Spectrum synthesis code SYNTH3

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General description

The spectrum synthesis code SYNTH3 is designed for fast and accurate calculation of the spectra of stars in a wide range of physical parameters (spectral types from early B to late M) under the assumption of the Local Thermodynamical Equilibrium (LTE) and plane-parallel hydrostatic stellar model atmosphere. The code includes molecular equilibrium solver (Valenti et al. 1998) which enables self-consistent computation of molecular absorption features and atomic spectral lines.

Being an independent program, SYNTH3 nevertheless relies heavily on the improved versions of the subroutines and numerical algorithms from the well-tested astrophysical software packages such as the ATLAS/SYNTHE program suite of Kurucz (1993), the SYNTH and SYNTHMAG codes of Piskunov (1992, 1999) and SME program written by Valenti & Piskunov (1996). The treatment of the hydrogen line absorption implemented in SYNTH3 is that of Barklem et al. (2000).

SYNTH3 uses non-magnetic version of the quadratic DELO (Piskunov & Kochukhov 2002) radiative transfer algorithm to evaluate intensity spectra at 7 angles between the line of sight and normal to the stellar surface. External routine S3DI can then be used to co-add intensity spectra for a given projected rotation velocity and macro-turbulent broadening.

SYNTH3 is able to compute spectra emergent from the stellar atmospheres with a depth-dependent chemical composition. The code automatically switches to this mode if any depth-dependent abundance is given as additional column(s) in the input model atmosphere file. Depth-independent abundances are read in from the line list (default) or from the model atmosphere header.

Input data

Input for the SYNTH3 spectrum synthesis calculation consists of a single ascii file containing parameters of the atomic and molecular absorption lines in a region of interest. The format of the input line list is that of the output returned by the VALD "Extract Stellar" request (see Piskunov et al. 1995). The file contains a reference to model atmosphere file in the "krz" format, which is similar to the Kurucz's "mod" format. A program KURKOL to convert a model in "mod" format to "krz" format is included with the SYNTH3 distribution. For late-type stars "krz"-format models are made available by the MARCS team [1].

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[1] http://marcs.astro.uu.se

Spectrum synthesis

The syntax of the SYNTH3 execution is

synth3 <input_line_list> <output_file>

Disk integration, rotational, macroturbulent and instrumental broadening

The SYNTH3 code produces an ascii file with the intensity spectra at 7 angles between the line of sight and normal to the stellar surface. The program S3DI can be used to produce disk-integrated flux spectrum and to include rotational, instrumental and radial-tangential macroturbulent broadening. The syntax of S3DI is

s3di <input_file> <output_file> [<$v_e \sin i$> <v_{macro}> <Resol> <Instrum>]

where `input_file` is the file produced by SYNTH3 at the previous stage, $v_e \sin i$ and v_{macro} are, respectively, the projected rotational velocity and radial-tangential macroturbulence in $km\,s^{-1}$. The sampling of the final spectrum on a grid logarithmically spaced in wavelengths is defined by the parameter Resol $= \lambda/\Delta\lambda$. Gaussian instrumental broadening corresponding to resolving power Instrum $= \lambda/\Delta\lambda_{instrum}$ can also be applied. The last four parameters are optional; the default is to produce spectra for Resol $= 10^6$ and apply no rotational, macroturbulent or instrumental broadening.

Example input and output files

A number of files showing examples of the SYNTH3 input and output are provided:

example.lin input line list in the VALD "Extract Stellar" format

example.krz input model atmosphere in "krz" format

example_stratified.krz shows how depth-dependent abundance can be set up in the input model atmosphere file

example.out sample output intensities produced with SYNTH3 by running
synth3 example.lin example.out

example.prf sample output flux for $v_e \sin i = 10$ $km\,s^{-1}$, $v_{macro} = 3$ $km\,s^{-1}$ produced with S3DI by running
s3di example.out example.prf 10.0 3.0

Executables

Statically compiled executables of SYNTH3, S3DI and KURKOL are available for Linux operating system (compiled on machine running Fedora Core release 3) and SunOS (compiled on SunOS v5.9) and Mac OSX 10.4 (compiled with IBM Fortran compiler).

Citing the code

The SYNTH3 is described in Kochukhov, O. "Spectrum synthesis for magnetic, chemically stratified stellar atmospheres" 2007, in *Magnetic Stars 2006*, eds. I.I. Romanyuk and D. O. Kudryavtsev, in press (astro-ph/0701084). This publication should be cited in the papers using SYNTH3.

References

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