Chapter 8

Preliminary Results

This chapter contains the results of preliminary testing of the spectrograph. Initial alignment and testing, using a diode laser, revealed some severe problems with the prism cross-disperser. The donation of a blazed transmission grating, however, allowed a number of segments of solar spectrum to be recorded.

As mentioned earlier in this paper, the large format TC215 CCD detector is not currently available so a small format camera based on the Texas Instruments TC211 CCD is used. The TC211, which is based on the same virtual phase technology, has similar characteristics to the TC215 except that there are only 192×165 pixels, each $13.75 \times 16 \mu$m in size.

8.1 Diode Laser

Diode lasers, with their very short cavity lengths, have an easily resolvable mode structure over a narrow range of wavelengths. Each individual mode, being essentially monochromatic (line width typically < 0.001Å), was expected to result in an image of the fibre end similar to the theoretical image of Figure 6.6 (binned into pixels of course). The results were abysmal! A brief investigation showed that this was due to the poor optical quality of the cross-dispersing prism. Fortunately the laser spectrum falls entirely within a single order so measurements were possible without the prism (which is now being used as a paper weight).

The CCD image of the diode laser spectrum is shown in Figure 8.1. The effect of the prism can be clearly seen. Figure 8.2 shows the resultant spectrum with the cross-dispersing prism removed.

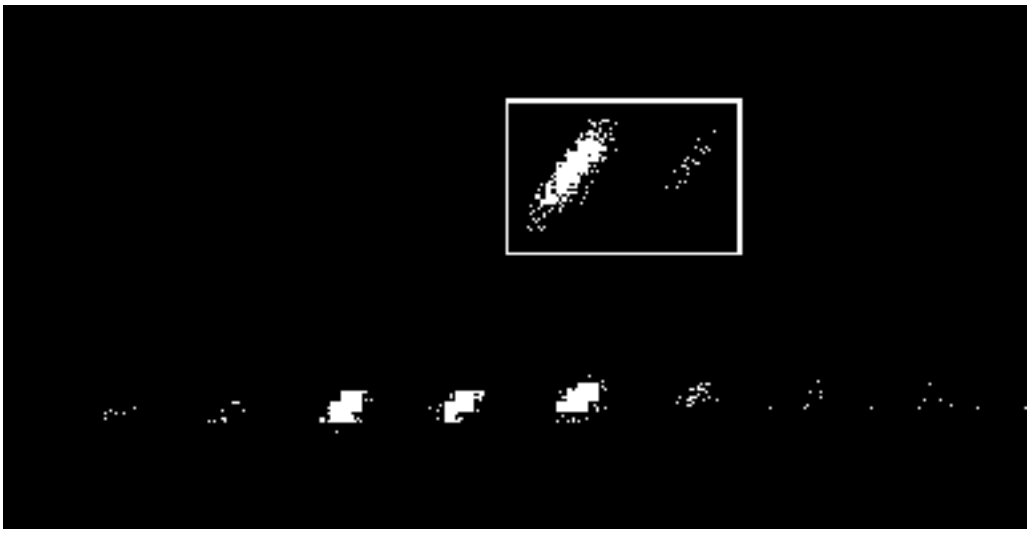

Figure 8.1: Part of CCD image showing the diode laser spectrum without prism. Insert shows similar portion of a CCD image with prism.

