# POLARIMETRY OF SYMBIOTIC STARS

V. Piirola
University of Helsinki
Observatory and Astrophysics Laboratory

ABSTRACT

Five symbiotic stars have been observed for linear polarization (UBVRI) in September 1981. Three systems, CH Cyg, CI Cyg and AG Peg show intrinsic polarization while in the case of Z And and AX Per the observed polarization seems to be mostly of interstellar origin. The position angle of polarization of CI Cyg and AG Peg rotates strongly vs. wavelength, as observed also for CH Cyg in 1977-80. The polarization of CH Cyg has decreased since May 1980, especially in the I, R and U bands, so that the maximum polarization is now in the blue ($P_B \sim 0.3$ %). Probably we are monitoring the formation, growth and disappearance of dust particles in the atmosphere of this star. Two related systems, PU Vul (Nova Vul 1979) and R Aql (Mira) have polarization behaviour rather similar to that of symbiotic stars which suggests that the M type giant present in these systems is responsible for most of the intrinsic polarization.

## 1. INTRODUCTION

The peculiar wavelength dependence of the polarization of CH Cyg and the time variability observed during the recent active phase in 1977-81 (Piirola, 1982) indicate the presence of a complicated scattering envelope in this system. Both the density, particle size distribution and scattering geometry of the envelope are varying on time scale of weeks. We report further polarization observations of CH Cyg and four other symbiotic stars.

## 2. OBSERVATIONS AND DISCUSSION

The observations were made during the period September 10-25, 1981 with the 1.25 m photometric telescope of Crimean Astrophysical Observatory using a multichannel version of the double image chopping photopolarimeter of the University of Helsinki. The observations were made



*M. Livio and G. Shaviv (eds.), Cataclysmic Variables and Related Objects, 211–216.*


https://doi.org/10.1017/S0252921100090345 Published online by Cambridge University Press

simultaneously in five colours using dichroic filters to split the light into five spectral regions. The resulting passbands are close to the standard UBVRI system, with effective wavelengths 0.37, 0.44, 0.53, 0.69 and 0.83 microns, respectively.

The polarization of CH Cygni (Figure 1) has decreased since May 1980, especially in R, I and U bands, so that the maximum polarization is now in the blue ($P_B \sim 0.3$ %). Also the position angle has rotated vs. time from $\Theta_U \sim 170^o$ in 1980 to $\Theta_U \sim 70^o$ in 1981. Accordingly, changes in particle size distribution and scattering geometry have occurred. In particular, the large dust particles ($a \sim 1$ μm) responsible for the polarization component increasing towards the I band (Piirola, 1982) have disappeared. The drop in ultraviolet polarization on the other hand could be explained by growth of the average small particle size from less than 0.05 μm to 0.08-0.10 μm.

In CI Cyg and AG Peg the position angle rotates strongly vs. wavelength (Figure 2) which indicates that the polarization cannot be entirely interstellar. In AG Peg the position angle is approximately constant from I to V but then clearly changes to B and U. This seems to coincide with the wavelength ($\lambda_o \sim 4000$ Å given by Viotti, 1982) where the spectrum of the hot source emerges. For wavelengths $\lambda > \lambda_o$ the cool spectrum dominates. In CI Cyg the rotation starts already in V band, consistent with the somewhat larger value of $\lambda_o \sim 5000$ Å.

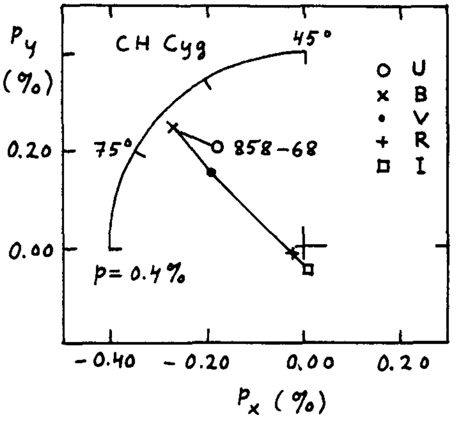


Figure 1. Polarization observations of CH Cygni in September -81 plotted in polar coordinates. The degree of polarization has maximum in the blue ($P_B \sim 0.35$ %, $\Theta_B \sim 70^o$) and decreases steeply towards the red.

https://doi.org/10.1017/S0252921100090345 Published online by Cambridge University Press

