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Commissioning and Science Verification of JAST/T80

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Abstract

Located at the Observatorio Astrofísico de Javalambre, the "Javalambre Auxiliary Survey Telescope" is an 80cm telescope with a unvignetted 2 square degrees field of view. The telescope is equipped with T80Cam, a camera with a large format CCD and two filter wheels which can host, at any given time, 12 filters. The telescope has been designed to provide optical quality all across the field of view, which is achieved with a field corrector. In this talk, I will review the commissioning of the telescope. The optical performance in the centre of the field of view has been tested with lucky imaging technique, providing a telescope PSF of 0.4; which is close to the one expected from theory. Most importantly, we present the preliminary results of science verification observations which combine the two main characteristics of this telescope: the large field of view and the special filter set.

1 Introduction

The Observatorio Astrofísico de Javalambre (OAJ) is a new astronomical facility located in the province of Teruel, in the south of Aragón, in mainland Spain. The OAJ is equipped with a two main telescopes, the Javalambre Auxiliary Survey Telescope (JAST/T80) and the Javalambre Survey Telescope (JST/T250). The latter is going to be equipped with JPCam, a panoramic camera with 14 large format CCDs, described in [5].

When fully operational, the OAJ will produce 1.5TB of data each night. The data are transferred from the observatory to Teruel and reduced by the "Unidad de Procesado y Archivo de Datos" (UPAD). A light version of the pipeline is constantly running at the observatory and used for the assessment of the data in almost real time. For a review on the UPAD, see [3].

Figure 1: A picture of JAST/T80 with the dome open. The secondary mirror (on top) and the intermediate baffle are clearly seen. T80Cam, at the Cassegrain focus, is also seen. Out of the dome, JST/T250, the main telescope of the OAJ.

2 The JAST/T80

The Javalambre Auxiliary Survey Telescope (JAST/T80) is a telescope designed to perform the photometric calibration for the main telescope of the OAJ, the Javalambre Survey Telescope (JST/T250). The JAST/T80 is a Ritchey-Chrétien telescope, with a primary mirror of 83cm. The focal length is 3712mm, corresponding to an f-number of 4.5. In order to overcome the field curvature which is intrinsic to its optical design, the optical system of the telescope contains a field corrector, made of 3 spherical lenses of fused silica. The pointing of the telescope has an accuracy of 0.3" (r.m.s.). Using a typical image, the absolute astrometry has an r.m.s. of 0.2", while the relative astrometry has an r.m.s. of 0.02".

In order to evaluate the goodness of the optical system of JAST/T80, we took advantage of the possibility to place at the focal plane, for a short time, a Prosilica high-speed camera which we used to perform "lucky imaging". This is a technique in which only a fraction of the images are stored and combined in order to obtain the best psf possible. Fig.2 shows that the psf of the telescope is of 0.46" (in agreement with Zemax simulations).

The focal plane of JAST/T80 is occupied by T80Cam, a wide field camera equipped with a 9k$\times$9k CCD manufactured by e2v and which was the prototype for the detectors of JPCam (see [5]). The pixel scale is 0.55", which corresponds to a field of view of about 2 sq.deg. (this is enough to observe M31 or M33 in a single exposure as shown in [4] and [7]).

T80Cam is equipped with two filter wheels which can host up to 12 filters at any given moment. The standard filter configuration is the J-PLUS filter set (see Fig.**??**) but visitor filters can be installed provided a previous agreement with the OAJ team has been reached (e.g. the GALANTE project).

