



[View in Aladin](#) • [View in WorldWide Telescope](#)



adsass.org

here is a 180-degree heatmap of article density on **all** kinds of objects, on the Sky, over **all** time

The ADS All Sky Survey

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Astronomy articles. In the sky.

FILTER BY

Object

All Stars Galaxies HII regions
Nebulae Other

Band

Radio Infrared Ultraviolet X-ray

Custom

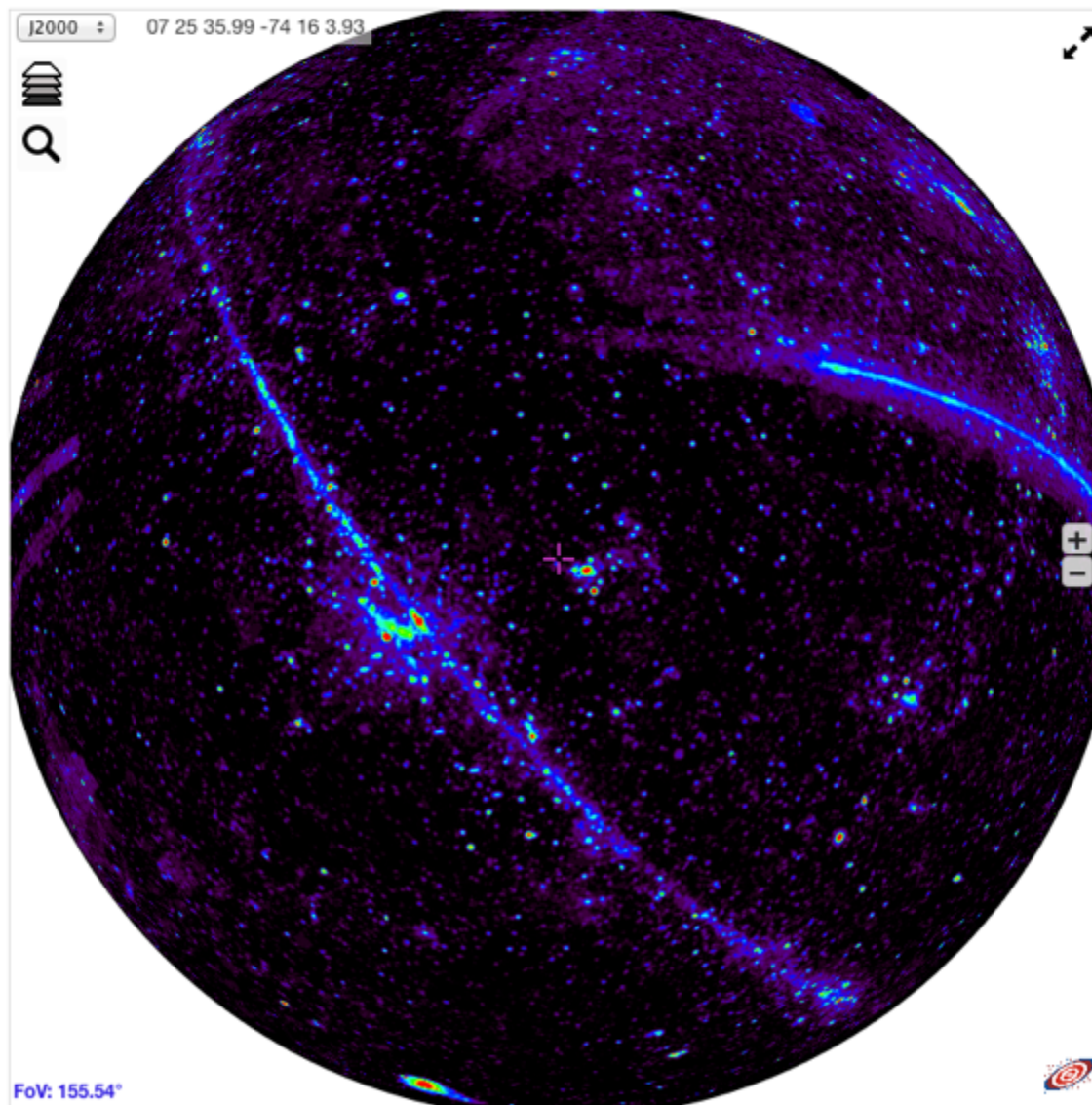
Harvard

Year

TOGGLE BASE LAYER

Optical Mellinger GALEX AIS
DSS2 Red IRIS 2MASS Halpha
VTSS

Select tool



let's zoom in (on Ophiuchus)

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All Stars Galaxies HII regions
nebulae Other

Band

Radio Infrared Ultraviolet X-ray

Custom

Harvard

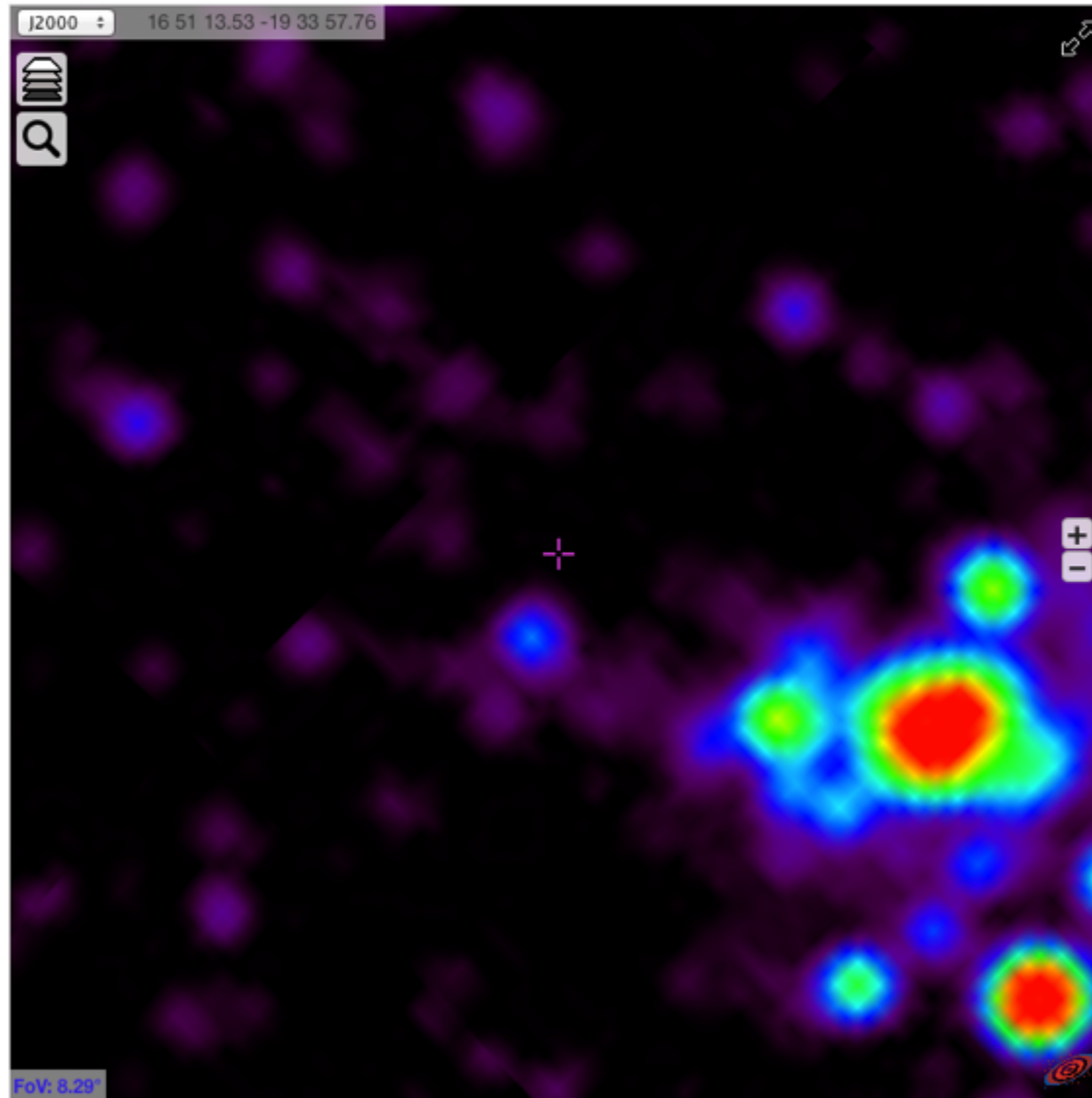
Year



TOGGLE BASE LAYER

Optical Mellinger GALEX AIS
DSS2 Red IRIS 2MASS Halpha
VTSS

Select tool



now, let's toggle on the "Mellinger" view of the Sky ...to see a nice optical image of Ophiuchus

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Harvard

Year



TOGGLE BASE LAYER

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DSS2 Red IRIS MAFSS Halpha
VTSS

Select tool



to add **markers** for SIMBAD sources, we can click the **Select Tool**

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All Stars Galaxies HII regions
Nebulae Other

Band

Radio Infrared Ultraviolet X-ray

Custom

Harvard

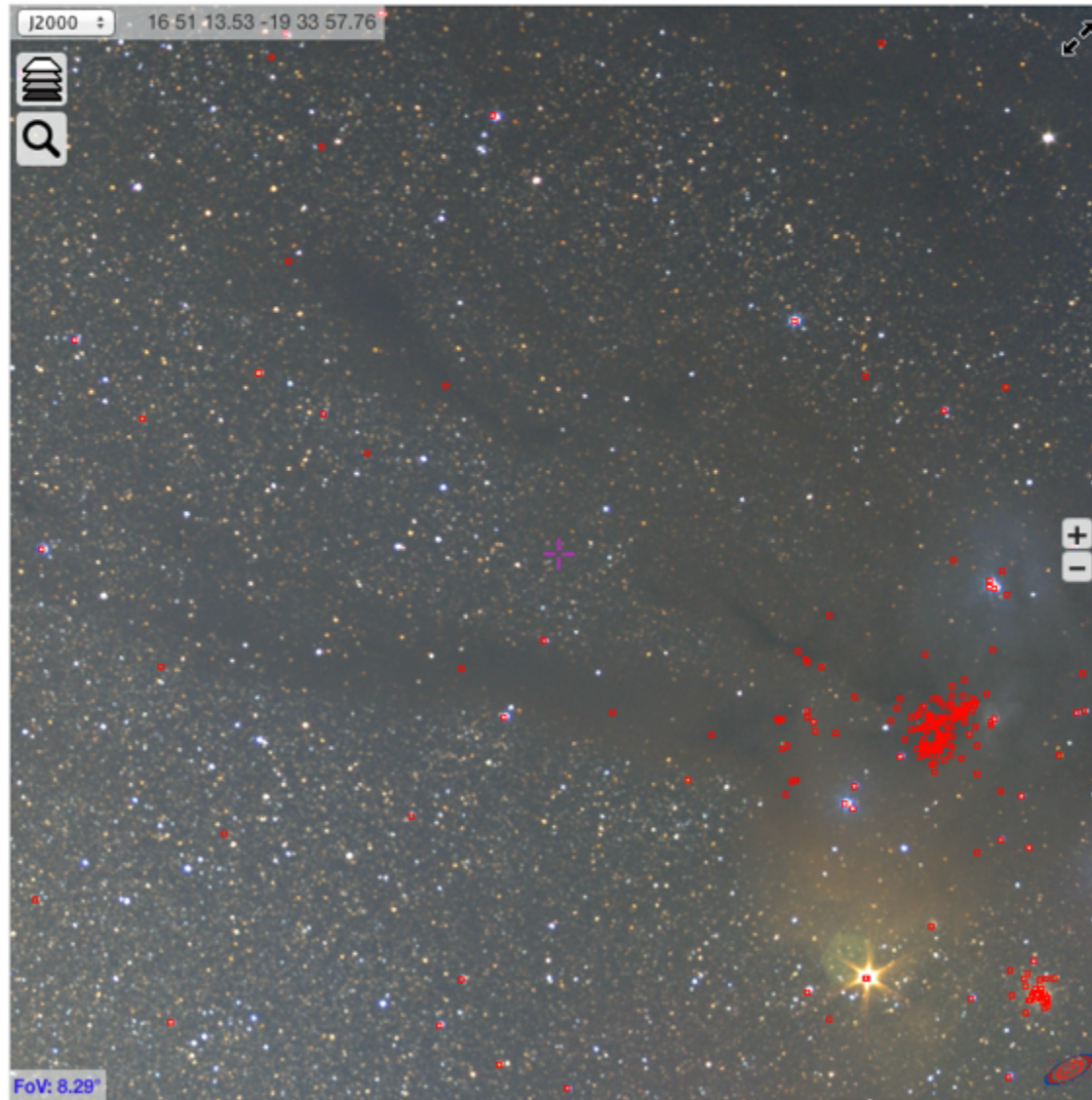
Year



TOGGLE BASE LAYER

Optical **Mellinger** GALEX AIS
DSS2 Red IRIS zMASS Halpha
VTSS

Select tool



now, if we re-select "All," we see **sources** on article distribution

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Object

All Stars Galaxies HII regions
nebulae Other

Band

Radio Infrared Ultraviolet X-ray

Custom

Harvard

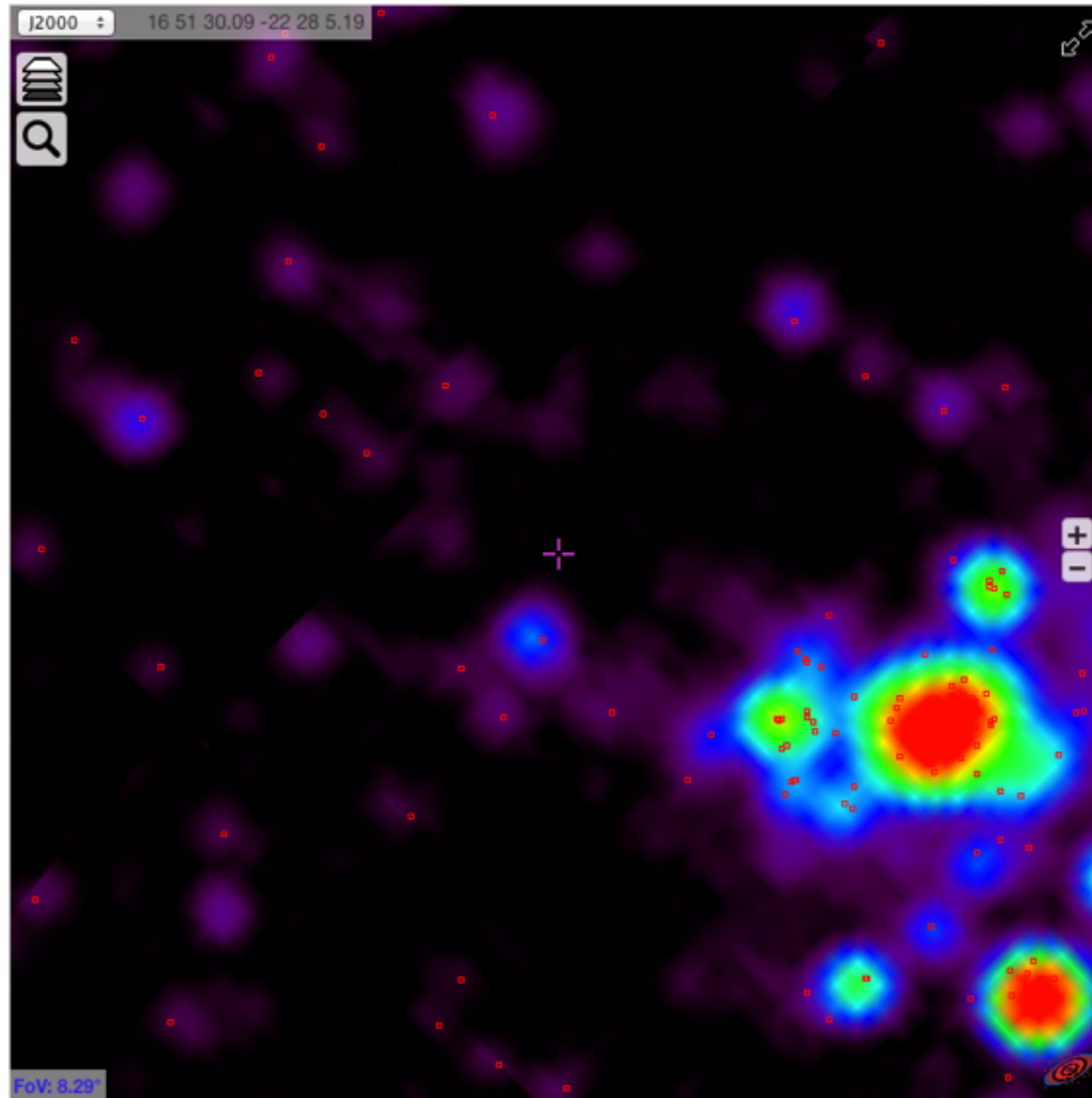
Year



TOGGLE BASE LAYER

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Select tool



panning over a bit, we can center our region of interest

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FILTER BY

Object

All Stars Galaxies HII regions
nebulae Other

Band

Radio Infrared Ultraviolet X-ray

Custom

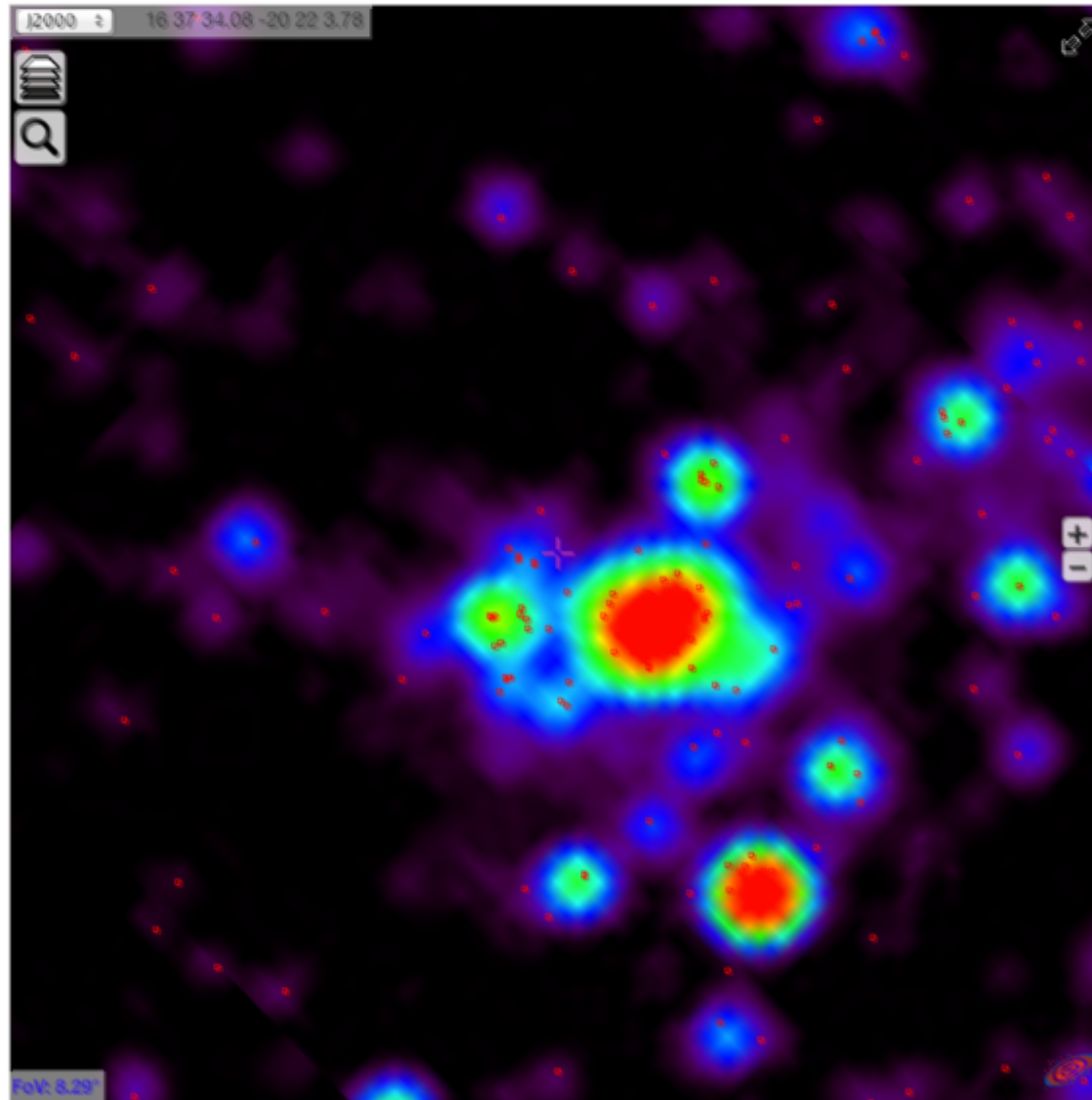
Harvard

Year

TOGGLE BASE LAYER

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DSS2 Red IRIS 2MASS Halpha
VTSS

Select tool



let's change the color table from rainbow to greyscale to make sources more apparent

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FILTER BY

Object

All Stars Galaxies HII regions
nebulae Other

Band

Radio Infrared Ultraviolet X-ray

Custom

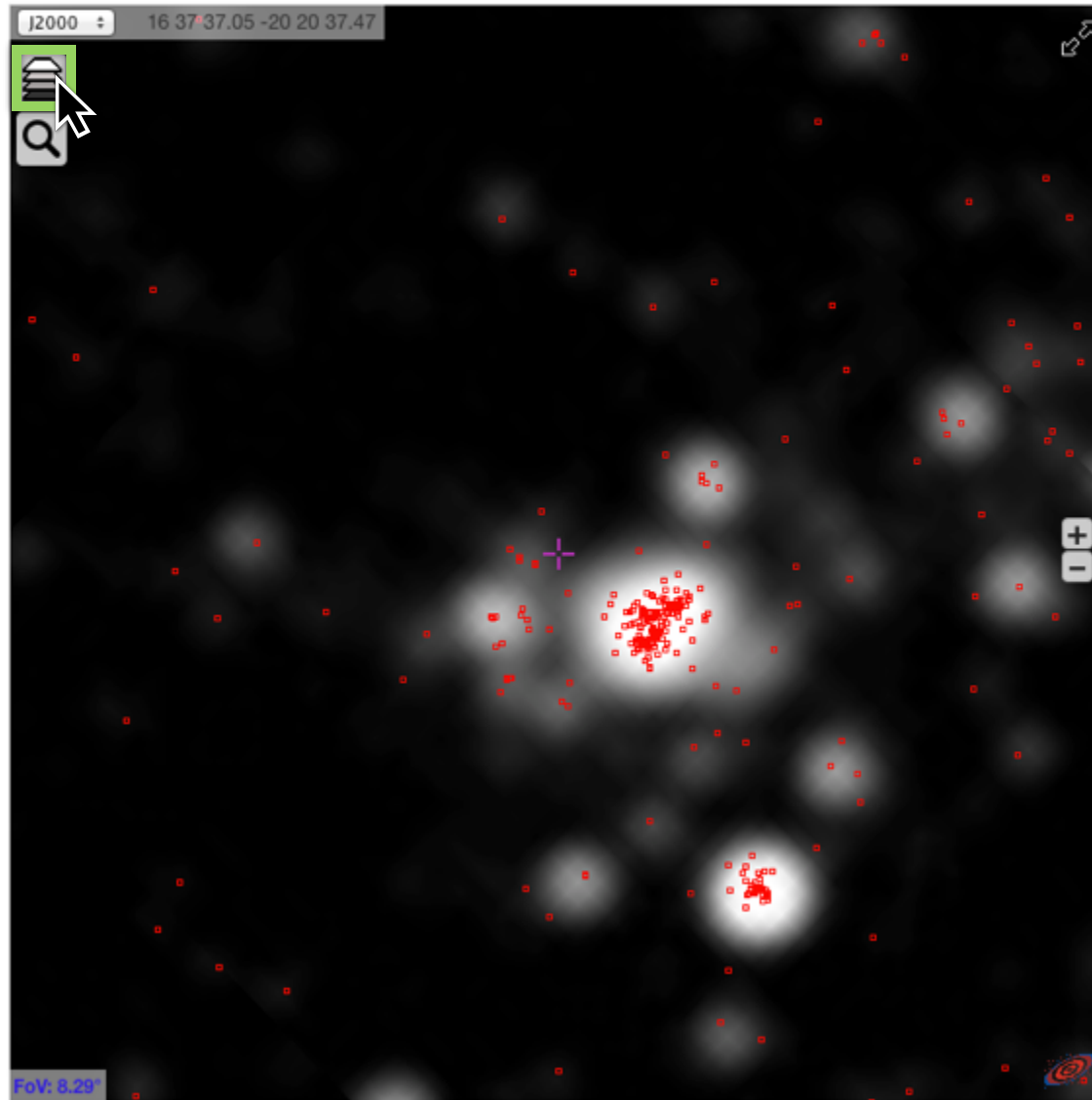
Harvard

Year

TOGGLE BASE LAYER

Optical Mellinger GALEX AIS
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VTSS

Select tool



let's look now at the distribution of articles about "HII regions" and *select* an area we're curious about

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Astronomy articles. In the sky.

FILTER BY

Object
All Stars Galaxies **HII regions**
Nebulae Other

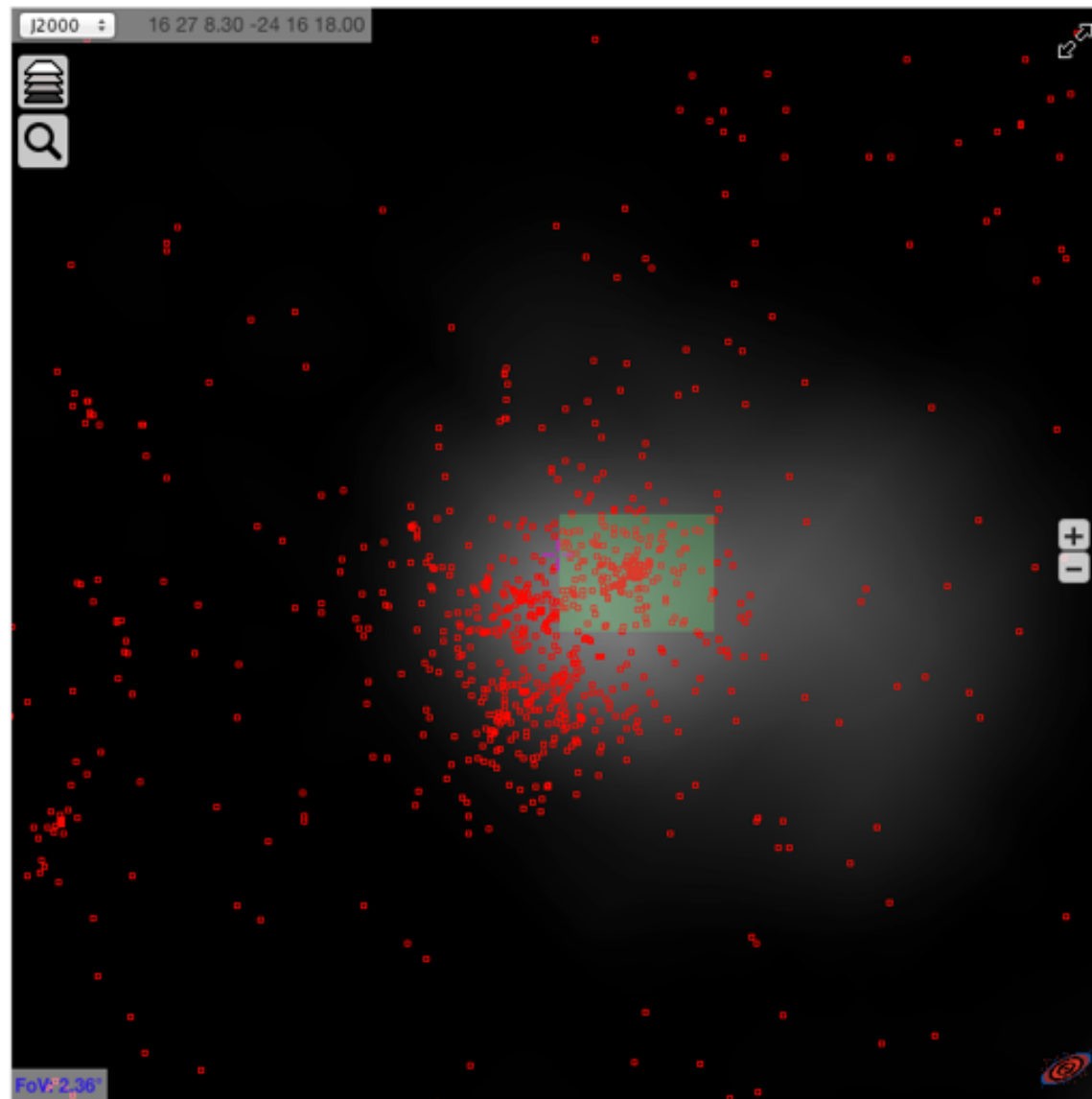
Band
Radio Infrared Ultraviolet X-ray

Custom
Harvard

Year

TOGGLE BASE LAYER
Optical Mellinger GALEX AIS
DSS2 Red IRIS 2MASS Halpha
VTSS

Select tool



when we *release* the selection rectangle, we get a pop-up list of papers (ADS) mentioning these objects, or a list of the objects (CDS/SIMBAD) we highlighted

The ADS All Sky Survey

About Watch videos Tour Open WWT version Astronomy articles. In the sky.

