Mon. Not. R. Astron. Soc. **000**, 000–000 (0000) Printed April 26, 2013 (MN LaTeX style file v2.2)

Description of Keck HIRES data reduction steps

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April 26, 2013

ABSTRACT
Material that may get included in a paper. Describes the data reduction steps carried out for the Keck HIRES spectra of the Orion proplyds. Basic reduction steps: order extraction, wavelength calibration, detilting, de-overlapping, flat-fielding. Decomposition into continuum plus line. Deconvolution of fine-structure multiplets. Decomposition of line into sky plus nebula plus proplyd. Sample results for slit p84 from the giant proplyd 244-440.

1 BASIC REDUCTION

With mhchem package: $O^{2+} 2\,s^2 2\,p^2\,{}^1D_2 \longrightarrow 2\,s^2 2\,p^2\,{}^3P_{0,1,2}$

With normal math commands: O^{2+} $2s^2\,2p^2\,{}^1D_2 \rightarrow 2s^2\,2p^2\,{}^3P_{0,1,2}$

2 DECOMPOSITION

2.1 Continuum subtraction

We fit the continuum and subtract it.

2.2 Deconvolution of multiplets

For the O I lines

2.3 Nebular subtraction

3 SAMPLE RESULTS: 244-440 SLIT 84

3.1 High-ionization lines

3.1.1 [O III] forbidden lines

The only [O III] lines that fall in the wavelength range of our observations are the three components of the ^{1}D–^{3}P 5007, 4959, and 4931 multiplet is the only one that is detected, with theoretical relative intensities 1:0.34:0.00013. Only the 5007 component is shown in Figure 1. The 4959 component shows identical structure, while the very weak 4931 component is barely detected.

The line is very strong from the nebula (X times H b) but significantly weaker from the proplyd (Y times Hb). As a result the proplyd contrast against the underlying nebula line is only 10–20%. Nonetheless, the very high S/N allows a reliable separation of the proplyd and nebula contributions, as shown in the right column of Figure 1. The proplyd emission separates into blue and red components peaking at $V_{\rm prop} = -19$ and $+15$ km/s in the proplyd reference frame. The red component is about 3 times weaker and more compact and shows a larger mean spatial shift of 2 arcsec from the proplyd center, as opposed to 1 arcsec for the blue component.

3.1.2 C II permitted line

This line is produced from the recombination of C^{2+}. It is 200 times weaker than [O III] 5007 and is a similar intensity to the adjacent continuum. However, the proplyd shows a contrast of about 100% with respect to the nebula, which again allows for a reliable separation. The proplyd emission is extremely similar to that of [O III].

It is an important question whether the apparent complete lack of emission around the proplyd systemic velocity is real or whether it is an artifact induced by extinction of background nebular emission by the proplyd. Henney & O'Dell (1999) discuss this issue in detail and show that an effective proplyd extinction as low as $A_V = 0.2$ would be enough to fill-in this missing emission. However, there are two reasons to believe that this does not occur in 244-440. First, the two-dimensional line profile would appear very unnatural, since the extra emission would appear at spatial positions in the core of the proplyd, rather than displaced along the slit, where the peak of the high ionization emission occurs. Secondly, the same amount of proplyd extinction would have a much smaller effect on C II than it would on [O III]

The conclusion is that in 244-440 is not affected by internal extinction of the nebular emission. This implies that either the extended neutral core of the proplyd is optically thin at visual wavelengths or that the majority of the nebular emission arises from gas that is foreground to the proplyd. This is consistent with the kinematic profile of this proplyd, which suggests that it is seen head-on and therefore lies behind its ionizing source.

3.2 Moderate-ionization lines

3.3 Low-ionization lines

3.4 Neutral collisional lines

3.5 [O I] lines

3.6 Fluorescent lines

3.6.1 [N I] lines

3.6.2 O I lines

3.6.3 Fe II lines

3.6.4 Si II lines

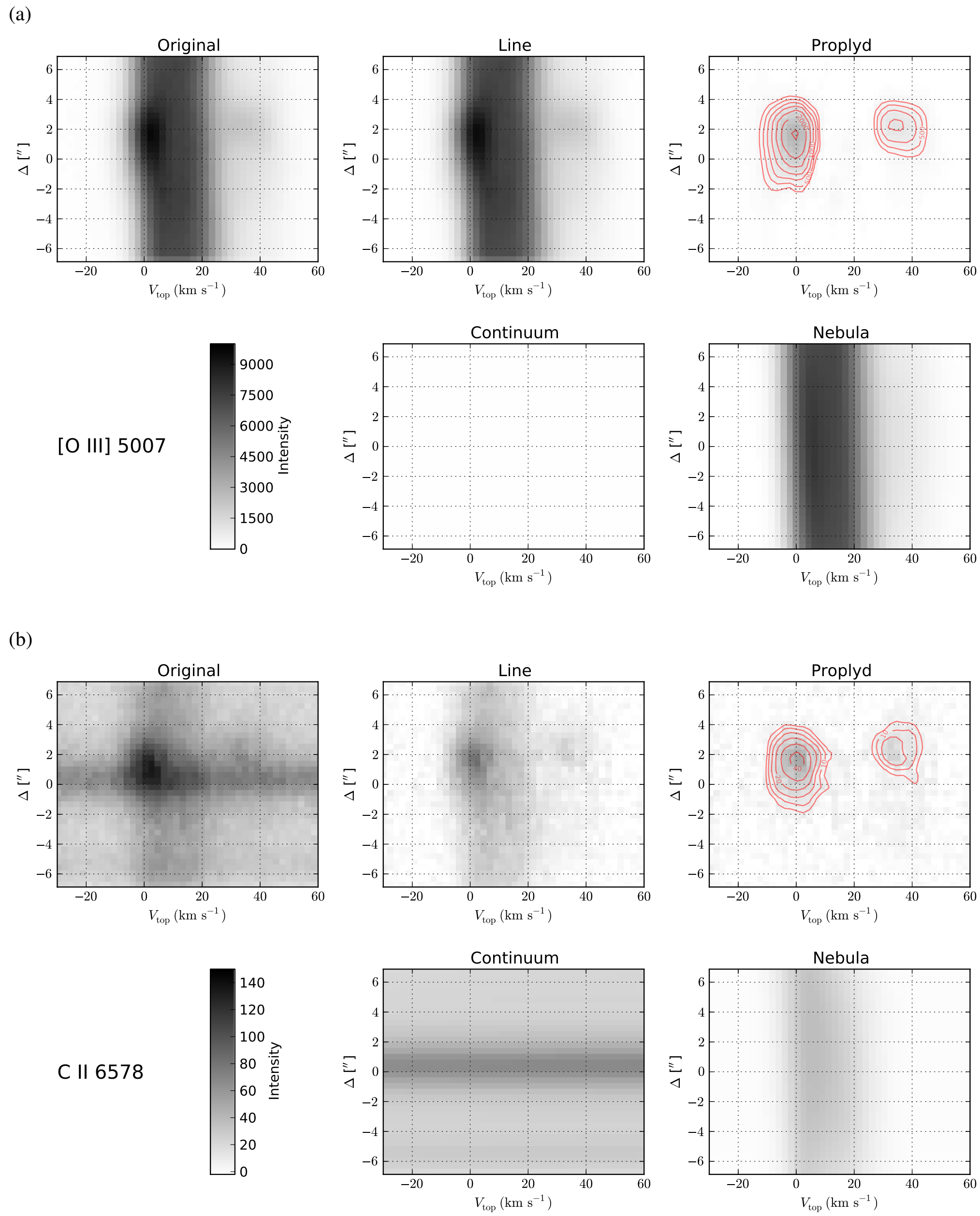


Figure 1. (a) Collisionally excited forbidden line of doubly ionized oxygen: [O III] λ5007. (b) Recombination line of singly ionized carbon: C II λ6578

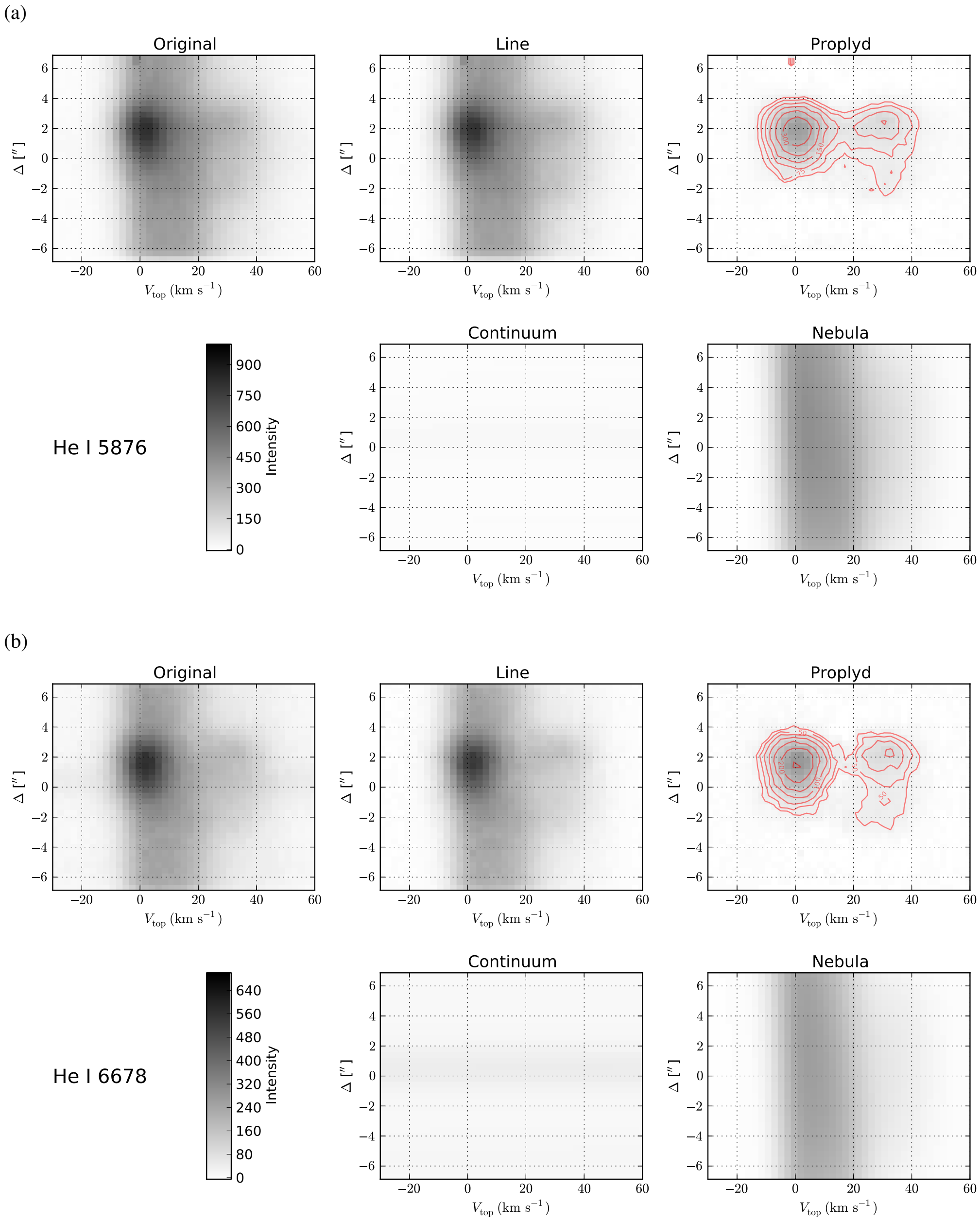


Figure 2. Recombination lines of neutral helium: (a) He I λ5876 triplet; (b) He I λ6678 singlet.

