

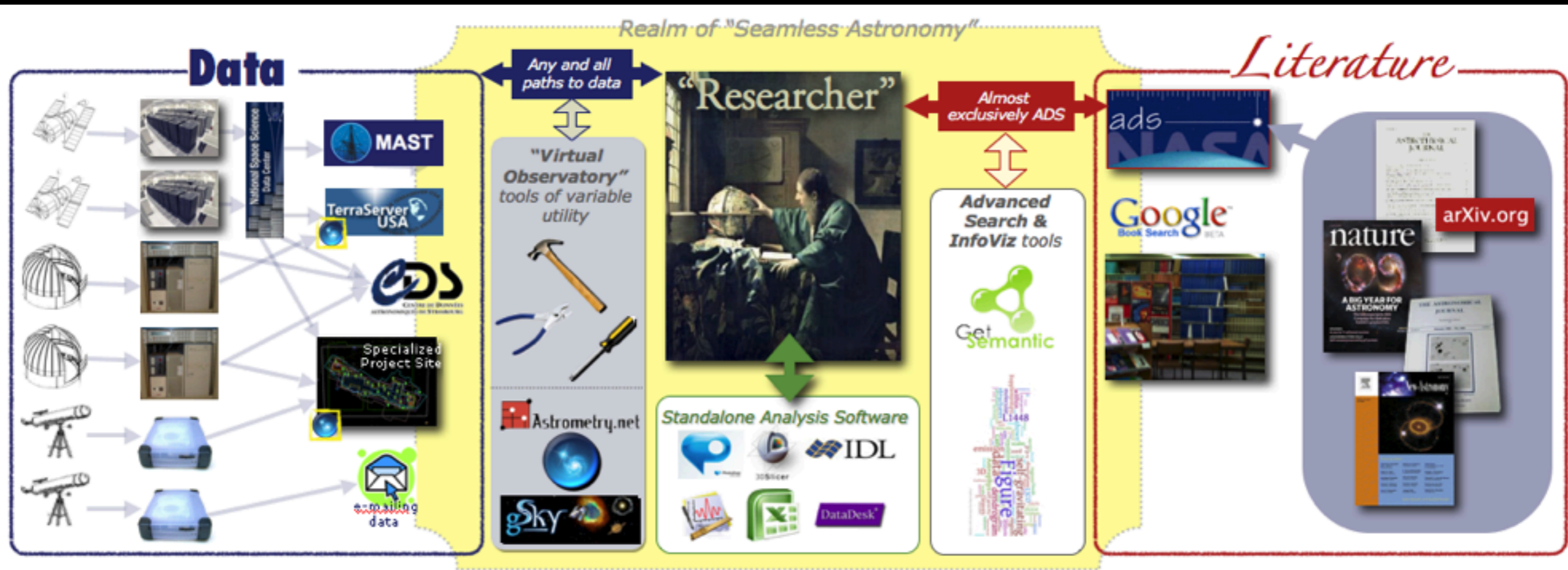
Evermore Seamless Astronomy

Alyssa A. Goodman
Harvard-Smithsonian Center for Astrophysics

with Alberto Accomazzi, Douglas Burke, Gus Muench & Michael Kurtz
(Harvard-Smithsonian CfA); Eli Bressert (U. Exeter); Tim Clark (Massachusetts
General Hospital/Harvard Medical School); Chris Borgman (UCLA);
Jonathan Fay & Curtis Wong (Microsoft Research)



Realm of Seamless Astronomy



3500 years of Observing

Stonehenge, 1500 BC



Ptolemy in Alexandria, 100 AD



Observatory Tower, Lincolnshire, UK, c. 1300



Galileo, 1600



The "Scientific Revolution"

Reber's Radio Telescope, 1937



NASA/Explorer 7
(Space-based
Observing)
1959

"The Internet"



Long-distance
remote-control/
"robotic"
telescopes
1990s

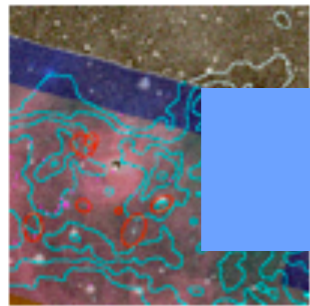


"Virtual
Observatories"
21st century

What can today's Astronomer's "Research" look like?

Research

In my *Astronomy* research, I am primarily interested in how the gas in galaxies constantly re-arranges itself over huge time spans to constantly form new stars. I have also had a long-standing interest in data *visualization*, and in improving the use of *computers* in all aspects of scientific research. I teach a course at Harvard called "The Art of Numbers," and I am very involved in the WorldWide Telescope Project, which brings astronomical data to everyone through an interface that demonstrates data delivery for the 21st Century of "e-Science."



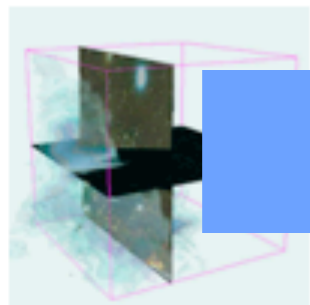
COMPLETE
The COordinated Molecular Probe

Data



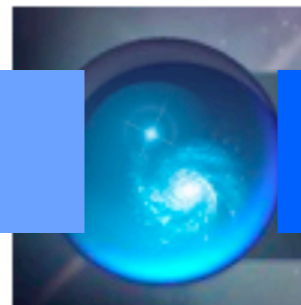
Star Formation Taste Tests
A community of theorists, numericists, and

Simulation



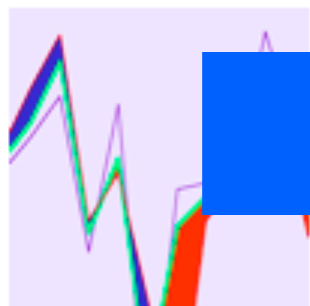
Astronomical Medicine
Exploiting the intersection of

Publishing



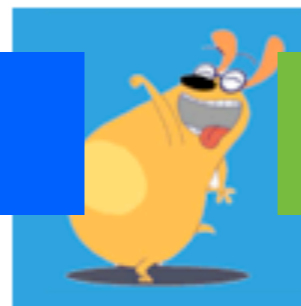
WorldWide Telescope
A beautiful portal to all of Astronomy for

e-Science Tools



Visualization

Viz



Science for Everyone

Outreach

Publishing

Data

Simulation



WorldWide Telescope

e-Science Tools

Viz

WorldWide Telescope Ambassadors Program
<http://www.cfa.harvard.edu/WWTambassadors/>

Harvard University, WGBH & Microsoft Research
Alyssa Goodman, Patricia Udprasert, Annie Valva & Curtis Wong

What is WorldWide Telescope and its Ambassadors Program?
WorldWide Telescope (WWT) is a fun-to-use "Universe Information System" created primarily by Curtis Wong and Jonathan Tay at Microsoft Research. It functions as a virtual astronomical observatory, giving its users a wealth of the world's store of online data and information about our Universe. WWT is evolving to become a key research tool within the online astronomy ecosystem. It is the only program of its kind that offers unprecedented new opportunities for STEM outreach.

Who are we?
The WorldWide Telescope Ambassadors Program promotes WWT as a fun-to-use way to teach and learn STEM concepts by recruiting astronomy-averse volunteers who are trained to be experts in using WWT as a teaching tool.

Who are the WWT Ambassadors, and what do they do?
WWT Ambassadors are carefully recruited for training from amongst: 1) retired STEM professionals and amateur astronomers with a demonstrable deep knowledge of astronomy and physics, 2) undergraduate and graduate students and postdoctoral fellows in Astronomy and Physics, and 3) science teachers. In their training, Ambassadors learn how to use WWT's tools in general, and also how to create and publish guided "Tours" of astronomical concepts. These Tours allow users to explore beautiful astronomical images in their proper context in the right way, while demonstrating the proper processes at work in these images. Ambassadors can create and use materials within WWT, give volunteer presentations at variety of public venues, help out in classroom settings, or choose to do more than one of the above.

What have we done so far?
Our program began in the fall of 2009. Initial Ambassadors are currently working with 80 middle school students and their teacher, Pamela Barry, at the Clarke Middle School in Lexington, MA, helping the students to prepare tours within WWT based on a six-week-long research assignment. WWT and its Ambassadors have generated tremendous enthusiasm from the students, and have inspired quality learning through exploration and discovery. Results from the Pilot at Clarke are being collected online through a dedicated commenting site open to all students, and an analysis of the Pilot experience will serve to inform the full program being submitted to launch in the Spring of 2010.

What's the whole plan, and what are the program's goals?
We are currently preparing a proposal to the National Science Foundation, based in large part on our "Pilot" experience, to implement "Phase 2" of the Ambassadors Project (see below), where we will begin a limited expansion within the US, carefully selecting sites and partners where we will be able to maximize success with the greatest resources, while increasing the socioeconomic diversity of our sites. We plan to expand nationally in Phase 2, and internationally in Phase 3. With national advertising, we have already received inquiries from dozens of interested and qualified potential volunteers in multiple states and countries.

A critical goal of this project is to create a full astronomy curriculum using WWT Tours created by our Ambassadors. These Tours will be vetted by the astronomy and science education professionals within our collaboration, and they will be freely available, centrally managed, and searchable, through web services at WWT. The entire WWT Ambassadors "Tour Curriculum" will be integrated with WGBH Teacher's Domain, which currently has nearly 400,000 registered users.

WorldWide Telescope can help change how students learn science by demonstrating the joys of inquiry and discovery, and the WWT Ambassadors Program is designed to help to increase science literacy in the general public while forming intergenerational connections within their communities.

Phase	Scale	Timeline
Phase 1	Local Area	Fall 2009-Spring 2010
Phase 2	United States	Fall 2010-Summer 2011
Phase 3	US-wide	Fall 2011-Summer 2012
Phase 4	International	2012+

Microsoft Research VVO WGBH

External Research Microsoft Research



WorldWide Telescope: a UIS from Microsoft Research [UIS=Universe Information System]



Seamless *Data/Literature Connections* (e.g. ADS)

“*Modular Craftsmanship*” (e.g. flickr)

Collections, Communities & Guided Tours

**The World Wide Telescope
an Archetype for Online-Science**

Jim Gray (Microsoft)

Alex Szalay (Johns Hopkins University)

Microsoft Academic Days in Silicon Valley

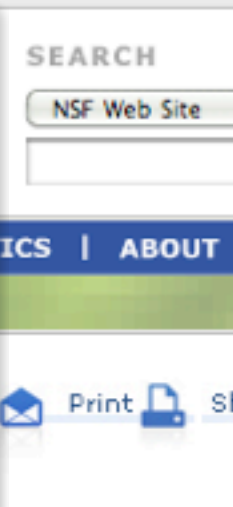
<http://research.microsoft.com/~gray/talks>

Created by Curtis Wong and Jonathan Fay at MSR; AG is “Academic Partner” on the WWT Project

The (US) Backstory

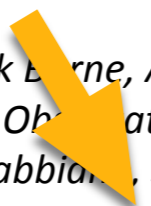
2001 2008 (2010)

Science News
\$10 Million N
ScienceDaily (O
its users the worl
research instituti
starting an ambiti
universe online.



