COPPER AND ZINC IN BULGE-LIKE STARS

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Abstract

The star formation history of a given population remains imprinted in the chemical distributions of their individuals. The parallel study of stellar abundances and nucleosynthesis helps to understand the production of the elements inside stars and their evolution in the interstellar medium. In the present paper copper and zinc abundances of a sample of bulge-like stars are inferred and compared to samples of the solar vicinity. A disk-like distribution of $\text{[Zn/Fe]}$ is found for the bulge-like stars, while underabundant $\text{[Cu/Fe]}$ ratios relative to disk samples are determined.

1. Introduction

Element production in the Universe (except for those forged by the Big Bang nucleosynthesis), occurs mainly in stellar interiors, during their numerous evolutionary stages. The production and ejection cycle of such elements in the interstellar medium of galaxies remains imprinted in the stellar abundance distributions, and depends basically on the nucleosynthetic processes occurred, and on the dynamical evolution of the born region. Input assumptions for the chemical evolution models as the star formation rate (SFR) and the initial mass function (IMF), are also constrained by the abundance ratios of elements produced in different stellar phases, and in stars of different stellar masses (e.g. Chiappini et al. 2001).

In the present work Cu and Zn abundances of a sample of bulge-like stars are reported. This sample is described in our previous papers (e.g. Pompéia et al. 2002, Paper I, and 2003, Paper II), which members are old G and K dwarf stars, with isochronal ages of 10 -11 Gyr, and probable originated near the bulge. The metallicity range of the sample is -0.80
\[ \leq [\text{Fe/H}] \leq +0.40, \text{ comprising one of the most metal-rich samples with derived Cu and Zn abundances.} \]

2. Abundance Analysis

Stellar parameters are calculated as follows. Temperatures are derived by using H\(\alpha\) line profiles; trigonometric surface gravities are inferred by using Hipparcos paralaxes; microturbulent velocities are calculated by requiring zero slope of [\text{Fe/H}] vs. EW for a list of Fe I lines; and finally iron abundances are calculated using Fe II lines. The final parameters are given in Table 1.

Abundances of Zn and Cu are derived by using the spectrum synthesis code described in Cayrel et al. (1991). Atomic data are from Sneden et al. (1991) for the Zn I line at \(\lambda 4722.15\) Å, Béumont & Godefroid (1980) for Zn I \(\lambda 4810.53\) Å, and from Sneden & Crocker (1988) with hyperfine splitting structure and isotopic data from Biehl (1976) for the Cu I line \(\lambda 5782.13\) Å. The final abundance ratios relative to iron are also given in Table 1.

3. Discussion

The production sites of Cu and Zn are still poorly understood. As iron-peak group members, they are predicted to be produced in massive stars by NSE (nuclear statistic equilibrium) and by explosive nucleosynthesis (e.g. Woosley & Weaver 1995). Important yields are inferred from s-process in massive stars, with a smaller contribution from AGB stars (e.g. Raiteri et al. 1992, Gallino et al. 1998). SNe Ia have also been claimed as stellar sources of Cu and Zn, but their contribution remains unclear (Mishenina et al. 2002).

In Figure 1, [Cu/Fe] and [Zn/Fe] trends with metallicity for the stars of our sample are depicted. Stars from Sneden et al. (1991), Mishenina et al. (2002) and Reddy et al. (2003) are also given. As shown in this Figure, our data for [Cu/Fe] ratios are underabundant relative to the disk samples for overlapping metallicities. Such behavior is in contrast with the r-process element Eu, for which we found overabundances relative to iron (Paper II). This result suggests a little or no contribution from SNe II for Cu abundances.

