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^{12}C/^{13}C in atmospheres of red giants and peculiar stars

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Abstract. We determine the carbon isotopic ratios in the atmospheres of some evolved stars in both globular clusters and the disk of our Galaxy. Analysis of ^{12}CO and ^{13}CO bands at 2.3 micron was carried out using fits to observed spectra of red giants and Sakurai's object (V4334 Sgr). The dependence of theoretical spectra on the various input parameters was studied in detail. The computation of model atmospheres and a detailed abundance analysis was performed in a self-consistent fashion. A special procedure for determining the best fits to observed spectra was used. We show, that globular cluster giants with [Fe/H] < -1.3 have a low ^{12}C/^{13}C $= 4 \pm 1$ abundance ration. In the spectra of Sakurai's object (V4334 Sgr) taken between 1997-98, the 2.3 micron spectral region is veiled by hot dust emission. By fitting UKIRT spectra we determined ^{12}C/^{13}C $= 4 \pm 1$ for the July, 1998 spectrum. CO bands in the spectra of ultracool dwarfs are modelled as well.

Keywords. stars: carbon, chemically peculiar, abundances, AGB and post-AGB, late-type, low-mass

1. Introduction

The carbon isotopes ^{12}C and ^{13}C are produced inside low and intermediate mass stars mainly. The carbon isotope ratio $^{12}C/^{13}C$ is often used as a tracer of the nucleosynthetic and chemical mixing processes inside stars. Fast evolving chemically peculiar stars provide a unique tool for the verification of our knowledge about the process of stellar evolution. In contrast, some low mass dwarfs do not fuse ^{1}H, these are known as brown dwarfs. These objects preserve their initial ^{12}C and ^{13}C, and can be used for testing the Galaxy evolution theories.

2. Procedure

A grid of model atmospheres, for red giants and Sakurai's object, with the non-solar abundances was computed by using the model atmosphere code SAM12(Pavlenko (2003)). Molecular and atomic line opacities were treated using the opacity sampling approach. For ultracool dwarfs solar abundances are used. To compute their spectra the NextGen model atmospheres (Hauschildt at al. (1999)) were used.

To determine the parameters of the "best fit", we use $F^x_\nu = \int F^y_\nu G(x-y)dy$, where F^y_ν and $G(x-y)$ are the synthetic fluxes and the broadening profile, respectively. We then find the minima of the 3D function $S(f_{\rm s}, f_{\rm h}, f_{\rm g}) = \sum \left(1 - f_{\rm h} F^{\rm synt}/F^{\rm obs}\right)^2$, where $f_{\rm s}$, $f_{\rm g}$, $f_{\rm g}$ are the wavelength shift, normalisation factor, and half-width of $G(x-y)$, respectively. The parameters $f_{\rm s}, f_{\rm h}$ and $f_{\rm g}$ are determined by the minimisation procedure for every computed spectrum (for details see Jones et al.(2002), Pavlenko, Geballe, Evans et al. (2004).

3. Sakurai's object(V4334 Sgr)

V4334 Sgr is believed to be a low mass star undergoing a very late thermal pulse (VLTP). After traversing the "sholder" of the post AGB evolutionary track the star experiences a final He flash on the way to white dwarf cooling track.

Pavlenko & Geballe (2003) found evidences that hot dust produces the significant continuous emission at long wavelengths ($\lambda > 2$ μm). When accounting for hot dust emission, our fits (Pavlenko, Geballe, Evans et al. (2004)) to the 2.3 μm CO bands yielded ^{12}C/^{13}C = 4 $\pm$ 1 for the July, 1998 spectra.This ^{12}C/^{13}C ratio is consistent with V4334 Sgr having undergone a VLTP.

4. Red giants of globular clusters

Pavlenko, Jones & Longmore (2003) fit the synthetic spectra across 2.3 μm to the observed spectra of a few globular cluster giants of different metallicites. We found:

- that the M3 and M13 giants ([Fe/H]< -1.3 dex) have about the same ^{12}C/^{13}C,
- we obtained some evidence of a lower ^{12}C/^{13}C ratio in giants with lower [Fe/H],
- giants of more metal rich clusters show larger dispersion of ^{12}C/^{13}C,
- more evolved stars show lower carbon abundance.

5. Ultracool dwarfs

Pavlenko & Jones (2003) compared observed and theoretical spectra of CO bands of some M-dwarfs. In the spectra of oxygen-rich stars the CO bands are severely blended by H_2O lines (see also Jones, Pavlenko, Viti et al., (2005)). We found the ^{13}CO band at 2.375 μm is more useful for isotopic ratio determination because the band suffers from far less contamination by water lines. We then show the contamination by water bands appears to be stronger for the Δv = 1 CO bands at 4.5 μm.

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