See Also: (NVO), headed by astronomer Alex

NVO senior personnel:
Charles Alcock, University of Pennsylvania Kirk Borne, Astro
Tim Cornwell, NSF National Radio Astronomy Observatory
Optical Astronomy Observatory Giuseppina Fabbiano, Smit
Observatory Alyssa Goodman, [Harvard University](#) Jim Gray
Hanisch, Space Telescope Science Institute George Helou, N
Analysis Center Stephen Kent, Fermilab Carl Kesselman, [Un](#)
Miron Livny, University of Wisconsin, Madison Carol Lonsda
and Analysis Center Tom McGlynn, GSFC/HEASARC/USRA A
University Reagan Moore, San Diego Supercomputer Cente
Naval Observatory, Flagstaff Station Ray Plante, [University](#)
Thomas Prince, California Institute of Technology Ethan Sch
STScI Nicholas White, NASA Goddard Space [Flight Center](#) R
of Technology



1 2 4

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Proposals and Awards

- [Proposal and Award Policies and Procedures Guide](#)
- [Introduction](#)
- [Proposal Preparation and](#)

Management and Operation of the Virtual Astronomical Observatory



CONTACTS

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Eileen D. Friel	efriel@nsf.gov

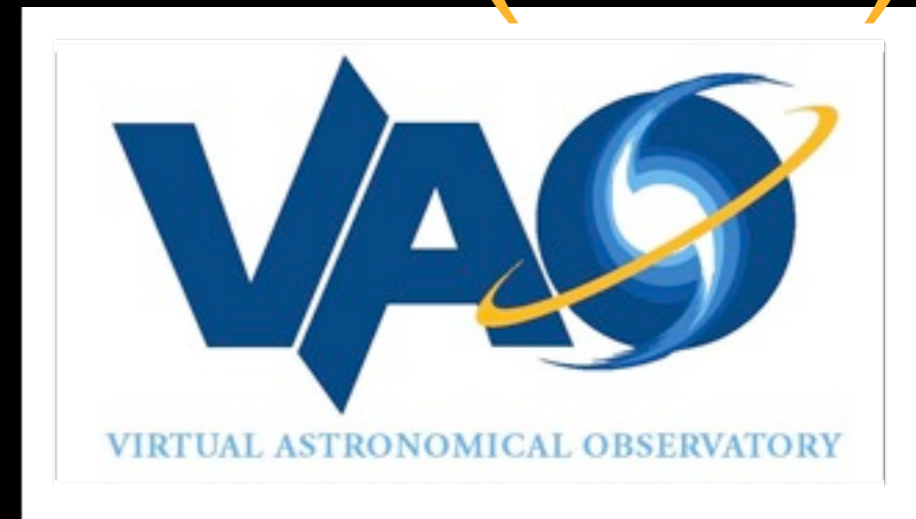
PROGRAM GUIDELINES

Solicitation [08-537](#)

Please be advised that the NSF Proposal & Award Policies & Procedures (PAPPG) includes revised guidelines to implement the mentoring pro the America COMPETES Act (ACA) (Pub. L. No. 110-69, Aug. 9, 2007.) specified in the ACA, each proposal that requests funding to support postdoctoral researchers must include a description of the mentoring that will be provided for such individuals. Proposals that do not comp this requirement will be returned without review (see the PAPP Guide Grant Proposal Guide Chapter II for further information about the implementation of this new requirement).

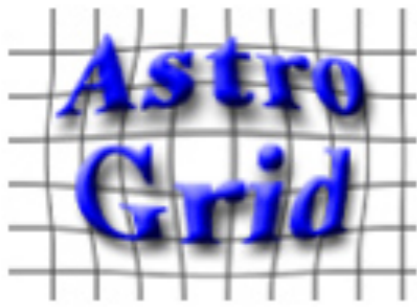


2001 2008 (2010)



and meanwhile...





What/where are/is “Data”?

COMPLETE Data Coverage Tool

http://www.worldwidetelescope.org/COMPLETE/WWTCoverageTool.html#

COMPLETE Data Available

Center on Perseus Center on Ophiuchus Center on Serpens

Full-Cloud Data (Phase I, All Data Available)

Dataset	Show	Perseus	Ophiuchus	Serpens	Link
GBT: HI Data Cube	<input type="checkbox"/>	✓	✓	⊘	Data
IRAS: Av/Temp Maps	<input type="checkbox"/>	✓	✓	✓	Data
FCRAO: 12CO	<input type="checkbox"/>	✓	✓	✓	Data
FCRAO: 13CO	<input type="checkbox"/>	✓	✓	✓	Data
JCMT: 850 microns	<input type="checkbox"/>	✓	✓	⊘	Data
Spitzer c2d: IRAC 1,3 (3.6,5.8 μm)	<input type="checkbox"/>	✓	✓	✓	Data
Spitzer c2d: IRAC 2,4 (4.5,8 μm)	<input type="checkbox"/>	✓	✓	✓	Data
CSO/Bolocam: 1.2-mm	<input type="checkbox"/>	✓	⊘	⊘	Data
Spitzer MIPS: Derived Dust Map	<input type="checkbox"/>	✓	⊘	⊘	Data

Targeted Regions (Phase II, Some Data Not Yet Available)

CTIO/Calar Alto: NIR (J,H,K _s)	<input type="checkbox"/>	✓	✓	⊘	Data
IRAM 30-m: N2H ⁺ and C18O	<input type="checkbox"/>	✓	⊘	⊘	Data
IRAM 30-m: 1.1-mm continuum	<input type="checkbox"/>	✓	⊘	⊘	Data
Megacam/MMT: r,z images	<input type="checkbox"/>	✓	⊘	⊘	Data

Catalogs & Pointed Surveys

NH3 Pointed Survey	<input type="checkbox"/>	✓	⊘	⊘	Data
YSO Candidate list (c2d)	<input type="checkbox"/>	✓	✓	✓	Data

Finder Scope
Classification: Reflection Nebula in Perseus
NGC 1333
RA: 03h29m20s Magnitude: n/a
Dec: 31 : 24 : 57 Distance: n/a
Alt: -09 : 53 : 42 Rise: 17:06
Az: 29 : 51 : 34 Transit: 01:32
Set: 09:48
Image Credits: Copyright DSS Consortium
http://www.gssc.stsci.edu/acknowledgments/

Research Show Object Close

Done

What/where is literature?

Object Query Results

http://adsabs.harvard.edu/cgi-bin/abs_connect?db_key=AST&sim_query=YES&object=NGC%207

agoodman@cfa.harvard.edu | [my Account](#) | [Sign off](#)

SAO/NASA Astrophysics Data System (ADS)

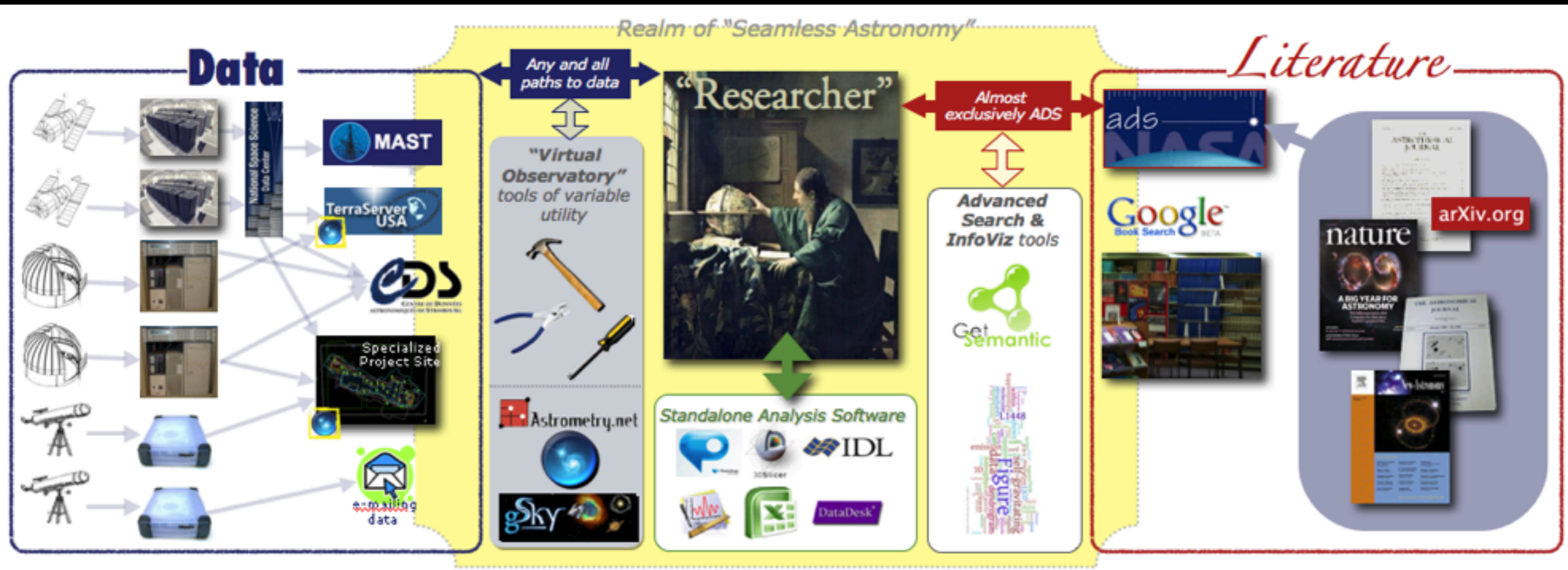
Query Results from the Astronomy Database

Retrieved 200 abstracts, starting with number 1. Total number selected: 393.

Sort options

#	Bibcode Authors	Score	Date	List of Links Access Control Help
1	2009ApJ...700.1609M Myers, Philip C.	1.000	08/2009	A Z E E L X R C S U
2	2009ApJ...700.1190D Desai, Vandana; Soifer, B. T.; Dey, Arjun; LeFloc'h, Emeric; Armus, Lee; Brand, Kate; Brown, Michael J. I.; Brodwin, Mark; Jannuzi, Buell T.; Houck, James R.; and 8 coauthors	1.000	08/2009	A Z E E L X R C S U
3	2009MNRAS.396.1851N Nutter, D.; Stamatellos, D.; Ward- Thompson, D.	1.000	07/2009	A Z E E L X R S U
4	2009A&A...502..175B Boersma, C.; Peeters, E.; Martín- Hernández, N. L.; van der Wolk, G.; Verhoeff, A. P.; Tielens, A. G. G. M.; Waters, L. B. F. M.; Pel, J. W.	1.000	07/2009	A Z E E L R S U
5	2009MNRAS.395.1695H Hernán-Caballero, A.; Pérez-Fourmon, I.; Hatziminaoglou, E.; Afonso-Luis, A.; Rowan-Robinson, M.; Rigopoulou, D.; Farrah, D.; Lonsdale, C. J.; Babbedge, T.;	1.000	05/2009	A Z E E L X R C S U

Seamless Astronomy



But, that was 2009...

Realm of "Seamless Astronomy"

Data



2010
Evermore
Seamless
Astronomy

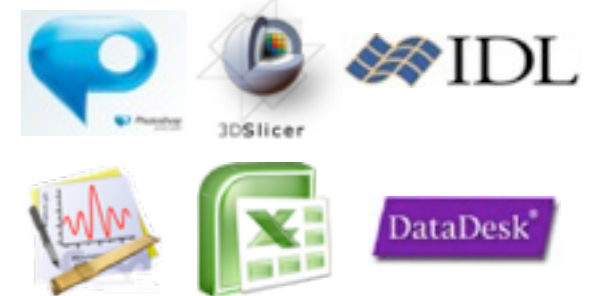
Advanced Search & InfoViz tools



Literature



Standalone Analysis Software



This simple argument, first made at the 2009 WWT session at AAS, seems to be working:

“Astronomy research tools should work as seamlessly as travel research tools.”

“Astronomy research tools should work as seamlessly as travel research tools.”

When the concept of a "**Virtual Observatory**" (**VO**) was first discussed by future-looking astronomers in the mid-1990s, all thoughts were about **distributed data** and a **common system** to access it. But, information access on today's web primarily works in the **reverse**: **distributed tools** accessing **common data centers**. Capability and ease-of-use improvements to the web typically now come in the form of **nesting, aggregating or connecting tools**. Think **kayak.com**, iGoogle, or Bing Maps. In the "Seamless Astronomy" view to be discussed, today's "VO" should be thought of as the **ever-improving set of data archives, tools, interconnections**, and **standards** that strive to make astronomical research as "seamless" as travel research. The good news is that the cutting-edge of the astronomical research environment is moving rapidly in this seamless direction. The most savvy institutions are beginning to realize that the original VO model of data distributed on thousands of individual researchers' desktop hard drives is not a sustainable model, and that they need to offer **data hosting, archiving, and stewardship** services the way libraries offer such services for printed matter. **Software tools** are becoming much more **interoperable** thanks to protocols for message-passing such as "**SAMP**." And, the improved speed of **web applications** is to some extent removing platform-dependence as an obstacle to programmers and users alike. The bad news is that **most astronomers are largely unaware** of the tools that this new nirvana offers, and instead still conduct online research in the same way they did a decade ago. In this talk, I will focus in particular on how our recent work on connecting Microsoft's **WorldWide Telescope** program to other commonly-used astronomical research tools--most notably literature searching tools--has made the astronomical research environment more seamless. More generally, I will emphasize and demonstrate that an **ever-increasing diversity of tools** allow researchers to carry out a particular research task, so that the **important research** for the future lies in figuring out **how to make the tools, their interconnections, and their connections to data and literature resources useful and well-known to the astronomical community**.

