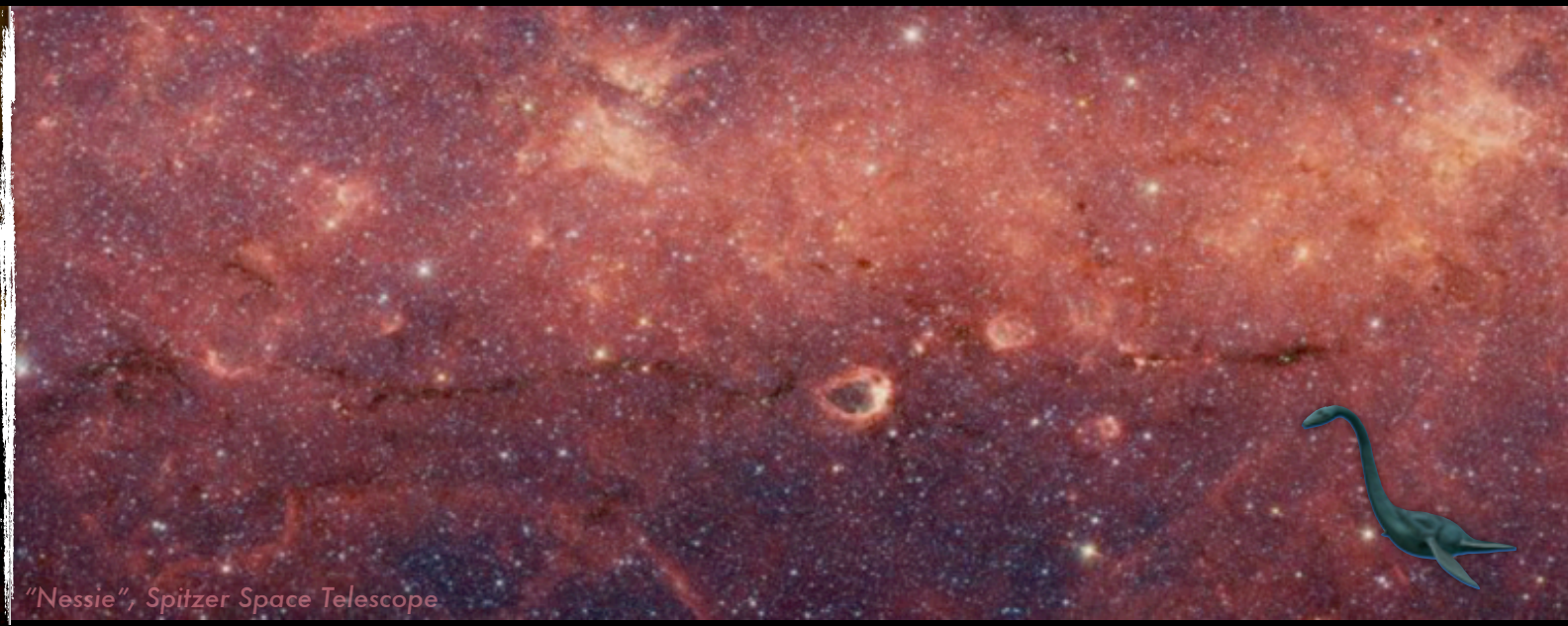
BELIEVE IN
BOSTON
KEEP WICKED
CALM
AND
CARRY THE
HELL ON

Seamless Astronomy...and The Bones of the Milky Way

The Astronomer, Vermeer



"Nessie", Spitzer Space Telescope

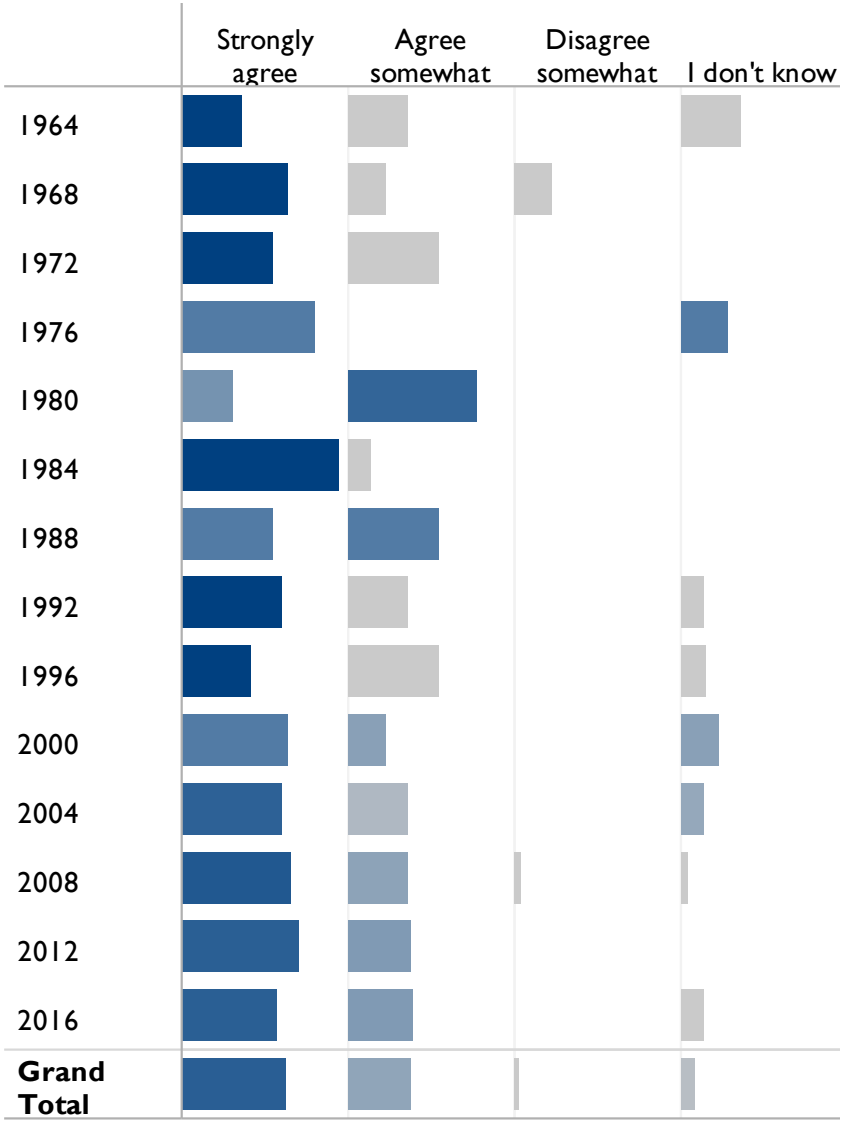
Alyssa A. Goodman

Harvard-Smithsonian Center for Astrophysics

Opinions

of 170 PhD-level Scientists at the Harvard-Smithsonian Center for Astrophysics (gathered April 17-18, 2013)

"I think that the future of astrophysical research will rely more on sharing of code and data in the future than it has in the past."



color code shows frequency of NASA archive use, darker is more; bar length gives percentage for each row

Full results at: http://tinyurl.com/cfa-data-survey-results

Data Sharing Practices

of 170 PhD-level Scientists at the Harvard-Smithsonian Center for Astrophysics (gathered April 17-18, 2013)

emailed data to a colleague upon request.

put data at an ftp-style site for a colleague to retrieve.

put data at a personal web site, such as http://cfa-www.harvard.edu/~agoodman

put data at a project-based web site, such as http://www.cfa.harvard.edu/COMPLETE/data_html_pages/data.html

put data at an organized institutional archive, such as http://theastrodata.org or http://tdc-www.harvard.edu

not shared my data, because I think it will endanger my career.

not shared my data due to large file sizes

not shared my data because I don't know how.

not shared my data because it takes too much effort.

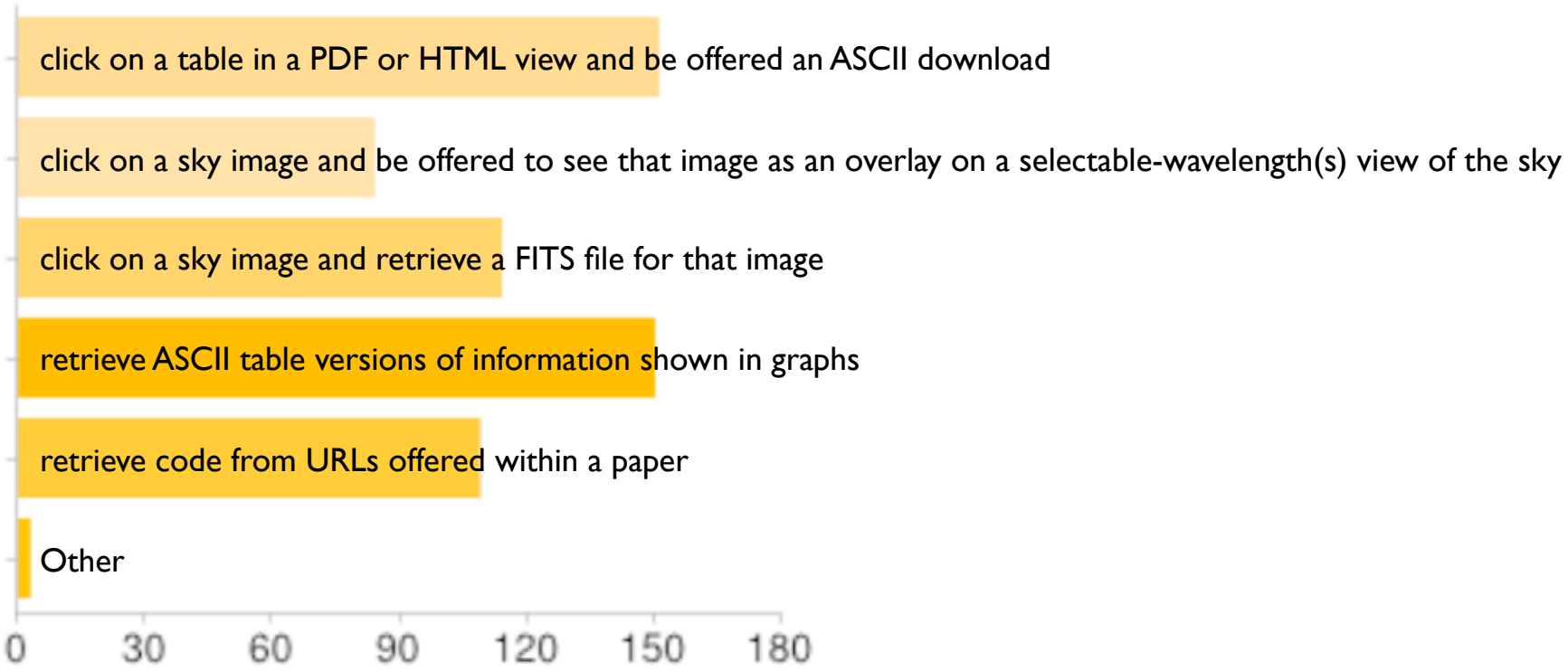
not shared my data because I don't think anyone will want it.

Other

Full results at: http://tinyurl.com/cfa-data-survey-results

Journal-Data/Code Desires

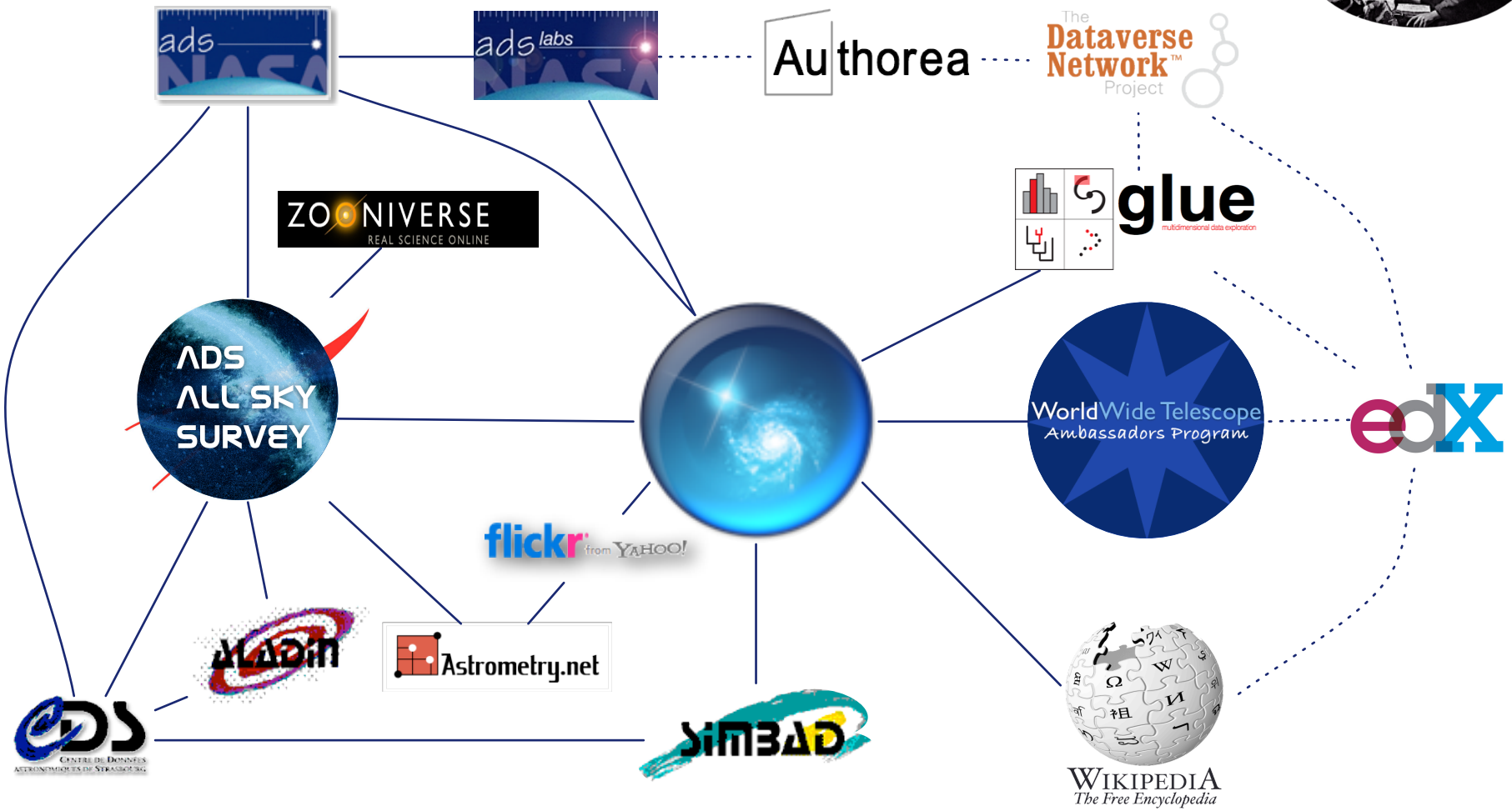
of 170 PhD-level Scientists at the Harvard-Smithsonian Center for Astrophysics (gathered April 17-18, 2013)



Full results at: http://tinyurl.com/cfa-data-survey-results

SEAMLESS ASTRONOMY

Linking scientific data, publications, and communities



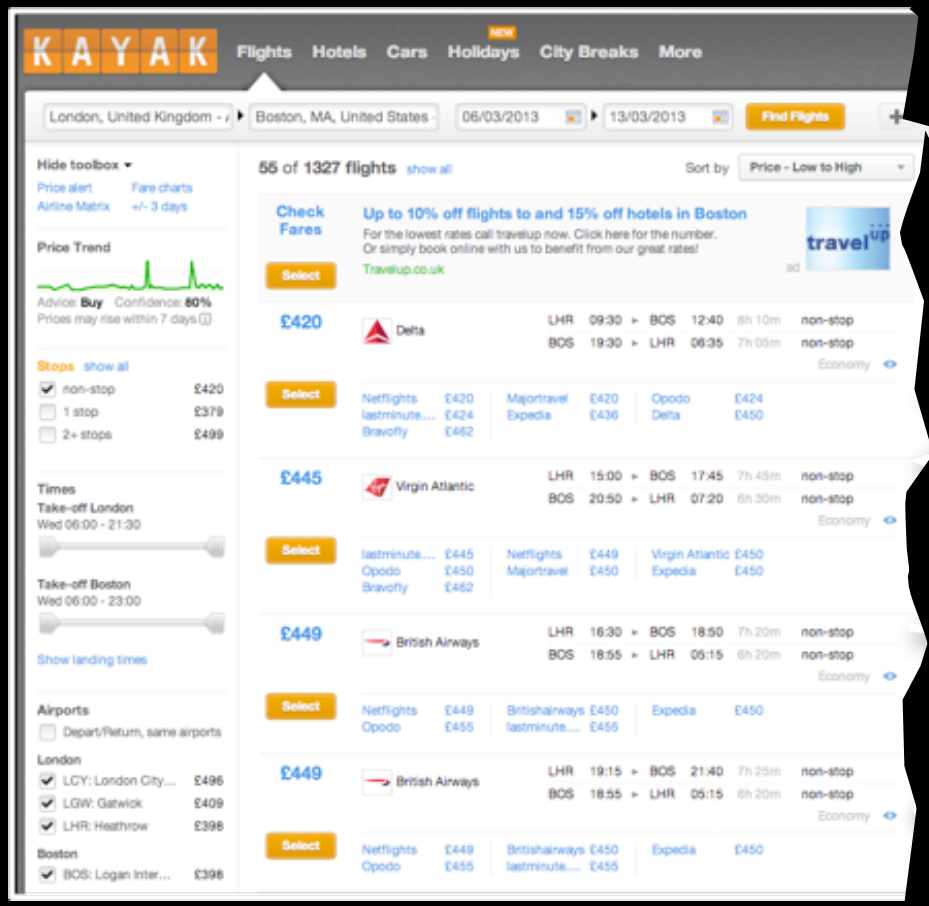
https://www.cfa.harvard.edu/~agoodman/seamless/

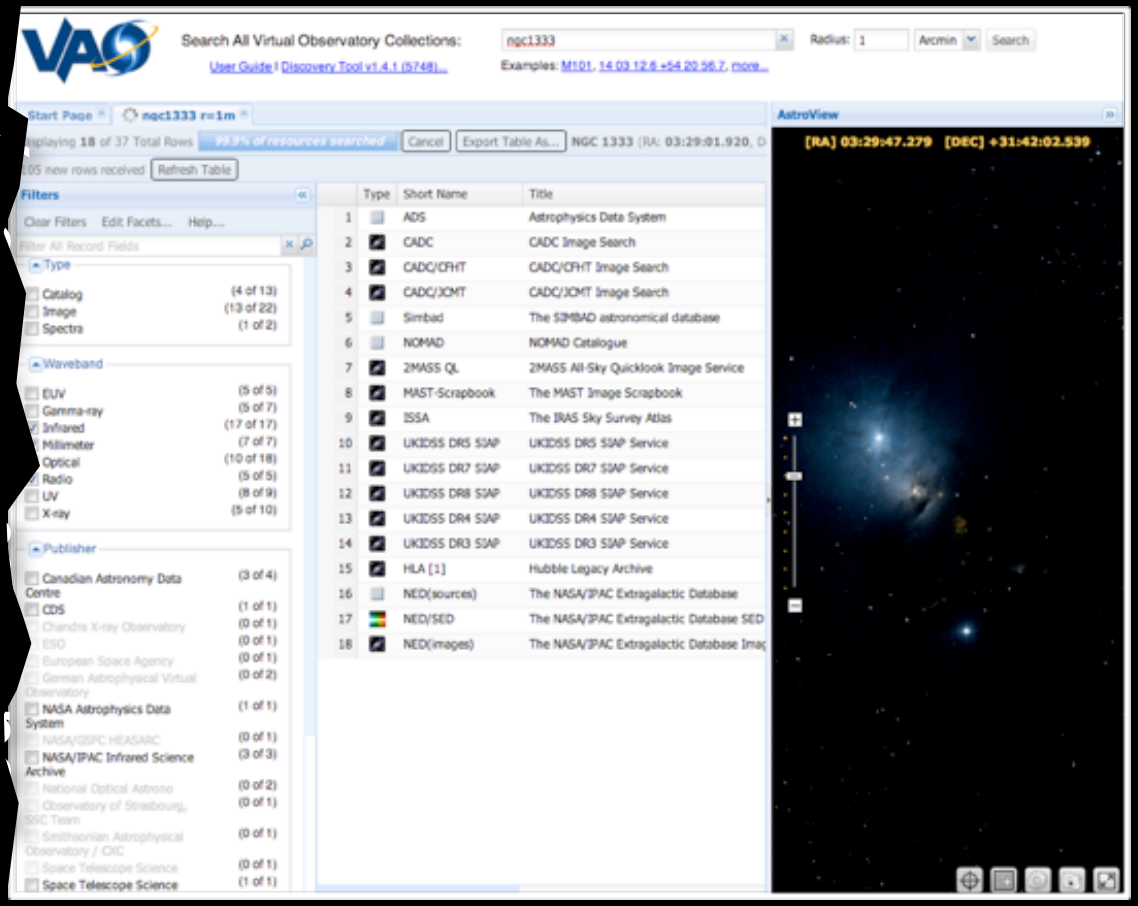
Supported by Microsoft Research NSF NASA Smithsonian

2008

Real Life

"Science"





KAYAK

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Evolution since the Revolution

PHILOSOPHICAL TRANSACTIONS

ASTROPHYSICAL JOURNAL

AN INTERNATIONAL REVIEW OF SPECTROSCOPY AND ASTRONOMICAL PHYSICS

VOLUME I JANUARY 1895 NUMBER 1

ON THE CONDITIONS WHICH AFFECT THE SPECTRO-PHOTOGRAPHY OF THE SUN.

