Isotopic composition of Hg and Pt in slowly rotating HgMn stars

S. Hubrig[1], **F. Castelli**[2] **and G. Mathys**[3]

[1] *University of Potsdam, Am Neuen Palais 10, D-14469 Potsdam, Germany*

[2] *CNR-Gruppo Nazionale Astronomia and Osservatorio Astronomico, Via G. Tiepolo 11, I-34131 Trieste, Italy*

[3] *European Southern Observatory, Casilla 19001, Santiago 19, Chile*

Abstract. Preliminary results from a study of the isotopic compositions of the elements Hg and Pt in a number of HgMn stars are presented. This work represents an improvement over previous studies thanks to the very high spectral resolution available (R = 118 000) and to the new information on wavelengths and atomic structure of Hg II and Pt II.

Key words: HgMn stars – isotopic abundances

1. Introduction

Almost all HgMn stars exhibit a strong absorption feature at 3984 Å, which has been identified as a line of Hg II. The wavelength at which this line is observed depends on the isotopic mix of Hg (White et al. 1976), which ranges from the terrestrial mix to nearly pure ^{204}Hg. Mercury is not the only very heavy element observed in HgMn stars. Lines of Pt II (Dworetsky & Vaughan 1973) and Au II (Guthrie 1985) are also observed. Dworetsky & Vaughan (1973) studied the Pt II λ 4046 line in a sample of nine HgMn stars. This line is the strongest Pt line at optical wavelengths, and in the nine stars studied it is shifted toward longer wavelengths by 0.04 to 0.09 Å, with respect to the centroid of the terrestrial platinum line. These shifts are interpreted as an isotopic effect. The corresponding anomalies are analogous to those found for Hg, in the sense that the heavier isotopes tend to dominate in cooler stars. Neither radiatively driven diffusion nor any other theory until now can account satisfactorily for the variations in the Hg and Pt isotope mix among the HgMn stars (Leckrone et al. 1993).

The main purpose of the work reported here was to provide additional observational constraints to guide the theorists in the understanding of the isotopic anomalies in HgMn stars, improving upon previous studies through the much better data quality obtainable now. Thanks to the availability of new laboratory measurements of isotope shifts in Pt II (Engleman 1989) it became possible to identify more definitely the Pt II isotopes.

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Table 1. Isotopic compositions

Star	Terrestrial abundance	χ Lup	HR 7775	HR 1800	74 Aqr	HR 6520
$T_{\rm eff}$ (K)		10680	10830	11070	11880	13250
$\log g$		3.99	4.11	3.75	4.03	4.17
[Hg]		+5.45	+5.65	+5.25		+5.10
			Hg isotopic structure (%)			
196	0.15	0.00	0.00	0.00	0.00	0.00
198	9.97	0.00	0.00	0.16	7.02	4.10
199a	7.14	0.00	0.00	0.32	6.19	10.99
199b	9.71	0.00	0.00	0.44	9.29	14.00
200	23.09	0.00	0.00	2.97	26.79	28.97
201a	4.80	0.00	0.10	1.77	6.01	8.61
201b	8.30	0.00	0.20	3.06	9.10	8.93
202	29.80	1.00	49.70	50.58	26.79	22.49
204	6.86	99.00	49.70	40.74	8.81	1.80
[Pt]		+4.00	+4.69	+3.30		
		Pt isotopic structure (%)				
194	32.90	0.00	0.00	0.00		
195b	18.78	0.00	7.50	0.00		
195a	13.15	0.00	10.00	0.00		
196	25.20	10.00	55.00	0.00		
198	7.19	90.00	27.50	100.00		

2. Observations and spectrum synthesis

Spectra were obtained with the ESO 1.4 m Coudé Auxiliary Telescope and the Coudé Echelle Spectrograph Long Camera at a resolving power R = $\lambda/\Delta\lambda$ = 118 000 and S/N $\geq$ 250. The observed wavelength ranges are 3965–4000 Å and 4018–4035 Å. Synthetic spectra and model atmospheres were computed with the SYNTHE and ATLAS9 codes (Kurucz 1997), respectively. A code similar to the TEFFLOGG code of Moon & Dworetsky (1985), but based on new computed uvbybeta indices, was used to obtain the stellar parameters (Castelli & Kurucz 1994). Observed indices were taken from the Mermilliod, Mermilliod, & Hauck catalogue (1997) and were dereddened using the UVBYBETA code of Moon (1985). For all the stars we assumed zero microturbulent velocity, while the rotational velocity was derived from the comparison of the observed and computed spectra, after having degraded the computed spectra for the broadening due to the instrumental profile. For the whole transition of Hg II 3983 Å we adopted $\log gf = -1.73$ (Dworetsky 1980). For each isotopic and hyperfine component this value was scaled in agreement with each observed relative intensity. For reference, the terrestrial intensities from Kurucz (1993) and from Smith (1997) were adopted. For the transitions of Pt II 4023.8, 4034.2, and 4046.4 Å we adopted log $gf = -2.61, -2.09$, and -1.19, respectively (Dworetsky & Vaughan 1973). The isotopic and hyperfine shifts and intensities were either taken directly from Engleman (1989) or were derived from Engleman (1989) and Kalus et al. (1997). One of the programme stars with very sharp lines is the double-lined spectroscopic binary χ Lup. An updated version of the BINARY code of Kurucz (1993, CD-ROM 18) has yielded as final computed spectrum the spectrum resulting from the contribution of both components. The atmospheric parameters of the secondary star and ratio of the radii of the primary to the secondary stars in χ Lup were taken from Wahlgren et al. (1994).

For five programme stars with extremely sharp spectral lines ($v \sin i <$ 3 km/s) the isotopic composition could be studied in greater detail. The results are summarized in Table 1. All stars have Hg overabundant by more than 5 dex compared with the solar abundance. The largest overabundance of Pt (4.69 dex) was found in the star HR 7775. No star shows terrestrial isotopic proportions. The most pronounced deviation from the terrestrial composition is found in the stars χ Lup and HR 7775, which are the coolest ones in our sample.

The large overabundances of Hg and Pt and the star-to-star variations in their isotopic composition clearly pose a challenge to any theory aimed at explaining the origin of chemical peculiarities.

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