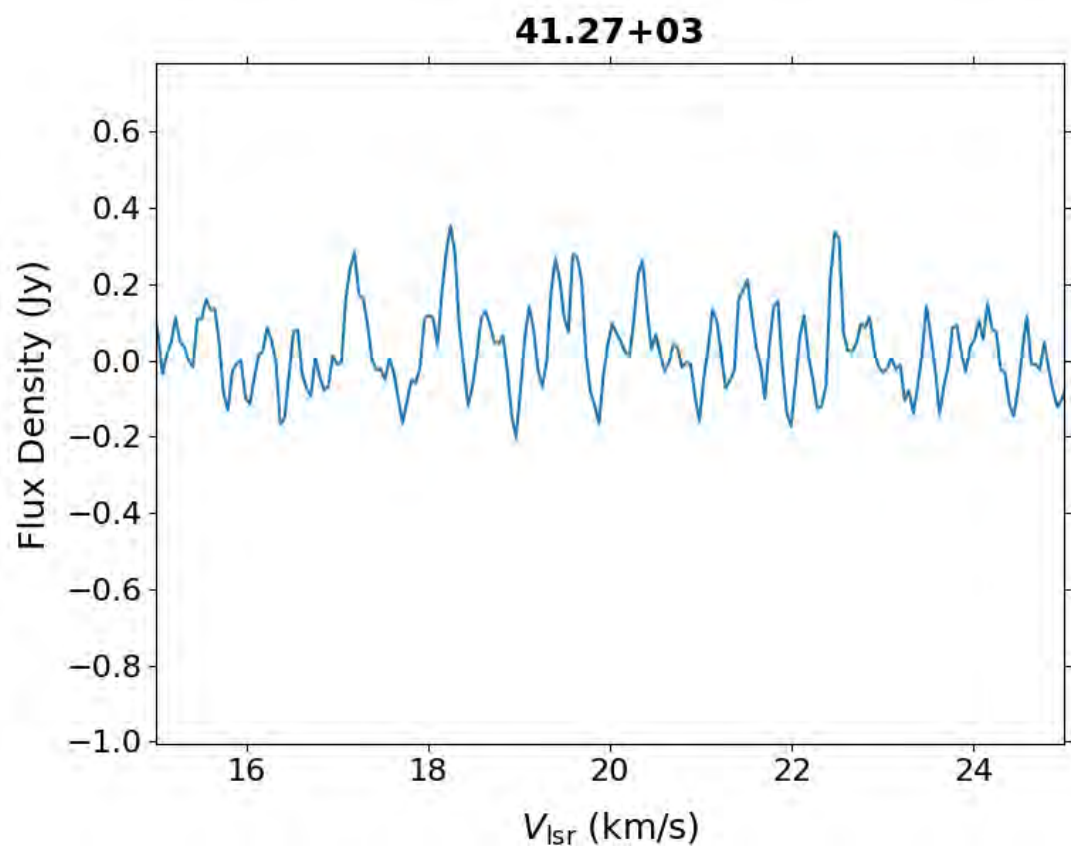
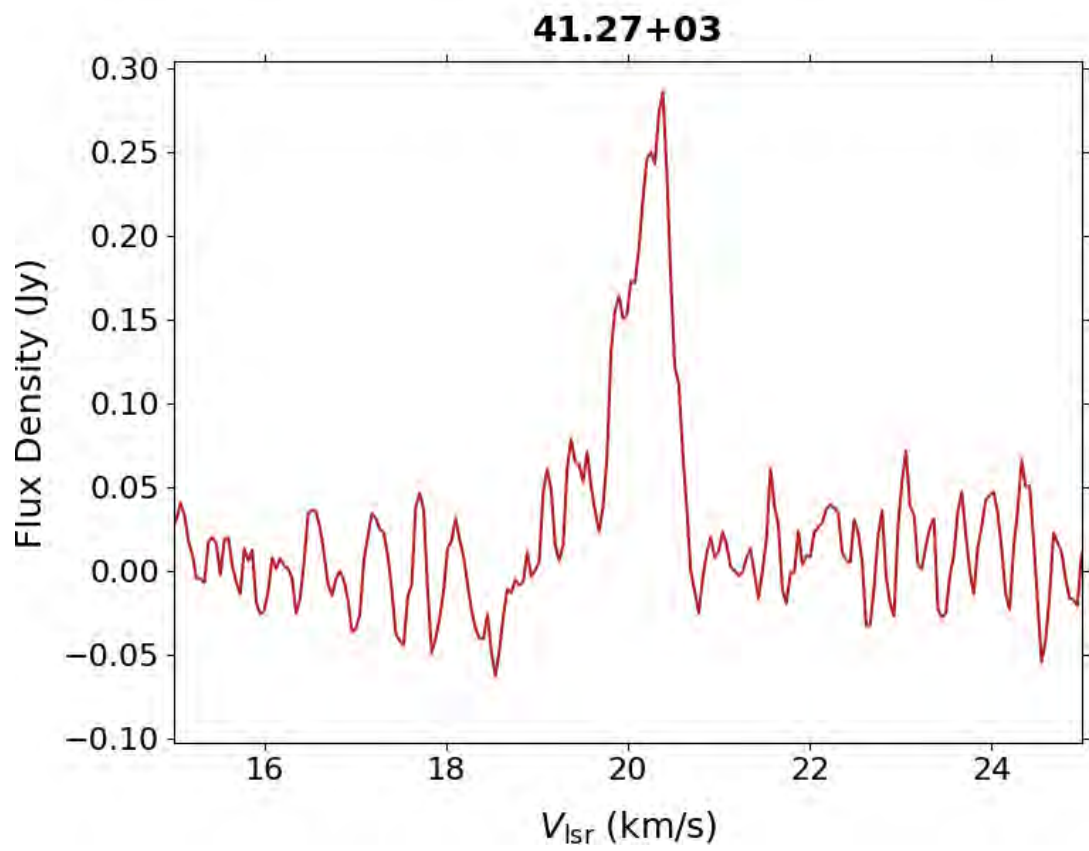


41.23-02

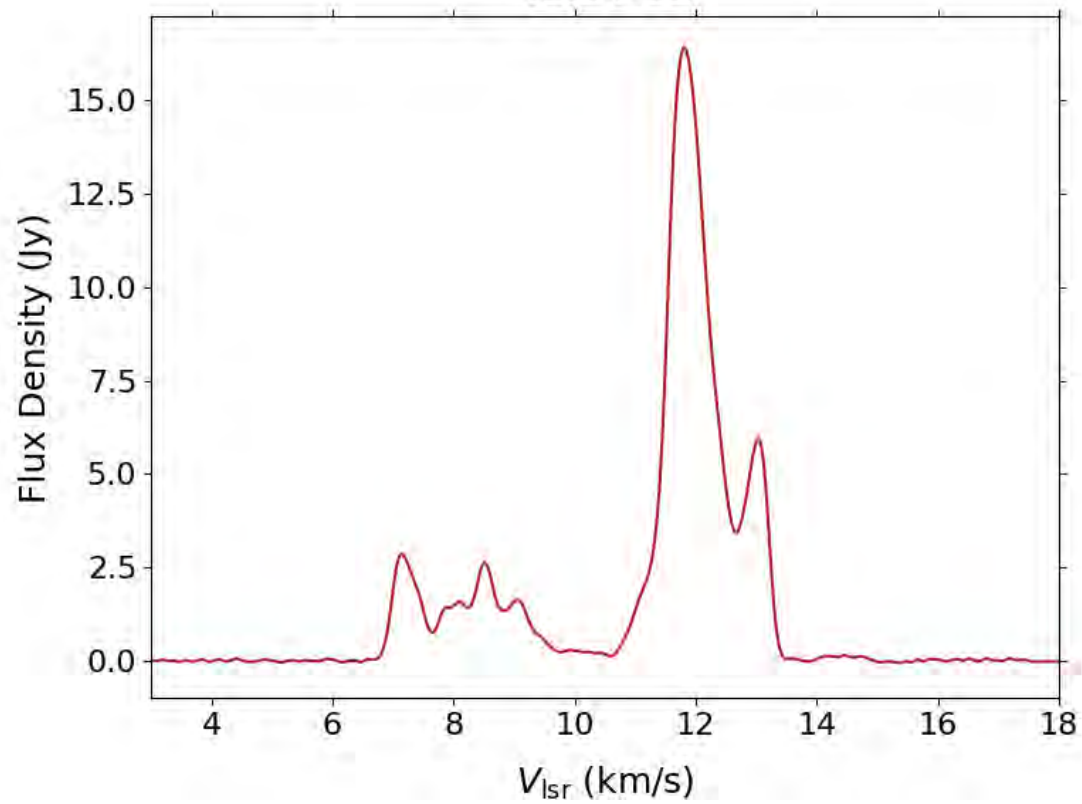


41.23-02

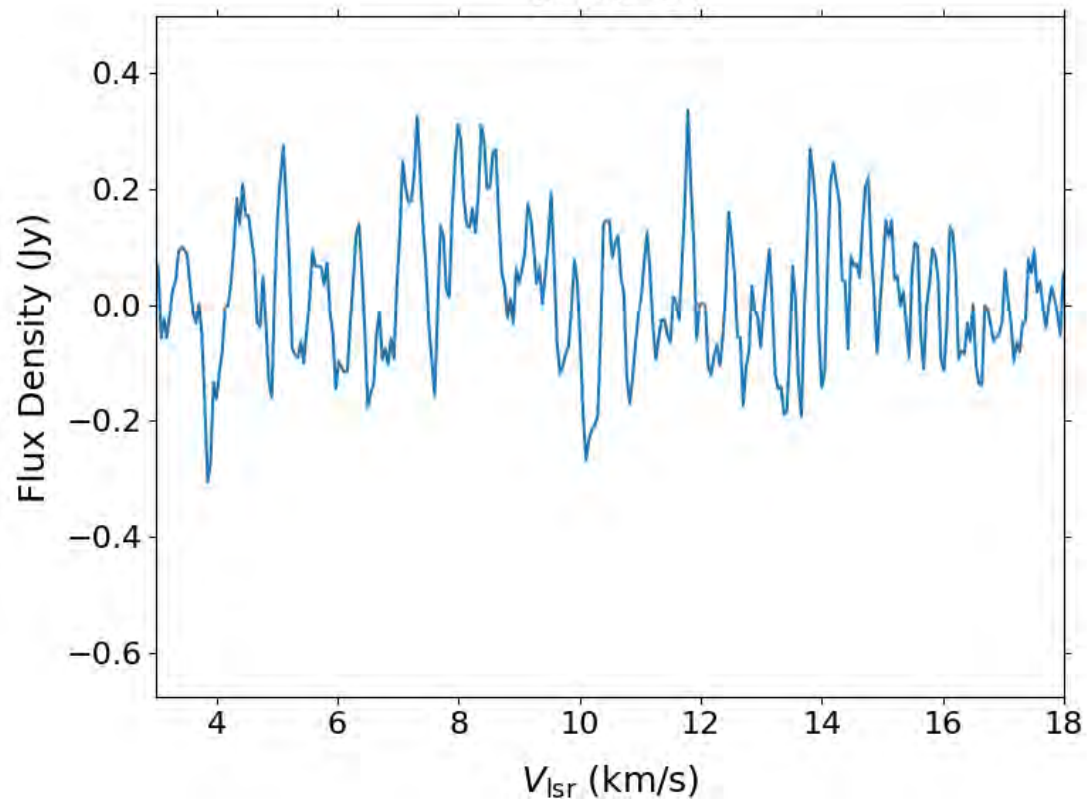


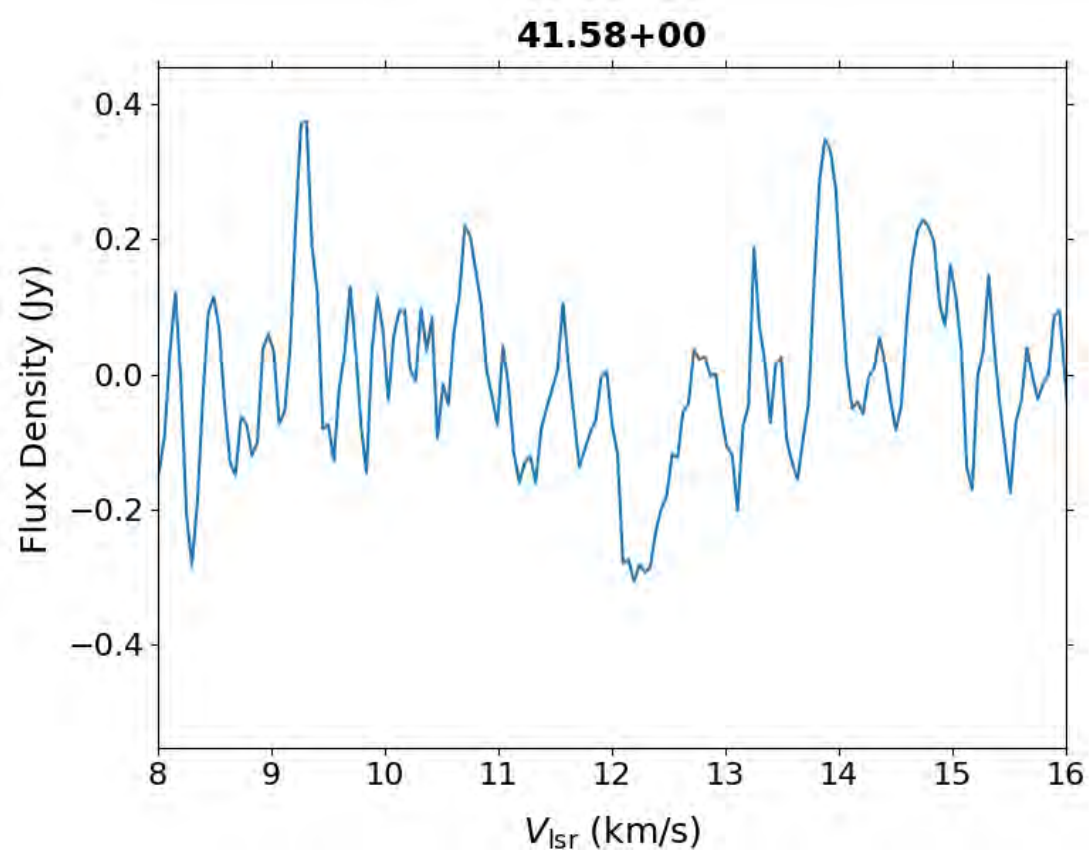
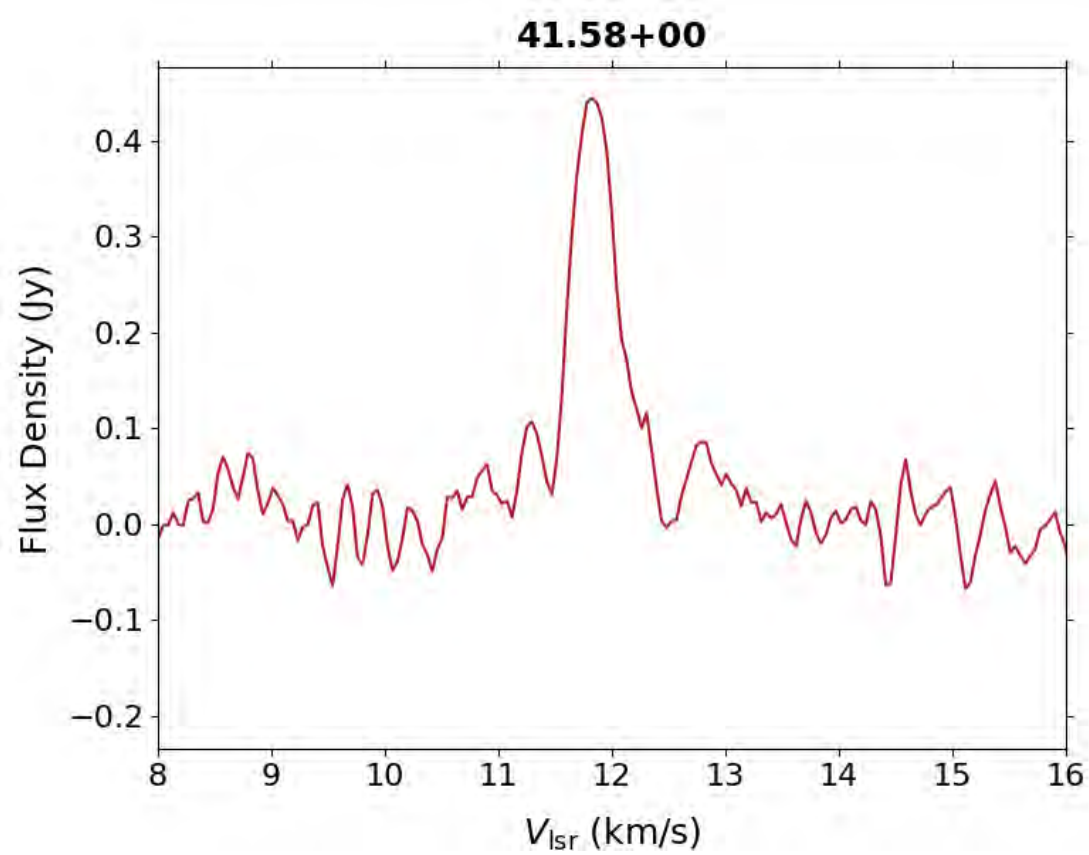


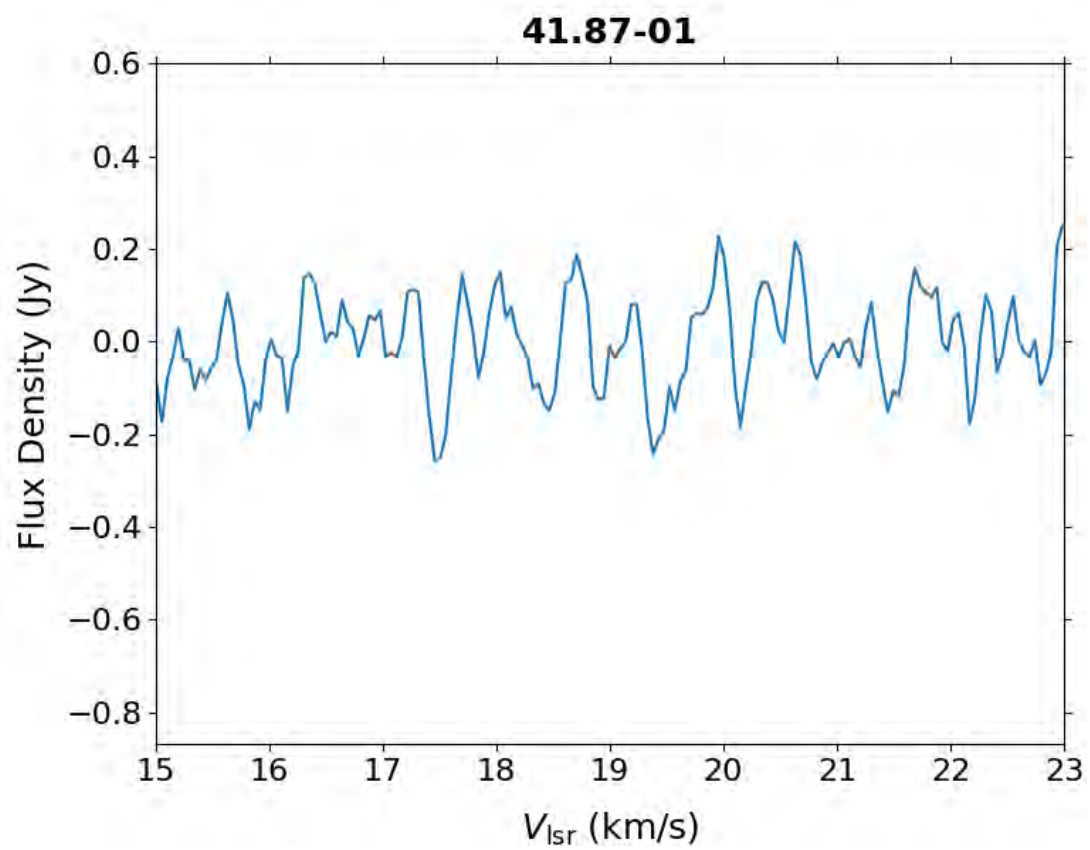
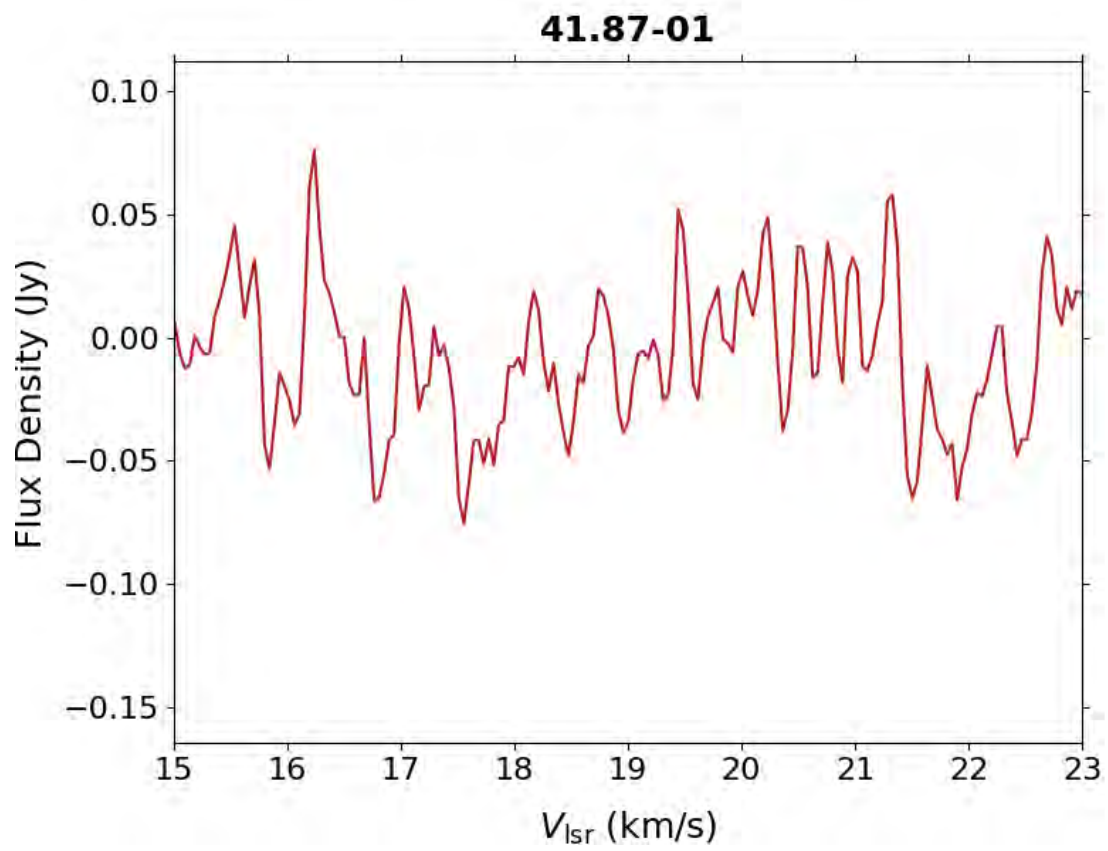
41.34-01

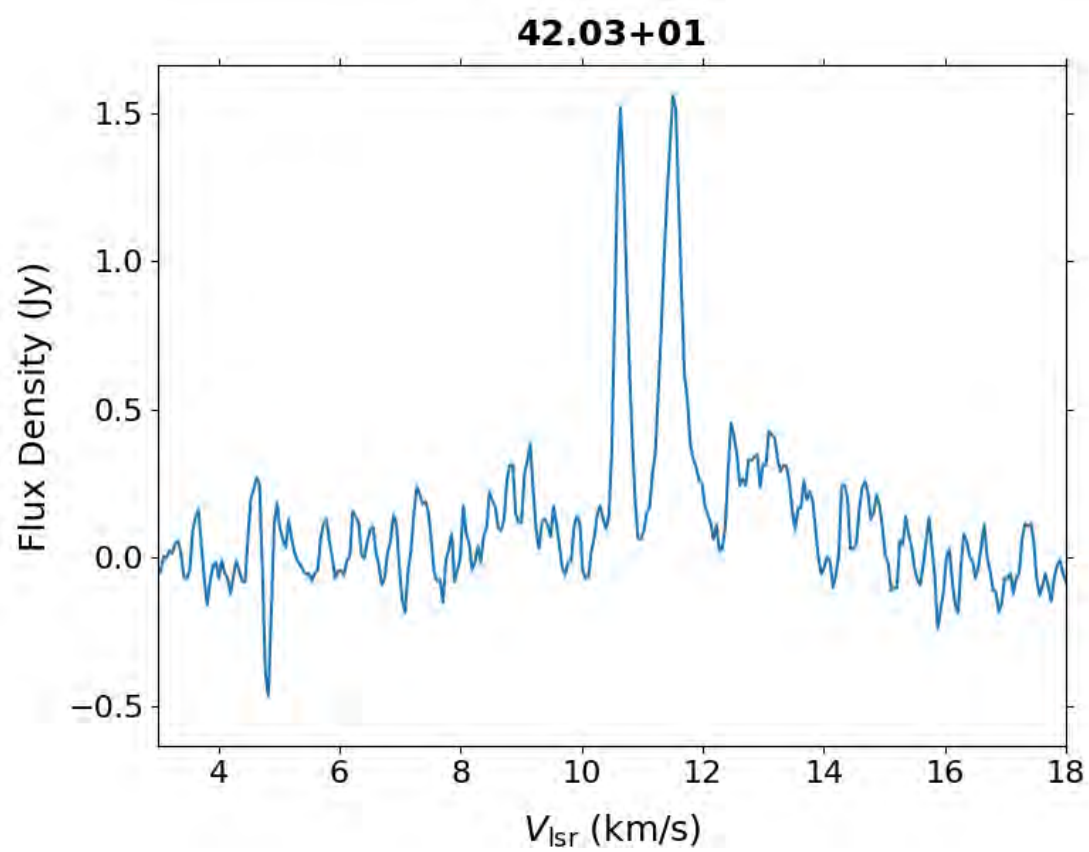
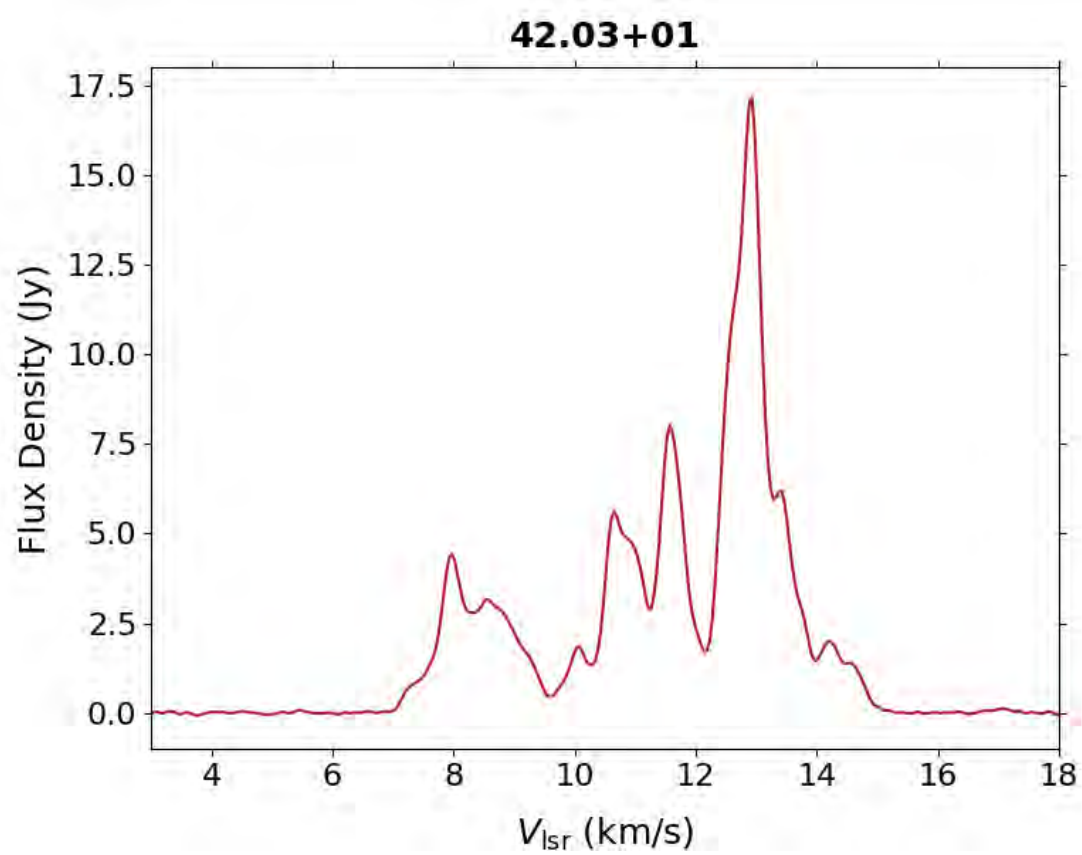


41.34-01

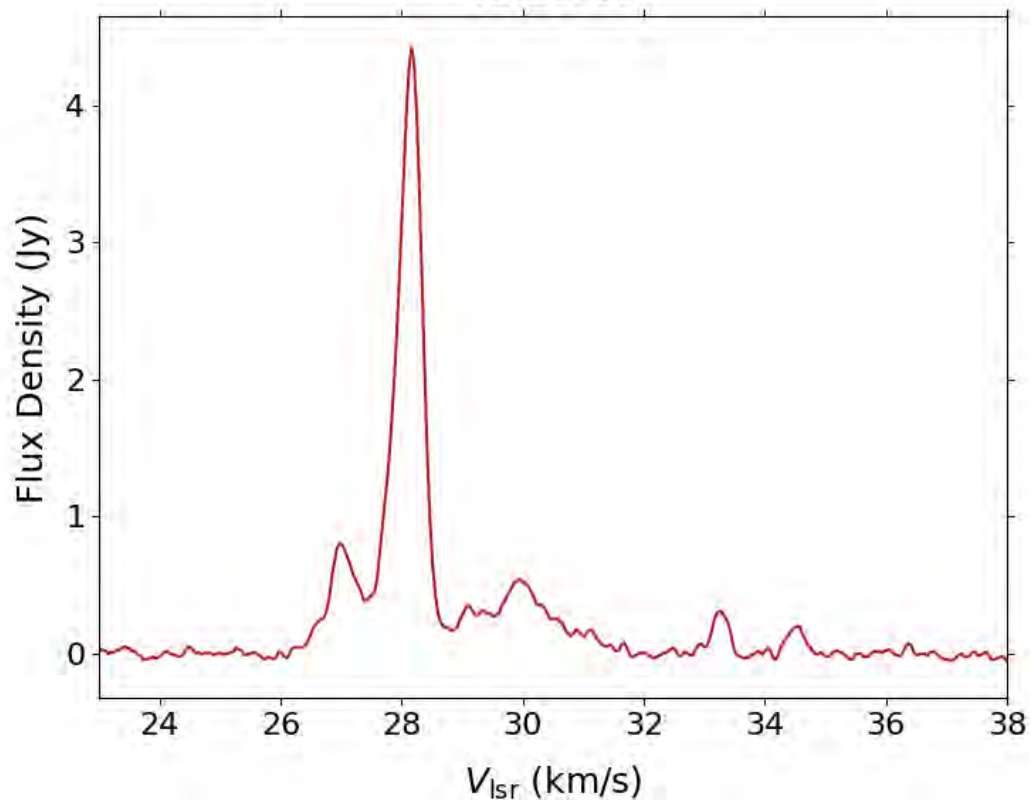




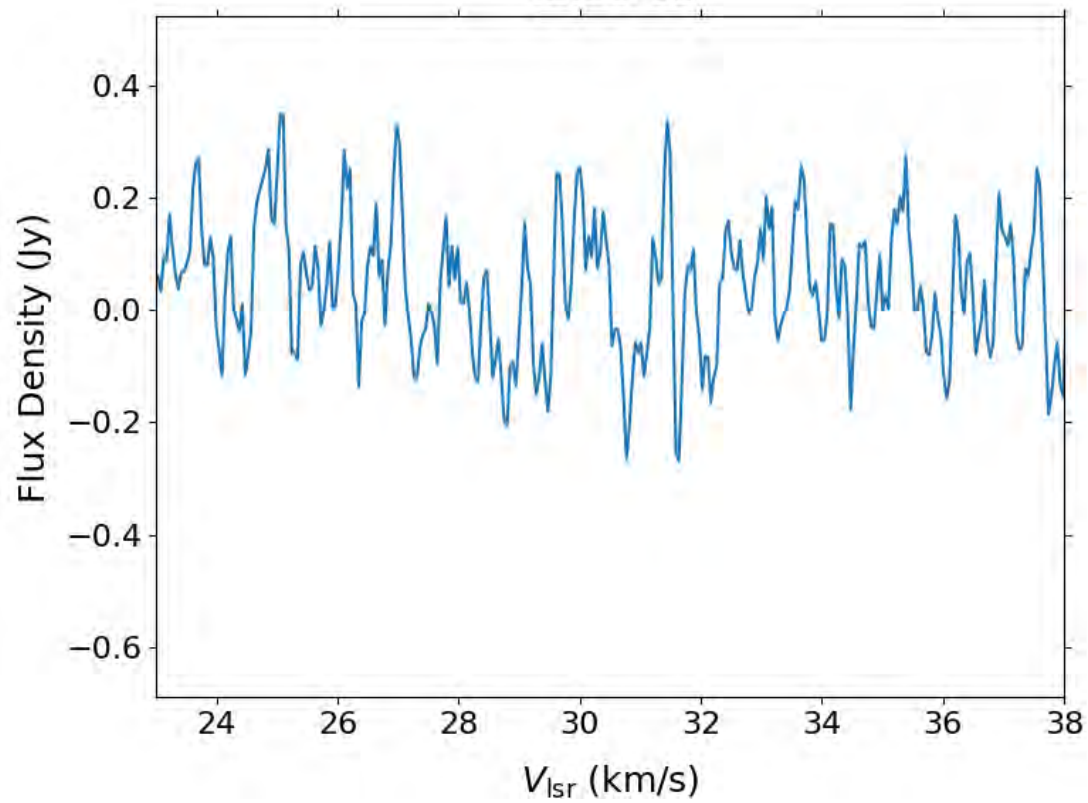


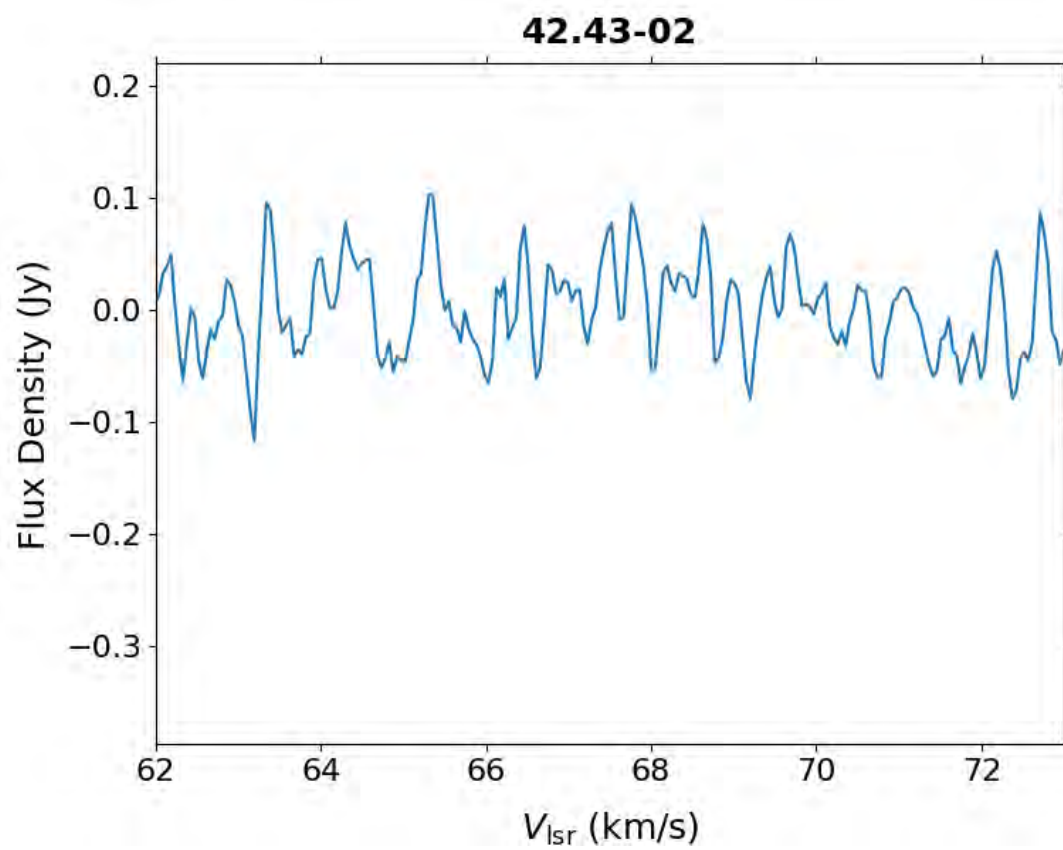
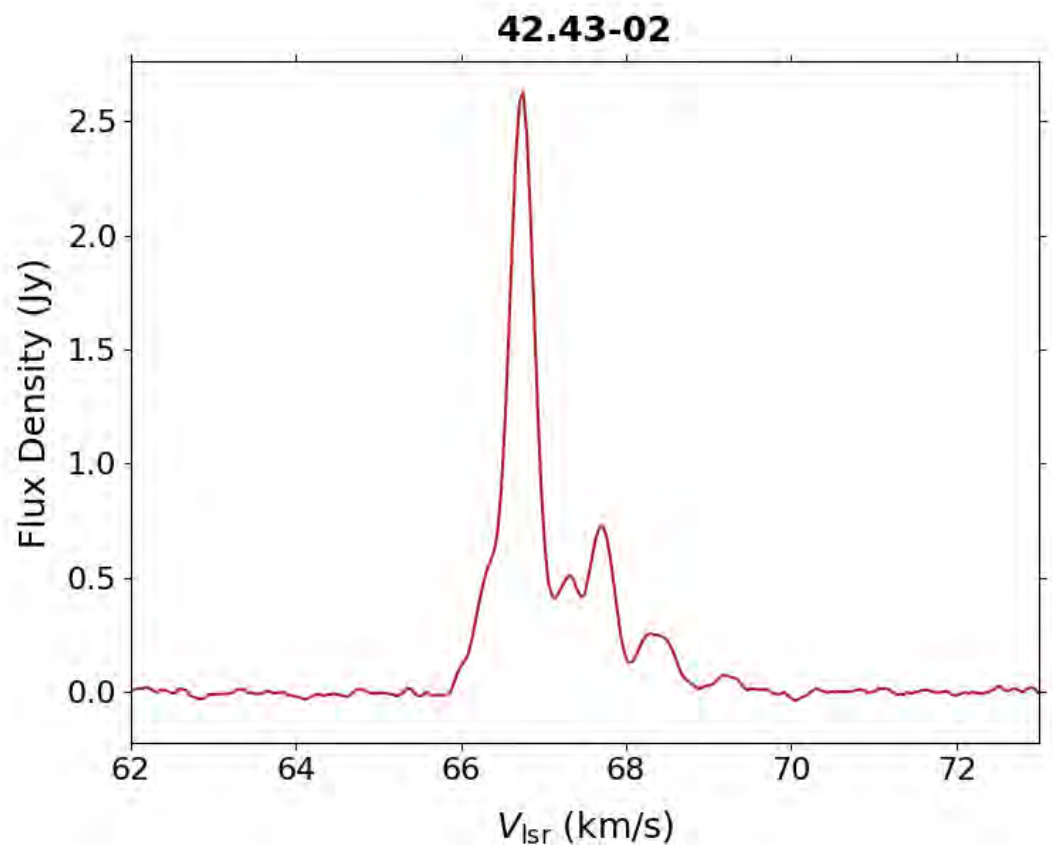


42.30-03

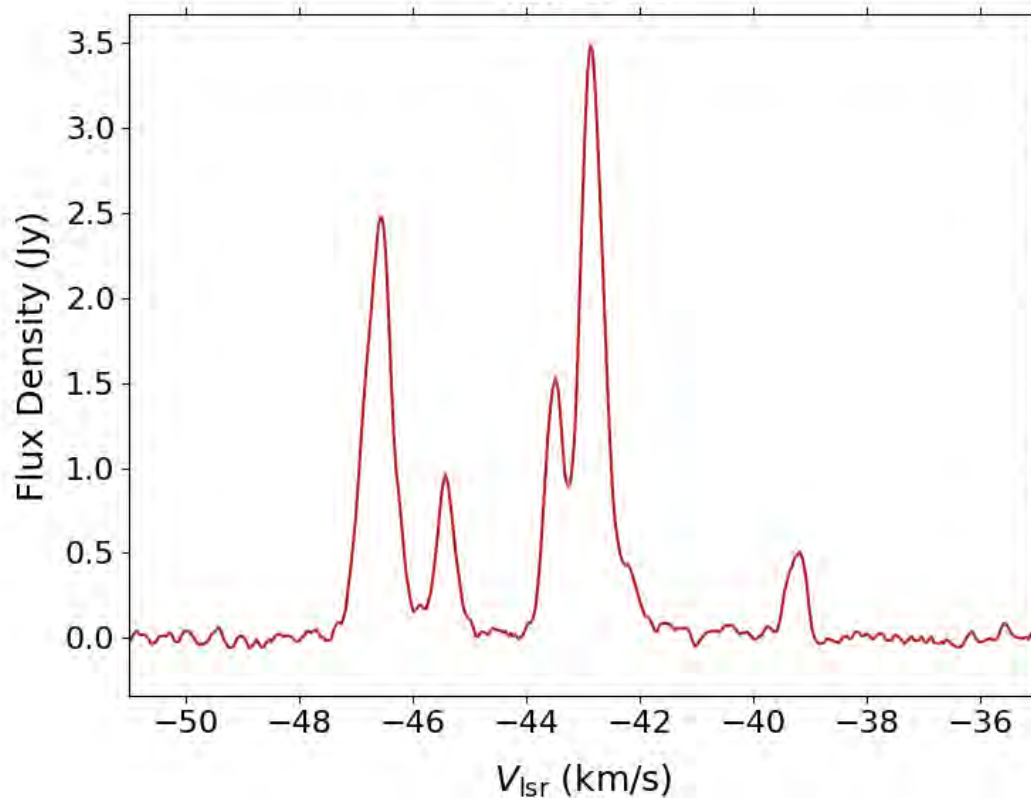


42.30-03

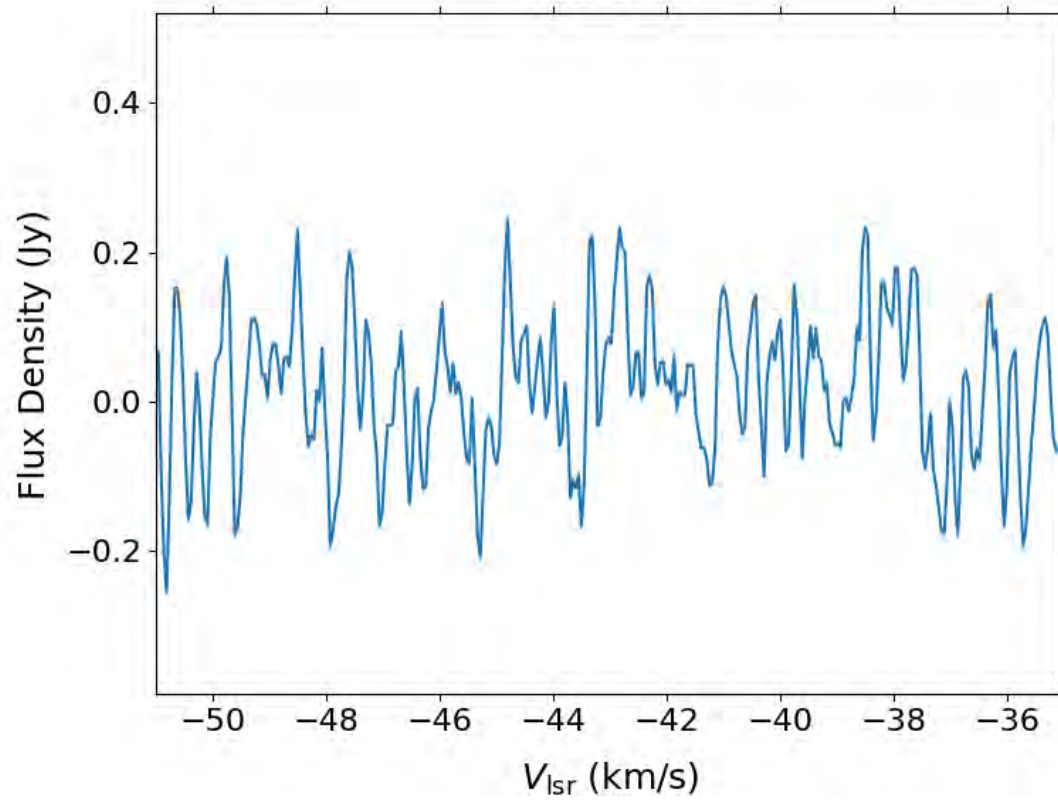




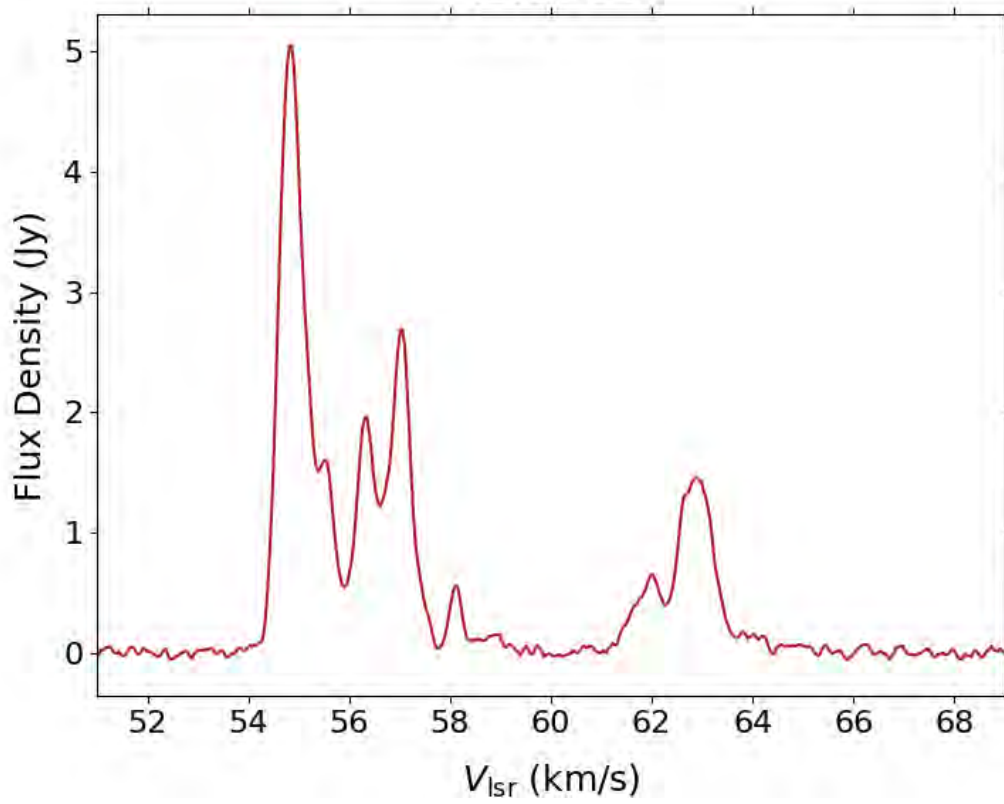
42.70-01



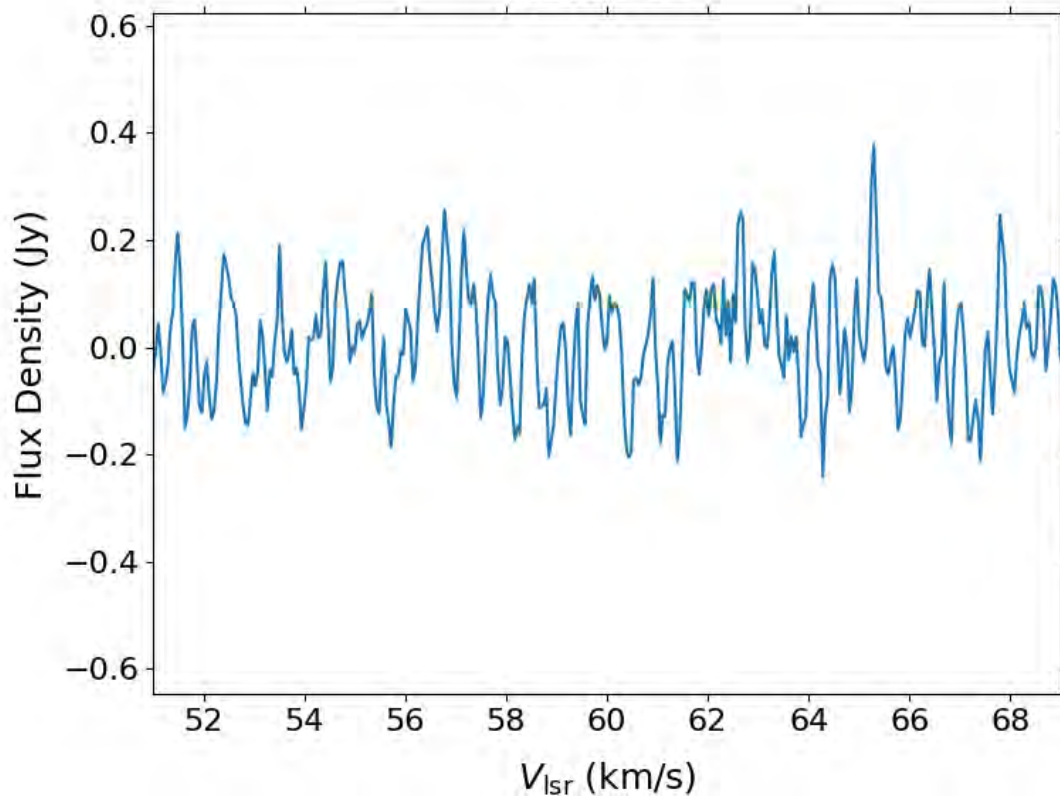
42.70-01



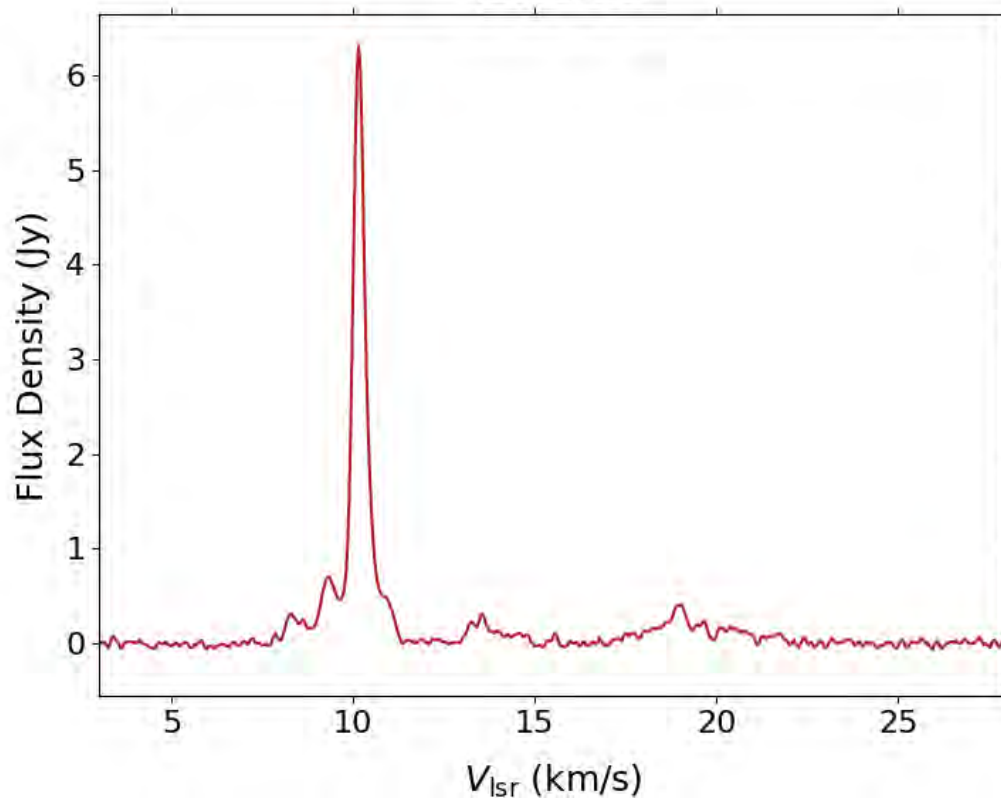
43.04-04



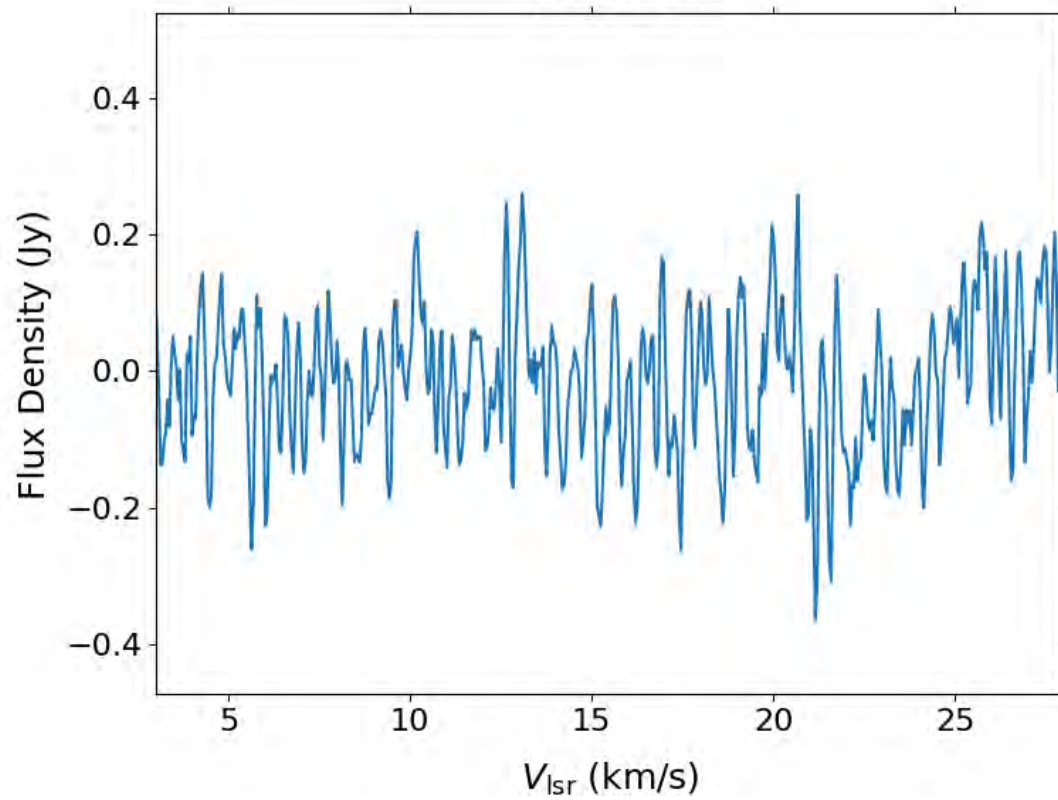
43.04-04

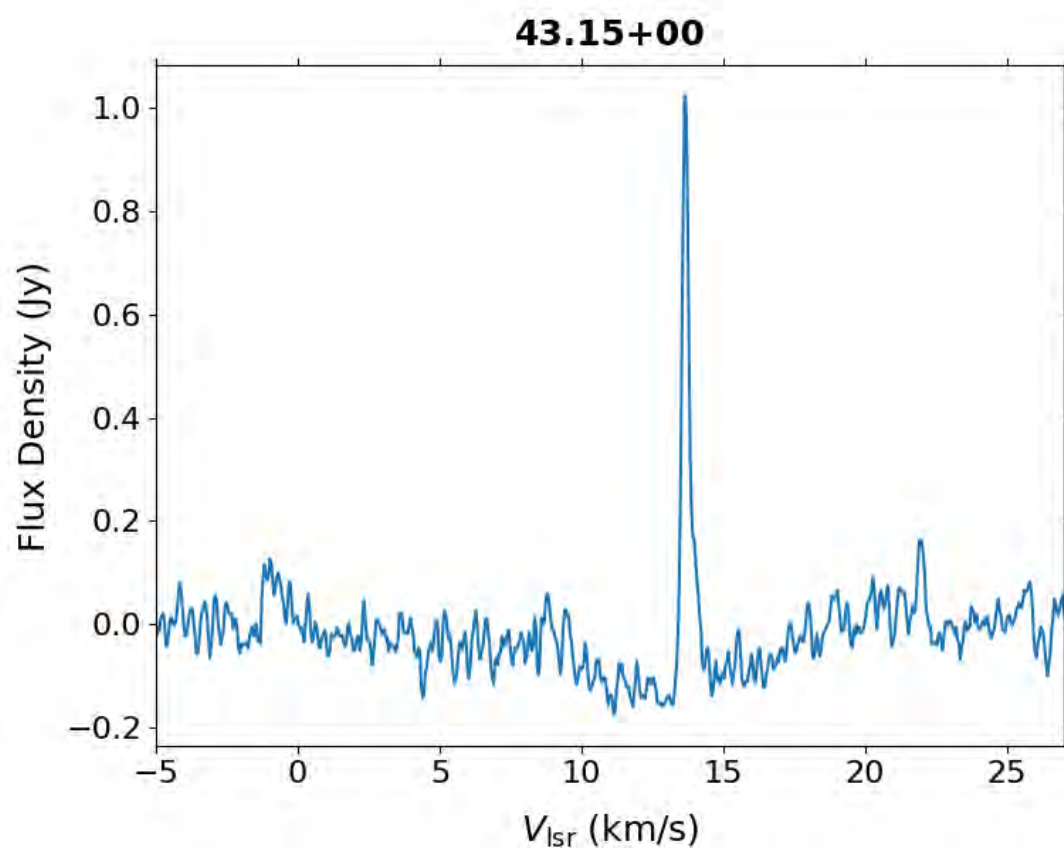
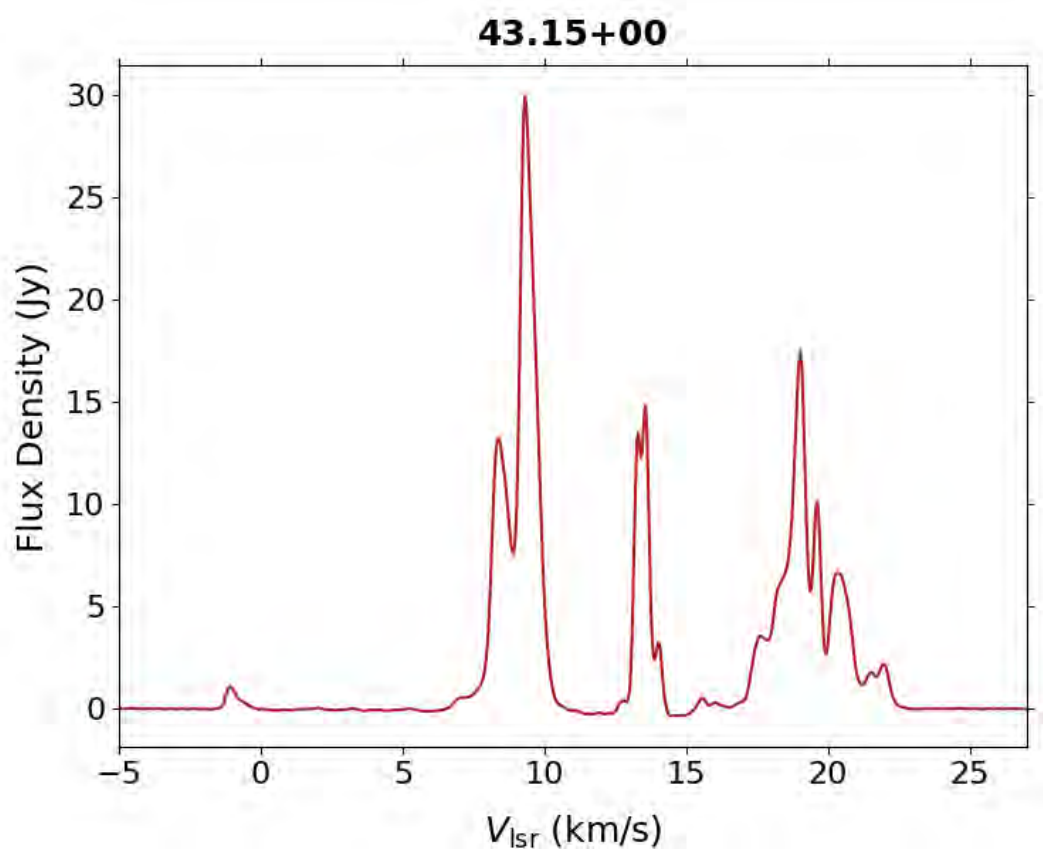


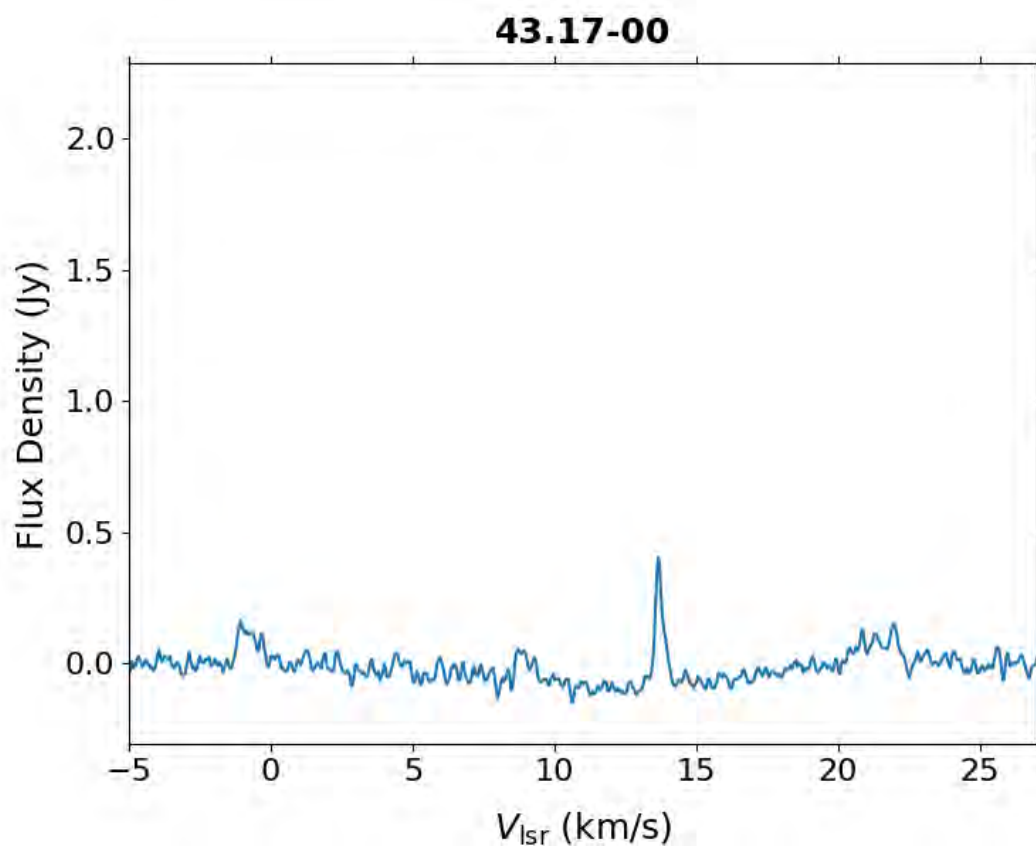
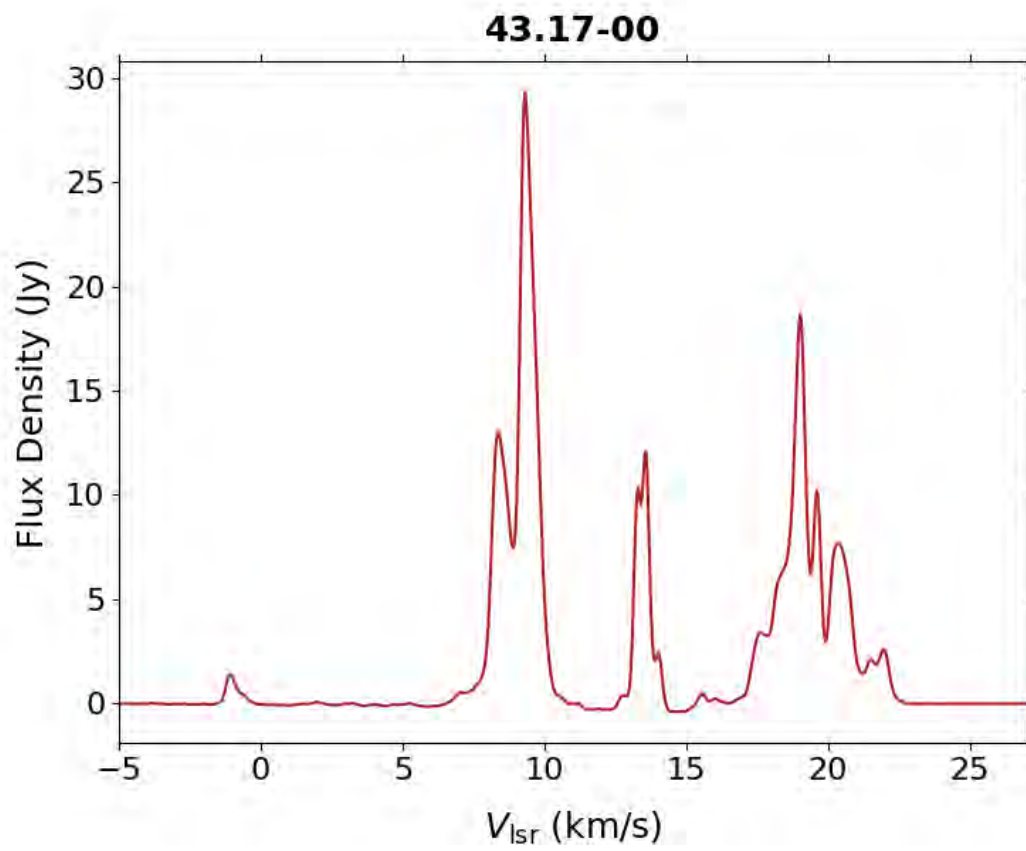
43.08-00

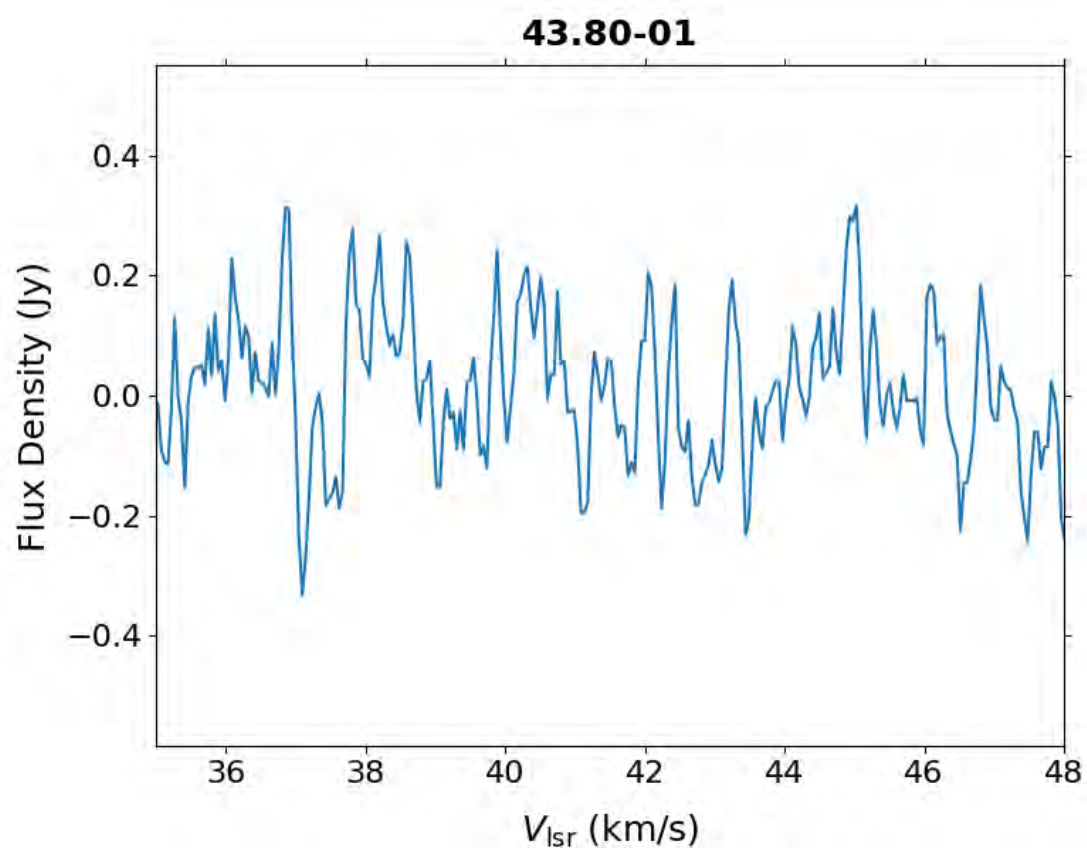
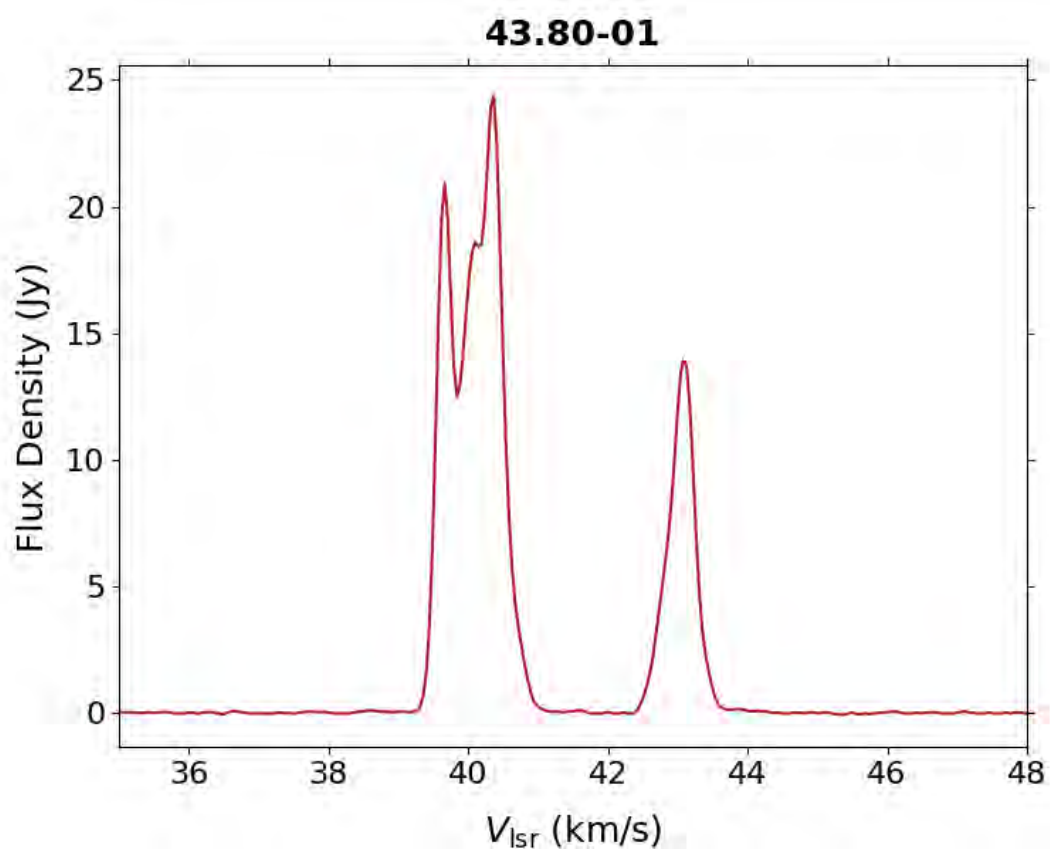


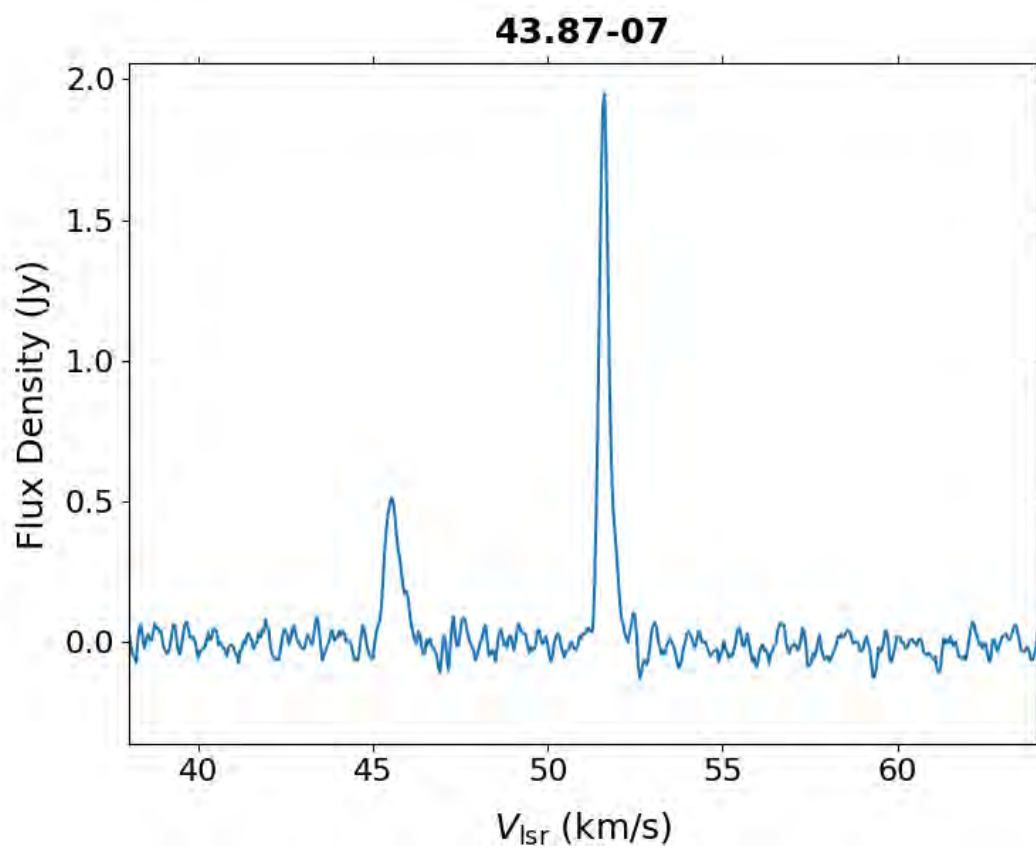
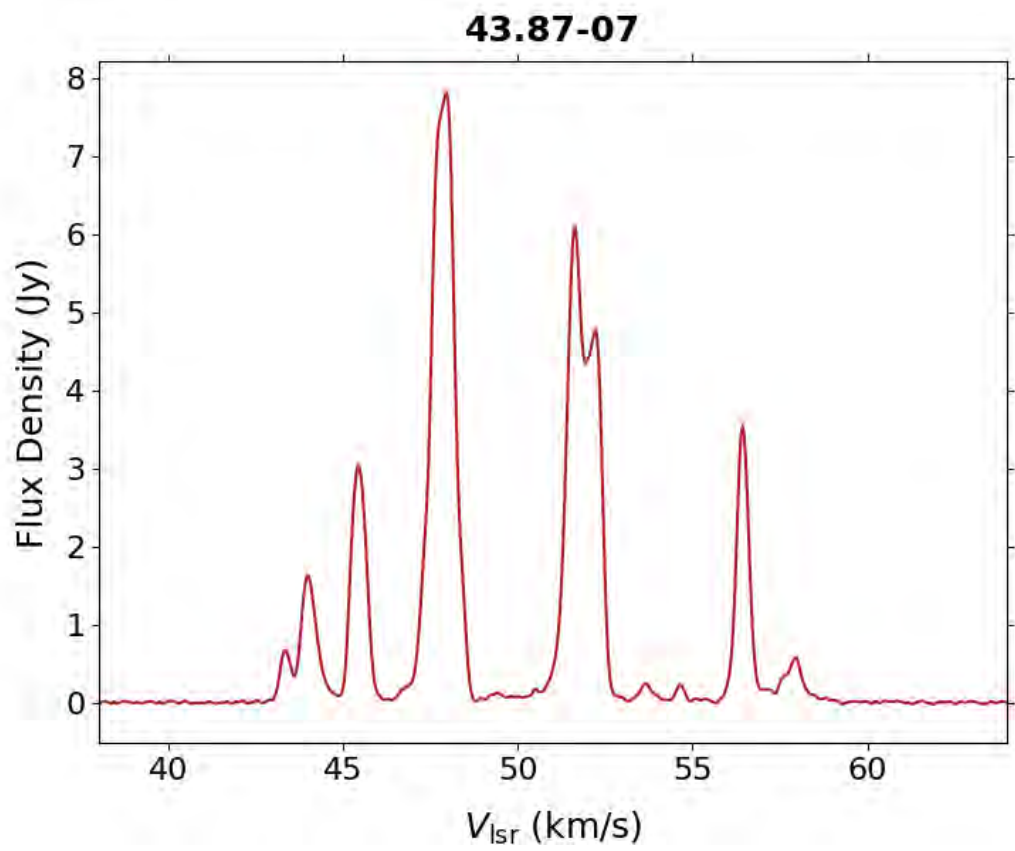
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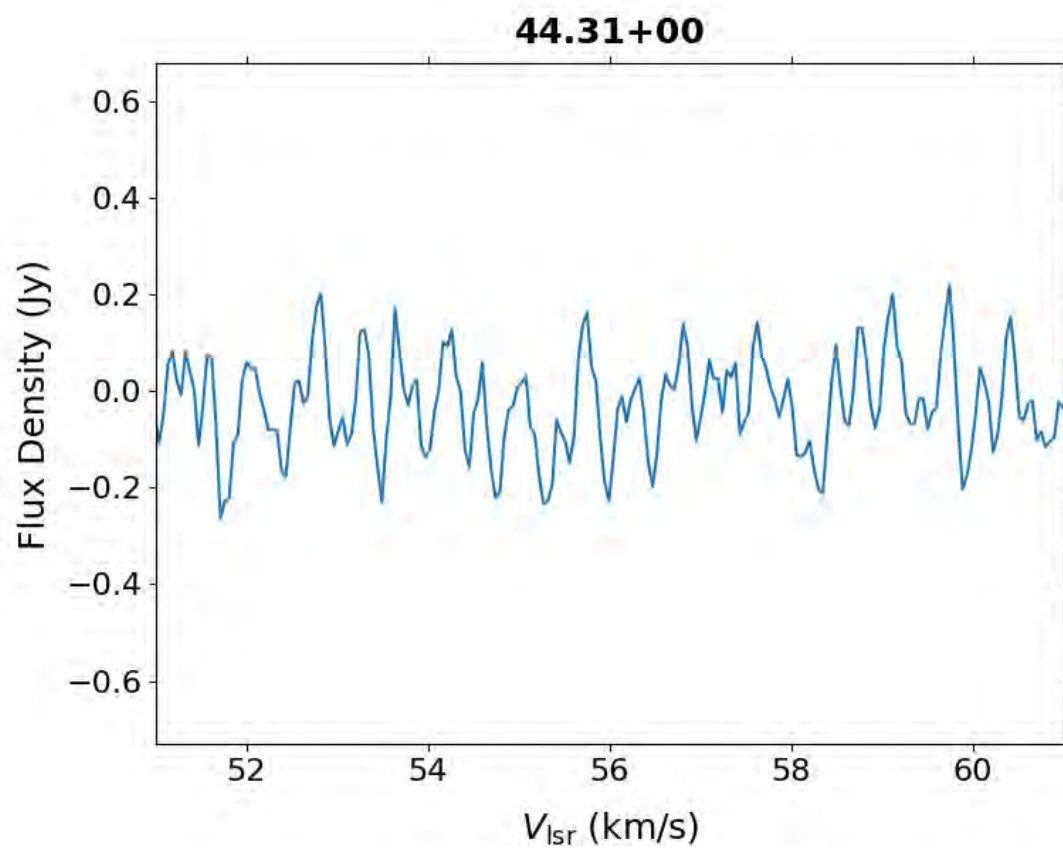
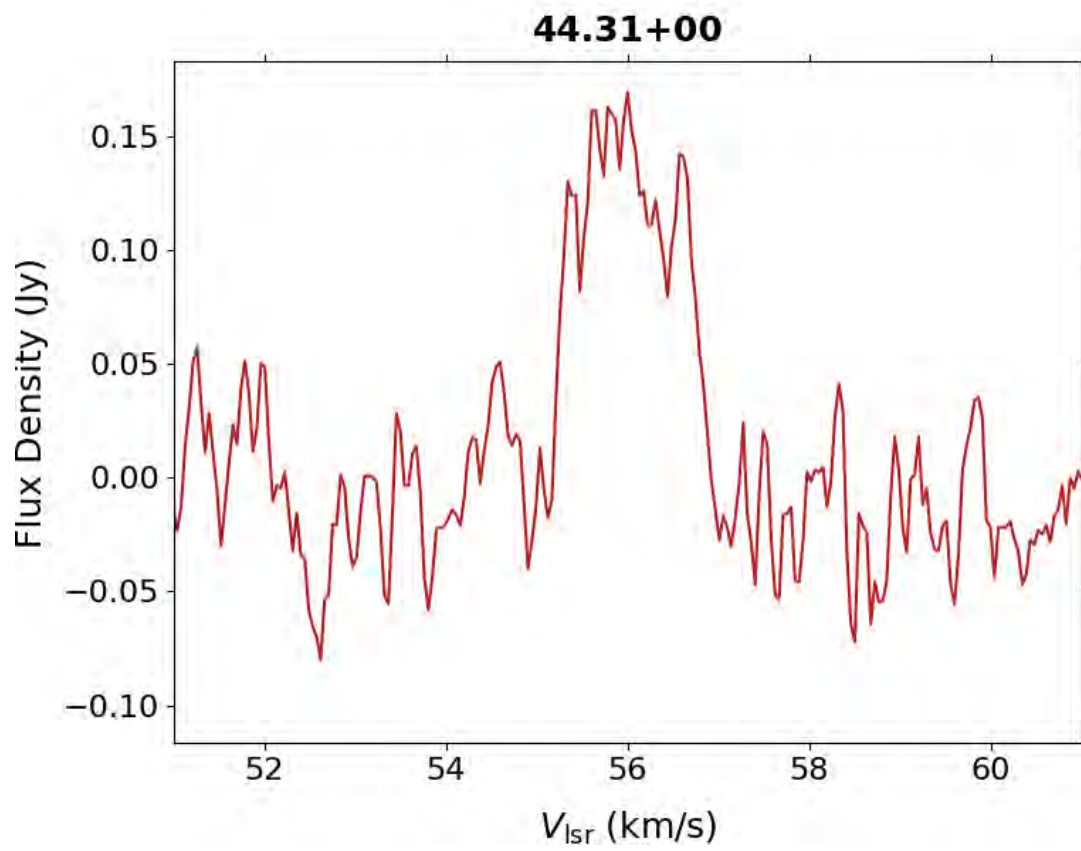


