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Dissecting quasars with the J-PAS narrow-band photometric survey

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Abstract. The J-PAS survey will soon start observing thousands of square degrees of the Northern Sky with its unique set of 56 narrow band filters covering the entire optical wavelength range, providing, effectively, a low resolution spectra for every object detected. Active galaxies and quasars, thanks to their strong emission lines, can be easily identified and characterized with J-PAS data. A variety of studies can be performed, from IFU-like analysis of local AGN, to clustering of high-z quasars. We also expect to be able to extract intrinsic physical quasar properties from the J-PAS pseudo-spectra, including continuum slope and emission line luminosities. Here we show the first attempts of using the QSFit software package to derive the properties for 22 quasars at $0.8 < z < 2$ observed by the miniJPAS survey, the first deg^2 of J-PAS data obtained with an interim camera. Results are compared with the ones obtained by applying the same software to SDSS quasar spectra.

Keywords. quasars: general, quasars: emission lines, galaxies: nuclei, galaxies: active, surveys, techniques: photometric

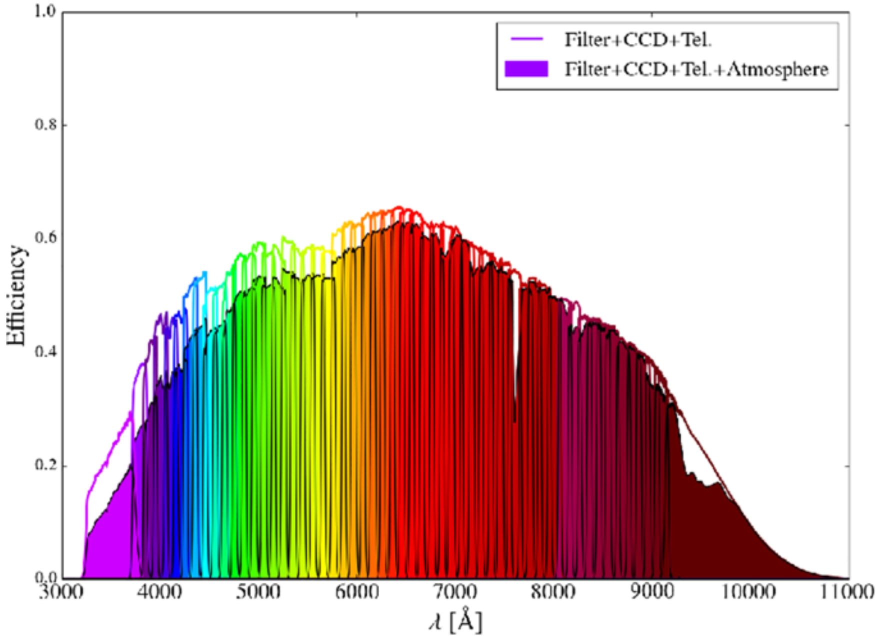

Figure 1. The measured transmission curves for the J-PAS filter set before and after accounting for sky absorption. Effects of the CCD quantum efficiency and the entire optical system of the JST/T250 telescope are included.

1. Introduction: the J-PAS survey

The Javalambre Physics of the Accelerating Universe Astrophysical Survey (J-PAS) is an ambitious photometric survey which will observe thousands of square degrees of the northern sky starting in mid-2020 Benítez *et al.* (2014). The novelty of the survey is in its filter system: 54 narrow band (FWHM$\sim$ 145$\AA$) covering from $\sim$3800$\AA$ to $\sim$9000$\AA$ and two medium bands extending to $\sim$3000$\AA$ in the blue side and to $\sim$10,000$\AA$ in the red side of the spectrum (see Figure 1).

The survey will be carried out from a new wide field-of-view telescope, the “JST/T250”, the largest telescope of the OAJ† observatory (Moles *et al.* 2010; Cenarro *et al.* 2014), located in continental Spain. Once equipped with the JPCam camera (1.2 Gpixel, 0.23″/pixel), the telescope will start observing 14 filters at the same time, covering a total of 4.2 deg^2/pointing Marín-Franch *et al.* (2017).

The unique filter system of J-PAS will effectively produce a low-resolution spectrum for every object observed, allowing to perform a wide variety of scientific projects, from Milky Way stellar population to galaxy evolution studies. The exquisite, sub percent, photometric redshifts Benítez *et al.* (2009) will also allow to perform cosmological experiments, from a precise mapping of the cosmic structure to galaxy clusters detection down to group masses.

