Numerical Analysis for Computer Scientists FMN011, Lund University 2012 Project #2 Finding the line strength of stars for an astronomer

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1 Introduction and Problem Background

This project is about solving real-world problems with their accompanied complexities and ambiguities. The best method must be determined and its limitations and possible errors must be known. In this project intensity of light from stars will be studied. Stars produces a continuous curve of light over a range of frequencies called the *spectrum* for that star. It can be measured in *relative intensity* ($\frac{\mathrm{W}}{\mathrm{m}^2 \times \mathrm{Hz}}$) as a function of the frequency (Hz) which is defined as the spectrum. What is interesting is that the surrounding gases of a star will either absorb (cold gas) or emit (warm) light which is visible at discrete fixed frequencies in the spectrum as *spectral lines*. By identifying these spectral lines the components of the star can be found because each chemical composition have a unique fingerprint of discrete frequencies [1] [2].

In this project a measured continuous spectrum for a star is given which contains six spectral lines evenly divided in absorption lines and emissions lines. The task for this project is to find the total intensity for each of these spectral lines called the *line strength* measured in $\frac{\mathrm{M}}{\mathrm{m}^2}$ [3]. This is achieved by finding the area under the curve at the peak-frequencies i.e. integrating the relative intensity over these frequencies.

The given data is a file with 4000 measurements of *Specific Intensity* in $\frac{\mathrm{W}}{\mathrm{m}^2 \times \mathrm{Hz}}$ at frequencies in the range $[3.50 \times 10^{14}, 4.29 \times 10^{14}]$.

2 Numerical Considerations

3 Results & Analysis

The first thing to do is, as always, to get an understanding of what are the given. Since studying the raw data is hard a graphical plot over the curve is desired to grasp the main characteristics of what we have. The relative intensity spectrum can be seen in figure 1 and the spectrum itself in figure 2. In these two plots the six spectral lines are clearly visible. Just for the interest the intensities are also show as a function of the wave lengths in figure 3 using the *MATLAB*® function *spectrumLabel*[4].

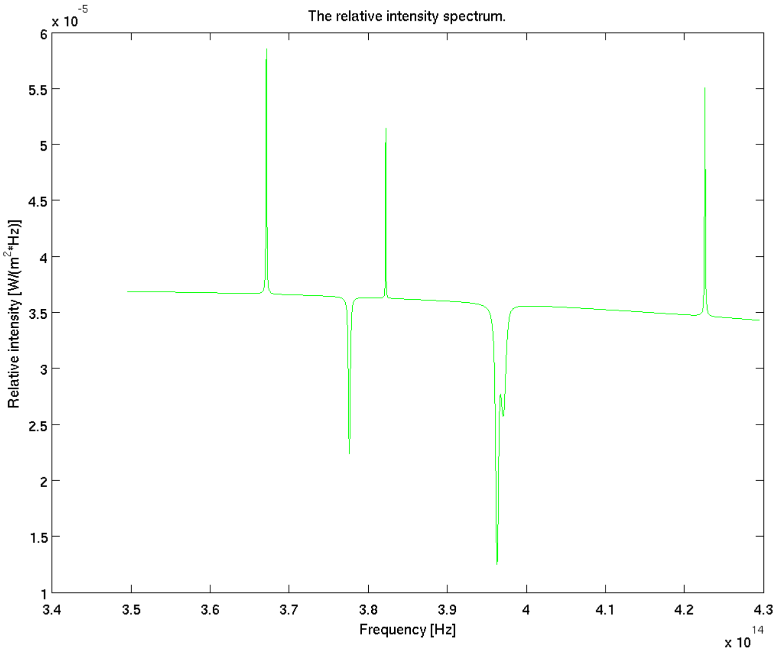

Figure 1:

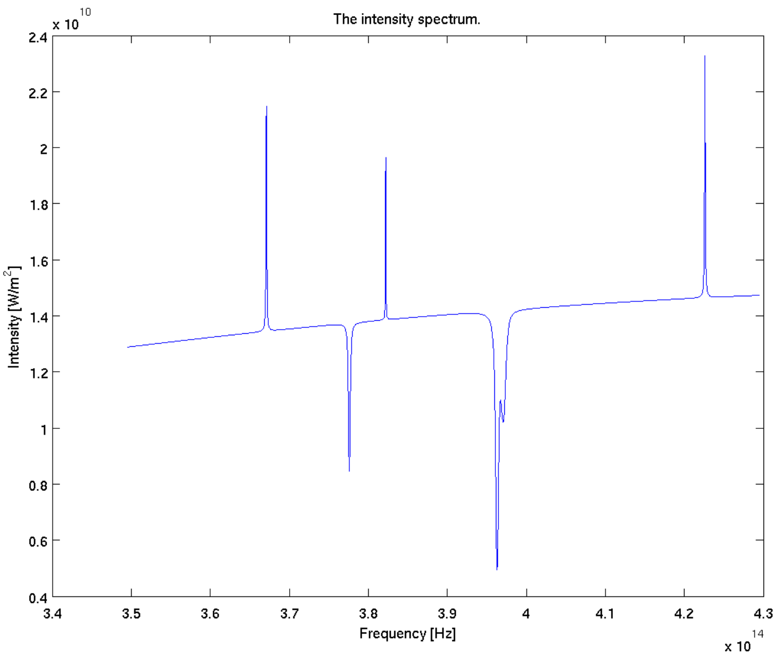

Figure 2:

