Some Concerns about the Reliability of LTE Abundance Analyses in Cool, Active Stars

Thierry Morel[1], Giuseppina Micela[1], and Fabio Favata[2]

[1] Istituto Nazionale di Astrofisica, Osservatorio Astronomico di Palermo G. S. Vaiana, Piazza del Parlamento 1, I-90134 Palermo, Italy
[2] Astrophysics Division - Research and Science Support Department of ESA, ESTEC, Postbus 299, NL-2200 AG Noordwijk, The Netherlands

Abstract. We discuss recent observational evidence illustrating the current limitations plaguing classical LTE abundance analyses of cool ($T_{\rm eff}$ < 5500 K), chromospherically active stars. Although significant progress on this issue can be evidently expected from a more realistic atmospheric modelling and treatment of NLTE line formation, a homogeneous abundance study of a large sample of *inactive* K-type stars may also prove valuable in disentangling temperature and activity effects.

1 Background

A growing body of data on chemical abundances of cool, young open cluster stars is yielding intriguing results. A dramatically increasing oxygen overabundance with decreasing effective temperature (up to 1 dex) has been, for instance, reported in cool Pleiades members [5], while an order of magnitude difference between the iron abundances derived from Fe I and Fe II lines has been found in K-type dwarfs of the Hyades [6]. This schematically calls for two main culprits: (a) the largely unknown importance of NLTE effects in this type of objects and/or (b) difficulties in modelling the atmospheric structure of stars exhibiting a plethora of peculiarities, from a thermally inhomogeneous photosphere (large spot groups, etc.) to an overlying, prominent chromosphere. It is of relevance to note that similar conclusions, albeit perhaps to a lesser extent, also seem to hold for inactive K-type stars in the field [1].

2 Insights from an Analysis of a Sample of Tidally-Locked Active Binaries

We have recently derived the abundances of 13 chemical elements in a sample of 14 single-lined RS CVn systems from a differential, curve-of-growth LTE analysis of high-resolution FEROS spectra (the reader is referred to [2] and [3] for further details). A significant overabundance of several elements (e.g., Na, Al) compared to inactive, Galactic disk stars of similar metallicities is found. The case of oxygen is particularly illustrative [4]. As can be seen in Fig. 1, the O I triplet yields for the coolest, most active stars puzzlingly high overabundances relative to solar of up to 1.8 dex (note that this phenomenon is not observed for [O I] λ6300 which is insensitive to departures from LTE). It is remarkable that the literature data exhibit similar temperature and activity trends, despite the heterogeneous nature of the analyses performed. Although it is not possible at this stage to clearly assess the relative importance of temperature and activity effects, it is hoped that our forthcoming abundance analysis of a large sample of inactive, K-type stars observed with FEROS will settle this issue.

References

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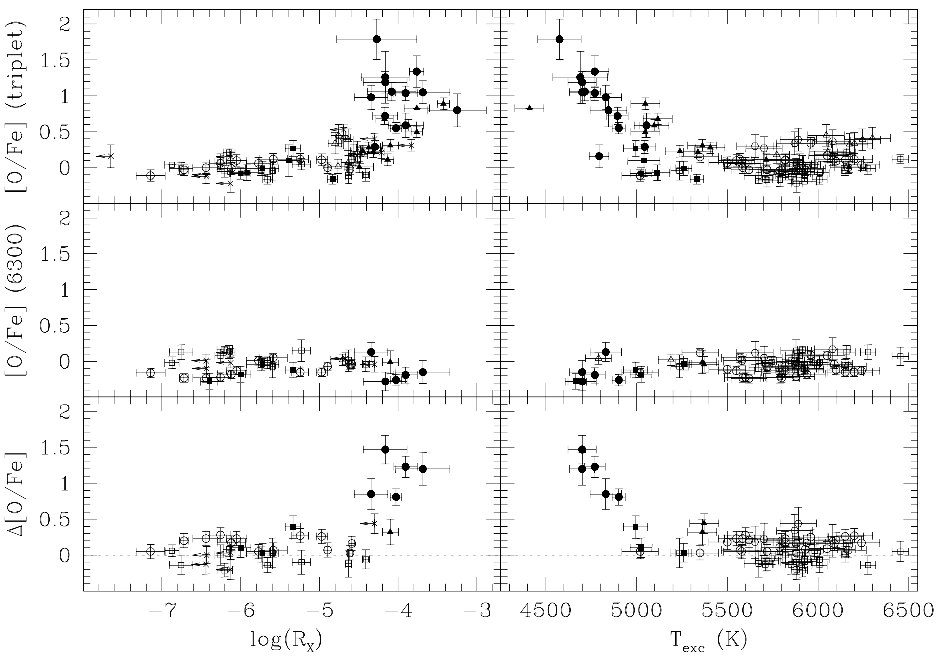

Fig. 1. Oxygen abundances as a function of the activity index, $R_{\rm X}$, derived from X-ray data (*left-hand panels*) and the excitation temperature $T_{\rm exc}$ (*right-hand panels*). The bottom panels show the difference between [O/Fe] yielded by the O I triplet at about 7774 Å and the [O I] λ6300 line. Filled circles: RS CVn binaries ([2] and [3]), filled squares: field subgiants [3], filled triangles: Pleiades stars, open triangles: Hyades stars, open circles, squares and hexagons: disk dwarfs. The source of the literature data for the open cluster and Galactic disk stars can be found in [4].