Selected papers/objects Open papers in ADS Open object list

Papers Objects

Note: List truncated to 200 most recent papers

NISINI B., et al. *Astron. Astrophys.*, 549A, 16-16 (2013)
TAFALLA M., et al. *Astron. Astrophys.*, 551A, 116-116 (2013)
BJERKELI P., et al. *Astron. Astrophys.*, 552, L8-8 (2013)
ZHANG M., et al. *Astron. Astrophys.*, 553A, 41-41 (2013)
VAN DER MAREL N., et al. *Astron. Astrophys.*, 556A, 76-76 (2013)
MURILLO N.M., et al. *Astrophys. J.*, 764, L15 (2013)
STUTZ A.M., et al. *Astrophys. J.*, 767, 36 (2013)
CHEN X., et al. *Astrophys. J.*, 768, 110 (2013)
HULL C.L.H., et al. *Astrophys. J.*, 768, 159 (2013)
GREEN J.D., et al. *Astrophys. J.*, 770, 123 (2013)
HSIEH T.-H., et al. *Astrophys. J., Suppl. Ser.*, 205, 5 (2013)
MAURY A., et al. *Astron. Astrophys.*, 539A, 130-130 (2012)
LISEAU R., et al. *Astron. Astrophys.*, 541A, 73-73 (2012)
ROBERTS J.F., et al. *Astron. Astrophys.*, 544A, 150-150 (2012)
BJERKELI P., et al. *Astron. Astrophys.*, 546A, 29-29 (2012)
PEZZUTO S., et al. *Astron. Astrophys.*, 547A, 54-54 (2012)
BOURKE T.L., et al. *Astrophys. J.*, 745, 117 (2012)
BARSONY M., et al. *Astrophys. J.*, 751, 22 (2012)
CHIANG H.-F., et al. *Astrophys. J.*, 756, 168 (2012)
NAKAMURA F., et al. *Astrophys. J.*, 758, L25 (2012)
BUSQUET G., et al. *Astron. Astrophys.*, 525A, 141-141 (2011)
BERGMAN P., et al. *Astron. Astrophys.*, 527A, 39-39 (2011)
NAKAMURA F., et al. *Astrophys. J.*, 726, 46 (2011)
GIANNINI T., et al. *Astrophys. J.*, 738, 80 (2011)
VELUSAMY T., et al. *Astrophys. J.*, 741, 60 (2011)
WARD-THOMPSON D., et al. *Mon. Not. R. Astron. Soc.*, 415, 2812-2817 (2011)
SIMPSON R.J., et al. *Mon. Not. R. Astron. Soc.*, 417, 216-227 (2011)
VAN DISHOECK E.F., et al. *Publ. Astron. Soc. Pac.*, 123, 138-170 (2011)
LISEAU R., et al. *Astron. Astrophys.*, 510, A98-98 (2010)
MAURY A.J., et al. *Astron. Astrophys.*, 512, A40-40 (2010)
LAHUIS F., et al. *Astron. Astrophys.*, 519, A3-3 (2010)

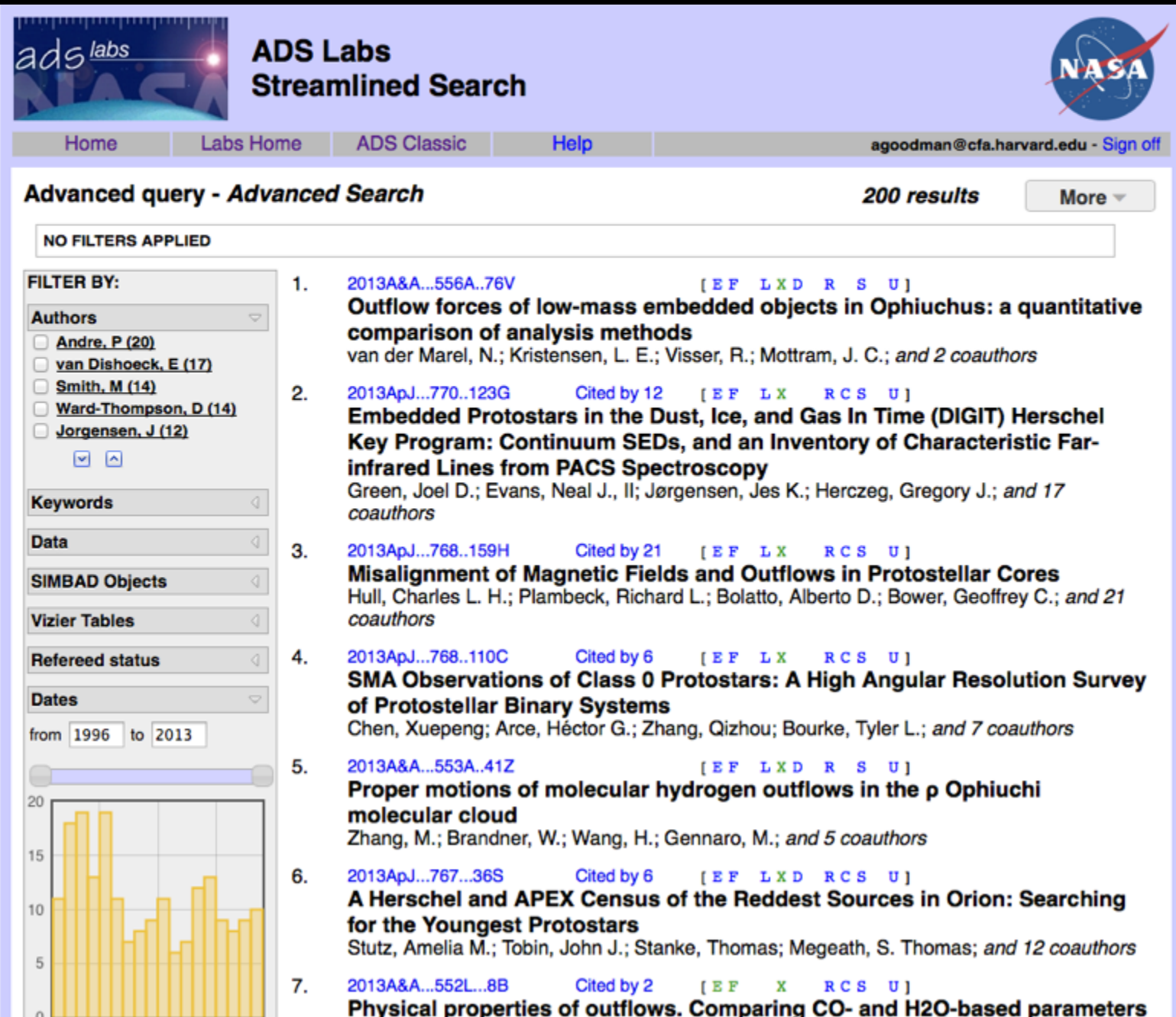
Optical Mellinger GALEX AIS
DSS2 Red IRIS 2MASS Halpha
VTSS

Select tool

ALADIN

selecting "Open Papers in ADS" opens the paper list in ADS Labs

(From here, we can filter the list more, and more. e.g. clicking "SIMBAD Objects" lets us see particular objects in context on the Sky in WWT or Aladin.)



The screenshot displays the ADS Labs Streamlined Search interface. At the top, there are logos for 'ads labs' and 'NASA', and the text 'ADS Labs Streamlined Search'. Navigation links include 'Home', 'Labs Home', 'ADS Classic', and 'Help'. A user email 'agoodman@cfa.harvard.edu' and a 'Sign off' link are visible. The main heading is 'Advanced query - Advanced Search' with '200 results' and a 'More' dropdown. A search bar contains 'NO FILTERS APPLIED'. On the left, a 'FILTER BY:' sidebar includes sections for 'Authors' (with checkboxes for Andre, P (20), van Dishoeck, E (17), Smith, M (14), Ward-Thompson, D (14), and Jorgensen, J (12)), 'Keywords', 'Data', 'SIMBAD Objects', 'VizieR Tables', 'Refereed status', and 'Dates' (set from 1996 to 2013). A bar chart at the bottom of the sidebar shows the number of papers per year from 1996 to 2013. The main results list shows 7 papers:

1. [2013A&A...556A..76V](#) [EF LXD RS U] **Outflow forces of low-mass embedded objects in Ophiuchus: a quantitative comparison of analysis methods**
van der Marel, N.; Kristensen, L. E.; Visser, R.; Mottram, J. C.; and 2 coauthors
2. [2013ApJ...770..123G](#) Cited by 12 [EF LX RCS U] **Embedded Protostars in the Dust, Ice, and Gas In Time (DIGIT) Herschel Key Program: Continuum SEDs, and an Inventory of Characteristic Far-infrared Lines from PACS Spectroscopy**
Green, Joel D.; Evans, Neal J., II; Jørgensen, Jes K.; Herczeg, Gregory J.; and 17 coauthors
3. [2013ApJ...768..159H](#) Cited by 21 [EF LX RCS U] **Misalignment of Magnetic Fields and Outflows in Protostellar Cores**
Hull, Charles L. H.; Plambeck, Richard L.; Bolatto, Alberto D.; Bower, Geoffrey C.; and 21 coauthors
4. [2013ApJ...768..110C](#) Cited by 6 [EF LX RCS U] **SMA Observations of Class 0 Protostars: A High Angular Resolution Survey of Protostellar Binary Systems**
Chen, Xuepeng; Arce, Héctor G.; Zhang, Qizhou; Bourke, Tyler L.; and 7 coauthors
5. [2013A&A...553A..41Z](#) [EF LXD RS U] **Proper motions of molecular hydrogen outflows in the ρ Ophiuchi molecular cloud**
Zhang, M.; Brandner, W.; Wang, H.; Gennaro, M.; and 5 coauthors
6. [2013ApJ...767...36S](#) Cited by 6 [EF LXD RCS U] **A Herschel and APEX Census of the Reddest Sources in Orion: Searching for the Youngest Protostars**
Stutz, Amelia M.; Tobin, John J.; Stanke, Thomas; Megeath, S. Thomas; and 12 coauthors
7. [2013A&A...552L...8B](#) Cited by 2 [EF X RCS U] **Physical properties of outflows. Comparing CO- and H₂O-based parameters**

let's try "Open WWT Version," so we can see this same view in WWT, and use a transparency slider

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FILTER BY

Object

All Stars Galaxies HII regions
Nebulae Other

Band

Radio **Infrared** Ultraviolet X-ray

Custom

Harvard

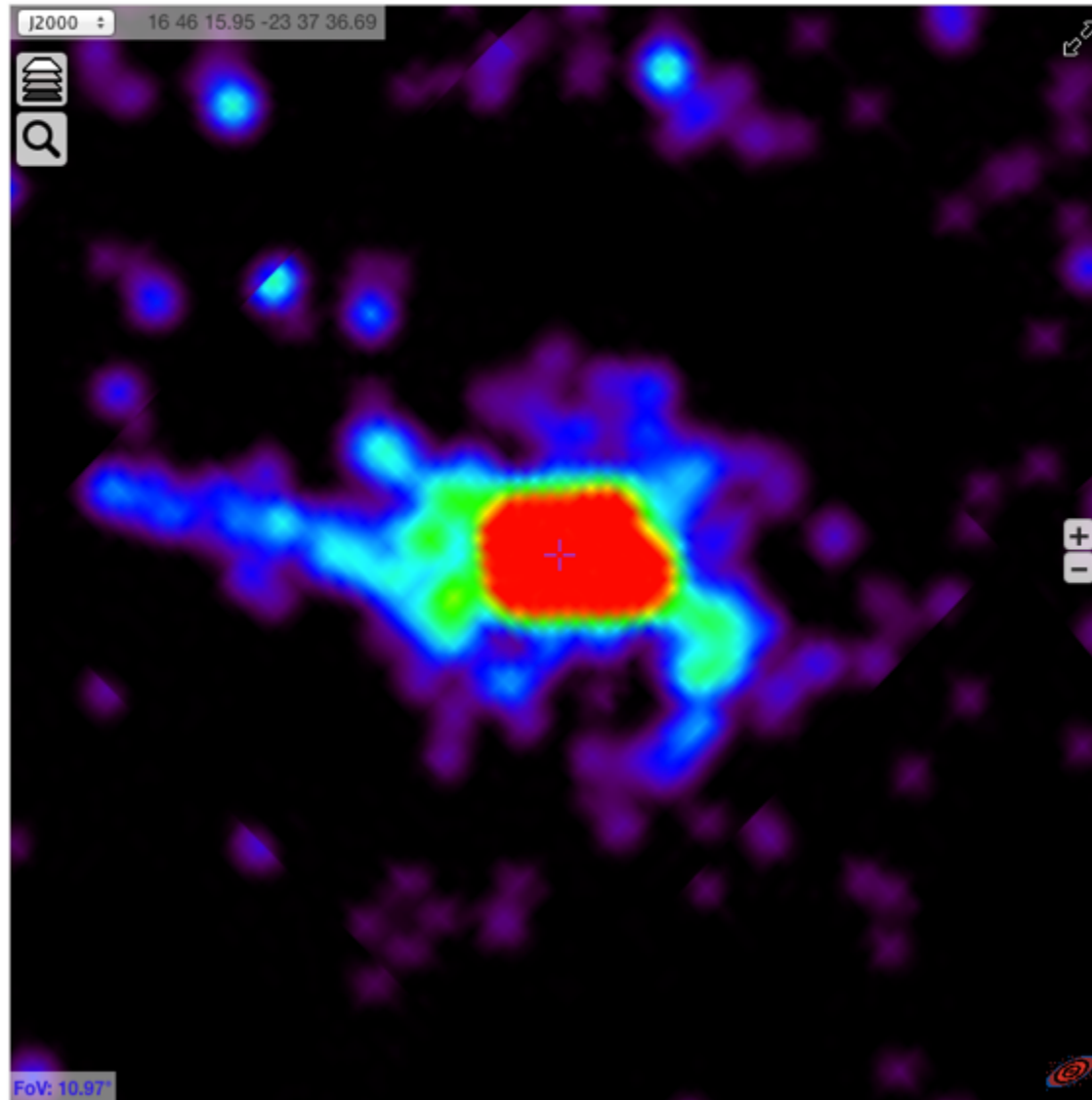
Year



TOGGLE BASE LAYER

Optical Mellinger GALEX AIS
DSS2 Red IRIS 2MASS Halpha
VTSS

Select tool



let's try the transparency (layer) slider in WorldWide Telescope

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CHOOSE HEATMAP

Object All Stars Galaxies HII regions Nebulae Other

Band Radio **Infrared** Ultraviolet X-ray

Custom Harvard/All

Year

Show Sources

Go to...



BACKGROUND LAYER

Optical 2MASS **WISE** SFD IRIS GLIMPSE H-alpha ROSAT Fermi VLSS

WISE **Infrared**

position slider
move slider to
"WISE" all the way to
"infrared"

(α, δ)=246.78°, -24.55° FOV= 11°

ADS All-Sky Survey is a NASA-funded project



dust is nice, but we're curious about HII regions, let's change view to **H-alpha**

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CHOOSE HEATMAP

Object All Stars Galaxies HII regions Nebulae Other

Band Radio Infrared Ultraviolet **X-ray**

Custom Harvard/All

Year

Show Sources

Go to...



BACKGROUND LAYER

Optical 2MASS WISE SFD IRIS GLIMPSE **H-alpha** ROSAT Fermi VLSS

H-alpha X-ray



(α, δ)=246.78°, -24.55° FOV= 11°

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now we want to find **X-ray** observations and see if any are near the HII regions, so we can slide between H-alpha and X-ray

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CHOOSE HEATMAP

Object All Stars Galaxies HII regions Nebulae Other

Band Radio Infrared Ultraviolet **X-ray**

Custom Harvard/All

Year

BACKGROUND LAYER

Optical 2MASS WISE SFD IRIS GLIMPSE **H-alpha** ROSAT Fermi VLSS

H-alpha **X-ray**

Show Sources

Go to...



(α, δ)=246.78°, -24.55° FOV= 11°

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now let's zoom in, and try "Show Sources" to see what the SIMBAD X-ray sources really are

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CHOOSE HEATMAP

Object All Stars Galaxies HII regions Nebulae Other

Band Radio Infrared Ultraviolet **X-ray**

Custom Harvard/All

Year

BACKGROUND LAYER

Optical 2MASS WISE SFD IRIS GLIMPSE **H-alpha** ROSAT Fermi VLSS

H-alpha X-ray

Show Sources

Go to...



select an
interesting
source

$(\alpha, \delta) = 246.72^\circ, -23.97^\circ$ FOV = 3°



and, we can have plenty of information on the source, via CDS/SIMBAD or via ADS.

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CHOOSE HEATMAP

Object All Stars Galaxies HII regions Nebulae

Band Radio Infrared Ultraviolet X-ray

Custom Harvard/All

Year

BACKGROUND LAYER

Optical 2MASS WISE SFD IRIS GLIMPSE

H-alpha X-ray

V* V2503 Opt

SIMBAD Entry

Open papers in ADS

x

Papers

- ESPAILLAT C., et al. *Astrophys. J.*, 762, 62 (2013)
- BROWN J.M., et al. *Astrophys. J.*, 770, 94 (2013)
- ARTEMENKO S.A., et al. *Astron. Lett.*, 38, 783-792 (2012)
- BAST J.E., et al. *Astron. Astrophys.*, 527A, 119-119 (2011)
- SALYK C., et al. *Astrophys. J.*, 731, 130 (2011)
- GUEDEL M., et al. *Astron. Astrophys.*, 519, A113-113 (2010)
- OLOFSSON J., et al. *Astron. Astrophys.*, 520, A39-39 (2010)
- PONTOPPIDAN K.M., et al. *Astrophys. J.*, 720, 887-903 (2010)
- McCLURE M.K., et al. *Astrophys. J., Suppl. Ser.*, 188, 75-122 (2010)
- VAN KEMPEN T.A., et al. *Astron. Astrophys.*, 498, 167-194 (2009)
- OLOFSSON J., et al. *Astron. Astrophys.*, 507, 327-345 (2009)
- FURLAN E., et al. *Astrophys. J.*, 703, 1964-1983 (2009)
- PADGETT D.L., et al. *Astrophys. J.*, 672, 1013-1037 (2008)
- GRANKIN K.N., et al. *Astron. Astrophys.*, 461, 183-195 (2007)
- GUENTHER E.W., et al. *Astron. Astrophys.*, 467, 1147-1155 (2007)
- LAHUIS F., et al. *Astrophys. J.*, 665, 492-511 (2007)
- ANDREWS S.M., et al. *Astrophys. J.*, 671, 1800-1812 (2007)
- MONIN J.-L., et al. *Astron. Astrophys.*, 446, 201-210 (2006)
- CORREIA S., et al. *Astron. Astrophys.*, 459, 909-926 (2006)
- McCABE C., et al. *Astrophys. J.*, 636, 932-951 (2006)
- RATZKA T., et al. *Astron. Astrophys.*, 437, 611-626 (2005)
- DUCOURANT C., et al. *Astron. Astrophys.*, 438, 769-778 (2005)
- MAHESWAR G., et al. *Astron. Astrophys.*, 402, 963-970 (2003)
- SARTORI M.J., et al. *Astron. Astrophys.*, 404, 913-926 (2003)
- MELO C.H.F. *Astron. Astrophys.*, 410, 269-282 (2003)
- BARSONY M., et al. *Astrophys. J.*, 591, 1064-1074 (2003)
- GEOFFRAY H., et al. *Astron. Astrophys.*, 369, 239-248 (2001)
- KAZAROVETS E.V., et al. *IAU Inform. Bull. Var. Stars*, 5135, 1 (2001)
- TEIXEIRA R., et al. *Astron. Astrophys.*, 361, 1143-1151 (2000)
- SHEVCHENKO V.S., et al. *Astron. J.*, 116, 1419-1431 (1998)
- JENSEN E.L.N., et al. *Astron. J.*, 114, 301-316 (1997)
- ASPIN C., et al. *Mon. Not. R. Astron. Soc.*, 284, 257-264 (1997)
- MONIN J.-L., et al. *The Messenger*, 89, 33-37 (1997)
- JENSEN E.L.N., et al. *Astrophys. J.*, 458, 310-326 (1996)

(α, δ)=246.72°, -23.97° FOV= 3°



Credits

funding **NASA ADAP** program

PI: Alyssa **Goodman**, Harvard-CfA

Co-I: Alberto **Pepe**, Harvard-CfA & Authorea

Co-I: August **Muench**, Smithsonian-CfA

with

Alberto **Accomazzi**, Smithsonian Institution, NASA/ADS

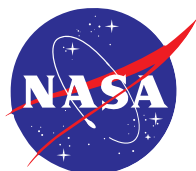
Christopher **Beaumont**, Harvard-CfA

Thomas **Boch**, CDS Strasbourg

Jonathan **Fay**, Microsoft Research

David **Hogg**, NYU, astrometry.net

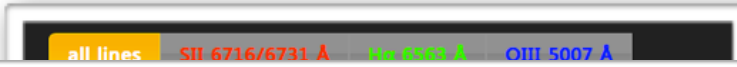
Alberto **Conti**, NASA/STScI, Northrup Grumman



**SEAMLESS
ASTRONOMY**
Linking scientific data, publications, and communities

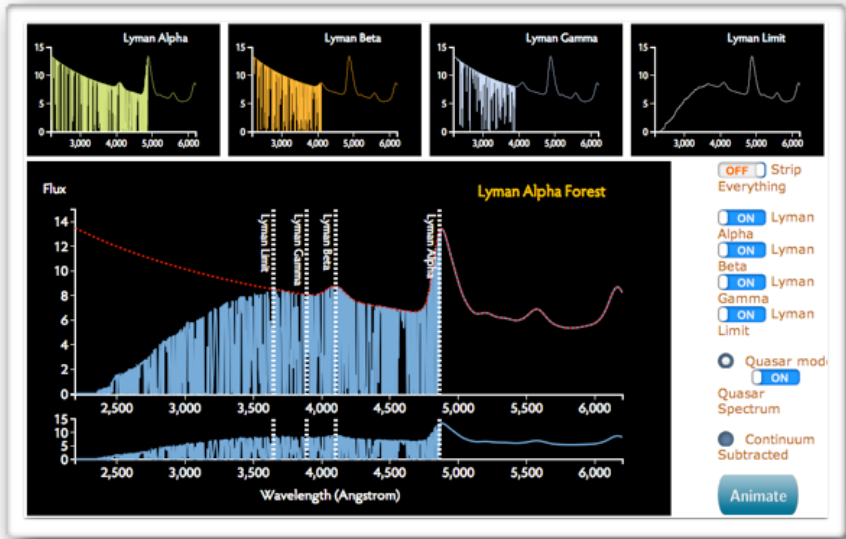


Stephen



Yuan-Sen
Ting

Interstellar Absorption and the Lyman Alpha Forest

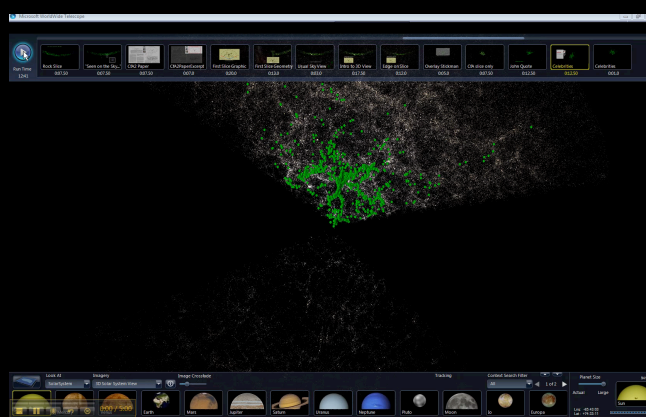
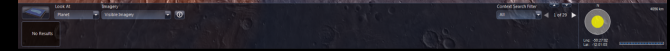
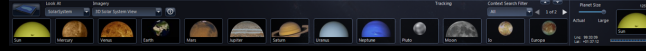
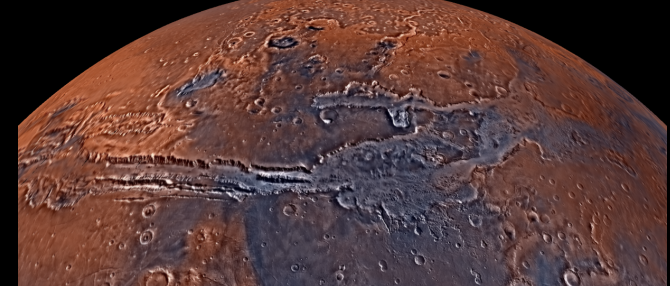
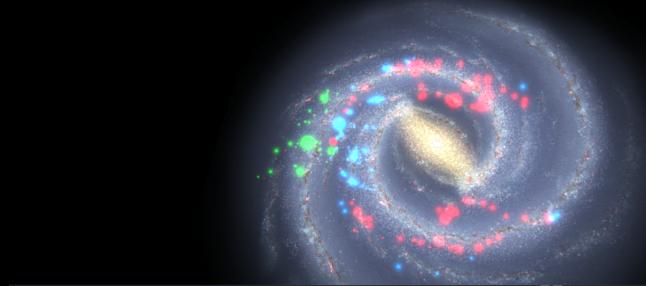
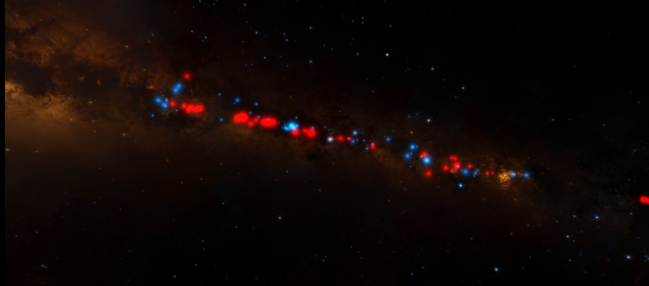
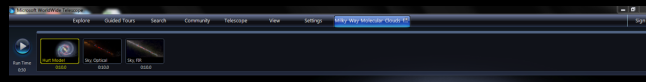
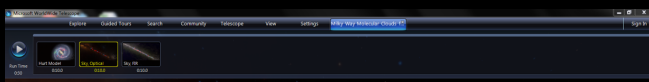
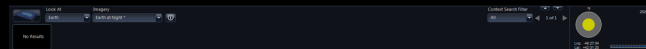
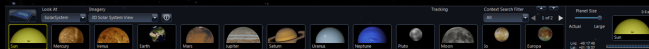
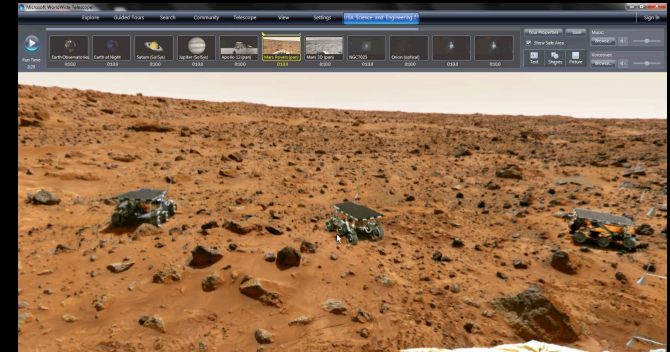
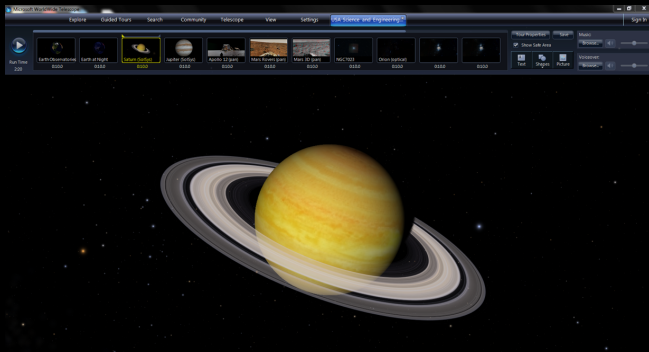
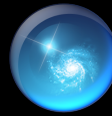


