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SPECTROSCOPIC OBSERVATIONS OF EXTREMELY YOUNG Hg-Mn STAR HD 47553 - MEMBER OF NGC 2264

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ABSTRACT. *The equivalent widths of C, Mg, Si, S, Sc, Ti, V, Cr, Mn, Fe, Sr, Y, Zr, Ba, Nd, Sm, Eu, Gd, and Hg are measured from the results of spectroscopic observations of Hg-Mn star HD 47553 with the Main Stellar Spectrograph of the 6 m telescope. The chemical composition is determined. Abundance of elements with A<22 and Fe is nearly solar. Other elements show different excesses. The Mn/Fe and Sr/Y/Zr abundance ratios are discarded with the nuclear odd-even effect.*

По спектрам ртутно-марганцевой звезды HD47553, полученным на II камере ОЗСП БТА с дисперсией 9 А/мм в интервале 3800-4800 А, измерены эквивалентные ширины линий C, Mg, Si, S, Sc, Ti, V, Cr, Mn, Fe, Sr, Y, Zr, Ba, Nd, Sm, Eu, Gd, Hg. Определен химический состав элементов. Содержание элементов с A < 22, а также железа практически солнечное. Остальные элементы показывают избытки различной величины. Отношение обилий Mn, Fe, и Sr, Y, Zr нарушают закон четности, соблюдающийся в процессах нуклеосинтеза.

INTRODUCTION

The young open stellar cluster NGC 2264 in the northern region of Monoceros is associated with the diffusive H II region, located approximately 5° to the North of the known Rosette nebula. The fiber emission structures, found here, may be attributed to the supernova expanding remnants (Holden, 1968; Van den Bergh et al., 1973).

The spectroscopic observations of NGC 2264 (Pyatkes, 1990) have allowed to consider HD 47553, the member of this open cluster, as a Hg-Mn star. The problems of how

to interpret the excesses of abundances of chemical elements in the upper layers of Hg-Mn star atmospheres still exist. The mechanism (radiative diffusion theory (Michaud, 1970), accretion hypotheses (Tomley et al., 1970; Havnes, 1979; Proffit and Michaund, 1989)), responsible for the anomalies in these objects, is not distinctly determined yet.

OBSERVATIONS AND PROCESSING

The HD 47553 spectrograms were obtained at the II camera of the Main Stellar Spectrograph of the 6 m telescope with the 9 Å/mm dispersion within λ 3800-4800 Å in 1987. The spectral resolution was 0.25 Å. Kodak IIaO photo emulsion was used. The procedure of the spectrogram processings is described in detail by Pyatkes (1990). The line identification was performed using the Tables of Moore (1945), the data of Adelman et at. (1984), Dobrichev et al. (1989), and Guthrie (1984).

HD 47553 is a star of B8IV spectral class with the following physical parameters of the atmosphere: T_{eff}=12200 K, lg g=3.6 (Pyatkes, 1990).

CHEMICAL COMPOSITION

Chemical composition of the atmosphere was calculated with the programme WIDTH 6 and Kurucz's blanketed models (1979) with the solar chemical composition adapted with the EC-1061 of the Urals' State University. To obtain an appropriate atmosphere model for the star under investigation we used the model interpolation programme MODINT written by Tsymbal and Lyashko (Simferopol State University). Kurucz's models were used for calculation of chemical composition of Hg-Mn stars earlier by Dobrichev et al. (1989).

To improve the reliability of the results we performed the qualitative selection of spectral lines, in which the line blending degree and the presence of atomic data for the element under investigation were the main criteria. We used the system of oscillator strengths of Kurucz and Peytremann (1975).

Microturbulence velocity in the atmospheres of Hg-Mn stars is usually close to zero (Adelman, 1989). That gives an additional argument in favour of stability of the atmosphere when using the radiative diffusion mechanism. The microturbulence velocity +2 km/s was determined from Fe and Mn lines using the standard procedure (Dobrichev et al., 1989). The result shows the minimum dependence on the equivalent widths of the lines used.

Table 1 presents the mean values of chemical element abundances lg $\varepsilon(x)$ for HD 47553, and also their solar values lg $\varepsilon(x)_{\odot}$ (Grevesse, 1984). Taking into account the errors of determination of equivalent widths and abundance scattering, caused by

inaccuracies in oscillator strengths, the mean error of the calculated abundance equals 0.4 dex. Fig. 1 shows the curve of chemical element abundances for Hg-Mn star HD 47553, referred to the solar composition.

DISCUSSION OF THE RESULTS

Analyzing the obtained chemical composition, it is convenient to divide all the elements into two groups: iron and atoms lighter than iron (A=26), and heavier than iron.

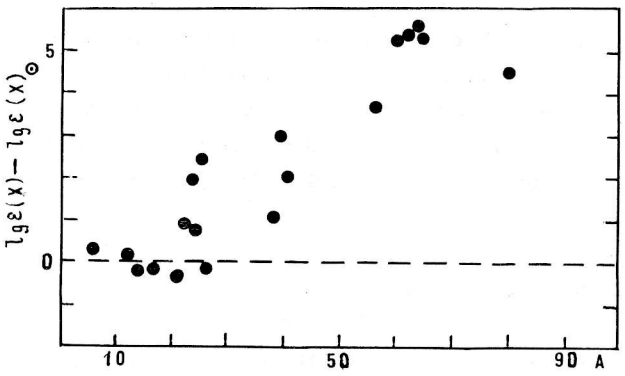

Fig. 1. *The curve of chemical element distributions in the atmosphere of Hg-Mn star HD 47553.*

