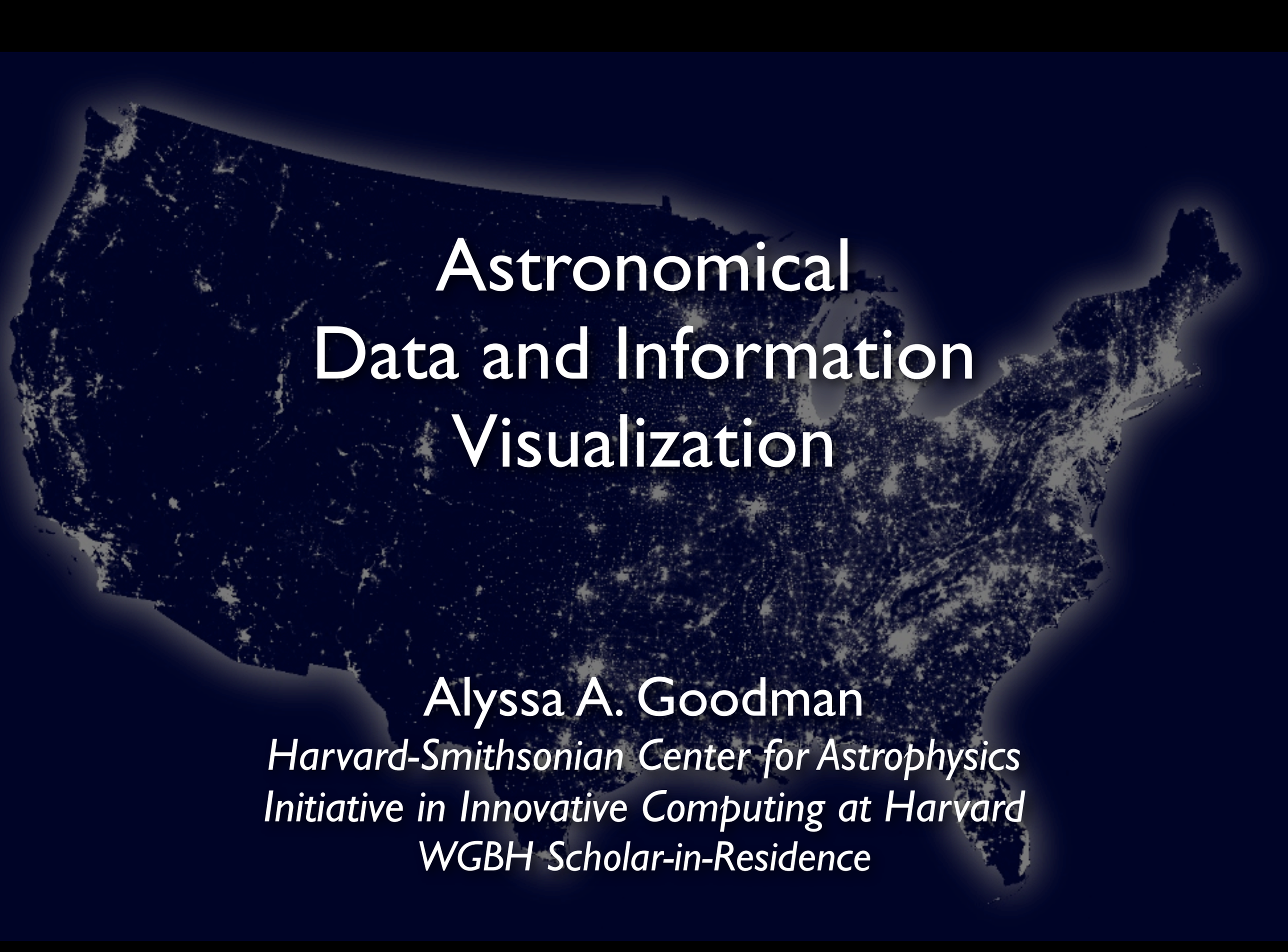


Astronomical Data and Information Visualization

Alyssa A. Goodman

Harvard-Smithsonian Center for Astrophysics

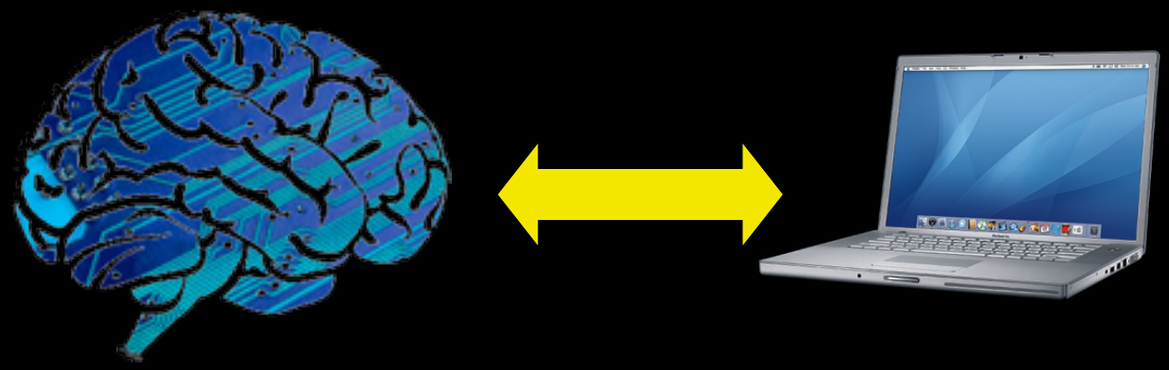
Initiative in Innovative Computing at Harvard

WGBH Scholar-in-Residence

Relative Strengths

Pattern Recognition
Creativity

Calculations



Data Reduction

Data Display

Context (e.g. journals + online data)

