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EXPANDING THE FRONTIERS OF SPACE ASTRONOMY

Astropy and the Virtual Observatory

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What is this talk about?

Encourage engagement between the Virtual Observatory and Astropy communities.





What is the Virtual Observatory?

Vision of the VO:

- Astronomical datasets, tools and services should work seamlessly together

International Virtual Observatory Alliance (IVOA):

- An organization that debates and agrees on the technical standards needed to make the VO possible
- A framework for discussing and sharing VO ideas
 - Seeks input from, and communicate to, the astronomical community



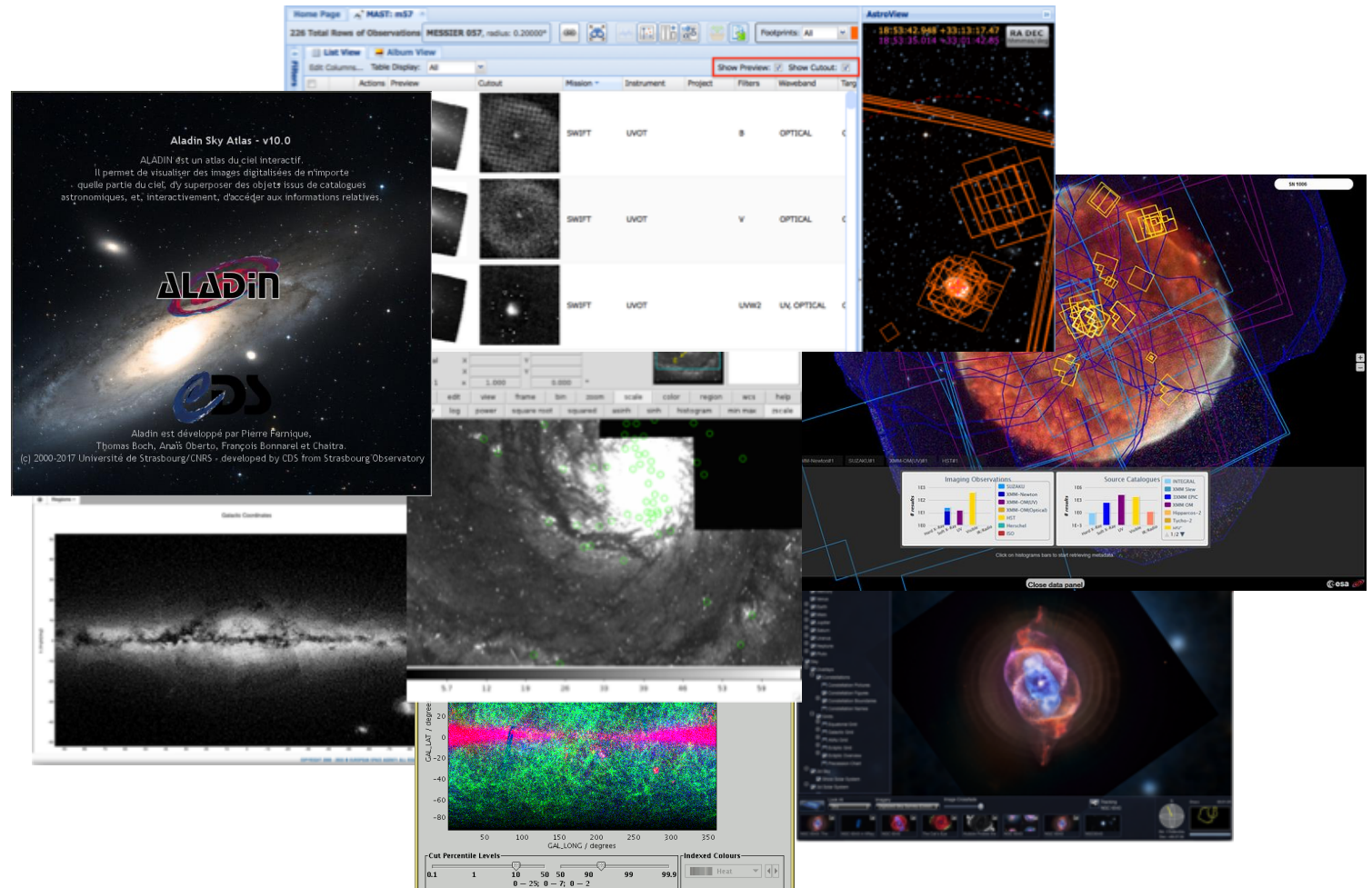
IVOA in 2018





VO Actively in Use

- Many popular tools make use of the VO for data discovery and access
 - Aladin
 - Topcat
 - ESA Sky
 - MAST Discovery Portal
 - WorldWide Telescope
 - DS9
- Archives small and large provide data via VO
 - Too numerous to mention
 - If you used Gaia data, you used the VO





Challenges with the VO

Perception problem in parts of the astronomy community

- Some standards created painfully slowly
- IVOA seen as a somewhat insular organization, not always driven by community needs
- Lingering usability issues with some standards limit progress towards the VO vision
- Relationships among the (too?) many standards not always clear