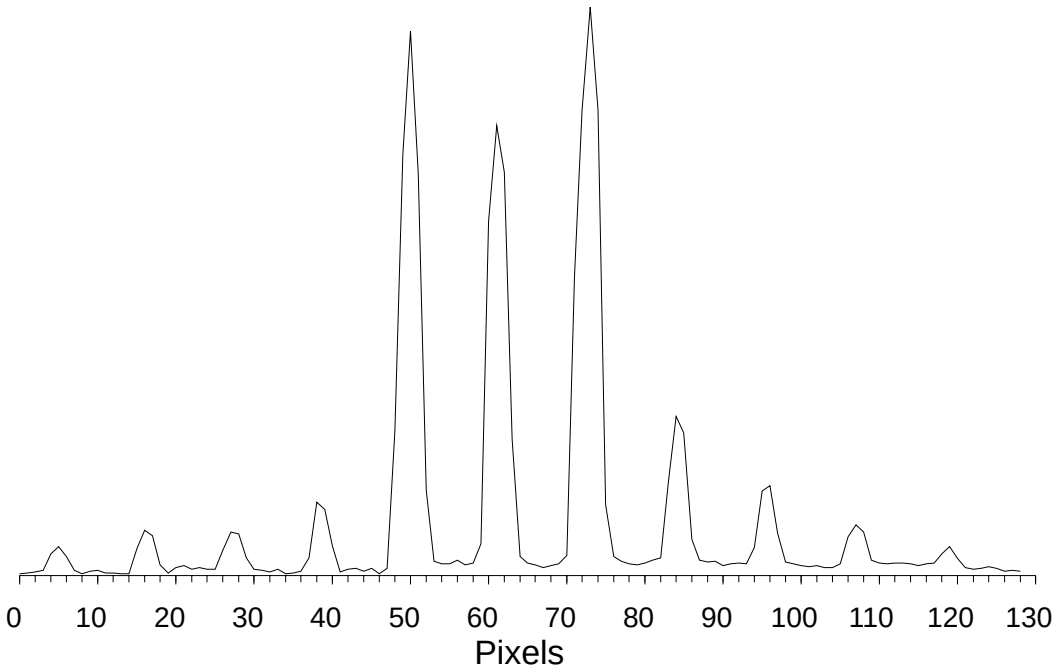

Figure 8.2: Diode laser spectrum (without prism).

With a wavelength of ≈670nm the order number, m, is 53. Using equation 7.4 from Chapter 7, one pixel ≈ 0.16Å. The following values are then derived from Figure 8.2:

- Mode spacing ≈ 1.8Å
- Line width (observed) ≡ resolution ≈ 0.5Å
- Resolving power ≈ 14000

8.2 Solar Spectra

In order to acquire the light from the sun, the input end of the optical fibre was placed near an open window at one end of the laboratory. A small, slightly defocussed lens was used to increase the light intensity in the fibre with tracking done by manual adjustment every 10 minutes. Using the blazed transmission grating to cross-disperse the light after the echelle, a number of parts of the solar spectrum were recorded. A sample CCD image is shown in Figure 8.3 with the sodium **D** lines clearly visible in the top order.

From this and other similar images the following regions of the solar spectrum were extracted:

1. 5887-5897Å: Na **D** lines.
2. 5160-5186Å: Mg / Fe **b** lines.
3. 4400-4432Å (required 2 CCD frames): various Fe & Ca lines.

Each set of data had the mean background level, determined from the “dark" pixels between orders, removed and was then normalised to compensate for variations in spectrograph efficiency. Because the spectra are of low photometric accuracy, as the CCD camera uses an 8 bit ADC, no attempt was made to remove the variations in pixel to pixel sensitivity of the CCD chip by flat fielding. However the data is of sufficient accuracy to demonstrate whether the predicted spectral resolution has been achieved

