RADIAL VELOCITY AND MAGNETIC VARIATIONS OF α DRACONIS

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ABSTRACT   Based on photographic Zeeman spectra a magne-
tic field has been detected for the giant star α Dra. One
of the two periods derived for the magnetic changes can
be interpreted as the half rotational period correspon-
ding to a slight variation of the radial velocity of 3.57
days. The application of an equatorially symmetric rota-
tor model with a magnetic field dominated by the quadru-
pole moment leads to a good agreement with the observed
magnetic variation. The orbital elements of α Dra were
newly derived.

INTRODUCTION

The star α Draconis (HD 123299) is a well-known single-lined
spectroscopic binary with a period of 51.4 days. Its spectral
type is A0 III (Hoffleit 1982), its orbital elements were de-
rived last by Elst a. Nelles (1983). The projected equatorial
velocity was determined by Slettebak *et al.* (1975) to 15 km/s
and by Adelman *et al.* (1987) to 20 km/s. According to Adel-
man the giant star is metal-weak and lies in the H-R diagram
intermediately between the mercury-manganese and the metallic-
lined stars. Until now no hints to a magnetic field of α Dra
were given in literature.

SPECTRAL ANALYSIS

Photographic Zeeman (30) and normal (38) spectrograms with a
reciprocal linear dispersion of 7.9 Å have been obtained at
the Coude spectrograph of the 2m telescope in Tautenburg over
a period of 13 years. Based mainly on the MgII(λ=4481 Å) line
the spectra were investigated in relation to the radial velo-
city, the line width representing the v*sini* and the effective
magnetic field.

Radial velocity

The values of the radial velocity show a dominant variation
due to the binary motion. Orbital elements were derived by a
common least square fit followed by differential corrections
varying the orbital period too (Fig. 1a). Except for the ex-

TABLE I   The orbital elements of α Dra

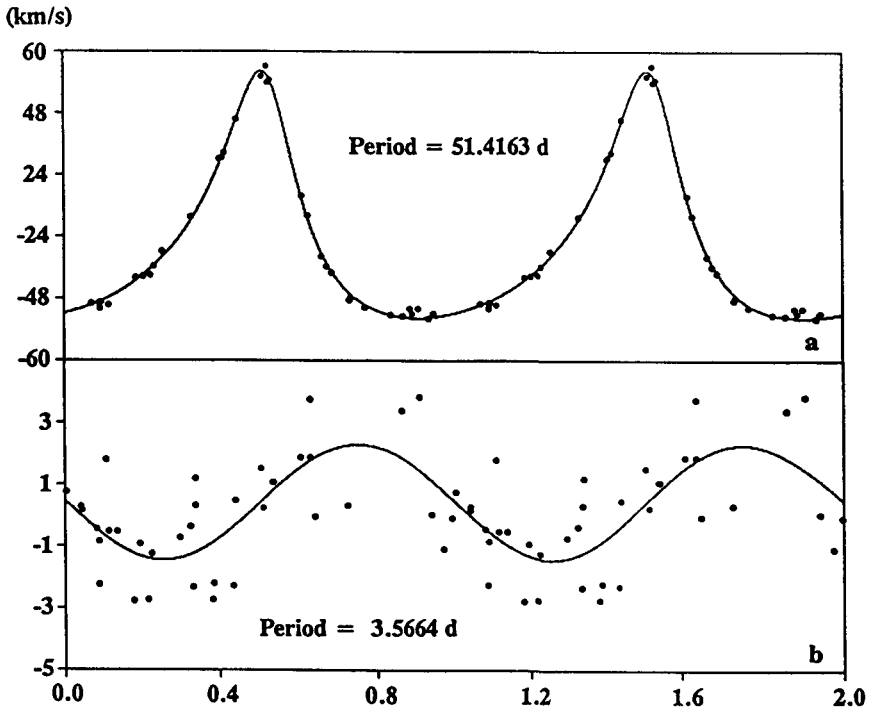|	Elst and Nelles (1983)		this paper	
P (d)	51.4167		51.4163	±0.0008
v_0 (km/s)	−14.0	±0.2	−15.0	±0.3
K (km/s)	49.7	±0.3	48.0	±0.4
e	0.400	±0.006	0.434	±0.005
ω (°)	23.2	±0.8	20.9	±1.8
T_0	2445117.37	±0.08	2442392.6	±0.1
σ (km/s)	2.3		1.74	
$σ_*$ (km/s)			1.29	

