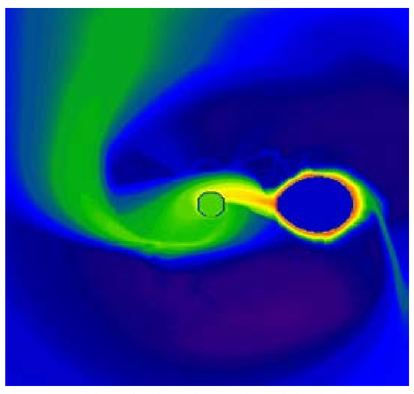

Simulation by Mkrtchian, D.,
private communication

Study of polarization variability of Algol-type binary stars using polarization-holographic imaging Stokes polarimeter

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INTRODUCTION

The Algol-type binaries are the semidetached interacting binary systems in which the cool secondary star have expanded to fill its Roche lobe and is transferring material through a gas stream onto the hot primary star. The Algol-type binaries should show polarization variability due to scattering in mass transfer streams and circumstellar discs, as well as Thomson scattering in the photospheres of their hot stars and Rayleigh scattering due to irradiation of their cooler stars. Although the measurement of polarization variability for Algol-type binaries are neglected even for a present time, which poses instrumental, observational and data processing challenges.

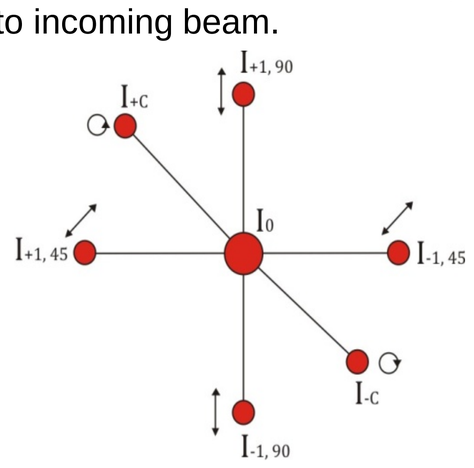
Here we present the first polarimetric test observations of some bright Algol-type variable stars using the innovative Polarization-Holographic Imaging Stokes Polarimeter (PHISP).

The polarization-holographic method was first proposed by Prof. Sh.Kakichashvili in 1972. It allows to create a unique polarization-holographic optical element capable to make a full analysis of polarization state in a real time and in a wide spectral range including near infrared. Such element is a main optical part of PHISP.

The PHISP equipped with the Starlight Express Trius SX-36 CCD and mounted at the 14' Schmidt-Cassegrain Telescope of Abastumani Astrophysical Observatory (Georgia).

METHOD & DESIGN

In the process of diffraction, the element decomposes light into orthogonal circular and linear basis. As a result the element forms two orthogonal circularly polarized beams with intensities I_{+C} and I_{-C}, two linearly polarized beams with an azimuth +45°, two linearly polarized beams *w*ith an azimuth +90° with intensities I_{45} and I_{90} correspondingly and also none diffracted beam with a state of polarization identical to incoming beam.



The general configuration of diffraction orders

Simultaneous measurement of the intensities of the diffracted beams allows to determine all four Stokes parameters and the corresponding parameters of the polarization ellipse

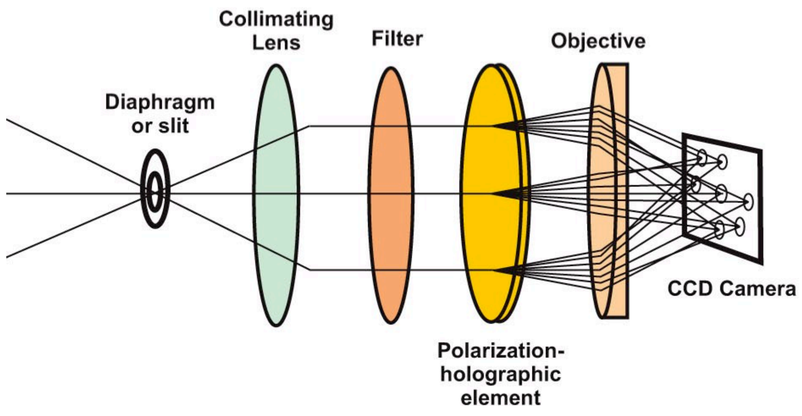
$$I = k_{+C} \cdot I_{+C} + k_{-C} \cdot I_{-C}$$

