VO for Everyone - Getting Ready for the 4th ASTERICS DADI VO School

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Abstract. We present an update on the efforts of the European Virtual Observatory (EURO-VO) to inform and educate the astronomical community about Virtual Observatory (VO) tools and services. From the 20th to the 22nd of November 2018 the fourth and last Virtual Observatory school of work package 4 (DADI) of the European ASTERICS project has been taking place in Strasbourg. In the light of this event, this paper provides details on the VO-School highlighting the elements of the schools that we consider makes them a success. We present a short overview of recent developments, the current status and content, and future plans for tutorials on the Virtual Observatory.

1. Introduction

The Astronomy ESFRI & Research Infrastructure Cluster (ASTERICS) project is a Horizon 2020 project funded by the European Commission. ASTERICS aims to bring together researchers, scientists, engineers, hardware and software specialists from astronomy, astrophysics and astro-particle physics to tackle the challenges of transferring, processing and storing of large amounts of data. The fourth work package of ASTERICS focuses on Data Access, Discovery and Interoperability (DADI), which includes a yearly Virtual Observatory (VO) school for early career researchers (ECR) throughout the duration of the ASTERICS project. The aim of these VO-schools is to familiarise young researchers with various tools and services of the VO. After the schools ECRs are expected to both be able to use the VO efficiently for their research and act as ambassadors for the VO. Previous schools have been organised in Madrid (Spain) in November 2017 and December 2015, and in Strasbourg (France) in November 2016. The next and last ASTERICS VO-school is taking place from 20th to the 22nd of November 2018 again in Strasbourg. The program of this school can be found on the school webpage [1] and will be discussed further below.

2. Current Status of VO tutorials

After each VO-school, the updated tutorials are published on the EURO-VO webpage[2]. Between schools, these tutorials are furthermore updated to account for recent advances

[1] https://www.ASTERICS2020.eu/dokuwiki/doku.php?id=open:wp4:school4:program

[2] http://www.euro-vo.org/?q=science/scientific-tutorials

in software development. In addition, comments from an anonymous feedback form that was fill by the participants at the end of each school was very useful to evolve and update tutorials. The tutorials on the EURO-VO webpage cover the following software packages, tools and services:

- The CDS portal is an entry point to the services provided by the CDS and links to other (CDS) services. These services include ALADIN, SIMBAD and VIZIER. ALADIN is an interactive sky atlas allowing to search, retrieve and manipulate image, coverage and table data from the VO (Bonnarel et al. 2000; Boch & Fernique 2014). SIMBAD is the CDS object data base (Wenger et al. 2000, Loup et al. in prep.). VIZIER is a database of catalogues as collected and curated by the CDS (Ochsenbein et al. 2000).

- TOPCAT (Taylor 2005) and STILTS (Taylor 2006) are versatile table manipulation tools, which can also connect to the VO. While TOPCAT has a graphical user interface, STILTS is a command line tool it thus is able to handle bigger tables.

- More specialised tools that help to obtain and analyse certain data products are also included in the tutorials. CASSIS [3] and SPLAT[4] allow to visualise and take measurements from spectra. VOSA analyses the spectral energy distribution (SED) of stars (Bayo et al. 2008).

In the tutorials, these tools are usually presented in the context of a science use case, e. g. identification of stellar clusters in the *Gaia* catalogues, obtaining information on particular galaxies or locating gravitational wave sources. The tutorials have been reworked for the VO-school. These updates account for changes both in software tools (e. g. changes in the workflow that came about with the release of Aladin version 10) and publicly available data (e. g. release of *Gaia* DR2).

3. Fourth ASTERICS Virtual Observatory School

The programmes of the VO-schools held in the ASTERICS project have evolved over time, taking into account the changes in the tools and services, and also the development of new scientific topics such as gravitational wave science. Feedback from participants of previous schools has also helped us to find a programme structure that best suits the needs of the participants in a three day event: The first two days focus on tutorials, while the third day is reserved for the students' own research project. On this third day, participants tackle their scientific questions with support from applying the skills they acquired the preceding days. To optimise the outcomes of day three, we interacted with participants to gather information on their scientific expertise and their previous experience with VO tools and services.