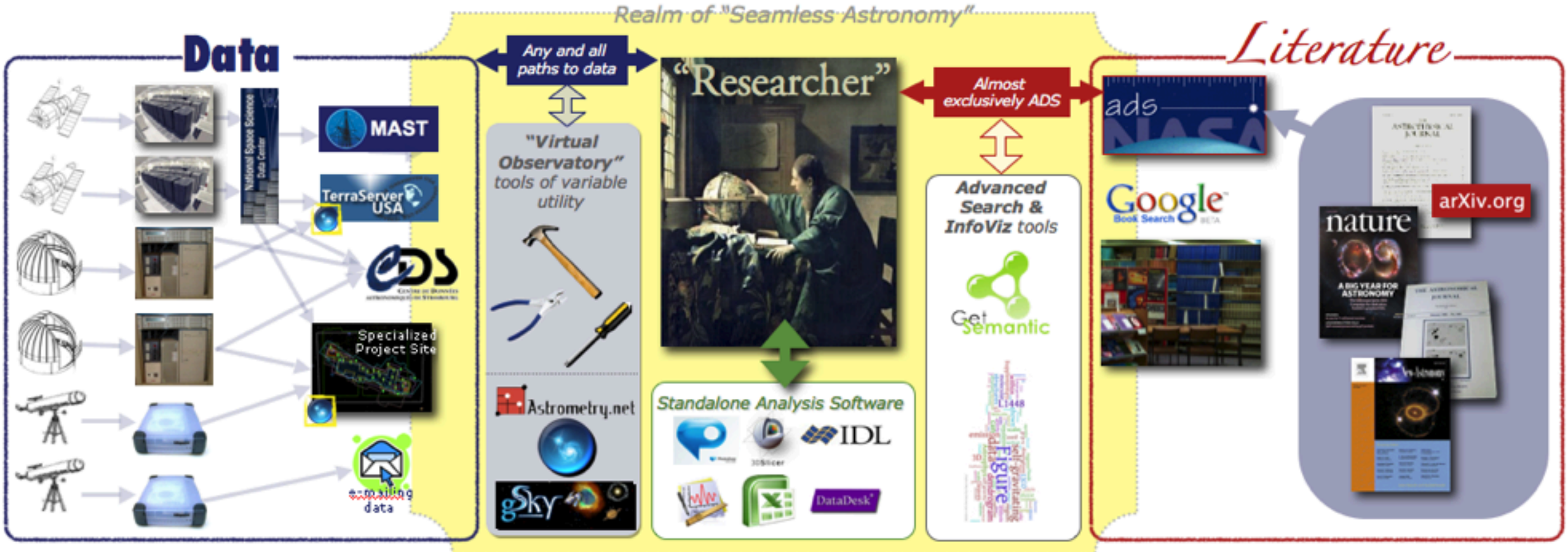
Simulation Design

Statistics Design

Data Exploration (Visualization)

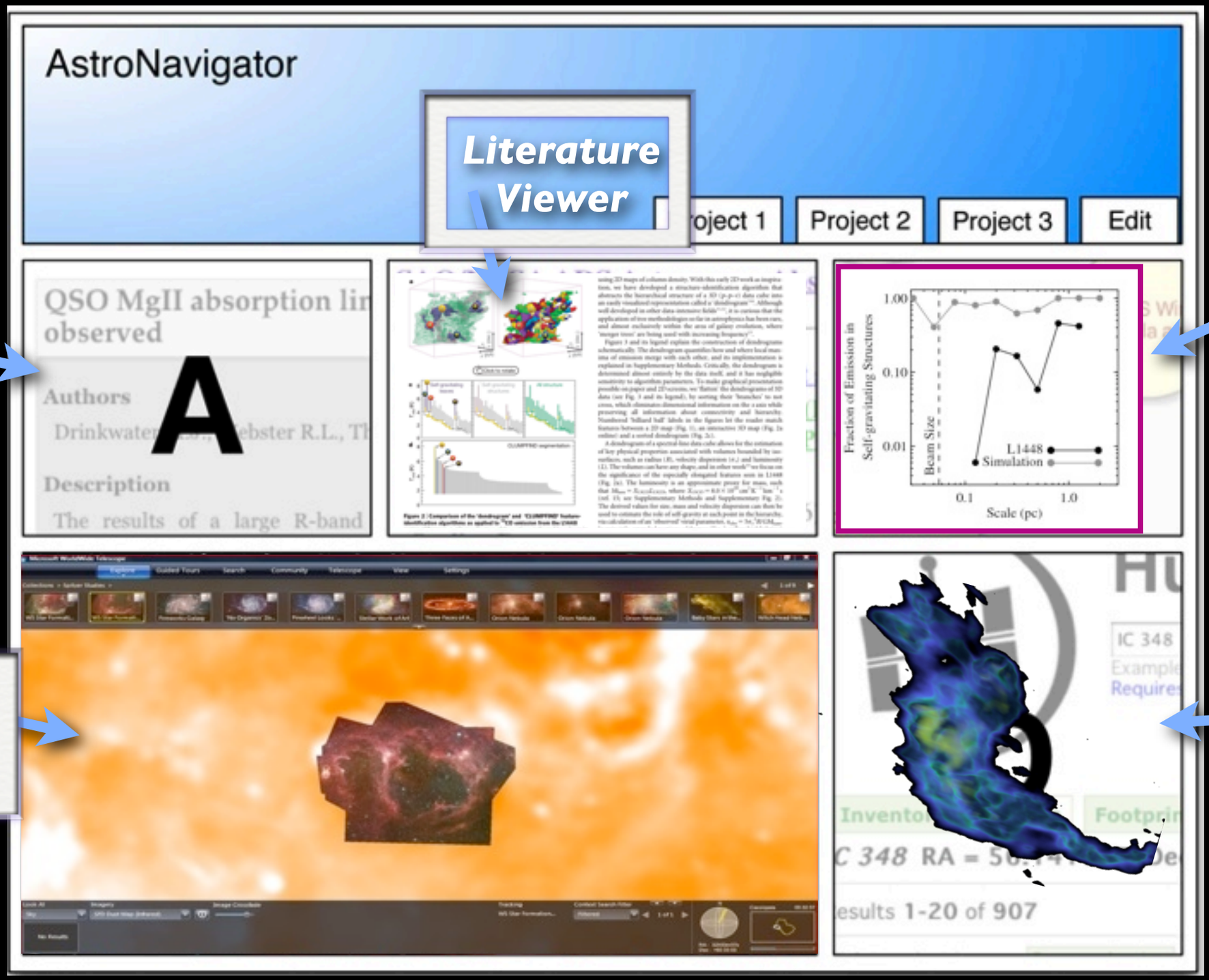
Seamless Astronomy

www.cfa.harvard.edu/~agoodman and worldwidetelescope.org



"Seamless Astronomy" is collaboration amongst many researchers at CfA, MSR, Princeton, STScI, NYU, RPI, and UCLA, and it is supported by NASA, NSF and Microsoft External Research.

