Faint NIR Polarimetric Standards

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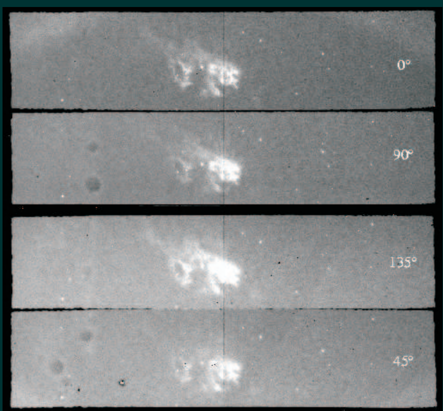
Abstract

We report on the preparation of a catalog of faint polarized standards for near infrared bands. The catalog will only contain faint targets (below J~14) which should be a reference list for observations in 10m class telescopes. We expect to have a list with more than 50 targets contained in several fields distributed in a wide right ascension range.
The data were collected using the polarization mode of LIRIS instrument (mounted at WHT telescope).
Here we show some examples of the use of LIRIS polarimetry and a first sample of the catalog.

The Polarimetry mode of LIRIS

LIRIS is a near-infrared (0.9-2.4 microns) intermediate resolution spectrograph (R=1000-3000), conceived as a common user instrument for the WHT (Manchado et al. 1998, 2000) at the Observatorio del Roque de los Muchachos (ORM La Palma). The detector is a Hawaii 1024x1024 pixel array that covers a 4´x 4´ field of view.
LIRIS also offers the polarimetric observing mode thanks to a **Wedged double Wollaston** device (WedoWo; Oliva, 1997).



Raw polarization frame of Ceph-A nebula. Each field represent a 4´x1´field of view

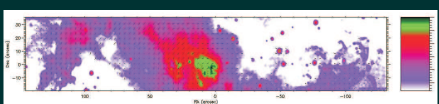
Polarization measurements can be performed with any of the available filters. Four polarized beams (0, 45, 90 and 135 deg) are registered simultaneously. The Stokes linear polarization parameters (Q, U) are calculated from differences in orthogonal polarization planes:

$$Q= I_0 - I_{90} \qquad U=I_{45}-I_{135}$$
$$I_1=(I_0+I_{90})/2 \qquad I_2=(I_{45}+I_{135})/2$$

And linear polarization is estimated as $P = \mathrm{sqrt}(Q^2 + U^2) / I$ and position angle of polarization vector as

$$\arctan(U/Q) / 2.$$

Figure below shows the polarization structure of Ceph-A nebula as observed by LIRIS during the commisioning in October 2004.



Polarization diagram of Ceph-A nebula. The highest degree of P is ~70%. The vectorial field shows a nearly point-symmetric pattern around the peak of the intensity.

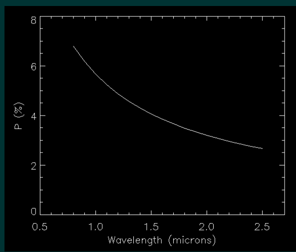
The case for faint polarimetric Standards in the NIR?

In general, polarimetry is today aplied to a wide field of braches in Astronomy, from cometary physics or planetary envelopes to acretion discs or AGNs. In particular, NIR polarimetry is specially interesting on the interstellar medium studies. In fact, an apropriated analysis of the polarization state of the light crossing interstellar clouds can give information on the composition, size, forms and possible alignments of the dust in the interstellar medium (Martin 1989).

The dependence of the linear polarization P whith in the interstellar dust is well known. This dependence follows the Serkosky law (Serkowsky et al, 1975; Whittet et al. 1992):

$$P/P_{max}=\exp[-(0.01+1.66\ _{max})\ln(\ _{max}/\ )]$$

Where P_{max} depends of the column density, and $_{max}$ is the wavelength where P_{max} occurs.



Serkowski law for a medium that reachs 10% maximum polarization at 0.5 m wavelength.

In general, the polarimetric calibration standards are very bright stars affected by a hight extinction of foreground inrestellar clouds. But there are two important problems:

1.- There is **few catalogs which contains a poor number of standards**.

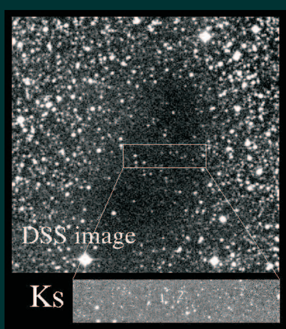
2.- Only a short subset of the sample is appropriated to be observed in 10m class telescopes. In fact, only a few catalogued standards present magnitudes J>12, and most of them can only be observed from the suthern hemisphere .

Therefore, our main goal is to construct a list of polarimetric standards, including unpolarized targets, in J, H and Ks infrared bands, apporpiated to be observed in large aperture telescopes. This means to catalog targets with J, H, Ks>13.

