





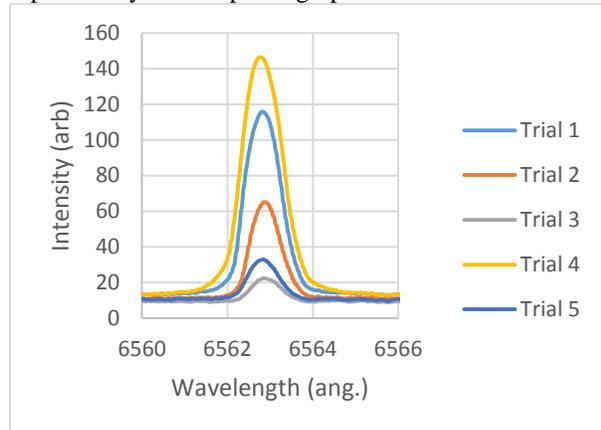
lines to the camera with the use of a business card. Finally, the camera is switched to video mode and the last distance adjustments can be made while watching the camera's LCD screen (to ensure the best possible focus).

This spectrograph bears many similarities to grazing incidence spectrograph used to record ultra violet light.<sup>3</sup> However, there are differences. The grazing incidence spectrographs in common use do not have an achromat collimating lens and the gratings used are concave which eliminates the need for focusing optics. These changes allow this spectrograph to work well within the visible region and provide good results that undergraduates can assemble in lab.

## RESULTS

By taking a photograph, rotating the grating by half a degree, taking another photograph, and then continuing the process, we can record the entire visible spectrum. Features on one photograph align with features from preceding and subsequent photos. In this way a grand compilation of the entire spectrum is formed.

We have also found that replacing or moving the light source has minimal effect on the data. Thus, by using a well-known spectrum like neon we can calibrate our results. Figure 5, shown below, helps illustrate the repeatability of our spectrograph.

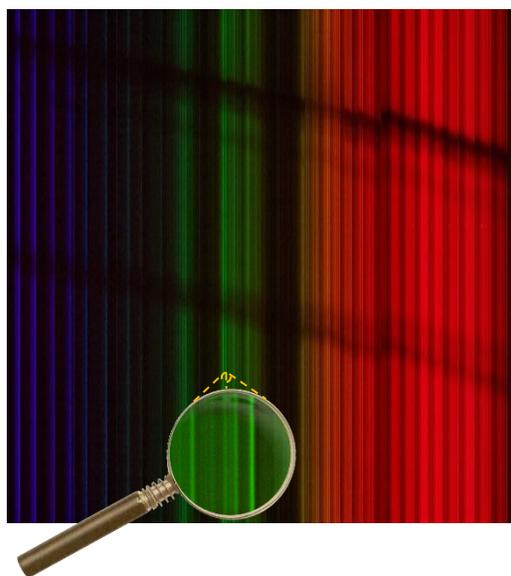


**FIGURE 5.** Multiple traces of Hydrogen's red Balmer line. Between each trial, the light source was replaced and moved. The traces shown above help illustrate the reliability of each photograph. The horizontal axis is based upon a separate set of photographs of the Neon spectrum. The known wavelength of the red Balmer line was not used for calibration.

Each trace represents a different picture of the hydrogen red Balmer line ( $H-\alpha$  as it is known historically) where the hydrogen source was literally moved and then replaced by a different hydrogen source. All the traces are from photographs which have synchronized pixels, but if one looks deeply enough at the peak location of all

the traces there small differences. The peak location of the traces ranged from a low of 6562.77 angstroms to a high of 6562.87 angstroms. The accepted value of the peak location is 6562.8518 angstroms (with two smaller nearby peaks at 6562.7110 angstroms and 6562.7248 angstroms).<sup>4</sup>

To help demonstrate this spectrograph's capabilities, Figure 6 shows a compilation of nitrogen spectra across the entire visible spectrum. We know the corresponding wavelengths of each of the lines by comparison back to an equivalent neon spectrum. A small portion of the entire spectrum is shown in Fig. 7. This intensity vs. wavelength graph is only a very small piece of the entire spectrum, but it shows all the spectral lines seen inside the magnifying glass.



**FIGURE 6.** Compiled nitrogen spectrum. The broad bands as seen in the larger picture are actually composed of many spectral lines. The "magnifying glass" was added to show some of the finer lines. The small spectral lines seen inside the "magnifying glass" come from the small region illustrated on the larger picture.