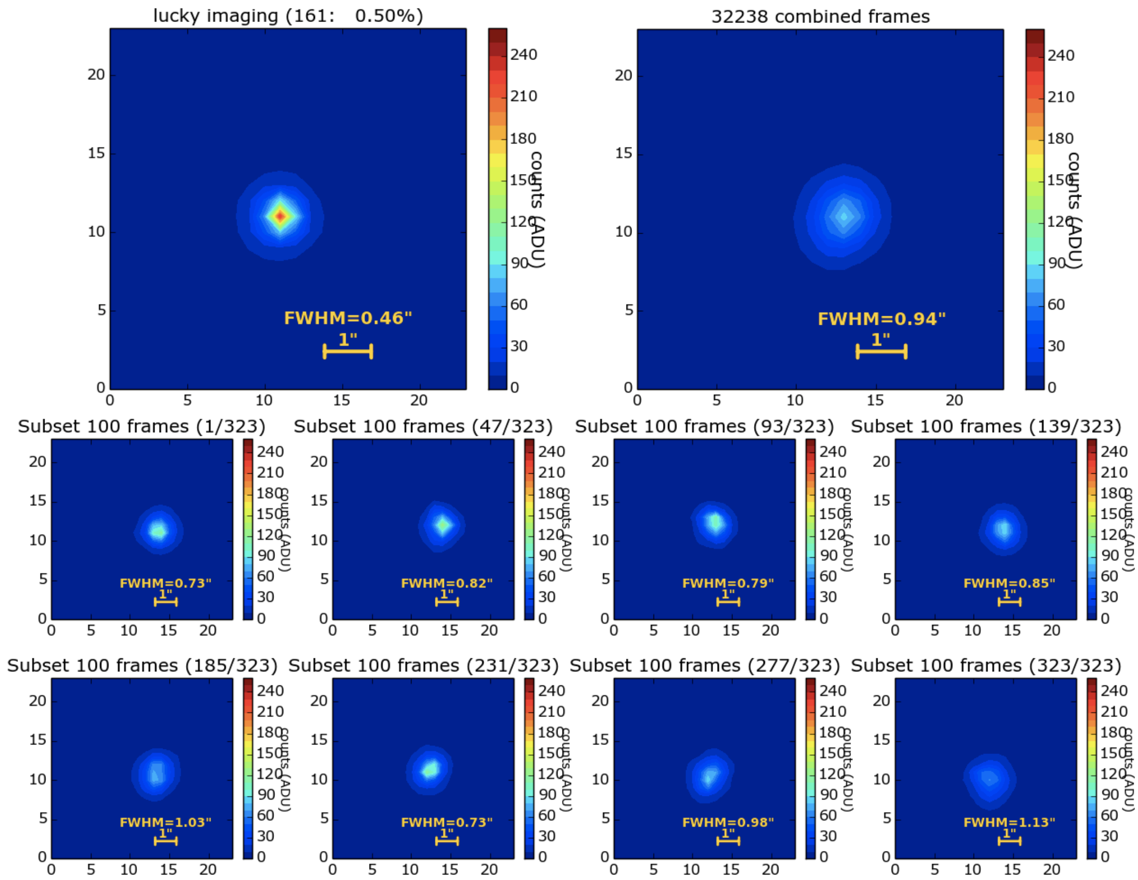

Figure 2: The result of the lucky imaging experiment on JAST/T80. One can see that, saving only the 0.5% of images (upper left panel), we can get a psf of 0.46", which is in agreement with the optical design of the telescope. The upper right panel shows how the image looks when all the frames are combined (psf = 0.94"). The other panels show how the psf varies along the test if one simply co-adds the exposures.

One of the main challenges of a telescope with such a wide field is flat-fielding. A significant effort was put in identifying a good sky position with respect to the sunset/sunrise to get the most uniform illumination as possible. In particular, it is operationally very expensive to take test exposures to obtain good illumination levels, hence we devised a different strategy to compute the exposure times of flat field images. All the observations are stored in a database which, among other things, also stores the background level. Hence, we can compute the counts which have been obtained in a given filter with a given exposure time in a given moment with respect to the twilight and this allows us to predict the exposure times which will be required on following nights. With a goal of ~30,000 counts, this method has an accuracy of ~1,000 counts.

On top of the flat field, we need to correct for illumination present when those cal-

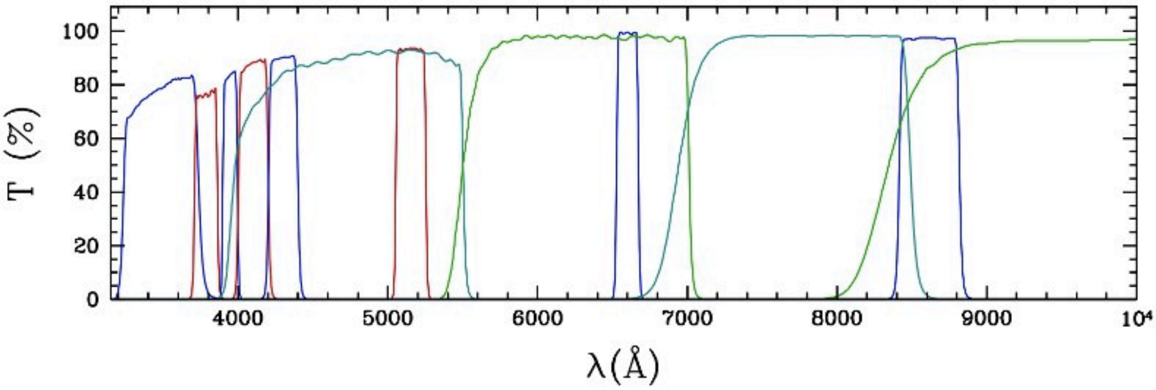

Figure 3: Response curves of the J-PLUS filters, from https://oaj.cefca.es/telescopes/t80cam.

ibration images were taken. This is done by observing a relatively dense stellar field in a short time, so that the transparency conditions remain stable enough, in dark stable nights and moving the field across the FoV in a cross-shaped pattern. A comparison with other surveys (like SDSS or APASS), shows that the dispersion of the obtained zero points within the image is reduced by up to a 50%, wiping out most of the 2D magnitude bias structure observed in uncorrected images.

