Visualizing the Universe

Alyssa A. Goodman

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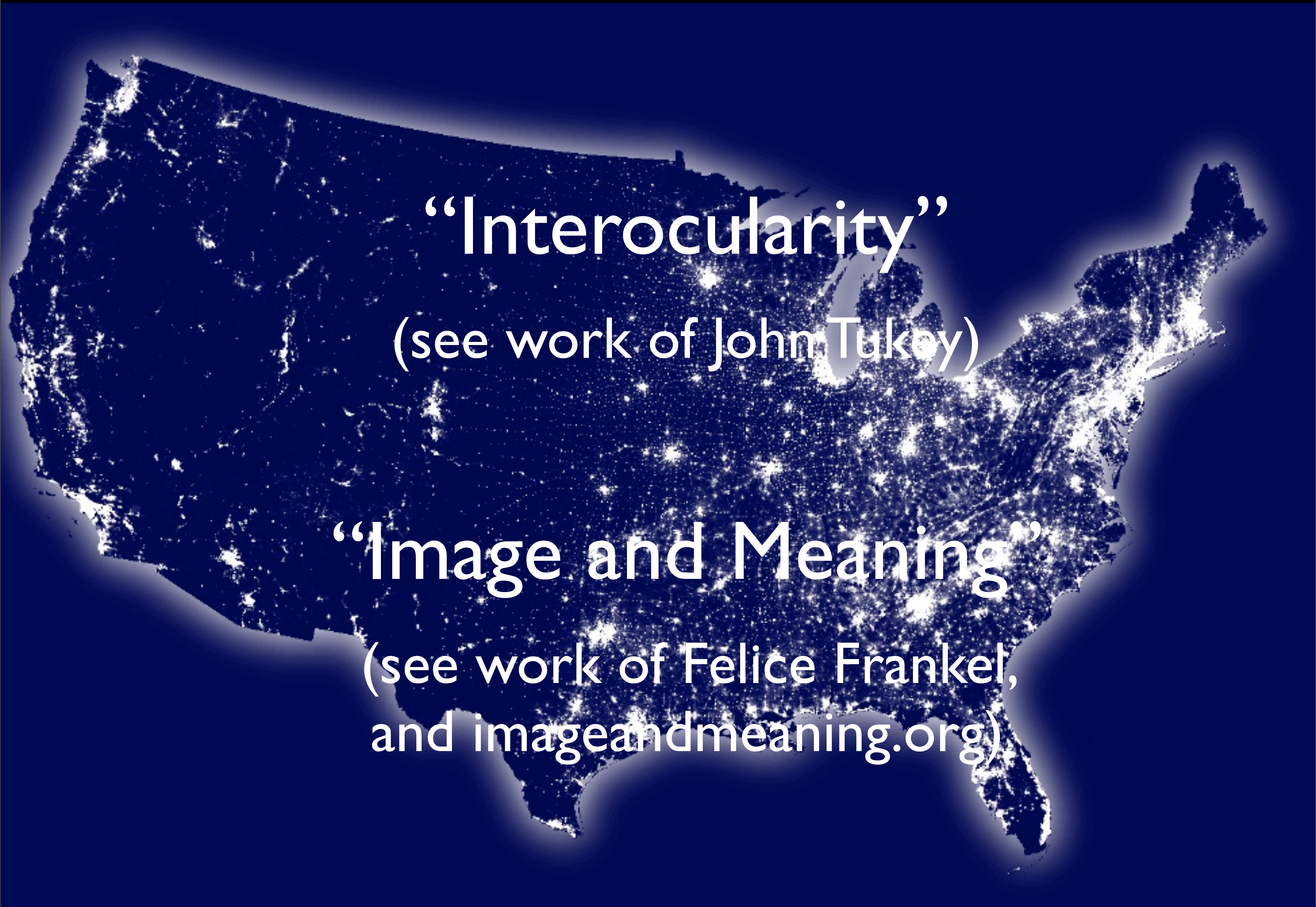
Scholar-in-Residence, WGBH

Relative Strengths

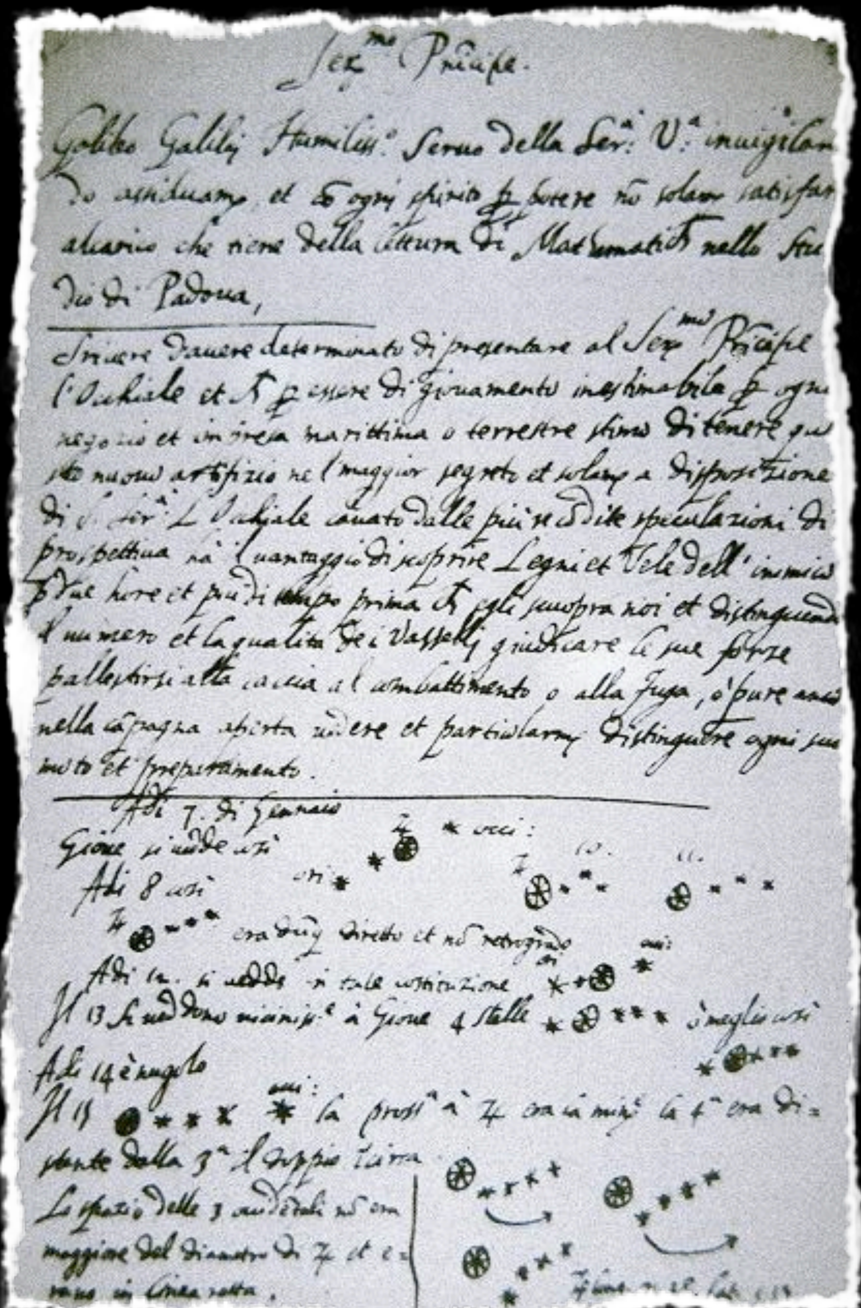
Pattern Recognition
Creativity

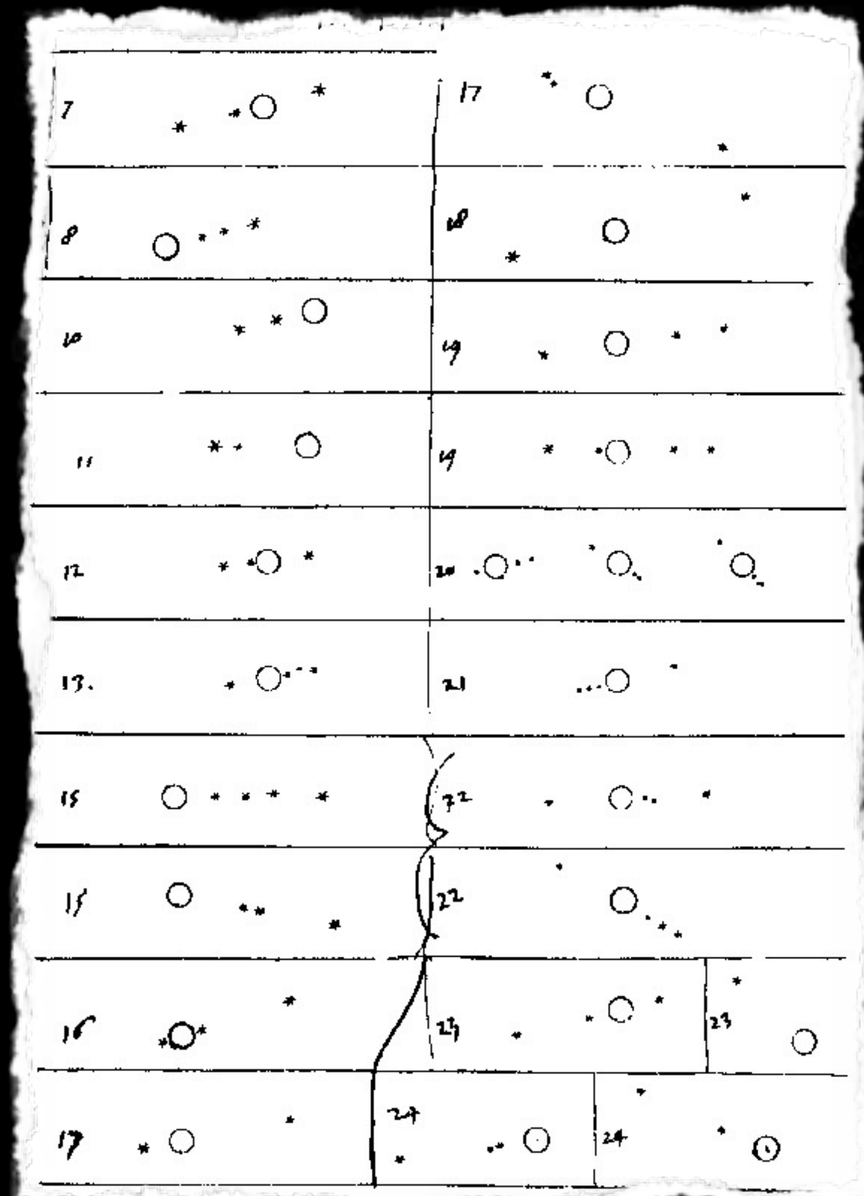
Calculations

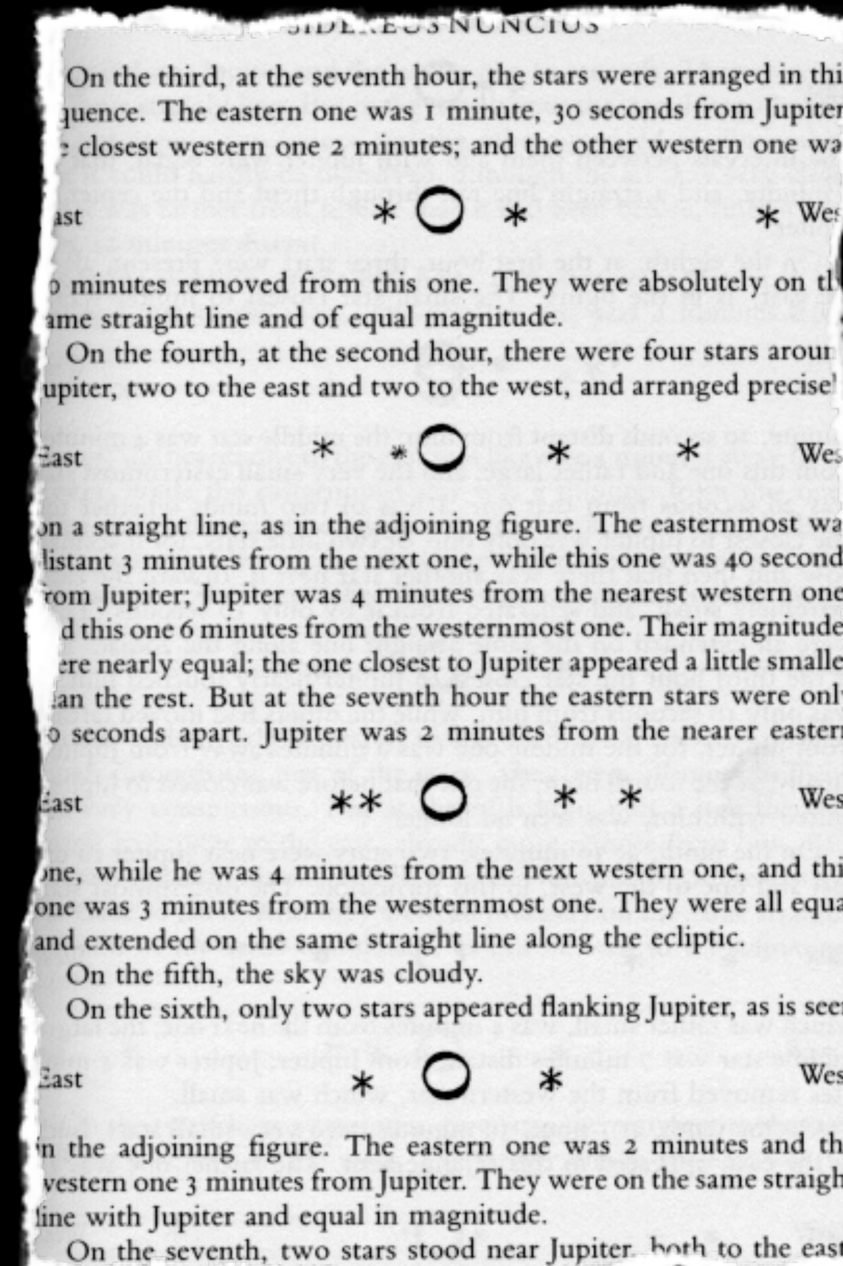

"Interocularity"
(see work of John Tukey)
"Image and Meaning"
(see work of Felice Frankel,
and imageandmeaning.org)

Galileo

(1564-1642)







SIDEREUS NUNCIUS

On the third, at the seventh hour, the stars were arranged in this quence. The eastern one was 1 minute, 30 seconds from Jupiter closest western one 2 minutes; and the other western one wa

ast * ◯ * * Wes

o minutes removed from this one. They were absolutely on th ame straight line and of equal magnitude.

