STELLA Observatory Project

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SES Automatic Spectral Analysis Tool
User Requirements

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1.2	13/12/2005	3.2, 4, 5	Keywords, task description, documentation

Contents

1 Introduction

1.1 Purpose & scope

This document is intended to define the requirements to the automated spectral analysis software, which will act on reduced spectra from the SES.

The document will, once approved, act as the user requirements that the final software product will have to fulfill.

Note: Before the final release this document is for discussion only. Hence elements listed here may not make it to the final release if they are deemed undesirable or unrealistic.

1.2 Reference documents

The following documents are referenced in this document:

[1] The SES pipeline: `http://www.aip.de/~aritter/STELLA-pipeline/`

1.3 Abbreviations and acronyms

The following abbreviations and acronyms are used in this document:

AIP	Astrophysical Institute Potsdam
ASPEX	Automatic Stellar Parameters EXtraction
CES@3.6	Coude Echelle Spectrograph at the ESO 3.6m telescope
ESO	European Southern Observatory
OS	Operating System
RV	Radial Velocity
SB	Spectroscopic Binary
SES	STELLA Echelle Spectrograph
SW	Software
TBD	To Be Determined/Discussed

Moreover, names of persons are abbreviated: CAP (Carlos Allende Prieto), LKO (Lars Koesterke), KGS (Klaus G. Strassmeier), THD (Thomas H. Dall).

1.4 Stylistic conventions

Bold is used to indicate subjects for discussion. Most likely, such paragraphs will not enter the final release of this document. **Bold** is also used for list headings. *Italic* are used to highlight words.

2 Overview

The SES will deliver high-resolution near full-range cross-dispersed echelle optical spectra. The raw data will be handled by the SES data reduction software to deliver extracted, wavelength calibrated, order-by-order and one-dimensional spectra, corrected to the Heliocentric frame.

This document describes the automated analysis of these spectra by the software tool ASPEX.

3 User requirements

3.1 Input

This is a description of the input spectra fits files as delivered from the SES data reduction software [1]. According to [1] the spectra will be wavelength calibrated but not normalized. The following requirements must be fulfilled:

- Wavelength scale corrected to heliocentric rest frame
- The following header keywords must be present:

  RADVEL Resonably accurate ($\pm$5 km/s) guess of the RV. Set to -999.99 if unknown.

  SB2 Flag (values "TRUE" or "FALSE") to say if the object is a known SB.

  VSINI Resonably accurate (**TBD**) guess of the $v\sin i$. Set to -999.99 if unknown.

  ACCVSINI Is value of $v\sin i$ reliable enough to use for spectral synthesis (values "TRUE" or "FALSE").

  SPECTYP Best guess on spectral type of target.

  VMINUSR The value of $V-R$. Set to -999.99 if unknown.

3.2 Output

The following list discuss the required output parameters from ASPEX and the accuracy that need to be attained. The case of known SB2's are not discussed, as it is assumed (**for now**) that these will have to be analyzed manually.

The derived parameters will be written to the image headers as specified below. Moreover, a reduction logfile will be dumped containing all of the reduction steps, warnings, errors etc. Finally, a "pretty" observing logfile should be produced containing information on the observation and the derived parameters.

	Accuracy	Details	Keyword
RV	50 m/s	Accuracy depends on $v\sin i$, spectral type, and S/N (**TBD**).	RADVEL
		Error estimate will be provided	ERVEL
		If SB2 is true, RV of secondary ...	RADVEL2
		as well as error estimate	ERVEL2
$v\sin i$	**TBD**	Requires unblended lines. The suitable lines to use will depend both on spectral type and on $v\sin i$	VSINI
		If SB2 is true, $v\sin i$ of the secondary will be evaluated	VSINI2
		as well as the uncertainties (**TBD**)	ERVSINI
			ERVSINI2
$\log R_{\rm HK}$	**TBD**	Depends on accuracy of provided $V-R$.	LOGRHK
		An error estimate will be provided (**TBD**)	ERLOGRHK
[Fe/H]	**TBD**	Accuracy depends on S/N, spectral type, and $v\sin i$	ABUNFE
		Error estimate on the Fe abundance.	ERABUNFE
$T_{\rm eff}$	**TBD**		TEFF
			ERTEFF
$\log g$	**TBD**		LOGG
			ERLOGG
$\xi_t, v_{\rm mac}$	**TBD**		VMIC
			VMAC
		Error estimates...	ERVMIC
			ERVMAC
[X/Fe]	**TBD**	The additional elements for which abundances should be determined automatically must include **Ca, Si, Ti, V, Ni, Co, Cr**. Naturally this depends on the number of identified lines and the quality of the lines.	ABUNCA, ABUNSI, ABUN*xx*, ...
		Error estimates on the abundances will be provided.	ERABUN*xx* ...