Seamless Astronomy



Semantic Search

Info-Bases for Analytics

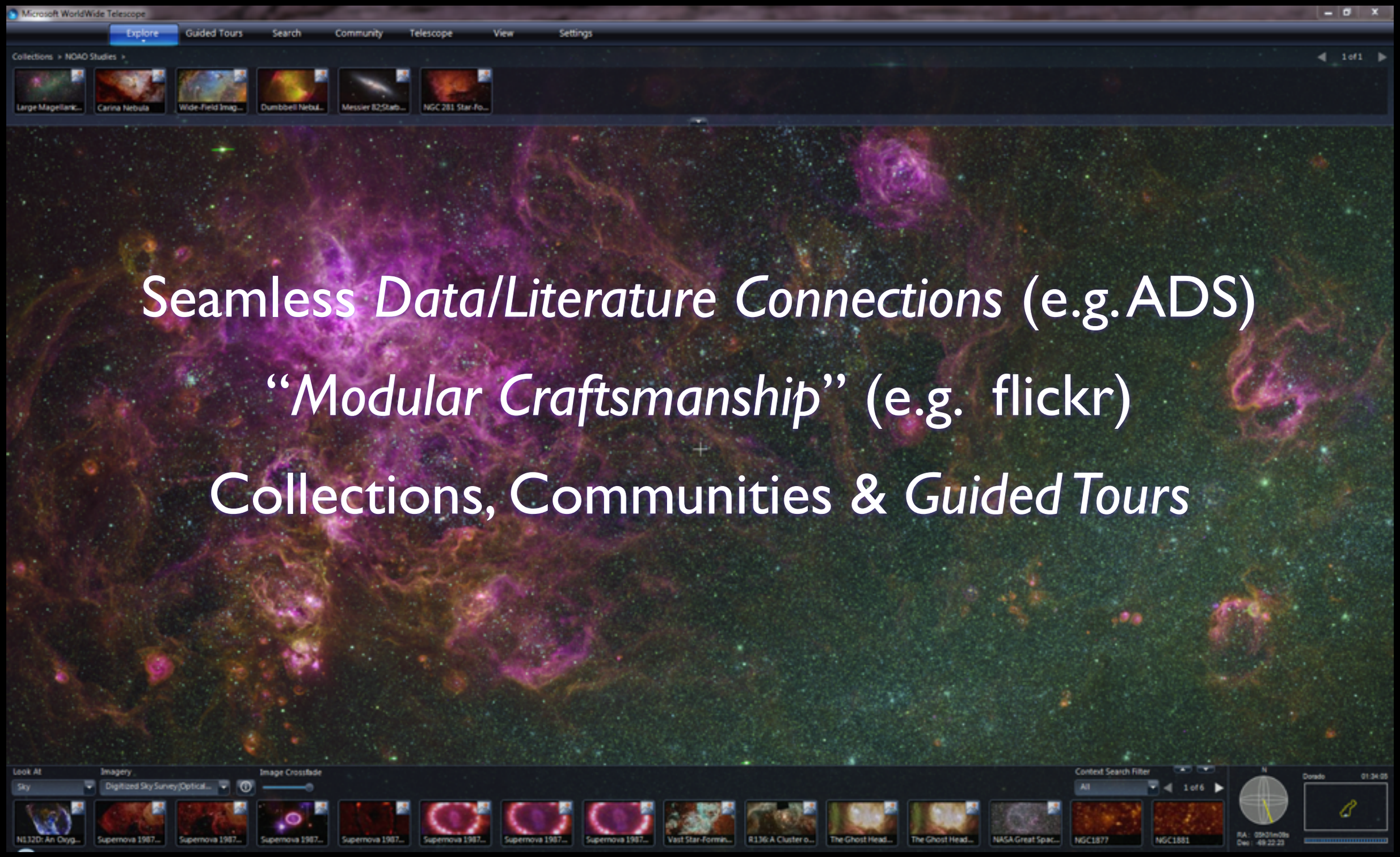
Analytic Results

Data Viewer (e.g. WWT)

ArcGIS Server 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

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



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

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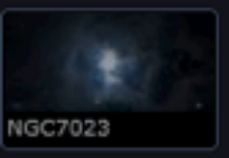
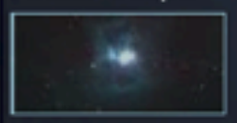
ngc 7023 | Plot Results | VO Search | J2000 | RA | Dec | Go | 1 of 2



Finder Scope



NGC 7023

Classification:
Reflection Nebula
in Cepheus

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/

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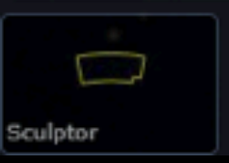

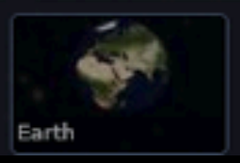

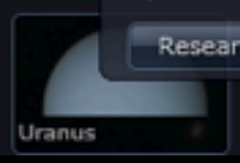

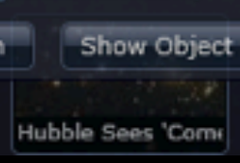

N

RA : 21h01m36s

Cepheus 00:14:04

Microsoft WorldWide Telescope Web Client

http://www.worldwidetelescope.org/webclient/

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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 : 53 : 38 Rise: Circumpolar
Transit: Circumpolar
Set: Circumpolar

Name:NGC 7023

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Look At Imagery

Sky Digitized Sky Survey (Opt

Sculptor Earth Uranus Sculptor Galaxy Cartwheel Galaxy Cartwheel Galaxy

1 of 23

N

RA : 21h01m36s
Dec : 68:10:11

Cepheus

Done

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 Title	Date	List of Links Access Control Help
1	2009ApJ...700.1609M Myers, Philip C.	1.000 Filamentary Structure of Star-forming Complexes	08/2009	A Z E F 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 Strong Polycyclic Aromatic Hydrocarbon Emission from z ≈ 2 ULIRGs	08/2009	A Z E F L X R C S U
3	2009MNRAS.396.1851N Nutter, D.; Stamatellos, D.; Ward-Thompson, D.	1.000 The initial conditions of isolated star formation - IX. Akari mapping of an externally heated pre-stellar core	07/2009	A Z E F 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 A spatial study of the mid-IR emission features in four Herbig Ae/Be stars	07/2009	A Z E F L R S U
5	2009MNRAS.395.1695H Hernán-Caballero, A.; Pérez-Fournon, I.; Hatziminaoglou, E.; Afonso-Luis, A.; Rowan-Robinson, M.; Rigopoulou, D.; Farrah, D.; Lonsdale, C. J.; Babbedge, T.;	1.000 Mid-infrared spectroscopy of infrared-luminous galaxies at z ~ 0.5-3	05/2009	A Z E F L X R C S U

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http://www.worldwidetelescope.org/webclient/

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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 : 53 : 38 Rise: Circumpolar
Transit: Circumpolar
Set: Circumpolar

Name:NGC 7023

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Look up on NED
Look up on SDSS

Look At: Sky
Imagery: Digitized Sky Survey (Opt

Sculptor Earth Uranus Sculptor Galaxy Cartwheel Galaxy Cartwheel Galaxy

1 of 23

N

Cepheus

RA : 21h01m36s
Dec : 68:10:11

Done

SIMBAD query result

http://simbad.u-strasbg.fr/simbad/sim-id?Ident=NGC+7023&jsessionid=B8F7CD92574727FFC8

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Simbad VizieR Aladin Catalogs Dictionary Biblio Tutorials Developers

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

query around with radius 2 arcmin

Other object types: Cl* (C,Cl,[BDB2003]) ,OpC (OCISM) ,HII (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 (1) : B 7.20 [-] D -

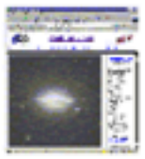
Identifiers (11) :

NGC 7023	IRAS 20599+6755	LBN 487	[BDB2003] G104.06+14.19
C 2059+679	IRAS F20599+6755	OCISM 50	AAVSO 2044+67
Cl VDB 139	LBN 104.08+14.21	OCl 235	

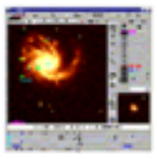
Plots and Images

plot around radius 10 arcmin

Aladin previewer



Aladin applet



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).

