STELLAR ABUNDANCES. FROM QUANTITY TO QUALITY?

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ABSTRACT. We present the overview of chemical compositions of the atmospheres of seven stars with the most detailed abundance patterns – the Sun, Przybylski's star, HD221170, Sirius, Procyon, ζ Cyg, δ Sct. The abundance pattern of the Sun is 73 chemical elements, for other stars (except HD221170) – more than 50 elements. A big quantity of known abundances permits to find a qualitatively new results. The lines of radioactive elements with short decay-time are found in the spectrum of Przybylski's star – Tc, Pm, and elements with atomic numbers $84 \leq Z \leq 99$. The abundances of heaviest elements in old halo star HD221170 permit us to show that it is not correct to use the ratio's of radioactive elements for determination of the age of the stars. The abundance patterns of barium star ζ Cyg and Sirius A can be explained by mass transfer in the binary system. The chemical composition of Procyon is solar, only Te is overabundant by 0.5 dex. Te is located at one of the peaks of *r*-process in the standard abundance pattern. The abundance pattern of δ Sct appears to be similar to that of δ Del type stars.

Keywords: stars: abundances, stars: individual (HD48915, HD61421, HD101065, HD172748, HD202109, HD221170), nucleosynthesis.

1. Introduction

The solar abundance pattern is 73 chemical elements (Grevesse&Sauval, 1998; Gopka et al., 2001). Some other well-determined abundance patterns are those for peculiar Przybylski's star – 57 elements (Cowley et al., 2000; Cowley et al., 2004; Shavrina et al., 2003), two halo stars: GS22892-05 – 57 elements (Sneden et al., 2003) and GS31082-001 – 56 elements (Aoki et al., 2003; Sneden et al., 2000), Procyon – 55 elements (Yushchenko&Gopka, 1996a; 1996b) HgMn star χ Lupi – 51 elements (Leckrone et al., 1999), and the prototype of mild barium stars ζ Cyg– 51 elements (Yushchenko et al., 2004a). In this review we will show the abundance patterns and main astrophysical results obtained for the Sun, Przybylski's star, halo star HD221170, Sirius, ζ Cyg, Procyon, and δ Sct. The discussion is based on our recently published papers and new results for Przybylski's star (HD101065), δ Sct, and Sirius. The use of spectrum synthesis for all stages of spectra processing, from continuum placement and line identification to the abundance calculations permits us to obtain these results.

2. The Sample

Sun. The review (Grevesse&Sauval, 1998) includes the abundances of 71 elements. The abundance of As was found in (Gopka et al., 2001). The meteoritic value for Th (Grevesse&Sauval, 1998) is used for the Sun. The abundances of Se, Br, Kr, Te, I, Xe, Cs, Ta, Re, Hg, Bi and all radioactive elements are unknown, upper limit is known for U. Fig. 1a is the solar abundance pattern.

Przybylski's star. All heavy elements show large overabundances in the atmosphere of this roAp star. The lines of Tc and Pm were identified in (Cowley et al., 2004). We found the abundance of Tc (log N(Tc)=4 in the scale log N(H)=12), and identified the lines of all radioactive elements with atomic numbers (Z) from 84 to 99, except 85 (At) and 87 (Fr) (Gopka et al., 2005). $Z<92$ elements can be explained by natural decay of Th and U. $Z>92$ elements can exist due to neutron capture reactions in the layers of the atmosphere with overabundances of Th and U. Spallation reaction, accretion can be used to explain this phenomena. Fig. 1b shows the abundances of 62 elements in Przybylski's star based on (Cowley et al., 2000; Shavrina et al., 2003) and our values for Tc, Pb, Bi, Ra, Am.

HD221170. The lines of 43 elements were found in its atmosphere. (Yushchenko et al., 2005). It appears to be thorium-rich halo star. Fig. 1c shows the abundances with respect to the Sun, Fig. 1d – with respect to barium abundance and scaled Solar system r-process abundances. The comparison of HD221170 with other four Th-rich stars permits us to find that the initial ratio's of Th, U and other r-process elements in dif-