This school started with introductory talks about the VO and ASTERICS, which were followed by three tutorials on the first day. On the second day participants were guided through another three tutorials of about the same length. Then the second day finished with the "Treasure Hunt". In this game, five questions like "How many Novae

[3] `http://cassis.irap.omp.eu`

[4] `http://star-www.dur.ac.uk/~pdraper/splat/splat.html`

have been detected within 2 arcmin of the centre of M 31 to date?" are to be answered by the participants within a given amount of time and by using VO tools.

The tutorials selected and updated for the VO-School are:

"The CDS tutorial", which guides participants through the various CDS services and tools in the search for information on peculiar galaxies. At this VO-school it came with an new section on using Jupyter notebooks for access to CDS services.

"Determination of stellar physical parameters using VOSA", in which participants learn to use VOSA to assemble and analyse SEDs of stars.

"Accessing and cross matching big datasets with ADQL", an extensive beginners guide to ADQL.

"Electromagnetic follow-up of gravitational-wave events", which teaches how to use ALADIN to analyse the location of gravitational waves and plan follow-up observations.

"Exploring Gaia with TopCAT and STILTS", where participants learn to use TOPCAT and STILTS efficiently to find and analyse stellar clusters in *Gaia* DR2 catalogues.

"Advanced usage of HiPS and MOCs" in which participants create their own HiPS and subsequently find all sources in a *Gaia-WISE* cross-match that are located within their HiPS and at low Galactic extinction.

Based on the experience of the series of VO-schools in ASTERICS, we can clearly identify that interaction between the participants and VO expert tutors (both scientists and software developers) is a key element for the success of these schools. A common observation is that the tutorials enable a much deeper understanding of the capabilities of the tools and what the VO can offer. While information is available on-line, the personal interaction afforded in a school greatly enhances the transfer of knowledge.

4. Future Plans

Python[5] is becoming more widely used in astronomy data analysis. We therefore work towards including example Python workflows in our tutorials. We consider interactive Jupyter notebooks (Kluyver et al. 2016) as a suitable way to present these workflows. A Python package of interest for these tutorials is **Astropy** (Astropy Collaboration et al. 2013), which aims to provide core utilities for astronomers. There are two Astropy affiliated packages that allow to query VO-services and will thus be relevant for the tutorials: **pyVO**[6] and **astroquery**[7]. In addition we would like to familiarise astronomers with **MOCPy**[8], a package to create, modify and use multi-order coverage (MOC) maps, and **ipyaladin**[9], which provides a a way to display a Aladin Lite widget in Jupyter notebooks. One example for these Jupyter notebooks was presented in the tutorial "All-sky astronomy with HiPS and MOCs"[10] (Derriere 2019). This pre-ADASS tutorial was

[5] `https://www.python.org/`

[6] `https://pyvo.readthedocs.io/en/latest/`

[7] `https://astroquery.readthedocs.io/en/latest/`

[8] `https://mocpy.readthedocs.io/en/latest/`

[9] `https://github.com/cds-astro/ipyaladin`

[10] `http://cds.unistra.fr/adass2018/`

also live streamed to Youtube. There, the CDS also publishes short video tutorials on VO-related topics on the CDS Youtube channel[11].

5. Summary and Conclusion

Between the ADASS XXVIII meeting and the publication of this paper, the Fourth ASTERICS VO-School was successfully held. In a final, anonymous evaluation round, participants found the knowledge they acquired throughout the school very useful. However, they also requested that more examples for scripting and automating certain tasks should be shown and taught. Bringing Python to upcoming VO-Schools and taking more time to discuss tools as STILTS and the scripting mode of ALADIN will satisfy this need and help to prepare astronomers for the era of data-intensive astronomy.

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[11] https://www.youtube.com/channel/UCUESQl7rNupLlV_VcceE0Ng