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# Secular Variation of the Magnetic Field of 52 Her - Precession?

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**Abstract.** The star 52 Her shows magnetic field strength variations which cannot be attributed solely to rotation. A clear secular variation is present, and we explore the possibility that it might be a result of precession in a binary system.

## 1. Introduction

Since the first detection of a positive magnetic field of 1450 G in the chemically peculiar (CP) star 52 Her (HD 152107, A2p) by Babcock (1949) more than half a century ago, 274 effective magnetic field stength, $B_{\rm eff}$, observations have been obtained by various authors. The observations of Wolff & Preston (1978) and Borra & Landstreet (1980) showed that the magnetic field is always positive, clearly implying that the star is viewed partly pole-on.

In 1967, 52 Her was included in the Tautenburg observational program. In the first season of observations, the positive polarity of the magnetic field was confirmed. However, in 1978 there occurred a surprising reversal of polarity, which at first was thought to be due to a technical problem. A thorough investigation of instrumental polarization was conducted at the 2-m telescope with a Zeeman analyser by Oetken (Potsdam) and Bartl (Tautenburg). In addition, comparison with quasi-simultaneous observations of the magnetic field of 53 Cam by Scholz (Potsdam) showed that an instrumental effect can be excluded.

## 2. Measuring results and period analysis

We use all available data of 52 Her, regardless of differences in observational technique, measurement and reduction (Fig. 1), for a period analysis (Fig. 2). Data from Tautenburg, Zelenchuk, and Rozhen play a significant role, because the process of securing the results was in control of the authors, guaranteeing a highly homogeneous data set.

Before the polarity reversal in 1978, the magnetic field strength $B_{\rm eff}$ was positive. It is possible, however, that field reversals may be periodic with a

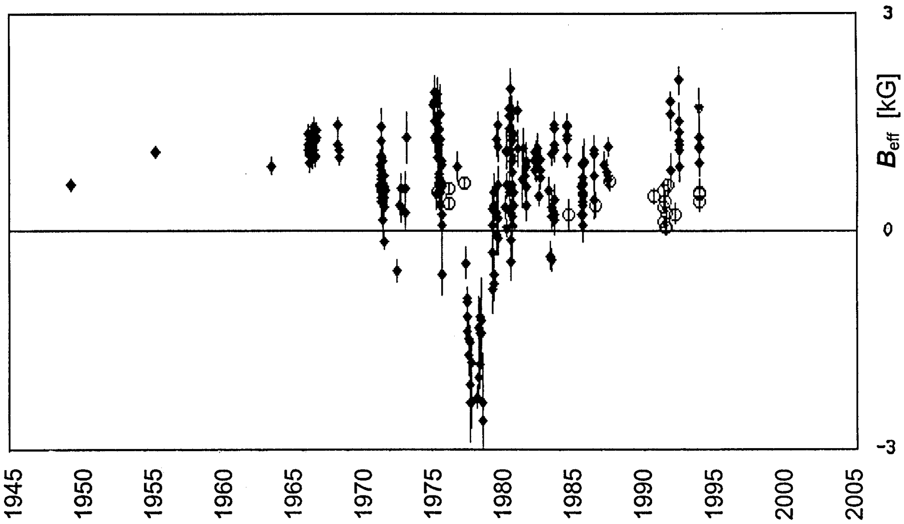


Figure 1. Time sequence of effective magnetic field strength, $B_{\text{eff}}$ (in kG), of 52 Her showing the negative peak in 1978. The symbols are: • – photographic data, ∘ – photoelectric data. Sources of the data are: Babcock (1958), Wolff & Preston (1978), Borra & Landstreet (1980), Gerth (1990), Glagolevskij et al. (1992), Bychkov & Elkin & Shtol (1992), last unpublished observations from 1994 (photographic: Glagolevskij & Gerth, photoelectric: Bychkov & Shtol).

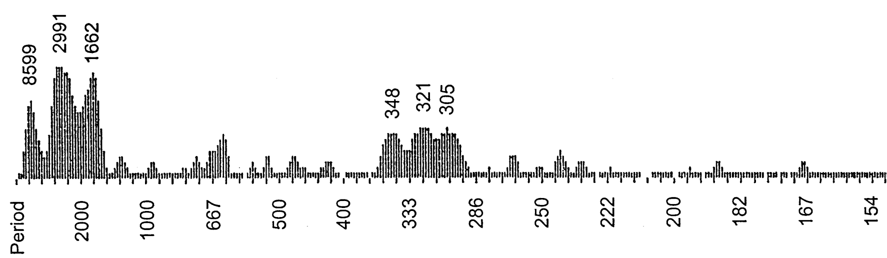


Figure 2. The Fourier periodogram of 274 non-equidistant $B_{\text{eff}}$ measuremants. The power (arbitrary units) is shown as a function of frequency (linear scale with the corresponding periods shown). The maxima in the power were calculated by quadratic interpolation. The periods of the most significant peaks are: $P_1$ = 8599 d, $P_2$ = 2991 d, $P_3$ = 1662 d. Their 1-year aliases are also shown.