On the fourth, at the second hour, there were four stars arour upiter, two to the east and two to the west, and arranged precise

East * * ◯ * * Wes

on a straight line, as in the adjoining figure. The easternmost wa listant 3 minutes from the next one, while this one was 40 second rom Jupiter; Jupiter was 4 minutes from the nearest western one d this one 6 minutes from the westernmost one. Their magnitude ere nearly equal; the one closest to Jupiter appeared a little smalle an the rest. But at the seventh hour the eastern stars were only o seconds apart. Jupiter was 2 minutes from the nearer easter

East ** ◯ * * West

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

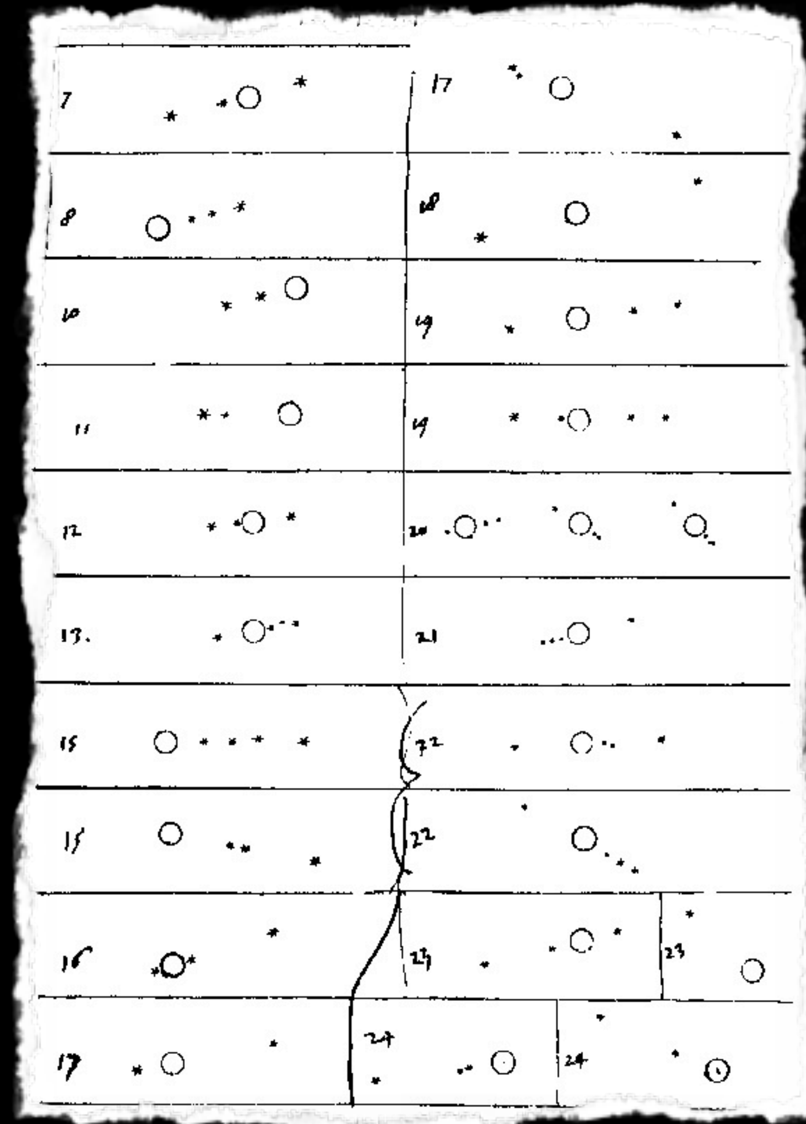
East * ◯ * West

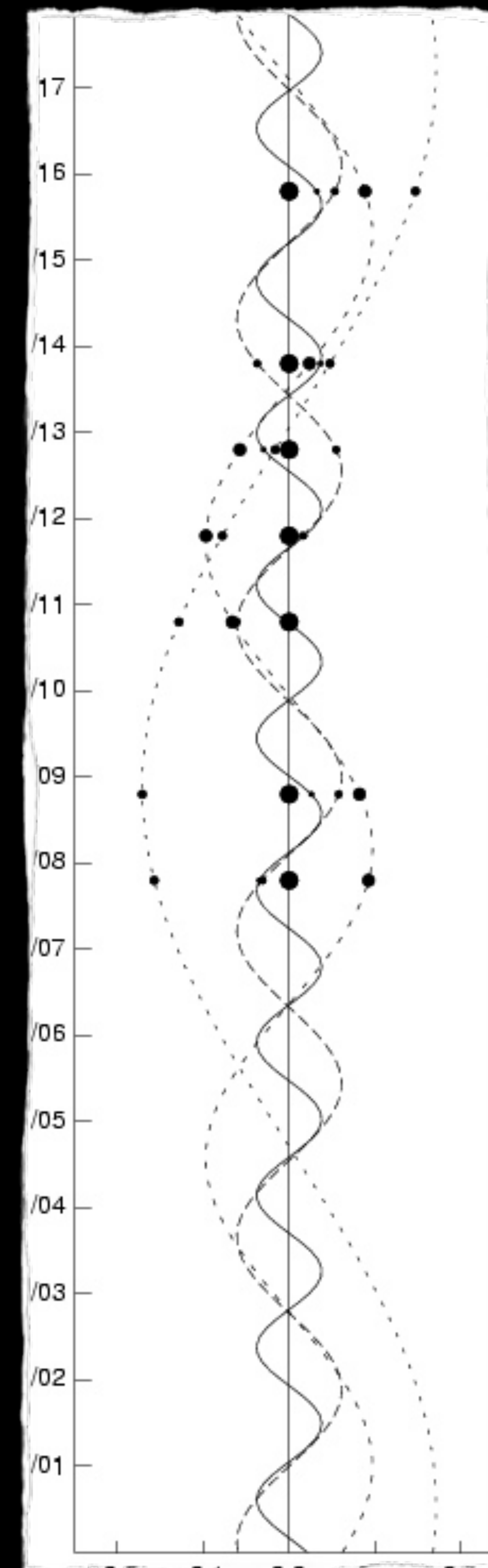
in the adjoining figure. The eastern one was 2 minutes and the western one 3 minutes from Jupiter. They were on the same straight line with Jupiter and equal in magnitude.

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

Notes for & re-productions of Siderius Nuncius

How could Galileo study Jupiter and its moons *now*?





GALILEO'S "NEW ORDER"

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

This slide is an intro to a ~10 minute demo of WorldWide Telescope, showing how one can visualize Galileo's observations, and also the 3D Jupiter+moons system.

What can we observe?

What can we “see”?

What can we imagine?

What can we explain?

What can we observe?

What can we “see”?

What can we imagine?

What can we explain?

What can we observe?

$$I(E, s, \vec{x}, t)$$

Intensity

Energy
(wavelength)

"State"
(e.g. polarization)

Spatial Position
(x, y, z)

Time

...and the science is in the interpretation of these measurements into physical quantities & processes.

What can we observe?

$$I(\qquad \vec{x} \quad)$$

Intensity

Spatial Position

$(x, y \quad)$

Optical Single-Band Image of NGC1333

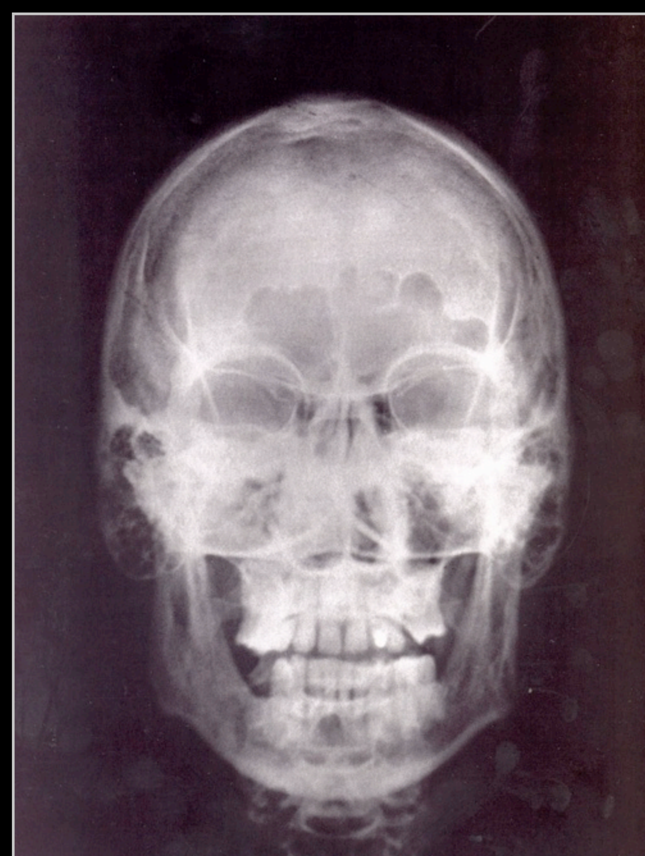
What can we observe?

$$I(\quad \vec{x} \quad)$$

Intensity

Spatial Position

$(x, y \quad)$



X-Ray of Human Skull, c. 1920

What can we observe?

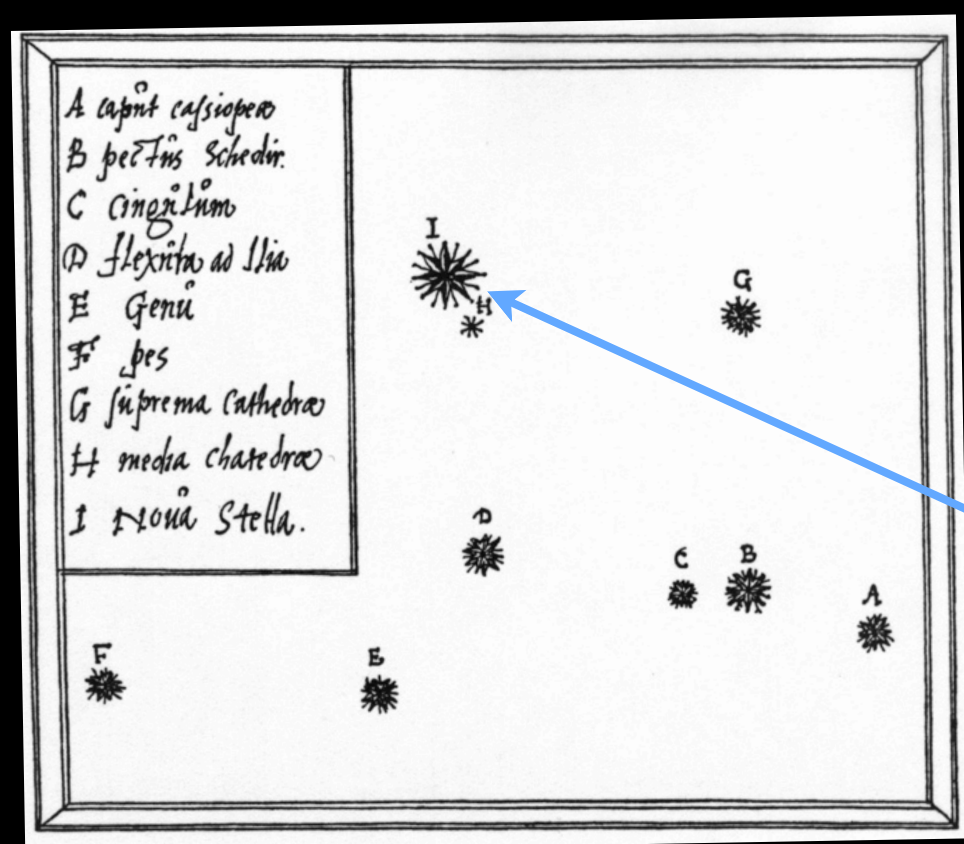
$$I(\vec{x}, t)$$

Intensity

Time

Spatial Position

(x, y, z)



"Nova Stella"
of Tycho, 1572

What can we observe?

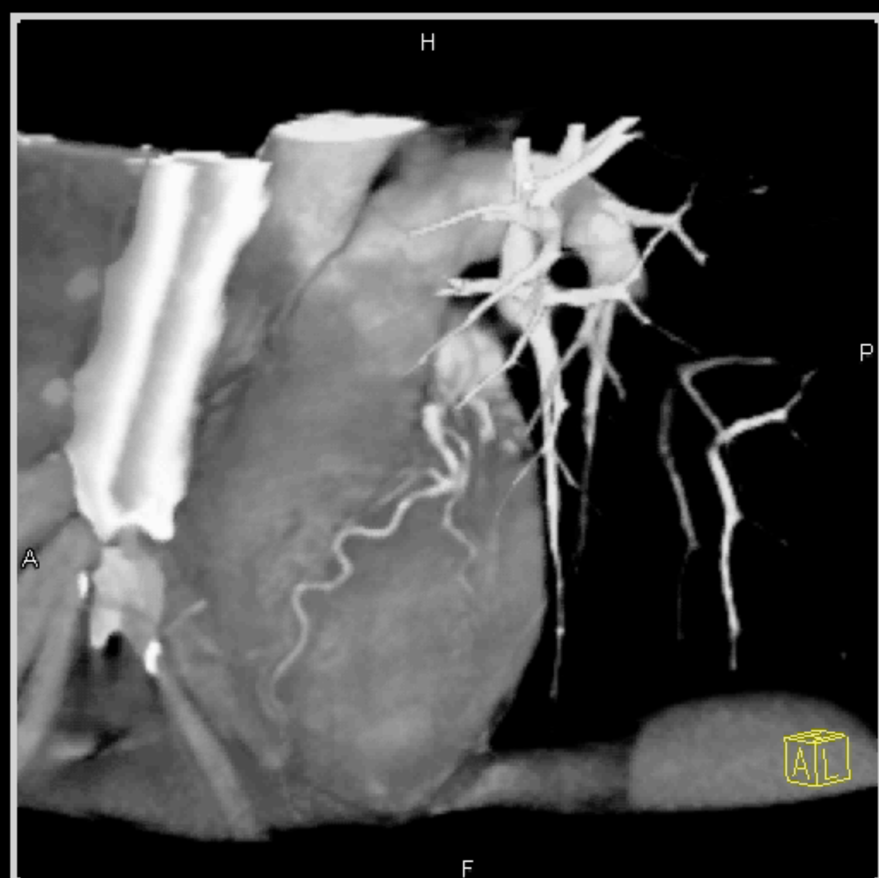
$$I(\vec{x}, t)$$

Intensity

Spatial Position

(x, y, z)

Time



Cardiac Motion

Cardiac Motion: This is an excellent demonstration of why we need to reconstruct at various sequences in the cardiac cycle. You will note how depending on the contracting heart, the right coronary artery is either absolutely normal or evaluation might be considered limited by motion related artifact. This is why we reconstruct all cases at 10% intervals. From: http://www.ctisus.org/rsna_2006/cardiac_cta/videos.html

What can we observe?

$$I(E, \quad \vec{x} \quad)$$

Intensity

Energy
(wavelength)

Spatial Position
$(x, y \quad)$

Optical (B,V,R) image
of NGC1333

What can we observe?