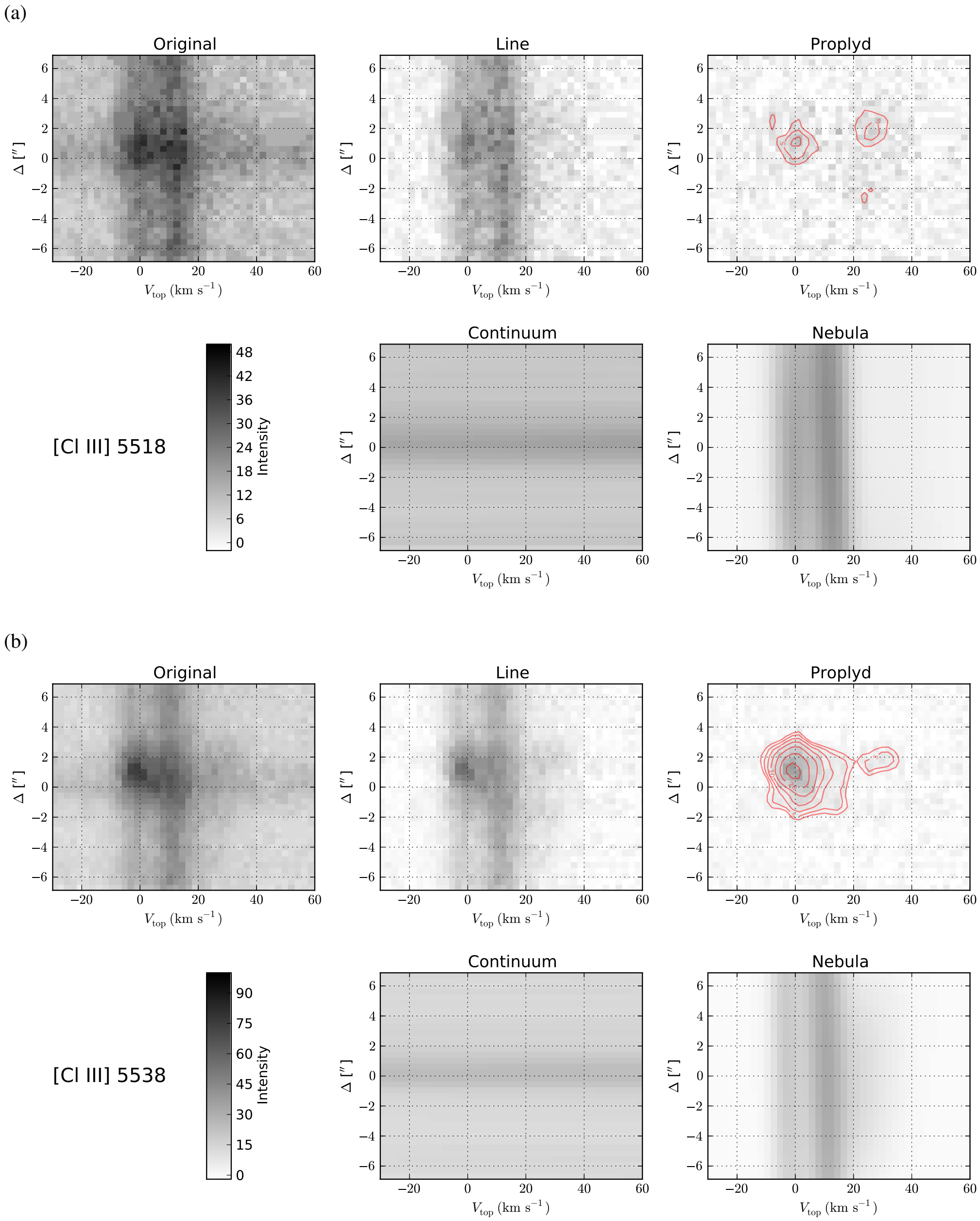


Figure 3. Collisionally excited lines of doubly ionized chlorine: (a) [Cl III] λ5518; (b) [Cl III] λ5538.

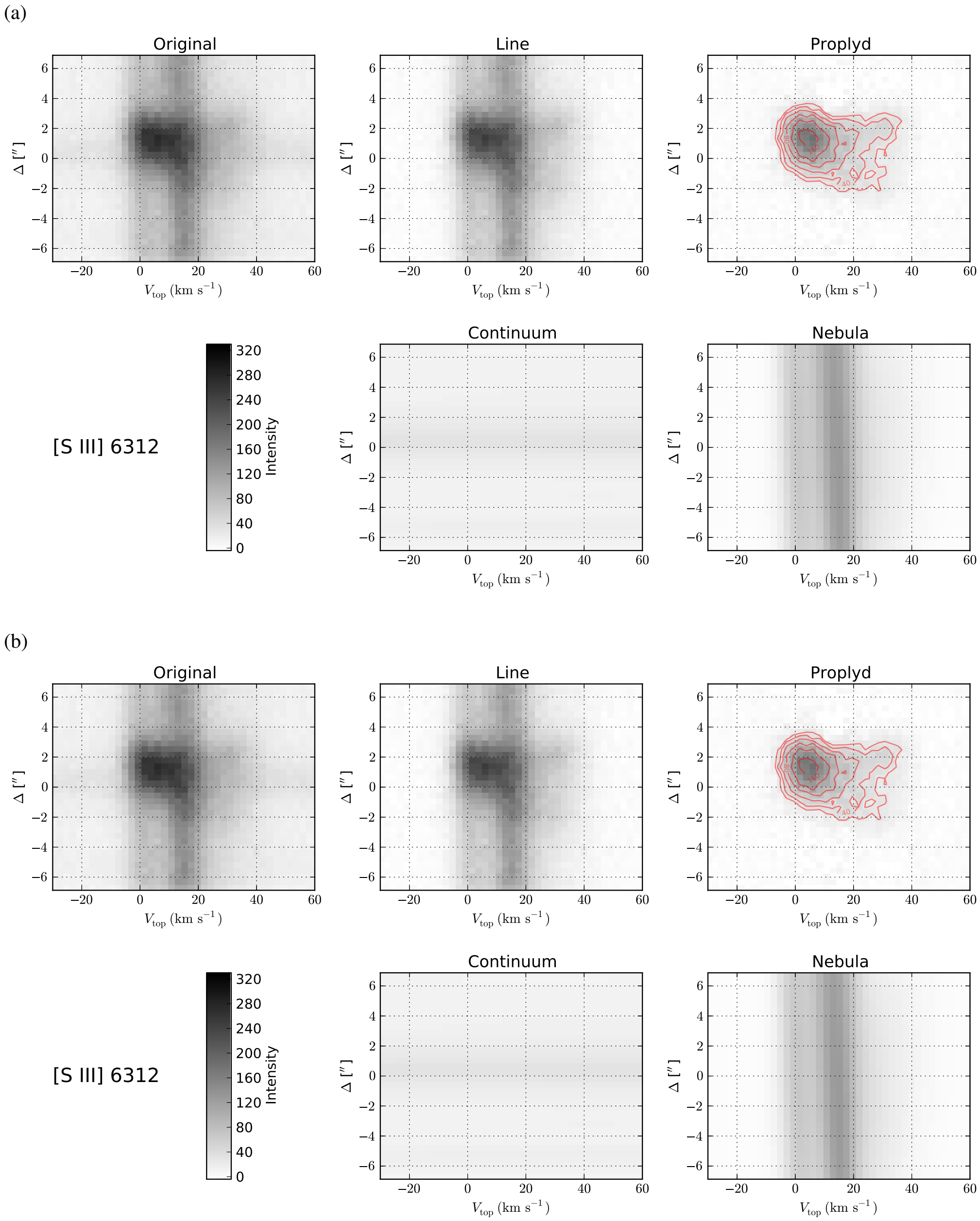


Figure 4. Collisionally excited line of doubly ionized sulfur: [S III] $\lambda 6312$.

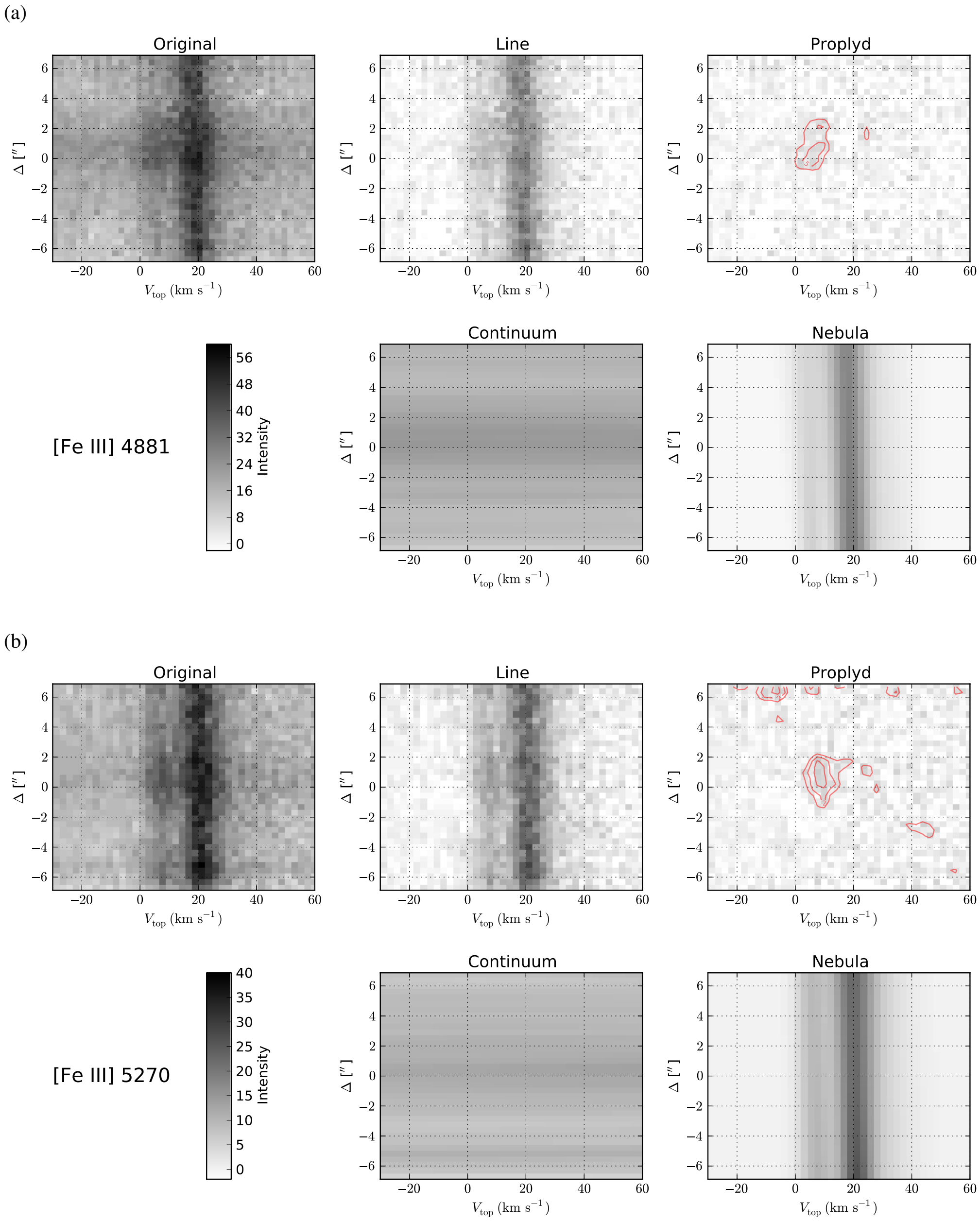


Figure 5. Collisionally excited lines of doubly ionized iron: (a) [Fe III] $\lambda4881$; (b) [Fe III] $\lambda5270$.