From: Abstract Service <ads@cfa.harvard.edu>
 Subject: myADS Notification (Astronomy database)
 Date: March 23, 2010 12:19:23 AM EDT
 To: Alyssa Goodman



myADS Personal Notification Service
 for Alyssa Goodman
 Tue Mar 23 00:19:23 2010
 Astronomy database

- ADS Main Queries**
- [Astronomy](#) **GOODMAN, ALYSSA - Citations: 3310 (total 4002)**
 - [Physics](#) **2010NewA...15..444K: Karatas,+:** New intrinsic-colour calibration for uvby-beta photometry
 - [arXiv e-prints](#) **2010MNRAS.403.1054D: Dabringhausen,+:** Mass loss and expansion of ultra-compact dwarf galaxies through gas expulsion
 - [FAQ](#) **2010ApJ...713..269F: Federrath,+:** Collapse and Accretion in Turbulent Clouds: Implementation and Comparison
 - [What's new](#) **2010ApJ...712.1403P: Pech,+:** Cloud Sink Particles in AMR and SPH
- Current Tables of Contents**
- [Astronomical Journal](#)
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- Favorite Authors - Recent Papers**
- No new articles found
- PROPER MOTION, etc - Recent Papers**
- 2010A&A...511A..90B: Breddels,+:** Distance determination for RAVE stars using stellar

From: Kayak Alert <alert@kayak.com>
 Subject: Your KAYAK Fare Alert: Boston (BOS) > Munich (MUC)
 Date: March 26, 2010 3:52:30 AM EDT
 To: Alyssa Goodman
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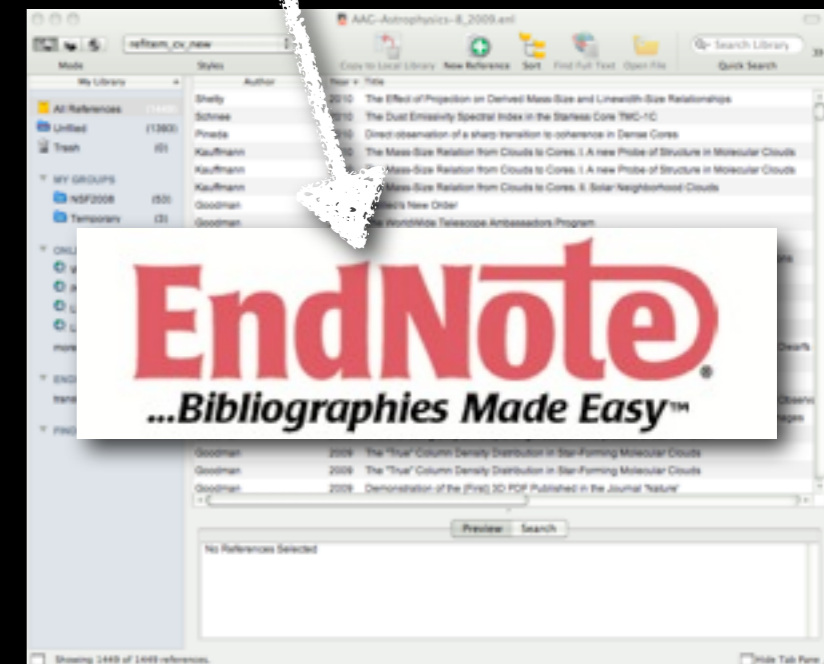
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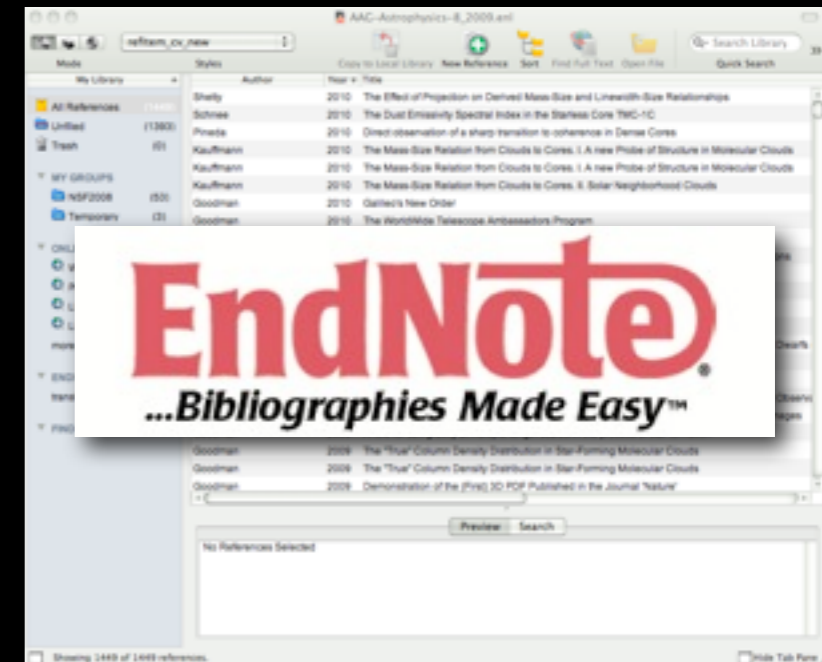
- \$99+ [Baltimore](#)
- \$144+ [Orlando](#)
- \$146+ [Washington](#)
- \$152+ [Atlanta](#)
- \$184+ [Fort Lauderdale](#)

Astronomers
 can see
 parallels...

Literature Handling: *Diverse Apps, Common Data*



What fraction of astronomy researchers know about these tools?



“writemypaper.org?”

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Please enter a list of authors whose publications are particularly relevant for you. They will define a reference region in the network of co-authorship. Experience shows that, on average, satisfactory results are obtained by entering about five names. However, depending on the range of interests, a longer list might be needed (it is usually a good idea to include yourself).

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39 papers

$P = 1.14 \times 10^{-2}$

[34] [arXiv:1003.4900 \[pdf\]](#)

Star-forming gas in young clusters

[Philip C. Myers](#)

Comments: To appear in Astrophysical Journal, May 2010

Subjects: Galaxy Astrophysics (astro-ph.GA)

Initial conditions for star formation in clusters are estimated for protostars whose masses follow the initial mass function (IMF) from 0.05 to 10 solar masses. Star-forming infall is assumed equally likely to stop at any moment, due to gas dispersal dominated by stellar feedback. For spherical infall, the typical initial condensation must have a steep density gradient, as in low-mass cores, surrounded by a shallower gradient, as in the clumps around cores. These properties match observed column densities in cluster-forming regions when the mean infall stopping time is 0.05 Myr and the accretion efficiency is 0.5. The infall duration increases with final protostar mass, from 0.01 to 0.3 Myr, and the mass accretion rate increases from 3 to $300 \times 10^{(-6)}$ solar masses/yr. The typical spherical accretion luminosity is ~ 5 solar luminosities, reducing the luminosity problem to a factor ~ 3 . The initial condensation density gradient changes from steep to shallow at radius 0.04 pc, enclosing 0.9 solar masses, with mean column density $2 \times 10^{(22)}$ $\text{cm}^{(-2)}$, and with effective central temperature 16 K. These initial conditions are denser and warmer than those for isolated star formation.

results are

“writemypaper.org?”

SAO/NASA Astrophysics Data System (ADS)

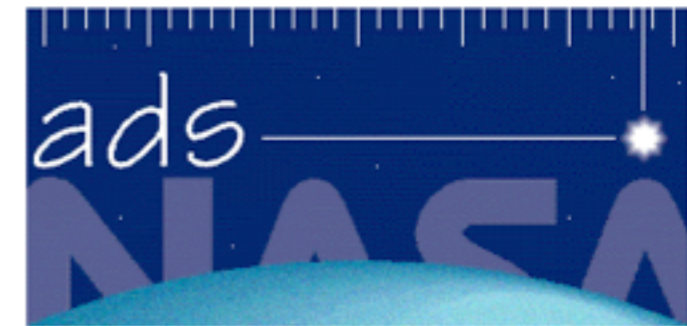
Query Results from the ADS Database

Related Objects

[NAME LMC \(26\)](#)
[NGC 292 \(15\)](#)
[SN 1987A \(13\)](#)
[M 31 \(9\)](#)
[NGC 7293 \(6\)](#)
[NGC 6888 \(6\)](#)
[NGC 6543 \(6\)](#)
[M 33 \(6\)](#)
[HIP 54283 \(6\)](#)
[HIP 33165 \(6\)](#)
[VV 344a \(5\)](#)
[V* eta Car \(5\)](#)
[V* CW Leo \(5\)](#)
[NGC 7027 \(5\)](#)
[SNR G111.7-02.1 \(4\)](#)
[NGC 6826 \(4\)](#)
[NGC 2438 \(4\)](#)
[NAME BUTTERFLY NEBULA \(4\)](#)
[MCG+12-08-033 \(4\)](#)
[GSC 06253-02182 \(4\)](#)
[WR 147 \(3\)](#)
[V* V1302 Aql \(3\)](#)
[V* V1042 Cyg \(3\)](#)
[SNR J052501-693842 \(3\)](#)
[PN G208.5+33.2 \(3\)](#)
[NOVA Aql 1919 \(3\)](#)
[NGC 7009 \(3\)](#)
[NGC 6537 \(3\)](#)
[NGC 3132 \(3\)](#)
[NGC 2440 \(3\)](#)
[NGC 2359 \(3\)](#)
[NGC 891 \(3\)](#)
[NAME MAGELLANIC CLOUDS \(3\)](#)
[NAME LOCAL GROUP \(3\)](#)
[NAME HOMUNCULUS NEBULA \(3\)](#)
[NAME FROSTY LEONIS NEBULA \(3\)](#)

Selected and retrieved 200 abstracts.