By Albert A. Michelson.

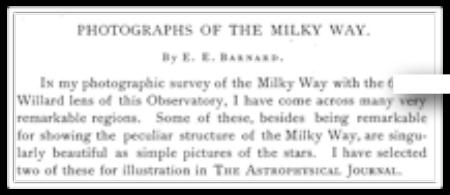
The recent developments in solar spectro-photography are in great measure due to the device originally suggested by Janssen and perfected by Hale and Deslandres, by means of which a photograph of the Sun's prominences may be obtained at any time as readily as it is during an eclipse. The essential features of this device are the simultaneous movements of the collimator-slit across the Sun's image, with that of a second slit (at the focus of the photographic lens) over a photographic plate. If these relative motions are so adjusted that the same spectral line always falls on the second slit, then a photographic image of the Sun will be reproduced by light of this particular wavelength.

Evidently the process is not limited to the photography of the prominences, but extends to all other peculiarities of structure which emit radiations of approximately constant wavelength; and the efficiency of the method depends very largely upon the *contrast* which can be obtained by the greater endeeble-

Authorea

The Bones of the Milky Way

1665 ..230 yr... 1895 ...114 yr... 2009 ...4 yr... 2013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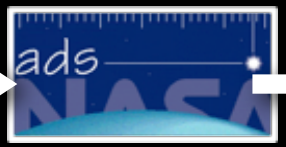


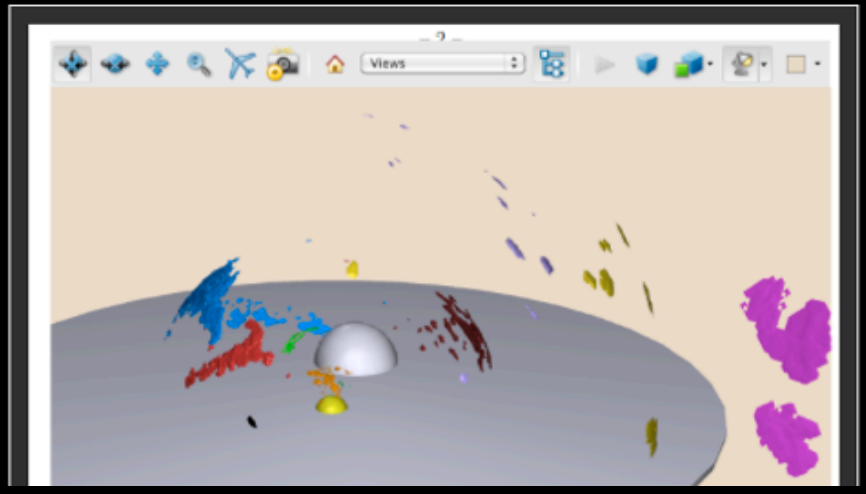
[demo 3D PDF]

Tutorial for embedding 3D interactive graphics into PDF

*by **Guest** on* March 7, 2012

Josh Peek (@joshuaegpeek) is a Hubble Fellow at Columbia University, specializing in the ISM in and around disk galaxies. He has a fascination with data presentation and design.

As an astronomer studying the complex three-dimensional structures of the interstellar medium, I've been taken with the idea of presenting that information in a compelling and interactive way to readers. The major mode of communication for astronomers is the refereed journal article, as distributed through PDF, so I got interested in how one can package interactive 3D scenes with the papers we write. Interactive graphics can be embedded in PDFs that can be rotated, panned, and zoomed.



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DETAILED DATA ANALYSIS AND VISUALIZATIONS, WRITTEN BY WORKING ASTROPHYSICISTS AND DESIGNED FOR PRAGMATIC ANALYSIS NEEDS.

DATA-DRIVEN
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yt is designed to provide a consistent, cross-code interface to analyzing and visualizing astrophysical simulation data from a physical perspective.

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Evolution since the Revolution

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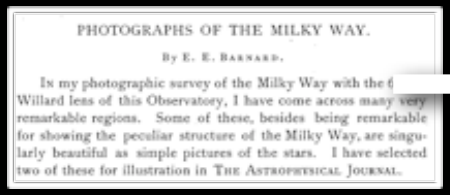
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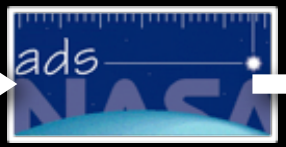
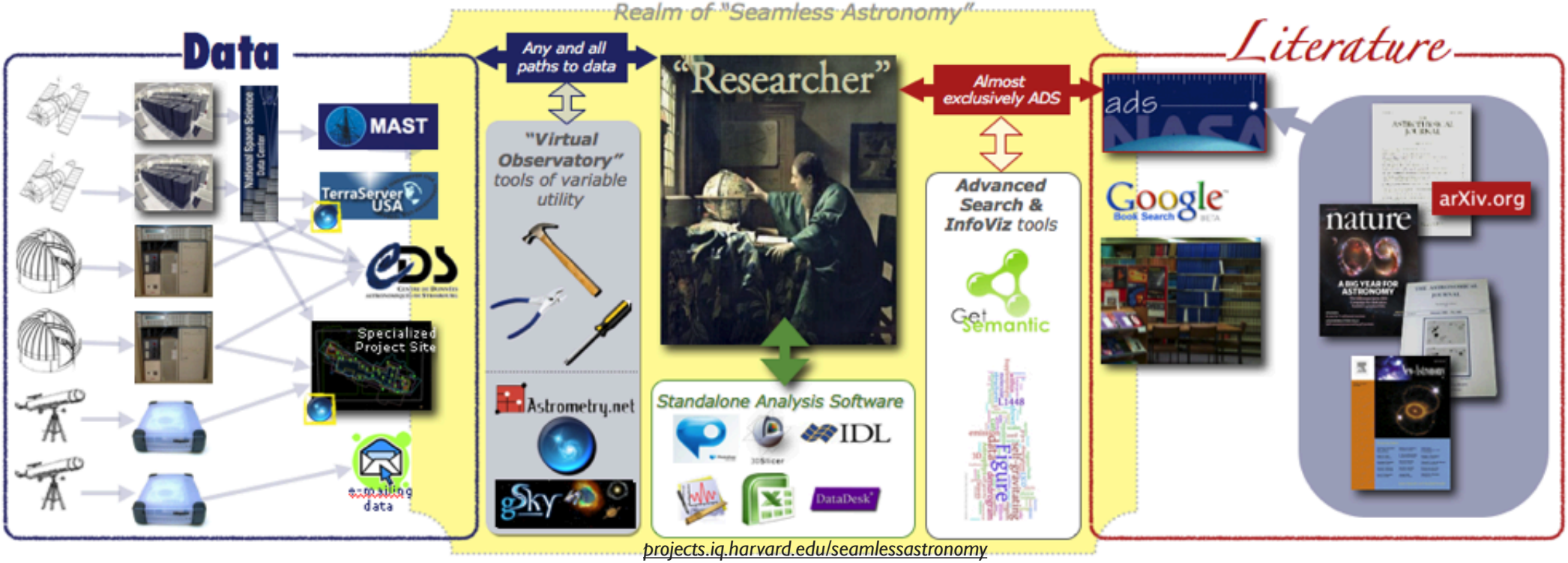


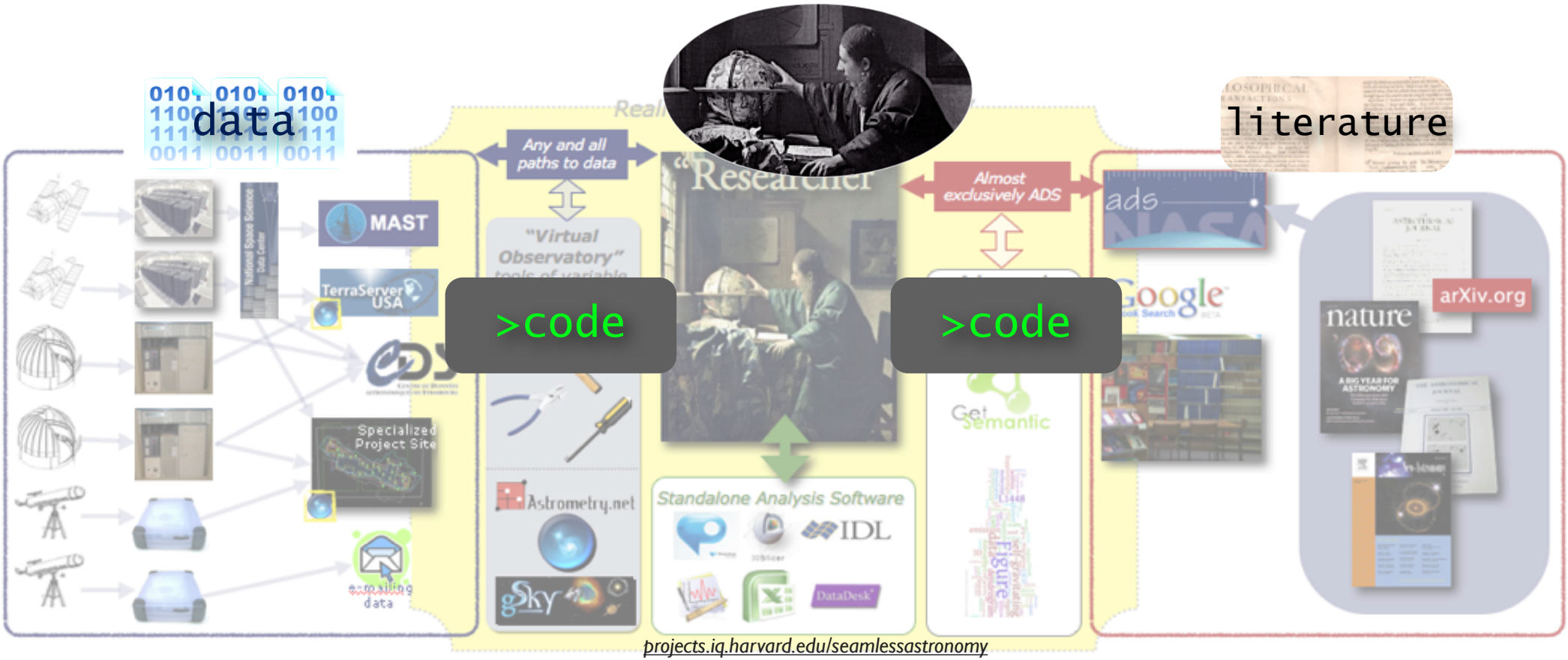
[demo flickr-WWT]

Seamless Astronomy



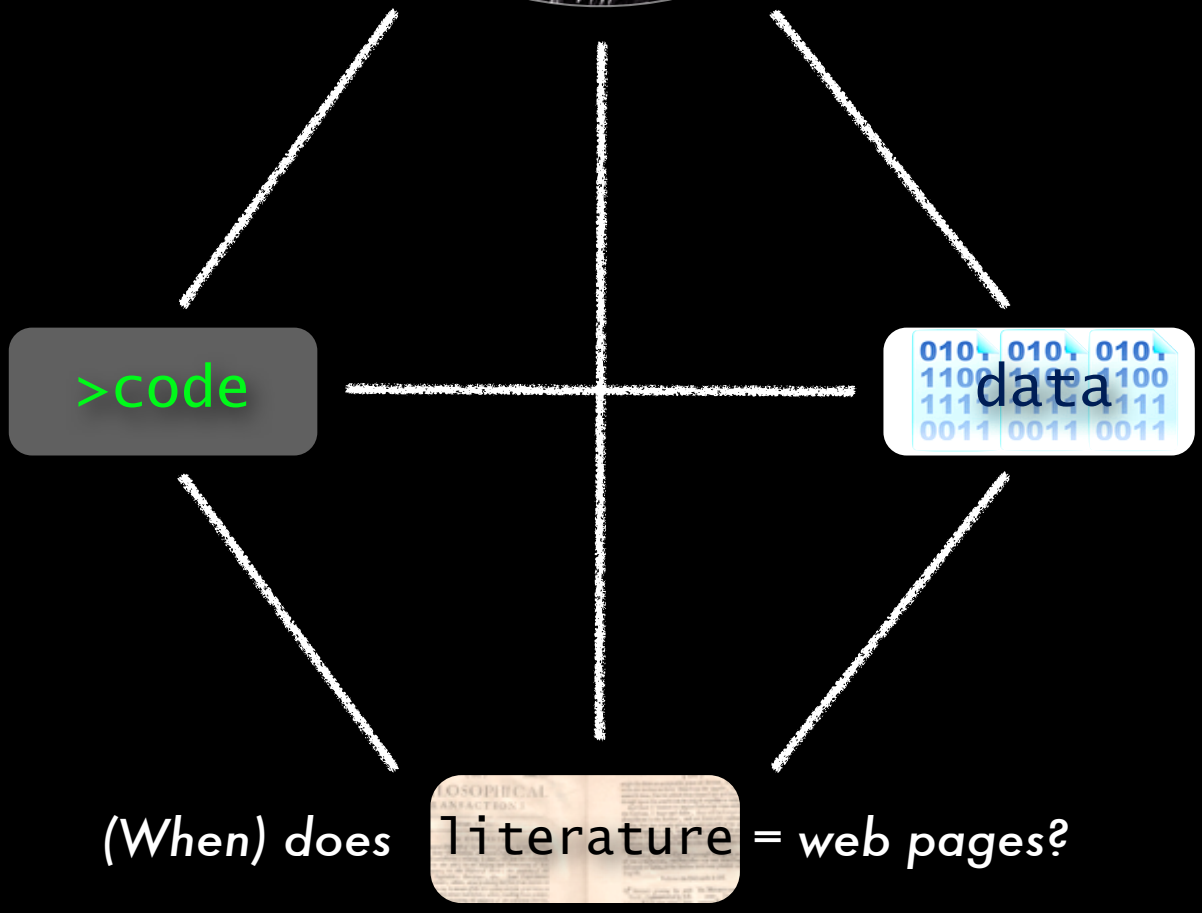
Alberto Accomazzi, Christopher Beaumont, Douglas Burke, Raffaele D'Abrusco, Rahul Davé, Christopher Erdmann, Pepi Fabbiano, Alyssa Goodman, Edwin Henneken, Jay Luker, Gus Muench, Michael Kurtz, Max Lu, Victoria Mittelbach, Alberto Pepe, Arnold Rots, Patricia Udomprasert (Harvard-Smithsonian CfA); Mercé Crosas (Harvard Institute for Quantitative Social Science); Christine Borgman (UCLA); Jonathan Fay & Curtis Wong (Microsoft Research); Alberto Conti (Space Telescope Science Institute)

