Extinction, Seeing and Sky Transparency Monitoring at the Observatorio Astrofísico de Javalambre for J-PAS and J-PLUS calibration and scheduling

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The Javalambre-Physics of the Accelerating Universe Astrophysical Survey (J-PAS) (see Benítez et al. 2014) and the Javalambre-Photometric Local Universe Survey (J-PLUS) will be conducted at the brand-new Observatorio de Astrofísica de Javalambre (OAJ) in Teruel, Spain. J-PLUS is going to start by the end of the summer of 2014 while J-PAS first light is expected to happen along 2015. Besides the two main telescopes (with 2.5m and 80cm apertures), several smaller-sized facilities are present at the OAJ devoted to site characterization and supporting measurements to be used to calibrate the J-PAS and J-PLUS photometry and to feed up the OAJ's Sequencer with input parameters, in particular: the integrated seeing and the sky transparency. The instruments in charge of these measurements are three: an extinction monitor: an 11" telescope estimating the atmospheric extinction at a set of ten selected bands in order to trace the Observatory's extinction curve, which is the initial step to J-PAS overall photometric calibration procedure; an 8" telescope implementing the Differential Image Motion Monitor (DIMM) technique to obtain the integrated seeing; and an All-Sky Transmission MONitor (ASTMON), a roughly all-sky instrument providing the sky transparency as well as sky brightness and the atmospheric extinction too. The main technical features of these instruments, their performance, their up-to-date results and their importance in the context of J-PAS, J-PLUS and the general operation of the Observatory are addressed here.

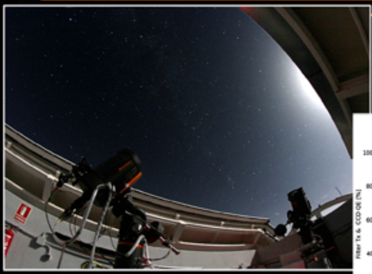


Fig 1: "Inside the Monitor's building during a moonlit night. The telescope on the right is the current extinction monitor: EXCALIBUR while the one in the left is the DIMM, the seeing monitor.

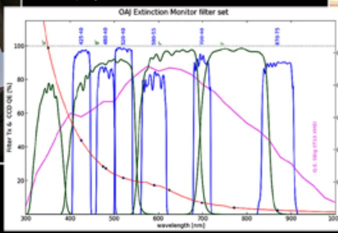


Fig 2: Extinction monitor filter set. Transmission curves of the six narrow-band and the four broad-band filters of the atmospheric extinction monitor. The current CCD's quantum efficiency curve is also represented in pink. Each filter's central wavelength is represented by a filled circle on an example of an extinction curve (in red) to illustrate the sampling of this curve.

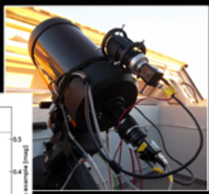


Fig 3. The seeing monitor.

There are plans to move it to the top of a specific tower that will be build very soon to meet the standards of this type of observation, i.e. to measure a few meters below the ground level to get rid of the main contribution of the surface layer turbulence.

Fig 4. The OAJ's Automatic Weather Station (AWS).

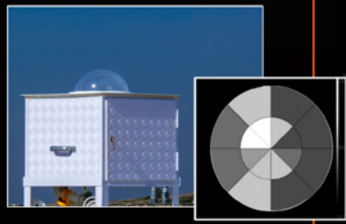


Fig 5. The ASTMON instrument (left picture) and a sample cloud coverage map (right diagram). This is the type of diagrams provided by ASTMON. The gray scale relies on the degree of cloud coverage: white areas means 100% covered while black ones indicates a cloud-free region (taken from Aceituno et al. 2011).

