MMODA: Multi-Messenger observatory platform of FACE

Denys Savchenko, Andrii Neronov, Cécile Cavet

Astroparticule et Cosmologie
Example: blazar TXS 0506+056 (a supermassive black hole).

A wealth of astronomical sources emit over very broad energy range. Understanding of emission mechanisms requires astronomical data collected with many different types of telescopes.

Individual astronomers cannot master data analysis techniques of all these telescopes at once. A system that helps (guides) them to obtain analysis-ready results for multiple types of astronomical instruments, would be useful.

Example: GW 170817 (a neutron star merger event).

A wealth of astronomical sources appears on the sky for a short period of time (down to milli- and microseconds in the case of “fast radio bursts”). Understanding of emission mechanisms requires “fast reaction”, to observe the source with multiple telescopes, while it is “in action”.

Individual astronomers cannot master all these telescopes at once. A system that helps coordinated observation campaigns and extracts data analysis results in automatic way would be useful.
Multi-Messenger data analysis

Only combining data together, it is possible to see a complete picture of physical phenomena in astronomical sources.

Fig: Meszaros et al. 2019
MMODA

The MMODA is a data management solution based on cloud computing and virtualization technology to address the challenges of efficient **sharing** and **re-use** of data, their **long-term preservation**, data analysis systems, **reproducibility** of results.

From the end-user perspective it provides the abstraction over the low-level data analysis of different instruments, allowing to operate with the science product, such as spectra, light-curves, sky-images. All difficult data analysis are performed under the hood in the containerized environments.

The MMO project is one of the main directions of the **François Arago Centre**
MMO in the cloud

We provide charts for Kubernetes orchestrator

two instances:

– UniGE
– FranceGrilles
Software layer

-- API access using dedicated python library

-- WEB-frontend

-- dispatcher coordinates data flow and job provisioning

-- data products are cached for later use

-- raw data from external services/archives

– provenance metadata in Knowledge Graph

https://github.com/oda-hub
MMODA service development
MMODA service development

Name resolver including GW events
MMODA service development

Python API access: available as `oda_api` pip package
Jupyter notebook to MMOADA service

Workflow notebook on Renku (SDSC data science platform)

[Image of workflow notebook]

- **oda-bot**
- **dispatcher**
- **nb2workflow-dispatcher-plugin**

- **fermi**
- **Instrument backends**

- **API**

- **Build & deploy backend container**

**Current development**

**Workflow parameters annotations**

**Outputs annotations**

- `src_name='Mrk 421'` # http://odahub.io/ontology#AstrophysicalObject
- `RA = 165.113886` # http://odahub.io/ontology#PointOfInterestRA
- `DEC = 38.206833` # http://odahub.io/ontology#PointOfInterestDEC
- `T1='2010-03-06T13:26:48.0'` # http://odahub.io/ontology#StartTime
- `T2='2020-03-06T13:26:48.0'` # http://odahub.io/ontology#EndTime
- `dT=2` # Integer in months

- `result lc.encode()` # http://odahub.io/ontology#Lightcurve

**Instrument backends**

- **fermi**

**Current development**

- **dispatcher**
- **nb2workflow-dispatcher-plugin**

- **API**

- **Build & deploy backend container**

- **oda-bot**

**Workflow parameters annotations**

**Outputs annotations**
Summary

- MMODA cloud platform for astronomical multi-messenger data analysis
- we are developing specific instrument services for MMODA multi-messenger platform
- main instance in UniGE, second instance using France Grilles resources
- current direction: facilitate MMODA services creation from workflow in .ipynb form

Future developments

- further services in collaboration with teams @APC
- “smart” multi-messenger & multi-product data combination service
- multi-site integration & resource federation
- integration with EOSC (SSO, workflow discovery etc.)