Seamless Astronomy



projects.iq.harvard.edu/seamlessastronomy

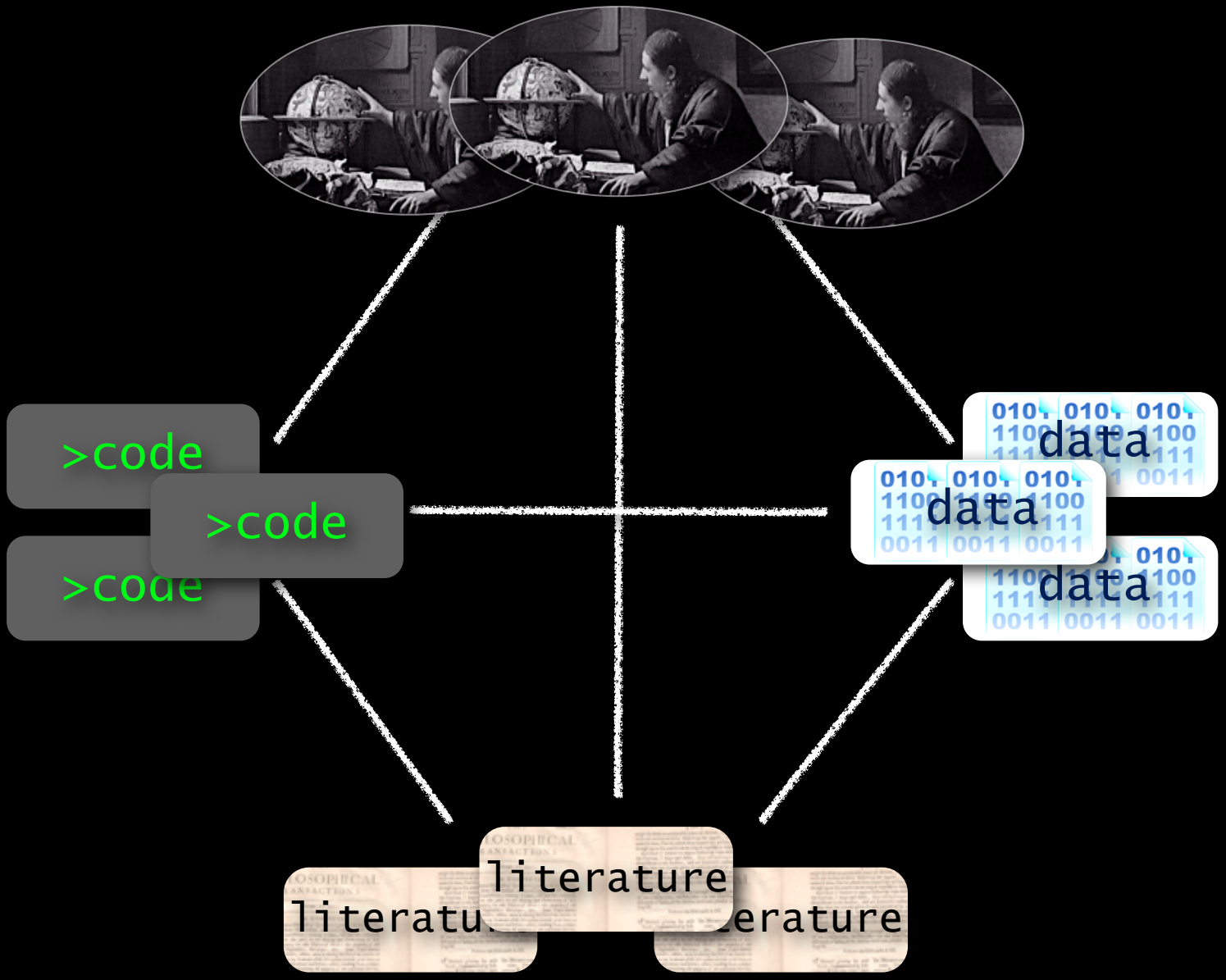
Seamless Astronomy



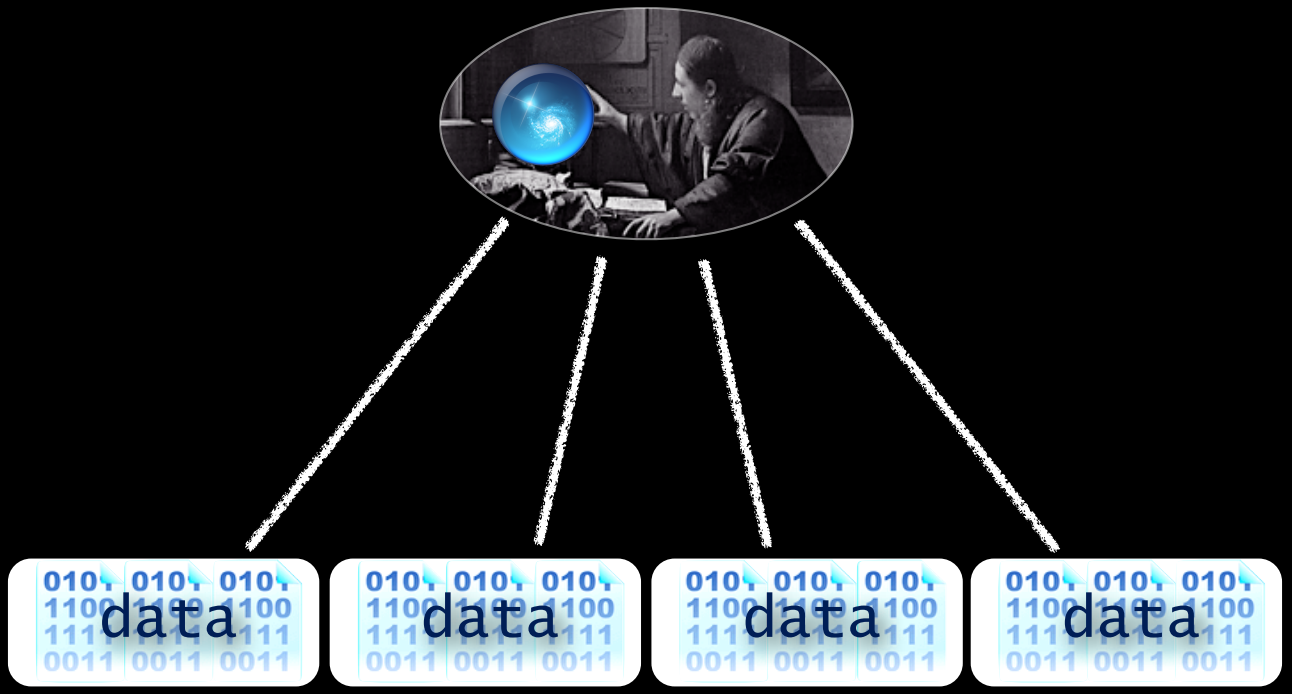
(When) does literature *= web pages?*

="The Internet"

Seamless Astronomy

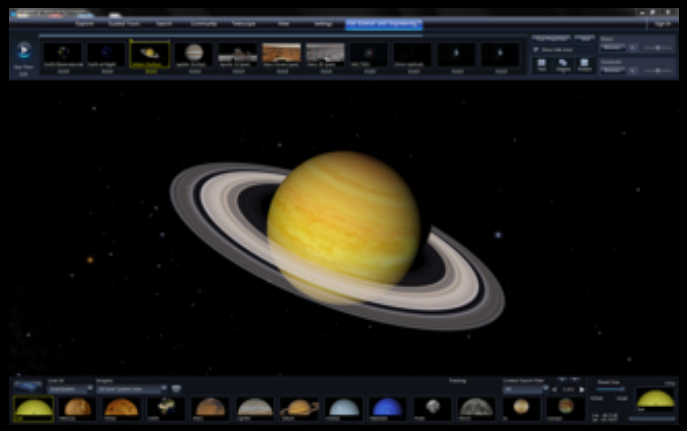
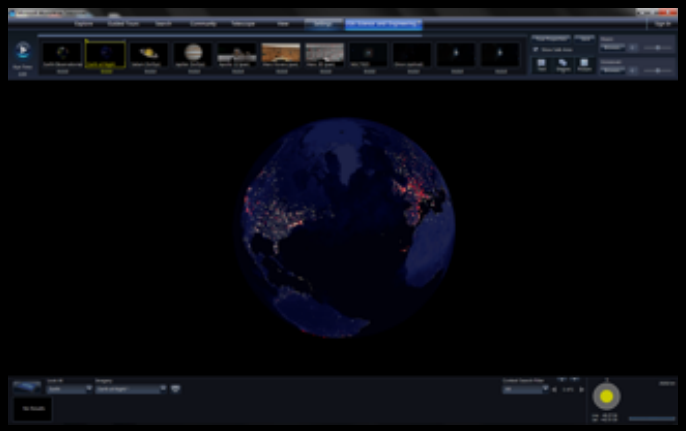
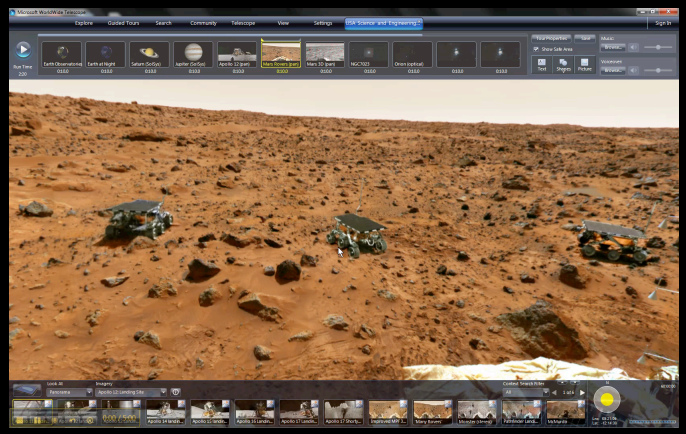
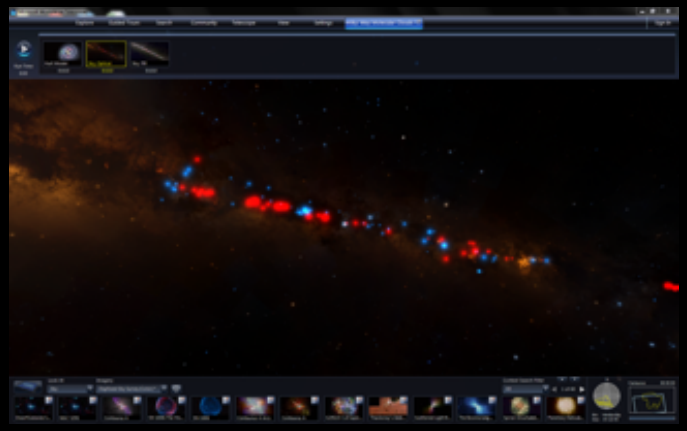
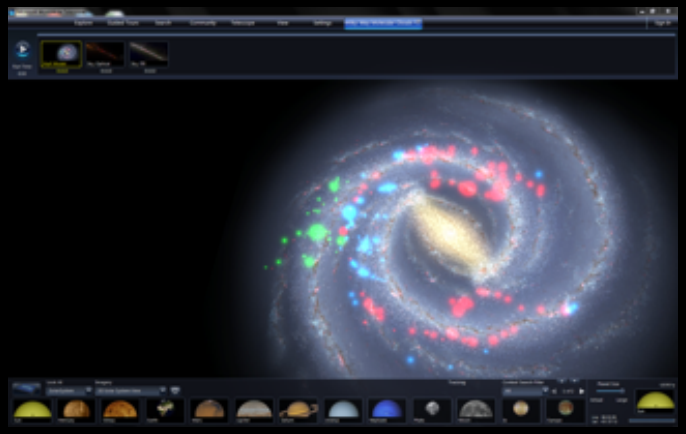
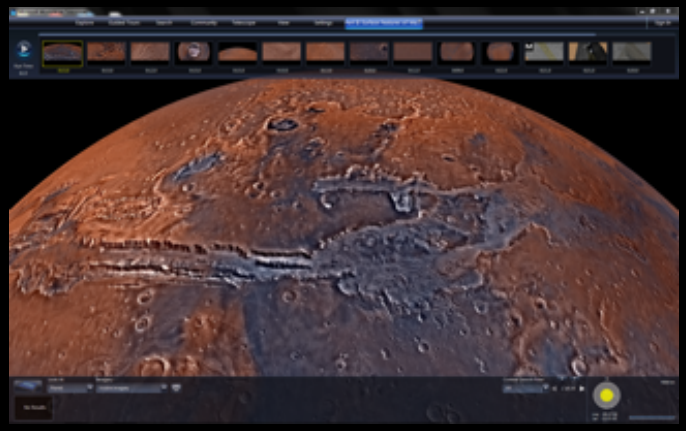


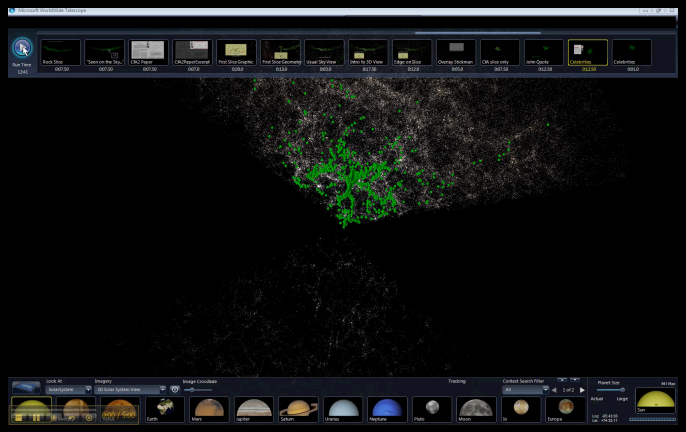
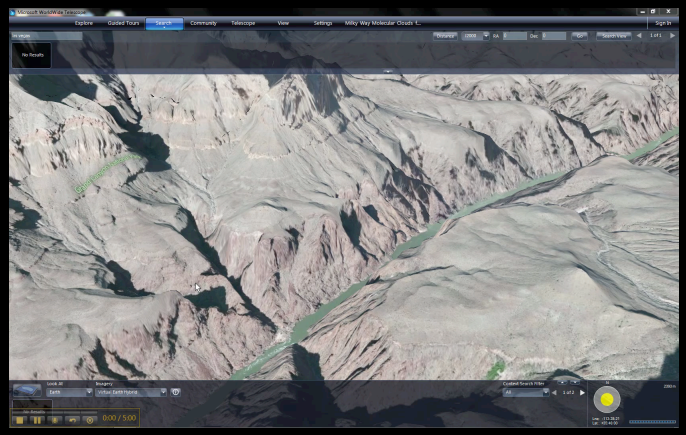
Seamless Astronomy



A "Virtual Observatory"

Best Instantiation: WorldWide Telescope
est. 2008

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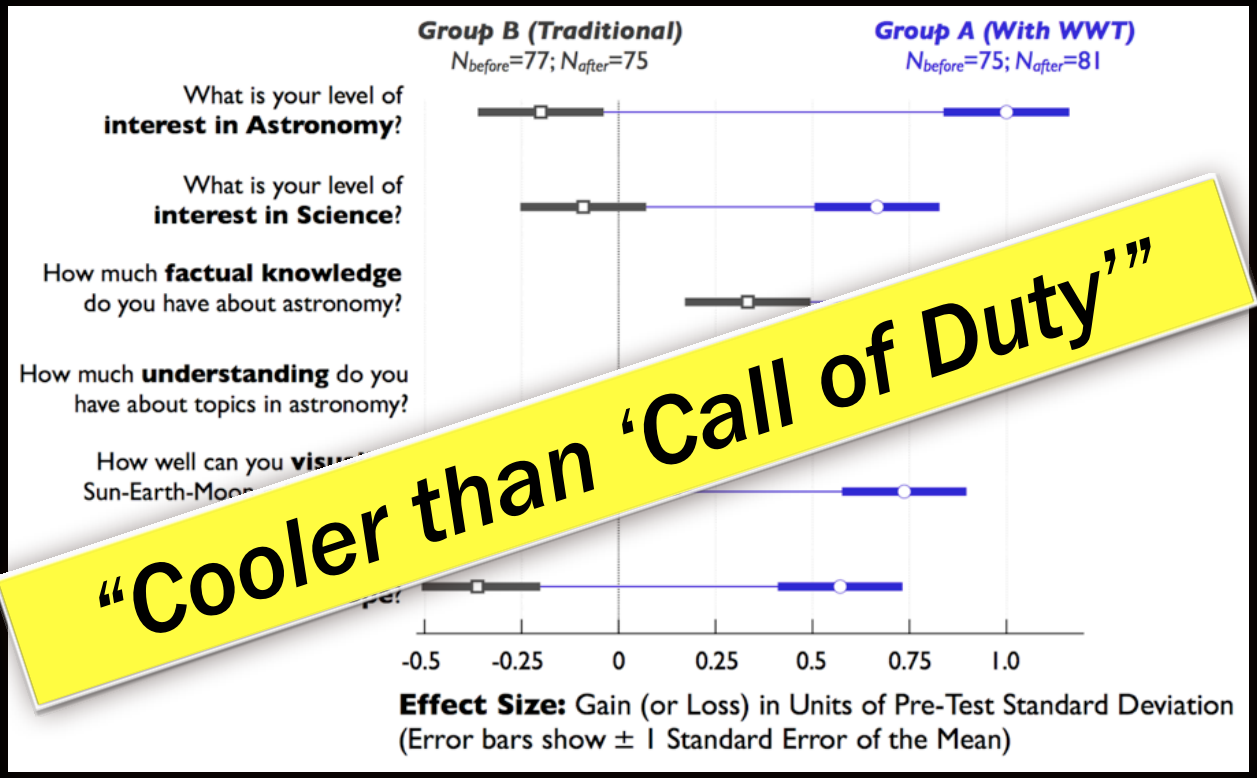
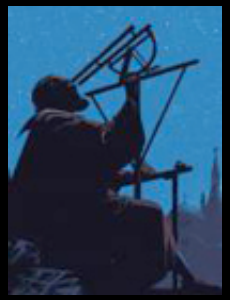
[demo]

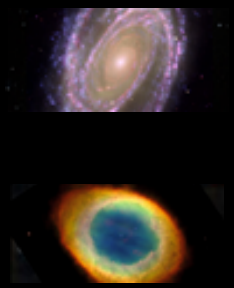
WWT Ambassadors



"Cooler than 'Call of Duty'"

"Tours"





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WWT in Higher Ed

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WWT in Research

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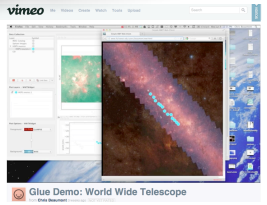


glue

multidimensional data exploration

Viz-e-lab

Seamless Astronomy

Best Instantiation: ADS
est. 1994*

literature

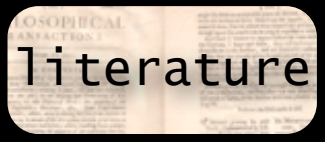
[demo not needed!]