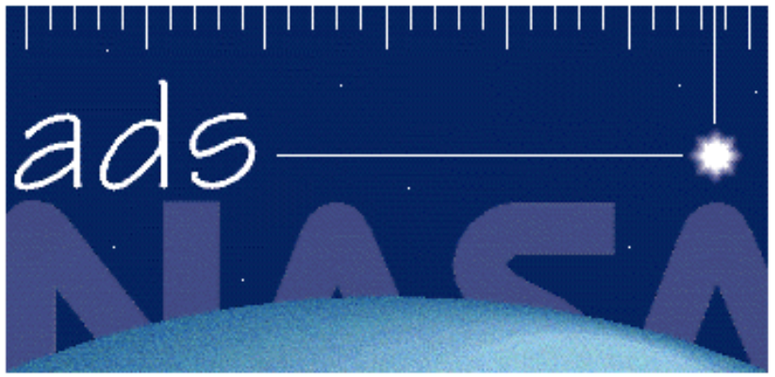
display reference summary

from: 1983 to: 2009

ADS Faceted Topic Search (Alpha)

http://adsres.cfa.harvard.edu/cgi-bin/topicFacetSearch

Google



ADS Faceted Topic Search (alpha)

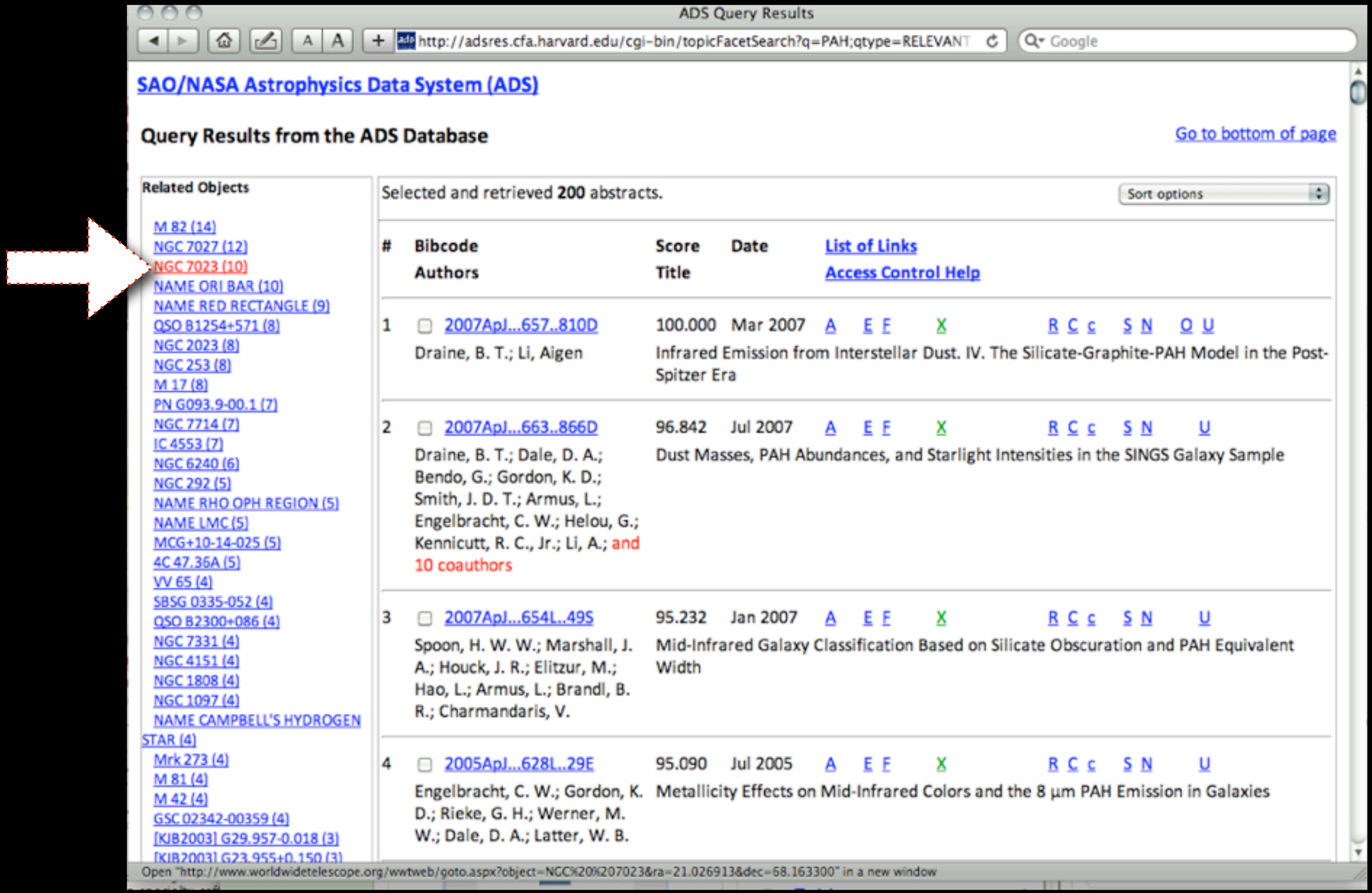
PAH Search

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

Keyword Search:	*Subject Area Search:*
◉ Most relevant	○ Most popular
○ Most recent	○ Most useful
○ Most important	○ Most instructive

ADS Home | Abstract Search | Help

"alpha" Faceted Topic Search in ADS
(courtesy of Michael Kurtz & Alberto Accomazzi)



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.