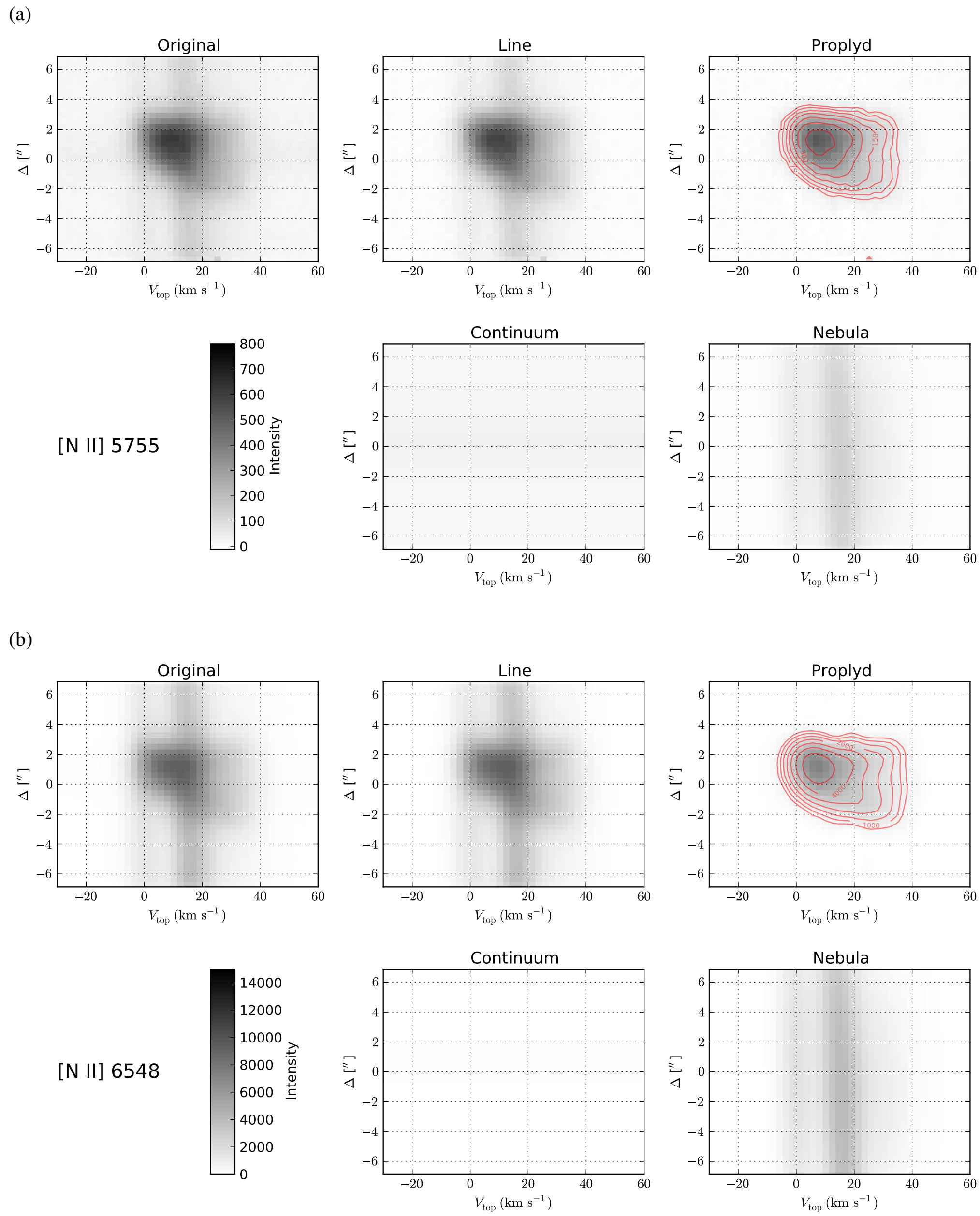


Figure 6. Collisionally excited lines of singly ionized nitrogen: (a) [N II] λ5575 auroral line; (b) [N II] λ6548 nebular line.

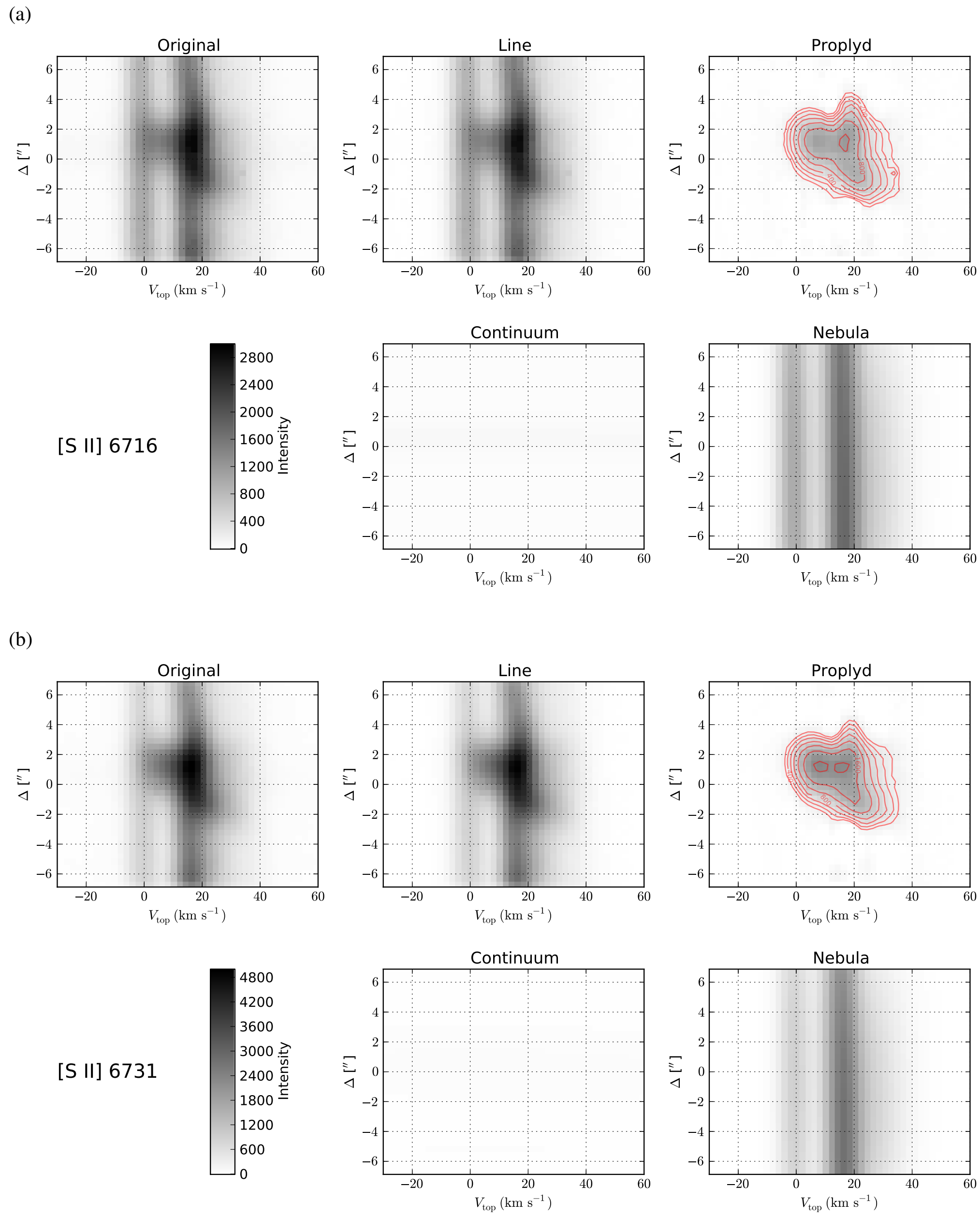


Figure 7. Collisionally excited lines of singly ionized sulfur: (a) [S II] λ6731; (b) [S II] λ6716.

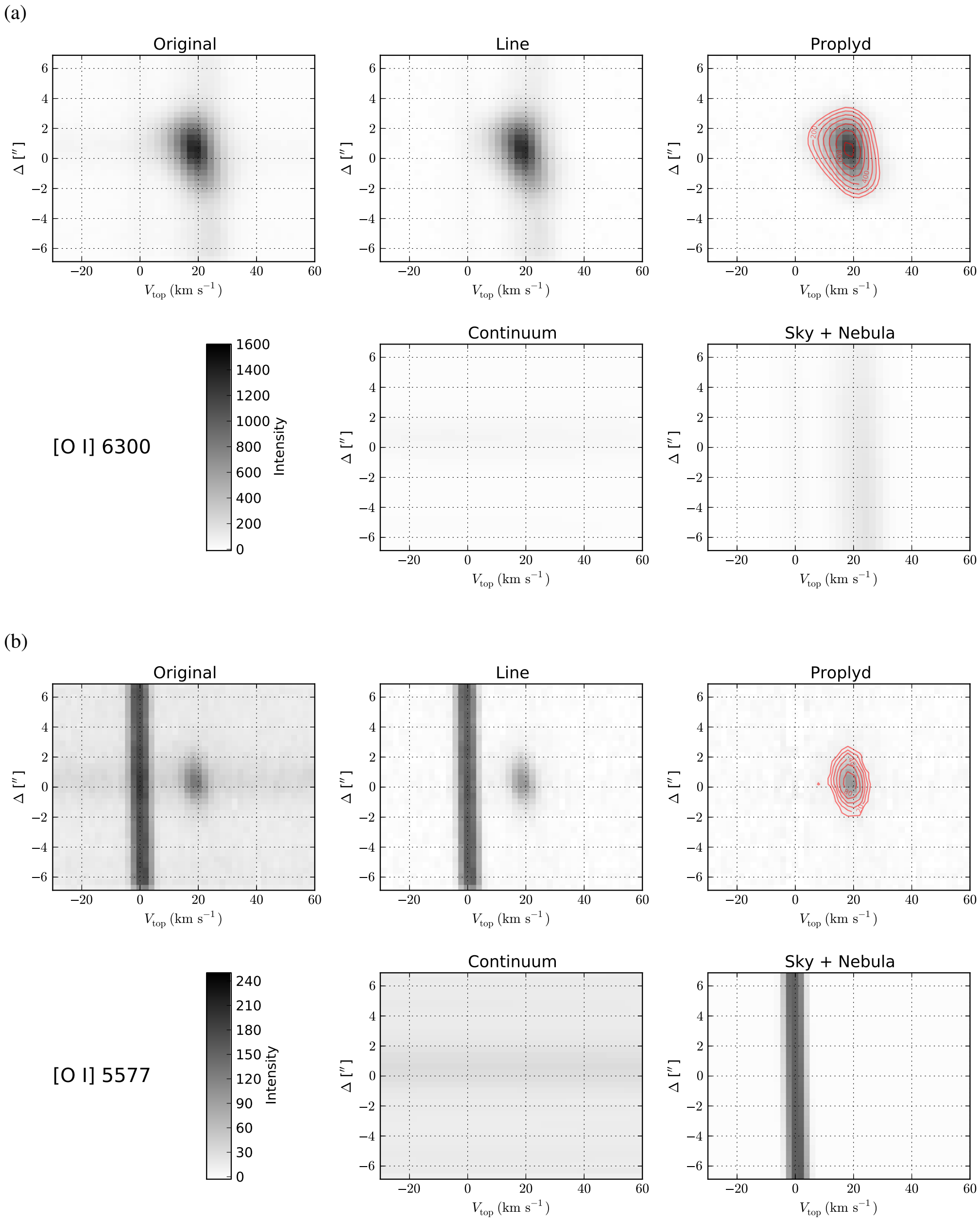


Figure 8. Collisionally excited forbidden lines of neutral oxygen: [O I] $\lambda 6300$ and $\lambda 5577$