 JavaScript

https://www.cfa.harvard.edu/~yuan-sen.ting/lyman_alpha.html

 JavaScript

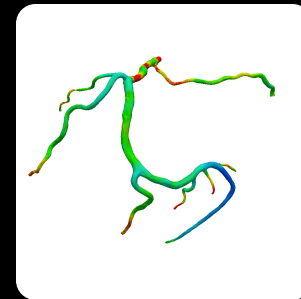
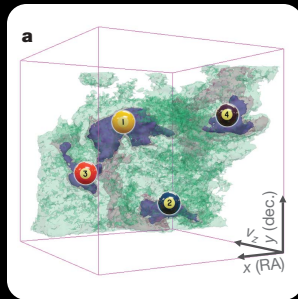
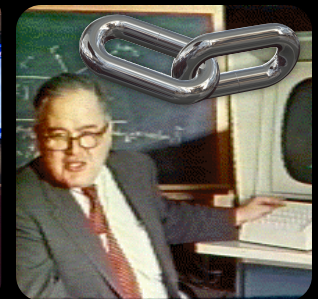
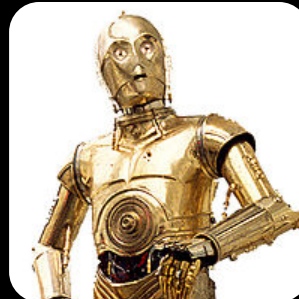
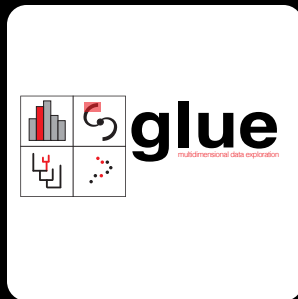
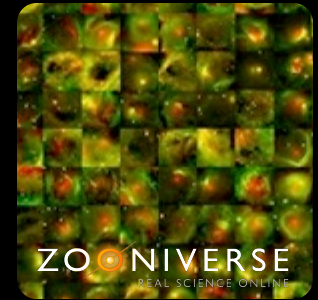
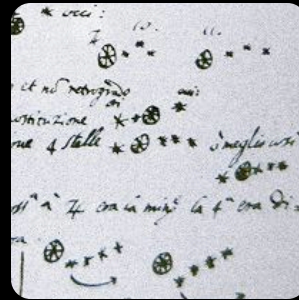
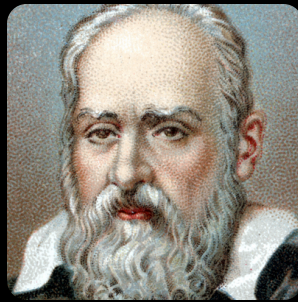
<http://portillo.ca/nebula/>



Experience WorldWide Telescope, free from Microsoft Research at worldwidetelescope.org

LINKING VISUALIZATION & UNDERSTANDING IN ASTRONOMY

ALYSSA A. GOODMAN
HARVARD-SMITHSONIAN
CENTER FOR ASTROPHYSICS
@AAGIE



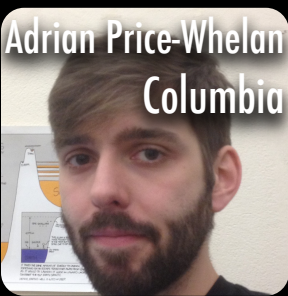
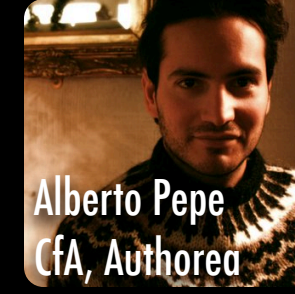
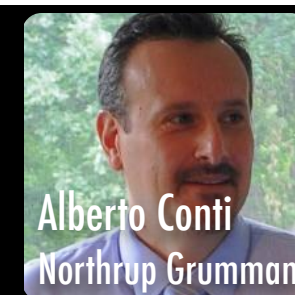
LINKING
VISUALIZATION &
UNDERSTANDING
IN ASTRONOMY

ALYSSA A. GOODMAN
HARVARD-SMITHSONIAN
CENTER FOR ASTROPHYSICS



<http://www.astrobetter.com/linking-visualization-and-understanding-in-astronomy-aas223>

COLLABORATORS



**SEAMLESS
ASTRONOMY**
Linking scientific data, publications, and communities

projects.iq.harvard.edu/seamlessastronomy

...including ADS team (Alberto Accomazzi, Michael Kurtz, Edwin Henneken, et al.) and Wolbach Library staff (Christopher Erdmann et al.)

RELATIVE STRENGTHS

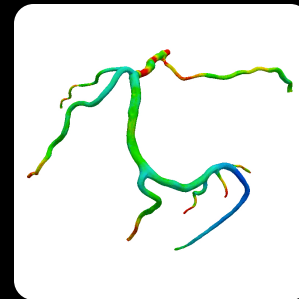
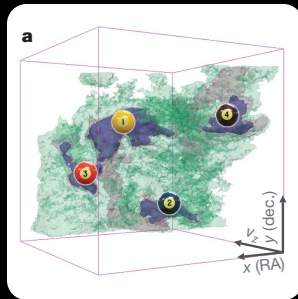
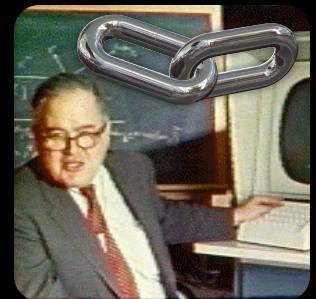
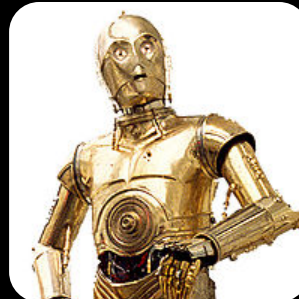
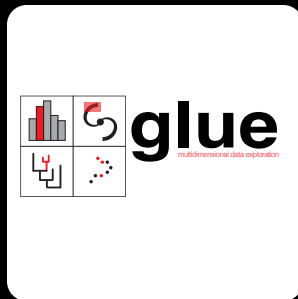
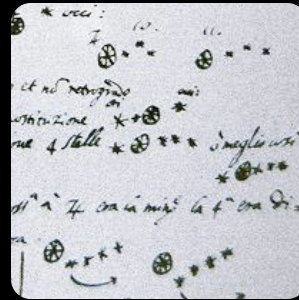
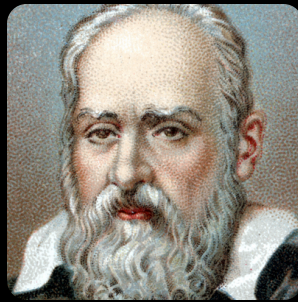


Pattern Recognition
Creativity



Calculations

LINKING VISUALIZATION & UNDERSTANDING IN ASTRONOMY





GALILEO GALILEI

(1564-1642)



Sec^{mo} Principio

*Galileo Galilei, Humilis^s Servus della Ser.^{ma} V.^{ra} invigilantissima
 Reale, et di ogni spirito di potere no solo scilicet
 avario che non della Lettera di Mathematici nelle Scuole
 di Padova,*

*In nome di Dio determino di presentare al Ser.^{mo} Principe
 l'Orbitale et il governo di gravamenti inanimabile di ogni
 regione et in linea marittima o terrestre senza di tenere per
 altro nuovo artificio nel maggior punto et usque a disposizione
 di un ser.^{mo} Principe cavato dalle più ree di speculazioni di
 pros.^{mo} potua in l'vantaggio di scoprire le leggi et volè dell' inanimato
 di un ser.^{mo} Principe prima et poi sopra noi et distinguendo
 il numero et la qualità dei vasselli giudicare le sue forze
 dalle forze alla caccia al combattimento o alla fuga, o pure anzi
 nella campagna spinta vedere et particolarmente distinguere ogni suo
 moto et movimento.*

Adi 7. di Gennaio
Gione si vede così
Adi 8. così
Adi 12. si vede in tale situazione
Adi 13. si vedono miris.^s a Gione 4 stelle
Adi 14. è angelo
*Adi 15. si vede la pros.^{ma} a 7. ora in miris.^s la 4. ora di
 spente della 3.^a l'occhio li era
 Li spazi delle 3. sudorali nel
 maggiore del diametro di 7. et di
 10. in linea retta.*

7	17
8	18
10	19
11	19
12	20
13.	21
15	22
15	22
16	23
17	24

SIDERIUS NUNCIUS

On the third, at the seventh hour, the stars were arranged in this sequence. The eastern one was 1 minute, 30 seconds from Jupiter; the closest western one 2 minutes; and the other western one was 3 minutes removed from this one. They were absolutely on the same straight line and of equal magnitude.

On the fourth, at the second hour, there were four stars around Jupiter, two to the east and two to the west, and arranged precisely on a straight line, as in the adjoining figure. The easternmost was distant 3 minutes from the next one, while this one was 40 seconds from Jupiter; Jupiter was 4 minutes from the nearest western one and this one 6 minutes from the westernmost one. Their magnitude were nearly equal; the one closest to Jupiter appeared a little smaller than the rest. But at the seventh hour the eastern stars were only 30 seconds apart. Jupiter was 2 minutes from the nearer eastern one, while he was 4 minutes from the next western one, and this one was 3 minutes from the westernmost one. They were all equal and extended on the same straight line along the ecliptic.

On the fifth, the sky was cloudy.

On the sixth, only two stars appeared flanking Jupiter, as is seen in the adjoining figure. The eastern one was 2 minutes and the western one 3 minutes from Jupiter. They were on the same straight line with Jupiter and equal in magnitude.

On the seventh, two stars stood near Jupiter. both to the east.

Notes for & re-productions of Siderius Nuncijs



GALILEO GALILEI



GALILEO'S "NEW ORDER"

Created by Alyssa Goodman, Curtis Wong
with advice from Owen Gingerich and David

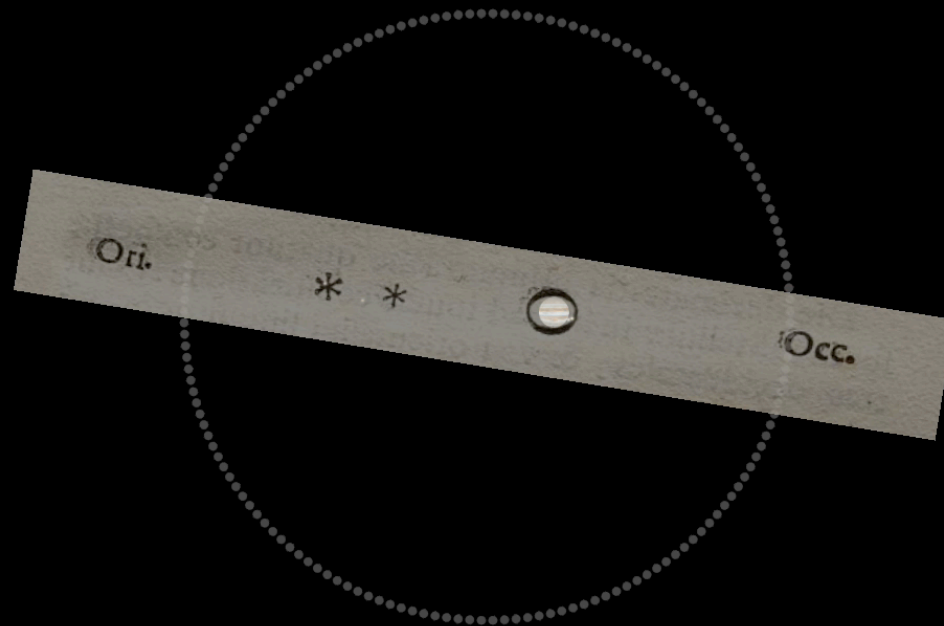




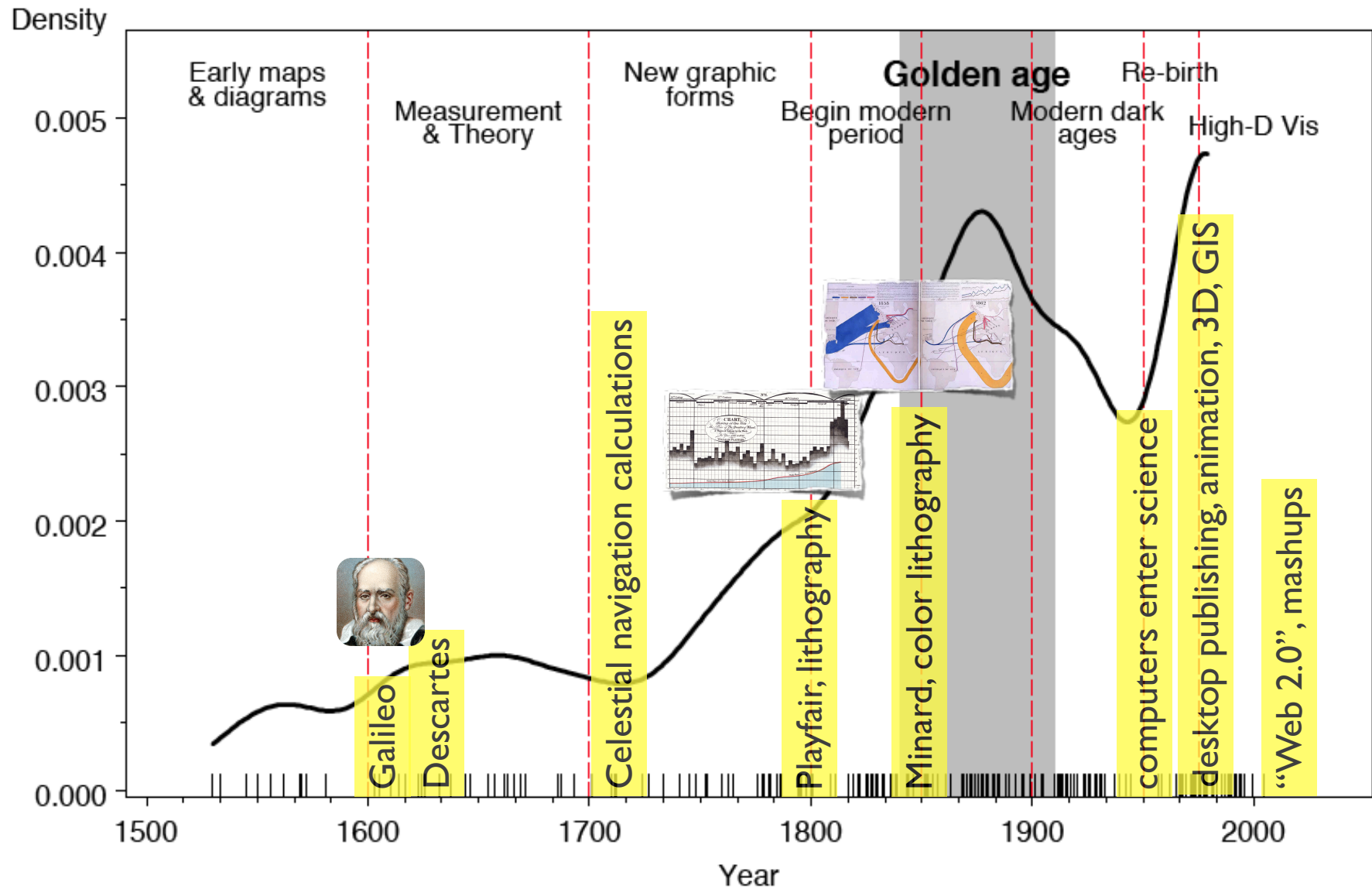
GALILEO GALILEI



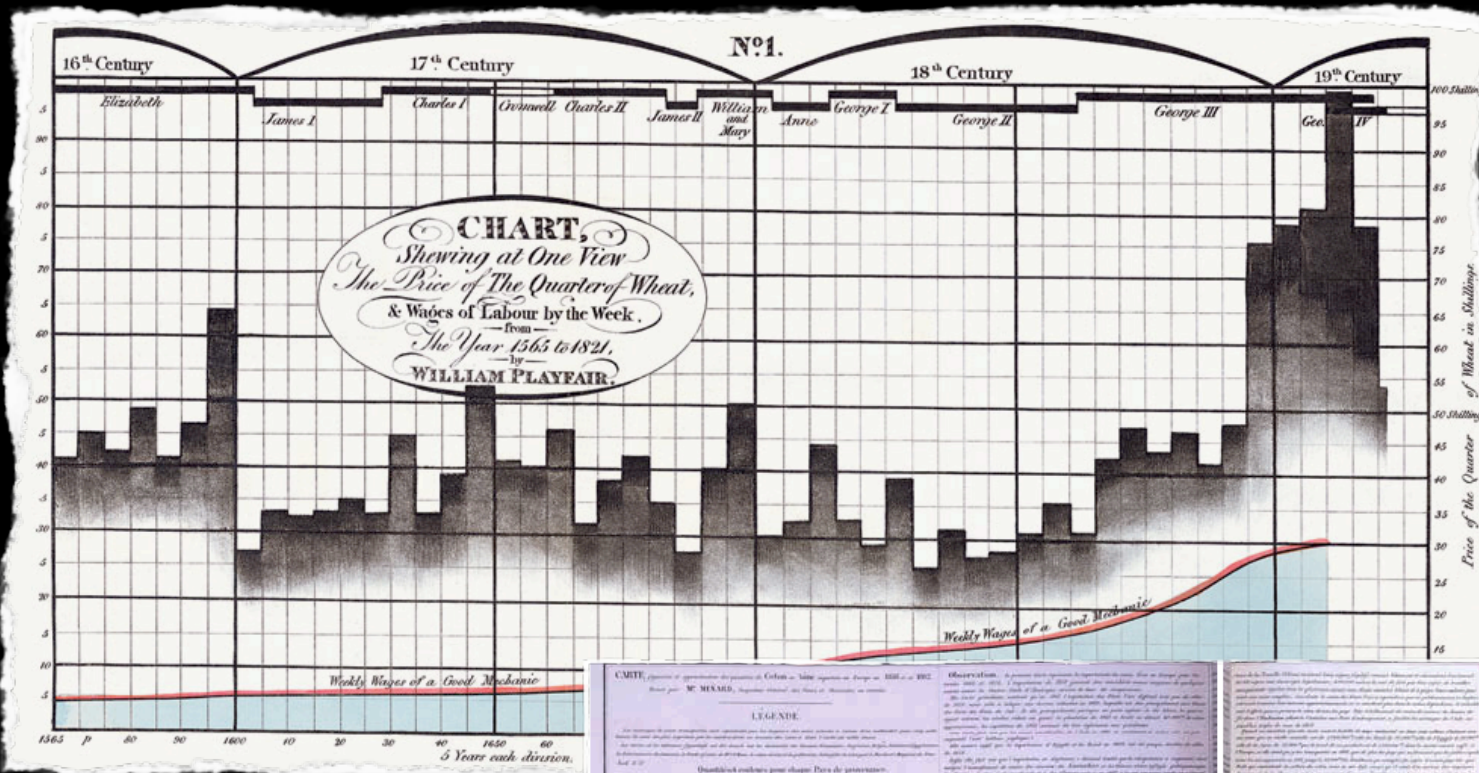
January 11, 1610



Milestones: Time course of developments

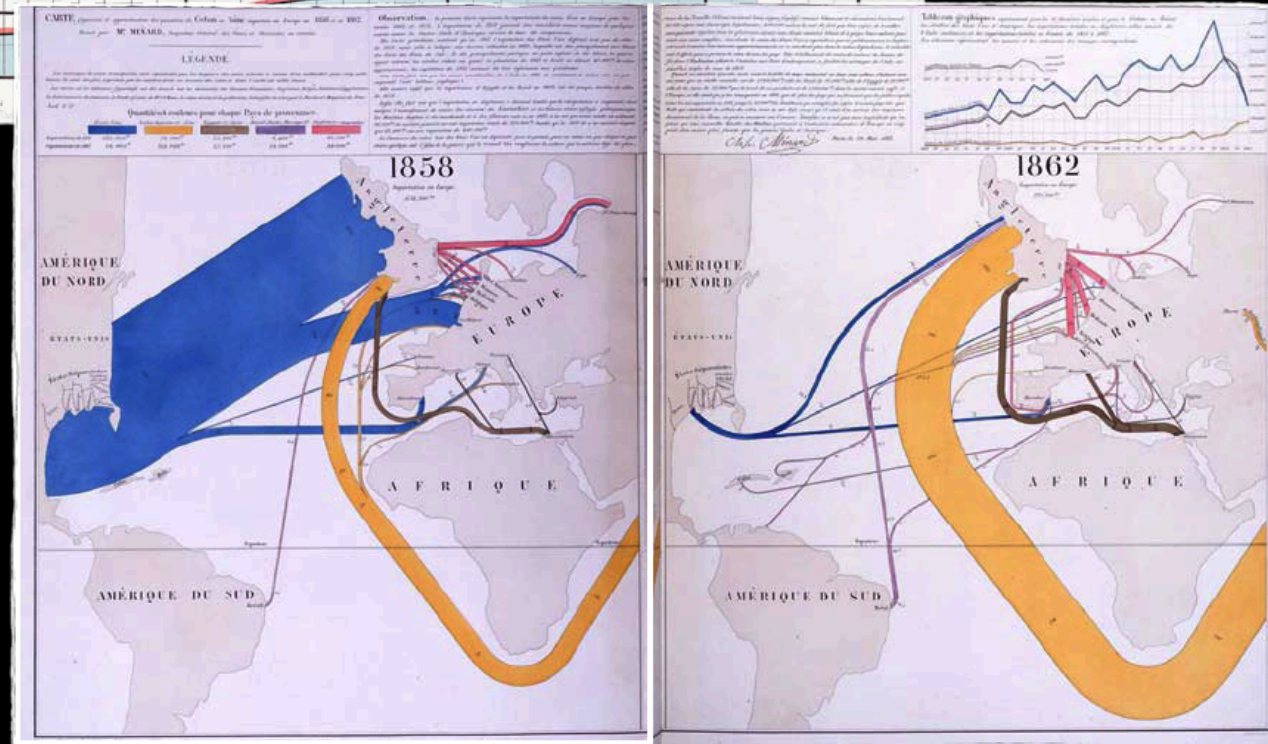


adapted from Friendly, "The Golden Age of Statistical Graphics," *Statistical Science*, 2009



Playfair, lithography

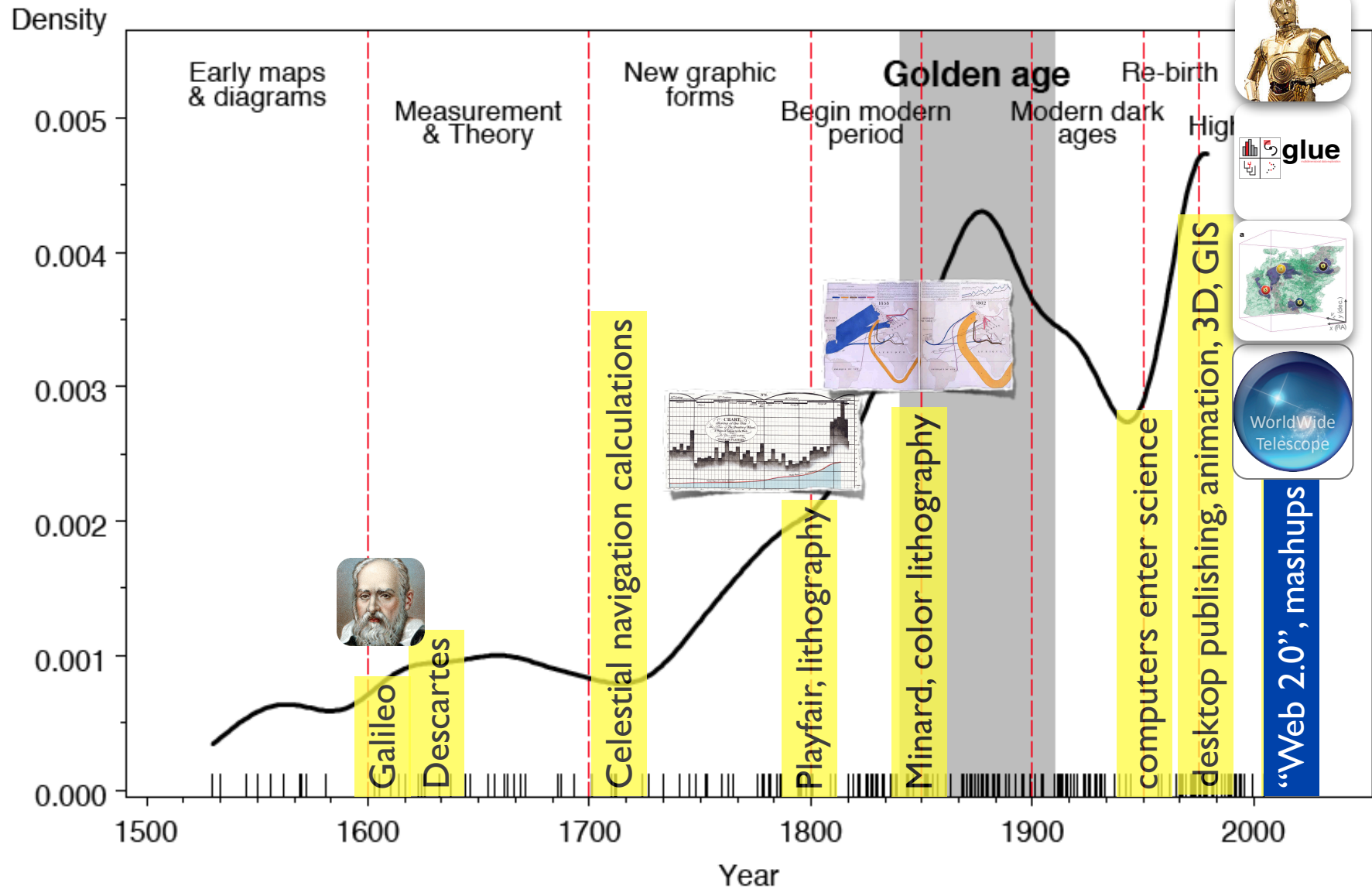
William Playfair (1759-1823)



Minard, color lithography

Charles Joseph Minard (1781-1870)

Milestones: Time course of developments



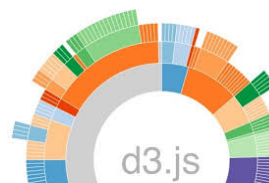
adapted from Friendly, "The Golden Age of Statistical Graphics," *Statistical Science*, 2009