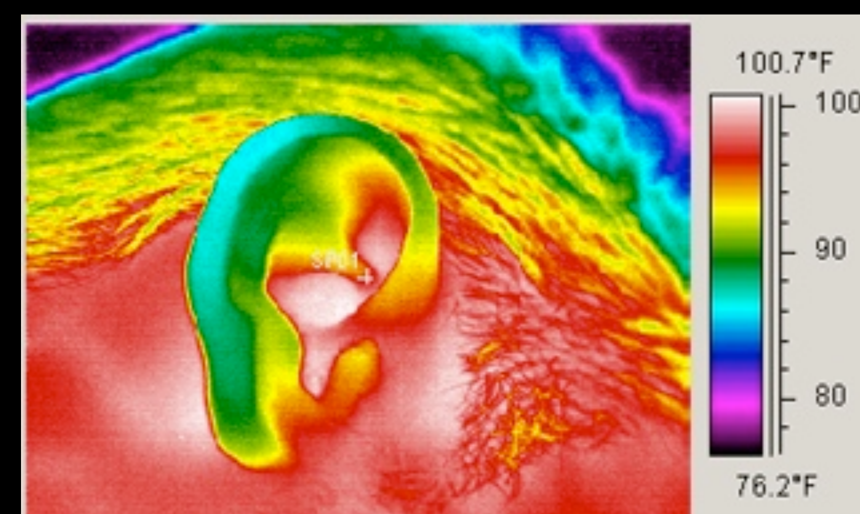
$$I(E, \quad \vec{x} \quad)$$

Intensity

Energy
(wavelength)

Spatial Position
$(x, y \quad)$

Human Ear,
Thermal Infrared



The Multiwavelength Universe

Ultra-high energy processes (e.g. black hole accretion, super-super novae)

Light from Very Hot Stars Diagnostic Spectroscopy

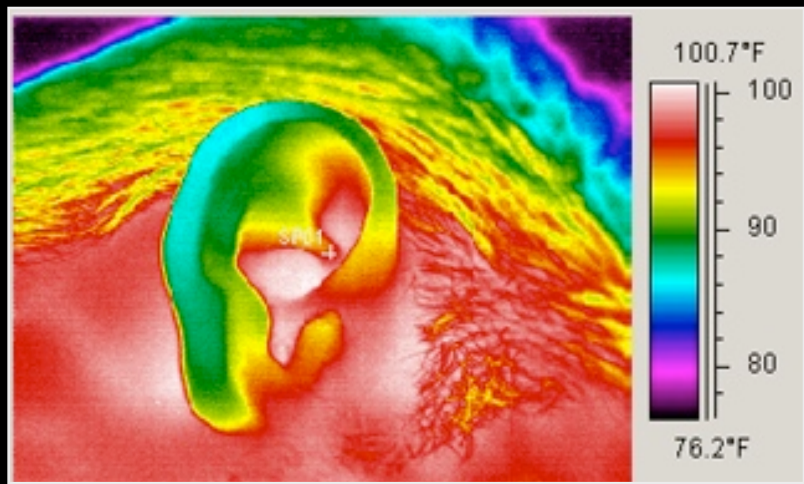
“Night Vision”: Seeing “Through” Dust

Spectral Lines from Cold and Warm Gas, Emission from Very Cold Dust

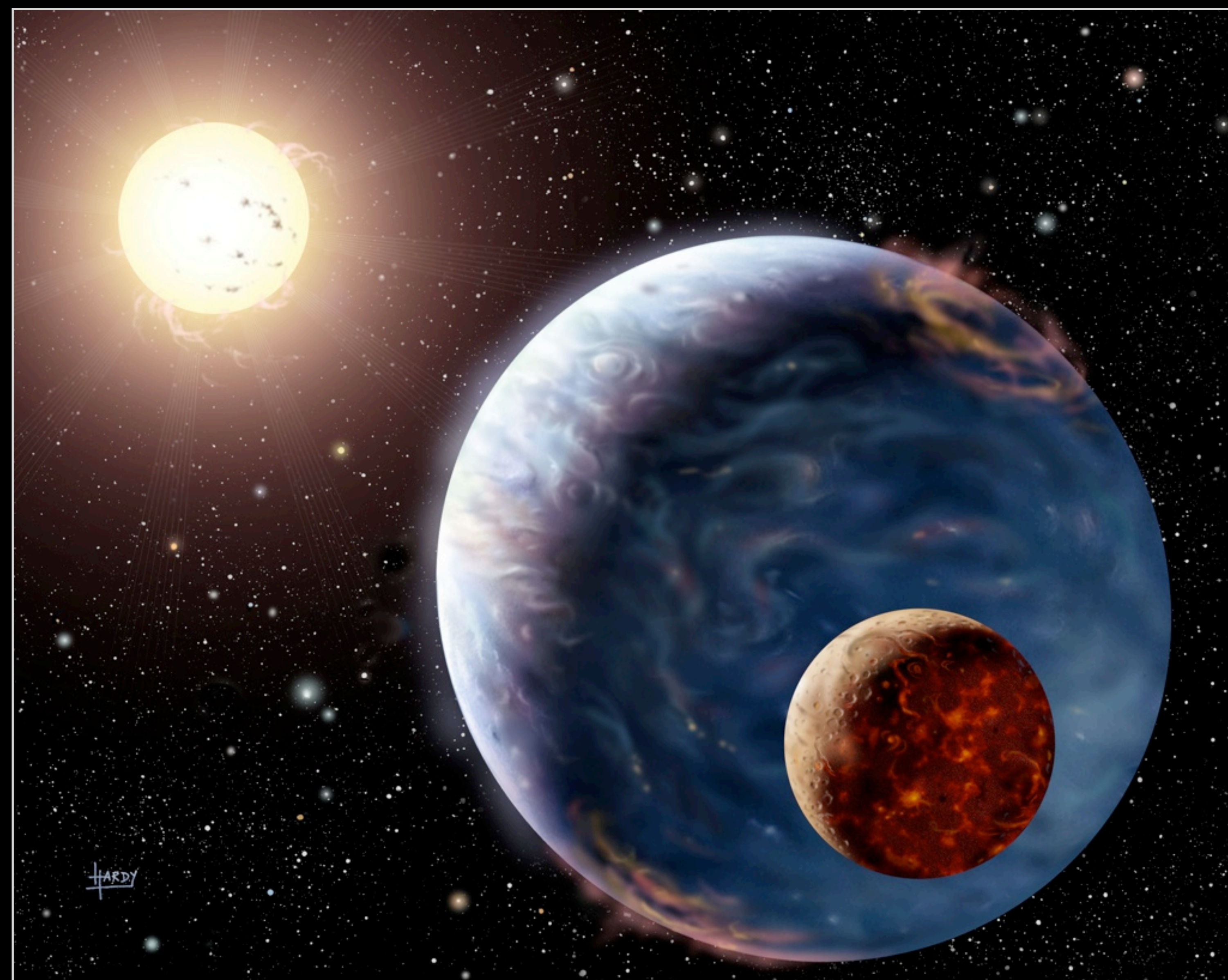
Hot gas in a variety of environments (e.g. in galaxy clusters, relativistic jets)

Emission from Dust Anywhere in the Universe

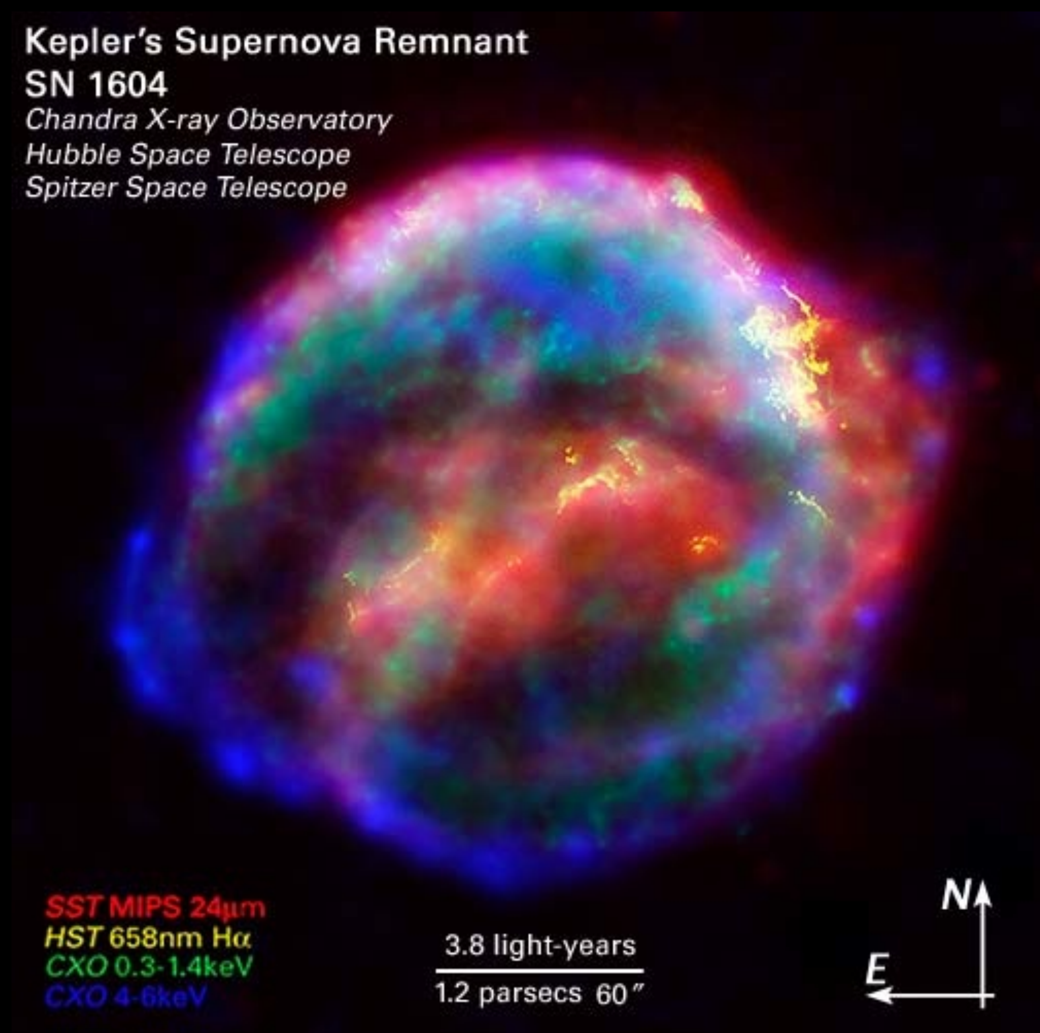
Emission from relativistic objects (e.g. pulsars, fast jets); emission from hot gas (supernova remnants, H II regions)

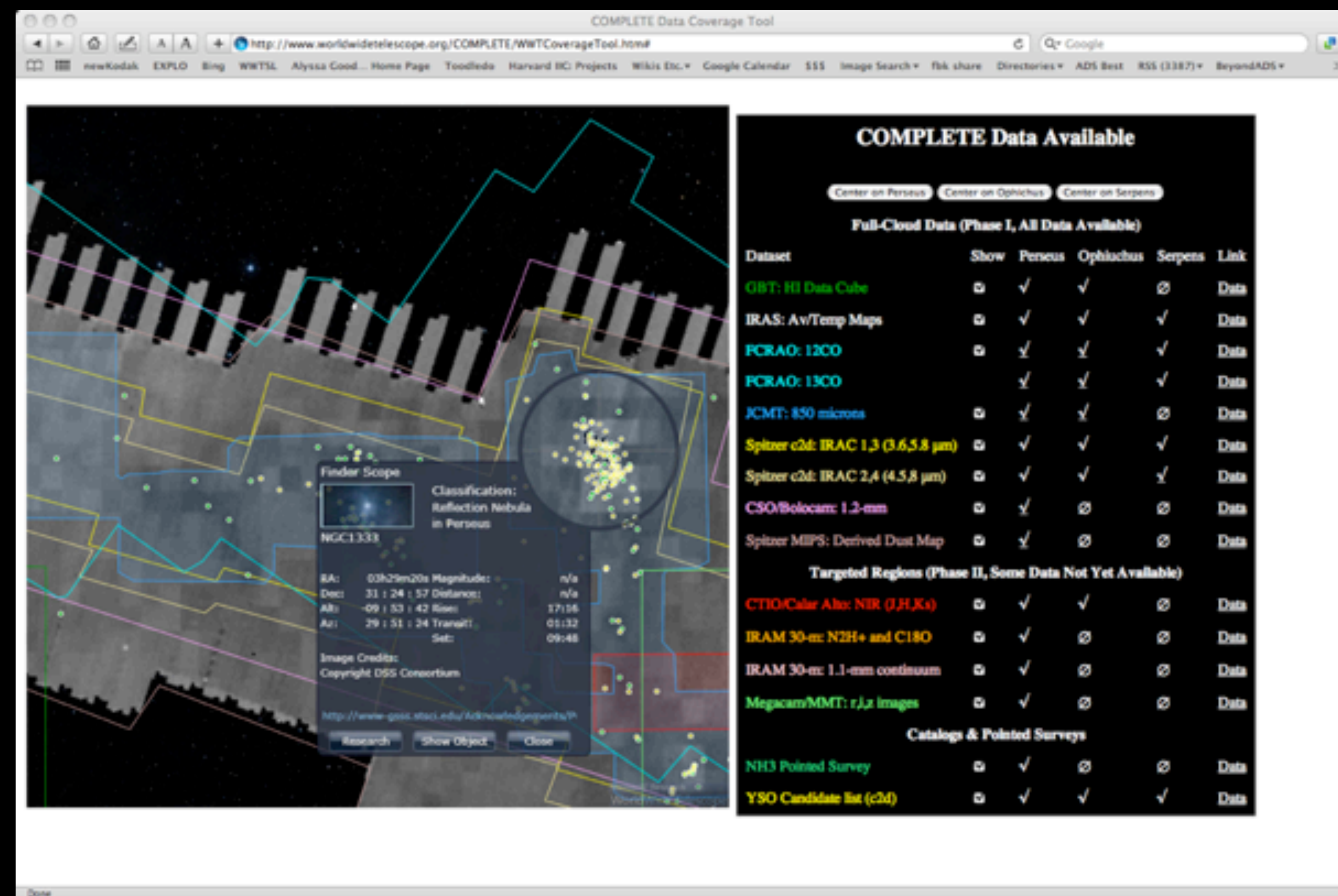


“False” Color



Does the public understand "multi-wavelength sensing"?





Does the public understand “multi-wavelength sensing”?

