NEOPol: Polish polarimeter for NEOs – first light and first results

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NEOPol is a prototype polarimeter built for the European Space Agency (ESA) to monitor Near Earth Objects (NEOs). The project's primary goal is to measure the polarization degree as a function of the NEOs' phase angle. By this dependence, we can obtain the observed NEOs' albedo and subsequently determine the corresponding asteroid class. NEOPol is going to work at the 1-m ESA Optical Ground Station Telescope at the Observatorio del Teide in Tenerife. The instrument's first light and tests were performed at the 60-cm Cassegrain telescope at the Institute of Astronomy of the Nicolaus Copernicus University in Toruń, Poland. Our presentation shows first results based on the observations of the highly polarized and low polarized standard stars, obtained in July 2020 and February 2021. We reach the expected accuracy on the level of 0.1% for the linear polarization degree and a few degrees for the position angle.

References

Sybilska et al., 2019, SPIE Proceedings Vol. 11132, Polarization Science and Remote Sensing IX, article id. 111320B

Acknowledgements

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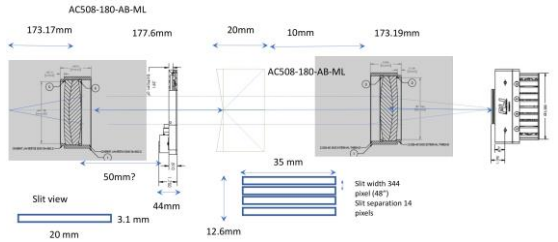
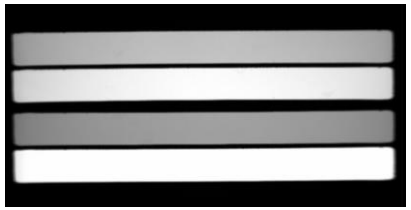


Fig. 1. The NEOPol polarimeter layout, from left to right: incoming beam from the telescope 1. filed mask, 2. two inches achromatic doublet lens, 3. FLI CFW1-5 filter wheel, 4. Wedged double Wollaston, 5. the second two inches achromatic doublet lens, 6. FLI ProLine. The field mask slit has a dimension of 3.1 mm and 35 mm. The incoming light from the focus plane is collimated by the two inches achromatic doublet lens. The collimated beam then goes through colour filter (V or R) and then trough the Wedged double Wollaston that allows to measure Q/I and U/I simultaneously with single exposure. The prism splits the incoming light beam into four separate components corresponding to four polarization plane angles 0, 90, 45 and 135 degrees. These images are separated stripes on the CCD chip (Fig. 2 and 3).

Fig. 2. An example of the evening flat field. Due to the Rayleigh scattering, the sky is highly polarized. Therefore, there is a significant difference in the 0, 90 and 45 and 135 polarization plane images. The 60-cm Cassegrain telescope (TC60) was used for the on-sky tests of the NEOPol polarimeter.



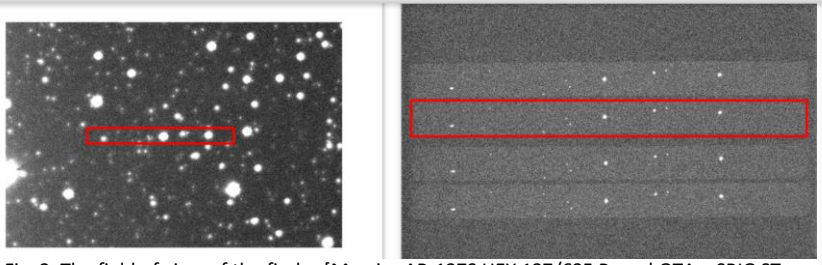


Fig. 3. The field of view of the finder [Messier AR-127S HEX 127/635 Pezval OTA + SBIG ST-7 CCD camera, 765 x 510 pixels, 9-micron square] 36.7' x 24.5' (left) and the NEOPol polarimter 15.65' x 1.36' (right). To position a target in the NEOPol FoV, the use of the finder is necessary. The finder CCD camera and the NEOPol CCD camera are aligned. First, the target is positioned at the centre of the finder CCD; then, with the fine movements, the target is positioned at the centre of the NEOPol FoV.

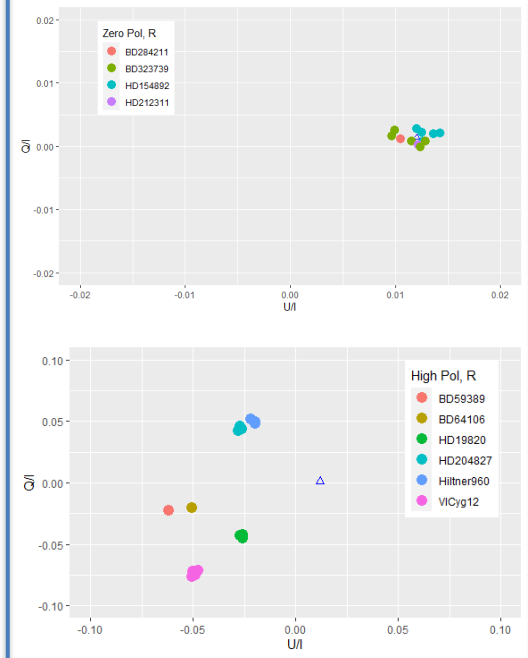


Fig. 4. Upper panel: normalized Stokes q-u plane for zero polarization standard stars in R filter. The blue open triangle shows the mean value of q and u, i.e. the instrumental polarization. Lower panel: normalized Stokes q-u plane for high polarization standard stars after subtracting instrumental q and u.

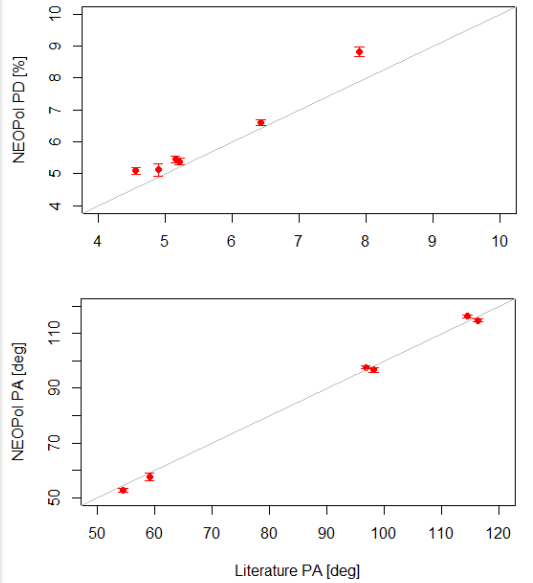


Fig. 5. Measured polarization degree (upper panel) and position angle (lower panel) as a function of literature values of high polarization standard stars in R filter. Grey line is y=x.

	u	q	PD	PD error	PA	PA error
BD59389	-0.0620	-0.0226	6.60	0.09	96.66	0.74
BD64106	-0.0505	-0.0204	5.45	0.11	97.67	0.62
HD19820	-0.0260	-0.0438	5.10	0.10	116.29	0.42
HD204827	-0.0270	0.0435	5.12	0.20	57.57	1.34
Hiltner960	-0.0203	0.0498	5.38	0.10	52.73	0.65
VICyg12	-0.0490	-0.0735	8.84	0.15	114.81	0.45

Results

Our results show that we managed to obtain median PD accuracy on the level of 0.1% in R and 0.12% in V (excluding the two variable stars in the sample) with the 60-cm telescope, for stars in the magnitude range of 7 - 12 in the R band.