IP[y]: IPython
Interactive Computing



JavaScript

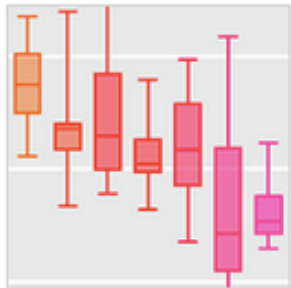
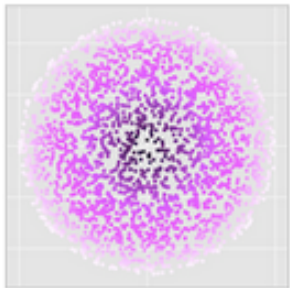
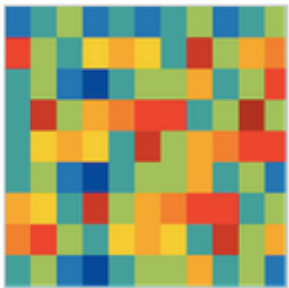
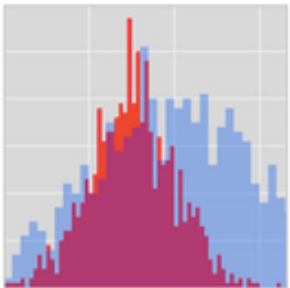
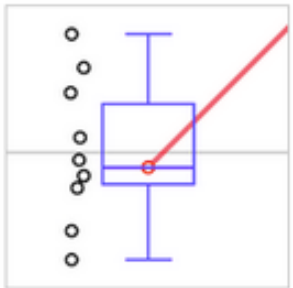
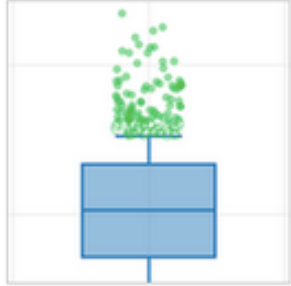
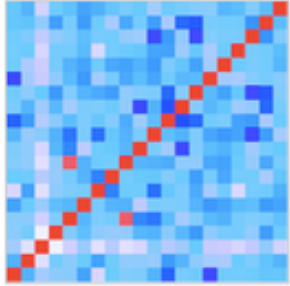
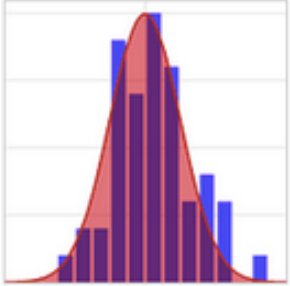
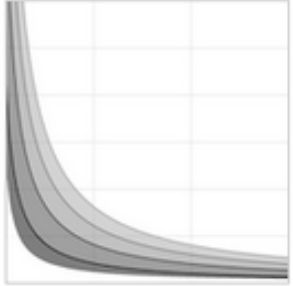
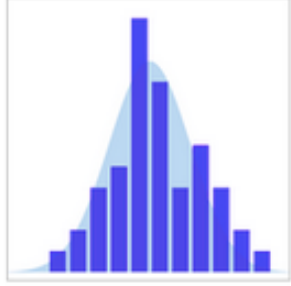
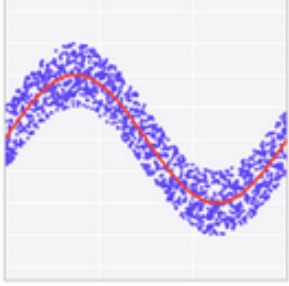
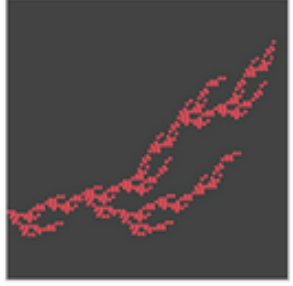
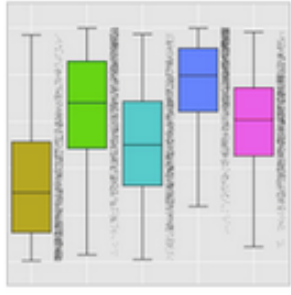
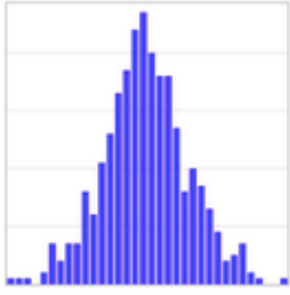
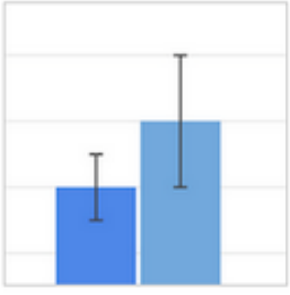
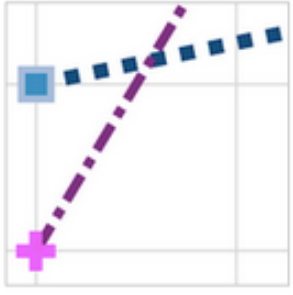


HTML

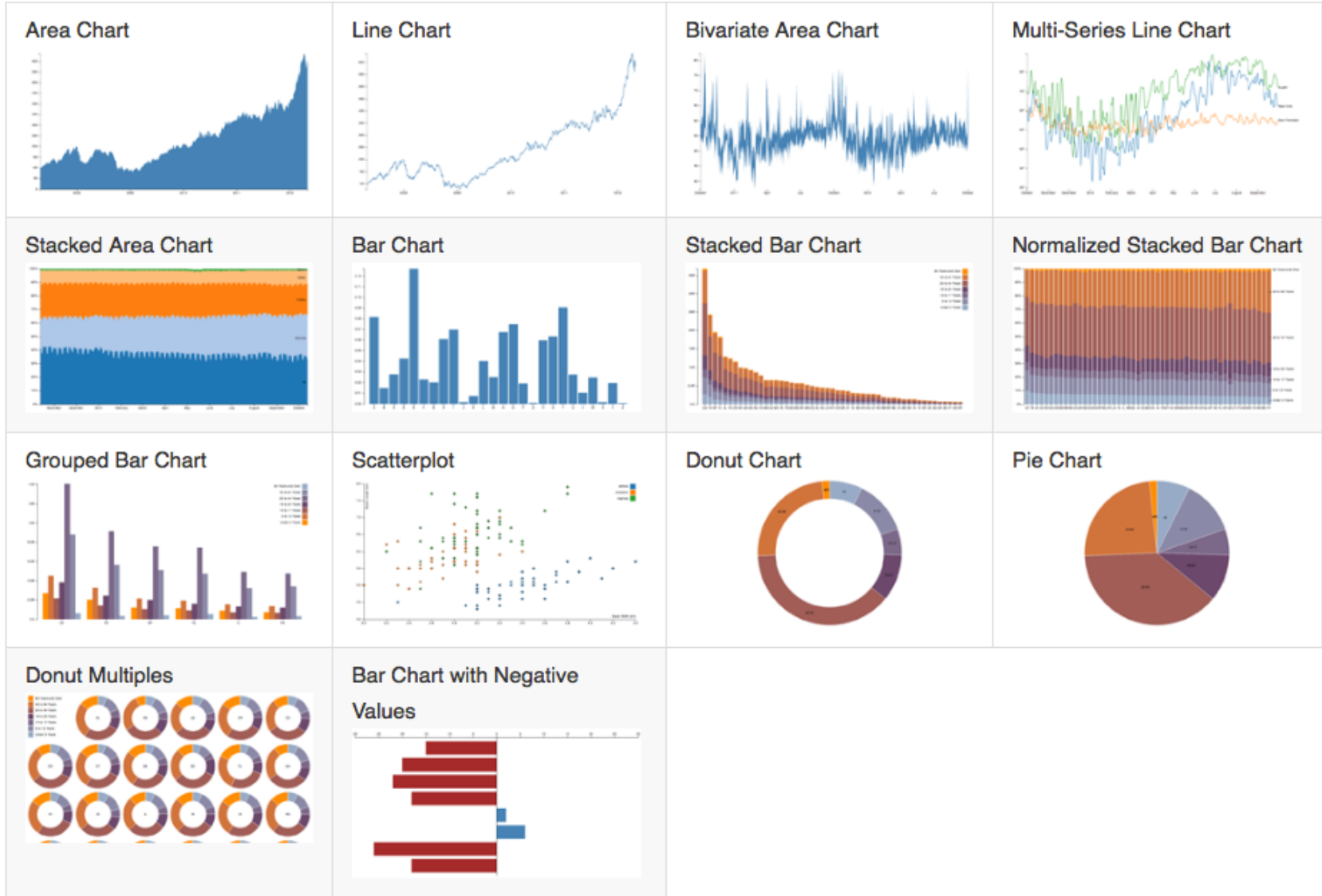


“Web 2.0”, mashups

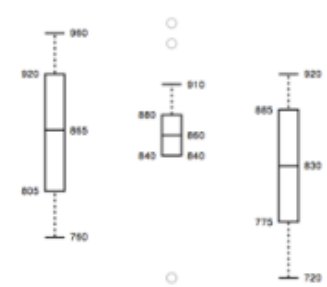
“Web 2.0”, mashups



PLOTTLY



Box Plots



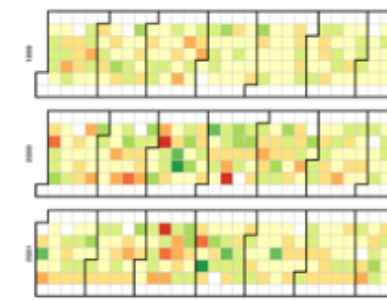
Bubble Chart



Bullet Charts



Calendar View



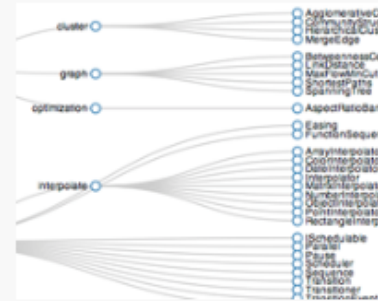
Non-contiguous Cartogram



Chord Diagram



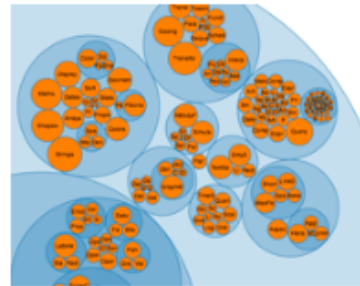
Dendrogram



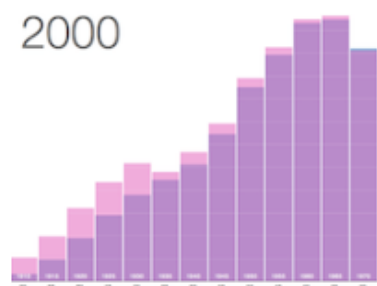
Force-Directed Graph



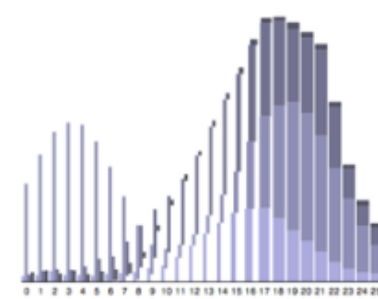
Circle Packing



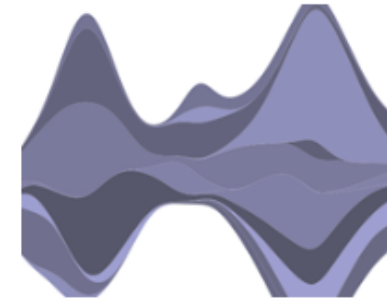
Population Pyramid



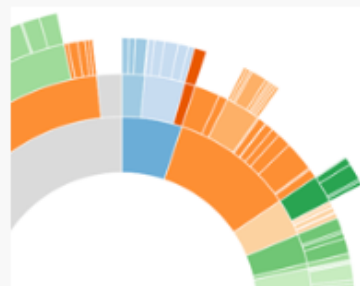
Stacked Bars



Streamgraph



Sunburst



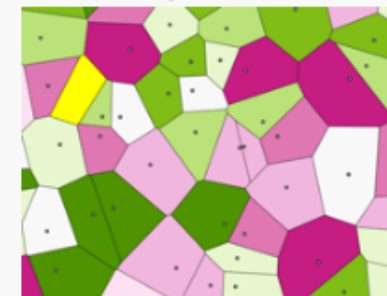
Node-Link Tree



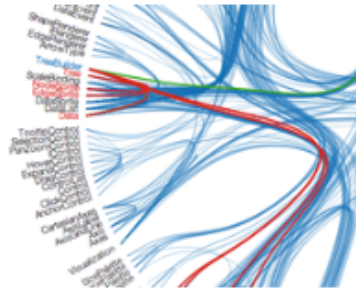
Treemap



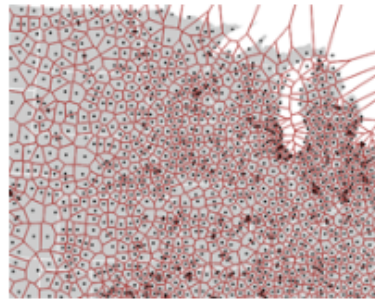
Voronoi Diagram



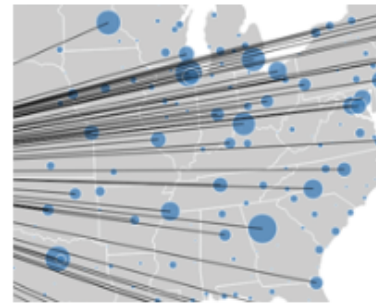
Hierarchical Edge Bundling



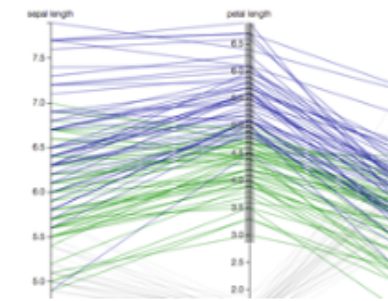
Voronoi Diagram



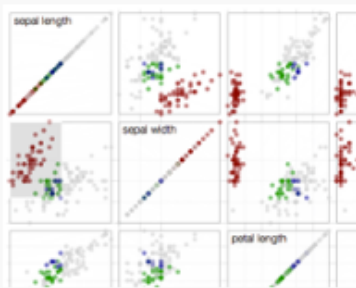
Symbol Map



Parallel Coordinates



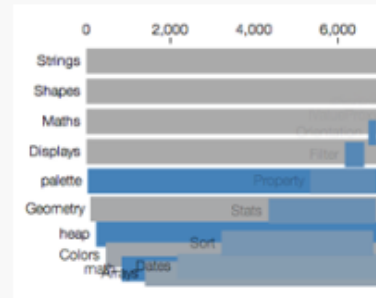
Scatterplot Matrix



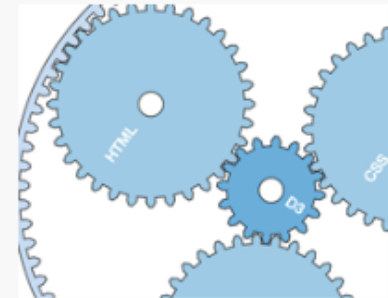
Zoomable Pack Layout



Hierarchical Bars



Epicyclical Gears



Collision Detection



Collapsible Force Layout



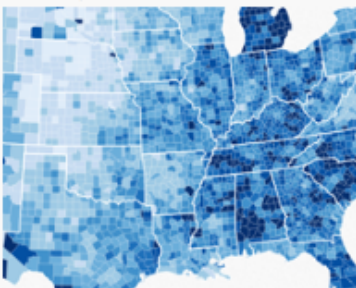
Force-Directed States



Azimuthal Projections



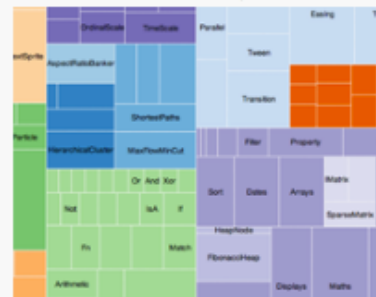
Choropleth



Collapsible Tree Layout

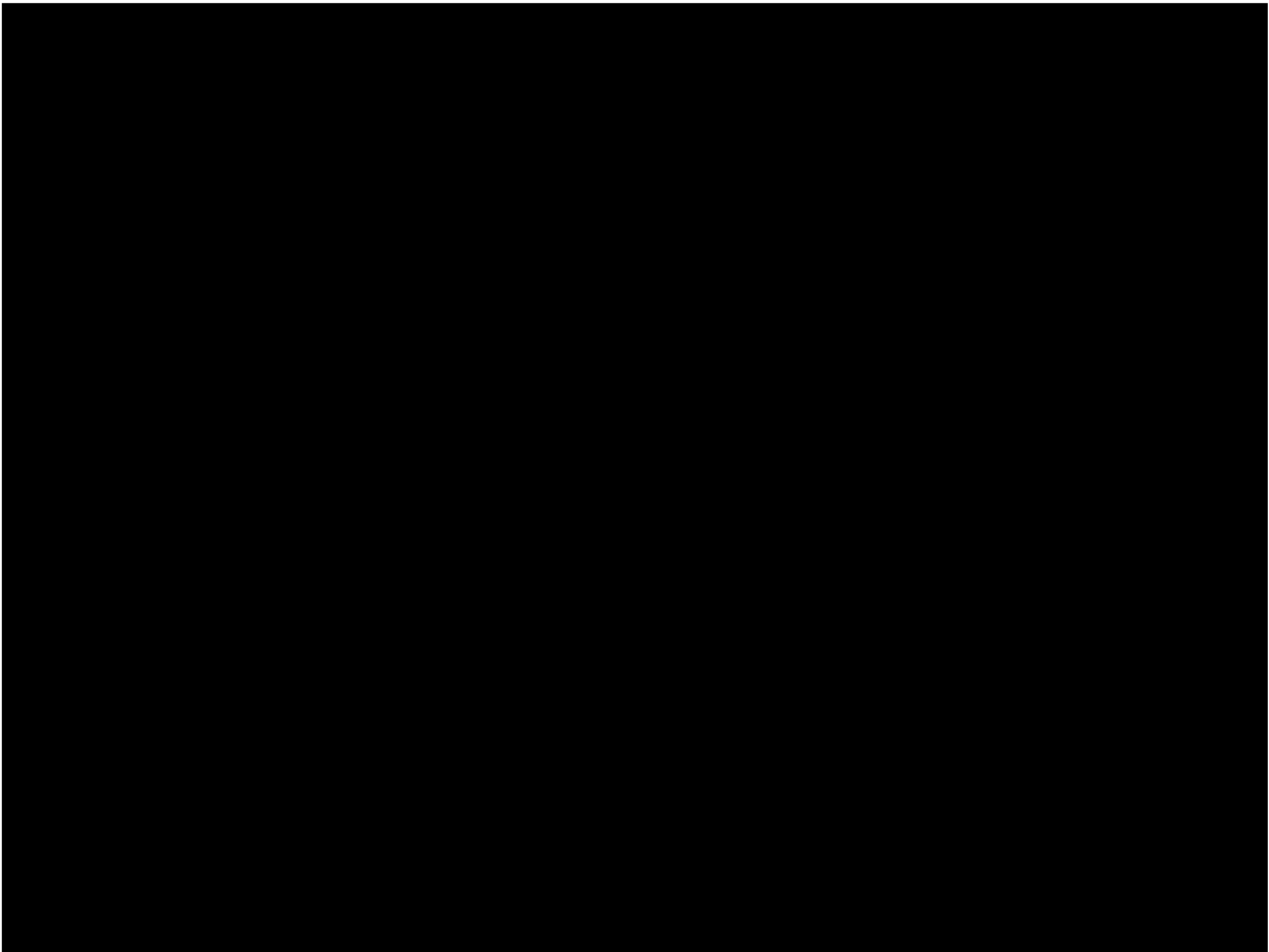


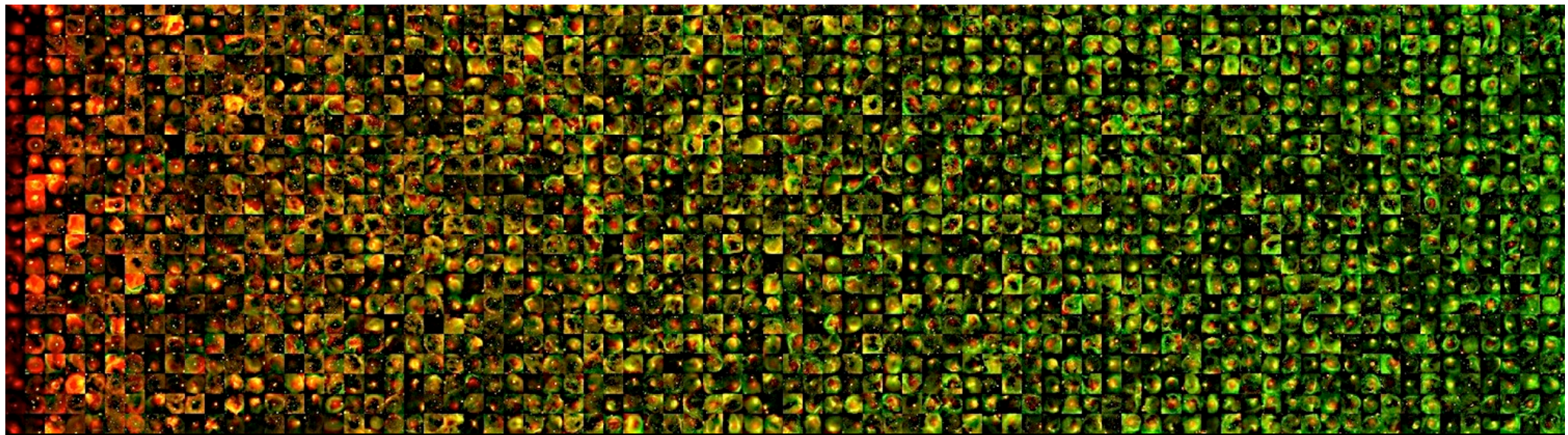
Zoomable Treemap



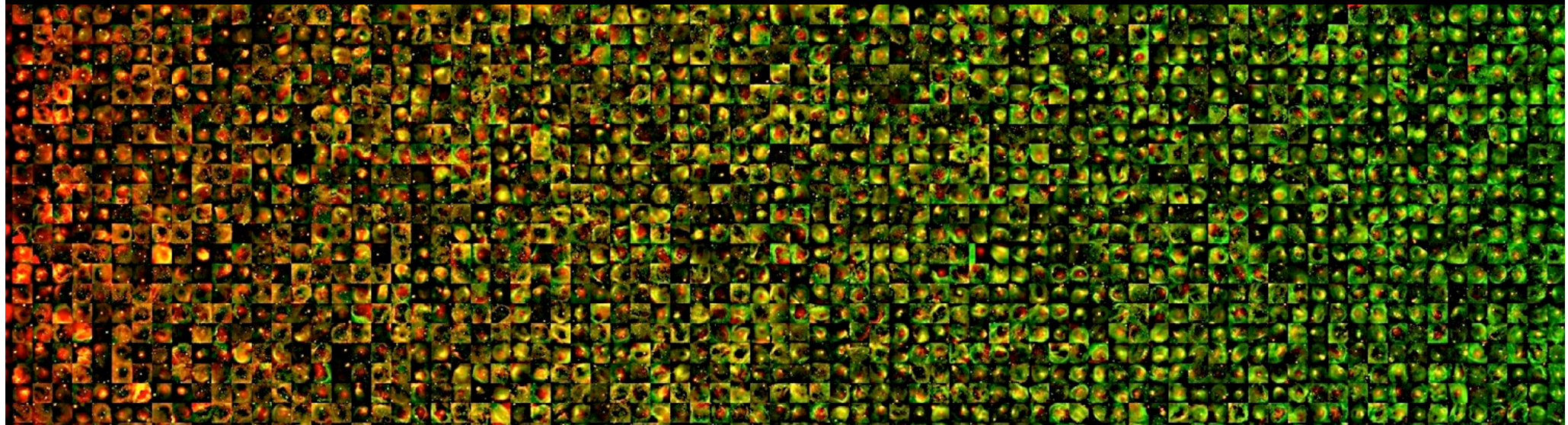
Zoomable Partition Layout

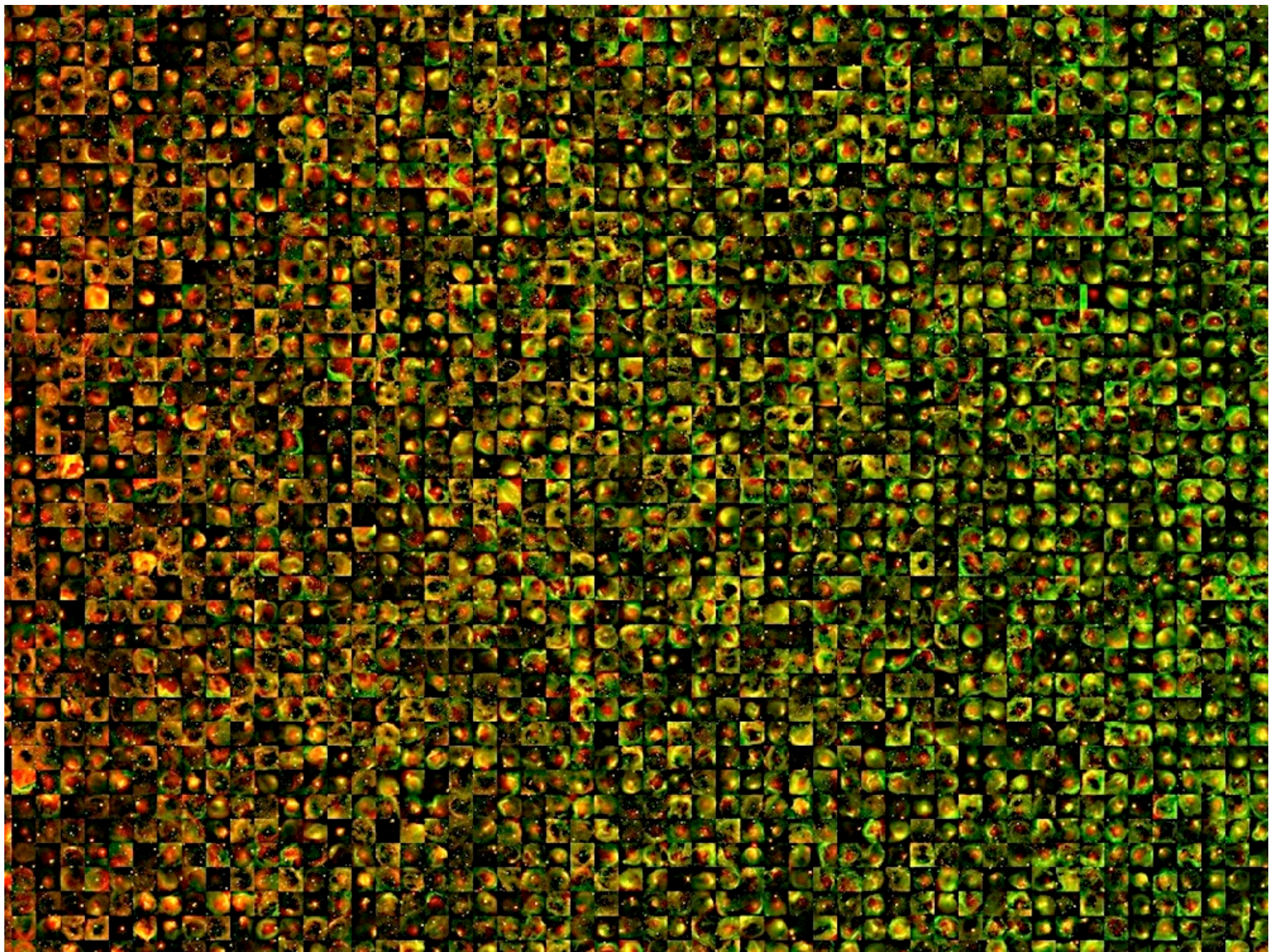




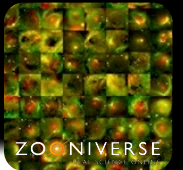


BIG DATA, WIDE DATA





BIG DATA AND "HUMAN-AIDED COMPUTING"

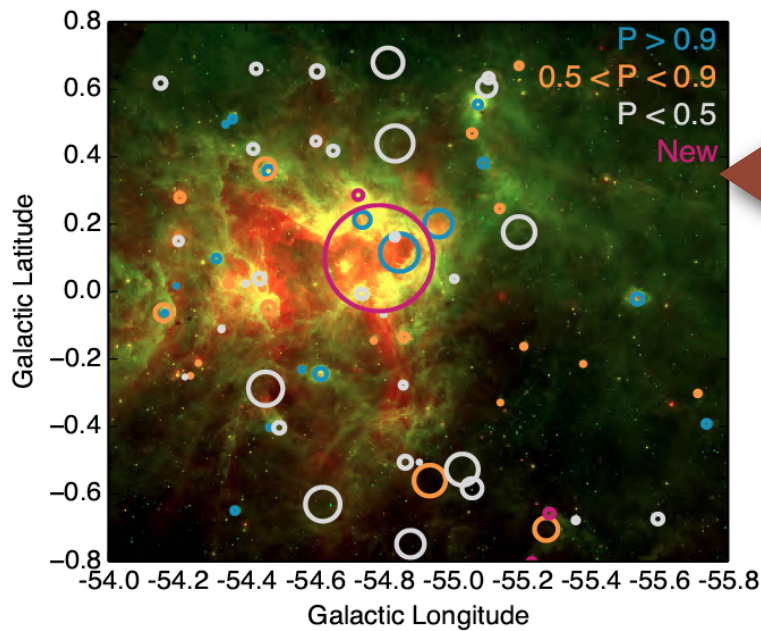
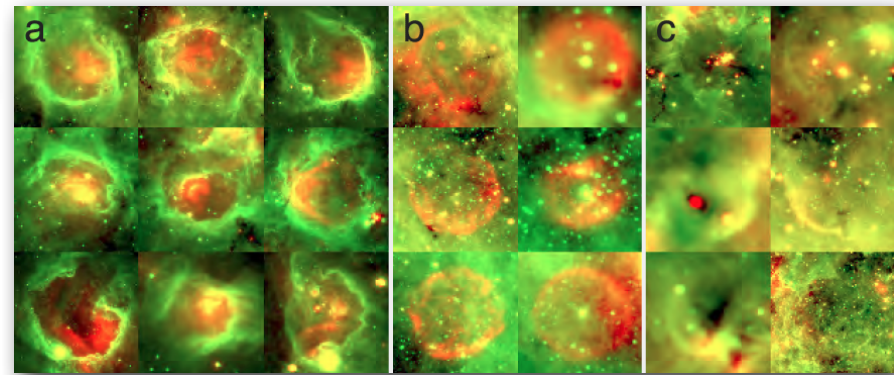


THE MILKY WAY PROJECT ZO NIVERSE REAL SCIENCE ONLINE

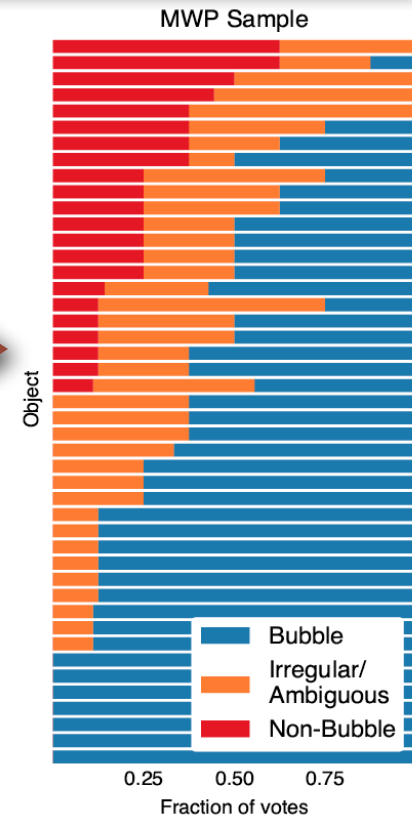
mark bubbles

What do you see in this image?

