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Catalogue of [Fe/H] determinations for FGK stars: 2001 edition*

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Abstract. The catalogue presented here is a compilation of published atmospheric parameters ($T_{\rm eff}$, $\log g$, [Fe/H]) obtained from high resolution, high signal-to-noise spectroscopic observations. This new edition has changed compared to the five previous versions. It is now restricted to intermediate and low mass stars (F, G and K stars). It contains 6354 determinations of ($T_{\rm eff}$, $\log g$, [Fe/H]) for 3356 stars, including 909 stars in 79 stellar systems. The literature is complete between January 1980 and December 2000 and includes 378 references. The catalogue is made up of two tables, one for field stars and one for stars in galactic associations, open and globular clusters and external galaxies. The catalogue is distributed through the CDS database. Access to the catalogue with cross-identification to other sets of data is also possible with VizieR (Ochsenbein et al. 2000).

Key words. catalogues – stars: abundances – stars: atmospheres – stars: fundamental parameters

1. Introduction

The [Fe/H] catalogue is an exhaustive compilation of references presenting determinations obtained by detailed analyses of the stellar atmospheric parameters ($T_{\rm eff}$, $\log g$, [Fe/H]) relying on high resolution, high signal-to-noise spectroscopic observations. Such observations have enabled the accurate measurements of equivalent width of weak metallic lines, which are proportional to the abundances of the corresponding elements.

Drastic changes have been introduced in the 2001 edition of the [Fe/H] catalogue as compared to the five previous ones (Cayrel de Strobel et al. 1980, 1981, 1985, 1992, 1997). The first change concerns the removal of stars hotter than 7000 K, the second concerns the removal of references prior to 1980 (mostly based on photographic material). The 1996 version (Cayrel de Strobel et al. 1997), which supersedes the older ones, is the work of reference for [Fe/H] determinations prior to 1980.

The [Fe/H] catalogue is now particularly suited for studies of chemical evolution by means of middle and low mass stars. Indeed, the abundances of such stars reflect, at least approximately, the chemical composition of the interstellar medium out of which they were formed. Massive stars have their atmospheric abundances modified by internal structure processes producing a large set of chemical peculiarities. The transition between low and high mass stars has been taken at about $T_{\rm eff} = 7000$ K.

The chemical evolution of the Galaxy is assessed using the metal/hydrogen ratios in stars. Nowadays, specialists of galactic evolution are also very interested in the behaviour of the abundances of C, N, O, Mg, Si ... in stars belonging to different populations. But the small number of lines of these species in the observed spectra results in iron being still the most widly used metallicity parameter. Unlike carbon, oxygen and magnesium, iron lines are extremely numerous in optical and near UV spectra.

A very important step in a spectral analysis of a star is the determination of accurate atmospheric parameters for the selection of the appropriate model atmosphere. No abundance can be derived unless the three physical parameters, effective temperature ($T_{\rm eff}$), surface gravity (g) and microturbulent velocity ($\xi_{\rm t}$) have been obtained. The metallicity is also one of the fundamental parameters of the atmosphere, as it controls the opacity in the continuum. It is obtained only by an iterative process, and is not limited to [Fe/H] but includes the abundance of all electron suppliers, such as the α–elements Mg or Si. We plan to include the ratio of the α–elements to iron, [α/Fe], in the next edition of the catalogue, both because it is an important parameter for a better characterization of the metallicities, but also because it is an important parameter in population studies.

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* The catalogue (Tables 1 and 2) is only available in electronic form at the CDS via anonymous ftp to `cdsarc.u-strasbg.fr (130.79.128.5)` or via
`http://cdsweb.u-strasbg.fr/cgi-bin/qcat?J/A+A/373/159`
and VizieR `http://vizier.u-strasbg.fr/`.

