G 240-72 -- A New Magnetic White Dwarf with Unusual Polarization

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ABSTRACT

GD 240-72 (=LP44-113), a DC white dwarf, is found to show elliptical polarization. There is no evidence of variability. The circular component, typically 0.5%, changes sign with wavelength, being negative in blue light and positive in red. There is a relatively strong component of linear polarization, 1.4% in blue light.

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Five magnetic white dwarfs have been reported, all being first identified through their circularly polarized continuum. Two are type DC with no detectable spectral features* and two have unusual spectra with associated Zeeman structure.+ Most of the DC and peculiar spectra white dwarfs classified by Greenstein and Eggen (Greenstein 1970 and references therein) have now been searched for circular polarization (Angel and Landstreet 1974b). Observations of white dwarf suspects with very high proper motion being made by two of us (PH and PAS) have identified several new DC white dwarfs, among them G 240-72.

Photometry at Steward Observatory of G 240-72 gives V = 14.12 ± .01, B-V = 0.52 ± .02, U-B = -0.33 ± .04. Plotted in a U-B, B-V diagram these colors lie close to the black body line. The indicated temperature is 7000°, intermediate between G 99-37 and G 99-47, the coolest degenerate magnetic dwarf. A widened spectrum at 95Å/mm obtained with the image tube spectrograph of the 90" telescope shows no feature at all in the range 3500 - 4900Å.

Broadband circular and linear polarization observations of G 240-72 were made in November and December 1973 at the 82" Struve telescope of McDonald Observatory. The equipment used was a pockels cell polarimeter, similar to that previously described by Angel and Landstreet (1970). For

*These are G195-19 (Angel, Illing and Landstreet 1972) and G 99-47 (Angel and Landstreet 1972).

+Grw + 70°8247 (Angel, Landstreet and Oke 1972) and G 99-37 (Angel and Landstreet 1974a).

this work, a NOVA computer was used to accumulate and display data. Glass filters were used to isolate several wavelength bands in the range 3300 - 8600Å. A list of the individual measurements is given in Table 1. No significant variability is apparent on an hour-to-hour or night-to-night basis, and the data in each band have been combined to give an average. The resulting values of circular polarization as a function of wavelength are shown in Figure 1. A striking feature is the changing sign of circular polarization with wavelength. The strength of polarization, of order 0.5%, is typical of other magnetic white dwarfs.

The linear polarization measured on two successive nights, in one wavelength band only, also appears steady and quite strong. The weighted mean value is (1.43 ± .07)% @ (47.5 ± 1.5)°.

It is interesting that in this star and in the recently reported magnetic white dwarf GD 229 (Swedlund, Wolstencroft, Michalsky and Kemp 1974) relatively strong linear polarization is observed. Of the previously discovered four dwarfs only Grw + 70°8247 had any detectable linear component. Lamb and Sutherland (1973) have emphasized that in the case of grey body magnetic dichroism circular polarization would generally be expected to be stronger than linear polarization by a factor ω/ω_L, where ω is the light frequency and ω_L the Larmor frequency. One could argue for Grw + 70°8247 that the field geometry happened to be particularly unfavorable for circular polarization (i.e., effectively perpendicular to the line of sight). However, now three out of six magnetic white dwarfs show a linear component at least as strong as the circular and this explanation cannot reasonably be used for all three. In these stars the observations could be explained if there are patches of strong magnetic field where the cyclotron frequency approaches optical frequencies ($B \geq 10^8$ gauss), producing strong linear and circular polarization. In this case the general features of wavelength dependence of polarization would depend on the particular field geometry and would thus be different from star to star, as is observed.