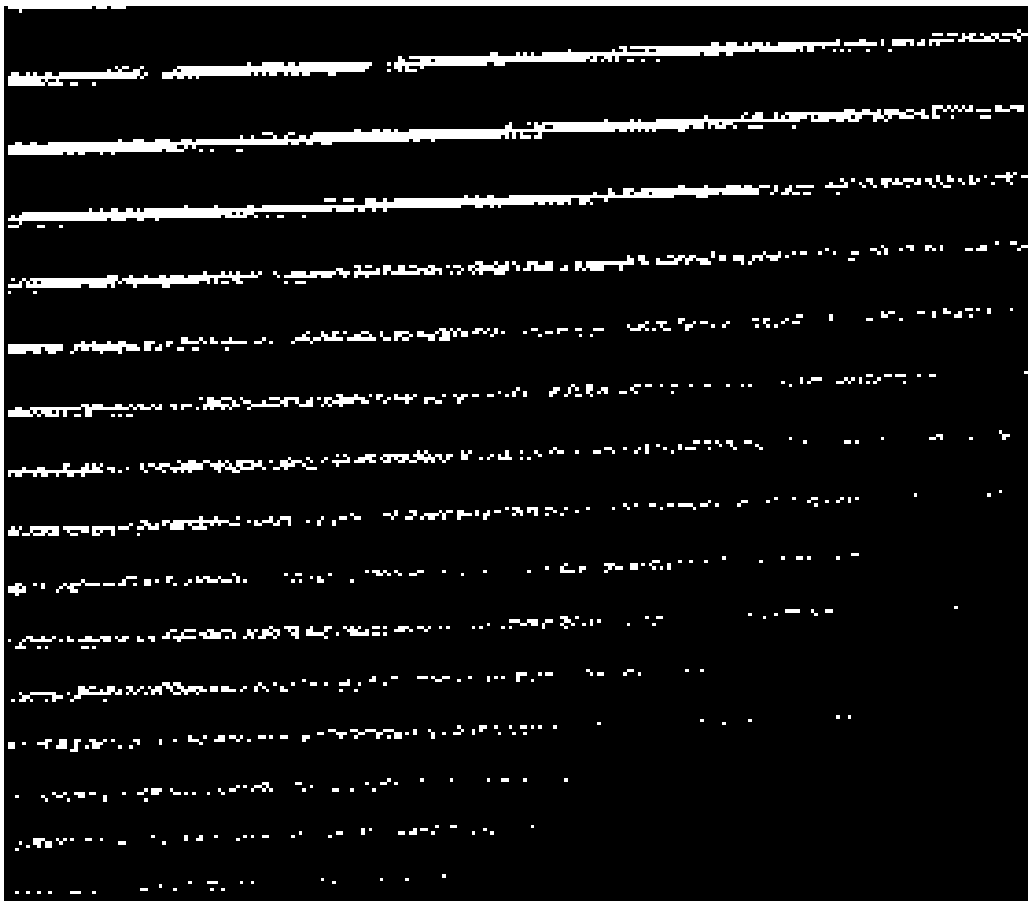

Figure 8.3: CCD image of solar echelle spectrum.

at several wavelengths. Major spectral features were then identified along with their wavelengths and used to extrapolate a full set of wavelength values. Data from the high resolution “Jungfraujoch" Photometric Atlas of the Solar Spectrum [Delbouille et al., 1973] was used for comparison purposes.

Portions of the solar spectrum are plotted in Figures 8.4, 8.5 and 8.6. In each figure the first plot is from the “Jungfraujoch" Atlas at high resolution. This was then convolved with the profile of the fibre image (Figure 7.1 from Chapter 7) to reduce the resolving power to 15000. Finally the corresponding UQES data is shown. As can be seen, from a comparison of the second and third plots in each figure, the resolving power of the prototype UQES is quite near the maximum theoretical value of 15000.