#	Bibcode	Score	Date	List of Authors	Title	A	E	F	X	R	C	c	S	U	
1	<input type="checkbox"/> 1995RvMP...67..661B	19.000	Jul 1995	Bisnovatyi-Kogan, G. S.; Silich, S. A.	Shock-wave propagation in the A.	A	E								
2	<input type="checkbox"/> 1999NewAR..43...31F	18.000	May 1999	Frank, A.	Bipolar outflows and the evolution of stars	A	E								
3	<input type="checkbox"/> 2007ARA&A..45..177C	13.000	Sep 2007	Crowther, Paul A.	Physical Properties of Wolf-Rayet Stars	A	E	F	X	R	C	c	S	U	
4	<input type="checkbox"/> 2002ARA&A..40..439B	13.000	n/a 2002	Balick, Bruce; Frank, Adam	Shapes and Shaping of Planetary Nebulae	A	E	F		R	C	c	S	U	
5	<input type="checkbox"/> 2008A&ARv..16..209P	12.000	Dec 2008	Puls, Joachim; Vink, Jorick S.; Najarro, Francisco	Mass loss from hot massive stars	A	E		X	R	C	c		U	
6	<input type="checkbox"/> 2005ApJ...631..435R	12.000	Sep 2005	Ramirez-Ruiz, Enrico; García-Segura, Guillermo; Salmonson, Jay D.; Pérez-Rendón, Brenda	The State of the Circumstellar Medium Surrounding Gamma-Ray Burst Sources and Its Effect on the Afterglow Appearance	A	E	F	X	R	C	c	S	U	
7	<input type="checkbox"/> 1992ARA&A..30..235C	12.000	n/a 1992	Chiosi, Cesare; Bertelli, Gianpaolo; Bressan, Alessandro	New developments in understanding the HR di	A		G		T	R	C	c	S	U



ADS Faceted Topic Search (alpha)

Enter one or more keywords on your subject of interest, sit back and relax.

winds and shells from stars

Search

e.g.: "dark energy", "extrasolar planets", "weak lensing", "spin hall"

Keyword Search:

- Most relevant
- Most recent
- Most important

Subject Area Search:

- Most popular
- Most useful
- Most instructive

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ngc 7023

Plot Results

VO Search

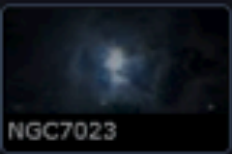
J2000

RA

Dec

Go

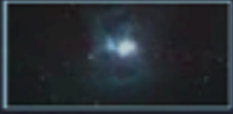
1 of 2



NGC7023



Finder Scope



Classification:
Reflection Nebula
in Cepheus

NGC 7023

RA:	21h01m36s	Magnitude:	n/a
Dec:	68 : 10 : 11	Distance:	n/a
Alt:	30 : 55 : 38	Rise:	Circumpolar
Az:	341 : 36 : 56	Transit:	Circumpolar
		Set:	Circumpolar

Image Credits:
Jack Newton

<http://www.jacknewton.com/>

Research Show Object Close

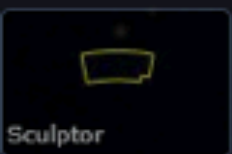
Look At

Imagery

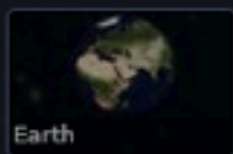
Sky

Digitized Sky Survey (Opt)

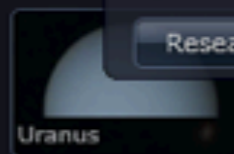
<http://www.jacknewton.com/>



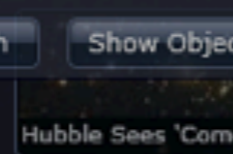
Sculptor



Earth



Uranus



Hubble Sees 'Coma'



NGC 300



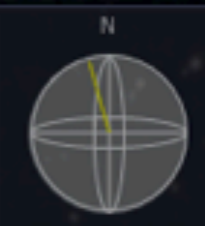
Sculptor Galaxy



Cartwheel Galaxy

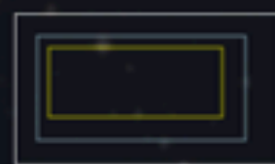


Cartwheel Galaxy



RA : 21h01m36s

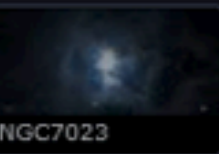
Cepheus 00:14:04



1 of 23

Explore Guided Tours Search View Settings


ngc 7023 Plot Results VO Search J2000 RA Dec Go 1 of 2



NGC7023



Finder Scope



Classification:
Reflection Nebula
in Cepheus

NGC 7023

RA: 21h01m36s Magnitude: n/a
Dec: 68 : 10 : 11 Distance: n/a
Alt: 30 : 53 : 38 Rise: Circumpolar

Name: NGC 7023

Information ▶
Imagery ▶
Virtual Observatory Searches ▶
Set as Foreground Imagery
Set as Background Imagery Close

Properties
Copy Shortcut

- Look up on SIMBAD
- Look up on SEDS
- Look up on Wikipedia
- Look up publications on ADS**
- Look up on NED
- Look up on SDSS



Look At Imagery

Sky Digitized Sky Survey (Optical)

Sculptor Earth Uranus

1 of 23



Cepheus 00:1

RA : 21h01m36s
Dec : 68:10:11

Sculptor Galaxy Cartwheel Galaxy Cartwheel Galaxy

[SAO/NASA Astrophysics Data System \(ADS\)](#)

Query Results from the Astronomy Database

[Go to bottom of page](#)

Retrieved 200 abstracts, starting with number 1. Total number selected: 393.

Sort options

#	Bibcode Authors	Score	Date	List of Links Access Control Help				
1	<input type="checkbox"/> 2009ApJ...700.1609M Myers, Philip C.	1.000	08/2009	A Z E F L X	R	C	S	U
2	<input type="checkbox"/> 2009ApJ...700.1190D Desai, Vandana; Soifer, B. T.; Dey, Arjun; LeFloc'h, Emeric; Armus, Lee; Brand, Kate; Brown, Michael J. I.; Brodwin, Mark; Jannuzi, Buell T.; Houck, James R.; and 8 coauthors	1.000	08/2009	A Z E F L X	R	C	S	U
3	<input type="checkbox"/> 2009MNRAS.396.1851N Nutter, D.; Stamatellos, D.; Ward- Thompson, D.	1.000	07/2009	A Z E F L X	R		S	U
4	<input type="checkbox"/> 2009A&A...502..175B Boersma, C.; Peeters, E.; Martín- Hernández, N. L.; van der Wolk, G.; Verhoeff, A. P.; Tielens, A. G. G. M.; Waters, L. B. F. M.; Pel, J. W.	1.000	07/2009	A Z E F L	R		S	U
5	<input type="checkbox"/> 2009MNRAS.395.1695H Hernán-Caballero, A.; Pérez-Fourmon, I.; Hatziminaoglou, E.; Afonso-Luis, A.; Rowan-Robinson, M.; Rigopoulou, D.; Farrah, D.; Lonsdale, C. J.; Babbedge, T.;	1.000	05/2009	A Z E F L X	R	C	S	U

ngc 7023

Plot Results

VO Search

J2000

RA

Dec

Go

1 of 2

NGC7023



Finder Scope



Classification:
Reflection Nebula
in Cepheus

NGC 7023

RA: 21h01m36s Magnitude: n/a
Dec: 68 : 10 : 11 Distance: n/a
Alt: 30 : 53 : 38 Rise: Circumpolar
Az: 341 : 10 : 11 Set: Circumpolar

Name: NGC 7023

- Information
- Imagery
- Virtual Observatory Searches
- Set as Foreground Imagery
- Set as Background Imagery
- Properties
- Copy Shortcut

- Look up on SIMBAD
- Look up on SEDS
- Look up on Wikipedia
- Look up publications on ADS
- Look up on NED
- Look up on SDSS



Look At: Sky

Imagery: Digitized Sky Survey (Optical)

Sculptor Earth Uranus

1 of 23

Cepheus 00:1



RA : 21h01m36s
Dec : 68:10:11

Sculptor Galaxy Cartwheel Galaxy Cartwheel Galaxy



SIMBAD query result

[other query modes](#) :
 [Identifier query](#)
[Coordinate query](#)
[Criteria query](#)
[Bibliography query](#)
[Basic query](#)
[Script submission](#)
[Output options](#)
[Help](#)

Object query : NGC 7023

C.D.S. - SIMBAD4 rel 1.132 - 2009.10.23CEST21:59:31

[Available data](#)[Basic data](#)[Identifiers](#)[Plot & images](#)[Bibliography](#)[Measurements](#)[External archives](#)[Notes](#)

Basic data :

NGC 7023 -- Open (galactic) Cluster

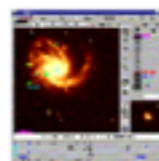
 with radius arcmin

Other object types: **C1*** (C,C1,[BDB2003]) ,**OpC** (OCISM) ,**MII** (LBN) ,**V*** (AAVSO) ,**IR** (IRAS)
 ICRS coord. (ep=2000): 21 01 36.9 +68 09 48 (-) [- - -] D -
 FK5 coord. (ep=2000 eq=2000): 21 01 36.9 +68 09 48 (-) [- - -] D -
 104.0616 +14.1926 (-) [- - -] D -
 Fluxes (I): **B** 7.20 [-] D -

Identifiers (11) :

NGC 7023	IRAS 20599+6755	LBN 487	IBDB2003 G104.06+14.19
C 2059+679	IRAS F20599+6755	OCISM 50	AAVSO 2044+67
C1 VDB 139	LBN 104.08+14.21	OCl 235	

Plots and Images

 radius arcmin


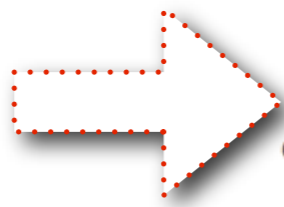
References (371 between 1983 and 2009)

Simbad bibliographic survey began in 1950 for stars (at least bright stars) and in 1983 for all other objects (outside the solar system).

from: to:



[ADS Faceted Topic Search \(alpha\)](#)



PAH Search

e.g.: ["dark energy"](#), ["extrasolar planets"](#), ["weak lensing"](#) ["spin hall"](#)

Keyword Search:

- Most relevant
- Most recent
- Most important

Subject Area Search:

- Most popular
- Most useful
- Most instructive

[ADS Home](#) | [Abstract Search](#) | [Help](#)

*“alpha” Faceted Topic Search in ADS
(courtesy of Michael Kurtz & Alberto Accomazzi)*

ADS Query Results

http://adsres.cfa.harvard.edu/cgi-bin/topicFacetSearch?q=PAH;qtype=RELEVANT

SAO/NASA Astrophysics Data System (ADS)

Query Results from the ADS Database [Go to bottom of page](#)

Selected and retrieved 200 abstracts. Sort options

#	Bibcode Authors	Score	Date	List of Links Access Control Help
1	<input type="checkbox"/> 2007ApJ...657..810D Draine, B. T.; Li, Aigen	100.000	Mar 2007	A E F X R C c S N O U
2	<input type="checkbox"/> 2007ApJ...663..866D Draine, B. T.; Dale, D. A.; Bendo, G.; Gordon, K. D.; Smith, J. D. T.; Armus, L.; Engelbracht, C. W.; Helou, G.; Kennicutt, R. C., Jr.; Li, A.; and 10 coauthors	96.842	Jul 2007	A E F X R C c S N U
3	<input type="checkbox"/> 2007ApJ...654L..49S Spoon, H. W. W.; Marshall, J. A.; Houck, J. R.; Elitzur, M.; Hao, L.; Armus, L.; Brandl, B. R.; Charmandaris, V.	95.232	Jan 2007	A E F X R C c S N U
4	<input type="checkbox"/> 2005ApJ...628L..29E Engelbracht, C. W.; Gordon, K. D.; Rieke, G. H.; Werner, M. W.; Dale, D. A.; Latter, W. B.	95.090	Jul 2005	A E F X R C c S N U

Related Objects

- [M 82 \(14\)](#)
- [NGC 7027 \(12\)](#)
- [NGC 7023 \(10\)](#)
- [NAME ORI BAR \(10\)](#)
- [NAME RED RECTANGLE \(9\)](#)
- [QSO B1254+571 \(8\)](#)
- [NGC 2023 \(8\)](#)
- [NGC 253 \(8\)](#)
- [M 17 \(8\)](#)
- [PN G093.9-00.1 \(7\)](#)
- [NGC 7714 \(7\)](#)
- [IC 4553 \(7\)](#)
- [NGC 6240 \(6\)](#)
- [NGC 292 \(5\)](#)
- [NAME RHO OPH REGION \(5\)](#)
- [NAME LMC \(5\)](#)
- [MCG+10-14-025 \(5\)](#)
- [4C 47.36A \(5\)](#)
- [VV 65 \(4\)](#)
- [SBSG 0335-052 \(4\)](#)
- [QSO B2300+086 \(4\)](#)
- [NGC 7331 \(4\)](#)
- [NGC 4151 \(4\)](#)
- [NGC 1808 \(4\)](#)
- [NGC 1097 \(4\)](#)
- [NAME CAMPBELL'S HYDROGEN STAR \(4\)](#)
- [Mrk 273 \(4\)](#)
- [M 81 \(4\)](#)
- [M 42 \(4\)](#)
- [GSC 02342-00359 \(4\)](#)
- [\[KIB2003\] G29.957-0.018 \(3\)](#)
- [\[KIB2003\] G23.955+0.150 \(3\)](#)

Open "http://www.worldwidetelescope.org/wwtweb/goto.aspx?object=NGC%20%207023&ra=21.026913&dec=58.163300" in a new window

list of objects with links to WWT browser
(thanks to ADS team & Jonathan Fay)

And now we got to NGC 7023 by using the literature as a filter.