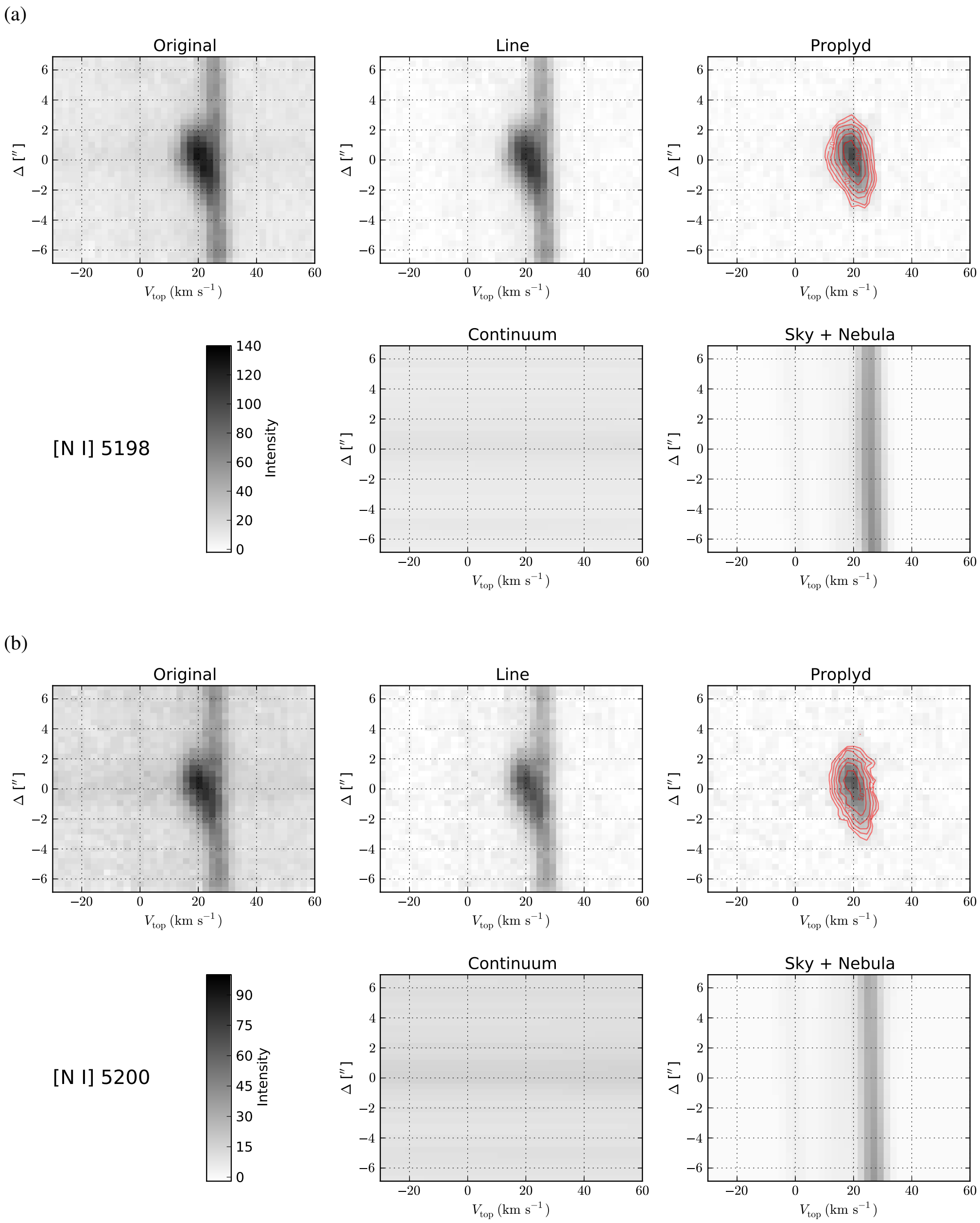


Figure 9. Continuum fluorescence-excited forbidden lines of neutral nitrogen: [N I] $\lambda\lambda 5198, 5200$

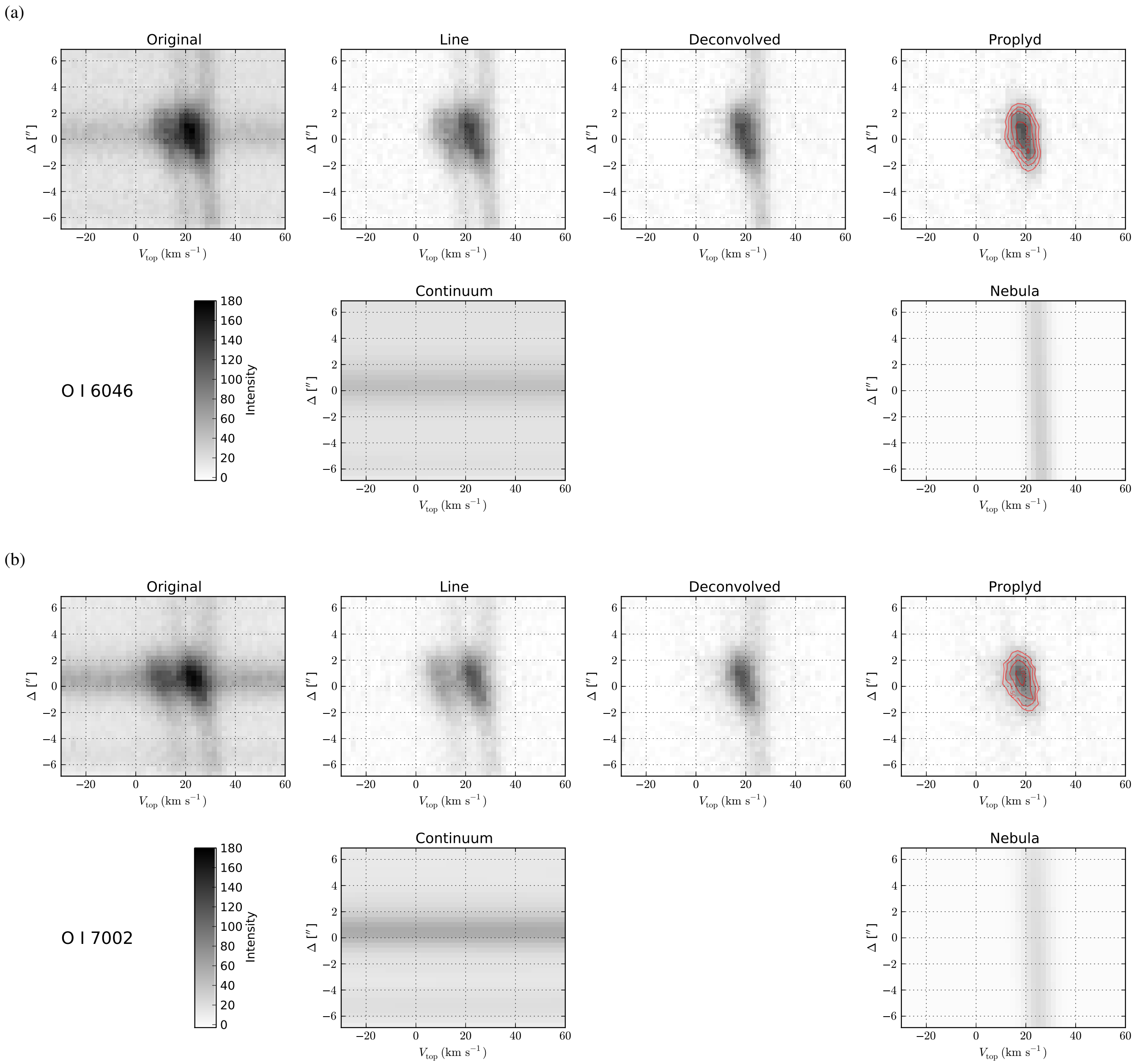


Figure 10. Continuum fluorescence-excited forbidden lines of neutral oxygen: [O I] λ6046 and λ7002.

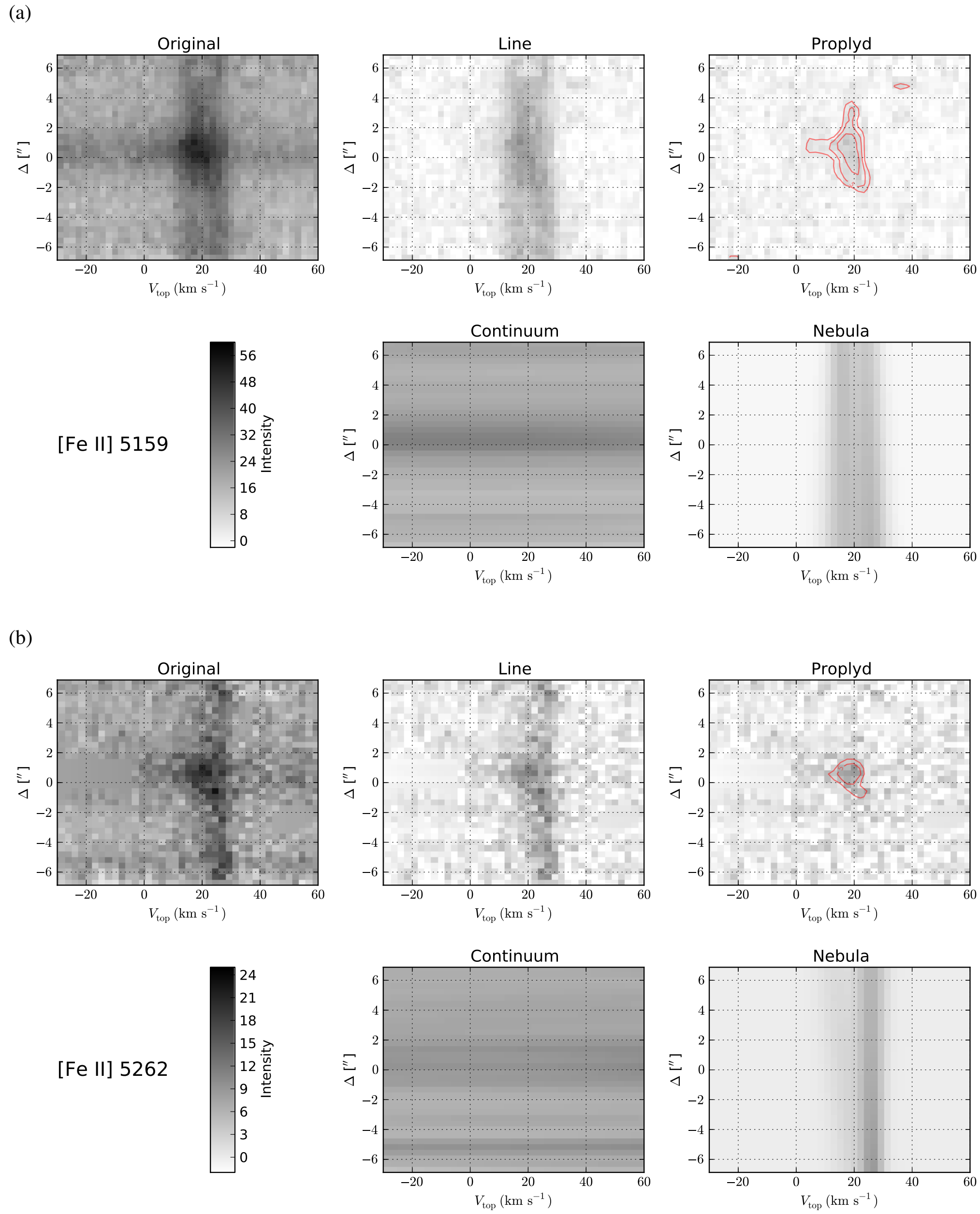


Figure 11. Continuum fluorescence-excited forbidden lines of singly-ionized iron: [Fe II] λ5159 and λ5262.

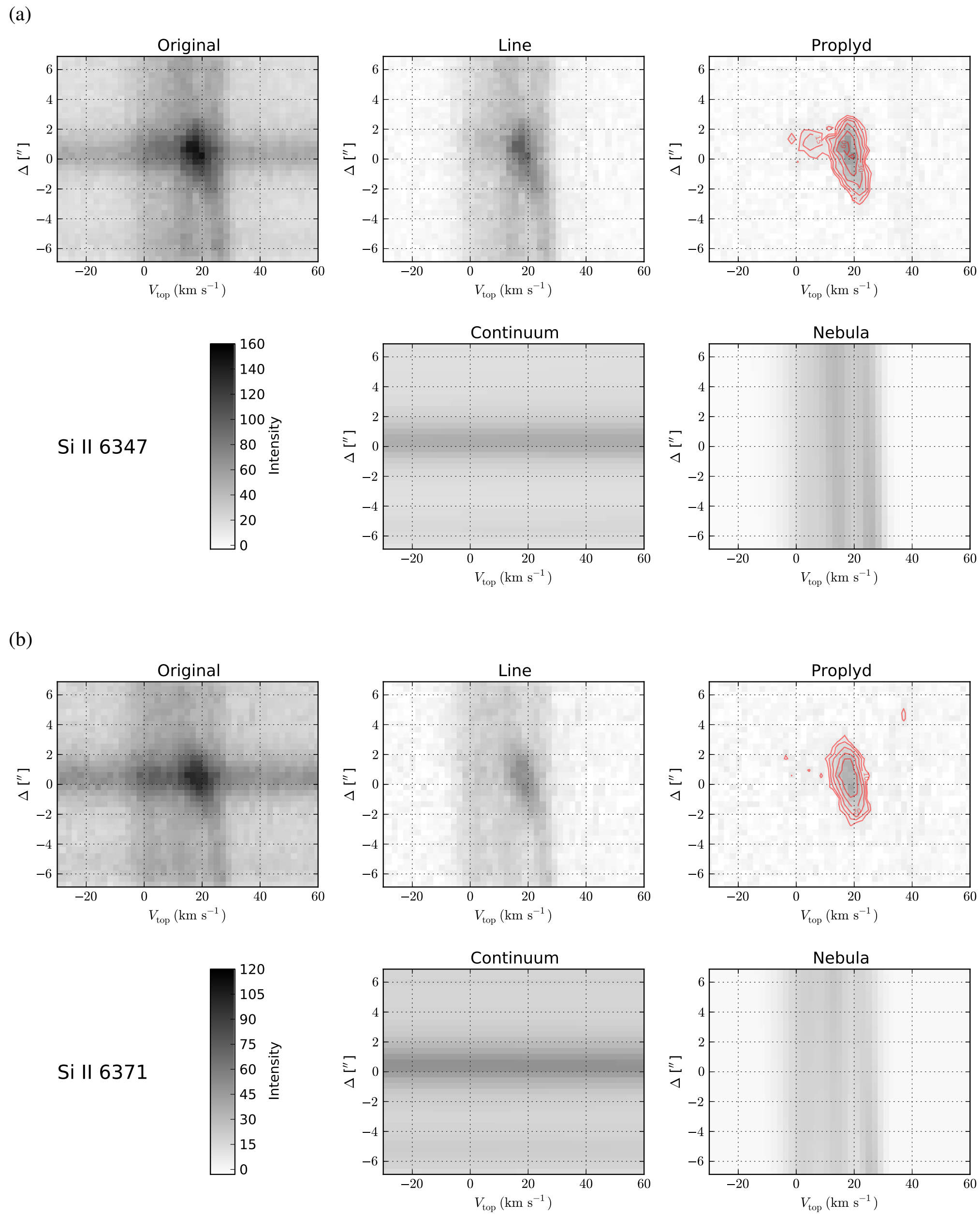


Figure 12. Continuum fluorescence/recombination-excited permitted lines of singly-ionized silicon: Si II λ6347 and λ6371.

