The Virtual Observatory standard formats, protocols and the IVOA

Ada Nebot

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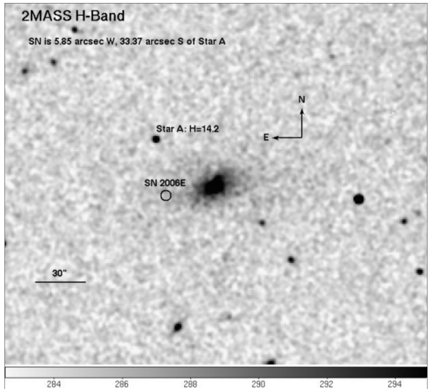
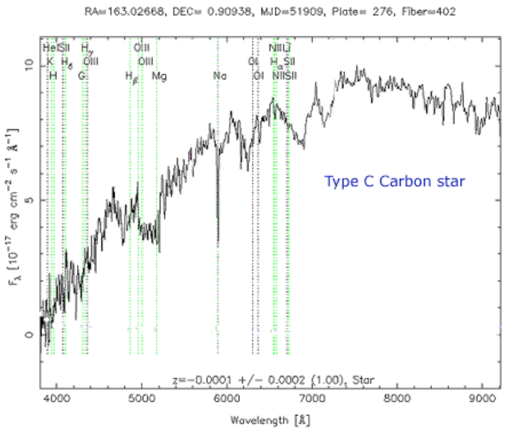
Centre de Données Astronomiques de Strasbourg

Observatoire astronomique de Strasbourg | ObAS

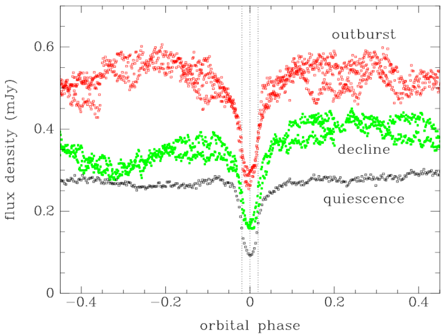
IVOA

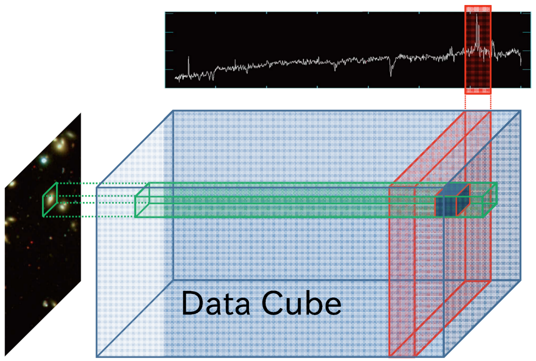
Astronomical data





HD	V [mag]	$B-V$ [mag]	$b-y$ [mag]	A_V [mag]	$v \sin i$ [km s^{-1}]	T_{eff} [K]	$\log g$(phot) [dex]	M_V [mag]	$\log L_*/L_\odot$
319	5.93	0.141	0.079	0.004	60	8020(135)	3.74(8)	+1.27(19)	1.45(8)
6870	7.49	0.246	0.164	0.000	165	7330(102)	3.84(11)	+2.29(42)	1.02(17)
7908	7.29	0.272	0.192	0.000		7145(87)	4.10(12)	+2.60(18)	0.90(7)
11413	5.94	0.147	0.105	0.004	125	7925(124)	3.91(21)	+1.49(10)	1.35(4)
13755	7.84	0.318	0.181	0.000		7080(161)	3.26(10)	+0.93(10)	1.57(4)
15165	6.71	0.333	0.191	0.010	90	7010(167)	3.23(10)	+1.12(16)	1.50(6)
23392	8.26	0.020	0.014	0.094		9805(281)	4.35(9)	+1.43(30)	1.45(12)
24472	7.09	0.304	0.214	0.003		6945(131)	3.81(16)	+2.14(11)	1.09(5)
30422	6.19	0.190	0.101	0.014	135	7865(108)	4.00(20)	+2.35(1)	1.01(1)
31295	4.65	0.085	0.044	0.063	115	8920(177)	4.20(1)	+1.66(22)	1.32(9)
35242	6.35	0.122	0.068	0.042	90	8250(103)	3.90(14)	+1.75(22)	1.26(9)
36726	8.84	0.086	0.043	0.202		9515(223)	4.36(10)	+1.74(30)	1.32(12)
42503	7.46	0.176	0.130	0.084		7680(282)	3.10(10)	−0.03(4)	1.96(2)





