CEFCA
Centro de Estudios de Física del Cosmos de Aragón

Observatorio Astrofísico de Javalambre

Scientific Requirements for the J-PAS database

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Table of Contents

1. Scope

This document summarizes the result of the interaction between the DMG and the SWG about the scientific content of the J-PAS catalogs.
This interaction was made through a small questionnaire which was submitted to the heads of the SWGs. The results were included in a proposal which was discussed in some detail during the J-PAS meeting in São Paulo (Brazil).
This document is largely based on the database which has been designed for the J-PLUS project. The extrapolation to J-PAS can be done taking into account the different number of filters.

2. Acronyms

CCD	Charge Coupling Device
DMG	Data Management Group
FWHM	Full Width at Half Maximun
J-PAS	Javalambre-PAU Astrophysical Survey
J-PLUS	Javalambre otometric Local Universe Survey
OAJ	Observatorio Astrofísico de Javalambre
PAU	Physics of the Accelerating Universe
SWG	Scientific Working Groups
TBC	To Be Confirmed
TBD	To Be Defined
UPAD	Unidad de Procesado y Archivo de Datos

3. Introduction

3.1 The J-PAS Survey

The Javalambre PAU Astrophysical Survey (hereafter, J-PAS) is a survey of 8000sq.deg. in 54 narrow band + 2 intermediate intermediate band (and three broad band) filters.
The scientific goal of J-PAS is the measurement of Baryonic Acoustic Oscillations (BAOs), which are the imprints of the physical conditions of the Universe before the reionization. Given the size and depth of J-PAS, there are several side projects which will enormously benefit from this survey.
J-PAS will be carried out with the JST/T250 telescope on the Pico del Buitre (Sierra de Javalambre), operated by the Centro de Estudios de Física del Cosmos de Aragón (CEFCA). The T250 will be equipped with a camera with 14 CCDs of 9.2k×9.2k pixels each. Each CCD receives light through a filter which is independent from the others.

3.2 The Strategy of J-PAS

In order to guarantee the best scientific outcome of J-PAS, a 2+1+1 strategy has been devised. This means that each field, in each filter, will be observed, for the first time, in two jittered positions in a night, then another (again, jittered) exposure will be obtained one month after and yet another with another month delay.
Observing with dithering is a common strategy in astronomy to overcome problems like bad pixels or cosmic ray hits. This strategy gives the possibility, among other things, to discover supernovae (SNe) which evolve on the time scale of weeks. In general, this strategy is potentially extremely good to discover variable sources of virtually any kind (with variabilities of more than 0.02 mag TBC in more than 100 sec).

3.3 Catalogs

3.3.1 The Importance of Catalogs in the Success of a Survey

In the case of large sky surveys, it is not possible to distribute the data to all the people who may be interested in the scientific output. It is therefore crucial to find a set of information which can be extracted from the data and which can be distributed to the community in the form of a catalog.
The "2 Micron All Sky Survey" (2MASS) and the "Sloan Digital Sky Survey" (SDSS) are probably two of the most successful surveys of the last decades and most of their success is due to the wide use of their catalogs which are easy to use and easy to access.

SDSS is probably one of the most successful projects of the history of astronomy. Its legacy goes from the definition of a new standard of broad band filters, to the study of the structure of the Milky Way and the large scale structure of the Universe. SDSS has had, so far, 8 data releases. The project has both a photometric and a spectroscopic part and it is now in its third phase where it has been split in four sub-projects. The Photometric Catalog of DR8 contains 469,053,874 primary sources, plus 324,960,076 secondary sources. For each source, the catalog lists if the source is primary or secondary, the quality of the photometry (with a series of flags), the "class" of the object (star or galaxy), the SDSS-DR8 name (and the identifier, and the ID in the various tables of the database), the coordinates (in the ICRS system) with associated errors (and even proper motions), the mean observation date, the spectroscopic redshift (and its error), the model magnitude in the five SDSS bands (with associated errors), then the measured magnitude (in the five SDSS bands) measured in different ways as well as the de Vaucouleurs fitted radius and ellipticity. This is a total of 157 fields per record[1]. One of the keys of the success of SDSS has been the possibility to access the catalog in a variety of ways. From SQL queries to the possibility to "navigate" through colour-composite images.
The 2MASS catalog is accessible through both a dedicated webpage [2] and the VizieR webpage. The catalog [3] reports, for all the detected sources, the coordinates (RA and Dec) with associated errors (and a position angle), the unique 2MASS designation, the magnitude in the three 2MASS bands (with their errors and signal to noise ratio), a series of quality flags, distance and position angle of vector from source to nearest neighbor, position in the scan, observation date, and characteristics of associated optical sources. This makes for 60 fields per record in the database. The whole 2MASS catalog has 470,992,970 sources.

