The double-lined spectroscopic binary α Andromedae: orbital elements and elemental abundances

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Abstract. We performed a spectroscopic study of the SB2 Mercury-Manganese star α And. Our measurements of the secondary's radial velocities result in improved orbital elements. The secondary shows abundances typical of the metallic-line stars: a Ca deficiency, small overabundances of the iron-peak elements, and 1.0 dex overabundances of Sr and Ba.

Key words: Stars: binaries: spectroscopic – Stars: atmospheres

1. Introduction

α And (HD 358, HR 15) is a bright, well known binary system with a HgMn primary. Pan et al. (1992) obtained its visual orbit from observations with the Mark III Stellar Interferometer. Later Tomkin et al. (1995) detected the weak secondary spectrum, measured the secondary's radial velocities near the nodes, and calculated the spectroscopic orbital elements of this SB2 system. Their derived mass ratio 0.42 ± 0.02 differs from 0.48 of Pan et al. and gives too large a mass for the primary. No abundances of the secondary are published.

2. Observations and orbital elements

α And was observed in 1990-91 and 1996-97 at Crimean Astrophysical Observatory (CrAO) and in 1992-94 at Dominion Astrophysical Observatory (DAO). CrAO spectra were obtained at the Coudé spectrograph of the 2.6m telescope with a CCD detector in three spectral regions centred at $\lambda\lambda$ 4960, 6347 and 6678 with $S/N \geq 300$. The DAO Reticon spectra were taken with the 1.22m telescope for a grid of central wavelengths between $\lambda\lambda$ 3830 and 5180 with 55 Å offsets. The typical S/N was ≥ 200.

Radial velocity measurements for both components were made using synthetic spectra calculated with the model atmospheres and abundances discussed below. For each spectral region we synthesized the primary's spectra and derived the radial velocities from the shifts of the calculated spectrum relative to

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the observations. The rotational velocities are $v \cdot \sin i$=52 km s^{-1}for the primary and $v \cdot \sin i$=110 km s^{-1}for the secondary.

We calculated the orbital elements for α And with a code by Tokovinin (1992) combining our measurements with those from Abt & Snowden (1973), Aikman (1976), and Tomkin et al. (1995). Table 1 compares these orbital elements.

Table 1. Orbital elements of α And

	Aikman(1976)	Tomkin et al.(1995)	Present
P(days)	96.6960 ± 0.0013	96.6963 (fixed)	96.7051±0.0030
T(JD2400000+)	42056.32± 0.20	49212.17± 0.20	48245.49± 0.23
e	0.521± 0.008	0.60 ± 0.02	0.560± 0.013
$\omega(^\circ)$	$77^\circ.1 \pm 1^\circ.3$	$74^\circ.9 \pm 1^\circ.3$	$78^\circ.5 \pm 1^\circ.5$
K_1(km s^{-1})	30.8 ± 0.3	27.8 ± 0.6	31.2 ± 0.6
K_2(km s^{-1})	...	66.2 ± 3.6	62.2 ± 1.4
γ(km s^{-1})	-11.6±0.2	-10.1±0.2	-10.7±0.3
m_A	...	5.5 ± 0.5	3.50± 0.20
m_B	...	2.3 ± 0.2	1.75± 0.08

Our orbital solution yields a mass ratio 0.50 ± 0.03, which agrees with the masses from the mass-luminosity relation. Figure 1 compares the observed and computed binary spectra in the 4957 Å spectral region for a few orbital phases in the rest frame of the primary. The contributions from the secondary are shown by dashed lines.

3. Physical parameters of the α And components

The effective temperatures and the surface gravities of the components of α And were obtained by fitting the observed spectrophotometry (Adelman & Pyper 1983). Combining data from the visual orbit measurements and from the spectroscopy and using evolutionary tracks by Schaller et al. (1992) we found:

Primary: $\log(L/L_\odot) = 2.38 \pm 0.14$, $m = 3.8 \pm 0.2 m_\odot$, $\mathrm{R_A} = 2.7 \pm 0.4\mathrm{R}_\odot$, $T_{\rm eff} = 13800$ K, $\log g = 3.75$, t=$6{\cdot}10^7$

Secondary: $\log(L/L_\odot) = 1.10 \pm 0.2$, $m = 1.85 \pm 0.13 m_\odot$, $\mathrm{R_B} = 1.65 \pm 0.3\mathrm{R}_\odot$, $T_{\rm eff} = 8500$ K, $\log g = 4.0$, t=$7{\cdot}10^7$

Both stars are close to the Zero Age Main Sequence. The abundances of both stars were derived by synthetic spectrum calculations (see Fig. 1). The chemical abundances of α And A are typical of hot HgMn stars. The secondary star shows abundances typical of the metallic-line stars: a Ca deficiency, small overabundances of the iron-peak elements, and 1.0 dex overabundances of Sr and Ba.

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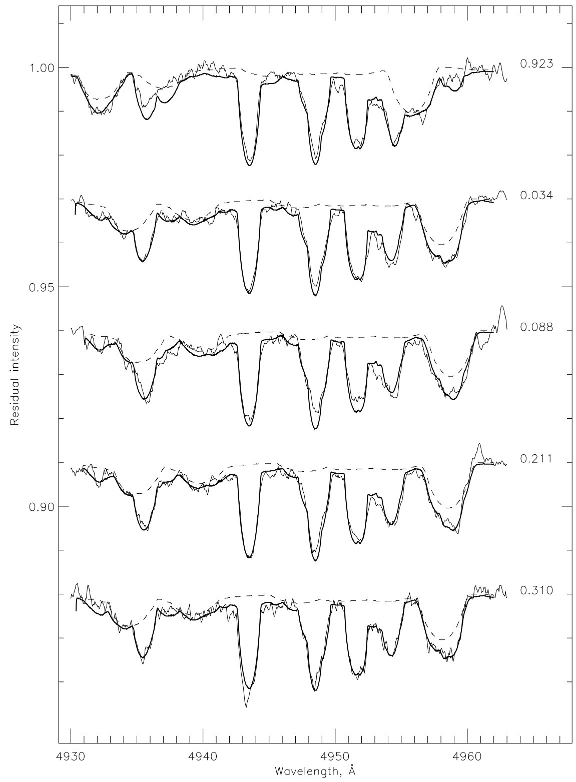

Figure 1. Comparison between the observed (thin lines) and the synthesized (thick lines) spectra of α And in the λ 4957 spectral region for different orbital phases. The contributions from the secondary are shown by the dashed lines.

References

Abt, H.A., Snowden, M.S.: 1973, *Astrophys. J., Suppl. Ser.*, **25**, 137

Adelman, S.J., Pyper, D.M.: 1983, *Astron. Astrophys.*, **118**, 313

Aikman, G.C.L.: 1976, *Publ. Dominion Astrophys. Obs.*, **14**, 379

Pan, X., Shao, M., Colavita, M.M., Armstrong, J.T., Mozurkewich, D., Vivekanand, M., Denison, C.S., Simon, R., Johnston, K.J.: 1992, *Astrophys. J.*, **384**, 624

Schaller, G., Schaerer, D., Meynet, G., Maeder, A.: 1992, *Astron. Astrophys., Suppl. Ser.* **96**, 269

Tokovinin, A.: 1992, in ASP Conf. Ser. **32**, *Complementory Approaches to Double and Multiple Star Research*, eds.: H.A. McAlister and W.I. Hartkopf, Astron. Soc. Pac., San Francisco, 573

Tomkin, J., Pan, X., McCarthy, J. K.: 1995 *Astron. J.* **109**, 780