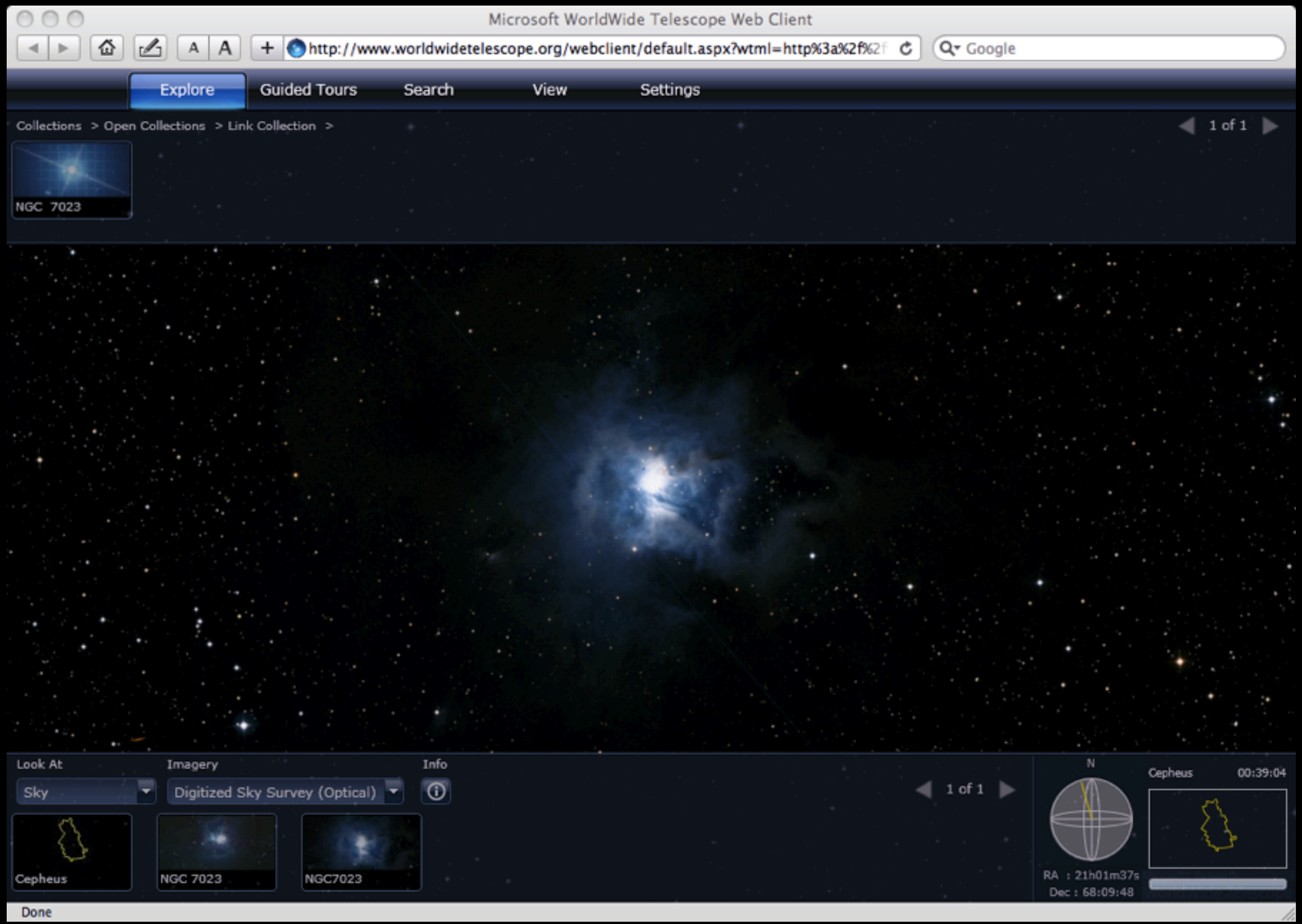


Image ssc2003-06f

http://www.spitzer.caltech.edu/Media/releases/ssc2003-06/ssc200

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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.

Seamlessness through...

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+
astrometry.net
+
WWT !?

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Signed in as Alyssa_Goodman (1 new) Help Sign Out

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HH4647

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This photo also belongs to:

astrometry (Pool)

Tags

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

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Additional Information

All rights reserved (edit)
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Collections > Open Collections > HH4647 >

1 of 1

HH4647

Look At: Sky

Imagery: Digitized Sky Survey (Optical)

