Photometric calibration of the J-PLUS and J-PAS surveys

J. Varela (CEFCA), N. Gruel (CEFCA), D. Cristóbal-Hornillos (CEFCA), M. Moles (CEFCA, IAA-CSIC), M.C.Díaz-Martín (CEFCA), J.L. Lamadrid (CEFCA)
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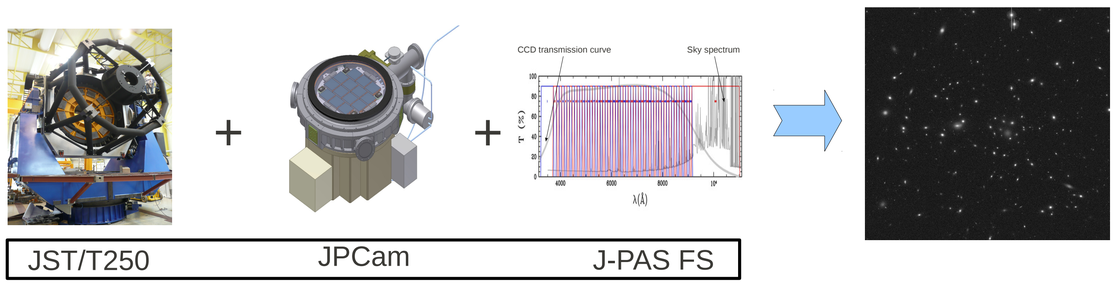
Abstract

The Observatorio Astrofísico de Javalambre (OAJ, Teruel) will be the location of a large étendue 255cm telescope (JST/T250) that will carry out a multiband (57 filters) 8000 deg^2 sky survey: The Javalambre PAU-Astrophysical Survey (J-PAS). To maximize the time on target of the telescope, a preliminary survey (J-PLUS) will be carried out with an auxiliary 83cm telescope (JAST/T80) that will image the same area beforehand in 12 filters. In addition, atmospheric extinction will be measured with a dedicated extinction monitor (EXCALIBUR). This poster outline the procedure designed to calibrate the exposures of J-PAS to achieve the required photometric accuracy (<2%) needed to obtain precise photometric redshifts of millions of galaxies with the scientific goal of measuring the Acoustic Baryonic Oscillations.

Introduction

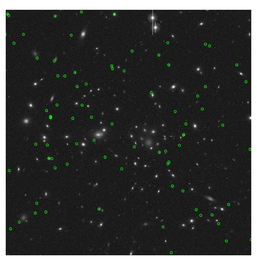
The Javalambre PAU-Astrophysical Survey (J-PAS, j-pas.org) will be an 8000 deg^2 sky survey in 54 narrow + 2 medium + 1 broad band filters. The main scientific goal is to measure the Baryonic Acoustic Oscillations measuring positions and photometric redshifts of several millions of galaxies with a precision better than 0.005 (1+z). The survey will be carried out with a large étendue 2.55m telescope (T250/JST), a panoramic camera with 14 CCDs (JPCam) and a special set of 57 filters designed to optimize the determination of photometric redshifts. The photometric calibration of the images will be done using an auxiliary 83cm telescope (JAST/T80), a wide field camera (T80Cam) and a set of 12 filters. The JAST/T80 will observe the same area of the sky beforehand in the Javalambre Photometric Local Universe Survey (J-PLUS), whose data will be used to calibrate the images taken with the JPCam@T250/JST as well as to carry out analysis of the local universe. To maximize the time on target of both telescopes, the computation of the atmospheric extinction will be done using an on-purpose extinction monitor called EXCALIBUR. The goal of the photometric calibration is to achieve a photometric accuracy better than 2%.

In the near future, JPCam@T250/JST will observe a given field



JST/T250 JPCam J-PAS FS

Secondary standard stars are identified in each CCD of the JPCam. Comparison between observed magnitudes and synthetic ones will produce the photometric zero points to be used with all the objects in the same exposure.

