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The HARPS-North@TNG polarimeter

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ABSTRACT

A new spectro-polarimetric unit for the High Accuracy Radial velocity Planet Searcher of North emisphere (HARPS-N) of the Telescopio Nazionale Galileo has been installed. Electro-opto-mechanical solutions adopted to link the dual-beam spectro-polarimeter located at a Nasmyth focus to the fiber-fed spectrograph and, at the same time, able to guarantee a correct orientation of optical axes in the celestial equatorial system are described. First results of science verification are reported.

Keywords: Polarimetry, Spectroscopy

1. INTRODUCTION

We present the updated version of the polarimeter for the HARPS-North spectrograph of the Telescopio Nazionale Galileo [1].

2. THE UPDATED POLARIMETER

HANPO concept is based on λ/2 and λ/4 waveplate retarders that can be alternatively inserted along the optical path and rotated in respect to a beam displacer (Foster) to measure the linear and the circular polarisation respectively [2]. The new HANPO opto-mechanical setup is sketched in Figure 2.1 and 2.2.

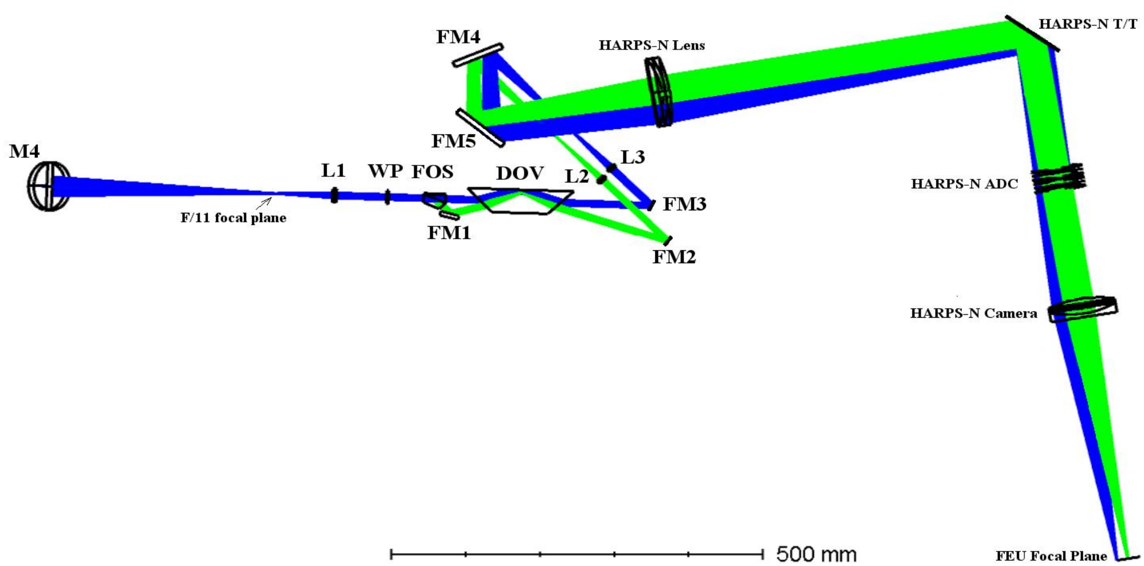

Figure 2.1 : The new HANPO optical setup.