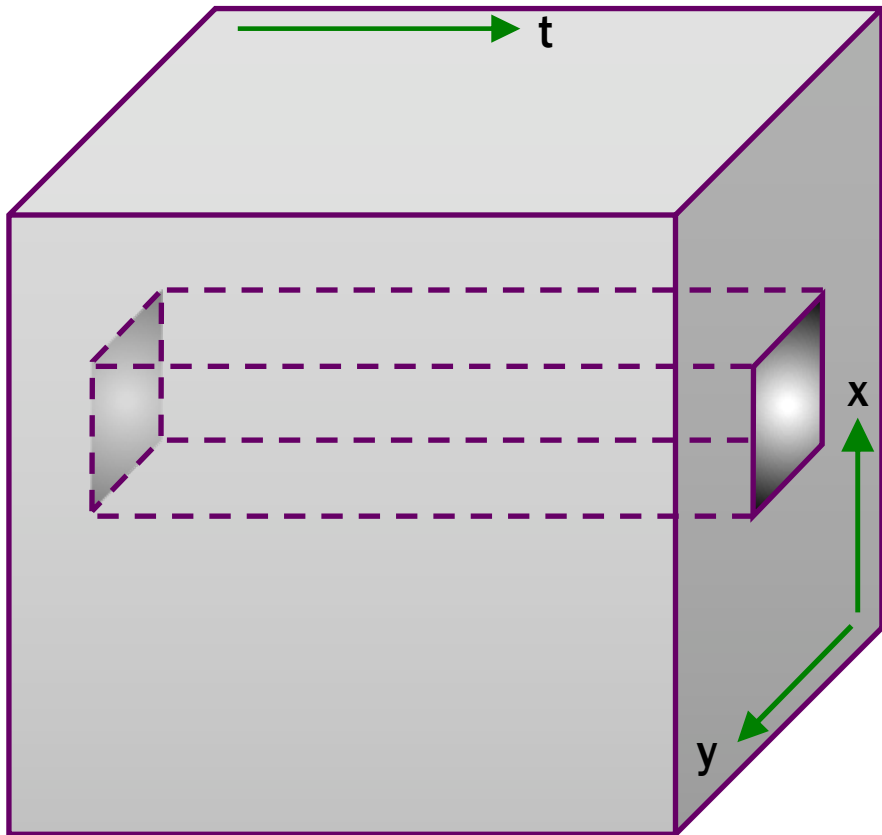
- Expectations
 - “Virtual Observatory” sounds like an end-user tool
 - ▶ Standards intended to enable an ecosystem of such tools
 - End users often not aware they benefited from VO standards

Results sometimes in disconnects within the community



Astrocut and SODA

Astrocut: A cutout service for TESS full-frame image sets (Clara Brasseur, ADASS 2018)



Three ways to query

1. Web form: <https://mast.stsci.edu/tesscut>
2. HTTP GET request:
<https://mast.stsci.edu/tesscut/api/v0.1/astrocut?ra=250.25&dec=3.52&y=3&x=3>
3. `astroquery.mast.Tesscut`:

```
>>> from astroquery.mast import Tesscut
>>> from astropy.coordinates import SkyCoord
>>> cutout_coord = SkyCoord(107.18696, -70.50919, unit="deg")
>>> hdulist = Tesscut.get_cutouts(cutout_coord, 5)
```



Astrocut and SODA

- Have you considered implementing Astrocut as a VO SODA service?
 - What's SODA? (IVOA standard for [Server-side Operations for Data Access](#))
 - 2 other people who work on VO standards also asked me about a SODA implementation
 - The question did not occur to anyone outside the IVOA
- Why not?
 - Priority is to provide cutouts to end user (who will not read the SODA doc to learn how to query)
 - SODA is more work to implement
 - SODA requires more complex input options which don't match directly with Astrocut's expectations
 - Requires understanding and complying with multiple VO standards laced with jargon
 - Requires related meta-services and registration of the service
- But... The longer view towards interoperability
 - Once implemented, Astrocut/SODA becomes available to generic tools and libraries
 - E.g., LSST web interface or Aladin could retrieve cutouts for LSST, TESS, Kepler, etc.



Why do users go to Astroquery?

- To find a predictable wrapper around data provider service queries
 - Can simplify access to potentially complex interfaces, VO or not

```
tap_params = {
    "request": "doQuery",
    "lang": "ADQL",
    "query": """
        select cap.ivoid, res.short_name, res.res_description, res.reference_url, int.access_url
        from rr.capability cap
        natural join rr.resource res
        natural join rr.interface int
        where cap.cap_type='singlespectralaccess' and cap.ivoid like '%heasarc%'
        order by short_name;
    """
}
```

