SF2A 2012
S. Boissier, P. de Laverny, N. Nardetto, R. Samadi, D. Valls-Gabaud and H. Wozniak (eds)

ABUNDANCE ANALYSIS OF B, A AND F DWARFS IN THE M6 OPEN CLUSTER: SPECTRUM SYNTHESIS METHOD

T. Kılıçoğlu[1], R. Monier[2,3] and L. Fossati[4]

Abstract. The chemical abundances of 10 stars in the M6 open cluster (∼100 Myr) were derived using spectrum synthesis. The stars were observed using the FLAMES/GIRAFFE spectrograph. We found star-to-star variations in abundances for A type stars. General enrichment of Si, Cr, and Y were obtained for the cluster.

Keywords: Stars: abundances , open clusters and associations: individual: M6

1 Introduction

M6 is a young (∼100 Myr) open cluster located in the constellation of Scorpius. The distance to the cluster can be adopted as 500 ± 70 pc from the published values (i.e. Vleeming 1974, Paunzen et al. 2006, and WEBDA Database). Differences in chemical compositions among main sequence late-B, A and F type stars within a given cluster are probably due to differences in their masses, rotation and various kind of mixing mechanisms. These star-to-star abundance differences were previously investigated by Monier (2005), Gebran & Monier (2008), Gebran et al. (2008), Fossati et al. (2008), Fossati et al. (2011), and Gebran et al. (2010). Here, our aim is to continue to test evolutionary models via abundance determinations of the members of M6.

2 Observations

The spectra of the program stars were observed using the FLAMES/GIRAFFE spectrograph with MEDUSA, mounted at UT2 (Kueyen), the 8 meter class VLT telescope in May and June, 2007. The spectral regions cover three wavelength intervals: 4500-5100 Å, 5140-5350 Å, and 5590-5840 Å at resolving powers of about 7500, 25900, 24200, respectively.

3 Abundance Analysis

The initial atmospheric parameters of the 10 stars were derived by using Geneva 7color Photometry together with Kunzli et al. (1997)'s calibrations (CALIB code, North, P., private communication). We then used Hβ line models to derive more accurate effective temperatures and surface gravities. In order to calculate model atmospheres, we used Linux version of ATLAS9 code assuming plane-parallel geometry, a gas in hydrostatic and radiative equilibrium and LTE (Kurucz 1993, Sbordone et al. 2004, Sbordone 2005). ATLAS9 models were computed adopting Grevesse & Sauval (1998)'s solar chemical abundances and new ODFs (Castelli & Kurucz 2003). Synthetic spectra were obtained by using SYNSPEC48 with its SYNPLOT interface (Hubeny & Lanz 1992). Chemical abundances were derived by adjusting synthetic spectra with observed spectra (Fig. 1). The abundances of the elements used to compute synthetic spectra of the stars were adjusted manually to minimize chi-squares.

[1] Ankara University, Faculty of Science, Department of Astronomy and Space Sciences, 06100, Tandoğan, Ankara, Turkey
[2] Laboratoire Lagrange, Université de Nice - Sophia Antipolis, 06108 Nice Cedex 2, France
[3] LESIA Observatoire de Paris Meudon, 5 Place J. Janssen, 92195, Meudon
[4] Department of Physics and Astronomy, Open University, Walton Hall, Milton Keynes MK7 6AA, UK.