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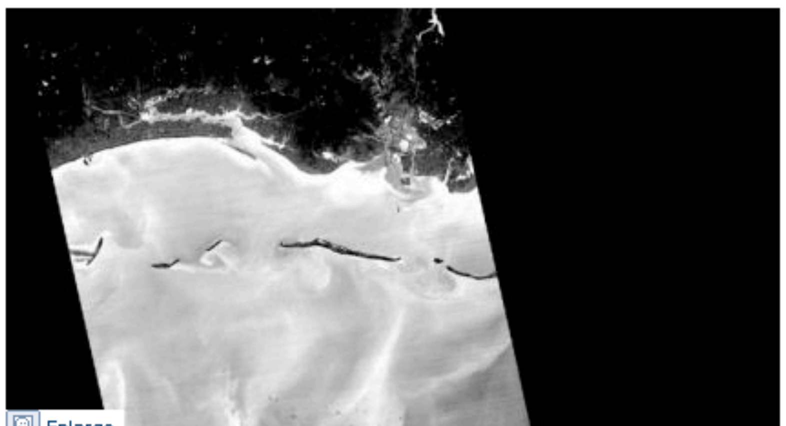
Find more articles on infrared oil spill

NASA Captures Night Infrared View of Gulf Oil Spill

May 10, 2010

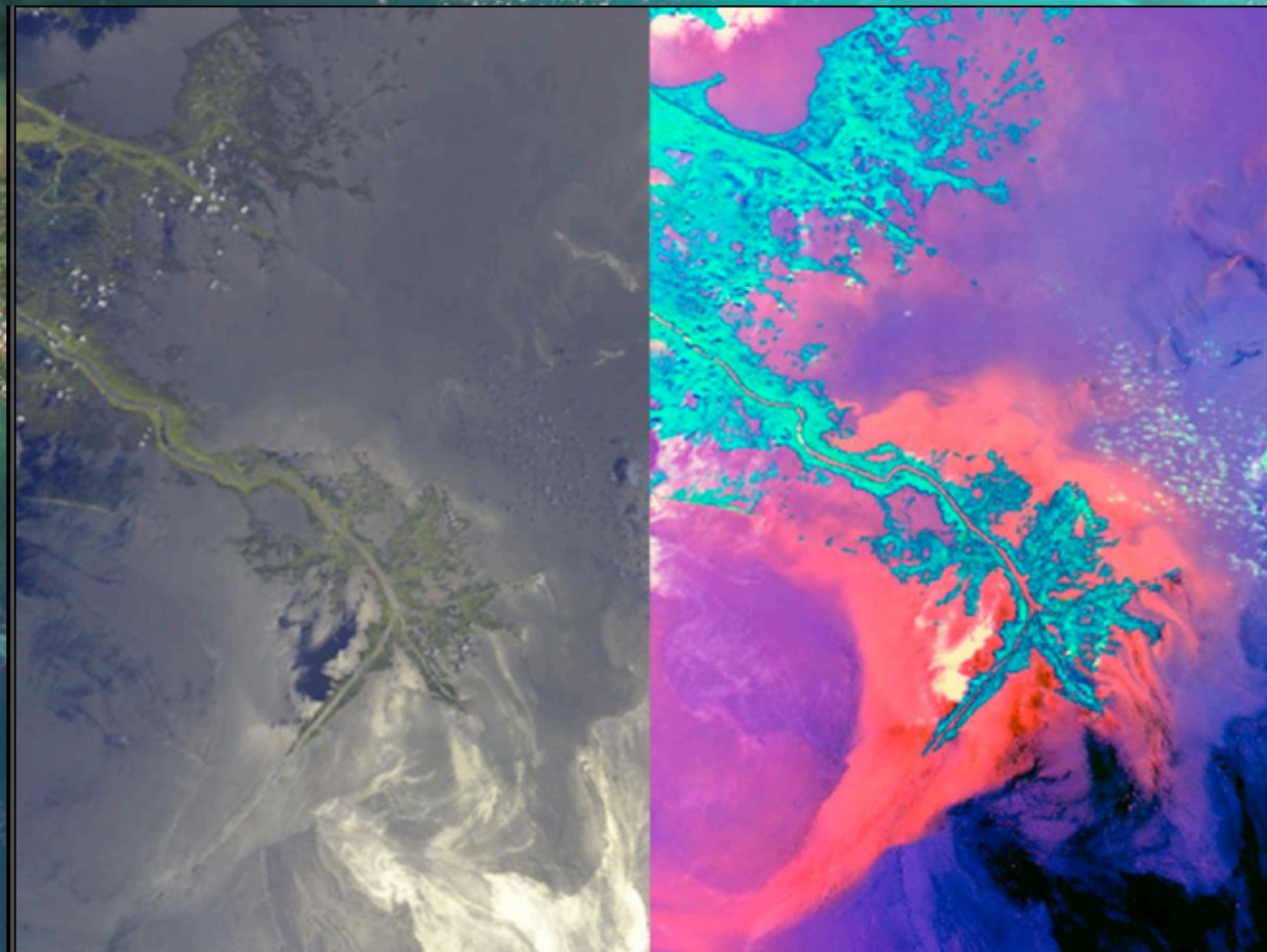


Enlarge

Image credit: NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team

(PhysOrg.com) -- A May 7 nighttime infrared image of the Gulf oil spill from an instrument on NASA's Terra spacecraft provides a different perspective on the oil slick nearing the Gulf coast.

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument on NASA's Terra spacecraft captured this nighttime image of the growing oil spill in the Gulf of Mexico on May 7, 2010. On April 20, an explosion destroyed the Deepwater Horizon oil platform operating in the Gulf 80 kilometers (50 miles) offshore, resulting in substantial loss of life



Leaking Oil Invades Louisiana Wildlife Habitats

Multiple cameras on JPL's MISR instrument on NASA's Terra spacecraft were used to create two unique views of oil moving into Louisiana's coastal wetlands.
Image Credit: NASA/GSFC/LaRC/JPL, MISR Team

Download Image
- Full Size
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- 800 x 600

Page Last Updated: June 2, 2010
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What can we observe?

$$I(\quad s, \vec{x} \quad)$$

Intensity

"State"
(e.g. polarization)

Spatial Position
$(x, y \quad)$

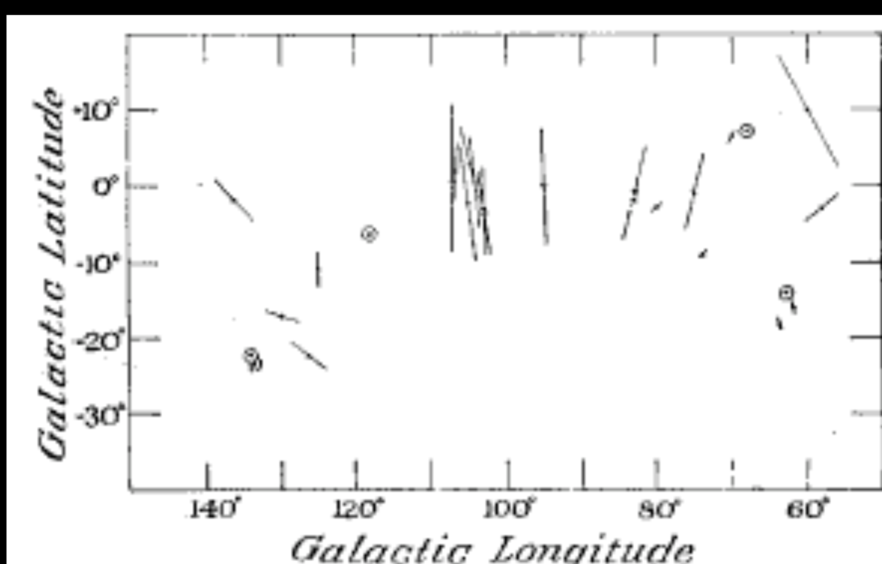


FIG. 4. Observational evidence that there is no one preferential orientation of the plane of polarization. Stars showing no polarization are represented by circles.

Hall 1949

What can we observe?

$$I(\quad s, \vec{x} \quad)$$

Intensity

Spatial Position

(x, y, z)

“State”

(~diffusivity)

What can we observe?

What can we “see”?

What can we imagine?

What can we explain?

Data • Dimensions • Display

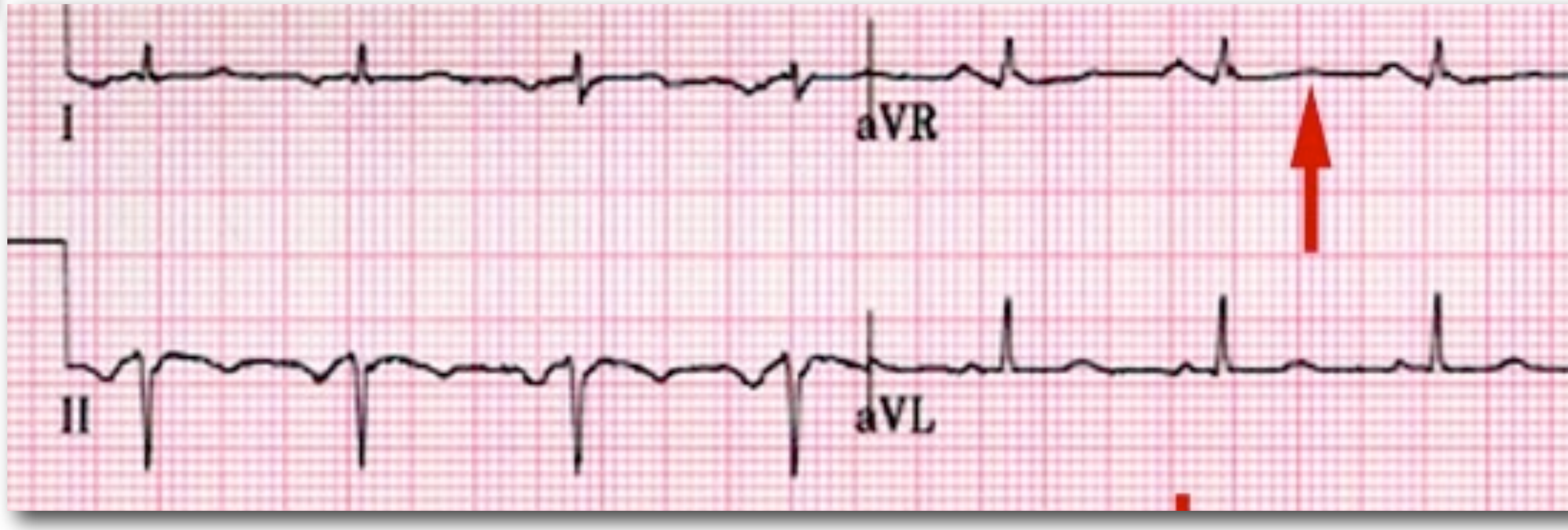
(DDD)

1 quantity | *on 0 dimensions*

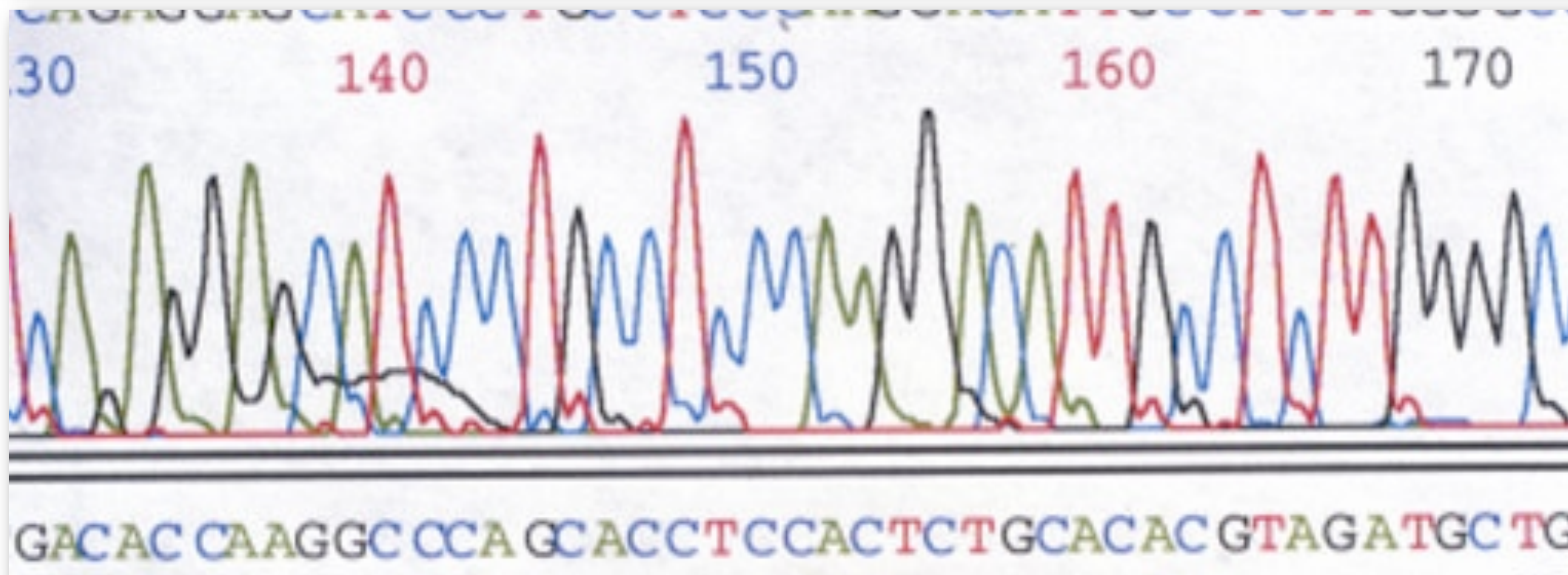
Medicine: My Pulse (bpm)	72
Genomics: Number of Nucleotides	4
Astronomy: Speed of Light (mps)	186,283