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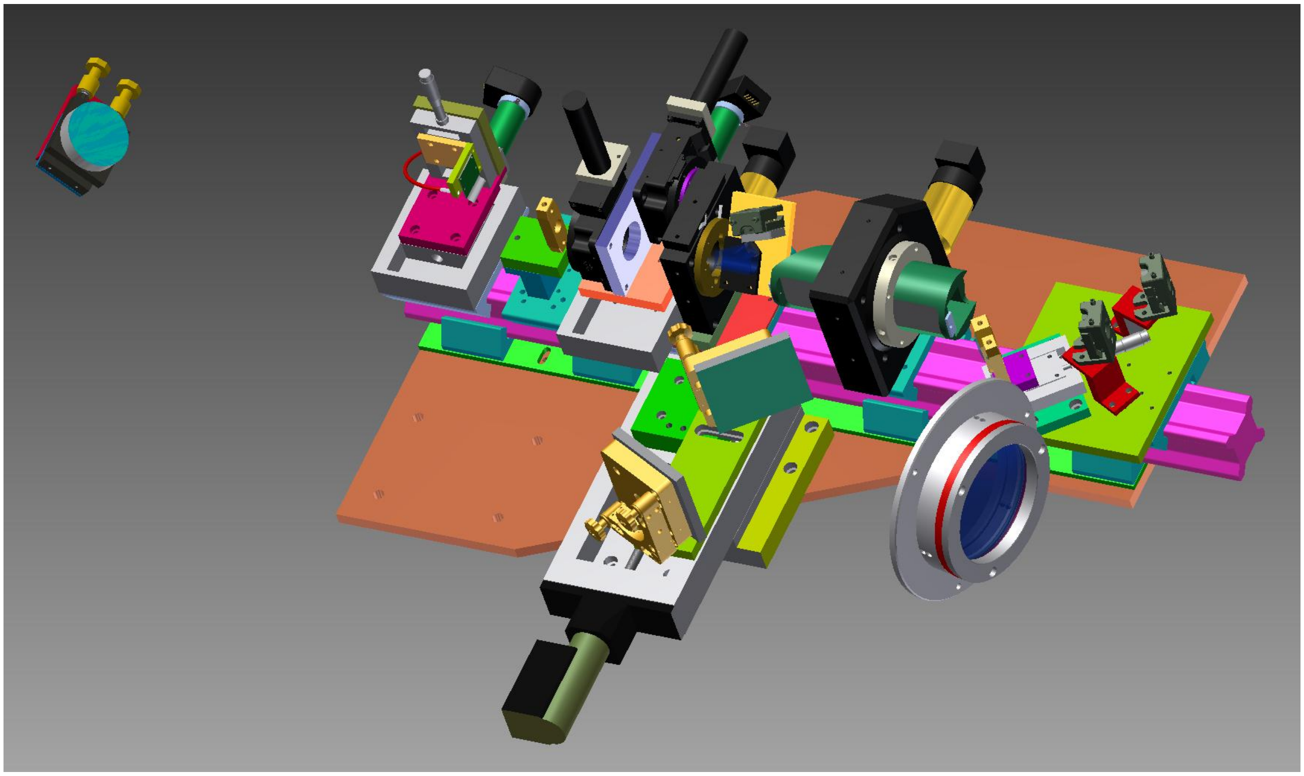

Figure 2.2 : The new HANPO mechanical setup.

Light beam coming from the telescope hits M4 folding mirror (see Fig. 2.3). It can be inserted to cross the telescope beam by an entrance slider used for selecting the desired scientific instrument, in this case HANPO. Another slit allows for translating it in the other direction. The main plate on which the polarimeter rail is inserted could also translate it in the remaining direction. The slit and the main plate translational modes and two tilting knobs allow for aligning the opto-mechanical axis of the polarimeter along the reference optical path traced by a laser.

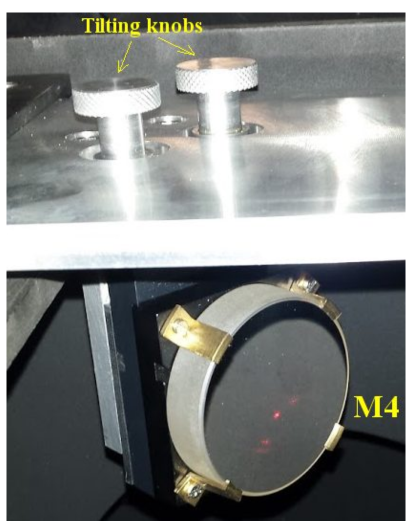

Figure 2.3 : M4 folding mirror system.