[Zn/Fe] values, on the other hand, show an overlapping behavior relative to disk stars, with a possible trend of increase with decreasing metallicities. For metallicities higher than solar, the abundance ratios indicate a flatter behavior.
### Table 1. Stellar Parameters and Chemical Abundances

| Star      | $T_{\text{eff}}$ | log $g$ | [Fe/H] | ξ | [Zn/Fe] | [Cu/Fe] |
|-----------|------------------|---------|--------|---|---------|---------|
| HD 143016 | 5575             | 4.11    | -0.35  | 0.70 | 0.11    | -0.35   |
| HD 143102 | 5500             | 3.85    | 0.03   | 1.05 | 0.03    | -0.10   |
| HD 148530 | 5350             | 4.43    | 0.10   | 0.80 | -0.10   | -0.20   |
| HD 149256 | 5350             | 3.73    | 0.34   | 0.80 | 0.10    | 0.00    |
| HD 152391 | 5300             | 4.45    | -0.05  | 0.50 | -0.03   | -0.42   |
| HD 326583 | 5600             | 3.81    | -0.30  | 0.60 | 0.25    | -0.33   |
| HD 175617 | 5550             | 4.56    | -0.44  | 0.60 | 0.13    | -0.22   |
| HD 178737 | 5575             | 3.90    | -0.35  | 0.60 | 0.23    | -0.20   |
| HD 179764 | 5450             | 4.26    | 0.06   | 1.10 | -0.09   | -0.10   |
| HD 181234 | 5350             | 4.25    | 0.40   | 1.10 | 0.00    | 0.00    |
| HD 184846 | 5600             | 4.40    | 0.06   | 0.50 | 0.10    | -0.42   |
| BD-176035 | 4750             | 4.36    | 0.46   | 0.70 | 0.00    | -0.15   |
| HD 198245 | 5650             | 4.31    | -0.60  | 0.60 | 0.11    | -0.22   |
| HD 201237 | 4950             | 4.08    | 0.15   | 0.50 | -0.11   | -0.15   |
| HD 211276 | 5500             | 4.05    | -0.39  | 0.50 | -0.09   | -0.35   |
| HD 211532 | 5350             | 4.46    | -0.54  | 0.80 | 0.02    | -0.14   |
| HD 211706 | 5800             | 4.25    | 0.16   | 0.80 | 0.00    | -0.40   |
| HD 214059 | 5550             | 3.81    | -0.38  | 0.75 | 0.31    | -0.12   |
| CD-40 15036 | 5350         | 4.34    | 0.00   | 0.70 | -0.05   | -       |
| HD 219180 | 5400             | 4.35    | -0.46  | 0.65 | 0.00    | -0.30   |
| HD 220536 | 5850             | 4.17    | -0.11  | 0.50 | -0.05   | -0.32   |
| HD 220993 | 5600             | 4.15    | -0.16  | 0.80 | 0.14    | -0.20   |
| HD 224383 | 5800             | 4.14    | -0.06  | 1.00 | 0.00    | -0.12   |
| HD 4308  | 5600             | 4.31    | -0.26  | 0.80 | 0.06    | -0.21   |
| HD 6734  | 5000             | 3.40    | -0.36  | 0.75 | 0.05    | -0.20   |
| HD 8638  | 5500             | 4.38    | -0.29  | 0.60 | 0.10    | -0.17   |
| HD 9424  | 5350             | 4.35    | 0.25   | 0.70 | -0.04   | -0.12   |
| HD 10576 | 5850             | 4.00    | -0.02  | 1.25 | -0.27   | -0.40   |
| HD 10785 | 5850             | 4.16    | -0.25  | 1.20 | -0.03   | -0.12   |
| HD 11306 | 5200             | 4.09    | -0.98  | 0.80 | -0.06   | -0.24   |
| HD 11397 | 5400             | 4.34    | -0.59  | 0.65 | -0.03   | -0.22   |
| HD 14282 | 5800             | 3.91    | -0.34  | 0.65 | 0.20    | -0.30   |
| HD 16623 | 5700             | 4.26    | -0.51  | 0.60 | 0.16    | -0.25   |
| BD-02 603 | 5450             | 3.75    | -0.79  | 0.70 | -0.03   | -0.12   |
| HD 21543 | 5650             | 4.37    | -0.55  | 0.50 | 0.16    | -0.22   |

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Figure 1. [Cu/Fe] and [Zn/Fe] abundance trends with metallicity for our sample stars (solid circles), and for the samples of Sneden et al. (1991) (down triangles), Mishenina et al. (2002) (stars) and Reddy et al. (asterisks).

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