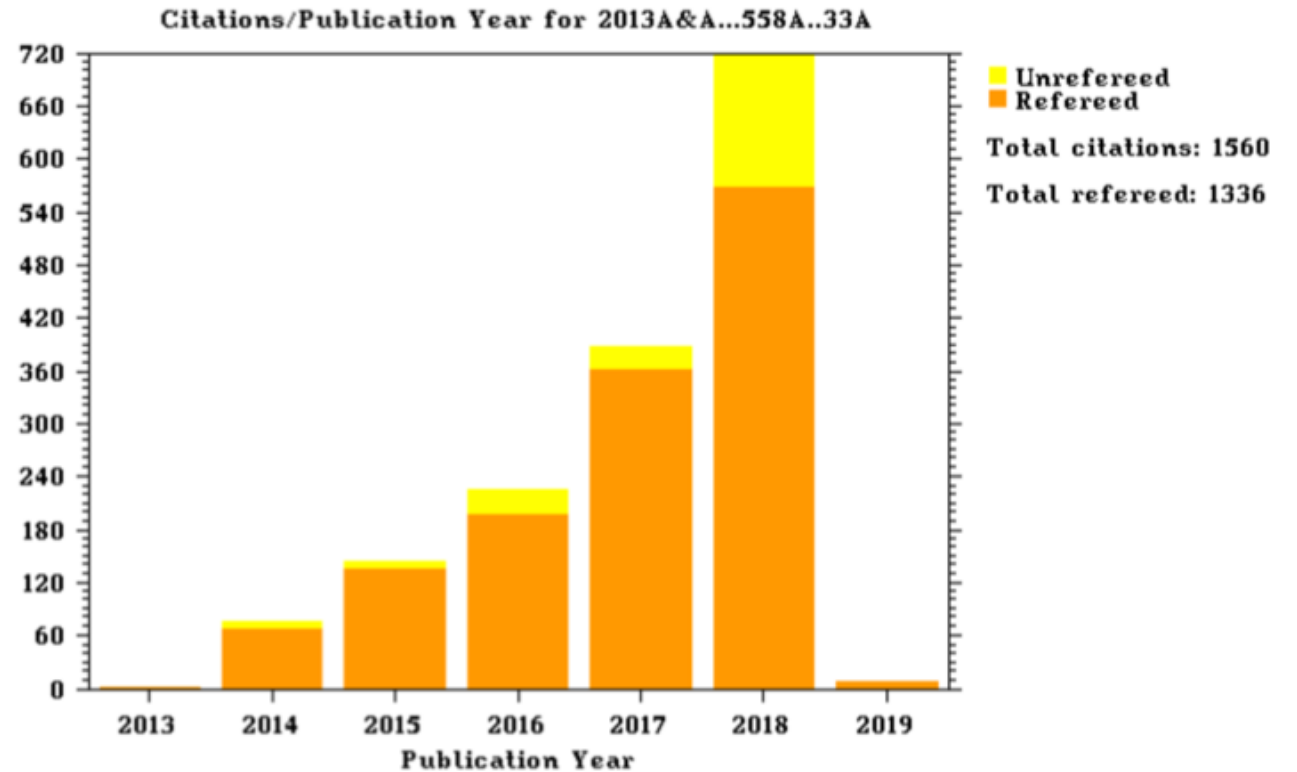


```
from astroquery.vo import Registry
|
# Find all SIA services from HEASARC.
heasarc_image_services = Registry.query(source='heasarc', service_type='image')
```



Astroquery – cont'd

- Similar goals to VO
 - Predictable API for querying astronomy data providers
 - Homogeneity comes in Python client instead of at web server.
- Astropy affiliated package
 - Use has increased rapidly





Already Some VO Presence in Astropy

- Astropy includes a robust VOTable parser
 - Supports conversions between Astropy Tables and VOTables
- PyVO is another Astropy affiliated package
 - Developed under the US VAO (Virtual Astronomical Observatory) project
 - Includes client access to several VO standards, with some VO jargon
 - Dormant for a while after VAO defunding
 - Some new developments have been added, though few contributors
- Astroquery
 - Has supported vo_conesearch for a while
 - Gaia and CADC data access built on generic VO access utilities
 - Table access protocol (TAP)
 - DataLink
 - VO Registry lookup
 - ESA Sky
 - Multi-Order Coverage map queries (HEALPix-based)



Potential Synergies from New VO Python Development

- Like VO enabled tools, Python APIs can present usable entry points to VO capabilities
- Astropy/Astroquery has wide user and contributor community
 - More science users could benefit from VO interoperability
 - Open development model invites new input on VO protocols
 - Is there a need?
 - Does the protocol meet the need?
 - May lead to more effective feedback into IVOA processes
- New Astropy human resources available
 - For new features, but also reviewers
- VO data modelling efforts directly informed by existing/evolving Astropy models
 - Models sufficient for Astropy users probably cover the most desired use cases



Challenges

- Within the larger Python ecosystems, where do new VO features belong?
 - PyVO, Astroquery, Astropy, other packages...
- What features, if any, should be developed?
- Are there higher level design/vision considerations?

Main Answer:

Embrace the open development model

- Participate where it exists (Astropy)
- Implement it where it doesn't exist (new packages)
- Adopt more of these techniques within the IVOA processes?



Conclusions

- IVOA could benefit greatly from increased participation within open development community
 - Improved open processes
 - Evolve more effective standards
 - Guidance for data model development
- Astropy/Astroquery users can benefit too!
 - Simplified predictable access to the effective VO features

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