Fig. 1.   Radial velocity versus phase. a) mean curve de-
rived from the orbital elements, b) residuals.

centricity, results are in good agreement with those derived
by Elst and Nelles in 1983 (Table I). An analysis of the resi-
duals of the radial velocity after subtracting the mean curve
resulting from the orbital elements give hints to only one pe-
riod at 3.5664 d (Fig. 1b). In Table I σ is the mean deviation
of the RV residuals and σ_* is the mean deviation after cor-
recting the residuals for the 3.5664 d period.

vsini

The profile of the line MgII(λ=4481 Å) was analyzed on spec-
trograms corresponding to the minimum and maximum phase of the
measured effective magnetic field strength. The vsini values
were derived by means of the Fourier transformation of the in-
tensity profiles followed by a Bessel transformation of the
Fourier coefficients (Deeming 1977). The resulting mean value
of 27 km/s is higher than those of 15 km/s resp. 20 km/s mea-
sured by Sletteback et al.(1978) and Adelman et al. (1987,
1989). Although our absolute value of vsini is somewhat uncer-
tain because of the low S/N of the photographic plates there
should be no dependence of vsini on time or magnetic field
strength exceeding 2 km/s.

Effective magnetic field

Only the spectral lines with the best S/N – MgII(λ=4481 Å) and
CaII(K) – have been used for deriving the magnetic field. Ob-
viously the star shows throughout a negative effective field
strength up to –4000 Gauss, the minimum field strength is
about 0 Gauss. The search for periods assuming a sinusoidal
variation give limits at two values: 55.071 days and 1.8076
days (Fig. 2a, 2b).

For the longer period some difficulties arise in respect
to an explanation by a rotator model. A rotational period of
55 days and vsini of about 20 km/s is in contradiction to the
stellar parameters which characterize α Dra as a giant. Even
though a relation of binary motion and magnetic field is indi-
cated the delay of the magnetic period compared to the orbital
period is hardly to explain. Therefore, we interprete the
shorter period of 1.8076 d as an indicator for the rotation
of α Dra.

DISCUSSION

Regarding the small scale variation of the radial velocity of
about 3.6 d as the rotational period of α Dra the short magne-
tic period of 1.8076 d can be interpreted as a double wave
produced by a magnetic quadrupole during one rotation of the
star. To test this hypothesis in a simple way we assume a ho-
mogeneous element distribution on the stellar surface and an
equatorially symmetric rotator model including both dipole

(Gauss)