1 quantity | *on 1 dimension*

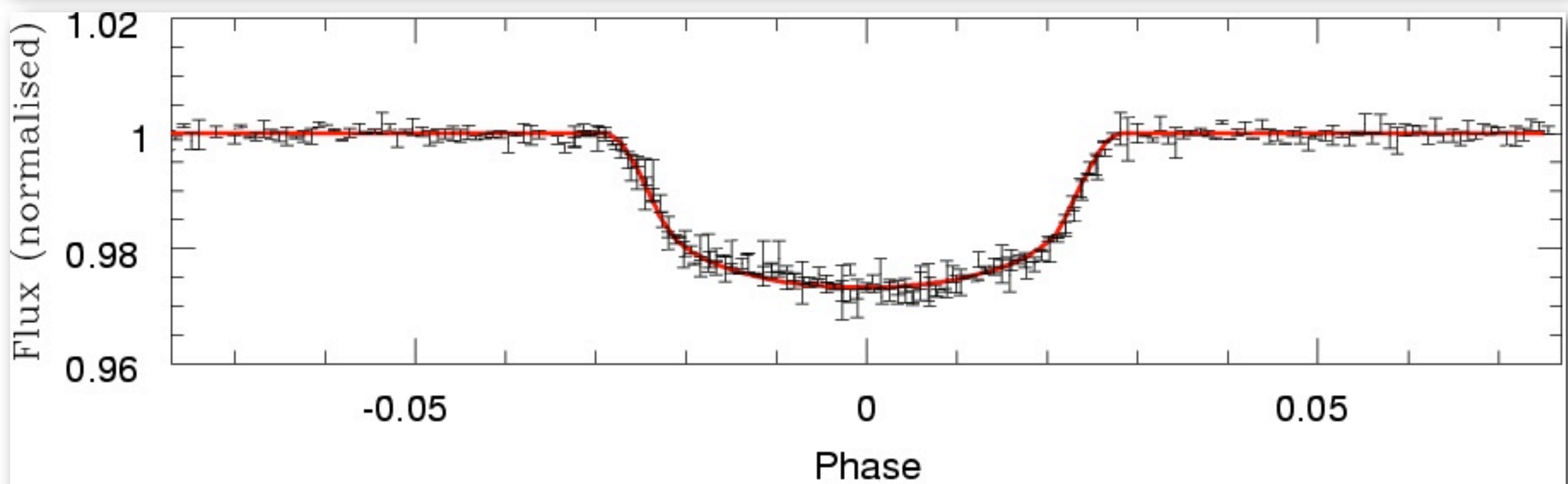
Medicine:
Heart Rhythms



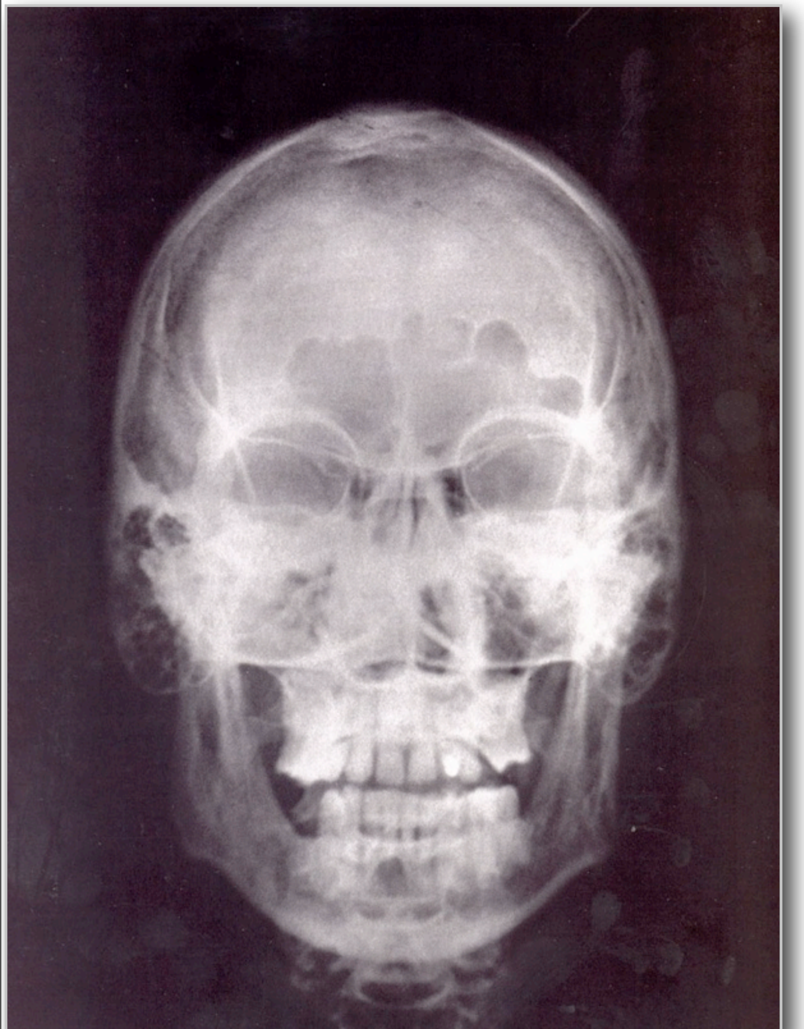
Genomics:
DNA Sequence



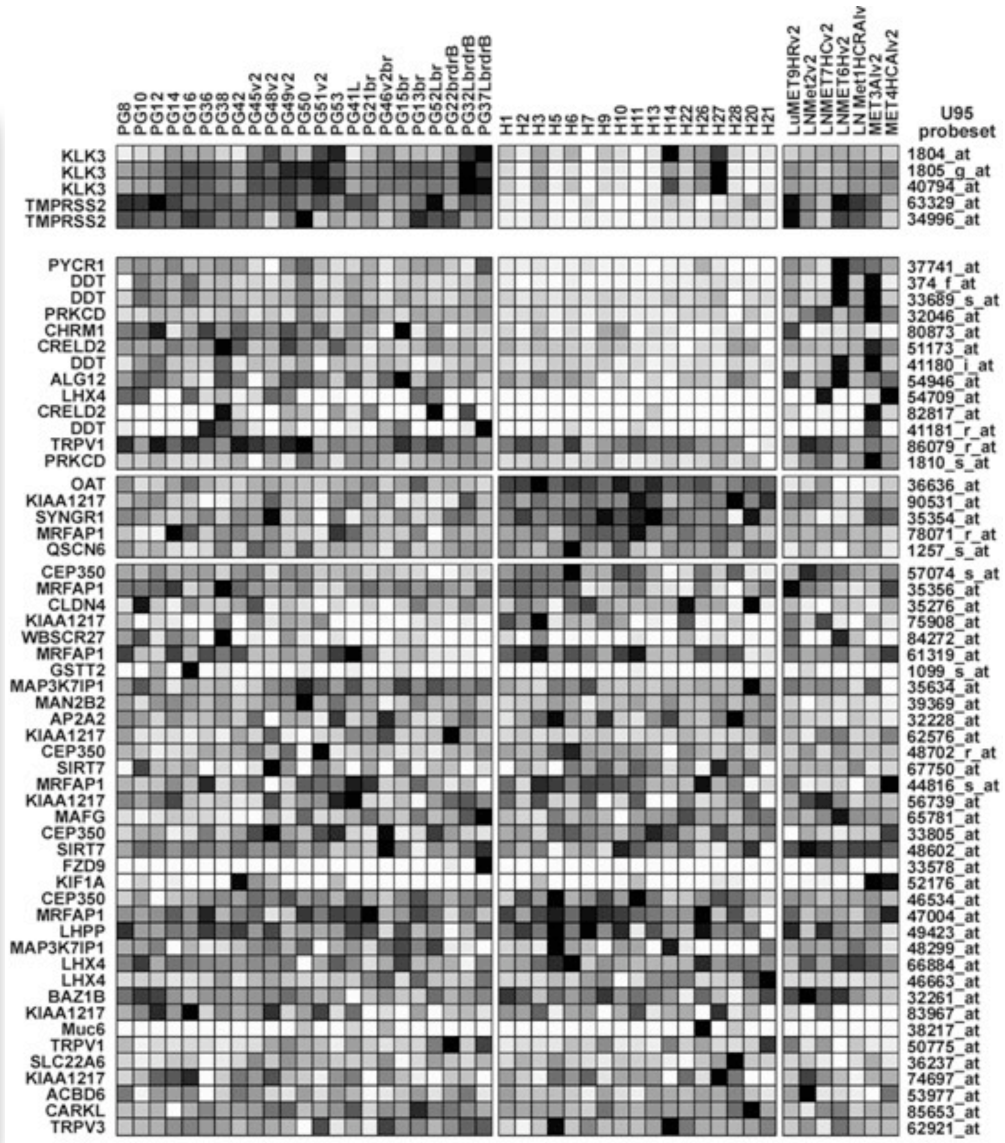
Astronomy:
Planet Transit



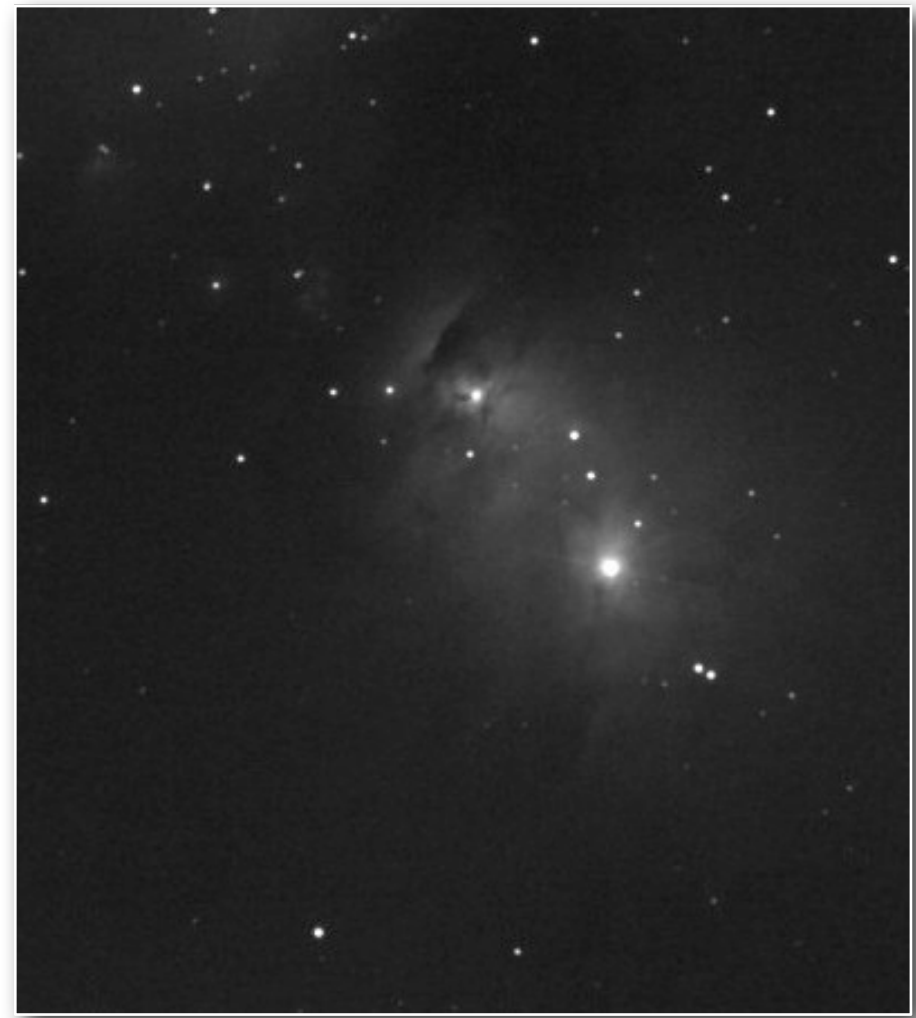
1 quantity | *on 2 dimensions*



Medicine:
X-Ray



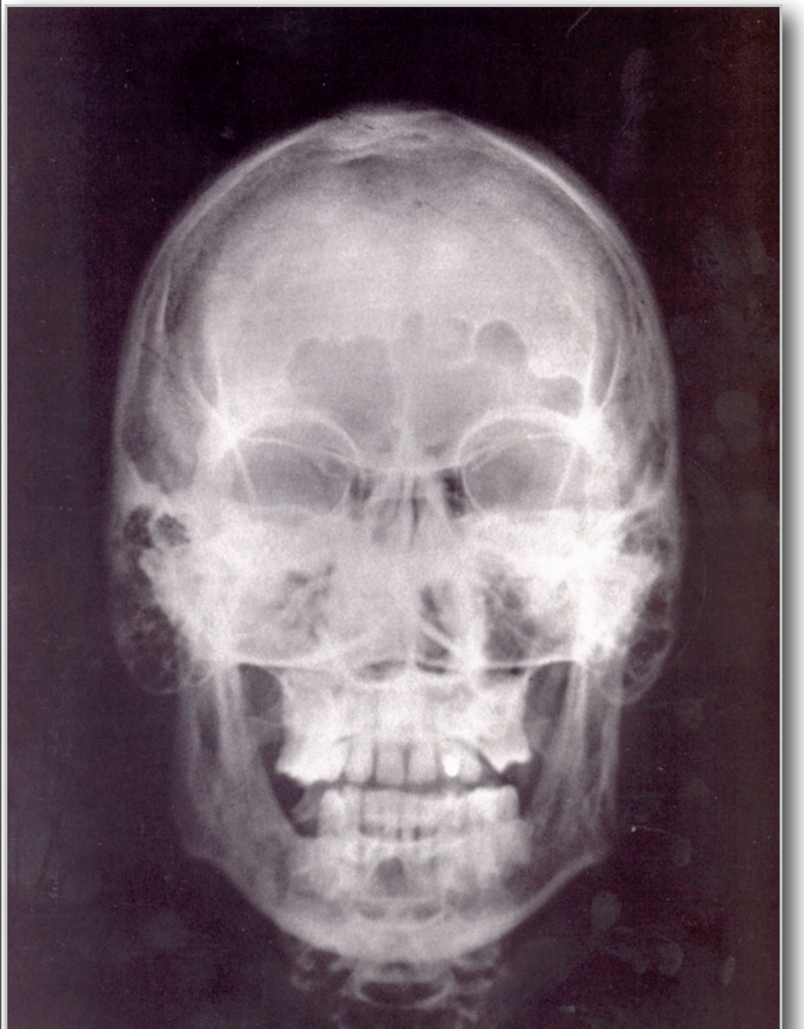
Genomics:
“Heatmap”