Info

Image Crossfade

1 of 1

Vela

Bubbly Little Star

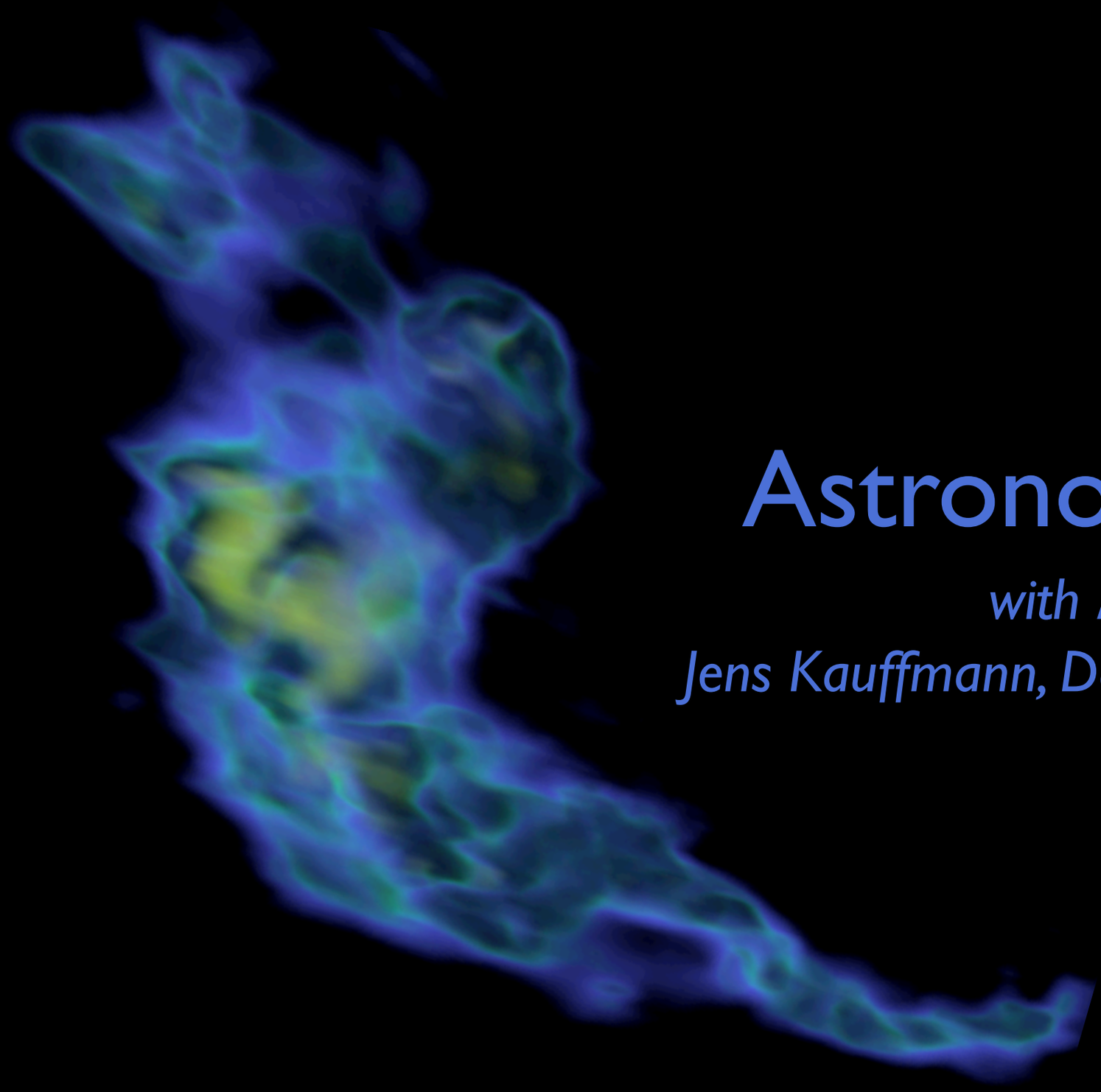
N

Vela 00:35:33

RA : 08h25m39s

Dec : -51:01:10

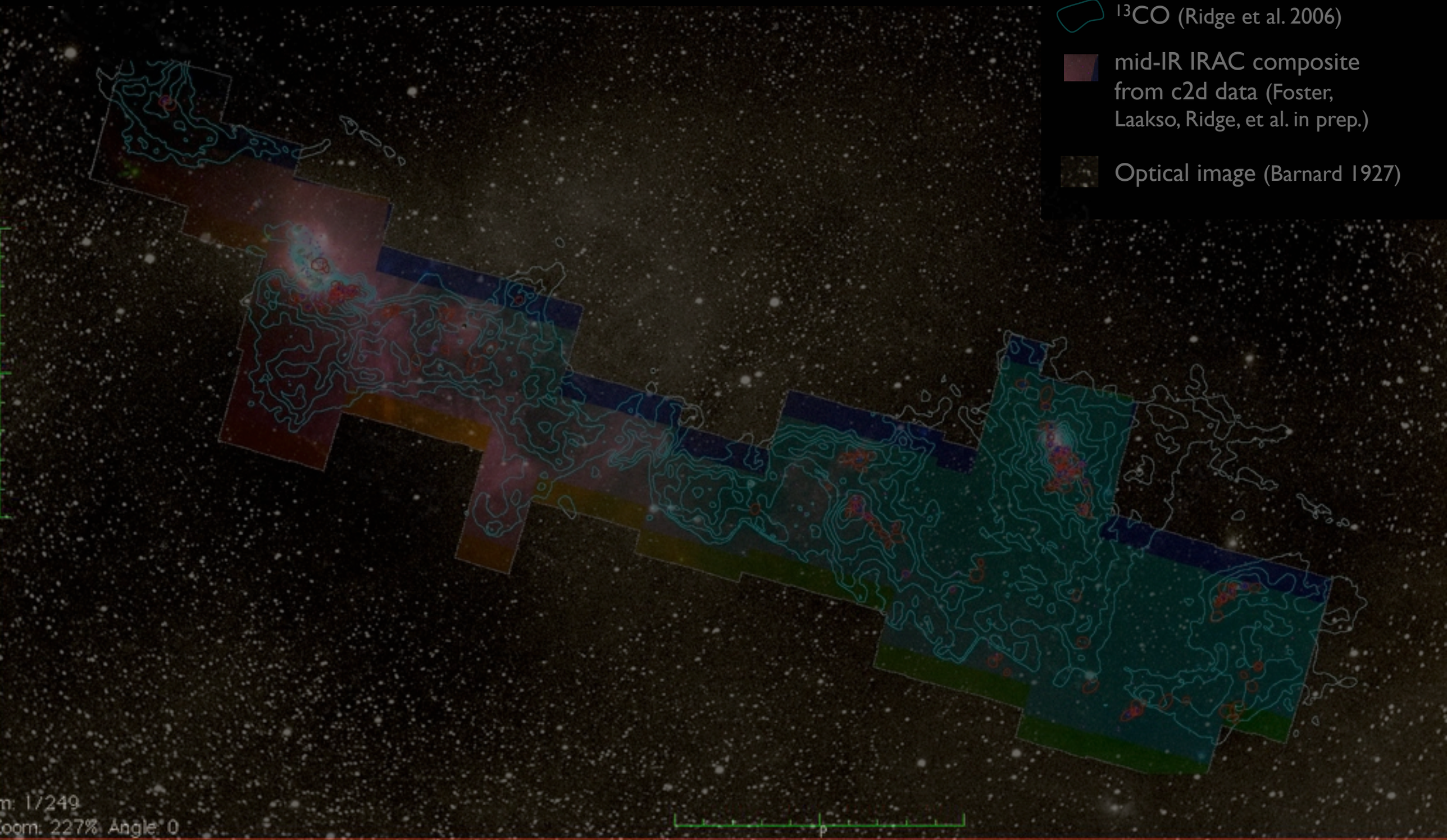
Done



Astronomical Medicine

with Michael Halle, Michelle Borkin, Jens Kauffmann, Douglas Alan, Erik Rosolowsky & Nick Holliman

COMPLETE Perseus



- mm peak (Enoch et al. 2006)
- sub-mm peak (Hatchell et al. 2005, Kirk et al. 2006)
- ^{13}CO (Ridge et al. 2006)
- mid-IR IRAC composite from c2d data (Foster, Laakso, Ridge, et al. in prep.)
- Optical image (Barnard 1927)

Perseus

3D Viz made with VolView

AstronomicalMedicine@

COMPLETE

3D PDF (demo)

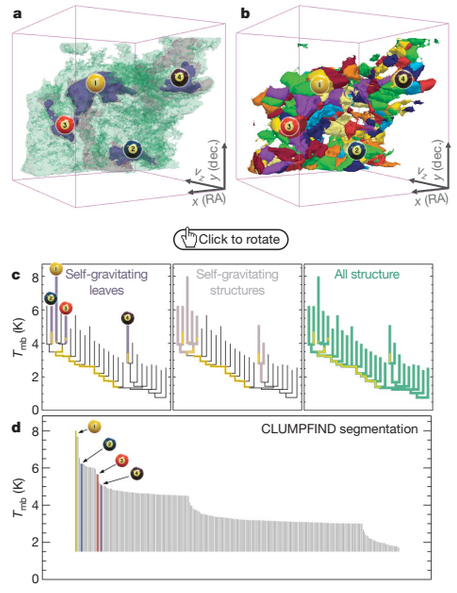


Figure 2 | Comparison of the 'dendrogram' and 'CLUMPFIND' feature-identification algorithms as applied to ^{13}CO emission from the L1448 region of Perseus. a, 3D visualization of the surfaces indicated by colours in the dendrogram shown in **c**. Purple illustrates the smallest scale self-gravitating structures in the region corresponding to the leaves of the dendrogram; pink shows the smallest surfaces that contain distinct self-gravitating leaves within them; and green corresponds to the surface in the data cube containing all the significant emission. Dendrogram branches corresponding to self-gravitating objects have been highlighted in yellow over the range of T_{mb} (main-beam temperature) test-level values for which the virial parameter is less than 2. The *x*–*y* locations of the four 'self-gravitating' leaves labelled with billiard balls are the same as those shown in Fig. 1. The 3D visualizations show position–position–velocity (*p*–*p*–*v*) space. RA, right ascension; dec., declination. For comparison with the ability of dendrograms (**c**) to track hierarchical structure, **d** shows a pseudo-dendrogram of the CLUMPFIND segmentation (**b**), with the same four labels used in Fig. 1 and in **a**. As 'clumps' are not allowed to belong to larger structures, each pseudo-branch in **d** is simply a series of lines connecting the maximum emission value in each clump to the threshold value. A very large number of clumps appears in **b** because of the sensitivity of CLUMPFIND to noise and small-scale structure in the data. In the online PDF version, the 3D cubes (**a** and **b**) can be rotated to any orientation, and surfaces can be turned on and off (interaction requires Adobe Acrobat version 7.0.8 or higher). In the printed version, the front face of each 3D cube (the 'home' view in the interactive online version) corresponds exactly to the patch of sky shown in Fig. 1, and velocity with respect to the Local Standard of Rest increases from front (-0.5 km s^{-1}) to back (8 km s^{-1}).

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 set[8] 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 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 frequency[13].

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 iso-surfaces, such as radius (R), velocity dispersion (σ_v) and luminosity (L). The volumes can have any shape, and in other work[14] 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 $M_{lum} = X_{13CO}L_{13CO}$, where $X_{13CO} = 8.0 \times 10^{20}$ cm^2 K^{-1} km^{-1} 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, $\alpha_{obs} = 5\sigma_v^2 R/GM_{lum}$. In principle, extended portions of the tree (Fig. 2, yellow highlighting) where $\alpha_{obs} < 2$ (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 fields[16], its measured value should only be used as a guide to the longevity (boundedness) of any particular feature.