Asteroseismic test of rotational mixing in low-mass white dwarfs

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ABSTRACT

We exploit the recent discovery of pulsations in mixed-atmosphere (He/H), extremely low-mass white dwarf precursors (ELM proto-WDs) to test the proposition that rotational mixing is a fundamental process in the formation and evolution of low-mass helium core white dwarfs. Rotational mixing has been shown to be a mechanism able to compete efficiently against gravitational settling, thus accounting naturally for the presence of He, as well as traces of metals such as Mg and Ca, typically found in the atmospheres of ELM proto-WDs. Here we investigate whether rotational mixing can maintain a sufficient amount of He in the deeper driving region of the star, such that it can fuel, through HeII-HeIII ionization, the observed pulsations in this type of stars. Using state-of-the-art

Astronomical data are diverse

Astronomy today

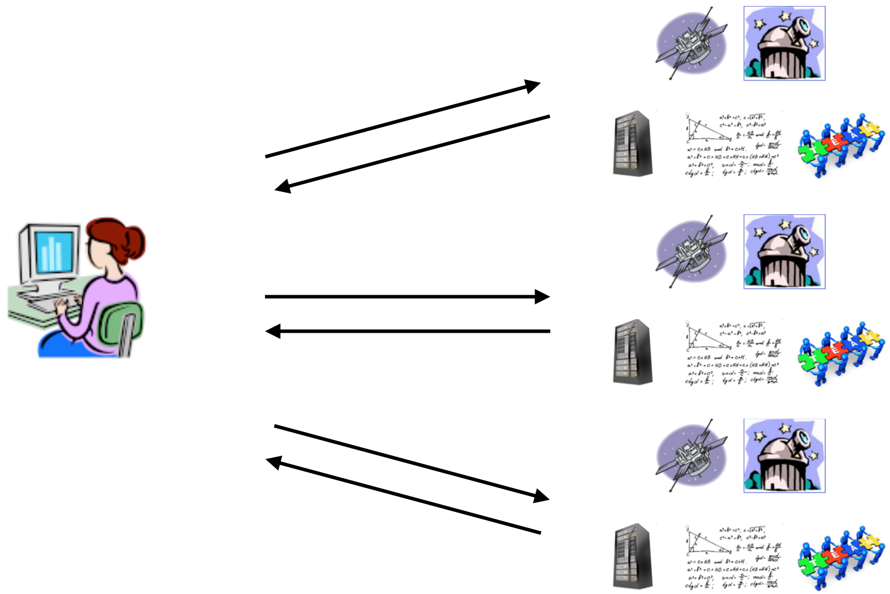
- **More data at our disposal than at any other time in history**
  - Larger telescopes
  - Better detectors
  - Survey missions
  - Multi-wavelength studies
  - Multi-messenger studies
  - … Next generation missions coming up

Production of huge amounts of data

Astronomical archives and data centers

Astronomical archives are heterogeneous

Data Access



Different methods to access data on different astronomical archives

The Virtual Observatory = interoperability

- "***The Virtual Observatory (VO)*** *is the vision that astronomical datasets and other resources should work as a seamless whole.*"

- **Interoperability:**
  - "The ability of computer systems or software to exchange and make use of information."
  - "The ability of different systems, devices, applications or products to connect and communicate in a coordinated way, without effort from the end user"

- **"A multi-wavelength digital sky that can be searched, visualised and analysed in new and innovative ways"** P. Fabianno

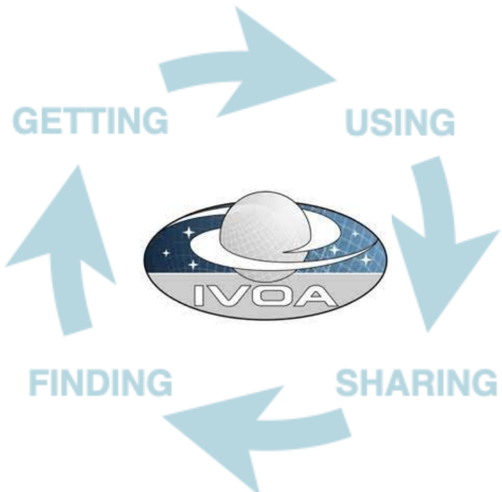
How does it work?