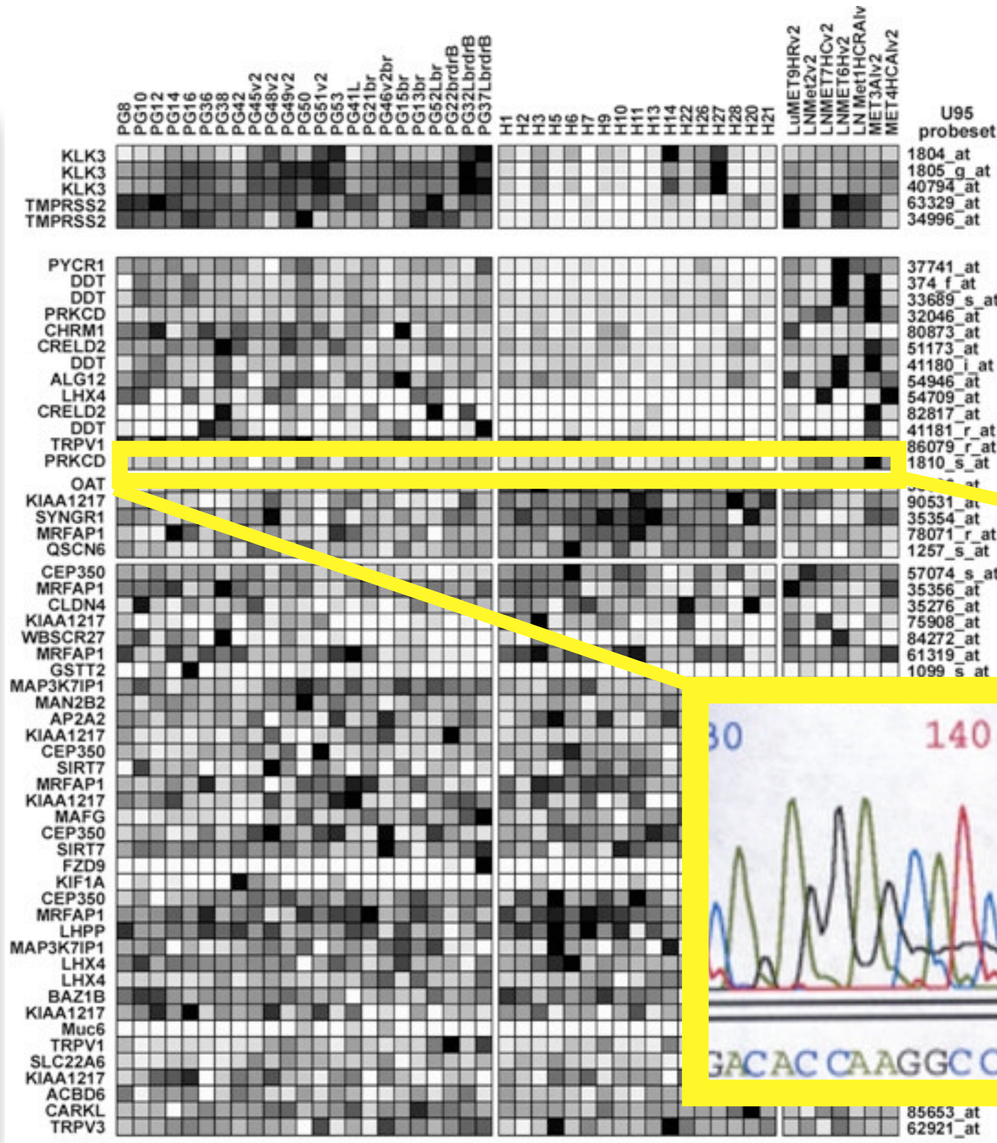


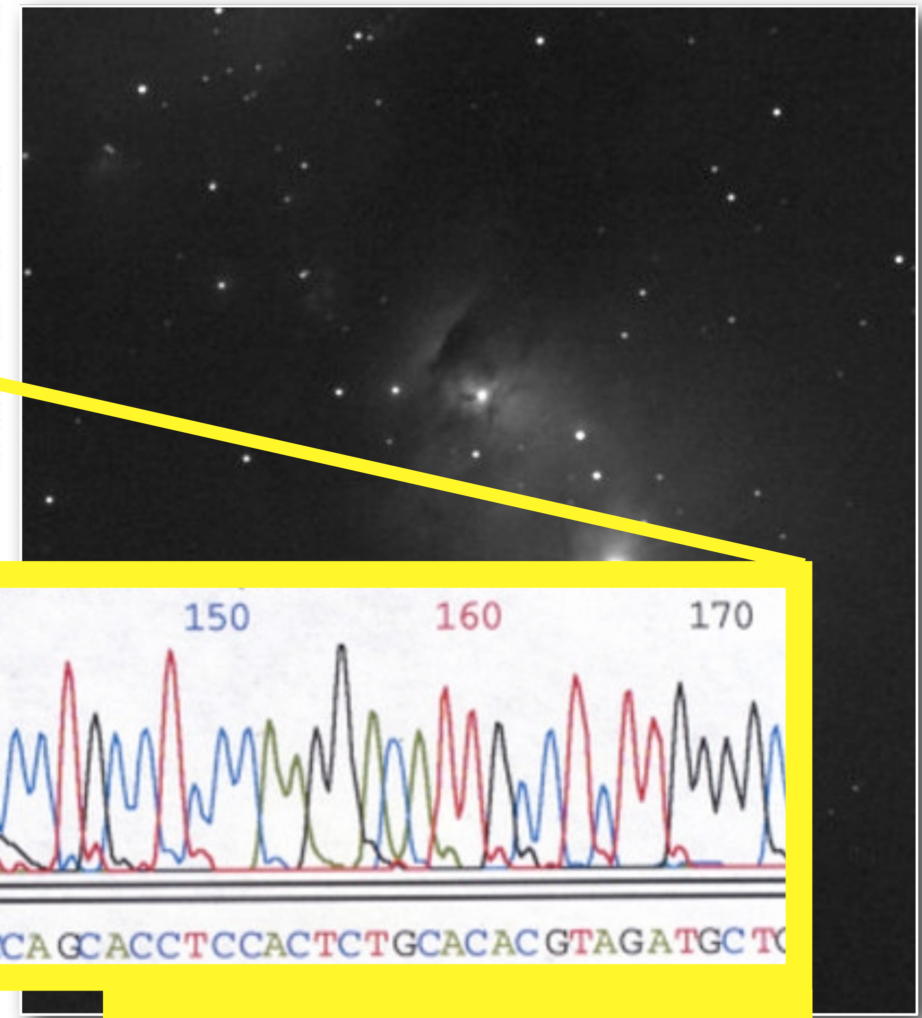
Astronomy:
Photograph

Middle Panel: Jariwala *et al. Molecular Cancer* 2007 **6**:39 doi:
10.1186/1476-4598-6-39

I quantity | *on 2 dimensions*







...on 1 dimension

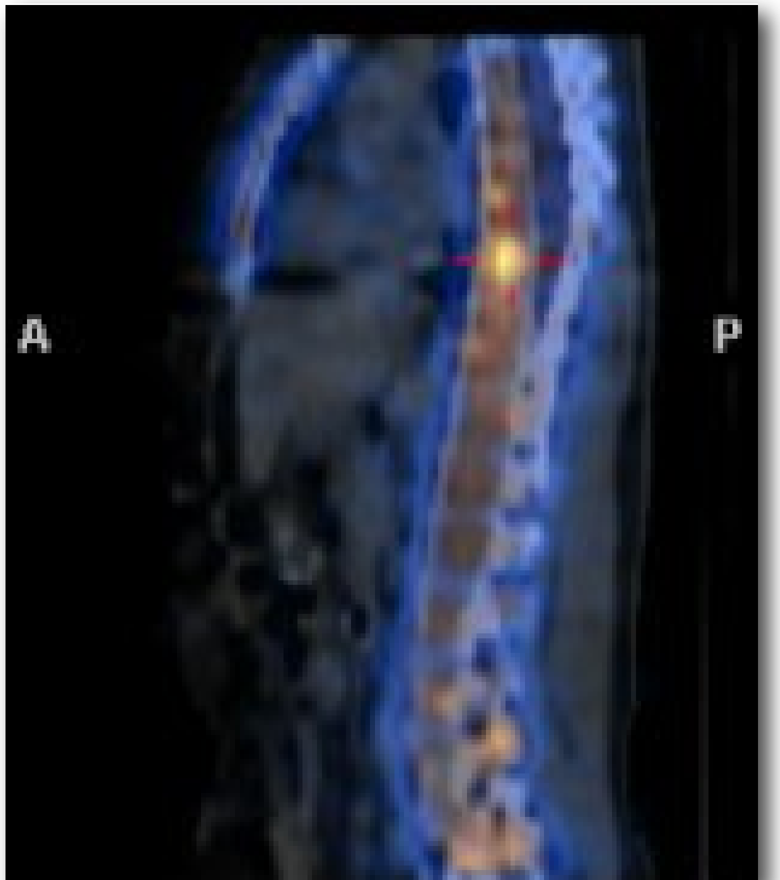
Medicine:
X-Ray

Genomics:
"Heatmap"

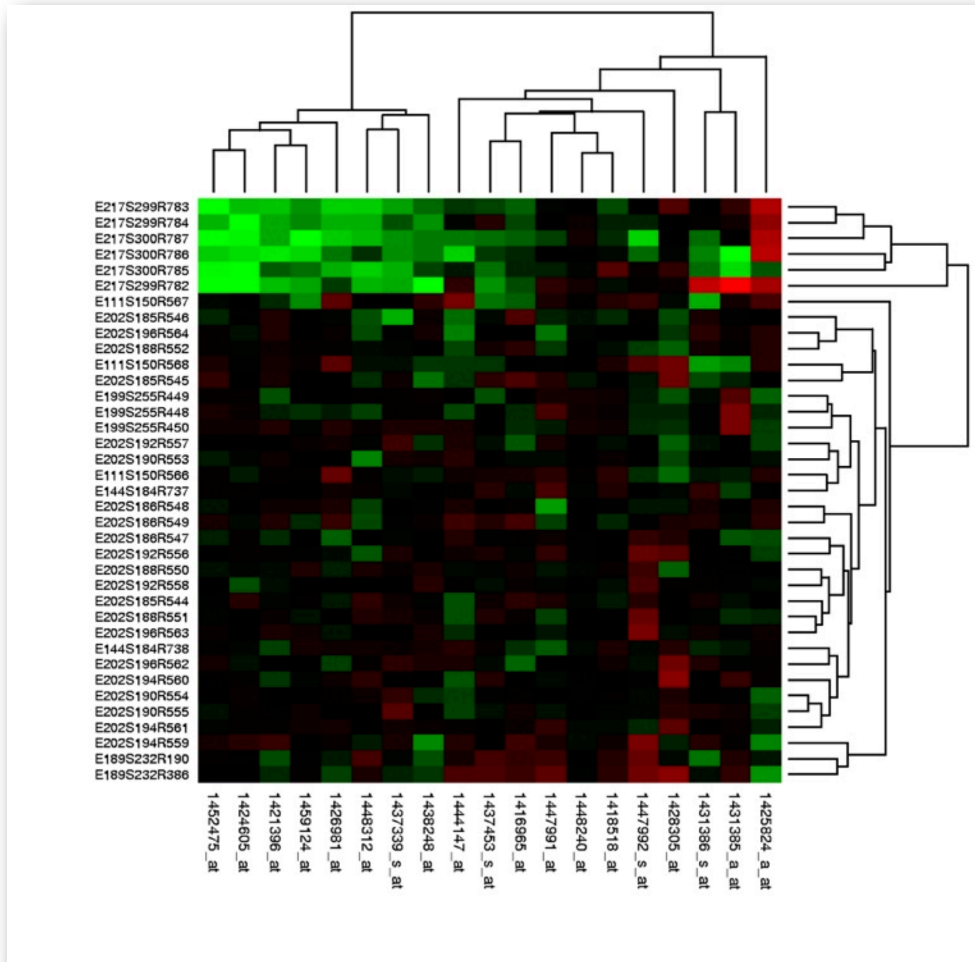
Photograph

Middle Panel: Jariwala *et al. Molecular Cancer* 2007 **6**:39 doi: 10.1186/1476-4598-6-39

>1 quantity | *on 2 dimensions*



Medicine:
Multimodal Imaging

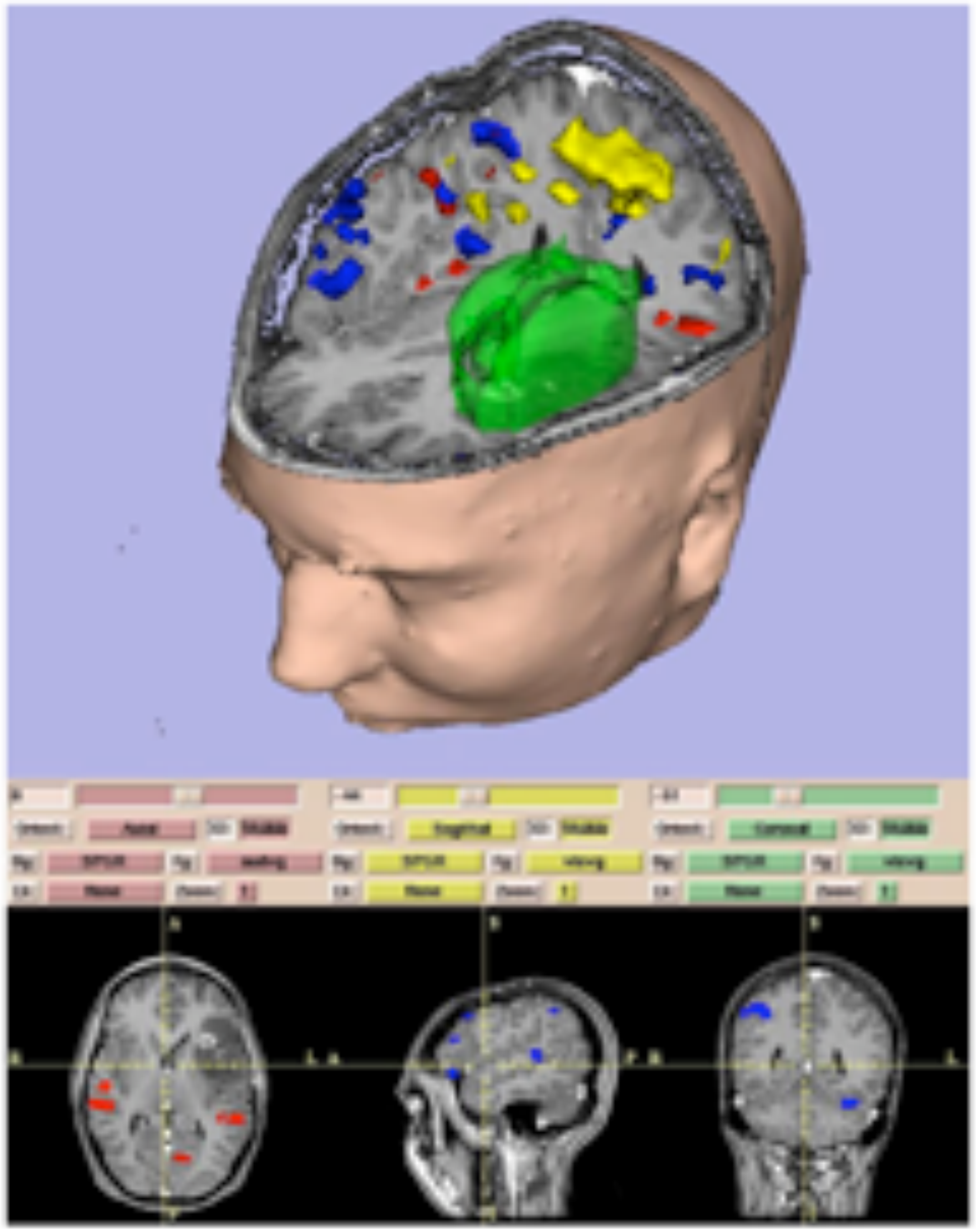


Genomics:
“Heatmap”