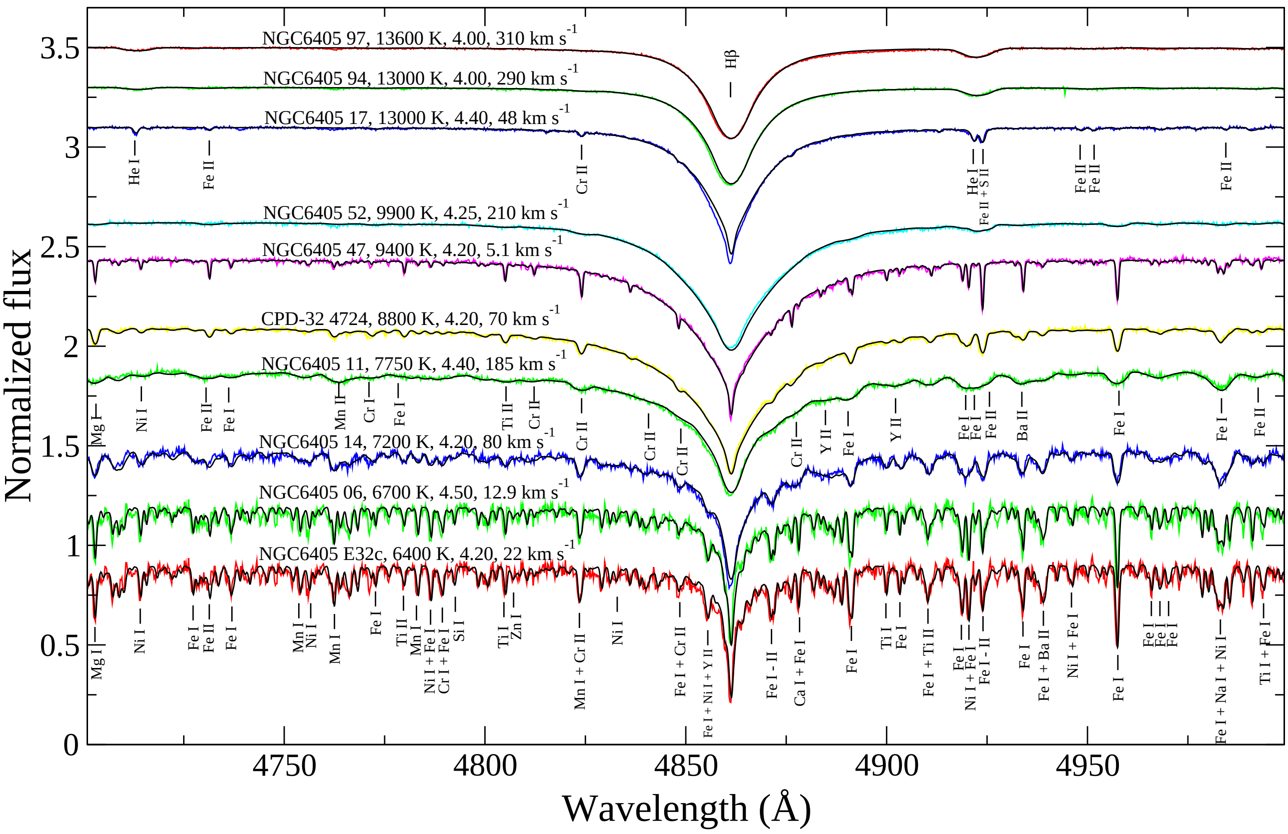

Fig. 1. The low resolution (R=7500) spectra of the cluster members (colored lines) with their final synthetic spectra (black lines) computed by using SYNSPEC48. The strongest lines are identified. The names, effective temperatures, logarithms of the surface gravities, and rotational velocities of the stars are collected above each spectrum. The normalized spectra have been shifted by an arbitrary amount in y-axis for display purpose.

