Synergies between SKA and J-PAS.

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Abstract

In this contribution, we present the basic aspects of the Javalambre-Physics of the Accelerating Universe Survey, and the possible synergies that will be generated with the arrival of the Square Kilometer Array.

1 Introduction

The Javalambre-Physics of the Accelerating Universe Survey (J-PAS) is a Spanish-Brazilian cosmological survey that will be carried out from the Javalambre Astrophysical Observatory (Teruel, Spain; see Figure 1) using a purpose-built, dedicated 2.5m telescope and a 4.7\textsuperscript{\ension}, 1.2Gpix camera. Starting in 2015, J-PAS will use 59 filters to measure high precision $\sigma_z \sim 0.003(1+z)$ photometric redshifts for $\gtrsim 90$ million galaxies plus several million QSOs, i.e., about 50 times more than the largest current spectroscopic survey, and sampling an effective volume of $\sim 14$ Gpc$^3$ up to $z = 1.3$. J-PAS will not only be the first radial baryonic acoustic oscillation (BAO) experiment to reach Stage IV; it will also detect and measure the mass of $\sim 7 \times 10^5$ galaxy clusters and groups, setting constraints on Dark Energy that rival those obtained with state-of-the-art BAO measurements.

The combination of a set of 145Å medium-band filters, placed 100Å apart from each other, and a multi-degree field of view makes the J-PAS camera an extremely powerful "redshift machine", equivalent to a 4000 multiplexing spectrograph, yet many times cheaper to build. The J-PAS camera is also equivalent to a very large, 4.7\textsuperscript{\ension} "Integral Field Unit", which will produce a time-resolved, 3D image of the Northern Sky with a very wide range of scientific applications in Galaxy Evolution, Stellar Physics and the Solar System.

J-PAS will be, by construction, a Northern Hemisphere survey. This renders possible synergies with SKA apparently less important or interesting. However, both practical and
scientific considerations have guided the selection of the J-PAS footprint to include a significant area in the Southern Galactic Hemisphere, close to the celestial equator. This area coincides, for the very same practical reasons, with the region observed by the Sloan Digital Sky Survey (SDSS) that includes, for example, the well-known SDSS Stripe82 and DEEP2 fields. This area will be part of the main J-PAS survey, and has also been selected for a possible extension to deeper magnitudes. We note that JPAS will be among the deepest and widest optical surveys (see Fig. 2). Moreover, SKA will certainly be able–from both its proposed sites–to routinely observe targets with $\delta > 0$.

2 Survey design

The scientific objective driving the design of J-PAS, as presented in [1], is to measure the properties of Dark Energy through the observation of BAOs in the space distribution of Luminous Red Galaxies and other cosmological objects. The determination of the redshifts of these sources will be based on photometric methods [1], and the necessary accuracy $[\sigma_z \sim 0.003(1 + z)]$ demands the production of a purpose-built set of 56+3 filters.

J-PAS will survey two separate areas, a larger one in the Northern Galactic Hemisphere (NGH) and a smaller one in the Southern Galactic Hemisphere (SGH, see Figure 3). These areas have been defined by combining three different motivations. First, we only selected areas whose observability from Javalambre at zenith distances $< 50^\circ$ is larger than a minimum, significant number of hours (> 200) per year. Second, areas at low galactic latitudes are avoided based on the dust maps by [3]. Finally, we artificially add an extra weight to areas in the SGH to avoid possible conflicts in the transition epochs around December and June,
Figure 2: Surveyed angular area (in squared degrees) vs. apparent limiting magnitude for a number of well-known optical (both spectroscopic and photometric) surveys. JPAS will be among the deepest and widest optical surveys, reaching a limiting magnitude significantly deeper than the SLOAN DSS with their broadband filters.

When the (excluded) Milky Way is high in the sky for large fractions of the night time.

With these premises we have defined the two separate areas, which cover approximately 6500 and 2300 square degrees in the sky. These regions will be imaged through a set of 56+3 filters that encompass the whole visible range, from the UV to the NIR atmospheric cuts. The bulk of the filters (53 of them) are top-hat filters of width $\simeq 145$ Å, with central wavelengths that cover from 3900 to 9100 Å in steps of 100 Å. Two other filters cover the blue and red ends of the visible spectrum, and the final three are the regular $ugr$ from the Sloan set. Figure 4 shows the J-PAS filters together with a $z = 1$ elliptical galaxy template.

There will be at least four exposures for every point of the surveyed area with every filter, taken following a 2+1+1 strategy, with a cadence time of one month between each subset. This strategy has been chosen to maximize the detection rate of supernovae and other variable/transient effects. The total real exposure time for every pixel will be $\sim 5.0$ hours.