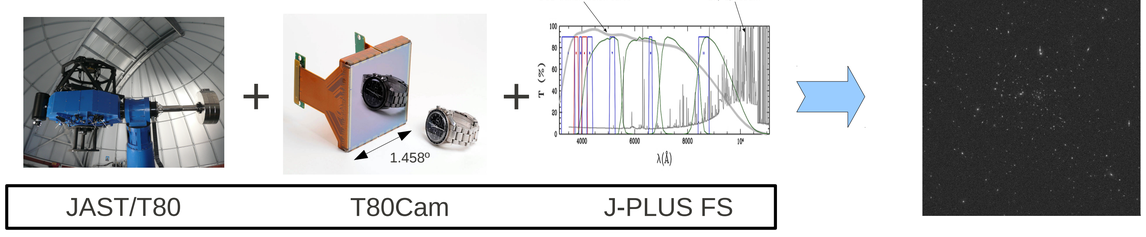


$$ZP_{\lambda;exp} = \langle m_{synth}^{SSS} - m_{instr}^{SSS} \rangle$$

$$m_{cal}^{Obj} = m_{instr}^{Obj} + ZP_{\lambda;exp}$$

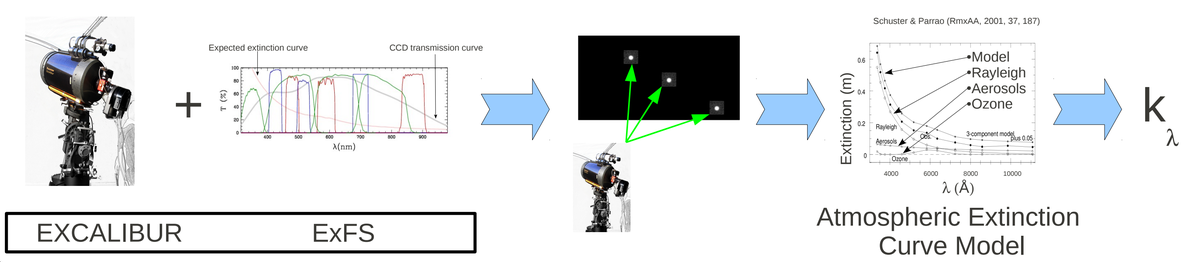
However, the calibration started a night several months before ....

T80Cam@JAST/T80 has observed the same field



JAST/T80 T80Cam J-PLUS FS

EXCALIBUR has been observing standard stars at different airmasses.
A model of atmospheric extinction of 3-components is fitted.
Then, extinction coefficients in any band (k_λ) can be computed.

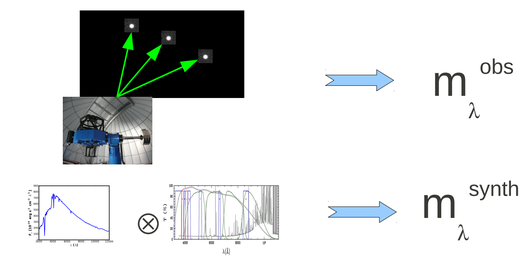


EXCALIBUR ExFS

Atmospheric Extinction Curve Model

k_λ

T80Cam@JAST/T80 has observed spectrophotometric stars.
Then, photometric zero points can be computed