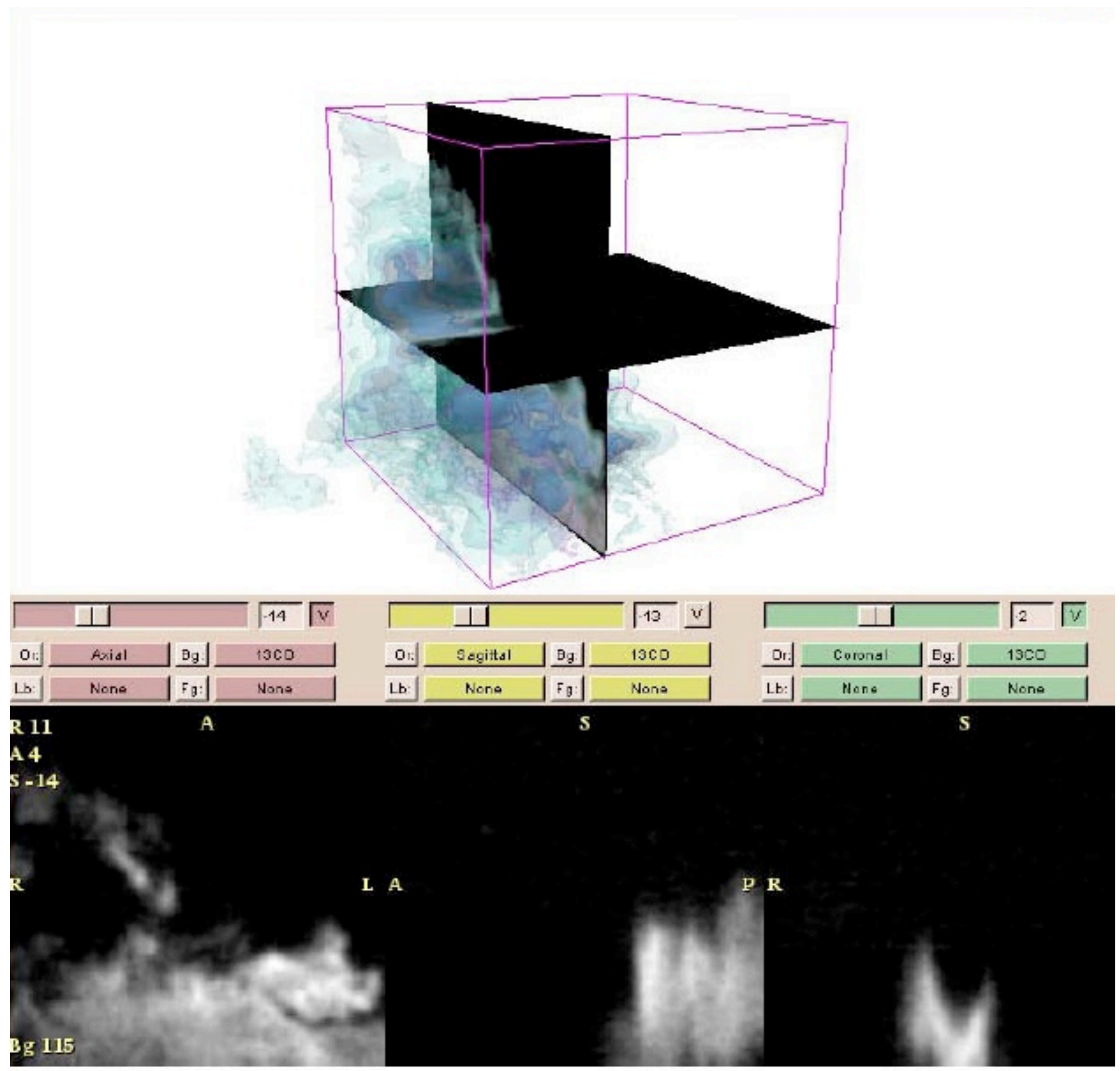
Astronomy:
Color Photograph

Middle Panel: Jariwala *et al. Molecular Cancer* 2007 **6**:39 doi: 10.1186/1476-4598-6-39

1 quantity | *on 3 Dimensions*



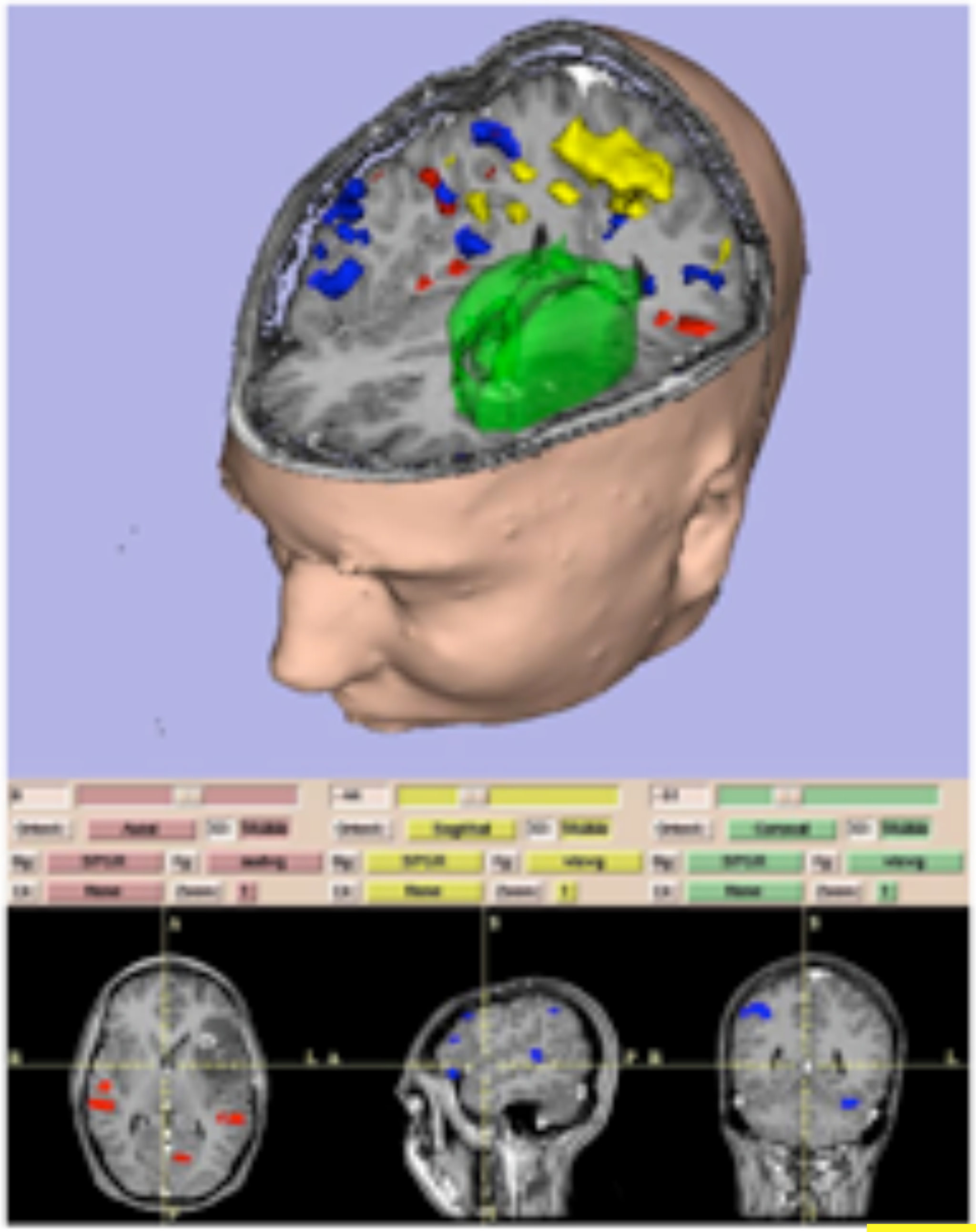
Medicine:
MRI



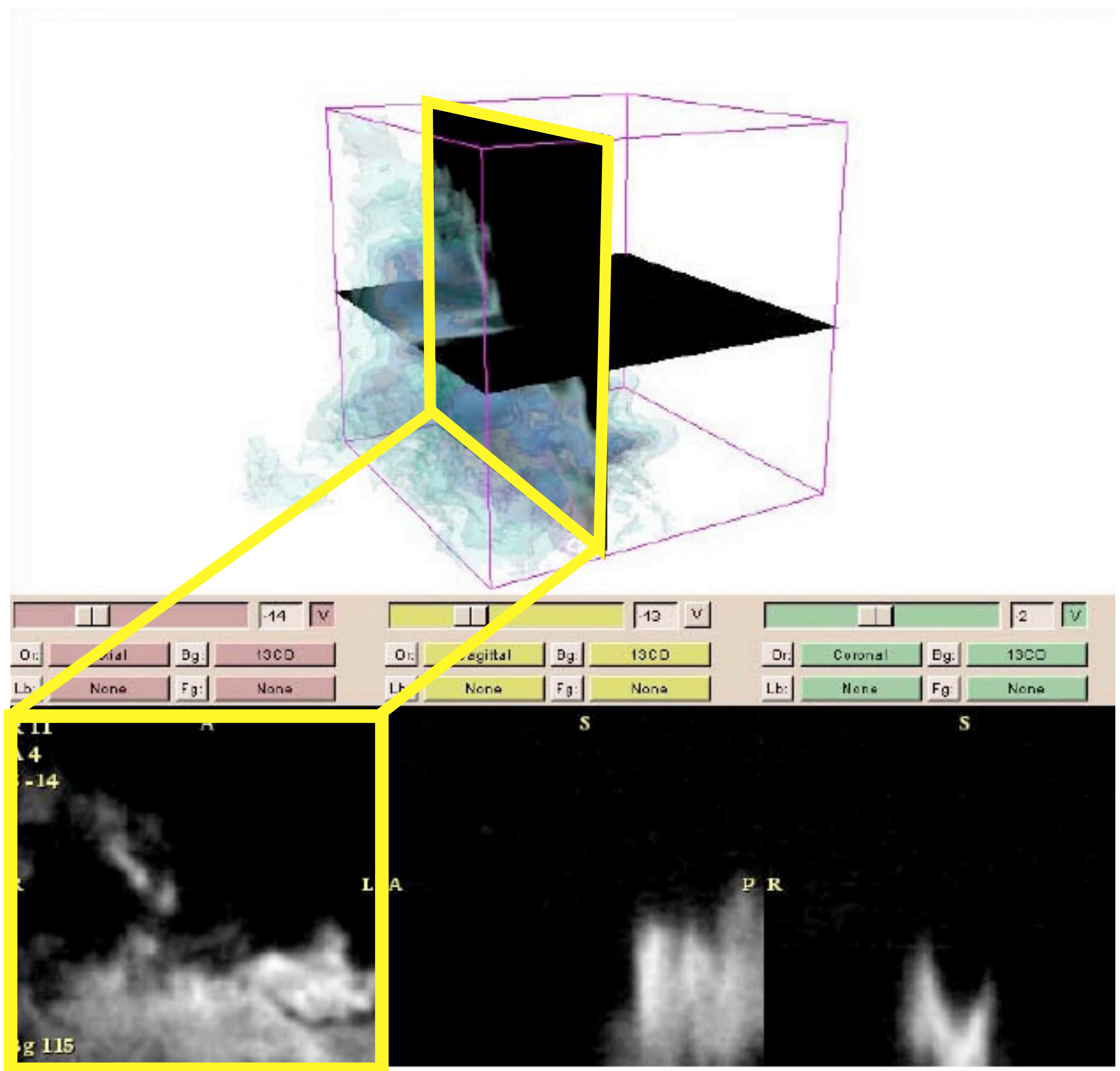
Astronomy:
Spectral-Line Data Cubes

Middle Panel: Jariwala *et al. Molecular Cancer* 2007 **6**:39 doi: 10.1186/1476-4598-6-39

1 quantity | *on 3 Dimensions*



Medicine:
MRI



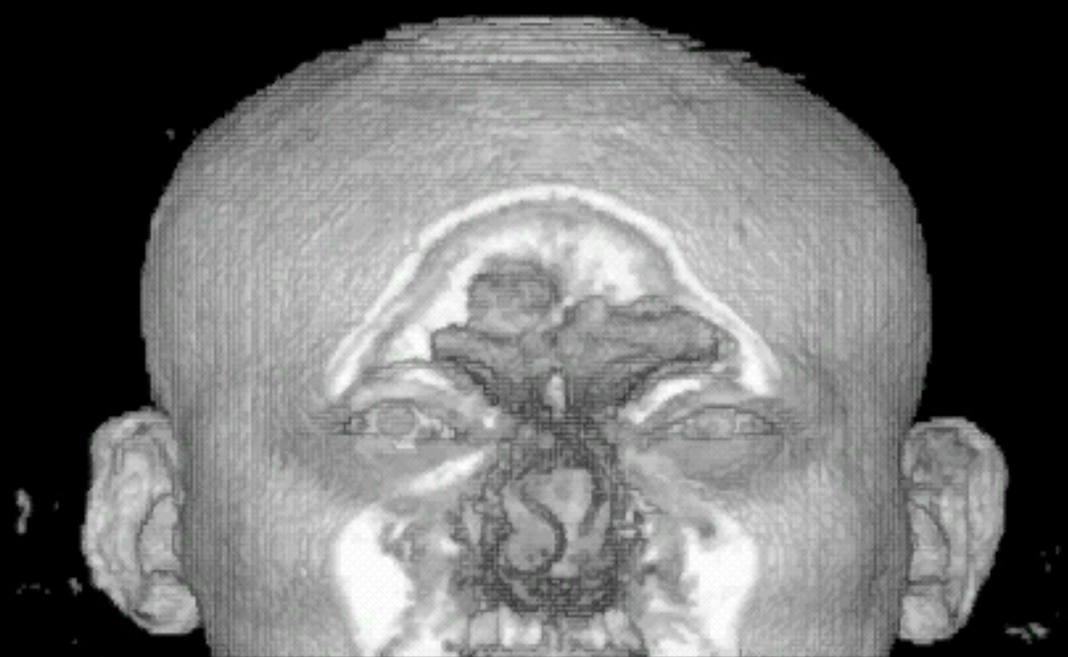
...in two dimensions

Astronomy:
Spectral-Line Data Cubes

Middle Panel: Jariwala *et al. Molecular Cancer* 2007 **6**:39 doi: 10.1186/1476-4598-6-39

"Astronomical Medicine"

"KEITH"