*see *Kurtz et al. 2000* for full history

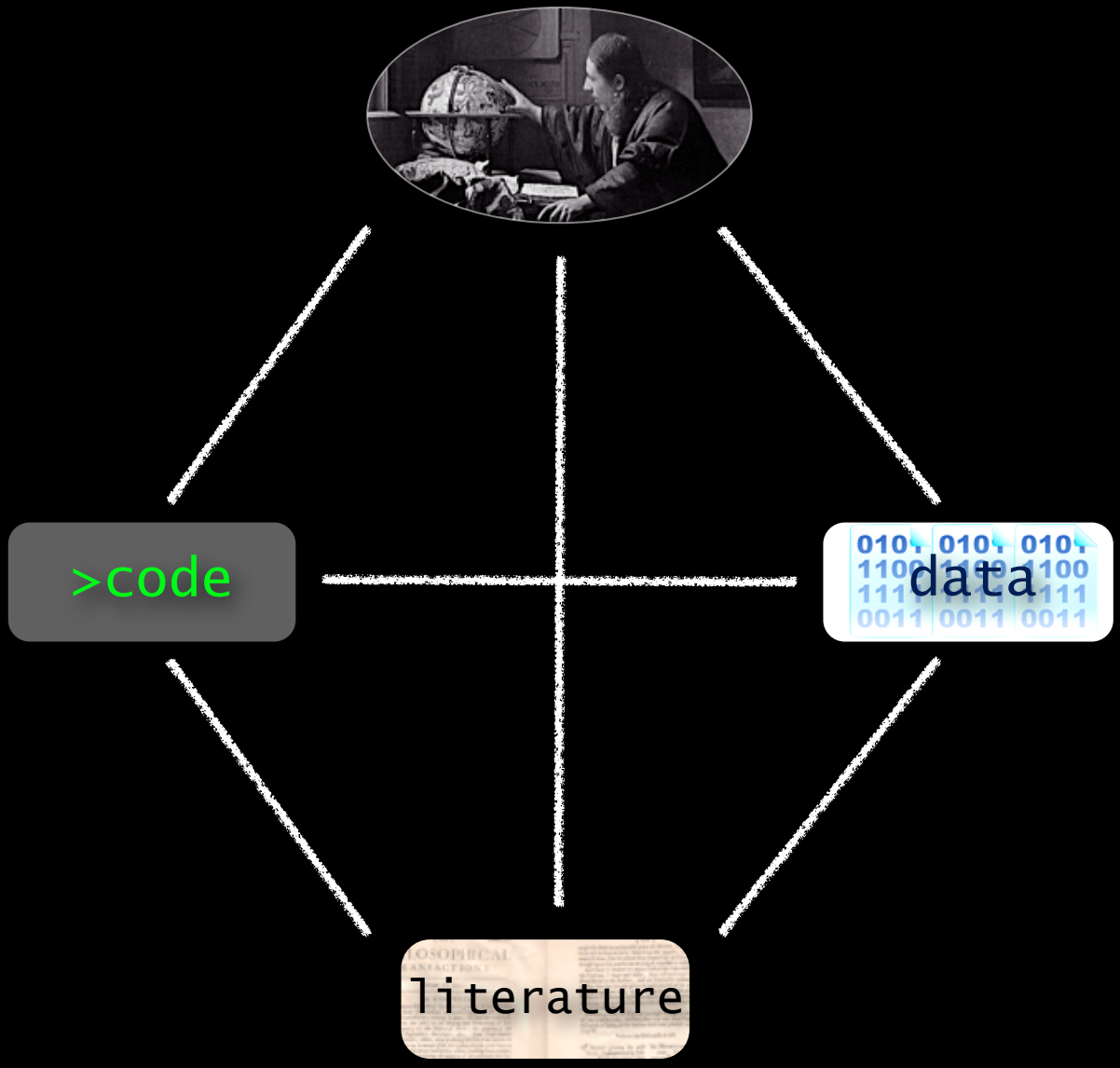
Seamless Astronomy

Better(!):
ADS Labs
est. 2011

[demo]

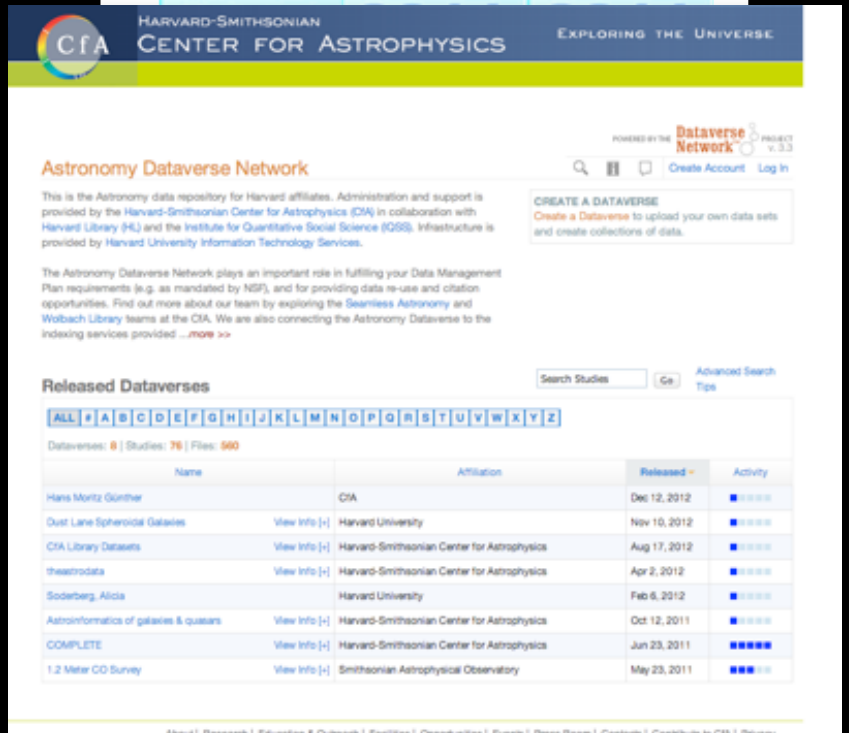


Seamless Astronomy



Seamless Astronomy

data(verse!)



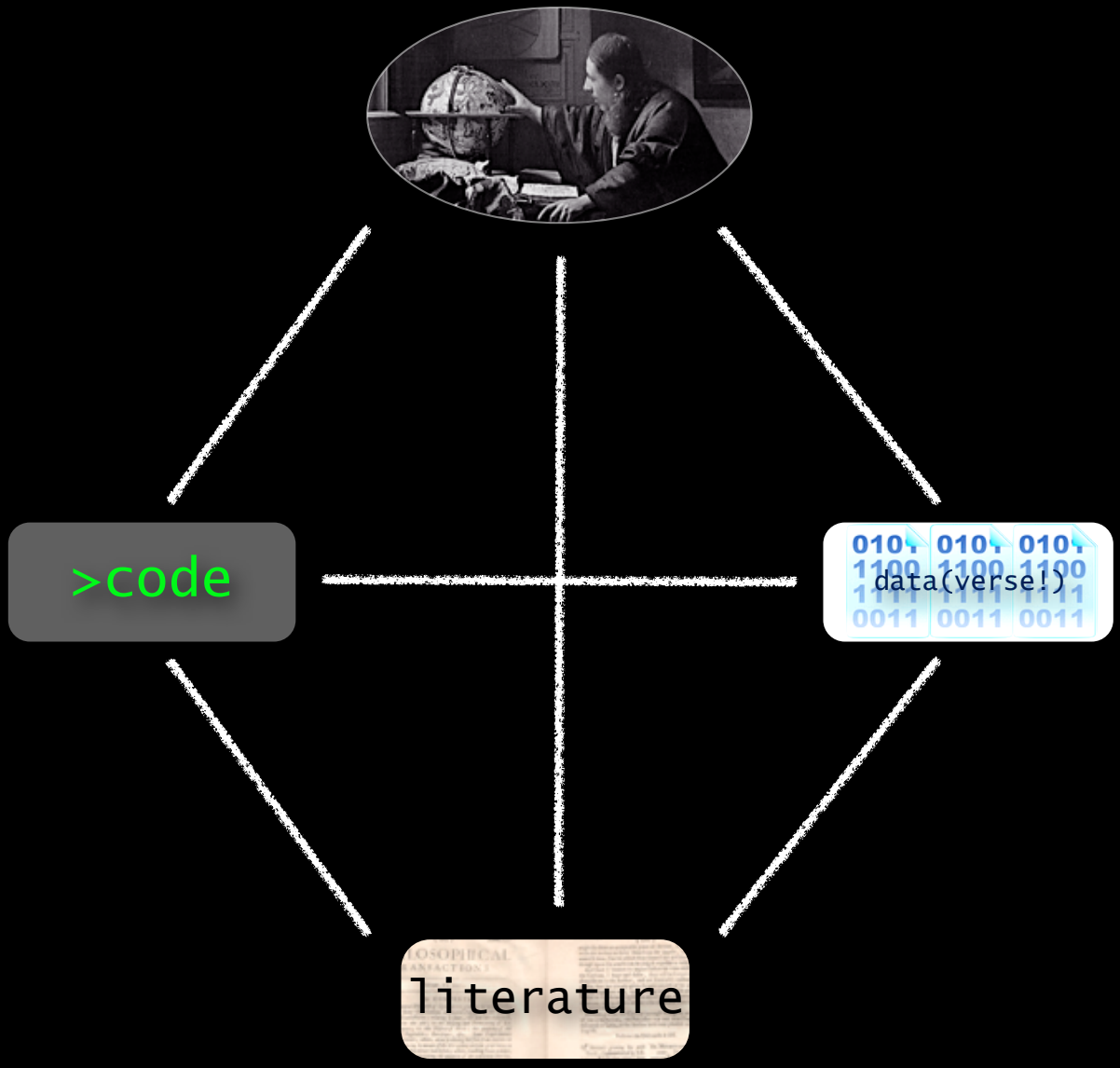
each data "set" gets unique, citable, identifier (hdl or DOI)

theastrodata.org

cf. thedata.org

The Dataverse Network™ Project

Seamless Astronomy



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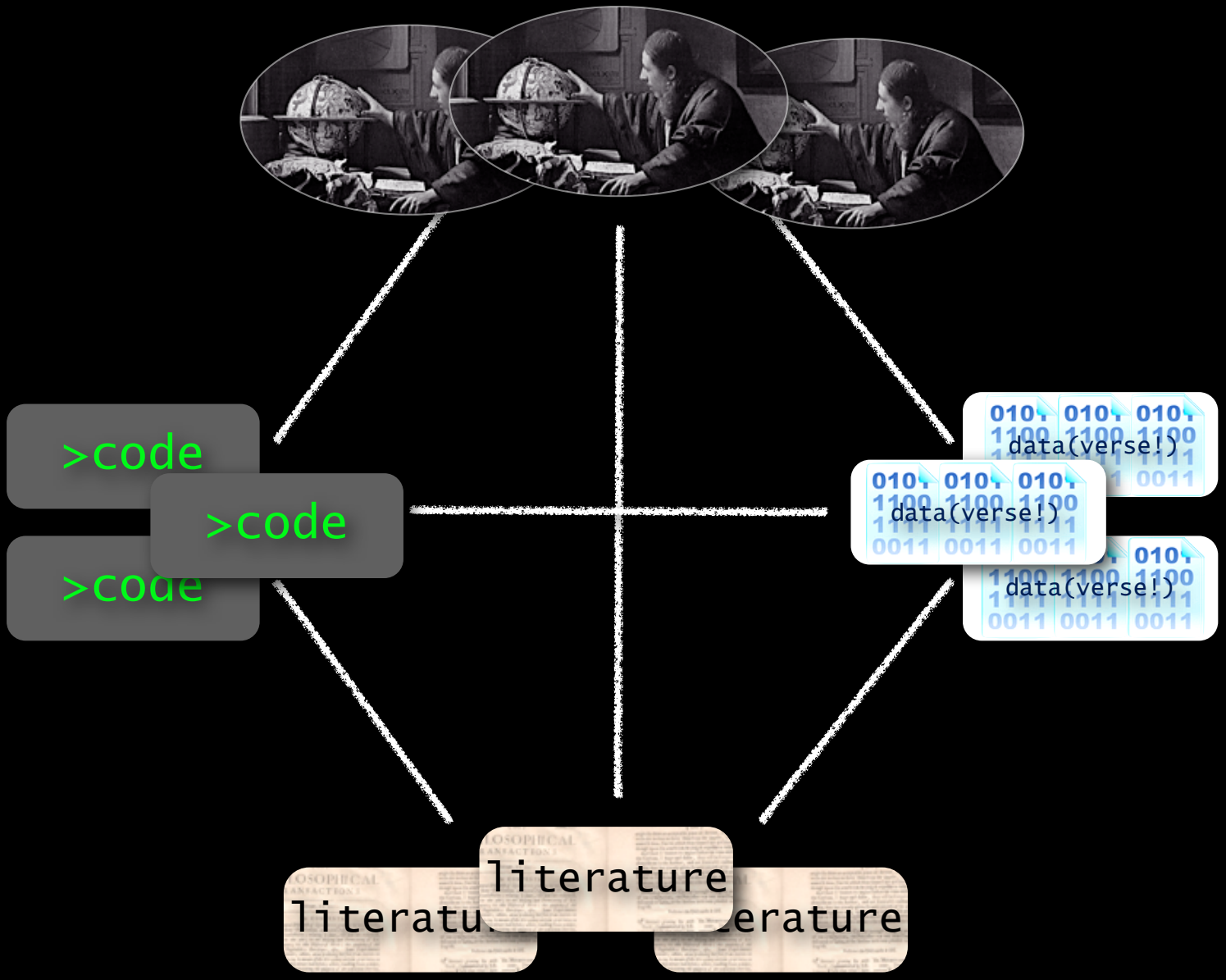

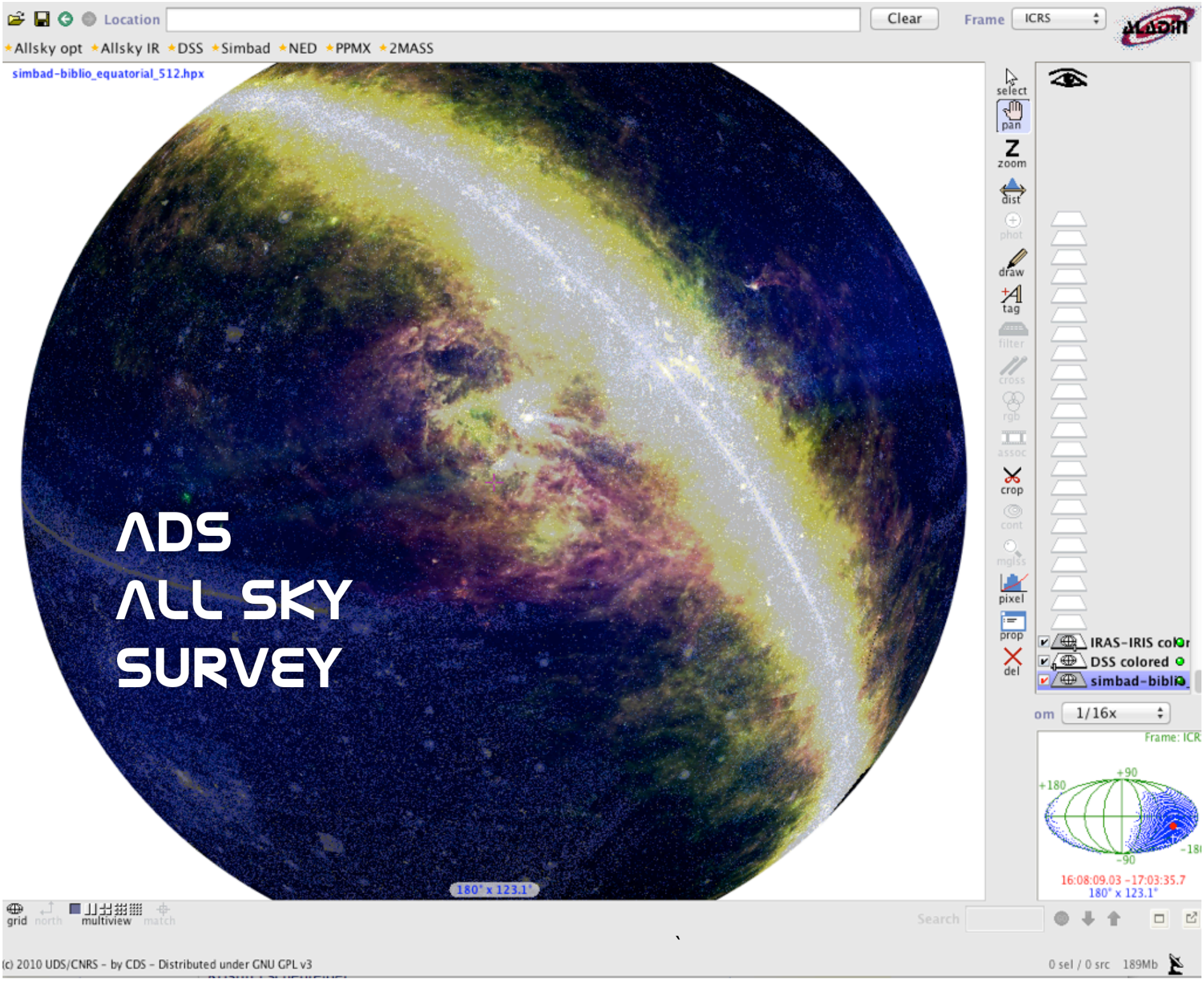
Location
Clear
Frame
ICRS
Allsky opt
Allsky IR
DSS
Simbad
NED
PPMX
2MASS
simbad-biblio_equatorial_512.hpx
ADS
ALL SKY
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select
pan
zoom
dist
phot
draw
tag
filter
cross
rgb
assoc
crop
cont
mgiss
pixel
prop
del
IRAS-IRIS color
DSS colored
simbad-biblio
1/16x
Frame: ICRS
+90
+180
-90
16:08:09.03 -17:03:35.7
180° x 123.1°
180° x 123.1°
grid
north
multiview
match
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0 sel / 0 src
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Seamless Astronomy: Citizen Science

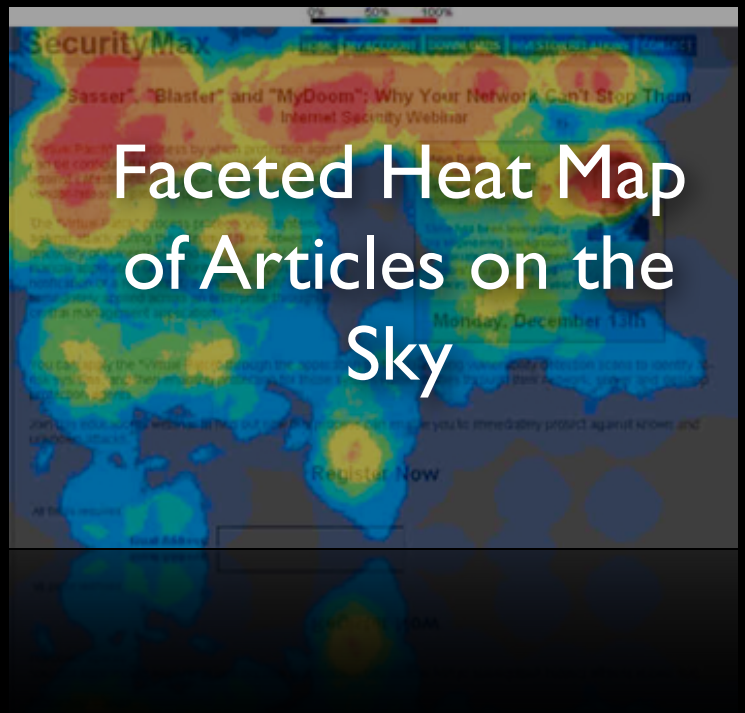
ZOONIVERSE
REAL SCIENCE ONLINE

Seamless Astronomy: ADS All Sky Survey

ZOONIVERSE
REAL SCIENCE ONLINE

ADSASS particpants include: ADS, CDS, STScI, NYU/astrometry.net, Microsoft Research & Zooniverse