The beam focuses on F/11 focal plane, ~300mm far from M4 mirror. In this plane, a system has been mounted which allows for inserting a fiber simulating the source and lamp calibrations, a small webcam (Raspberry P2) towards the telescope for pointing and centering the sky source on HANPO or nothing for sky source spectropolarimetric measurements. On this focal plane a ∅=20mm, f=80mm L1 lens focus lies, outputting a ~∅7mm collimated beam which enters λ/2 or λ/4 waveplate (WP) and finally in the Foster polarizer (FOS) which splits it into ordinary (s-polarized) and extraordinary (p-polarized) beams. Both, the waveplates and the Foster polarizer, must co-rotate with the field of view to analyze source polarization in respect to a fixed direction (N-S). Due to such co-rotation, the extraordinary beam, 45° exiting from Foster polarizer, is reflected by a small FM1 folding mirror with a ~2.6° angle in respect to the opto-mechanical axis. On the 45° beam exit surface of the Foster, a λ/2 waveplate has been glued for changing p-polarized state to s-polarized one of the beam to maximize outputs after reflection on FM1 folding mirror. Then, the ordinary and extraordinary beams pass through a Dove prism (DOV) which rotates half an angle of the WP+FOS system for maintaining the exiting ones in a fixed direction. These beams hit the correspondent folding mirror FM2 and FM3 which bend them towards the two ∅=20mm, f=80mm L2 and L3 lenses which, together L1 one, recover the optical scale of HARPS-N optical setup before entering the HARPS-N lens and collimate them on two focuses separated ~21.5mm., 116arcsec on-sky, the separation of the two fibers A and B. A two mirrors FM4+FM5 folding system bends the two beams towards the HARPS-N lens in such way they are focused on the A and B fibers, inside the HARPS-N Front End Unit (FEU) which drive the signal to the spectrograph.