Other requirements

- Raise a flag in case of SB2, large $v\sin i$ or “strange” values (**TBD**).
- ASPEX should offer the possibility to re-reduce spectra online or semi-online, with a set of changed parameters.

4 Flow chart and task breakdown

Fig. 1 shows the flow chart describing the workings of ASPEX. In the following, the individual tasks (processes) will be discussed.

Queue process The queue process is monitoring the reduced data directory. Once a new spectrum arrives, the process starts the next step in the ASPEX analysis chain. Only one spectrum at a time can be processed, the rest being lined up for later reduction. The queue also takes care of logging information about the outcome. Existing SW for the ESO CES@3.6 will be used. This is fully functional and need only minor modification to suit the directory structure of the data reduction machine.

Extract header information Extraction of header information is necessary in order to give ASPEX a reasonable idea about the properties of the star. The necessary parameters are: (1) First guess at RV, (2) Binary

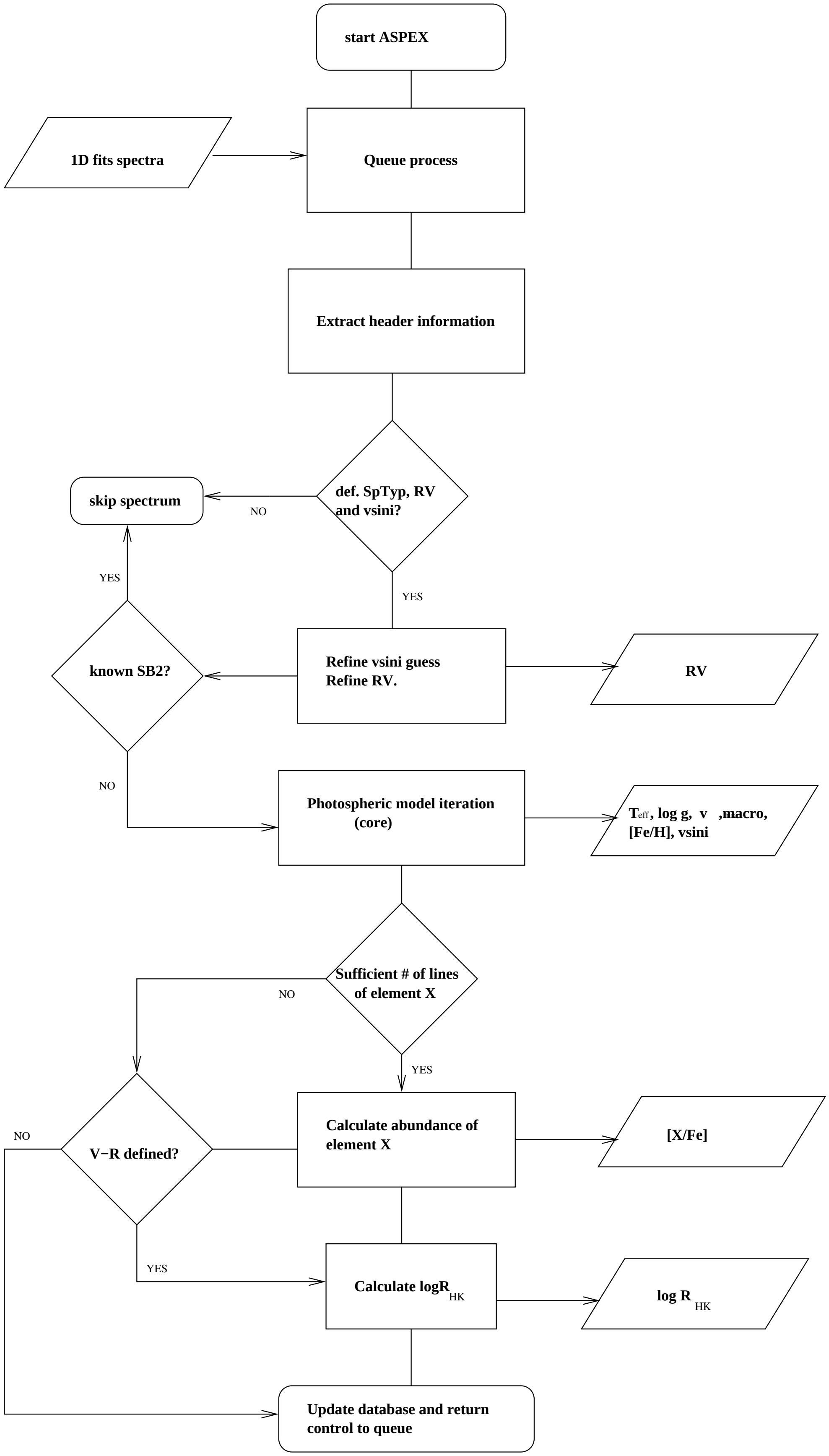

Figure 1: Flow chart for ASPEX

flag, (3) First guess at $v \sin i$, (4) Approximate spectral type, (5) $V - R$ value. SW within scisoft can be used with little or no modification. Modified parameters and newly derived quantities will be included in the image headers, so that in the end, all relevant parameters can be found in the headers.

Refine vsini This step is not supposed to yield the final value, but serves mainly as a preparation for the RV calculation. If $v \sin i$ is accurate enough (header keyword ACCVSINI), then this step can be skipped, otherwise the profiles of a set of lines are compared to a predefined set of template spectra of the proper spectral type (header keyword SPECTYP) with