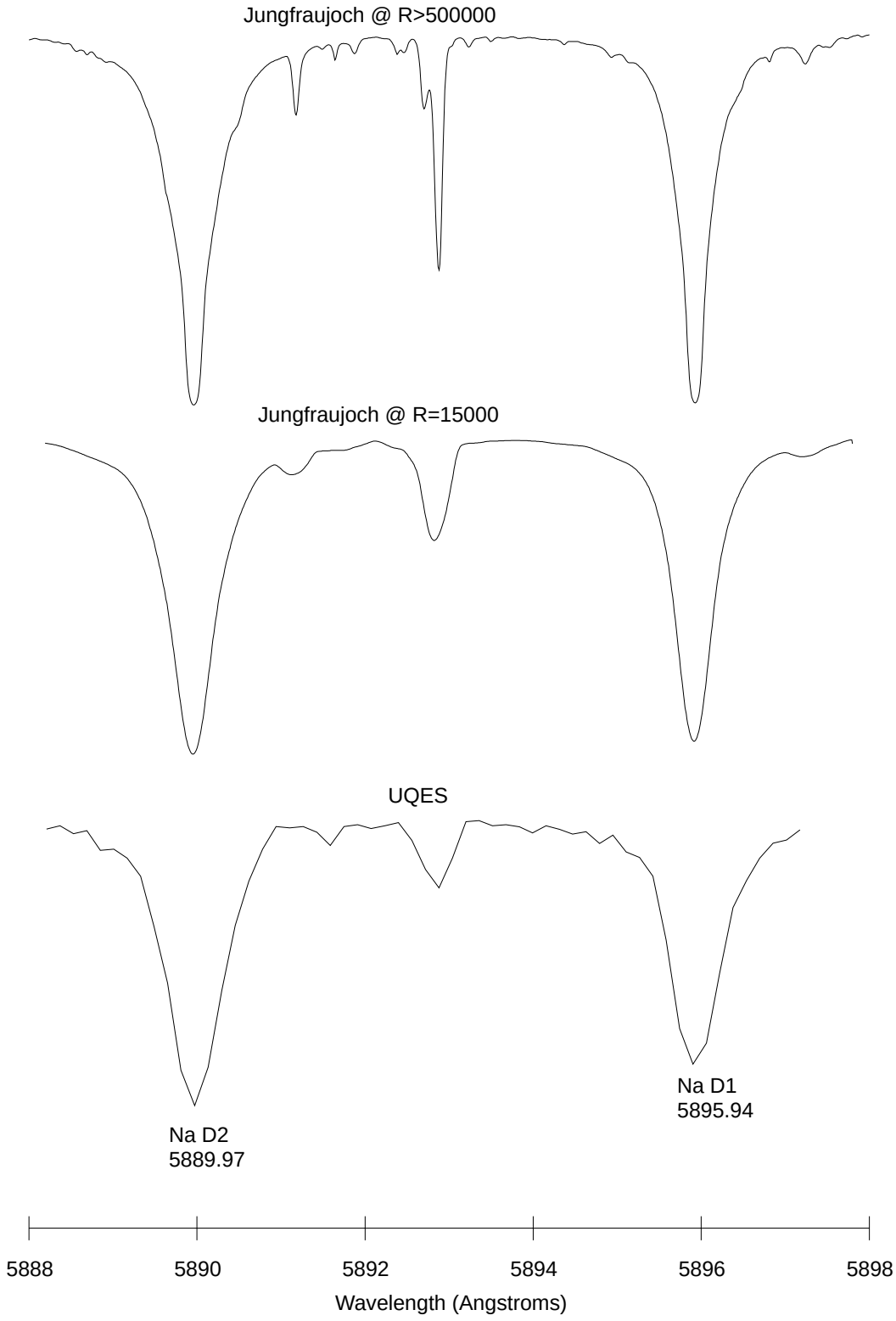

Figure 8.4: Solar spectrum 5887-5897Å: Sodium **D** lines.

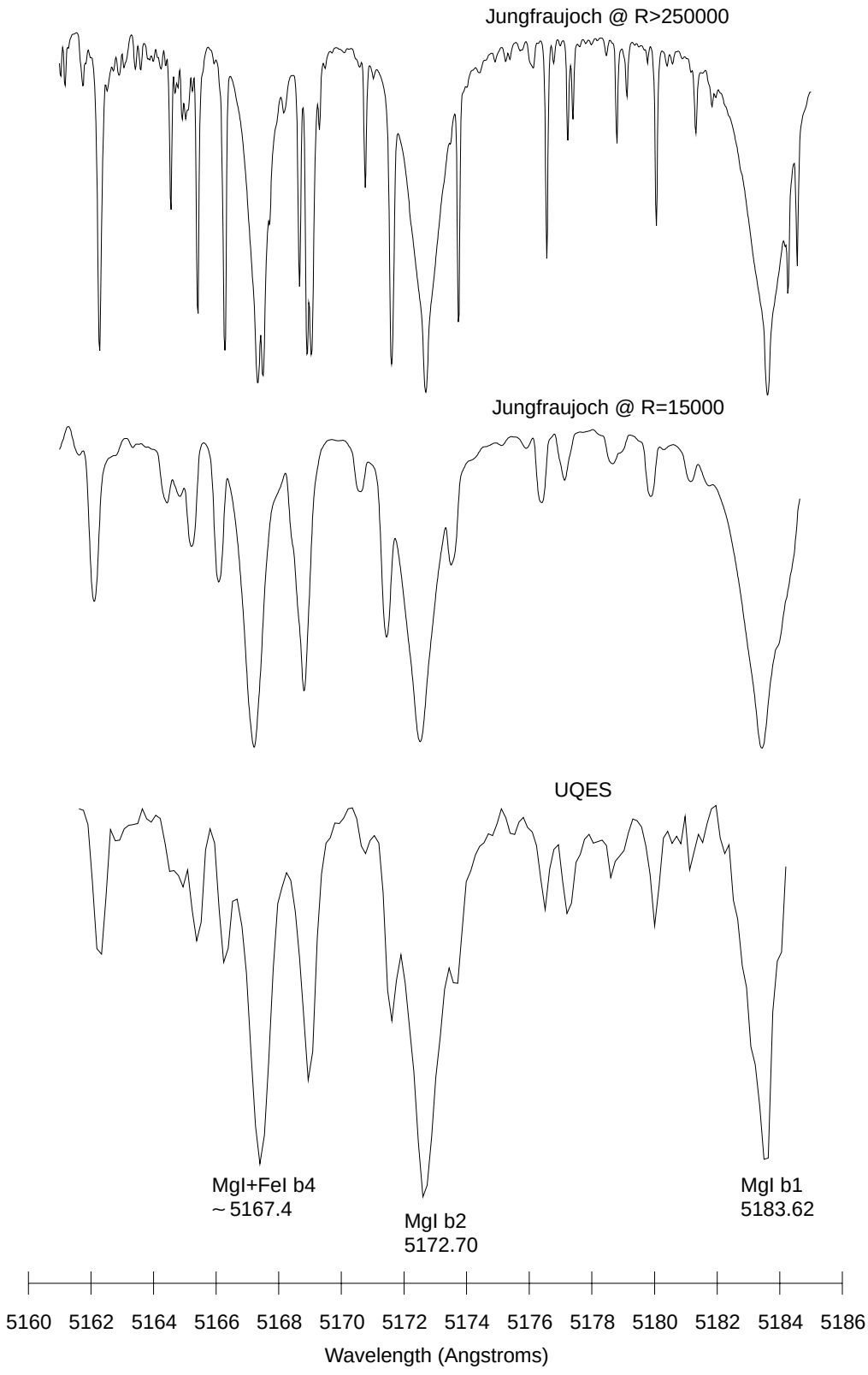

Figure 8.5: Solar spectrum 5160-5186Å: Magnesium / Iron **b** lines.