The screenshot displays the Microsoft WorldWide Telescope Web Client interface. At the top, the browser address bar shows the URL <http://www.worldwidetelescope.org/webclient/default.aspx?wtml=http%3a%2f%2f>. The navigation menu includes 'Explore', 'Guided Tours', 'Search', 'View', and 'Settings'. Below the menu, a breadcrumb trail reads 'Collections > Open Collections > Link Collection >'. A small thumbnail of NGC 7023 is visible in the top left corner, labeled 'NGC 7023'. The main viewing area shows a large, detailed image of the star cluster NGC 7023, which is a bright blue-white star surrounded by a diffuse blue nebula. The bottom control panel features a 'Look At' dropdown set to 'Sky', an 'Imagery' dropdown set to 'Digitized Sky Survey (Optical)', and an 'Info' icon. Below these are three thumbnail images: 'Cepheus', 'NGC 7023', and 'NGC7023'. On the right side of the control panel, there is a compass rose, a map of the constellation Cepheus with a yellow box indicating the current view, and the coordinates RA : 21h01m37s and Dec : 68:09:48. The text 'Cepheus 00:39:04' is also present. The bottom left corner of the interface shows the word 'Done'.

NEWSROOM

- Press Releases
 - Chronological
 - By Subject
 - Outside Institutions
- What's Happening Archive
- Visuals
 - Image Use Policy
- Update Notifications
 - Mailing List
 - RSS Feed (XML)
- References
 - Fast Facts
 - Press Kit (.pdf)
 - Fact Sheet (.pdf)
 - Field Guides
 - Glossary
- Media Contacts

INTRODUCTION PRESS RELEASE VISUALS QUICK FACTS



Credit: NASA/JPL-Caltech/A. Noriega-Crespo (SSC/Caltech), Digital Sky Survey

HH46/47

This image from NASA's Spitzer Space Telescope transforms a dark cloud into a silky translucent veil, revealing the molecular outflow from an otherwise hidden newborn star. Using near-infrared light, Spitzer pierces through the dark cloud to detect the embedded outflow in an object called HH 46/47. Herbig-Haro (HH) objects are bright, nebulous regions of gas and dust that are usually buried within dark clouds. They are formed when supersonic gas ejected from a forming protostar, or embryonic star, interacts with the surrounding interstellar medium. These young stars are often detected only in the infrared.

The Spitzer image was obtained with the infrared array camera. Emission at 3.6 microns is shown as blue, emission from 4.5 and 5.8 microns has been combined as green, and 8.0 micron emission is depicted as red.

HH 46/47 is a striking example of a low-mass protostar ejecting a jet and creating a bipolar or two-sided outflow. The central

Seamlessness
through...

flickr
+
astrometry.net
+
WWT !?

HH4647

Share This

ADD NOTE SEND TO GROUP ADD TO SET BLOG THIS ALL SIZES ORDER PRINTS ROTATE EDIT PHOTO DELETE



Embedded Outflow in HH 46/47

Spitzer Space Telescope • IRAC

NASA / JPL-Caltech / A. Noriega-Crespo (SSC/Caltech)

Instr: visible light (IRAC) bsc2003-064

Uploaded on January 6, 2009 by Alyssa_Goodman

Alyssa_Goodman's photostream




16 uploads

browse

This photo also belongs to:

+ astrometry (Pool) x

Tags

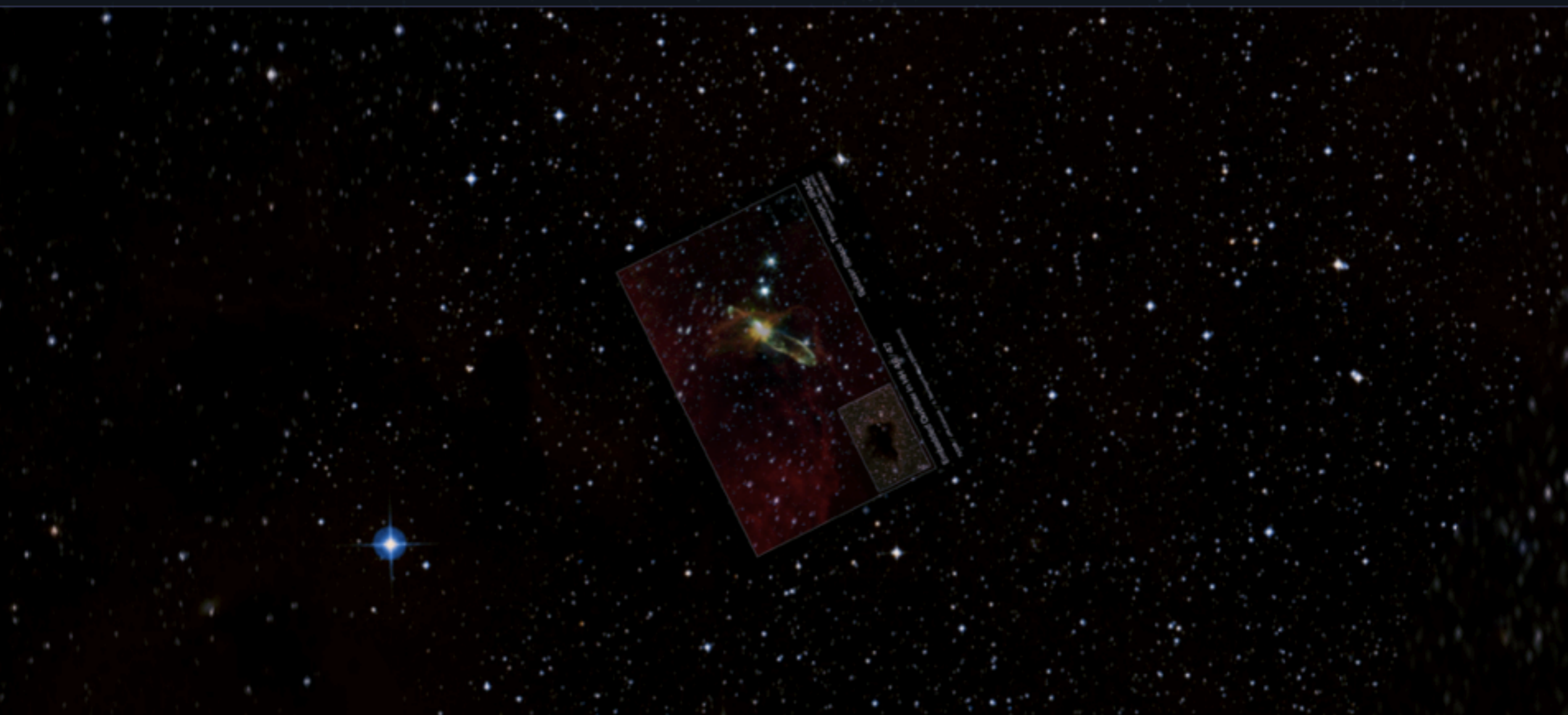
- Astrometrydotnet:version=10145 x
- Astrometrydotnet:id=alpha-200901-20629873 x
- Astrometrydotnet:status=solved x

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Additional Information

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- Viewed 7 times (Not including you)
- [Edit title, description, and tags](#)

[Flag your photo](#)



Look At: Sky | Imagery: Digitized Sky Survey (Optical) | Info: ⓘ | Image Crossfade: [Slider]