- Through the **development and adoption** of **common standards scientifically driven**, as an international community effort where astronomers, software engineers and documentalists are involved.

➡Allows astronomers to interrogate multiple data centres in a seamless and transparent way.

➡Provides new powerful analysis and visualisation tools within that system.

➡Gives data centers a standard framework for publishing and delivering services using their data.



- **Enabling science**

The IVOA: what?

What is the International Virtual Observatory Alliance?

- A science driven organisation that builds the technical standards
- A place for discussing and sharing VO ideas and technology to enable science
- It is open to participation

http://ivoa.net/

The International Virtual Observatory Alliance

- **Existing global framework** populated by major data providers (space and ground based) that is heavily used by the community (e.g. Gaia data access is fully VO).

Some standard formats & protocols

Each tailored to specific use cases:

- **VOTable** the format for tabular data for allowing interoperability (coosys, timesys, ucd, utype, VOunits, datalink).
- **HiPS** more than a format for images - tailored for large data volumes
- Search for data:
  - **Cone search** — spatial + temporal search
  - **MOC** — spatial and temporal indexing for large data volumes and more complex areas in the sky
  - TAP + ADQL — Table Access Protocol & astronomical data query language
  - ObsCore & ObsTAP — description of observations
- Planning of observations:
  - **ObjVisSAP** — visibility of object to plan observations
  - **ObsLocTAP** — facilitate coordination of observations
  - Facilities / observatory list (under dev.)
- **...**

Alerts formats and protocols within the VO

- Sky Event Reporting Metadata — VOEvent
  - **Content**: a core data model for alerts
    - Who, What, WhereWhen, Why, and How, citations, description, reference
    - Defined by the community (e.g. FRB)
  - A **format**: a serialization of that data model (xml)
- VTP - VOEvent Transport protocol:
  - a communication protocol for publishing, and subscribing to alerts

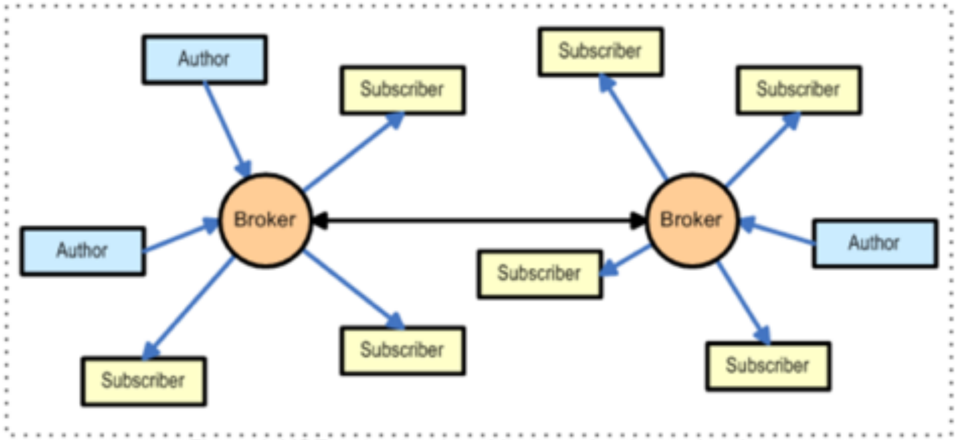
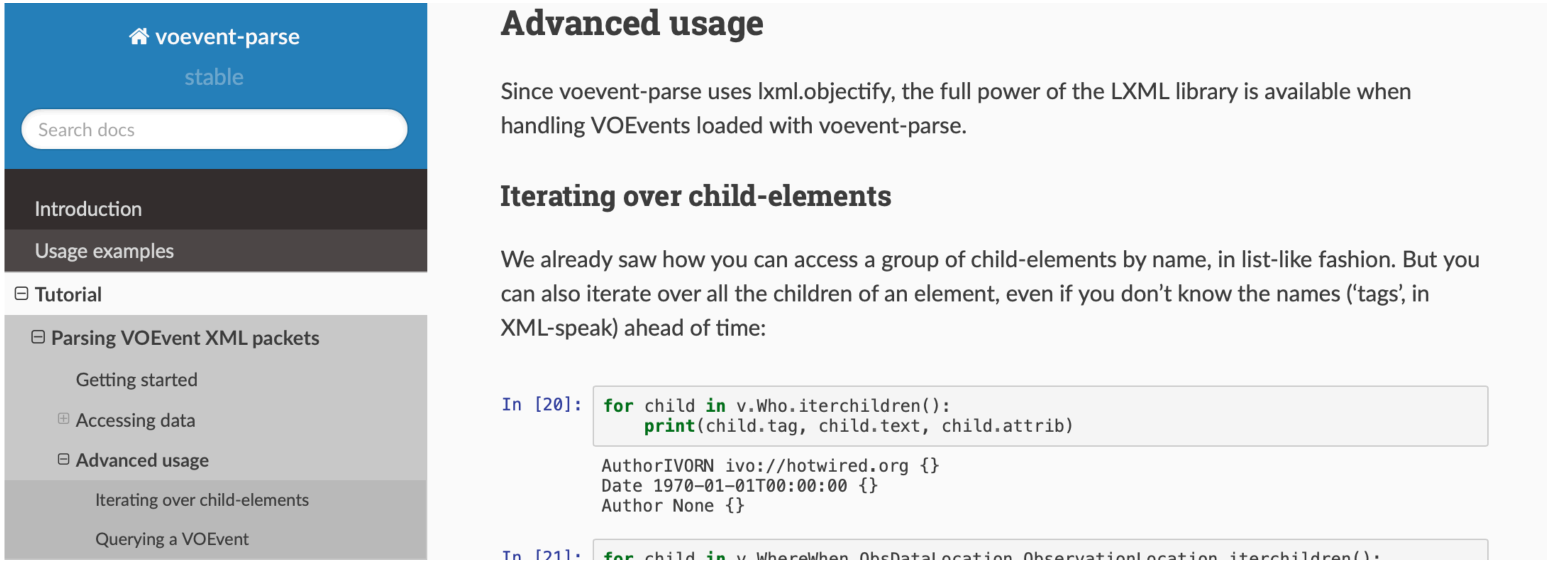