3. ALIGNMENT IN OPTICAL LABORATORY

HANPO has been mounted in optical laboratory as shown in Fig.3.1

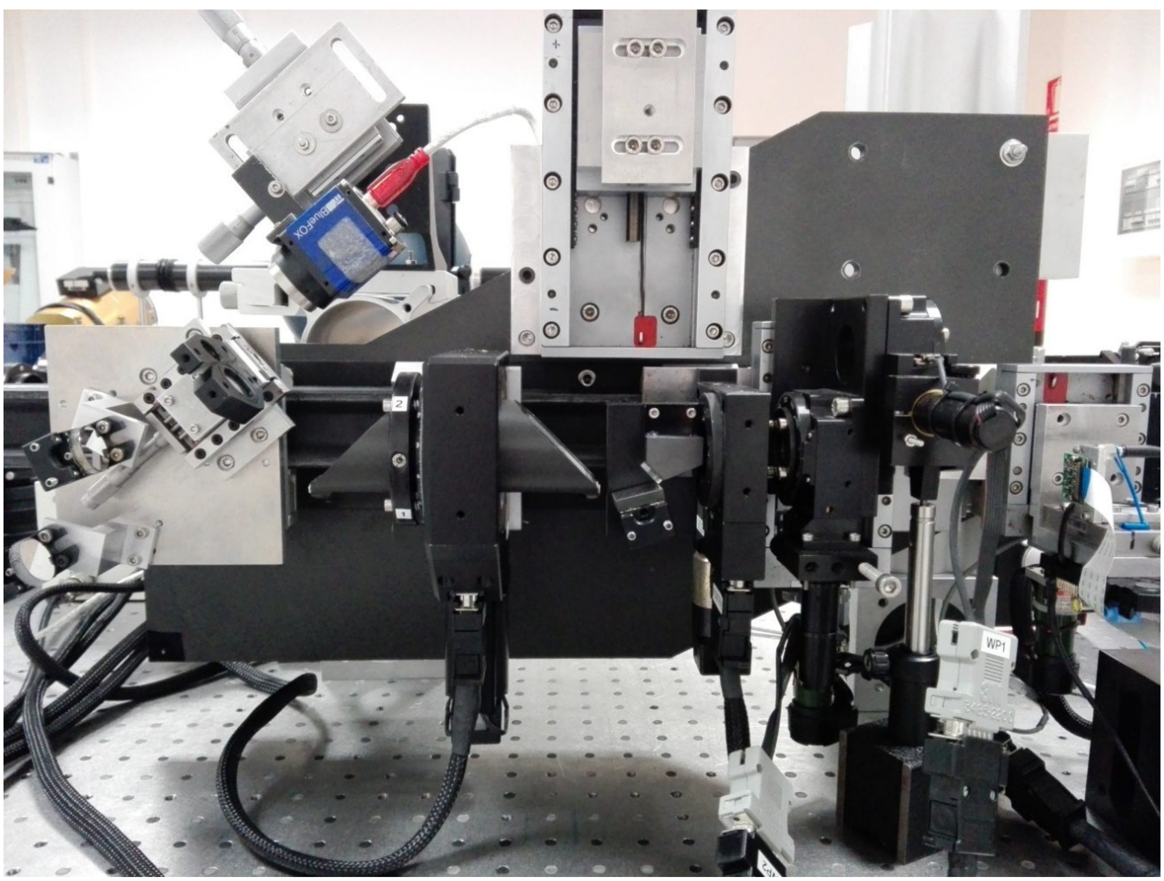

Figure 3.1 : HANPO mounted in optical laboratory for alignment and testing.

The fiber has been set to the focus nominal position. Lens L1 has been aligned by autocollimation and centered in such way the ~∅7mm collimated output beam was centered along the HANPO optomechanical axis. The beam resulted centered on WPs, FOS and DOV. The FM1 folding mirror has been adjusted for hitting DOV in the nominal position with the nominal ~2.6° angle. The DOV prism has been aligned for minimizing the wobbling (conical) movement of the beam during its rotation. A precise fiber alignment finally optimized this wobbling minimization and its position has been registered on the Raspberry P2 webcam as reference during on-sky source pointing.
Then, the two FM2 and FM3 folding mirrors have been adjusted to parallely bend the two beams exiting from DOV towards the corresponding L2 and L3 lenses separated 21.5mm center-to-center each other. This was obtained by autocollimation putting a flat mirror in front of FM2 and FM3 folding mirrors. L2 and L3 lenses focuses the corresponding beam on a new F/11 focal plane (the HARPS-N lens focal plane) with a 21.5mm interdistance. A CCD camera has been mounted on a micrometric translational stage for moving its sensor on such focal plane in the direction of the two focuses.
This allowed to measure the positions of the two focuses corresponding to different DOV+FOS positions in a 360° FOS rotation. In Fig,3.2 the final image is reported. The separation of the two focus pair is 21.4±0.2mm, that is, a 1arcsec error on-sky for an overall 360° FOS rotation which will be never used since scientific exposure will not last more than 30min during which the field of view rotates by 15° in the most critical altazimuth setup. The residual wobbling (~∅30arcsec for 360° FOS rotation) of each beam (corresponding to the circle of dots in the Fig. 3.2) is also not critical since the T/T system inside the FEU freeze the beam on to fiber A and consequently on the other one B.

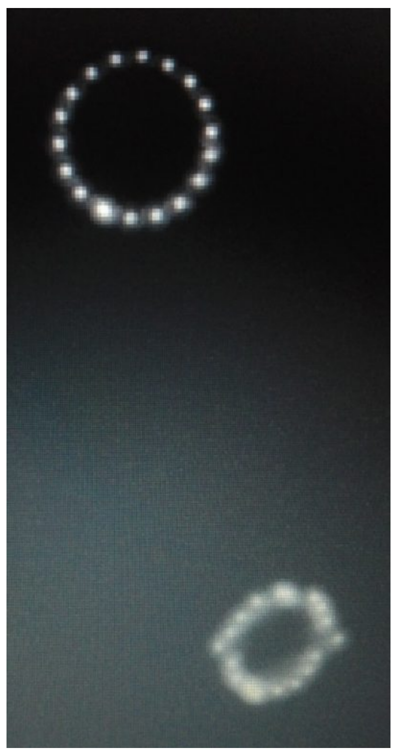

Figure 3.2 : The focuses of the two beams move during the DOV+FOS rotation.

4. AT THE TELESCOPE

HANPO has been successfully tested at the telescope by observing the well known magnetic star HD201601 that, for very long, more than 70 years, rotational period, is commonly used as a standard star [3], [4]. Figure 4.1 shows the perfect match, within the photon noise, between HANPO and HARPS circular spectropolarimetry of the FeI 5044.18 A line.