The present version of the catalogue has been built up from the previous one (Cayrel de Strobel et al. 1997), which was complete up to December 1995, keeping 258 references, corresponding to 3880 determinations of atmospheric parameters for 2484 stars. 120 references from refereed journals, published between January 1996 and December 2000, have been added to the catalogue. They correspond to 2474 new determinations, and 873 new analysed stars.

The presentation of the catalogue, completely revised and reformatted, is described in Sect. 2. Some comments about the input data, the stellar content of the catalogue and its connection to the Hipparcos mission are given in Sect. 3. Concluding remarks are given in Sect. 4.

2. Description of the catalogue

The format of the catalogue was modified compared to the previous version in order to make its use more convenient. When possible, the field stars have been identified by three designations to make the cross-reference between papers easier. The basic data on stars include ICRS 2000.0 coordinates, apparent V magnitude and spectral type. The atmospheric parameters are given with their error bars when available.

As usual [Fe/H] is defined by:

$$[\mathrm{Fe/H}] = \log(\mathrm{Fe/H})_{\mathrm{star}} - \log(\mathrm{Fe/H})_{\mathrm{Sun}}$$

where Fe/H is the ratio of the number of iron atomes to the number of hydrogen atomes in the atmosphere of either the star and the Sun. Values in the previous versions given with respect to a standard star other than the Sun have been converted to the solar scale. Another improvement of the catalogue concerns the references which are no longer given in a separate table, but in the last column of Tables 1 and 2. They are presented in the form of standard CDS and ADS codes which allow a direct access to the publication.

Tables 1 and 2, corresponding respectively to field stars and to stars in clusters or external galaxies, contain the following columns:

1. *Identifiers*
For field stars, 3 identifiers are proposed. The first column presents an identifier which was chosen according to the following rule: HD is chosen preferentially if available, if not available, BD is chosen, then CD/CPD, then Giclas. Such a rule allowed us to gather together all the [Fe/H] determinations for the same star. The HIP number is also given for more than 90% of the stars in Table 1, as well as an alternate designation for the bright stars which are often designated in the literature by their name or their number in a constellation. For cluster stars, a great variety of names were found in the literature for the same object. The SIMBAD database was consulted in order to adopt the most appropriate designation for each star. Except for 51 objects not recognized by SIMBAD (designated with "?" at the beginning of their name), the chosen identifier can be used in a SIMBAD interrogation. In many cases, problems related to identifiers were solved thanks to the WEBDA[1] database devoted to stellar open clusters. There is no redundancy between the list of field stars and the list of cluster stars. We encourage authors of abundance analyses to verify the syntax of the identifiers they use in the SIMBAD and WEBDA databases or the Dictionary of Nomenclature of Celestial Objects (Lortet et al. 1994) and to use preferentially the HD number for field stars.
2. *ICRS 2000.0 equatorial coordinates*
The ICRS 2000.0 equatorial coordinates have been collected through SIMBAD or WEBDA, but they are not available for all the stars. They have been included in the catalogue for optimal use of the VizieR Service (Ochsenbein et al. 2000).
3. *Visual magnitude V*
The visual V magnitudes are from the SIMBAD database. The sources of the visual magnitudes in SIMBAD are various and heterogeneous and as a consequence, this value should be considered only as an indicator of brightness. For precise photometry, the users have to consult specialised catalogues which are included in the General Catalogue of Photometric Data[2] (Mermilliod et al. 1997). In some cases, the magnitude indicated in this column is the B magnitude (a letter B follows the value of the magnitude in this case). Only a few faint stars do not have any visual magnitude at all.
4. *Spectral type*
The spectral types come from the cross-identification of the catalogue and the SIMBAD database. The same syntax has been used (see the SIMBAD user's guide and reference manual, chapter 15). We have corrected some spectral types which were clearly in disagreement with the effective temperature and gravity resulting from a detailed analysis, especially for metal deficient population II stars. In particular, for a fairly numerous sample of population II bright yellow giants, we found it necessary to give a more advanced spectral type and a brighter luminosity class, reflecting more correctly their position in the HR diagram. This misclassification of very evolved population II stars, still present in major stellar catalogues, is due to the great metal deficiency of their atmosphere. The MK spectrum of such stars mimics the MK spectrum of a hotter unevolved star. To such stars we have assigned a more appropriate spectral type, KIIvw (the "vw" stands for "very weak" lines).
5. *Effective temperature T_{eff} and its error*
The value listed is the one which was adopted by the author for the abundance determination in the detailed analysis. The effective temperature of a star, which is

