

INTERACTIVE SPECTRAL ANALYZER AND COMPARATOR (ISAAC)

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Abstract. We are developing an application for graphical comparison of observed and synthetic spectra (ISAAC). Synthetic spectrum calculation is performed by SPECTRUM, Stellar Spectral Synthesis Program by Richard O. Gray that we use with his kind permission. This program computes line profiles under LTE condition in the given wavelength interval using a stellar (solar) atmosphere model, a spectral line data list (wavelength, energy levels, oscillator strengths, and damping constants), a file containing data for atoms and molecules, as well as a data file for hydrogen line profiles calculation. ISAAC offers a simple interface for viewing and changing any atomic parameter SPECTRUM uses for line profile calculation, enabling quick comparison of the new synthetic line profile with the observed one. In this way parameters like relative abundances, oscillator strengths and van der Waals damping constants can be improved, achieving a better agreement with the observed spectrum.

1. INTRODUCTION

Comparison of calculated (synthetic) and observed spectra is one of the fundamental tools of astronomical spectroscopy, which greatly increases the researcher's ability to perform successful analysis and investigation of the observed object. Usually the calculation of spectrum and its comparison with the observed one are independent procedures. When the goal of comparison is the improvement of the fit between the observed and synthetic spectra by changing the parameters of calculation and comparing the obtained calculated spectrum with the observed one, such a procedure becomes very uncomfortable. This was the motivation for developing an interactive program named ISAAC (Interactive Spectral Analyzer And Comparator) that provides the comparison of calculated and observed spectra ("graphics screen"), and changing the parameters of calculation ("text screen") on the same screen.

2. DESCRIPTION

ISAAC is intended to display graphically two spectra: a synthetic spectrum, currently calculated by SPECTRUM, and an observed one, supplied by the user (in default, ISAAC will display the spectrum from High Resolution Solar Spectrum observed by Delbouille L., Neven L., Roland G. in 1972 at Jungfraujoch Observatory), obtained via Internet (e.g., [http : //mesola.obspm.fr/form_spectre.html](http://mesola.obspm.fr/form_spectre.html)), and covering spectral

range from 300 nm to 700 nm). The main purpose of the program is to provide the possibility of visual comparison of the two spectra, so that the values of atomic parameters used for calculating the synthetic spectrum can be corrected, or estimated with more certainty. To facilitate this task further, ISAAC is designed to provide easy access to atomic parameters needed for synthetic spectrum calculation.

The program window consists of two sections: the data section, and the graphics section. In the graphic display area of the window, ISAAC shows the two spectra, plotted in different colors. Above the spectra, spectral lines are drawn. Below the main graph ISAAC can plot the difference of the two spectra. The default amount of data displayed on one screen is about 0.025 nm, but can be changed. The data display area consists of several tabs. The Lines Tab shows a list of spectral lines from the current range, with all the data SPECTRUM requires (wavelength, species, energies of the lower and higher energy level, oscillator strength, van der Waals damping coefficient, type of transition). ISAAC allows insertion, deleting and changing of spectral lines. When user decides to change line parameters, ISAAC rewrites this line list to reflect the changes, and then calls SPECTRUM to do the calculations with new data. When SPECTRUM finishes, ISAAC updates its display to show the newly calculated spectrum against the old one, and the observed one, so the user can decide weather the changed parameters are more satisfying than the original ones. User can also "disable" a line and temporarily exclude it from calculations. For convenience, lines can be selected by clicking on their visual representation in the graphics area. The Abundances Tab works in a similar fashion, showing the content of another file SPECTRUM uses for its calculations (atom.dat). Here the abundance of some elements or molecules can be adjusted. The Spectra Tab shows information about spectra. The source of observational data is selected here. The file that contains the observed spectrum may be in any ASCII format as long as it has two columns: first containing wavelengths, and second the intensity values (which will have to be normalized). Specifying microturbulent velocity and wavelength step can adjust synthetic spectrum calculation further. User will be asked to specify the range of data for immediate use, and will be able to scroll through it using the keyboard. Limitations on the selected range are posed primarily by the speed of calculation and the amount of observational data. Finally, the Display Tab offers many ways to customize the appearance and behavior of user interface.

3. AN EXAMPLE OF USING ISAAC

It is an interesting fact that some calculated spectral lines are very different from appropriate lines in the observed spectrum, while the others are in good agreement. These large differences can be due to errors or to badly determined values of tabulated spectral line parameters (wavelength, identification of the atom or ion, oscillator strength etc.). We believe that identifying these problems is very useful for successful use of these tabulated data in further research. For this purpose we used ISAAC and compared calculated and observed spectra in wavelength range from 500 nm to 510 nm. In this relatively short wavelength interval we identified more than 150 problematic spectral lines. As an example in Table 1. we show the results from the 501-502 nm region. As one can see from Table 1. there are several types of problems, which are noted in the last column and explained at the end of the table. ISAAC also provides an opportunity for improving these erroneous data. For instance, the oscillator