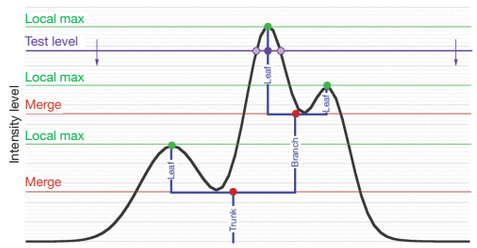
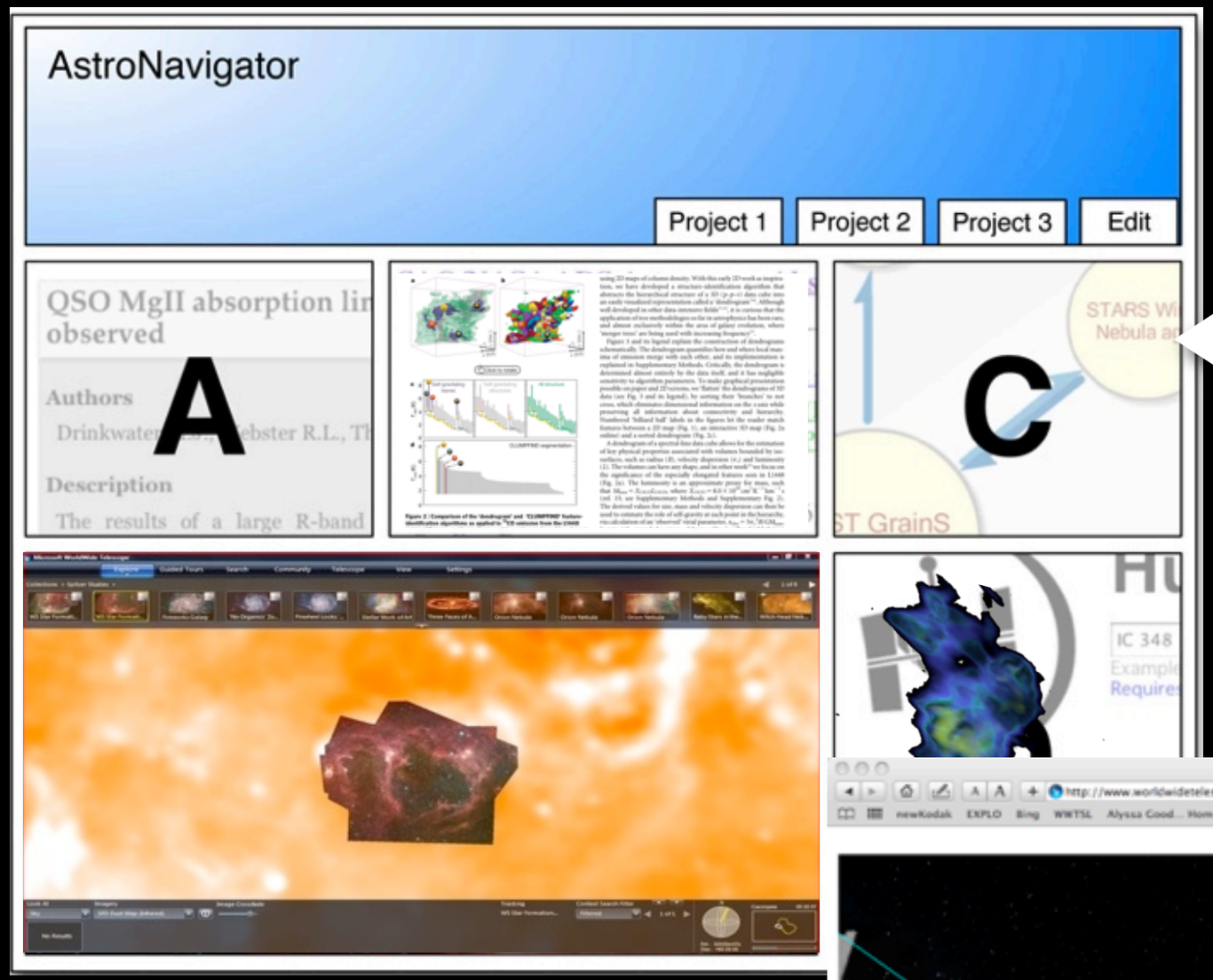


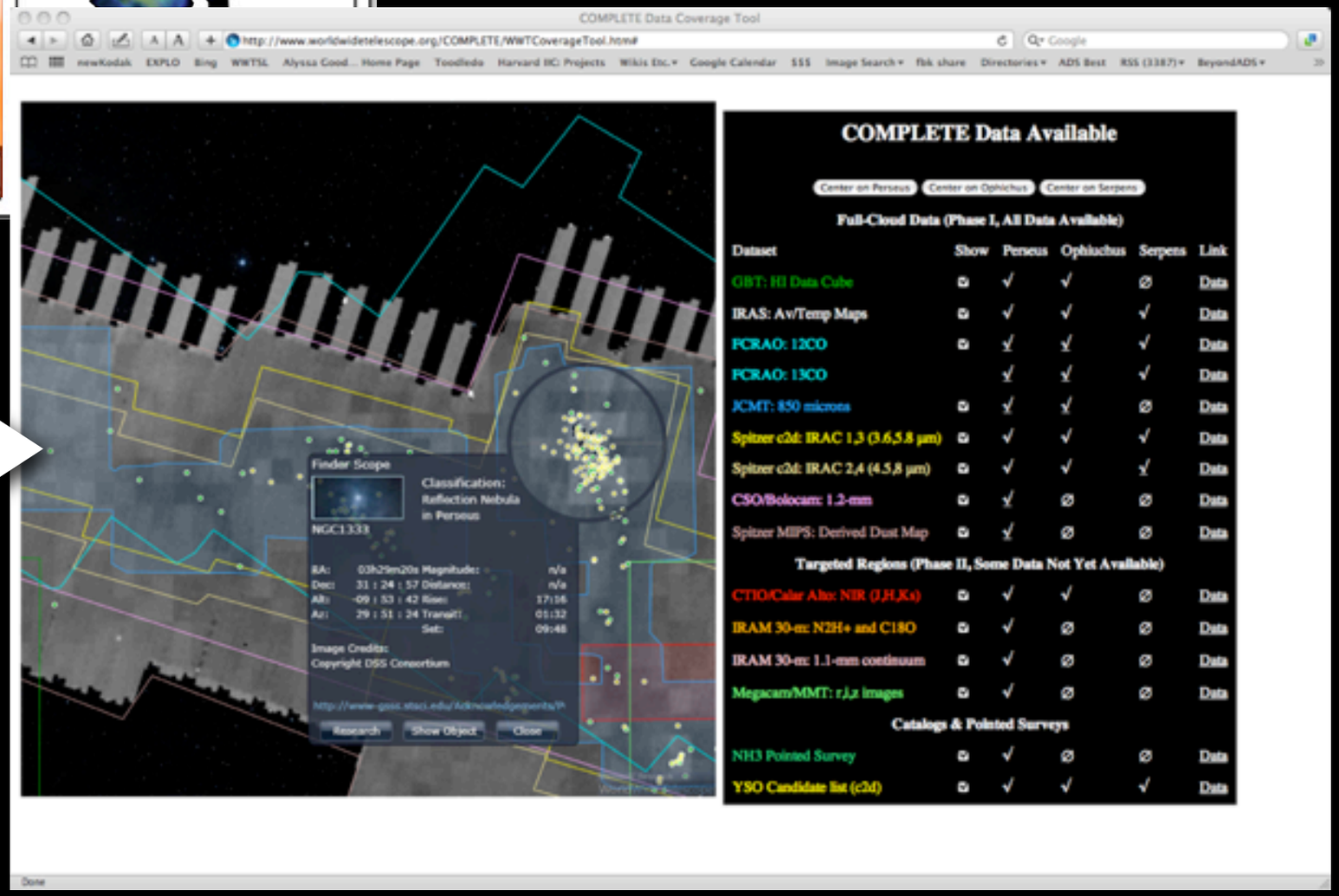
Figure 3 | Schematic illustration of the dendrogram process. Shown is the construction of a dendrogram from a hypothetical one-dimensional emission profile (black). The dendrogram (blue) can be constructed by 'dropping' a test constant emission level (purple) from above in tiny steps (exaggerated in size here, light lines) until all the local maxima and mergers are found, and connected as shown. The intersection of a test level with the emission is a set of points (for example the light purple dots) in one dimension, a planar curve in two dimensions, and an isosurface in three dimensions. The dendrogram of 3D data shown in Fig. 2c is the direct analogue of the tree shown here, only constructed from 'isosurface' rather than 'point' intersections. It has been sorted and flattened for representation on a flat page, as fully representing dendrograms for 3D data cubes would require four dimensions.

