Manual of
F.A.M.A. (Fast Automatic MOOG Analysis)

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The idea of this program is to do in an automatic way what usually is done by hand, i.e., running MOOG several times trying to minimize the trends of iron abundances versus EP (thus setting the effective stellar temperature) and EW (deriving the correct microturbolence value), and the difference between FeI and FeII (obtaining the surface gravity).

Since this process is time consuming, we automate it using some procedures written in the *perl* language. The procedures are connected by the main code, **automoog_simple.pl**, which calls the other procedures and the MOOG code several times since the convergence is reached.

Ideally this program has to be used **together with DAOSPEC or other automatic codes for EW measurement.**

How F.A.M.A works:

The program consists of several routines in *perl*:

• **Driver_marcs.pl and driver.pl** (in two versions: the one which uses Kurucz models, called driver.pl, and the one which uses MARCS models, called driver_marcs.pl).
Driver.pl is main body of the program and it guides the loop of MOOG leading to the final model for which the slopes of EP and EW, and the difference between FeI and FeII abundances are minimized.

Driver.pl needs two inputs: the **file containing the measured EWs of FeI and FeII lines** in the MOOG format and the file with the **initial guess for the stellar parameters**. At this level, we need only iron lines to set the stellar parameters (Teff, logg, Fe/H, microturbolence).

In the figures (Fig 1 and 2) an example of the two input files.
• **Read_out2.pl:** this routine reads the slope of the EW and EP correlations in the out2, and the average FeII and FeI abundances. These values are used to modify the stellar parameters in order to minimize slopes and differences.
• **Sigmaclipping.pl:** this procedure is used only once after the first run of MOOG and allows us to remove the EWs which produce iron abundances outside 2sigma (or 1sigma) of the average value. There is a parameter which can be varied in order to set the different value of sigma clipping. The default is a 2-sigma clipping.

• **Confronta.pl:** this is the most important part of the code because it drives the variation of the stellar parameters in order to minimize the trend with EW, EP, and FeI and FeII differences. The loop works as follows:

1) The Teff is varied to minimize the EP trend,
2) The microturbolence is varied to minimize the EW trend,
3) logg is varied to minimize the difference between FeI and FeII,
4) Finally the metallicity is also varied.

These steps are repeated three times, each times with much smaller variation of Teff, micro, and logg.The loop is stopped when the final conditions are reached and these final conditions are based on the quality of the spectrum, i.e., the sigma around the average FeI abundace.

These conditions are easily modifiable in the code, and they depend on the EW measurement quality: good spectra allow us to reach a greater accuracy in the stellar parameter determination. The results of the last run of MOOG, the final stellar parameters are all written in the directory OUTPUT and saved with the name of the input EW file and the extensions: out1, out2, end (with final parameters), .abu.end (with all abundances in 12 + log (el/H) units), and .ps (a check plot summarizing and visualizing the final solution)

• **Automoog_simple.pl:**
To make the final solution as unique and independent of the initial guess parameters as possible, the procedure of finding the ionization and excitation equilibria, are repeated for six times, each time starting from the final convergenge point of the previous step.
At each step the convergence criterion are reduced, using a the so-called p parameter.
This script, once the final set of stellar parameter is found, computes also the individual element abundances and produce the final control plot.

Installation of the program:

The code is given together with the MOOG2010 version and with the MARCS model atmospheres.

Some modifications to MOOG files have been done to run in an automatic way:

Moog.f → to put MOOG in silent mode (modified moog.f, where also the DIR has to be changed)
Infile.f → to read automatically a give input file, called something2.par
Inmodel.f → to read interpolated MARCS models
Batom.f → to put MOOG on Grevesse+07 solar scale.

So, if have already installed MOOG you have to re-install using these 4 updated routines.

Thus the first step is to compile MOOG with the given Makefile, remembering to modify the Moog.f file with the current directory.

make -f Makefile.xxx where xxx = "rh", "mac" or "rh64"

(this compiles MOOG and tries to link to the appropriate libraries in redhat linux, Mac powerbook, or 64-bit linux machines; note that the appropriate paths to libraries on your machine will need to be set in the Makefile.xxx). Now in the current directory you will have an executable file called MOOG.

In the file automoog.par modify the names of the directories and the parameters you want to modify in the analysis;

1) OUTPUT dir
2) MOOG dir

3) MARCS models dir
4) 1.0 (default) percentage of the dispersion of FeI abundances to be considered to compute the errors on the stellar parameters, 1.0 means 100%, thus to compute e.g., the error on Teff we allow to code to find the Teff corresponding to a slope given by sigma(FeI)/range(EP).
5) 1.2 (default) Sigma clipping for FeI lines
6) 1.0 (default) sigma clipping for FeII lines
7) 1.0 (default) sigma clipping for the other elements
8) 1.0 (default) value of the p parameter, higher values mean less strong convergence criteria.

The perl procedures do not need to be compiled, but only to be executable.

The atmospheric models and the interpolation code

To run MOOG we also need a set of atmospheric models, and a code to interpolate.
When MOOG is used in the manual way, we usually start with a first model atmosphere (obtained by interpolation with a first set of stellar parameters). If in the output of MOOG trends on EP and/or EW, or differences between FeI and FeII are present, then the stellar parameters are modified and a new atmospheric model is produced. This is done many times since the convergence is reached.
In the case of the automated version of MOOG, the interpolated atmospheric models are produced in the loop driven by driver.pl.

Interpolator for the Kurucz models:

In the dir MODEL_ATMO there are contained the **Kurucz atmospheric models together with the interpolation code, makekurucz64.f.**
To compile use:

g77 -ffixed-line-length-132 makekurucz64.f makekuruczsub.f phdlibsd.f -o makekurucz64.e

When changing systems one needs to update the directory for the Kurucz model grid.
The executable file, makekurucz64.e needs an input file with the stellar parameters:

Makekurucz64.e < sun.par

The interpolated atmospheric model is called RESULTS.
The file RESULTS will be written in the directory where makekurucz64.e runs,
thus it is better to run it from the directory where MOOG is contained.

Interpolator for the MARCS models:

In the dir MARCS_MODELS there contained the MARCS modes to which I have
changed the names, maintaining only:
P(s) for the plane parallel or spherical models
Teff
G gravity
T microturbolence
Z metallicity

This is the complete list of models given for the GES analysis.
In the dir MARCS_MODELS the perl procedure marcs_auto_sp.pl allows to compute the interpolate the model atmosphere. The path is automatically setted with the values given in

automoog.par. The interpolated model atmosphere is called RESULTS and will be written in the MOOG. Compile the MARCS interpolator with the following command:

gfortran interpol_modeles.f –o interpol_modeles

Summary of the installation:

1) Uncompress the tarball containing F.A.M.A. In the same directory where MOOG files are present.

2) Install MOOG2010 (with the updated four routines)
   make -f Makefile.xxx where xxx = "rh", "mac" or "rh64"

3) Compile the interpolator of MARCS models in directory with the model atmospheres
   gfortran interpol_modeles.f –o interpol_modeles

4) Edit automoog.par with your options and check that the perl codes are exectubles

5) **Run F.A.M.A!**
   .\automoog_simple.pl star.iron star.moog sun.par

Only abundances with fixed parameters:

To recompute abundances without varying the stellar parameters:

In addition to the normal use of the code, it is possible to compute elemental abundances without iterating on the stellar parameters.
This can be due using the version: automoog_onlyabundances.pl

This code requires the files with .iron and .moog, and the file with final parameters,
called star.iron.fix.end, and will produce a final abundance files called:
star.abu.fix.end