Seamless Astronomy: ADS All Sky Survey

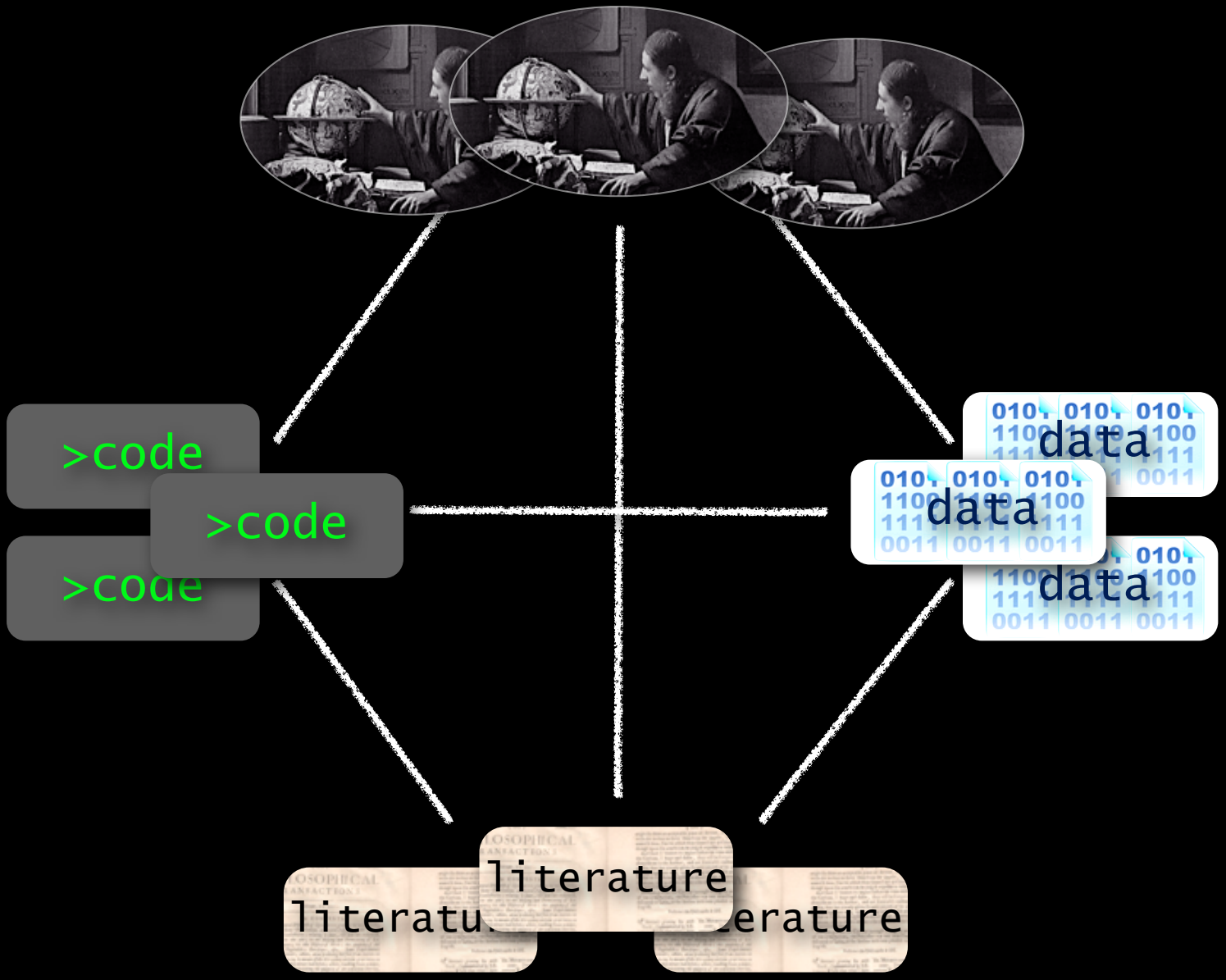


ADS-CDS-Seamless-MSR collaboration

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

ADS-Seamless-astrometry.net-MSR-Zooniverse collaboration

Seamless Astronomy



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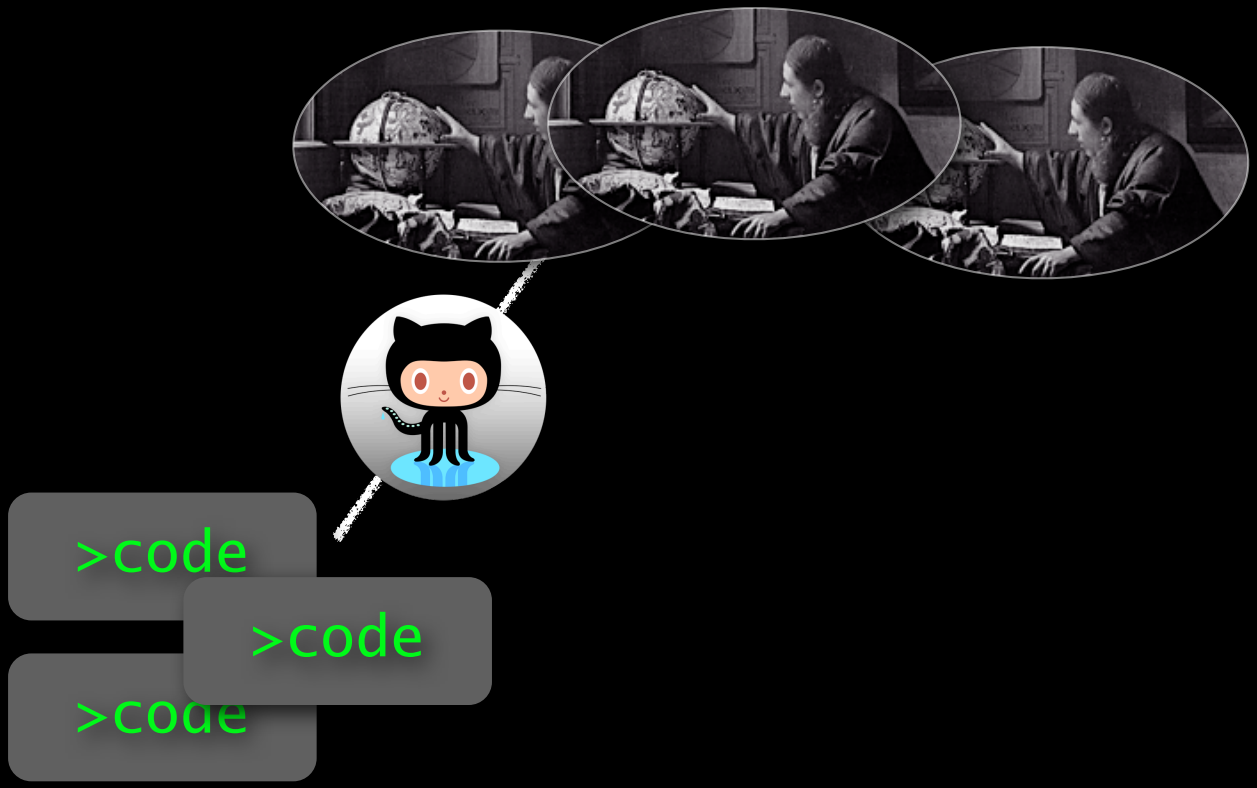


code sharing, e.g. github

Search or type a command Explore Gist Blog Help aagoodman

Adrian Price-Whelan

adrn

Columbia University
NYC
http://www.adrianpricewhela...
Joined on Jan 25, 2011

11 followers **22** starred **14** following

Organizations

Contributions Repositories Public Activity Follow

Popular repositories

- AchtungCoaddVerboten — 3 ★
- apwlib — 2 ★ — Various useful astronomical code.
- Python-Columbia — 2 ★ — Repository with example code, tutorials, an...
- specutils — 1 ★ — Affiliated package for 1D spectral operation...
- mala-strana — 1 ★

Repositories contributed to

- astropy/astropy — 148 ★ — Main AstroPy repository
- astropy/astropy-tutorials — 2 ★ — Tutorials for the Astropy package
- astropy/astropy-api — 0 ★ — Repository for API documents for Astropy
- dfm/emcee.js — 6 ★ — Just a slick little Markov chain Monte Carlo ...
- astropy/astropy-v0.2-paper — 0 ★ — Paper describing Astropy v0.2

adrn's Open Source Contributions

Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar

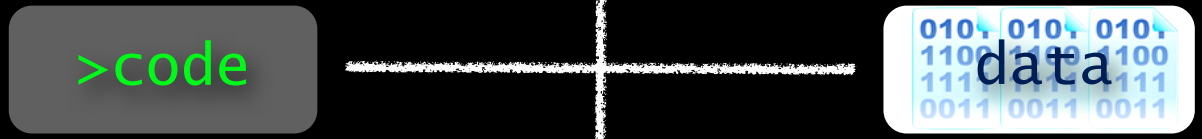
M W F

Summary of Pull Requests, issues opened and commits. Learn more. Less More

913 Total	20 days	20 days
Apr 19 2012 - Apr 19 2013	March 30 - April 18	March 30 - April 18
Year of Contributions	Longest Streak	Current Streak

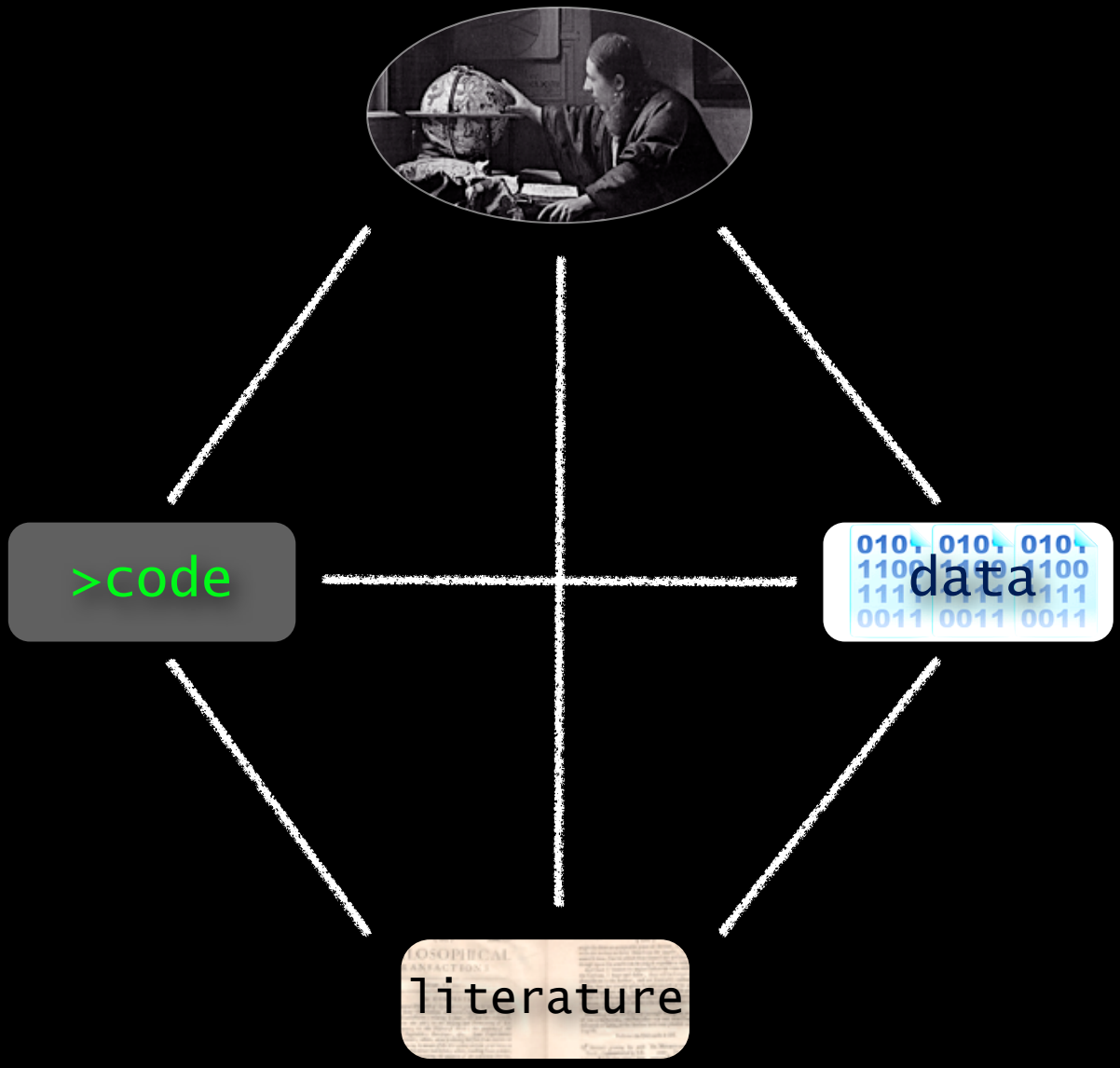
Contribution Activity Period: 1 Week

Seamless Astronomy

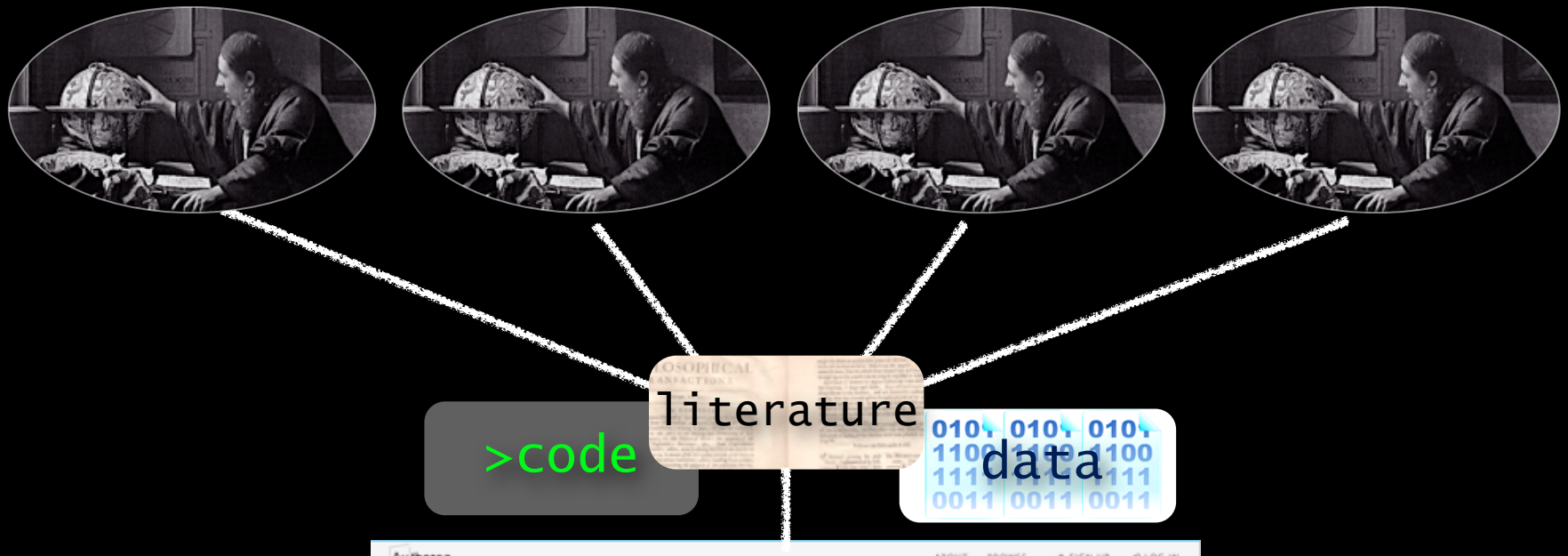


(When) does literature *= web pages?*

Seamless Astronomy

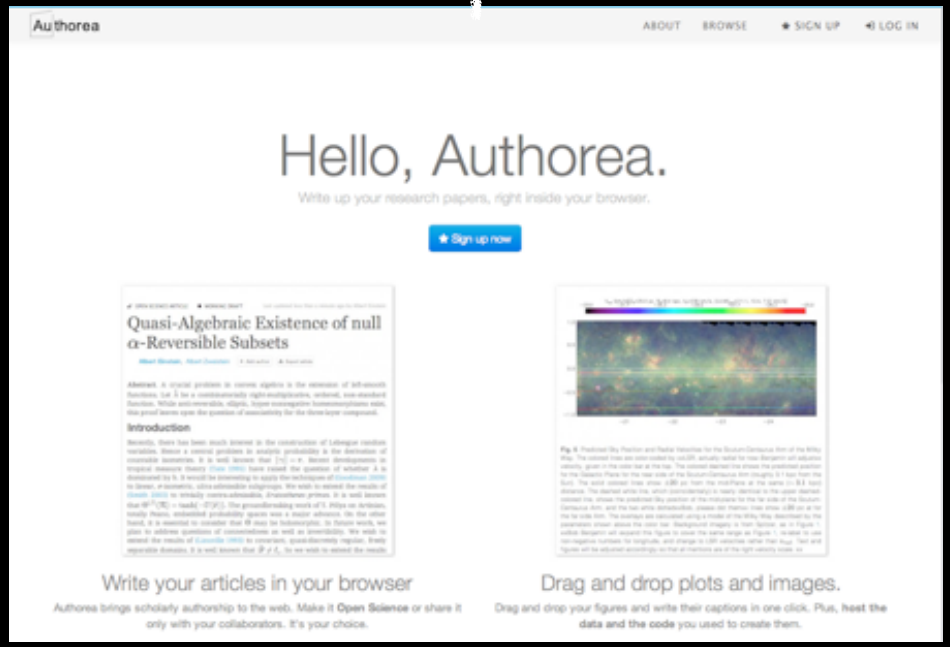


Seamless Astronomy: Authorea



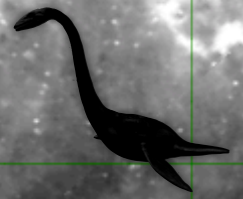
each collaborative project ("paper") can be public or private

versioning model=github



authorea.com

The Bones of the Milky Way



Alyssa A. Goodman (Harvard-Smithsonian Center for Astrophysics)

with collaborators at (alphabetically by insitution):

Boston University: James Jackson

Caltech: Jens Kauffmann

Harvard - Smithsonian: Christopher Beaumont, Michelle A. Borkin, Thomas M. Dame

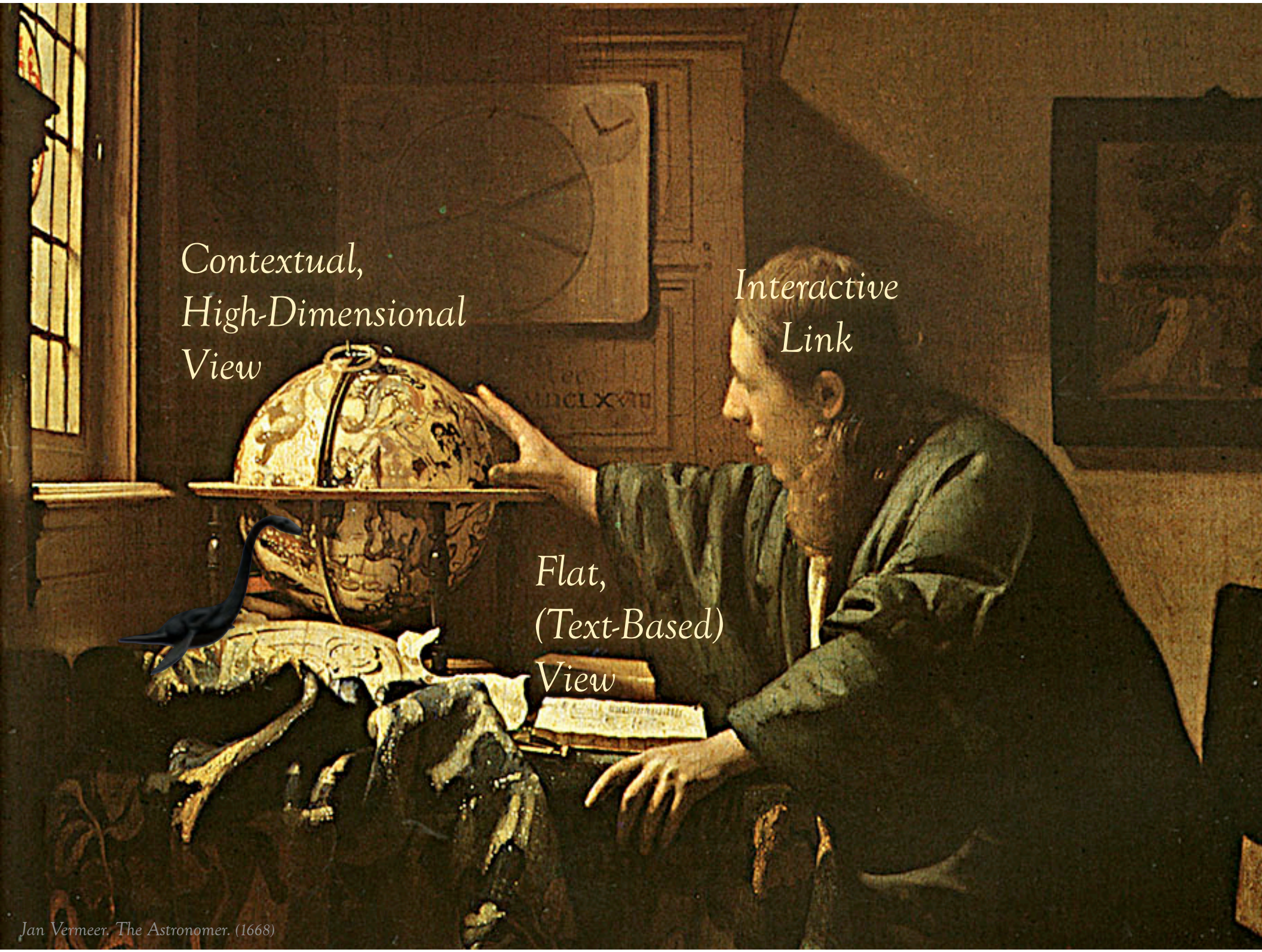
Max Planck Insitute for Astronomy: Thomas Robitaille

