VARIATION OF POLARIZATION IN YOUNG PLANETARY NEBULAE AND PROTOPLANETARY NEBULAE

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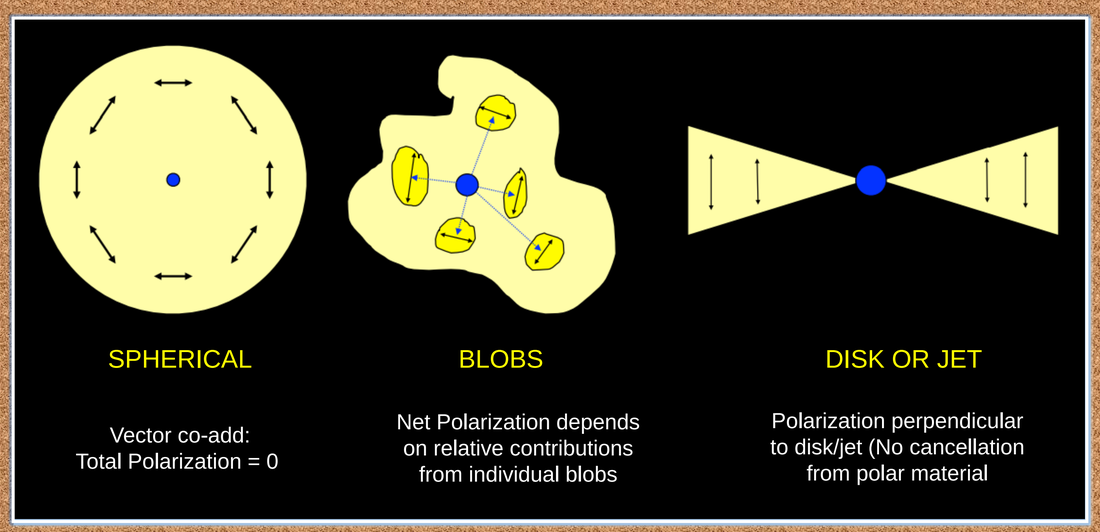
Introduction

Causes of gas flow collimation in bipolar planetary nebulae (PN) is still an open debate. Suggested mechanisms includes magnetic fields, star rotation and the presence of an accretion disk as a consequence of mass transfer in a binary star system. In the latter case the use of polarimetry techniques can be a useful diagnostic of asymmetries without being able to resolve the source and even more, gives information about the orbital parameters.
Main goal of this long term work is monitor proto planetary nebulae (PPN) and young planetary nebulae (YPN) and search for variations in polarization states as evidence of binary star systems.



Effect of asymmetries in unresolved systems from Bjorkman 2011.

Stokes parameters

The normalized Stokes parameters Q and U are defined and calculated by mean of the following equations:

$$Q = \frac{I(0) - I(90)}{I(0) + I(90)} \qquad U = \frac{I(45) - I(135)}{I(45) + I(135)}$$

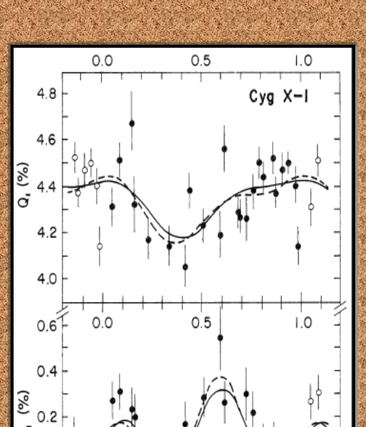
Where $I(\theta)$ is the flux of the object in the image at a position angle θ of the polarizer optical axis. Q and U parameters are related to the degree P and angle θ polarization by equations:

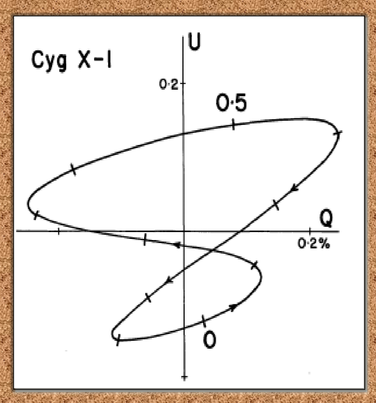
$$P = \frac{Q^2+U^2}{2I} \qquad \theta = \tan^{-1}(U/Q)/2$$

The intensity parameter I can be obtained from:

$$I = I(\theta) + I(\theta + 90)$$

In a classical work Rudy and Kemp (1978) presented a method for estimating the orbital inclinations of binary systems from polarization variations when those variation arise from single-scattering processes. They show that the variable polarization traces an ellipse in the $Q - U$ diagram.