Atmospheric extinction monitor EXCALIBUR

The extinction monitor is aimed to measure the atmospheric extinctionat different spectral bands in order to fit the extinction curve above the Observatory as a first and necessary step to calibrate J-PAS and J-PLUS observations obtained with the two main telescopes. In this sense, itsperformance is key for the surveys' calibration. Currently, this OAJ's system is the EXtinction CAmera and LIght BackgroUnd Register (EXCALIBUR) (see Fig 1), developed by CEFCA and iTec Astronómica. It consists of a Celestron C11 telescope on top of a CGE Pro equatorial mount and with a focuser and a SBig ST10-XMEI camera attached to it. The filter set used was carefully selected to sample the extinction curve in the optical range: from 300nm y 925nm. It includes four broad band (u', g', r' and i') and six narrow-band (with widths from 40nm to 75nm) filters (see Fig 2).

Seeing monitor DIMM

The integrated seeing is monitored by a 8-inches Celestron telescope (see Fig 3) implementing the Differential Image Motion Monitor (DIMM) technique. The statistics of the relative positions of two images of the same star produced by a 2-holes Hartmann mask, one of which holding an optical wedge deflecting the light towards the detector, are measured along the longitudinal direction defined by the two subapertures and the transverse one. The variances of these distances are directly related to the integrated seeing (see e.g. Sarazin & Roddier, 1990, Tokovinin, 2002). In order to measure these quantities very fast and short exposure times have to be adopted; typically, a few hundred images with exposure times of 10ms or less are taken (200 images and 8ms in our particular case).

Sky transparency monitor ASTMON

The All-Sky Transmission Monitor (ASTMON) (Aceituno et al. 2011) is a robotic instrument monitoring most of the night sky. It c onsists of a fixed camera pointing towards the zenith (see Fig 5) and acquiring images regularly. There are several outcomes of these observations: an estimation of the atmospheric extinction coefficients at the wavelengths of its set of filters (Johnson's B, V, R and I), the sky brightness and the cloud coverage (see the diagram in Fig 5). This information by itself is valuable at any observatory but, in particular, some pieces of information are specifically used to feed the observations Scheduler.

OAJ's atmospheric extinction

The extinction monitoring is the starting point of the photometric calibration of J-PLUS and J-PAS. The fitted coefficients at the different spectral bands are used to fit the atmospheric extinction curve above the OAJ with a three-components model: Rayleigh scattering, Ozone absorption and aerosols' scattering. The inclusion of this telescope prevents the JAST/T80 from losing the observing time required to make pointings at different airmasses, and so, accelerating the execution of the J-PLUS. Results for the Javalambre Observatory are shown in Fig 6 compared with published average curves at Paranal and San Pedro Mártir Observatories. This curve allows the determination of the extinction coefficients associated to the specific bands of J-PLUS and J-PAS filters that, in the case of the JAST/T80, are then employed to obtain the corresponding photometric zero points by means of observation of spectrophotometric stars. The main goals of the JAST/T80 is the establishment of secondary standard stars for the final photometric calibration of J-PAS (see Varela et al. 2013 for details).

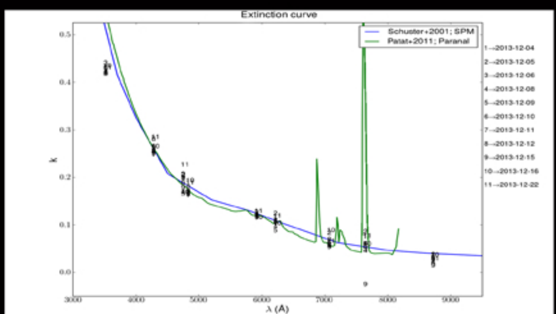
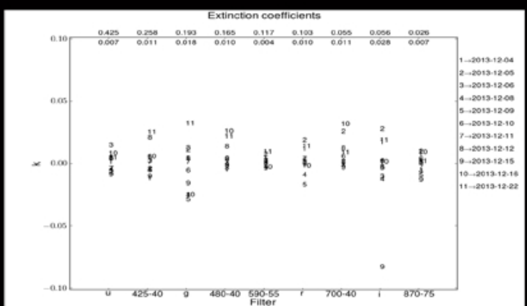