[1] http://obswww.unige.ch/webda/
[2] http://obswww.unige.ch/gcpd/gcpd.html

the critical parameter, is mainly derived from narrow-band photometry, or on purely spectroscopic grounds from the comparison between H_α observed profiles and H_α computed profiles.
When available, the error on $T_{\rm eff}$ determined by the author is also given. The best determinations of $T_{\rm eff}$ listed in the catalogue quote errors of 25 K, whereas they can reach 250 K in some cases (faint stars, cold stars, unresolved stars...).

6. *Logarithm of gravity* $\log g$ *and its error*
The value of $\log g$ is the one used by the authors in the spectrum analysis. Usually, the spectroscopic surface gravity is determined from ionisation and excitation equilibria, as obtained from neutral and ionized lines, carefully chosen in the stellar spectrum, and from wings of strong lines, broadened by collisional damping. In some recent papers, the Hipparcos parallax was used to determine the gravity. The error on $\log g$ is given if available.
7. *[Fe/H] and its error*
Contrary to the previous versions of the catalogue, [Fe/H] is always given with respect to the Sun. Values in the previous versions given with respect to another standard star have been converted to the solar scale. It is worth noticing that the solar scale can change from author to author, with $\log \epsilon_\odot$(Fe) varying from 7.47 to 7.67. Several determinations have been flagged, by the letter M when [M/H] is given instead of [Fe/H] and by the letter N when the Fe abundances are based on NLTE analysis (Thévenin 1999). The error on [Fe/H] is given if available.
8. *Reference*
The reference of each [Fe/H] determination includes the name of the first author in an abbreviated form and the standard reference code (bibcode) of the paper. In such way, all the papers quoted in the catalogue can be retreived easily through ADS or VizieR Service. Only the following journals have been searched for [Fe/H] determinations: A&A, A&AS, AJ, ApJ, PASP, PASJ, NewA, MNRAS.

As in the last two editions of the catalogue (1991, 1997), the microturbulence velocity $\xi_{\rm t}$ has been omitted due to the fact that not all the authors use the same definition for it. This parameter must be recovered from the original reference.

The field stars list (Table 1) includes 4918 determinations of [Fe/H] for 2447 different stars. The second part of the catalogue (Table 2) includes 1436 determinations of [Fe/H] for 909 stars in 79 stellar systems.

We have been requested several times, between the successive editions, to include an average of the different determinations of [Fe/H] for each star. This is outside the scope of the [Fe/H] catalogue, which is purely bibliographical, but a paper presenting averaged atmospheric parameters for a sub-sample of the catalogue is under preparation.

3. Some comments on the catalogue

3.1. Input data

It is interesting to have a look at the growth of the catalogue over 20 years. Figure 1 presents the evolution per year of the number of [Fe/H] determinations, the number of new stars included in the catalogue and the number of papers presenting [Fe/H] determinations for FGK stars. The peak in 1990 is mainly due to the papers of McWilliam (1990) (668 determinations) and Balachandran (1990) (189 determinations). The number of papers has been growing slowly up to 2000, as has the number of new stars which underwent a detailed analysis. The number of [Fe/H] has been increasing faster, especially during the year 2000. As a matter of fact, more and more often the determination of [Fe/H] is only the first step in studying other elements in stars which are already known to belong to a given population. For this reason, some stars might be analysed several times by the same author or by different authors interested in elements other than iron. Also, a few stars are used as comparison stars to test a method and have many determinations of atmospheric parameters. As an example, the star which is the most studied is the metal poor halo subgiant HD 140283 (30 [Fe/H] determinations between 1980 and 2000). There is more than 400 K difference between the temperature proposed by Magain 1984 (5419 K) and that of Fuhrmann et al. (1997) (5843 K). The iron abundance [Fe/H] consequently has a large range of values, from −3.06 (Magain 1984) and −2.21 (NLTE, Thévenin 1999) or −2.29 (Zhao 2000; Fuhrmann 1998). This shows that even with high quality observations and a careful analysis, the atmospheric parameters vary from author to author.