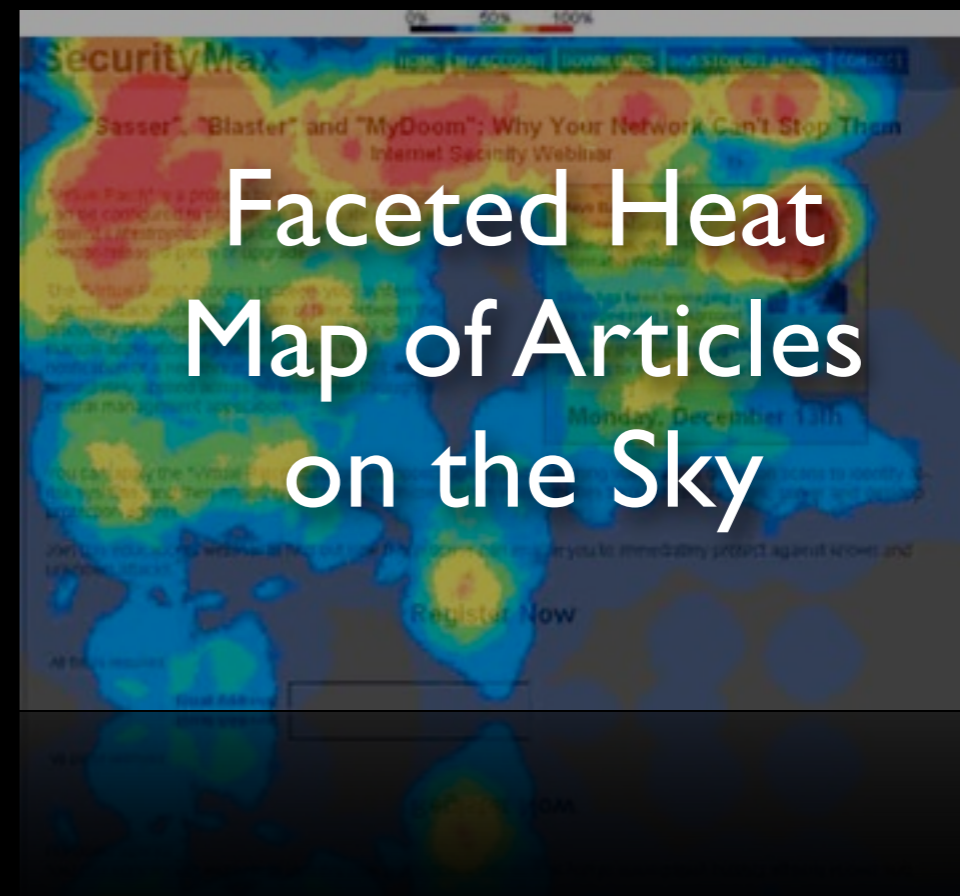
Navigation: 1 of 1

Map: Vela constellation, RA: 08h25m39s, Dec: -51:01:10, 00:35:33

Thumbnail: Vela | Bubbly Little Star

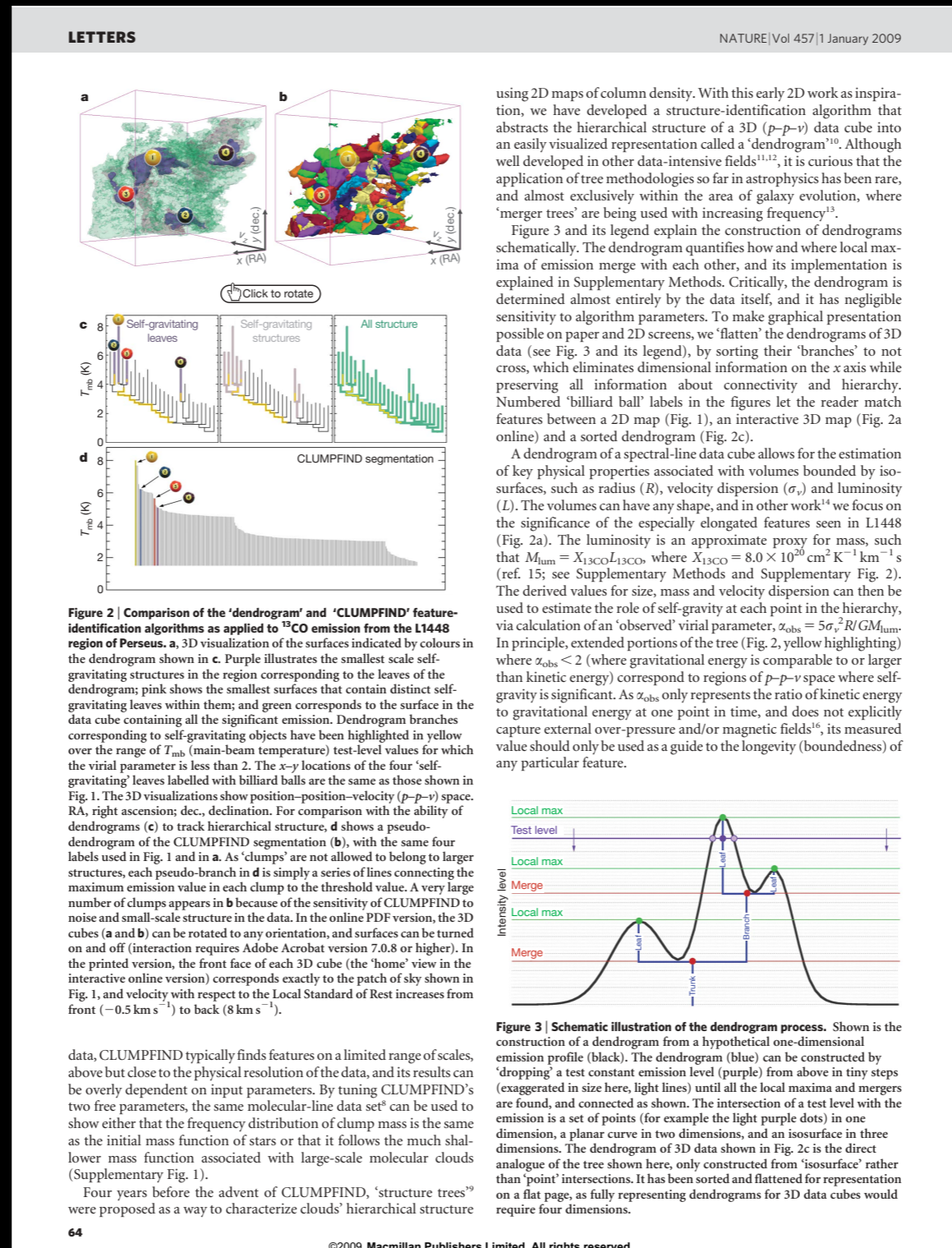
Coming Soon from ADS (I hope!)

Historical Image Layer
Extracted from ALL
ADS holdings (using
astrometry.net)



The future is here... data *IN* articles

Note: This work came from the "AstroMed" project am.iic.harvard.edu



using 2D maps of column density. With this early 2D work as inspiration, we have developed a structure-identification algorithm that abstracts the hierarchical structure of a 3D (p - p - v) data cube into an easily visualized representation called a 'dendrogram'¹⁰. Although well developed in other data-intensive fields^{11,12}, it is curious that the application of tree methodologies so far in astrophysics has been rare, and almost exclusively within the area of galaxy evolution, where 'merger trees' are being used with increasing frequency¹³.

Figure 3 and its legend explain the construction of dendrograms schematically. The dendrogram quantifies how and where local maxima of emission merge with each other, and its implementation is explained in Supplementary Methods. Critically, the dendrogram is determined almost entirely by the data itself, and it has negligible sensitivity to algorithm parameters. To make graphical presentation possible on paper and 2D screens, we 'flatten' the dendrograms of 3D data (see Fig. 3 and its legend), by sorting their 'branches' to not cross, which eliminates dimensional information on the x axis while preserving all information about connectivity and hierarchy. Numbered 'billiard ball' labels in the figures let the reader match features between a 2D map (Fig. 1), an interactive 3D map (Fig. 2a online) and a sorted dendrogram (Fig. 2c).

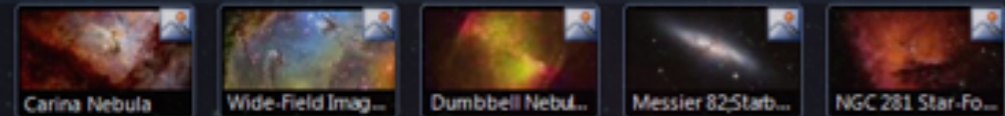
A dendrogram of a spectral-line data cube allows for the estimation of key physical properties associated with volumes bounded by isosurfaces, such as radius (R), velocity dispersion (σ_v) and luminosity (L). The volumes can have any shape, and in other work¹⁴ we focus on the significance of the especially elongated features seen in L1448 (Fig. 2a). The luminosity is an approximate proxy for mass, such that $M_{\text{lum}} = X_{13\text{CO}} L_{13\text{CO}}$, where $X_{13\text{CO}} = 8.0 \times 10^{20} \text{ cm}^{-2} \text{ K}^{-1} \text{ km}^{-1} \text{ s}$ (ref. 15; see Supplementary Methods and Supplementary Fig. 2). The derived values for size, mass and velocity dispersion can then be used to estimate the role of self-gravity at each point in the hierarchy, via calculation of an 'observed' virial parameter, $\alpha_{\text{obs}} = 5\sigma_v^2 R / GM_{\text{lum}}$. In principle, extended portions of the tree (Fig. 2, yellow highlighting) where $\alpha_{\text{obs}} < 2$ (where gravitational energy is comparable to or larger than kinetic energy) correspond to regions of p - p - v space where self-gravity is significant. As α_{obs} only represents the ratio of kinetic energy to gravitational energy at one point in time, and does not explicitly capture external over-pressure and/or magnetic fields¹⁶, its measured value should only be used as a guide to the longevity (boundedness) of any particular feature.

data, CLUMPFIND typically finds features on a limited range of scales, above but close to the physical resolution of the data, and its results can be overly dependent on input parameters. By tuning CLUMPFIND's two free parameters, the same molecular-line data set⁸ can be used to show either that the frequency distribution of clump mass is the same as the initial mass function of stars or that it follows the much shallower mass function associated with large-scale molecular clouds (Supplementary Fig. 1).

Four years before the advent of CLUMPFIND, 'structure trees'⁹ were proposed as a way to characterize clouds' hierarchical structure



Studies >



“Old Data”

astrometry.net/flickr/WWWT

“New Data”

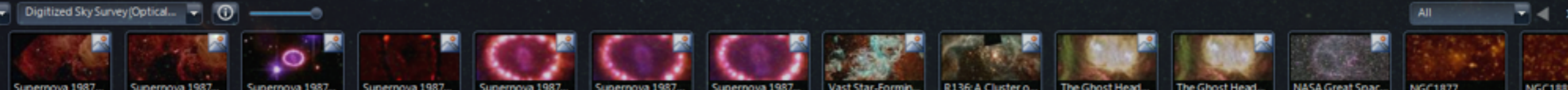
WWWT/ADS/SIMBAD/NAO

WWWT as API

“Your Data”

3D PDF

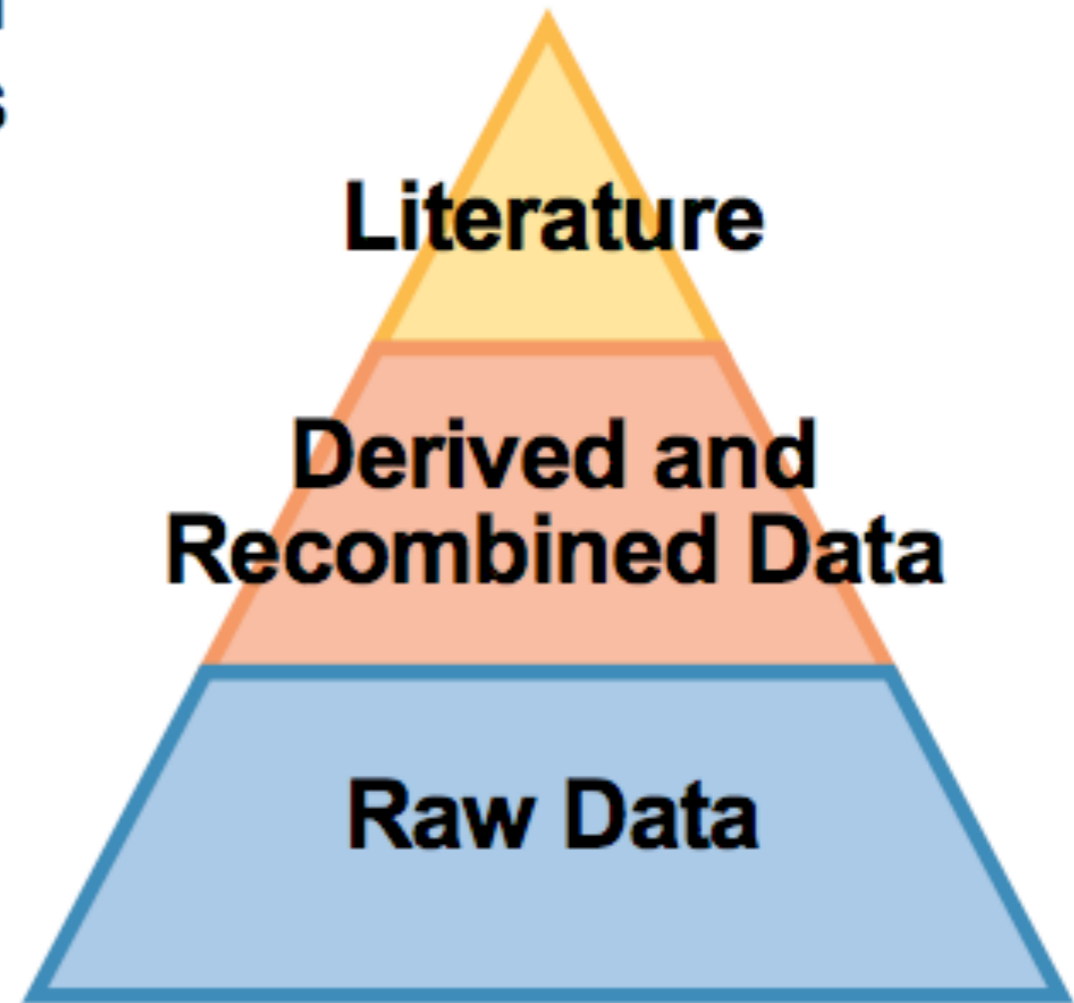
“My Data”



Jim Gray (& Alex Szalay) had it right (in 2004)

All Scientific Data Online

- Many disciplines overlap and use data from other sciences
- Internet can unify all literature and data
- Go from literature to computation to data back to literature
- Information at your fingertips for everyone-everywhere
- Increase Scientific Information Velocity
- Huge increase in Science Productivity



Jim Gray (& Alex Szalay) had it right (in 2004)

The World Wide Telescope an Archetype for Online-Science

Jim Gray (Microsoft)

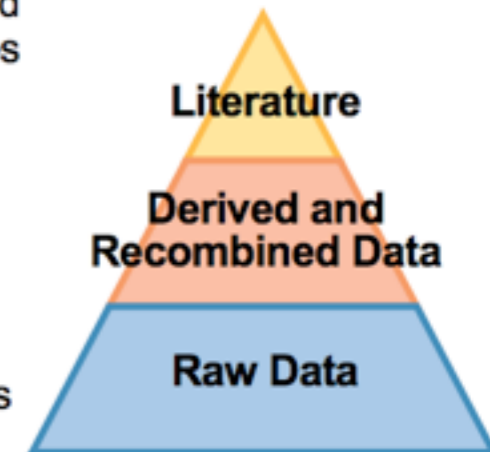
Alex Szalay (Johns Hopkins University)

Microsoft Academic Days in Silicon Valley

<http://research.microsoft.com/~gray/talks>

All Scientific Data Online

- Many disciplines overlap and use data from other sciences
- Internet can unify all literature and data
- Go from literature to computation to data back to literature
- Information at your fingertips for everyone-everywhere
- Increase Scientific Information Velocity
- Huge increase in Science Productivity