Period = 55.071 d

a

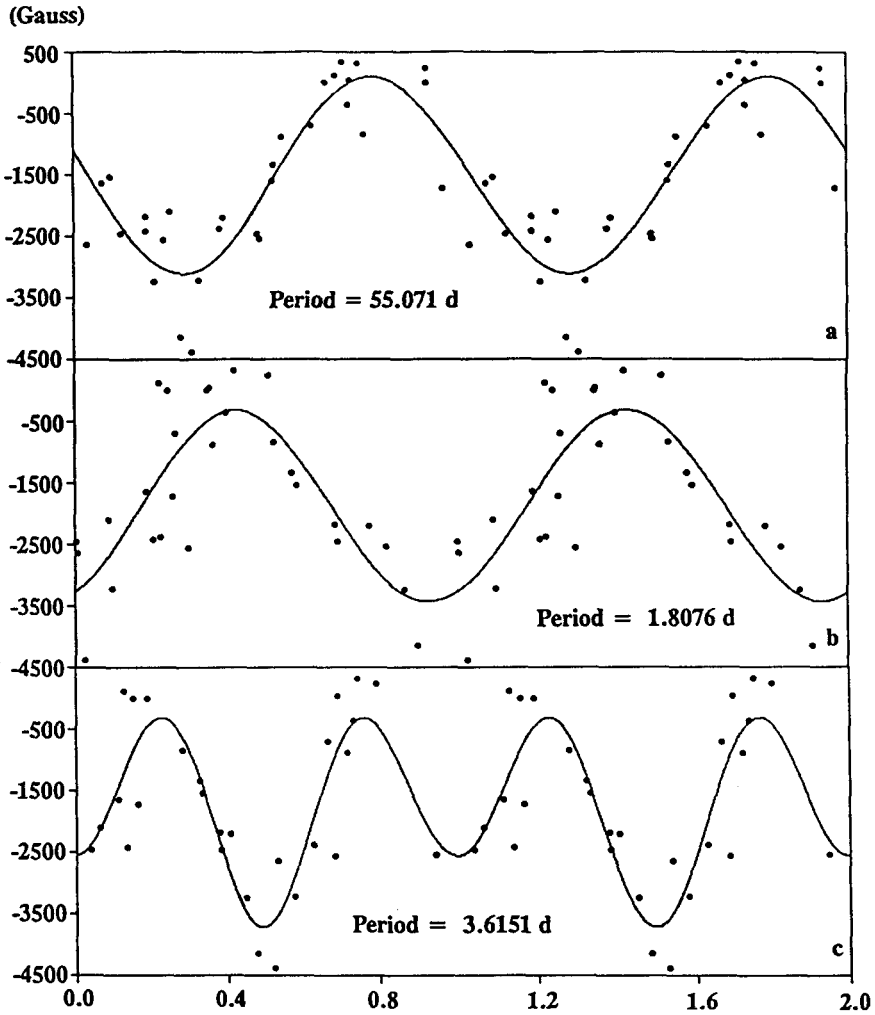Period = 1.8076 d

. b

Period = 3.6151 d

c

Fig. 2.   Effective magnetic field strength versus phase.
a) and b) fitting to a sinusoidal variation, c) fitting
to equation (1).

(u_{10}) and quadrupole (u_{20}) moments (Oetken 1977). Then the ob-
served variation of the effective magnetic field can be de-
scribed by

$$B_{eff} = C_1 + C_2 \cos(2\pi/P \cdot t) + C_3 \cos(4\pi/P \cdot t), \tag{1}$$

$$C_1 = (0.08130 - 0.12195 \sin^2 i) u_{20}/c,$$
$$C_2 = -0.52020 \sin i \cdot u_{10}/c,$$
$$C_3 = -0.12195 \sin^2 i \cdot u_{20}/c,$$

the constants follow from the values for the limb darkening coefficients of $\mu = 0.52$, $\kappa = 0.19$ used by Oetken. Fig. 2c shows the results of the application of a special period finding technique based on that model. The optimum period is $P = 3.6151$ d in good agreement with the period found for the residuals of the radial velocity and the half period of the adopted double wave of 1.8076 d.

From the constants C_i the inclination of the rotational axis and the fraction of the dipole and quadrupole moments can be derived: $i = 17^{\circ}$, $u_{10}/u_{20} = 0.03$. The values $P_{rot} = 3.6$ d, $i = 17^{\circ}$ and $v\sin i = 20$ km/s give a radius of α Dra of 8.9 $R_{\odot}$ which is above the typical value of 5-6 $R_{\odot}$ for a A0 III star. But calling to mind the uncertainties arising from the simple model which allows only an estimation of the inclination as well as from the determination of $v\sin i$ this should be not a principal contradiction to the assumption, that the equatorially symmetric rotator model dominated by the quadrupole field is valid for the giant star α Dra.

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