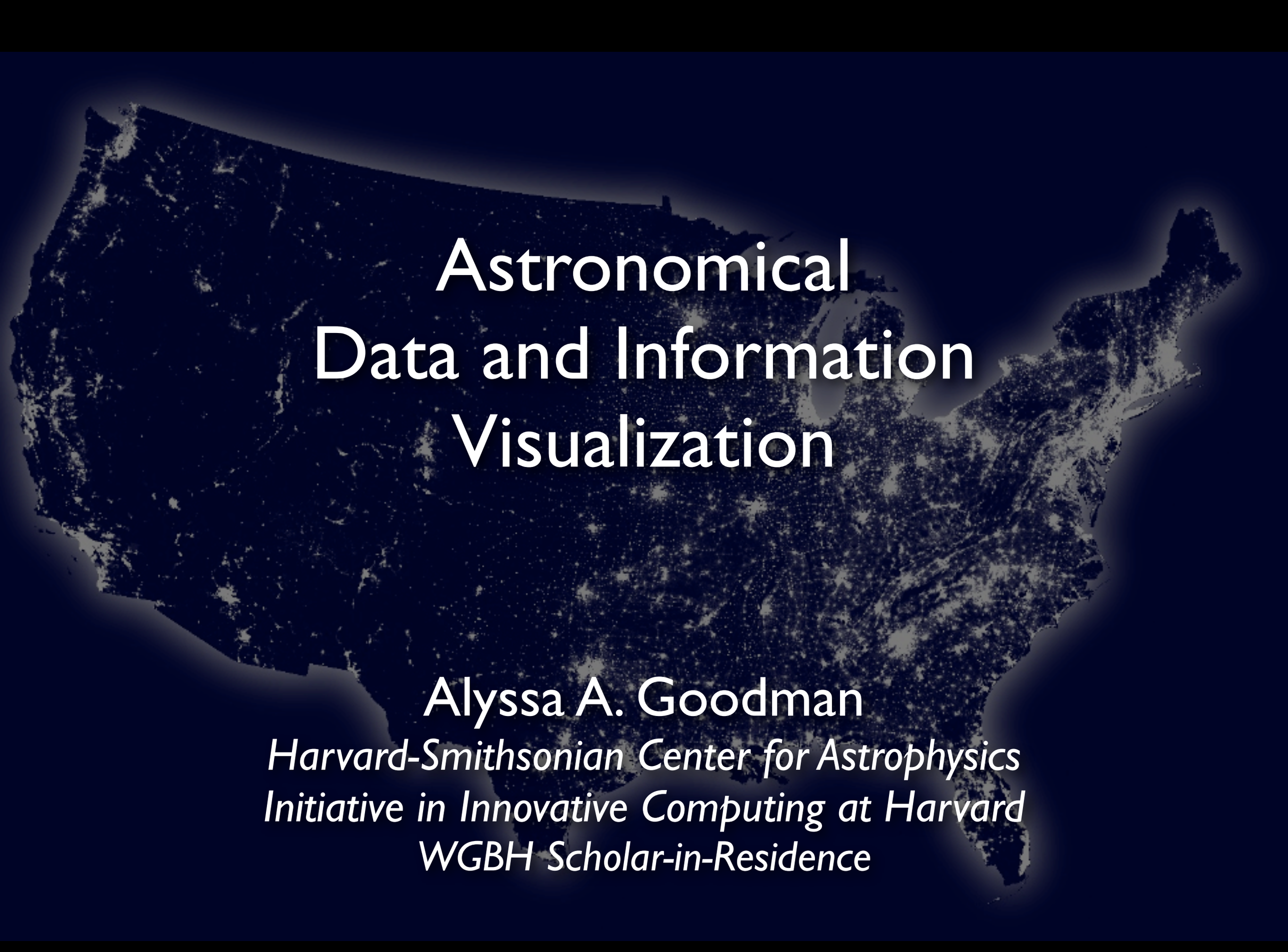
Goodman et al. *Nature*, 2009



Fiction
(for now)

Fact
(right now)





Astronomical Data and Information Visualization

Alyssa A. Goodman

Harvard-Smithsonian Center for Astrophysics

Initiative in Innovative Computing at Harvard

WGBH Scholar-in-Residence

Astronomical Data and Information Visualization

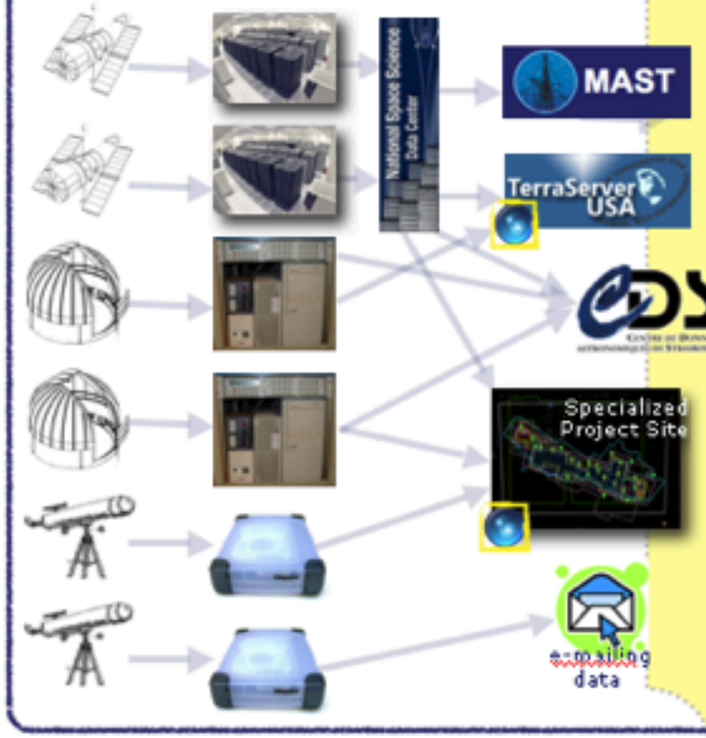
Organization, Anarchy, or Organized Anarchy?

Sea

www.cfa.harvard.edu telescope.org

Realm of "Seamless Astronomy"

Data



Any and all paths to data

"Virtual Observatory" tools of variable utility

Astrometry.net

gSky

Standalone Analysis Software

IDL

DataDesk

Almost exclusively ADS

Advanced Search & InfoViz tools

Get Semantic

Literature

ads NASA

Google Book Search BETA