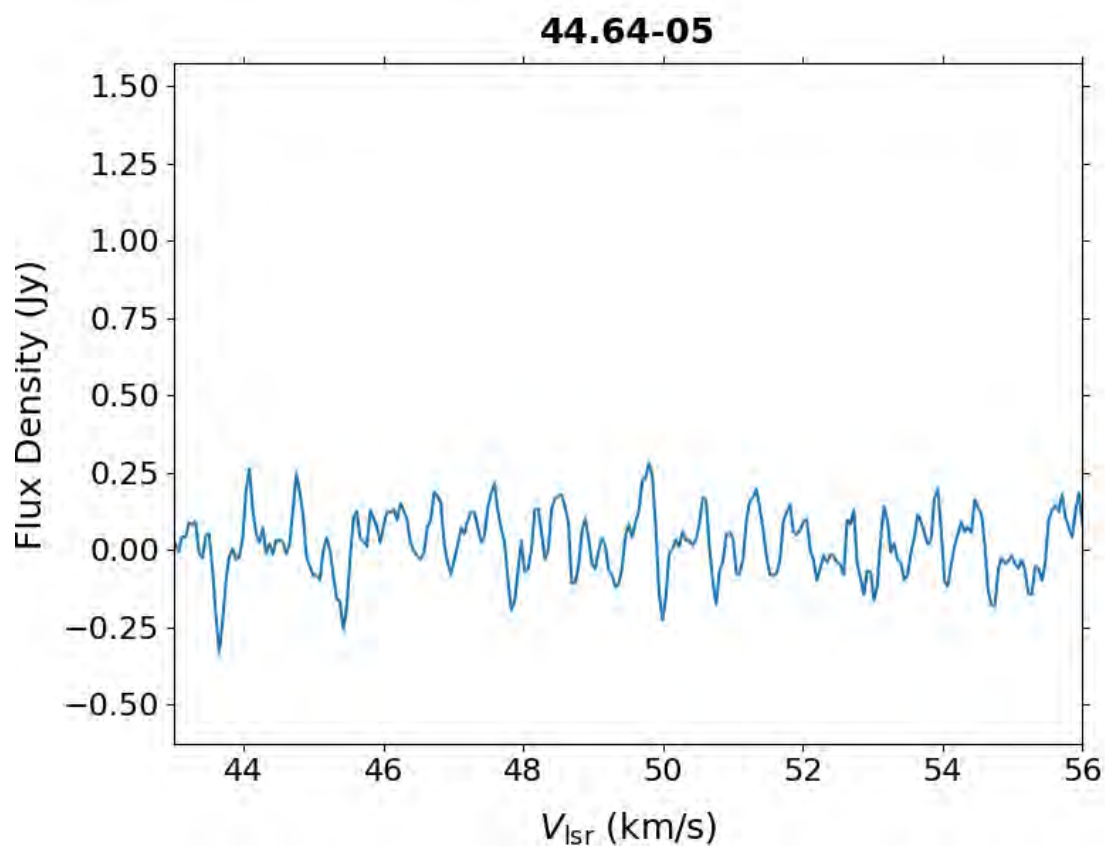
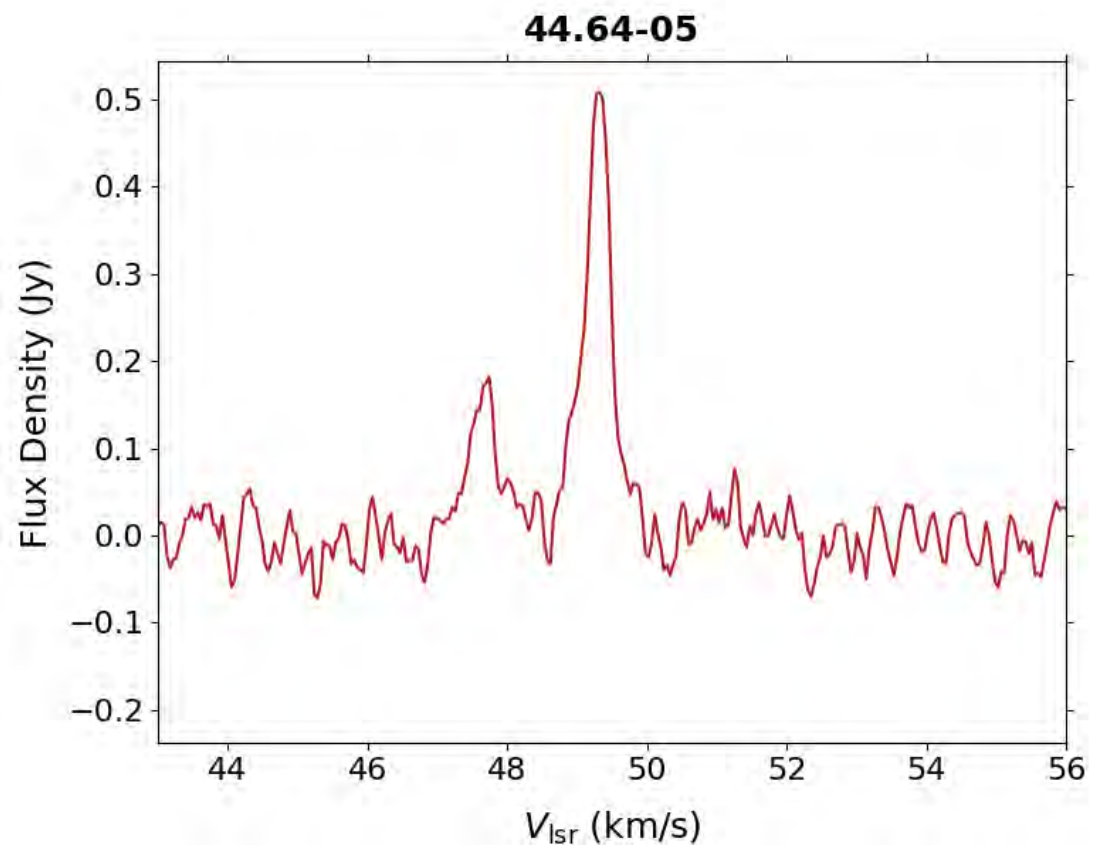


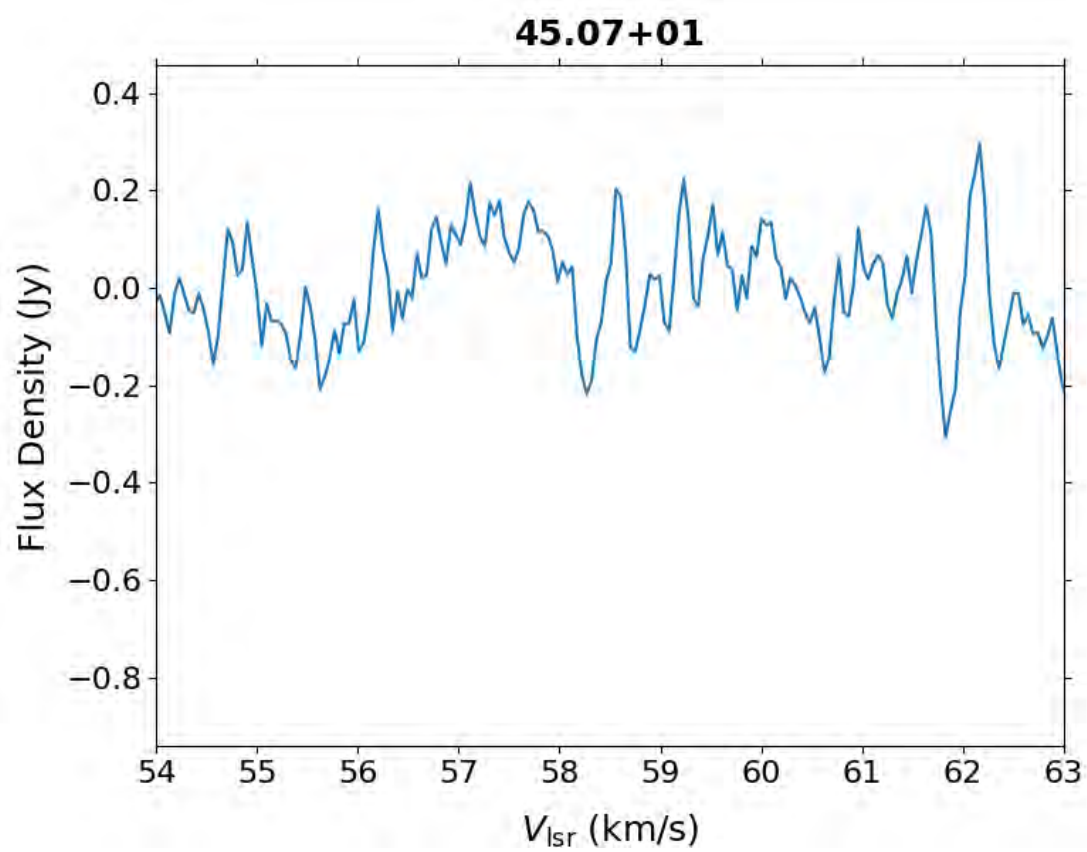
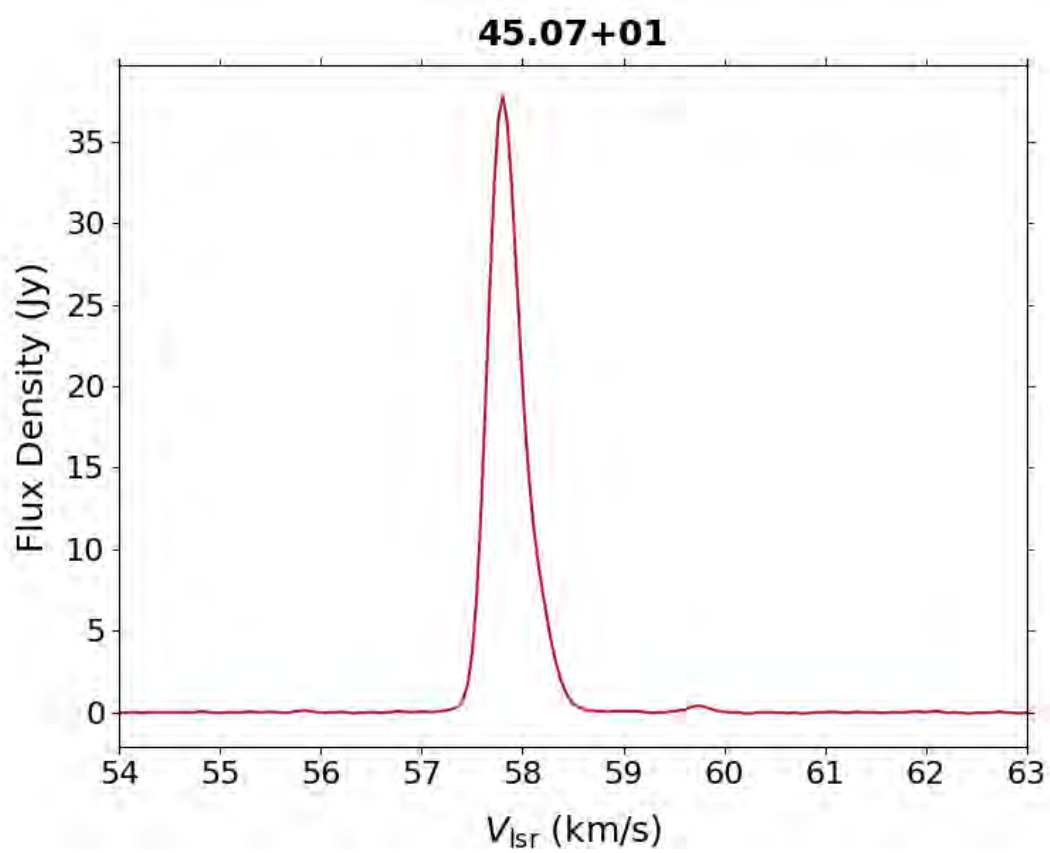


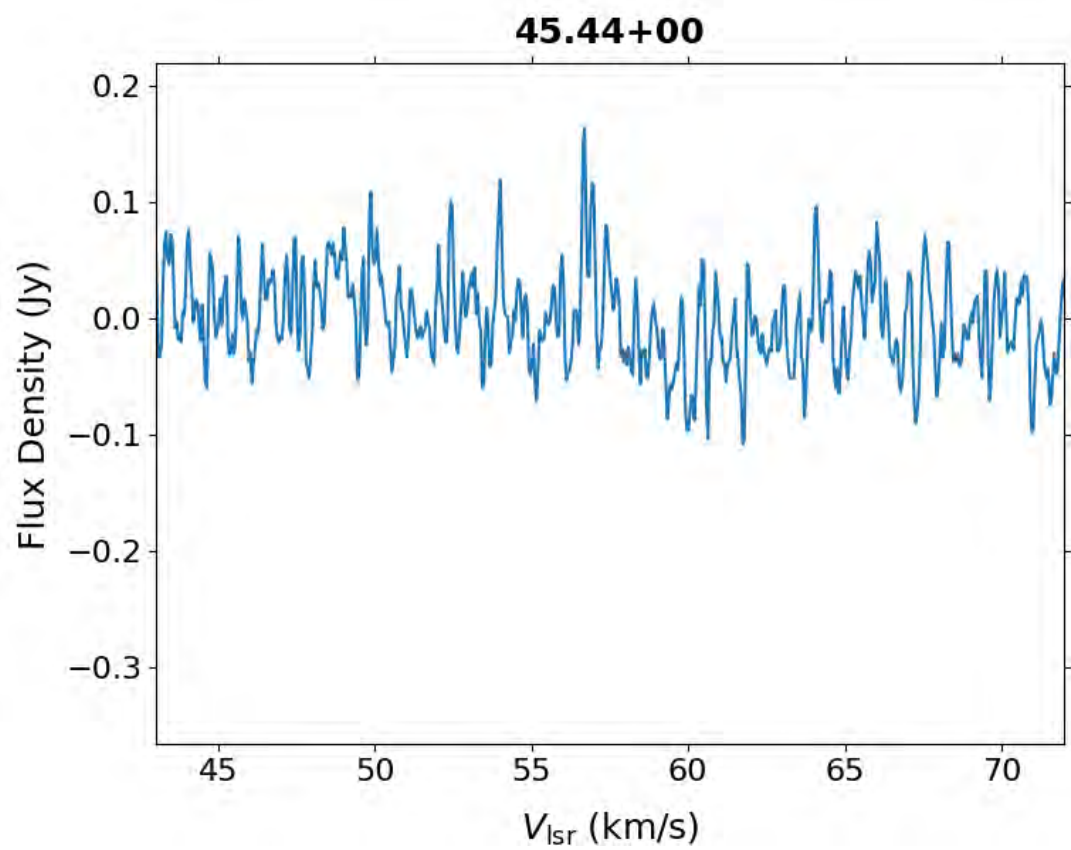
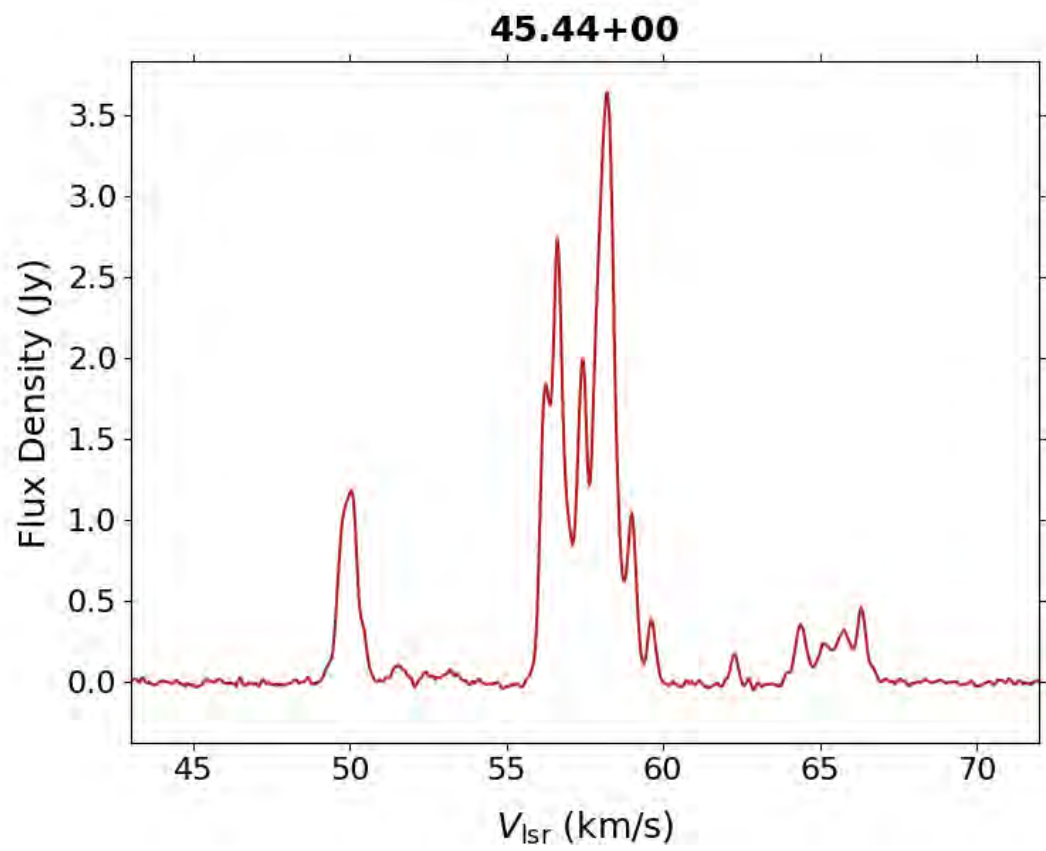


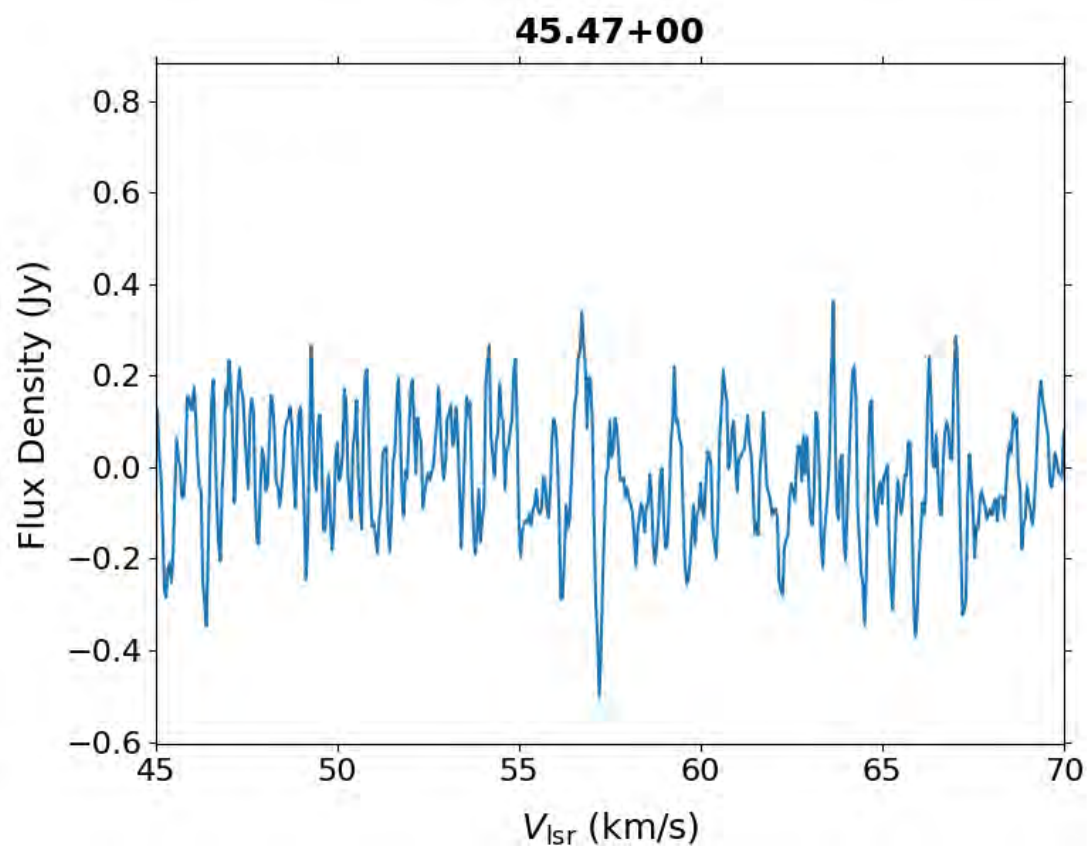
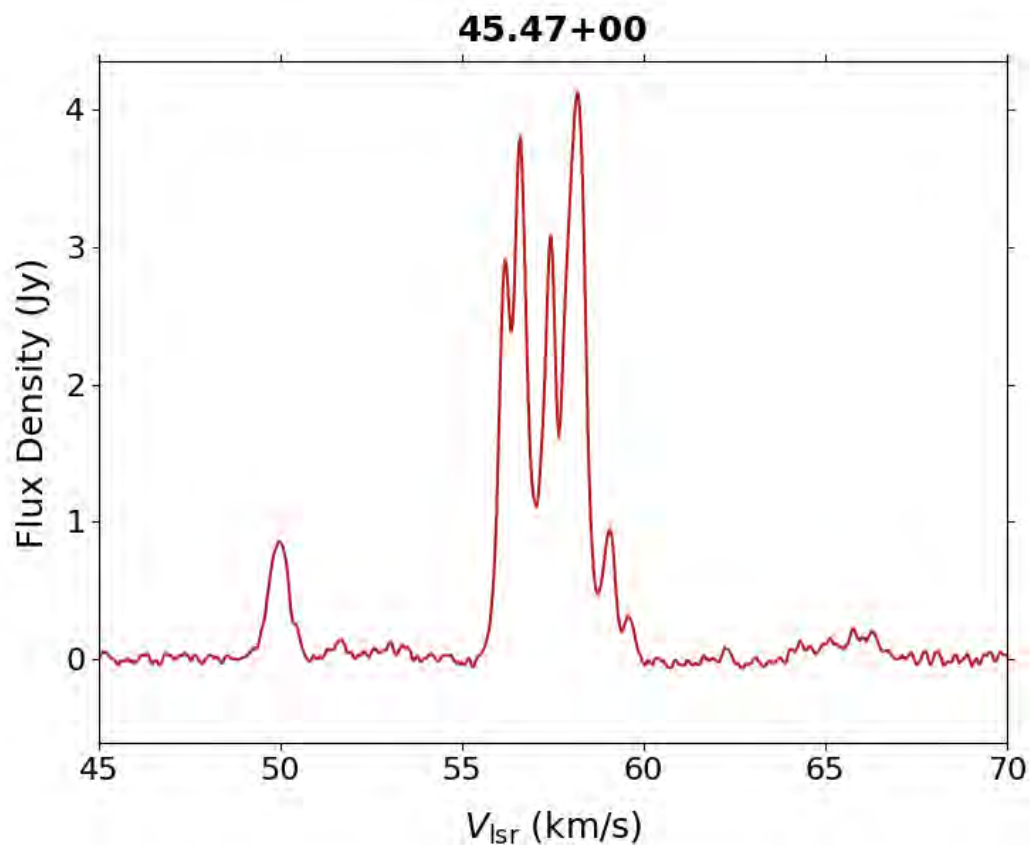


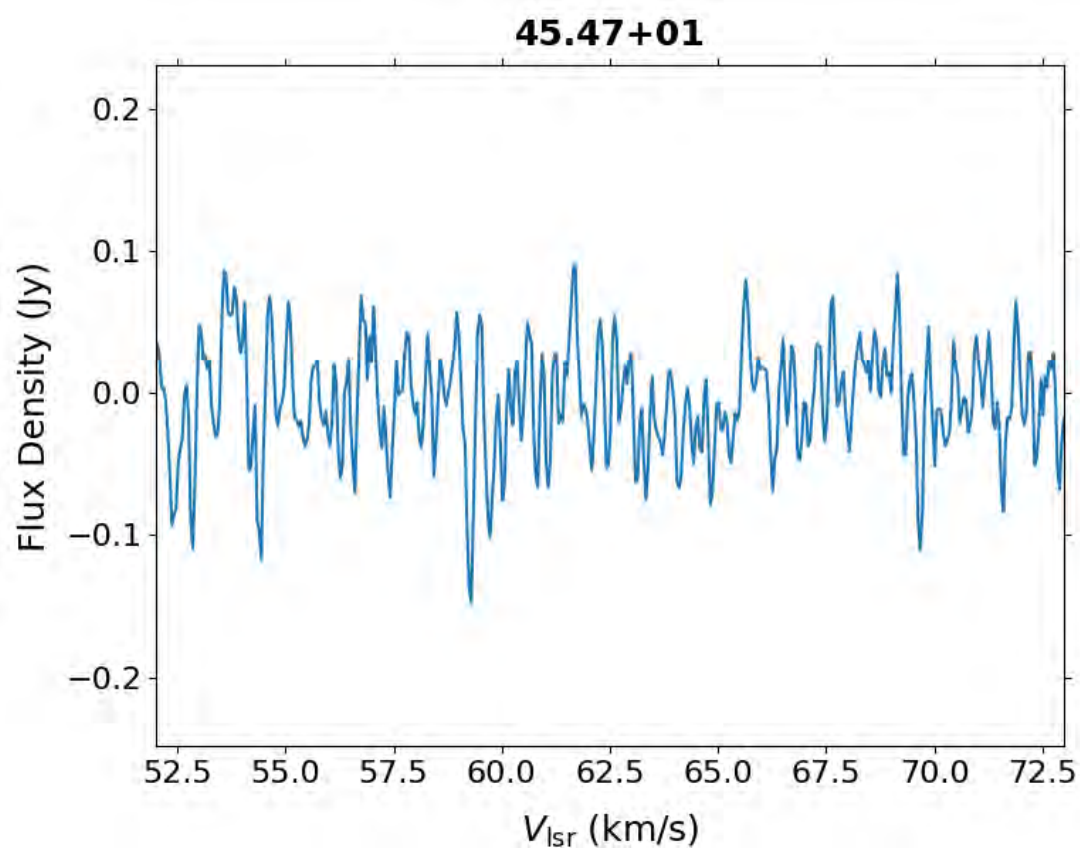
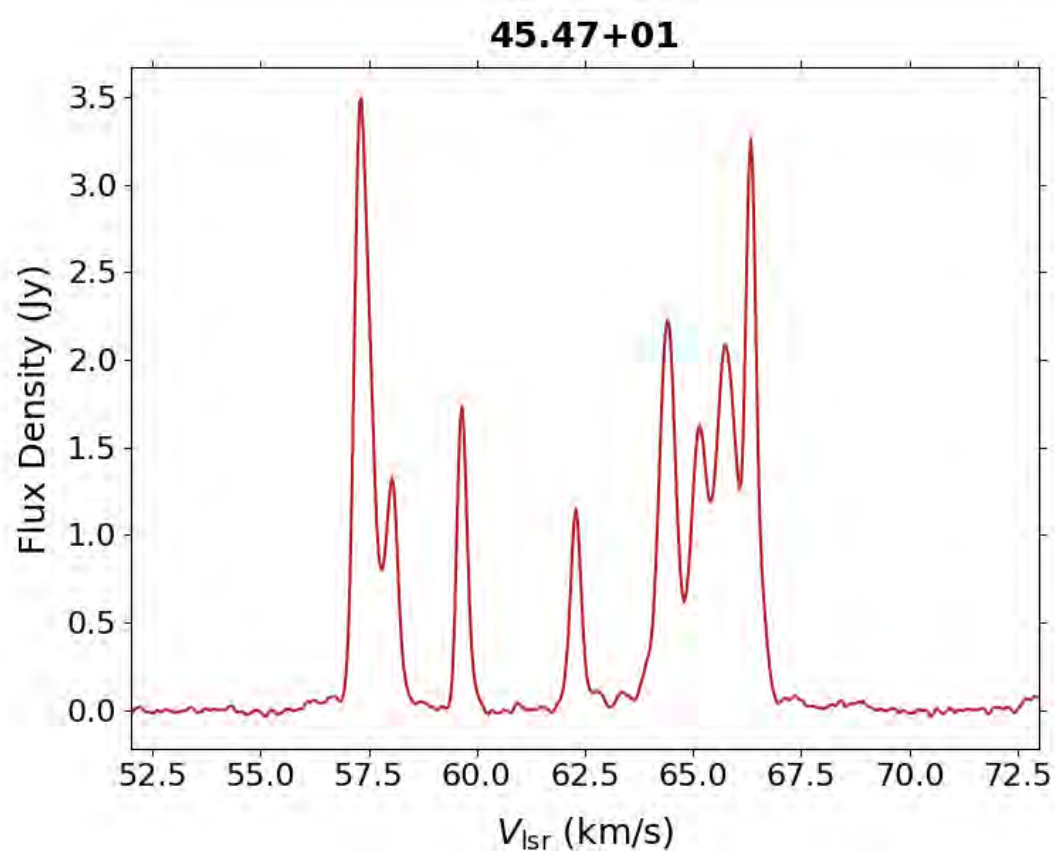




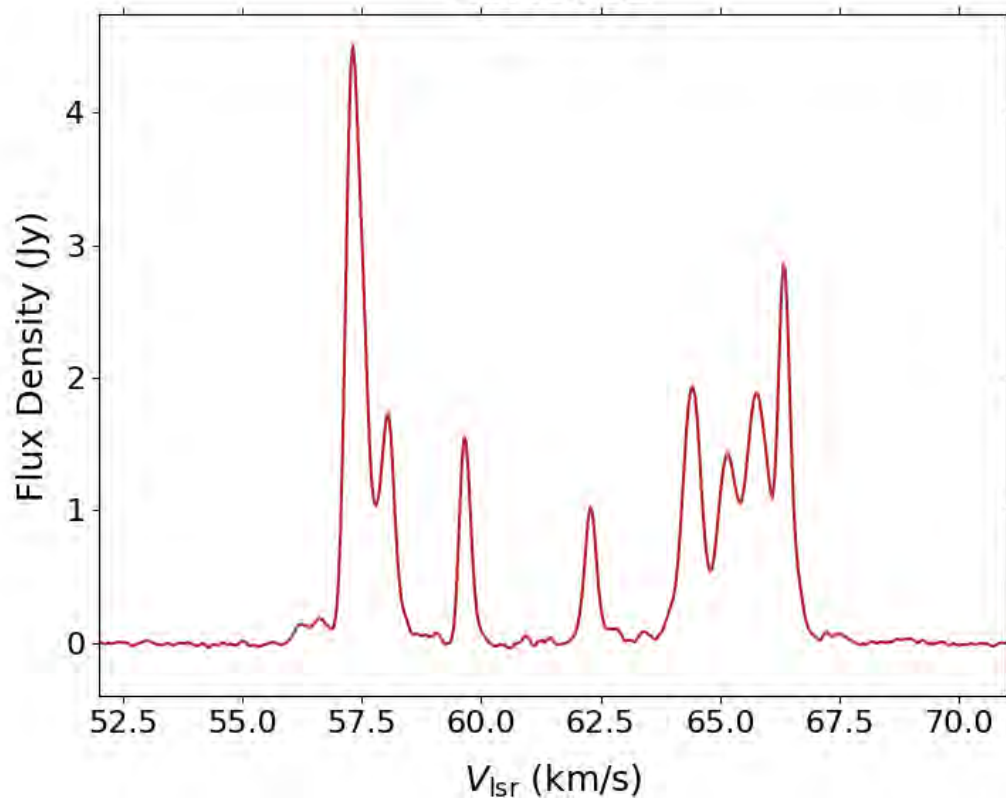




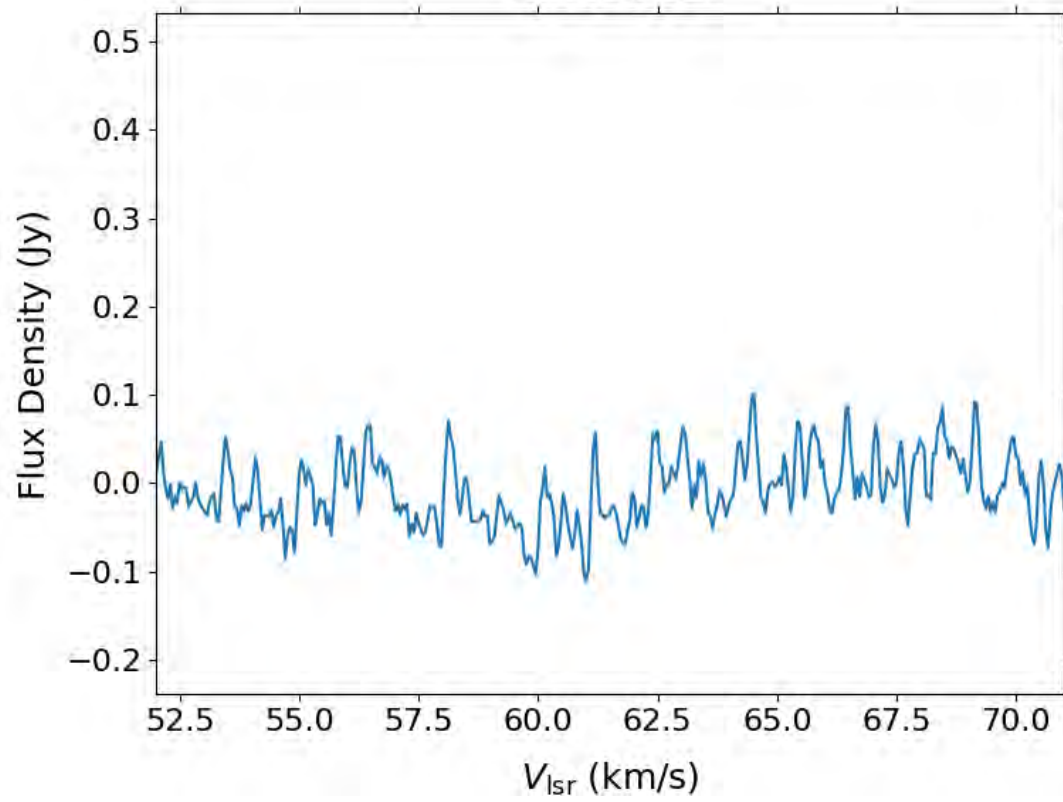


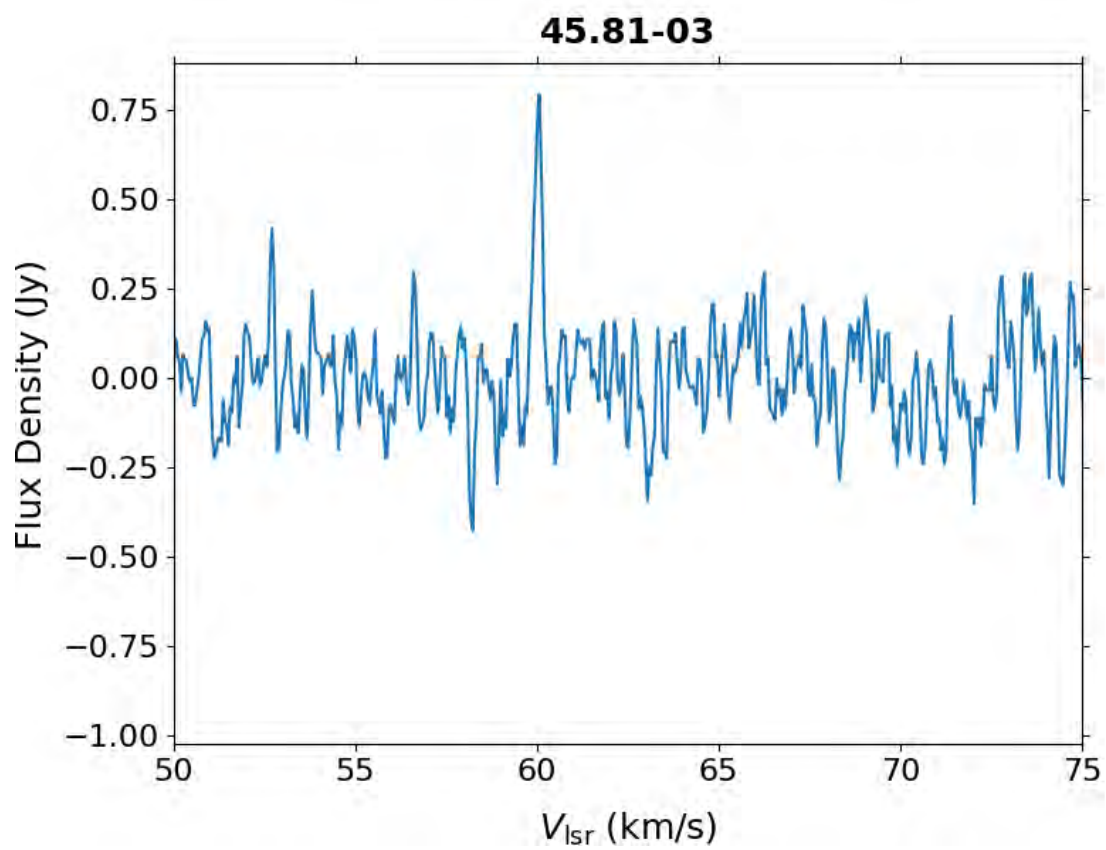
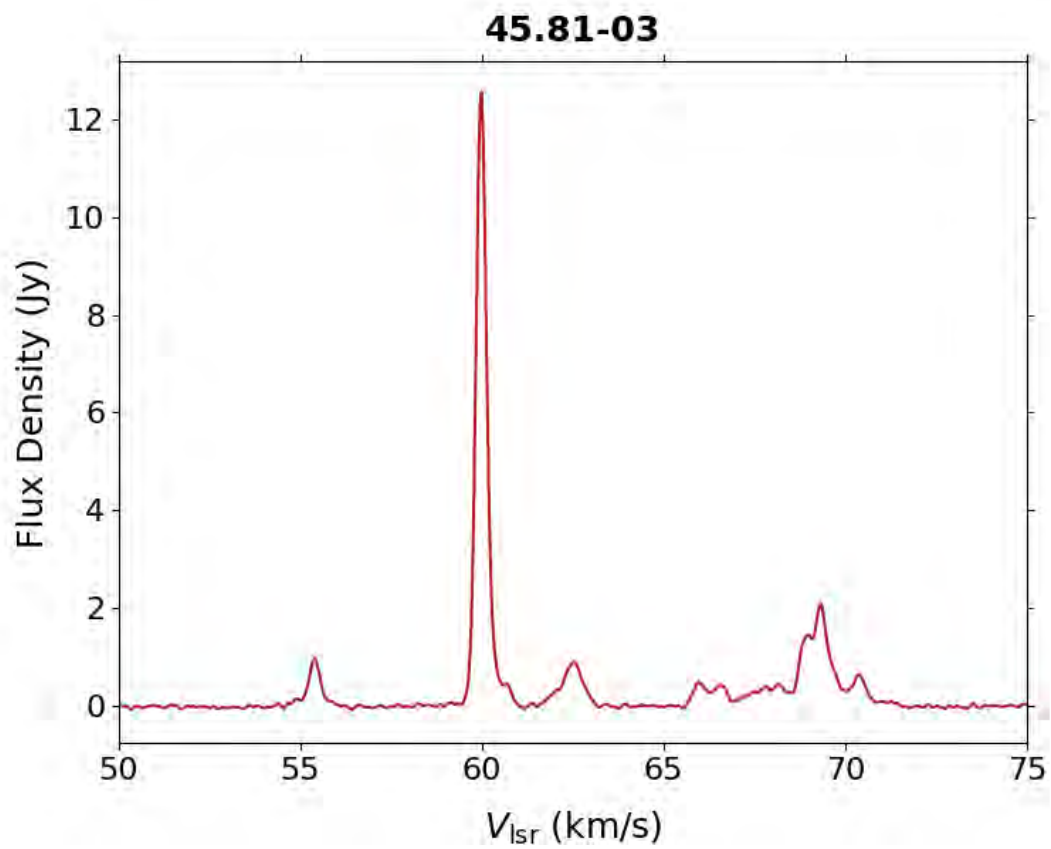


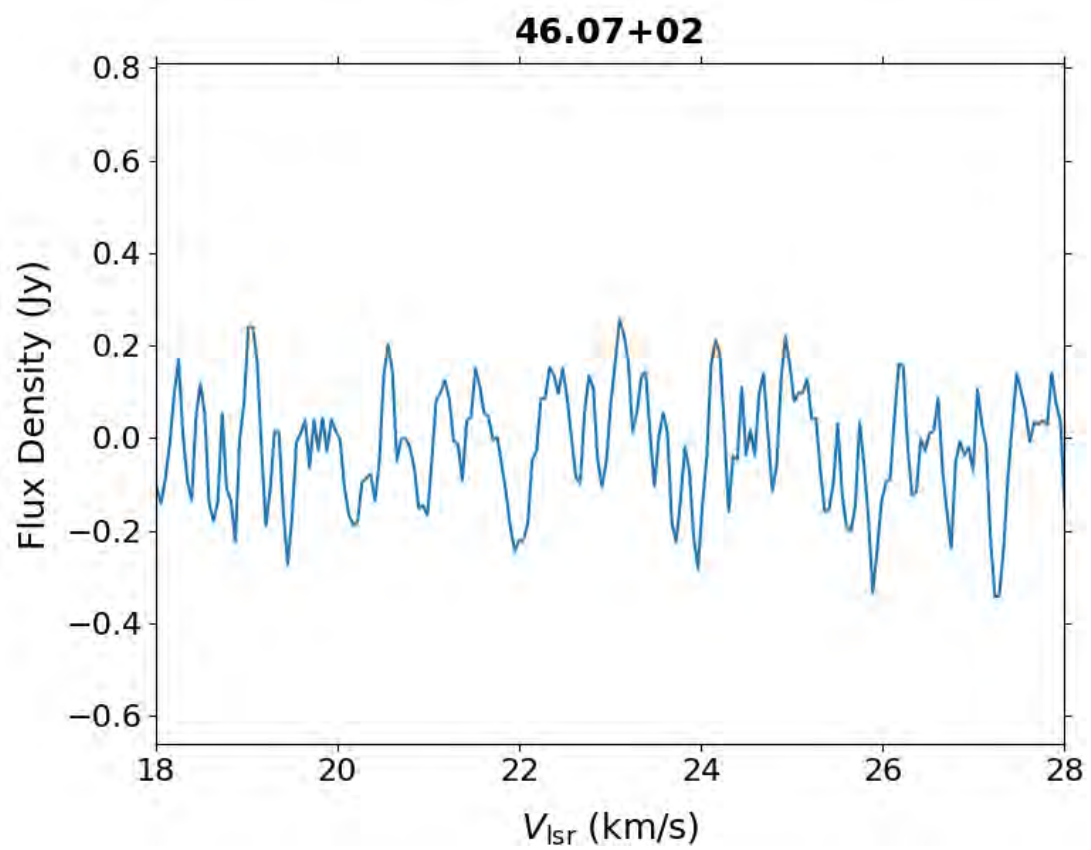
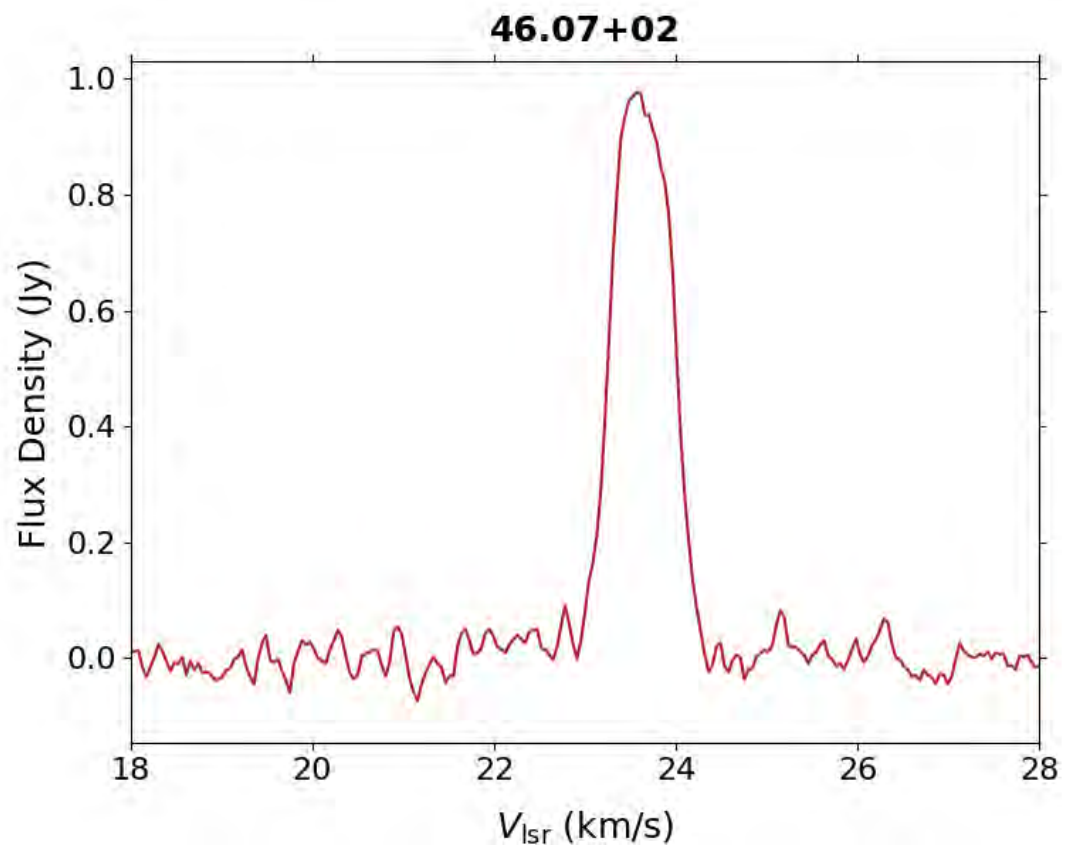
45.49+01

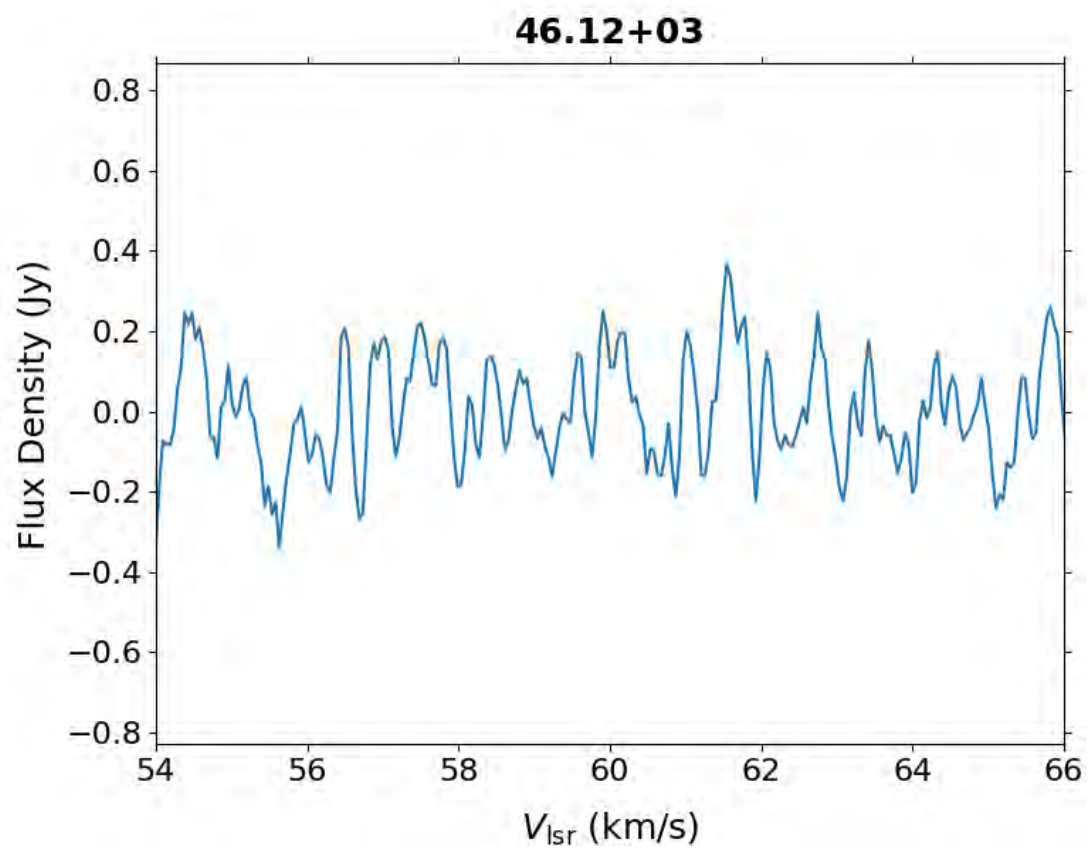
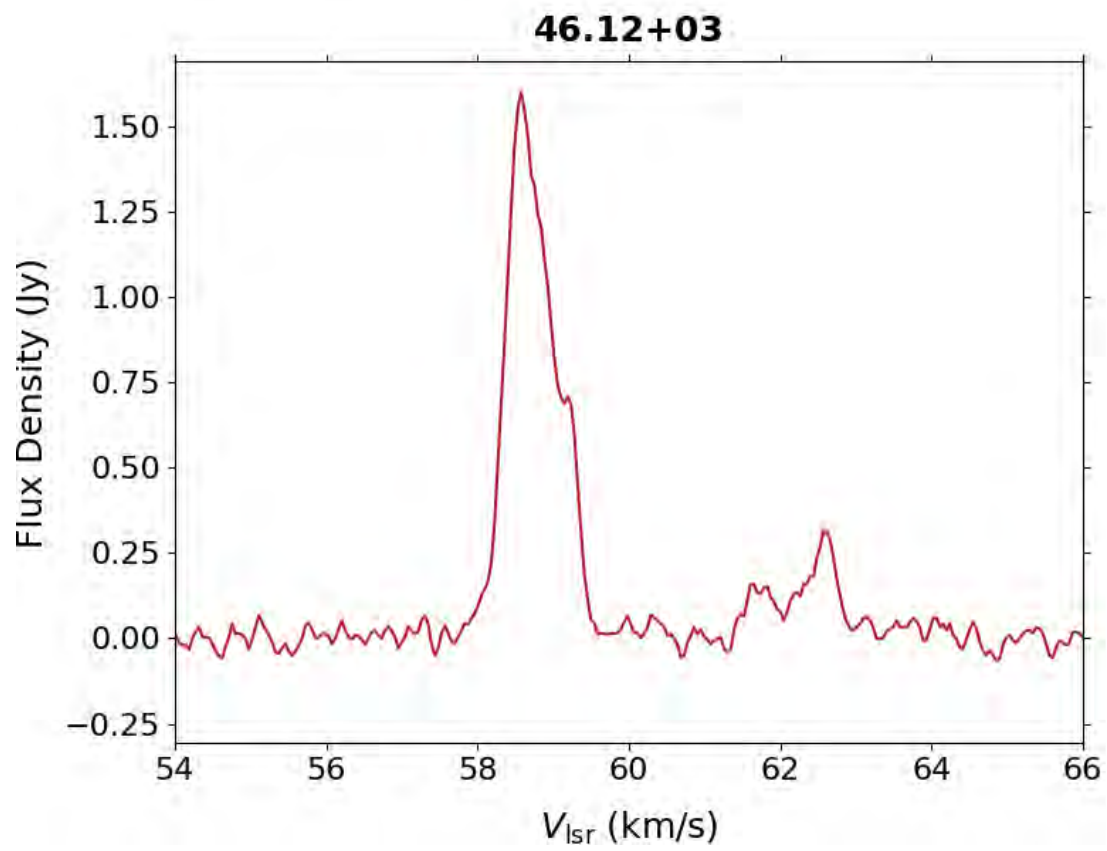


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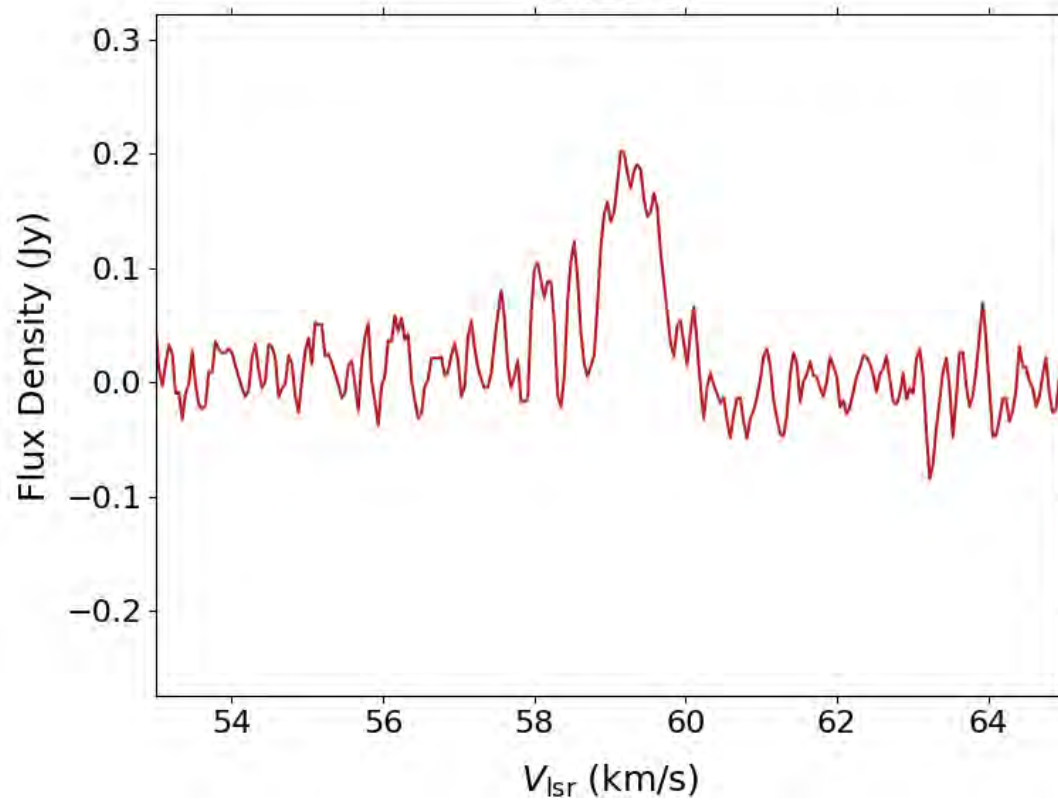




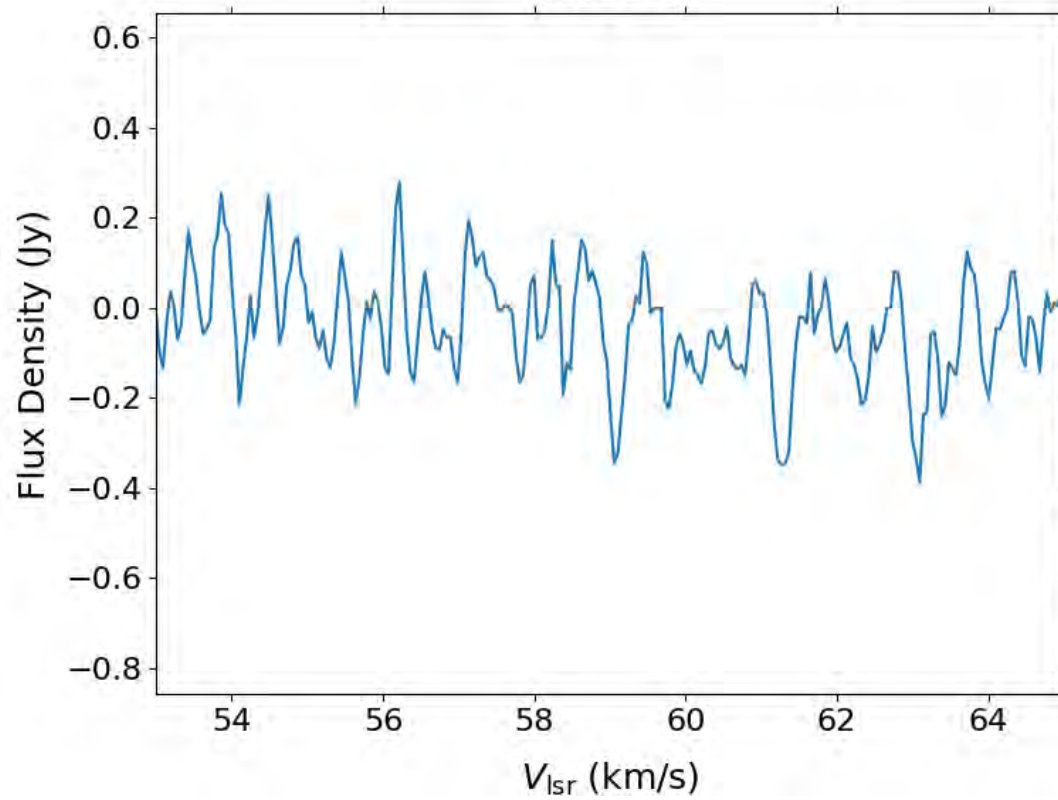




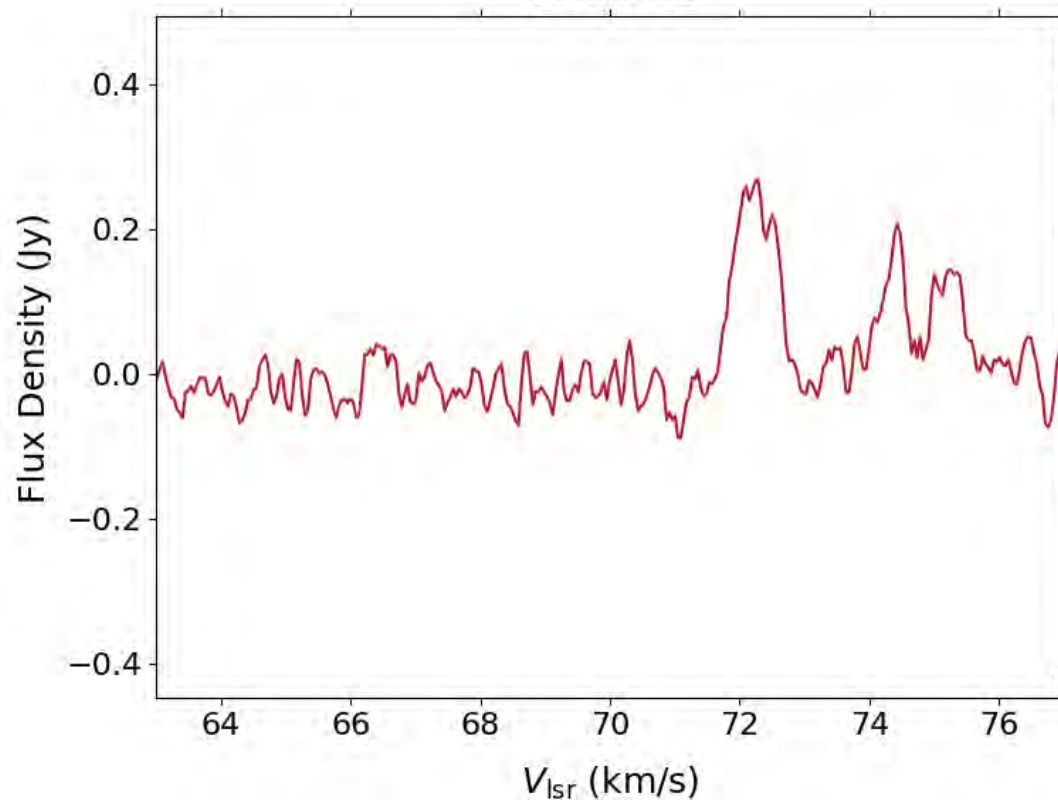
48.89-01



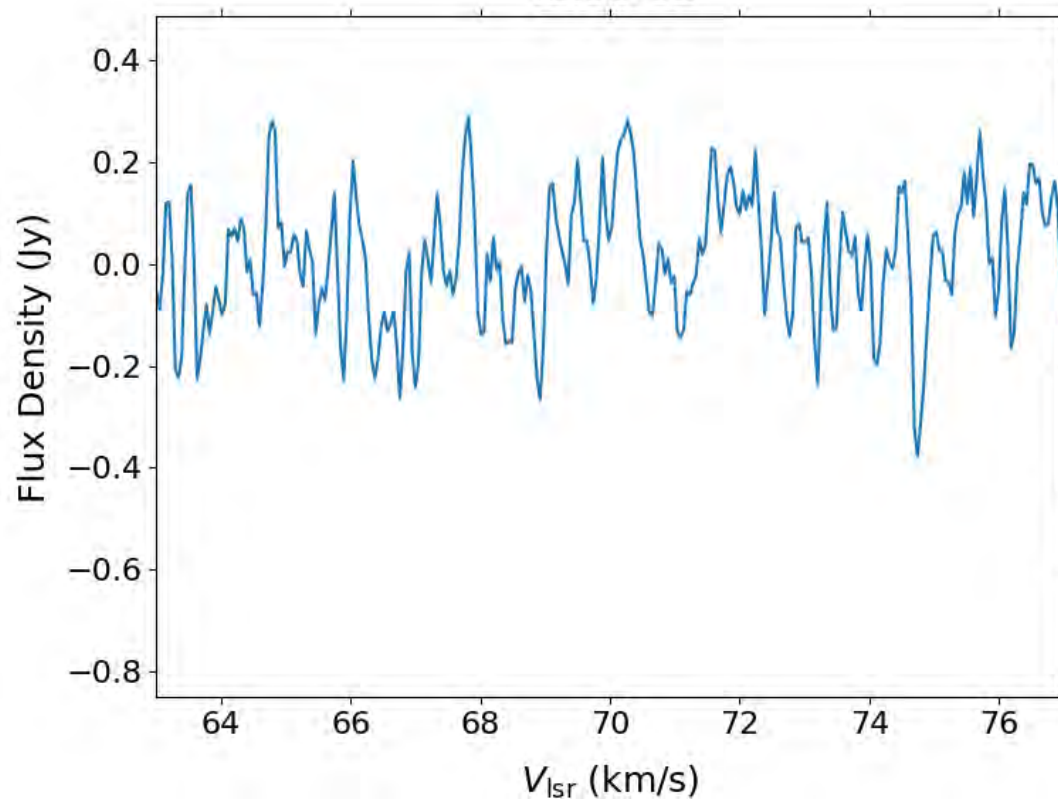
48.89-01

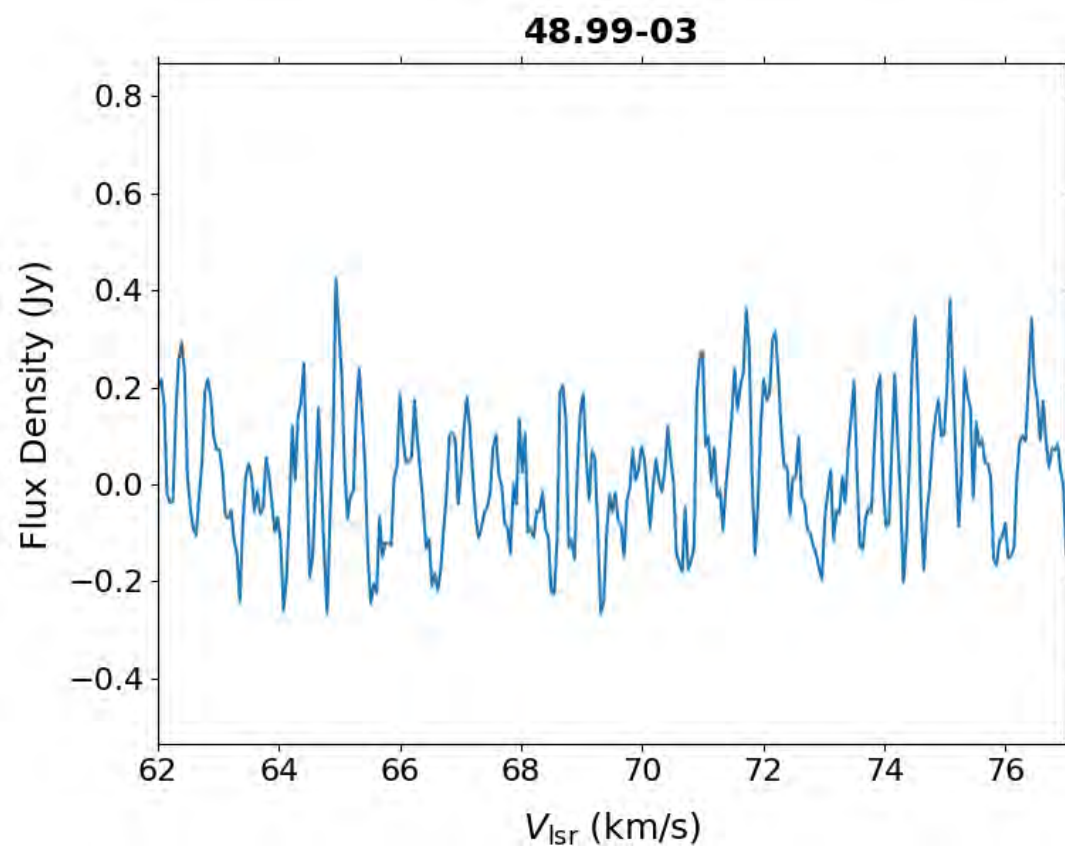
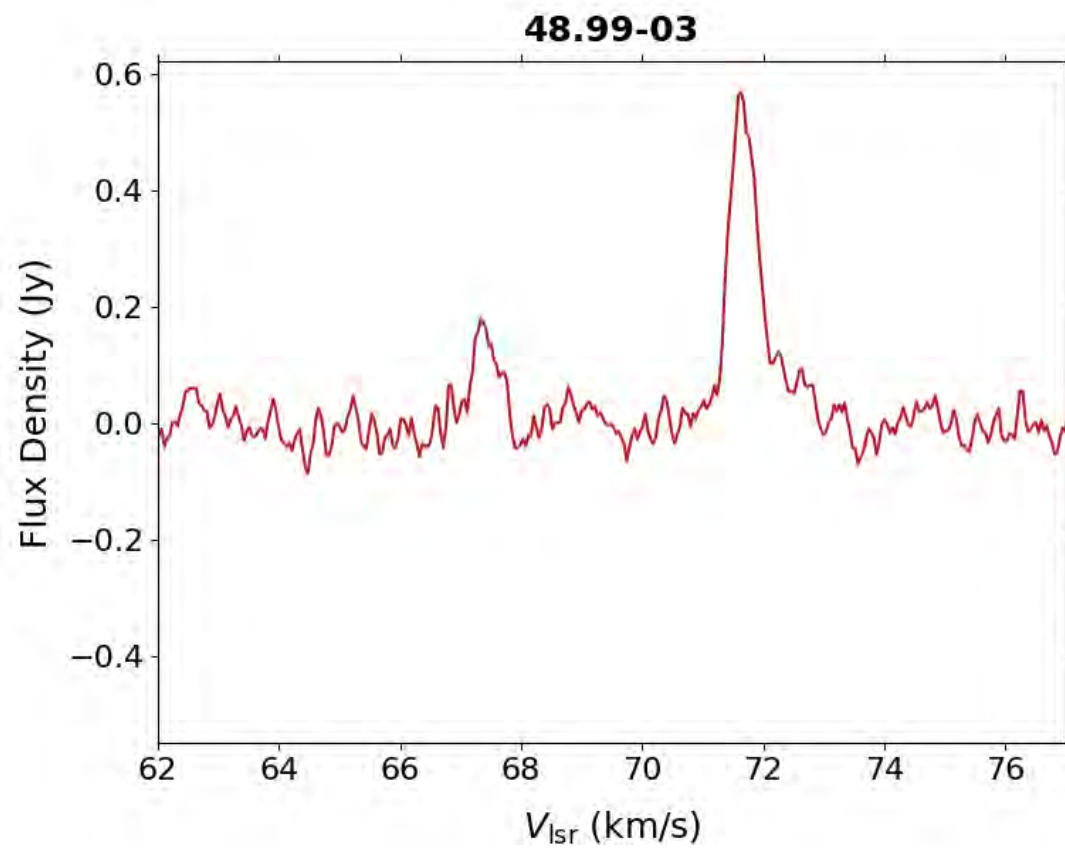


48.90-02

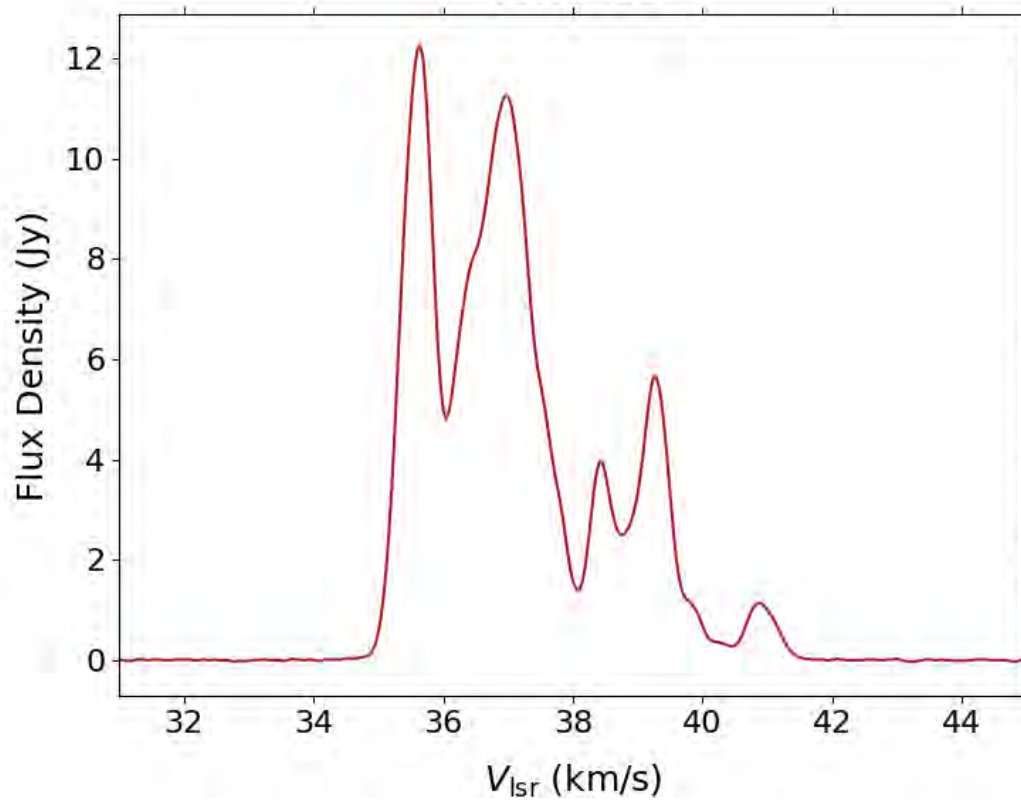


48.90-02

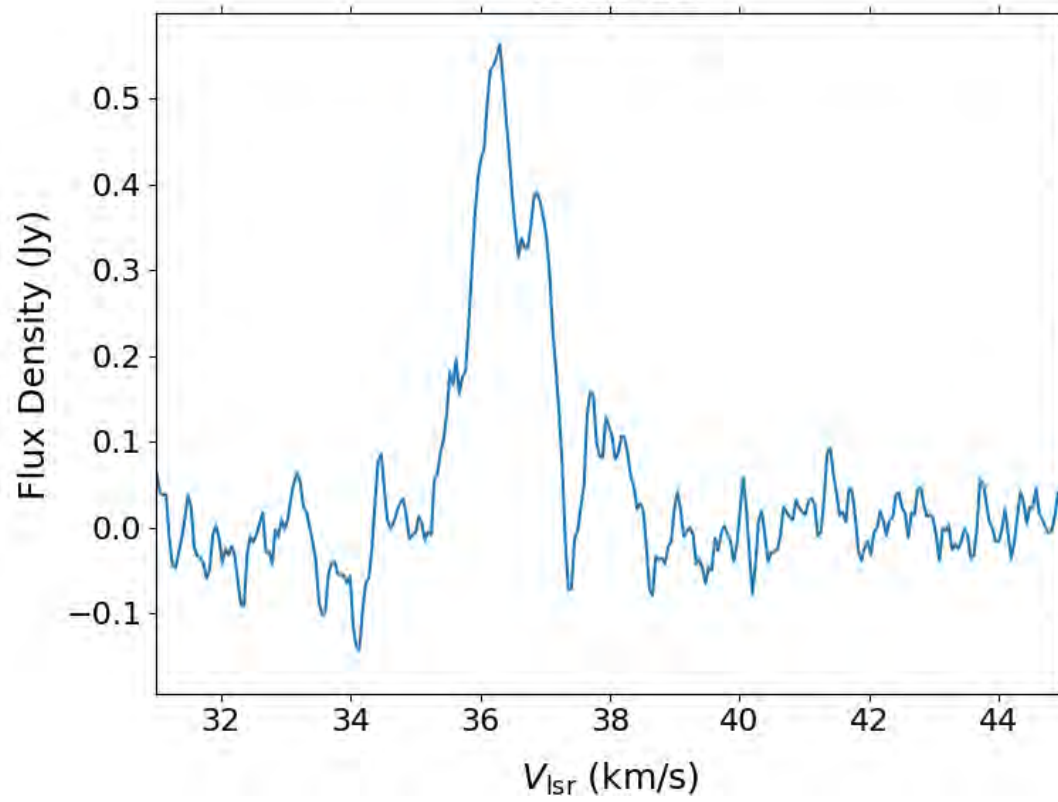


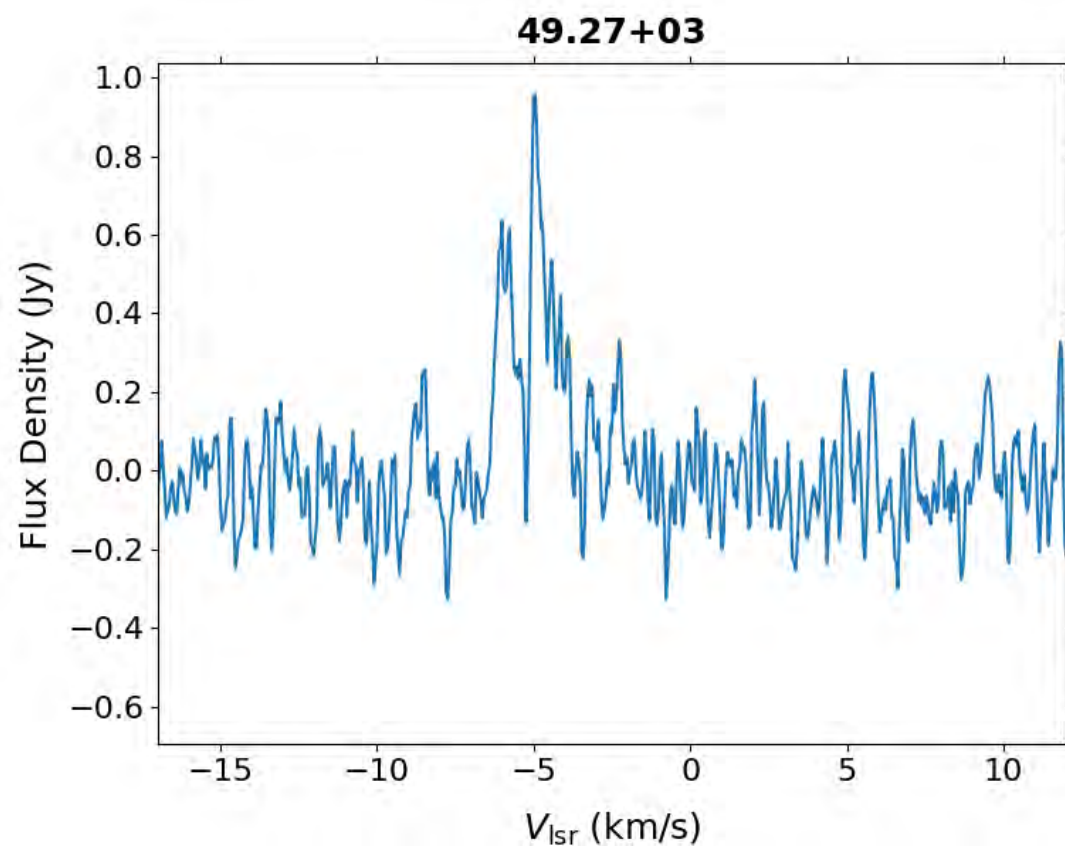
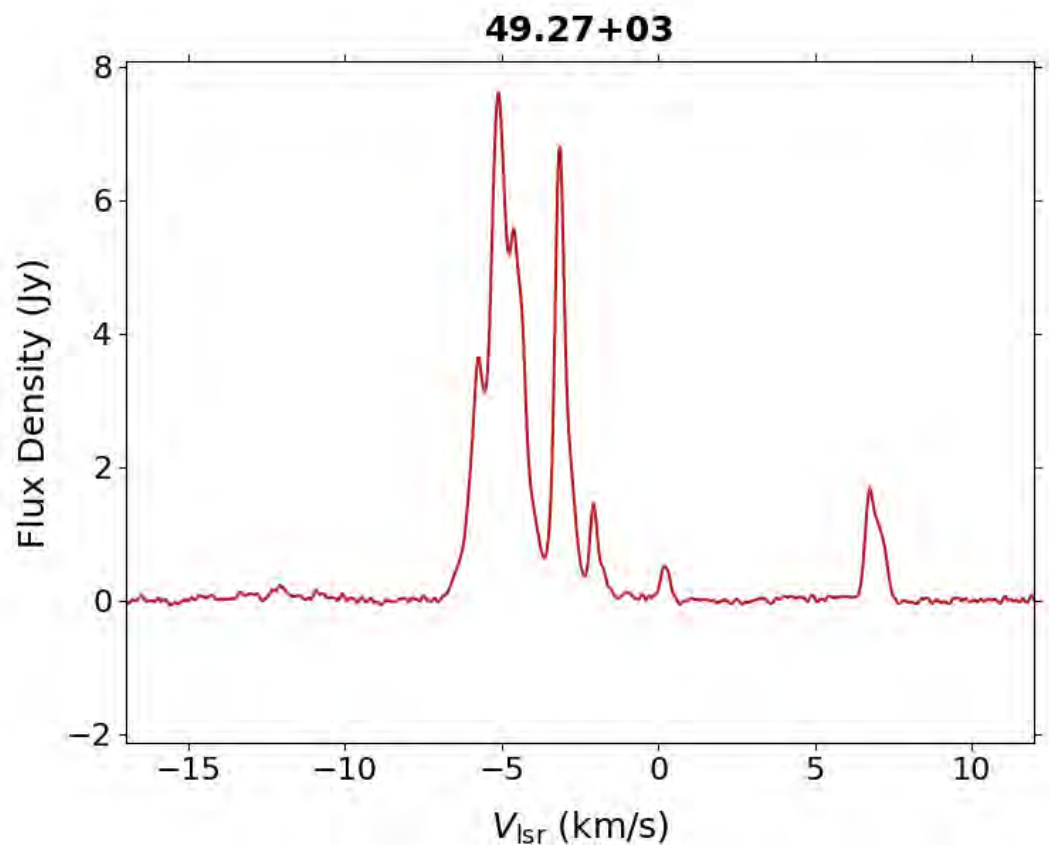