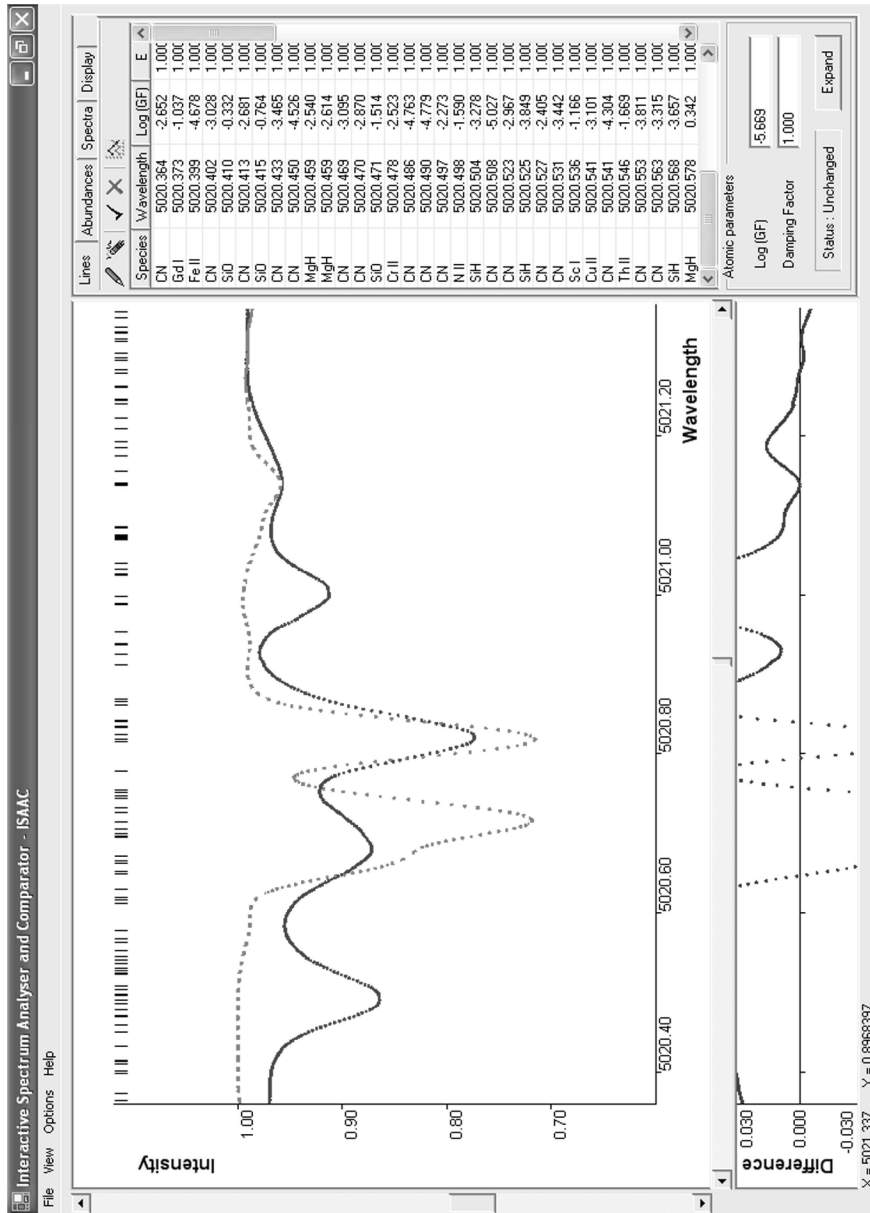


Figure 1: ISAAC displays observed (dots) and synthetic (full line) spectra.

Table 1: Comparison of the observed and calculated spectral lines

Identification	Wavelength	Notes
NiI	5010.022	S(1.37)
TiII	5010.212	S(1.43)+B
MnI	5010.388	S
FeI	5011.213	S(2.60)
FeI	5011.239	L
NiI	5012.438	S(1.22)+W+L
FeI	5012.441	L
TiII	5013.677	S(1.40)+P
-	5013.910	O
-	5015.300	O
FeI	5016.476	S(1.45)
FeI	5016.655	S
-	5016.580	O
FeI	5019.160	S(3.00)
MnI	5019.152	L
CrI	5019.172	L
FeI	5019.246	S(2.00)
FeII	5019.462	W
FeI	5019.660	S(2.50)
FeI	5019.732	S(1.92)

strength of a transition can be found by changing its tabulated value until one gets a good fit of the observed and calculated line profile. We plan to correct the tabulated oscillator strengths and damping enhancement factors of medium strength lines (lines of equivalent width from about 1 pm to 15 pm) in the wavelength interval from 500 nm to 650 nm.

- B Bad overlapping
- L The line forms a single profile with one or more of previous lines
- W Wings (the wings of observed line are approx. twice wider than the synthetic one)
- O The line is absent in the synthetic spectrum
- S The line exists in the synthetic spectrum but is absent in the observed one
- S(x) The line is x times deeper in the synthetic spectrum than in the observed one
- P The line is shifted

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