4 MORE SAMPLE RESULTS: 244-440 SLIT 85

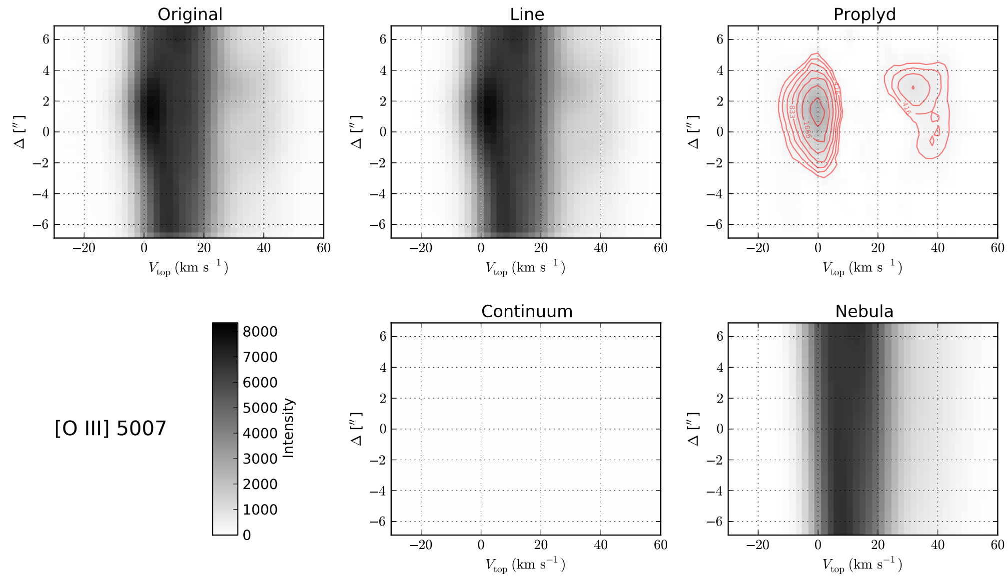
ACKNOWLEDGEMENTS

WJH and NFF acknowledge financial support from DGAPA-UNAM through project PAPIIT IN102012 and from a postdoctoral fellowship to NFF.

References

Henney W. J., O'Dell C. R., 1999, AJ, 118, 2350

(a)



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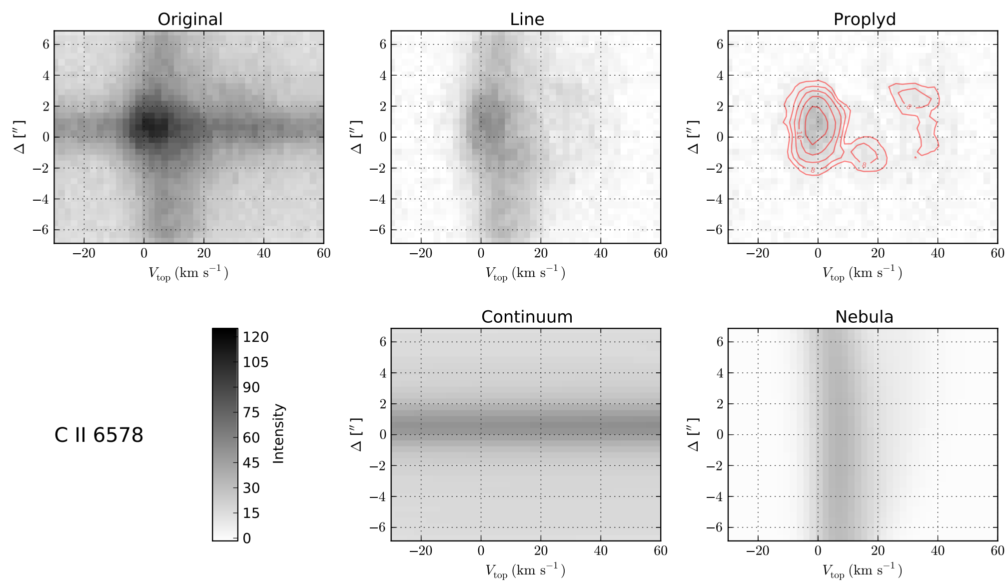
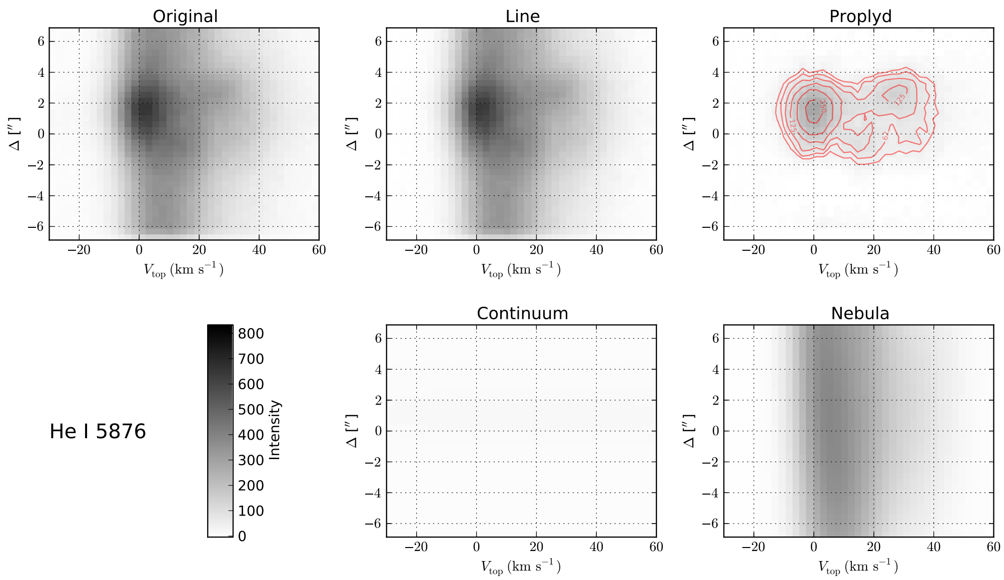


Figure 13. (a) Collisionally excited forbidden line of doubly ionized oxygen: [O III] λ5007. (b) Recombination line of singly ionized carbon: C II λ6578

(a)



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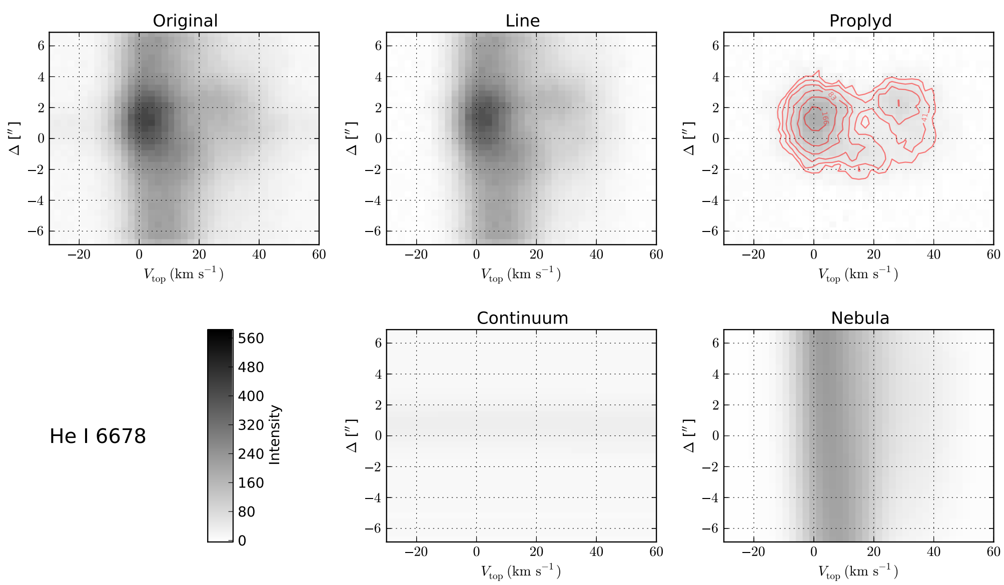
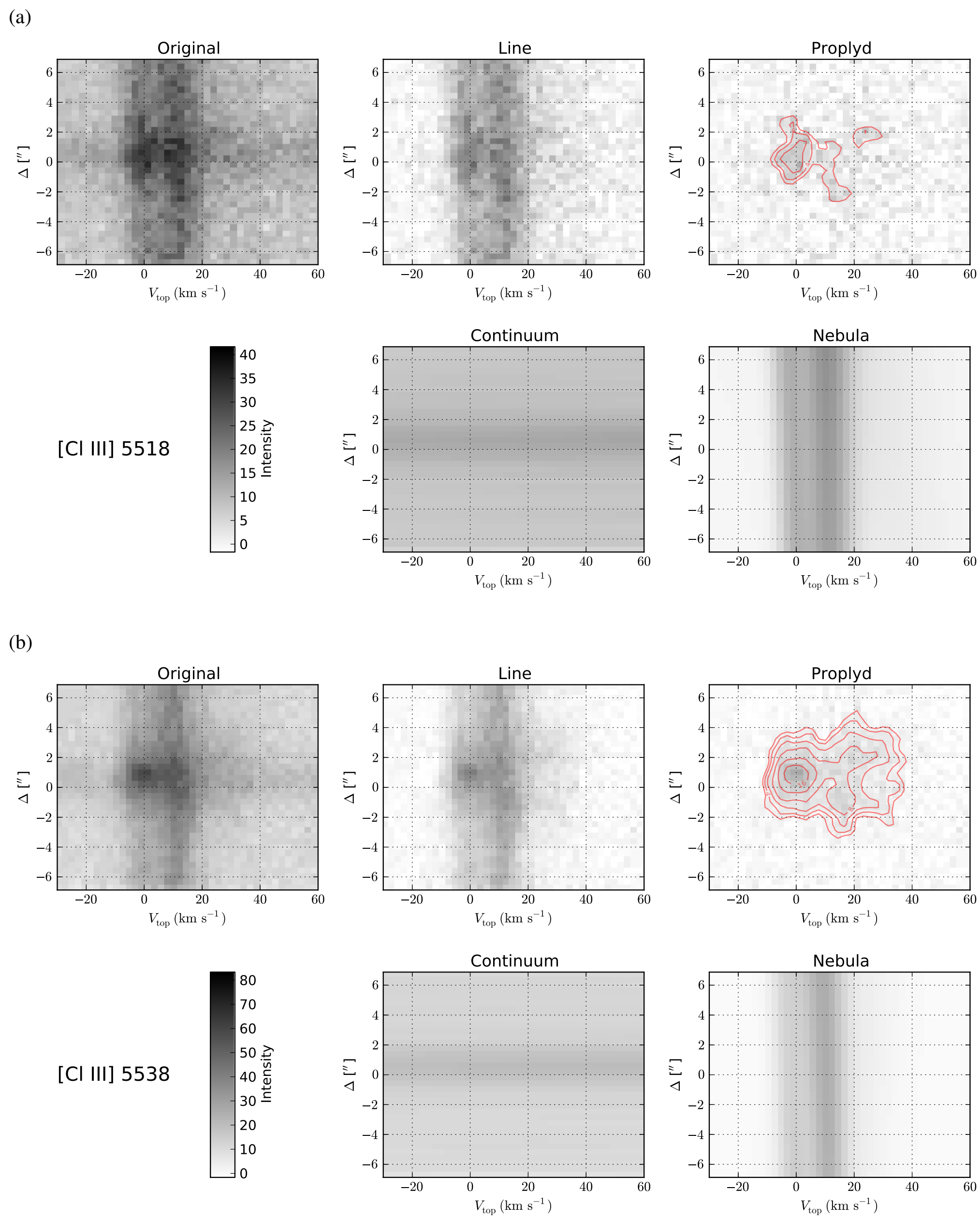


Figure 14. Recombination lines of neutral helium: (a) He I λ5876 triplet; (b) He I λ6678 singlet.