Observations

Because the origing of polarization is the interstellar dust, one of the best zone to get polarization standards are the edges of molecular clouds at low galatic latitudes where the extinction is high, but no so high to observe in J band. These fields contain stars behind (polarized sources) and in front of the interstellar cloud (no extinguished and so unpolarized stars). The **Barnard clouds** meet these requirements.
We chose **Barnard 64, 68, 163, 346 and 352** clouds as target of our observations in July 2006.
Each fiel was observed with position angles of 0 and 90 deg in order to avoid differential transmission of the WedoWo prism.

Barnard 64 cloud. The Ks image was taken using LIRIS polarimetry mode (FOV~4'x1'). "1" and "2" label the targets which show linear polarization.



Instrumental polarization

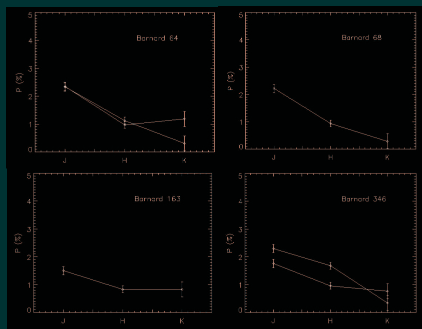
For instrument calibrations we used the umpolarized standard star WD1344+106 (J=14.407, H=14.139, Ks=14.235) of ISAAC polarimetric standards. Next table shows the instrumental polarization of LIRIS:

	J	H	Ks
$Q(\%)$	0.231	−0.098	0.640
$U(\%)$	−0.350	−0.436	−0.548
$P(\%)$	0.419	0.446	0.843

Instrumental polarization. The errors of this determination is around 0.2% for J and H bands, and ~ 0.35% for Ks.

The first standards

We identify 6 polarized standards in these fields. The polarization P in J band is about 2-3% and dicreases until 0.5-1% for Ks band following the Serkowski law. Table bellow presents the magnitudes, linear polarization P and position angle in each band.



Linear polarization P of some targets in the observed Barnard fields.

ID	RA	Dec	J	H	Ks	$P(J)$	$P(J)$	$P(Ks)$	θ(J)	θ(H)	θ(Ks)
$B64_1$	17 : 17 : 14.5	−18 : 29 : 28	15.94	1.00	1.00	2.35	0.97	1.18	6.4	3.5	−10.8
$B64_2$	17 : 17 : 13.6	−18 : 29 : 27	16.56	0.66	0.81	2.33	1.13	0.30	−12.2	−13.5	0.6
$B68_1$	17 : 22 : 37.2	−23 : 51 : 24	16.52	0.78	0.96	2.22	0.94	0.29	12.1	18.3	21.6
$B163_1$	21 : 35 : 57.9	57 : 26 : 08	14.76	0.43	0.47	1.50	0.83	0.83	21.8	9.8	11.4
$B346_1$	20 : 27 : 04.5	43 : 39 : 01	15.87	1.01	1.34	2.30	1.68	0.35	43.3	42.2	32.2
$B346_2$	20 : 27 : 03.7	43 : 38 : 49	13.64	0.90	1.20	1.76	0.96	0.77	37.5	28.3	1.7

Linear polarization P and positio angle of the selected standards candidates.

In addition we select some unpolarized standards. In fact, the field Barnard 352 only contains stars with no-polarization. We list bellow some of these targets

ID	RA	Dec	J	$J-H$	$J-Ks$
$B352_1$	20 : 57 : 06.2	45 : 49 : 58	14.76	−1.34	−1.30
$B352_2$	20 : 57 : 06.5	45 : 49 : 51	16.50	0.35	0.35
$B352_3$	20 : 57 : 07.2	45 : 50 : 13	17.20	0.25	0.27
$B352_4$	20 : 57 : 04.8	45 : 50 : 18	16.52	0.32	0.34
$B352_5$	20 : 57 : 06.7	45 : 50 : 19	15.46	0.37	0.40

Zero-polarization standards candidates.In all cases P(J) is below 0.5%.

For the future ...

Fot the future we plan to continue the observations of Barnard fields. In fact, we plan the next strategy:

1. We will measure these **fields again** in order to reject targets with possible variabilities.

2. We will also perform **optical polarimetry** of these targets. These observations will be carried out using the TURPOL polarimeter in the NOT telescope. If the polarization follows the Serkowski law these candidates will be confirmed as actual polarization standards.

3. We will also provide **standards fields for winter time**. For this purpose, we will use LIRIS at WHT and TURPOL at NOT.

References

1. Manchado et al. 1998, SPIE, 3354,448
2. Manchado et al. 2000, SPIE, 4008, 1162
3. Martin 1989, IAU Symp 135, 375
4. Oliva, 1997, A&AS, 123, 589
5. Serkowski et al. 1975, ApJ, 196, 261
6. UKIRT Polarized and Unpolarized standards
7. Whittet, 1992, ApJ, 386,562