The photographic Zeeman spectra from Tautenburg (Germany), Niznij Arkhyz (Russia), and Rozhen (Bulgaria) were measured on the Modified Abbe-Comparator (Gerth et al. 1977) at the Astrophysical Observatory Potsdam. In one reduction procedure, the radial velocity and the effective magnetic field $B_{\text{eff}}$ (Stokes V) was determined from the centroid and Zeeman shifts of individual spectral lines, taking the Landé-factor (z-value) into account.

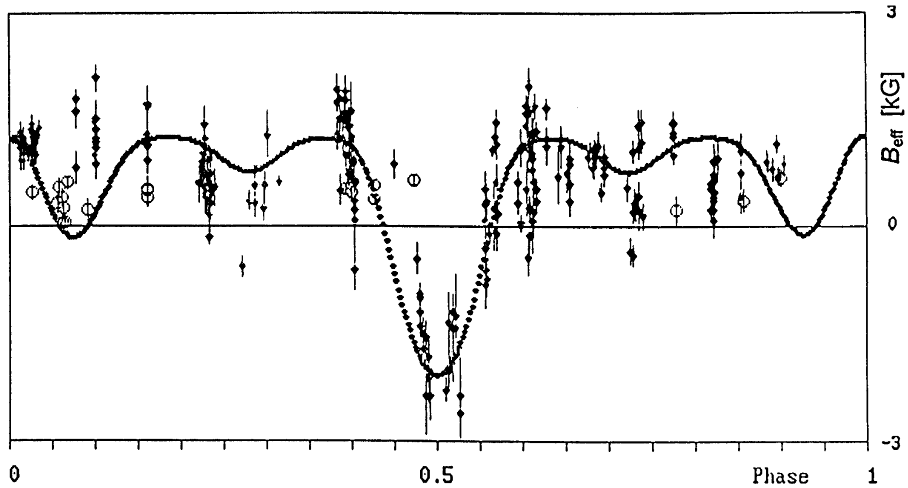


Figure 3. Phase plot of the 274 observational $B_{\rm eff}$ data of 52 Her centered to the negative peak in 1978 with period $P = 8600$ d and a Fourier fit consisting of the fundamental period and the first two harmonics.

secular period. The search for periods by Fourier analysis yielded a possible period of about 23.5 years. Thus, the next negative peak could be expected in 2002. Fig. 3 shows the data phased with this period and a fitted 3rd order Fourier curve. From photographic Zeeman spectra we could also measure the radial velocity, the phasing of which shows a modulation wave with a period of 12.5 y (Gerth 1990). The radial velocity as well as the magnetic field strength vary with a period of $P_r = 3.8575$ d caused by rotation (Wolff & Preston 1978).

The short term rotational period and the secular period of magnetic field variation as well as the radial velocity wave modulation can be explained by assuming a close binary system with a magnetic primary and a companion of smaller mass. The system precesses by dissipatively synchronized rotation and orbital motion. The binary consists of a gravitationally bound system of two rotationally flattened stars with tilted torque, angular momentum, and orbital plane, which oscillates with five eigenfrequencies (rotation and precession of both stars, precession of the orbital plane). Precession as an explanation for secular variations was first proposed by Gerth (1984) and later discussed and justified by Lehmann (1987, 1988).

In the precession model, the varying inclination angle $i$ has to be taken into account. We made an attempt to model only the phase curve of the positive $B_{\rm eff}$ values (Fig. 4, left panel). The MCD method of Gerth & Glagolevskij (2001) was used for mapping the positive values of magnetic field assuming an average inclination $i = 40°$. The mapping for the northern hemisphere fits best with a quadrupole magnetic field located close to the equator (Fig. 4, right panel).

This model is also valid for the southern hemisphere. The rather short precessional period of 23.5 y for a rigid stellar body of 2.6 $M_\odot$ can be more easily

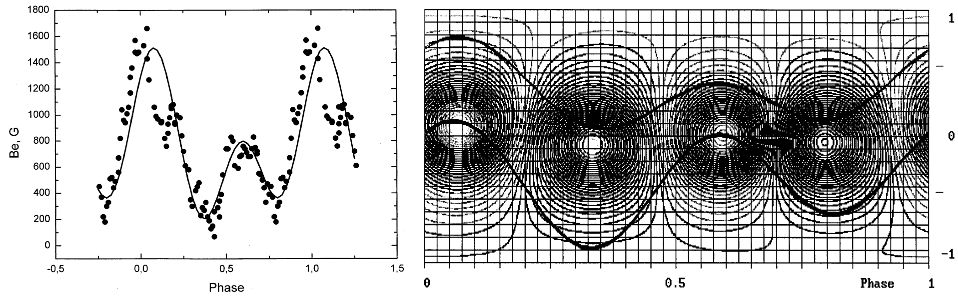


Figure 4. Left panel: moving average of the positive magnetic values phased with the rotation period, $P = 3.8575$ d. Right panel: map of the quadrupole model with phase curves for $i = 40°$ (top) and $i = 130°$ (bottom).

understood if we assume *differential precession* (Gerth 1984) of a fluid body in which the outer layers of the star preferentially participate in the precession.

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