Before JPCam is being installed on the telescope, the JST/T250 has been equipped with the *Pathfinder* camera, a single-CCD, 9.2k × 9.2k pixel camera with an effective field of view of 0.27 deg^2. The *Pathfinder* camera has been used to perform the commissioning of the JPCam Actuator System and to start the scientific operation of the JST/T250. In particular, it carried out the JPAS-*Pathfinder* survey, also called

† http://www.oaj.cefca.es

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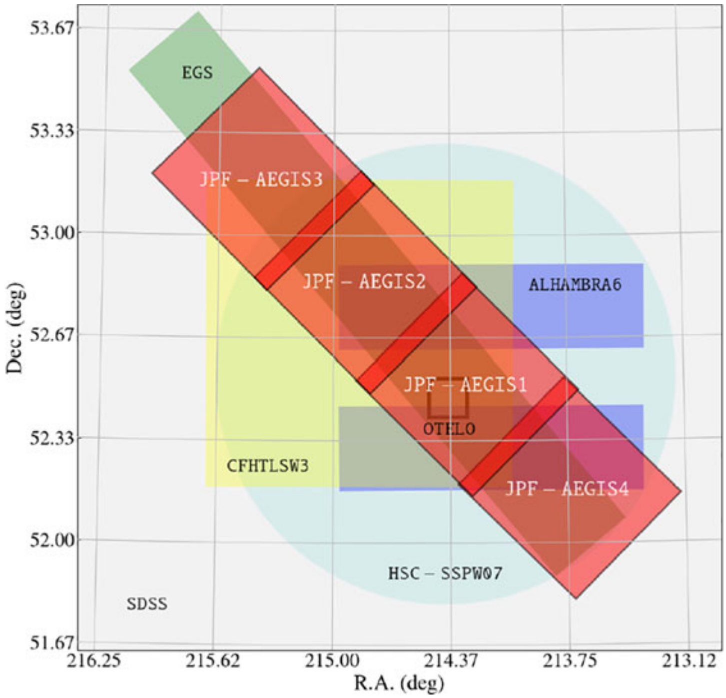

Figure 2. Footprint of the miniJPAS field, with individual pointings shown as red squares. The footprints of other projects are also shown.

"miniJPAS", a 1 deg^2 along the Extended Gorth Strip observed to full depth† with all J-PAS filters (see the footprint in Figure 2. The miniJPAS data have been recently made public to the whole astrophysical community (http://www.j-pas.org/datareleases/minijpas_public_data_release_pdr201912) and are been used to test the capabilities of J-PAS data (Bonoli *et al.*, in prep).

2. AGN and Quasar studies with the J-PAS narrow bands

The narrow bands of the J-PAS filter system make J-PAS data particularly suited to study and characterize emission line objects, active galaxies with broad emission lines in particular. In Figure 3 we show two quasars observed in miniJPAS, with the photometric data (red points) compared to the SDSS spectroscopic data (gray line).

It is clear visually how the strong emission features typical of quasars can be properly identified in the J-PAS pseudo-spectra. Indeed, quasars can be identified and their photo-z estimated to sub-percent precision (Bonoli *et al.*, in prep.).

To test the full capabilities of J-PAS data to estimate quasar spectral properties, we used the QSFit‡ software package to analyze the low-resolution miniJPAS spectra, and compare the results with the corresponding analysis carried out on SDSS data. QSFit is a software aimed to perform automatic spectral analysis of AGN optical/UV spectra Calderone *et al.* (2017), and its fitting procedure takes into account several components simultaneously, providing estimates of broad band continuum luminosities and slopes, emission lines luminosities and width, etc. In order to compare the spectral quantities measured on the J-PAS and SDSS spectra we chose to limit the analysis in the redshift range $0.8 < z < 1.2$, since in this range the several broad band components building up the

† $\mathrm{mag_{AB}}$ between 22 and 22.5 for the narrow bands (depth at 5σ in a $3''$ aperture).
‡ https://qsfit.inaf.it/

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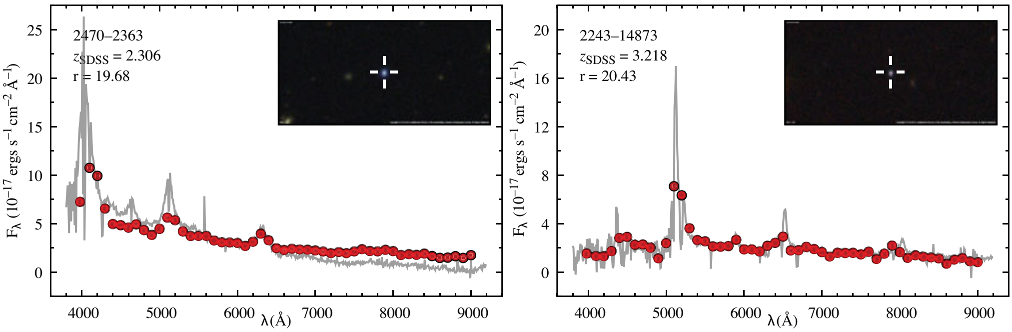

Figure 3. Two examples of SDSS quasar spectra (gray lines) as observed with miniJPAS (red points).