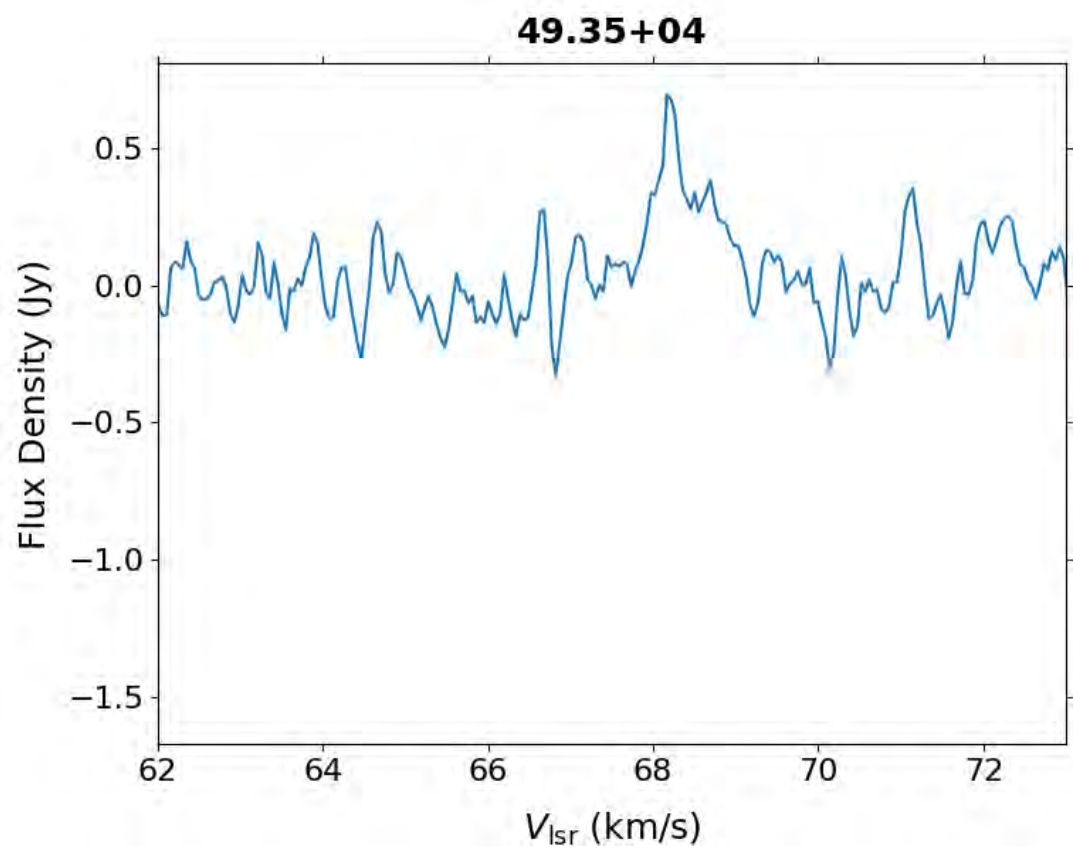
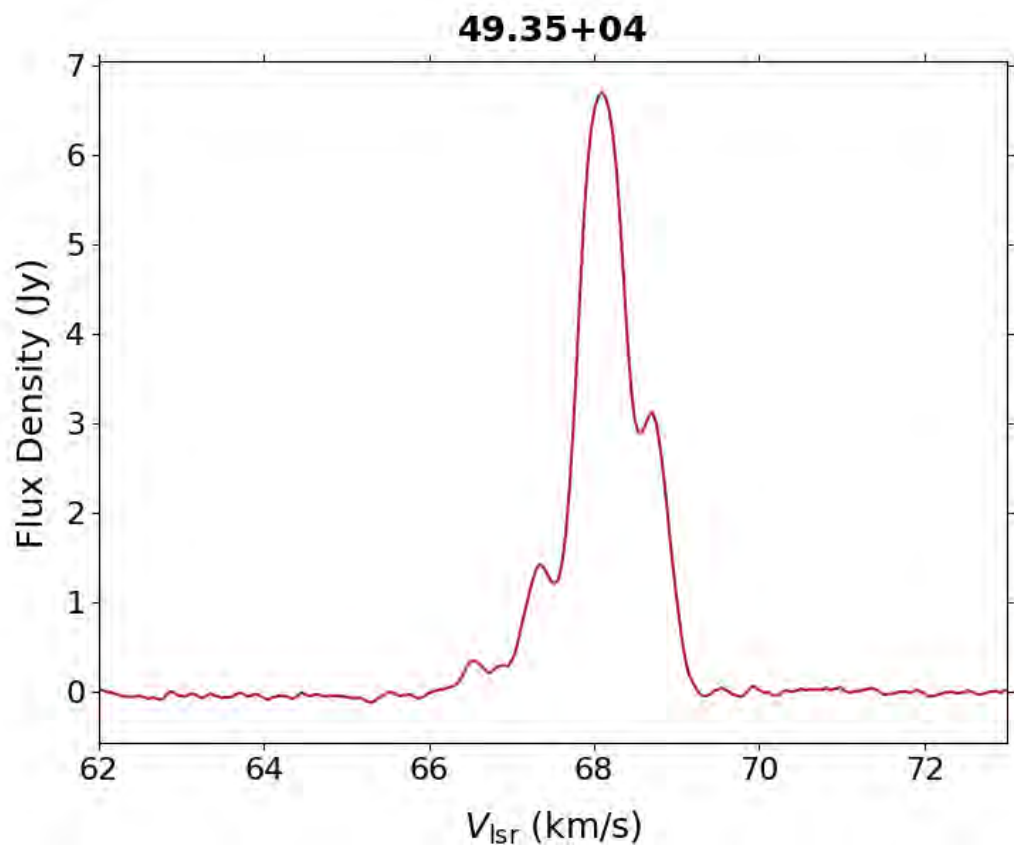
49.03-10



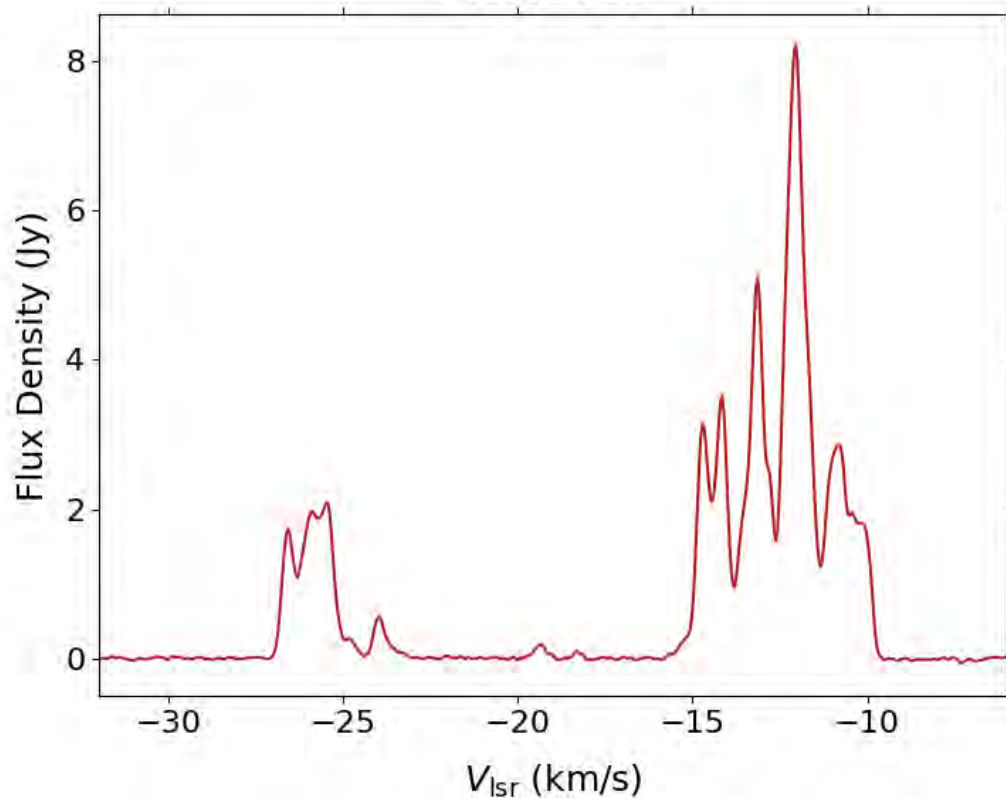
49.03-10



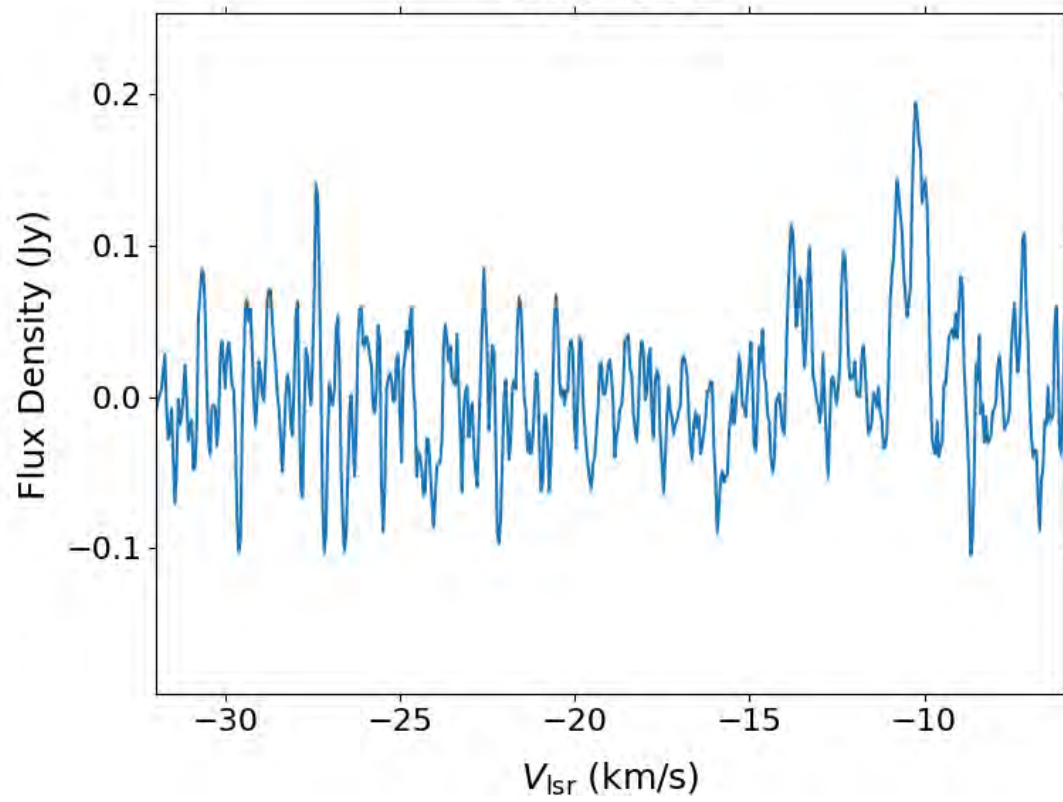




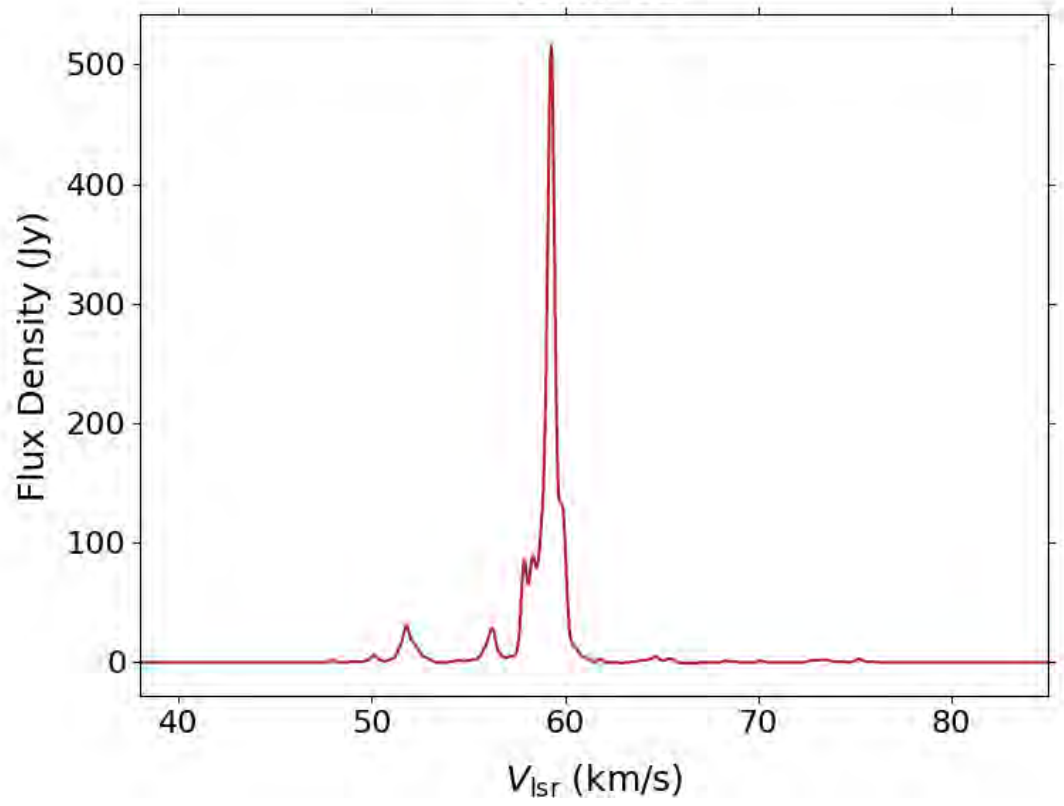
49.41+03



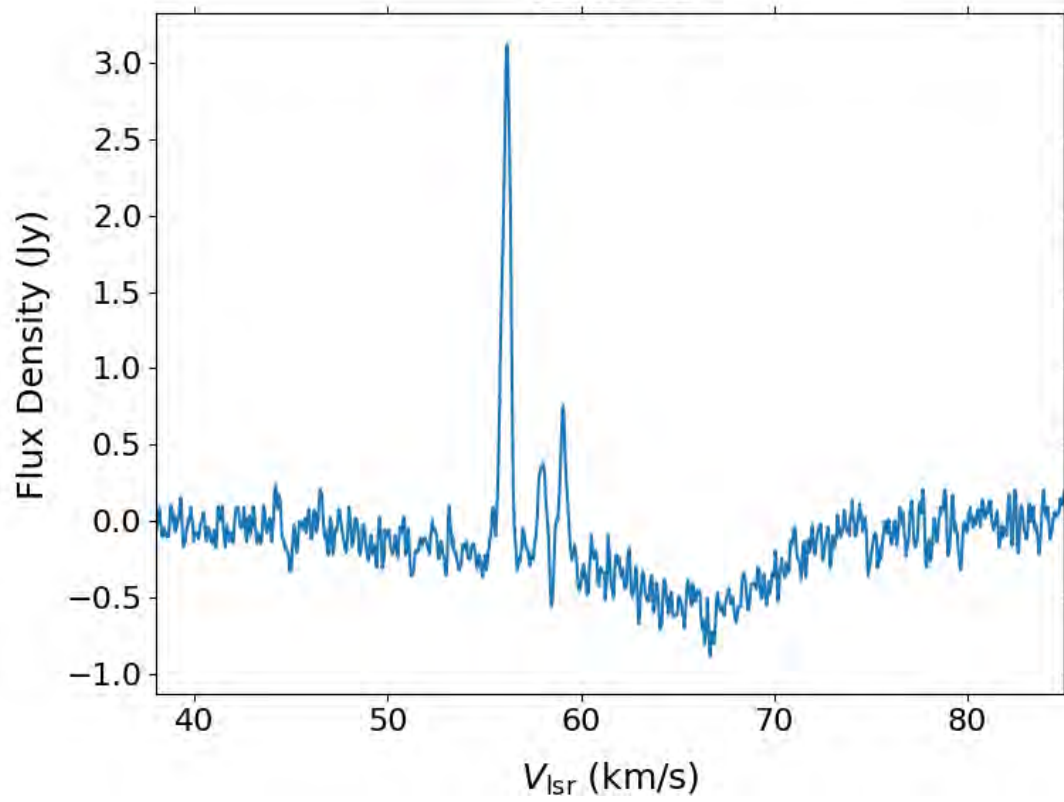
49.41+03



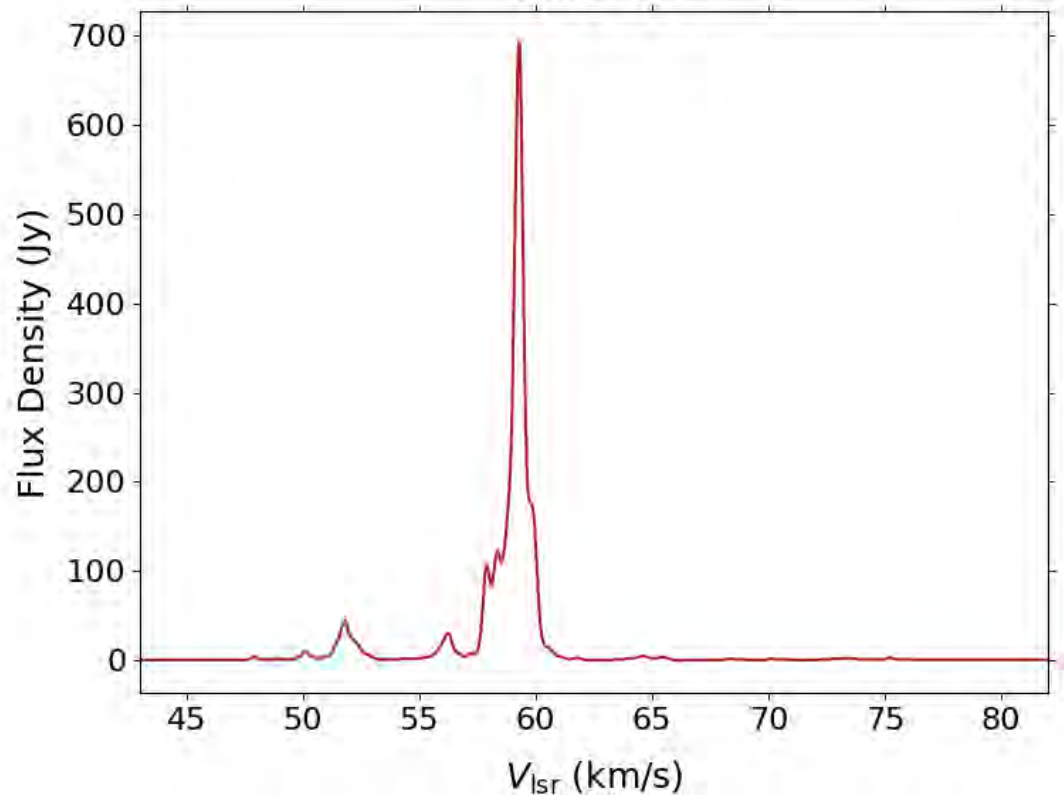
49.47-03



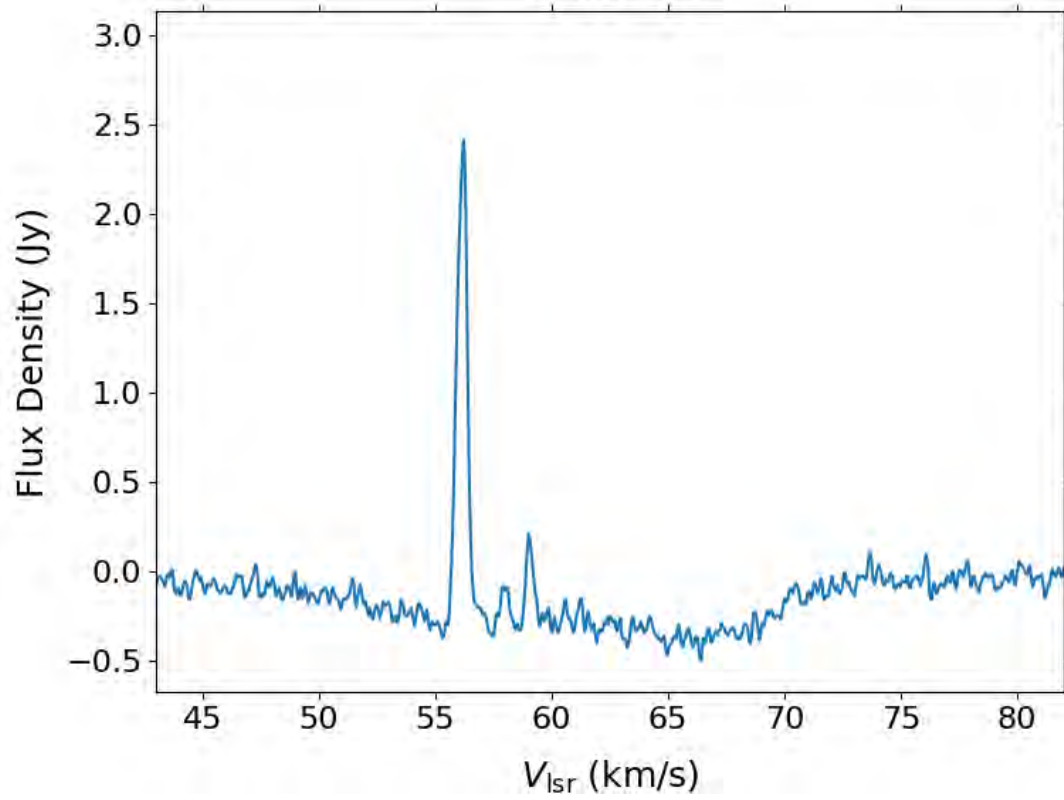
49.47-03



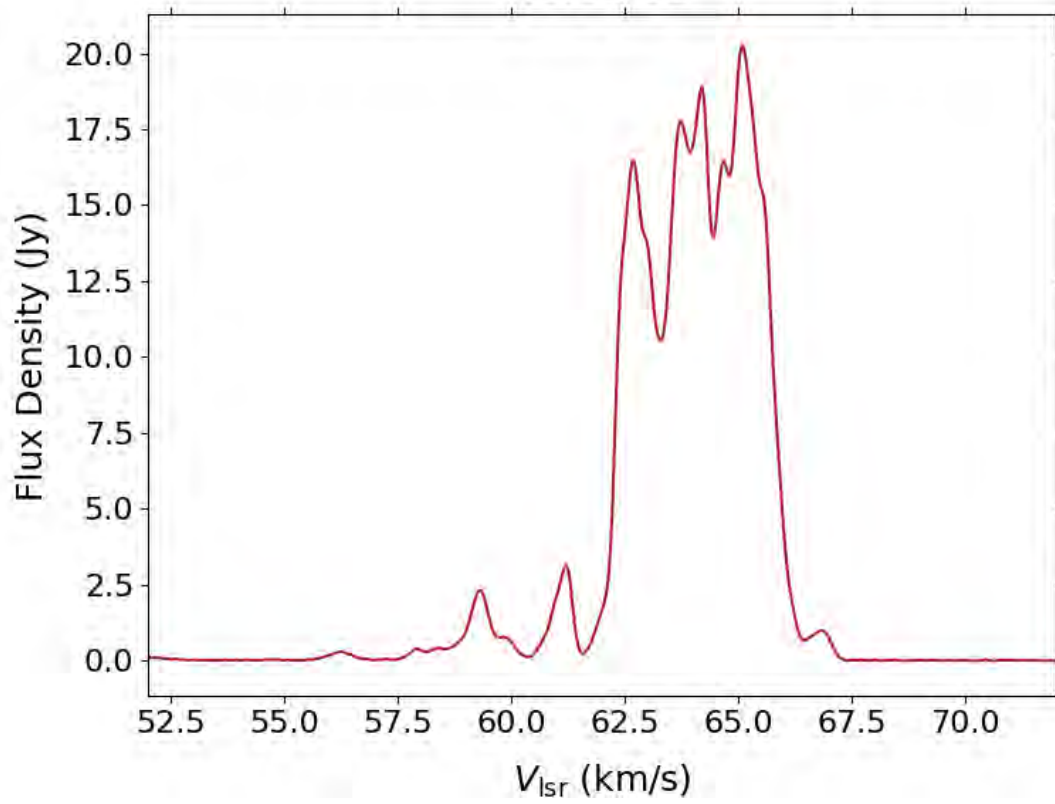
49.49-03



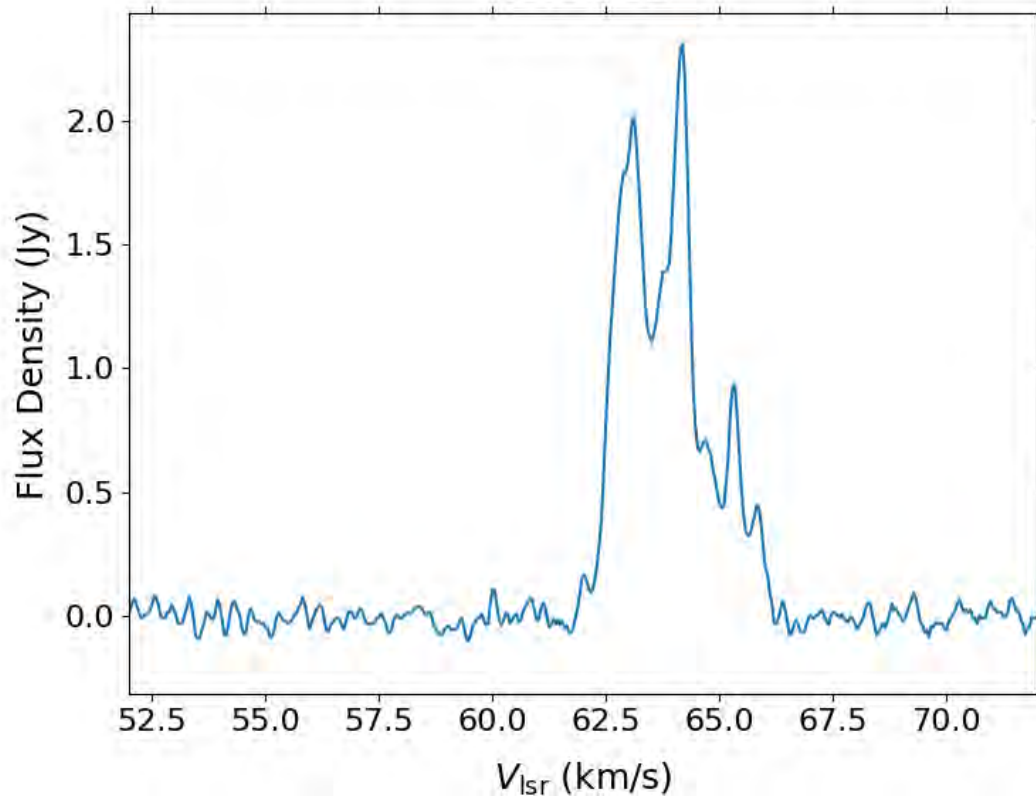
49.49-03

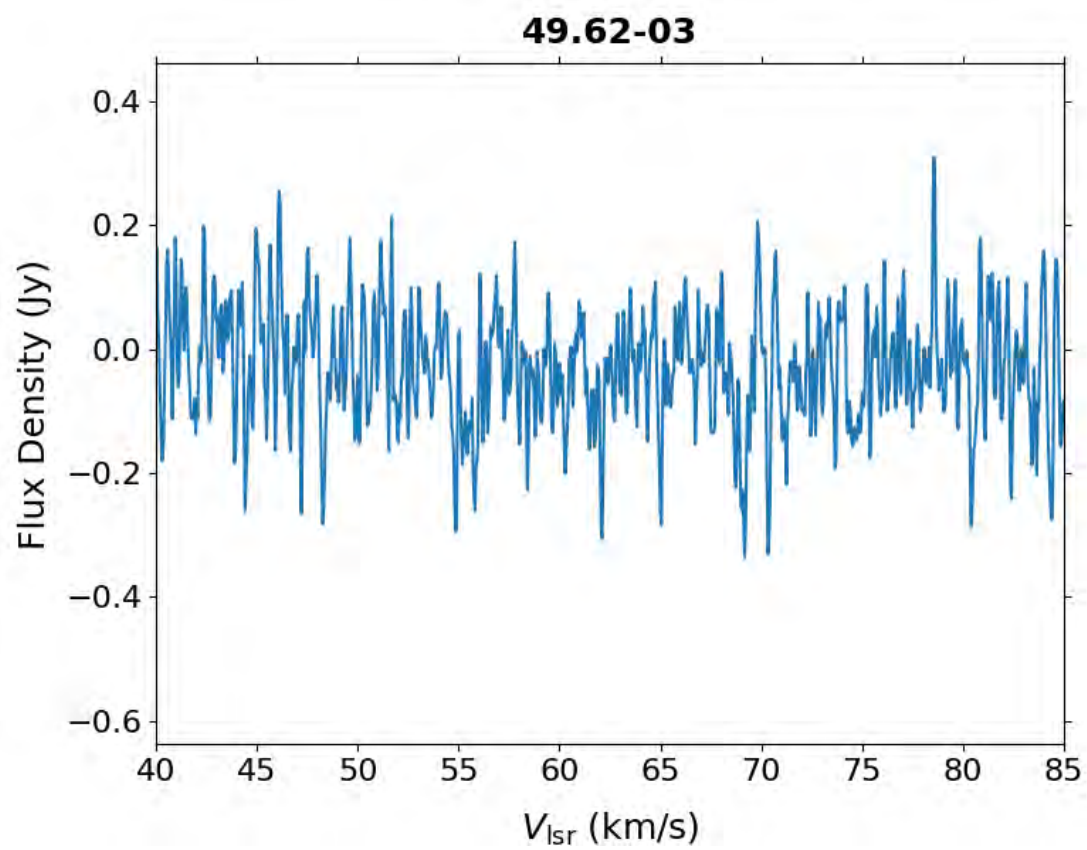
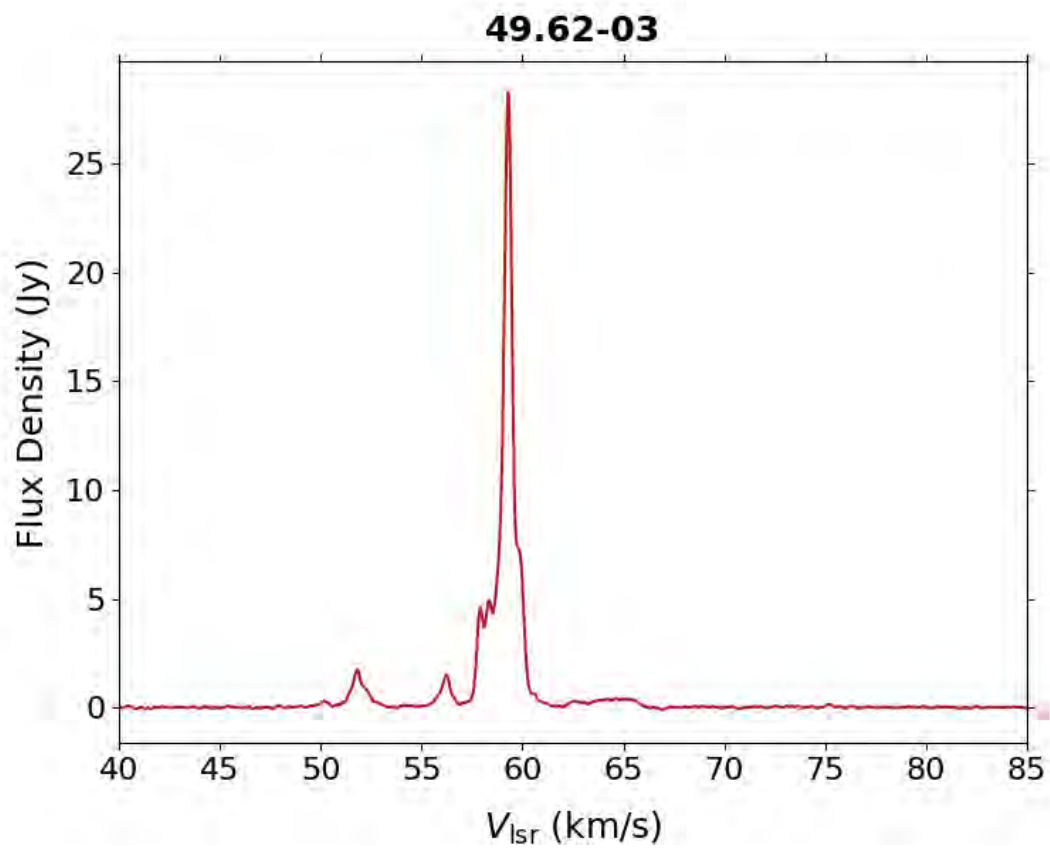


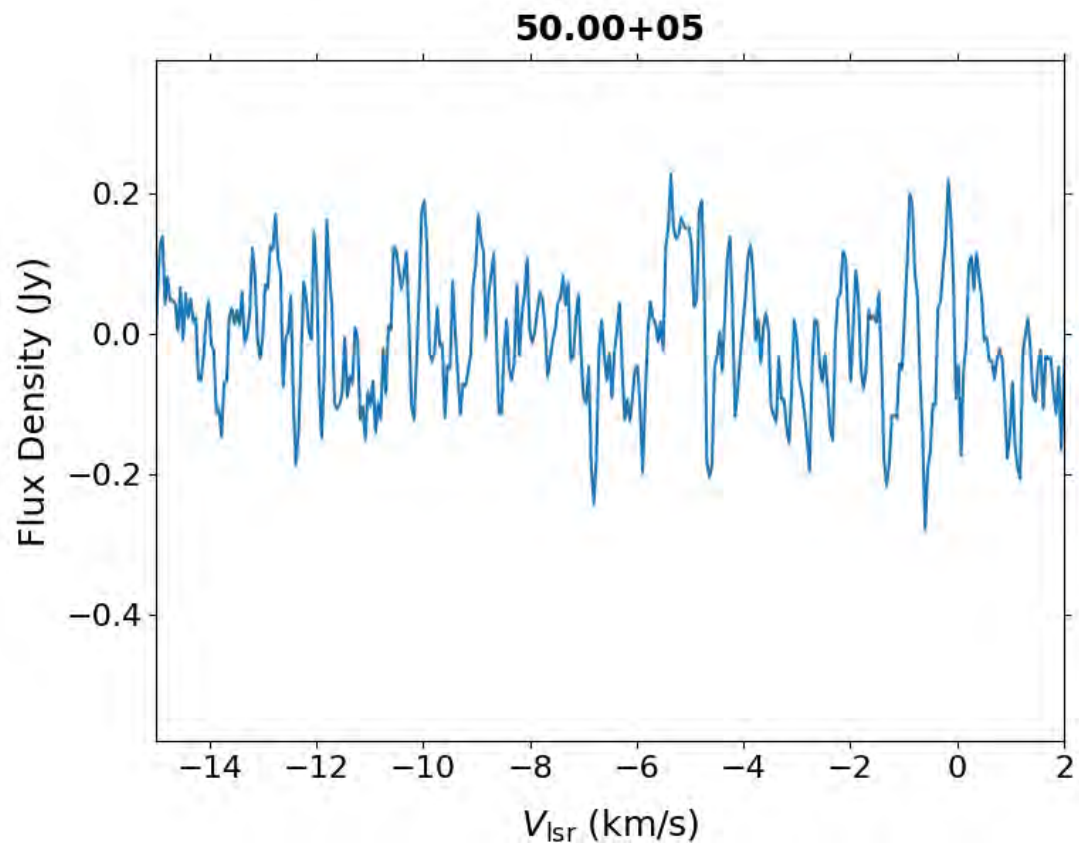
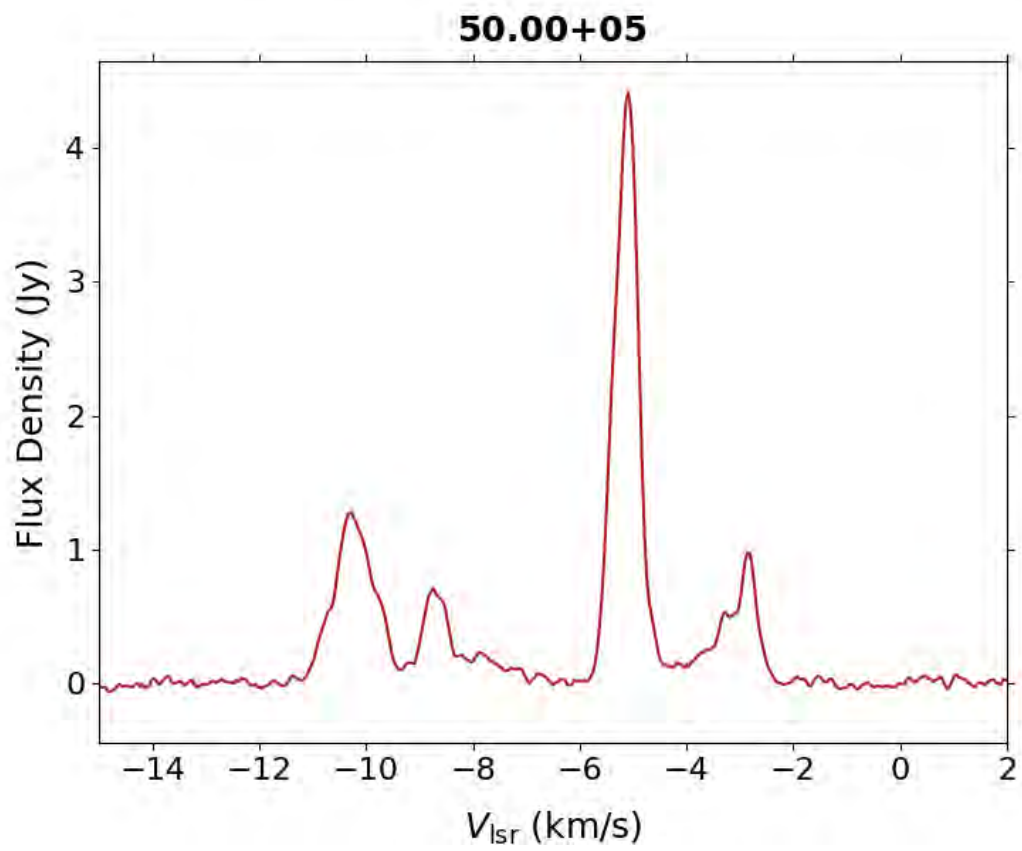
49.60-02

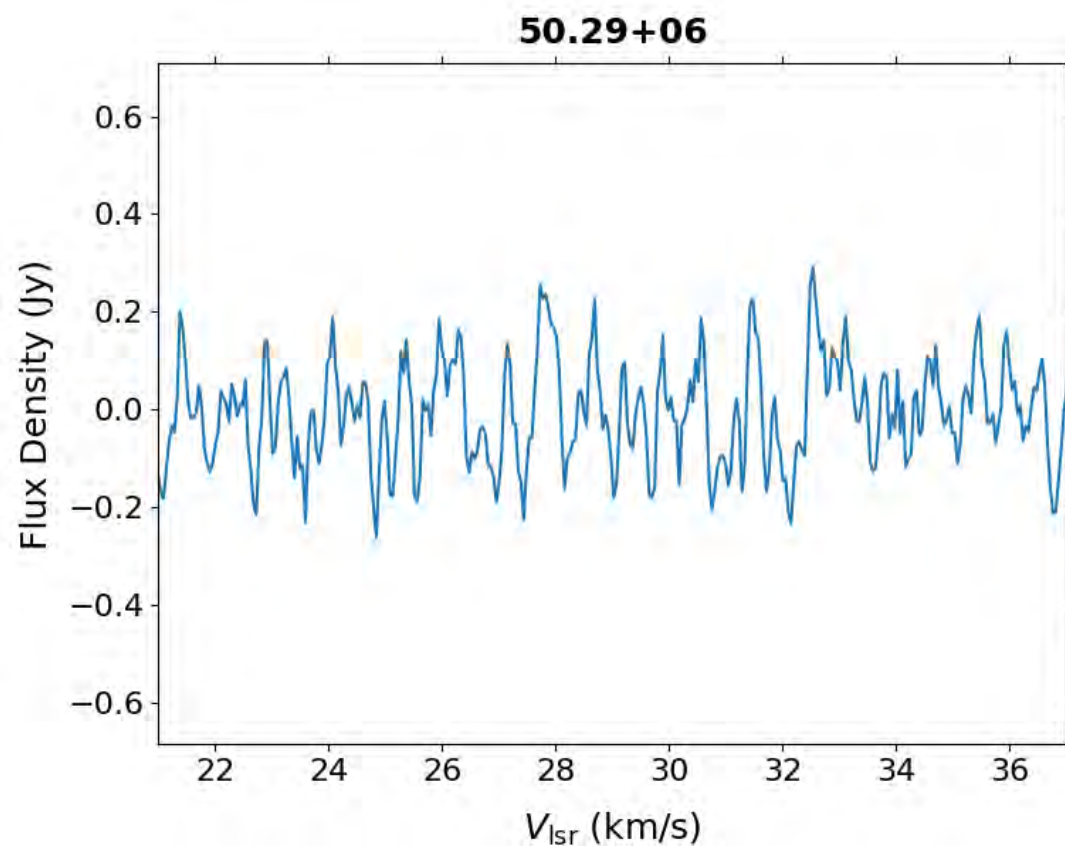
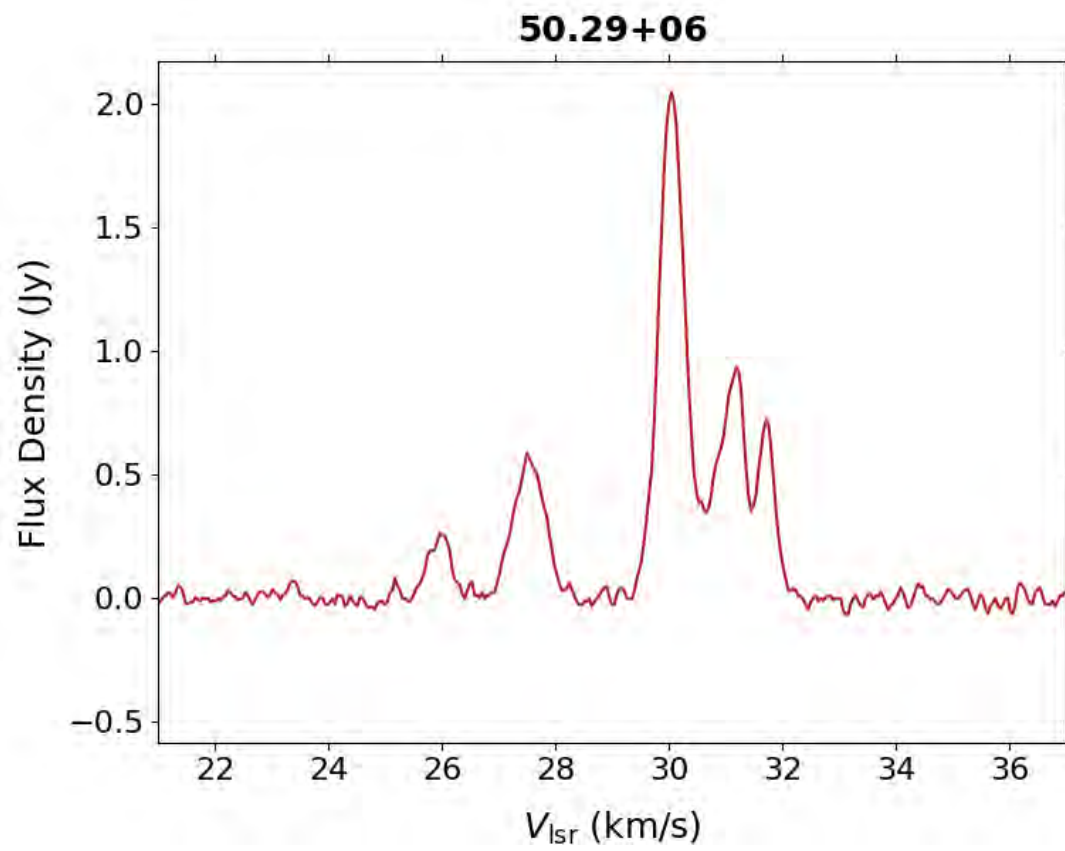


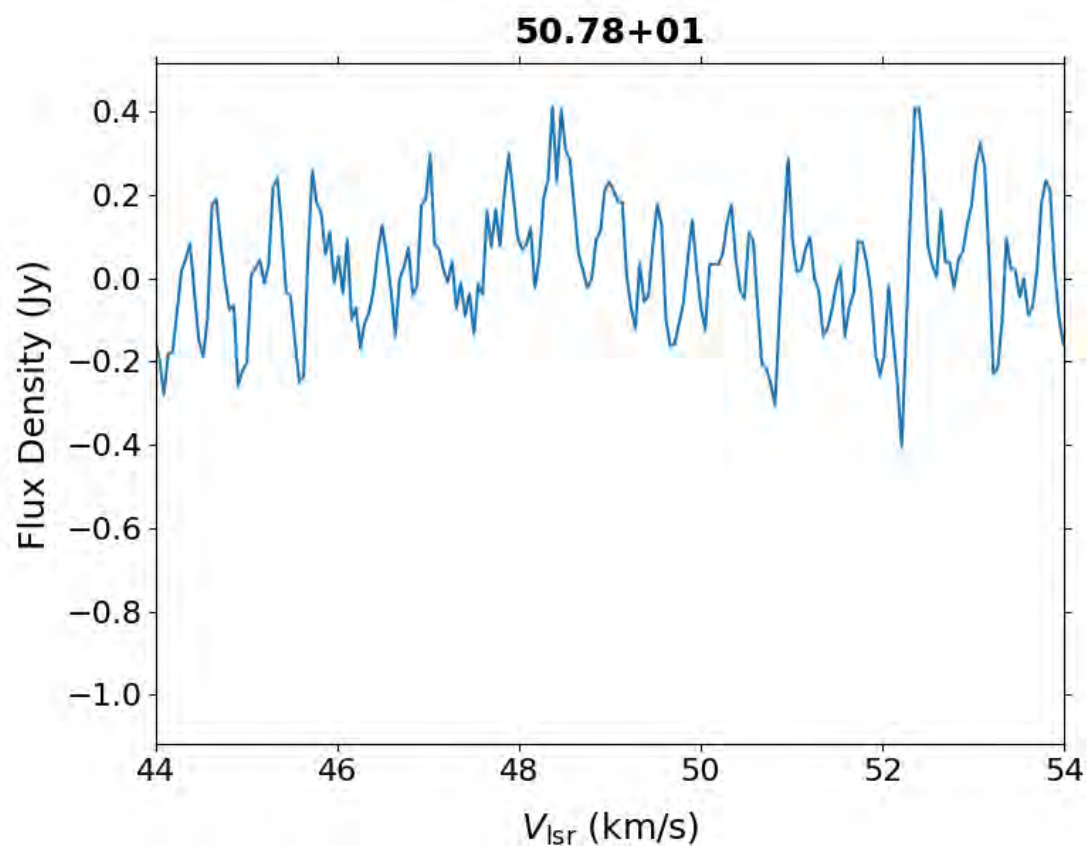
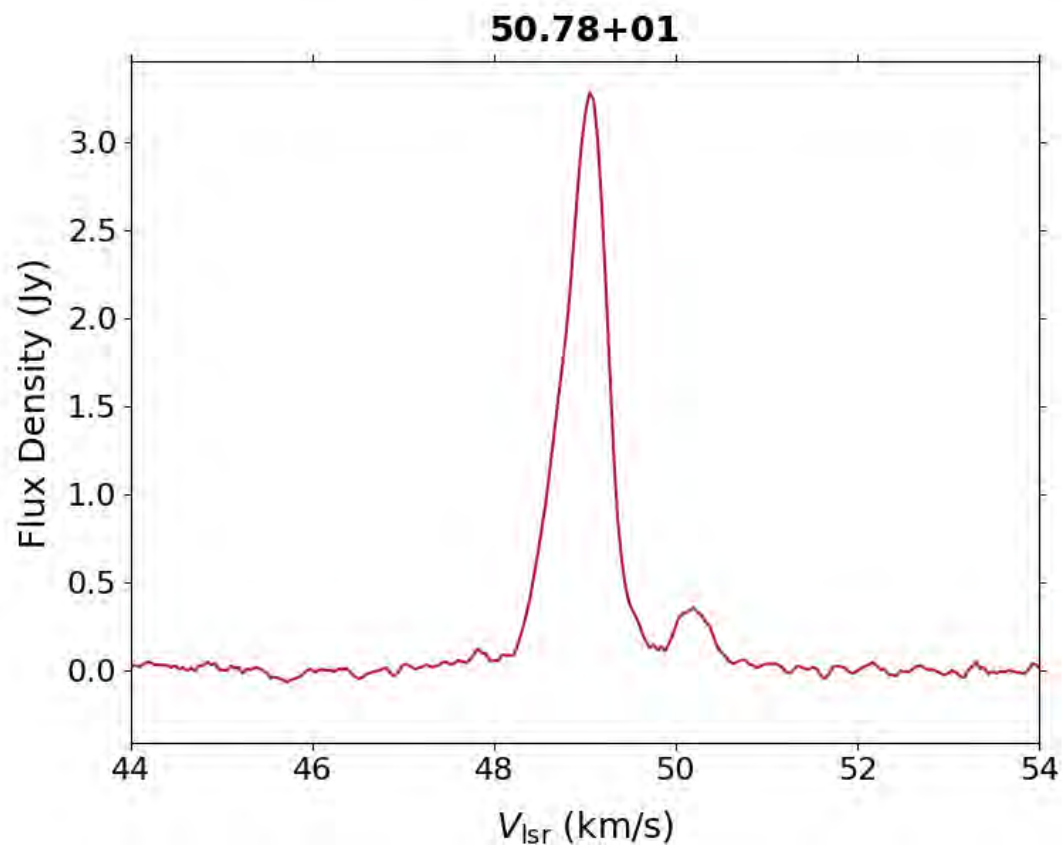
49.60-02

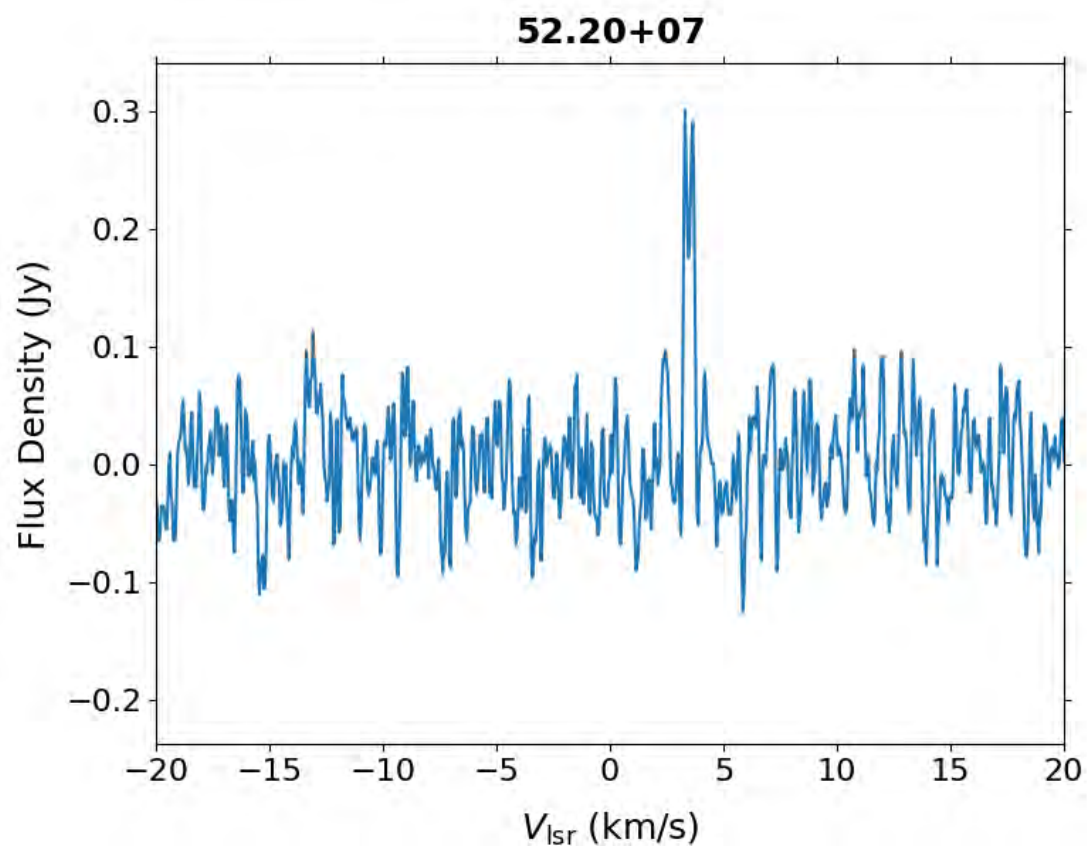
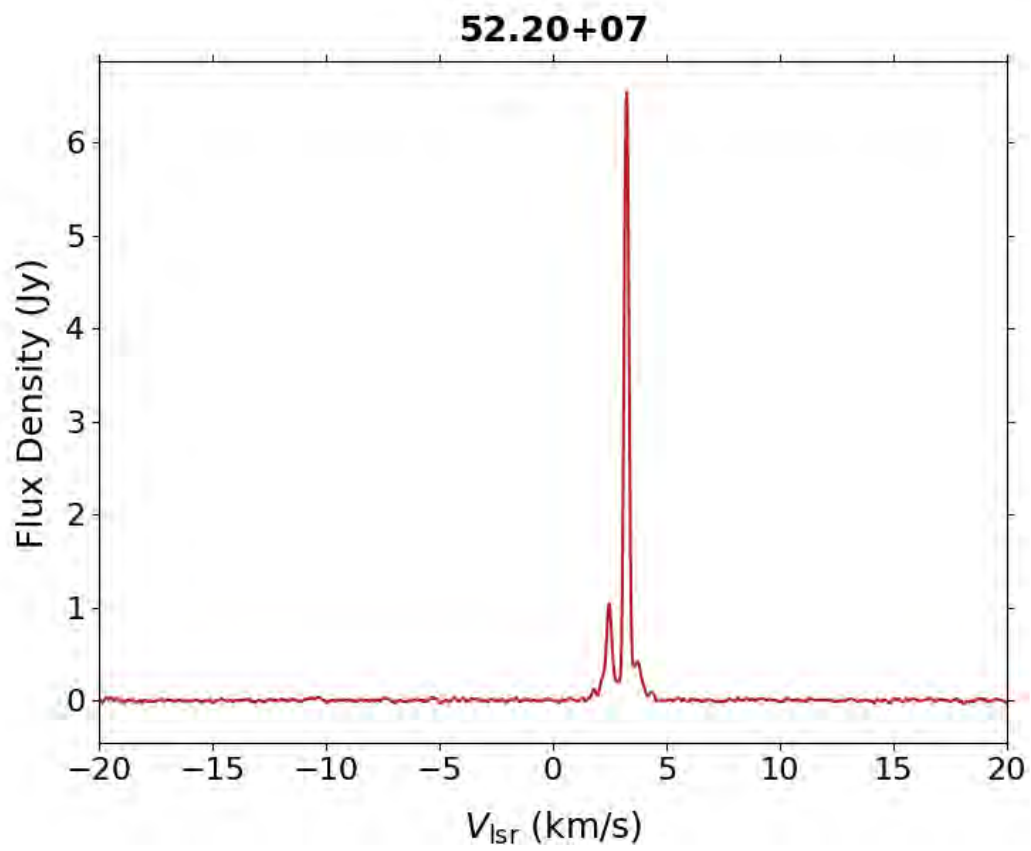




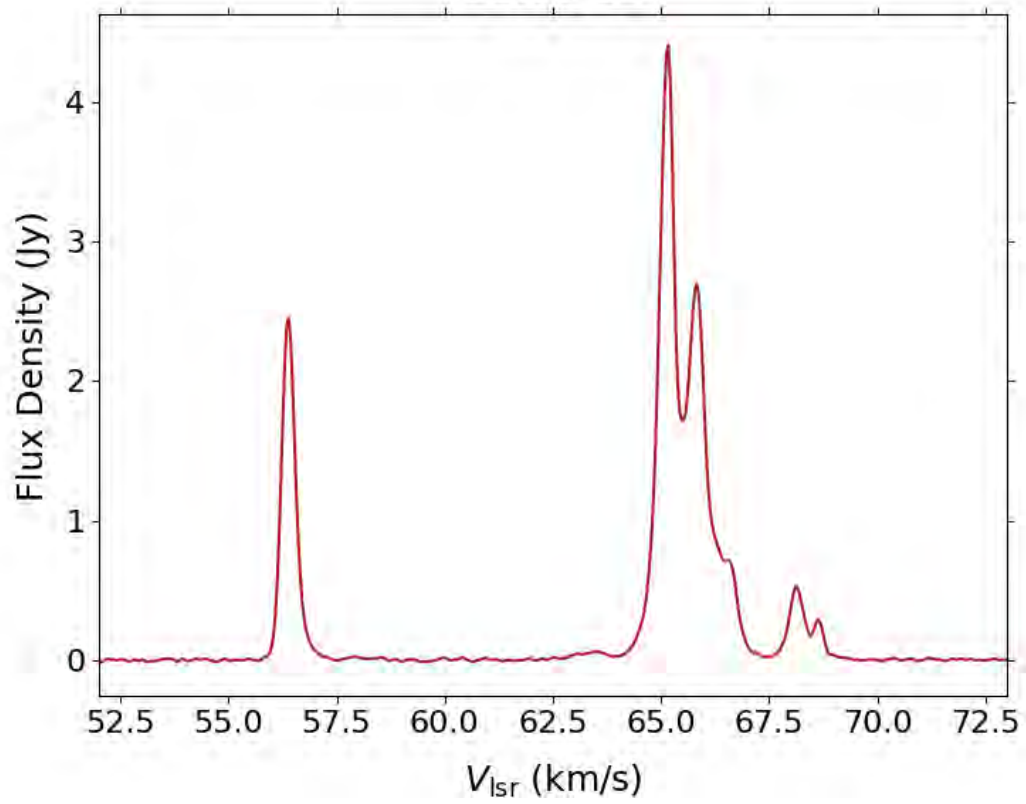




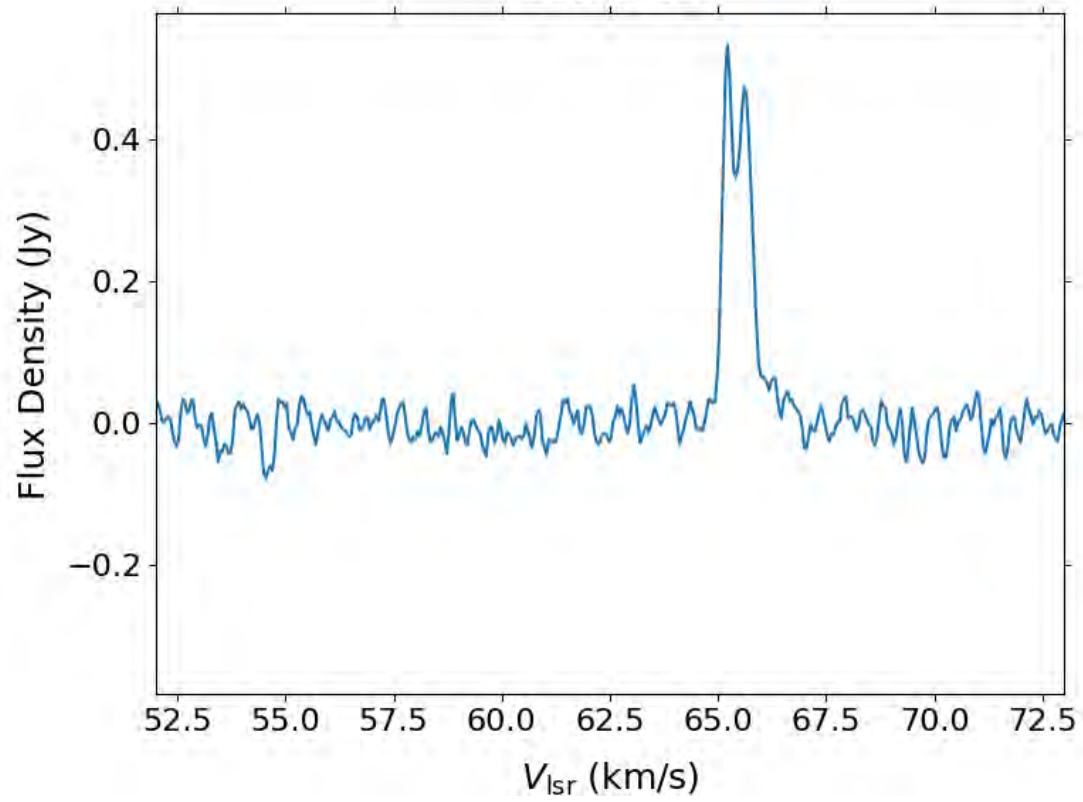


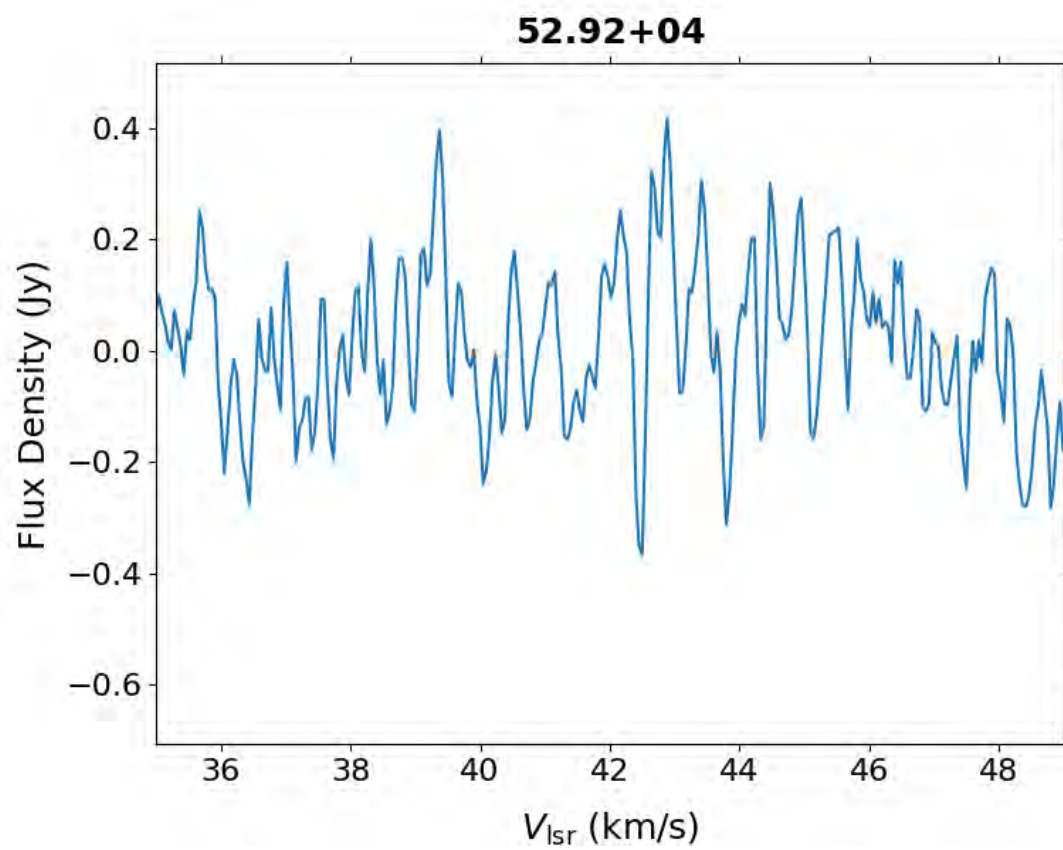
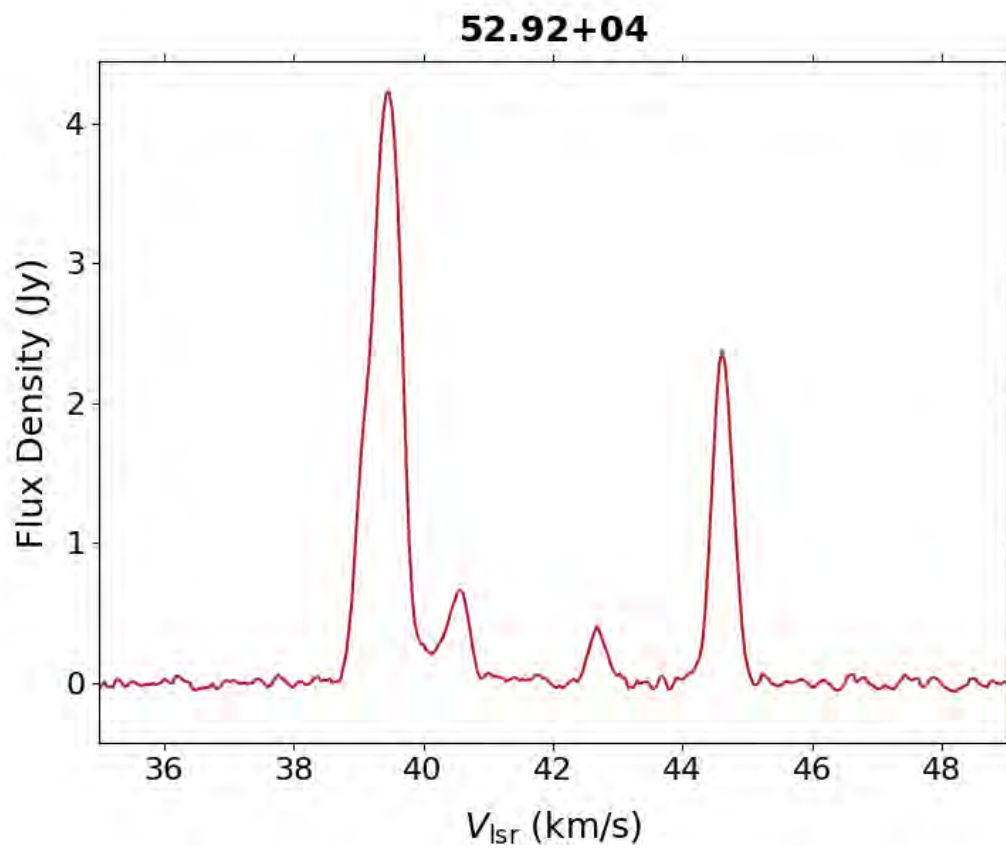


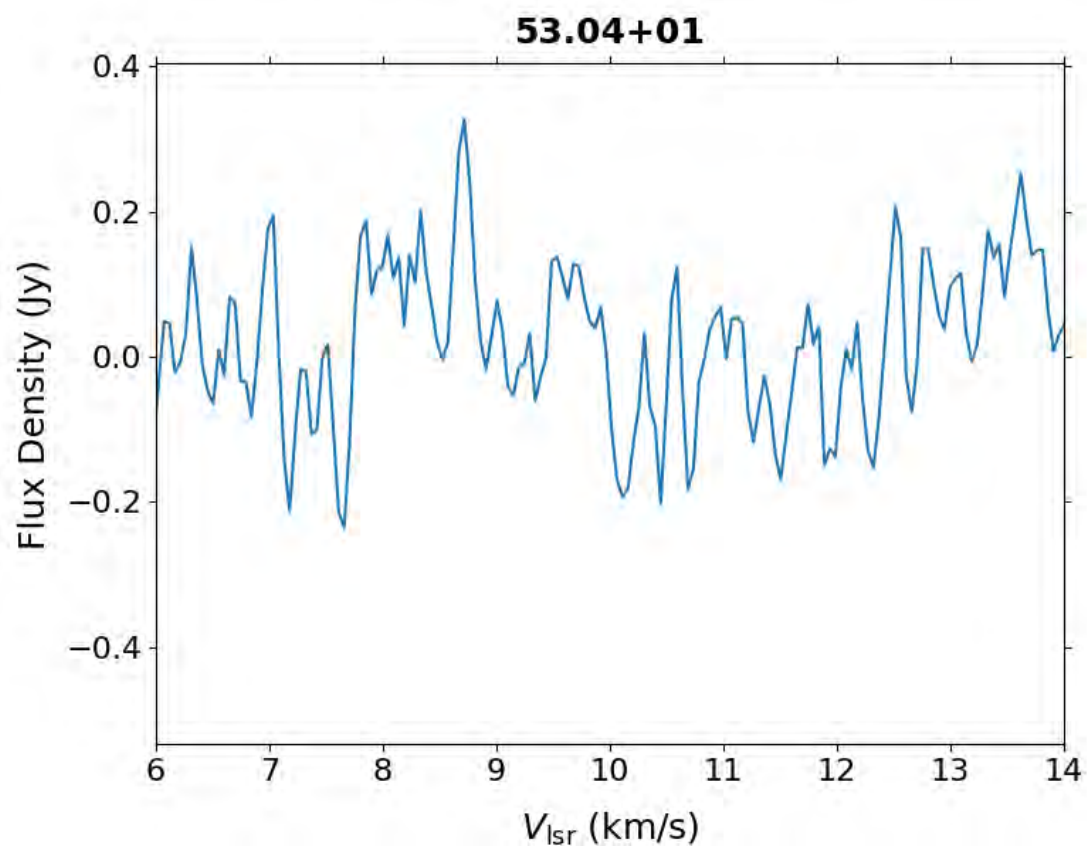
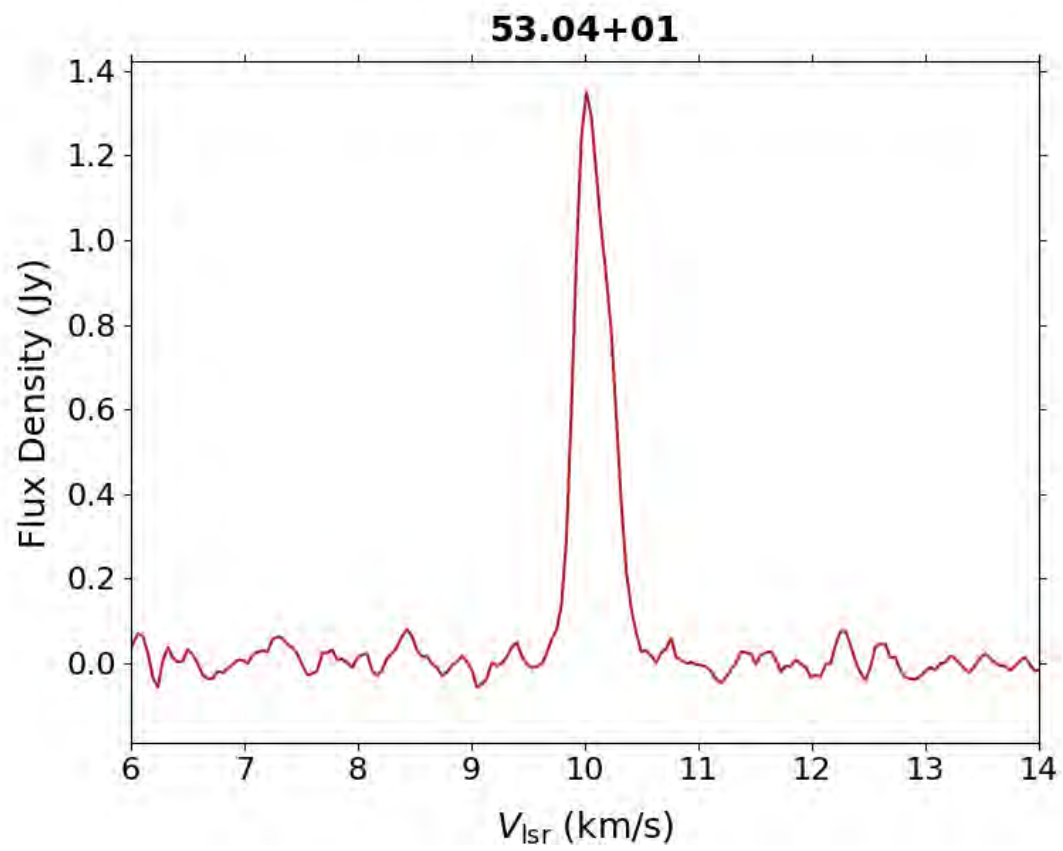
52.66-10

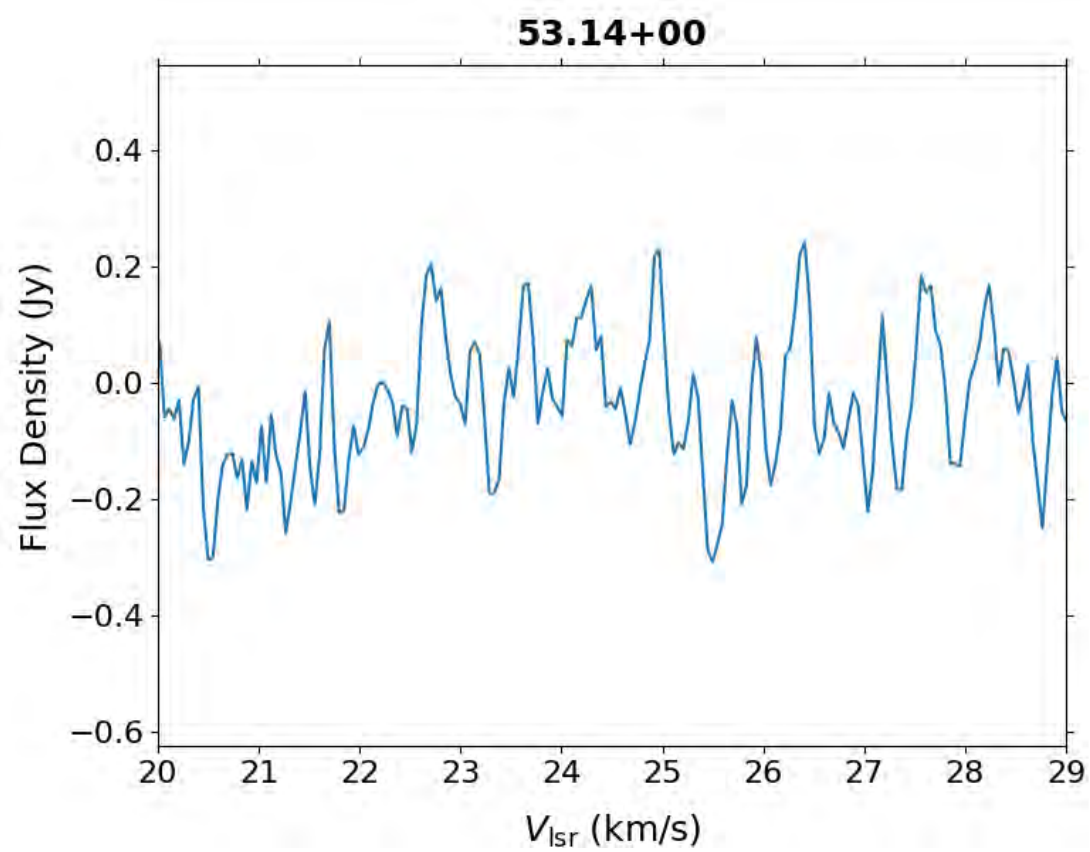
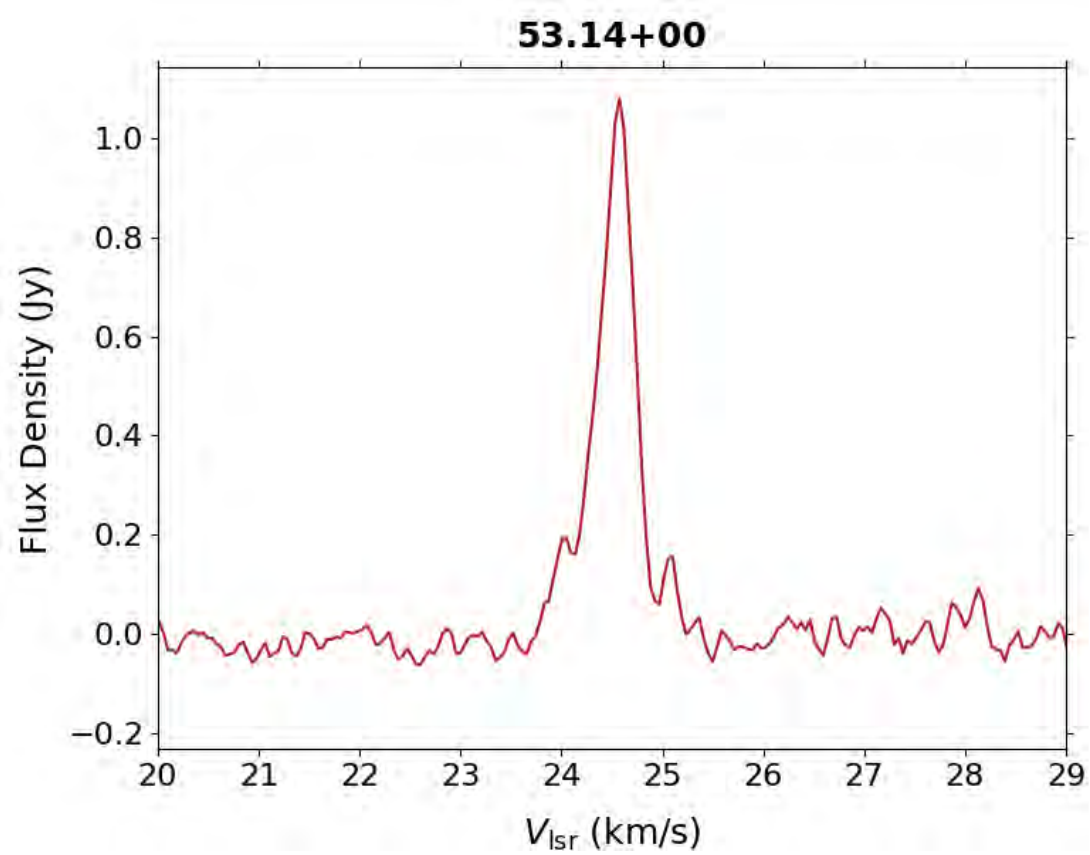