[1] http://cdsarc.u-strasbg.fr/viz-bin/Cat?II/306
[2] http://irsa.ipac.caltech.edu/
[3] http://cdsarc.u-strasbg.fr/viz-bin/Cat?II/246

4. The J-PAS database

4.1 Introduction

Given the enormous amount of information in J-PAS (56+3 filters and about 8200 square degrees of sky with a typical seeing better than 1 arcsec), assuming that one may want to keep photometric (value of the flux of a source, measured in different ways, and its error), positional and shape information, the size of the database can easily become hard (or even impossible) to handle. This section summarizes what is going to be stored on the basis of the feedback received by the science users. The UPAD will store the essential information that will be queried frequently inside the database. Other information will be stored in external compressed archives. The DMG will provide access to both the database and the external files through a web portal or applications using the framework provided by the Virtual Observatory. The main difference will be the time to access the information, being slower for the information not stored inside the database.

4.2 Dual Mode and Single Mode

Photometry will be carried out on both individual and co-added images with `SExtractor`. This software can be run both on an individual image or on an image using another image as "reference" (so-called "dual mode"in the `SExtractor` jargon).
"Dual mode is essential. Single mode is interesting" is the sentence that best summarizes the outcome of the discussion about the source extraction method to be used for the J-PAS catalogs.
Catalogs will be given as the output of dual mode. A single mode catalog will be created and maintained on a best effort basis.
In summary, here is the list of fields that we expect to include in the database for J-PAS. Sources will be extracted from the combined tiles (i.e. the image obtained by the combination of different dithered exposures).

4.2.1 Catalogs with detection in individual filters (single Mode)

In this case the detection and the photometry is done on each image, using the broad-band image only as an astrometric reference and cross-matching between different bands. The fields that are going to be stored in the database are:

Position related	
ALPHA_J2000	right ascension (J2000.0)
DELTA_J2000	declination (J2000.0)
TILE_ID	tile identifier
FILTER_ID	filter identifier
X_IMAGE	x-position in the tile
Y_IMAGE	y-position in the tile
Shape related	
FWHM_WORLD	FWHM in degrees
R_EFF	Effective radius (in pixels)
A_WORLD	semi-major axis (in arcseconds)
B_WORLD	semi-minor axis (in arcseconds)
RELERRA_WORLD	relative error on semi-major axis (in arcseconds)
RELERRB_WORLD	relative error on semi-minor axis (in arcseconds)
THETA_J2000	position angle
RELERRTHETA_J2000	relative error on position angle
ISOAREA_WORLD	isophotal area above threshold (degrees squared)
CLASS_STAR	star-galaxy classifier
KRON_RADIUS	Kron radius
PETRO_RADIUS	Petrosian radius
Photometry	
FLUX_AUTO	flux (SExtractor's "Auto")
FLUX_RELERR_AUTO	relative error of SExtractor's "Auto" flux
FLUX_ISO	flux (SExtractor's "ISO")
FLUX_RELERR_ISO	relative error of SExtractor's "ISO" flux
FLUX_PETRO	flux (SExtractor's "Petrosian")
FLUX_RELERR_PETRO	relative error of SExtractor's "Petrosian" flux
FLUX_MAX	peak surface brightness above background
FLUX_APER_XXX	flux (different apertures, see below)
FLUX_RELERR_APER_XXX	relative error on flux (different apertures, see below)
MU_MAX	peak surface brightness above background (in magnitudes per arcsecond squared)
BACKGROUND	background at centroid position (counts)
THRESHOLD	detection threshold above background (counts)
Other	
FLAGS	SExtractor flag

The apertures (shown as XXX) are: 0.8, 1.0, 1.2, 1.5, 2.0, 3,0, 4.0, 6.0 arcsecs.