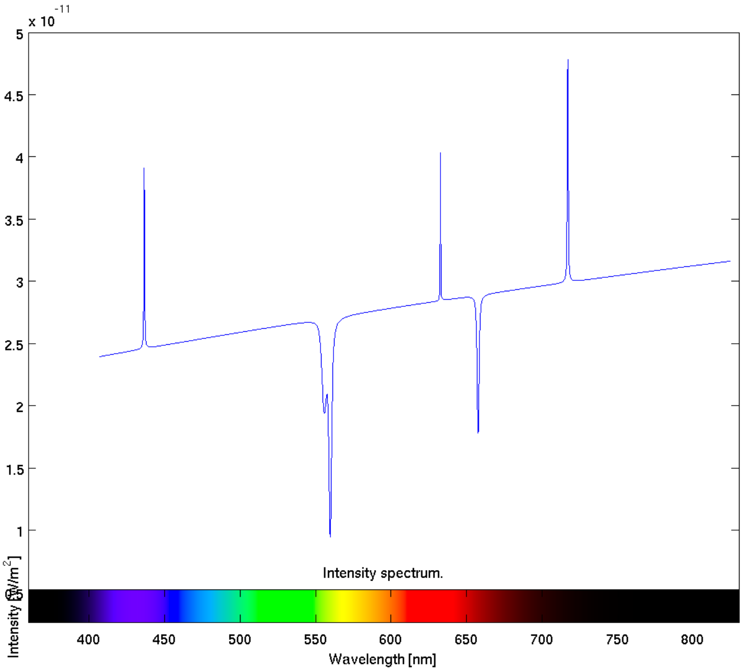
x 10^-11
5
4.5
4
3.5
3
2.5
2
1.5
1
Intensity spectrum.
Intensity [W/m^2]
400
450
500
550
600
650
700
750
800
Wavelength [nm]

Figure 3:

4 Lessons Learned

From this project several theoretical understandings are gained.

- ...
- ...

5 Acknowledgments

References

[1] N. Strobel, “Production of light.” Accessed 2012-04-21.

[2] N. Strobel, “Discrete spectrum.” Accessed 2012-04-21.

[3] S. D. S. Survey, “Spectral types.” Accessed 2012-04-21.

[4] J. Mather, “Spectral and xyz color functions.” Downloaded 2012-04-21.

Appendix

A Program listings

Here the *MATLAB*® functions and scripts used to achieve the results above are listed.

A.1 Scripts

The following scrips are the drivers for producing the results found in this report.

src/project2.m

```
clc % Clear command screen.
format long % Format of floating point numbers.
close all  % Close all figures.
fprintf(1, '-->Project #2.\n');
clear all

[ d_freq,  d_intens ] = pr2.import_data('../spectrum_data.xls');

% Plot relative spectrum.
fig = figure('visible','off'); % Don't display the plot.
plt_relspectrum = plot(d_freq, d_intens, 'g');
xlabel('Frequency [Hz]')
ylabel('Relative intensity [W/(m^2*Hz)]')
title('The relative intensity spectrum.')
saveas(plt_relspectrum, '../img/spectrum_relative.eps', 'eps')
saveas(plt_relspectrum, '../img/spectrum_relative.png', 'png')
set(fig ,'visible','on') % Enable plots again.
close(fig);

% Plot spectrum
fig = figure('visible','off'); % Don't display the plot.
plt_spectrum = plot(d_freq, d_freq .* d_intens, 'b');
xlabel('Frequency [Hz]')
ylabel('Intensity [W/m^2]')
title('The intensity spectrum.')
saveas(plt_spectrum, '../img/spectrum.eps', 'eps')
saveas(plt_spectrum, '../img/spectrum.png', 'png')
set(fig ,'visible','on') % Enable plots again.
close(fig)

% Plot wavelengths spectrum.
fig = figure('visible','off'); % Don't display the plot.
ax = axes();
d_wavelen = 2.998e8 ./ d_freq; % wavelength = c / freq.
d_wintens = d_wavelen .* d_intens;
plt_wave = plot(d_wavelen, d_wintens, 'b');
spectral_color.spectrumLabel(ax);
xlabel('Wavelength [nm]')
ylabel('Intensity [W/m^2]') % TODO correct?
title('Intensity spectrum.')
saveas(plt_wave, '../img/spectrum_wave.eps', 'eps')
saveas(plt_wave, '../img/spectrum_wave.png', 'png')
set(fig ,'visible','on') % Enable plots again.
close(fig)
```

A.2 Functions

The following functions implements the algorithms and the rest serves as helper functions to these algorithms and the scripts. To distinguish these from other *MATLAB*®-functions in the global namespace these reside in a own package called *pr2*.