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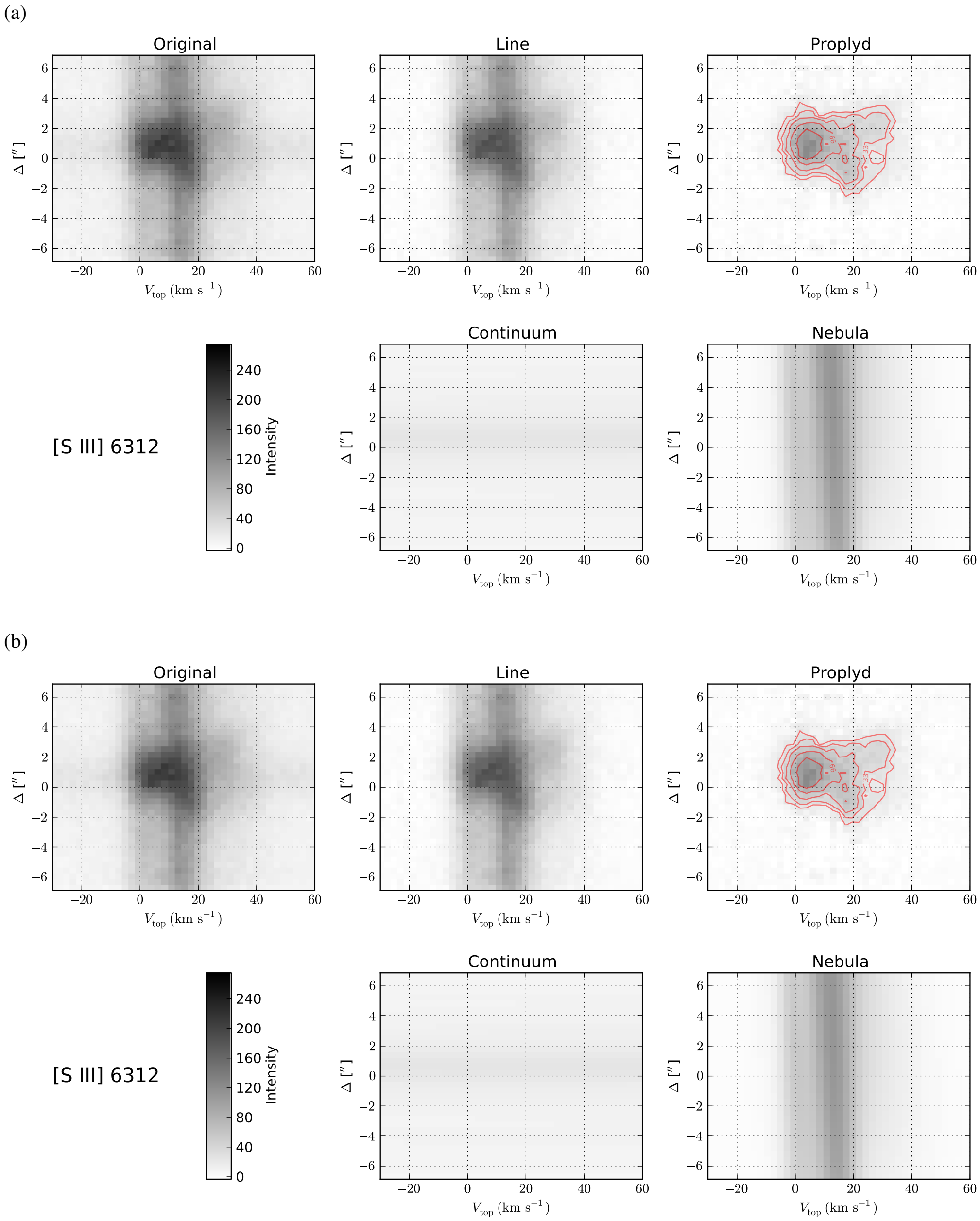


Figure 16. Collisionally excited line of doubly ionized sulfur: [S III] $\lambda 6312$.

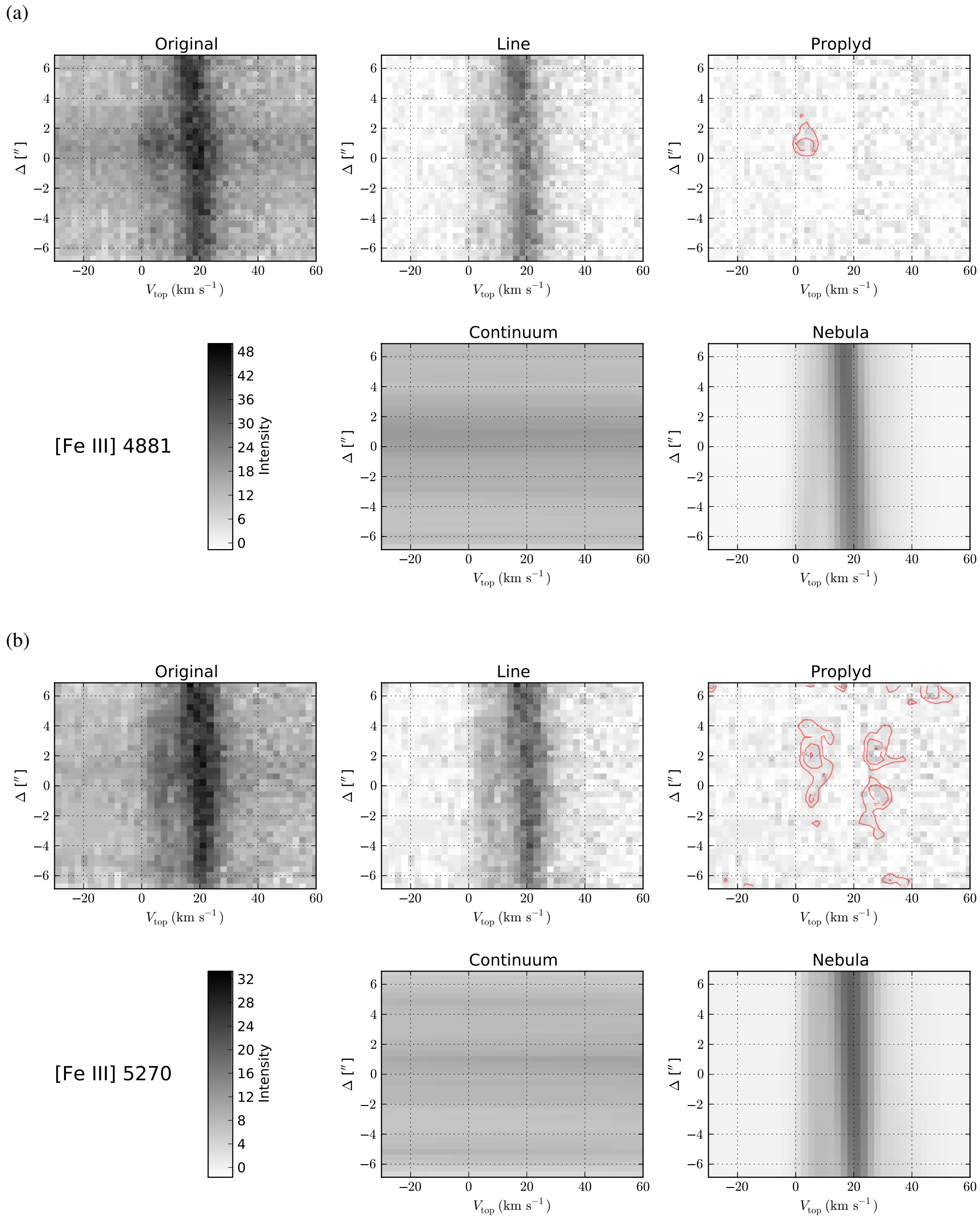


Figure 17. Collisionally excited lines of doubly ionized iron: (a) [Fe III] λ4881; (b) [Fe III] λ5270.