We prefer to store calibrated fluxes over magnitudes to have some information when the fluxes are negative (noise) in faint objects.

Relative errors (i.e. σ_f/f) are preferred over errors, since they can be stored occupying less space in the database.

Petrosian and Kron radii are stored as in the output of SExtractor, i.e. they are dimensionless.
We also expect to include a ”VARIABLE” flag (see section 4.3, TBC).

Catalogs with detection in reference broad filter (Dual Mode)

This table will contain the outputs of the codes ColorPro + BPZ and contains the ”seeing corrected” photometry that are used to compute the photometric redshifts. In this case the cross-match between bands is not needed, as the detections and apertures are defined in the broad band filter.
As an example, the table 4.1 contains the information in the ALHAMBRA catalogs which are the inputs to compute the photometric redshifts.

Tabla 4.1 Content of the Alhambra catalogs devoted to compute photo-z

(computed from detection image)	
SOURCEID	
ALPHA_J2000	Right Ascension in decimal degrees
DELTA_J2000	Declination in decimal degrees
X_IMAGE	X-pixel coordinate
Y_IMAGE	Y-pixel coordinate
ISOAREA_IMAGE	Isophotal aperture area (pixels)
FWHM_WORLD	Full width at half maximum for detection image (arcsec)
CLASS_STAR	SExtractor 'stellarity' (1 = star; 0 = galaxy)
KRON_RADIUS	Kron apertures in units of A or B (pixels)
A_WORLD	
B_WORLD	
ERRA_WORLD	
ERRB_WORLD	
THETA_J2000	
ERRTHETA_J2000	
R_EFF	0.5 Fraction-of-light radii (pixels)
FLAG	SExtractor Photometric Flag
PercW	Percentual Photometric Weight (on detection image).
(compute per filter ID)	
MAG_ISO_ID	Isophotal magnitude [AB]
MAGERR_ISO_ID	Isophotal magnitude uncertainty [AB]
FLAG_ID	SExtractor quality flag
irms_ID	Percentual Weight on 1/RMS image (within ISOphotal Area).

Notice that in this case the coordinates are unique for each object as the apertures are defined in the detection image. The fluxes and magnitudes are ”seeing corrected” using

the information in the broad band image (computed by ColorPro). Other magnitudes, like AUTO, APERTURES (1-6 arcsecs) or Petrosian can be also provided ("seeing corrected") (TBC). In all those cases the aperture is always defined in the detection images (r-Sloan broad band filter).
As in the case of the "single mode", we will provide calibrated fluxed instead of magnitudes and we expect to include a "VARIABLE" flag (see section 4.3, TBC).
The fields stored in the catalogue generated in double mode would then be:

Position related	
ALPHA_J2000	right ascension (J2000.0)
DELTA_J2000	declination (J2000.0)
TILE_ID	tile identifier
FILTER_ID	filter identifier
X_IMAGE	x-position in the tile
Y_IMAGE	y-position in the tile
Shape related	
FWHM_WORLD	FWHM in degrees
R_EFF	Effective radius (in pixels)
A_WORLD	semi-major axis (in arcseconds)
B_WORLD	semi-minor axis (in arcseconds)
RELERRA_WORLD	relative error on semi-major axis (in arcseconds)
RELERRB_WORLD	relative error on semi-minor axis (in arcseconds)
THETA_J2000	position angle
RELERRTHETA_J2000	relative error on position angle
ISOAREA_WORLD	isophotal area above threshold (degrees squared)
CLASS_STAR	star-galaxy classifier
KRON_RADIUS_VEC	Kron radius
PETRO_RADIUS_VEC	Petrosian radius
Photometry	
FLUX_AUTO_VEC	flux (SExtractor's "Auto")
FLUX_RELERR_AUTO_VEC	relative error of SExtractor's "Auto" flux
FLUX_ISO_VEC	flux (SExtractor's "ISO")
FLUX_RELERR_ISO_VEC	relative error of SExtractor's "ISO" flux
FLUX_PETRO_VEC	flux (SExtractor's "Petrosian")
FLUX_RELERR_PETRO_VEC	relative error of SExtractor's "Petrosian" flux
FLUX_APER_XXX_VEC	flux (different apertures, see below)
FLUX_RELERR_APER_XXX_VEC	relative error on flux (different apertures, see below)
Other	
FLAGS_VEC	SExtractor flag