$$Q = I - 2k_{90} \cdot I_{90}$$

$$U = 2k_{45} \cdot I_{45} - I_{\lambda}$$

$$V = k_{+C} \cdot I_{+C} - k_{-C} \cdot I_{-C}$$

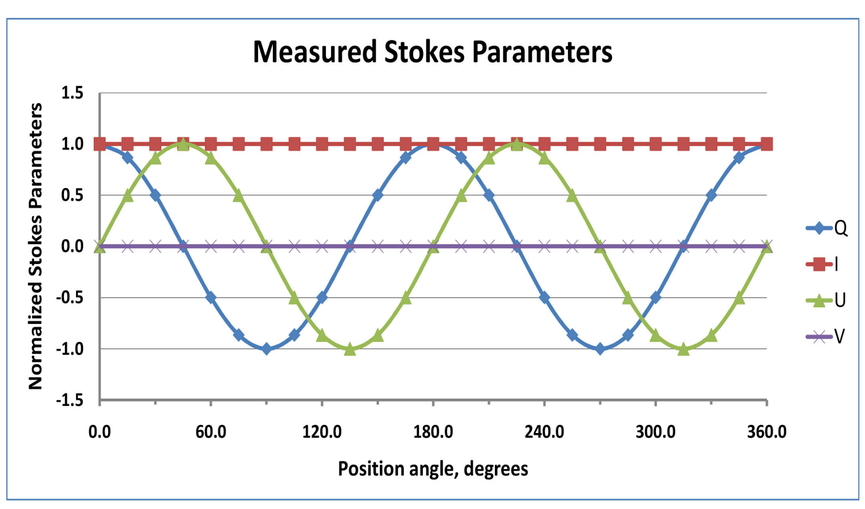
where *k* terms are coefficients connected with absorption of a light in an element, diffraction efficiency of an element and the optoelectronic transformations by the photo-detectors. The values of these coefficients are determined experimentally during calibration. The operating spectral range of an element varies between 500-1600 nm with diffraction efficiency equal to 20% at 532 nm, 16% at 635 nm and 2% at 1550 nm. The diffraction gratings have 330 lines/mm density and spectral dispersion of about 70 nm/mm.



The principal schema of PHISP

CALIBRATION

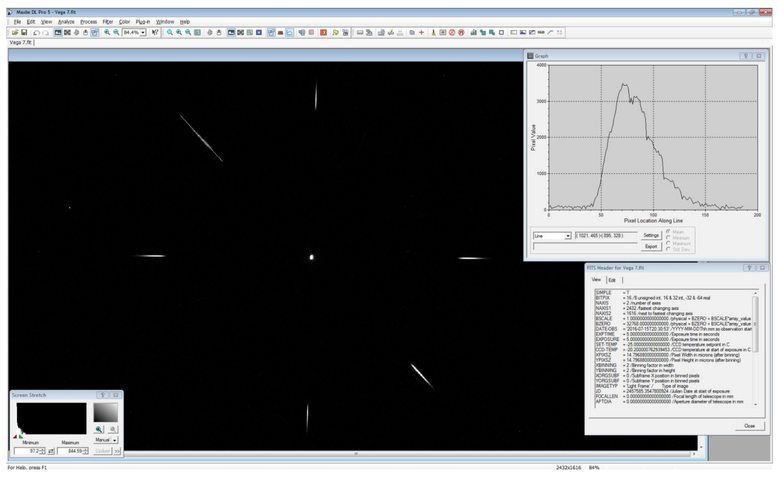
For calibration of the PHISP, the observations of Vega were carried out through the standard V filter. A polarizer was attached at the front of the telescope to compensate any instrumental polarization and rotated with a fixed angle equal to 15° to get a sequence of CCD images with known linear polarization and position angles. The measured intensities of I_0, I_{+c}, I_{-c}, I_{90} and I_{45} were integrated for all wavelengths and used to estimate coefficients in relations above. The normalized Stokes parameters were calculated for the same measurements. The figure below shows the variations of all Stokes parameters with position angles of the linearly polarized light.