3.2. Stellar content of the catalogue

The great change of this new edition of the catalogue of [Fe/H] determinations is the restriction to middle and low mass FGK stars which span a large range of ages. In its present form, the catalogue is principally suited to studies of the chemical evolution of the Galaxy. The distribution of the 6354 [Fe/H] determinations of the catalogue is shown in the plane ($T_{\rm eff}$, $\log g$) in Fig. 2, in the plane ($T_{\rm eff}$, [Fe/H]) in Fig. 3 and in the histogram of Fig. 4. In Fig. 2, the Herzsprung-Russell gap, due to the extremely rapid evolution of the stars in their subgiant phase, is visible between $\log g \sim 3.0$ and $\log g \sim 4.2$. In Fig. 3, the separation between extreme Population II subdwarfs ($T_{\rm eff} \sim 6000$ K) and extreme Population II bright giants ($T_{\rm eff} < 4800$ K) is clearly seen. This is mainly an observational selection effect, extremely metal-poor dwarfs being picked-up by surveys only if they are bright enough (i.e. near the turn-off).

Despite the improvement of telescopes and spectrographs, there is still a lack of G and K dwarfs, which are intrinsically faint and more difficult to observe at high resolution and high S/N than the giants corresponding to the

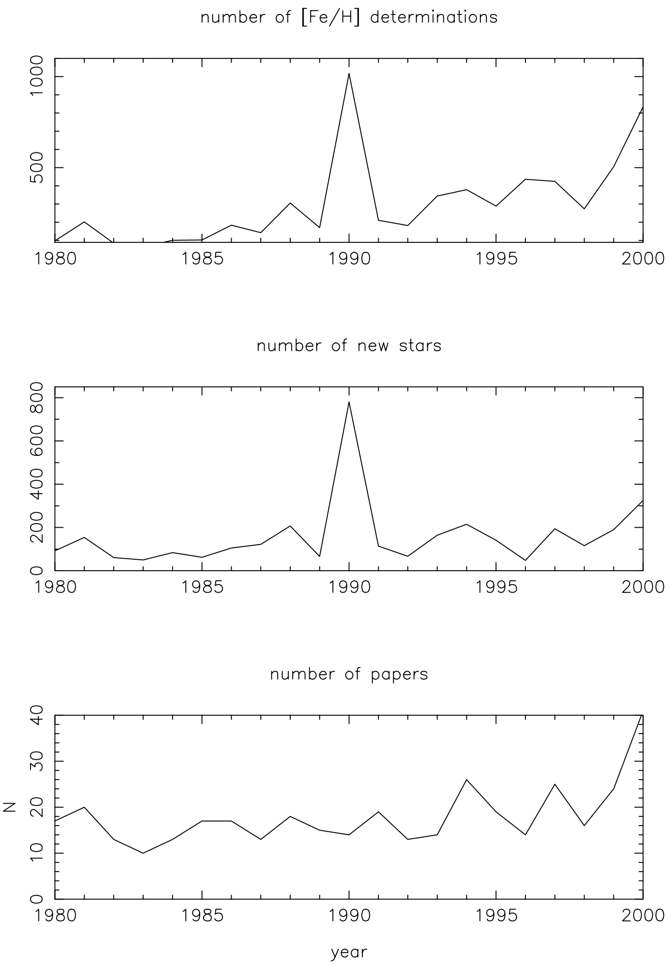

Fig. 1. From top to bottom, evolution of the number per year of [Fe/H] determinations, of new stars introduced in the catalogue and of papers quoting spectroscopic [Fe/H] determinations for FGK stars.

same $T_{\rm eff}$. A few M stars have been introduced in the catalogue but they are largely underepresented because they are difficult to analyse in detail.