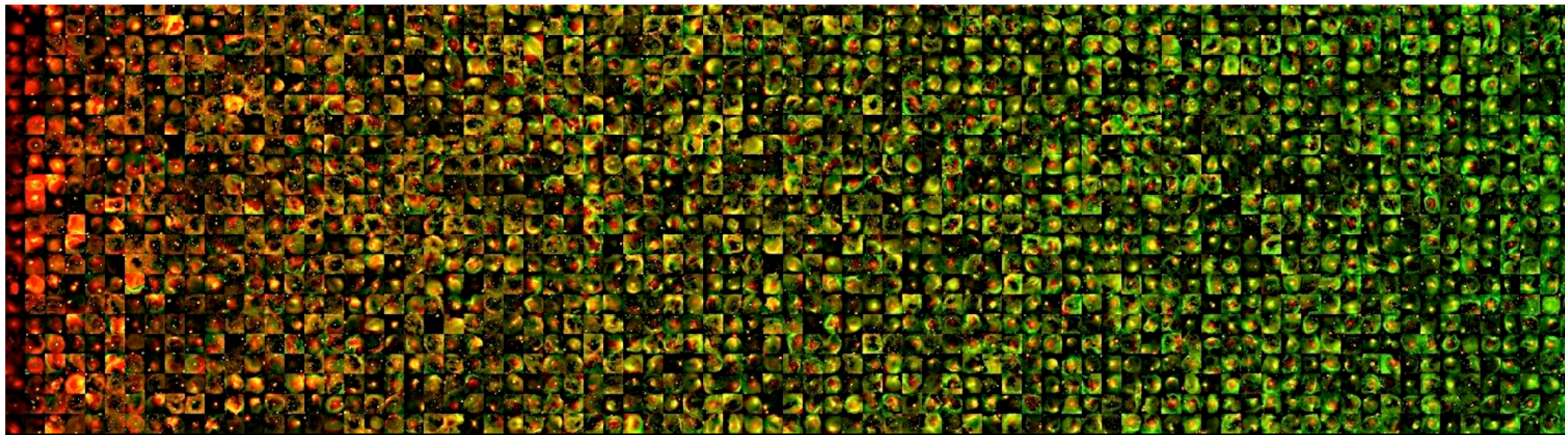
Bubble Star Cluster EGO Galaxy Object I'm done!



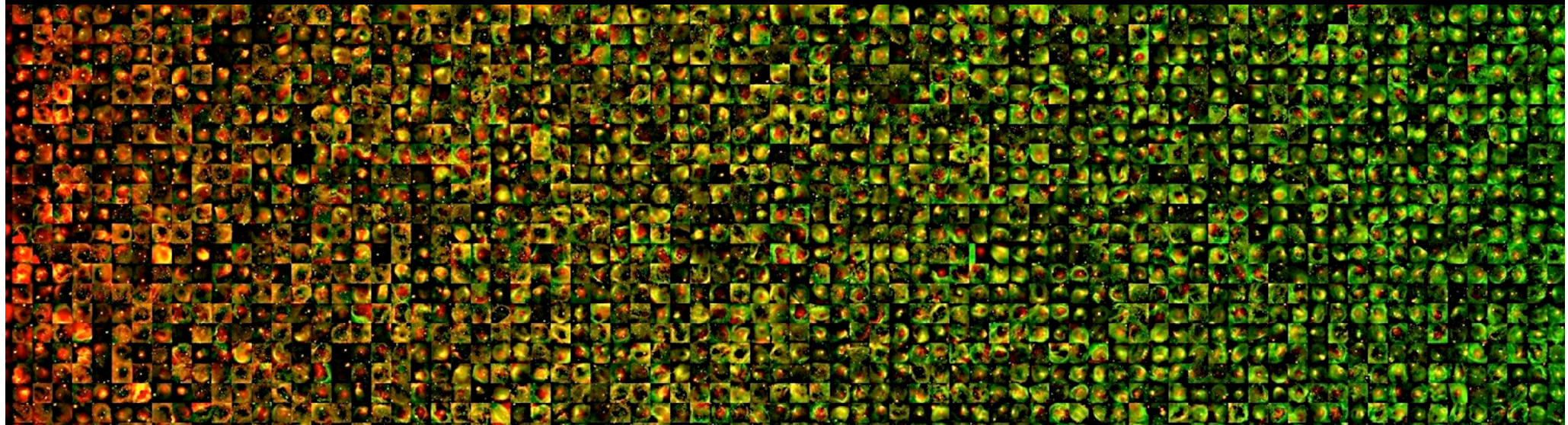
machine-learning algorithm (Brut)



example here from: **Beaumont, Goodman, Kendrew, Williams & Simpson 2014**; based on **Milky Way Project** catalog (Simpson et al. 2013), which came from **Spitzer/GLIMPSE** (Churchwell et al. 2009, Benjamin et al. 2003), cf. Shenoy & Tan 2008 for discussion of HAC; **astroml.org** for machine learning advice/tools





BIG DATA, WIDE DATA




WIDE DATA

COMPLETE

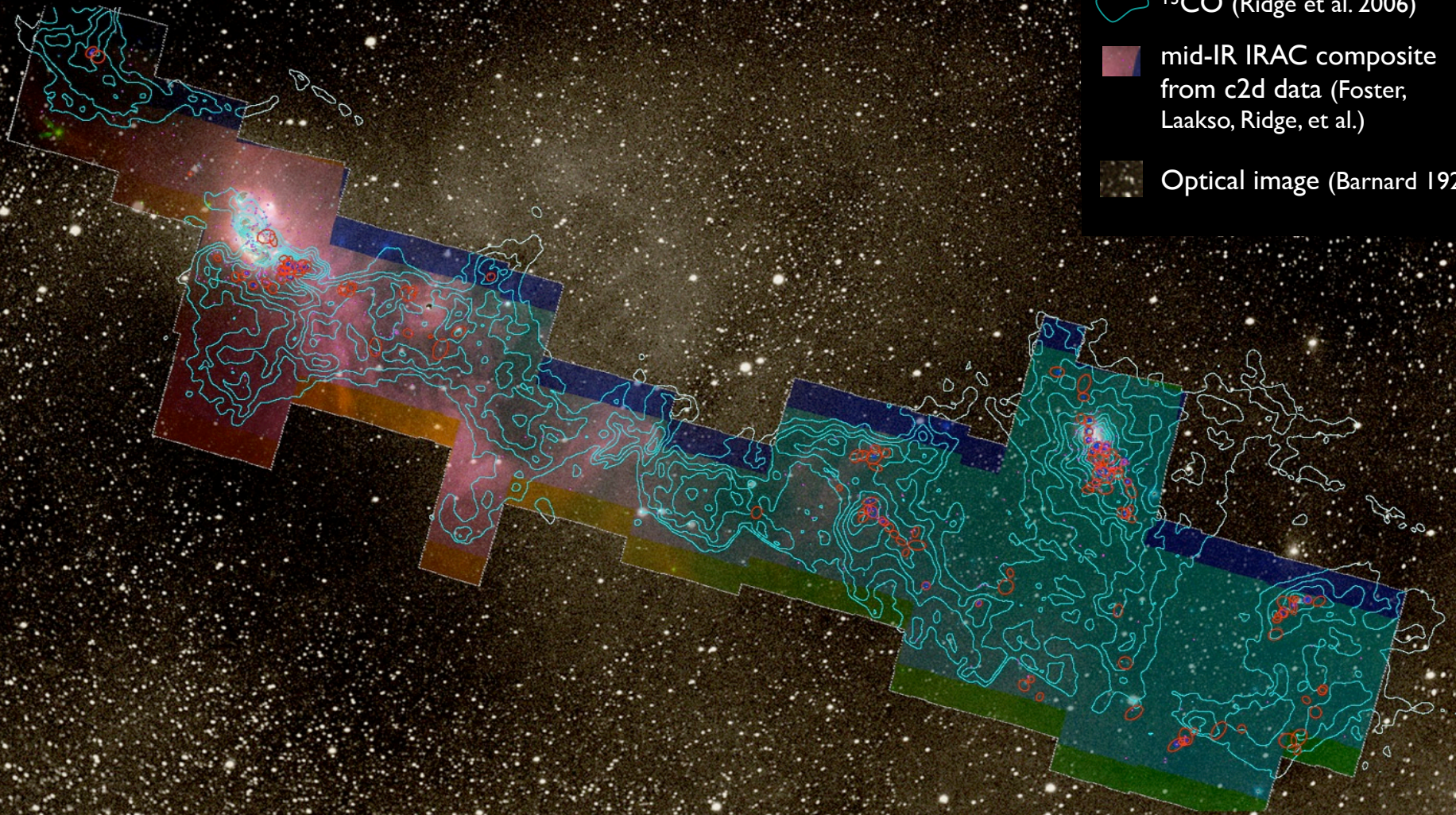
 mm peak (Enoch et al. 2006)

 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.)

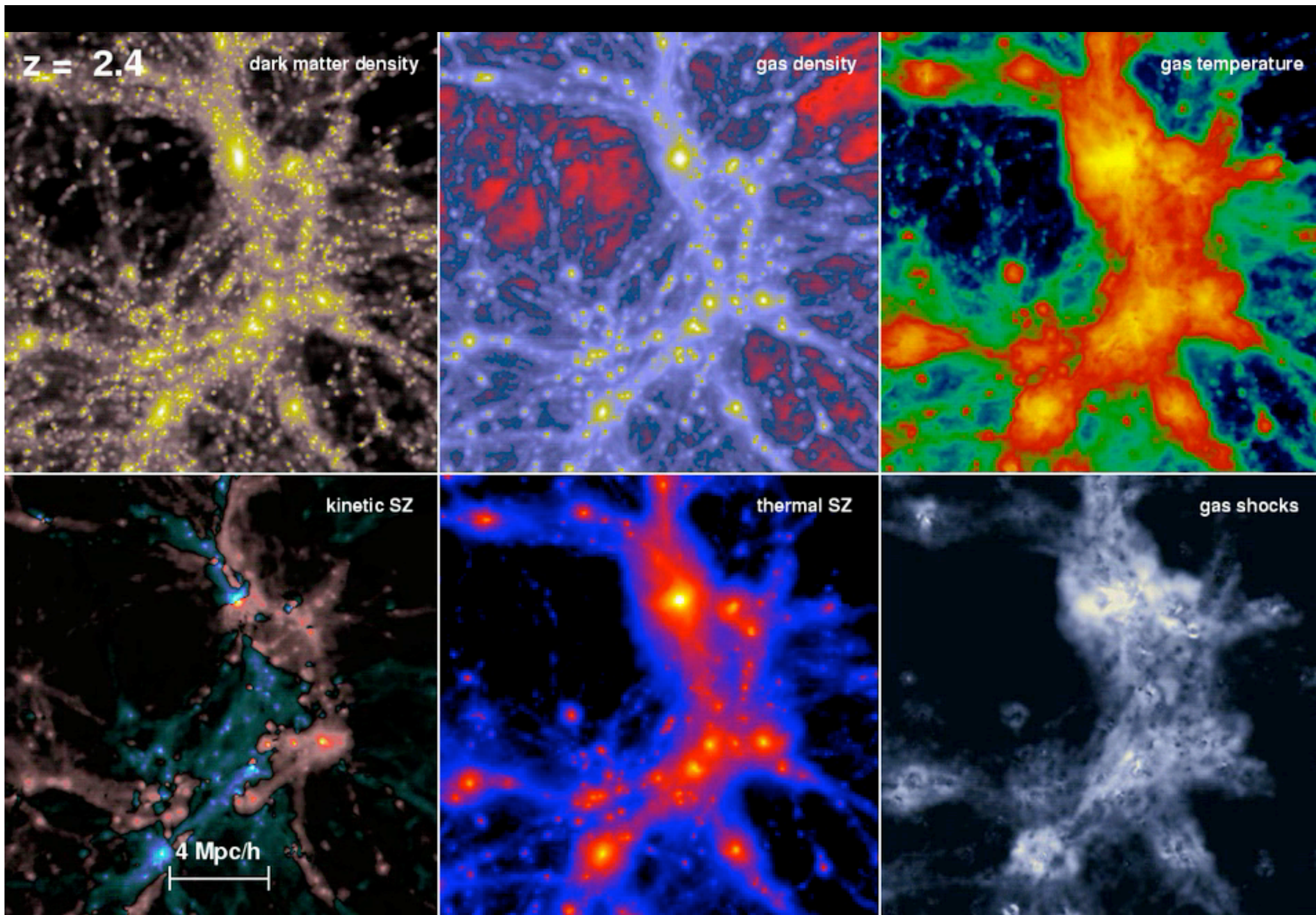
 Optical image (Barnard 1927)



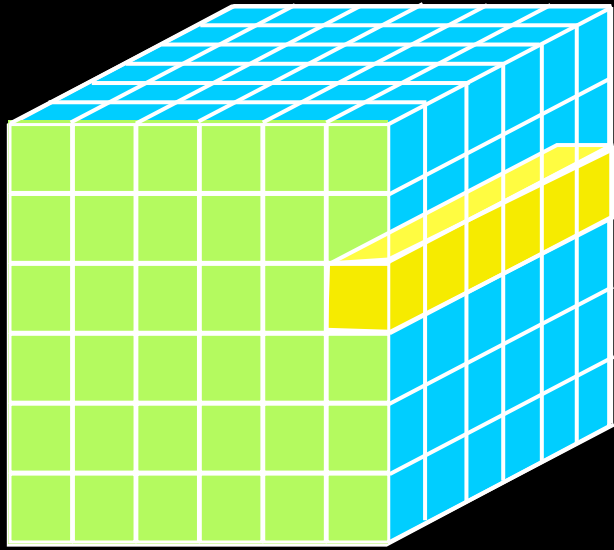


BIG AND WIDE DATA










Movie: Volker Springel, formation of a cluster of galaxies

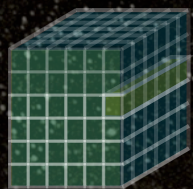


"DATA, DIMENSIONS, DISPLAY"

- 1D:** Columns = "Spectra", "SEDs" or "Time Series"
- 2D:** Faces or Slices = "Images"
- 3D:** Volumes = "3D Renderings", "2D Movies"
- 4D:** Time Series of Volumes = "3D Movies"

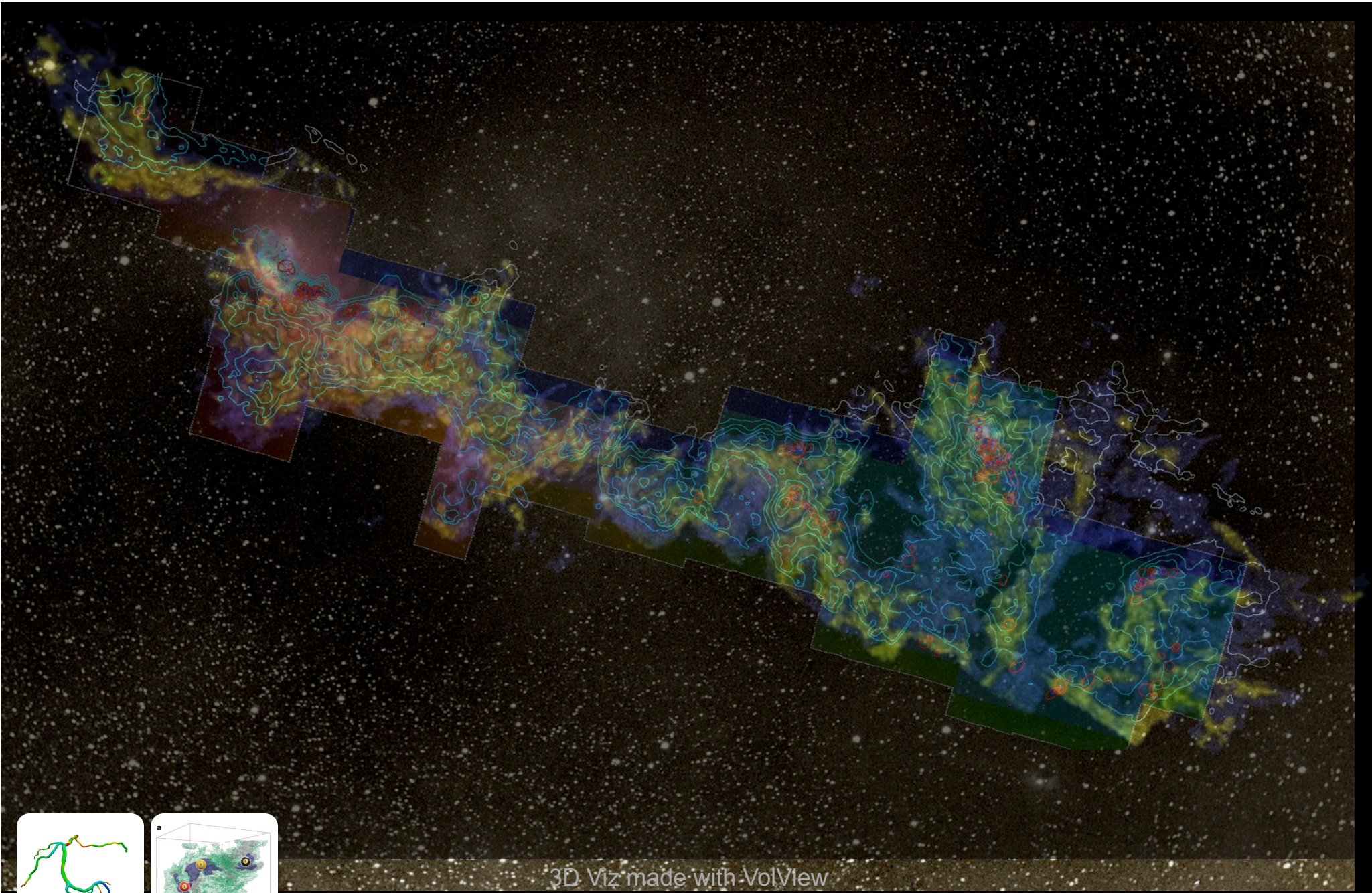
WIDE DATA, "IN 3D"

-  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.)
-  Optical image (Barnard 1927)

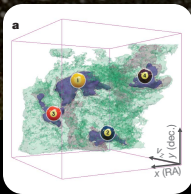


m: 1/249
zoom: 227% Angle: 0





3D Viz made with VolView



AstronomicalMedicine@iig

COMPLETE

1610



SIDEREUS NUNCIIUS

On the third, at the seventh hour, the sequence. The eastern one was 1 minute, the closest western one 2 minutes; and the

East * ○ * * West

to minutes removed from this one. They were absolutely on the same straight line and of equal magnitude.

On the fourth, at the second hour, there were four stars around Jupiter, two to the east and two to the west, and arranged precisely

East * * ○ * * West

on a straight line, as in the adjoining figure. The easternmost was distant 3 minutes from the next one, while this one was 40 seconds from Jupiter; Jupiter was 4 minutes from the nearest western one, and this one 6 minutes from the westernmost one. Their magnitudes were nearly equal; the one closest to Jupiter appeared brighter than the rest. But at the seventh hour the eastern star was 30 seconds apart. Jupiter was 2 minutes from the

East ** ○ ** *

one, while he was 4 minutes from the next western one was 3 minutes from the westernmost one. They extended on the same straight line along the ecliptic. On the fifth, the sky was cloudy.

On the sixth, only two stars appeared flanking Jupiter.

East * ○ *

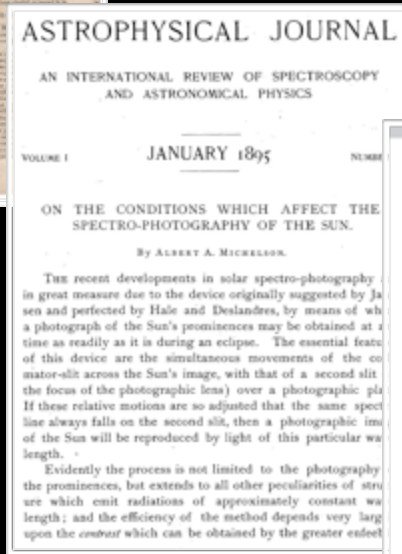
in the adjoining figure. The eastern one was 2 minutes from Jupiter, the western one 3 minutes from Jupiter. They were on the same straight line with Jupiter and equal in magnitude.

On the seventh, two stars stood near Jupiter, both arranged in this manner.

1665

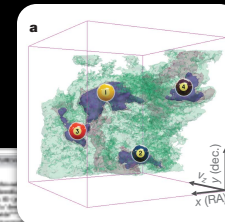
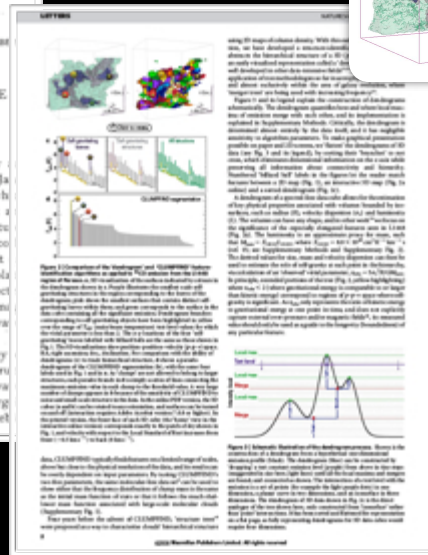


1895



WHAT DO WE PUBLISH?

2009



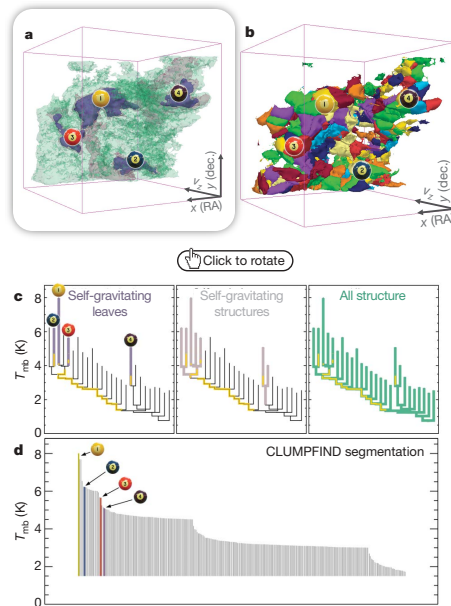


Figure 2 | Comparison of the 'dendrogram' and 'CLUMPFIND' feature-identification algorithms as applied to ^{13}CO emission from the L1448 region of Perseus. **a**, 3D visualization of the surfaces indicated by colours in the dendrogram shown in **c**. Purple illustrates the smallest scale self-gravitating 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 set⁹ 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 work as inspiration, we have developed a structure-identification algorithm that abstracts the hierarchical structure of a data cube into an easily visualized representation called a dendrogram. Well developed in other data-intensive fields, dendrograms have application in a wide range of fields and almost exclusively within the astronomical community. 'Merger trees' are being used with increasing frequency.

Figure 3 and its legend explain the dendrogram process schematically. The dendrogram is constructed from a 3D data cube of emission merge with each other. The dendrogram is determined almost entirely by the sensitivity to algorithm parameters, which is possible on paper and 2D screen data (see Fig. 3 and its legend), which eliminates dimensions, preserving all information. Numbered 'billiard ball' labels are features between a 2D map (online) and a sorted dendrogram.

A dendrogram of a spectrum reveals key physical properties of the emission, such as radius (R), luminosity (L). The volumes can have any shape, and the significance of the especially elongated features is revealed (Fig. 2a). The luminosity is an approximate proxy for mass, such that $M_{\text{lum}} = X_{13\text{CO}} L_{13\text{CO}}$, where $X_{13\text{CO}} = 8.0 \times 10^{20} \text{ cm}^{-2} \text{ K}^{-1} \text{ s}$ (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, $\alpha_{\text{obs}} = 5\sigma_v^2 R / G M_{\text{lum}}$. 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.