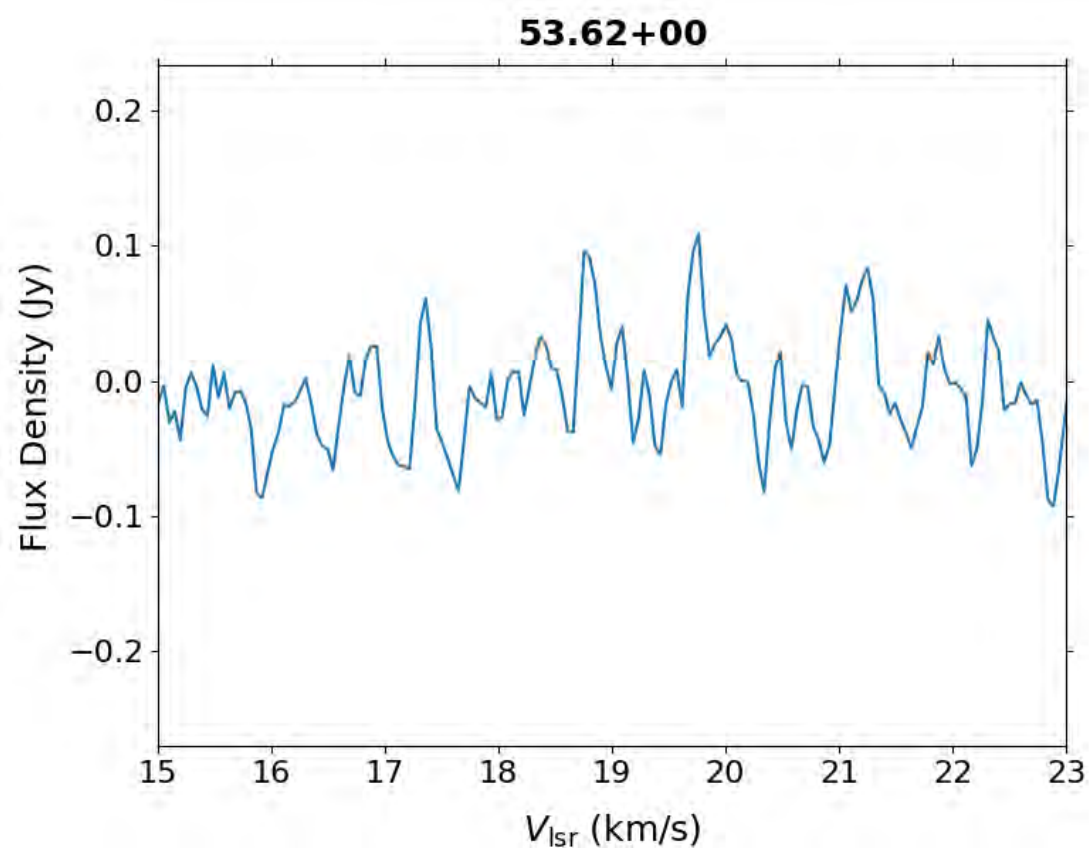
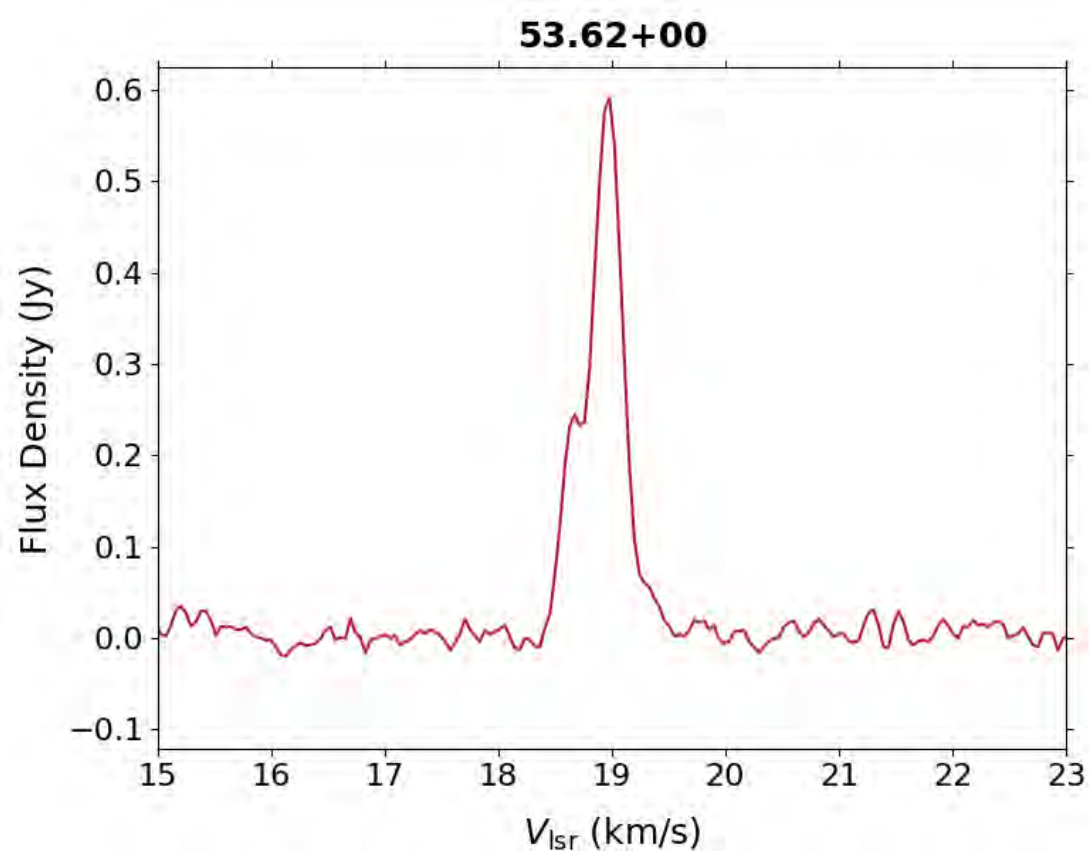
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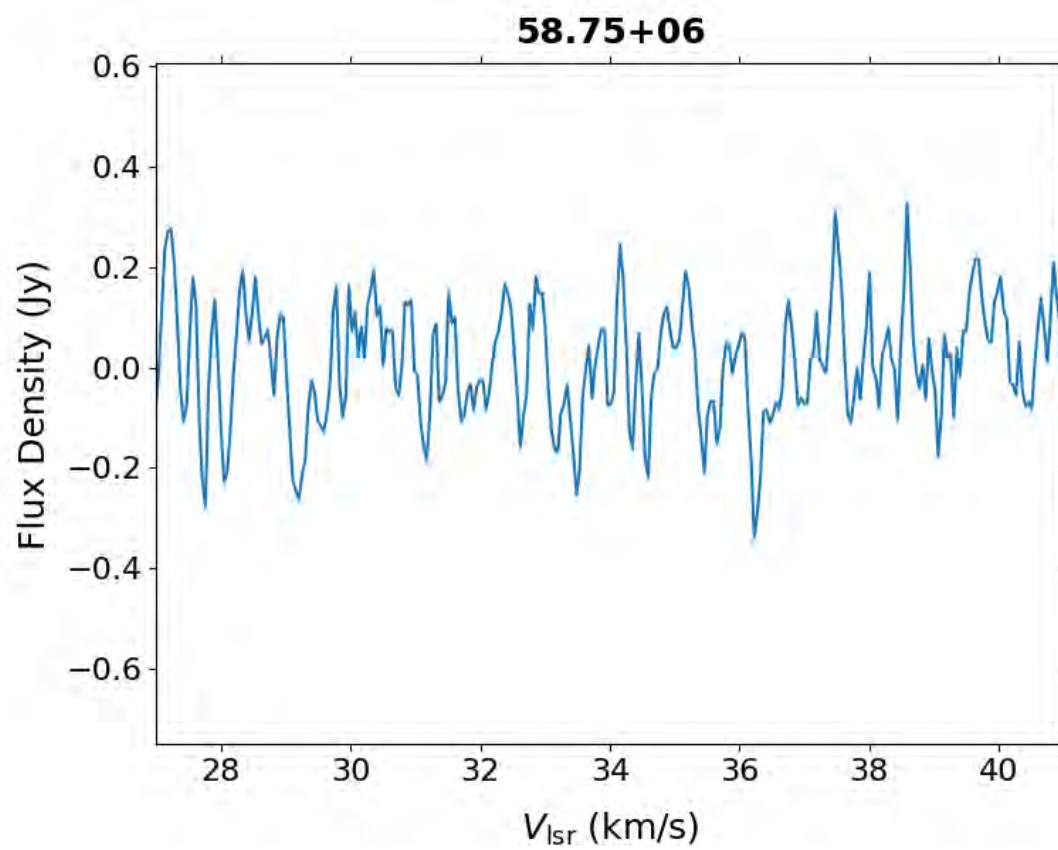
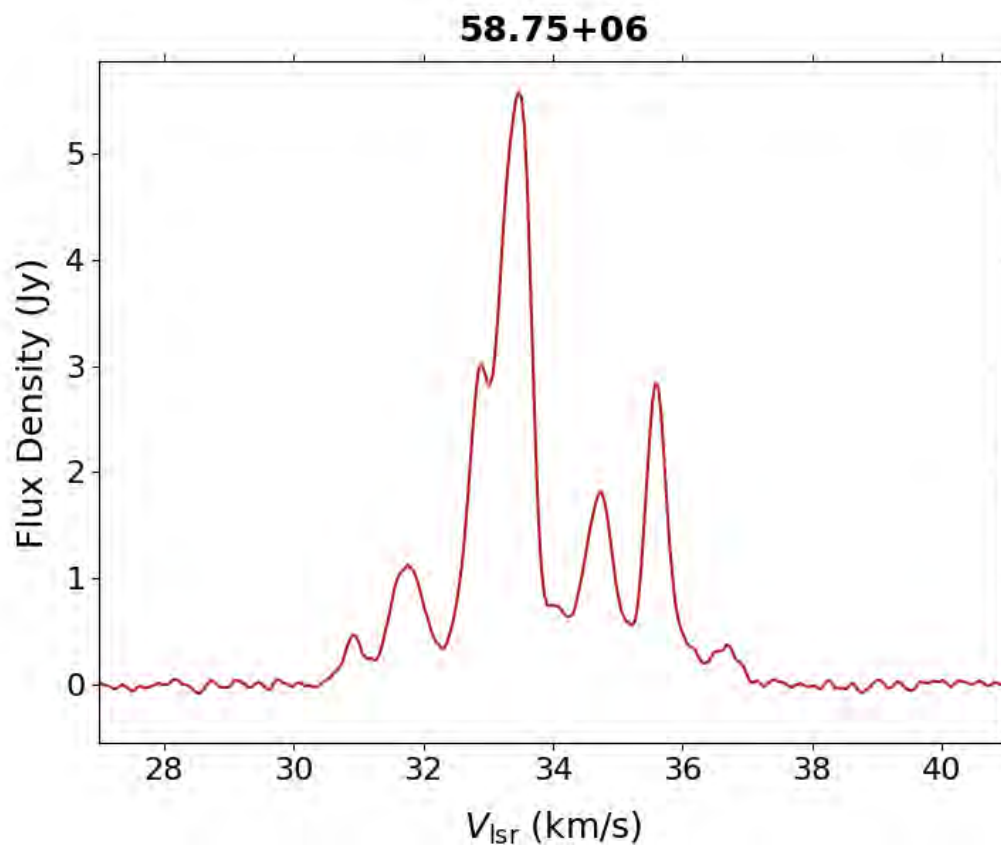


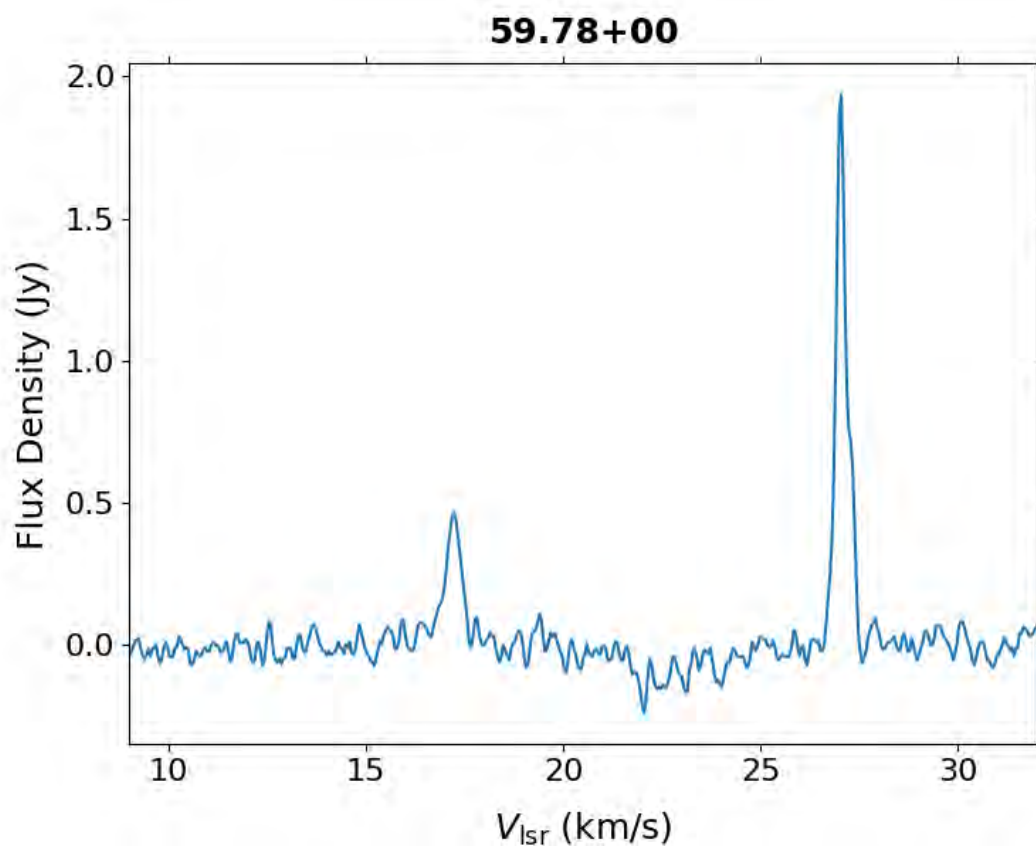
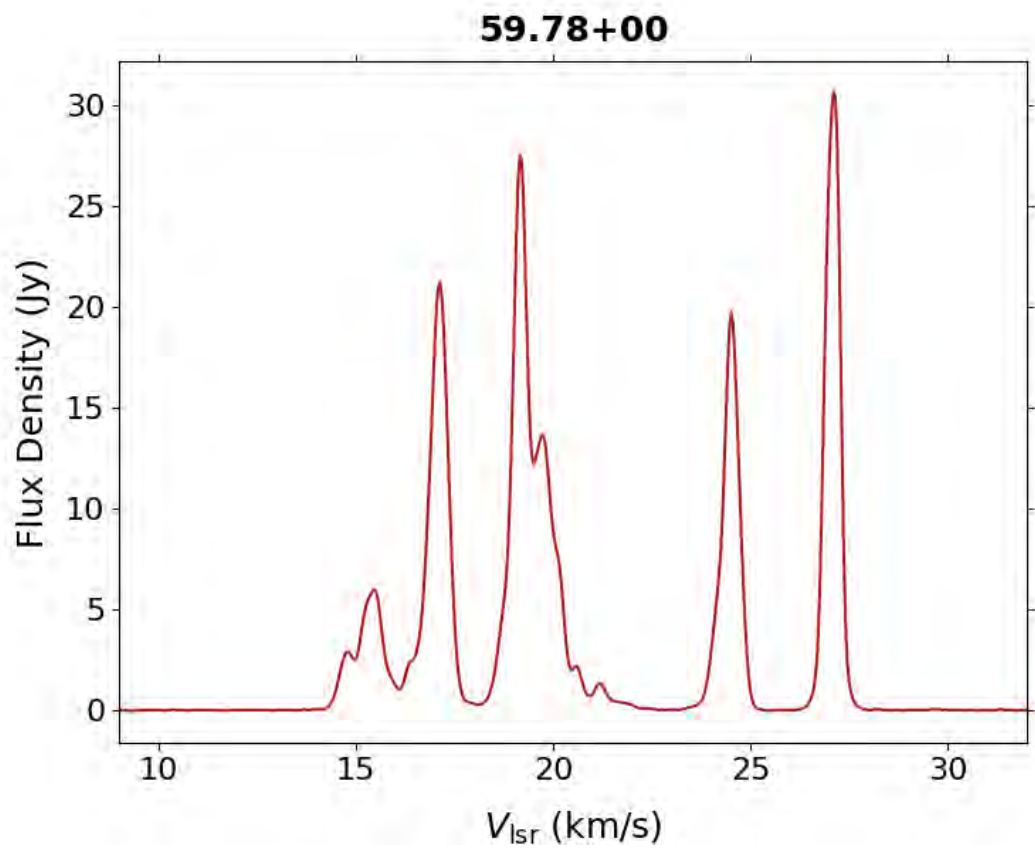


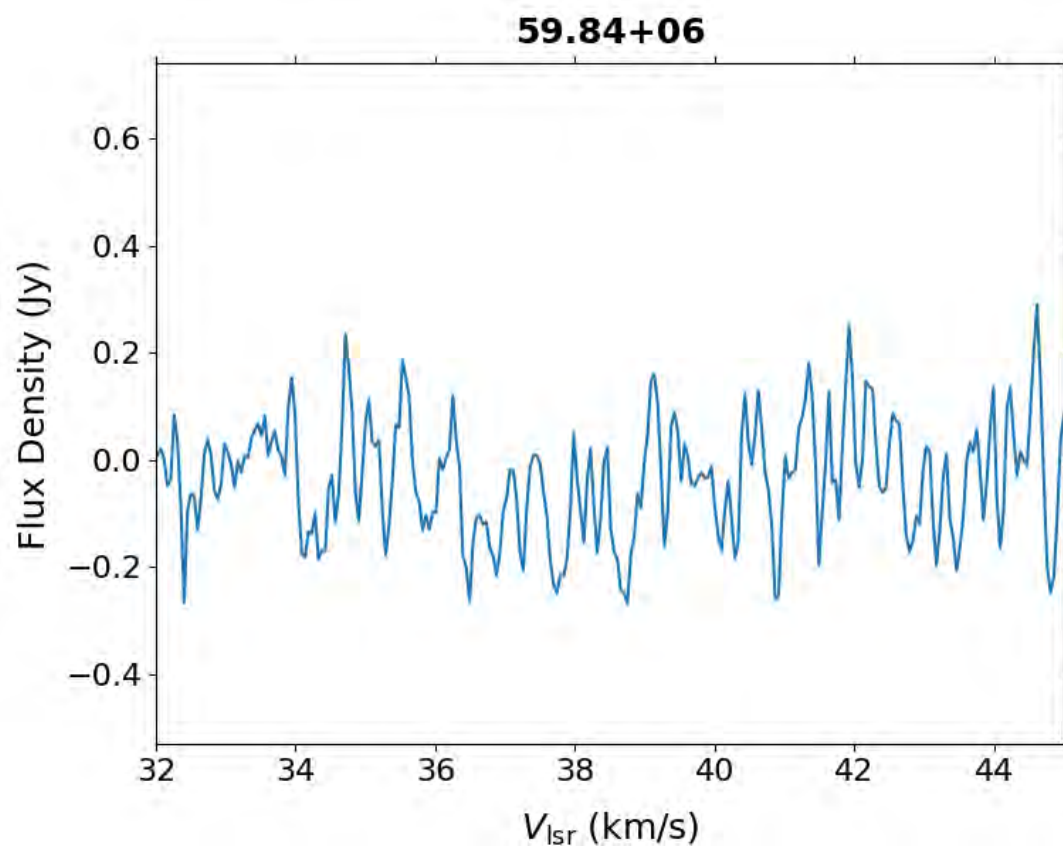
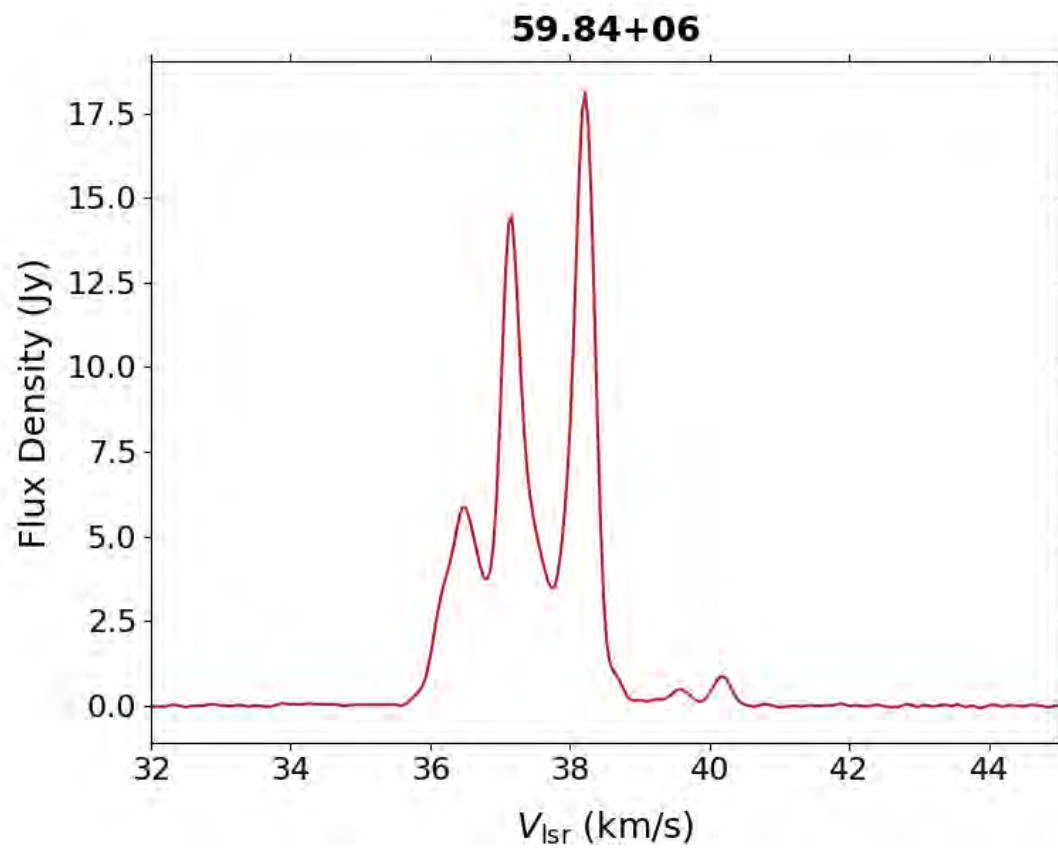


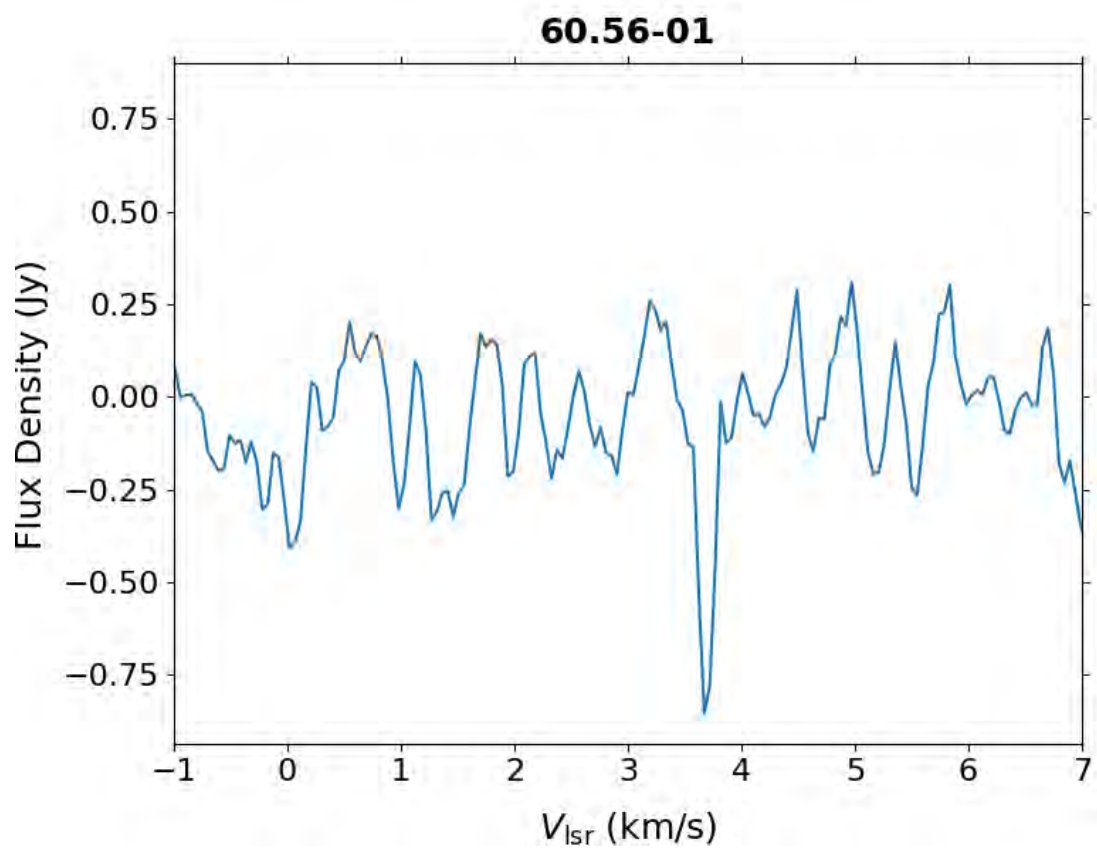
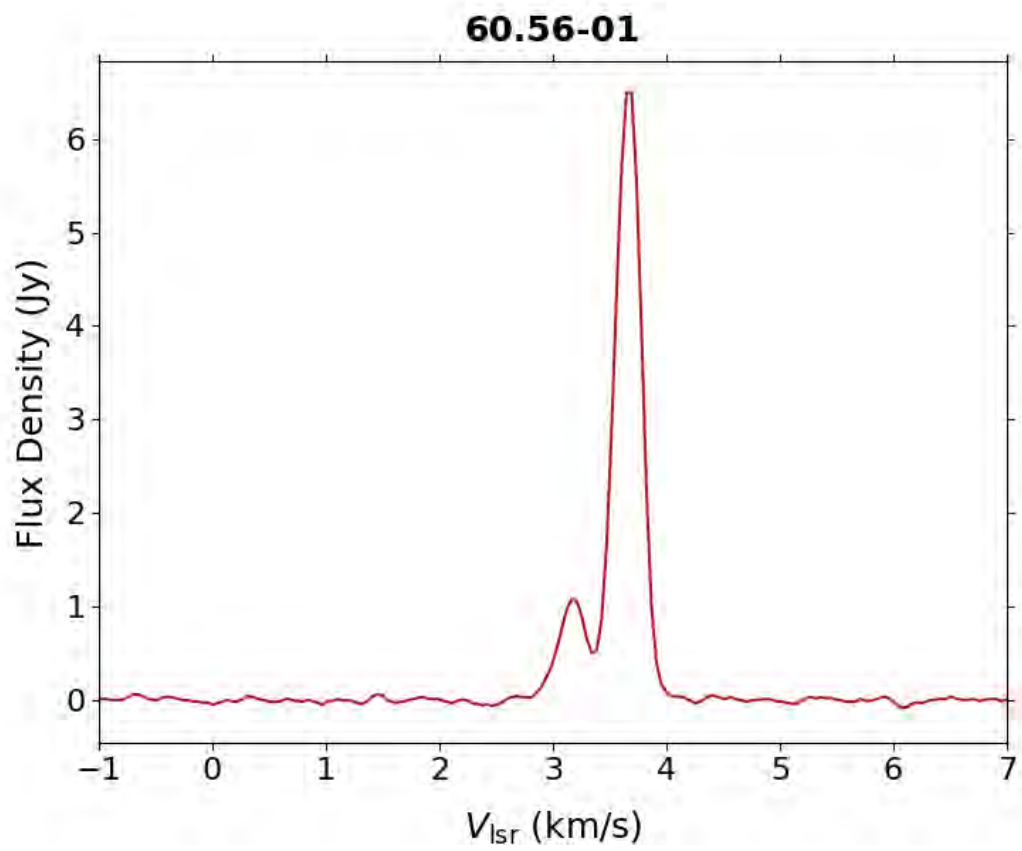


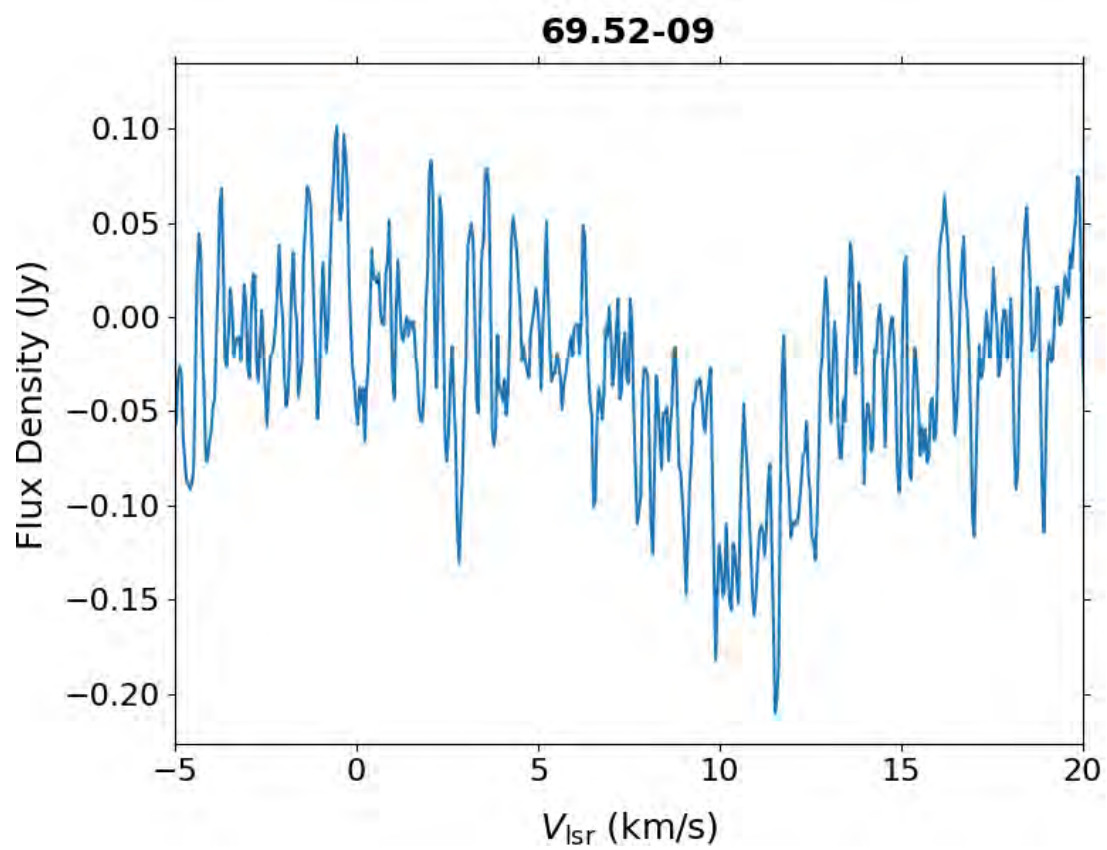
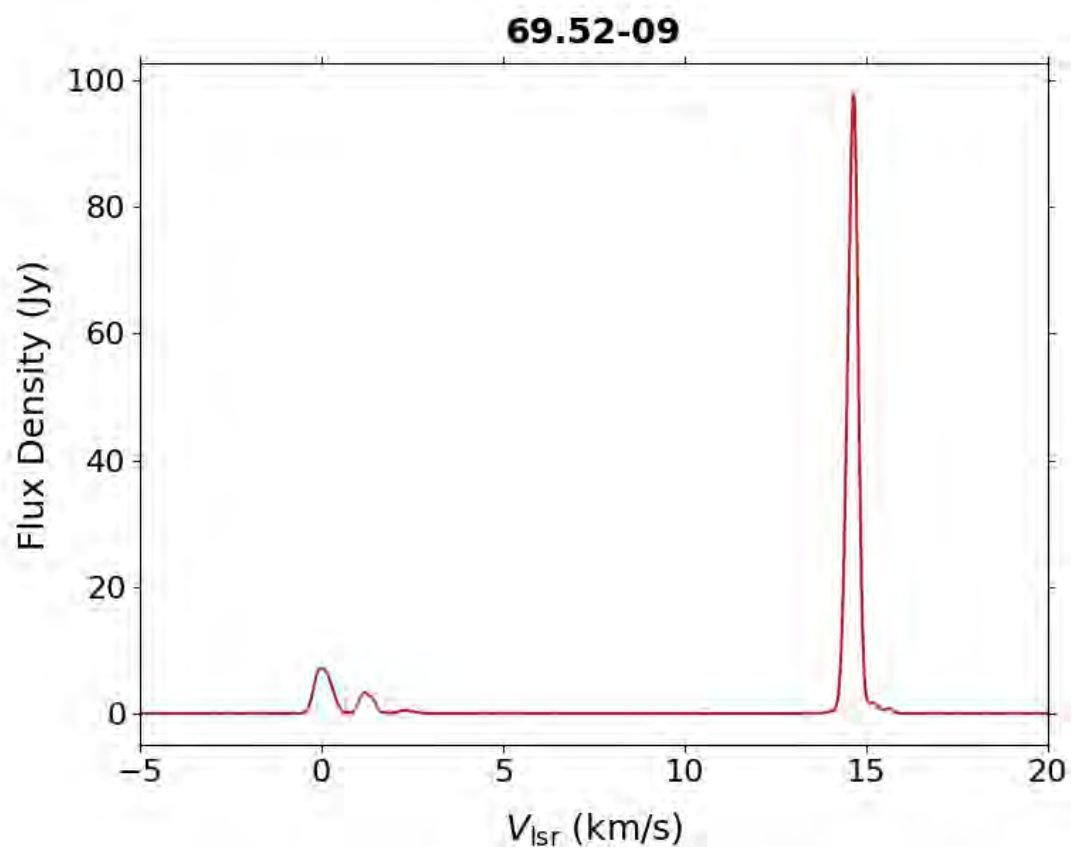


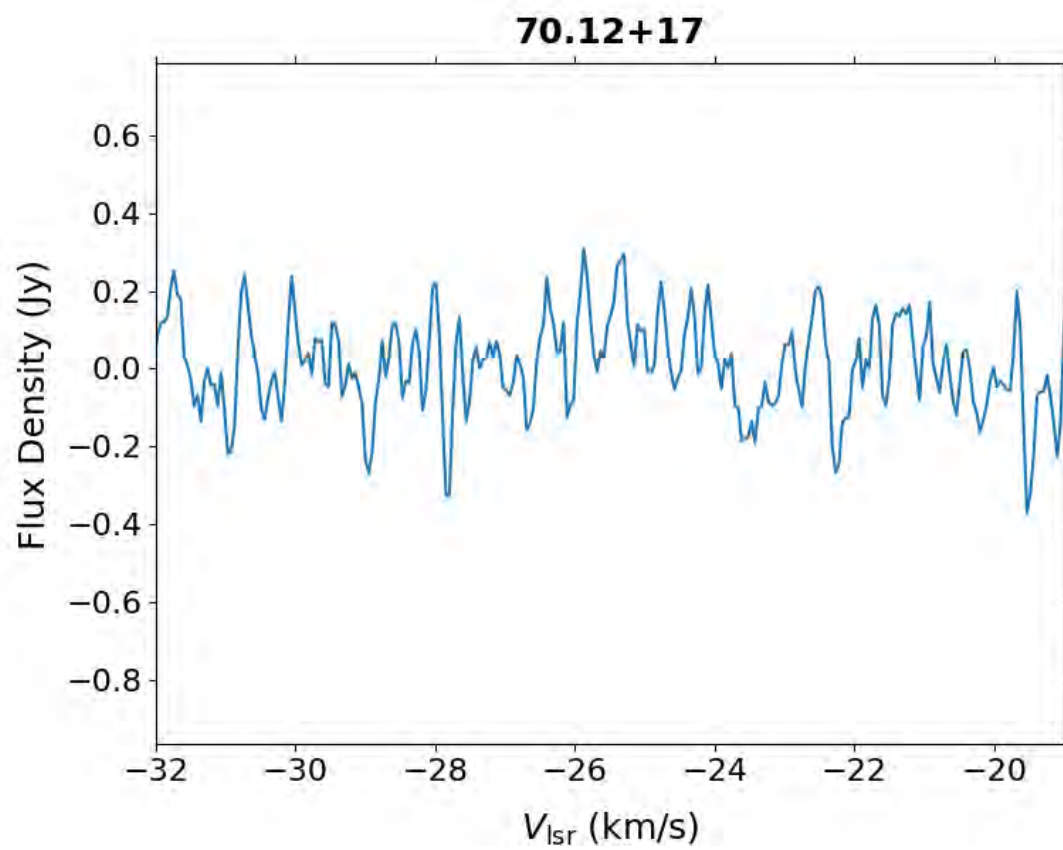
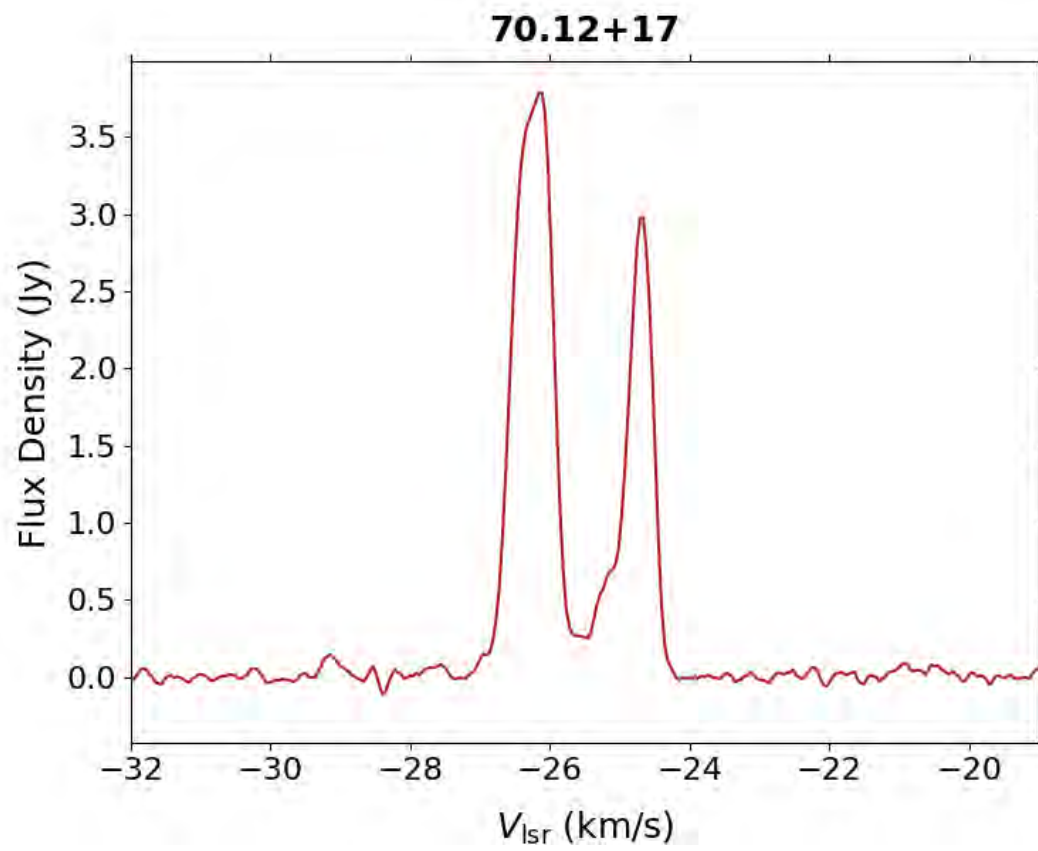




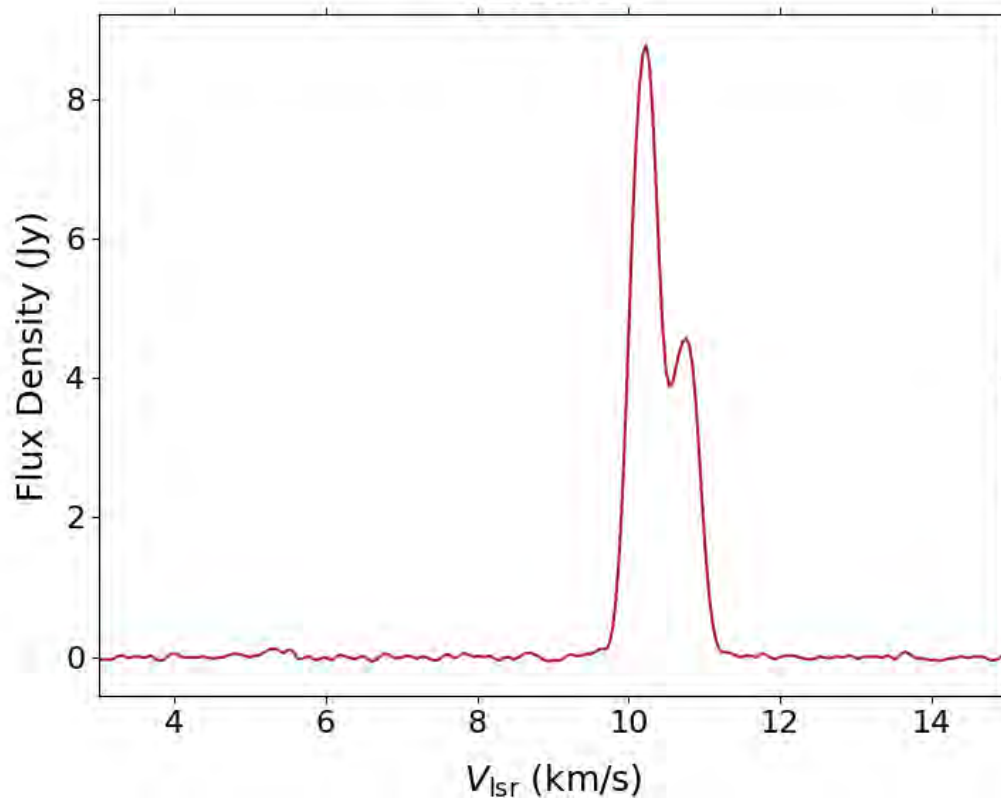




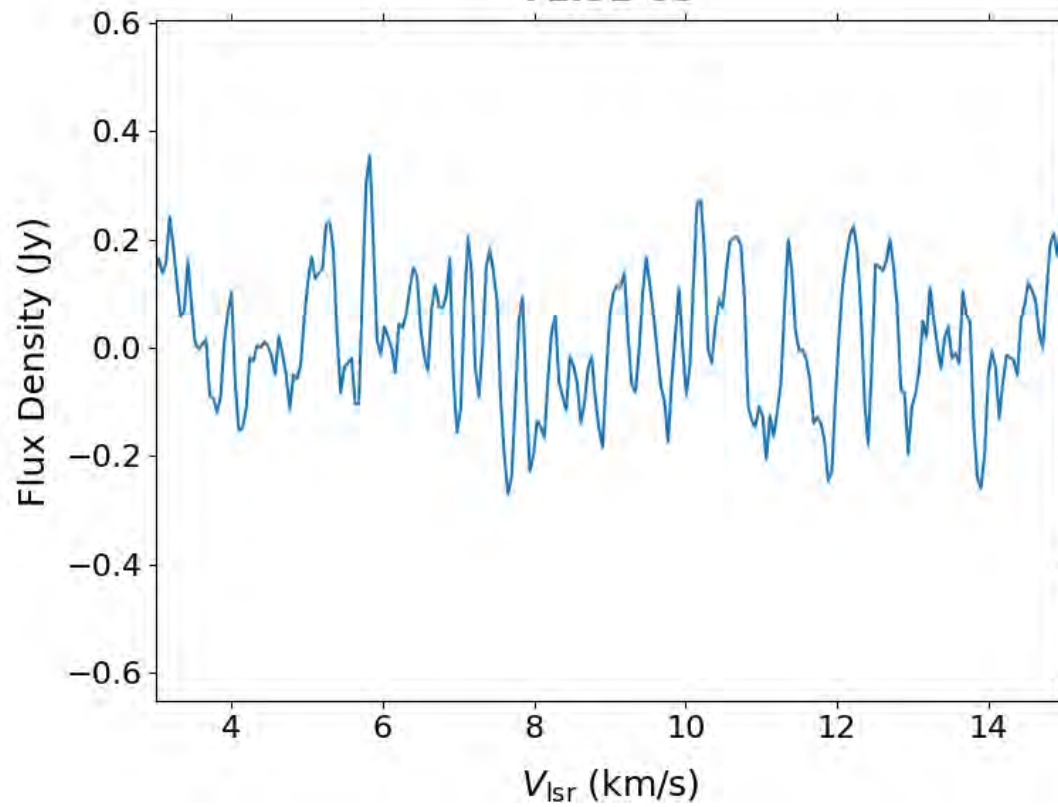


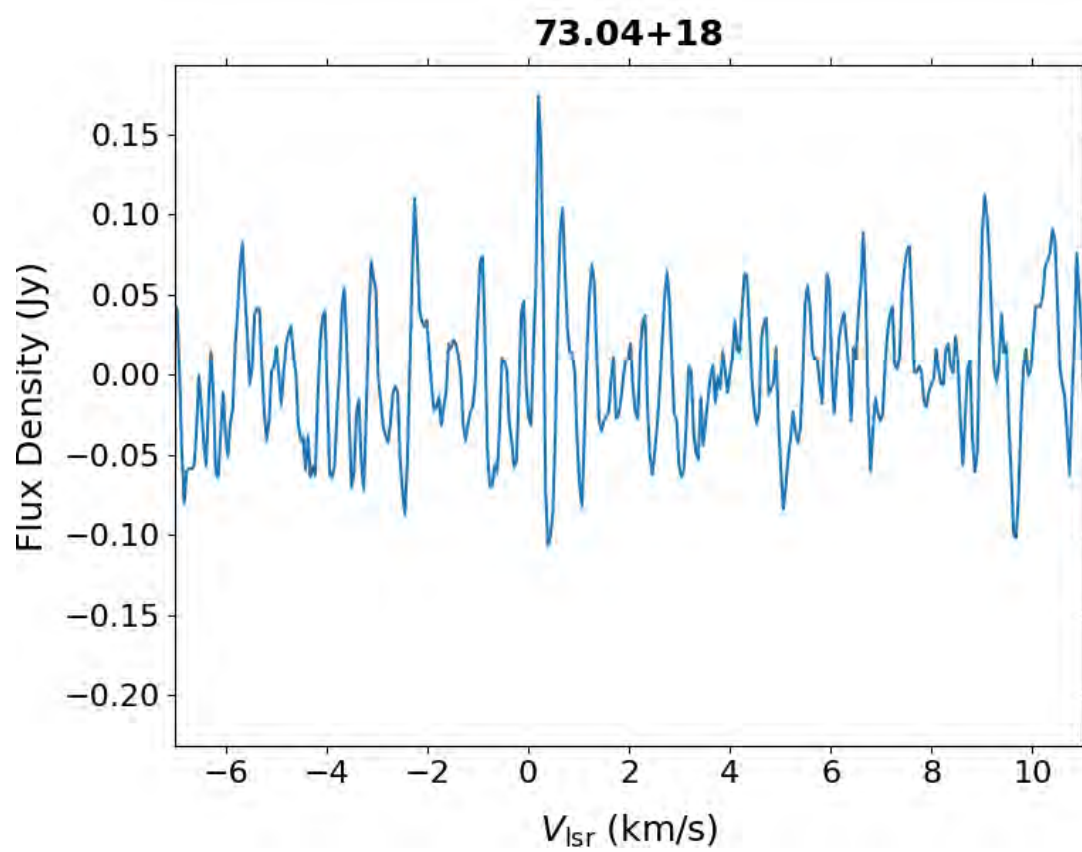
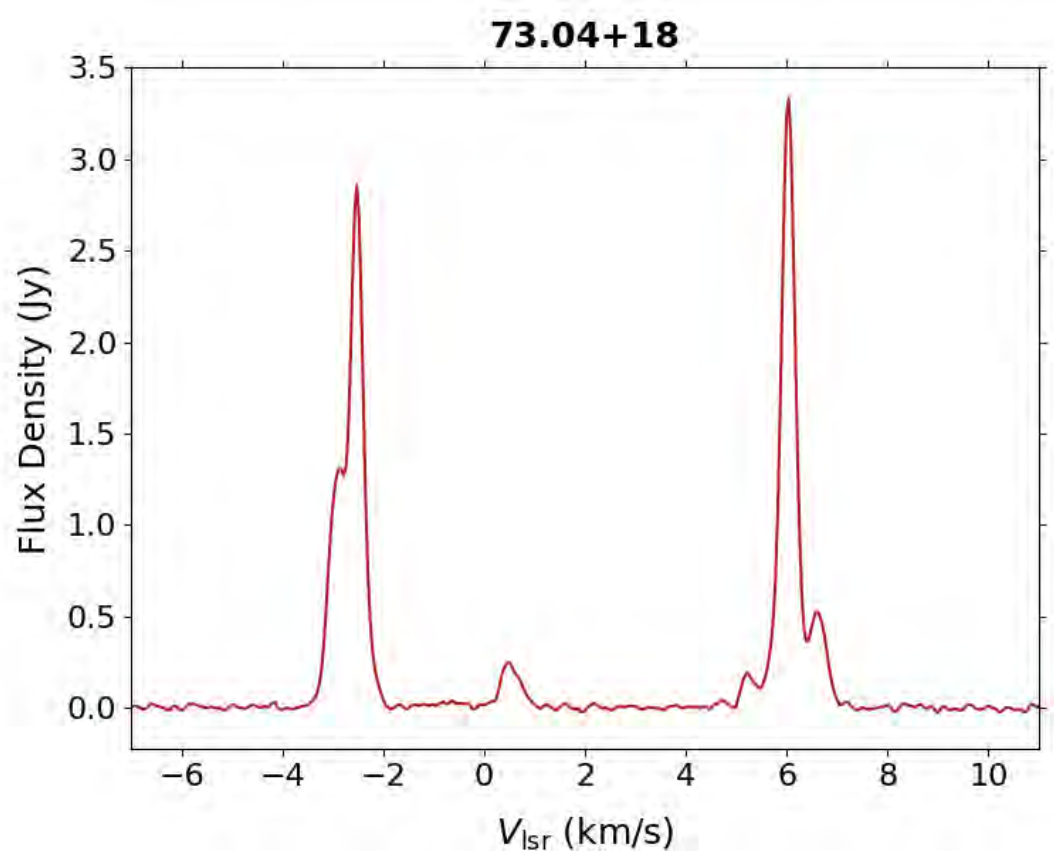


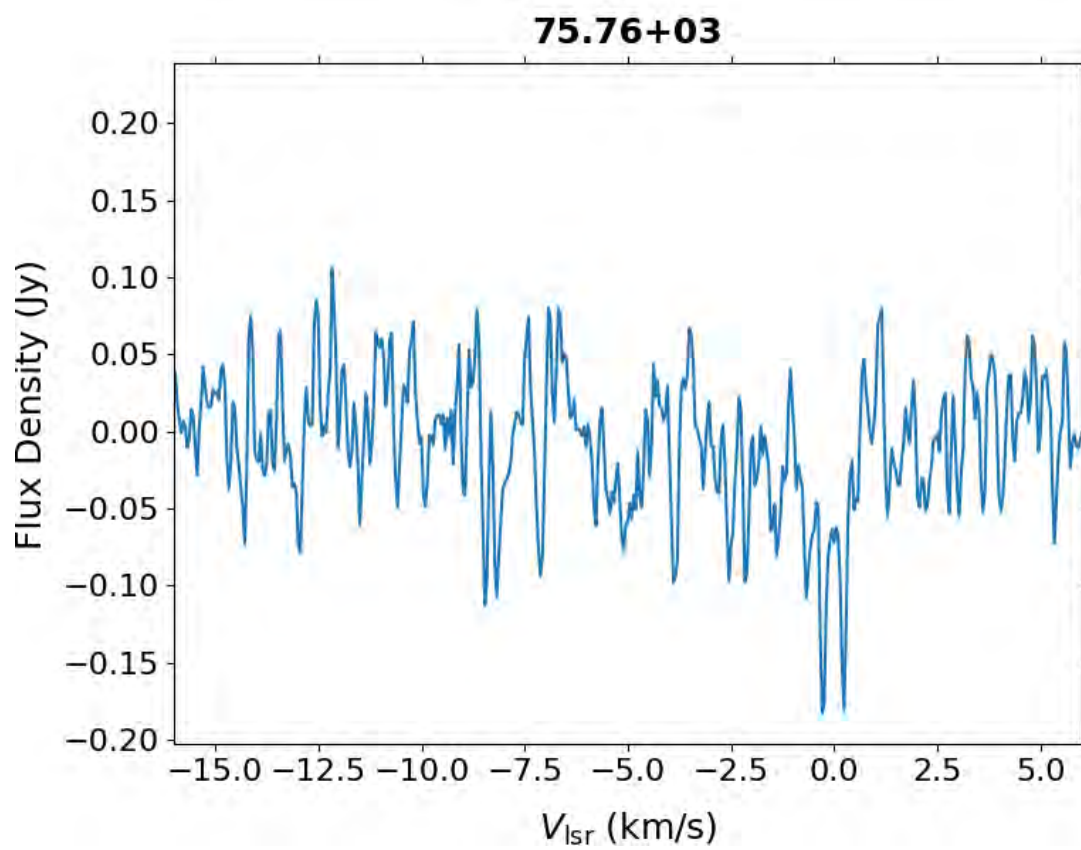
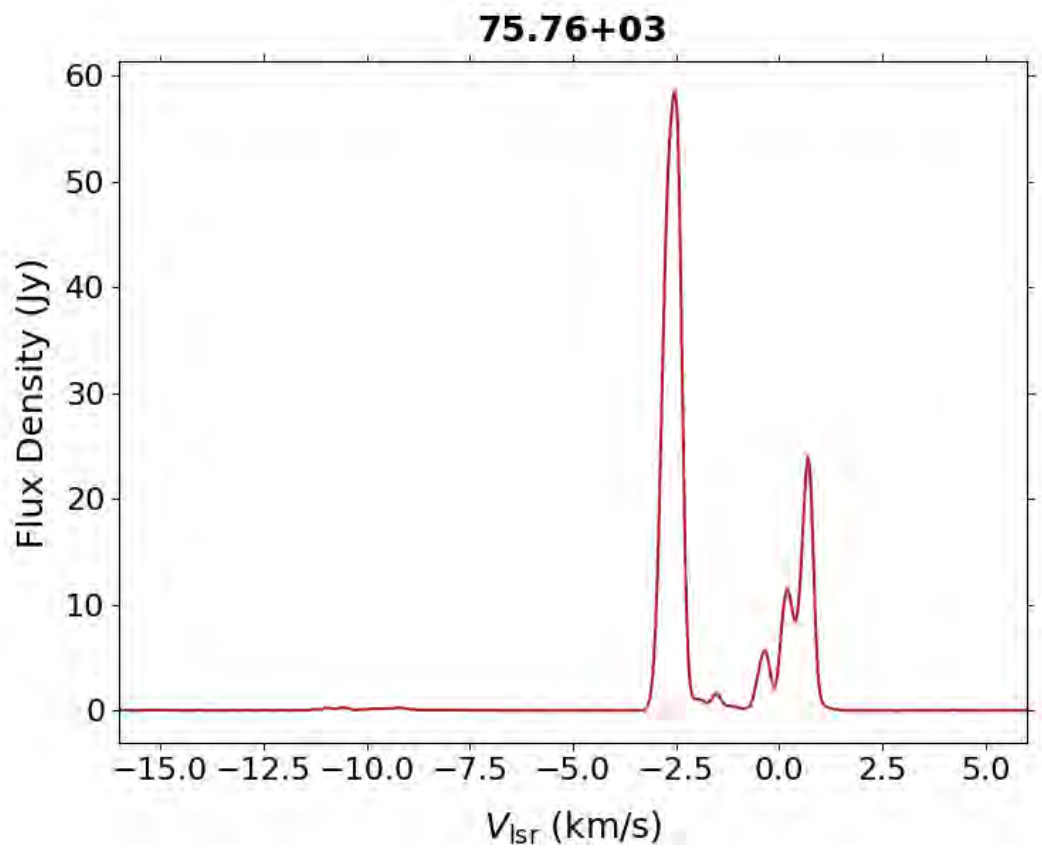
71.51-03

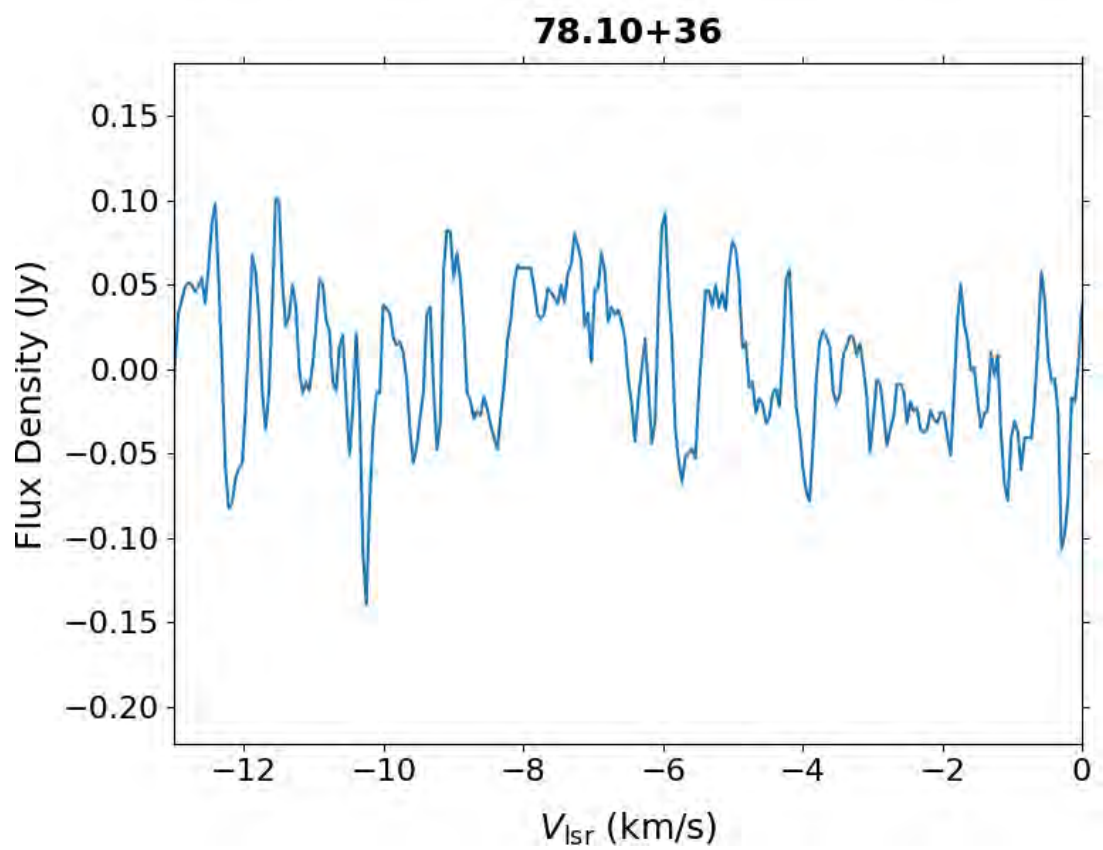
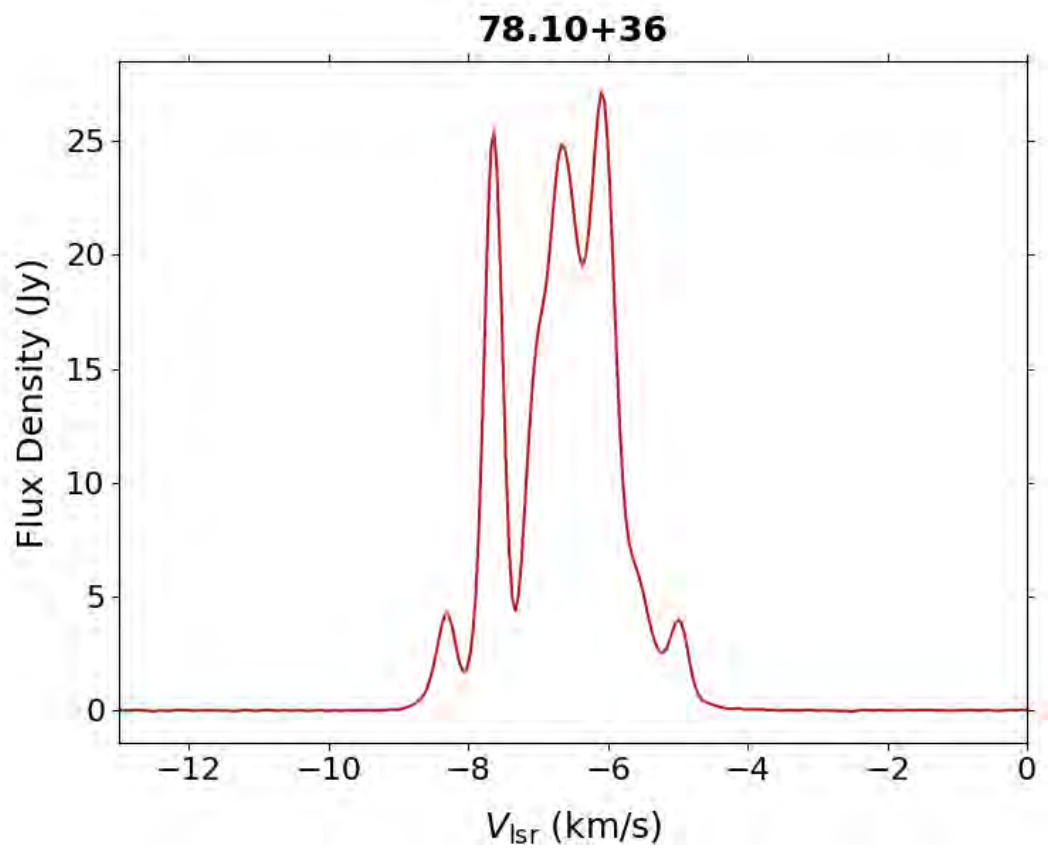


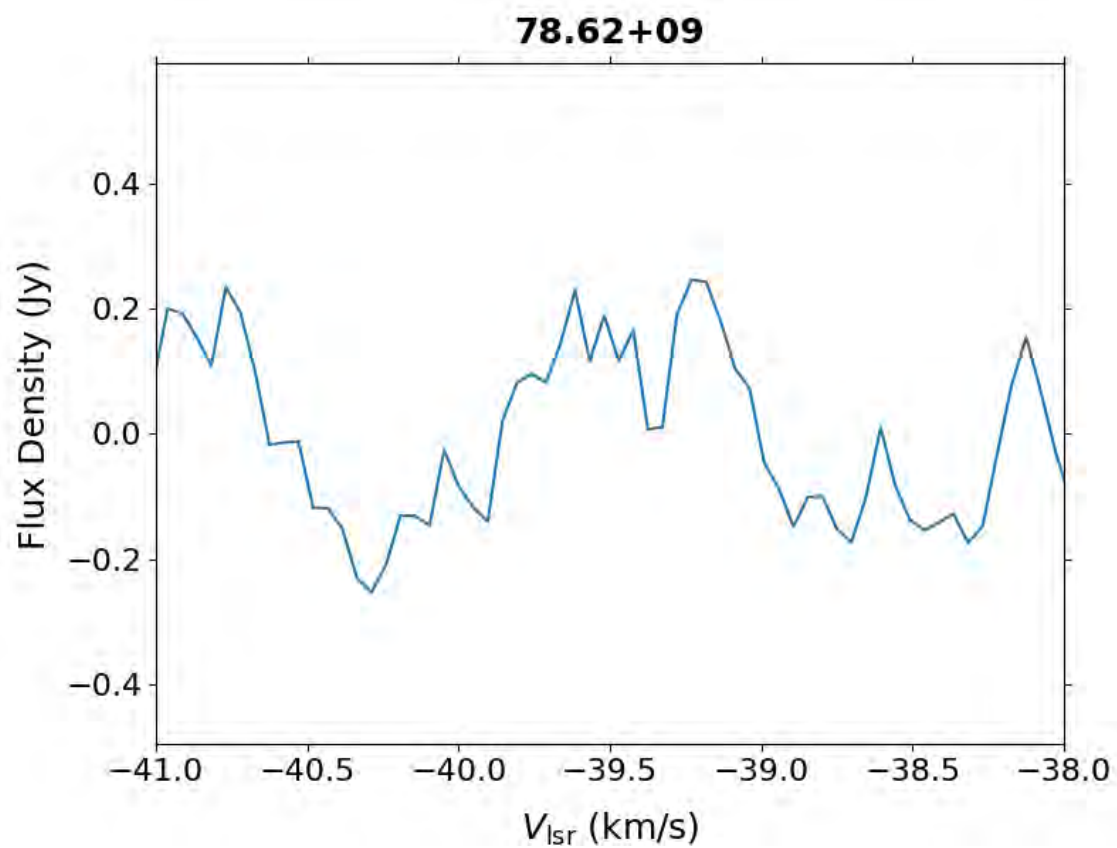
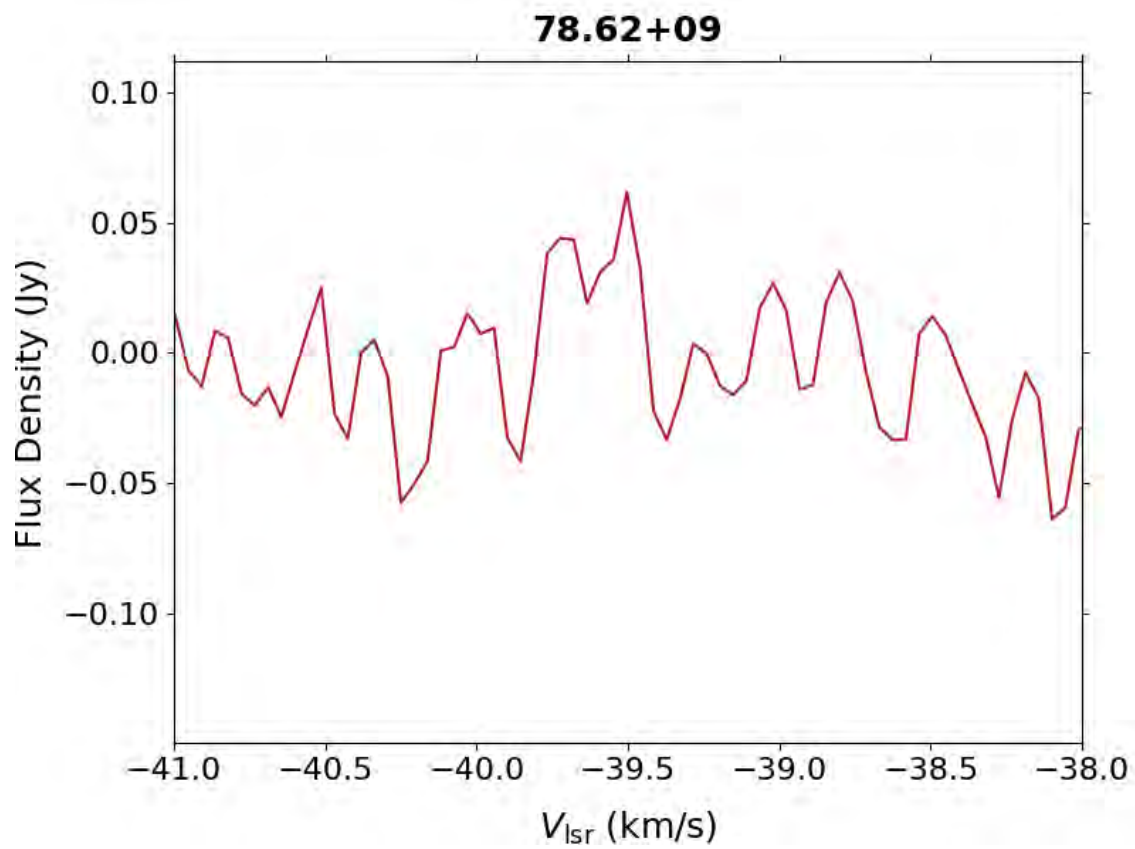
71.51-03

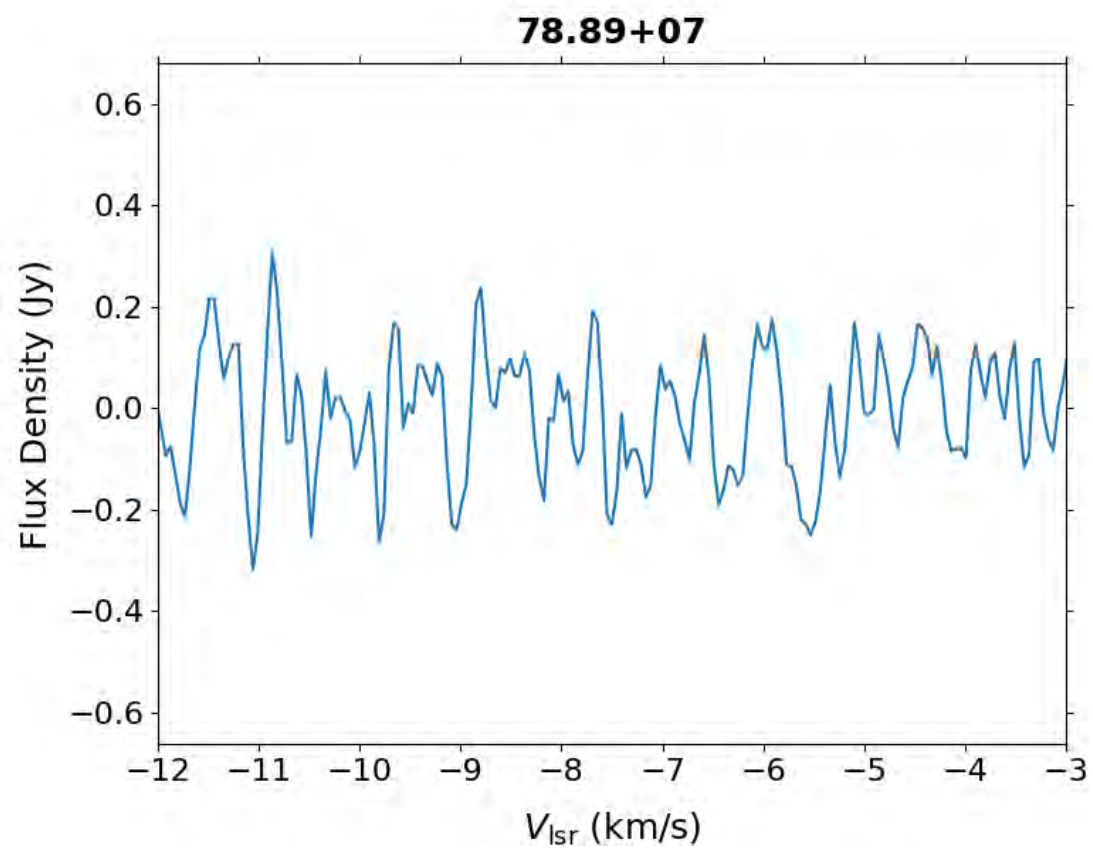
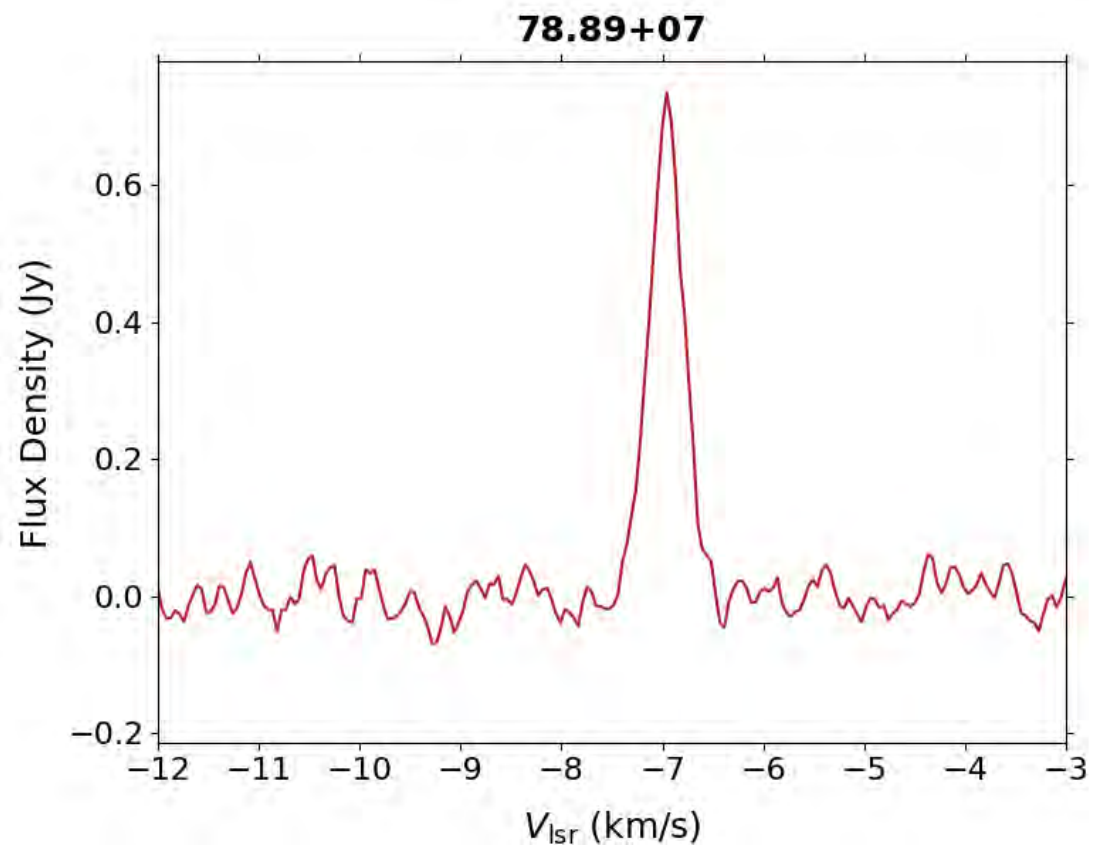


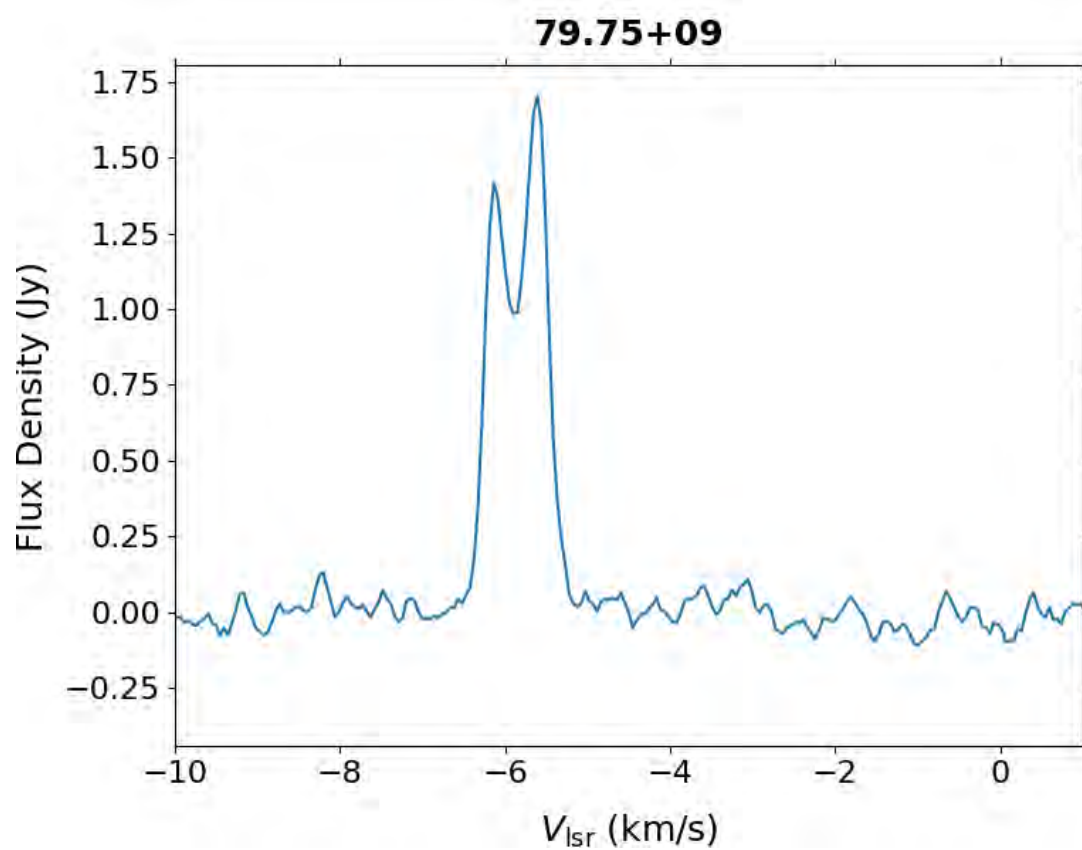
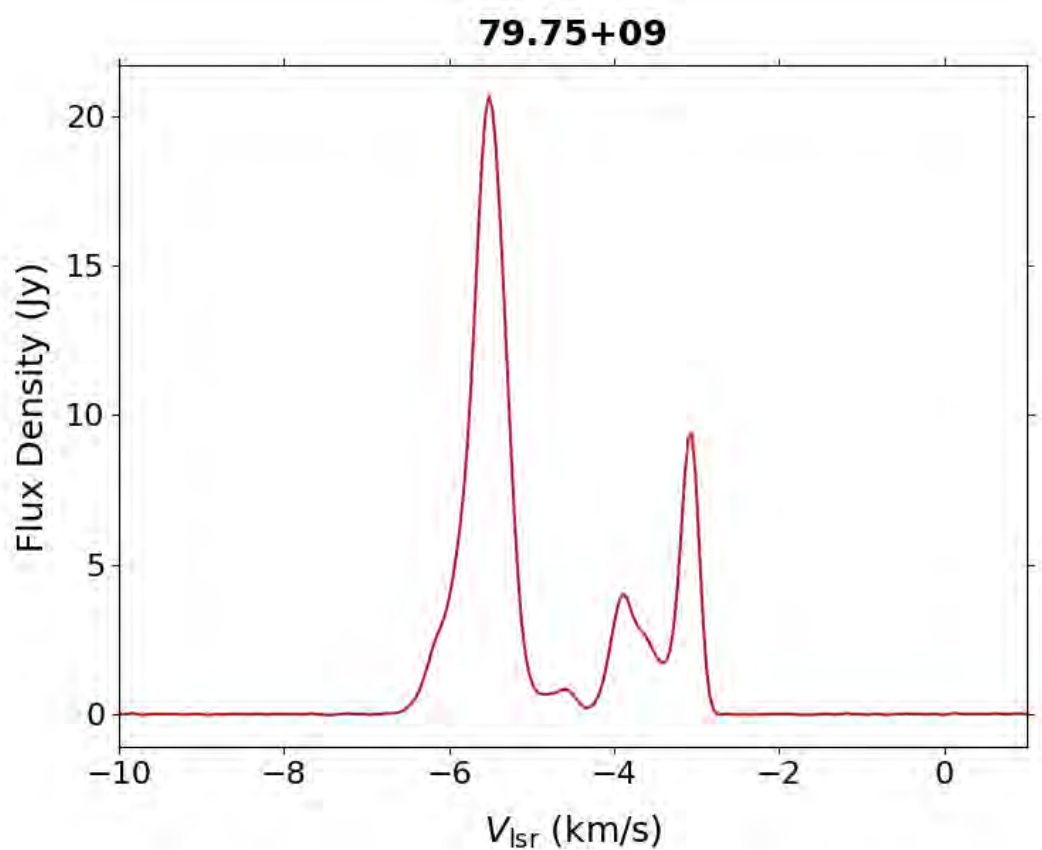


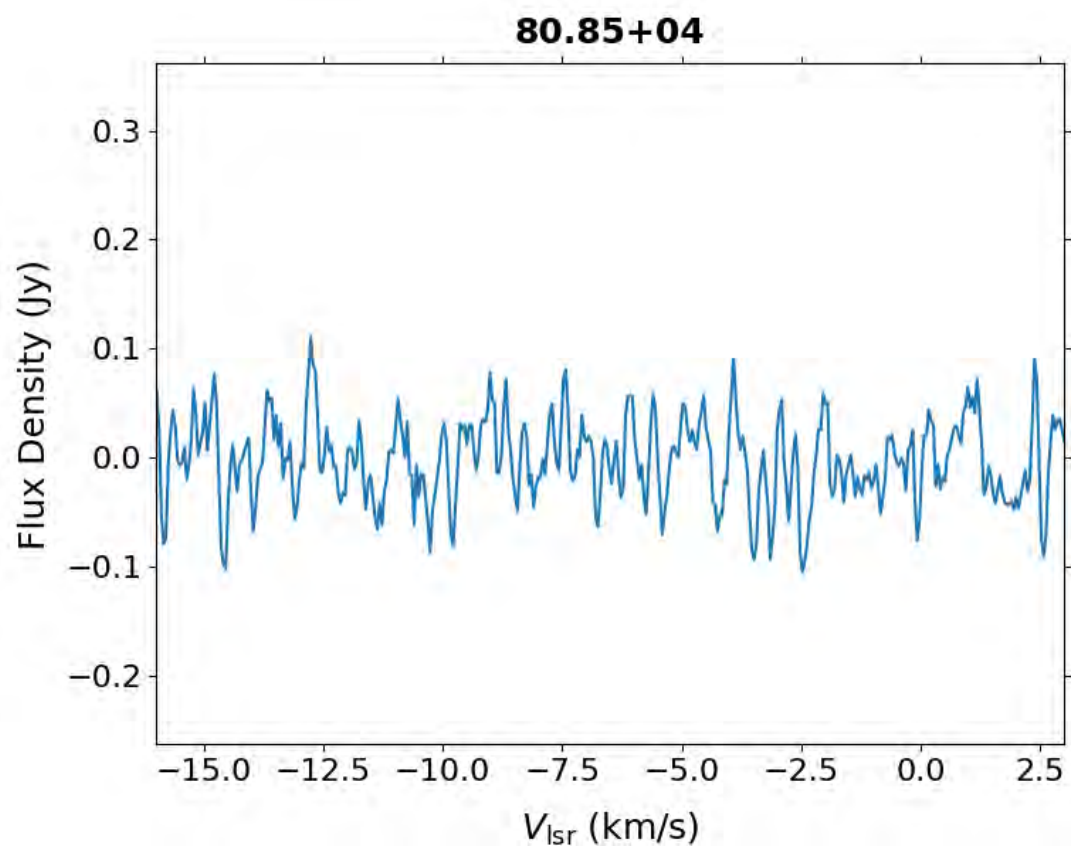
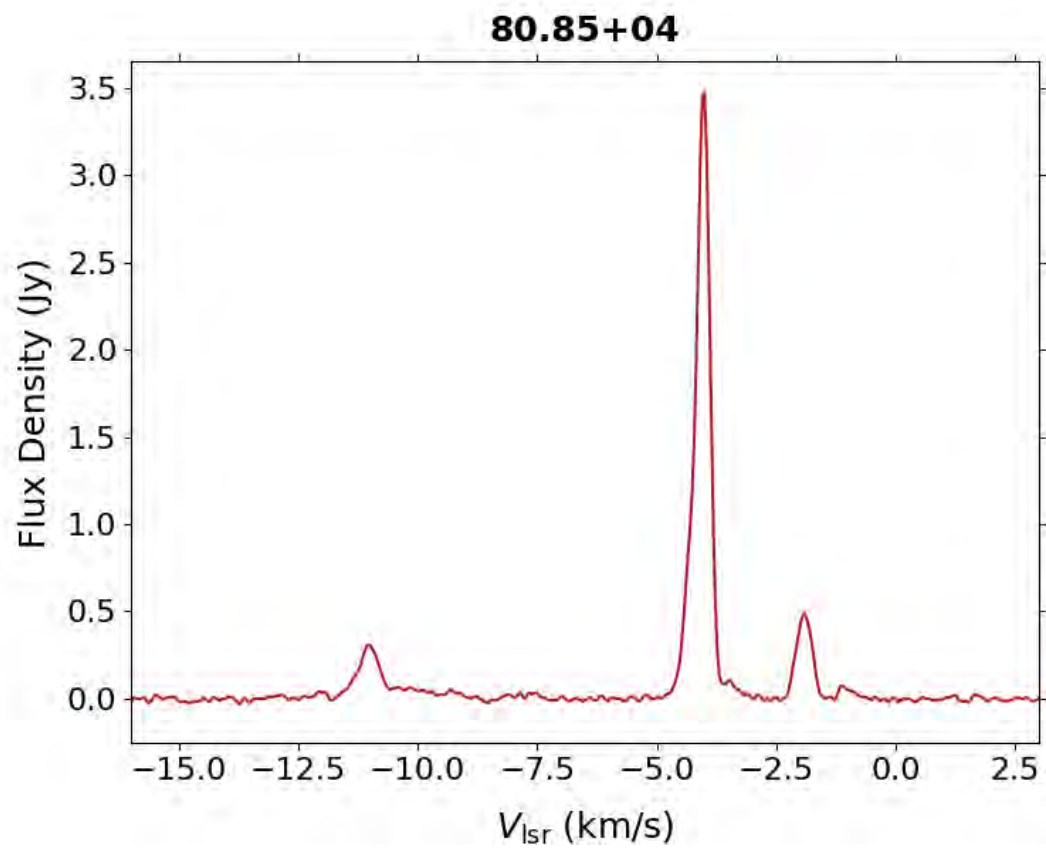


