

• Title for the tutorial

Wide-field multi-wavelength images and mosaics: creating a visually appealing presentation and building a value-added catalog

• Presenters

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• Description of the main topic

With the advent of modern wide-field surveys in different wavelength domains and wide availability of mosaic detectors on ground-based and space telescopes, some of the important challenges are: how to visualize the data and make it easily accessible; how to process multi-wavelength datasets originating from different facilities and having different depth, resolution, and coverage in a uniform way to assemble source catalogs, which would be useful for science. In our tutorial we will present a suite of state-of-the-art technological solutions and algorithms to perform efficient (post-)processing and analysis of wide-field images and present them in a visually appealing way.

• Primary learning objectives

The audience will learn how to:

- *Access wide-field survey and archival images using VO protocols from Python, download cutout images*
- *Reproject the cutouts, post-process them (creating RGB color images, perform de-noising and color enhancements)*
- *Configure and run modern image analysis software on them (SourceExtractor++) and create catalogs of point and extended sources*
- *Generate HiPS maps to display in Aladin/AladinLite (including a web-page integration)*

• Detailed tutorial structure, with timeline for each section, each exercise.

- **15 min (slides):** Speakers' intro; brief overview of VO access mechanisms for images (SIAP); what is HiPS and why is it needed; FITS vs jpeg/png HiPS
- **15 min (interactivity):** accessing cutout images using SIAP (command-line / python); accessing HiPS services from Aladin and Aladin Lite
- **30 min (interactivity + slides):** Downloading the cutout images for an extended area of the sky (e.g. the Large Magellanic Cloud from near-infrared VISTA surveys); reprojecting them using *swarp* (and checking the astrometric calibration using *scamp*); introduction to de-noising, RGB generation, and color enhancement, performing these steps from Python
- **30-45 min (interactivity):** how to use *SourceExtractor++*, how to configure it to process a single-band image, how to configure it to process multi-band images; generating PSFs using *psfex*; running *SourceExtractor++* on the images downloaded at the previous step
- **30-45 min (interactivity):** generation of a HiPS tessellation for the post-processed RGB image; generating HiPS for source catalogs generated at a previous step; displaying the results in Aladin or Aladin Lite
- **5 min (slides):** concluding remarks

• Tutorial material, the more complete the better. (Eg. slides, jupyter notebook, webpages.)

For this tutorial, we have already prepared color-enhanced HiPS survey maps for the two near-infrared surveys, Vista Hemisphere Survey (ESO, Southern Hemisphere) and UKIDSS (UKIRT, Northern Hemisphere):

- HiPS for VHS: https://voparis-srv-paris.obspm.fr/vo/survey/hips/VHS_RGB/
- HiPS for UKIDSS: https://data.voxastro.org/HiPS/UKIDSS_RGB/

The description of the two standards relevant to this tutorial is available online at the IVOA web-site:

- IVOA HiPS standard: <https://www.ivoa.net/documents/HiPS/>
- IVOA Simple Image Access: <https://www.ivoa.net/documents/SIA/>

We will make our Python software for tiling, re-projections, image post-processing, and RGB generation available closer to the tutorial date.

The slides will be made available via Google Presenter to the conference attendees closer to the tutorial date.

Additional images and screenshots are attached at the end of this document.

• List of what the participant will need, e.g. laptop, specific software, etc.

Hardware:

- Laptop with Linux, preferably Ubuntu/Debian (incl. WSL) or Mac OS X with MacPorts or Homebrew
- At least 30Gb of disk space (100Gb preferred)
- Preferably a high-resolution display (at least FullHD)

Software:

- Astromatic software (SExtractor, scamp, swarp, psfex) installed from packages/ports. The project web-site: <https://www.astromatic.net/software/>
- SourceExtractor++ (from sources or a package)
- CDS Aladin (<https://aladin.cds.unistra.fr/>)
- A working Python installation with the following packages: astropy, astroquery, numpy, scipy and PIL
- Optional: SAO Image DS9 (<https://ds9.si.edu/>)
- Optional: a local web-server installation (Apache) to display HiPS

• Infrastructure requirements, eg. Wi-Fi, power, table arrangement, etc.

Presenters:

- Own laptop + power plugs (US style)
- Stable internet connection (WiFi: eduroam or a dedicated network; or Ethernet)
- A high-resolution projector (at least full-HD, better 4k) or a video wall

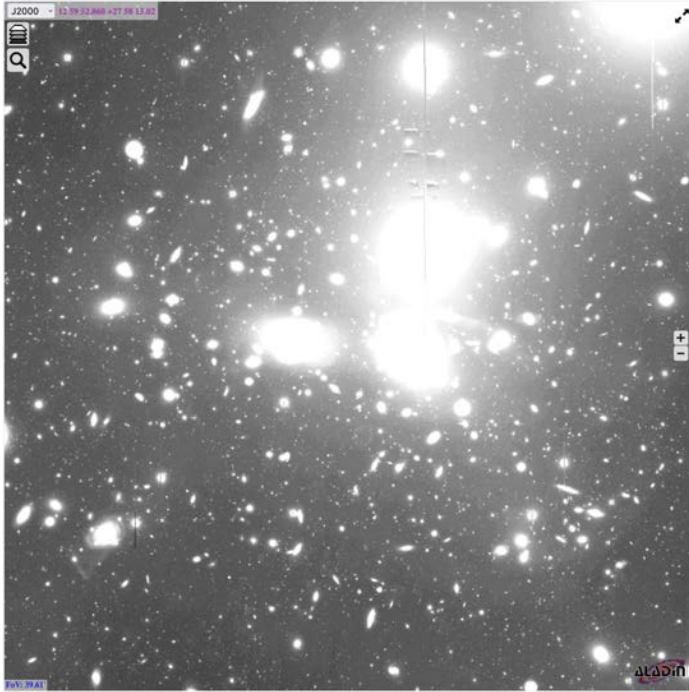
Participants:

- Own laptops (+power plugs, preferably). The software WILL NOT work on iPads (and likely on other tablets)
- WiFi internet access
- Table arrangement with a good view of the projector's screen or a video wall (so, not too far away)
- If USB flash drives are expected to be given to participants as a part of a conference kit, we can ask the organizers to place some data there (~10Gb) rather than on a cloud to avoid connectivity problems

• Additional tutorial materials:



- A composite color image in J and K bands from the UKIRT Hemisphere Survey (UHS) released in June/2023, centered on UGC6697 (Abell 1367 galaxy cluster). This will become one of the datasets which we plan to use in the tutorial and we will likely have a fully functional HiPS service for the UHS by the tutorial date.



- The deepest to date *g*-band optical image of the Coma cluster of galaxies obtained using the 8-m Subaru telescope (HyperSuprimeCam) presented as a HiPS map as viewed in the Aladin Lite software. This dataset will be used as an example of how wide-field images from PI projects can be presented, accessed, and made available within collaborations and for the entire astronomy community. This mosaic image is a result of our own data reduction applied to publicly available archival data.



- A composite color image in J and Ks bands from our HiPS service for the VISTA Hemisphere Survey for a fragment of the Large Magellanic Cloud centered on NGC 2077 (color-enhanced and noise-suppressed J and Ks near-infrared bands).