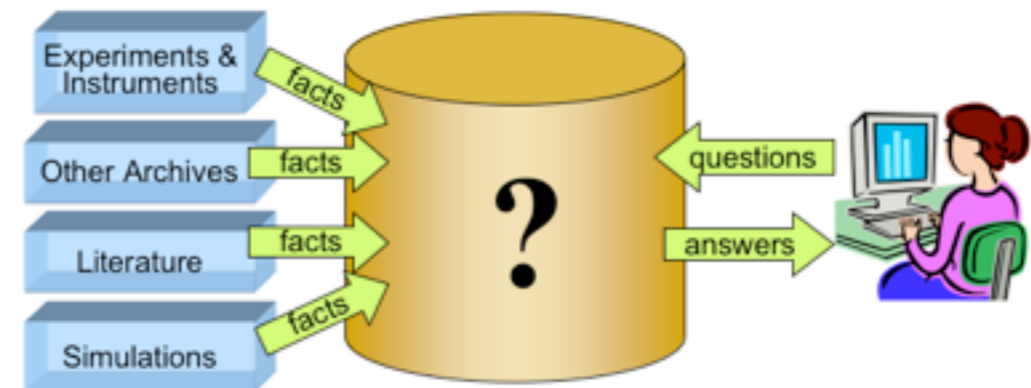
World Wide Telescope Virtual Observatory

<http://www.ivoa.net/>

- Premise:
 - **Most data is (or could be online)**
- The Internet is the world's best telescope:
 - It has data on every part of the sky
 - In every measured spectral band: optical, x-ray, radio
 - As deep as the best instruments (2 years ago).
 - It is up when you are up. The "seeing" is always great (no working at night, no clouds no moons no..).
 - **It's a smart telescope: links objects and data to literature on them.**



The Big Picture



The Big Problems

- Data ingest
- Managing a petabyte
- Common schema
- How to organize it?
- How to reorganize it
- How to coexist with others
- **Query and Vis tools**
- **Support/training**
- Performance
 - Execute queries in a minute
 - Batch query scheduling

How do we increase the fraction of astronomy researchers who know about these tools?



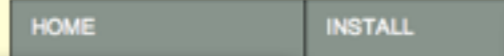
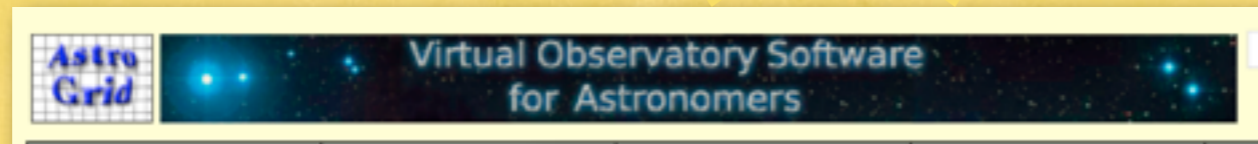
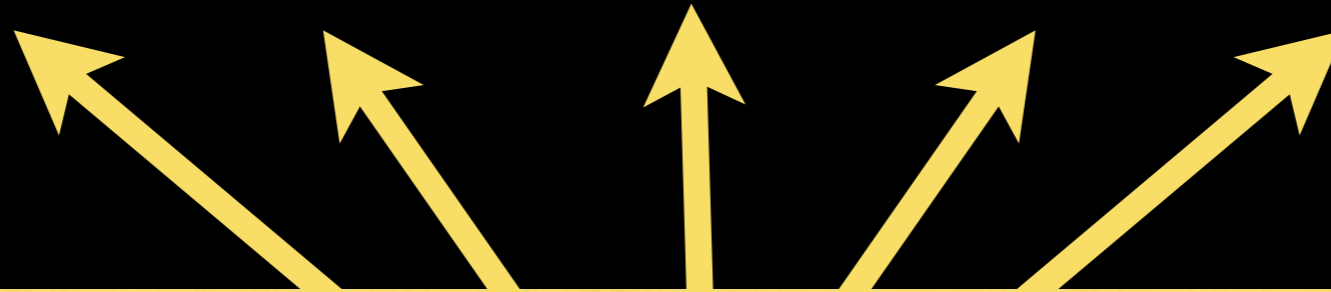
User Groups
(CfA now has one)



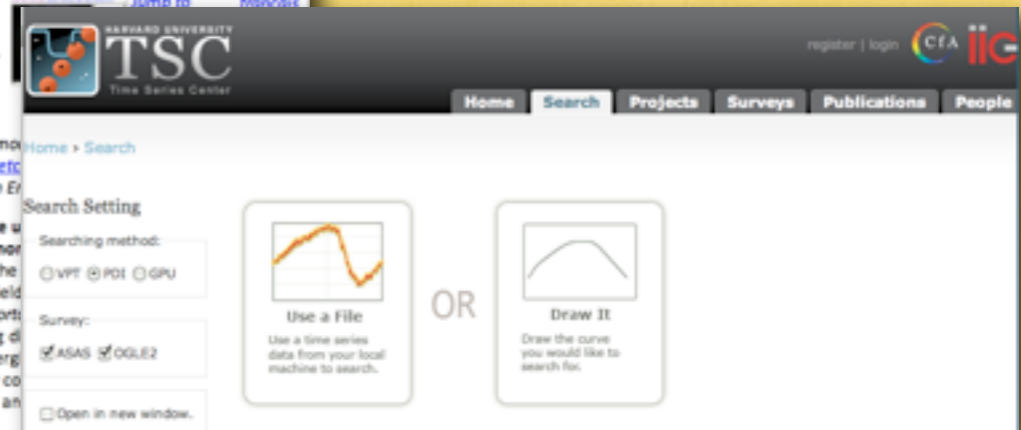
+Suggestions?!



User Groups (CfA now has one)



oGrid is the doorw
ple astronomers to
OSpace, query dat
automate sequences



How do we increase the number of people who create and interlink new tools?

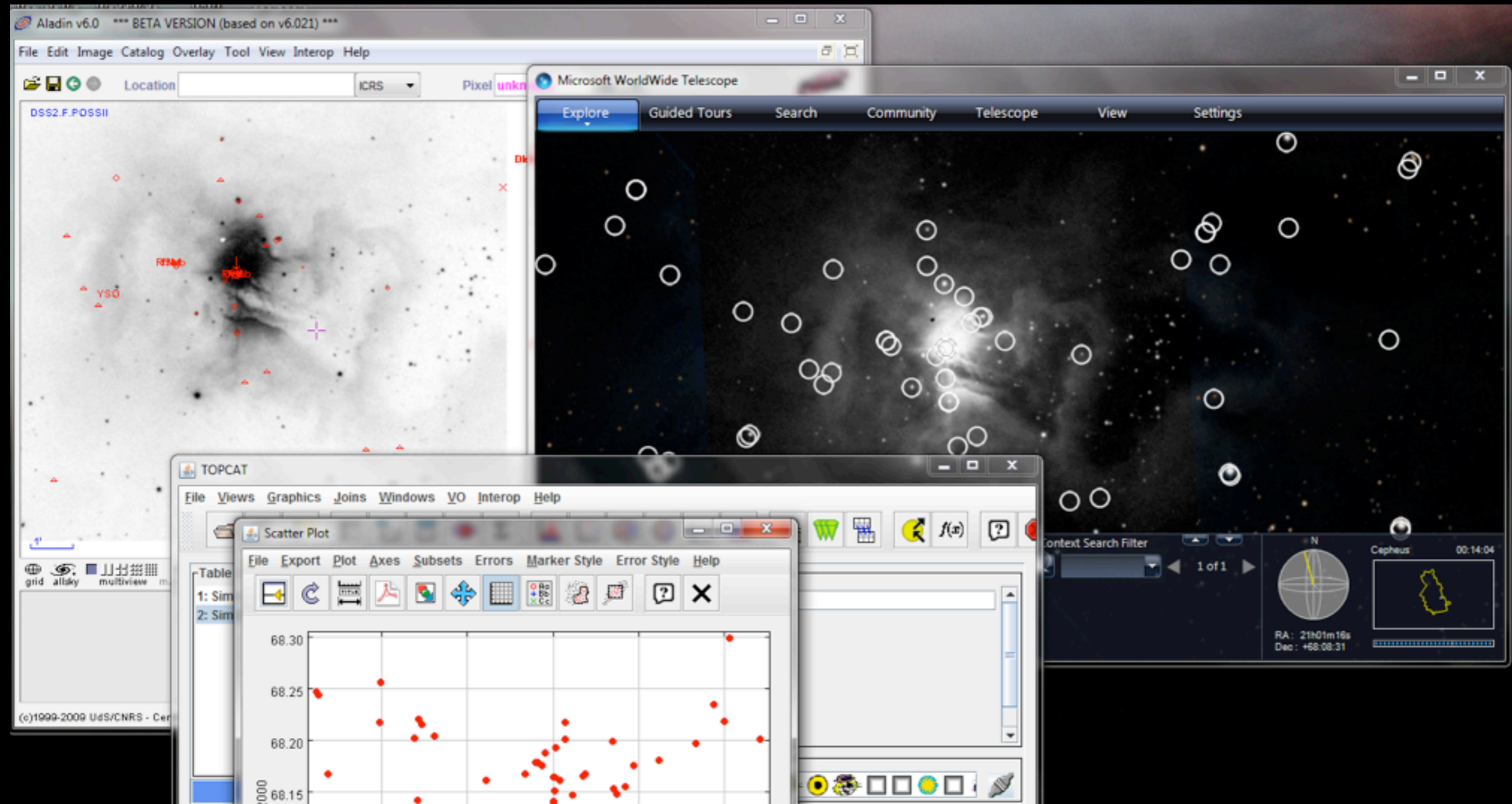
Kiva model  proposed here in 2009...

Now being implemented through VAO “Associates”
and WWT Partners.

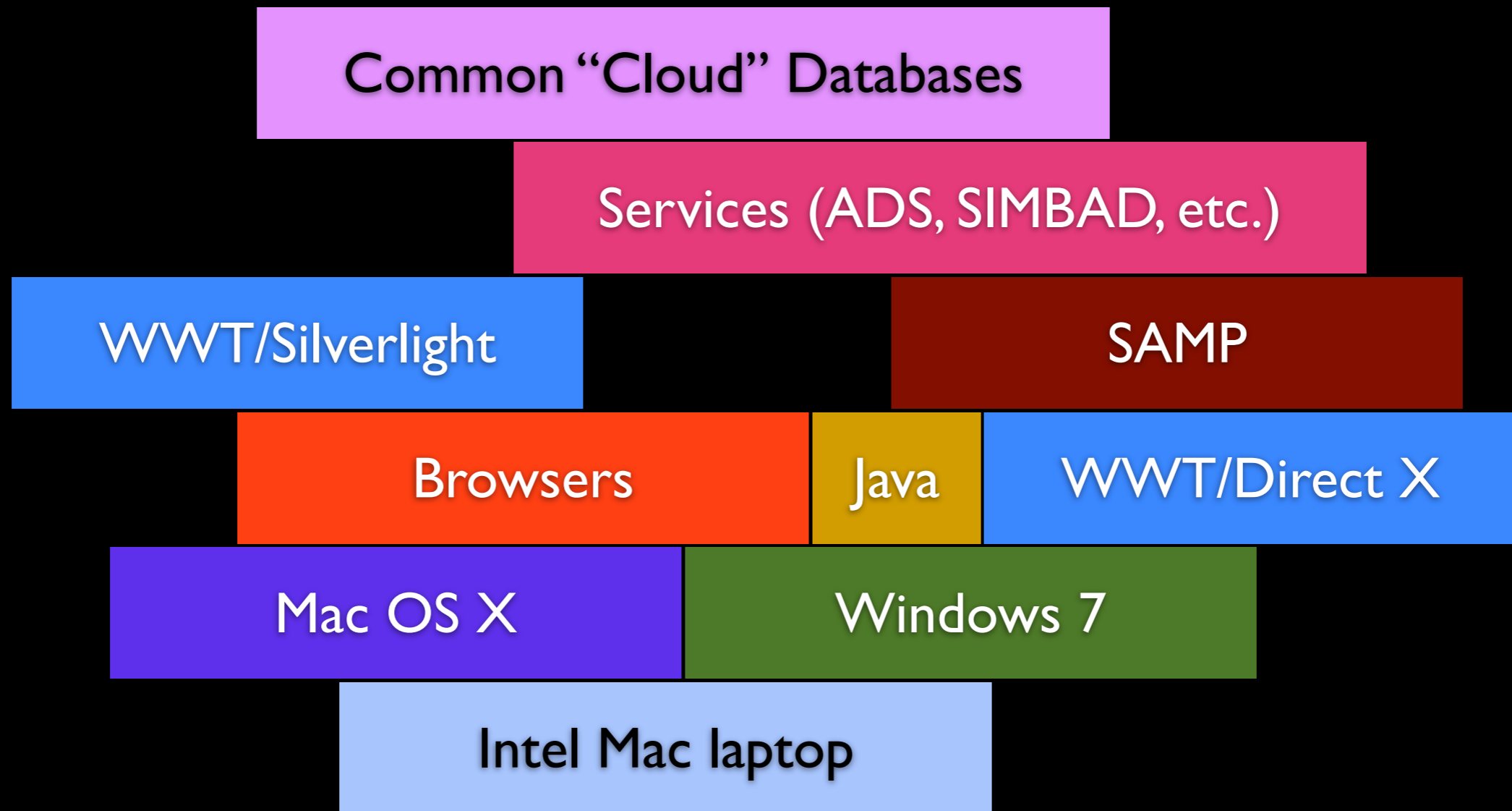
How do we organize such diverse tools, so as to make them interoperably useful?....