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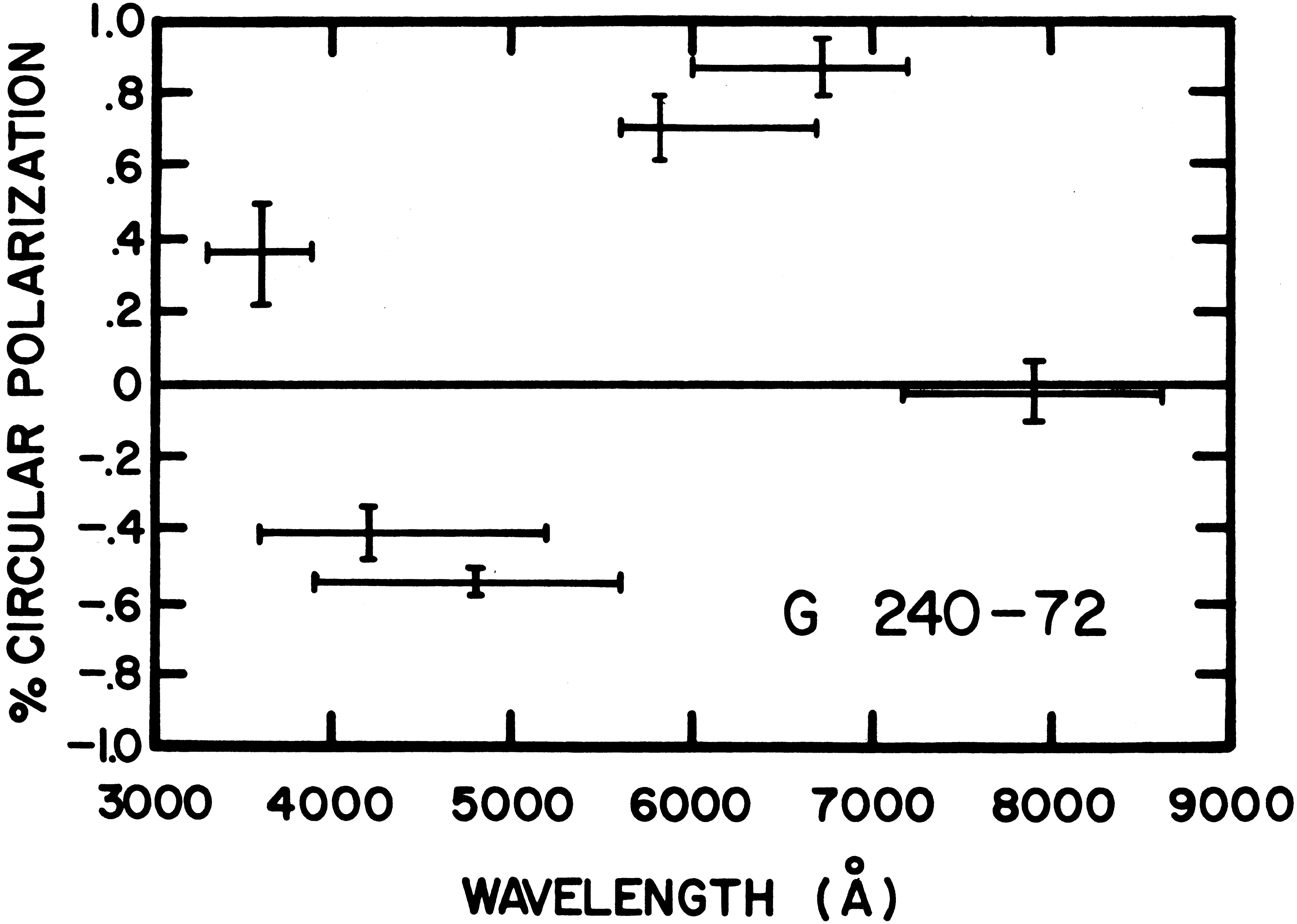
TABLE 1

Column 1 gives the wavelengths at which the sensitivity is half the peak value, taking into account the phototube filter and extinction. Two types of photomultiplier were used, RCA C31005C (Bialkali) and C31034A (GaAs). The Corning and Schott filters of standard thickness are listed in column 2. The errors in column 4 are one standard deviation computed from counting statistics.

Wavelength Range, Å	Photocathode and Filter	Date UT, 1973	Polarization %
3300-3900	GaAs with C7-54+$CuSO_4$	Nov. 18.09	Circular: +0.36 ± 0.14
3600-5200	Bialkali, glass	Nov. 17.08	Circular: -0.41 ± 0.05
3900-5600	GaAs, C 4-96	Nov. 18.06	Circular: -0.66 ± 0.05
"	"	Nov. 18.16	" -0.41 ± 0.07
"	"	Dec. 20.06	" -0.45 ± 0.12
"	"	Dec. 21.06	" -0.52 ± 0.08
3900-5600	GaAs, C 4-96	Dec. 20.08	Linear: 1.18±0.17 @ 47° ± 4°
"	"	Dec. 21.09	" 1.49±0.08 @ 47.5° ± 1.5°
5600-6700	GaAs, C 3-67+BG 38	Dec. 21.12	Circular: +0.70 ± 0.08
6000-8600	GaAs, C 2-63	Nov. 18.13	Circular: +0.43 ± 0.04
"	"	Nov. 18.20	" +0.44 ± 0.06
7200-8600	GaAs, RG 715	Nov. 18.18	Circular: -0.02 ± 0.08

FIGURE CAPTION

Circular polarization of G 240-72. Plotted points are averages of all measurements in a given band from Table 1. The vertical bars indicate the random errors ($\pm$ 1σ) from counting statistics. The horizontal bars indicate the wavelength range over which sensitivity is more than half the peak. The value for the range 6000 - 7200Å is obtained by subtraction of the data for the 6000Å and 7200Å sharp cut filters.


% CIRCULAR POLARIZATION
1.0
.8
.6
.4
.2
0
-.2
-.4
-.6
-.8
-1.0
3000
4000
5000
6000
7000
8000
9000
WAVELENGTH (Å)
G 240-72