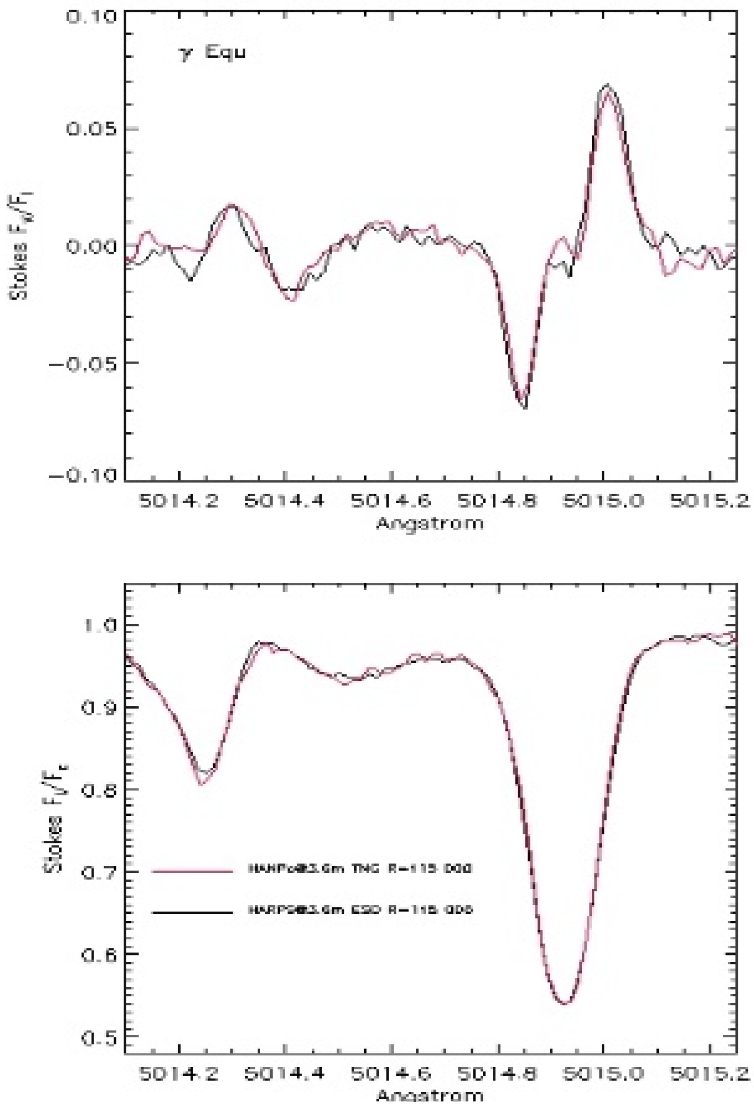

Figure 4.1 : First HANPO on-sky measurements.

5. THE GRAPHICAL USER INTERFACE

To provide a mechanism of interoperability between the polarimeter hardware and the rest of HARPS-N software we have developed a Java-based service. This software has been developed under JavaEE specification using Glassfish

Open Source Application Server, and a custom JSON[1] API that allows querying the telemetry of the axes, sending commands to the motors and controlling the polarimeter tracking loop. All the system configuration is stored in a file, which is loaded each time the service starts, allowing to make permanent changes easily.

Furthermore we also have developed a web interface for tests and maintenance operations using the polarimeter service. This interface has been built up using JavaScript and React[2], allowing its use for almost any modern devices which have a web browser.

REFERENCES

[1] Leone, F.,Cecconi, M., Cosentino, R., Ghedina, A., Giarrusso, M., Gonzalez, M., Lorenzi, V., Munari, M., Perez Ventura, H., Riverol, L., San Juan, J.,Scuderi, S., 2014, SPIE 9147, 2

[2] Leone F., Bruno P., Calì A., Cosentino R., Gentile, G., Gratton, R., Scuderi, S., SPIE 2003, 4843, 465

[3] Leone F. 2007, MNRAS 382, 1690

[4] Leone F., Vacca W.D., Stift M.J. 2003, A&A 409, 1055

[1] JavaScript Object Notation is a lightweight data-interchange format based on a subset of the JavaScript Programming Language, Standard ECMA-262 3rd Edition - December 1999.

[2] A Javascript Library for building user interfaces. https://facebook.github.io/react/