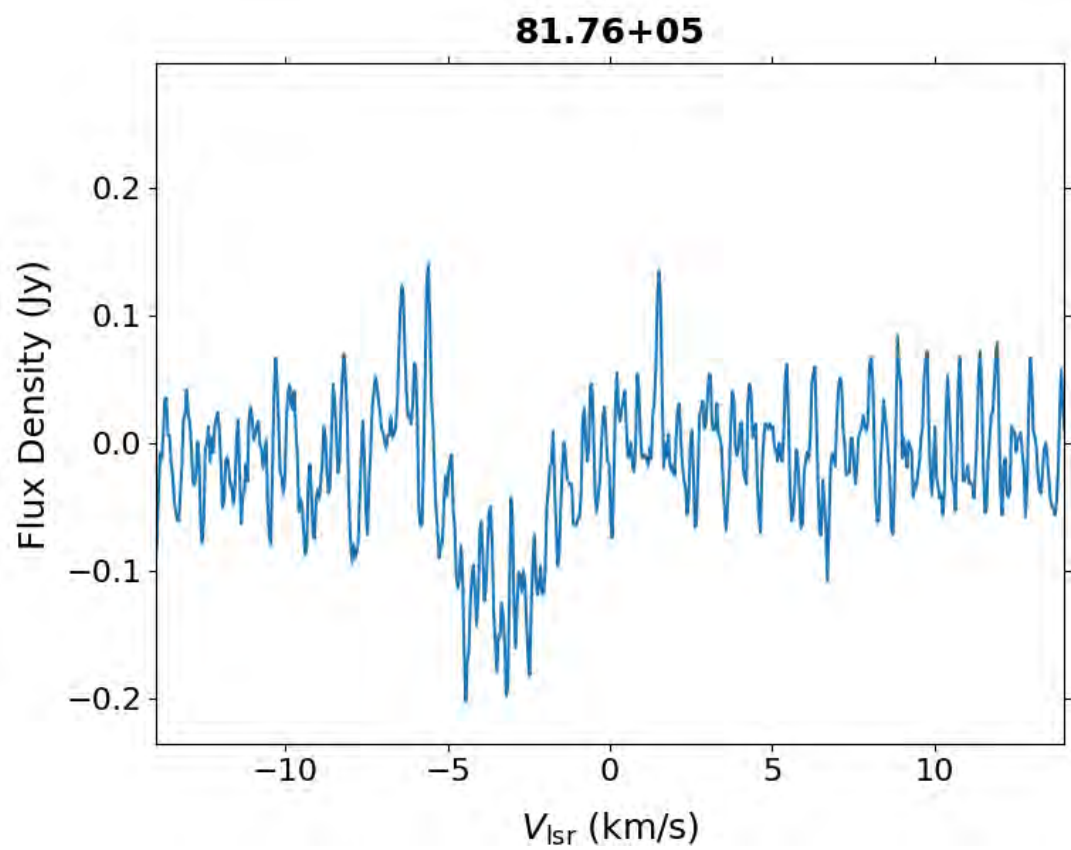
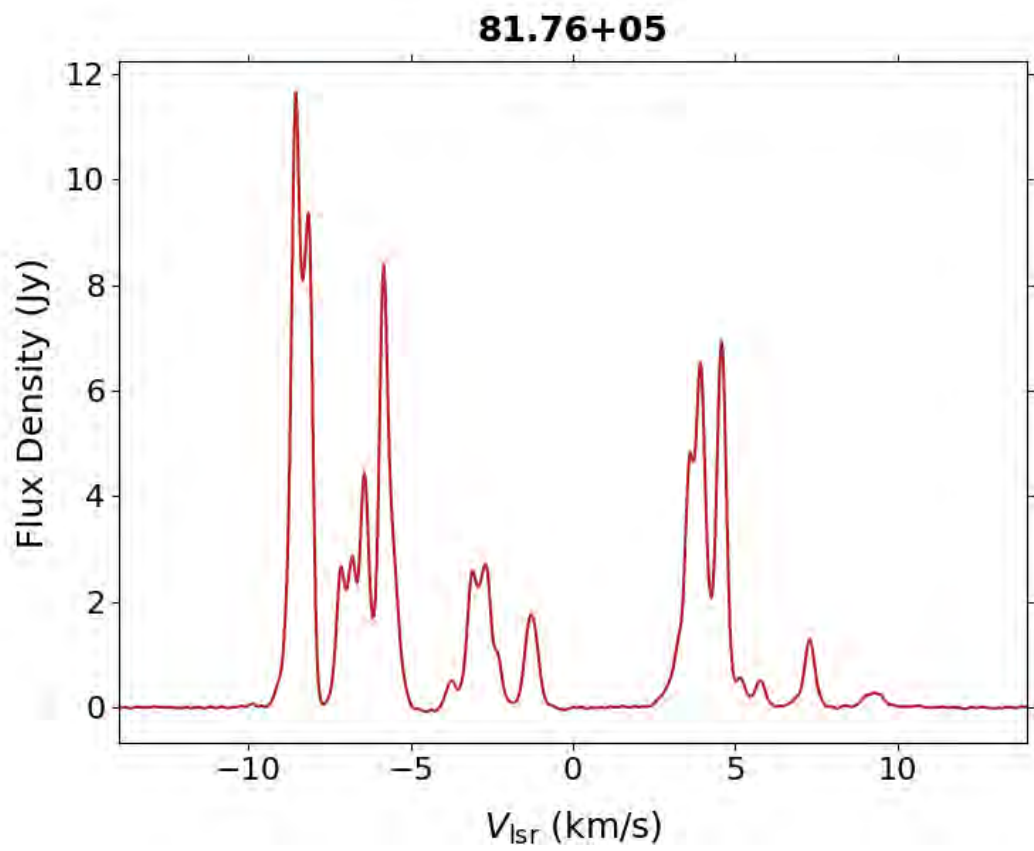


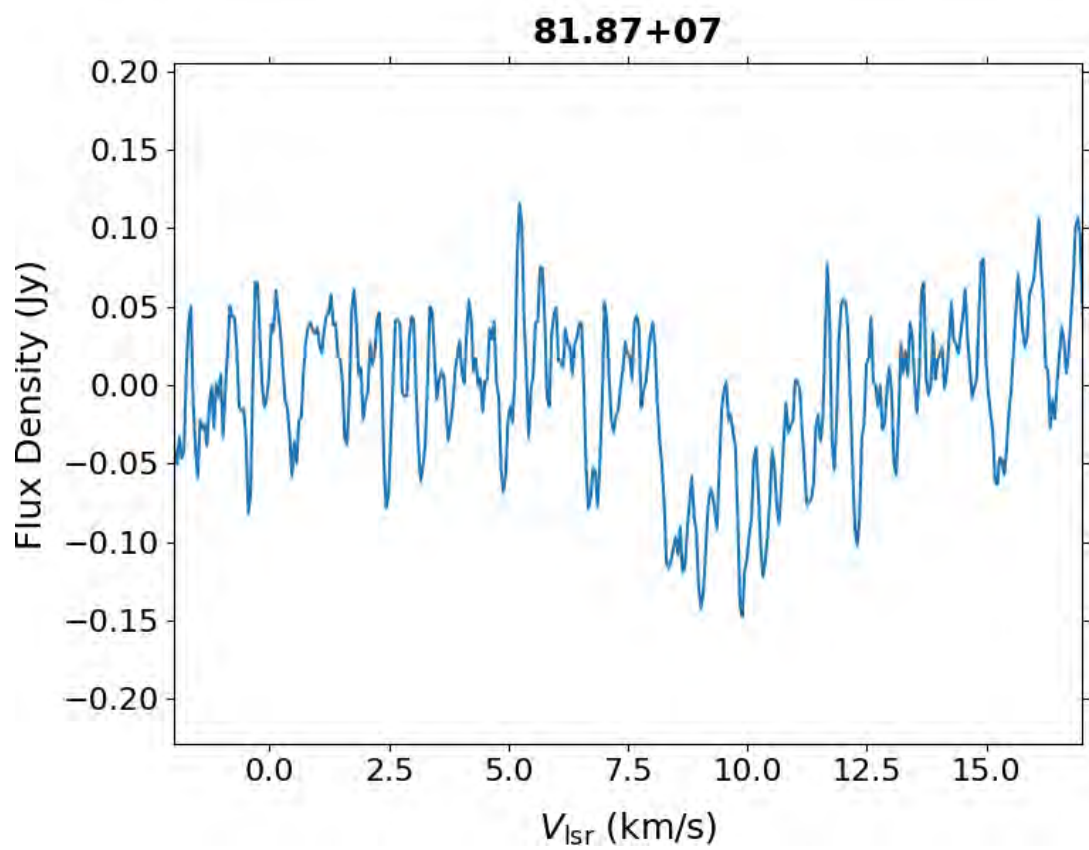
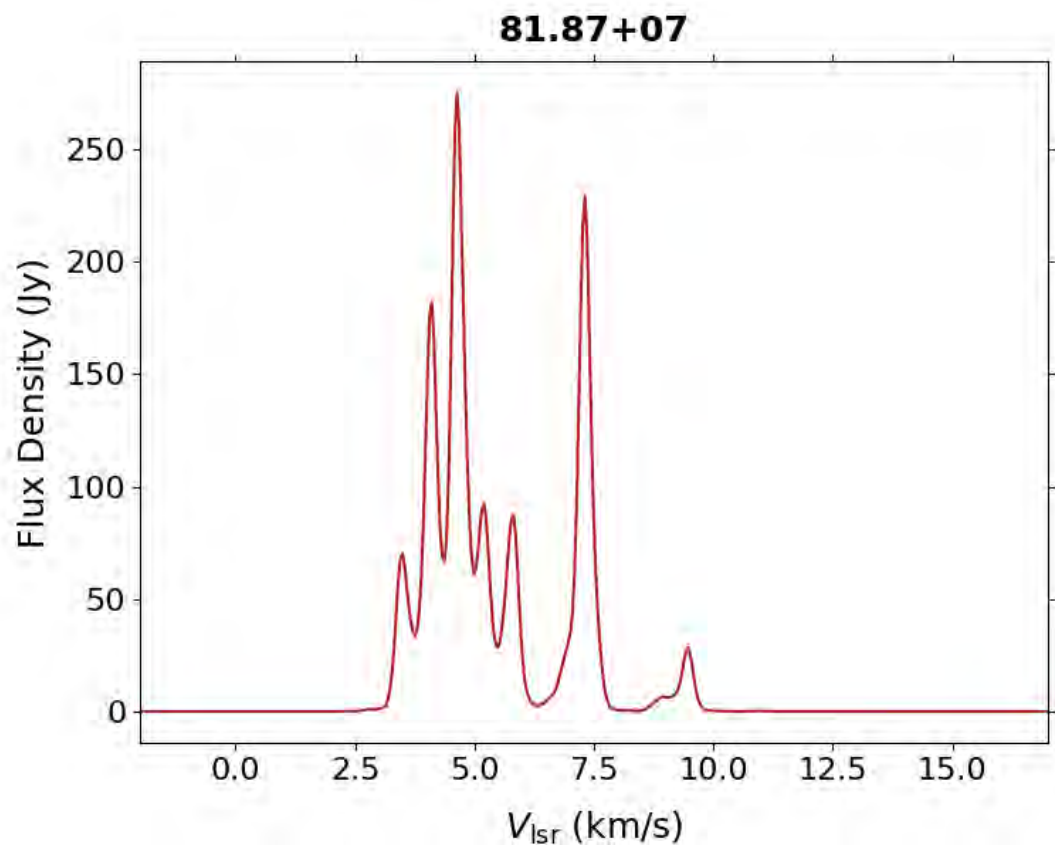




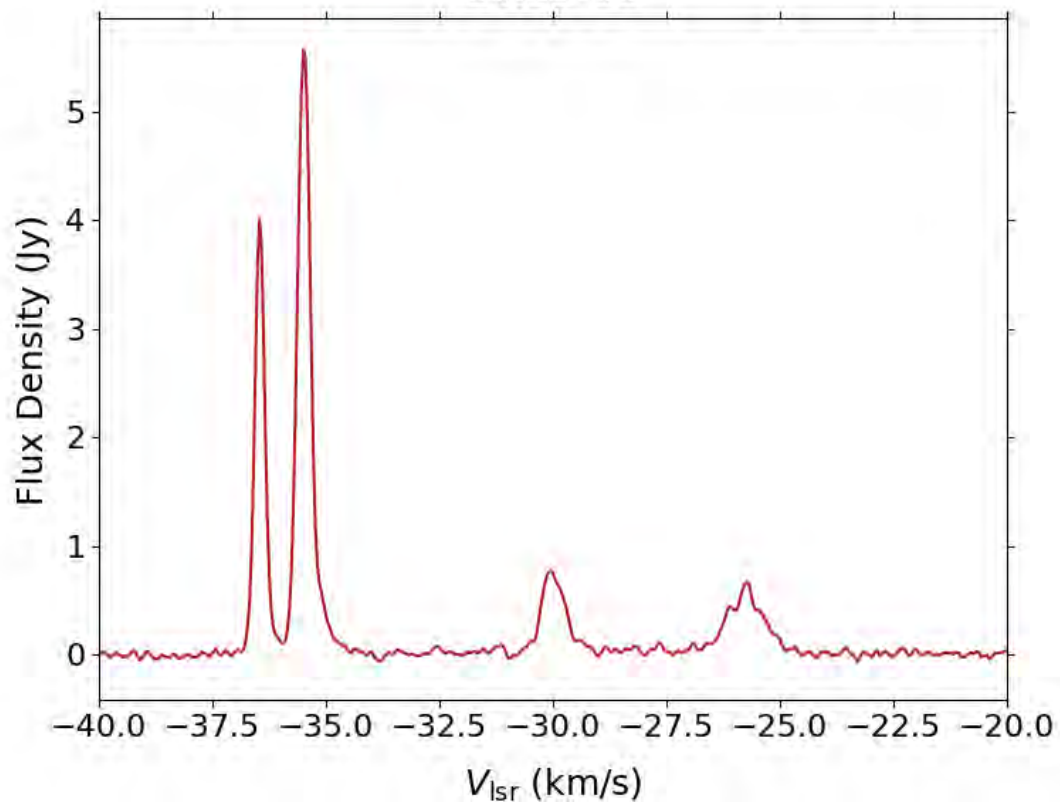




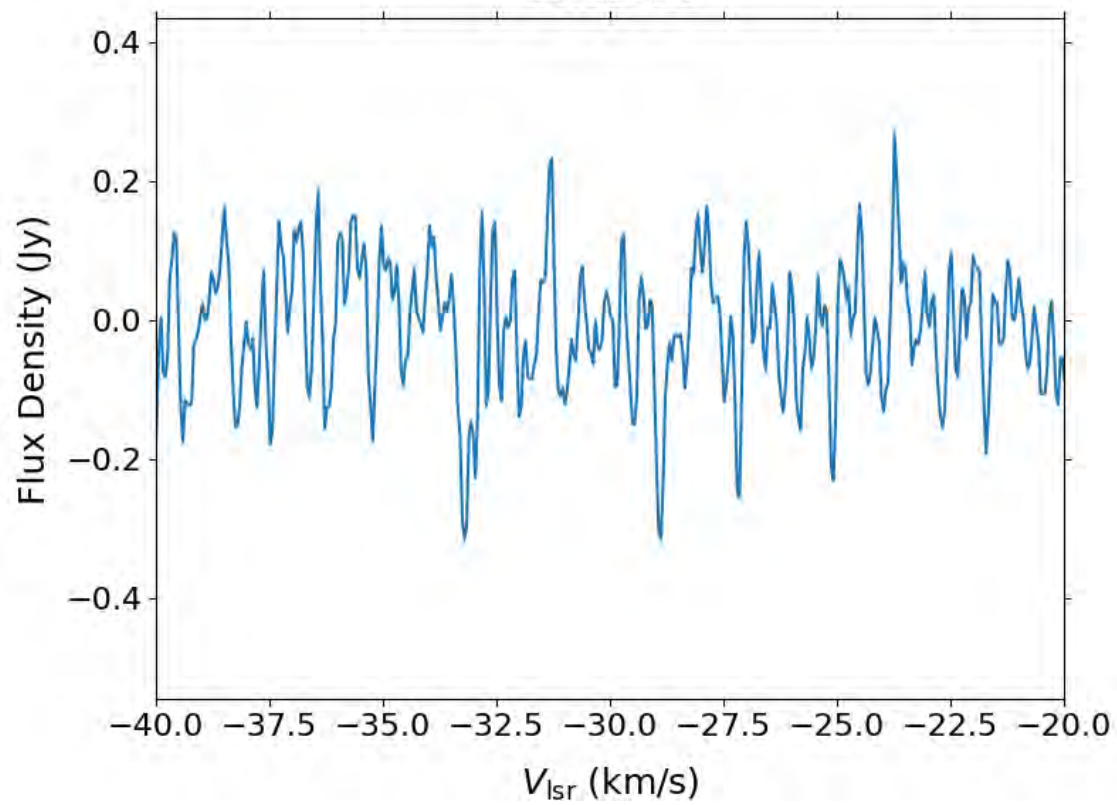


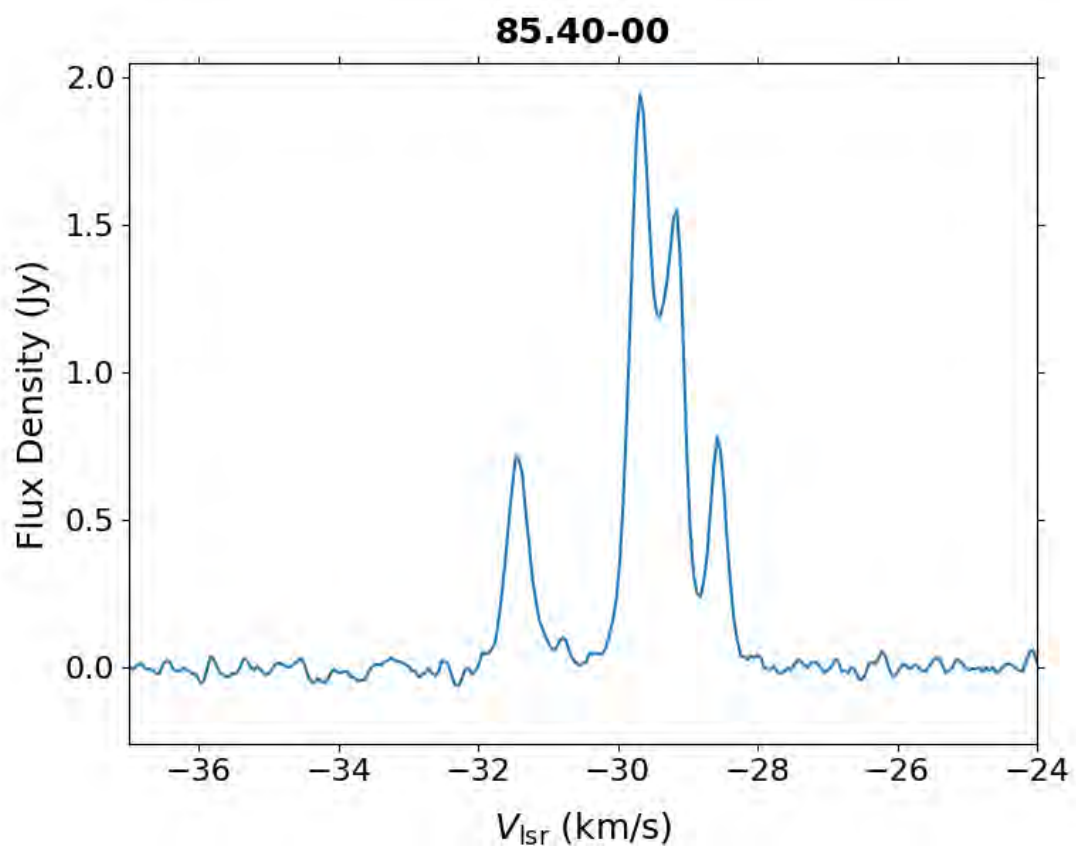
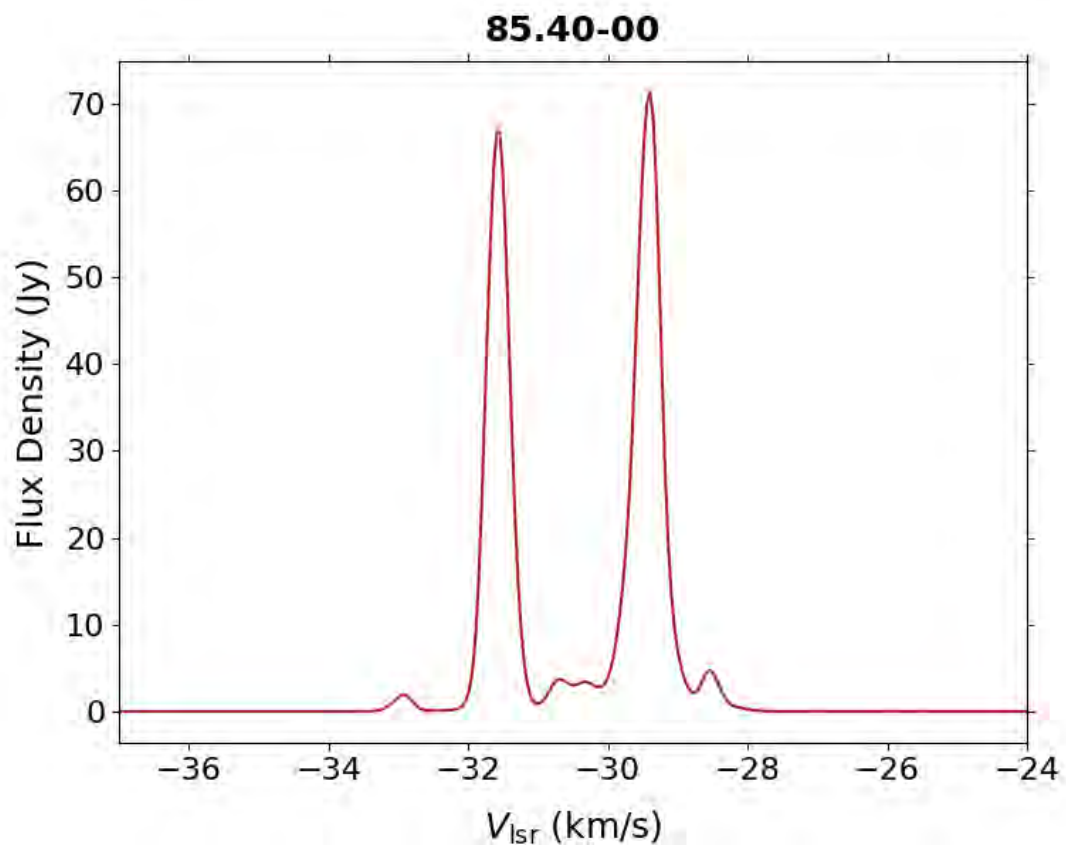


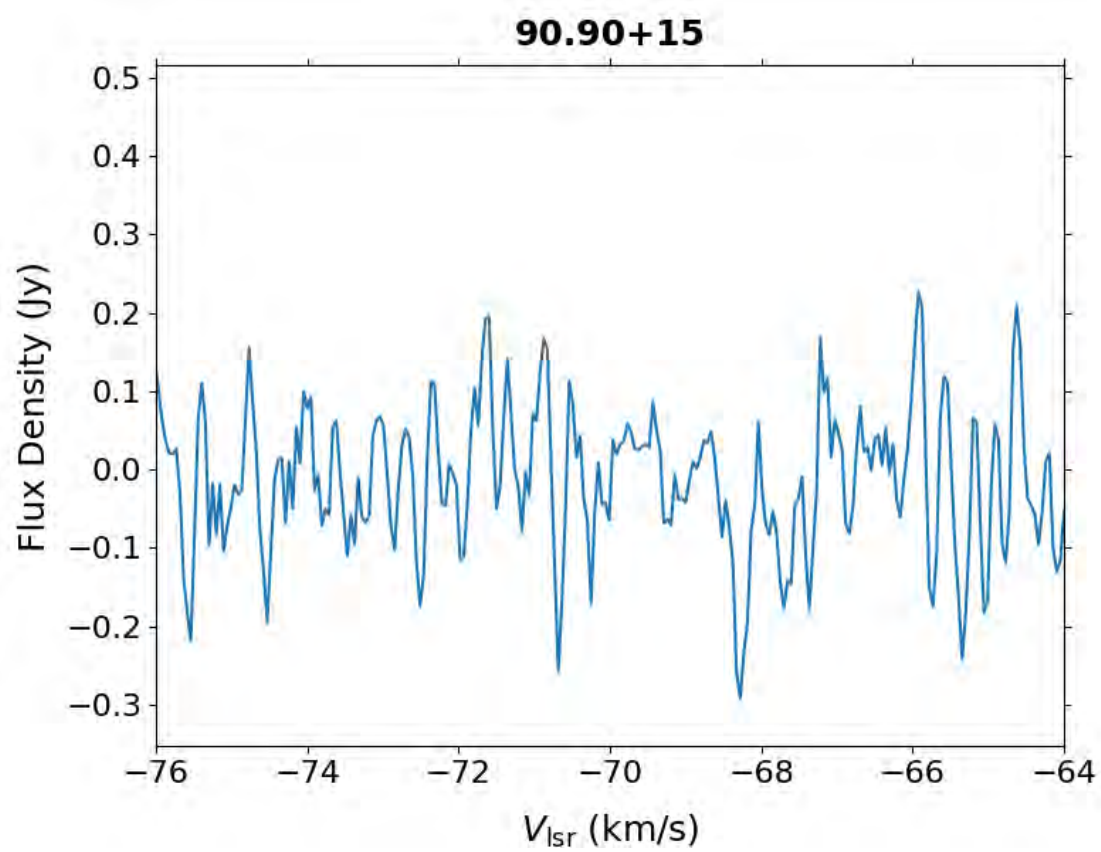
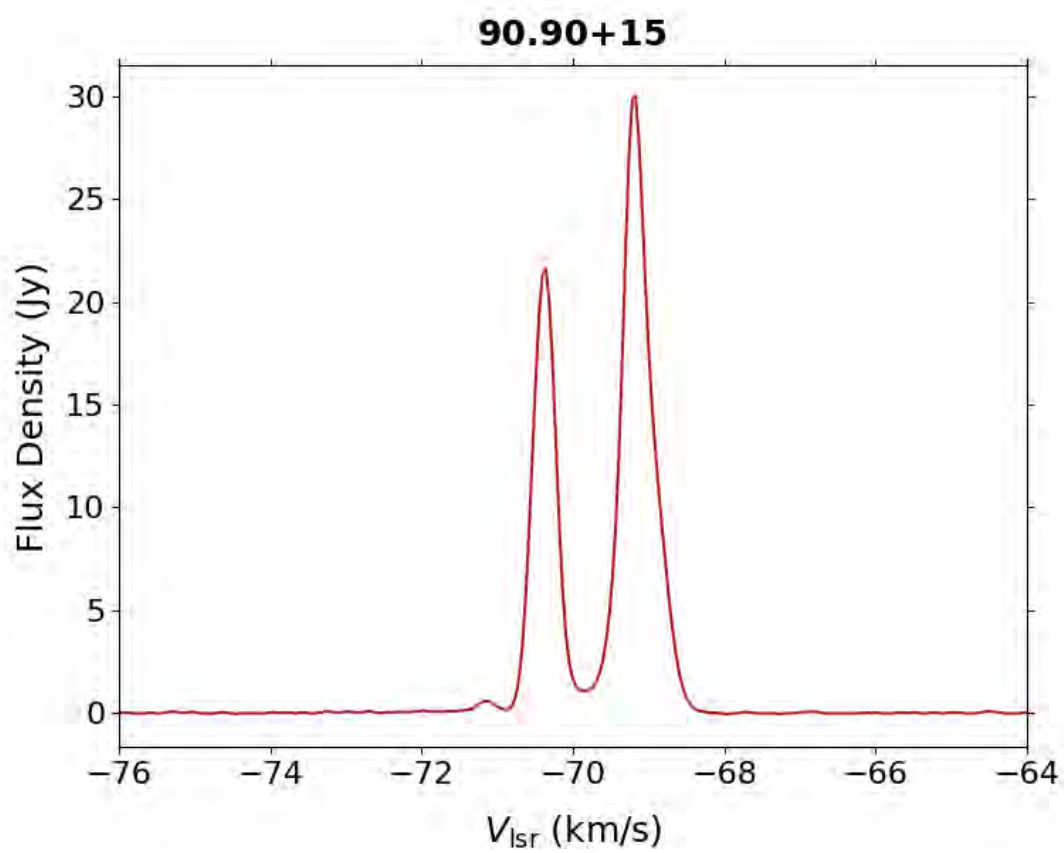
84.95-06

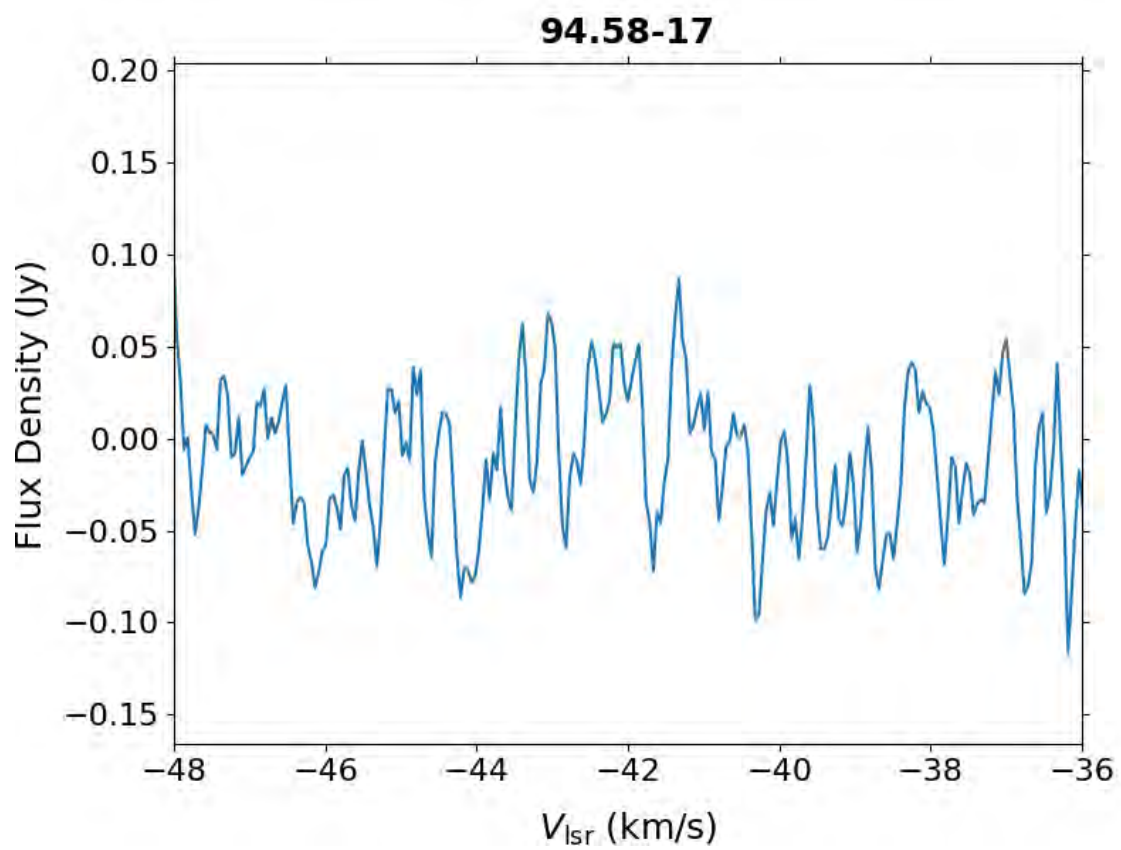
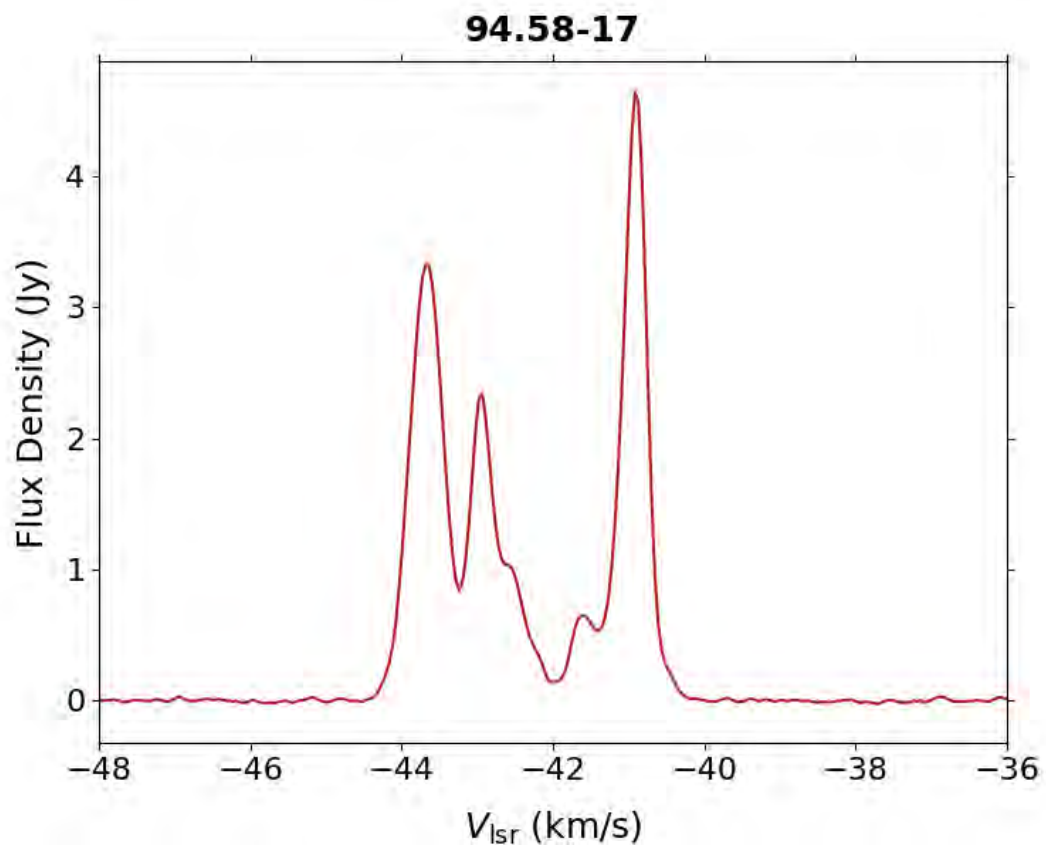


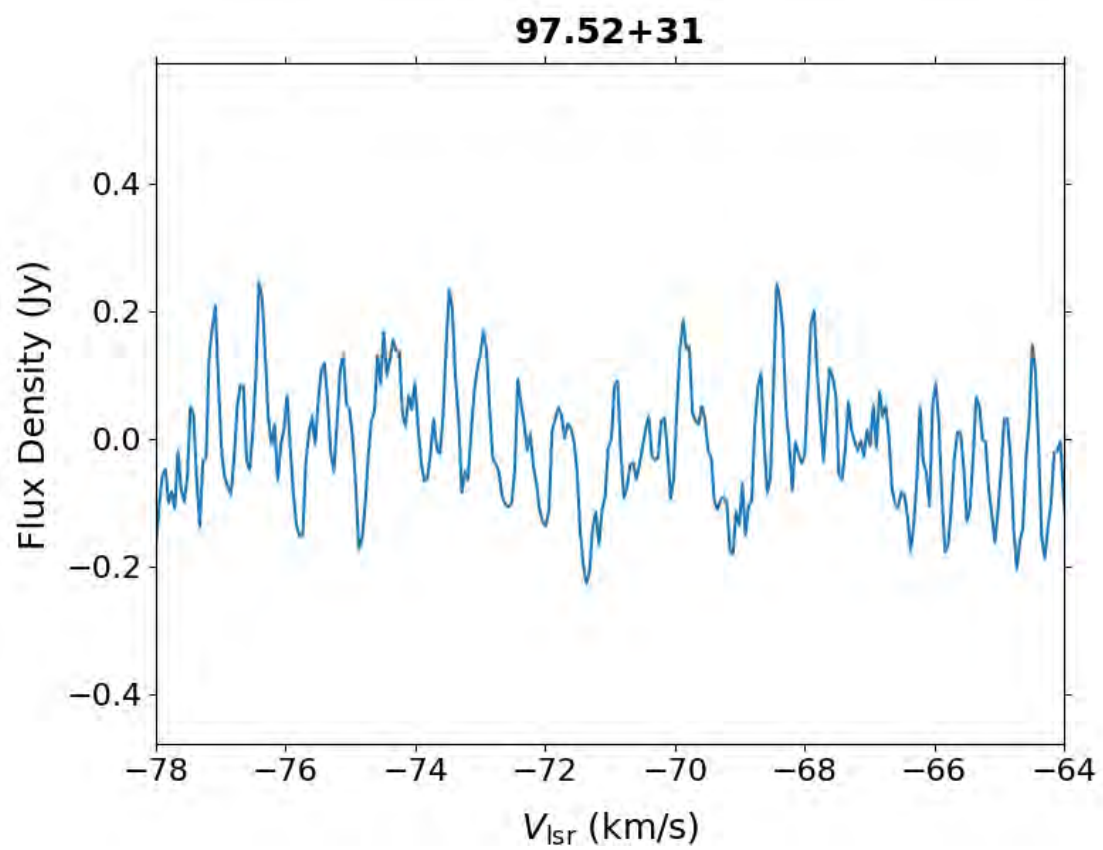
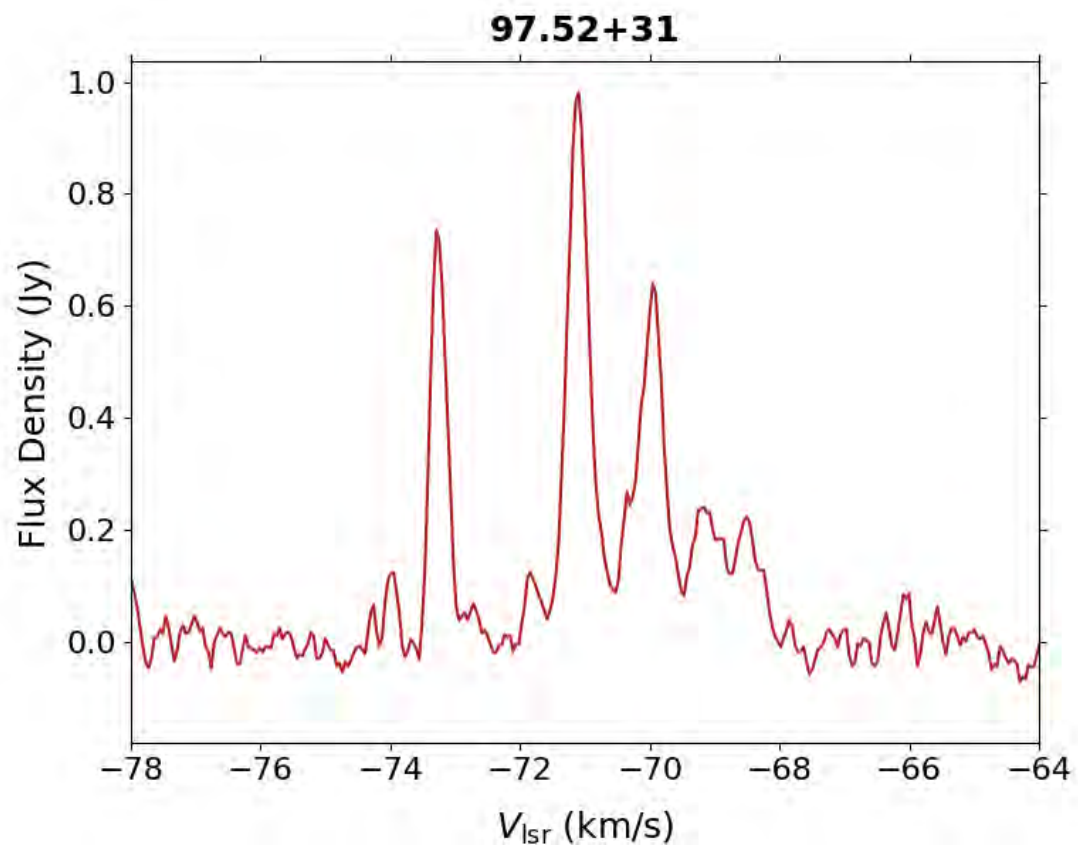
84.95-06

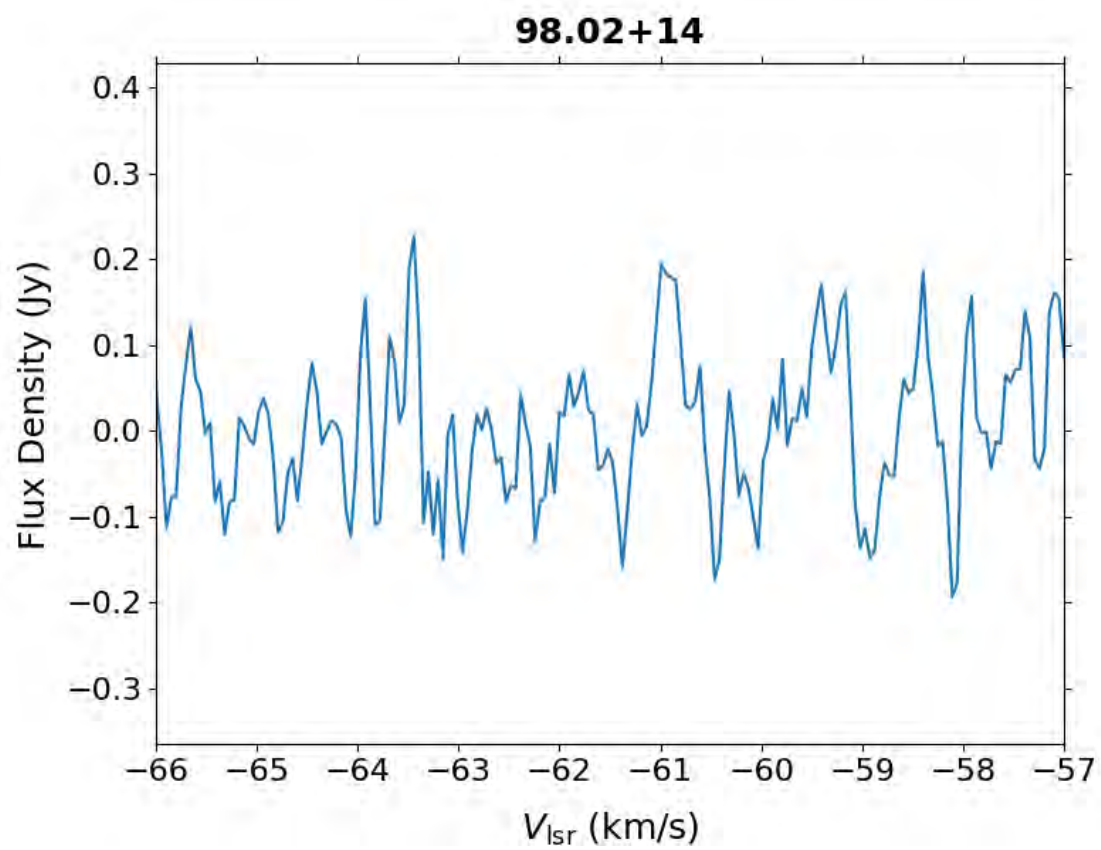
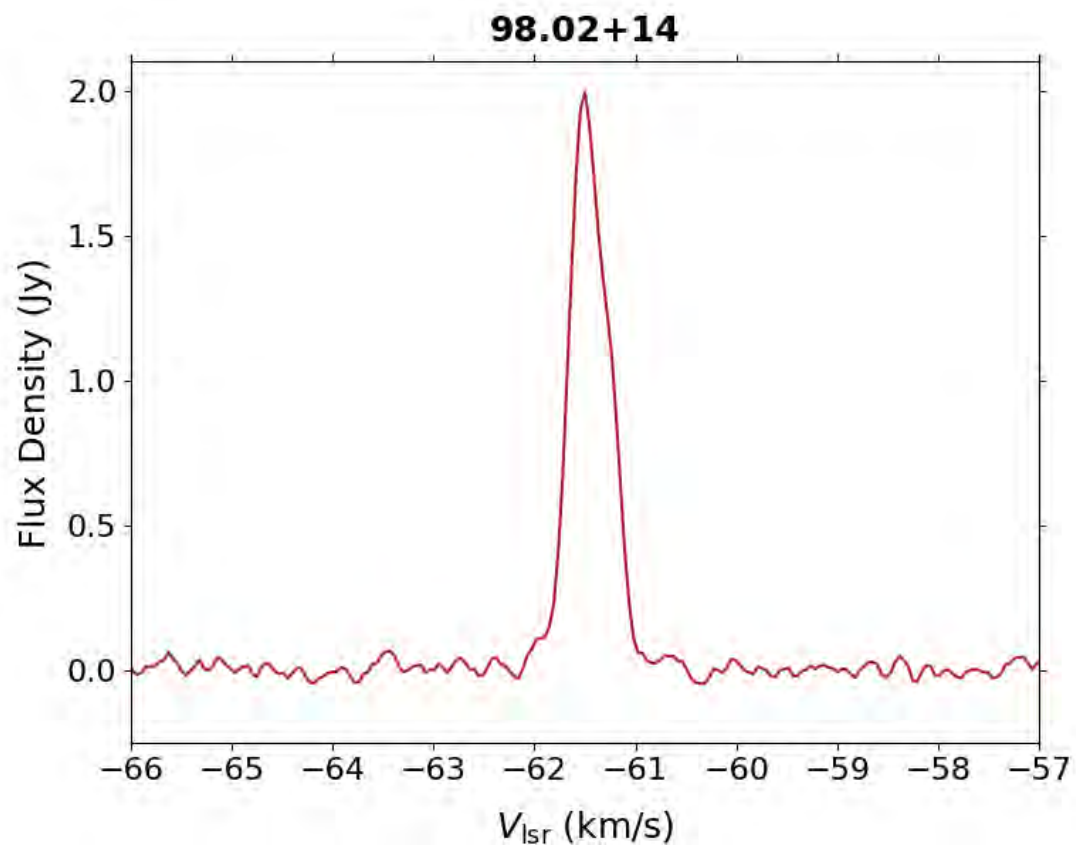


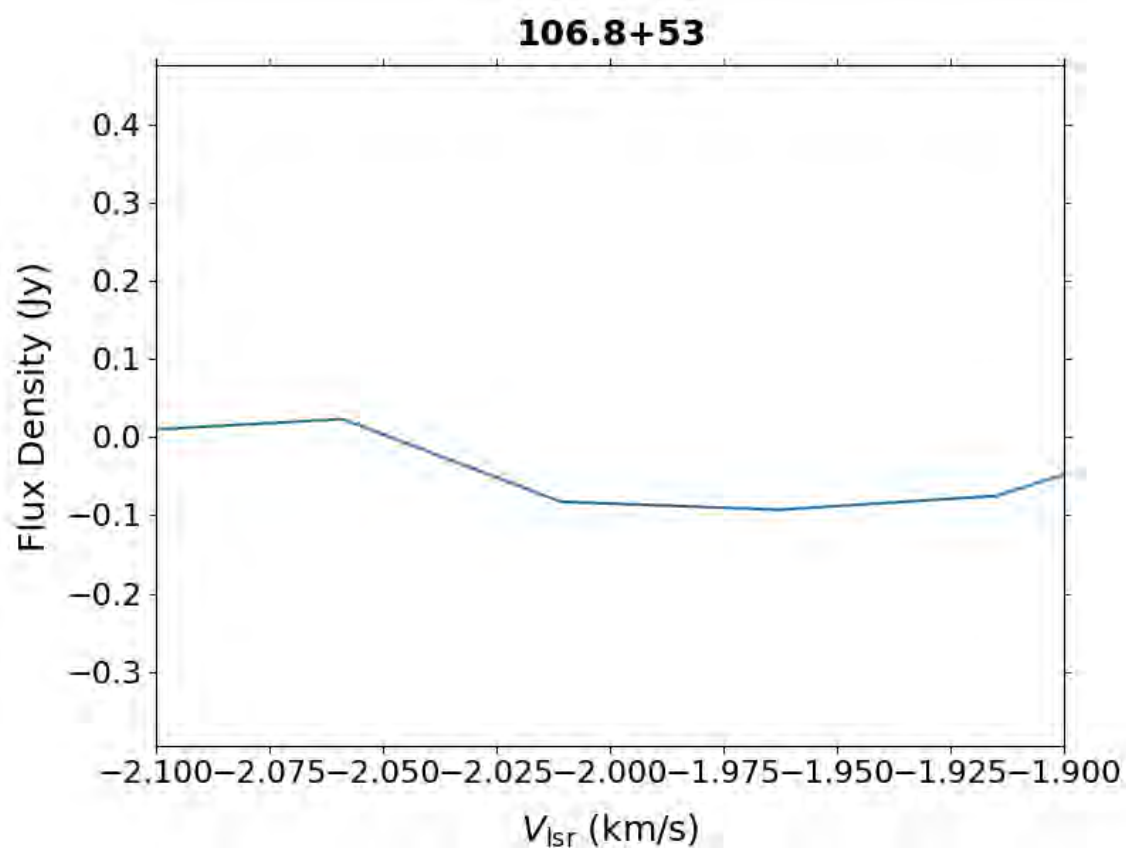
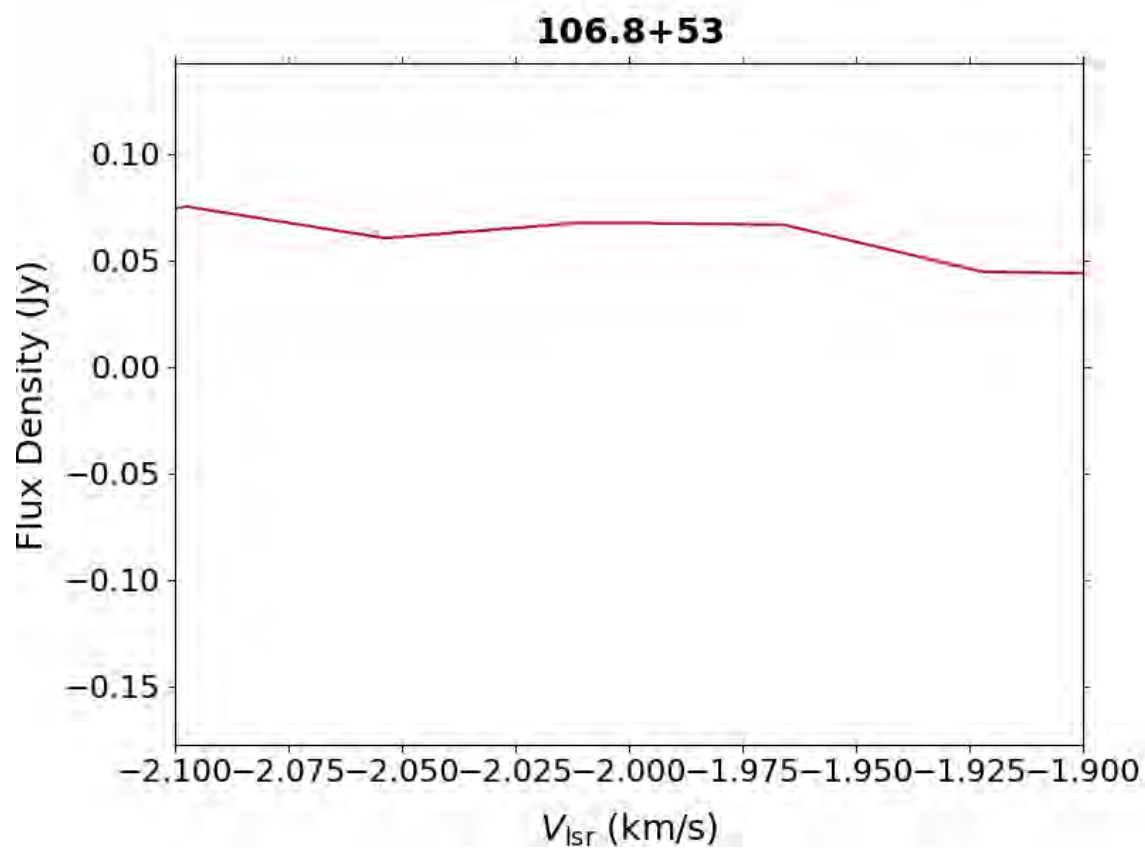


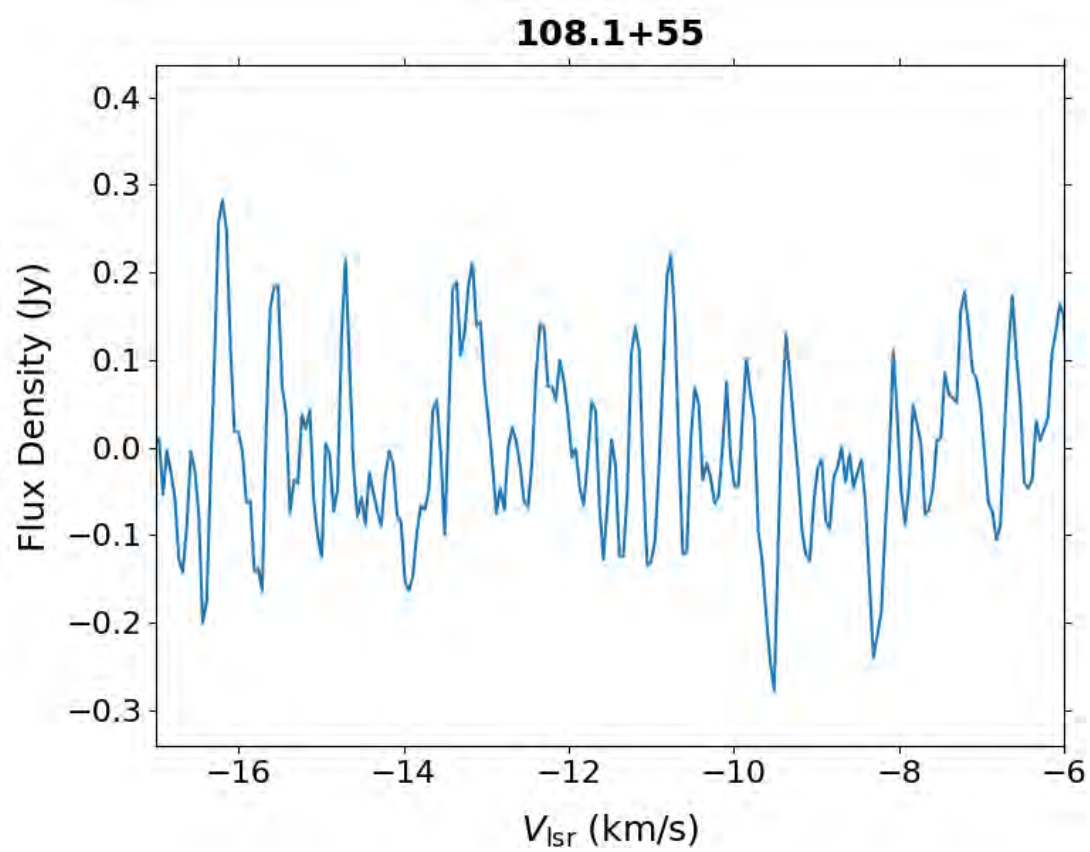
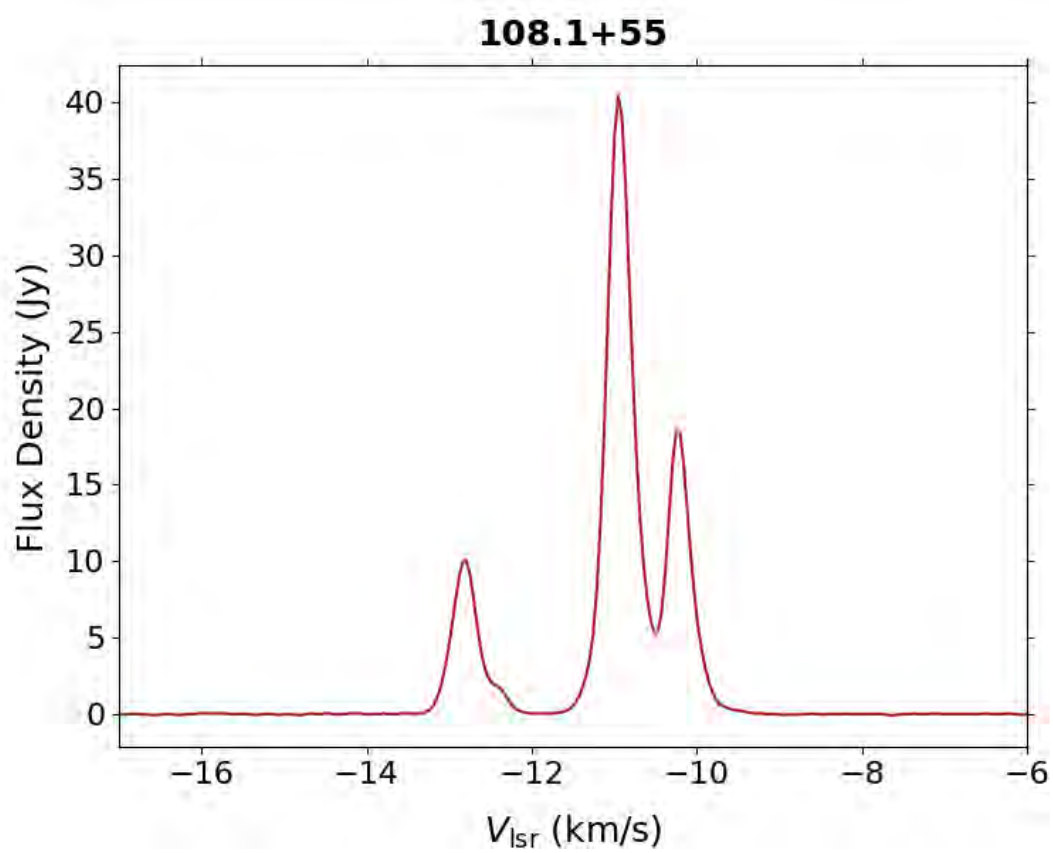




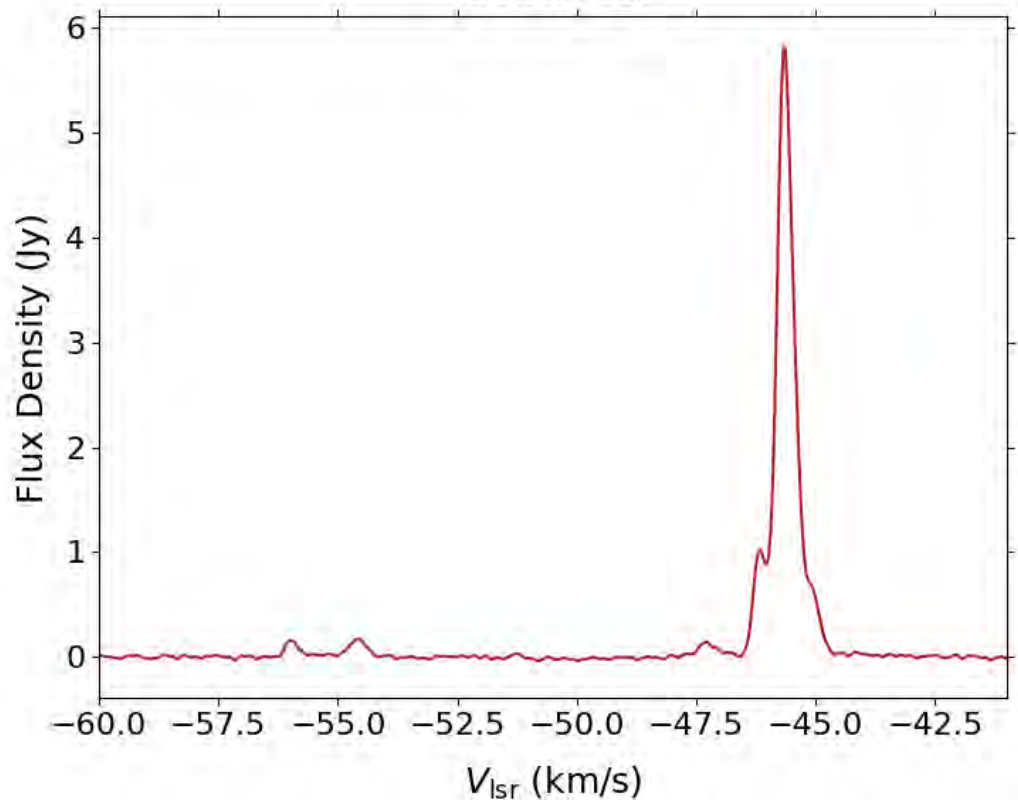




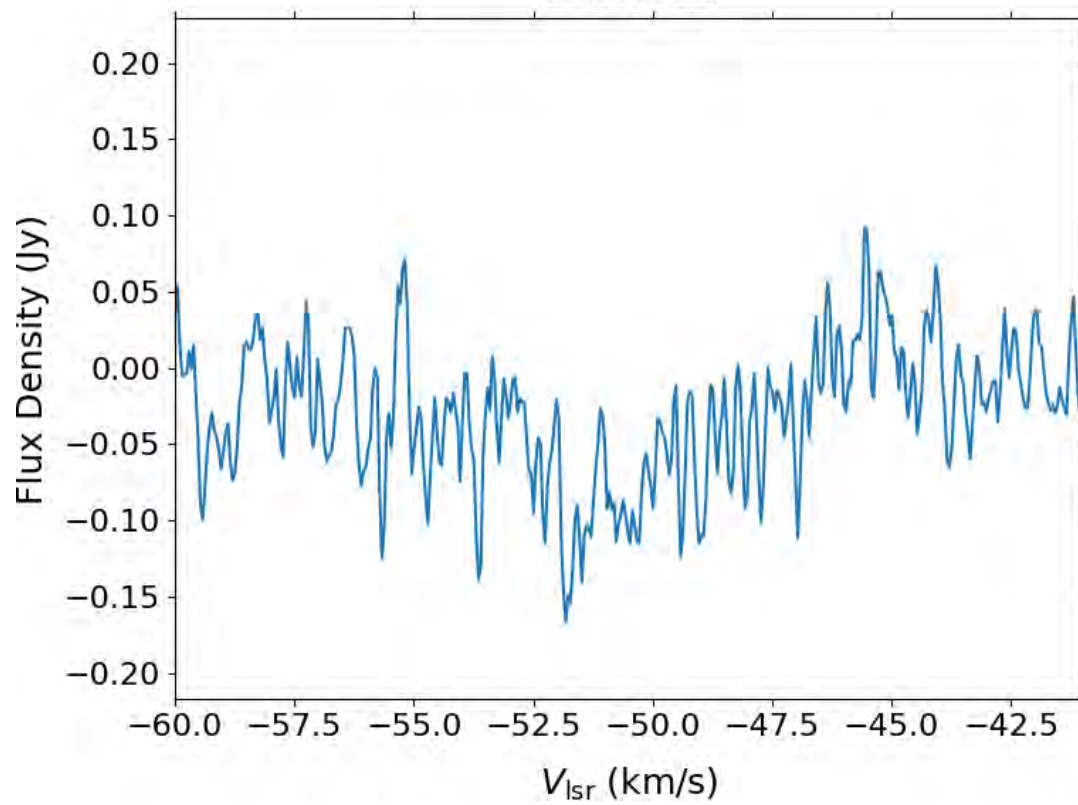


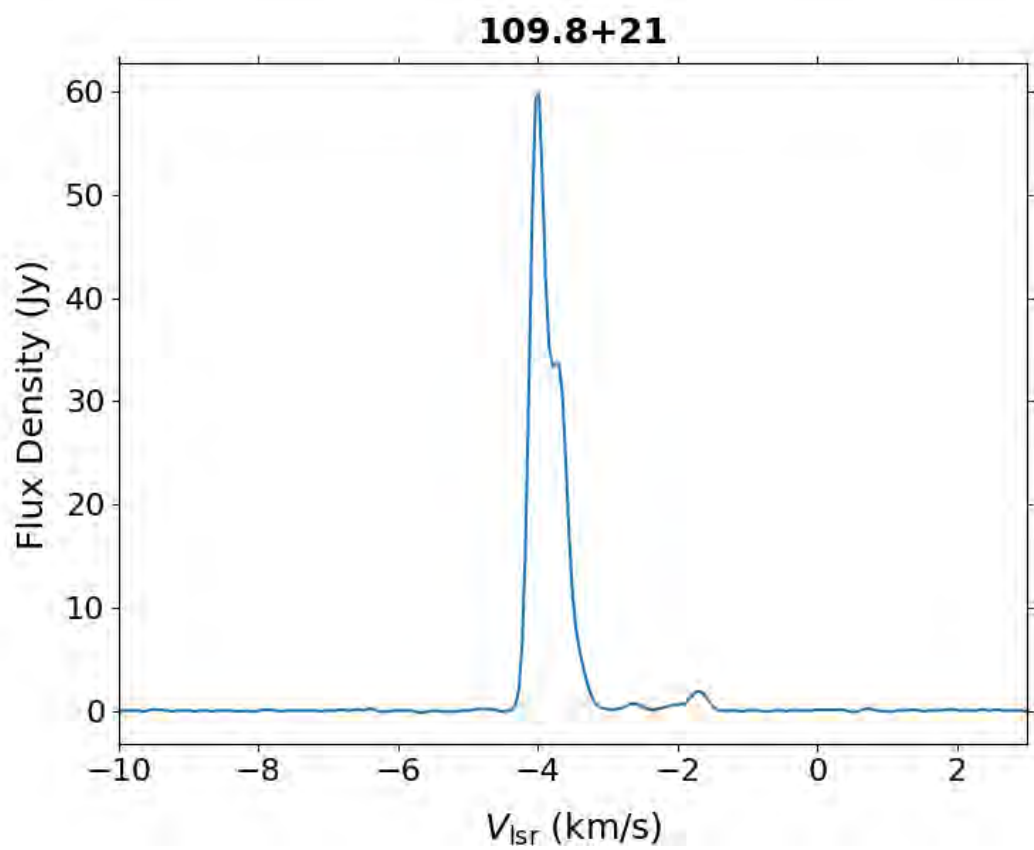
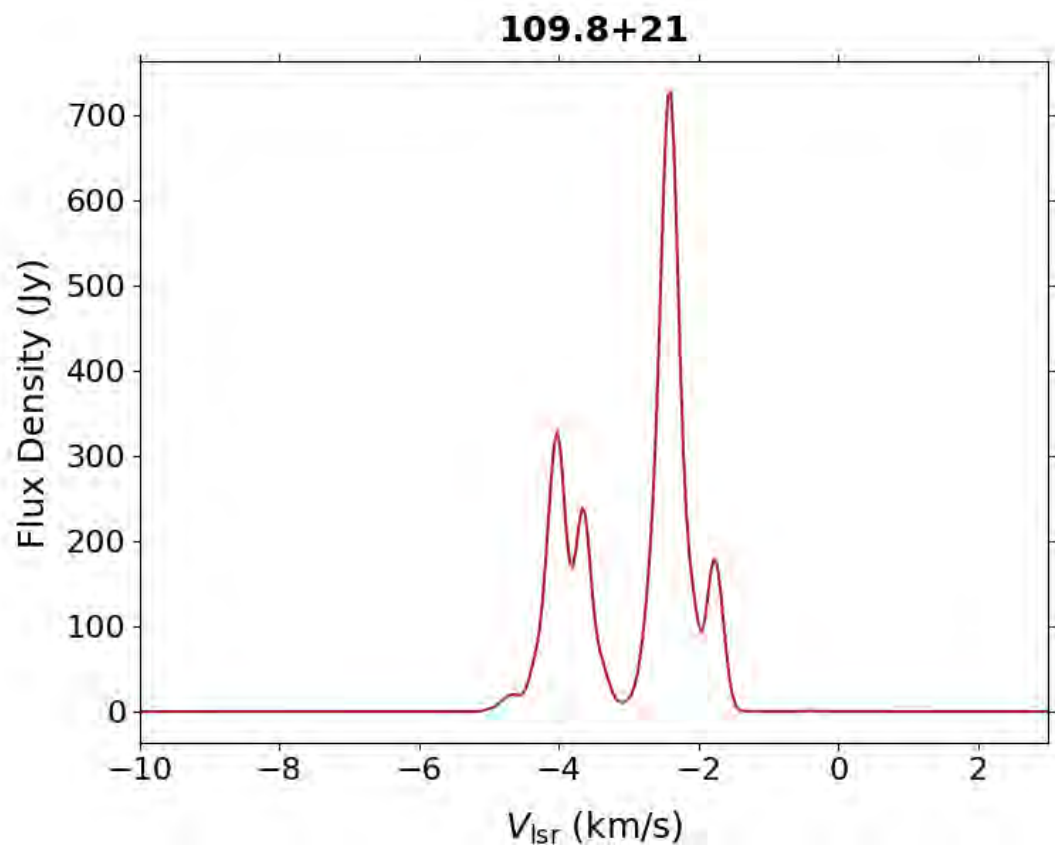


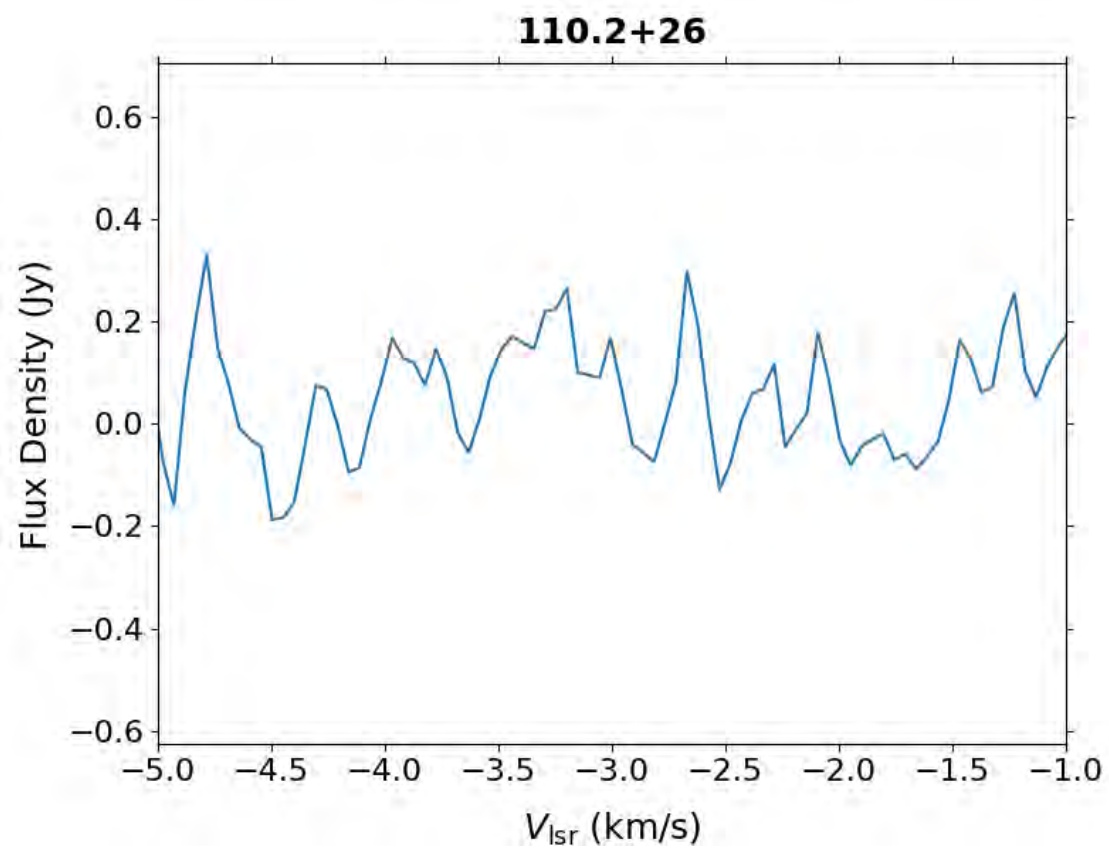
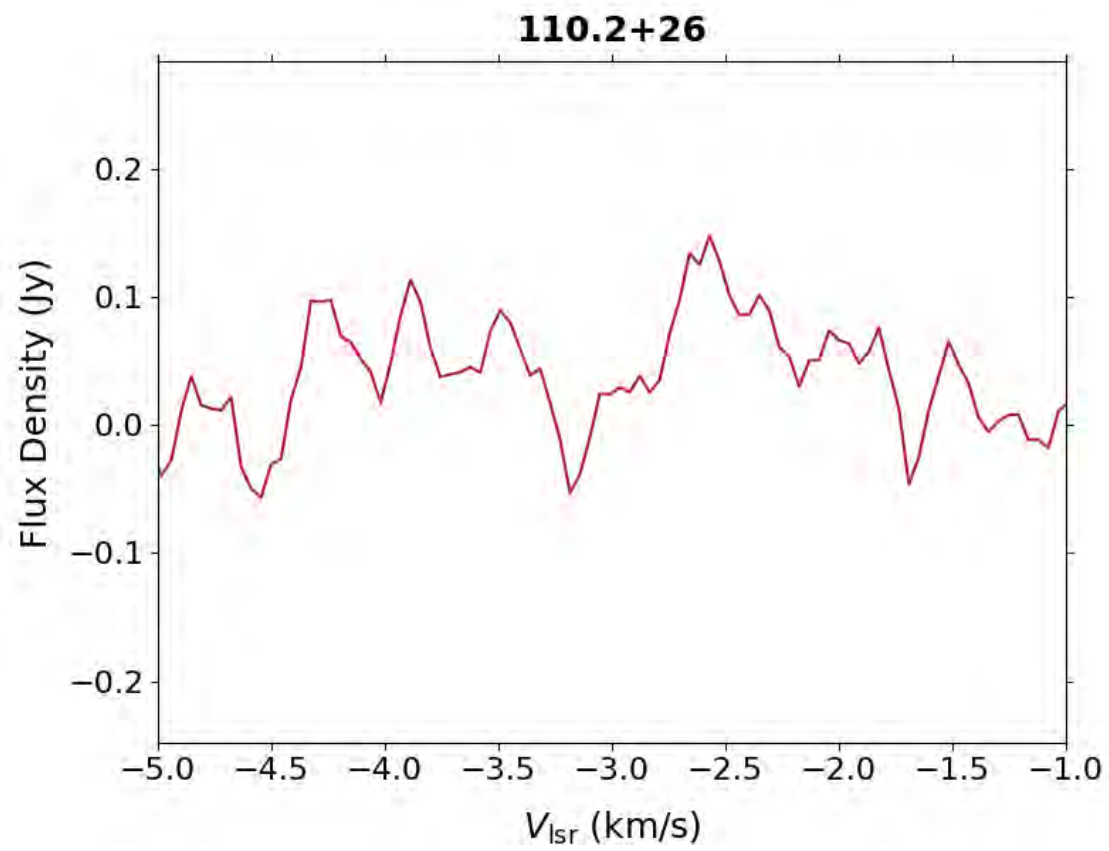
108.7-09



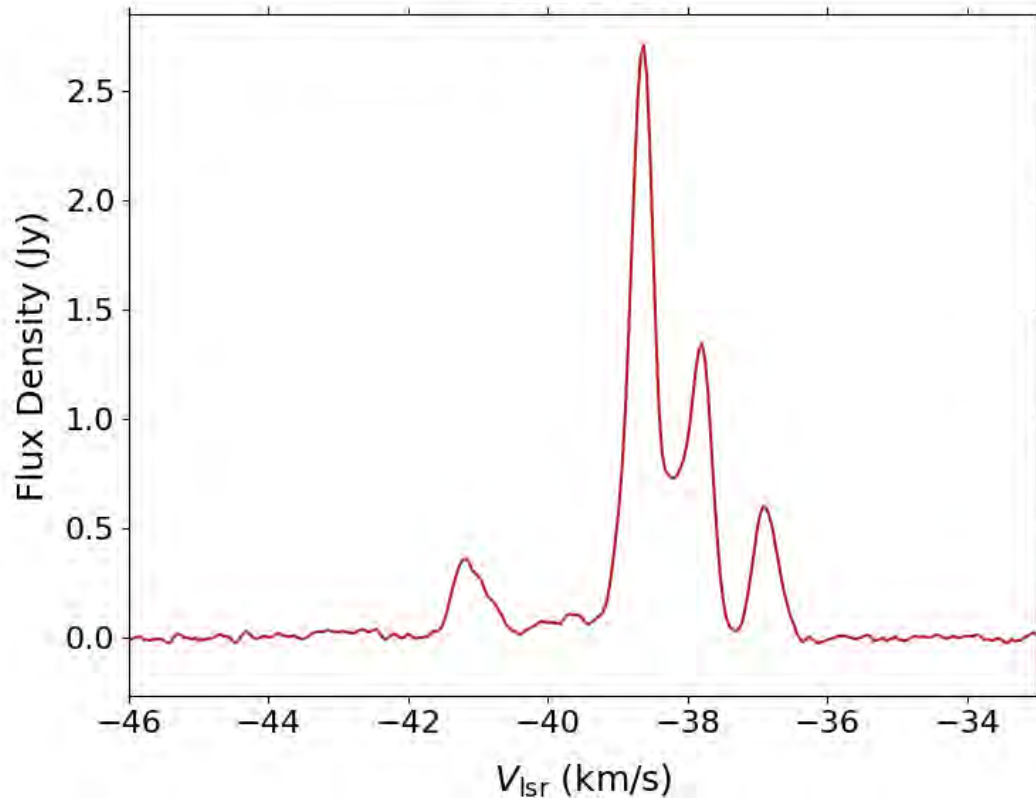
108.7-09



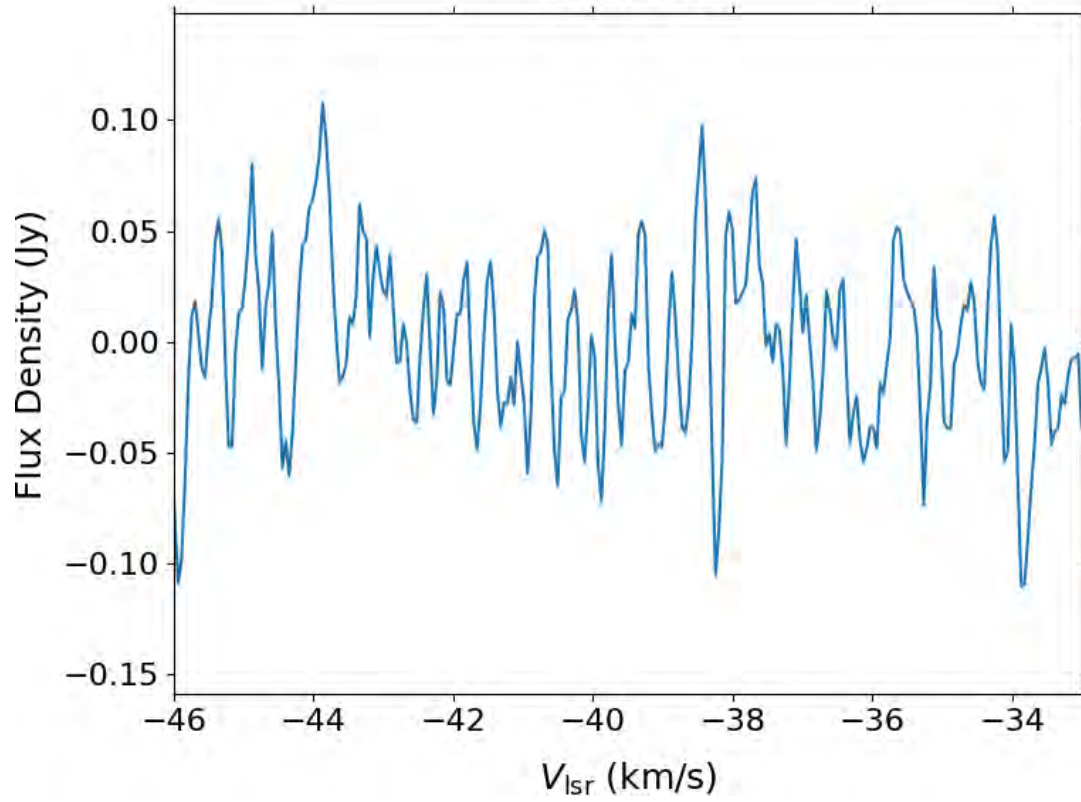


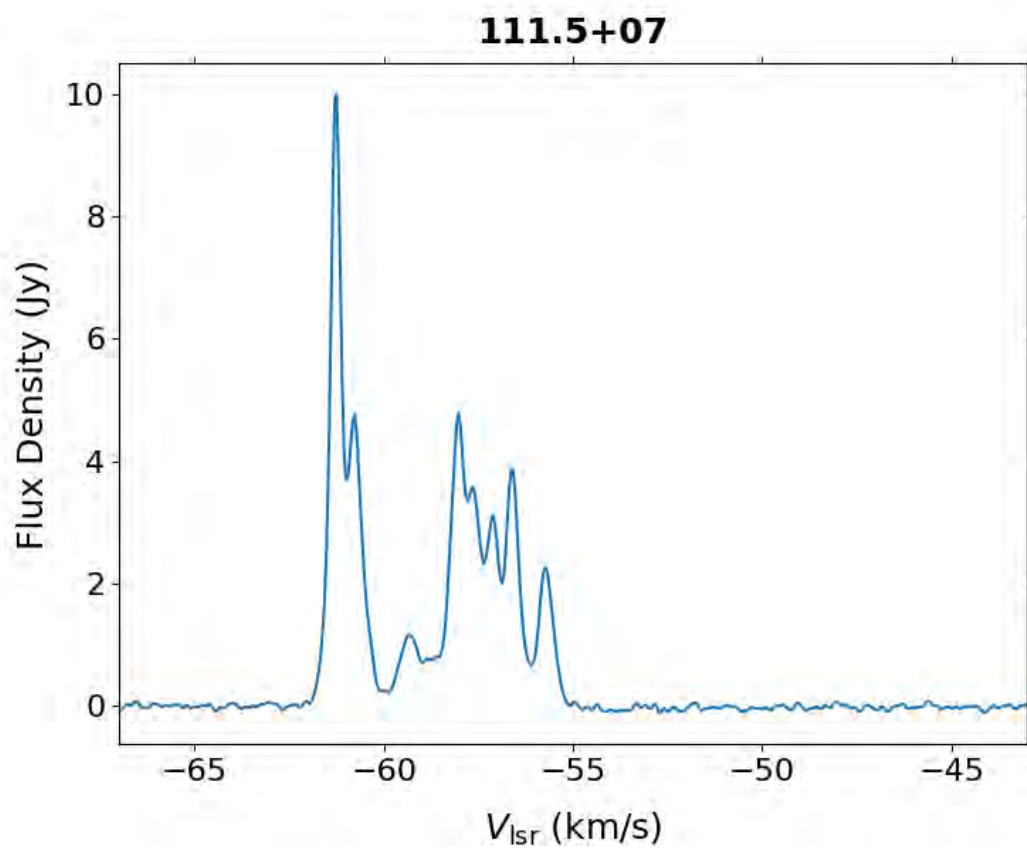
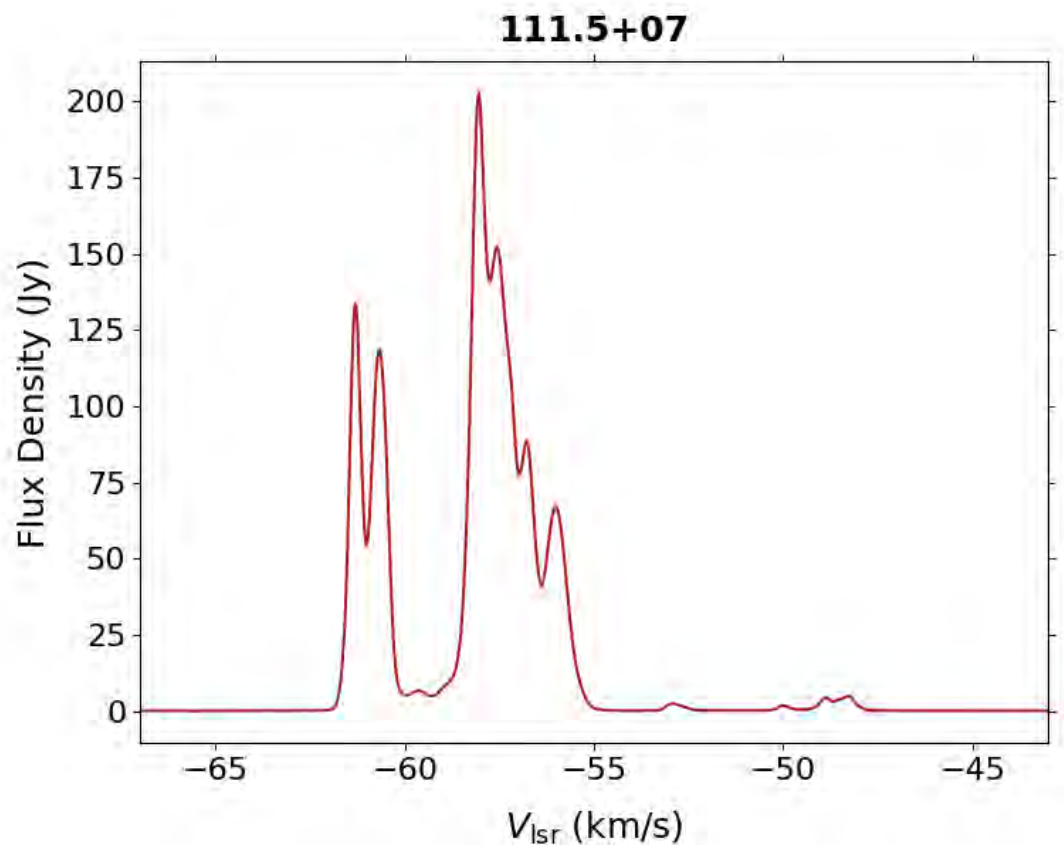