The sample of stars in this new edition of the catalogue, with $T_{\rm eff} < 7000$ K, cannot be considered as representative of the stellar content of the solar neighbourhood. Evidently, the various observing programs, spanning from stellar structure problems to stellar population studies, from which the catalogue was built, introduce some biases in the distributions of ($T_{\rm eff}$, $\log g$, [Fe/H]).

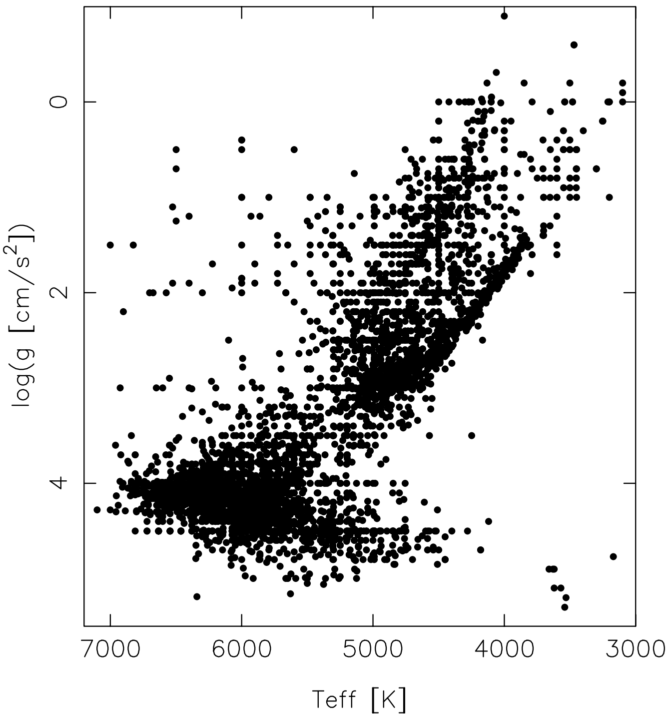

Fig. 2. $T_{\rm eff}$ vs. $\log g$ for the 6354 entries of the catalogue.

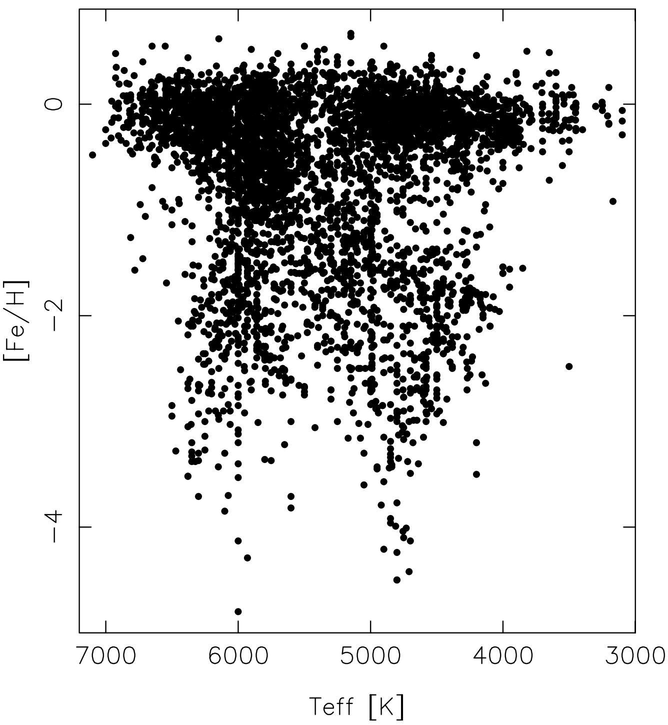

Fig. 3. $T_{\rm eff}$ vs. [Fe/H] for the 6354 entries of the catalogue.