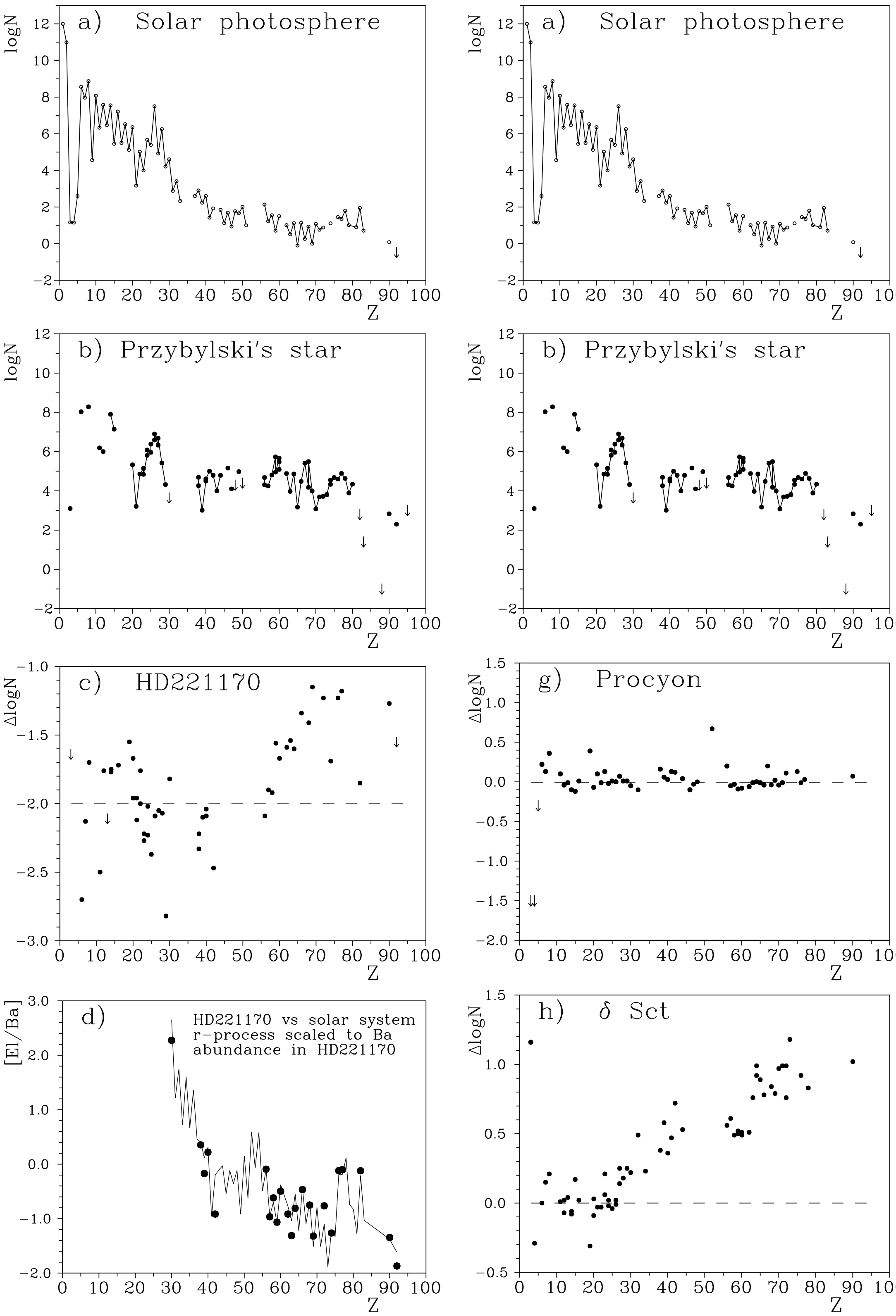

Figure 1: The abundances of chemical elements in the Sun (a), Przybylski's star (b), HD221170 (c-d), ζ Cyg (e), Sirius (f), Procyon (g), δ Sct (h). The axes are the atomic numbers and the absolute (a, b) or relative abundances: (d) – with repect to barium abundance in HD221170, (c, e-h) – with respect to solar system values.

ferent Supernova explosions were not similar. That is why it is not correct to use the abundance ratio's of radioactive and stable elements to find the ages of halo stars.

ζ Cyg, Sirius, Procyon. We found the abundances of 51 elements in ζ Cyg (Yushchenko et al., 2004a), 50 – in Sirius (Yushchenko, 1996; Gopka, 2000), and 55 – in Procyon (Yushchenko&Gopka, 1996a; 1996b). These are the binary systems with white dwarf (WD) companions. The orbital periods are 18, 50, and 40 years respectively. Mass transfer in these systems can influence on the chemical composition. WD could be a primary in the past, before loosing the great fraction of it's mass. Fig. 1e shows the chemical composition of ζ Cyg (Yushchenko et al., 2004a) and theoretical abundances which can appear due to wind accretion from WD (former AGB star). Fig. 1f is the abundance pattern of Sirius and it's approximation by the same, but scaled, theoretical curve. It is obvious that the combination of wind accretion and diffusion can explain the chemical composition of Sirius. Fig. 1g is the abundance pattern of Procyon. The abundances of heavy elements are solar. 0.5 dex overabundance of Te (Z=52) can be explained by fission of transuranium elements with Z>100 (Yushchenko&Gopka, 1996b).

δ Sct. The abundances of 49 elements were found (Yushchenko et al., 2004b). Now we can add several elements to this pattern, the final pattern will be 52-54 elements. The chemical composition of δ Sct is very similar to that of δ Del subtype stars, so it seems reasonable to change the classification of the stars in this region of HR diagram.

3. Conclusion

During the last decade the number of chemical elements investigated in the photospheres of several sharp-lined stars exceeds 50. It permits to find the qualititatively new results. Part of these results are the different production of heavy elements in different Supernova explosions (Yushchenko et al., 2005), the existence of radioactive elements in Przybylski's star (Gopka et al., 2005), the overabundance of Te in Procyon (Yushchenko&Gopka, 1996b), the explanation of the abundance pattern of Sirius as a combination of accretion and diffusion.

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