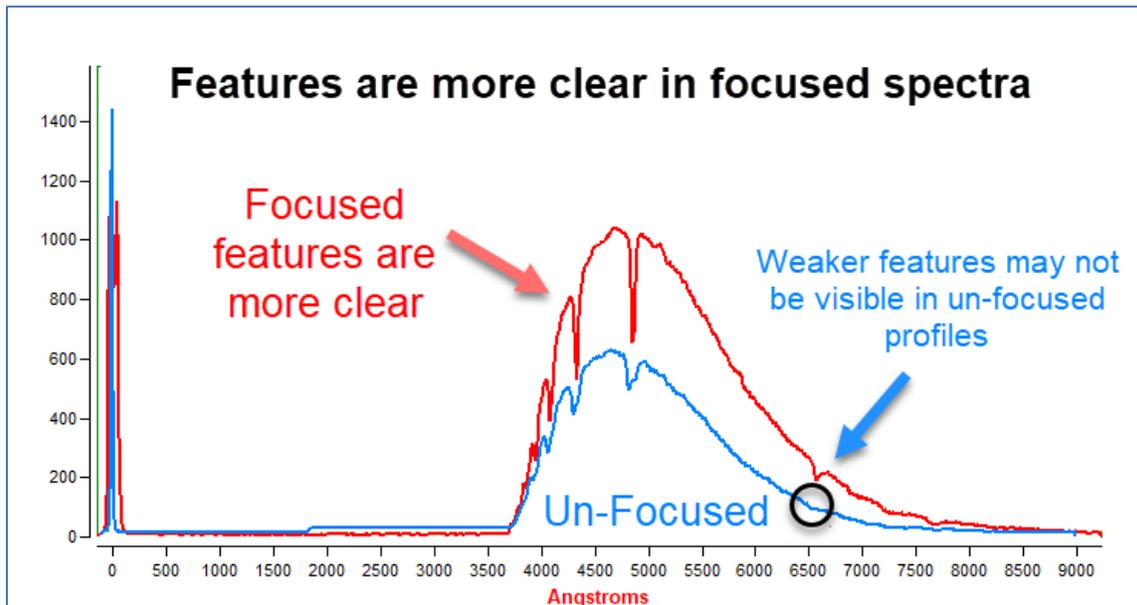


## How does incorrect focus affect a spectrum profile?

The image below shows two profiles of the same Type A star.

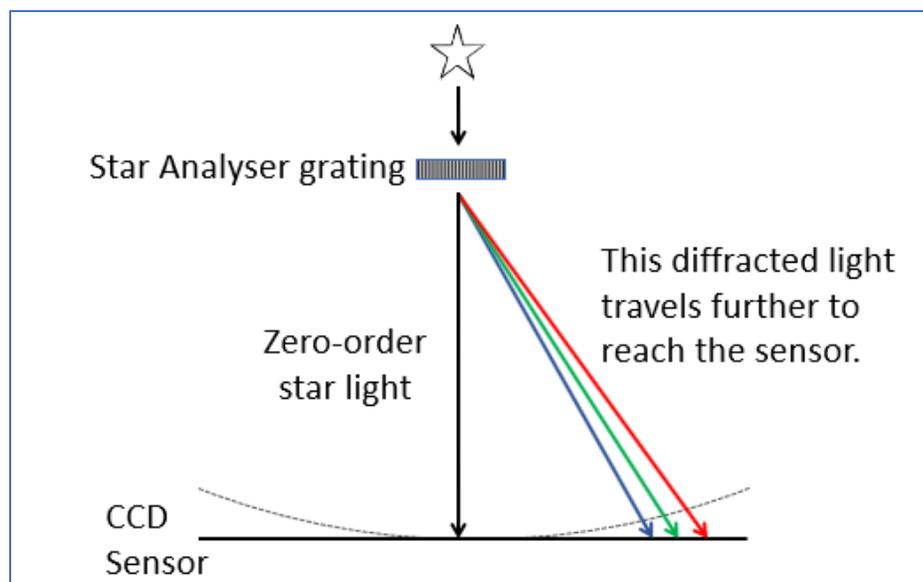
The red profile is the correctly focused spectrum. Features are sharp and deep.

The blue profile was captured without proper focus. Features are weak, distorted or missing.



## Why is the focus for a spectrum different than its zero-order star?

Diffracted light travels further to reach the CCD than the zero-order star light. The different longer light path requires different focus.



Achieving proper focus on a spectrum captured with a slit-less device can be a challenge. If you focus on the star, the spectrum will not be in focus.