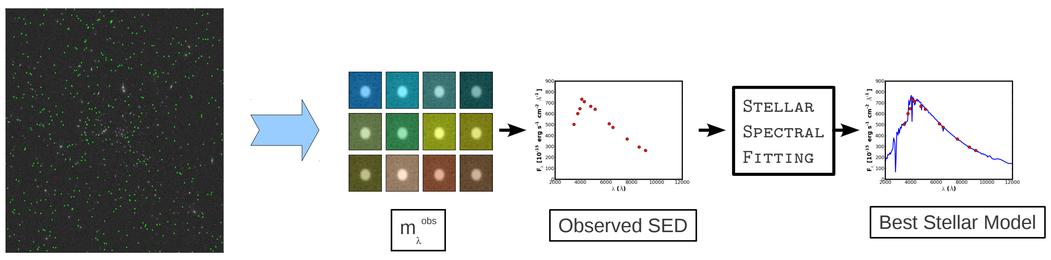
$$m_\lambda^{obs} - x\,k_\lambda$$

$$m_\lambda^{synth}$$

$$ZP_\lambda = m_\lambda^{synth} - (m_\lambda^{obs} - x\,k_\lambda)$$

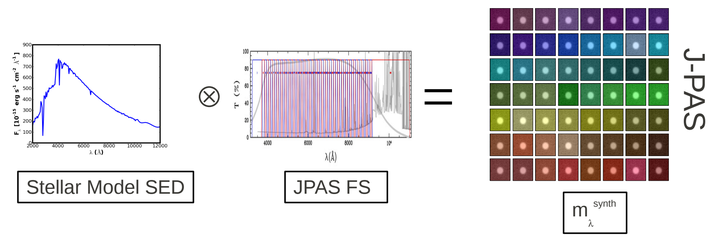
Stellar SED J-PLUS FS

On the calibrated field, stars with SNR>50 are selected and stellar spectral models are fitted.
These are identified as Secondary Standard Stars (SSS).



m_λ^{obs} Observed SED Best Stellar Model

The synthetic magnitudes of the SSS in the J-PAS filter system are computed



Stellar Model SED JPAS FS m_λ^{synth}

To dive into the details

- **Extinction computation**
  The atmospheric extinction is computed using an extinction monitor called EXCALIBUR. EXCALIBUR is a 25cm telescope that will observe stars at different airmasses during every night in 10 different filters. This will allow to compute the atmospheric extinction coefficients in 10 wavelengths which will be fitted to a model of atmospheric extinction of 3 components: Rayleigh scattering, ozone absorption and aerosol scattering.

- **J-PLUS Zero points computation**
  The photometric zero points of the J-PLUS system will be computed observing spectrophotometric stars several times every night. After correcting for atmospheric extinction with the data from EXCALIBUR and comparing with synthetic magnitudes in the J-PLUS filter system, we will be able to measure the photometric zero points in the 12 filters of the J-PLUS system.

- **Stellar fitting of the Secondary Standard Stars**
  Given the uniqueness of the J-PAS filters, we need to compute synthetically the magnitudes of the secondary standard stars in that system. To do so, first of all, the J-PLUS photometry of these stars is fitted with stellar spectral models. It has been shown with simulations, using high resolution flux calibrated synthetic star templates from the library by Coelho *et al.* (2005, A&A, 443,735), that for stars with SNR>50 in the 12 J-PLUS filters it is possible to recover the stellar parameters with enough accuracy in >90% of the cases. Finally, the best stellar spectral model found for each star will be convolved with the J-PAS filters+CCDs transmission curves to obtain the synthetic magnitudes in the J-PAS bands. These synthetic magnitudes will be used to calibrate the J-PAS exposures.

- **Availability of Secondary Standard Stars**
  Exposure times of J-PLUS observations have been chosen to have a least 50 stars with SNR>50 in the 12 J-PLUS filters within an area equivalent to one CCD of the JPCam. This will ensure that we will have enough SSS to perform the calibration of any exposure of the J-PAS survey.

- **Übercalibration**
  Once the J-PAS survey is finished, an improved internal calibration will be done using fields observed more than once, following the technique of Padmanabhan *et al.* (2008, ApJ, 674,1217).

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What is ...?

J-PAS: Javalambre PAU-Astrophysical Survey (8000 deg^2 survey in 57 filters)
JST/T250: Javalambre Survey Telescope (255cm; 3 deg FoV)
JPCam: Javalambre Panoramic Camera (14 CCDs, 9.2k x 9.2x, 0.23"/pixel)
J-PAS FS: J-PAS Filter System (54 narrow + 2 medium + 1 broad band filters)
J-PLUS: Javalambre Photometric Local Universe Survey (8000 deg^2 survey in 12 filters)
JAST/T80: Javalambre Auxiliary Survey Telescope (82cm, 2 deg FoV)
T80Cam: T80 Camera (1 CCD, 10.5k x 10.5k, 0.5"/pixel)
J-PLUS FS: J-PLUS Filter System (12 filters)
EXCALIBUR: EXtinction CAmera and LumInance BackgroUnd Register (25cm telescope)
ExFS: EXCALIBUR Filter System (10 filters)