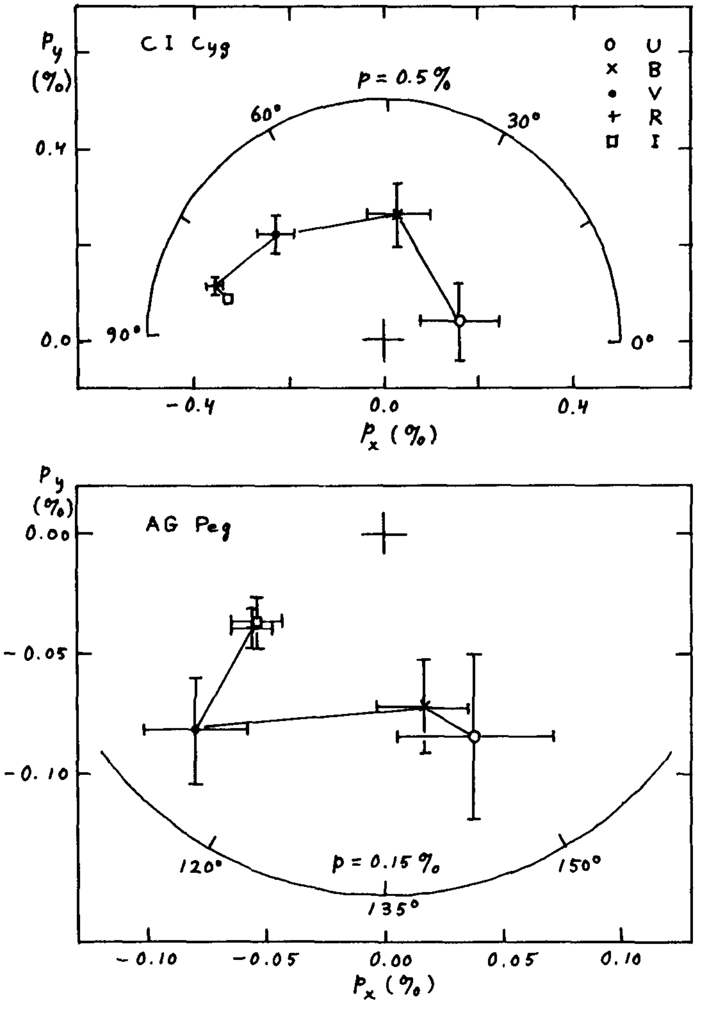


Figure 2. Polarization observations of CI Cyg and AG Peg show strong rotation of position angle as a function of wavelength which indicates the presence of intrinsic (circumstellar) polarization.

https://doi.org/10.1017/S0252921100090345 Published online by Cambridge University Press

The wavelength dependence of polarization in Z And ($P_V \sim 1.2$ %, $\Theta_V \sim 53^o$) and AX Per ($P_V \sim 1.3$ %, $\Theta_V \sim 95^o$) approaches that of interstellar polarization and more observations are needed to reveal possible time variations and consequently intrinsic polarization.

For comparison, Figure 3 shows polarization diagrams of related objects, namely PU Vul (Nova Vul 1979) and a Mira-type star R Aql, obtained in Sept. -81 (R Aql was too bright to be observed in R and I): The approximately similar polarization behaviour points to the possibility that the common feature, the presence of an M-type giant may be the main source of polarization. The degree of polarization usually increases towards the ultraviolet nearly proportional to $\lambda^{-4}$ which requires either small particle size or Rayleigh scattering by gas molecules. The correlation between infrared excess near 10 μm and polarization in many late type giants (see e.g. Zellner and Serkowski, 1972) supports dust particles as the main source of polarization in these stars. Further infrared photometry of symbiotic stars is needed to establish the possible correlation between infrared excess and polarization.

The contribution of the hot companion, e.g. a white dwarf and accretion disk to the polarization depends on the relative fluxes from the WD and the M giant and the existence of scattering agents in the vicinity of the white dwarf. The near $\lambda^{-4}$ dependence of polarization of CH Cyg during time intervals when high additional hot continuum is present would suggest that the light from the hot companion is effectively scattered by the dust particles in the M giant envelope and/or by free electrons in the disk, but more quantitative modelling is still required to decide which one is dominant.

We are grateful to Prof. A.A. Boyarchuk of Crimean Astrophysical Observatory for the opportunity to use the 125 cm telescope in connection with our polarimeter. Thanks are also due to Drs. N.M. Shakhovskoi and Y.S. Efimov for valuable help during the observations.

