Rediscovering our Galaxy
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Developing an astrophysical line list for Keck/Nirspec observations of red giants in the Galactic centre

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Abstract. A major avenue in the study of the Galaxy is the investigation of stellar populations and Galactic chemical evolution by stellar spectroscopy. Due to the dust obscuration, stars in the centre of the Galaxy can only be observed in the near-IR wavelength region. However, existing line lists in this wavelength region are demonstratively not of good enough quality for use in stellar spectroscopy. In response to this, we have developed an empirical astrophysical line list in the K-band based on modelling against the Sun and testing against Arcturus. Of ca. 700 identified interesting lines about 570 lines have been assigned empirically determined values.

Keywords. stars: atmospheres, stars: late-type, Galaxy: bulge, Galaxy: center, infrared: stars

1. Introduction

In the context of how the Milky Way was formed we are specifically investigating the Galactic centre and its connection to the rest of the bulge. We want to study whether the Galactic centre is distinct when it comes to stellar populations, star formation history, and initial mass function. Our goal is therefore to observe the metallicity distribution function and detailed abundances of stars in the Nuclear Star Cluster surrounding the dormant super massive black hole and compare these to observations made further out in the bulge.

Due to the dust obscuration in the line-of-sight, stars in the centre of the Galaxy can only be observed in the near-IR wavelength region. In the near-IR wavelength region, atomic line list information is almost solely based on theoretical calculations when it comes to understanding the strength of the lines. The theoretical calculations are demonstratively not of good enough quality for use in stellar spectroscopy. In response to this, this study seeks to develop a line list in the K-band (ca. 2.0 μm to 2.4 μm) with empirical values obtained by analysing synthetically generated spectra based on stellar modelling against the Sun and Arcturus.

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2. Developing the line list

The line list we have developed is based on the VALD3 atomic physics database (Piskunov *et al.* 1995; Ryabchikova *et al.* 1997; Kupka *et al.* 2000; Ryabchikova *et al.* 2015). There exist a few laboratory experiments (O'Brian *et al.* 1991; Wickliffe *et al.* 2000; Blackwell-Whitehead *et al.* 2006; Lawler *et al.* 2013; Pehlivan *et al.* 2015) that measure the gf-values of lines in the K-band, which have been included in our line list.

With the BSYN&EQWIDTH codes (based on routines from the MARCS model atmosphere code (Gustafsson *et al.* 2008)), equivalent widths are calculated for all lines in the data set using the MARCS atmospheric model and the stellar parameters and chemical composition (Grevesse *et al.* 2007) of the Sun as input. Selecting all lines with an equivalent width larger than 5 mÅ gives a set of about 700 lines deemed interesting. Synthetic solar spectra are generated around each individual line and fitted against the corresponding part of a high resolution observed solar spectrum (Livingston & Wallace 1991). These fits give rise to updates on about 570 of the lines, including changes to gf-values, wavelength and broadening parameters.

The line list with solar empirical values together with stellar parameters and chemical compositions of Arcturus (Ramírez & Allende Prieto 2011; Ryde *et al.* 2009, 2010) is used to generate a synthetic spectrum, and it is compared to a high resolution observed spectrum of Arcturus (Hinkle *et al.* 1995). A good agreement is found for most lines between the synthetic spectrum and the observed spectrum (Thorsbro *et al.* in prep.).

3. Conclusion

The line list is currently in use for analysis of Galactic centre red giants observed with KECK/NIRSPEC described in more detail by Ryde *et al.* (these proceedings) and in Rich *et al.* (in prep.). Further test of the line list against other benchmark stars is also forthcoming (Thorsbro *et al.*, in prep.), which also will include recent laboratory measurements (Pehlivan Rhodin *et al.*, in prep.)

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