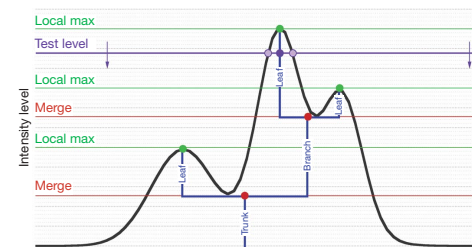


Figure 3 | Schematic illustration of the dendrogram process. Shown is the construction of a dendrogram from a hypothetical one-dimensional emission profile (black). The dendrogram (blue) can be constructed by 'dropping' a test constant emission level (purple) from above in tiny steps (exaggerated in 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.

using 2D work as inspiration, we have developed a structure-identification algorithm that

A role for self-gravity at multiple length scales in the process of star formation

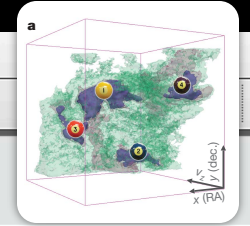
Alyssa A. Goodman^{1,2}, Erik W. Rosolowsky^{2,3}, Michelle A. Borkin^{1†}, Jonathan B. Foster², Michael Halle^{1,4}, Jens Kauffmann^{1,2} & Jaime E. Pineda²

Self-gravity plays a decisive role in the final stages of star formation, where dense cores (size ~ 0.1 parsecs) inside molecular clouds collapse to form star-plus-disk systems. But self-gravity's role at earlier times (and on larger length scales, such as ~ 1 parsec) is unclear. Some molecular cloud simulations that do not include self-gravity suggest that 'turbulent fragmentation' alone is sufficient to create the stellar initial mass function. Here we report a 'dendrogram' (hierarchical tree-diagram) analysis that reveals that self-gravity plays a significant role over the full range of possible scales traced by ^{13}CO observations in the L1448 molecular cloud, but not everywhere in the observed region. In particular, more than 90 per cent of the compact 'pre-stellar cores' traced by peaks of dust emission⁹ are projected on the sky within one of the dendrogram's self-gravitating 'leaves'. As these peaks mark the locations of dense cores, our analysis reveals that self-gravity is significant in overlapping features as an option, significant emission found between prominent clumps is typically either appended to the nearest clump or turned into a small, usually 'pathological', feature needed to encompass all the emission being modelled. When applied to molecular-line



2009
3D PDF
INTERACTIVITY
IN A "PAPER"

Goodman et al. 2009, Nature,
cf: Fluke et al. 2009



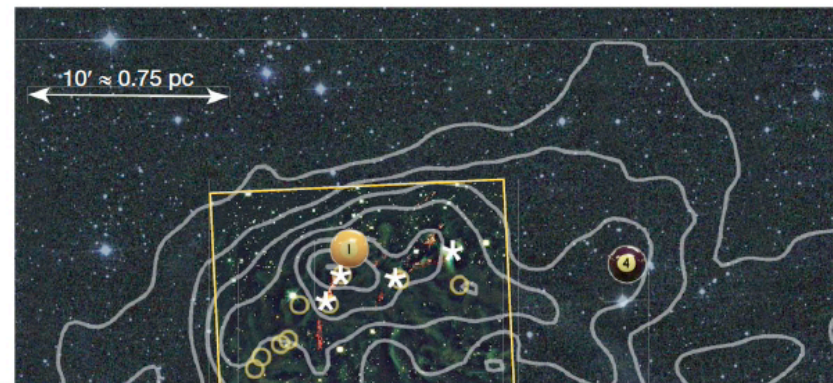
LETTERS

A role for self-gravity at multiple length scales in the process of star formation

Alyssa A. Goodman^{1,2}, Erik W. Rosolowsky^{2,3}, Michelle A. Borkin^{1†}, Jonathan B. Foster², Michael Halle^{1,4}, Jens Kauffmann^{1,2} & Jaime E. Pineda²

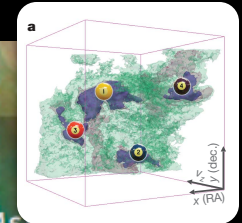
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overlapping features as an option, significant emission found between prominent clumps is typically either appended to the nearest clump or turned into a small, usually 'pathological', feature needed to encompass all the emission being modelled. When applied to molecular-line



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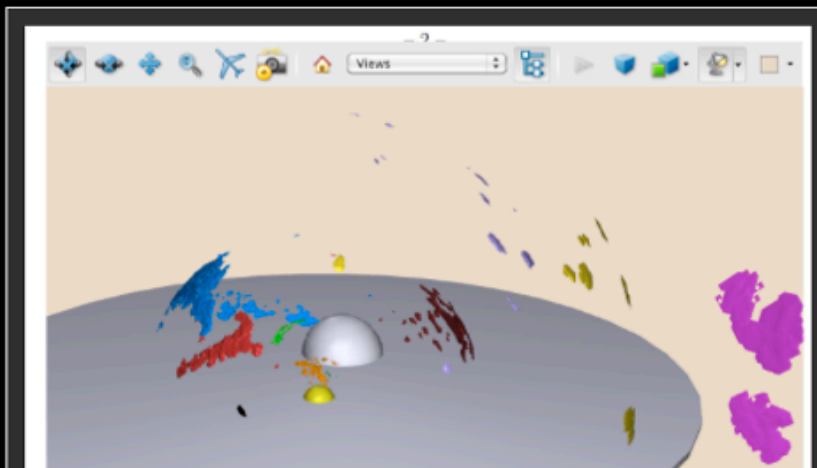
by *Guest* on March 7, 2012

Josh Peek
Columbia



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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RIVETING SEQUEL TO COME, BUT, FIRST...

1610

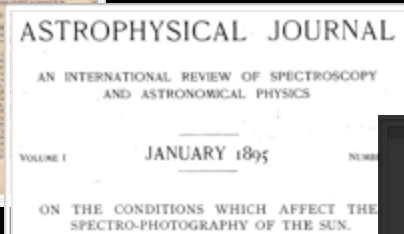


SIDEREUS NUNCIVS
On the third, at the seventh hour, the sequence. The eastern one was 1 minute, the closest western one 2 minutes; and the
East * ○ * * West
to minutes removed from this one. They were absolutely on the same straight line and of equal magnitude.
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1665



1895



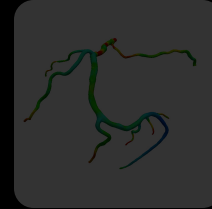
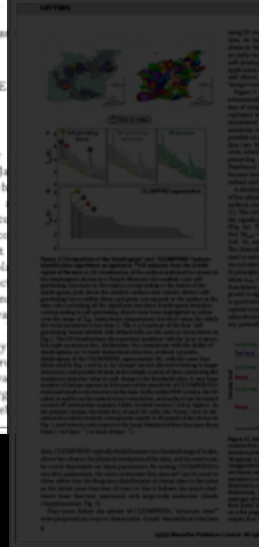
PHOTOGRAPHS OF THE MILKY WAY.

By E. E. BARNARD.

In my photographic survey of the Milky Way with the 6-inch Willard lens of this Observatory, I have come across many very remarkable regions. Some of these, besides being remarkable for showing the peculiar structure of the Milky Way, are singularly beautiful as simple pictures of the stars. I have selected two of these for illustration in THE ASTROPHYSICAL JOURNAL.

...the process is not limited to the photography of the prominences, but extends to all other peculiarities of stars 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 extent

2009



astronomy



2014

Authora

Beyond Galileo

Joseph Peck, Alberto Pepe, Adrian Price-Whelan, Chris Beaumont

In the last portion of Sidereus Nuncivus, Galileo reported his discovery of four objects that appeared to form a straight line of stars near Jupiter. The first night, he witnessed a line of three little stars close to Jupiter parallel to the ecliptic; the following nights brought different arrangements and another star into his view, totaling four stars around Jupiter. (Galileo 1610)

Throughout the text, Galileo gave illustrations of the relative positions of Jupiter and its attendant companion stars as they appeared nightly from late January through early March 1610. The fact that they changed their positions relative to Jupiter from night to night, but always appeared in the same straight line near Jupiter, brought Galileo to deduce that they were four bodies in orbit around Jupiter. On January 11 after 4 nights of observation he wrote:

It therefore concluded and decided unhesitatingly that there are three stars in the heavens moving about Jupiter, as Venus and Mercury round the Sun, which at length was established as clear as daylight by numerous subsequent observations. These observations also established that there are not only three, but four, emulous sidereal bodies performing their revolutions round Jupiter; the revolutions are so swift that an observer may generally get differences of position every hour. (Galileo 1610)



1610



SIDEREUS NUNCIVS

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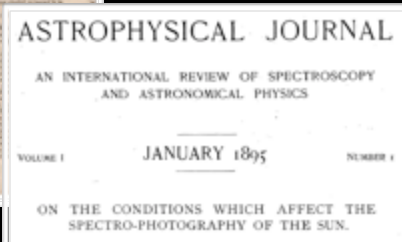
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1665



1895



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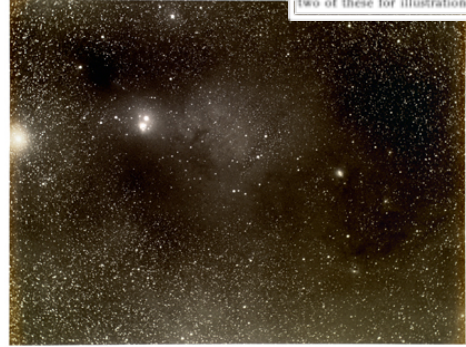
.....HOW TO "UN"PUBLISH GRAPHICAL DATA





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α (1875) 3h 30m 30s, δ (1875) $+31^{\circ} 00'$

Area
In Perseus and Taurus

Galactic Coordinates
 $127^{\circ}, -18^{\circ}$

Scale
1 cm = 18'.2 or 1 in = 46'.2



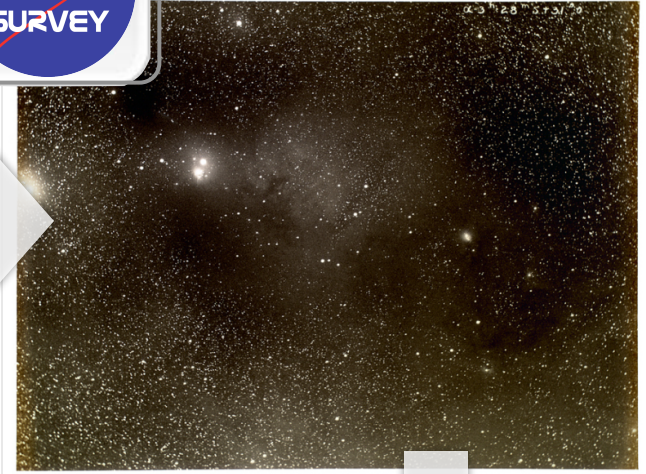
Table

Star	Mag.
ADS 148723	11.8
ADS 148724	11.8
ADS 148725	11.8
ADS 148726	11.8
ADS 148727	11.8
ADS 148728	11.8
ADS 148729	11.8
ADS 148730	11.8

Text

One of the most difficult bits of work in the great Milky Way survey was the identification of individual stars through the swirling dust lanes of the Galaxy.

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Bar-pt1-p1003_sm

Barnard's Image of Perseus, from www.library.gatech.edu/bpd/bpd1.php

December 17, 2003

1 comment

astrometry.net 12m

Hello, this is the blind astrometry solver. Your results are: (RA, Dec) center: (54.3098782184, 31.431266374) degrees Orientation: 5.21349891764 deg E of N Pixel scale: 18.516371997 arcsec/pixel Your field contains: NGC 1465 IC 1985 IC 1987 IC 1989 IC 2003 IC 348 IC 2003 View in World Wide Telescope — If you would like to have other images solved, please submit them to the



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California Nebula

WorldWide Telescope

AND, SOON...HUMANS WILL SEE THE INVISIBLE!

ADS ALL SKY SURVEY

+

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No. 1, 1998

ORIGIN AND EVOLUTION OF THE CEPHEUS BUBBLE

243

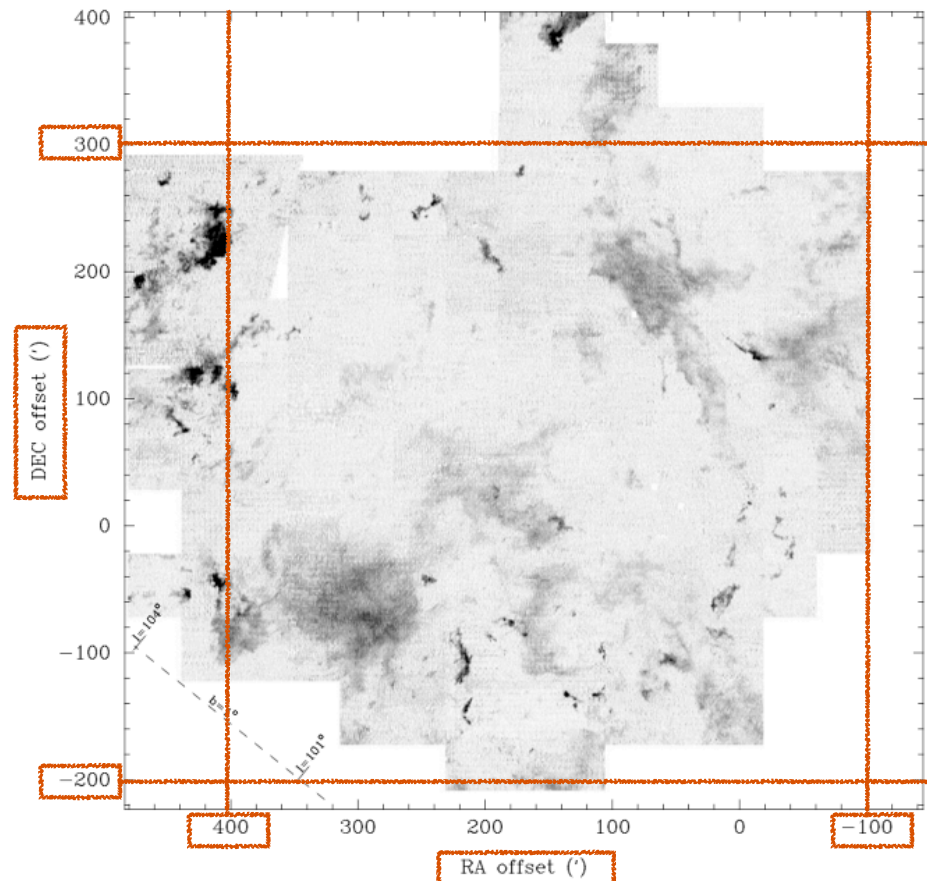
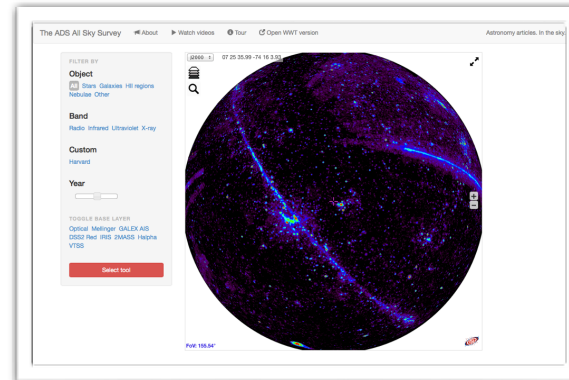


FIG. 1.—Peak intensity of CO 1–0 emission. The gray scale represents antenna temperature values scaled linearly between 0 and 3.5 K. The strongest emission occurs at the S140 region and globule A of IC 1396, where the peak antenna temperature is about 10 K. The position offsets are measured from $\alpha(1950) = 21^{\text{h}}18^{\text{m}}00^{\text{s}}$, $\delta(1950) = 59^{\circ}30'00''$, near S129.

Patel et al. 1998, page 243, Figure 1, with markup (orange) to be made by a citizen scientist using oldAstronomy tools.



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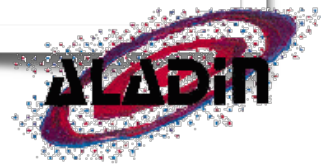
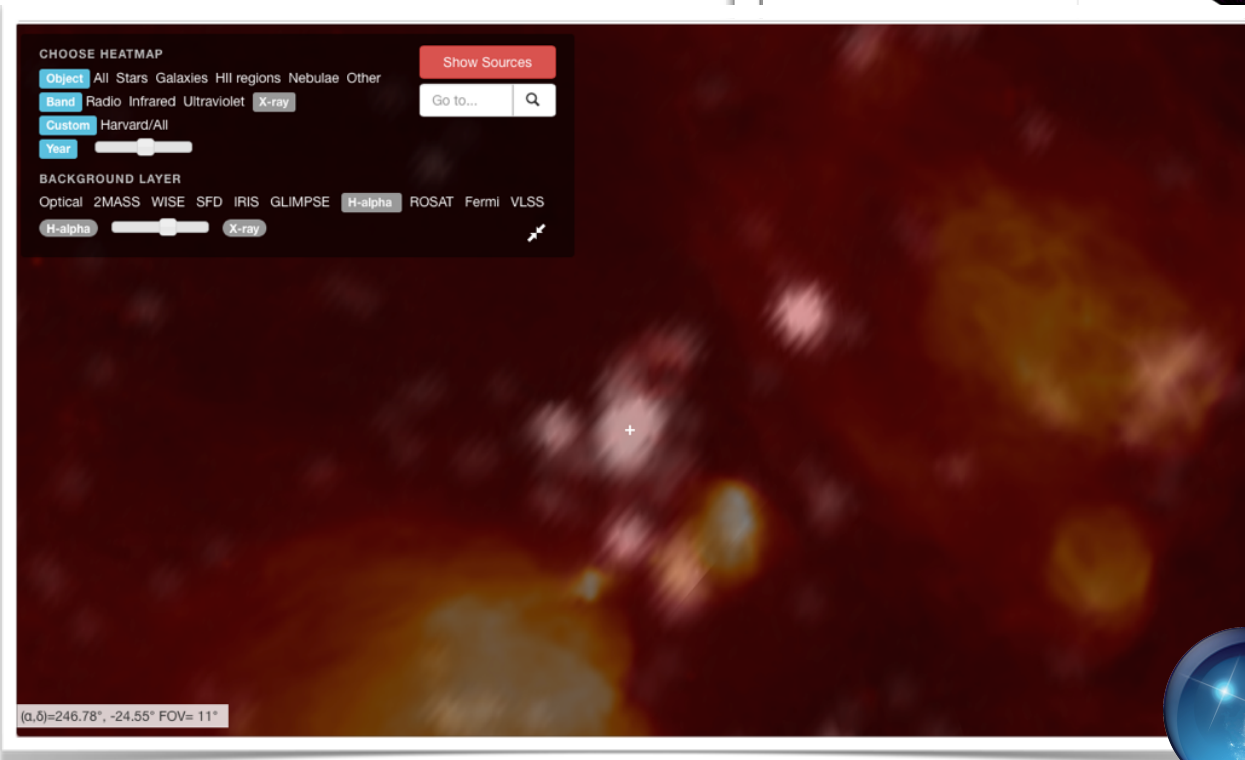
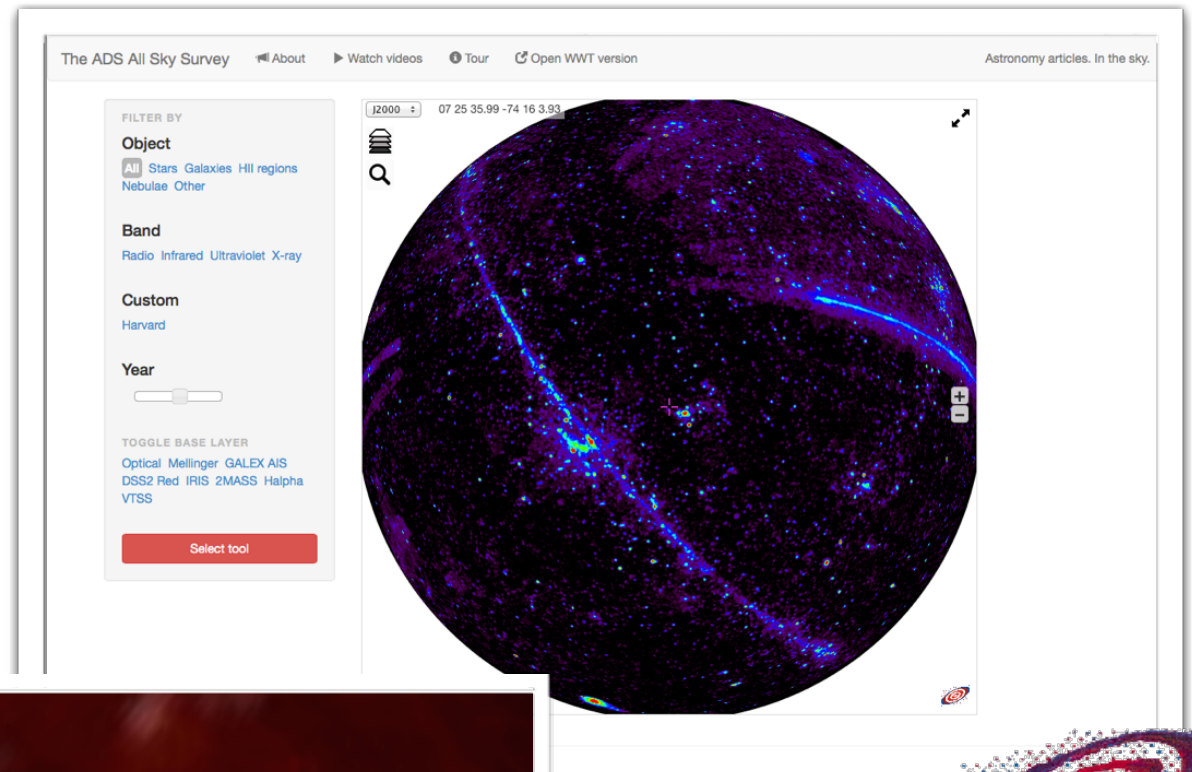
DATA VIEWERS



slide courtesy of Alberto Pepe



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both javascript.
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1610



SIDEREUS NUNCIVS

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East * ○ * * West

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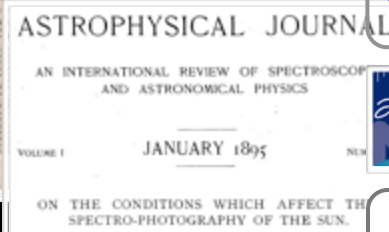
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1665



1895



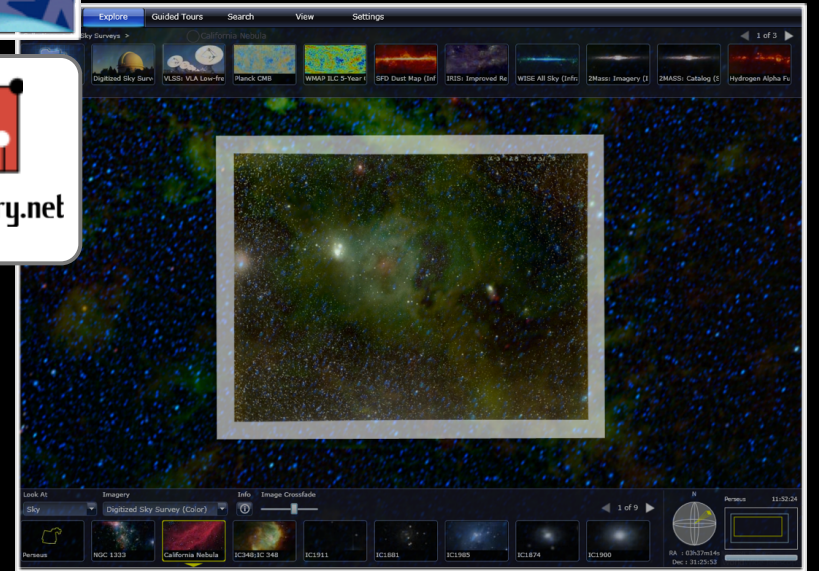
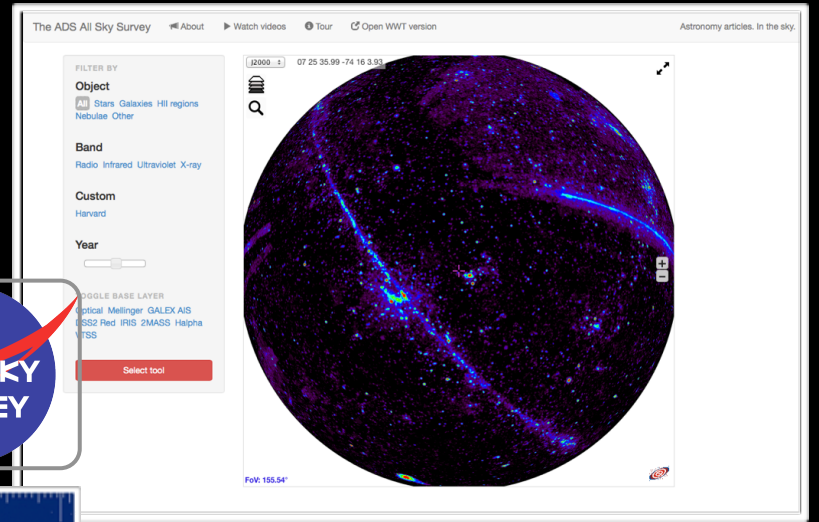
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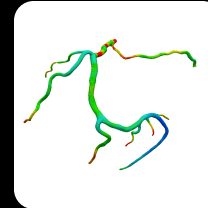
...photographic image of the Sun will be reproduced by light of this particular wavelength.

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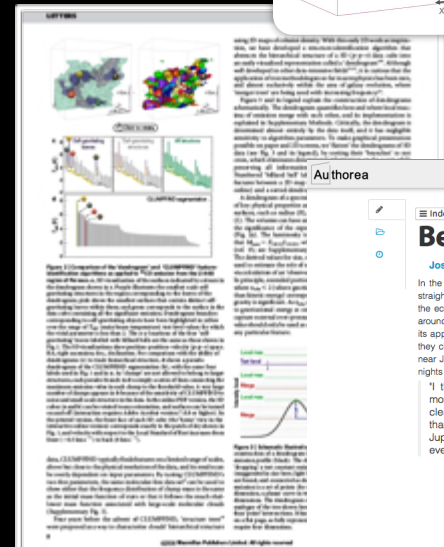
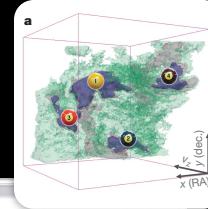


THE RIVETING SEQUEL

2009



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Index ROUGH DRAFT OPEN SCIENCE

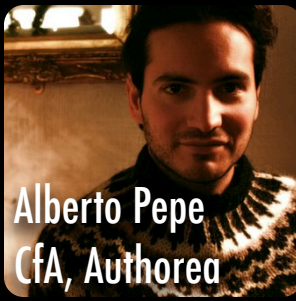
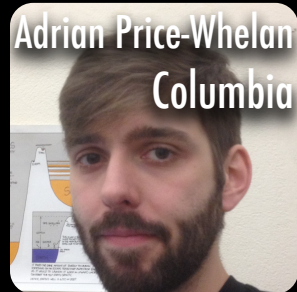
Beyond Galileo

Josh Peek, Alberto Pepe, Adrian Price-Whelan, Chris Beaumont

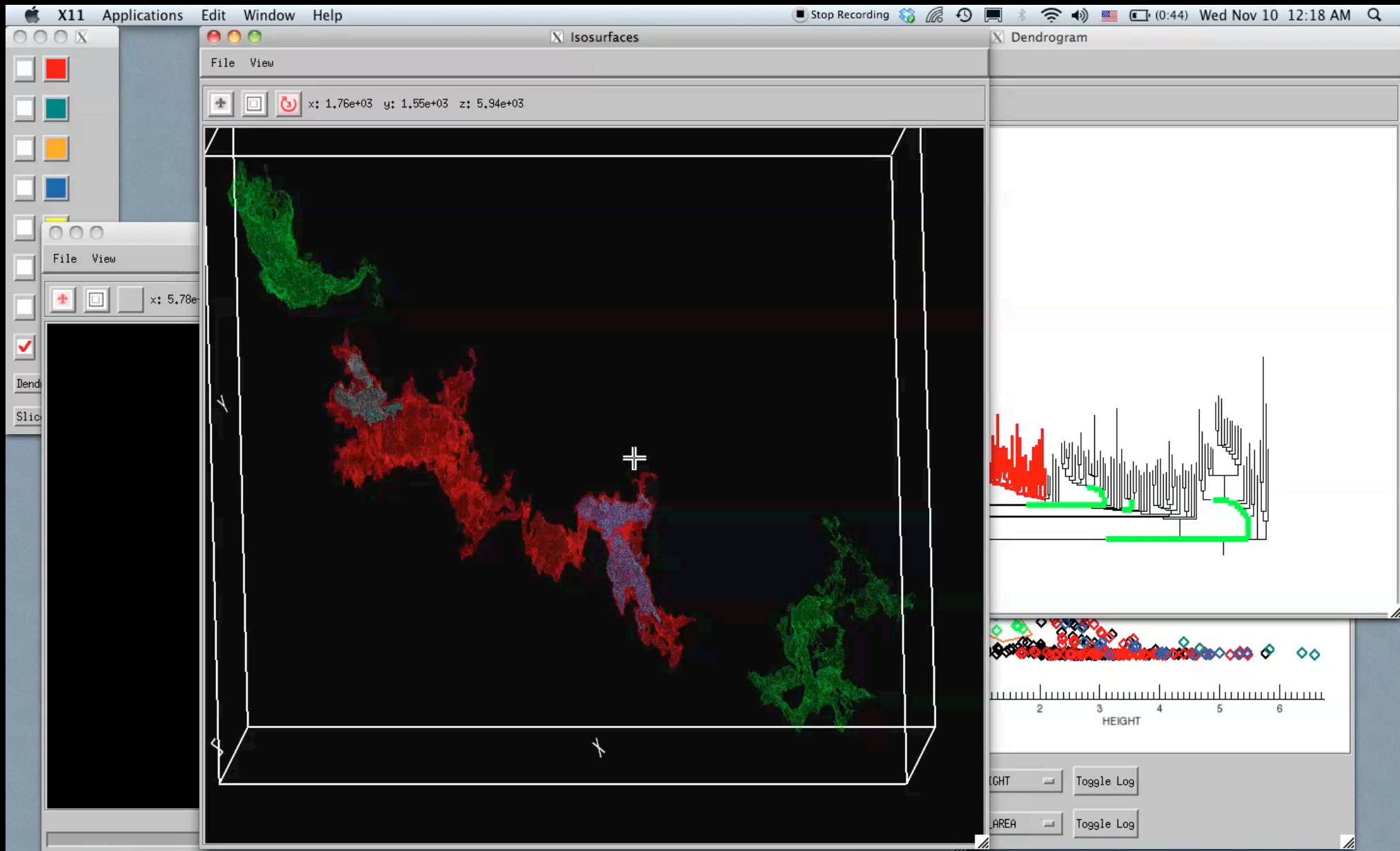
In the last portion of *Sidereus Nuncius*, Galileo reported his discovery of **four objects** that appeared to form a straight line of stars near **Jupiter**. The first night, he witnessed a line of three little stars close to Jupiter parallel to the ecliptic; the following nights brought different arrangements and another star into his view, totaling four stars around Jupiter. (Galileo 1610) Throughout the text, Galileo gave illustrations of the relative positions of Jupiter and its apparent companion stars as they appeared nightly from late January through early March 1610. The fact that they changed their positions relative to Jupiter from night to night, but always appeared in the same straight line near Jupiter, brought Galileo to deduce that they were four bodies in orbit around Jupiter. On January 11 after 4 nights of observation he wrote:

