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Precision Chemical Abundance Measurements

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Abstract. This talk covers preliminary work in which we apply a strictly differential line-by-line chemical abundance analysis to high quality UVES spectra of the globular cluster NGC 6752. We achieve extremely high precision in the measurement of relative abundance ratios. Our results indicate that the observed abundance dispersion exceeds the measurement uncertainties and that many pairs of elements show significant correlations when plotting [X1/H] vs. [X2/H]. Our tentative conclusions are that either NGC 6752 is not chemically homogeneous at the $\simeq$0.03 dex level or the abundance variations and correlations signify star-to-star He abundance variations.

Keywords. Stars: abundances, globular clusters: individual: NGC 6752.

1. Introduction

The Milky Way globular clusters show enormous complexity in colour-magnitude diagrams (Piotto 2009) as well as a large diversity in the chemical compositions of stars within a given cluster (Gratton *et al.* 2012). The key question we seek to answer in the present work is "how low are the abundance dispersions for 'well-behaved' elements like Ti and Ni in the 'least complex' globular clusters"? The answer to this question may contain important new clues for understanding the formation and evolution of globular clusters.

A number of recent papers have conducted a so-called "line-by-line strictly differential chemical abundance analysis" (e.g., Meléndez *et al.* 2009, Nissen & Schuster 2010). These works have achieved very high precision in relative abundance measurements, in some cases as low as σ[X/H] = 0.01 dex. In this work, we apply the same analysis techniques to the globular cluster NGC 6752.

2. Analysis and Preliminary Results

We adopt the procedure outlined in Meléndez *et al.* (2012) in the analysis of high quality UVES spectra of NGC 6752 stars (i) near the luminosity bump (these data are described in Grundahl *et al.* 2002) and (ii) near the tip of the red giant branch (these data are described in Yong *et al.* 2003). That is, we conducted a line-by-line strictly differential chemical abundance study of the luminosity bump sample and a similar independent analysis of the red giant branch tip sample. The elements we studied included the light element Na, various alpha elements, Fe-peak elements and neutron-capture elements. Our analysis also includes neutral and ionised species of a given element (e.g., TiI and TiII as well as CrI and CrII). The main results can be summarised as follows:

1. Taking into account all error terms as described in Johnson (2002), we find that the abundance errors for a given element in a given star can be as low as ∼0.01 dex.

2. For most elements, the observed abundance dispersion in either the luminosity bump sample or the red giant branch tip sample exceeds the typical measurement uncertainty for a given sample. In some cases, the difference exceeds a factor of three.

3. When plotting pairs of elements [X1/H] vs. [X2/H] (e.g., [Ca/H] vs. [Si/H]), in the majority of cases there are positive correlations between the abundance ratios. Furthermore, in many cases the correlations are highly significant, 5-σ or higher.

If these results are real, then NGC 6752 is not chemically homogeneous as the ≃0.03 dex level, for all elements studied in the present work. Star-to-star differences in He abundance may be another possible explanation for these results. We are continuing this work in order to explore these, and other, possibilities.

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