different broadenings, after being Doppler shifted to the rest wavelength (header keyword RADVEL). The templates are constructed using STARMOD (Montes et al.), and the RV and $v \sin i$ are refined iteratively. Due to the non-perfect match of the template and the spectrum, the derived $v \sin i$ will generally not be accurate enough, and the final $v \sin i$ will be derived as part of the model iteration (the core — see below).

Refine RV Using the appropriate spectral type (SPECTYP), a template spectrum (or appropriate individual orders) is constructed and refined iteratively using STARMOD, simultaneously fitting the RV and $v \sin i$. The spectrum is then Doppler-corrected to the rest wavelengths, and the refined RV written to the image header in keyword RADVEL.

Model iteration This process is referred to as the *core*. Simultaneously solve for $T_{\rm eff}$, $\log g$, [Fe/H], ξ_t, $v_{\rm mac}$, $v \sin i$ using large grids of synthetic spectra. The core code will search for the optimum solution and make sure it is unique. The code will be developed in three stages, each stage producing a set of output parameters:

1. Three output parameters: $T_{\rm eff}$, $\log g$, [Fe/H]. ξ_t is constant and $v_{\rm mac} = 0$. First tested with synthetic data and noise, then with libraries of real data.
2. Five parameters: $T_{\rm eff}$, $\log g$, [Fe/H]. ξ_t, $v \sin i$. $v_{\rm mac} = 0$. First tested with synthetic data and noise, then with libraries of real data.
3. 6+ parameters: $T_{\rm eff}$, $\log g$, [Fe/H]. ξ_t, $v \sin i$, $v_{\rm mac}$, [X/Fe].

Abundance of X Provided a sufficient number of lines are available, this task should be straightforward. It needs to be assessed how these abundancs may be obtained from the core code, which elements should be determined, and what the deadline for delivery should be.