U. Munich: Andreas Burkert

U. Vienna: Joao F. Alves

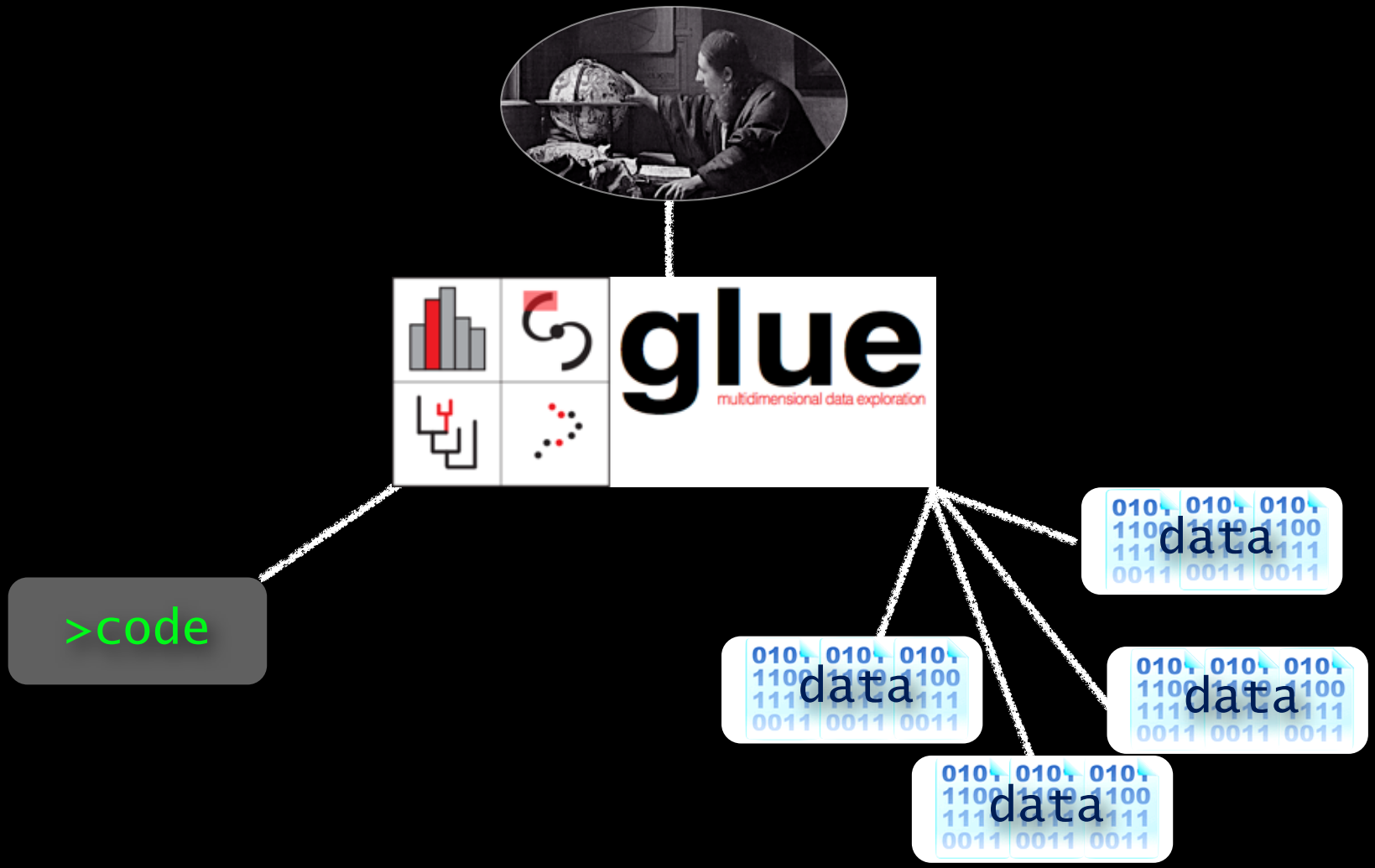
U. Wisconsin: Robert A. Benjamin

Alyssa Goodman, m:617-230-7080; url: milkywaybones.org



Jan Vermeer. The Astronomer. (1668)

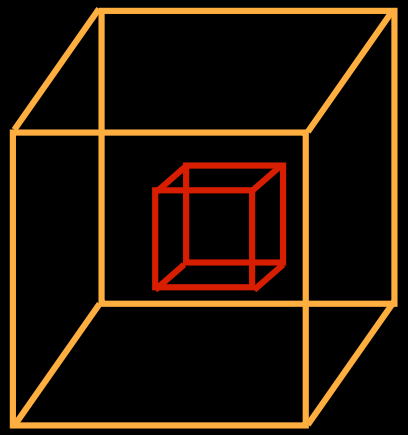
Seamless Astronomy: Data Visualization



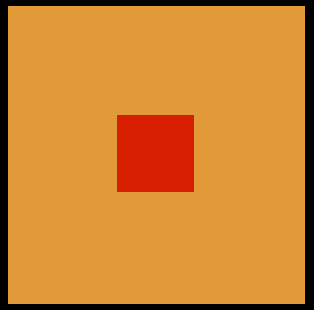
Glue collaboration (see *glueviz.org*): Chris **Beaumont**, lead & Alyssa **Goodman** (Harvard-CfA);
Michelle **Borkin** & Hanspeter **Pfister** (Harvard-SEAS/CS) and Thomas **Robitaille** (MPIA Heidelberg)

"Linked Views" = glue

multidimensional data exploration

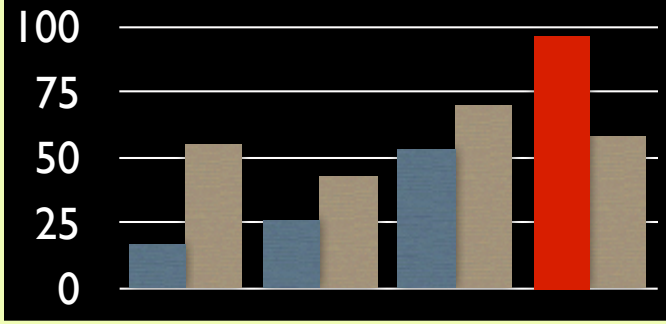


3D

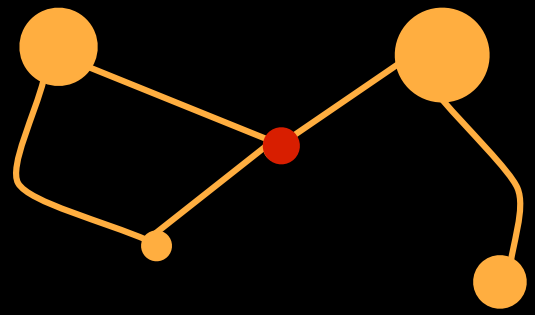


2D

Statistics

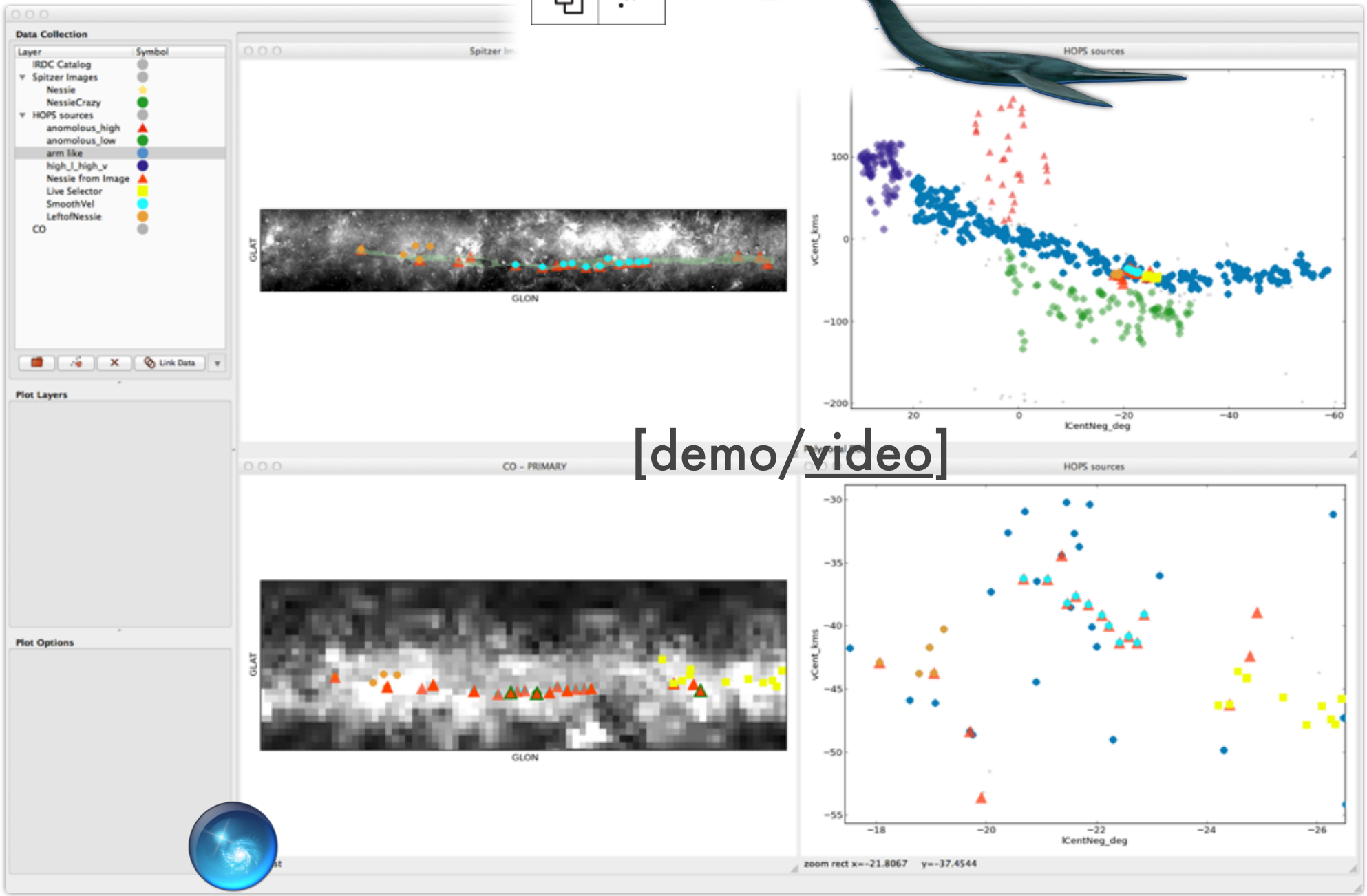


Data Abstraction



glue

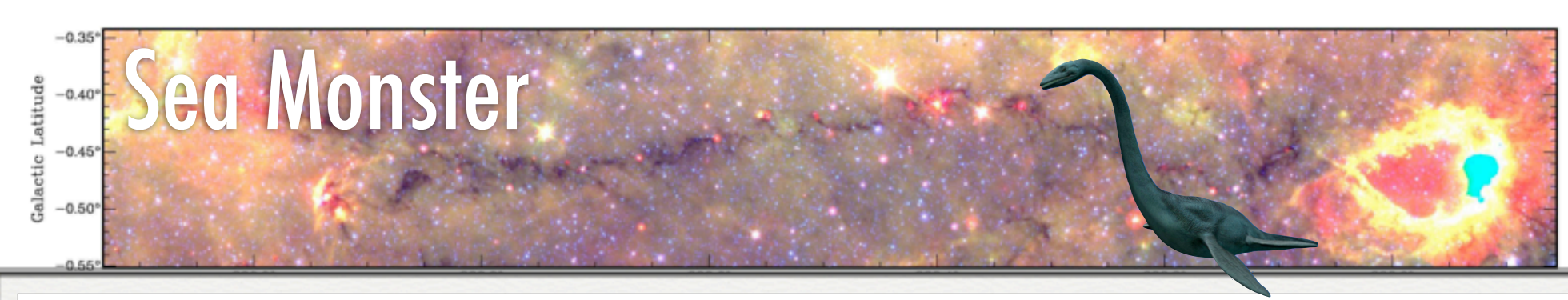
multidimensional data exploration



[demo/video]

http://www.glueviz.org/en/latest/

Glue collaboration: ***Beaumont****, Borkin, Goodman, Pfister, Robitaille*



The Astrophysical Journal Letters, 719:L185–L189, 2010 August 20 doi:10.1088/2041-8205/719/2/L185
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THE "NESSIE" NEBULA: CLUSTER FORMATION IN A FILAMENTARY INFRARED DARK CLOUD

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[2] Department of Physics and Astronomy, Northwestern University, Evanston, IL 60208, USA; e-chambers@northwestern.edu
[3] Australia Telescope National Facility and Universidad de Chile, Santiago, Chile; rathborn@das.uchile.cl
[4] I. Physikalisches Institut, Universität zu Köln, 50937 Köln, Germany; simonr@ph1.uni-koeln.de
Received 2010 April 13; accepted 2010 July 21; published 2010 August 3

ABSTRACT

The "Nessie" Nebula is a filamentary infrared dark cloud (IRDC) with a large aspect ratio of over 150:1 (1.°5 × 0.°01 or 80 pc × 0.5 pc at a kinematic distance of 3.1 kpc). Maps of HNC (1–0) emission, a tracer of dense molecular gas, made with the Australia Telescope National Facility Mopra telescope, show an excellent morphological match to the mid-IR extinction. Moreover, because the molecular line emission from the entire nebula has the same radial velocity to within ±3.4 km s^{-1}, the nebula is a single, coherent cloud and not the chance alignment of multiple unrelated clouds along the line of sight. The Nessie Nebula contains a number of compact, dense molecular cores which have a characteristic projected spacing of ~4.5 pc along the filament. The theory of gravitationally bound gaseous cylinders predicts the existence of such cores, which, due to the "sausage" or "varicose" fluid instability, fragment from the cylinder at a characteristic length scale. If turbulent pressure dominates over thermal pressure in Nessie, then the observed core spacing matches theoretical predictions. We speculate that the formation of high-mass stars and massive star clusters arises from the fragmentation of filamentary IRDCs caused by the "sausage" fluid instability that leads to the formation of massive, dense molecular cores. The filamentary molecular gas clouds often found near high-mass star-forming regions (e.g., Orion, NGC 6334, etc.) may represent a later stage of IRDC evolution.

Key words: ISM: clouds – stars: formation

Jackson et al. 2010

Monster to Bone

There could be ~1000 more of these to find...a full skeleton perhaps?

milkywaybones.org

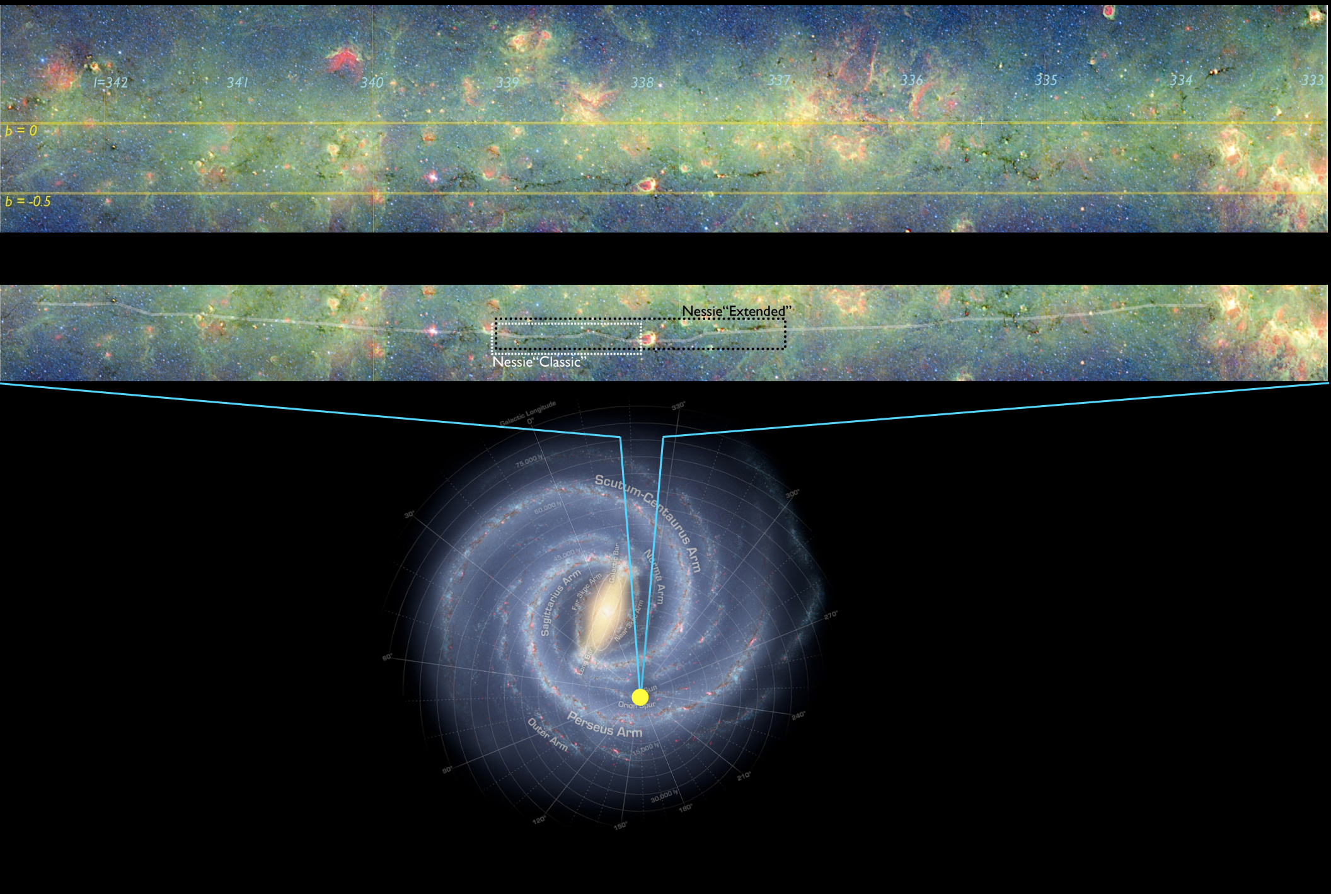
Ringberg Castle, Bavaria
"Early Phases of Star Formation"
July 2012

QUESTION *Andi Burkert*: Is Nessie "parallel to the Galactic Plane"?