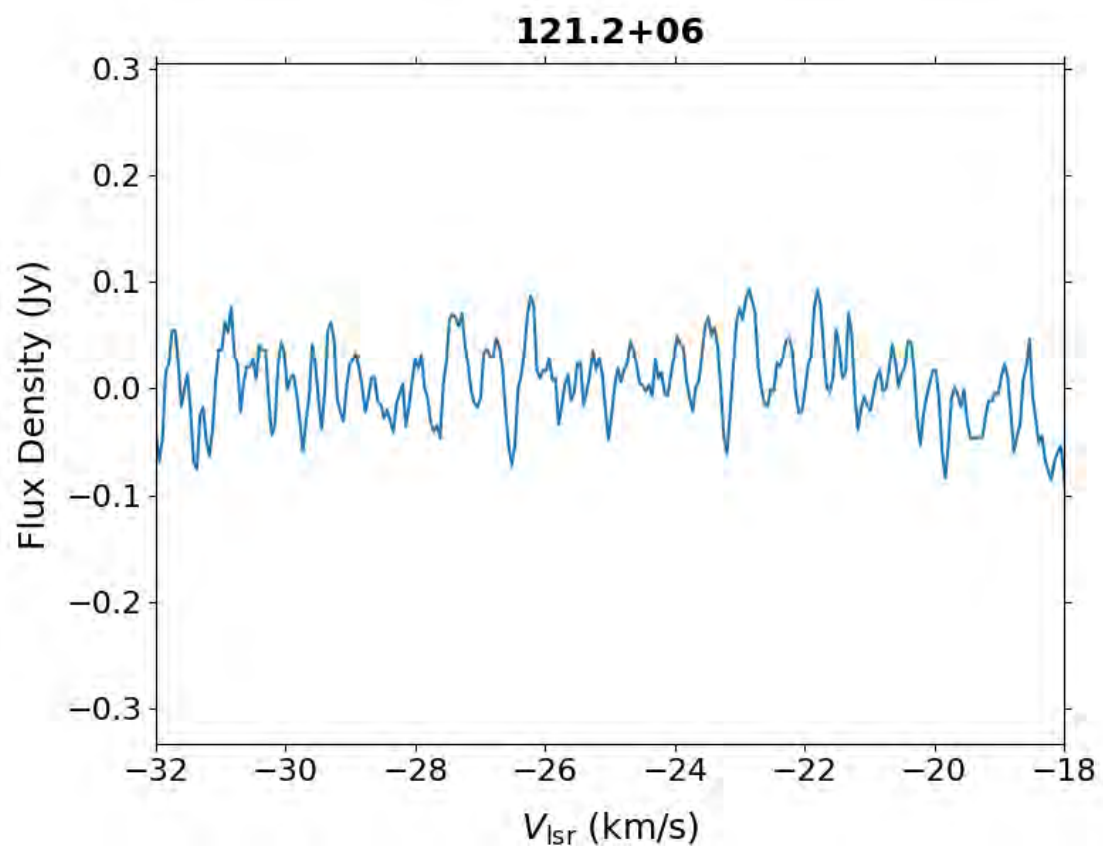
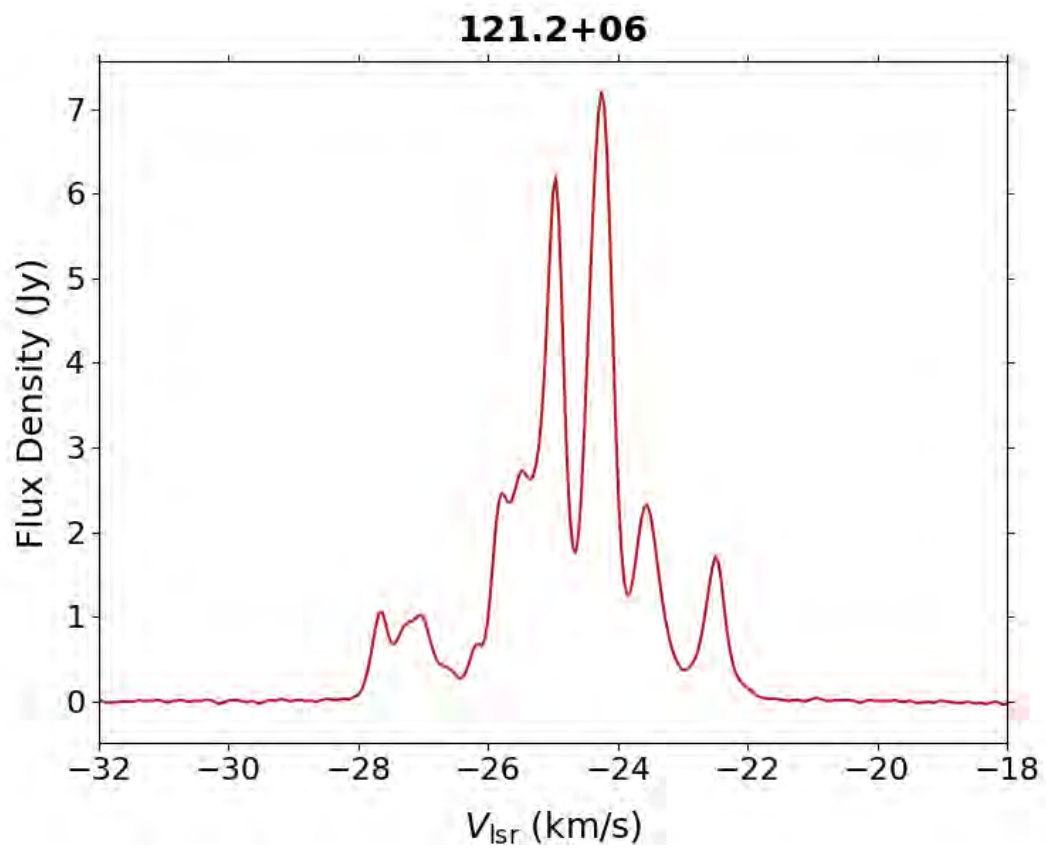
111.2-07



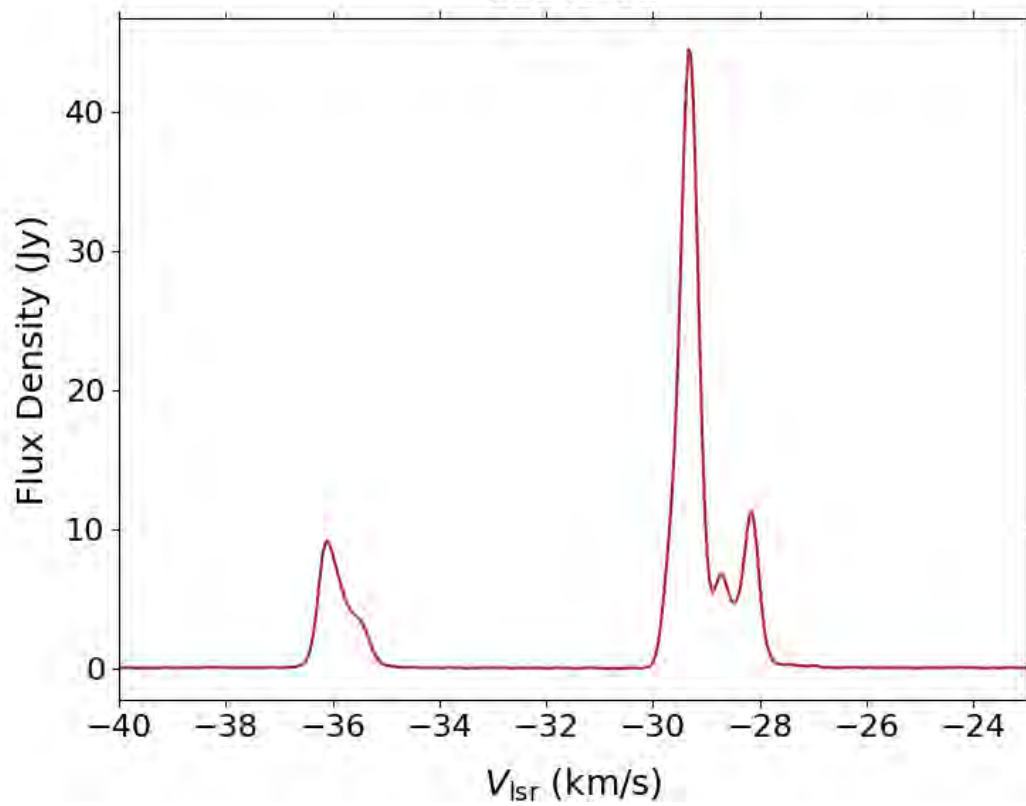
111.2-07



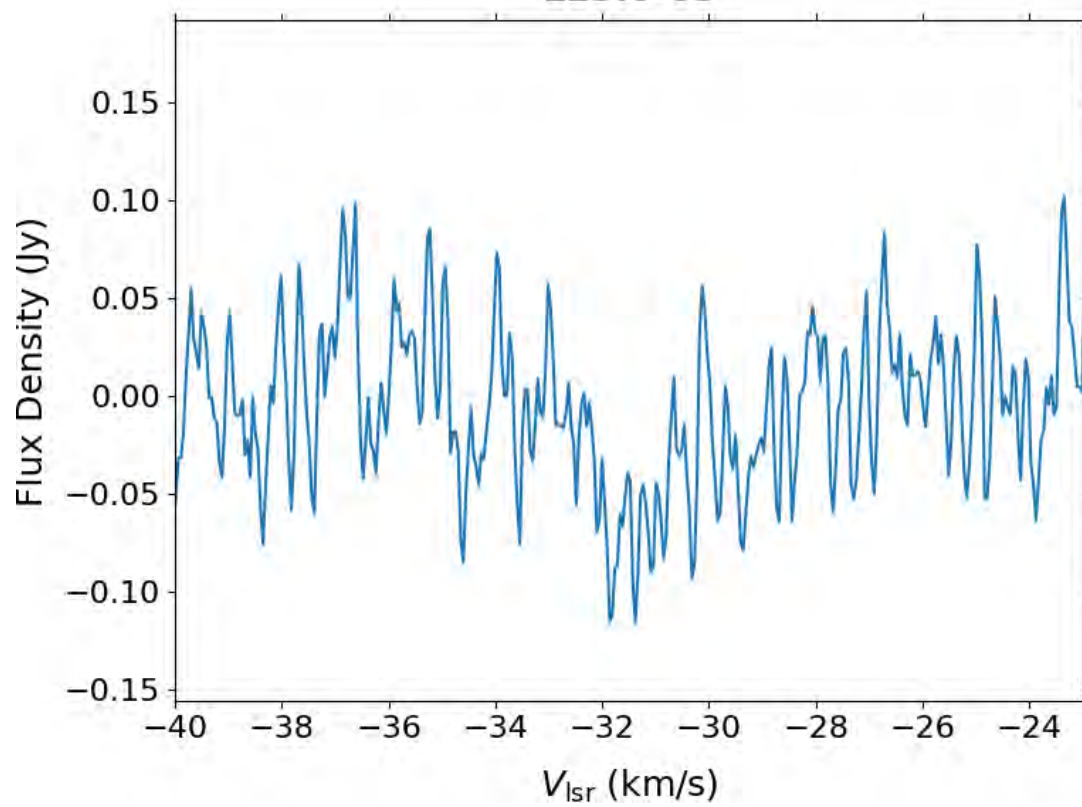


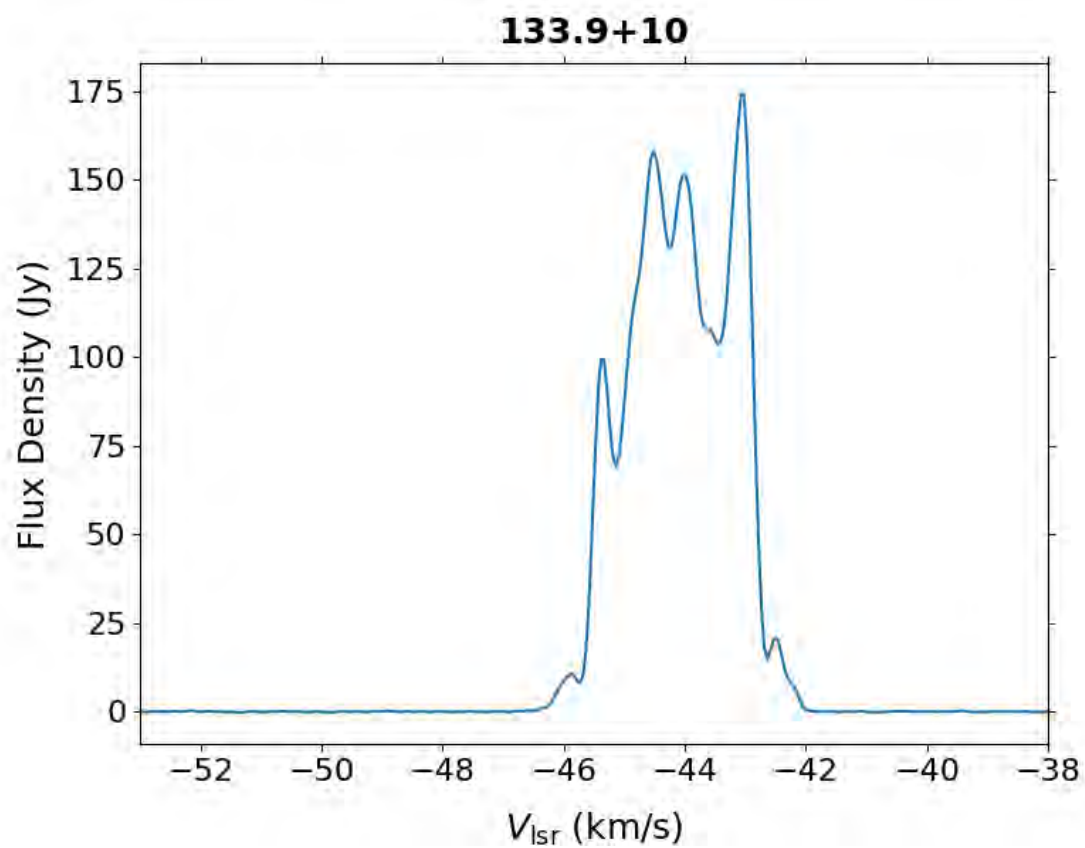
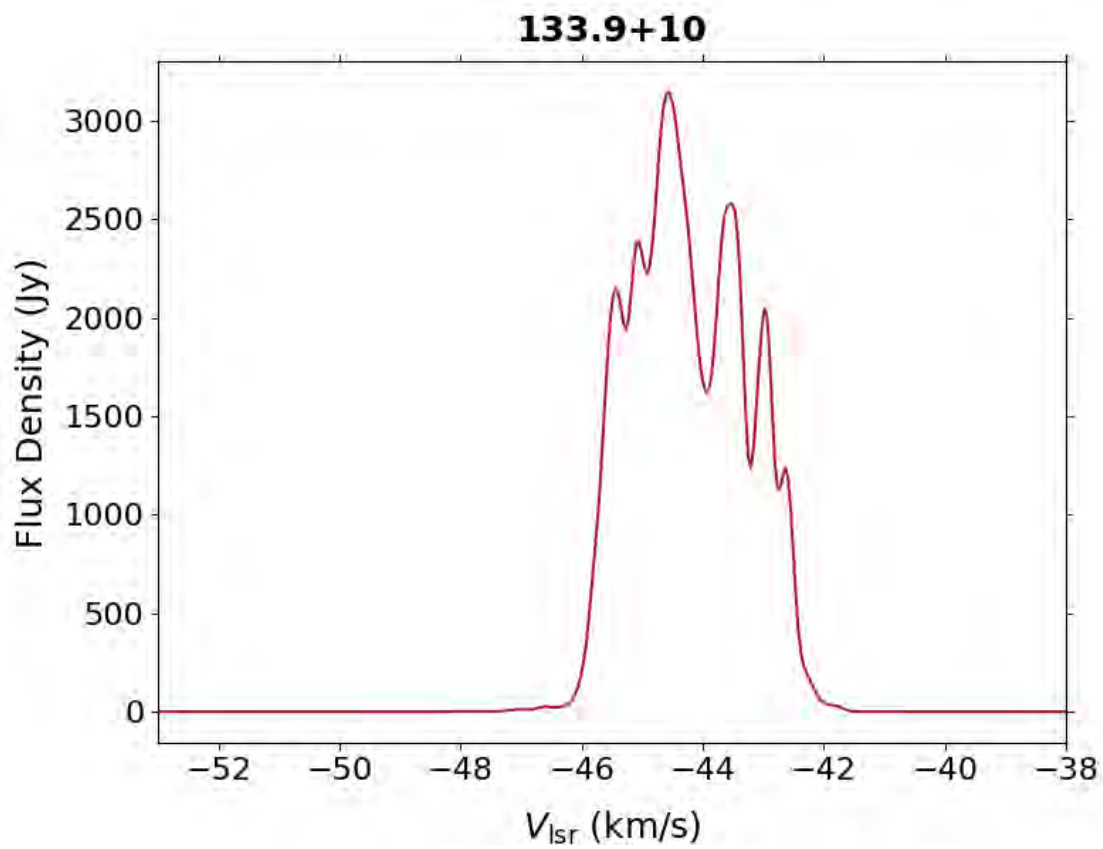


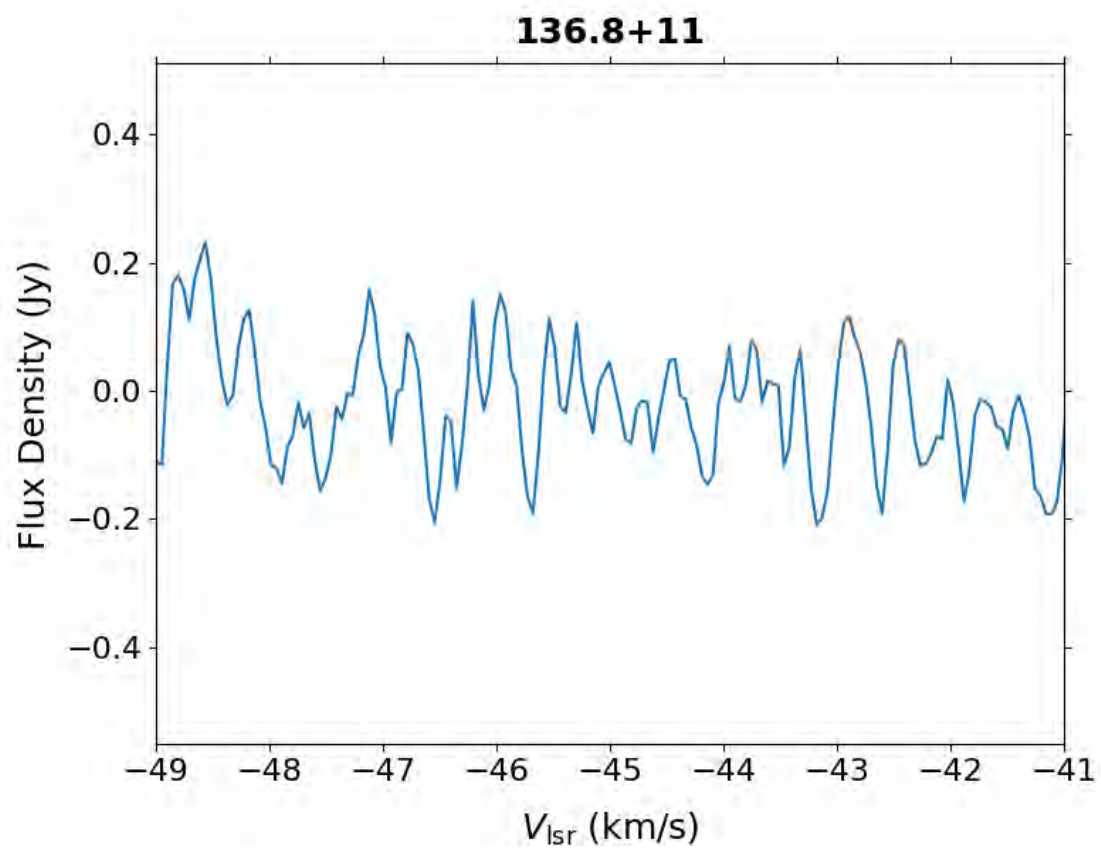
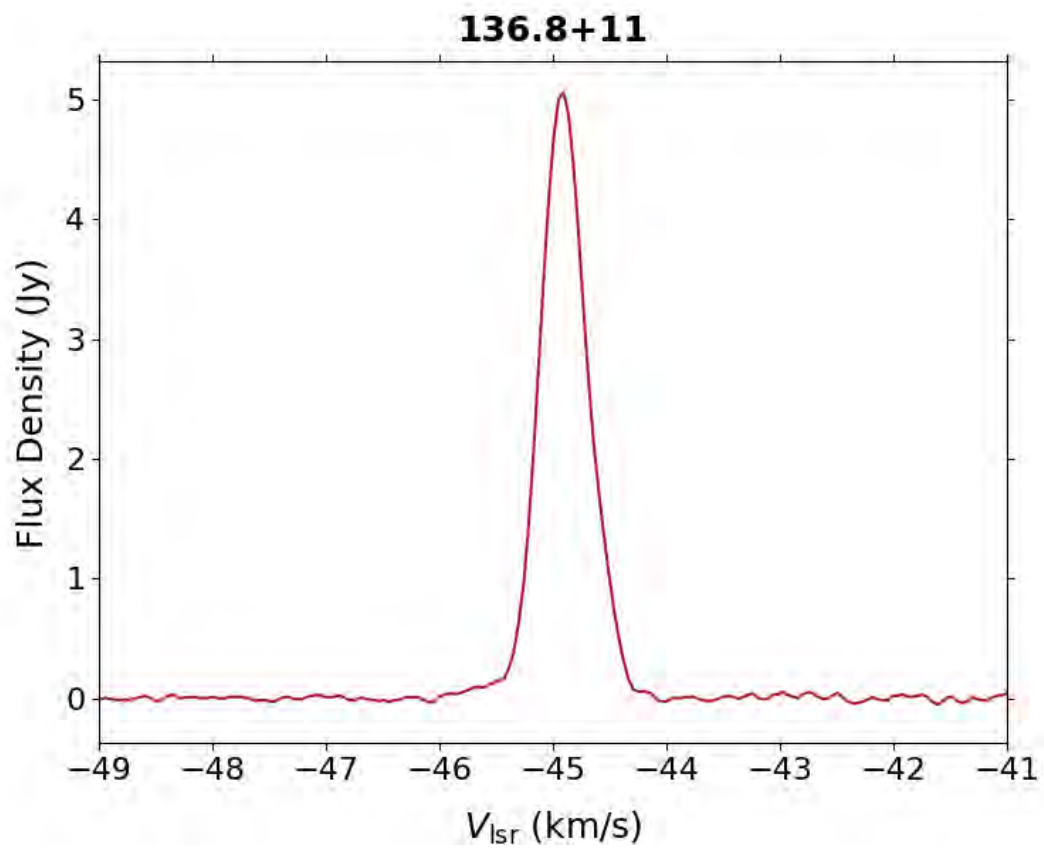
123.0-63

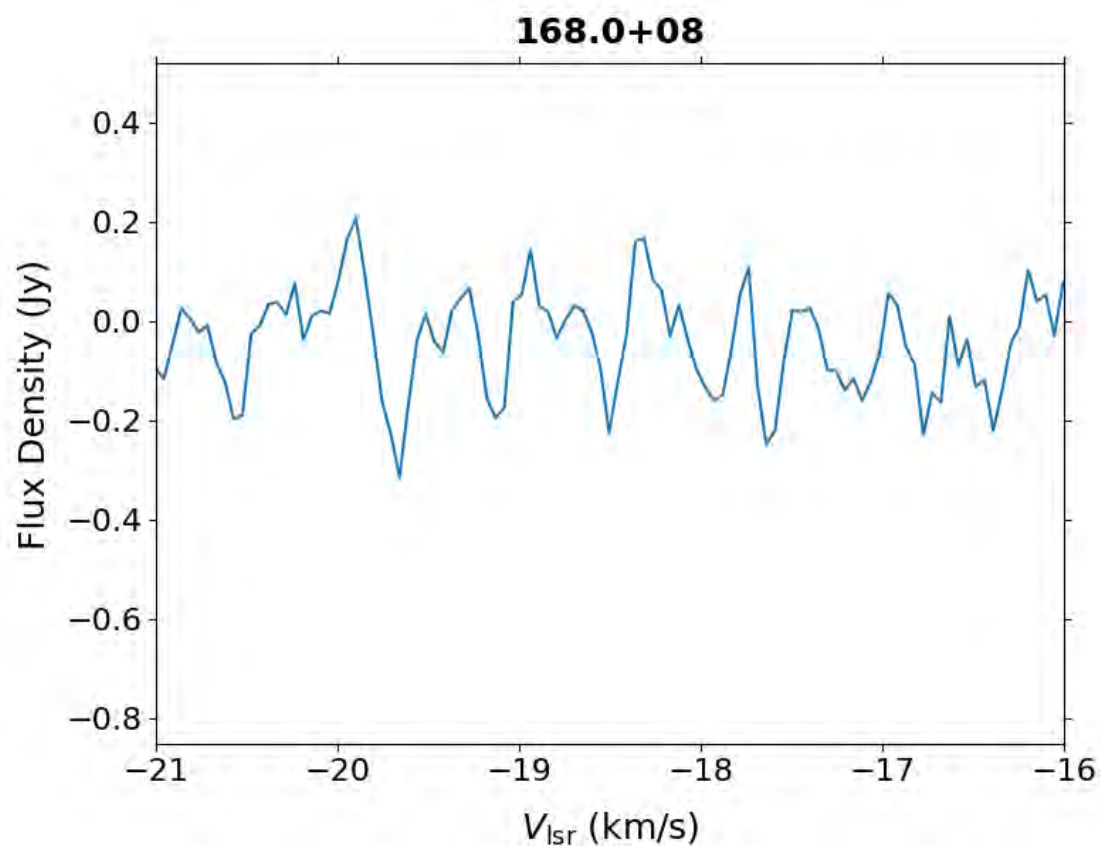
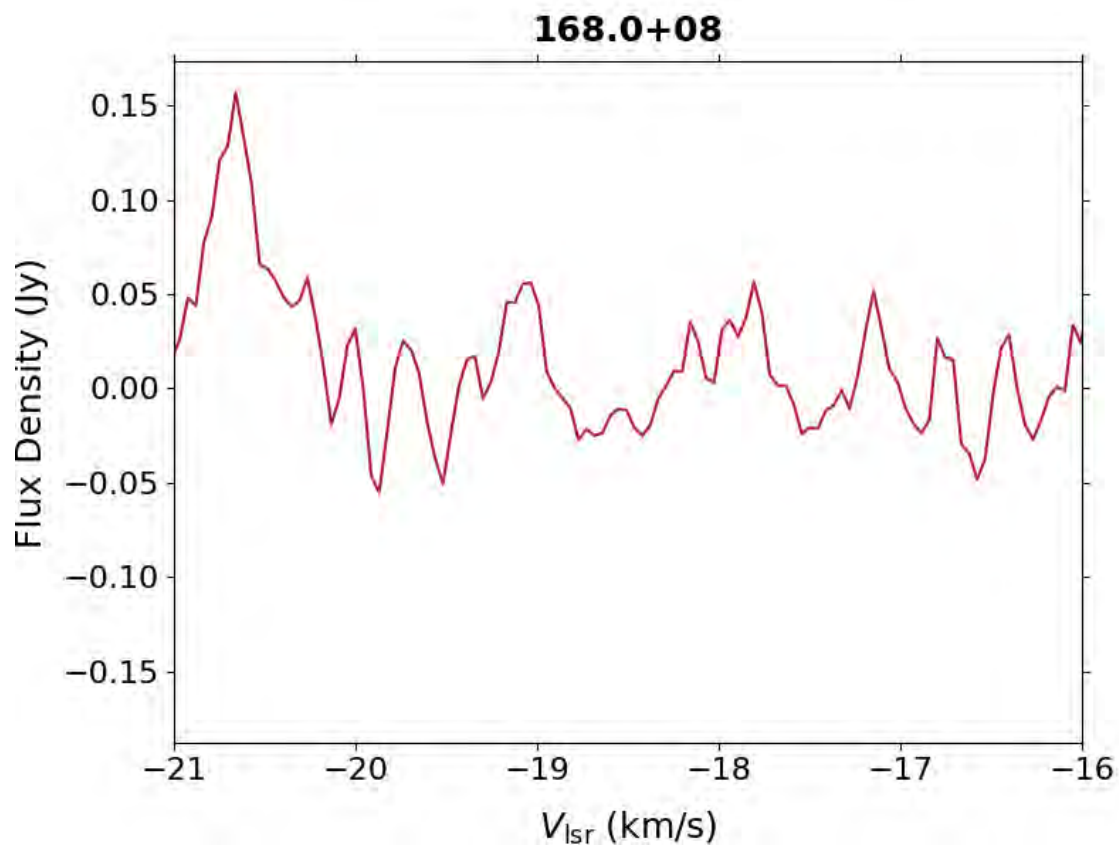


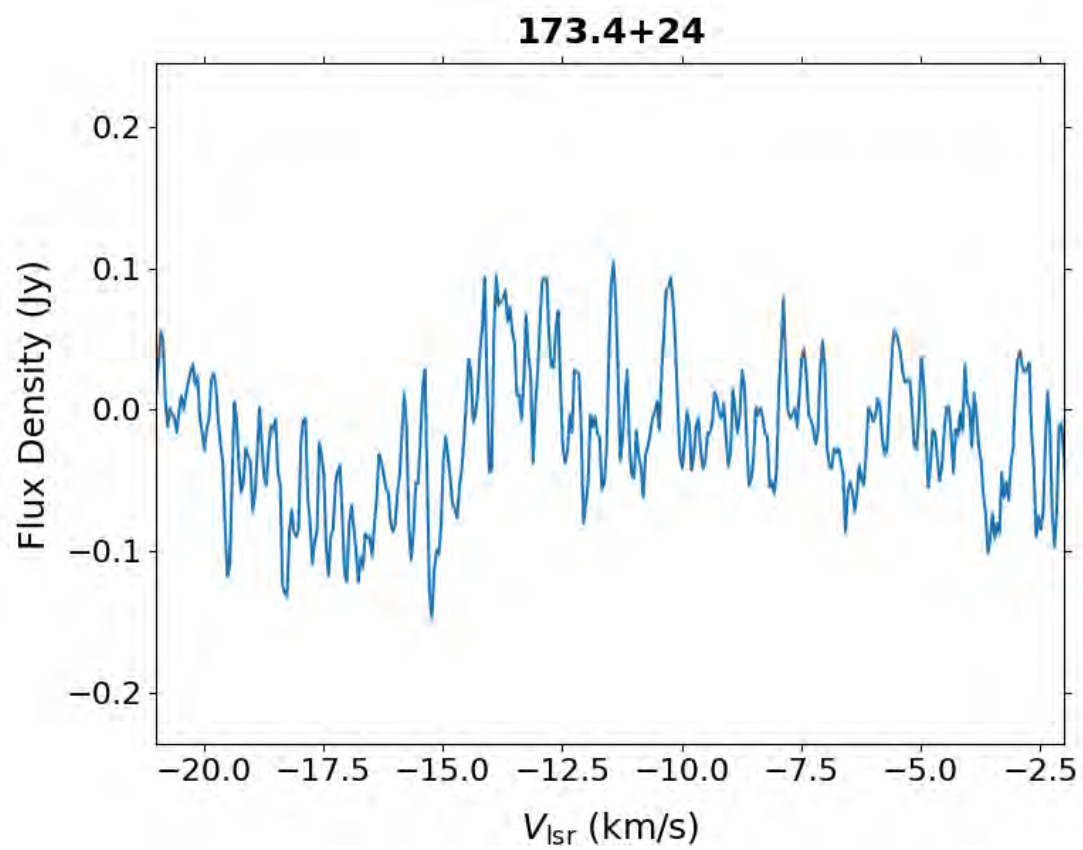
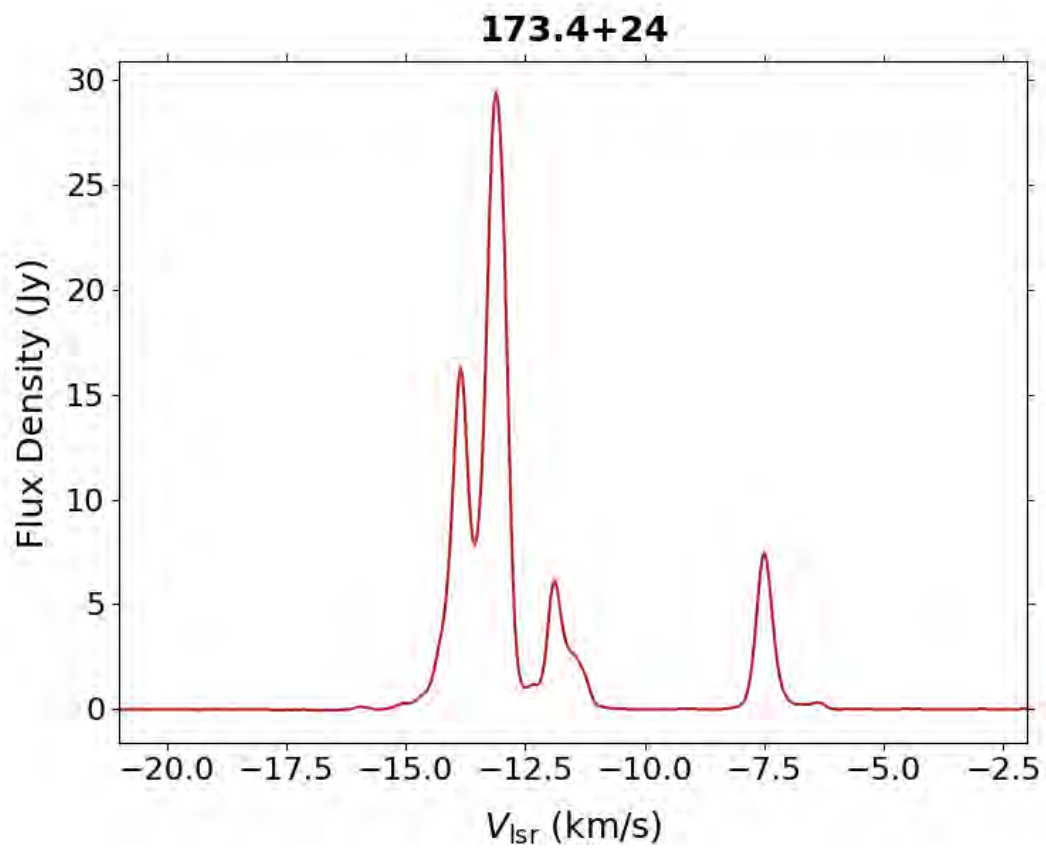
123.0-63

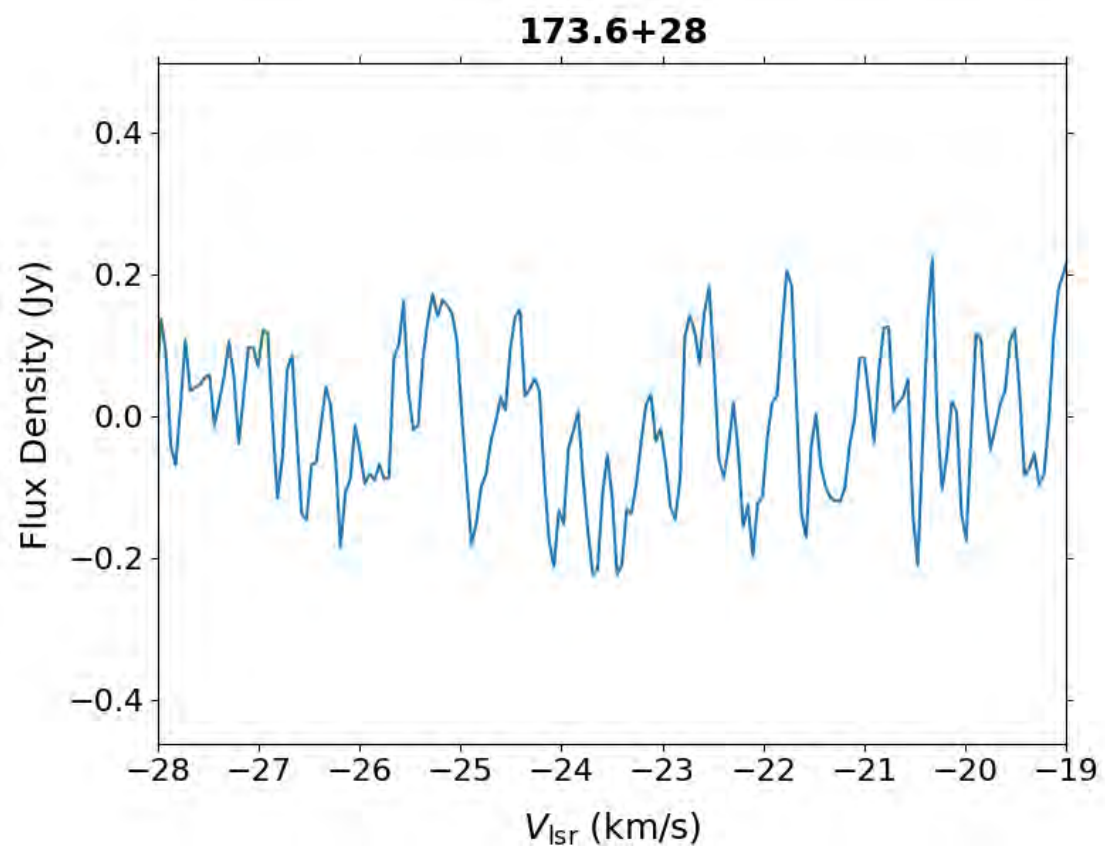
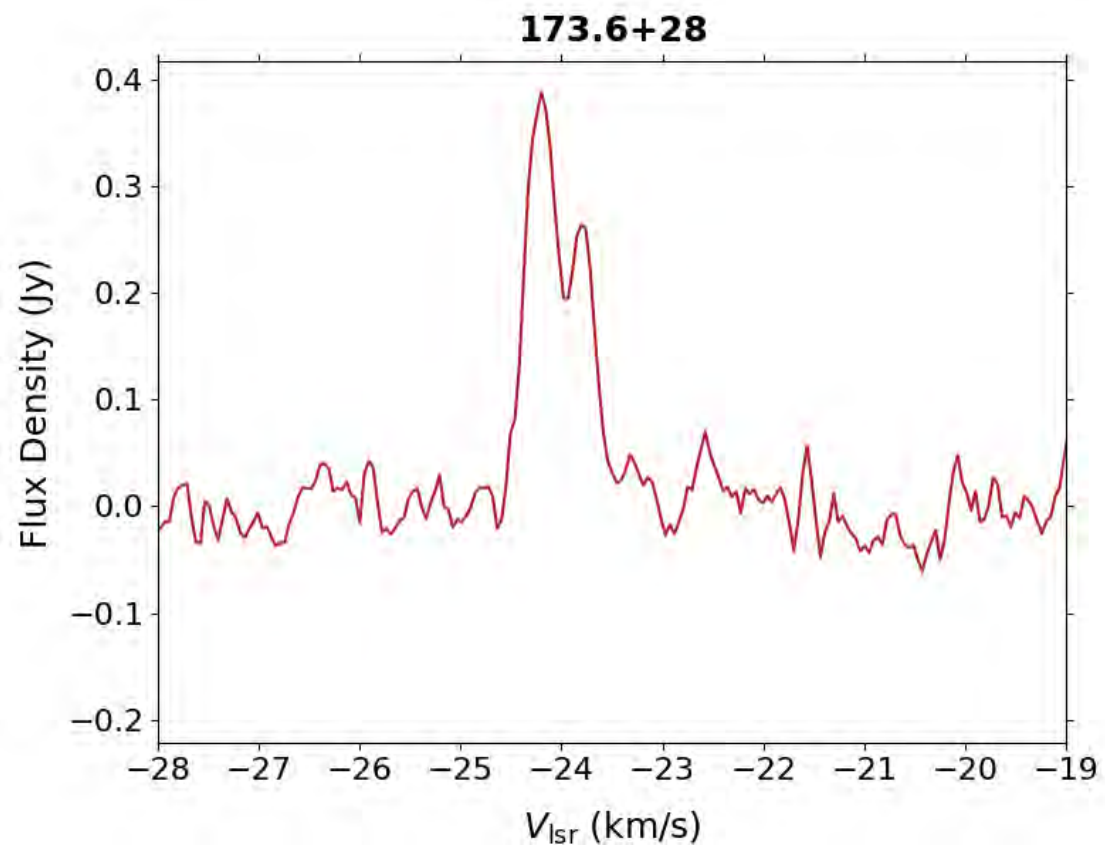


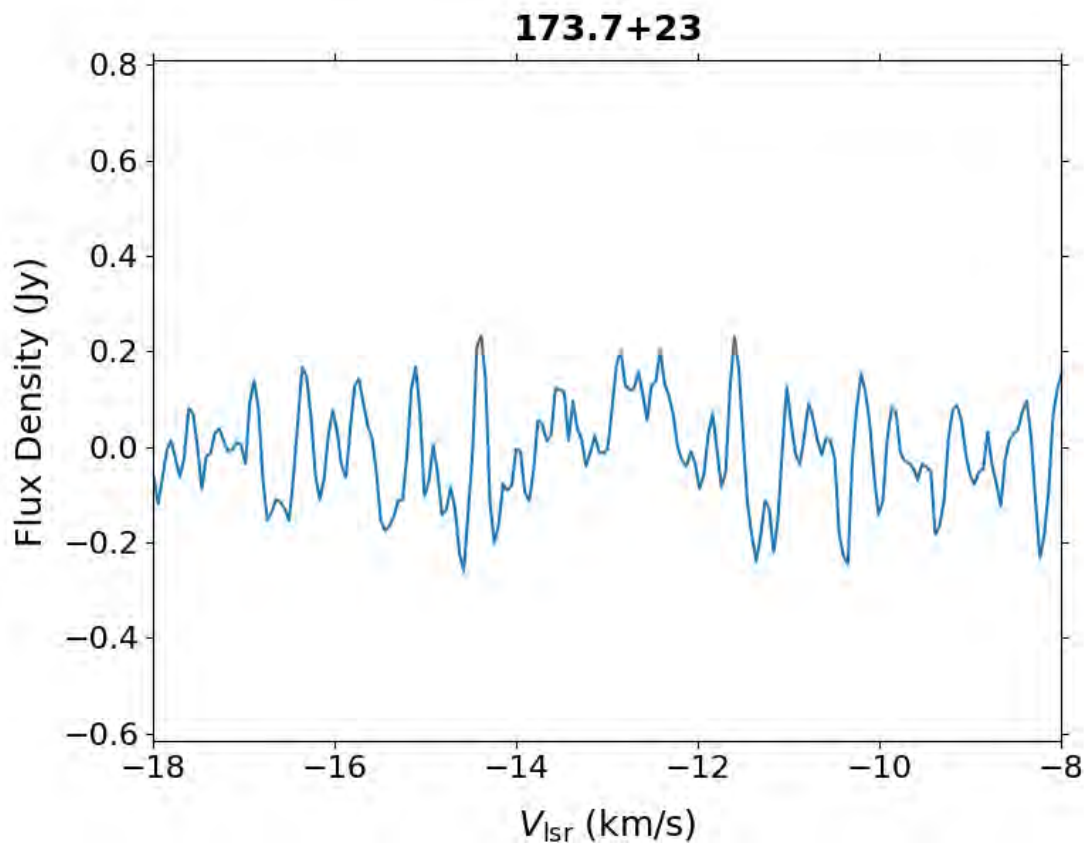
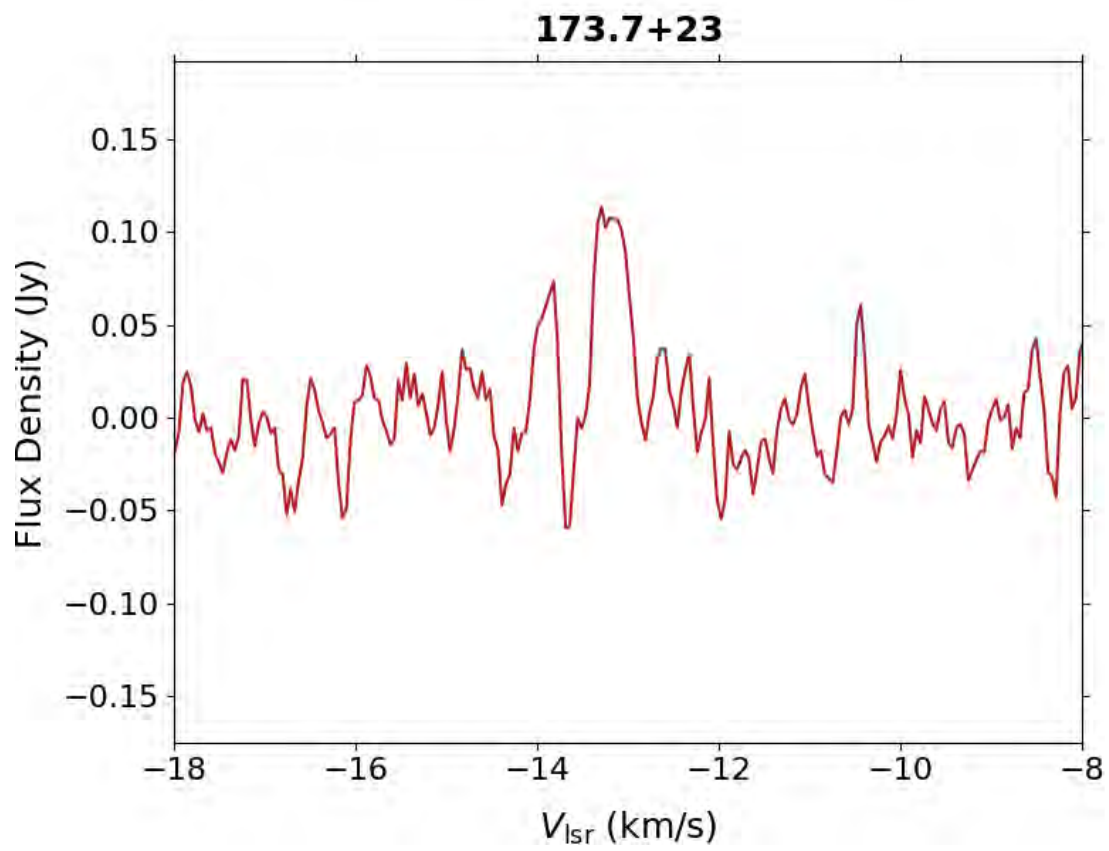


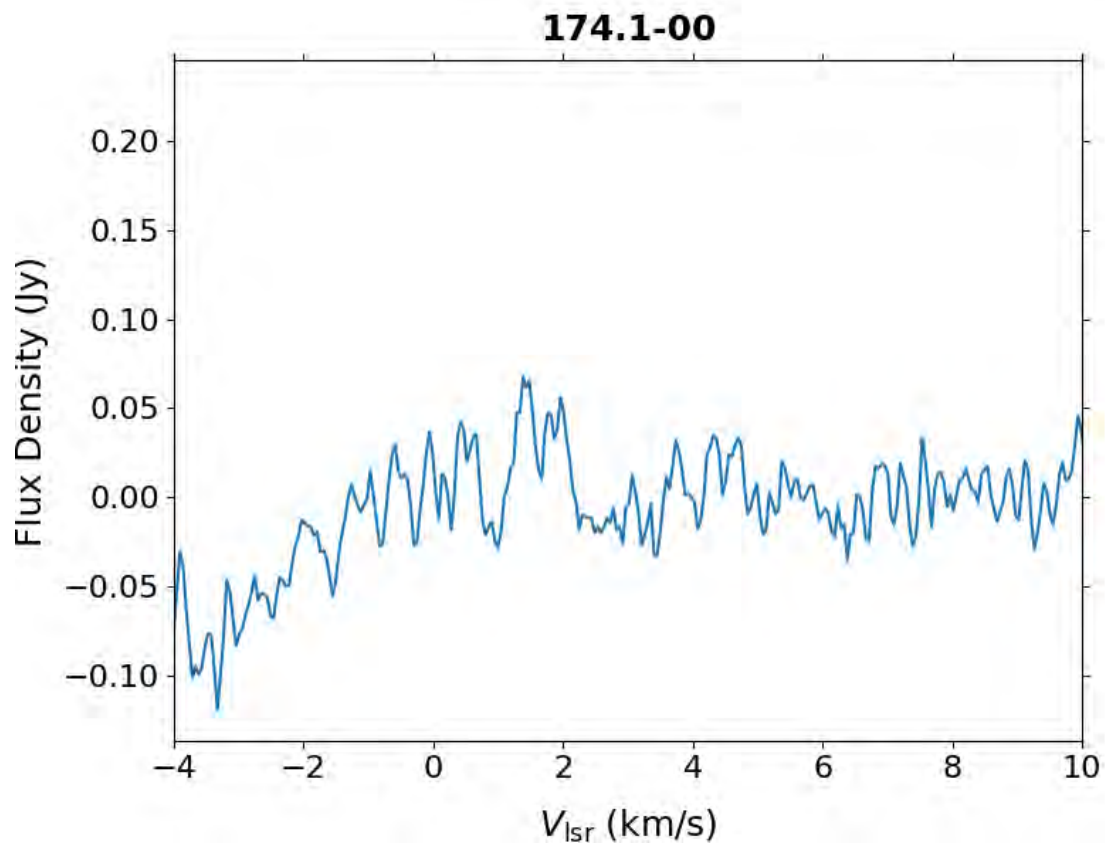
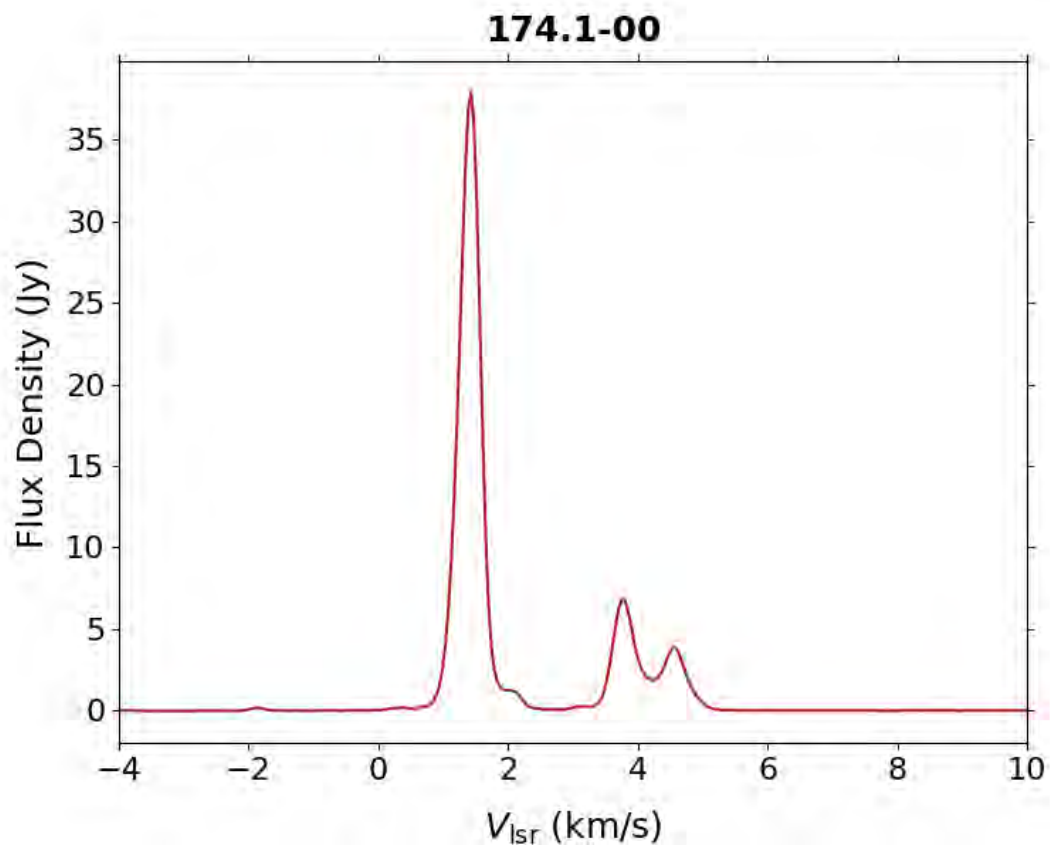




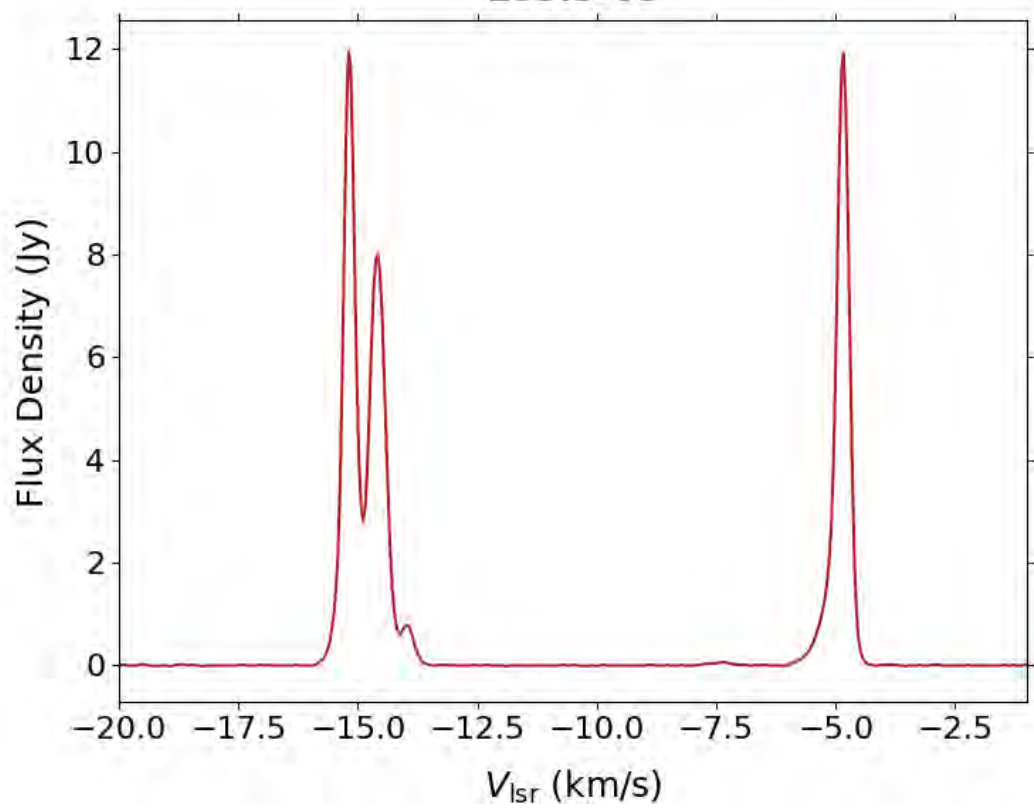




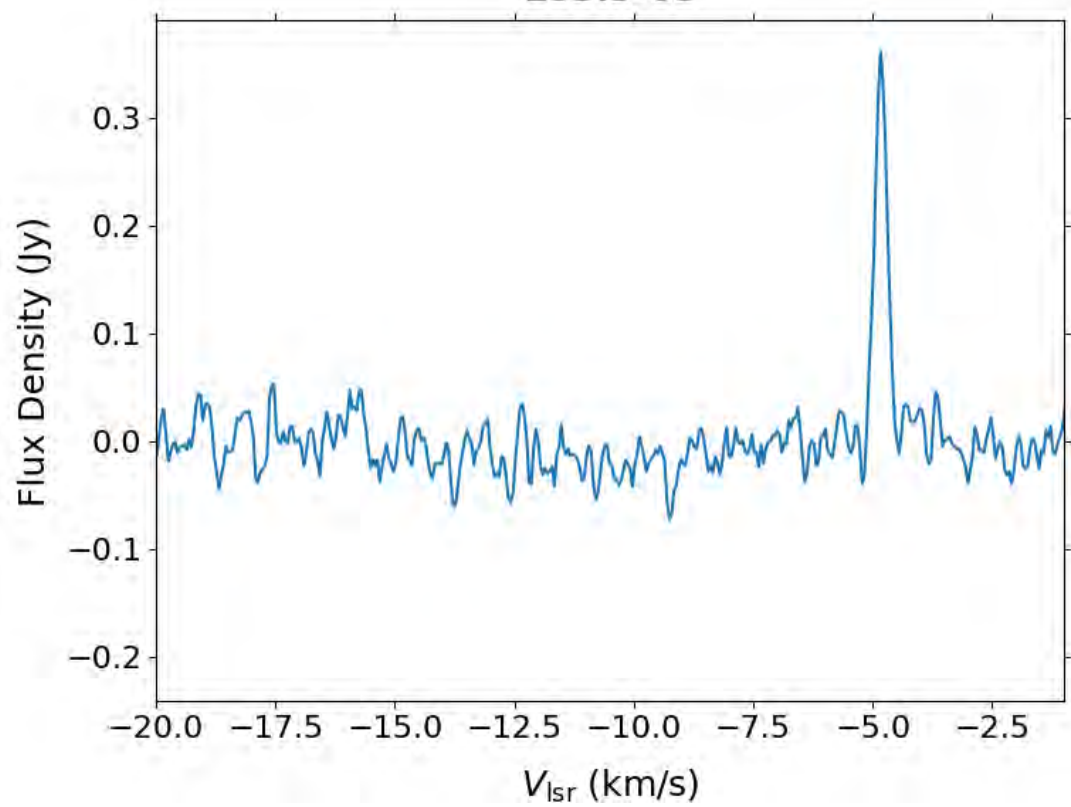


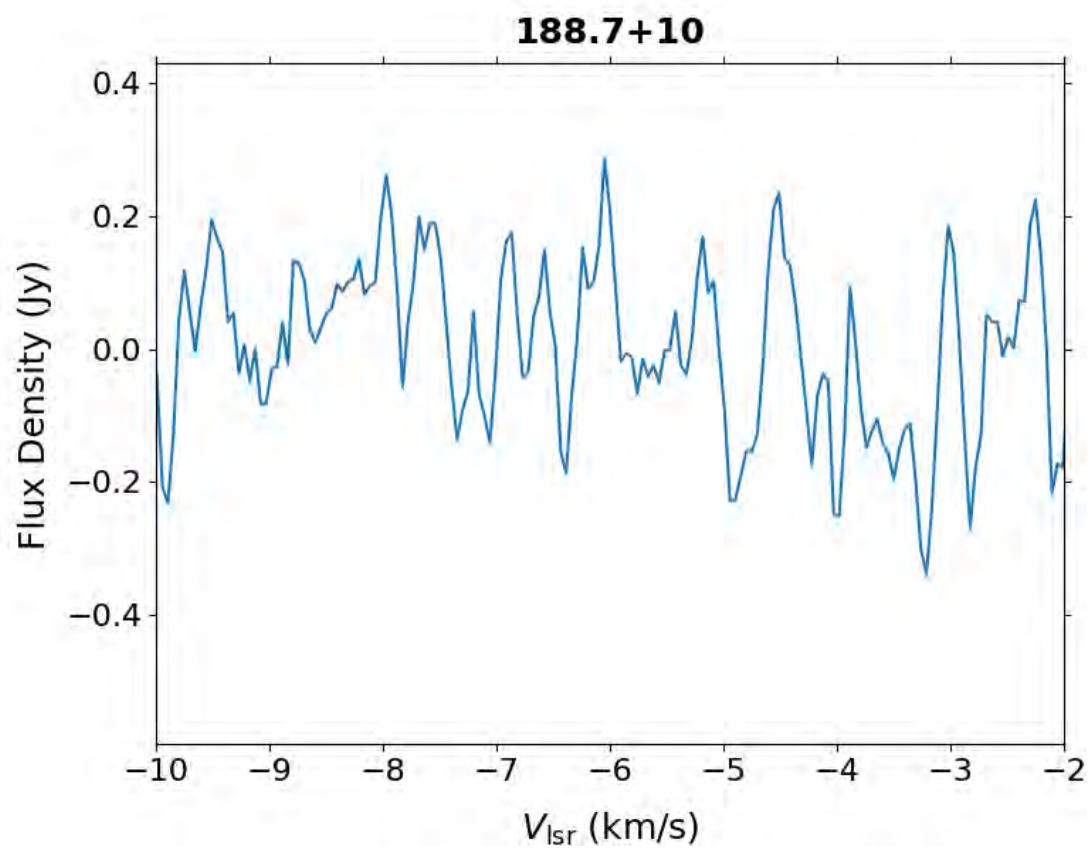
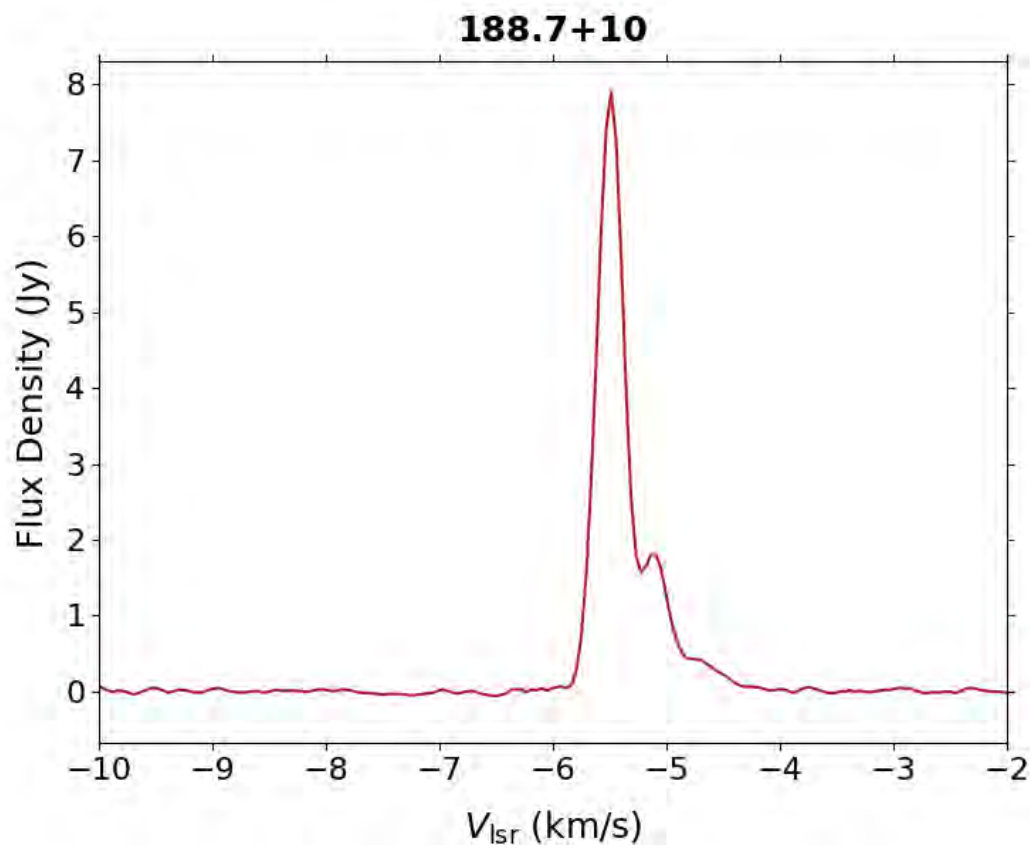


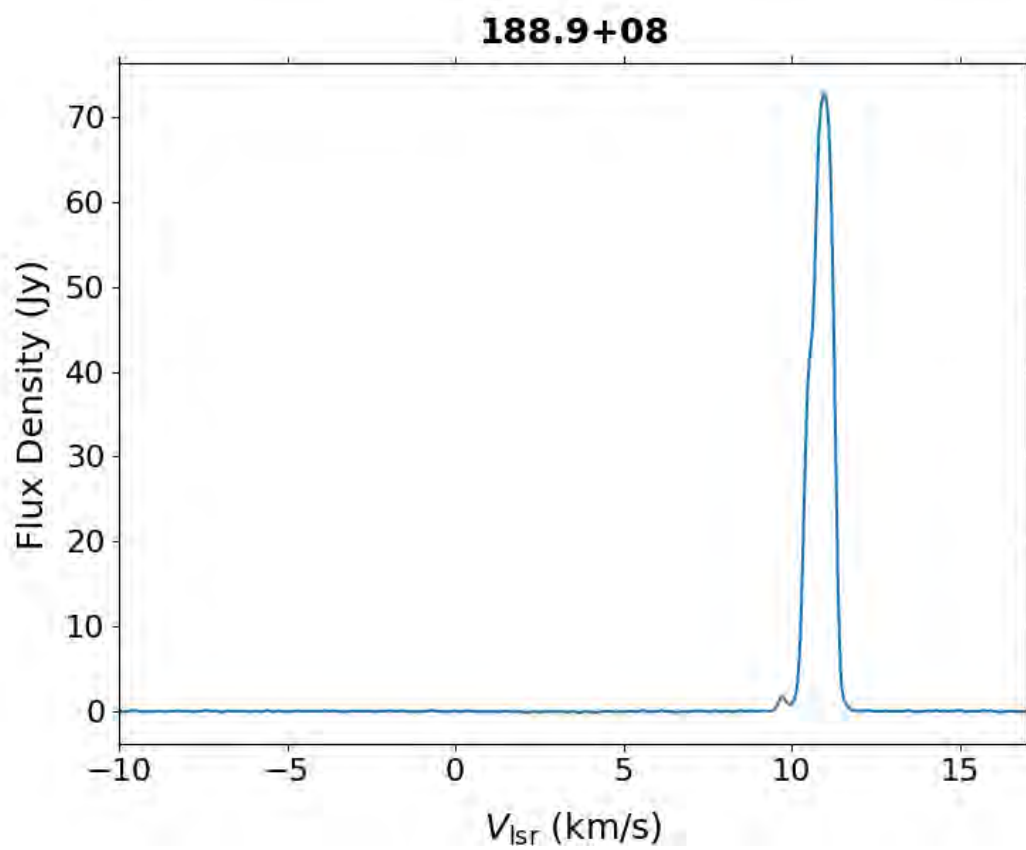
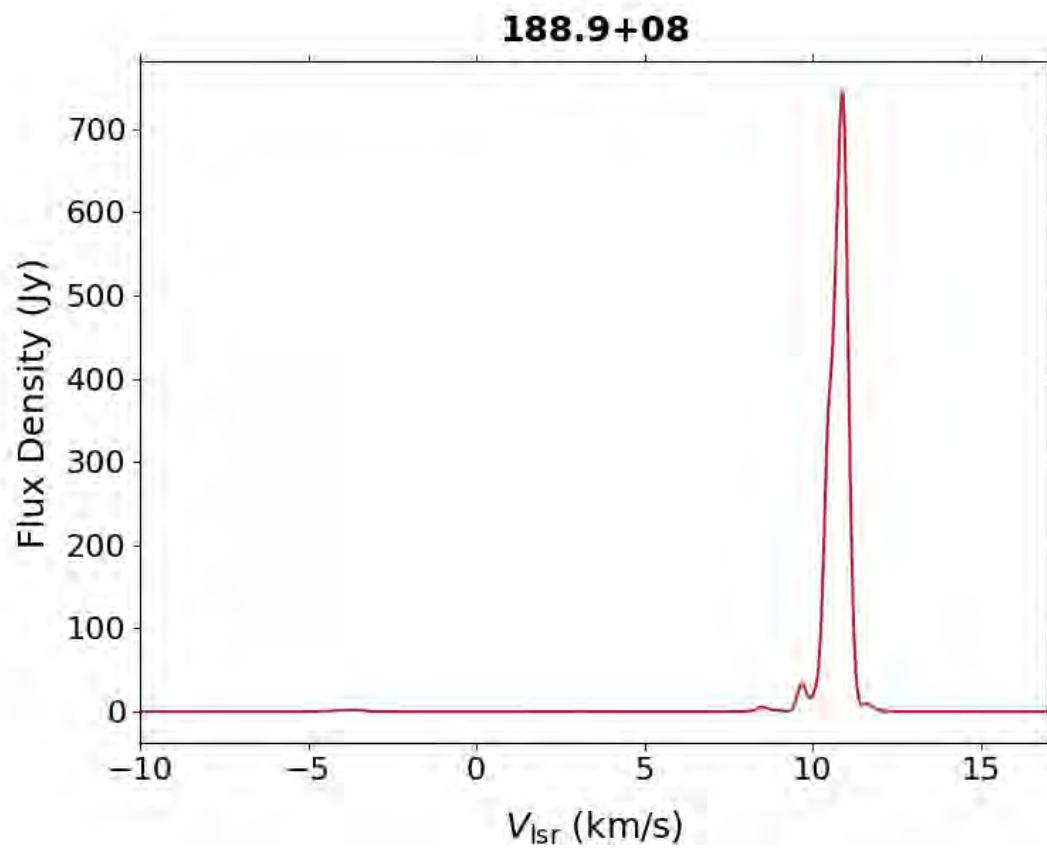
183.3-05

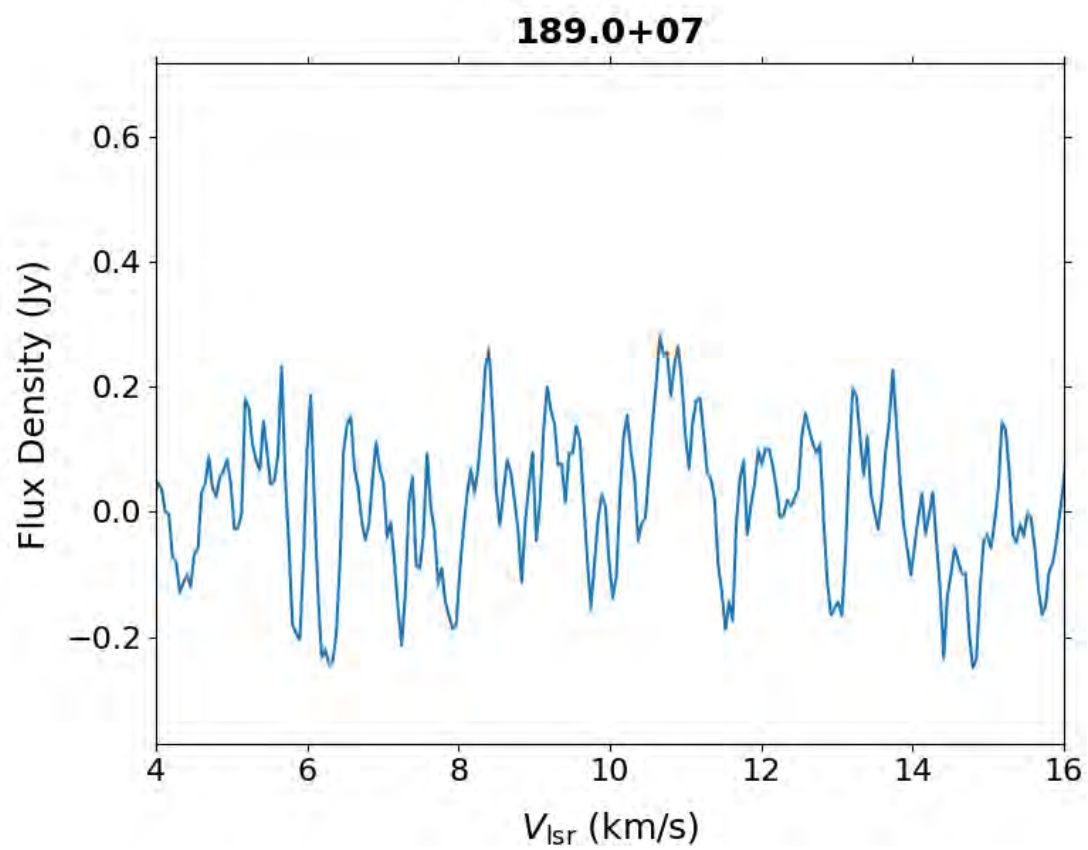
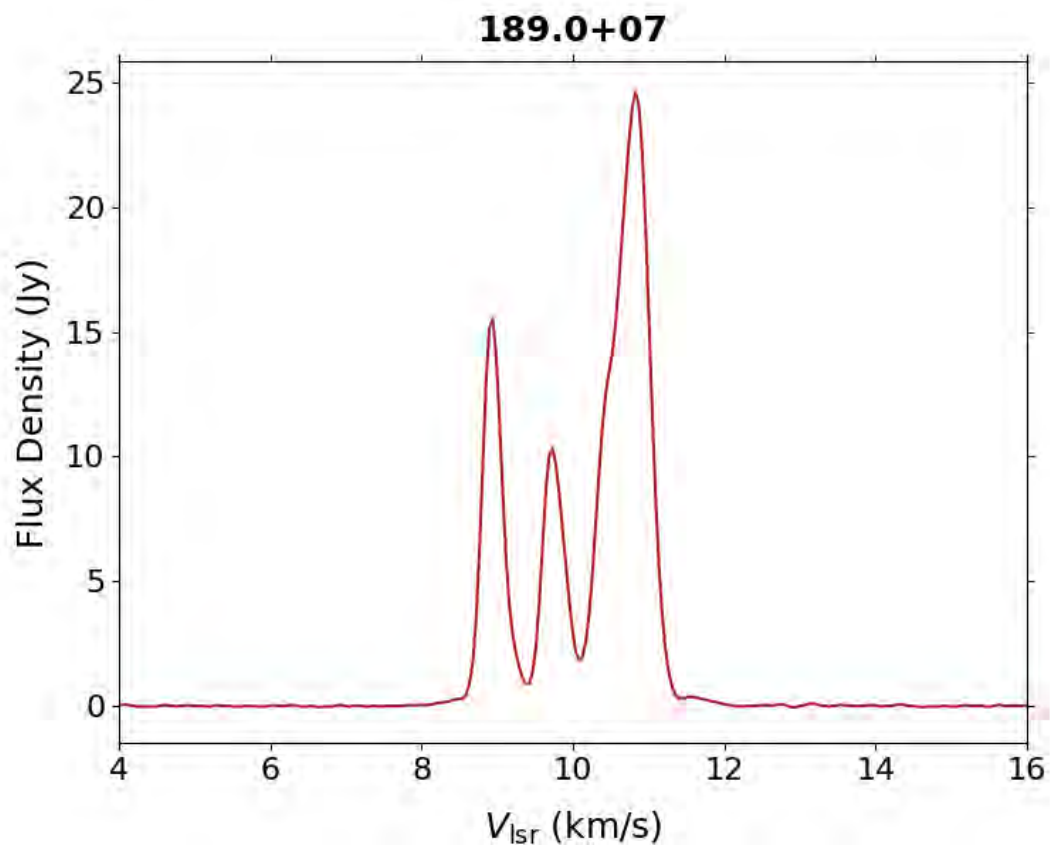


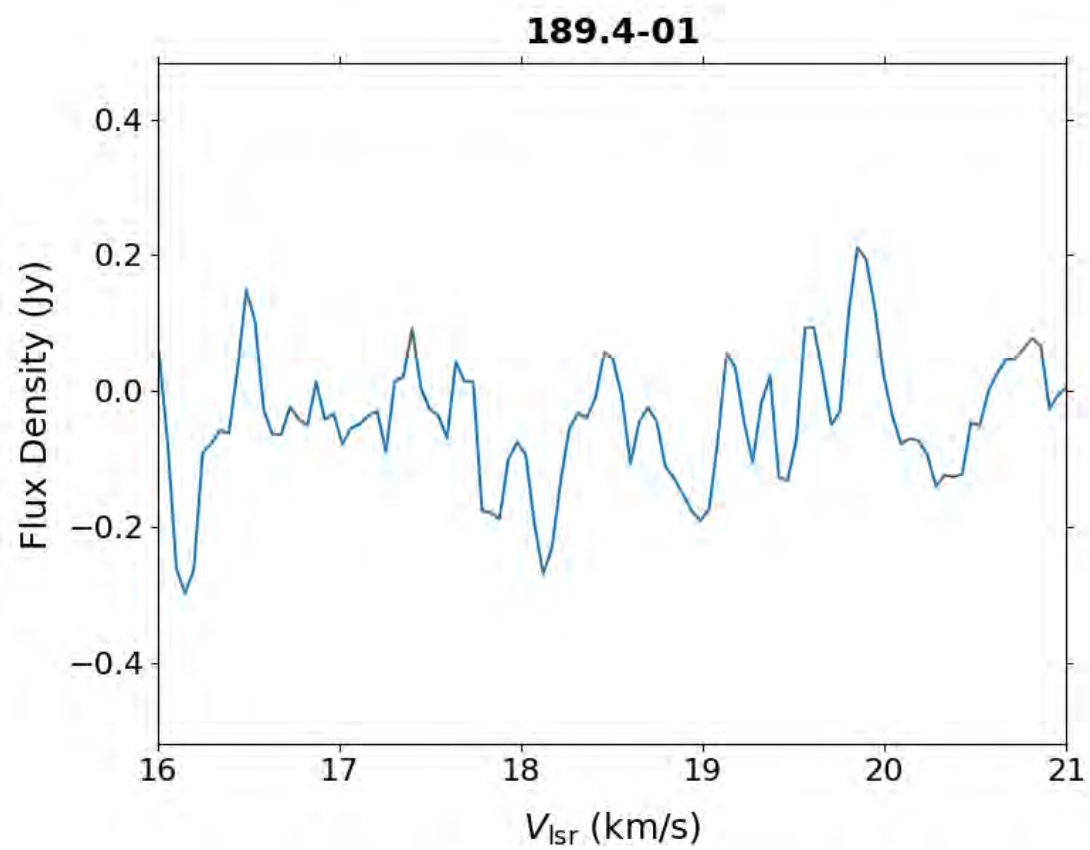
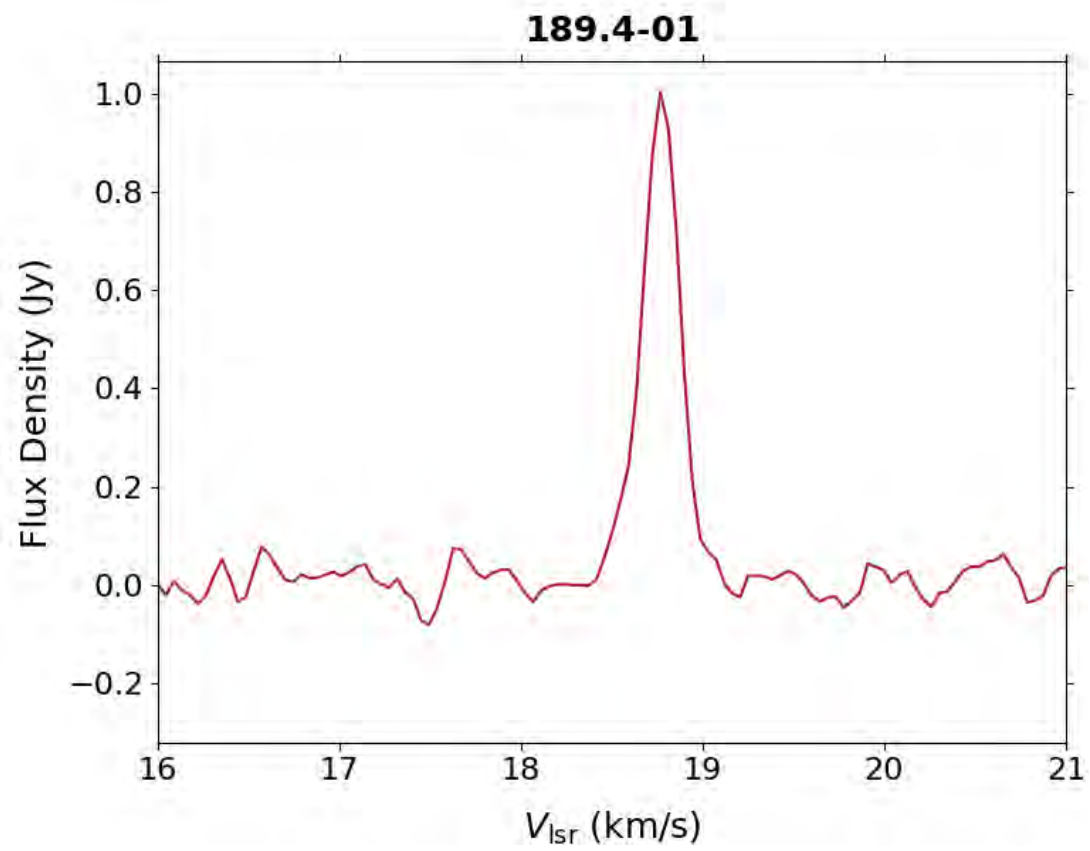
183.3-05