$\log R_{HK}$ **calculation** Based on the $V - R$ from the header (VMINUSR) and the atmospheric parameters derived earlier, the emission reversals are identified and the calculation performed. Existing tool performs semi-automatic calculation, only prompting user for the boundaries of the emission peaks. This algorithm needs to be updated for automatic detection of the emission reversals. Only single stars will have this calculation performed.

4.1 Platform, development and documentation

ASPEX must be able to run under Linux on a standard PC. Only free and readily available software packages and extensions should be used (e.g. scisoft tools only) for potability. Software packages that are free of charge for non-commercial use can also be used as an integral part of ASPEX.

ASPEX will be developed along two paths. The core model atmosphere fitting and iteration procedures will be developed by CAP and LKO, while the pipeline aspects, initial RV corrections, and activity index calculation will be developed by THD. The integration of the different parts will be done by THD, while the installation will be done by THD and KGS. The final acceptance of ASPEX, including its documentation, will be by KGS.

Hardcoded parameters, limits and conditions should be avoided. Instead, a simple set of configuration files and/or image header parameters should provide ASPEX with the necessary input.

All parts of the software must be accurately documented, both in terms of in-line comments in the code, and in terms of detailed written stand-alone documentation. It must be possible for people with no knowledge of the programs to assume responsability for future maintenance and development, using only the written documentation.

4.2 Delivery and timeline

The tool is to run on AIP computers located at the institute in Potsdam, automatically analyzing incoming reduced spectra from the SES pipeline [1]. Alternatively, ASPEX could run on a dedicated machine at the observatory site.

The time of delivery of the final product should be no later than the start of regular SES operation. Testing and integration of ASPEX should be started as soon as first spectra start arriving from SES.

Tentative time line is as follows:

When	Who	What
ult. Jan.2006	LKO,CAP	Delivery of core, stage 1 (with libraries)
ult. Jan.2006	THD	Start integration of core with rest of pipeline to yield ASPEX, stage 1
ult. Mar.2006	THD,KGS	First installation of ASPEX stage 1 at AIP
ult. Mar.2006	LKO,CAP	Delivery of core, stage 2 (evt. without libraries)
ult. Mar.2006	KGS	First assesment of documentation to be made
Apr.2006	LKO,CAP	Delivery of core, stage 2 (with libraries), incl. documentation
Apr.2006	THD,KGS	Installation of ASPEX stage 2 at AIP
Apr.2006	KGS	Full documentation (preliminary) review.
Apr.2006	KGS	First on-line test of ASPEX on real science spectra
15-19 May 2006	all	Pipeline meeting, Tenerife
17 May 2006	all	STELLA official inauguration, Tenerife
June 2006	LKO,CAP	Delivery core, stage 3
June 2006	THD	Integration and installation of ASPEX stage 3 at AIP
summer 2006	all	ASPEX in normal operation.
summer 2006	THD,LKO,CAP	Full ASPEX documentation delivered
summer 2006	KGS	Full ASPEX documentation reviewed and accepted

5 Summary

5.1 Critical urgent points

The following are the most critical and urgent points to consider:

1. A tentative agreement has been made to meet (KGS, CAP, LKO, THD) May 2006 in Tenerife for the inauguration of STELLA. A meeting will be scheduled at this occasion to discuss ASPEX issues.
2. Abundances of other elements: It is not clear how this should be done, and for which elements. We need to make a list of elements and the conditions in terms of S/N, $v \sin i$ etc., under which these abundances will be determined. The definition of these conditions will likely depend on actual pipeline performance.
3. Interfacing between pipeline outer layers and core fitting routines need to be defined. Which parameters should be passed and how? Parameters will be passed to the core in the image headers, but an additional parameter file(s) could be passed if required. Likewise, it is foreseen that the output from the core will enter into the image headers before further pipeline processing.
4. Documentation: The written documentation could follow the structure and layout of this document, but this point is open for discussion. However, any piece of documentation should address the following points: Scope & Purpose, Overview, Synopsis, Description, Files & Environments, Examples & Walk-throughs, Output, Bugs & To-Do's. Moreover, code must be extensively commented.

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