ANSWER *no one* immediately knew the answer!

AG decides to look into this and...

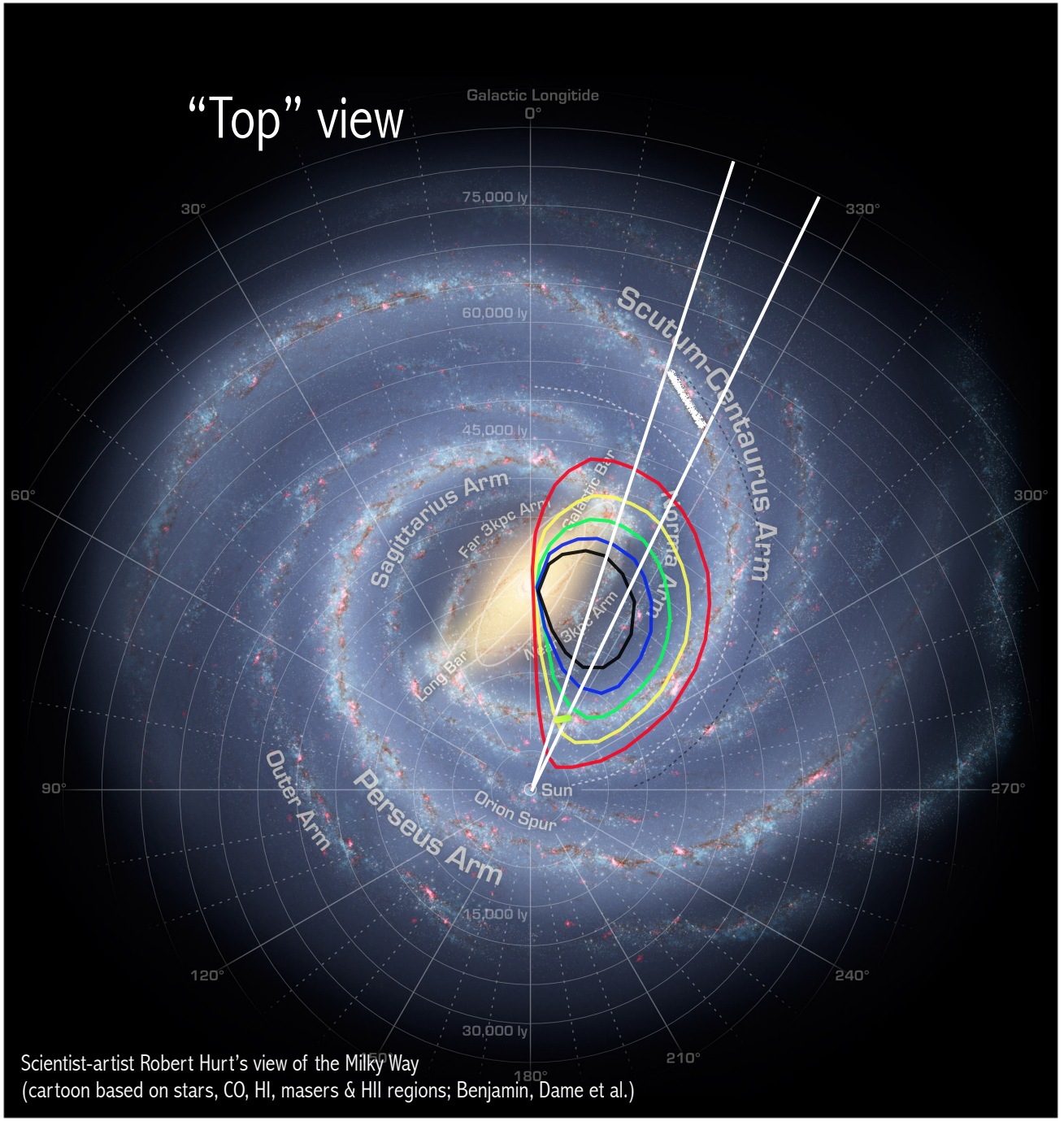
"Is Nessie Parallel to the Galactic Plane?"


l=342
341
340
339
338
337
336
335
334
333
b = 0
b = -0.5
Nessie"Extended"
Nessie"Classic"
Galactic Longitude 0°
330°
300°
270°
240°
210°
180°
150°
120°
90°
60°
30°
75,000 ly
60,000 ly
45,000 ly
30,000 ly
15,000 ly
Scutum-Centaurus Arm
Norma Arm
Sagittarius Arm
Galactic Bar
Far 3kpc Arm
Near 3kpc Arm
Long Bar
Sun
Orion Spur
Perseus Arm
Outer Arm

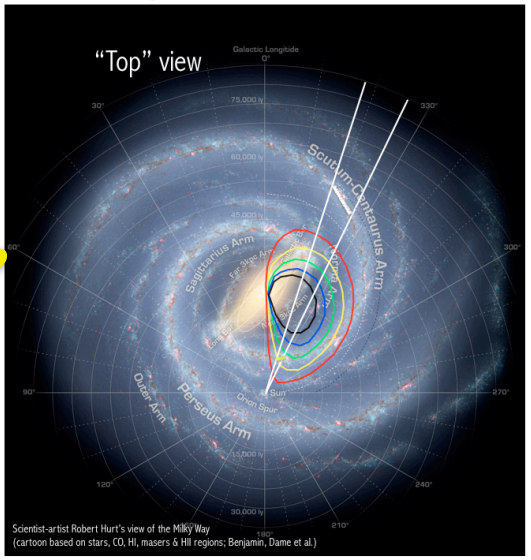
The Milky Way

The Milky Way
(Artist's Conception)

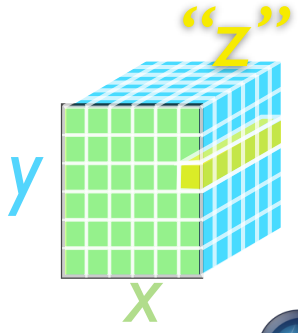
Using Velocity Constraints



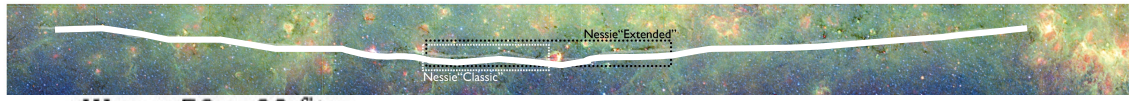
Using Velocity Constraints



-20
-40
-60
-80
-100

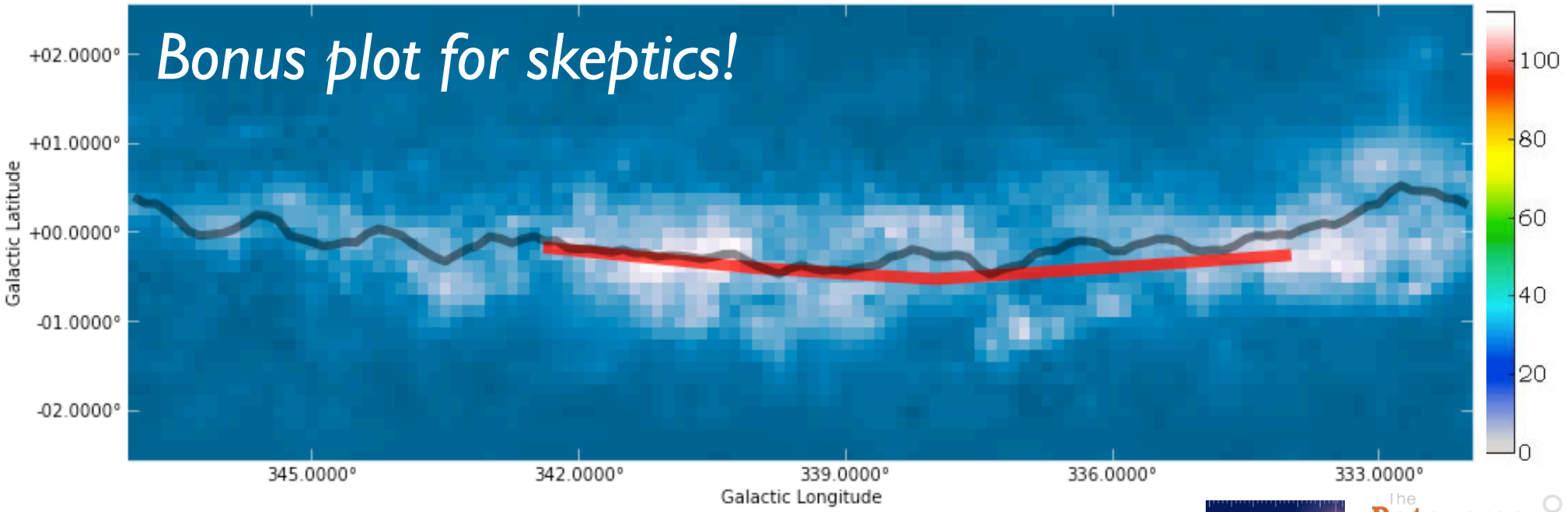


1 degree ~ 60 pc at 3.5 kpc



Wco m50 m30.fits

Bonus plot for skeptics!

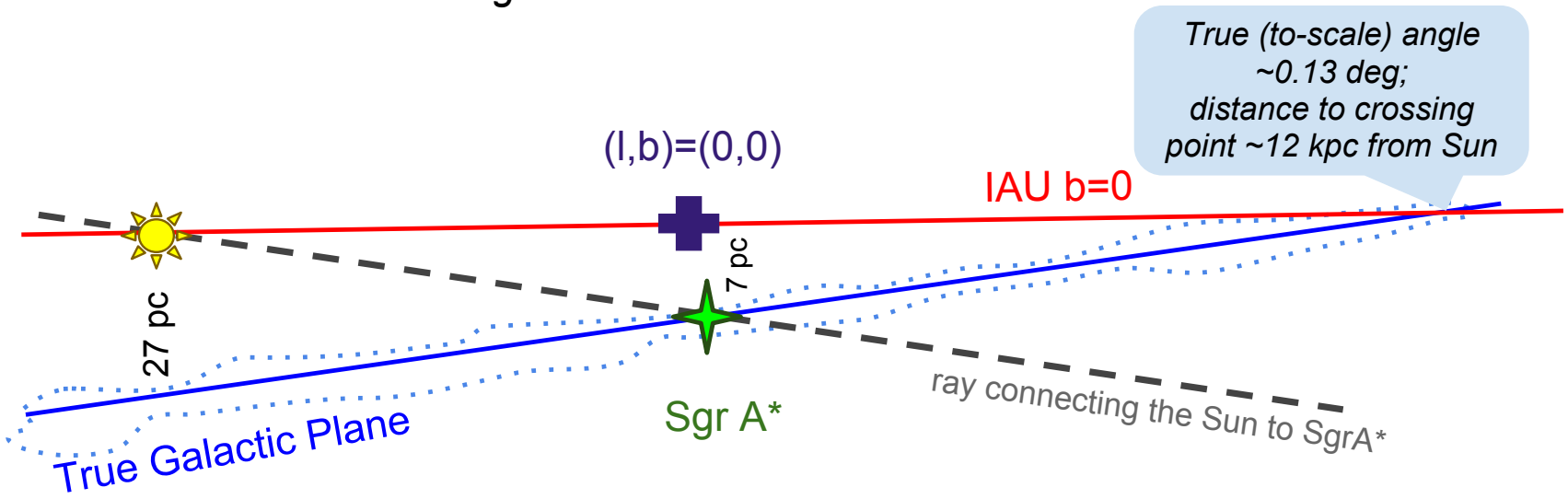


ads labs NASA

The Dataverse Network™ Project

Why b<0?!
Galactic Geometry: 1959 and Now

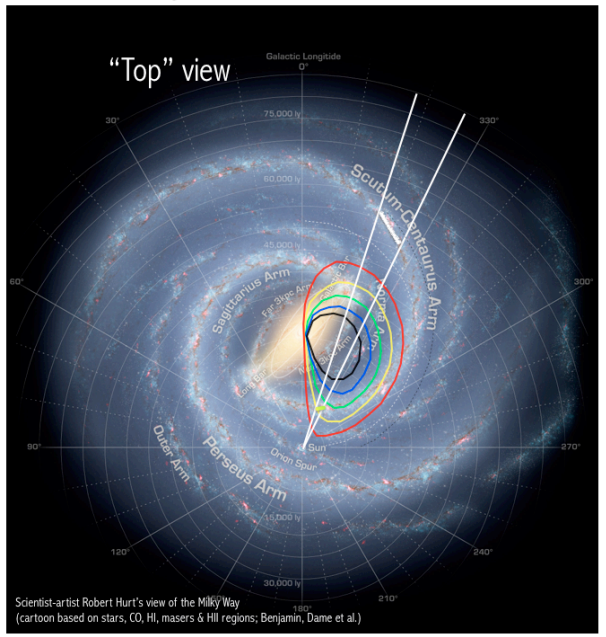
Drawing is schematic--NOT to scale



The equatorial plane of the new co-ordinate system must of necessity pass through the sun. It is a fortunate circumstance that, within the observational uncertainty, both the sun and Sagittarius A lie in the mean plane of the Galaxy as determined from the hydrogen observations. If the sun had not been so placed, points in the mean plane would not lie on the galactic equator.

[Blaauw et al. 1959]

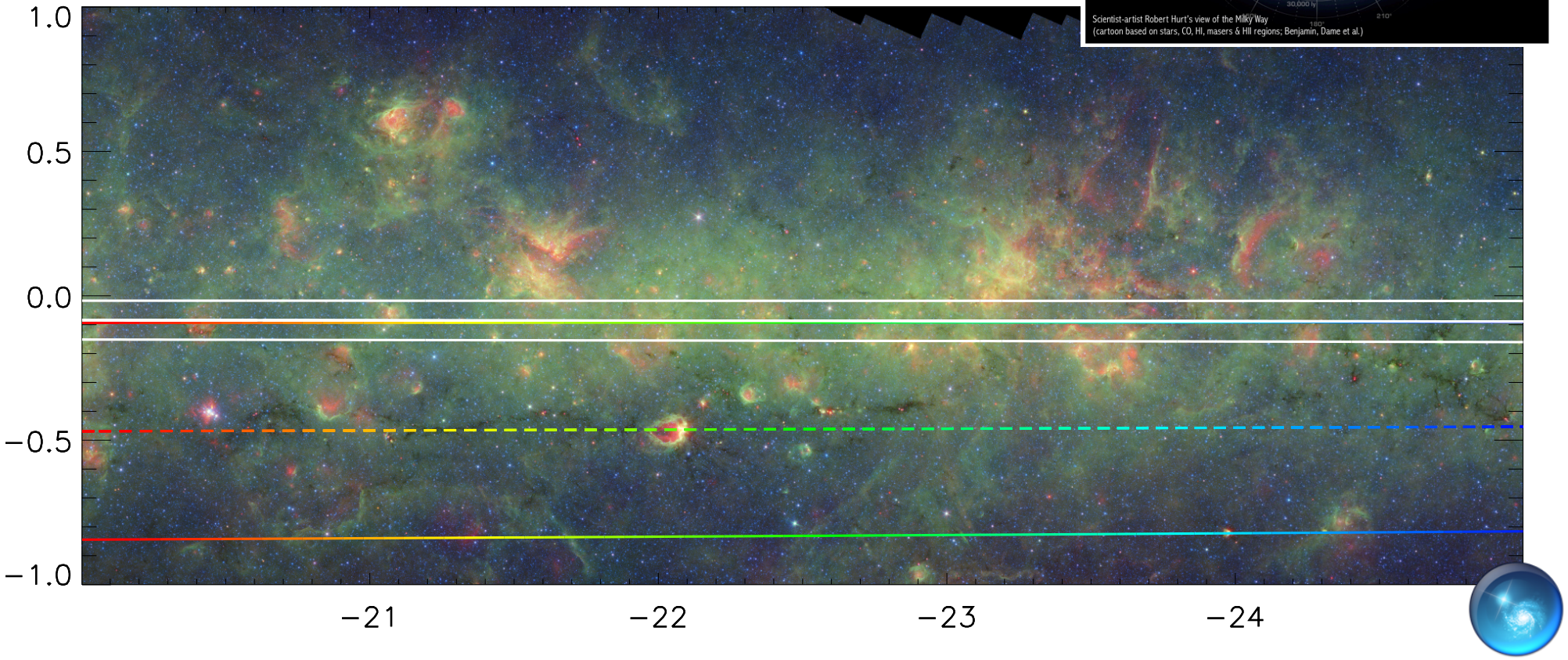
Predicted Near & Far Scutum-Centaurus Arm