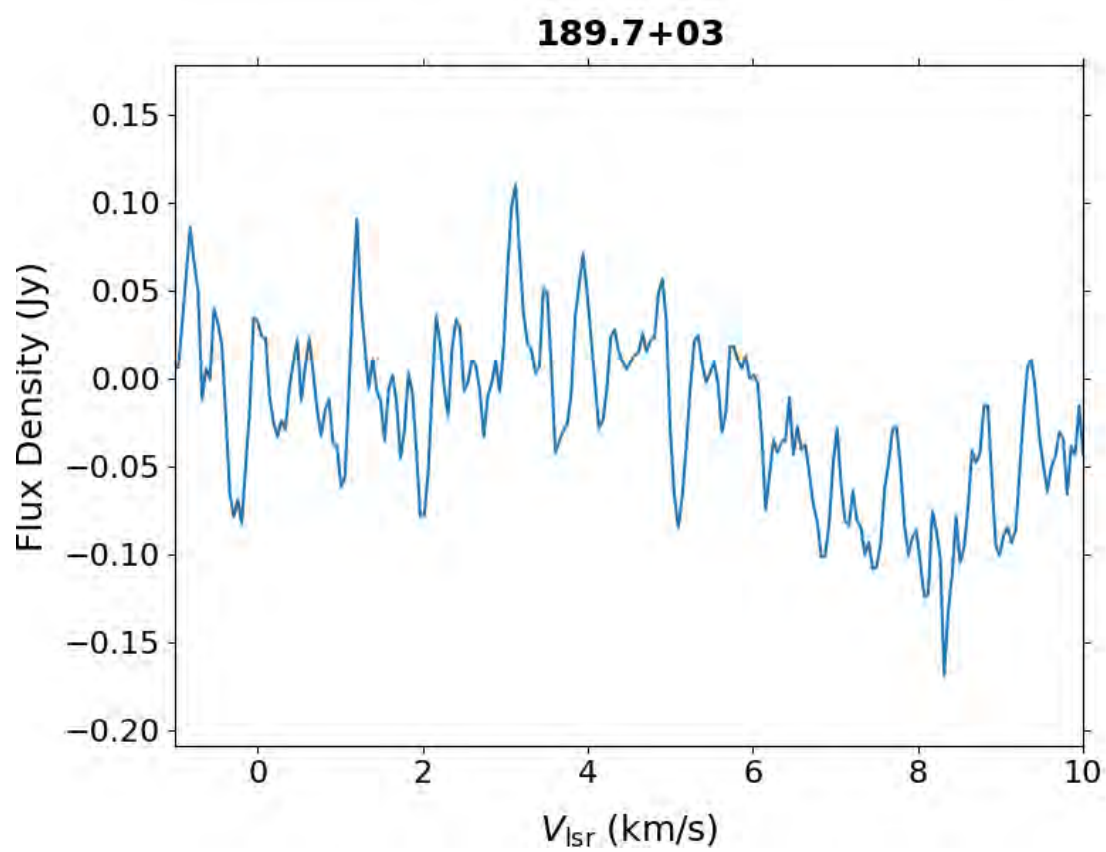
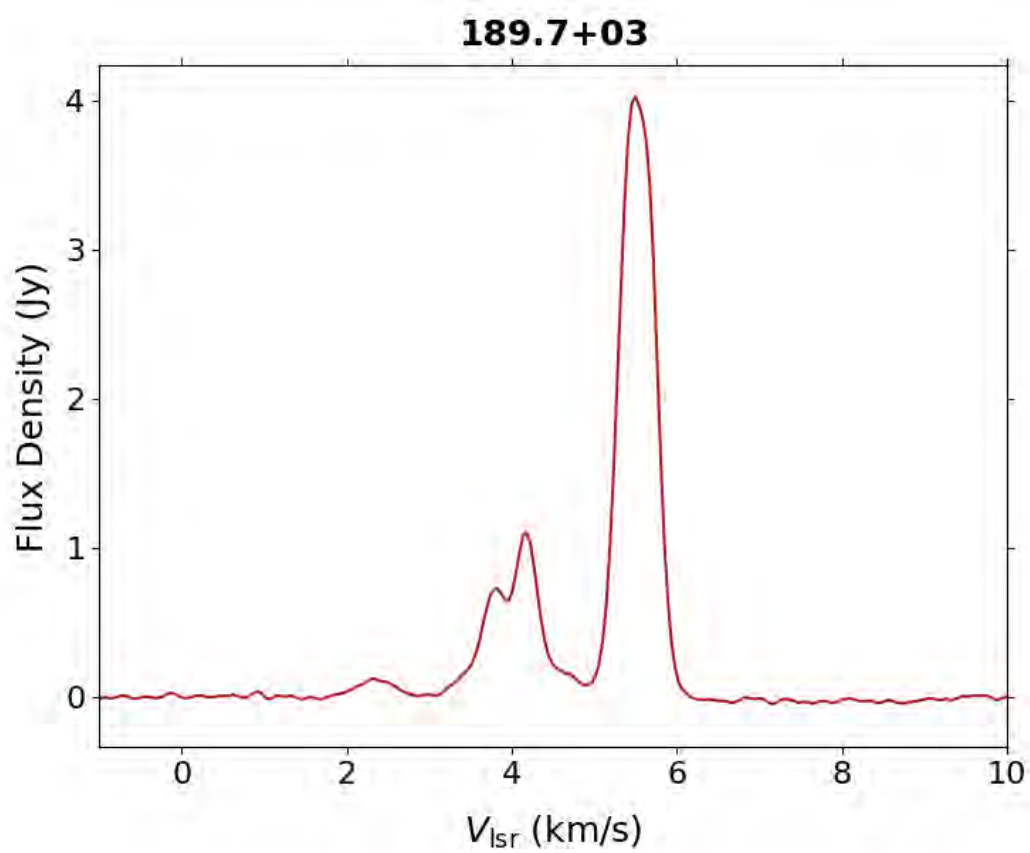


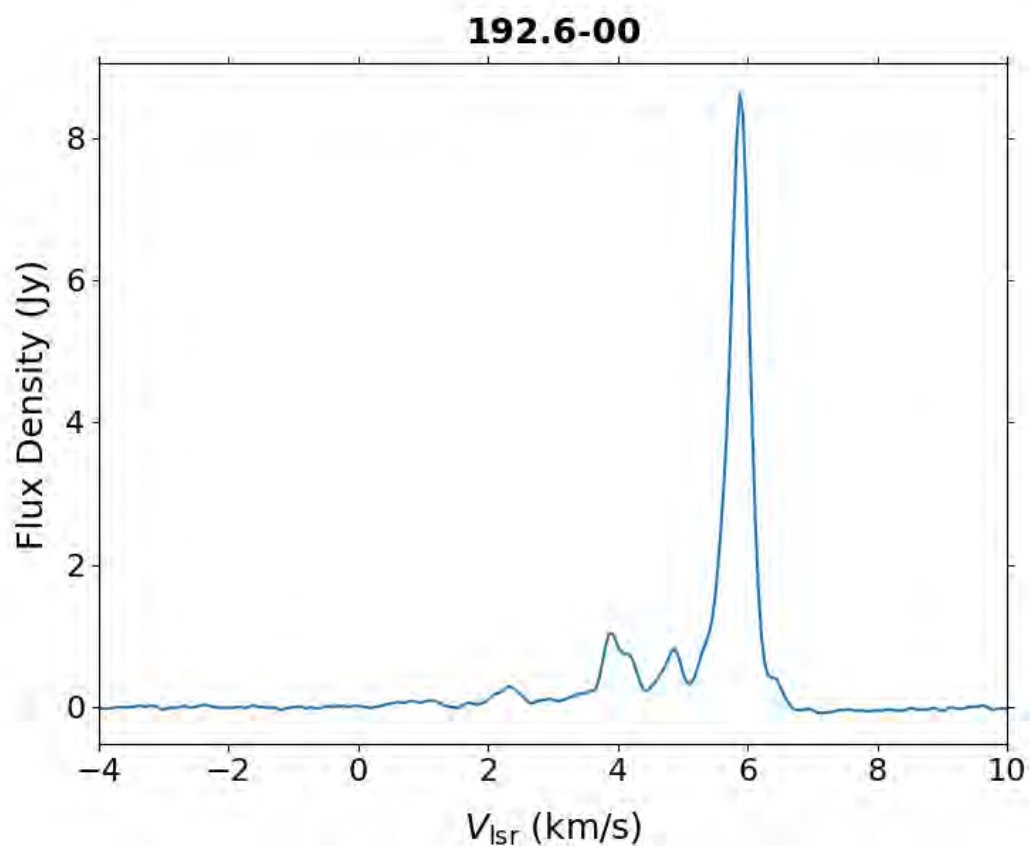
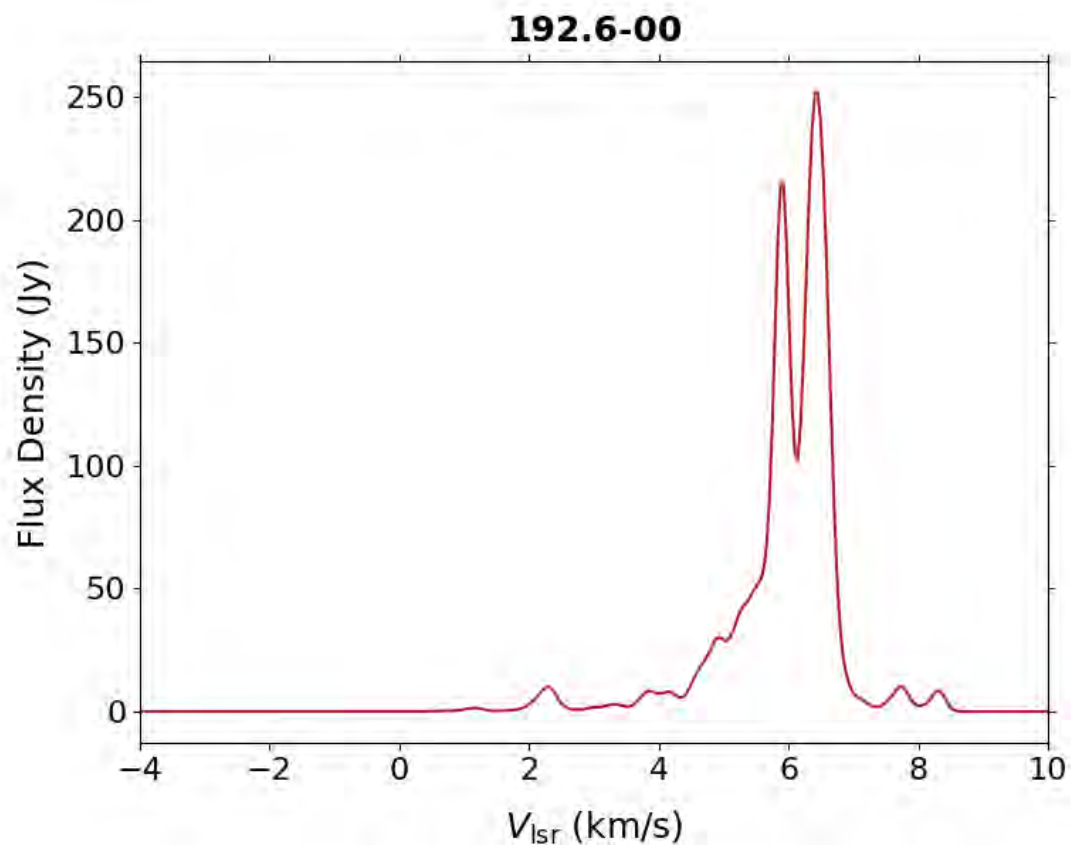


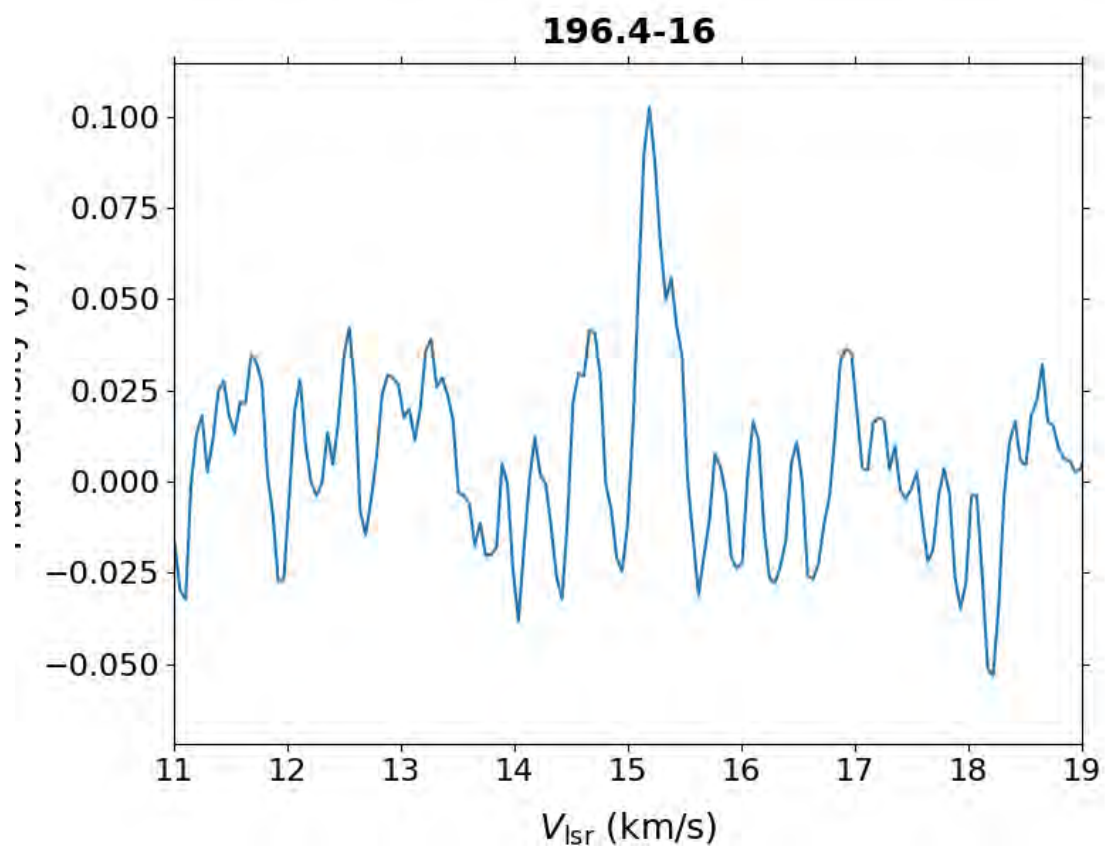
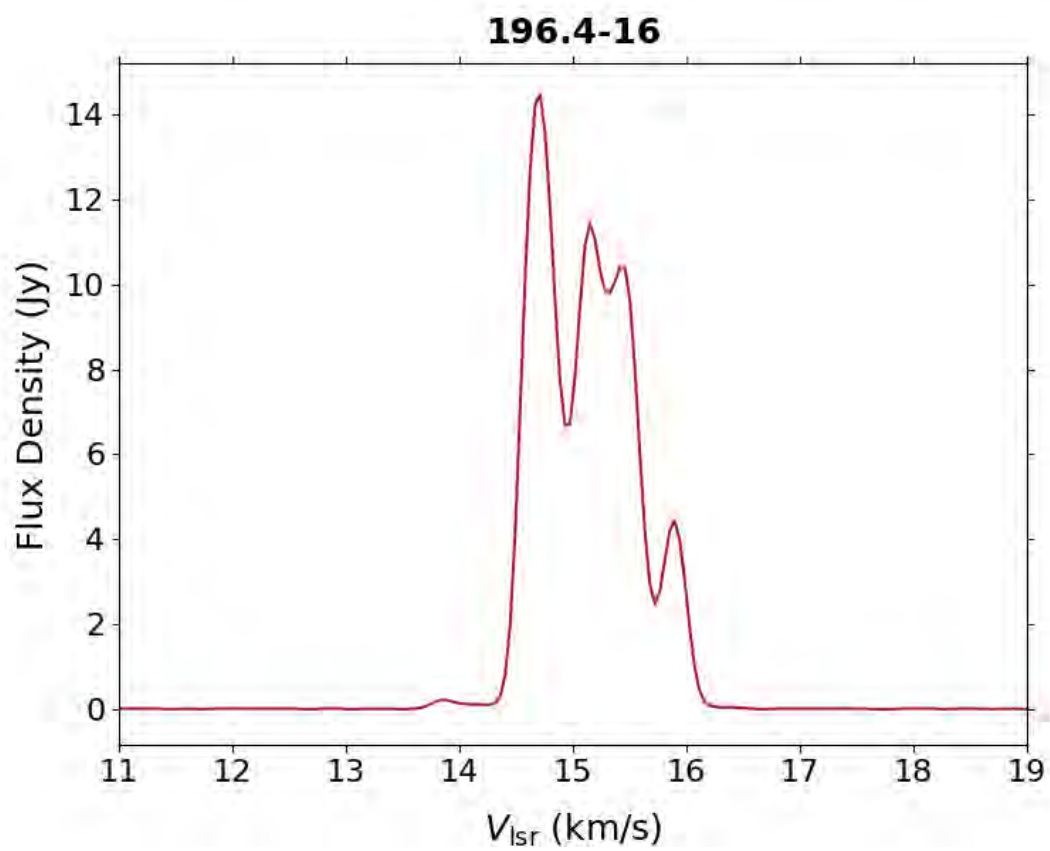


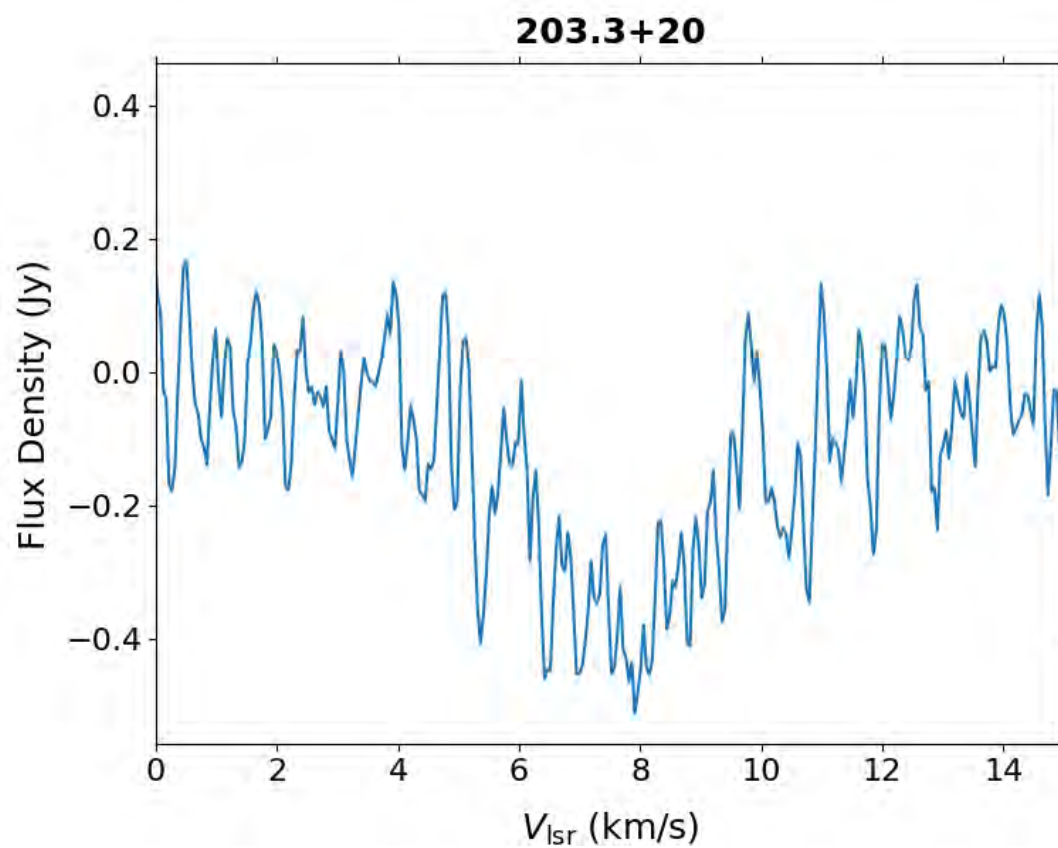
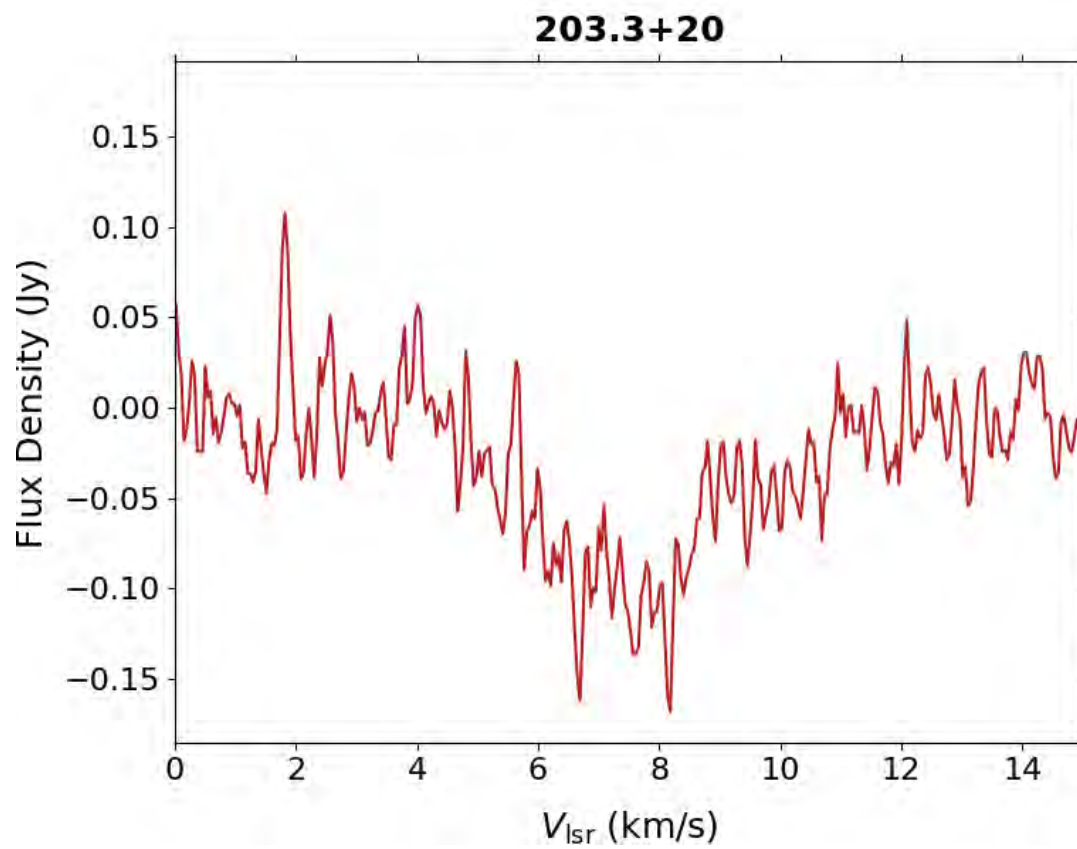


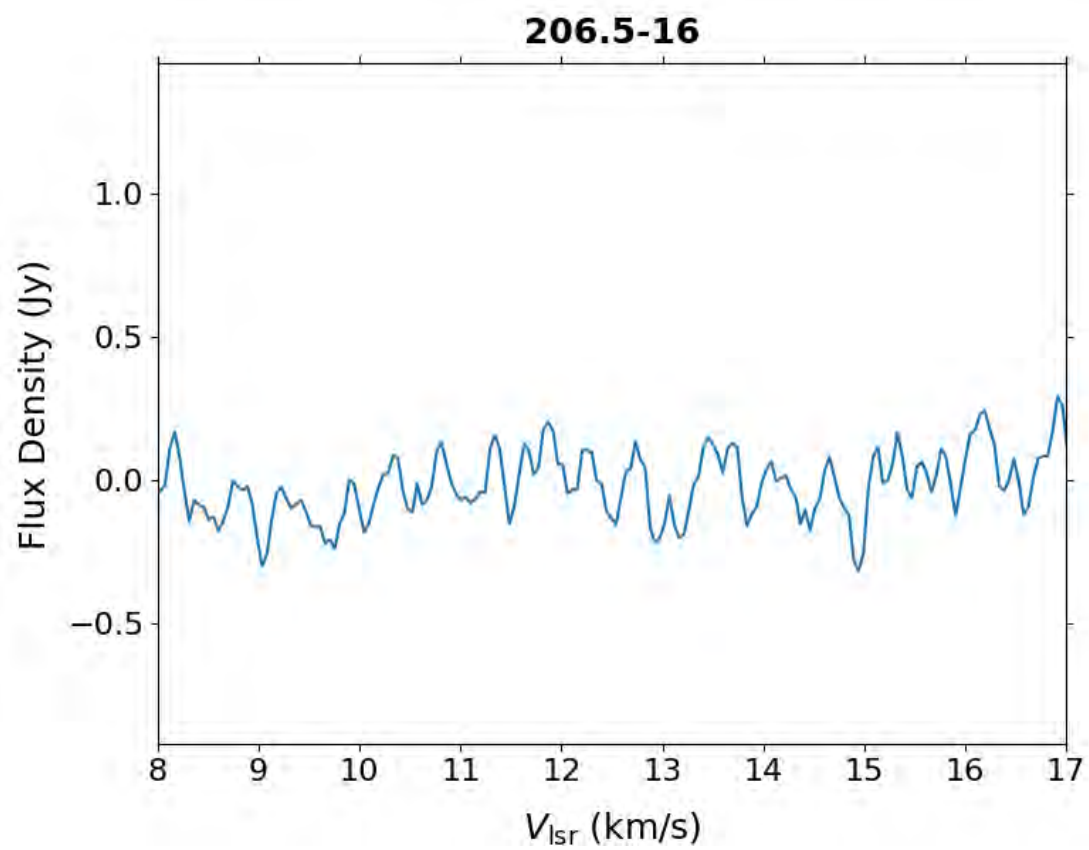
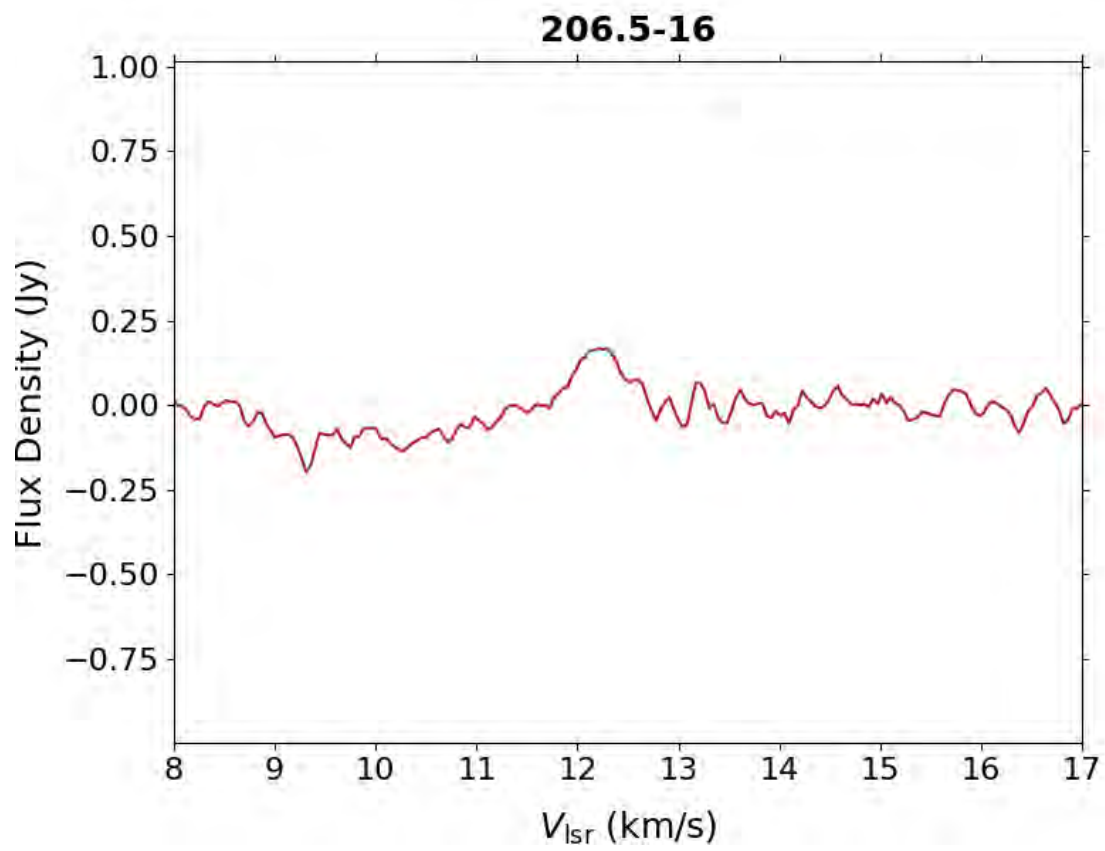




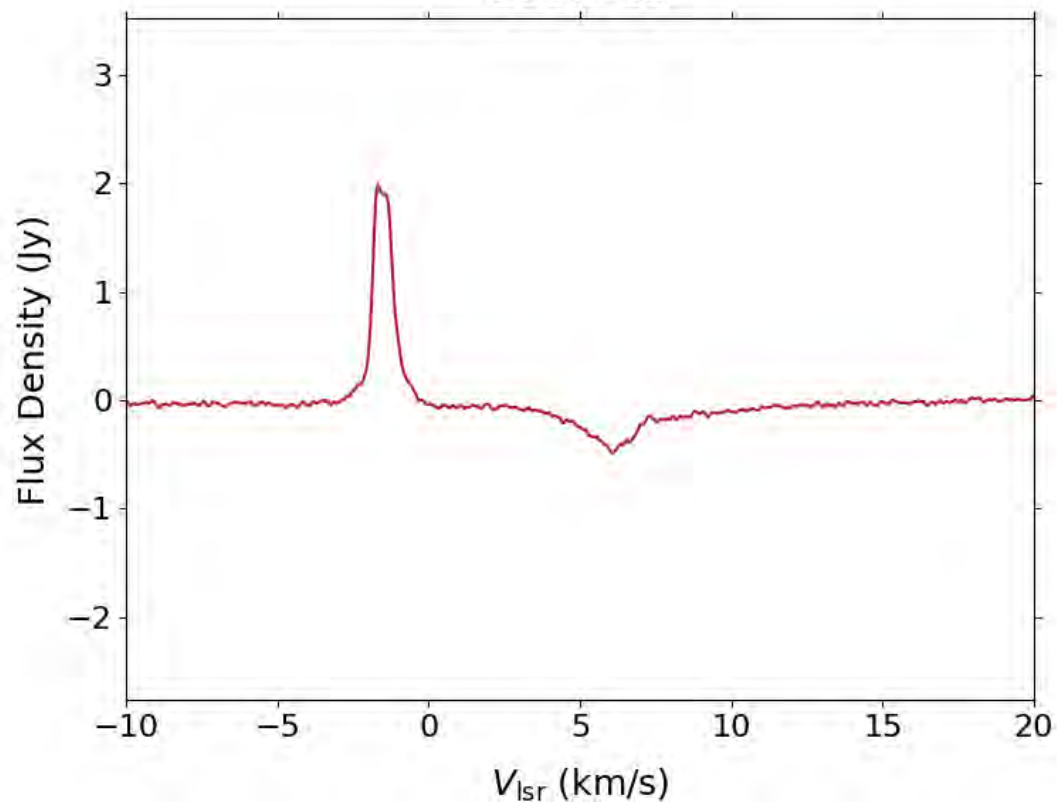




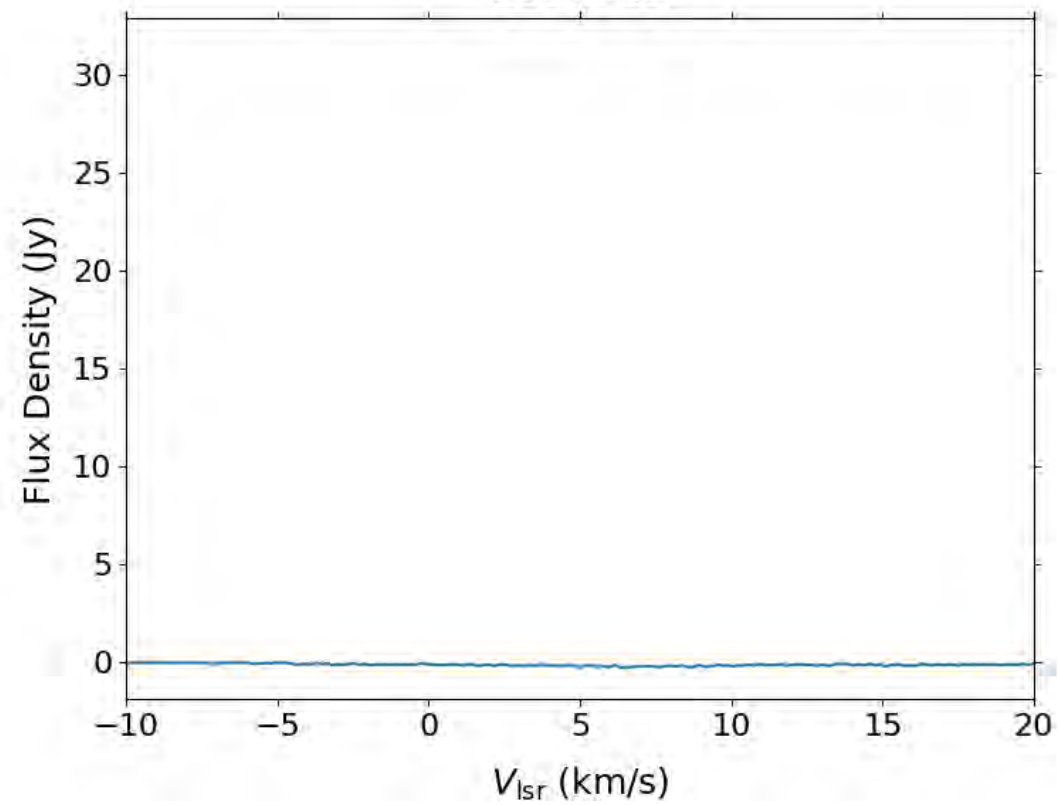




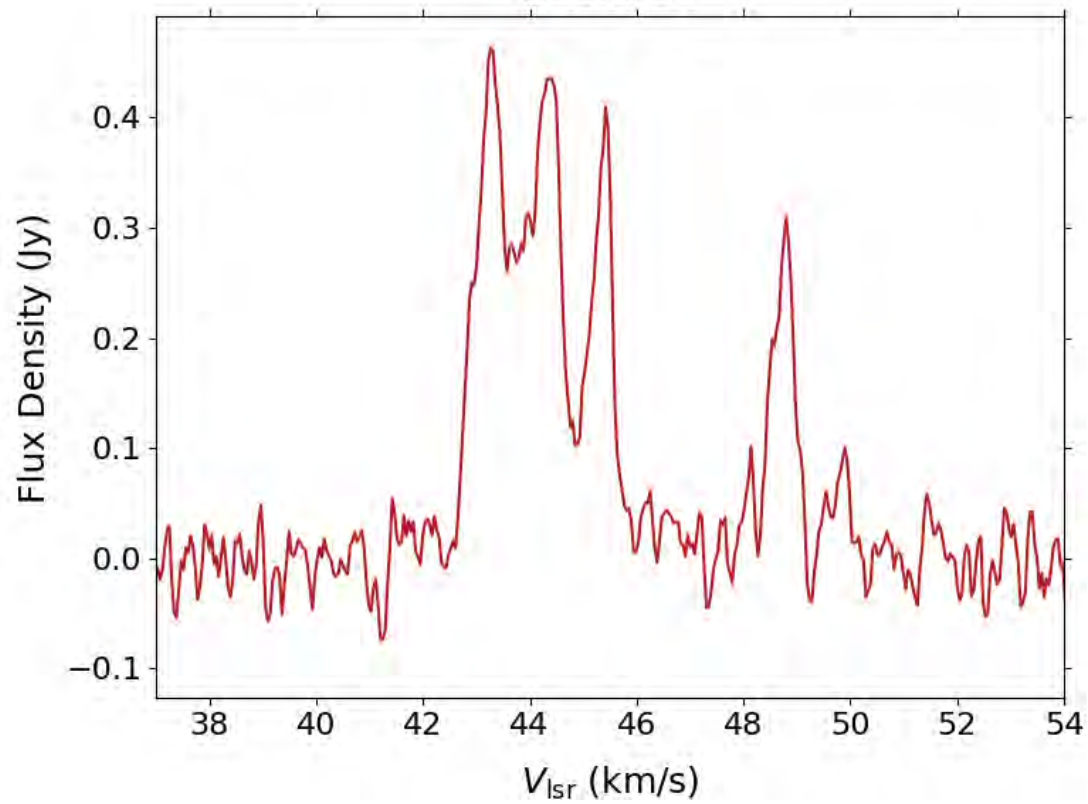
209.0-19



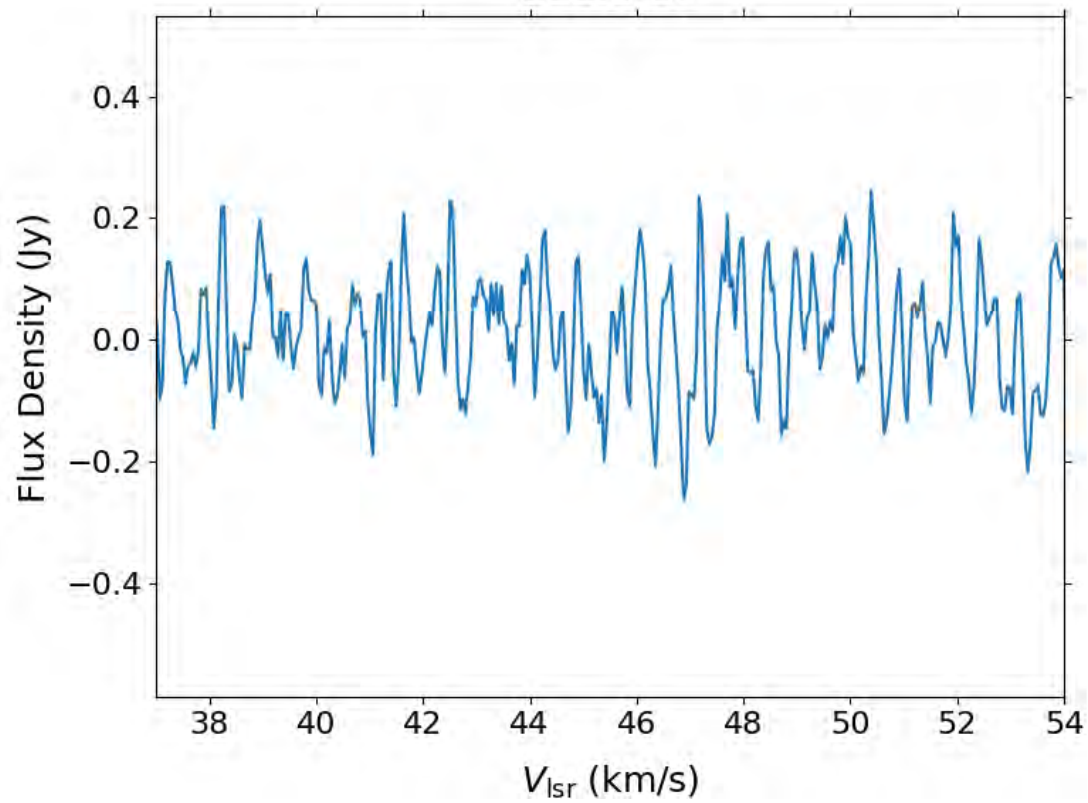
209.0-19



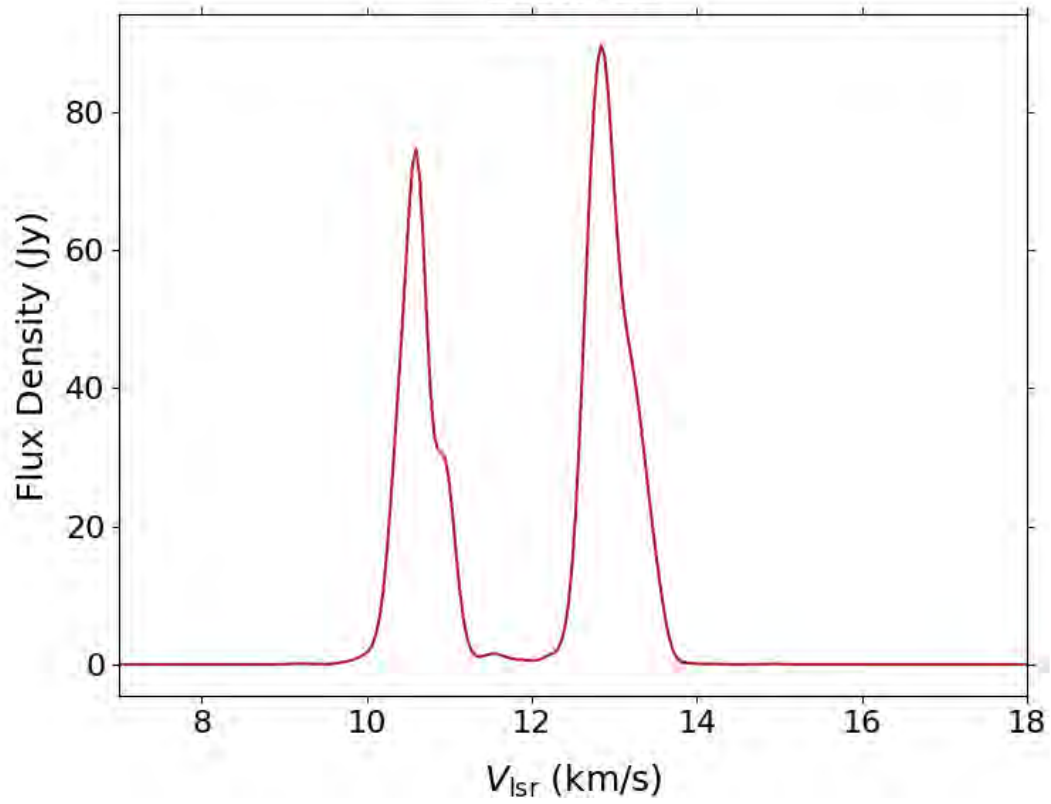
212.0-07



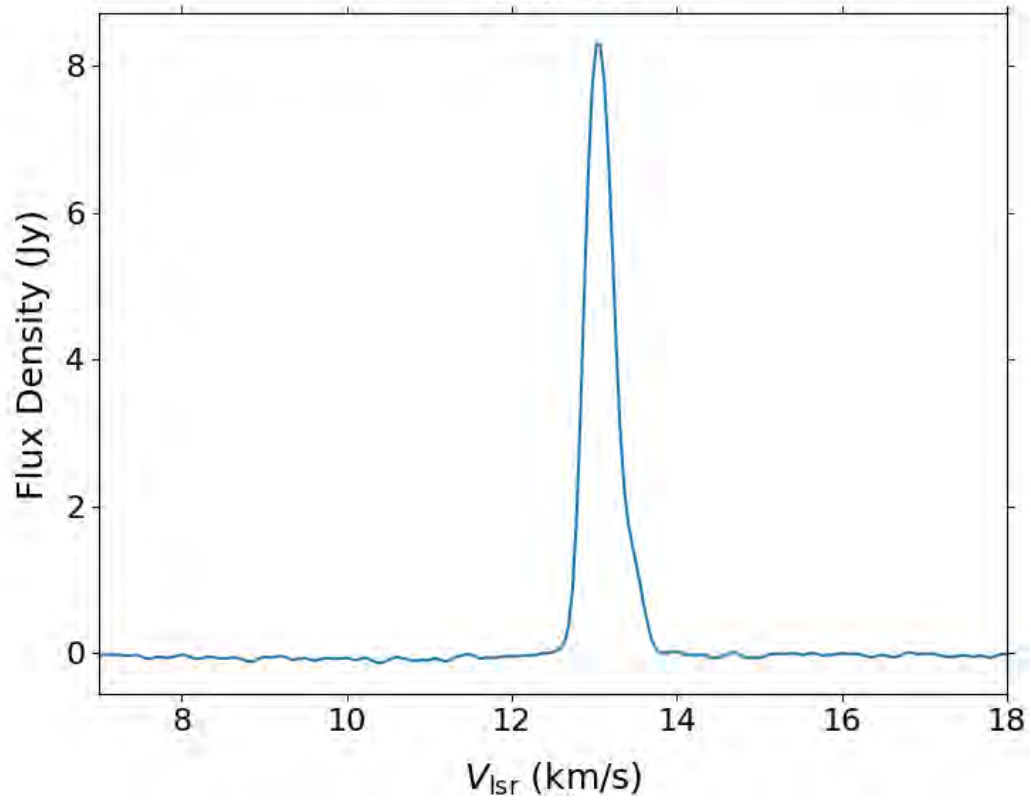
212.0-07

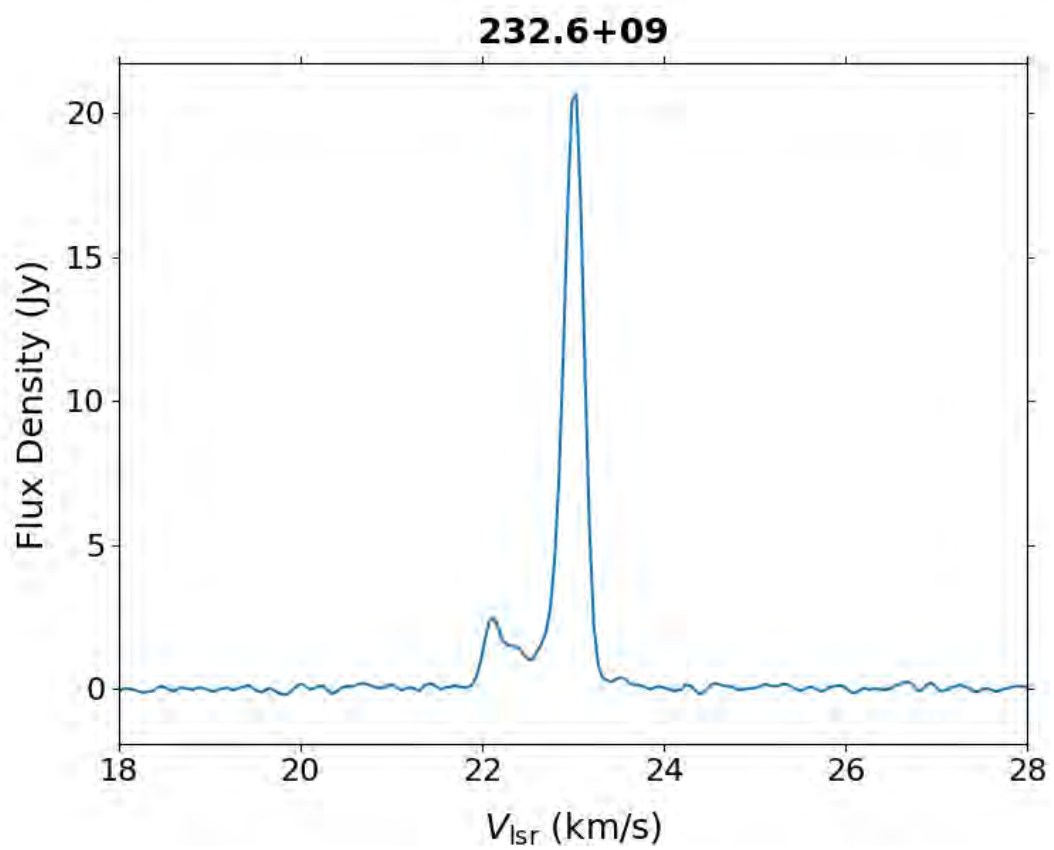
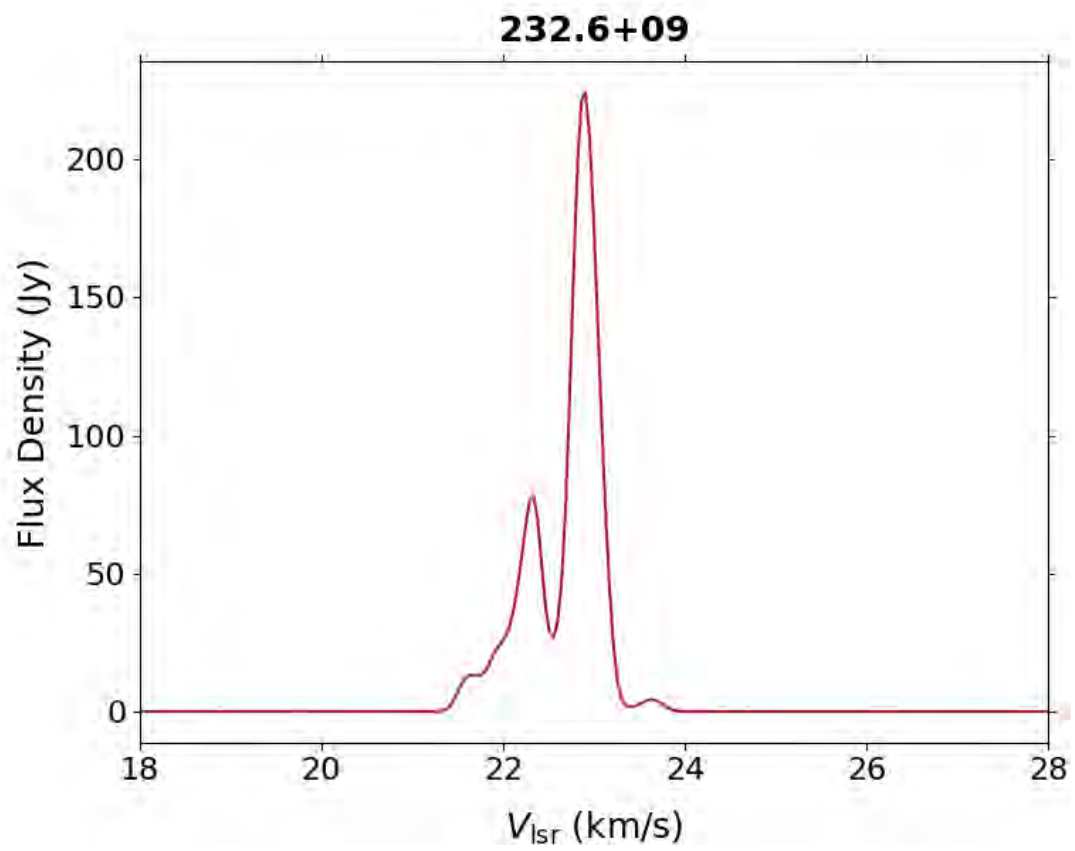


213.7-12

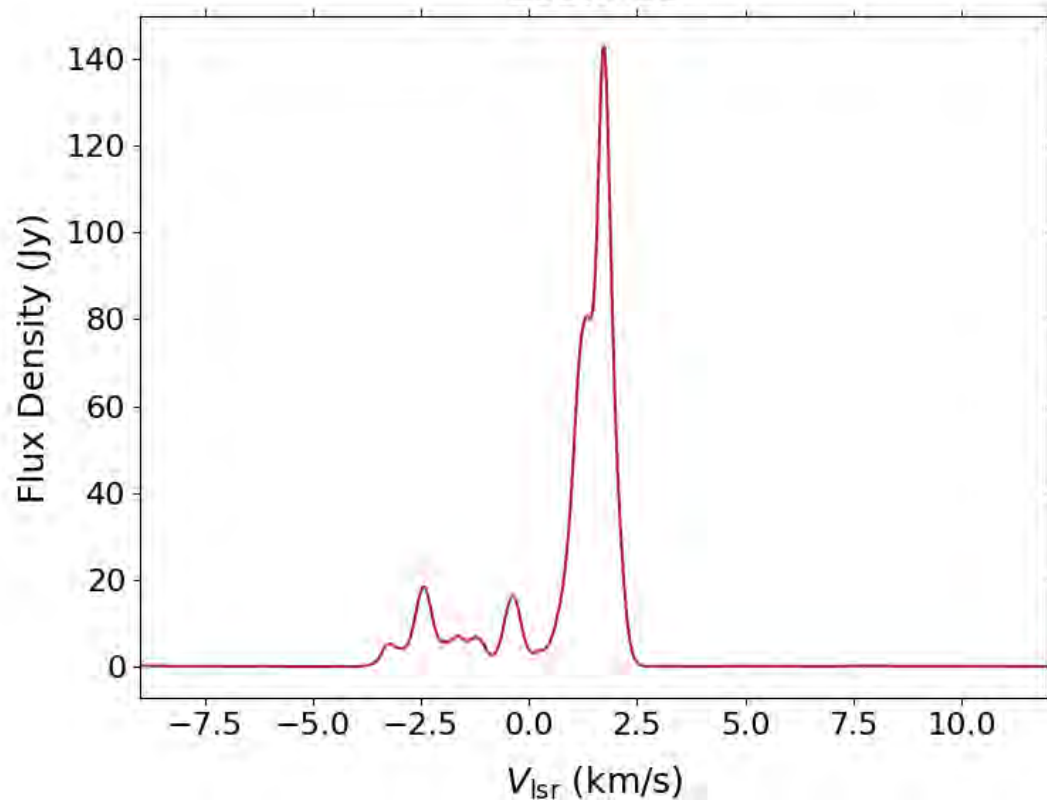


213.7-12

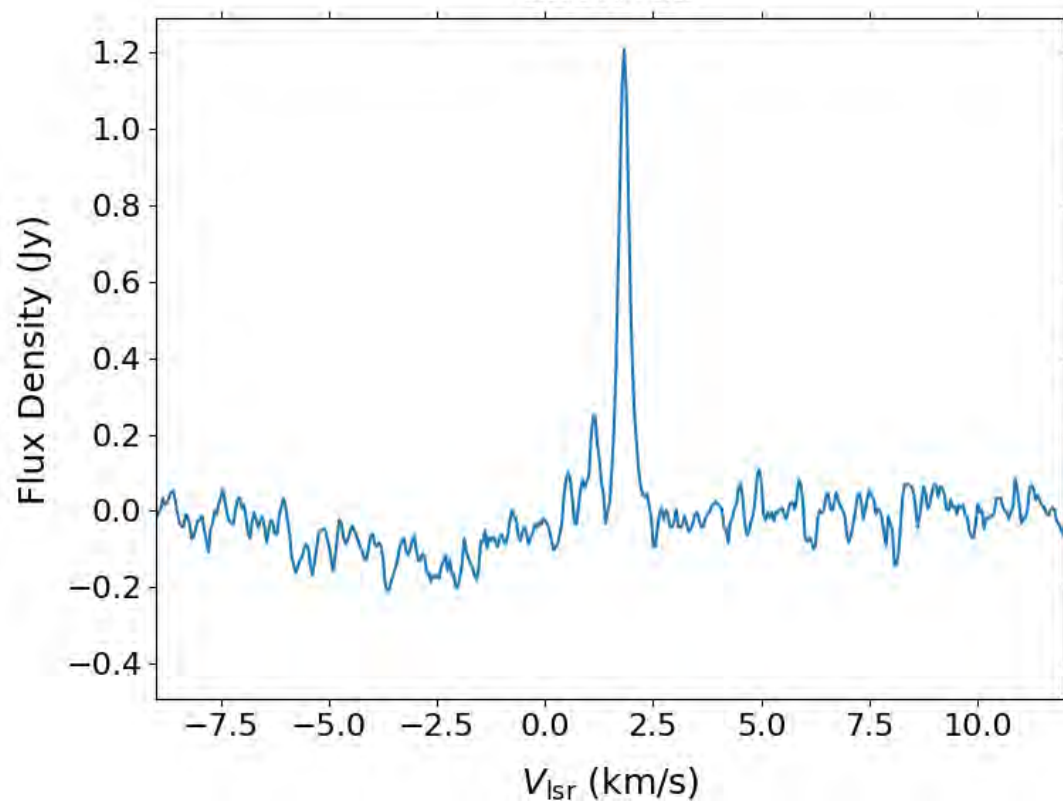


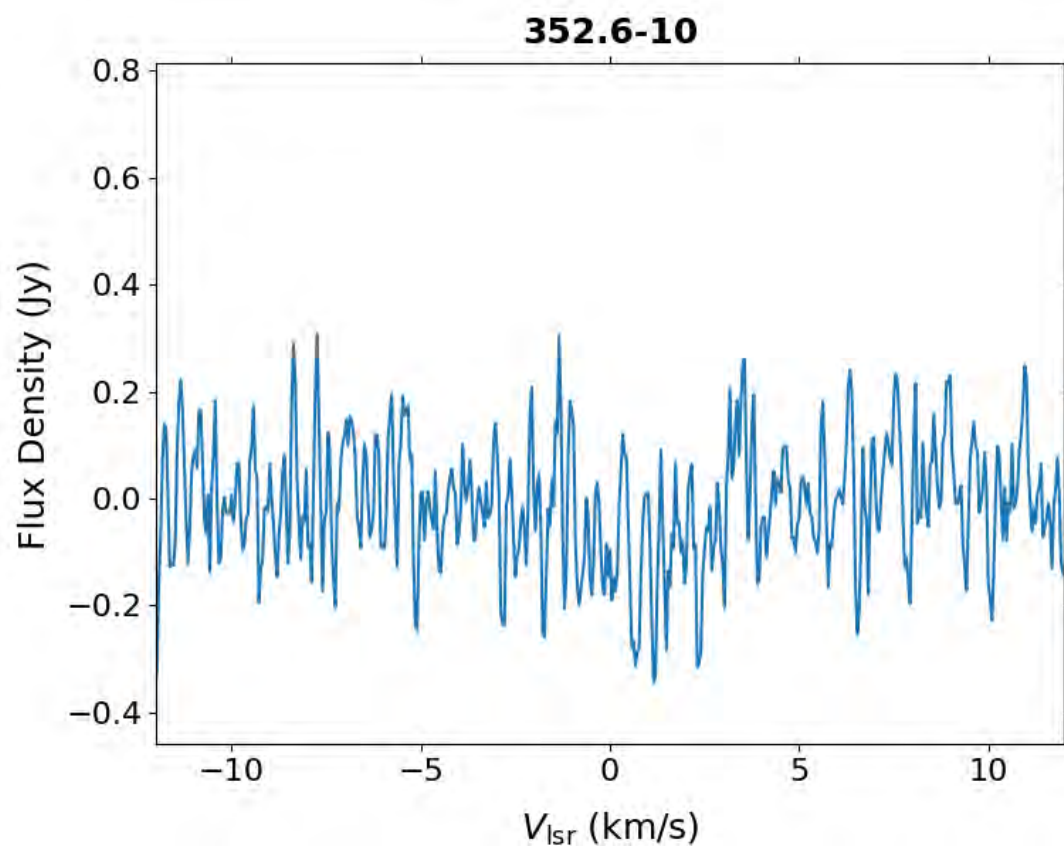
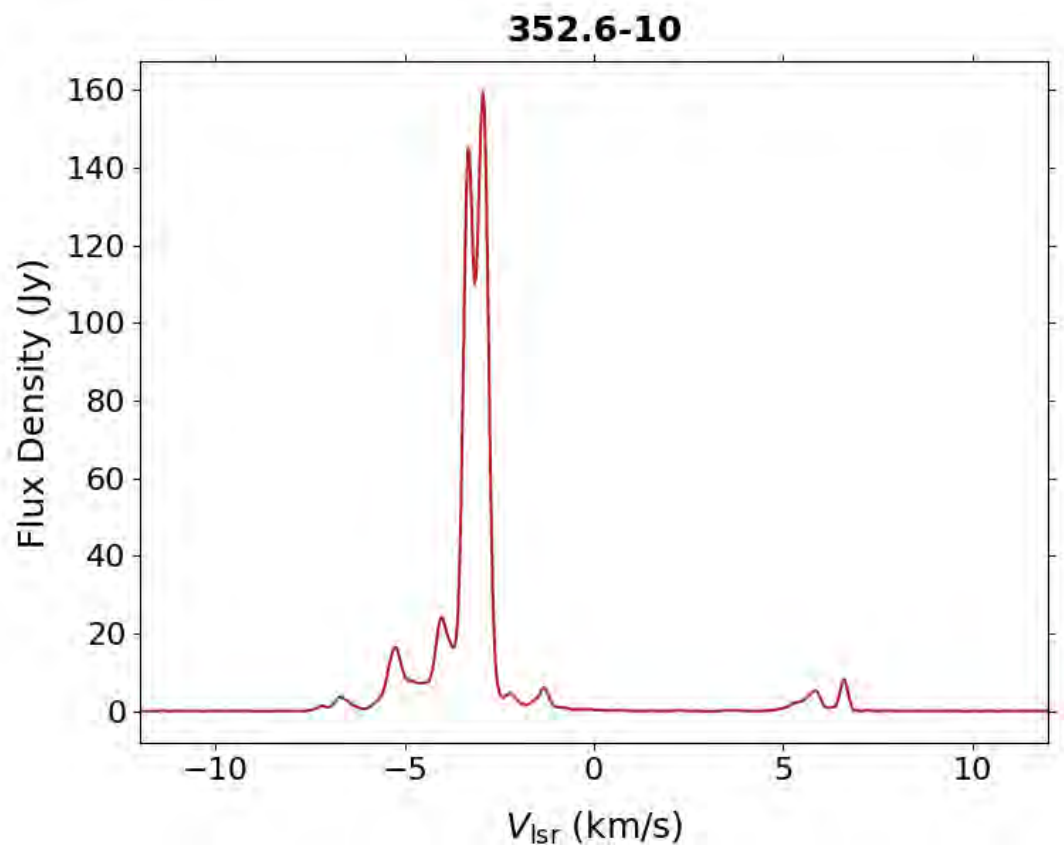


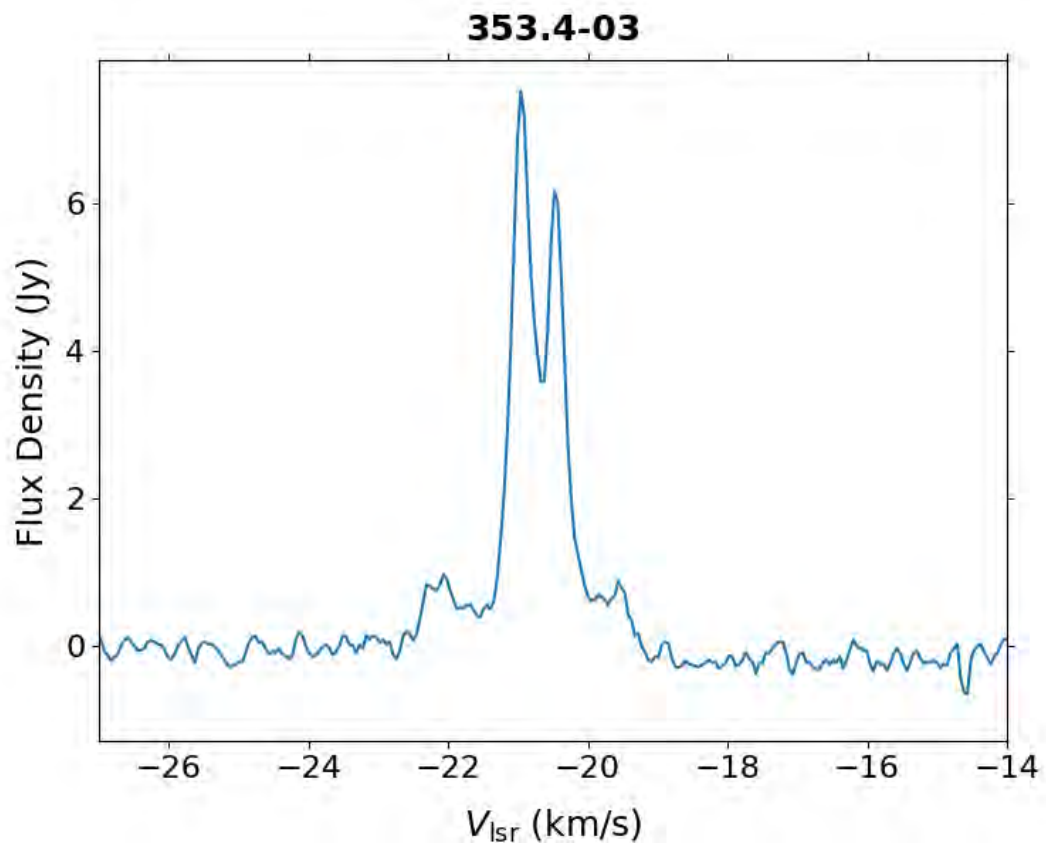
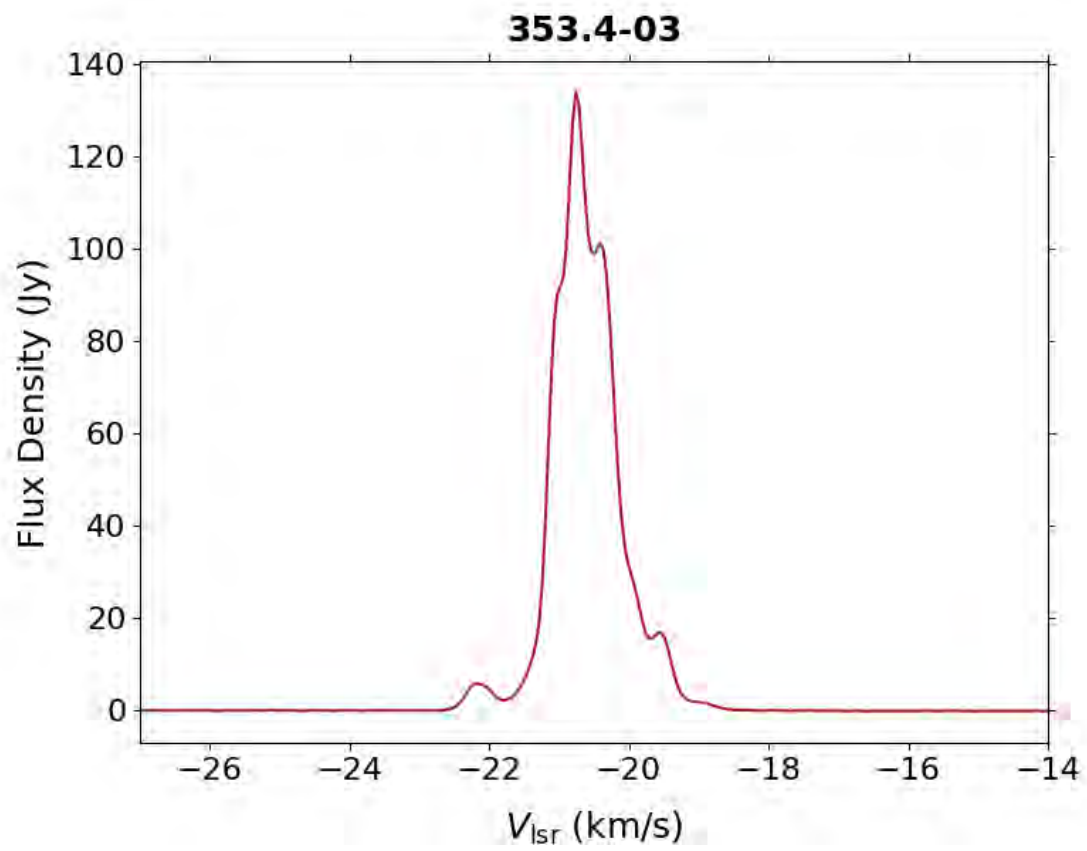
351.7-05

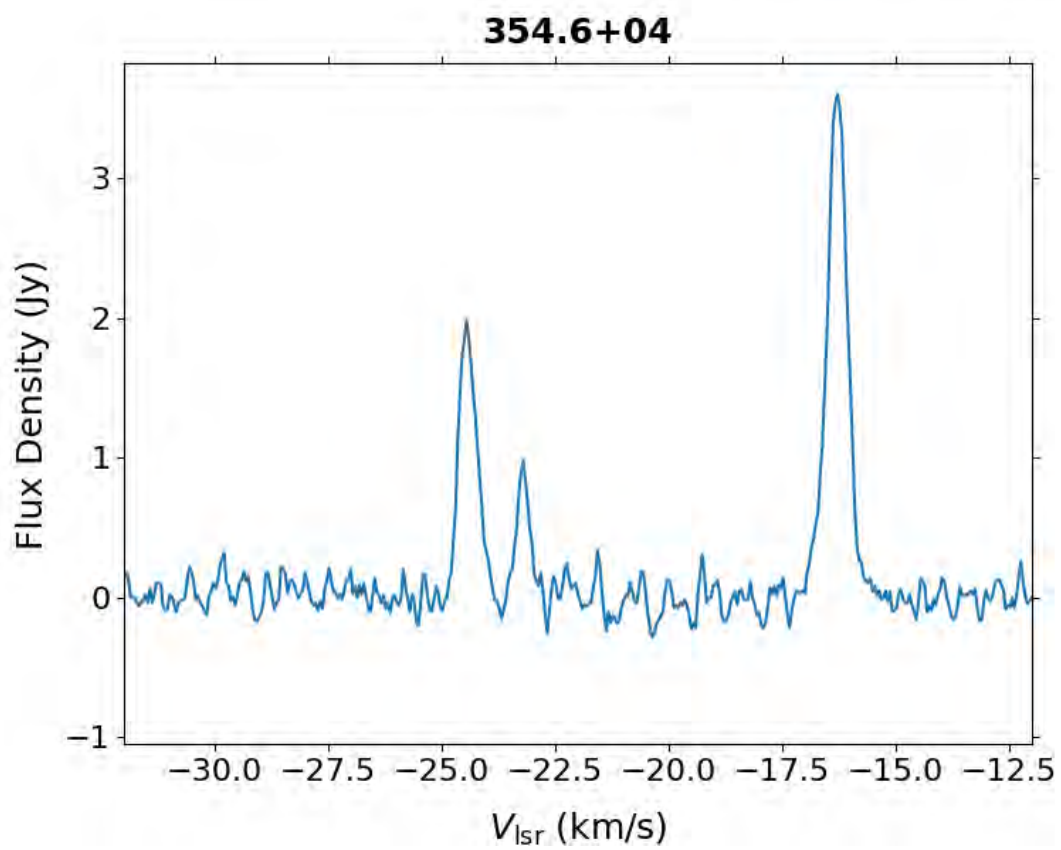
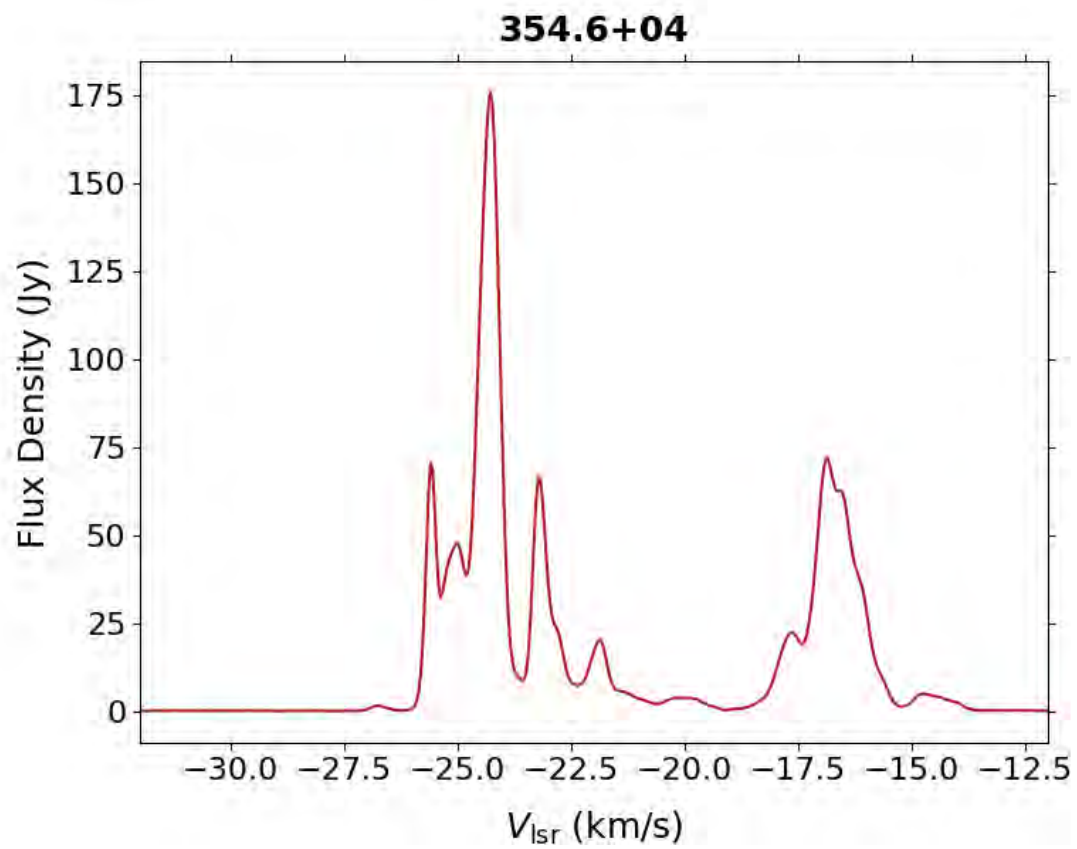


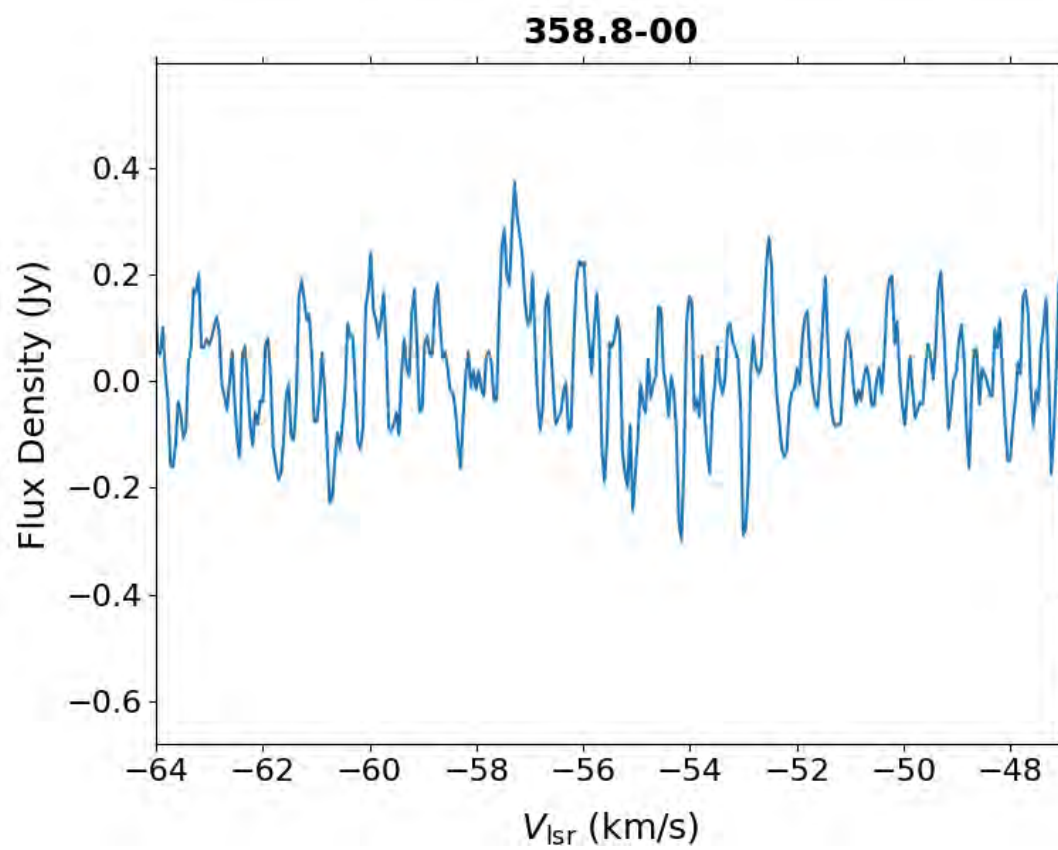
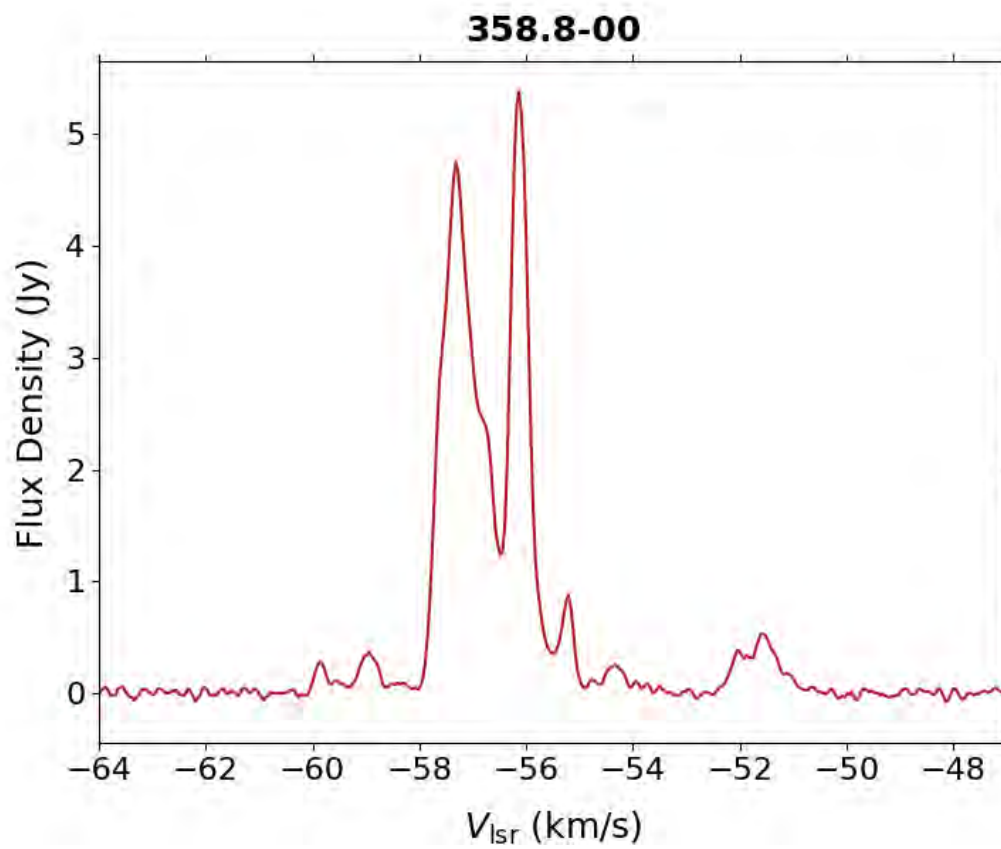
351.7-05