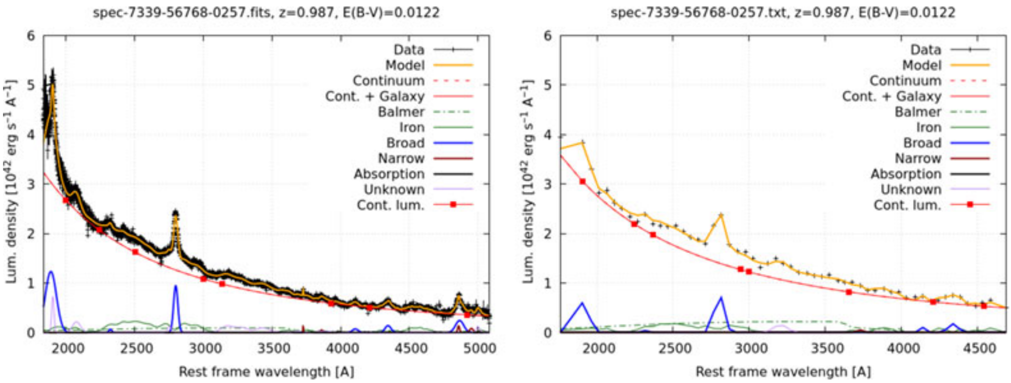

Figure 4. An example of the best fit spectral model obtained running the QSFit software on a SDSS data (left panel) and on the corresponding low-resolution miniJPAS spectrum (right panel) of a $z \sim 1$ quasar. The data (black points) and the overall model (orange lines) are shown, together with the contributions of the different components, from the continuum (dashed red lines) to the broad line components (blue lines), as reported in the legend.

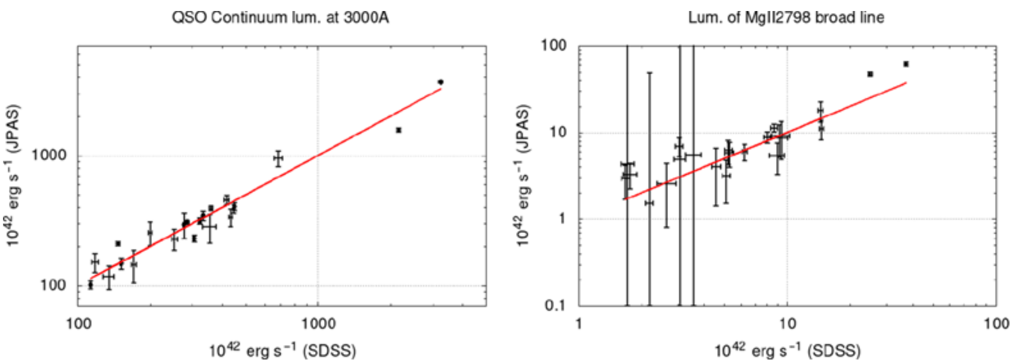

Figure 5. Comparison between the spectral quantities estimated on the SDSS spectra and on the correspoding miniJPAS pseudospectra, as obtained with the QSFit software. Left panel: QSO continuum luminosity at 3000Å. Right: integrated luminosity of the MgII emission line.

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model can be reliably constrained using just data in the optical waveband (see discussion in Calderone *et al.* (2017)). In the miniJPAS footprint there are 22 quasars in the $0.8 < z < 1.2$ range in common with SDSS (DR14Q). An example of the best fit model obtained in the two cases is shown in Figure 4.

The comparison of the spectral quantities typically shows a good agreement for quantities which do not require a high spectral resolution, such as the QSO continuum luminosity and slope, and the integrated luminosity of the broad components of emission line (Figure 5). On the other hand, the widths of broad emission line show a much larger scatter, and the narrow components can not be constrained with just the miniJPAS data. In the future we plan to extend our analysis to object at $z < 0.8$ and $z > 2$.

3. Conclusions

We ran the QSFit spectral analysis software on a small sample of 22 quasars with $0.8 < z < 1.2$ selected from the miniJPAS survey and with corresponding SDSS spectra. The comparison of the resulting spectral quantities shows a very good agreement for the quantities associated to broad band component (such as the QSO continuum) or integrated quantities (such as the luminosities of broad emission lines). While being still preliminary and based on a small number of objects, this first analysis shows the great potential of performing spectral analysis on the J-PAS photometric data. Once the J-PAS survey will start observing at full speed, we expect to scan several hundreds of deg^2/yr, thus detecting hundreds of thousands of quasars to which this spectral analysis can be performed. Although possibly inaccurate on a object-by-object basis, we expect to be able to statistically derive intrinsic physical properties of large quasar samples, spanning a wide range in redshift and luminosities. This spectral analysis, combined with environment and clustering studies, will provide important information on the redshift evolution of active galaxies.

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