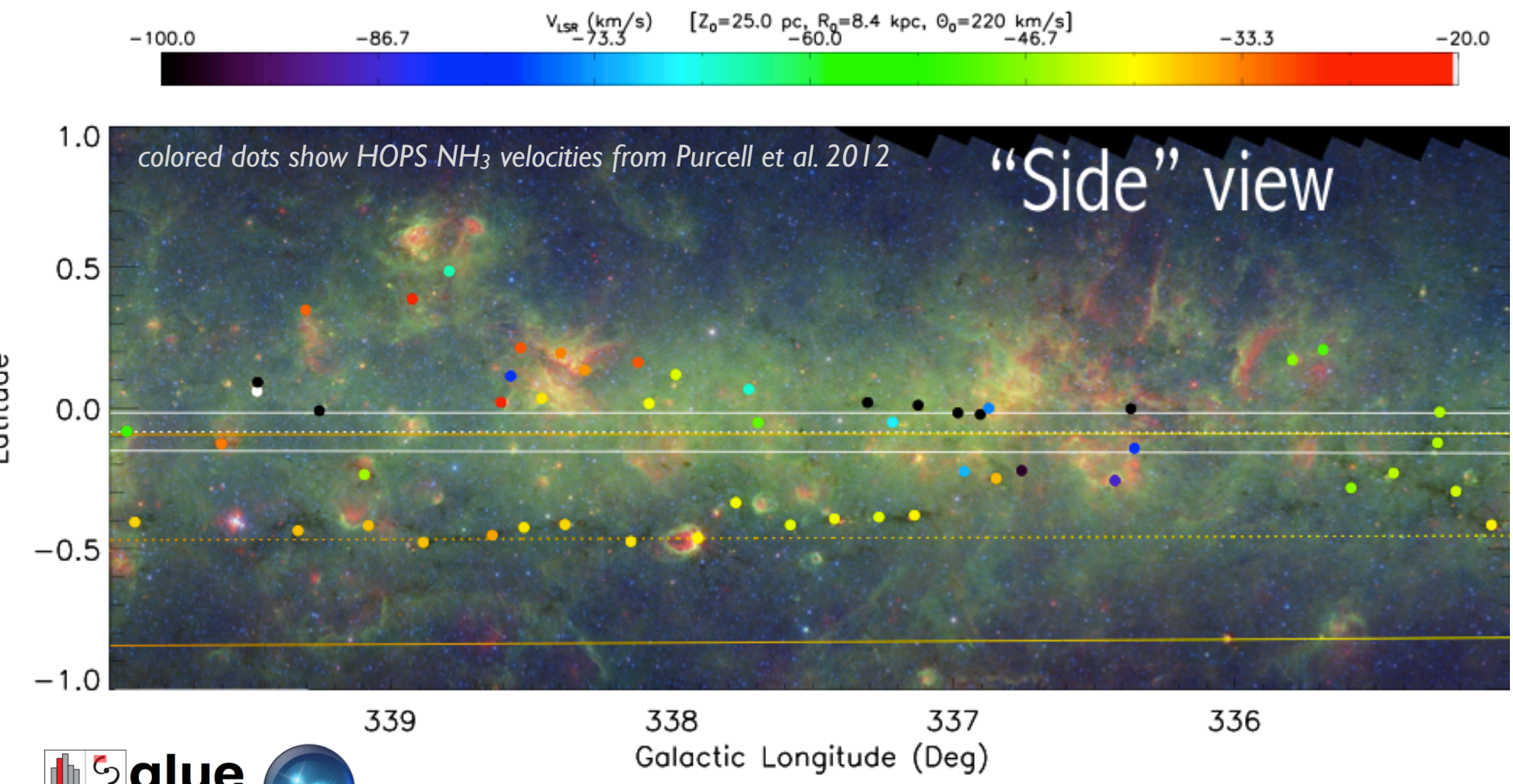
-20
-40
-60
-80
-100

V_{rad} (km/s) [Z_0=25.0 pc, R_0=8.4 kpc, V_0=239 km/s, $(U,V,W)_{sun}$=(11

−33.0 −31.7 −30.3 −29.0 −27.7

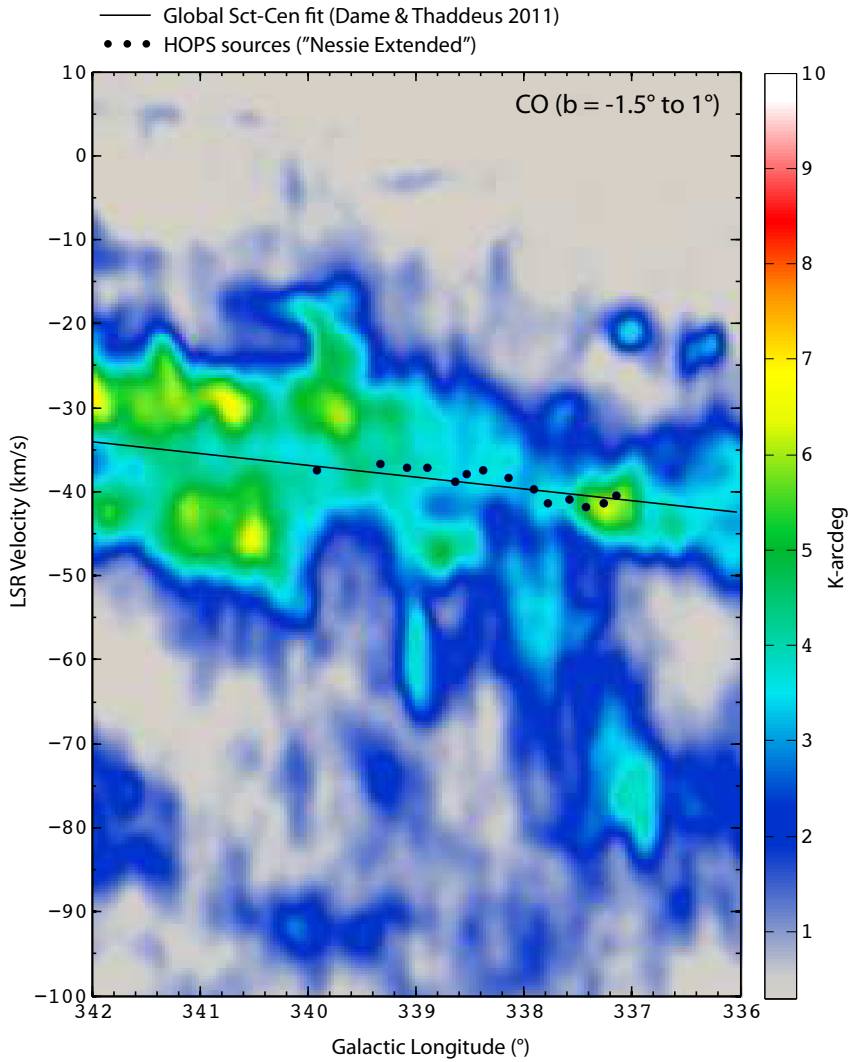


Predicted Velocities match NH_3 Cores in Nessie Perfectly



glue
multidimensional data exploration

Predicted Velocities match NH_3 Cores in Nessie Perfectly



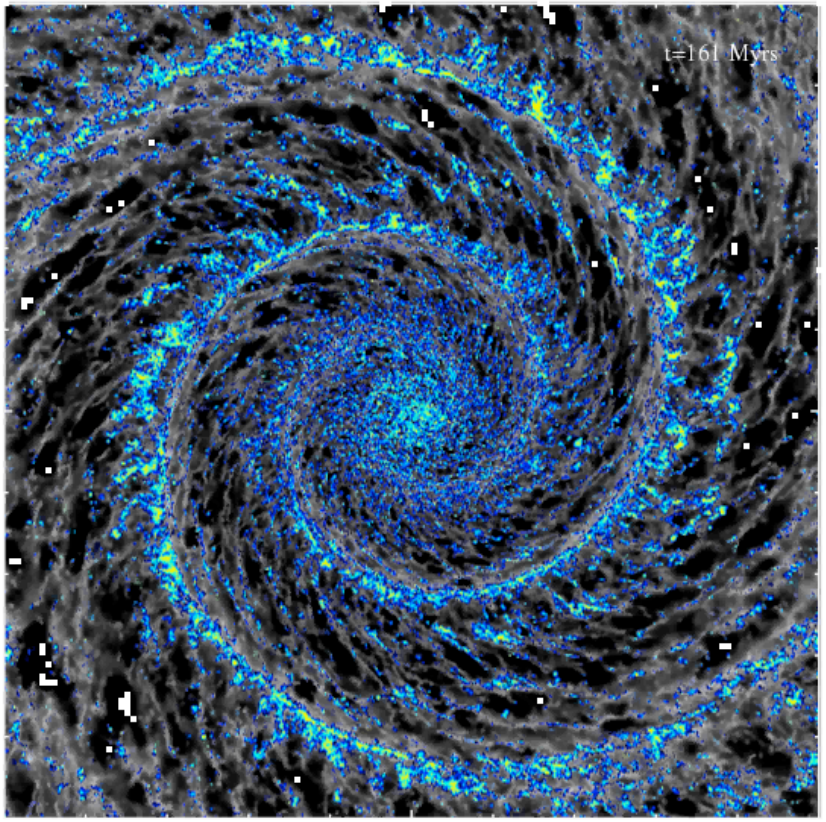
black dots show HOPS NH_3 velocities from Purcell et al. 2012; color is CO; line is log-spiral fit to full Scut-Cen Arm

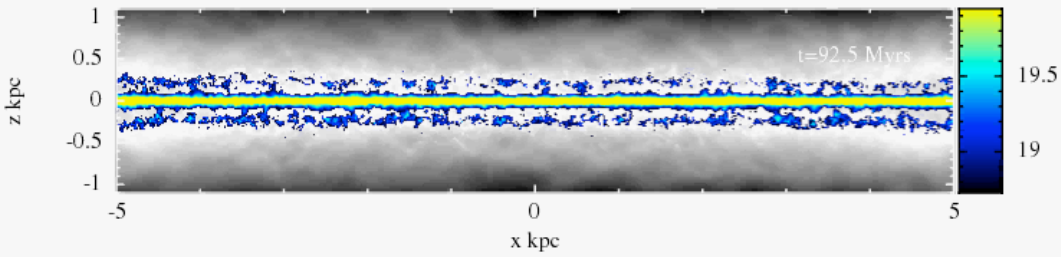
Nessie is a Bone of the Milky Way

(flipped) image of IC342 from Jarrett et al. 2012; WISE Enhanced Resolution Galaxy Atlas

What does that mean?

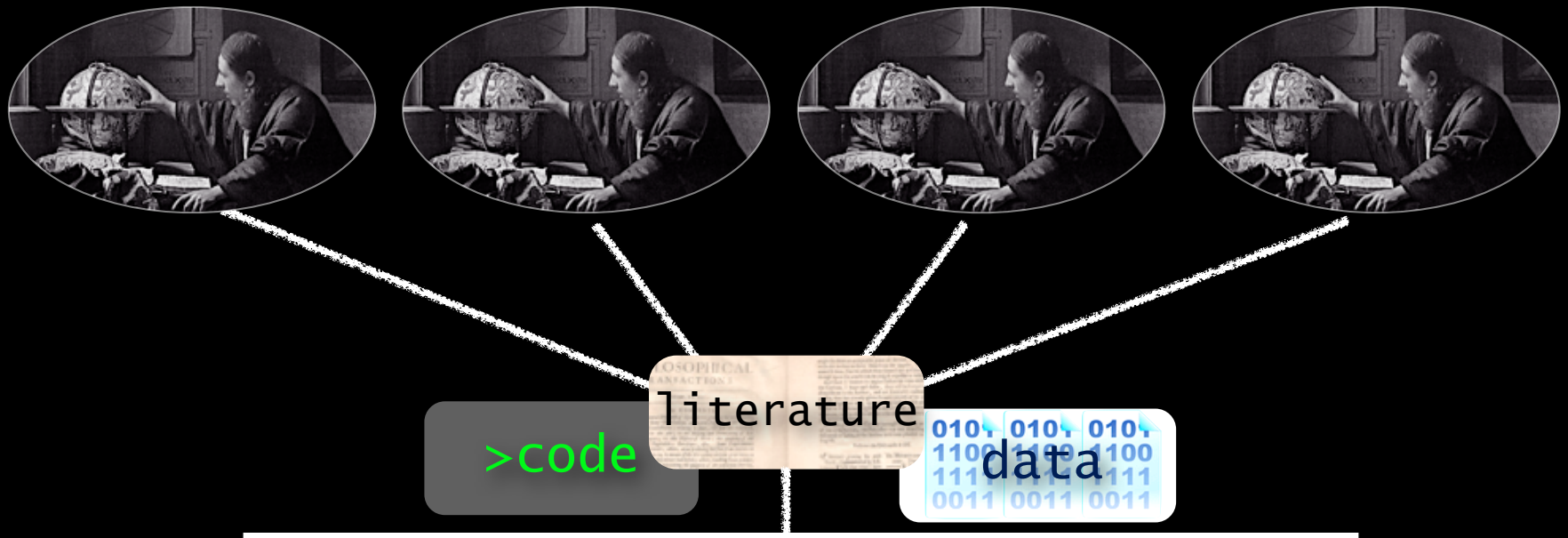
(flipped) image of IC342 from Jarrett et al. 2012; WISE Enhanced Resolution Galaxy Atlas





simulations courtesy Clare Dobbs

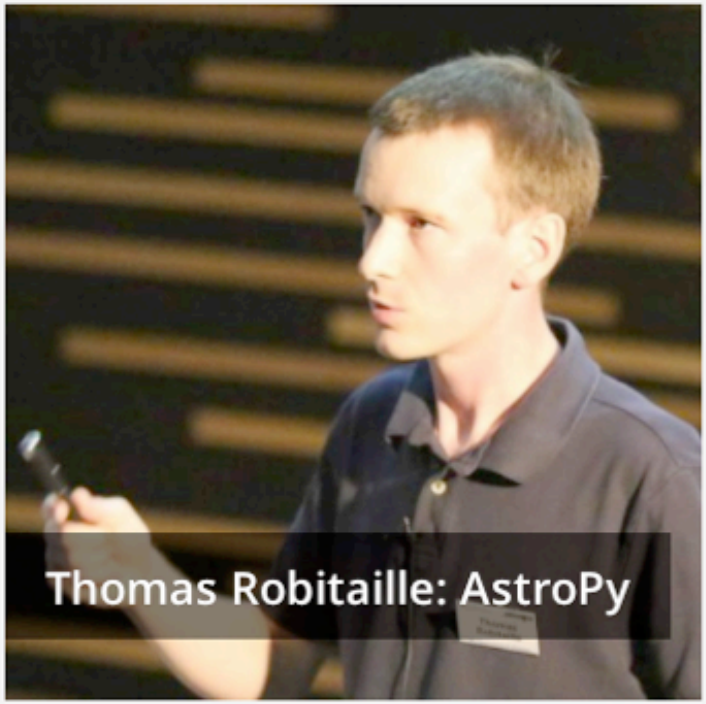
Seamless Astronomy: Authorea



each collaborative pr
("paper"
be public or pr

versioning model=g

orea.com



Unproceedings of .Astronomy 4

We're very pleased to present the Unproceedings of the Fourth .Astronomy Conference (.Astronomy 4), which was held in Heidelberg, ...

Hack Day In New York

.Astronomy is all about sharing ideas and making astronomy happen. Sometimes this means producing code that can fit data really quickly ...

Come to Cambridge For .Astronomy 5

.Astronomy 5 will be hosted by Harvard's Seamless Astronomy group at Microsoft's NERD Center in Cambridge, MA, USA. Mark ...

Publishing with FigShare

Posted: September 6th, 2012 | **Author:** Aleks Scholz | **Comments:** 0

"Publishing 2.0" was an unconference session at this year's dotastronomy conference, and FigShare was one of the new tools discussed in this session. In a nutshell, FigShare is a free online repository for scientific results from all

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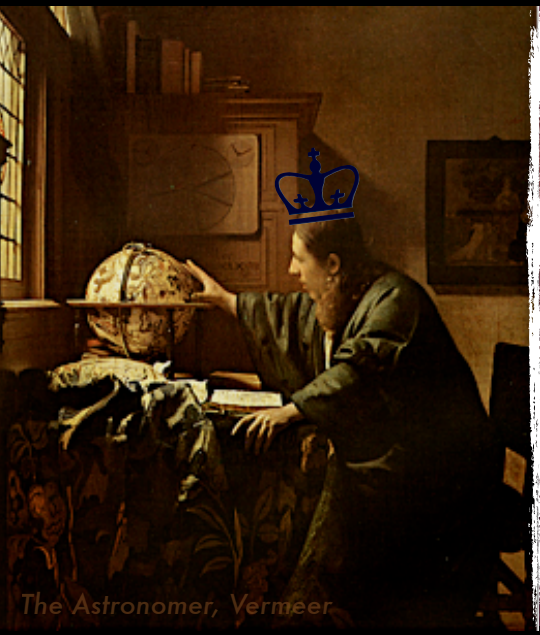
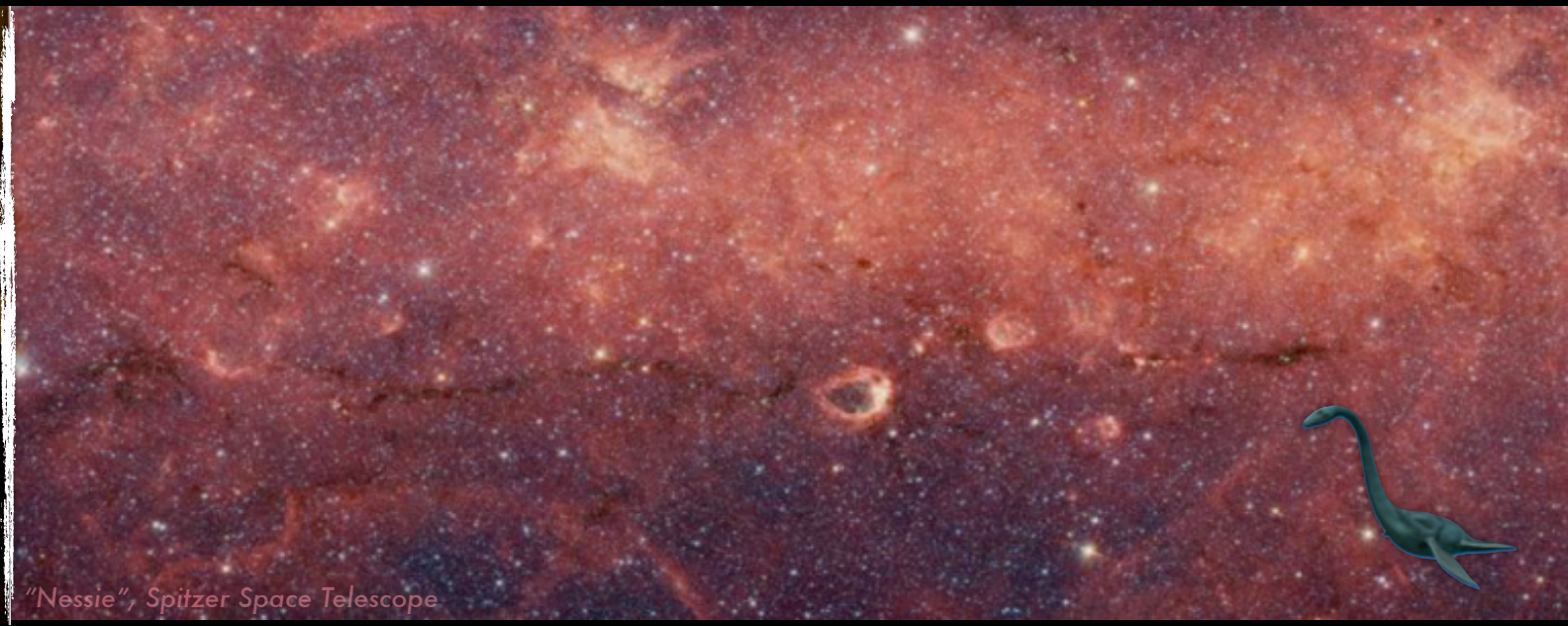
- Unproceedings of .Astronomy 4
- Hack Day In New York
- Come to Cambridge For .Astronomy 5

Seamless Astronomy...and The Bones of the Milky Way


The Astronomer, Vermeer


"Nessie", Spitzer Space Telescope

Alyssa A. Goodman

Harvard-Smithsonian Center for Astrophysics