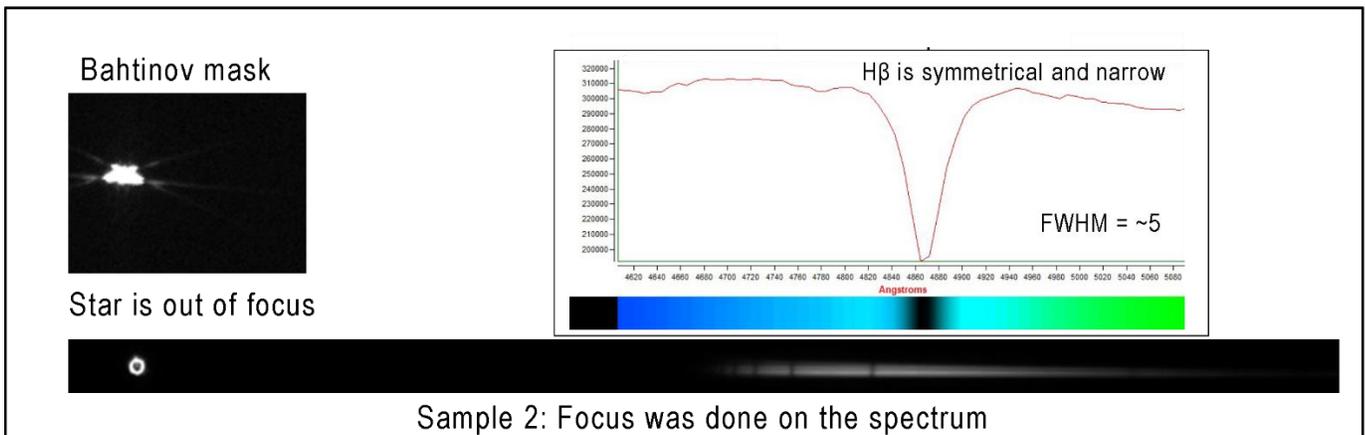
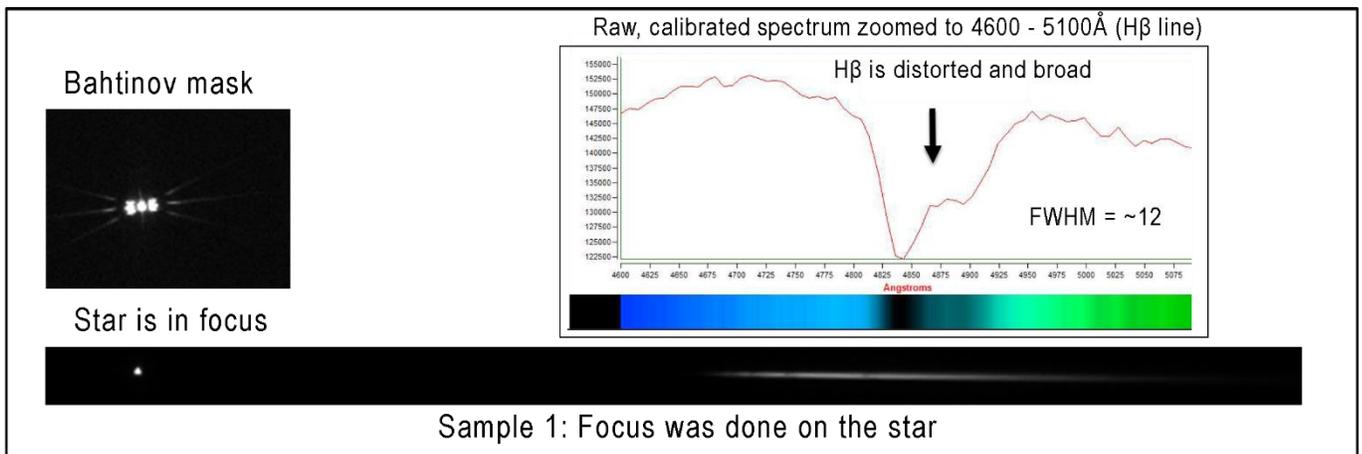
The two samples below were captured with different focus settings.

The first sample is focused on the star using a Bahtinov mask. Examining the profile graph, we can see that the H $\beta$  line is distorted. It's overly wide and has a small "bump" on the right.

The second sample is focused on the spectrum. Even though the star is out of focus, the H $\beta$  line is narrow and symmetrical with a lower FWHM.

Recommended focusing technique: initially focus on the zero order star. Then gradually adjust focus for the sharpest features in the profile graph.

Provided your equipment configuration hasn't changed, the amount you have to de-focus from the zero order star to get best spectrum will be the same for all targets. Make a note how much you have to defocus for the best spectrum profile. On subsequent spectra of any star type, you can first focus on the star and then simply de-focus that same amount.



**If you use a Bahtinov mask**, here's a focusing technique: By trial and error, find the best spectrum focus point with a bright A-type star like Vega, which has strong, easily visible hydrogen Balmer absorption lines. Then place the Bahtinov mask on the telescope and capture the appearance of the zero order image (similar to the Bahtinov masked image in sample 2 on the previous page.) With this reference image in hand, you can start every new observing session by first finding any bright star. Place the Bahtinov mask on the telescope and adjust the focus until the zero order image matches the reference. The spectrum is now in focus and you can move on to your targets for the night (just don't forget to remove the Bahtinov mask!).

(Note that the focus of your telescope may drift with temperature changes so it is a good idea to let your telescope cool down first and if the temperature changes significantly during the night you may need to readjust your focus)

Concept and sample data courtesy of Hugh Allen. Vega Captured with an 8" Meade LX90 at f/10, with a Star Analyser 200 threaded onto the nosepiece of an Atik314L monochrome CCD camera to give a spectral dispersion of 7.4 Å/pixel