The results of calibration measurements: variation of normalized Stokes parameters with position angle of linearly polarized light

TEST OBSERVATIONS

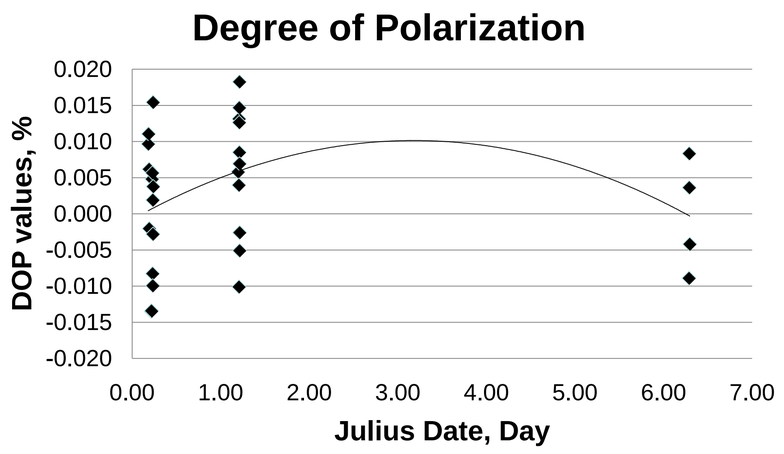
The series of polarization-holographic images of α Lyr, β Lyr and some other Algol-type variables in the standard V filter were obtained during 2017 using 14" Schmidt-Cassegrain telescope of the Abastumani Astrophysical Observatory (Georgia) where PHISP was mounted in combination with Starlight Express Trius SX-36 CCD.



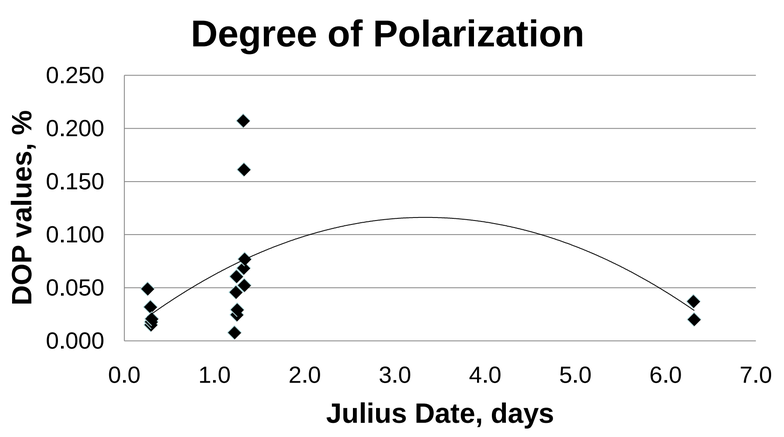
Starlight Express Trius SX-36 CCD polarization-holographic image of Vega.

TEST RESULTS

The intensities of each diffraction order were integrated into one value and were transformed to the Stokes parameters using the calibration coefficients. The Stokes parameters calculated for each CCD frame were used to calculate the degree of polarization P_V (%). The polynomial fitting of the trend lines clearly show the variation of the polarization. The standard deviations estimated for each observational day show that the errors are near 10^{-3} %.



Time series variations of degree of polarization of α Lyr (Vega) in the standard V filter, P_V (%).



Time series variations of degree of polarization of β Lyr in the standard V filter, P_V (%).

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