Example of variation of the Stokes parameters over a period (left) and shape in the $Q - U$ diagram (up). The case of binary Cygnus X-1 taken from Brown et al. 1978)

Observations

Optical linear polarimetry of PN and YPN were performed at the 0.84m, f/15 telescope at Observatorio Astronomico Nacional in México using a CCD camera and the POLIMA polarimeter (Hiriart et al. 2005) in February and September 2010, February 2011 and February and June 2012.
Images of polarized and no polarized standard stars were used in order to quantify the instrumental polarization and calibrate the prism orientation.

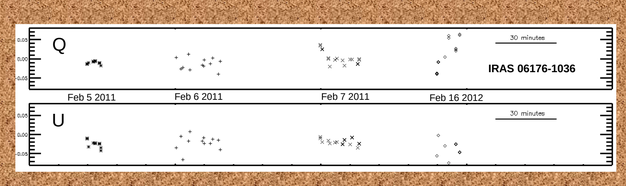
Selected objects

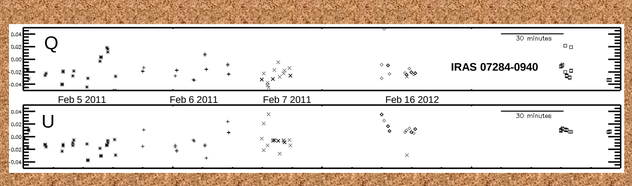
Observation of 25 objects has been done along the 2010, 2011 and 2012 observing runs. In the table below basic data of the six most monitored objects are presented.

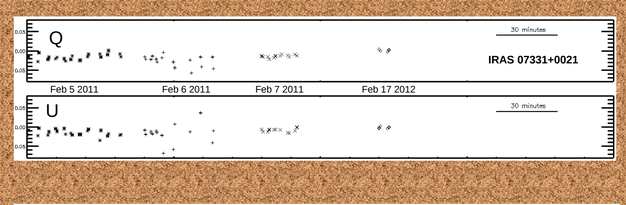
IRAS	Name	m_v	Spectral Type	Type
06176-1036	Red Rectangle	8.8	B8V D	Post – AGB (PPN)
07284-0940	V* U Mon	6.8	K0I bpv	Variable Star of RV Tau type
07331+0021	V* AI CMi	8.3	G5 Iab	Pulsating variable Star
10158-2844	V* AG Ant	5.5	B9.5 Ib	Post – AGB (PPN)
12359+0715	V* R Vir	7.8	M3.5-7e	Variable Star of Mira Cet type
12538-2611	V* LN Hya	6.7	F3Ia	Semi-regular pulsating Star

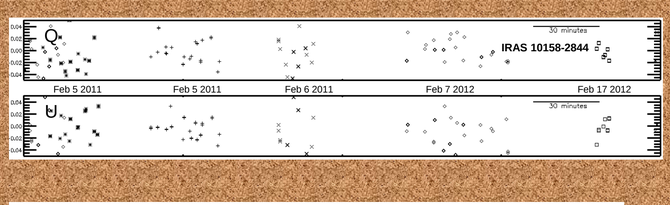
Preliminary results

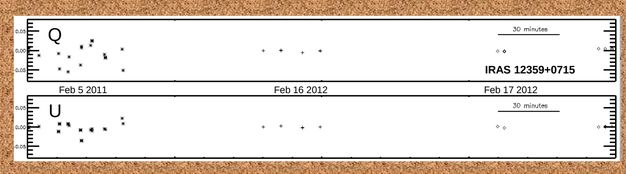
Variations of polarization has been found in all the observed objects as is shown in graphics below. A lot of future work is needed in order to analyze if these features are just a general variability, which is known property of single post main sequence stars or are periodic variations caused by the orbital motion in binary systems.

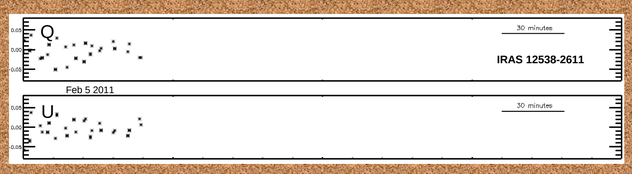












Q and U Stokes parameters vs time

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