## REFERENCES

Piirola, V.: 1982, in The Nature of Symbiotic Stars, eds. M. Friedjung and R. Viotti, IAU Coll. 95, 139
Viotti, R.: 1982, private communication
Zellner, B. and Serkowski, K.: 1972, P.A.S.P. 84, 619

https://doi.org/10.1017/S0252921100090345 Published online by Cambridge University Press

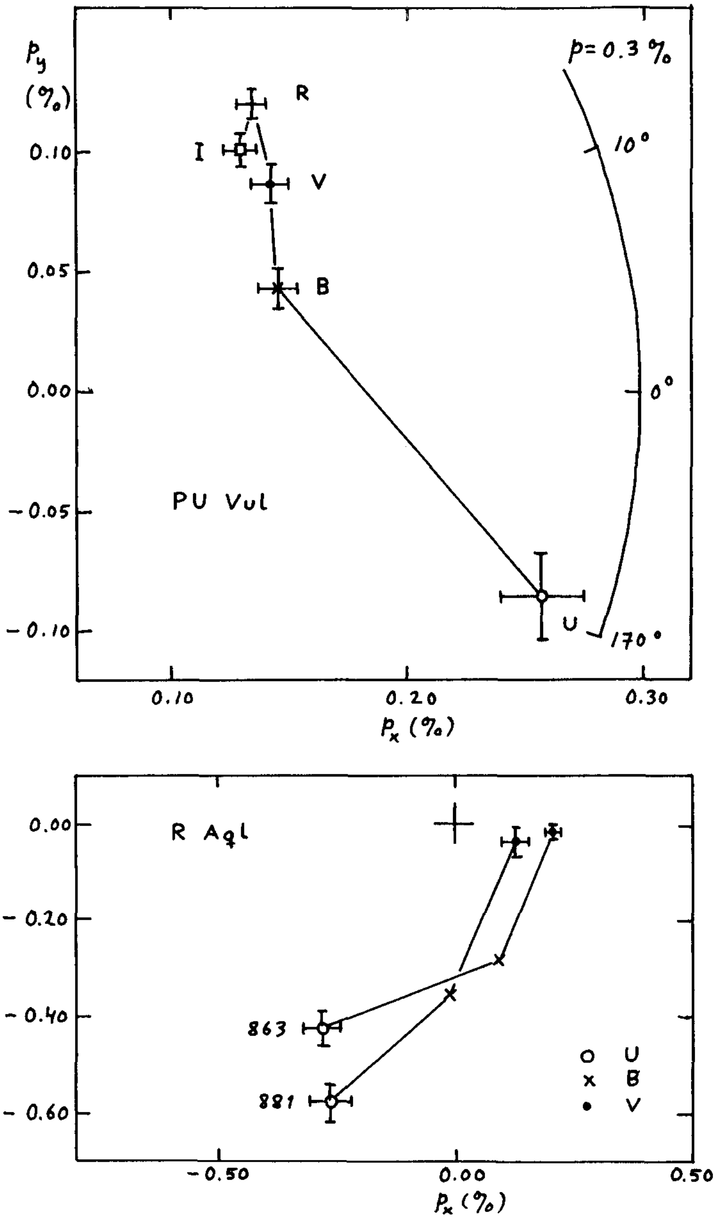


Figure 3. Polarization observations of two systems related to symbiotic stars, PU Vul (Nova Vul 1979) and R Aql (Mira) in September -81 plotted in polar coordinates.

https://doi.org/10.1017/S0252921100090345 Published online by Cambridge University Press

DISCUSSION FOLLOWING V. PIIROLA'S TALK

MITCHELL: Do you see any pulsations in the red component and if so is it possible to correlate those with the inferred changes in the grain size characteristics of CH Cyg?

PIIROLA: So far I cannot tell about the pulsations from these observations.

MATTEI: Could you tell me when you did the CI Cyg and Z And observations? Is the detection of polarization phase dependent in the light curve?

PIIROLA: I started these observations of CI Cyg in September 1981 and observed it also in June 1982.

MATTEI: So it was out of its eclipse.

PIIROLA: I observed Z And in September 1981.

MATTEI: At its minimum phase then. So they were in different phases in their light curve.

EVANS: Can you say anything about the composition and the distribution of the dust?

PIIROLA: The recent observations of CH Cyg show that the average dust particle size has increased, because the maximum was in the blue and not in UV. You can fit grain models to the wavelength dependence and quite accurately fit the average size of the grains. It is impossible to get the geometry of the scattering matter without eclipses.

MITCHELL: Can you put in any numbers on the grain size?

PIIROLA: It was something like 0.1μ.

TAPIA: First, I am happy that you have demonstrated that very large changes in the polarization in AM Her occur not only in my observations. Now, I would like to ask, were the observations of CH Cyg motivated by any particular reason?

PIIROLA: Yes, I was informed that an active phase started.