3.3. The catalogue and the Hipparcos mission

Many stars contained in this catalogue were included in different programs linked to the Hipparcos mission. The crossing between the Hipparcos data and the spectroscopic results gathered in this catalogue has a strong impact on the methods of analysis of stellar spectra. In particular, thanks to Hipparcos, spectroscopic gravities, based on ionisation equilibrium, have shown to be in error in very metal poor stars (Nissen 1997; Fuhrmann 1998). The Hipparcos number of the stars is given, when available, in Col. 2 of Table 1.

4. Conclusion

We have presented the new version of the catalogue of [Fe/H] determinations which is now restricted from middle to low mass F, G and K stars. The [Fe/H]

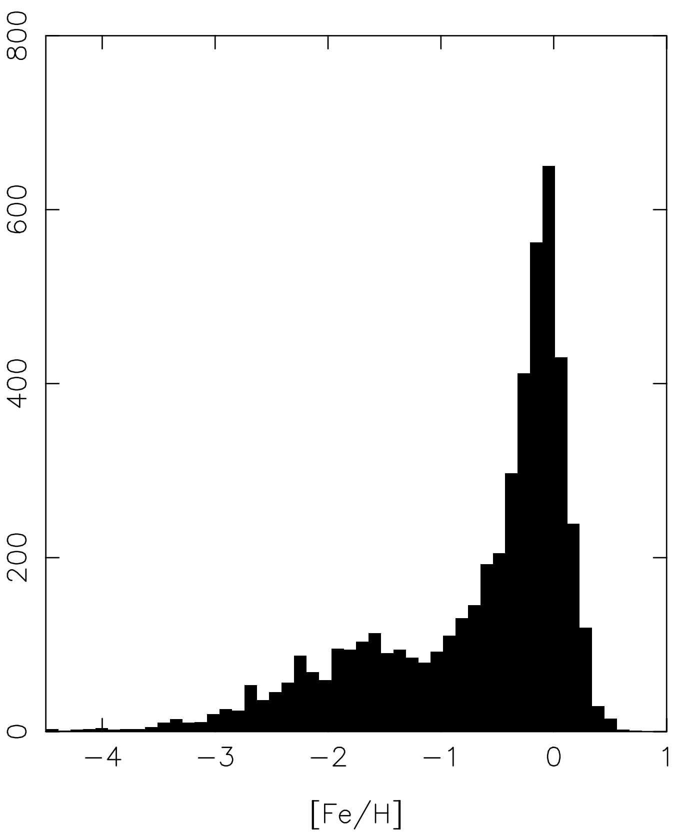

Fig. 4. [Fe/H] histogram for the 6354 entries of the catalogue.

values contained in the catalogue come almost all from differential detailed analyses. Greenstein introduced, in the late fifties, the technique of the differential curve of growth analysis. The principle of differential detailed analyses is to obtain the abundances of the elements in star A relative to the abundances in star B, taken as a standard. If we take the Sun as a standard, and if we restrict the effective temperature interval to F, G, and K stars, the same spectral lines can be used, and the knowledge of the oscillator strengths is no longer needed. Another advantage of this method is that it cancels systematic errors in equivalent width measurements if the same spectroscopic equipment is used to get the spectra of both stars. A third advantage of the differential method is that the effects of departure from local thermodynamic equilibrium (LTE) are minimized because they are expected to be about the same in both stars. Nevertheless, if we take a quick look at the catalogue, concentrating on stars analysed several times in Table 1, we see that the differences between some authors are still, in the mean, higher than the standard errors attributed to each analysis. Let us hope that these differences will be minimized with the future progress both in observation and theory.

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