“SAMP” is a great technical start, but offers a very significant user interface challenge.

SAMP



Think about the “modules” needed to make this work...but do the details matter, to your research, if the system works seamlessly?



Seamless Astronomy

The interface is titled "AstroNavigator" and features a navigation bar with "Project 1", "Project 2", "Project 3", and "Edit" buttons. A "Literature Viewer" window is open, displaying a search result for "QSO MgII absorption lines observed" by Drinkwater and Webster. The result includes a large letter "A" and a description. To the right of the literature viewer is a "Data Viewer" showing a 3D visualization of a galaxy cluster with a central red region. Below the literature viewer is a "Figure 2" plot showing the "Fraction of Emission in Self-gravitating Structures" versus "Scale (pc)" on a log-log scale. The plot compares "Simulation" (circles) and "L1448" (squares) data. The simulation data shows a high fraction of emission in self-gravitating structures across all scales, while the L1448 data shows a much lower fraction. A "Data Viewer (e.g. WWT)" window is also visible, showing a 3D visualization of a galaxy cluster. On the right side, there is a "Ar3Dive Browser" window showing a 3D visualization of a galaxy cluster and search results for "IC 348".

Semantic Search

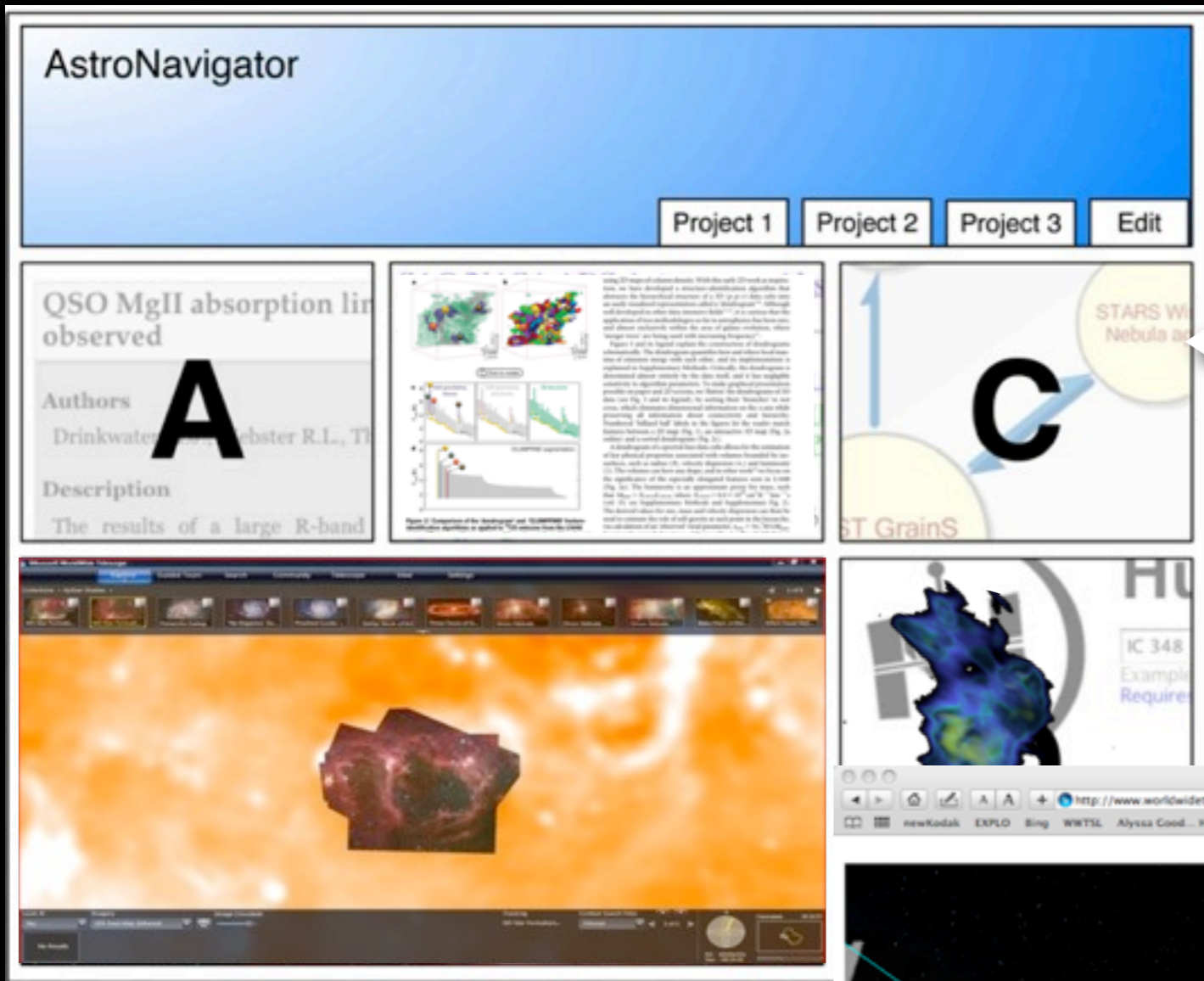
Literature Viewer

Info-Viz for Analytics Results

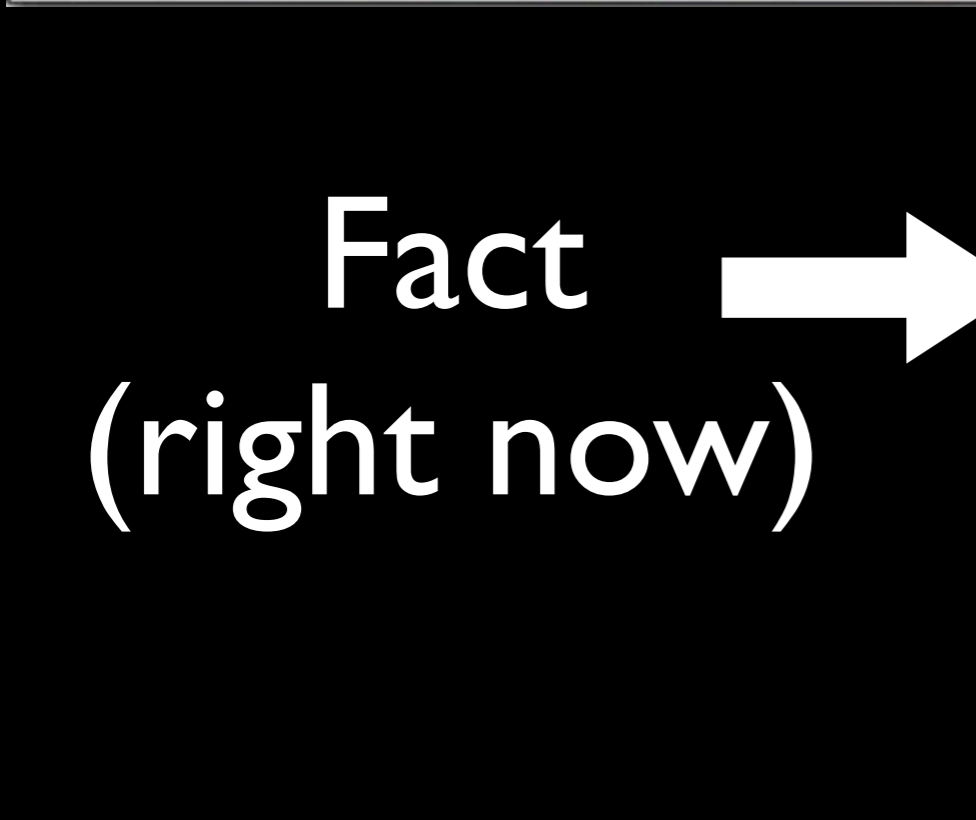
Data Viewer (e.g. WWT)

Ar3Dive Browser

Mockup based on work of Eli Bressert, excerpted from NASA AISRP proposal by Goodman, Muench, Christian, Conti, Kurtz, Burke, Accomazzi, McGuinness, Hendler & Wong, 2008



Fiction
(for now)



Fact
(right now)

COMPLETE Data Available					
Dataset	Show	Perseus	Ophiuchus	Serpens	Link
Full-Cloud Data (Phase I, All Data Available)					
GBT: HI Data Cube	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Data
IRAS: Av/Temp Maps	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Data
FCRAO: 12CO	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Data
FCRAO: 13CO	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Data
JCMT: 850 microns	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Data
Spitzer c2d: IRAC 1.3 (3.6,5.8 μm)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Data
Spitzer c2d: IRAC 2.4 (4.5,8 μm)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Data
CSO/Bolocam: 1.2-mm	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Data
Spitzer MIPS: Derived Dust Map	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Data
Targeted Regions (Phase II, Some Data Not Yet Available)					
CTIO/Calar Alto: NIR (J,H,Ks)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	Data
IRAM 30-m: N2H+ and C18O	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Data
IRAM 30-m: 1.1-mm continuum	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Data
Megacam/MMT: r,i,z Images	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Data
Catalogs & Pointed Surveys					
NH3 Pointed Survey	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	Data
YSO Candidate list (c2d)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	Data



Skyalert Worldwide Telescope Display



These events are dynamically retrieved from [Skyalert](#).

SWIFT last 50

Fermi last 50

CRTS last 50

CSS_NEO last 50

Clear All

Select image background here:

IRAS/IRIS Infrared

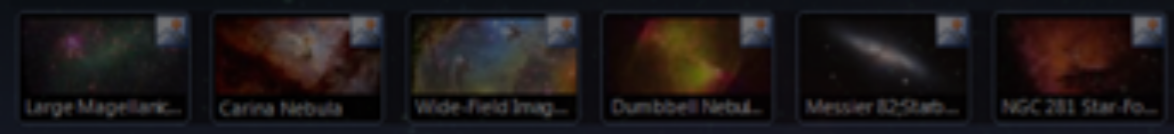


Built with the web-client of
[Microsoft WorldWide Telescope](#)

Click in the center of any event for window with detailed data.

Initial display is [CRTS](#) most recent 50 events.

George will show you more...



Evermore Seamless Astronomy

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with Alberto Accomazzi, Douglas Burke, Gus Muench & Michael Kurtz
(Harvard-Smithsonian CfA); Eli Bressert (U. Exeter); Tim Clark (Massachusetts
General Hospital/Harvard Medical School); Chris Borgman (UCLA);
Jonathan Fay & Curtis Wong (Microsoft Research)