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Four Centuries of Discovery A Chasm in Mass Some are Similar... but Most are Different

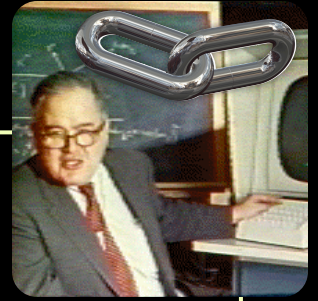


LINKED VIEWS OF HIGH-DIMENSIONAL DATA

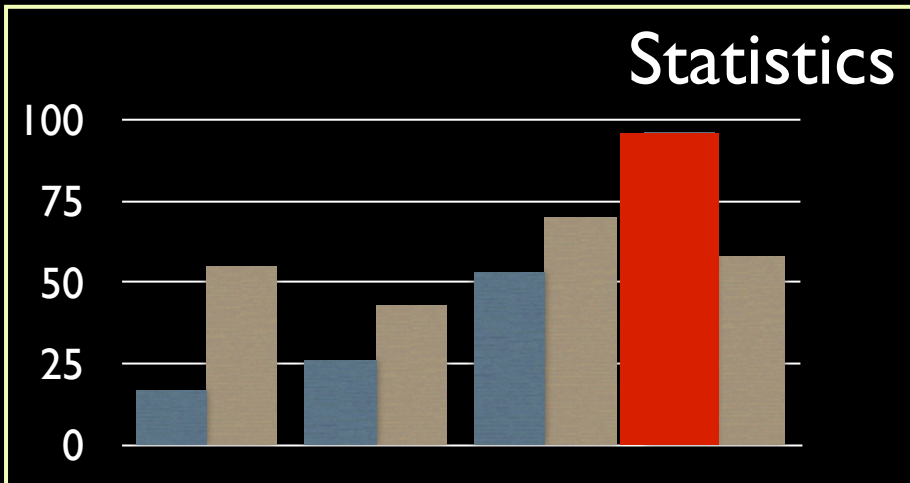
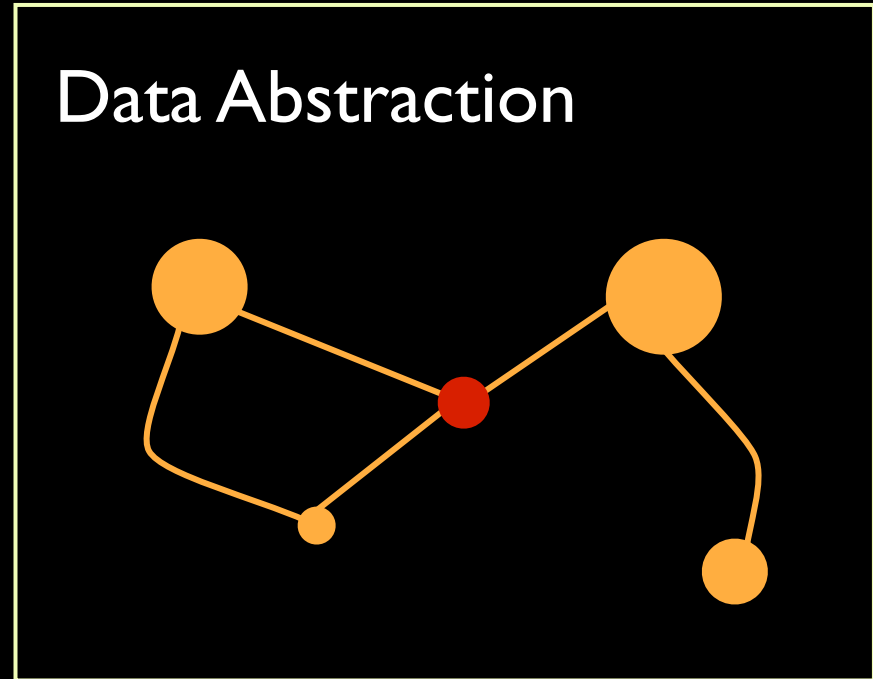
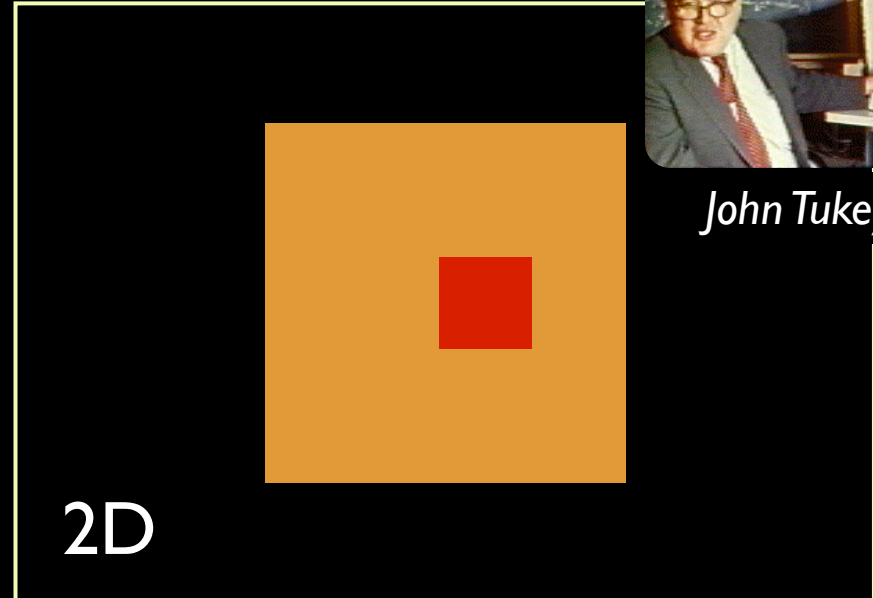
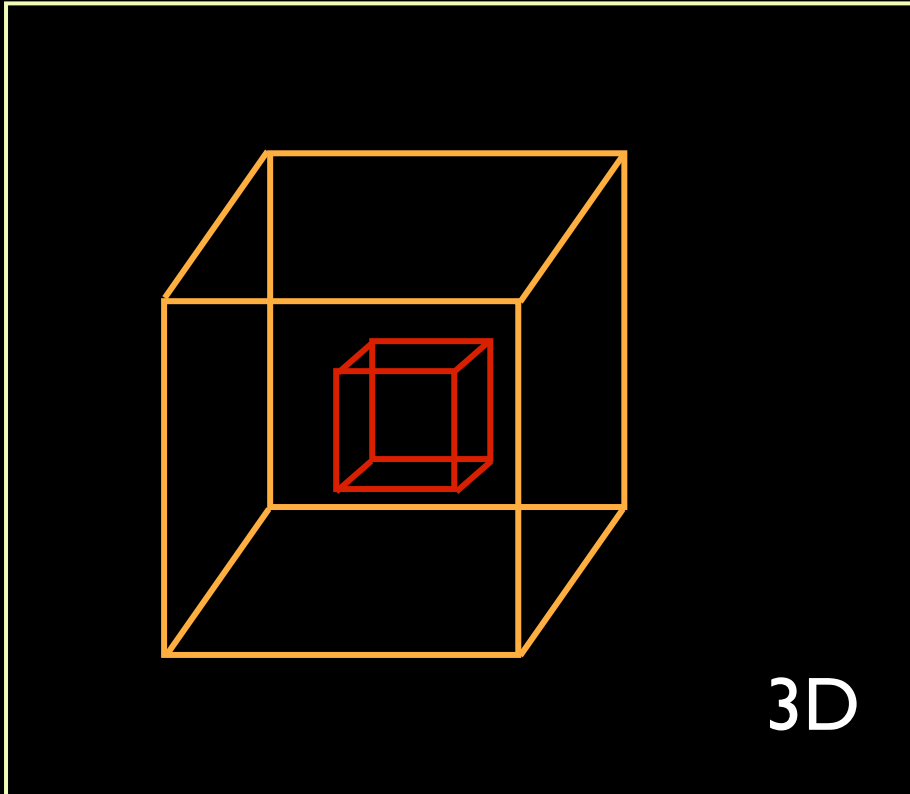


Video & implementation: Christopher **Beaumont**, CFA;
inspired by AstroMed work of Douglas Alan, Michelle Borkin, AG, Michael Halle, Erik Rosolowsky

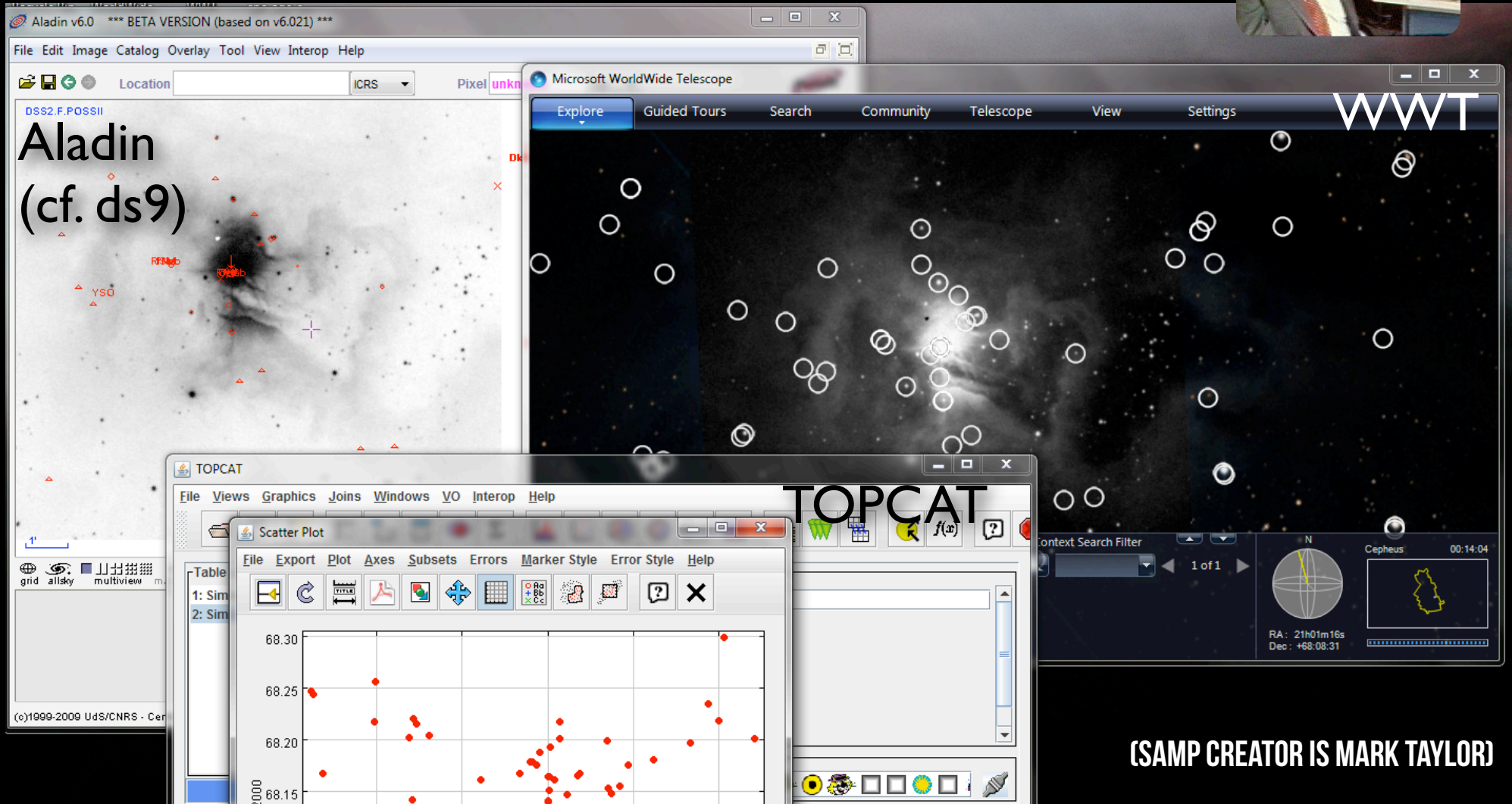
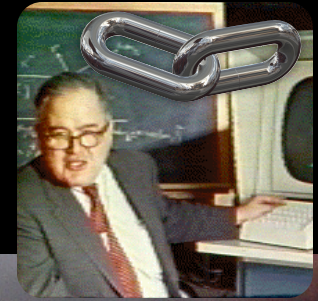
LINKED VIEWS OF HIGH-DIMENSIONAL DATA



John Tukey



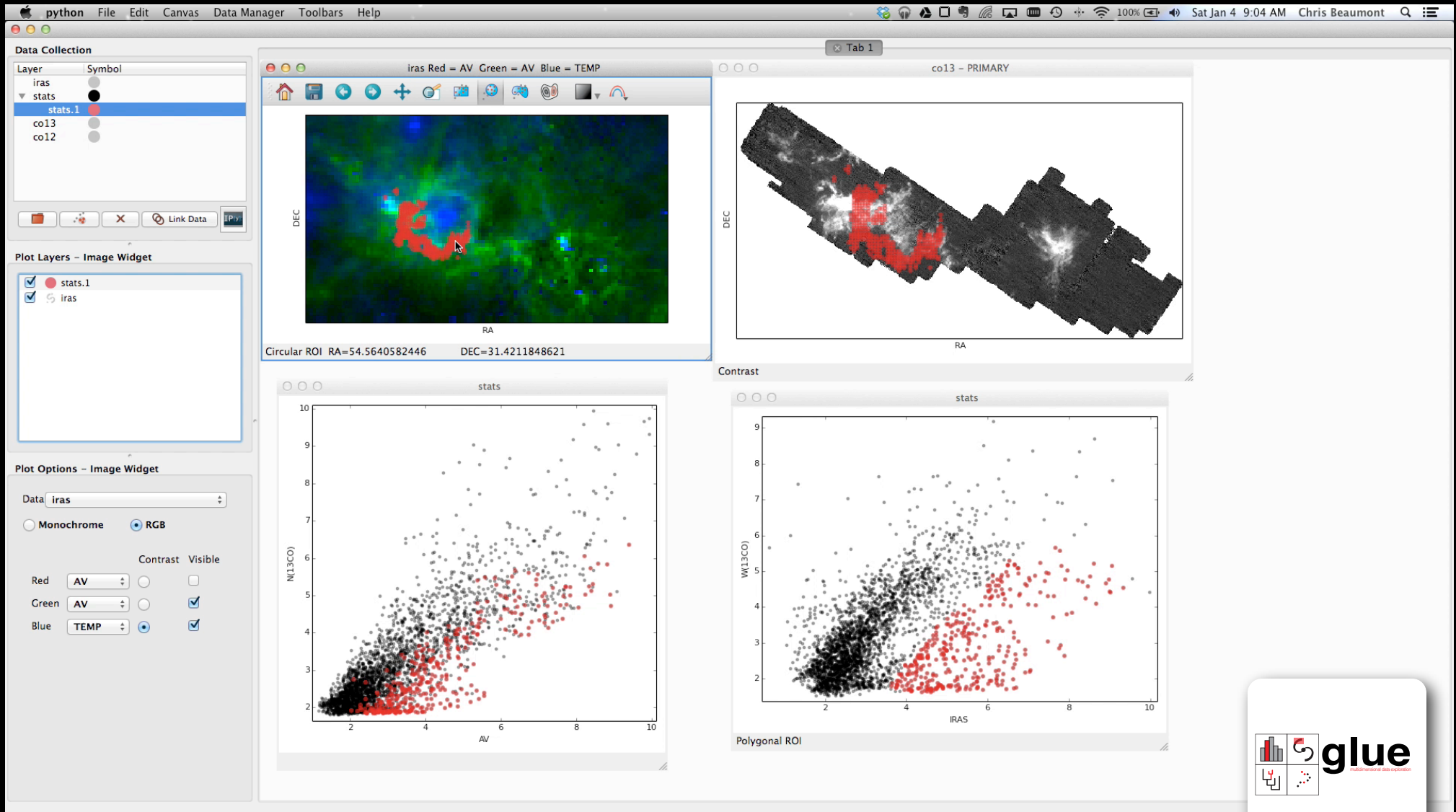
LINKED VIEWS OF HIGH-DIMENSIONAL DATA "SAMP"



(SAMP CREATOR IS MARK TAYLOR)

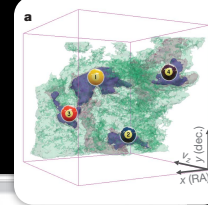
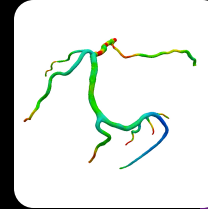
figure, showing SAMP screenshot, reproduced from [Goodman 2012](#), "Principles of High-Dimensional Data Visualization in Astronomy"

LINKED VIEWS OF HIGH-DIMENSIONAL DATA GLUE



THE RIVETING SEQUEL

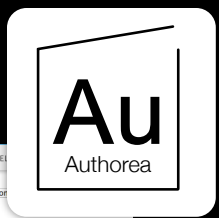
2009



astronomy



2014



Beyond Galileo
Josh Peek, Alberto Pepe, Adrian Price-Whelan, Chris Beaumont

In the last portion of *Sidereus Nuncius*, Galileo reported his discovery of **four objects** that appeared to form a straight line of stars near **Jupiter**. The first night, he witnessed a line of three little stars close to Jupiter parallel to the ecliptic; the following nights brought different arrangements and another star into his view, totaling four stars around Jupiter. (Galilei 1610) Throughout the text, Galileo gave illustrations of the relative positions of Jupiter and its apparent companion stars as they appeared nightly from late January through early March 1610. The fact that they changed their positions relative to Jupiter from night to night, but always appeared in the same straight line near Jupiter, brought Galileo to deduce that they were four bodies in orbit around Jupiter. On January 11 after 4 nights of observation he wrote:

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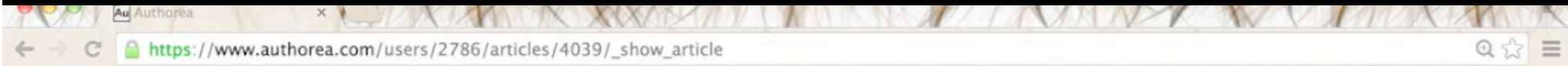
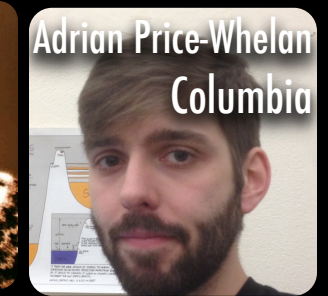
Inclination (deg) vs Eccentricity

Eccentricity	Inclination (deg)
0.0	0.0
0.1	0.0
0.2	0.0
0.3	0.0
0.4	0.0
0.5	0.0
0.6	0.0

log Mass (log kg) vs Semi-major axis (km)

Semi-major axis (km)	log Mass (log kg)
0	14
1e+7	14
2e+7	14
3e+7	14

"THE STORY & THE SANDBOX" (GLUE:D3PO:AUTHOREA)



Authorea

BROWSE ABOUT CONTACT PLANS FEEDBACK HELP JOSH PEEK ▾



Index ROUGH DRAFT OPEN SCIENCE

Settings

Fork

Quick edit ▾

Tour

0 Comments

Export



Beyond Galileo

Josh Peek, Alberto Pepe + Add author

In the last portion of *Sidereus Nuncius*, Galileo reported his discovery of **four objects** that appeared to form a straight line of stars near **Jupiter**. The first night, he witnessed a line of three little stars close to Jupiter parallel to the ecliptic; the following nights brought different arrangements and another star into his view, totaling four stars around Jupiter. (Galilei 1618) Throughout the text, Galileo gave illustrations of the relative positions of Jupiter and its apparent companion stars as they appeared nightly from late January through early March 1610. The fact that they changed their positions relative to Jupiter from night to night, but always appeared in the same straight line near Jupiter, brought Galileo to deduce that they were four bodies in orbit around Jupiter. On January 11 after 4 nights of observation he wrote:

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THE FUTURE IS IN ONLINE




10 Simple Rules for the Care and Feeding of Scientific Data

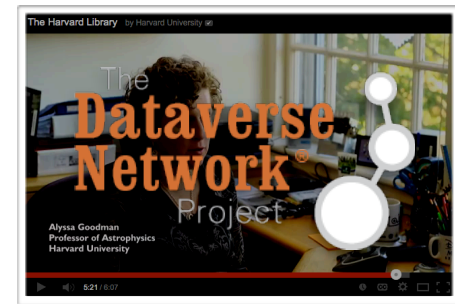
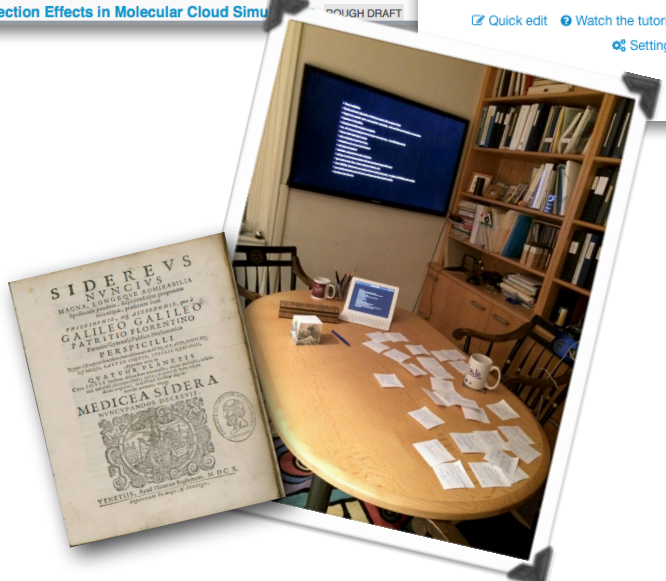
Alyssa Goodman, Alberto Pepe, Alexander W. Blocker, Christine L. Borgman, Kyle Cranmer, Merce Crossas, Rosanne Di Stefano, Yolanda Gil, Paul Groth, Margaret Hedstrom, David W. Hogg, Vinay Kashyap, Ashish Mahabal, Aneta Siemiginowska, Aleksandra Slavkovic

Introduction

In the early 1600s, Galileo Galilei turned a telescope toward Jupiter. In his log book each night, he drew to-scale schematic diagrams of Jupiter and some oddly-moving points of light near it. Galileo labeled each drawing with the date. Eventually he used his observations to conclude that the Earth orbits the Sun, just as the four Galilean moons orbit Jupiter. History shows Galileo to be much more than an astronomical hero, though. His clear and careful record keeping and publication style not only let Galileo understand the Solar System, it continues to let *anyone* understand *how* Galileo did it. Galileo's notes directly integrated his **data** (drawings of Jupiter and its moons), key **metadata** (timing of each observation, weather, telescope properties), and **text** (descriptions of methods, analysis, and conclusions). Critically, when Galileo included the information from those notes in *Siderius Nuncius* (Galilei 1610), this integration of text, data and metadata was preserved, as shown in Figure 1. Galileo's work advanced the "Scientific Revolution," and his approach to observation and analysis contributed significantly to the shaping of today's modern "Scientific Method" (Galilei 1618, Drake 1957).

Today most research projects are considered complete when a journal article based on the analysis has been written and published. Trouble is, unlike Galileo's report in *Siderius Nuncius*, the amount of real data and data description in modern publications is almost never sufficient to repeat or even statistically verify a study being presented. Worse, researchers wishing to build upon and extend work presented in the literature often have trouble recovering data associated with an article after it has been published. More often than scientists would like to admit, they cannot even recover the data associated with their own published works.

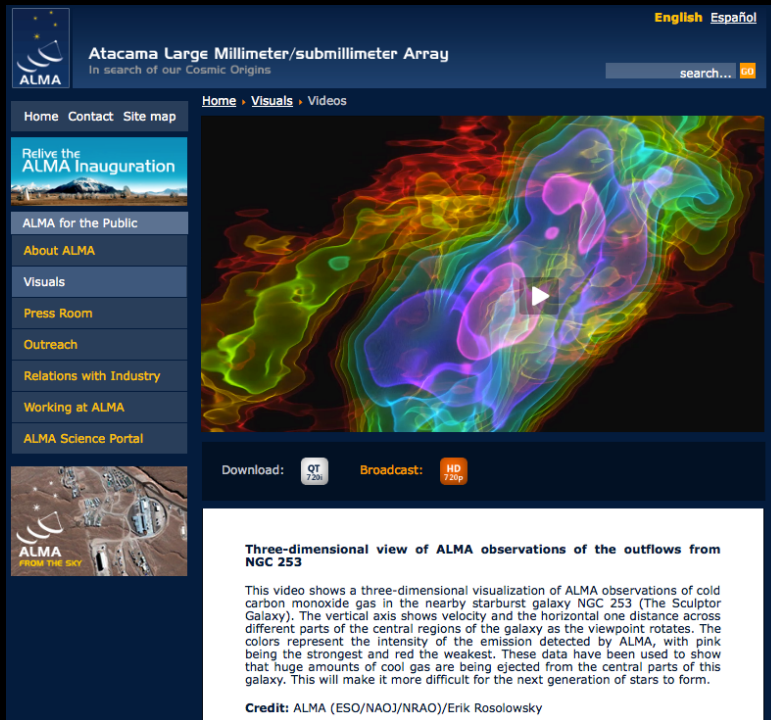
BUT WE DO
NEED TO
FIGURE OUT
HOW NOT
TO LOSE IT.



tinyurl.com/acidfreedigital

WHAT'S AN
"ACID-FREE"
DIGITAL RECORD?

THE FUTURE IS IN 3D



Atacama Large Millimeter/submillimeter Array
In search of our Cosmic Origins

English Español

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ALMA for the Public

About ALMA

Visuals

Press Room

Outreach

Relations with Industry

Working at ALMA

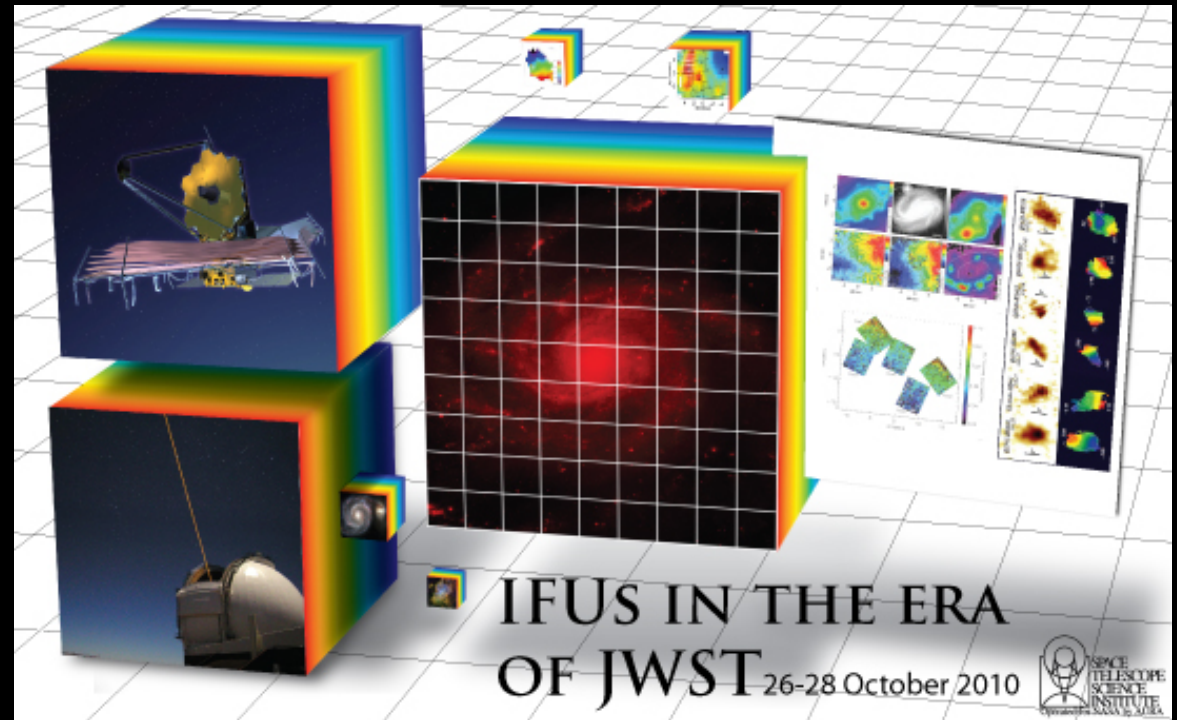
ALMA Science Portal

Download: QT 720p Broadcast: HD 720p

Three-dimensional view of ALMA observations of the outflows from NGC 253

This video shows a three-dimensional visualization of ALMA observations of cold carbon monoxide gas in the nearby starburst galaxy NGC 253 (The Sculptor Galaxy). The vertical axis shows velocity and the horizontal one distance across different parts of the central regions of the galaxy as the viewpoint rotates. The colors represent the intensity of the emission detected by ALMA, with pink being the strongest and red the weakest. These data have been used to show that huge amounts of cool gas are being ejected from the central parts of this galaxy. This will make it more difficult for the next generation of stars to form.