The apertures (shown as XXX) are: 0.8, 1.0, 1.2, 1.5, 2.0, 3,0, 4.0, 6.0 arcsecs.

The _VEC means that the value is actually stored as a vector, each element corresponding to a filter.

The output of BPZ is stored in a separate table, which contains:

photo-z	
zb	best redshift
zb_min	minimum redshift
zb_max	maximum redshift
tb	best-fitting template
Odds	Odds
z_ml	best redshift using maximum likelihood
t_ml	best-fitting template using maximum likelihood
Chi2	χ^2
PercW	
irms_ID	
irms_Flag	
theoretical_flux_VEC	SED of the best fitting template (tb)

4.3 The Variability

Variability has been recognized as an important scientific issue in the J-PAS collaboration. The sources which are detected as variables (the main variability detection strategy is expected to be the differential imaging develped for the SN case but other strategies are under investigation) will be flagged as variables. The individual flux measurements (together with their errors and the times of observation) will be archived in a dedicated table within the database only devoted to variable objects.

The variability database is still under development. Currently, the following parameters per variable object detection are expected to be stored:

Position related	
ALPHA_J2000	right ascension (J2000.0)
DELTA_J2000	declination (J2000.0)
TILE_ID	tile identifier
FILTER_ID	filter identifier
X_IMAGE_VEC	x-position in the tile
Y_IMAGE_VEC	y-position in the tile
Time related	
MJD_VEC	modified julian date
Shape related	
FWHM_WORLD_VEC	FWHM in degrees
Photometry	
FLUX_AUTO_VEC	flux (SExtractor's "Auto")
FLUX_RELERR_AUTO_VEC	relative error of SExtractor's "Auto" flux
FLUX_ISO_VEC	flux (SExtractor's "ISO")
FLUX_RELERR_ISO_VEC	relative error of SExtractor's "ISO" flux
FLUX_APER_XXX_VEC	flux (different apertures, see below)
FLUX_RELERR_APER_XXX_VEC	relative error on flux (different apertures, see below)
Other	
FLAGS_VEC	SExtractor flag

As before, the apertures (shown as XXX) are: 0.8, 1.0, 1.2, 1.5, 2.0, 3,0, 4.0, 6.0 arcsecs and the _VEC means that the value is actually stored as a vector, each element corresponding to a filter.

4.4 Data Access

In order to provide a quick access to the information. For the first DB version, we will optimize searches:

- by coordinates RA,DEC
  - as a sky region i.e. all the objects with right ascension between $\alpha_{\rm min}$ and $\alpha_{\rm max}$ and declination between $\delta_{\rm min}$ and $\delta_{\rm max}$
  - as a "cone", i.e. all the objects which are found within a radius r from some coordinates
- by range of magnitudes
- by colours
- by the image from where the object are extracted (tile or individual frame). This provide the link with the observation epoch