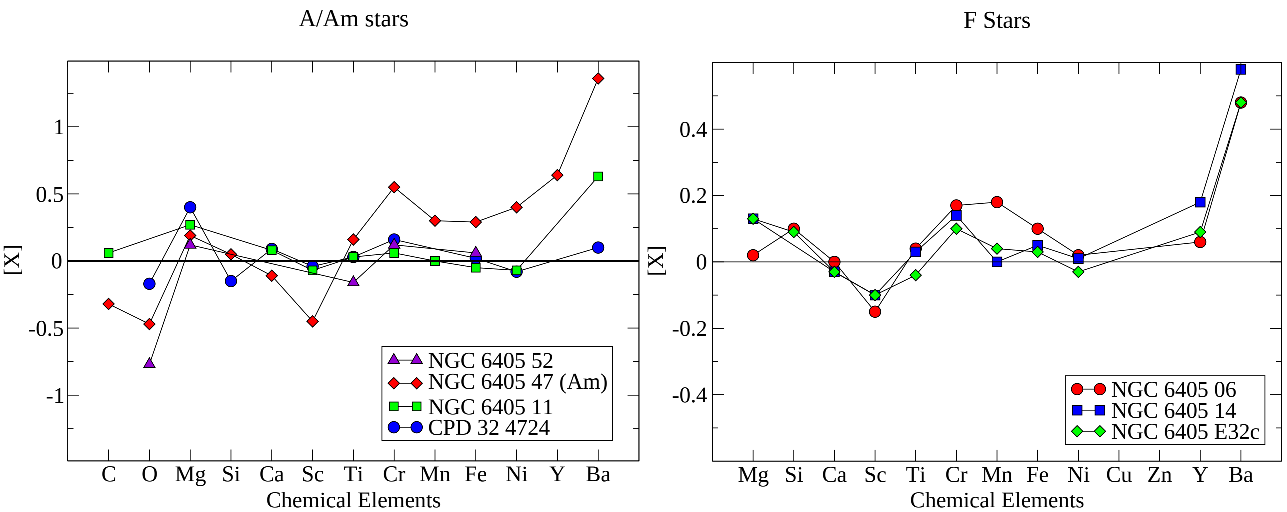

Fig. 2. Left: The derived abundances relative to the Sun for A type members. **Right:** Same for the F stars.

4 Results

We derived the chemical abundances of up to 16 chemical elements of 10 B, A, and F type dwarfs of the young open cluster M6 (Fig. 2). Gebran et al. (2008) reported a large star-to-star abundance variations for

A stars in Coma Berenices. These variations are present for C, O, Na, Sc, Ti, Mn, Fe, Ni, Sr, Y, Zr and Ba elements. Monier (2005), Gebran & Monier (2008), and Gebran et al. (2010) found similar variations for A stars in Hyades and Pleiades open clusters. Gebran et al. (2008) theorize that this peculiar behavior is a signature of the occurrence of transport processes competing with radiative diffusion. The normal A-type stars in M6 also display star-to-star variations, particularly for Mg, Ti and Ba. In contrast, the abundance patterns of the F type stars in the cluster differ little from each other, except for Mg and Mn. The chemical abundances of F stars suggest an initial enrichment of M6 in Si, Cr, Y, and particularly Ba. Analysis of a larger sample of stars having different atmospheric parameters in this cluster will help us to elucidate the mechanisms of mixing at play in the interiors of these main-sequence stars.

We kindly thank Pierre North for making his code CALIB available. This research has been supported by the Scientific and Technological Research Council of Turkey (TUBITAK, Research Fellowship of 2214), and has used SIMBAD, WEBDA, VALD, and NIST databases.

References

Castelli, F. & Kurucz, R. L. 2003, in IAU Symposium, Vol. 210, Modelling of Stellar Atmospheres, ed. N. Piskunov, W. W. Weiss, & D. F. Gray, 20P

Fossati, L., Bagnulo, S., Landstreet, J., et al. 2008, A&A, 483, 891

Fossati, L., Folsom, C. P., Bagnulo, S., et al. 2011, MNRAS, 413, 1132

Gebran, M. & Monier, R. 2008, A&A, 483, 567

Gebran, M., Monier, R., & Richard, O. 2008, A&A, 479, 189

Gebran, M., Vick, M., Monier, R., & Fossati, L. 2010, A&A, 523, A71

Grevesse, N. & Sauval, A. J. 1998, Space Sci. Rev., 85, 161

Hubeny, I. & Lanz, T. 1992, A&A, 262, 501

Kunzli, M., North, P., Kurucz, R. L., & Nicolet, B. 1997, A&AS, 122, 51

Kurucz, R. 1993, ATLAS9 Stellar Atmosphere Programs and 2 km/s grid. Kurucz CD-ROM No. 13. Cambridge, Mass.: Smithsonian Astrophysical Observatory, 1993., 13

Monier, R. 2005, A&A, 442, 563

Paunzen, E., Netopil, M., Iliev, I. K., et al. 2006, A&A, 454, 171

Sbordone, L. 2005, Memorie della Societa Astronomica Italiana Supplementi, 8, 61

Sbordone, L., Bonifacio, P., Castelli, F., & Kurucz, R. L. 2004, Memorie della Societa Astronomica Italiana Supplementi, 5, 93

Vleeming, G. 1974, A&AS, 16, 331