Using APOGEE Stellar Parameters

Table of Contents

This page attempts to address some common questions about APOGEE stellar parameters that are determined from the APOGEE Stellar Parameters and Chemical Abundances Pipeline (ASPCAP). Additional details are given in Holtzman et al (in prep.).

Overview of APOGEE Stellar Parameters

The term "stellar parameters" encompass a set of parameters that are required to make a global description of an APOGEE spectrum. More specifically, the APOGEE Stellar Parameters and Chemical Abundances Pipeline (ASPCAP) uses these parameters to find a "global match" between the observed spectrum and a spectrum from the spectral grid. These stellar parameters are then adopted for the determination of individual element abundances in ASPCAP.

ASPCAP uses eight parameters that include four atmospheric parameters and four abundances, as follows:

- ☆ the effective temperature (T_{eff}),
- ☆ surface gravity (log *g*),
- ☆ microturbulent velocity (v_{micro}),
- ☆ the total metallicity ([M/H]),
- ☆ carbon abundance ([C/M]),
- ☆ nitrogen abundance ([N/M]),
- ☆ alpha element abundance ([α/M]), and
- ☆ the macroturbulent velocity (v_{macro}) for giants or rotational velocity (v*sini*) for dwarfs.

Why are there multiple abundances included APOGEE's stellar parameters?

ASPCAP includes four abundance parameters ([M/H], [α/M], [C/M], and [N/M]) to fit stellar spectra, because molecular absorption from CO, OH, and CN is prevalent in many APOGEE spectra, and C, N and O can vary independently of the overall metallicity.

Back to Top

Multiple columns with stellar parameters

We provide multiple columns that record APOGEE's stellar parameters. The raw fit (or FERRE) parameters (which we refer to as the spectroscopic parameters) are given in the `FPARAM` array, calibrated parameters (different for T_{eff}, log g, and [α/M]) are given in the `PARAM` array and, finally, "named" columns that duplicate the spectroscopic and calibrated parameters (e.g., `TEFF`, `TEFF_SPEC`, `LOGG`, `LOGG_SPEC`), but only for the subset of objects that are not flagged as potentially bad.

Calibrations are made for effective temperature and surface gravity because the spectroscopic parameters deviate slightly from parameters determined by independent methods, such as photometric effective temperatures (which may be tied to stars that have measured radii) and asteroseismic surface gravities. Depending on the use case, you may prefer to use the calibrated parameters rather than the spectroscopic ones, but the spectroscopic ones are used by ASPCAP for subsequent abundance determination. A very small zero point calibration is applied to [α/M] to make the median [α/M]=0 for solar metallicity stars in the solar neighborhood.

For the most complete set of objects, use the `FPARAM` or `PARAM` arrays, but be aware that there may be objects for which these may be poorly or erroneously determined, e.g., because some assumption of the analysis is not met. For example, stars whose parameters fall at the edge of the spectral grid or a likely spectroscopic binary may not be well fit. *However, for some users, these may be interesting objects!* If you use these arrays, you should pay attention to the `ASPCAPFLAG` bitmask to determine if any criteria are met that you need to know about.
The order of the parameters in the `FPARAM` and `PARAM` arrays is: T_{eff}, log *g*, v_{micro}, [M/H], [C/M], [N/M], [α/M], and vsini.

To access the set of objects for which the parameter determinations are most secure, we advise use of the named columns: `TEFF` (calibrated) or `TEFF_SPEC` (spectroscopic), `LOGG` (calibrated) or `LOGG_SPEC` (spectroscopic), `M_H`, `ALPHA_M`, `VMICRO`, `VSINI` (for dwarfs only), and `VMACRO` (adopted for giants, not fit). These are populated from the arrays but only for objects that do not have the `STAR_BAD` or `CHI2_BAD` bits set in `ASPCAPFLAG`.

Back to Top

Abundance parameters and individual element abundances

Metals parameter and Fe abundance

[M/H] is the total metallicity as fit to the entire spectrum and is generally very close to the often used [Fe/H], because there are many Fe lines in the APOGEE window and because, astrophysically, it appears that most iron-group elements usually vary in lockstep. There may be small differences between [M/H] and [Fe/H], because [Fe/H] is measured *directly* from Fe lines, whereas [M/H] is influenced by other elements with strong or numerous lines in a given stellar spectrum. Because of this, users may prefer to use the [Fe/H] abundance (from the `X_H` array or the `FE_H`) rather than the [M/H] parameter to better match what is commonly presented in literature.

α element parameter and individual α element abundances

[α/M] is the total α abundance and is influenced by a combination of all α-elements (O, Mg, S, Si, Ca, Ti). The strongest/most numerous α-element lines change with stellar parameters (especially T_{eff}), so the [α/M] parameter (`ALPHA_M`) may reflect the abundance of different α elements (often O, Mg, or Si since these elements have the strongest lines) in different regions of parameter space. Therefore, it may be preferred to use specific elemental abundances instead of the [α/M] parameter when comparing stars across the Hertzsprung-Russell diagram. If all of the α-elements vary in lockstep, than the [α/M] parameter might be the most precise (`ALPHA_M`).

C and N parameters and abundances

[C/M] and [N/M] are parameters used to derive a best ASPCAP fit spectrum, however it is preferred to use the [C/Fe] and [N/Fe] abundances because they come from more carefully defined regions of the spectrum. Therefore, there are no named tags for these two parameters.

Back to Top

Uncertainties

Empirical uncertainties for calibrated parameters are estimated from repeat observations of stars. The uncertainties for `TEFF`, `LOGG`, `M_H`, and `ALPHA_M` can be found in `TEFF_ERR`, `LOGG_ERR`, `M_H_ERR`, and `ALPHA_M_ERR`, respectively. Uncertainties for all other named tag parameters can be found in the diagonal elements of the `PARAM_COV` matrices. Note that for the empirical uncertainties, no covariances have been determined, so all off-diagonal elements are identically zero.

The raw covariances from the FERRE fits can be found in the `FPARAM_COV` matrices. However, these are generally unrealistically small, potentially because systematic issues dominate over random ones.

Back to Top

v_{macro} and v sin i?

v_{macro} is a parameter that characterizes the macroscopic motions in the atmosphere of a star. For giants, APOGEE adopts a parametric relationship between the adopted macroturbulent velocity and the metallicity.

v*sini* is the rotational velocity, which also broadens spectral lines. This parameter is fit for dwarfs.

While the broadening kernels for macroturbulent velocity and rotation are different, the differences cannot be distinguished at the resolution of the APOGEE spectra. For the dwarf grids, we include v*sini* as a parameter, and it absorbs any broadening due to macroturbulent motions. We do not include rotation in the giant grids because the extra dimension leads to grids that are too unwieldy, unfortunately. We can get away with this because most giants do not have significant rotation. However, for the small fraction that do, the ASPCAP results may be unreliable, so users need to be aware of this possibility.

Back to Top

What should I do if I see a strange feature?

If you encounter strange features in the data, it is recommended to consult the `ASPCAPFLAG` and `STARFLAG` bitmasks. These bitmasks contain descriptive flags of the quality of the data and the ASPCAP fits, and can often explain the presence of strange data.

The named tags already have some quality cuts applied to them, but these descriptive bitmasks may be used to further clean data, or flag lower quality data.

Back to Top

SDSS is supported by

Funding is provided by the Alfred P. Sloan Foundation, the Participating Institutions, and the U.S. Department of Energy Office of Science.