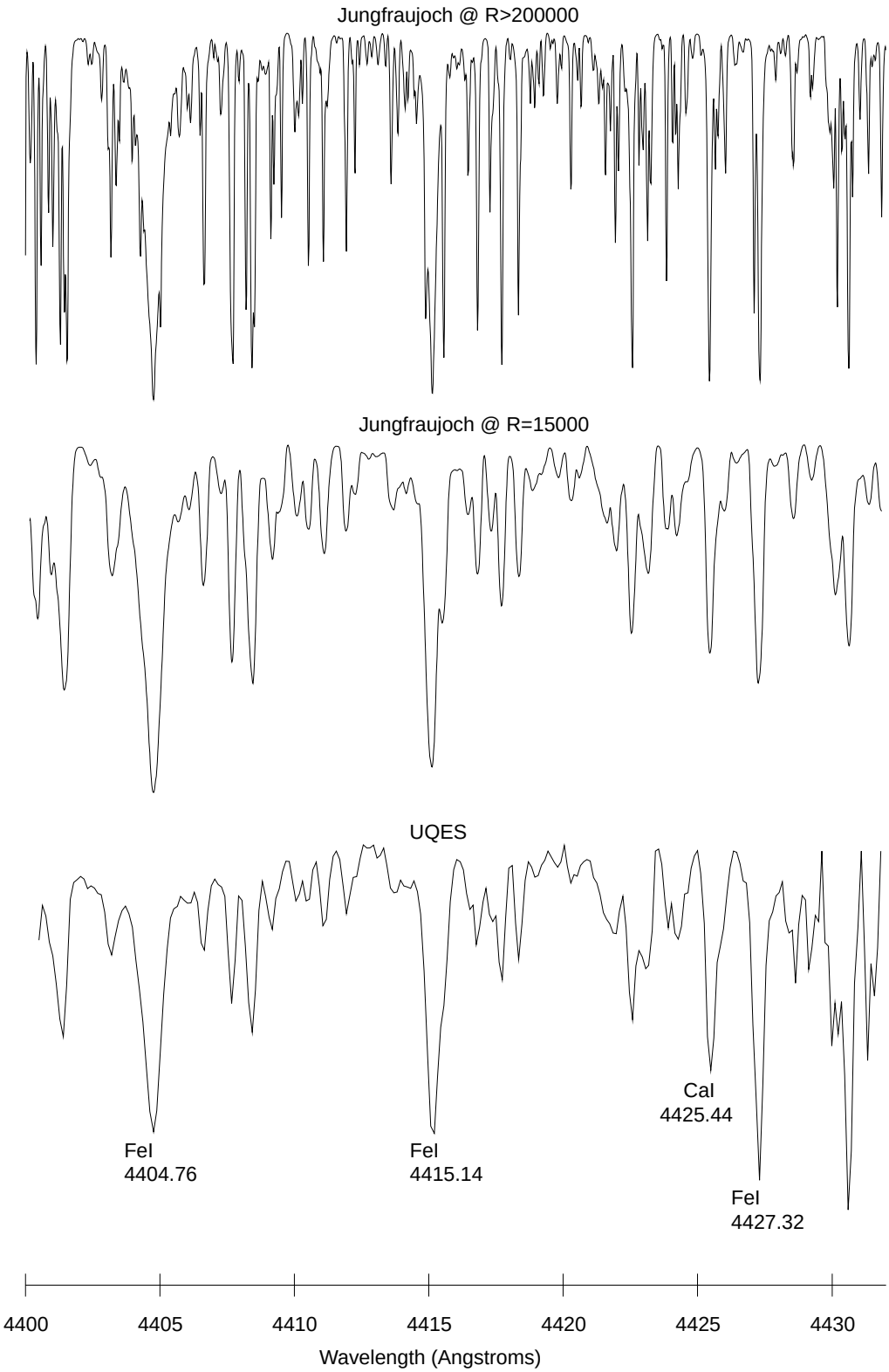

Figure 8.6: Solar spectrum 4400-4432Å: various Iron & Calcium lines.