It is worth mentioning that we could perform an analysis of the background of each image in each filter with respect to the distance and the phase of the Moon. An example of this for the rSDSS filter is shown in Fig.4. These values were used to improve the Exposure Time Calculator [1] with empirical and realistic sky backgrounds.

3 The Science Verification

In March 2015, a call for Science Verification proposals was issued to the J-PAS collaboration. Thirty proposals were received, half of them aimed at galaxy evolution studies. Two proposals were focused on cosmology, one on Solar System objects and the rest split between Milky Way studies or stellar physics. At the moment of writing this paper, 28 projects have been (at least partially) observed and data have been delivered.

Interestingly, two thirds of the projects asked for grey or dark time and all (but three) projects required a seeing better than 1.2 arcsec. Moreover, all (but three) projects asked for cloud-less sky (in fact, half of the projects asked for photometric conditions).

Most projects have been aimed at the observation of known objects to test the possibilities of the J-PLUS filter set. In particular, [6] showed that, using the 12 filters of J-PLUS, photometric redshifts can reach an accuracy of 4% at magnitude ∼20, while [1] showed that the unique filter set of J-PLUS is ideal to recover cataclysmic variables.

The operational effort to observe the Science Verification projects has provided the

[1] http://www.cefca.es/jplusetc/

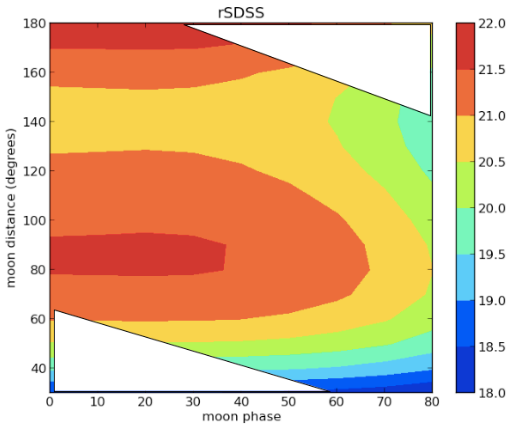

Figure 4: The sky background due to the lunar distance and phase. Meaningless regions have been masked out. It is worth noting that, even with a lunar illumination of 50%, it is possible to observe with a sky background comparable to new Moon if only one selects fields at a good distance.

expertise and the tools to be able to perform “Open Time” observations (see Sec.5).

4 Javalambre Photometric Local Universe Survey (J-PLUS)

Covering about 8,500 sq.deg., the Javalambre Photometric Local Universe Survey (J-PLUS) is the project aimed at the scientific exploitation of observations aimed at the photometric calibration of J-PAS. (see [2] and references therein). About 90 sq.deg. have already been observed and a paper introducing the survey is in preparation [2].

5 Open time

Since October 2014, the OAJ is a Spanish “Instalación Científico Técnica Singular”. For this, the OAJ is committed to offer to the astronomical community 20% of its observing time. So far two calls for proposals have been issued (semesters 2016B and 2017A). So far, JAST/T80 is the only telescope offered in the call for proposals. Three types of proposals can be submitted:

- Regular Programs (RPs) are only awarded time for a semester and they have available a total of 120 h
- Large Programs (LPs) are programs spanning more than a semester. They can last a minimum of 48 h per semester and they are allowed a maximum of 148 h.
- Director Discretionary Time (DDT)

During 2016B, the OAJ received proposals for $\sim$40 h of DDT (executed for 80%). In 2016B, 9 RPs and 1 LP have been received, while in 2017A, 12 RPs and 3LPs were awarded time. Given the characteristics of the instrumentation offered at OAJ, there is a high pressure on dark time (in 2017A the oversubscription rate of dark time only was $\sim$3) and clear/photometric conditions..

6 Summary

We have presented the commissioning and first science with JAST/T80 at the OAJ. The telescope has a psf of 0.46" and good care is placed in all the calibration process (in particular, flat fielding). Science Verification programs have been successfully observed and some papers are in preparation. Likewise, the main project related with the telescope (J-PLUS) has been started. Finally, since July 1, 2016, the telescope is performing observations for the community and proposals can be submitted by Mar 15 (semesters "B") and Sep 15 (semesters "A") each year.

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