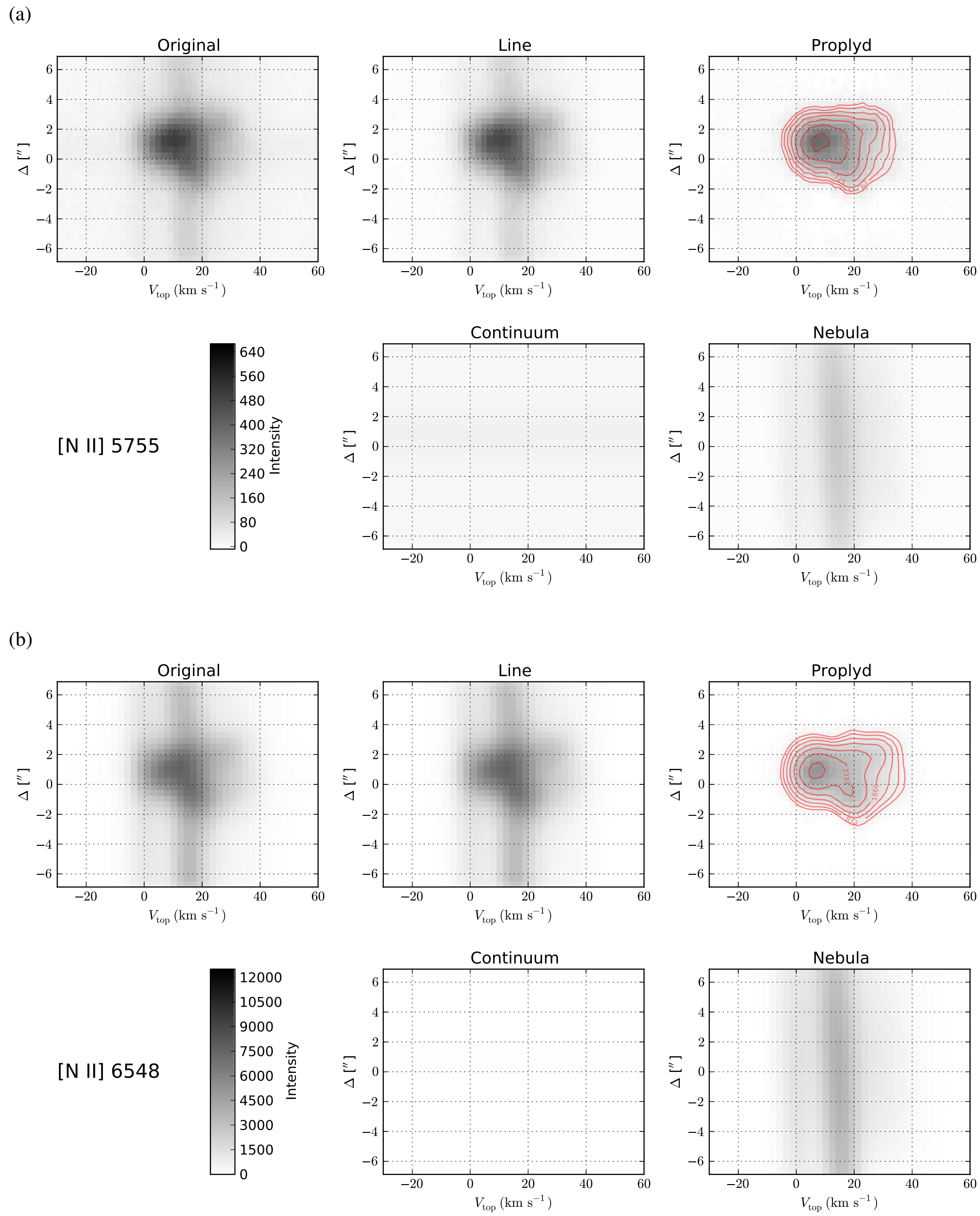
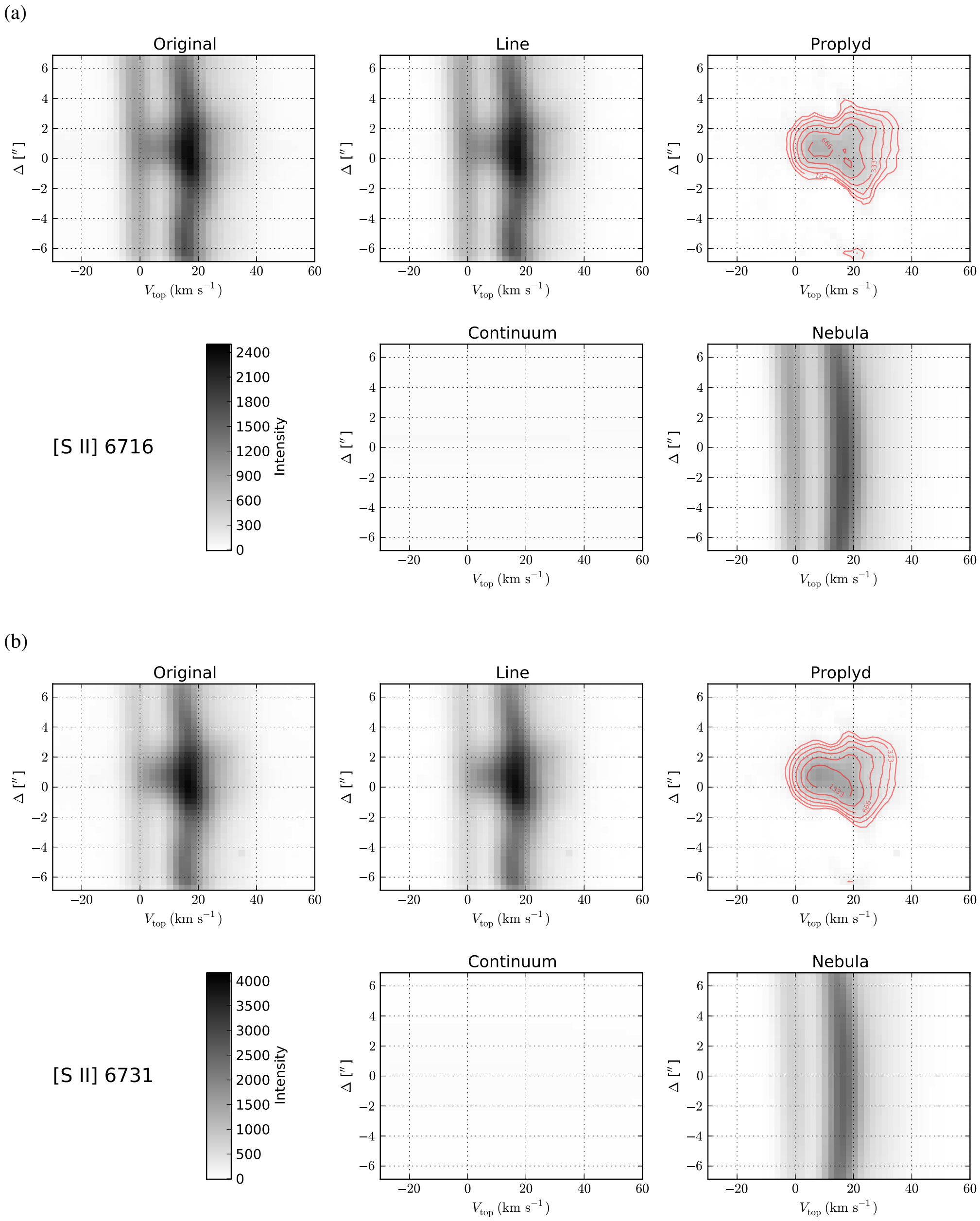


Figure 18. Collisionally excited lines of singly ionized nitrogen: (a) [N II] λ5575 auroral line; (b) [N II] λ6548 nebular line.



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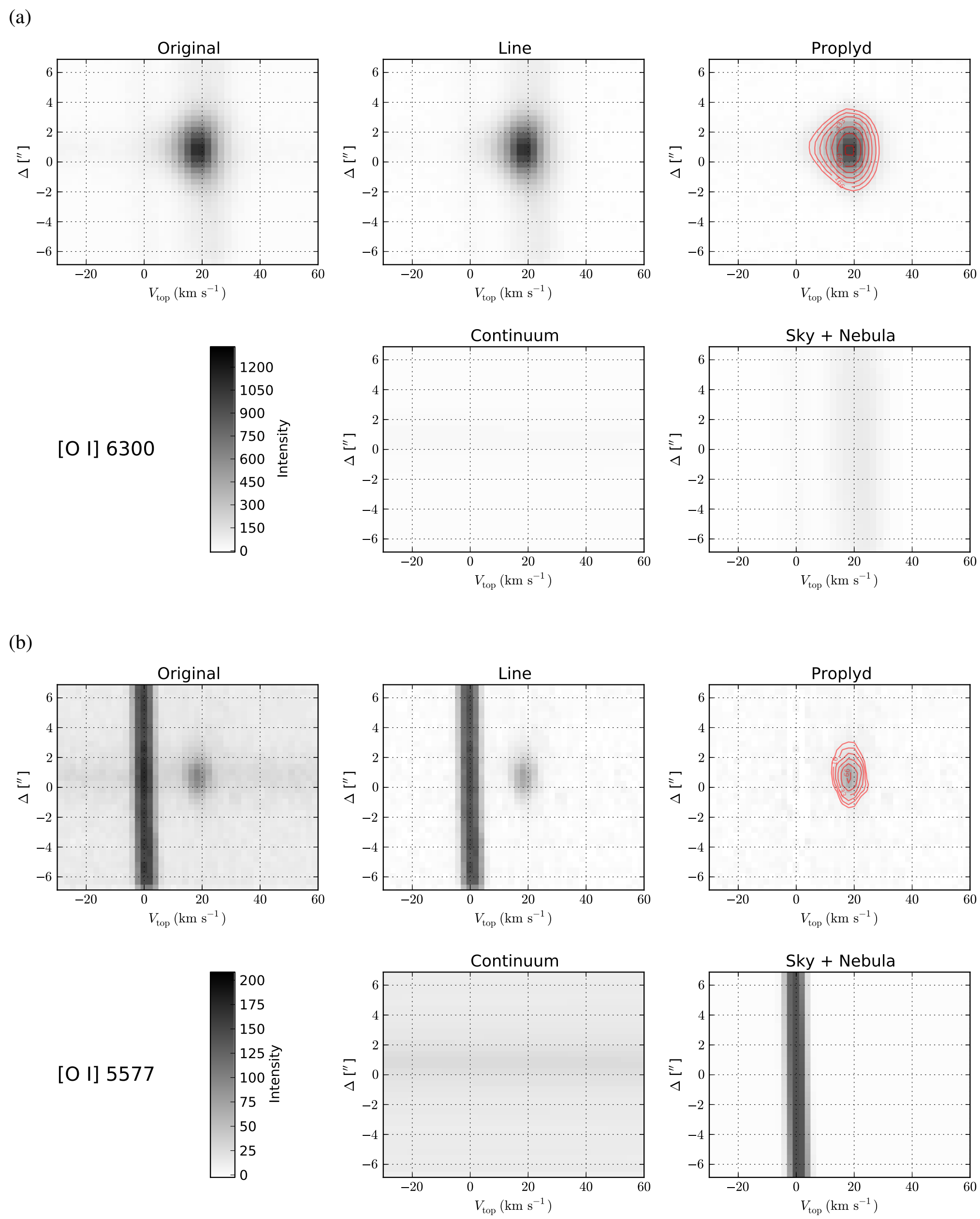
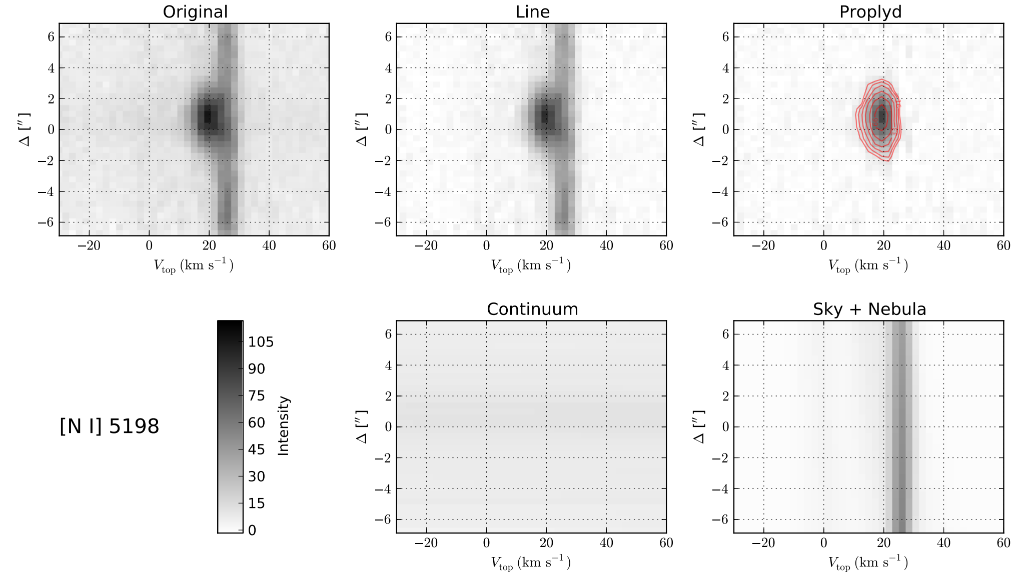


Figure 20. Collisionally excited forbidden lines of neutral oxygen: [O I] $\lambda 6300$ and $\lambda 5577$

(a)



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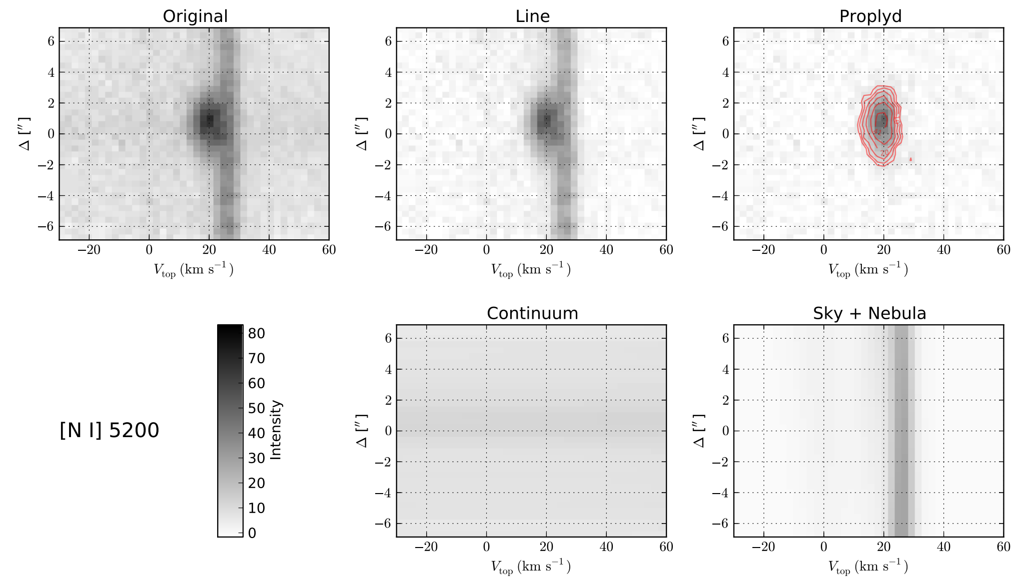
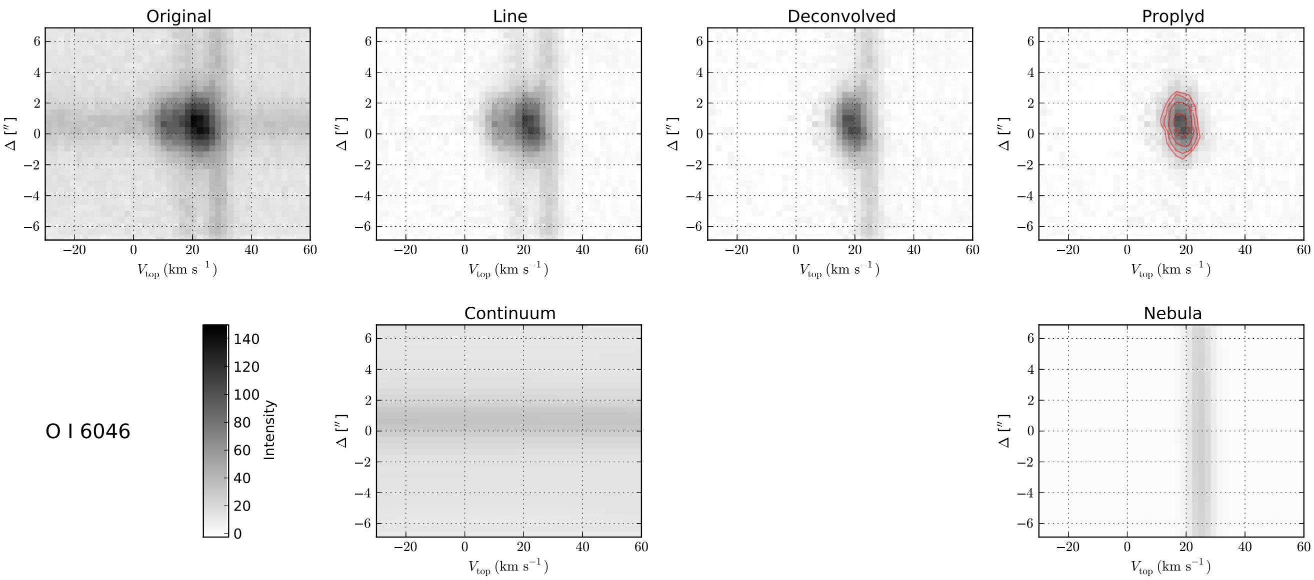