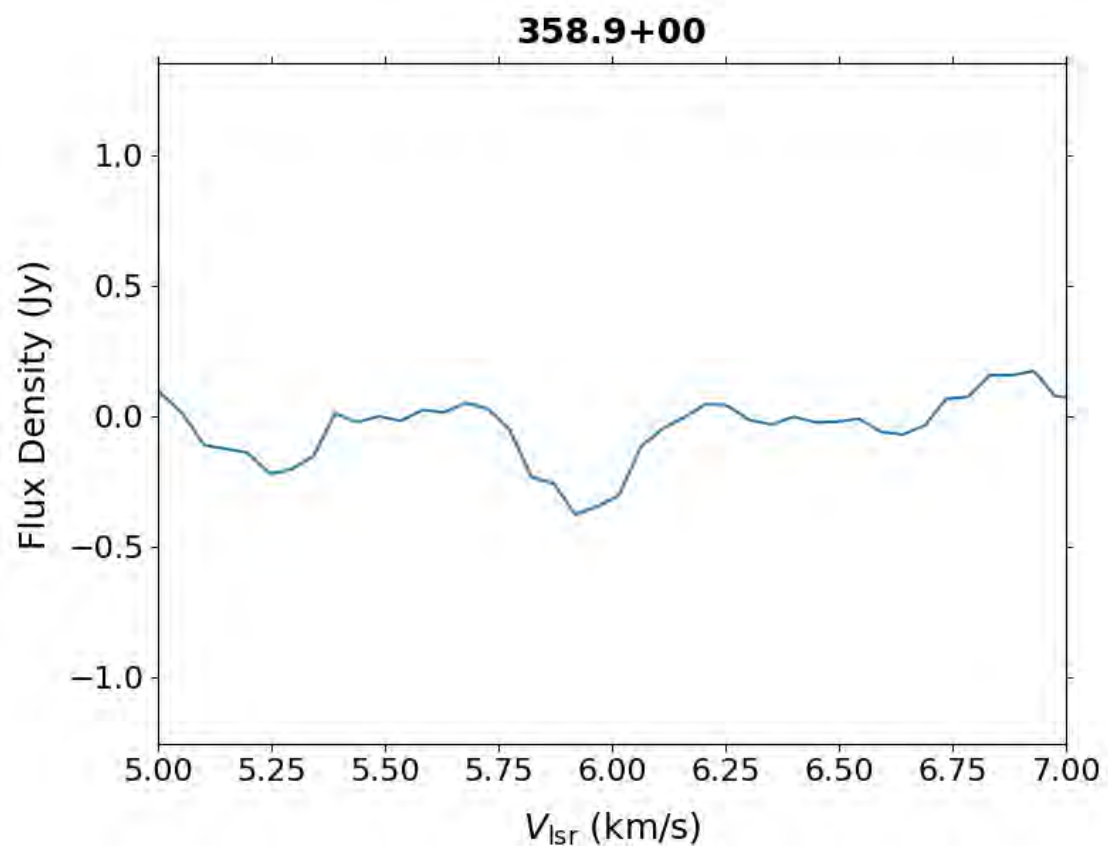
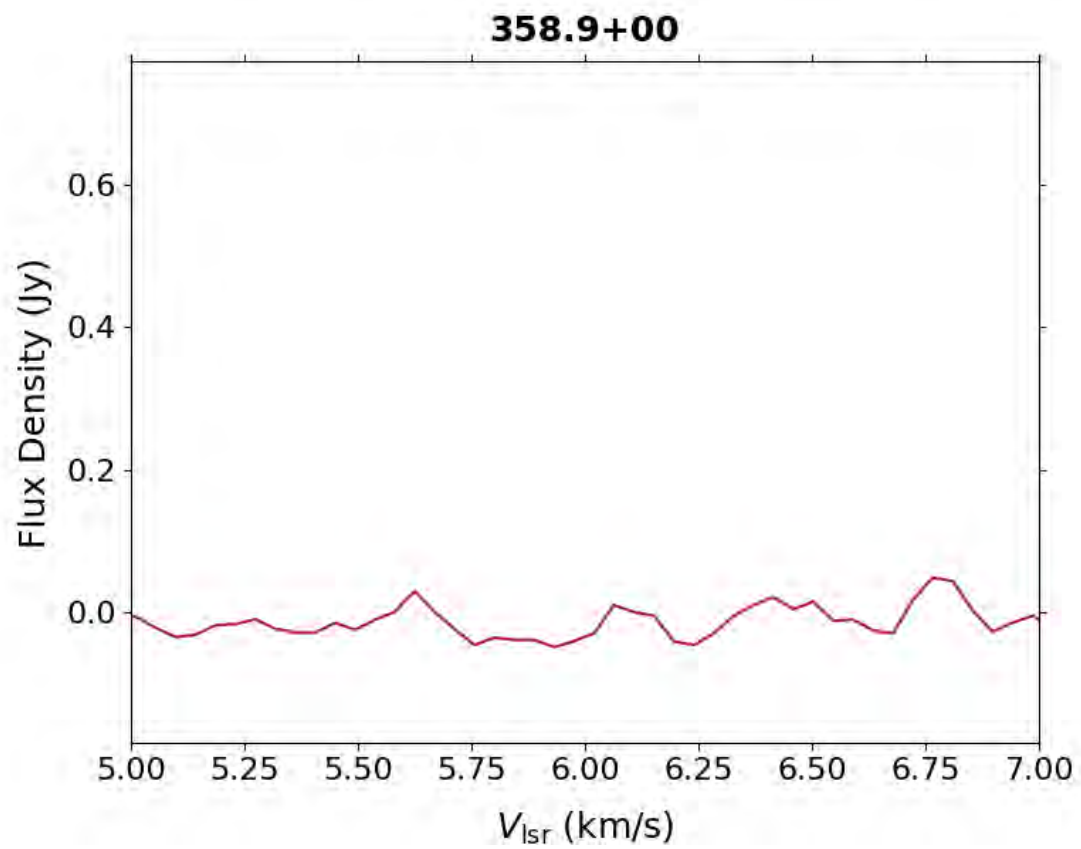


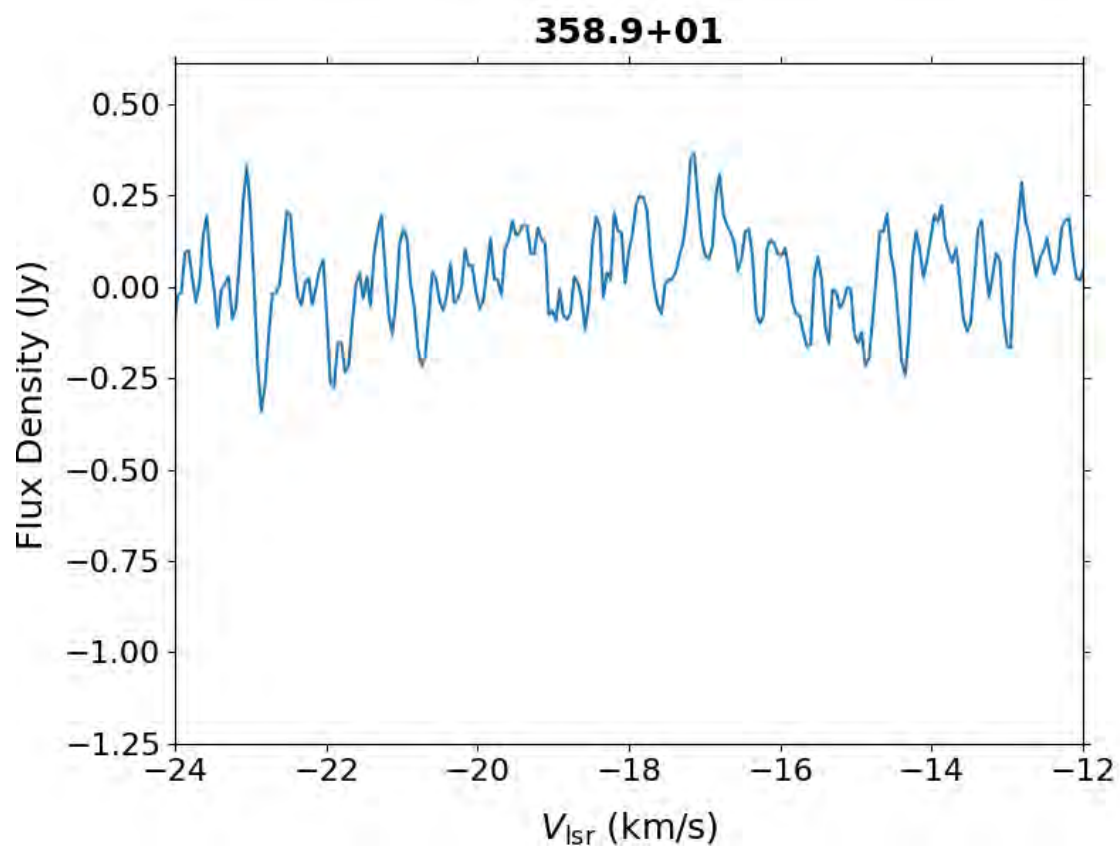
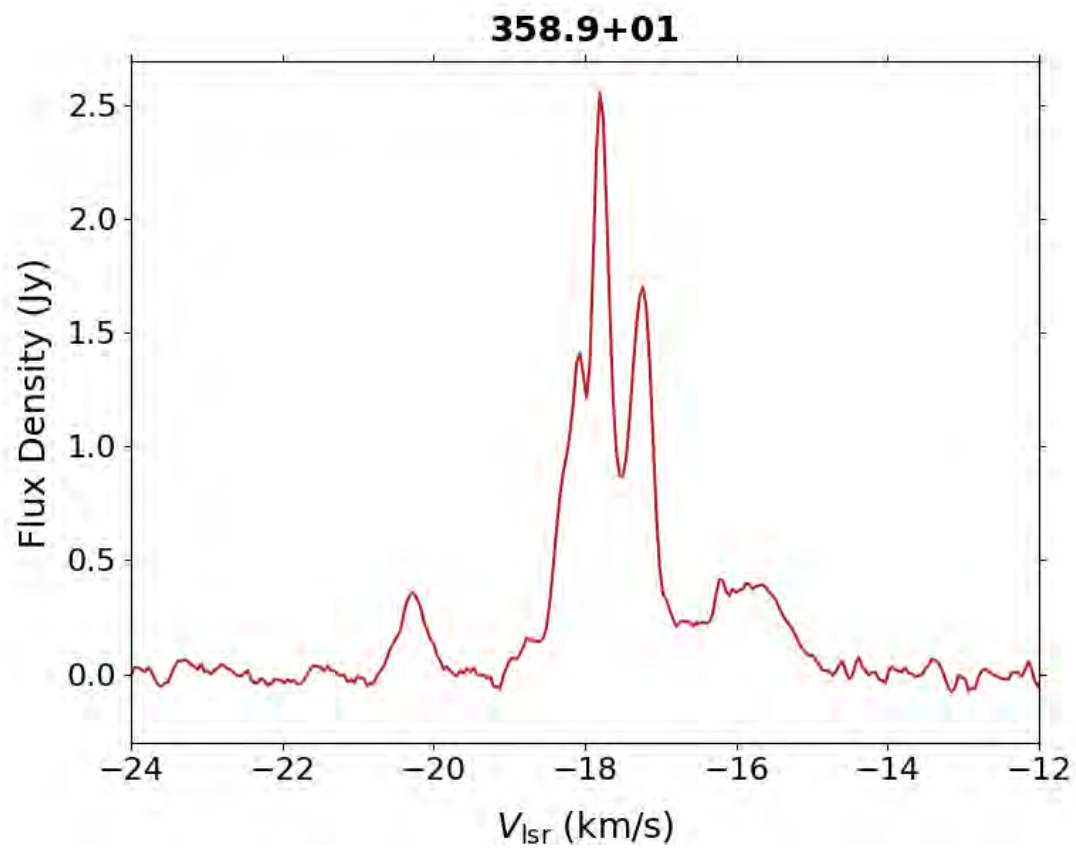


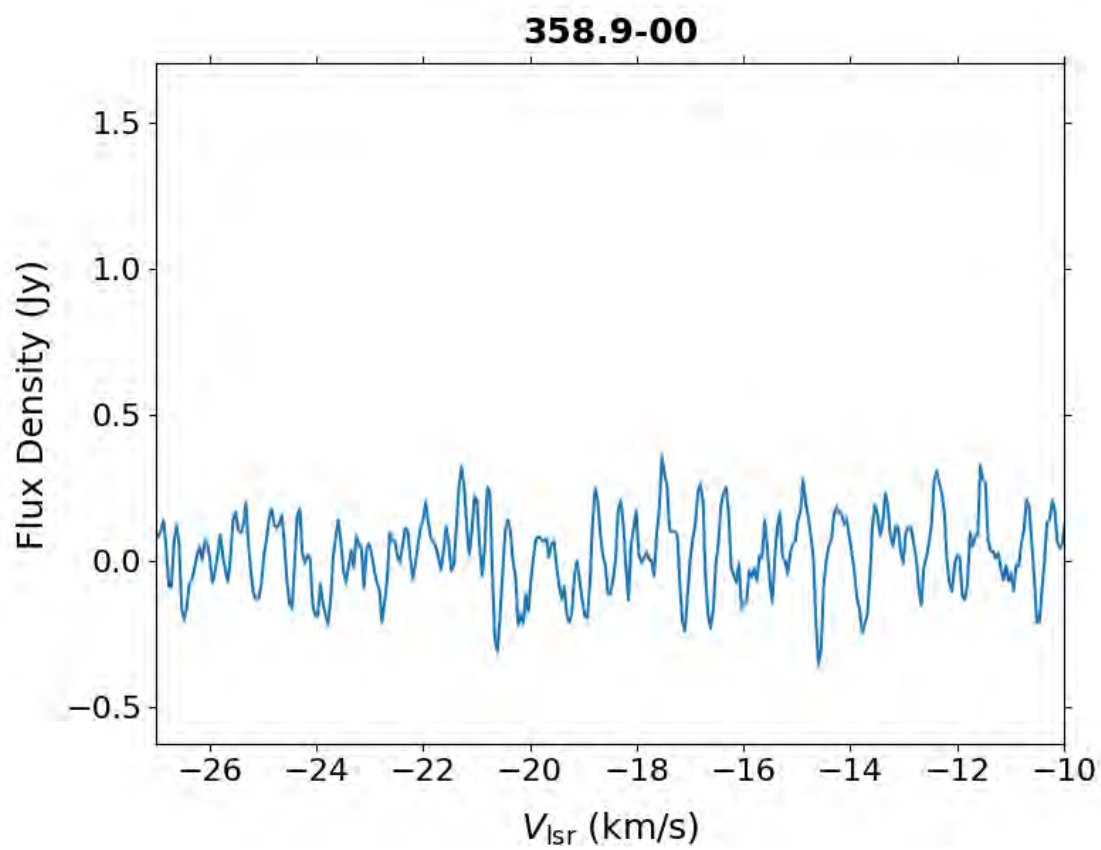
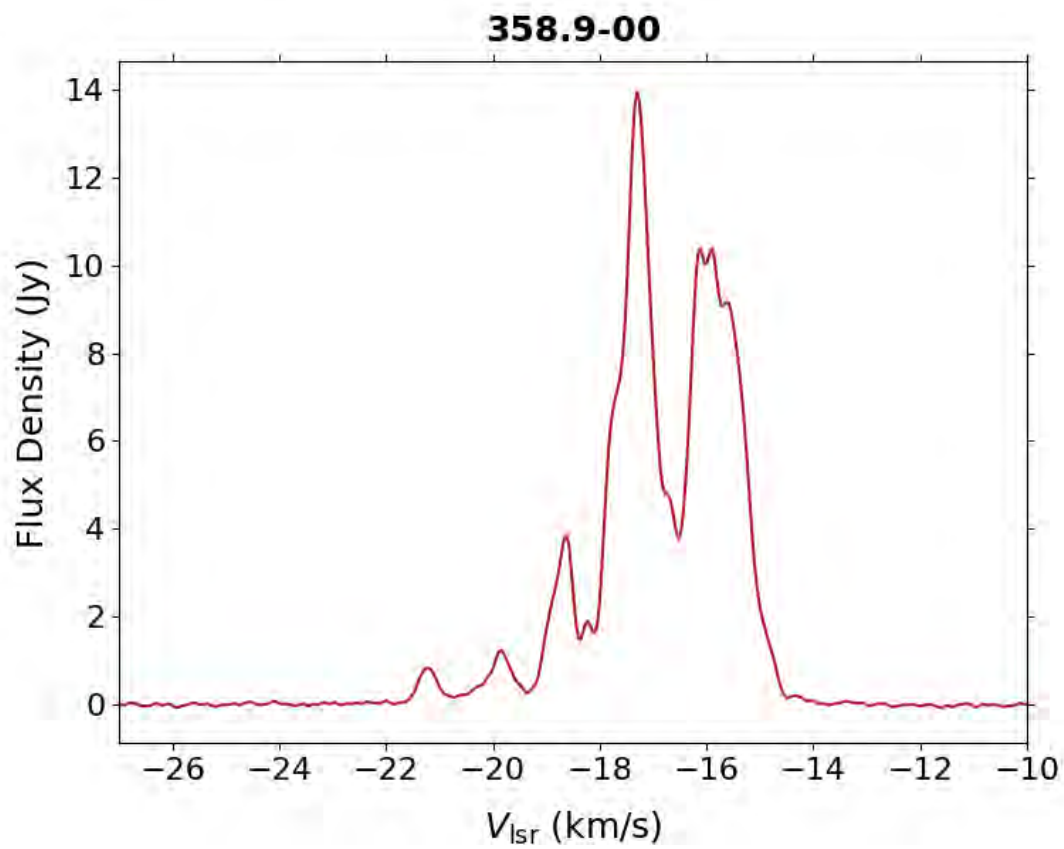


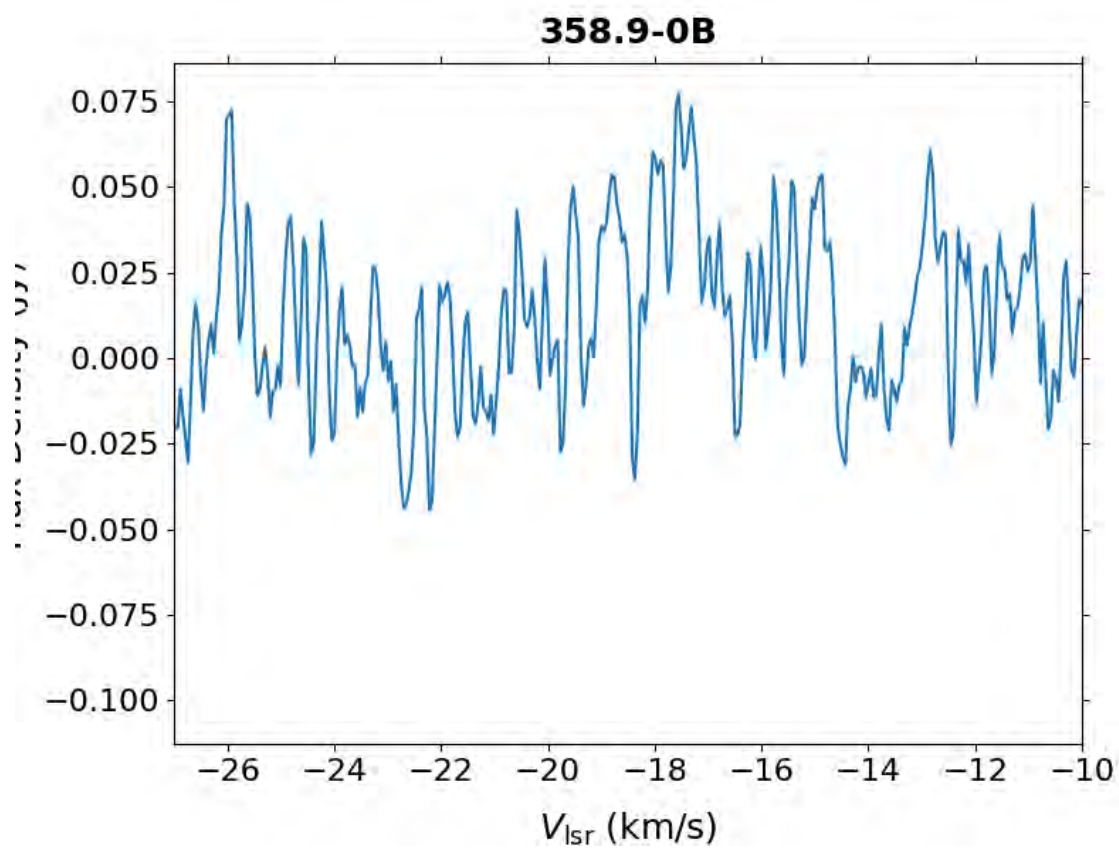
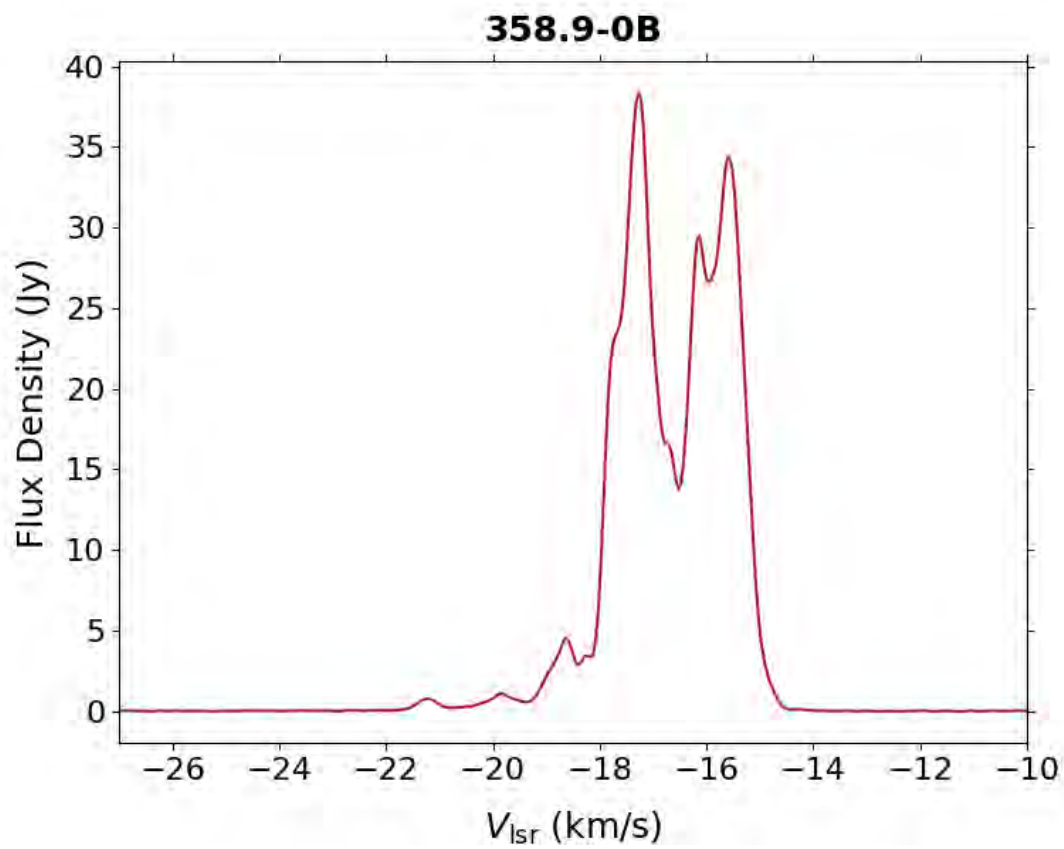


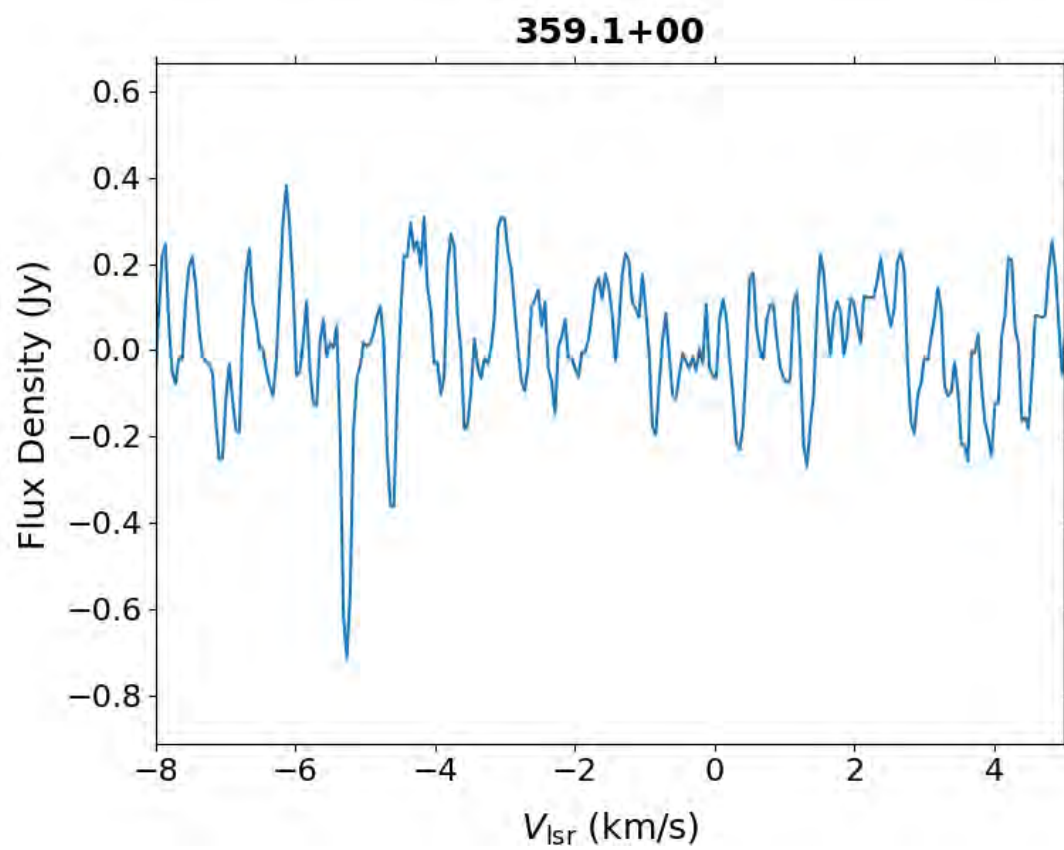
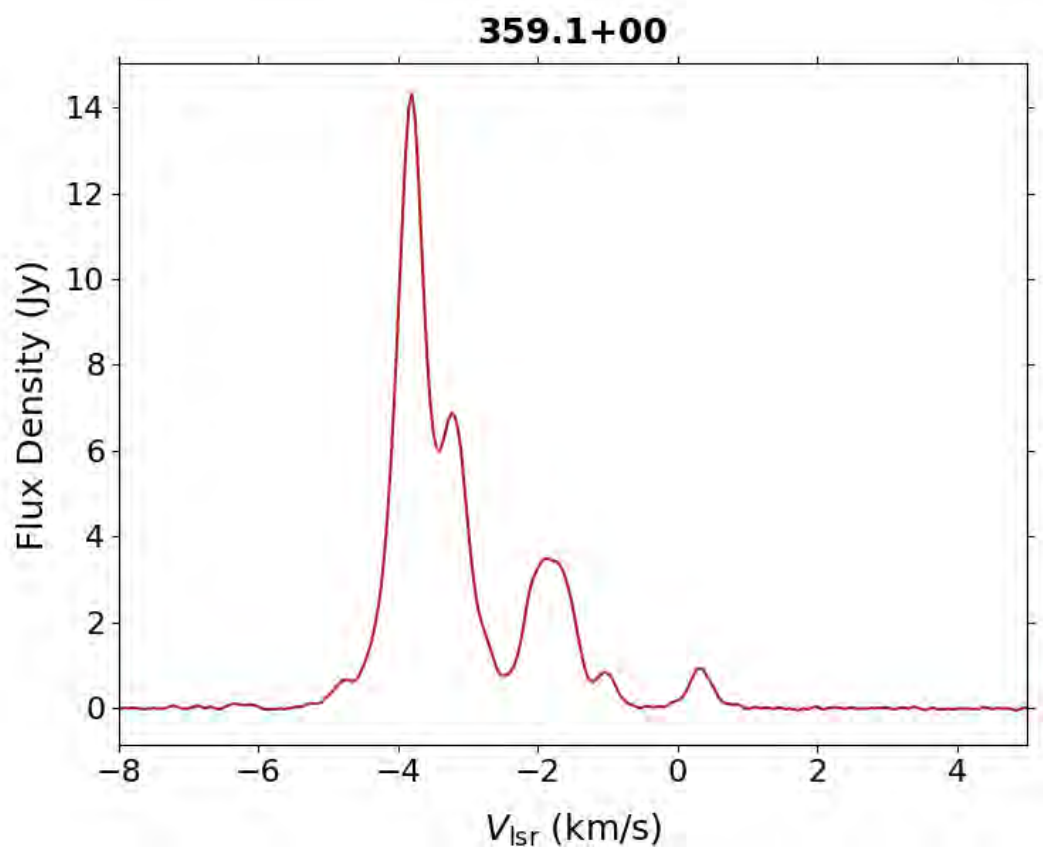


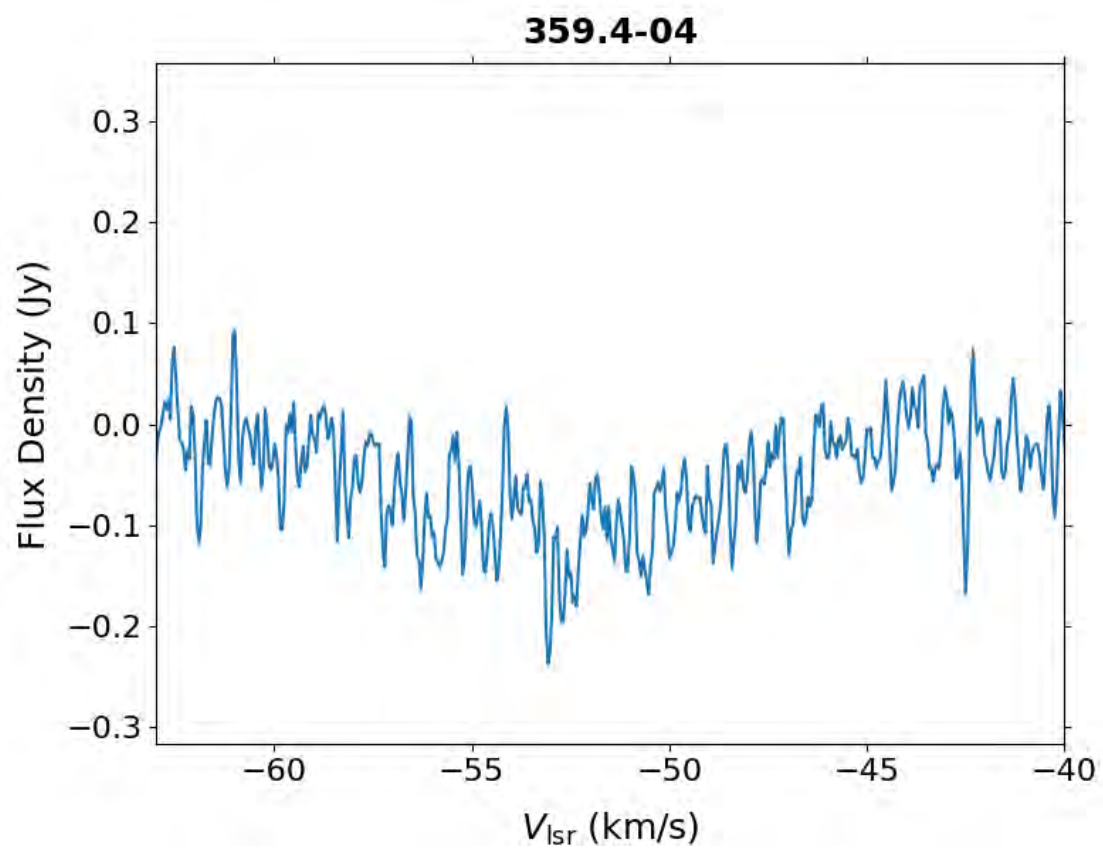
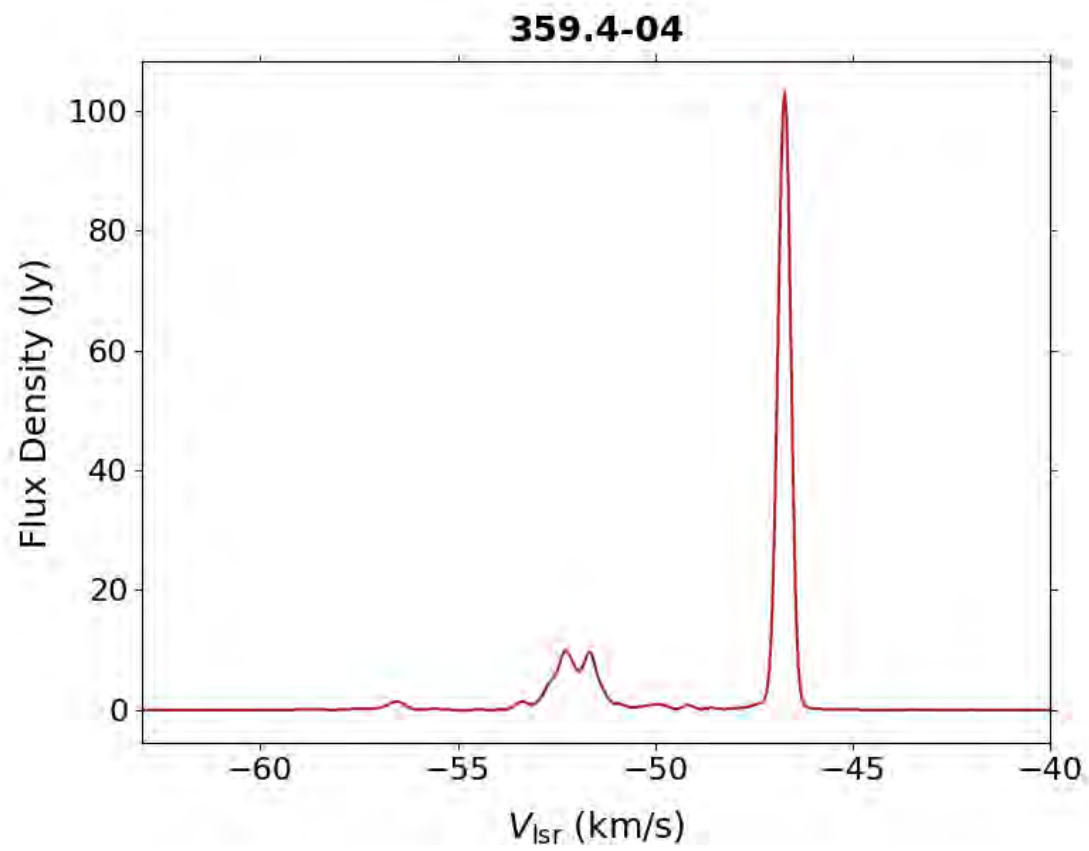




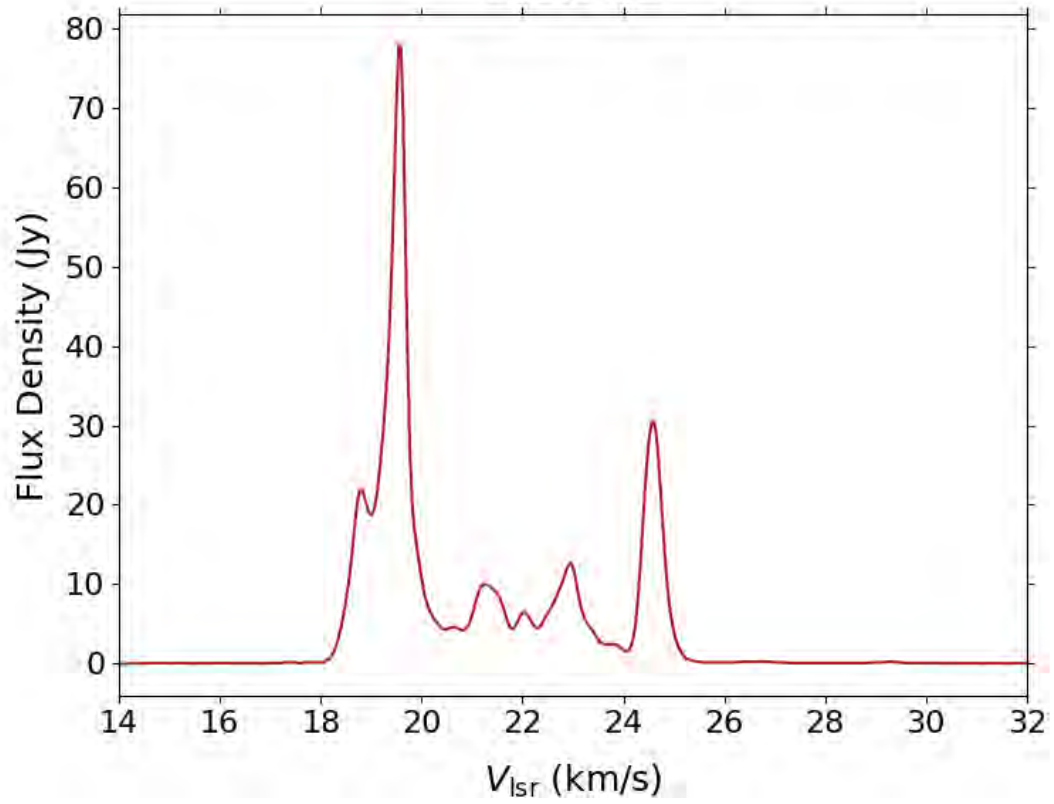




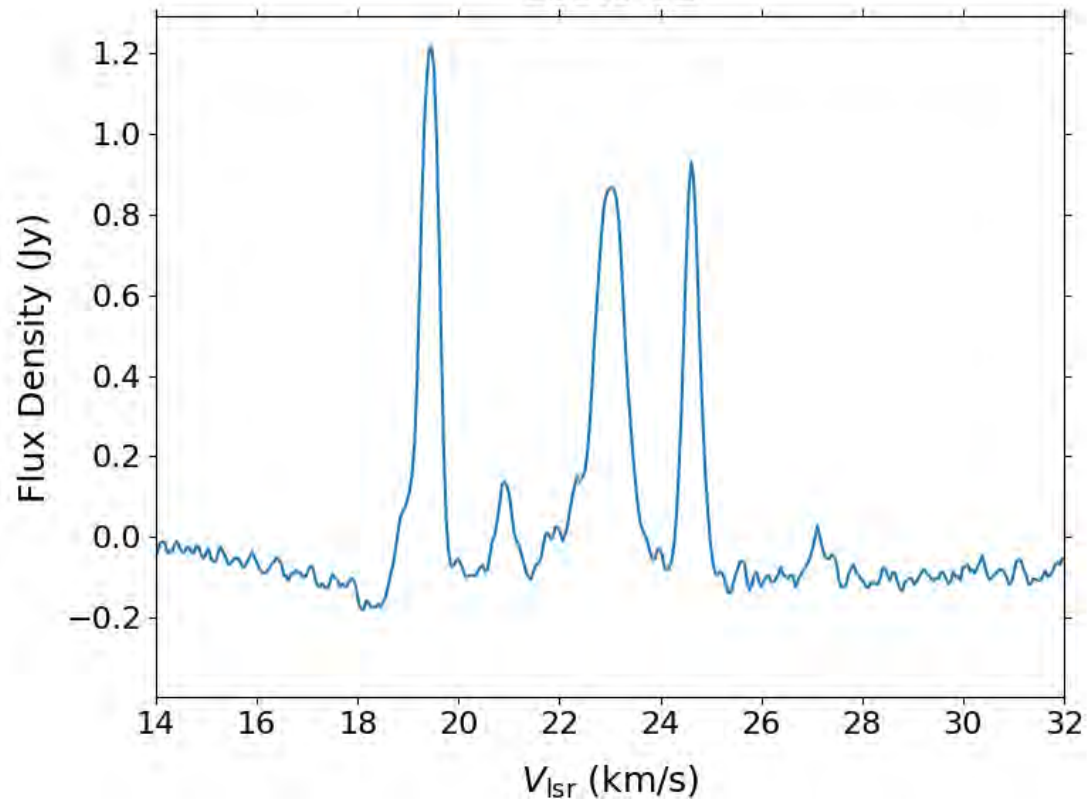


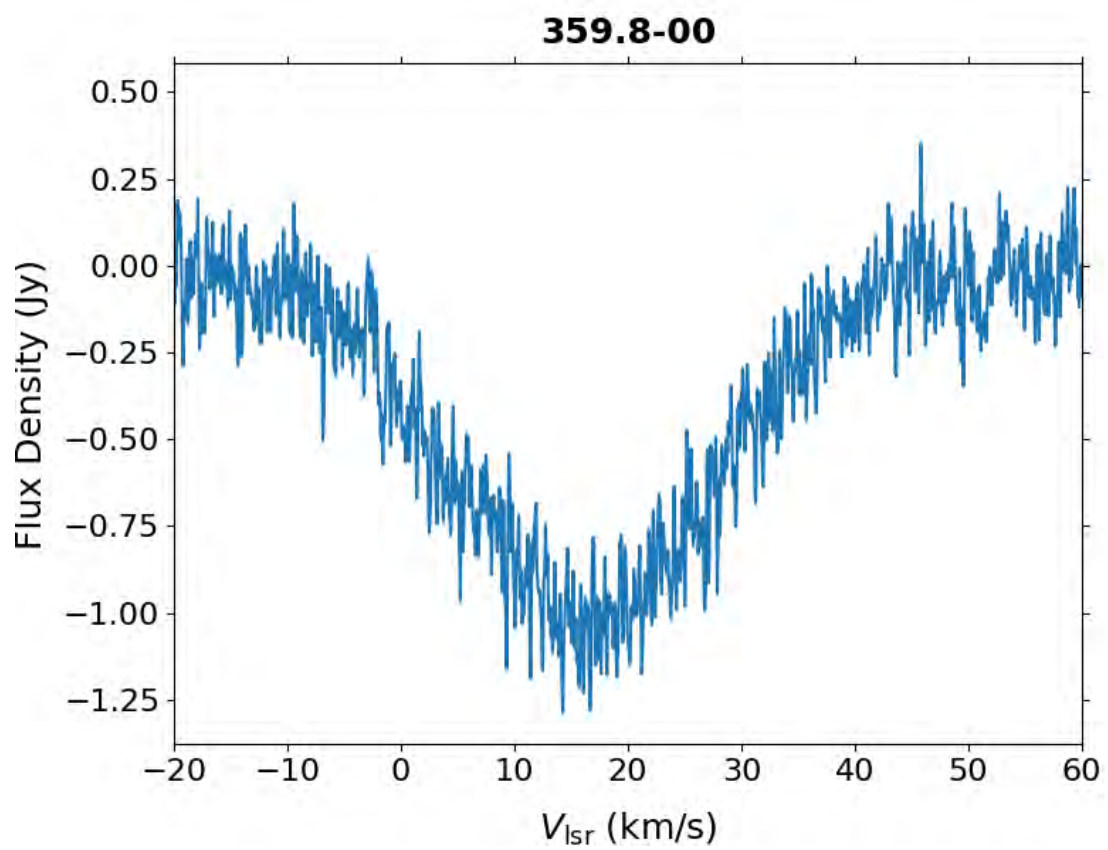
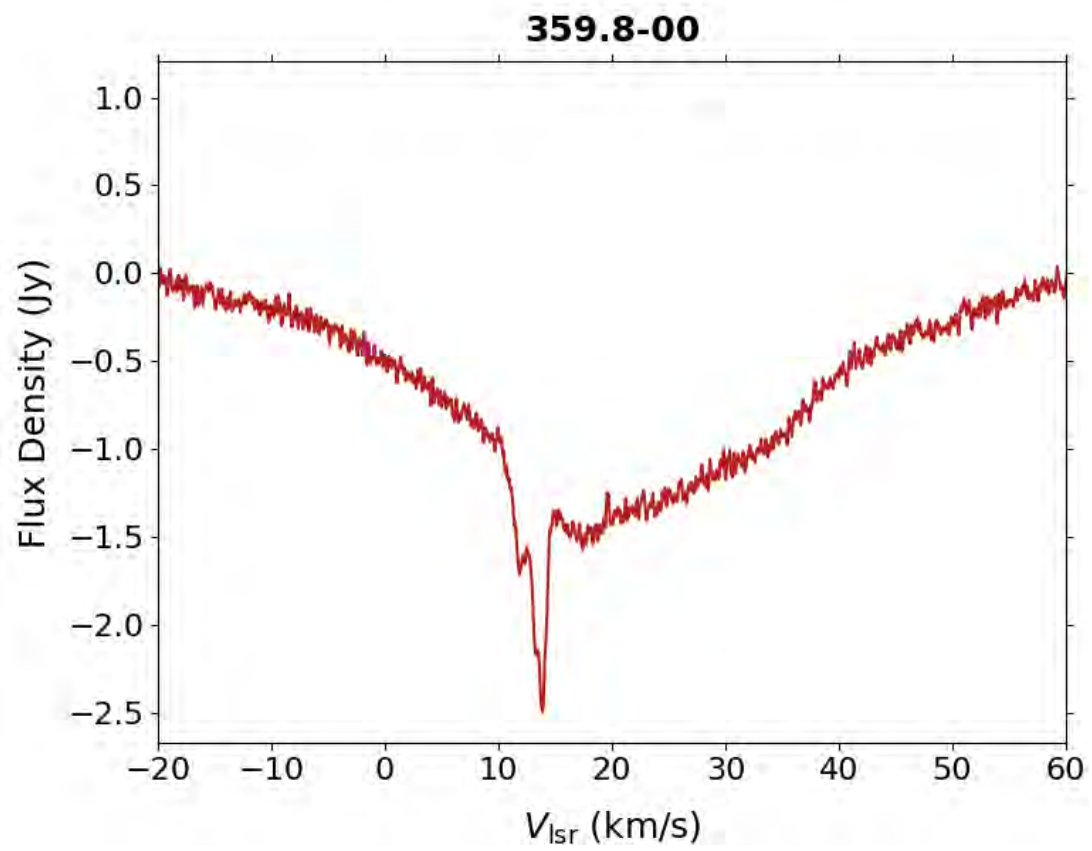


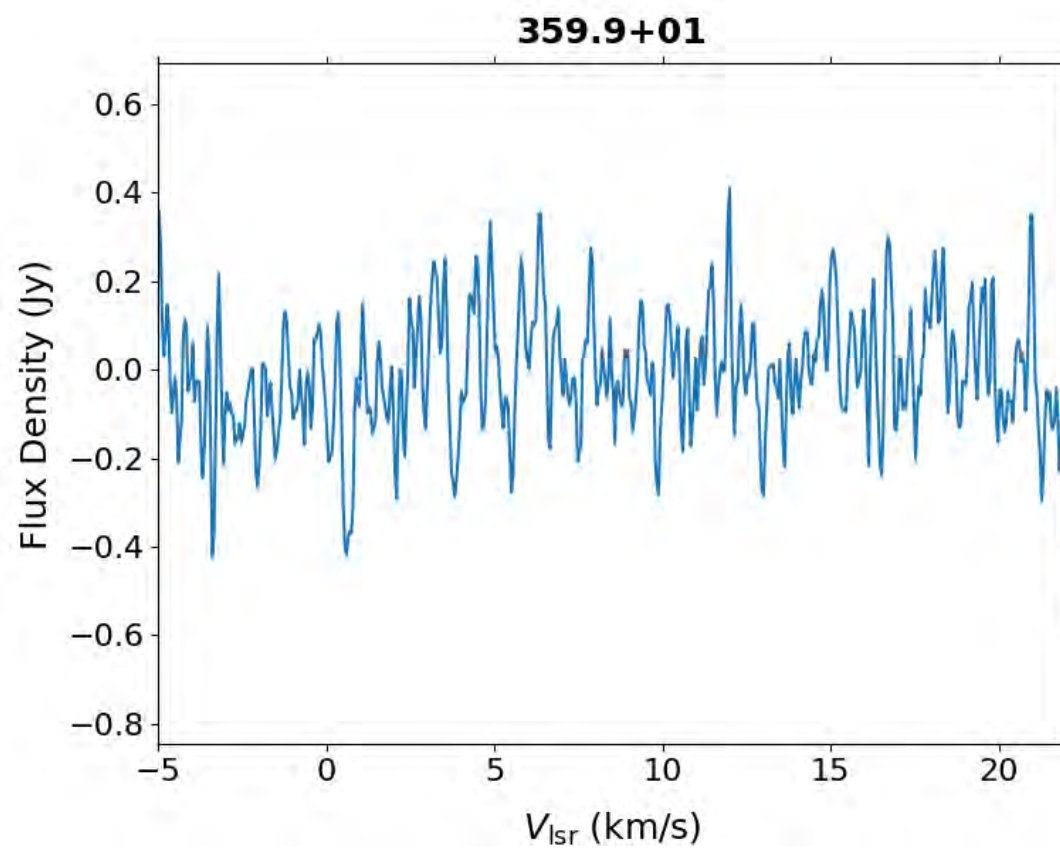
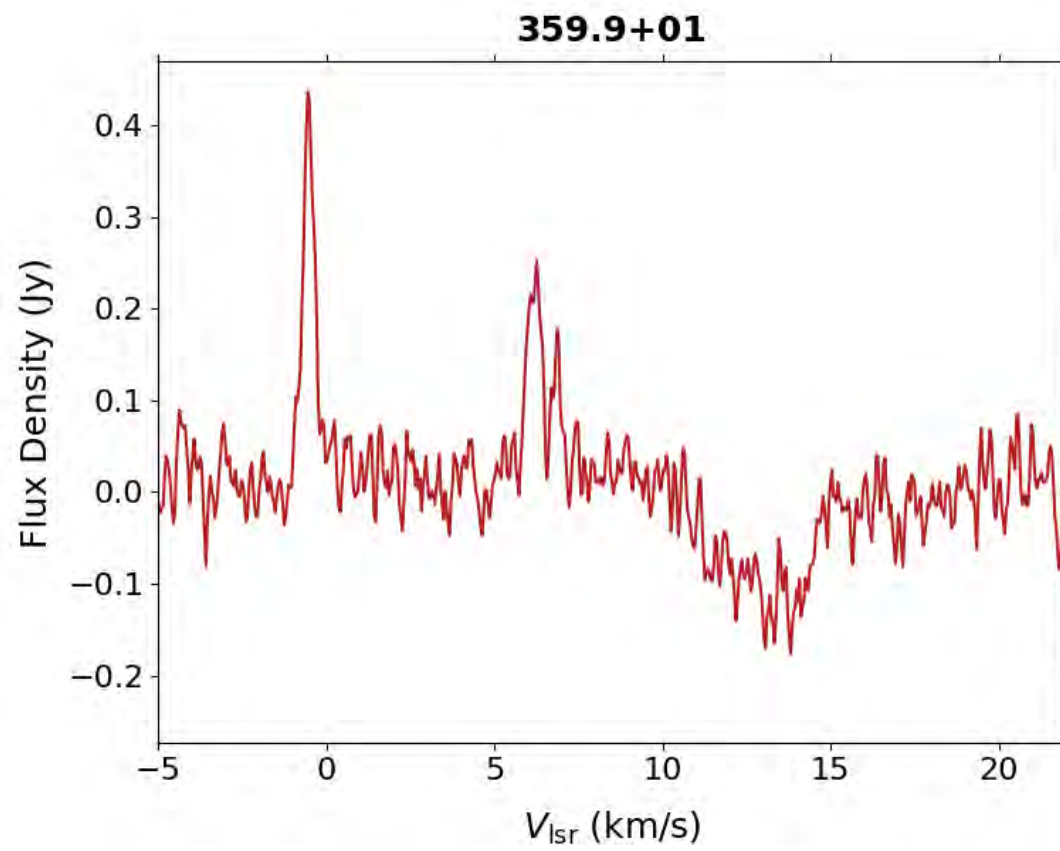
359.6-02

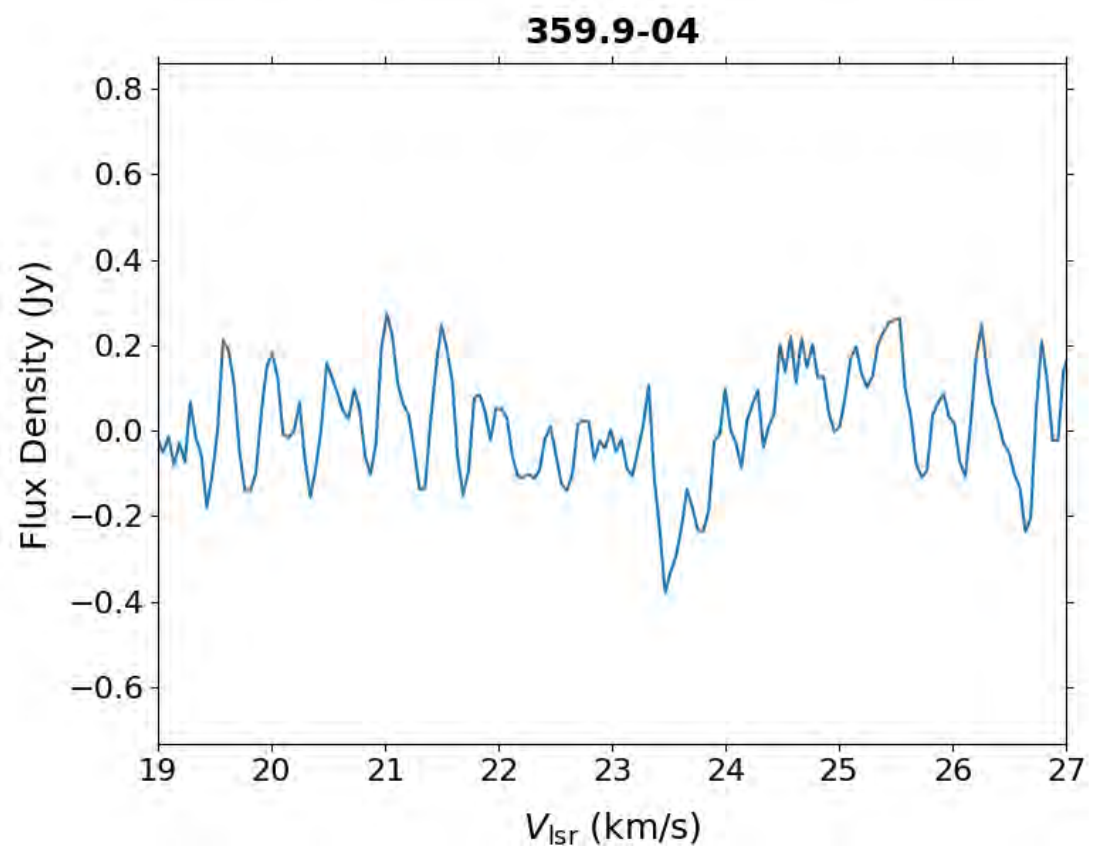
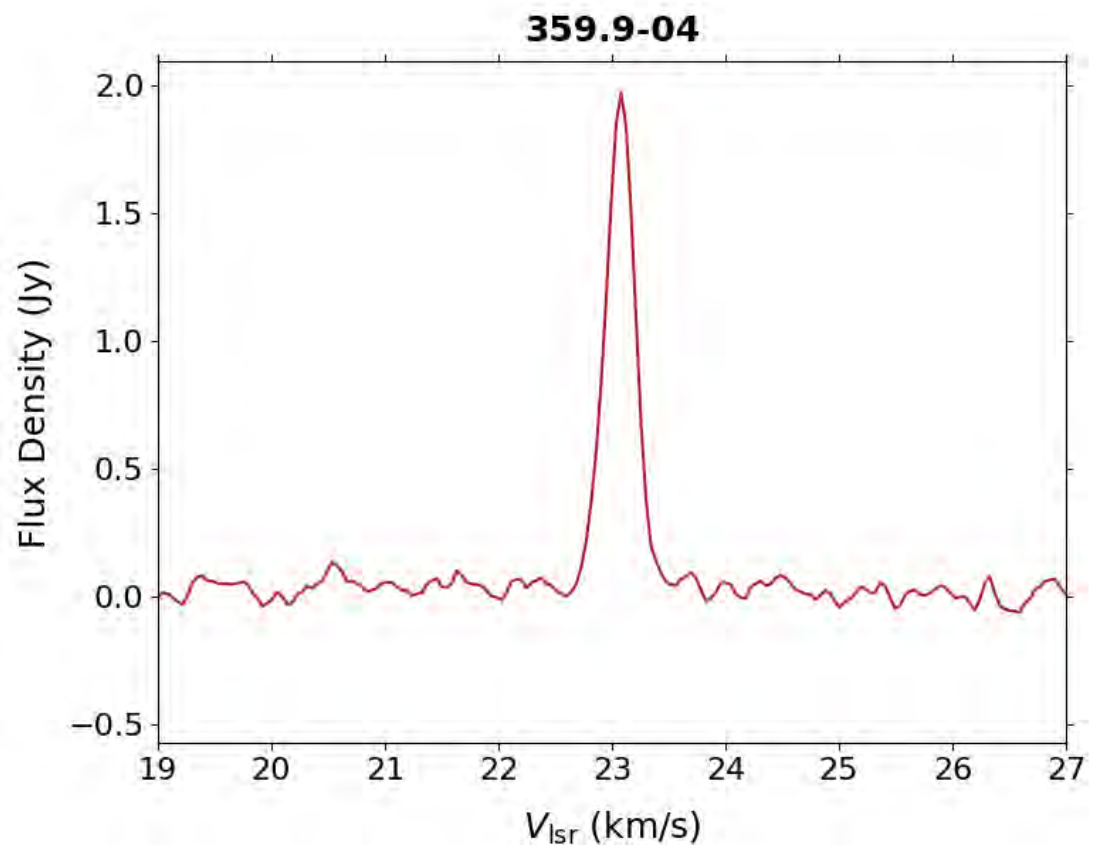


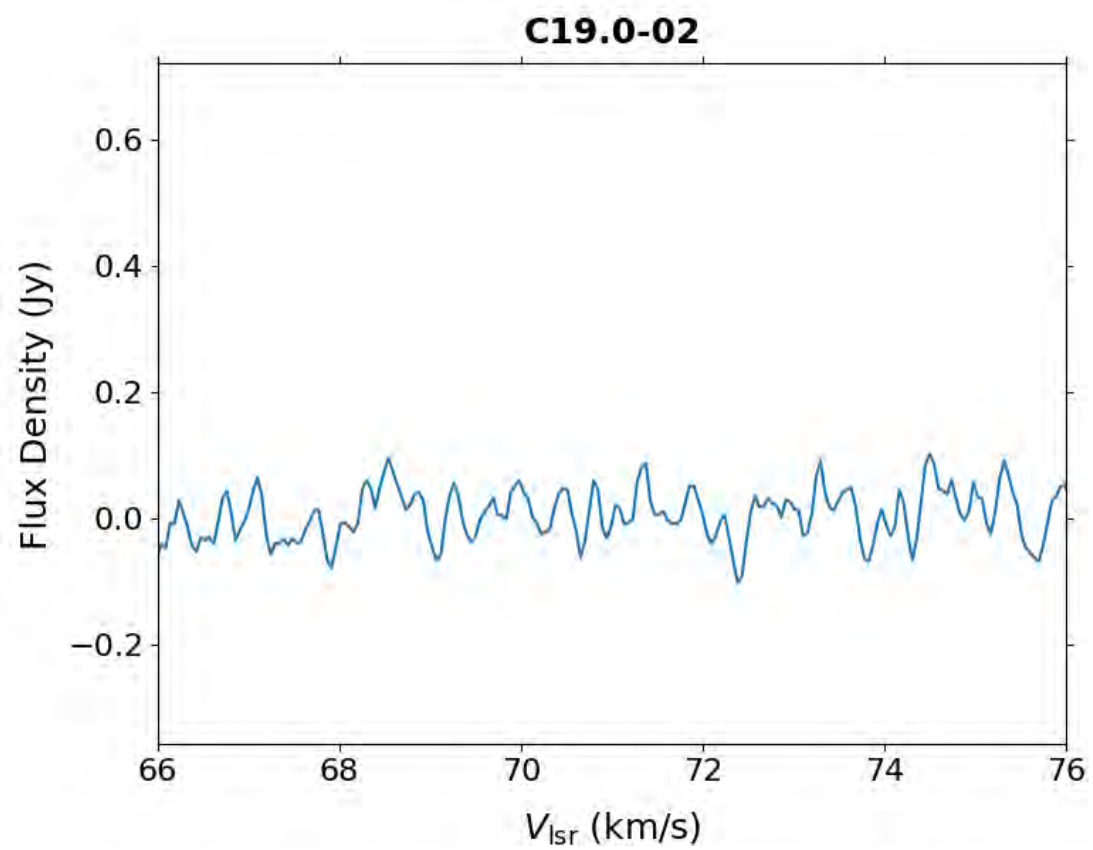
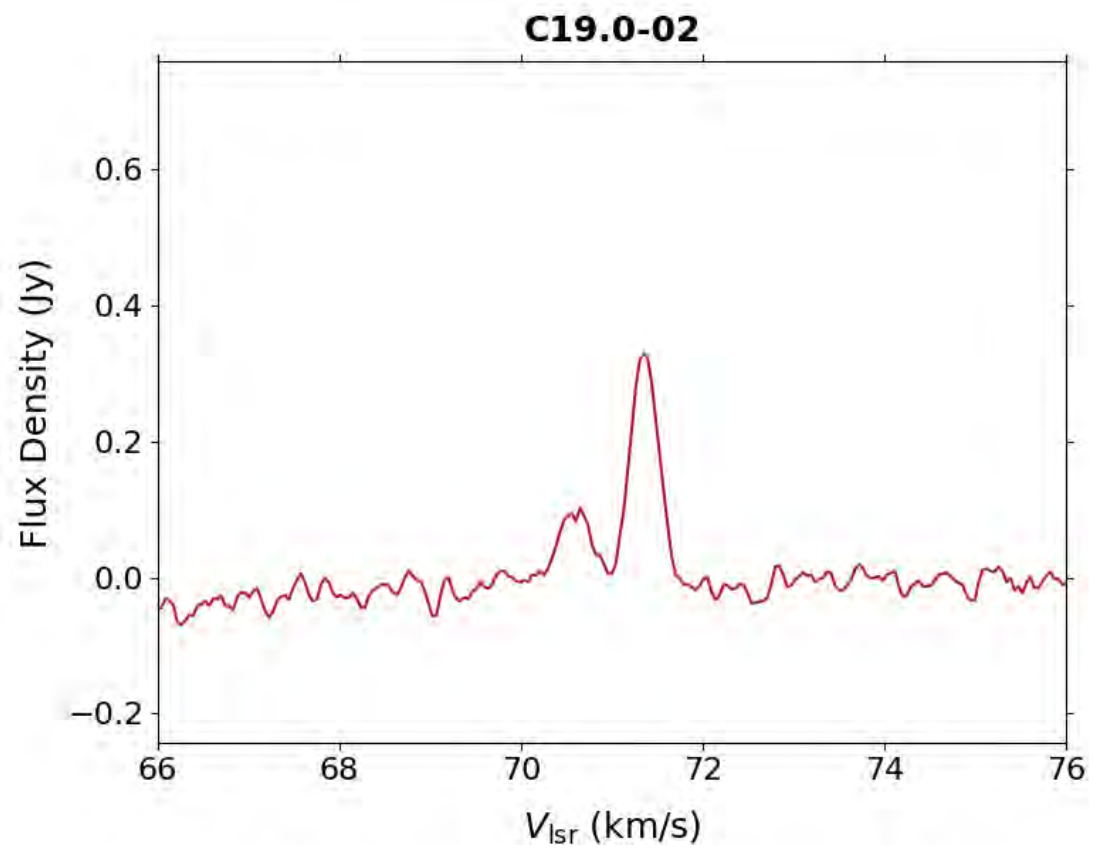
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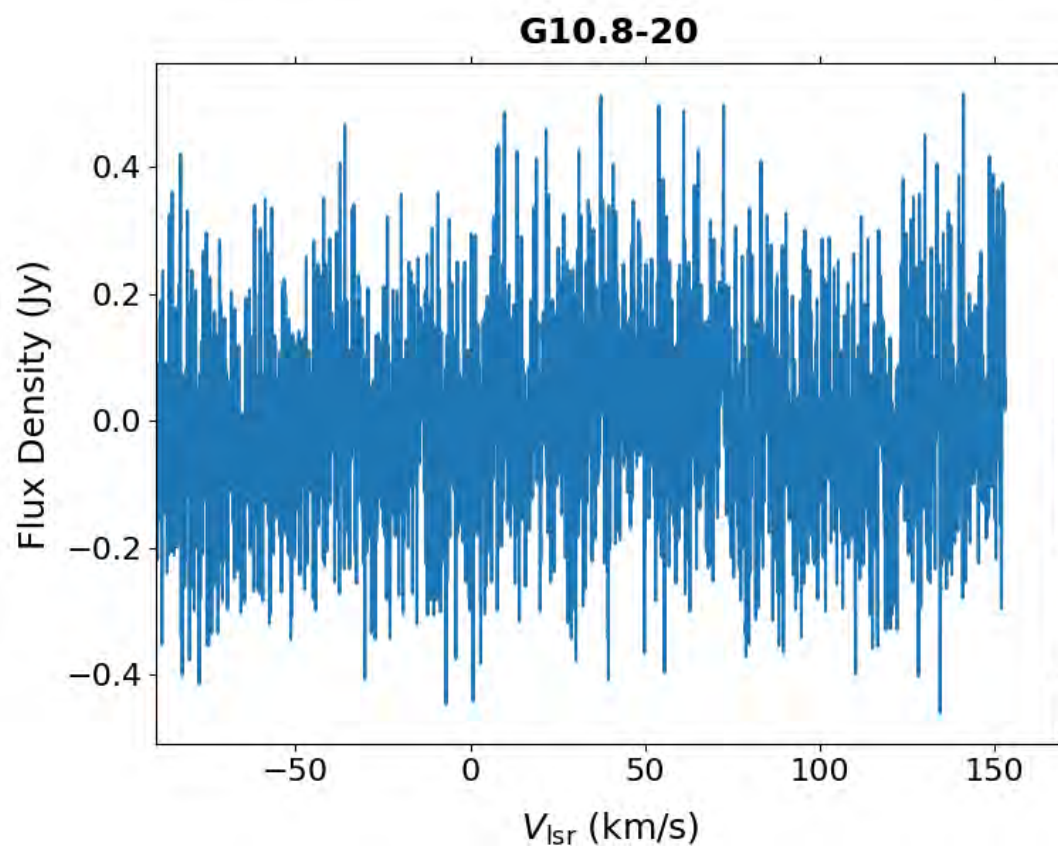
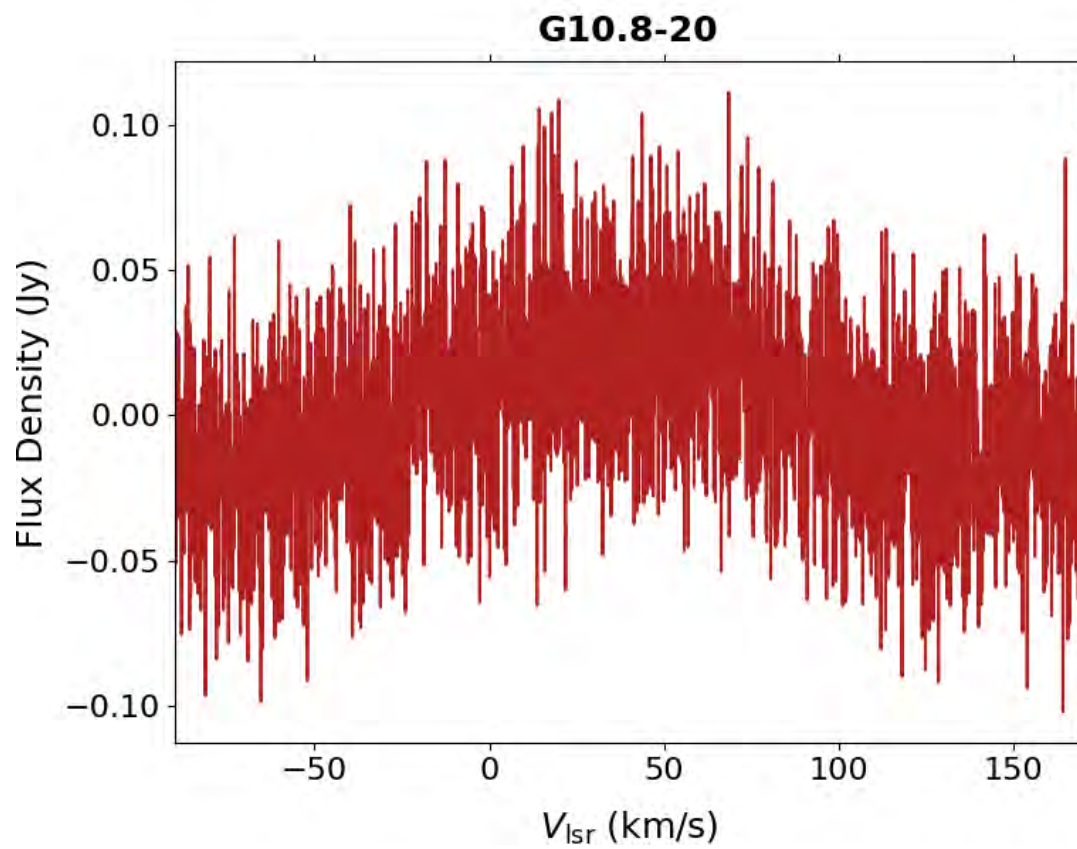


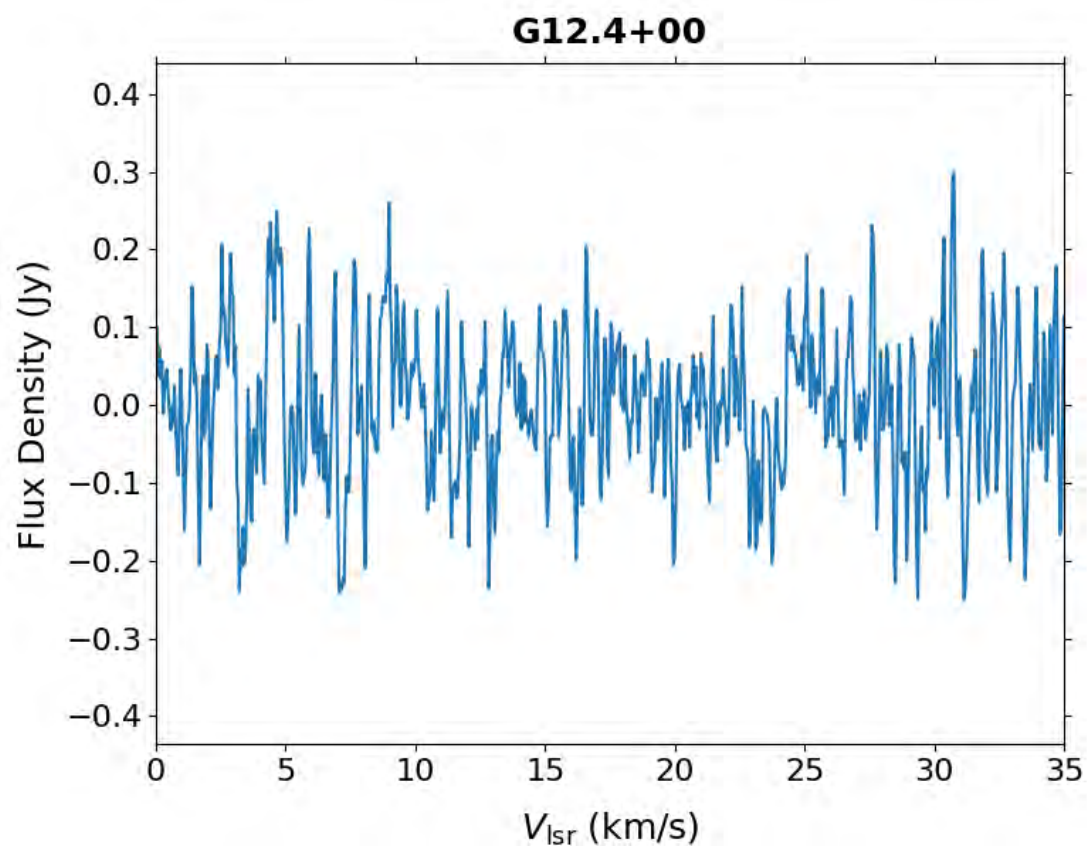
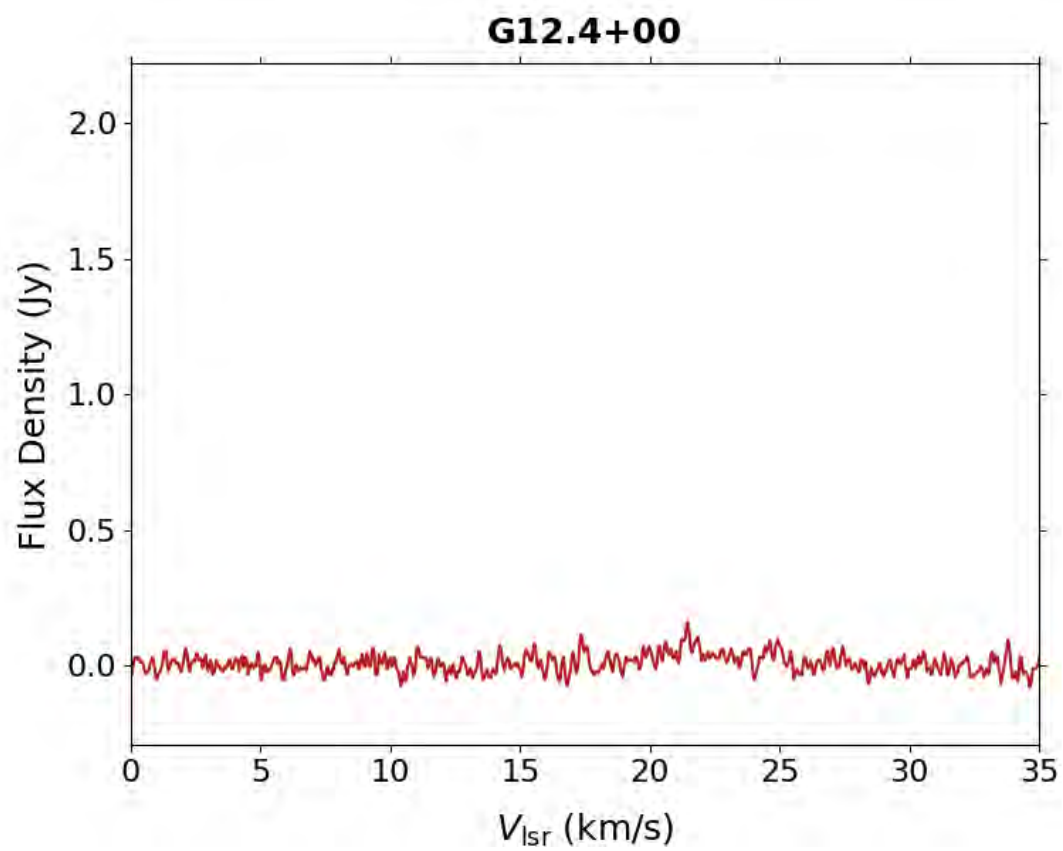


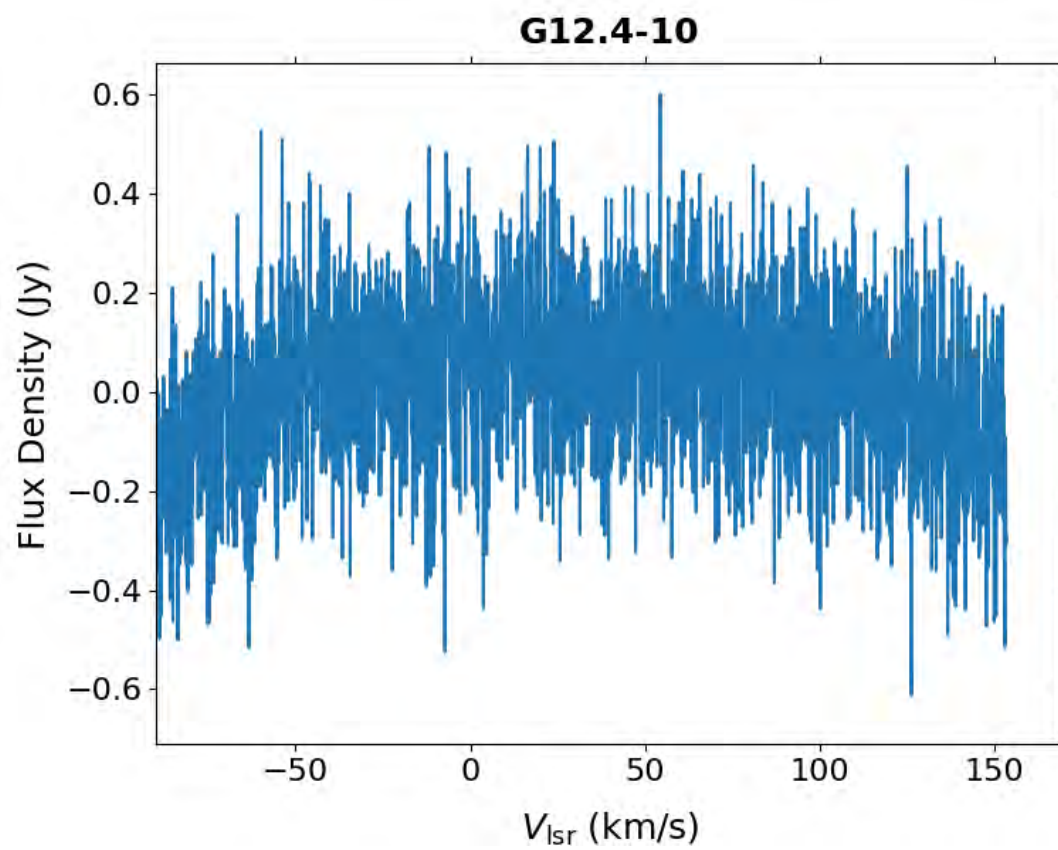
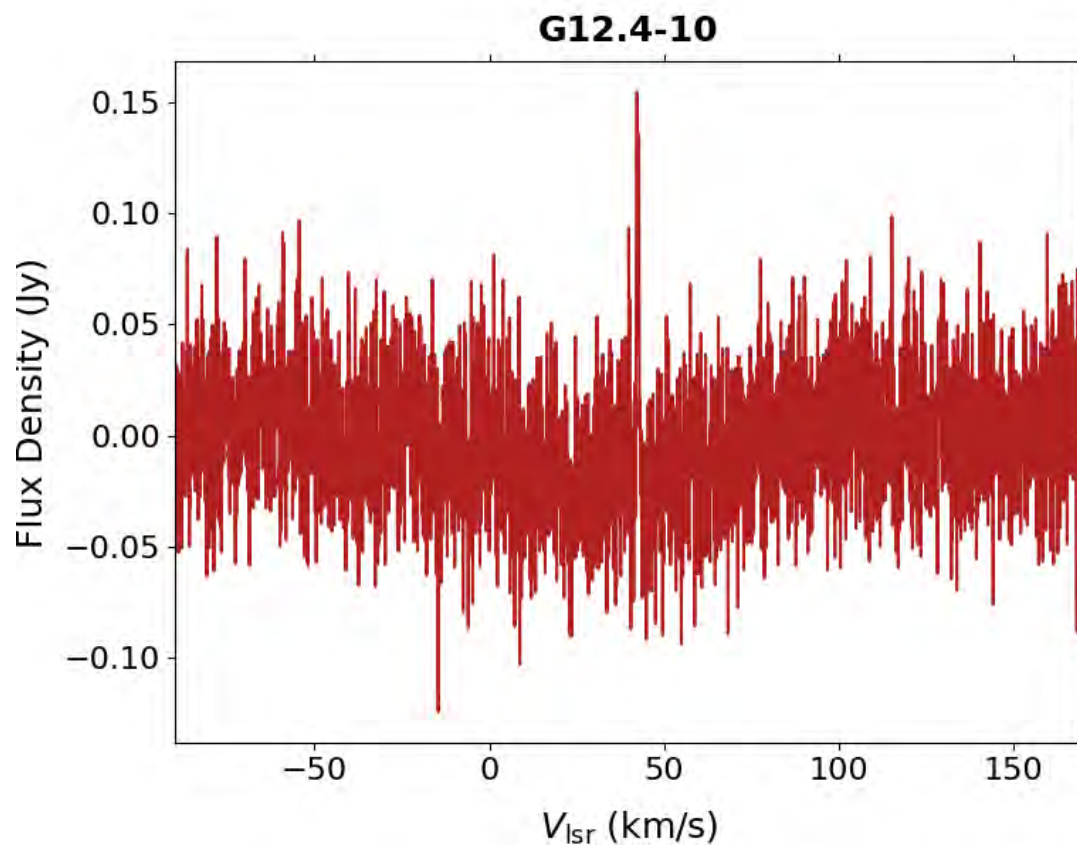




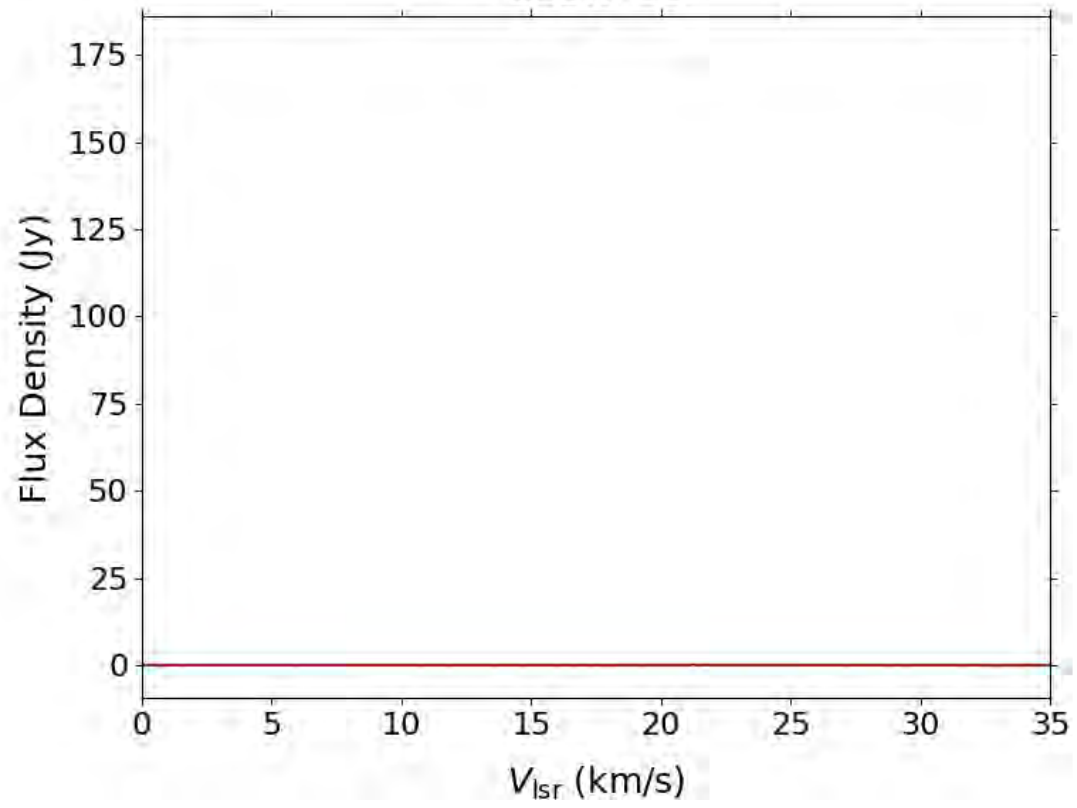








G12.7-00



G12.7-00