Credit: ALMA (ESO/NAOJ/NRAO)/Erik Rosolowsky



IFUS IN THE ERA OF JWST 26-28 October 2010

SPACE TELESCOPE SCIENCE INSTITUTE

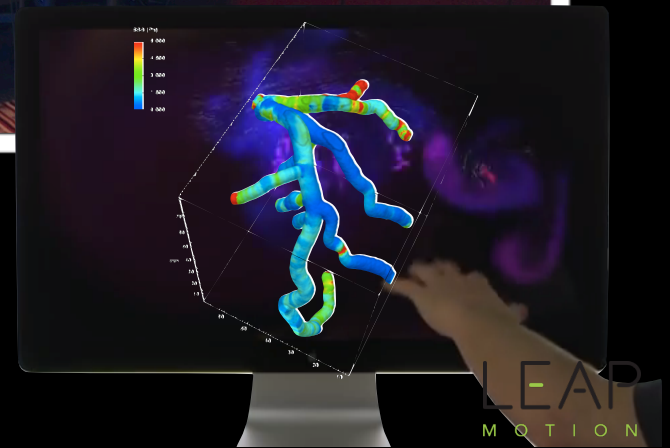
yt viz from ALMA data
(Turk, Rosolowsky)

IFUs on JWST...with Glue!
(coming soon)

THE FUTURE IS MODULAR, OPEN-SOURCE, AND NOT (JUST) ON THE DESKTOP

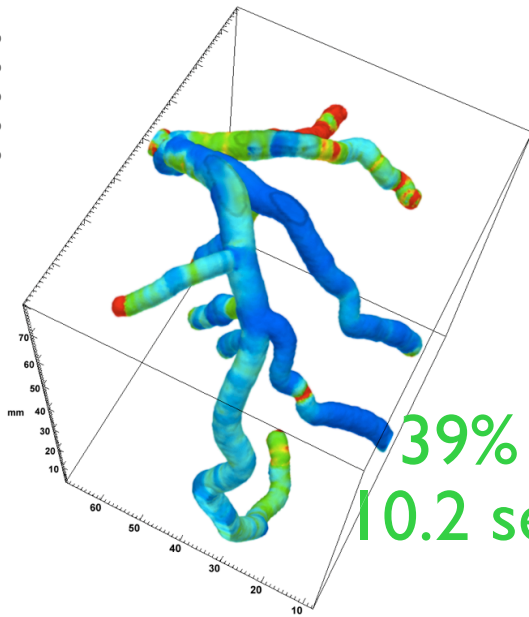


**HACK
TO THE
FUTURE**



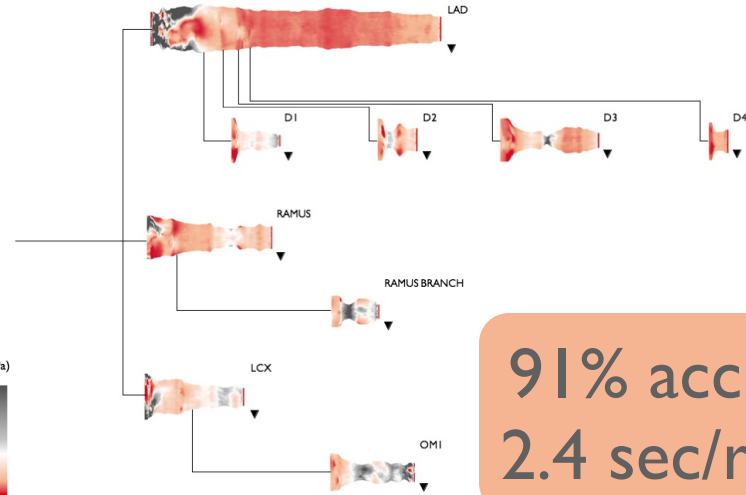
DIMENSIONALITY AND COLOR

ESS (Pa)
6.000
4.500
3.000
1.500
0.000

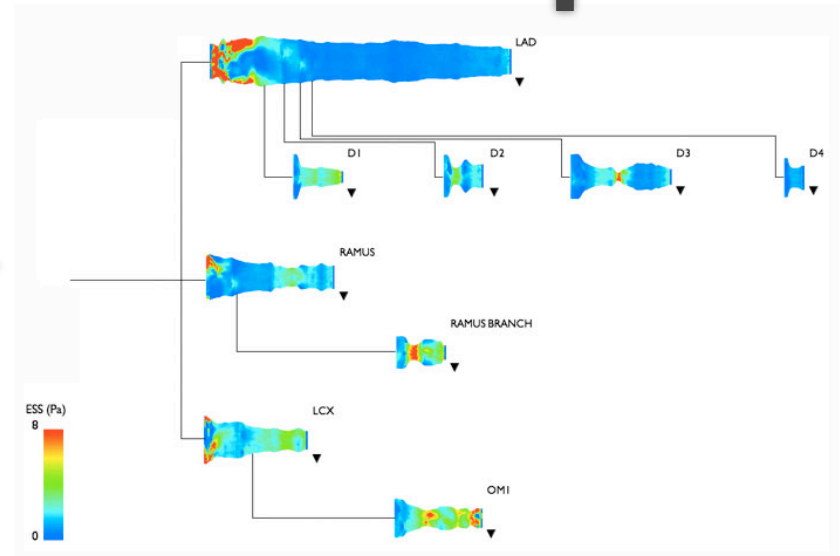
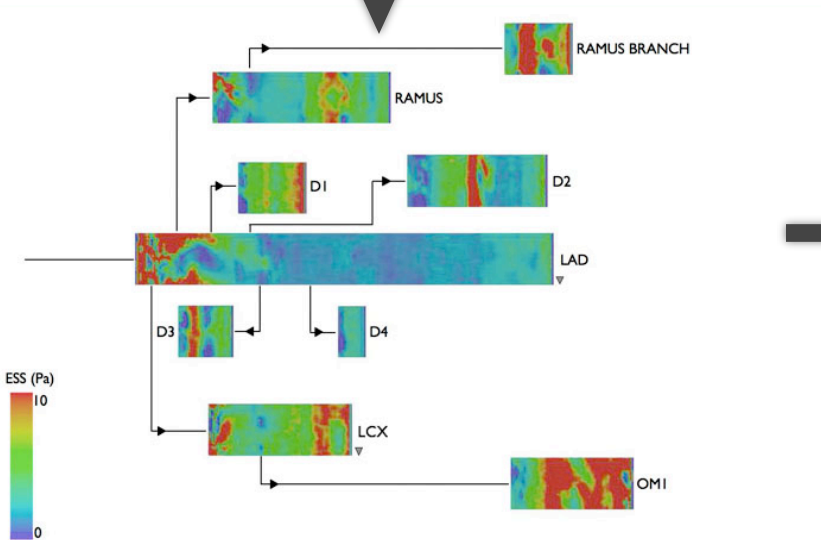


39% accurate
10.2 sec/region

ESS (Pa)
8
3
0



91% accurate
2.4 sec/region



Borkin et al. 2011
cf. colorbrewer2.org

THE FUTURE OFFERS NEW WAYS TO LEARN

WorldWide Telescope Ambassadors



Higher Ed

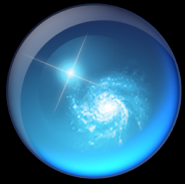
the 2013 experiment

HARVARD UNIVERSITY
ASTRONOMY 201B
DEMOFEST

LOCATION
Perkin Lobby and Wolbach Library, 60 Garden Street

TIME
11-12 for drop-in demos
12-12:45 lunch for students & their guests

PREVIEW
<http://ay201b.wordpress.com/topical-modules>



Microsoft® Research WorldWide Telescope

Experience WWT at worldwidetelescope.org



The screenshot shows the WorldWide Telescope interface. At the top, there are navigation tabs: **Explore**, **Guided Tours**, **Search**, **View**, and **Settings**. Below these are several thumbnail images representing different astronomical data sets: **Digitized Sky Survey**, **VLSS: VLA Low-frequency Sky Survey**, **WMAP ILC 5-Year Temperature Anisotropy Map**, **SFD Dust Map (Infrared)**, **IRIS: Improved Resolution Images**, **2MASS: Two Micron All Sky Survey**, and **Hydrogen Alpha Filter**. A central view shows a starry field with a large circular field of view centered on a galaxy. A **Finder Scope** panel is open, displaying details for **NGC 224**, including its classification as a **Spiral Galaxy in Andromeda** and its coordinates: RA: 00h42m42s, Dec: 41:16:00, Distance: 70:06:26, Rise: 275:42:17, and Transit: 00:35. Below the main view, there are panels for **Look At** (set to **Sky**), **Imagery** (showing **Digitized Sky Survey**), **Image Credits** (citing NASA satellites IRAS and COBE), and a **Context bar** showing **NGC 221** and **M31**. A **Context globe** shows the current field of view on a celestial sphere.

Seamlessly explore imagery from the best ground and space-based telescopes in the world

Expert led tours of the Universe

Control time to study how the night sky changes

View and compare images from across the electromagnetic spectrum

Much more than "just" the sky at night! 3D features can take you to other planets, stars & galaxies.

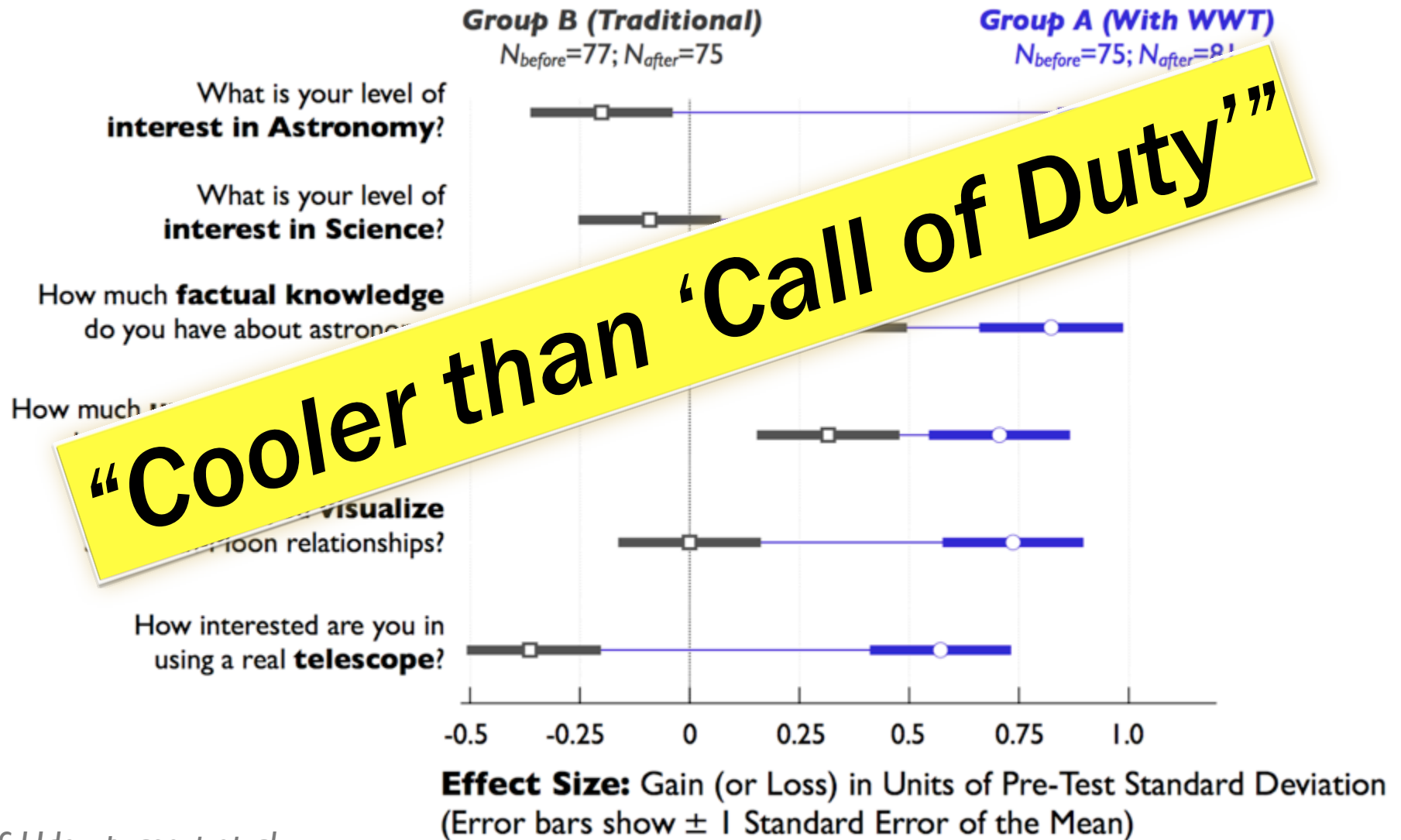
Finder Scope links to Wikipedia, publications, and data, so you can learn more

Context bar shows items of interest in current field of view

Context globe shows where you're looking.

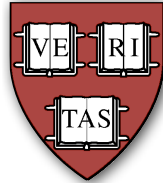
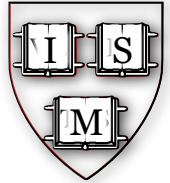
GAINS IN STUDENT INTEREST AND UNDERSTANDING

(“Traditional Way” vs “WWT Way”)



the 2013 experiment

HARVARD UNIVERSITY ASTRONOMY 201B DEMOFEST



LOCATION

Perkin Lobby and Wolbach Library, 60 Garden Street

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PREVIEW

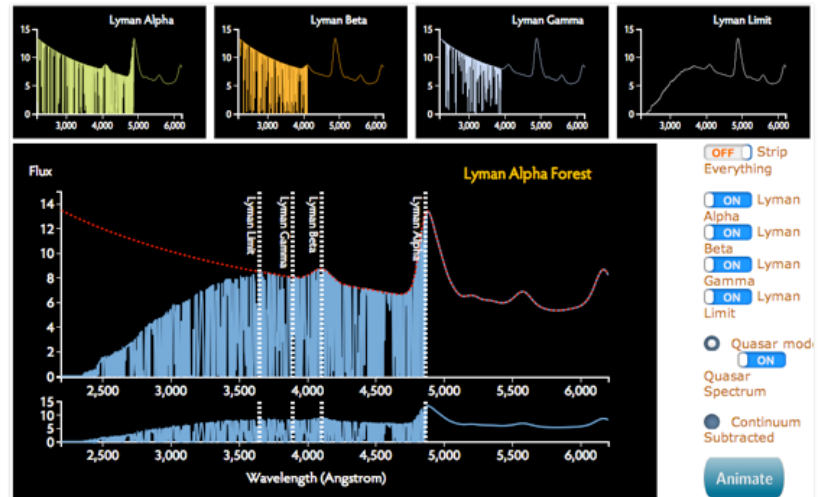
<http://ay201b.wordpress.com/topical-modules>

Stephen

Yuan-Sen
Ting

Interstellar Absorption and the Lyman Alpha Forest

all lines SiII 6716/6731 Å HeI 6683 Å OIII 5007 Å



JavaScript

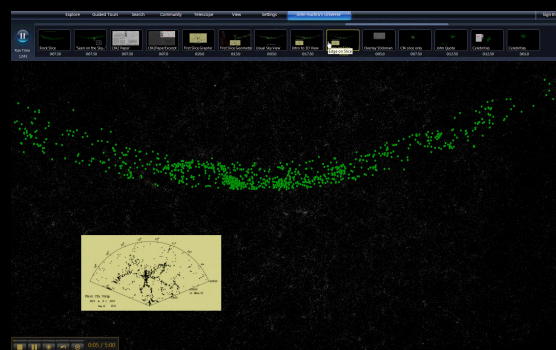
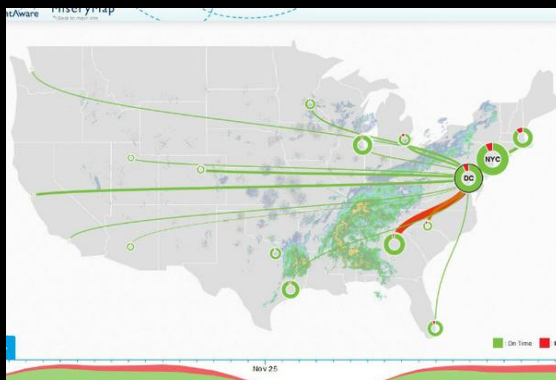
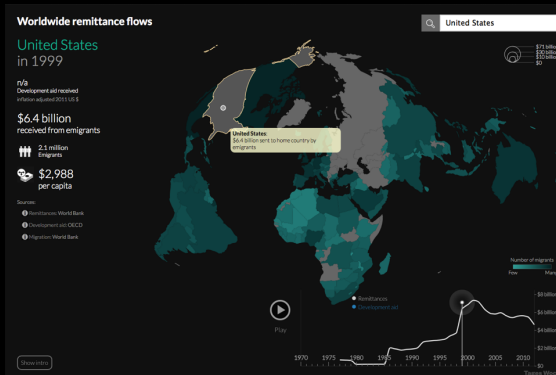
https://www.cfa.harvard.edu/~yuan-sen.ting/lyman_alpha.html

JavaScript

<http://portillo.ca/nebula/>



CHALLENGES



What can we afford?

What do we teach?

Is visualization, and computation more generally, the new "instrumentation"?

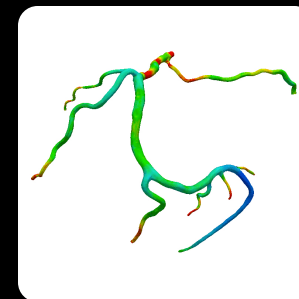
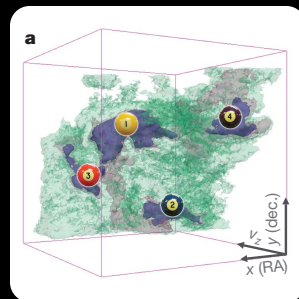
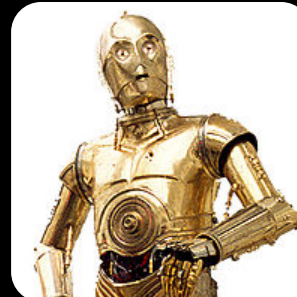
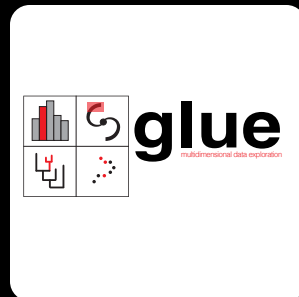
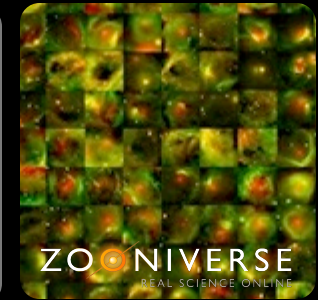
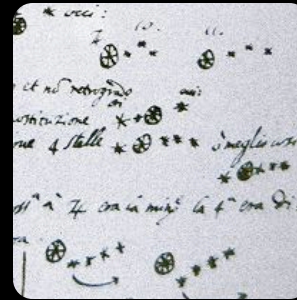
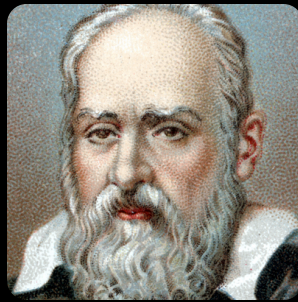
How do we value visualization specialists?

How much customization?

Will tools be preserved?

How much organization (orchestration) is too much?

LINKING VISUALIZATION & UNDERSTANDING IN ASTRONOMY



extra slides (not shown)

LINKING VISUALIZATION & UNDERSTANDING IN ASTRONOMY

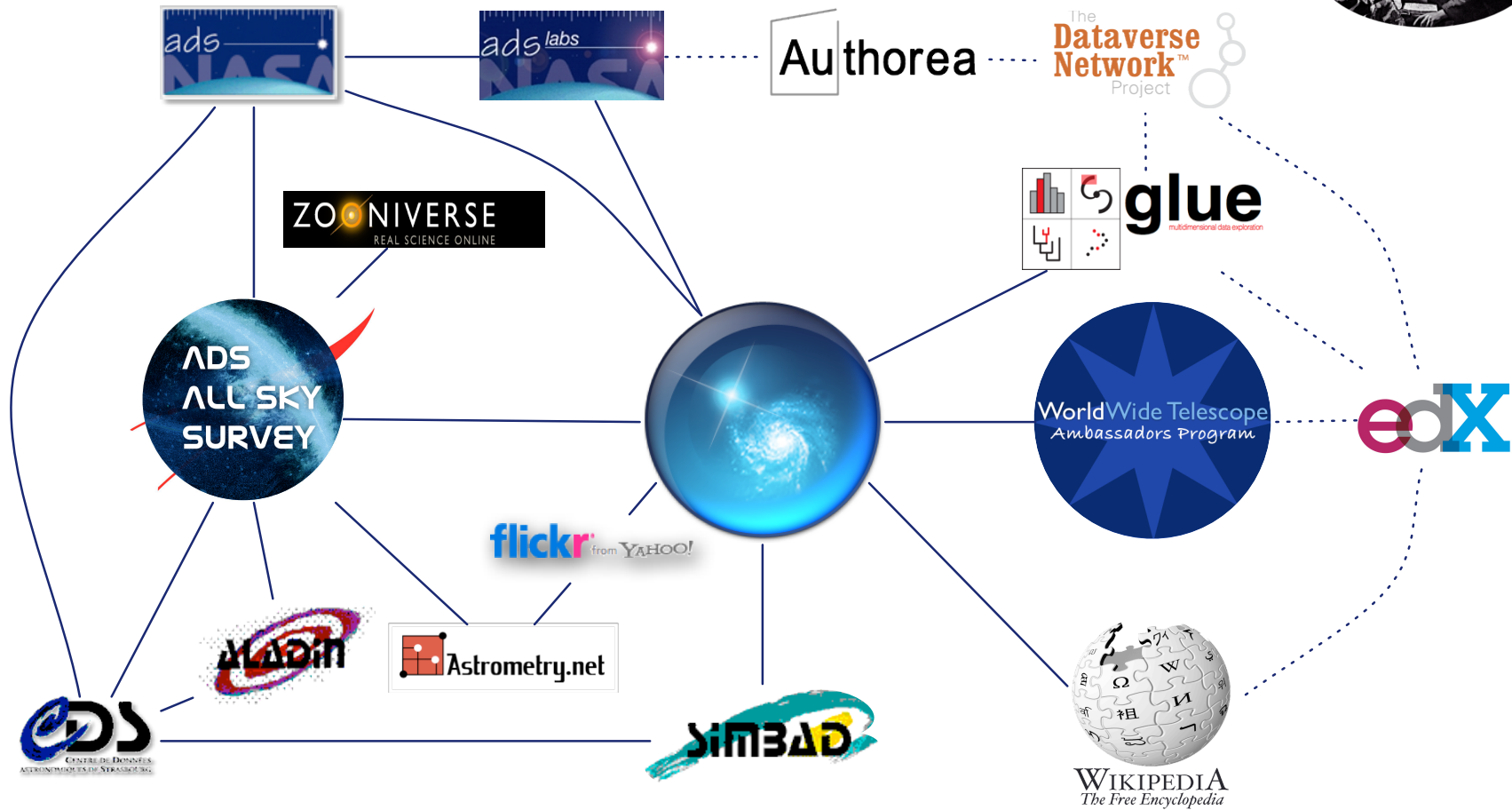
ALYSSA A. GOODMAN
HARVARD-SMITHSONIAN
CENTER FOR ASTROPHYSICS





SEAMLESS ASTRONOMY

Linking scientific data, publications, and communities



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



Made possible by MANY collaborators, listed at projects.iq.harvard.edu/seamlessastronomy

1610



SIDEREUS NUNCIIUS

On the third, at the seventh hour, the sequence. The eastern one was 1 minute, the closest western one 2 minutes; and the

East * ○ * * West

to minutes removed from this one. They were absolutely on the same straight line and of equal magnitude.

On the fourth, at the second hour, there were four stars around Jupiter, two to the east and two to the west, and arranged precisely

East * * ○ * * West

on a straight line, as in the adjoining figure. The easternmost was distant 3 minutes from the next one, while this one was 40 seconds from Jupiter; Jupiter was 4 minutes from the nearest western one, and this one 6 minutes from the westernmost one. Their magnitudes were nearly equal; the one closest to Jupiter appeared than the rest. But at the seventh hour the eastern stars were 30 seconds apart. Jupiter was 2 minutes from the

East ** ○ **

one, while he was 4 minutes from the next western one was 3 minutes from the westernmost one. They extended on the same straight line along the ecliptic.

On the fifth, the sky was cloudy.

On the sixth, only two stars appeared flanking Jupiter.

East * ○ *

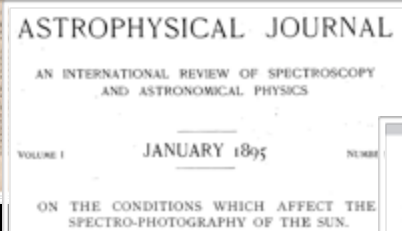
in the adjoining figure. The eastern one was 2 minutes from Jupiter, the western one 3 minutes from Jupiter. They were on the same straight line with Jupiter and equal in magnitude.

On the seventh, two stars stood near Jupiter, but arranged in this manner.

1665



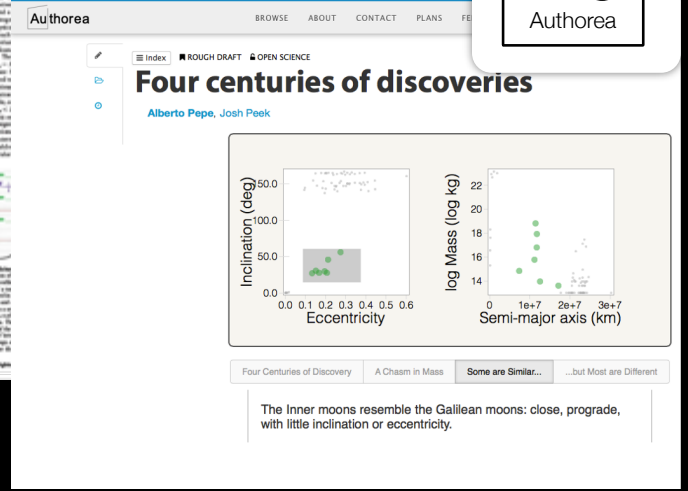
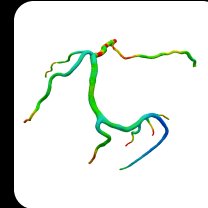
1895



2009



2014



MEANINGFUL ABSTRACTION IS OFTEN BETTER THAN REALISM.