The focal plane of the Javalambre 2.5m telescope covers $4.7^2$, which means that the effective survey speed is $1^2/h$, and that $\simeq 9000$ hours of real observing time will be needed.
to complete the survey. Taking into account technical and instrumental overheads, visibility issues, the Moon cycle, and the local meteorology, we estimate that seven years will be necessary to complete the project, with incremental releases becoming public after year 2.

3 Data products

The main deliverable of J-PAS will be a photometric catalogue of all galactic and extragalactic sources in its $8500^{\circ}$ footprint, down to AB$\simeq 22.3$ in the narrow filters from 3500 to 7000 Å, and AB$\simeq 21.5$ in those from 7000 to 9000 Å, reaching AB$\simeq 24$ in the broad-band $gr$ filters. This shall amount to over 15 million red galaxies and 70 million emission line galaxies having redshift quality $dz/(1+z) < 0.003$, the rms accuracy target of our survey. The catalog will also include photometric information for approximately 300 million galaxies with worse photometric redshifts. It will also include and identify approximately two million quasars, reaching $g \simeq 24$ and $z \simeq 5$.

The data releases will be incremental both in terms of area and spectral coverage. The first two years of the survey (currently expected to begin in 2016) will mostly be devoted to observations with the reddest filters. This is driven by practical considerations—these filters will be the first to arrive at the telescope—as well as by scientific reasons: luminous red galaxies at moderate redshift will be targeted in a particularly efficient way with these filters, yielding some of the most exact results on dark energy parameters from the beginning of the survey.

4 Synergies with SKA

Both sites that have been accepted for the SKA telescope lie at a latitude of approximately 25° South. Depending on how relaxed the observing conditions can be acceptable, as well as on the particular instruments under consideration, this translates to a maximum reachable declination of $\approx 35°$ North. This means that most of the SGH portion of the J-PAS footprint, and a fraction of the NGH portion, will be available to SKA.

In order to feed the SKA community and the large surveys that are planned with information on J-PAS and the catalogs it will produce, these are some of the most important pieces of information:

- For the community at large, perhaps the best way to understand J-PAS will be to think of a deeper, finer-grained and close to spectroscopic version of the photometric SDSS catalogue.

- All galaxies with $L > L^*$ and $z < 1$ in the $\approx 8500^{\circ}$ covered by the survey will be fully characterized, with their redshift and spectral energy distributions accurately measured. SKA will be able to measure the neutral gas content and dynamics for large samples of this kind of objects.
Figure 3: Representation in Lambert Projection of the Northern and Southern Galactic Hemispheres. Each plot shows in pink the area with relatively high galactic extinction (as given by $E(B-V) > 0.1$ in the Schlegel et al. 1998 maps), and in white the area that is chosen when taking the best $(6000 + 2000)$ selected separately in both hemispheres. The blue line is the ecliptic. We take the areas marked in red as compactified versions of the white ones, that define the J-PAS North and South areas. They cover approximately $(6400 + 2250)^\square$. 
Synergies between the SKA and J-PAS.

Figure 4: The J-PAS filter system. We have included the redshifted spectrum of an early type galaxy at $z=1.0$ from [2]. The filters are spaced by about 100 Å but have FWHM of 145 Å, what produces a significant overlap among them. The blue squares represent the flux which would be observed through the filters. Note that many spectral features apart from the 4000 Å break are resolved, which is why the precision in redshift is much larger than that which would be produced by a single break, $\Delta z/(1+z) \simeq \Delta \lambda/\lambda \simeq 0.02$.  

![Diagram of J-PAS filter system with spectra and throughput graph](image-url)
• For galaxies in the local Universe J-PAS will offer detailed resolved colour/morphology data with resolution of $\approx 1$ arcsecond, that can be complemented with detailed measurements of the neutral gas and molecules as measured by SKA and other large facilities in the future.

• As was mentioned before, J-PAS will identify approximately 2 million quasars up to high redshifts $z \approx 5$. It will be possible to use these objects as markers for large mass overdensities at high redshift, that will be further explored with SKA. The properties of the neutral/ionised gas surrounding these targets will be of particular interest.

• The ability to cross-identify sources combining data from J-PAS and the SKA surveys will be a basic ingredient in both cases, as they will cover widely different ranges in wavelength/energy.

5 More Information

We advice those interested in the latest status of the survey to check the following sites:
- http://www.cefca.es/es/proyecto-oaj, status of the Javalambre Observatory,
- http://j-pas.org with the most up-to-date project information.

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References