Fig 6: Results from a sample of nights. The numbers are placed on the obtained extinction coefficients from the extinction monitor data during the indicated nights. These values are compared to published extinction curves (top panel) from Paranal (Patat et al. 2011) and San Pedro Mártir (Schuster et al., 2001); the later from spectroscopic data. The fitted coefficients and their dispersions are shown in



The Scheduler and the Sequencer

The way the observations will be organized at the OAJ is determined by the Scheduler and the Sequencer (see Fig 7). Given the active main scientific programs (in the forthcoming few years, J-PLUS and J-PAS), the alternative ones and other specific observations, the selection of the most optimal pointing to be executed is entrusted to this piece of software (see Ederoclite et al., 2012). In order to take the decision, many parameters have to be taken into account to conform a Figure of Merit (FoM). Some of them have nothing to do with the weather and the atmospheric conditions; i.e. the programs' targets, the observable fields in the current epoch and the degree of completion of those fields within those programs. But others are directly concerned to the particular conditions of the night: weather parameters such as wind speed and direction (provided by the automatic weather stations), but also the cloud coverage, the sky brightness and the integrated seeing are needed (see Fig 8). The last are monitored by the instruments described here.

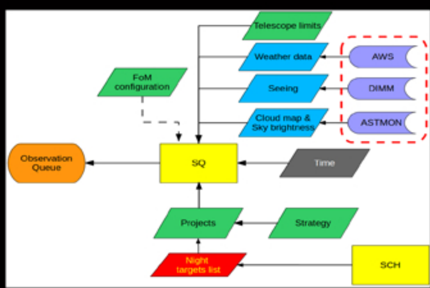
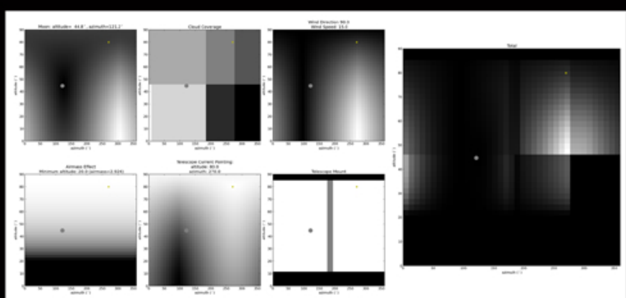


Fig 7: The Sequencer.

This diagram shows the Sequencer's data flow (including the inputs coming from the Scheduler). The data provided by the Monitors and the AWS are encircled with a red dashed line. The output of the Sequencer is the final observation queue.

Fig 8. Inputs for the FoM function.

Each panel contributes to the FoM that is used to decide the next pointing. The star symbol is the current pointing, while the gray circle is the Moon position. Dark regions indicate low preference for the next pointing and the opposite stands for the light ones. From top left to bottom right (left small panels): Moon's position, cloud coverage, wind direction and speed (with moderate wind speeds the azimuth of the dome is relevant), airmass, distance to current pointing and telescope mount's limits. The resulting function for the next pointing is shown in the large right panel



The information provided by ASTMON regarding cloud coverage and sky brigthness are the two paramters managed by the Sequencer to take decisions. In particular, at a given night, the figure of merit (FoM) built to choose the next telescope pointing shall contain the ASTMON output. At the same price, this instrument also provides a rough estimation of the extinction at the wavelengths associated to its filters (Johnson- like B, G, R and I).

The seeing is also an important input parameter of the Sequencer. It determines whether the main scientific program can be executed or a less demanding one, in terms of atmospheric turbulence, has to be addressed. Its value may also grant priority to several filters at th e expense of others: under good seeing conditions the broad-band filters (in particular, the r' filter, the one used as the reference for the dual image mode aimed to sources detection and also for weak lensing measurements), increase their priority.

Acknowledgements

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