Figure 21. Continuum fluorescence-excited forbidden lines of neutral nitrogen: [N I] $\lambda\lambda 5198, 5200$

(a)



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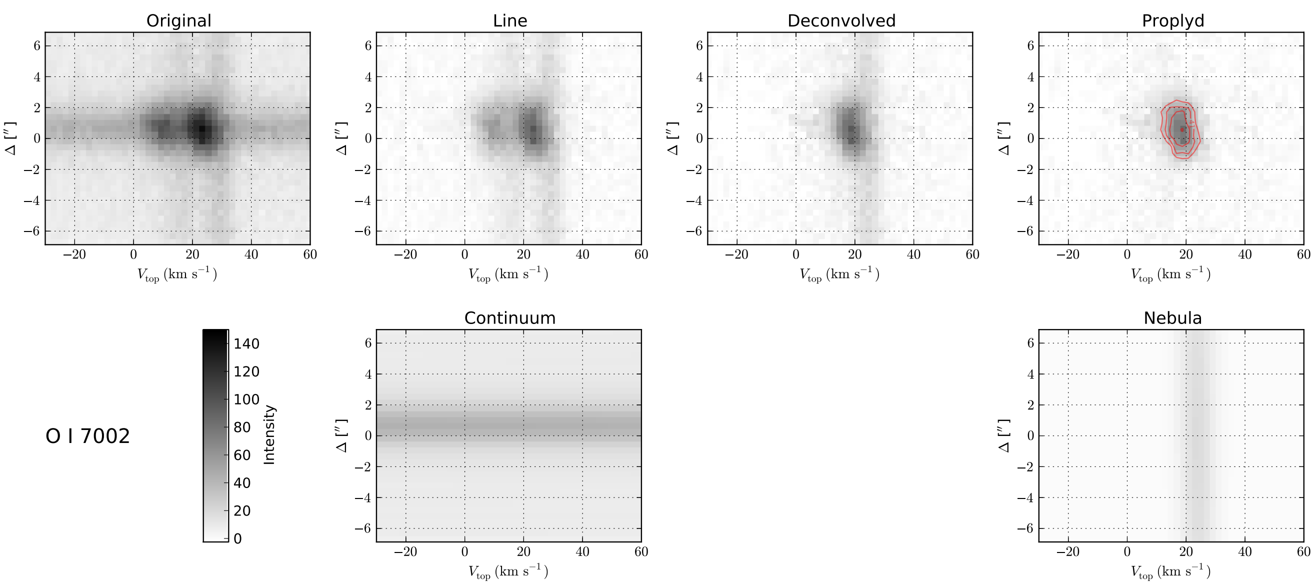

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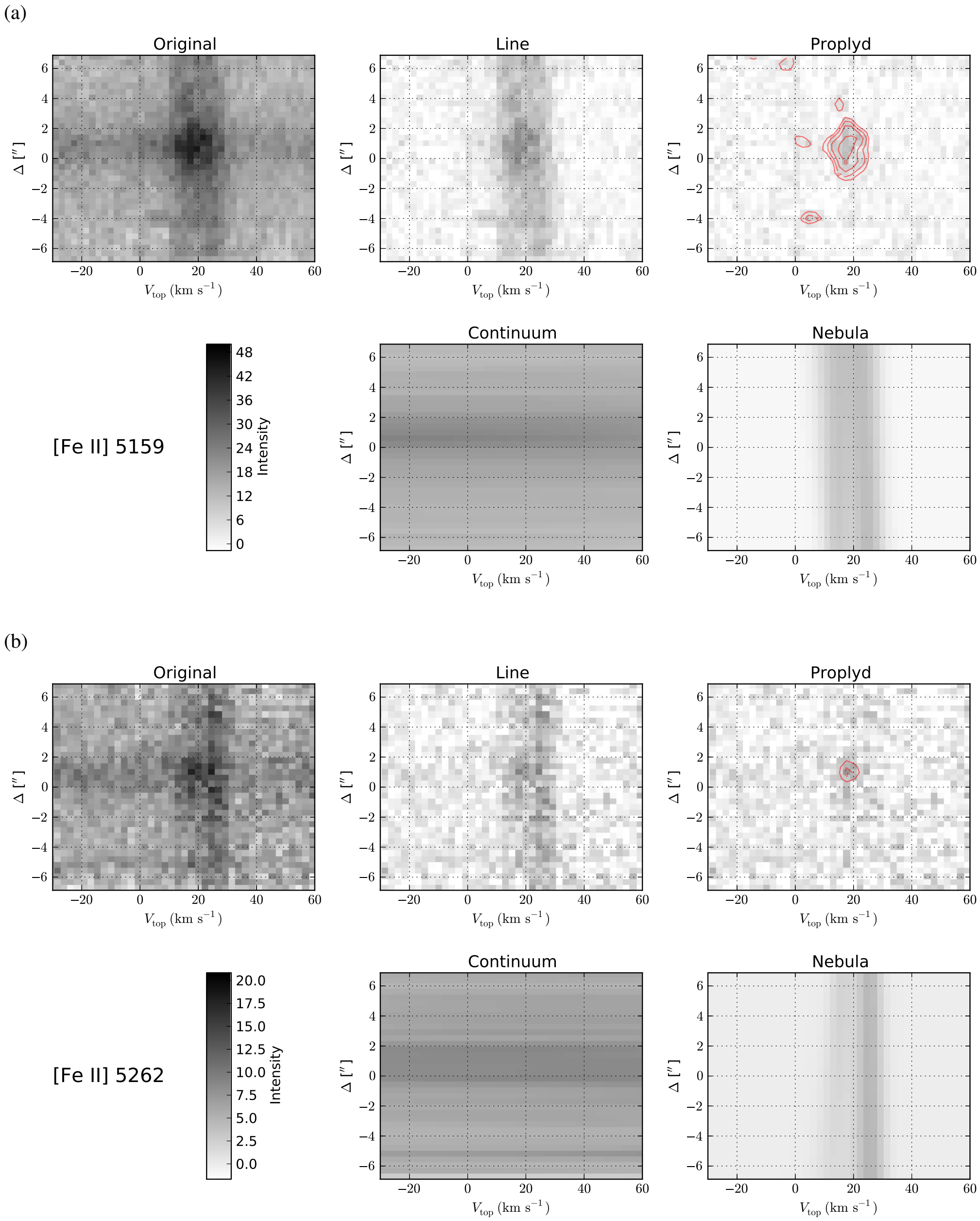

Figure 23. Continuum fluorescence-excited forbidden lines of singly-ionized iron: [Fe II] λ5159 and λ5262.

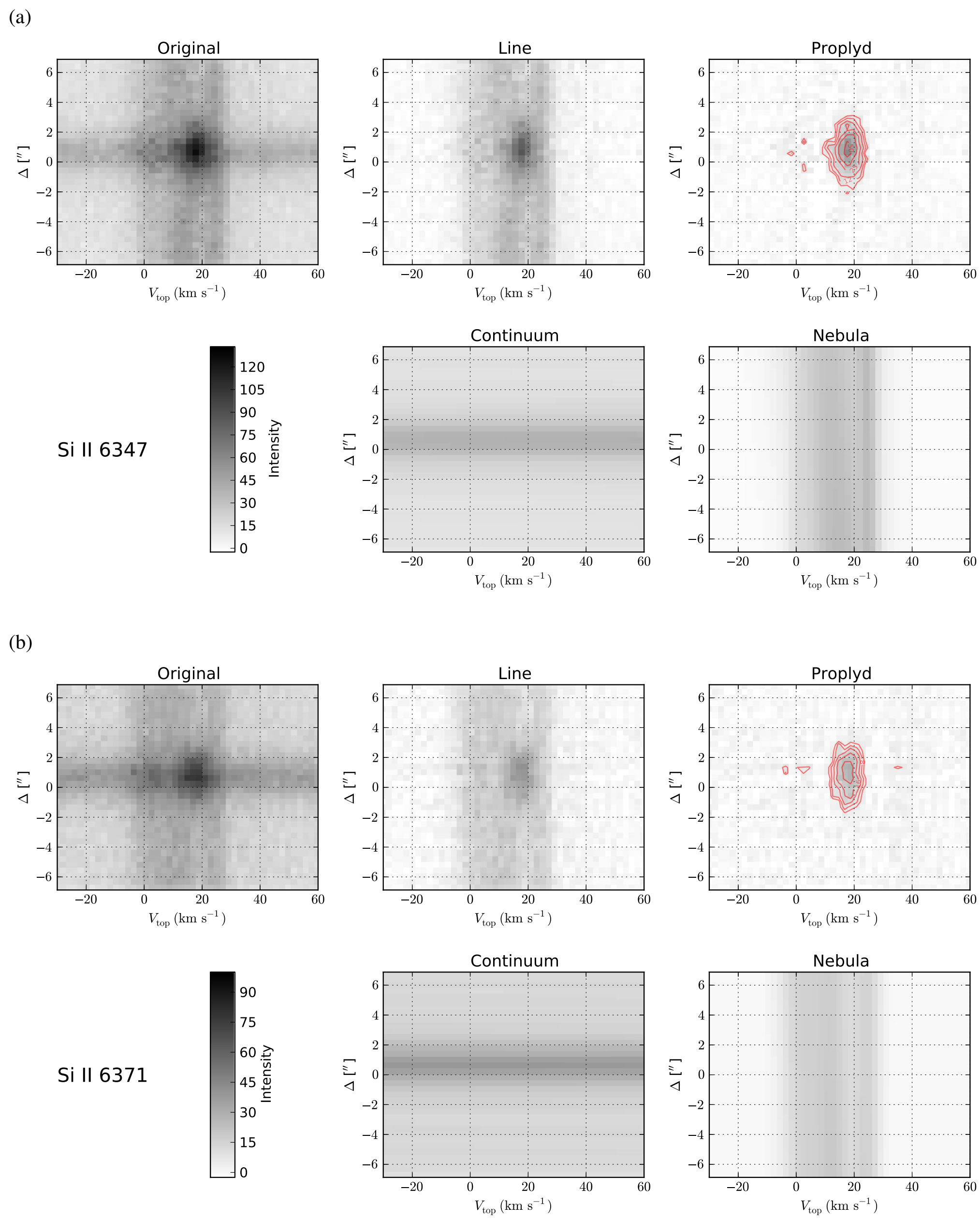

Figure 24. Continuum fluorescence/recombination-excited permitted lines of singly-ionized silicon: Si II $\lambda6347$ and $\lambda6371$.