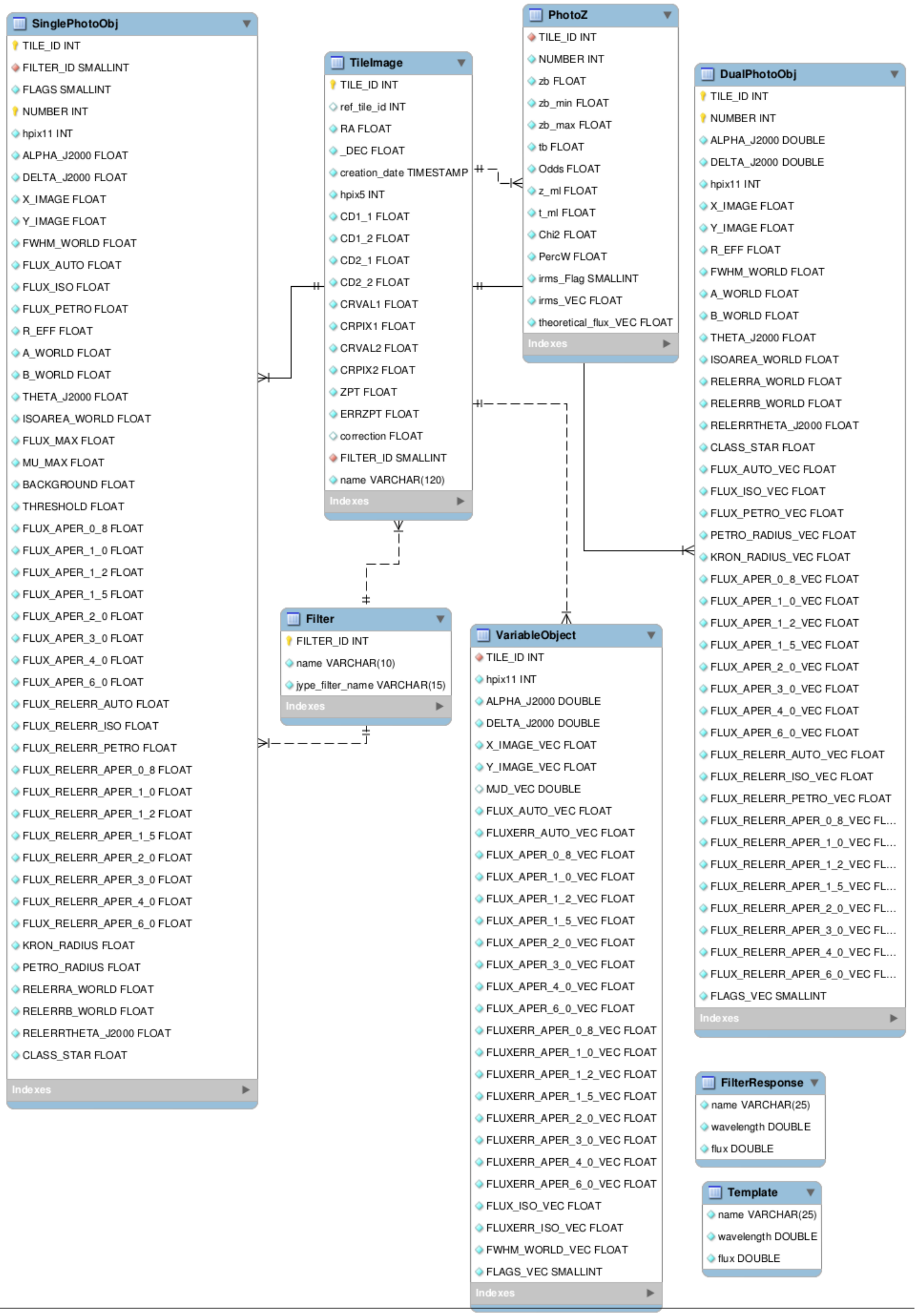

Figura 4.1 The scheme of the fields which have been suggested to be included in the database.

It will be possible to optimize by redshift interval when the redshift will be included in the database.

4.5 Future Developments

The DMG acknowledges the problem of the variation of the response function of the filters with the position. Since this can be recovered through the search for the position of a source in the individual sources, it is decided that it is not an option to provide, as part of the final catalog, the synthetic filter which would result from observations with large dithering. It is also acknowledged that psf-photometry may be of some interest. The use of the PSFex package to derive the psf of images and using SExtractor to perform psf-photometry is under development.