Figure 1. VOEvent network architecture showing node roles

VOEvent tools

- **There are tools for:**
  - Generating, Reading and Manipulating VOEvents:
    - VOEventLib
    - voevent-parse
  - Working with the VOEvent Transport Protocol:
    - The Dakota VOEvent Tools
    - Comet
    - PyGCN
  - VOEvent Databases: voeventdb

Tutorials



voevent-parse
stable
Search docs

Advanced usage

Since voevent-parse uses lxml.objectify, the full power of the LXML library is available when handling VOEvents loaded with voevent-parse.

Iterating over child-elements

We already saw how you can access a group of child-elements by name, in list-like fashion. But you can also iterate over all the children of an element, even if you don't know the names ('tags', in XML-speak) ahead of time:

```
In [20]: for child in v.Who.iterchildren():
             print(child.tag, child.text, child.attrib)

AuthorIVORN ivo://hotwired.org {}
Date 1970-01-01T00:00:00 {}
Author None {}

In [21]: for child in v.WhereWhen.ObsDataLocation.ObservationLocation.iterchildren():
```

Tutorials

https://wiki.ivoa.net/twiki/bin/view/IVOA/EduResourcesTutorials#Graduate_level

TUTORIALS	DESCRIPTION	Link
Abell 1656: The Coma Cluster of Galaxies	This tutorial uses the advanced VO functionalities of Aladin (interactive sky atlas), TOPCAT (tools to work on catalogs) and Cassis (interactive spectrum analyzer) to study interactively the Coma cluster of galaxies. The user can visualize the Coma cluster of galaxies and build a subset of these galaxies with Aladin. With TOPCAT, they can analyze this subset. Finally, they can study an HST power spectrum with Cassis.	Jupyter Notebook

NASA-NAVO Workshops Notebooks

Search the docs ...

Preparing a proposal

The Story: Suppose that you are preparing to write a proposal on NGC1365, aiming to investigate the intriguing black hole spin this galaxy with Chandra grating observations (see: Monster Blackhole Spin Revealed)

FAIR data

- The IVOA standards are built to enable data access, data discovery and ultimately **interoperability**

Meeting **FAIR** principles by design

Findable
Accesible
Interoperable
Reusable

The IVOA needs the community to participate! (That's you!)

Want to participate?

http://ivoa.net/

https://www.ivoa.net/members/index.html

https://join.slack.com/t/ivoa/shared_invite/zt-1k0gwfsp1-_pmYmFZG7yI4r99uYU1bvQ

https://github.com/ivoa-std