Table 1. Chemical element abundance in the atmosphere of Hg-Mn star HD 47553.

lg ε	C	Mg	Si	S	Sc	Ti	V	Cr	Mn	Fe
	A=6	12	14	16	21	22	23	24	25	26
-lg ε(x)	3.07	4.27	4.63	4.93	9.2:	6.04	6.07	5.58	4.10	4.43
$-\lg \varepsilon(x)_\odot$	3.31	4.42	4.45	4.79	8.90	6.98	8.00	6.33	6.55	4.33

lg ε	Sr	Y	Zr	Ba	Nd	Sm	Eu	Gd	Hg
	A=38	39	40	56	60	62	63	64	80
-lg ε(x)	8.02	6.82	7.48	6.13:	5.22:	5.67:	5.74:	5.60:	6.27
$-\lg \varepsilon(x)_\odot$	9.10	9.76	9.44	9.87	10.50	11.00	11.30	10.88	10.83

The first group includes the following elements: C, Mg, Si, S, Sc, Ti, V, Cr, Mn and Fe. Carbon, magnesium, sulphur, silicon and scandium within the errors have approximately the solar abundance, that agrees well with the results of Adelman (1988), who investigated a sample of Hg-Mn stars. The similar result was obtained

recently by Smith (1991) for silicon, that confirms the predictions of diffusion theory concerning this element (Vauclair et al., 1979). The [Fe/H] ratio also appeared to be traditional for Hg-Mn stars, it almost coincides with the solar one. The abundance of Mn, within the error bar, coincides satisfactorily with the trend of the effective temperature obtained by Adelman (1989) (see Fig. 2). This correlation gives one more argument in favour of diffusion. The found excesses of Ti, V and Cr abundances are close to those observed in Hg-Mn stars.

The second group, we have selected, includes the elements of s- and r-processes; the cause of their overabundances in the atmospheres of Hg-Mn stars is still hard to explain.

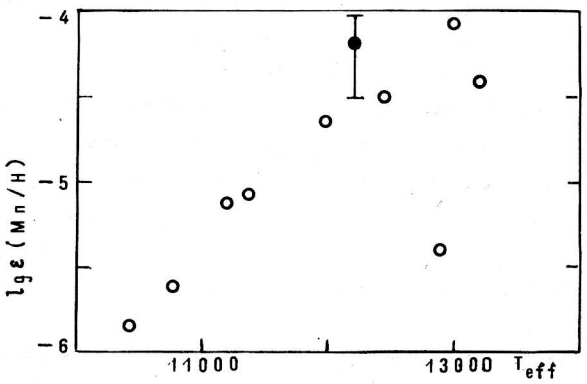

Fig. 2. *The abundances from Mn II lines versus the effective temperature for Hg-Mn stars.*
o - results of Adelman (1989);
x - HD 47553 from our work within the error bar.

The group of "light", according to Kipper and Wallerstein (1990), elements of the s-process, such as Sr, Y, Zr, shows the excesses from 1 to 3 dex, while their heavier neighbours Ba, Nd and Sm have the overabundance, as compared with solar, of 3.5, 5 and 5.5 dex respectively. Such a result for Ba, Nd and Sm is not very reliable owing to the unique lines of these elements in the considered wavelength range and possible errors in the atomic data.

The analogous considerable excesses, approximately 5.5 dex, were found for the elements of r-process (Eu, Gd, Hg) whose lines are observed in the spectrum of HD 47553. The accuracy of this result is comparable with that for Ba, Nd and Sm.

The obtained values of element abundances of s-process (Sr, Y, Zr) have confirmed the fact of violation of the odd-even effect, established for Hg-Mn stars. The abundance of yttrium, odd element, turned out to be higher as compared with the abundance of two even neighbours in periodic Table, strontium and zirconium. Here we can see a departure from the conventional universal tendency for the abundances of elements behind the iron peak, that states the extreme underabundance of the odd elements as compared with their even neighbours (Cameron, 1973). The standard mixture of s- and r-processes can not account for the distribution of relative abundances of Sr, Y and Zr in Hg-Mn stars either. This effect can not be explained in terms of dif-

fusion mechanism (Allen, 1977). According to the observations of Borra and Landstreet (1980), Landstreet (1982) Hg-Mn stars have no significant magnetic fields with an accuracy up to 170 Gs. Therefore to explain the overabundance of yttrium we do not manage to use the selective magnetic accretion mechanism, proposed by Havnes (1979).

The violation of the odd-even effect in case of Mn/Fe abundances ($\varepsilon(Mn)/\varepsilon(Fe) \geq 1$ for HD 47553) disagrees with conventional predictions of the nucleosynthesis theory either. This result is characteristic of Hg-Mn stars (Guthrie, 1984). Allen and Cowley (1977) have shown that at any expanded process of generation of these elements it results in be their abundance, related to "cosmic", (abundance ratio $<<1$). Therefore, to explain the Mn/Fe excesses, it is necessary to appeal to some kind of non-nuclear processes.

Klochkova and Kopylov (1986) statistically grounded, that the peculiarity degree does not depend on the age of CP stars at the evolution stage within the MS. Therefore, taking into account the time of appearance of anomalies on the star surface one can assert, that the detection of Hg-Mn star with great overabundances of chemical elements in the extremely young cluster (NGC 2264 is about $3 \cdot 10^6$ years (Perez et al., 1989)) shifts the line of chemical anomalies below the MS of zero age.

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