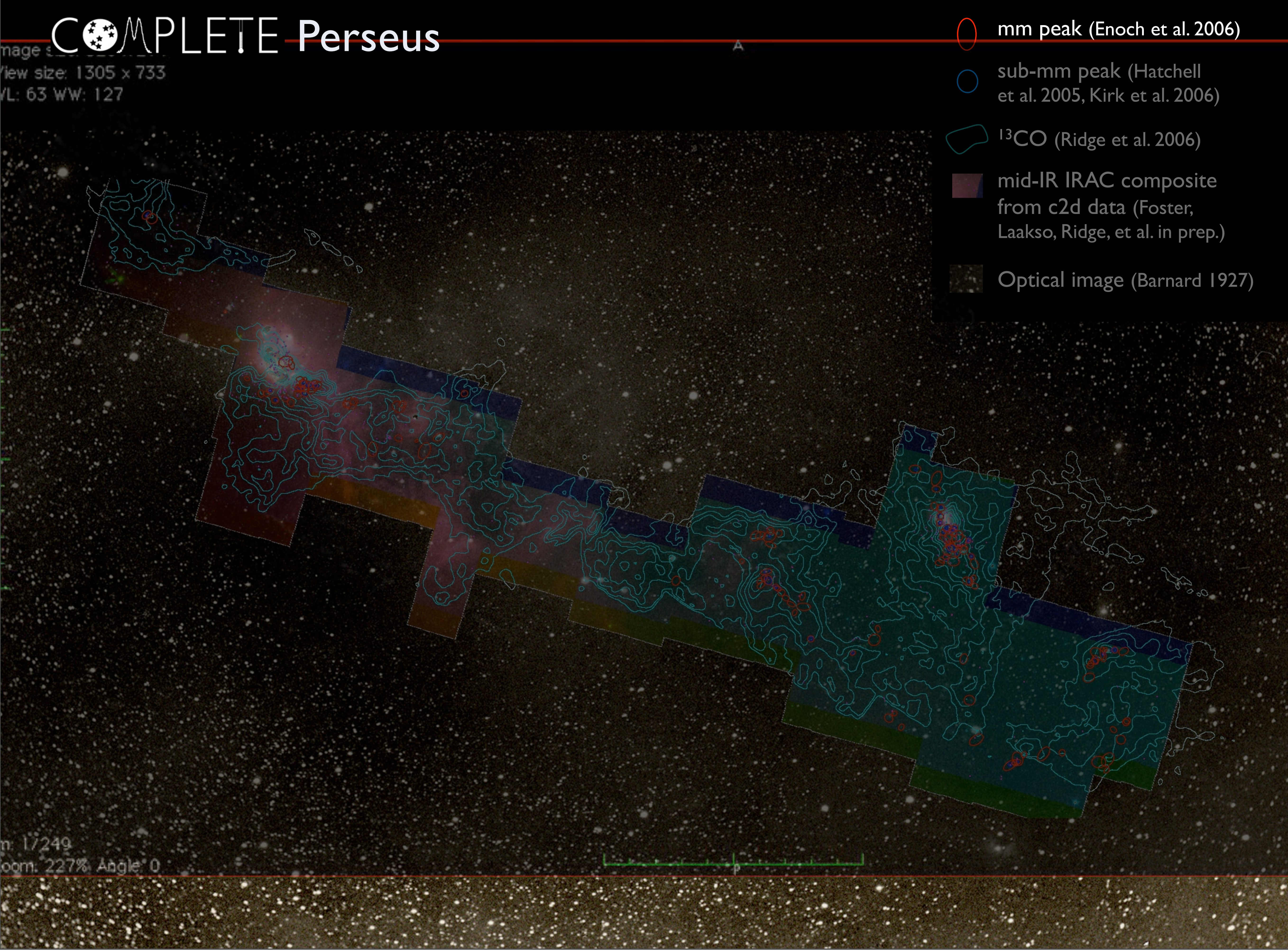
"PERSEUS"

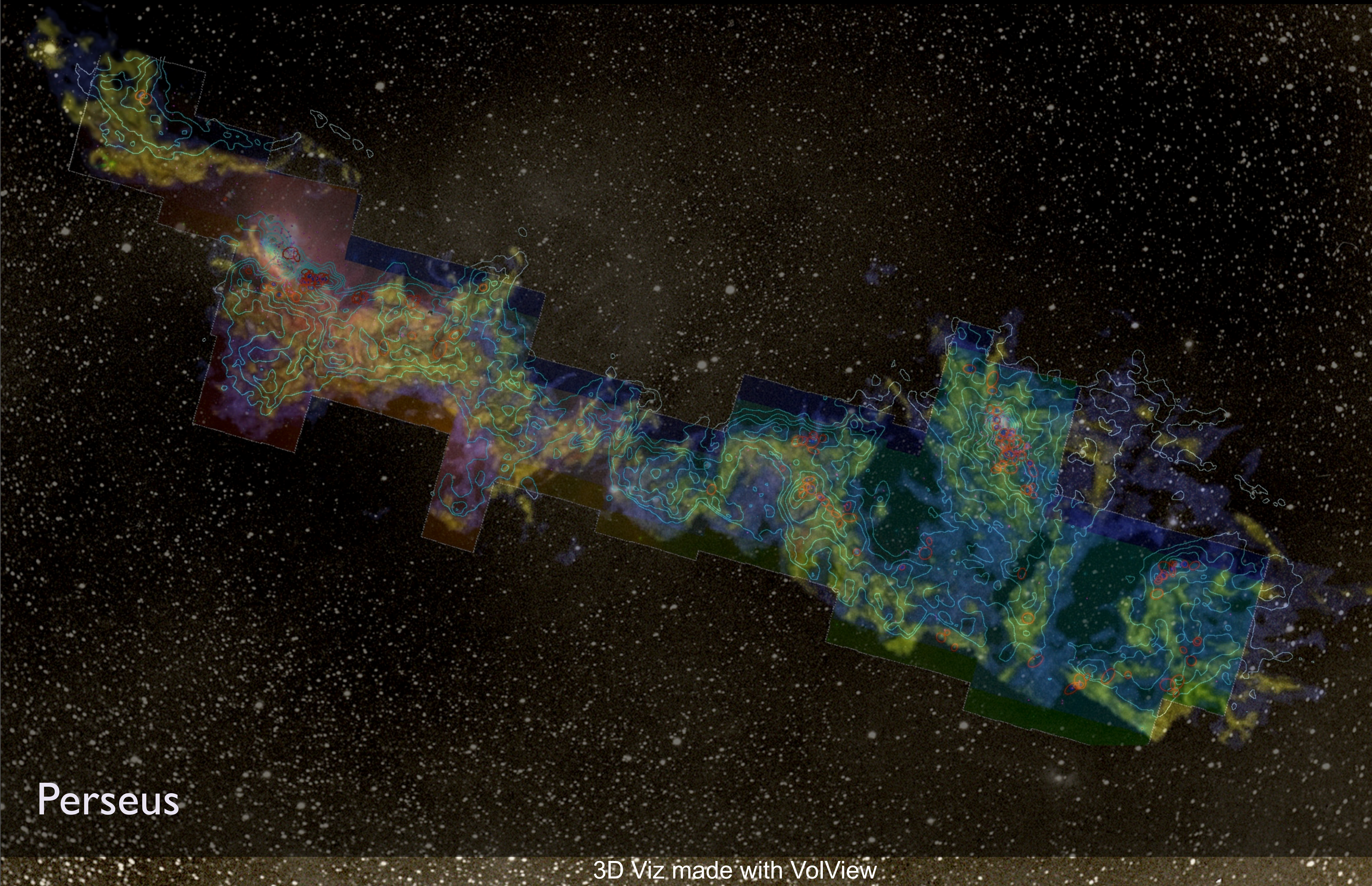
"z" is depth into head

"z" is line-of-sight velocity

(This kind of "series of 2D slices view" is known in the Viz as "the grand tour")

COMPLETE Perseus





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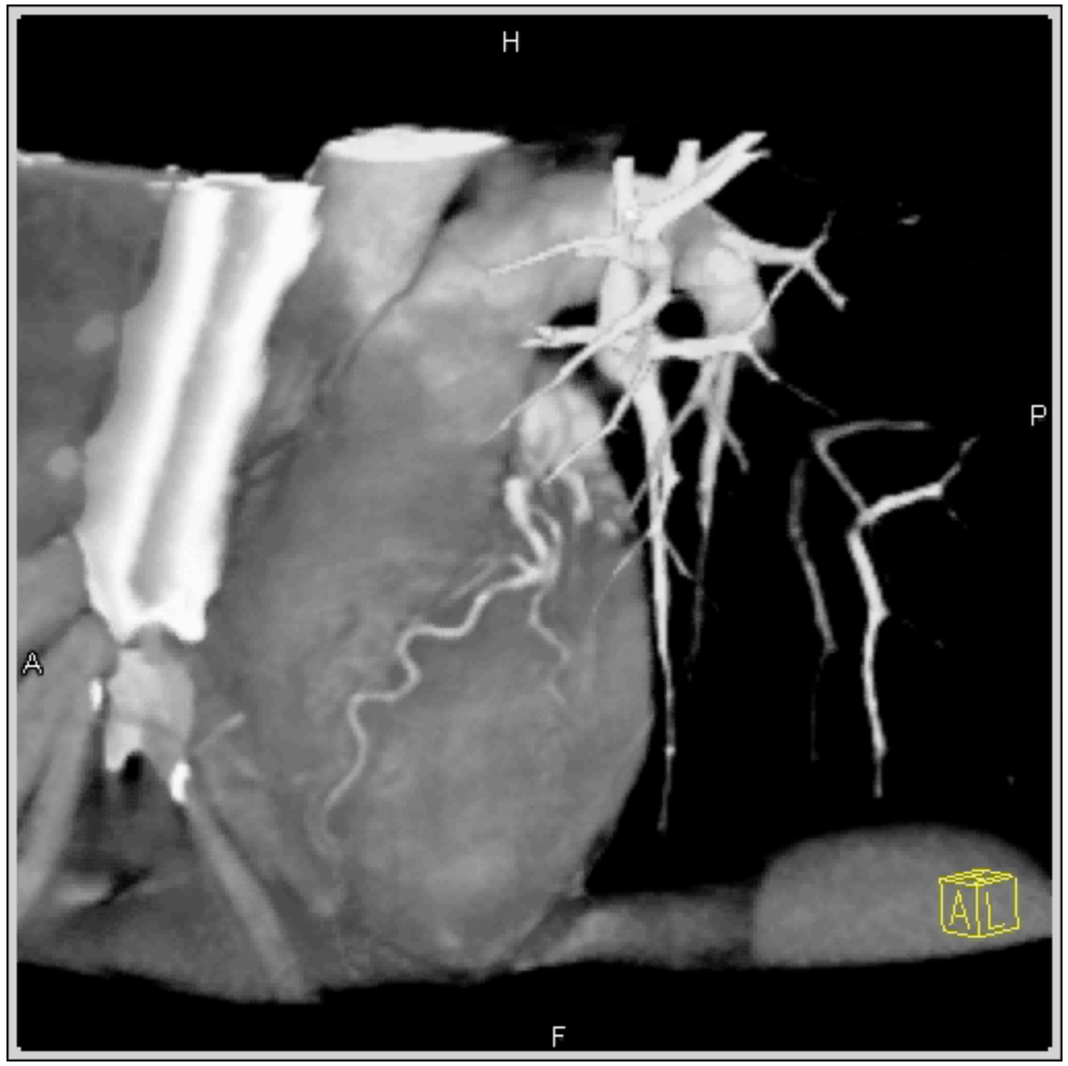
COMPLETE

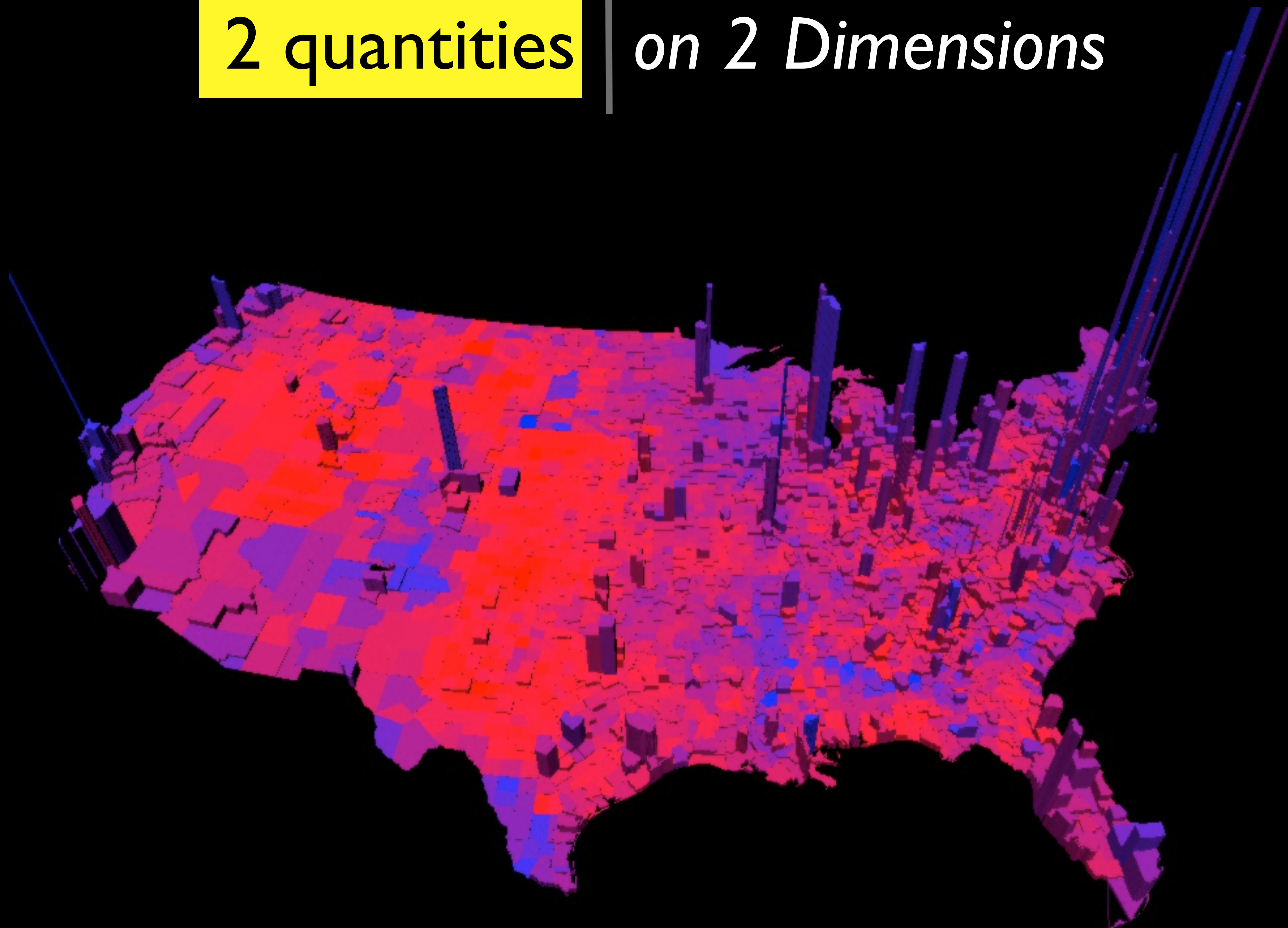
1 quantity | *on 4 Dimensions*



Medicine:
Time-Resolved 3D Imaging

Middle Panel: Jariwala *et al. Molecular Cancer* 2007 **6**:39 doi: 10.1186/1476-4598-6-39

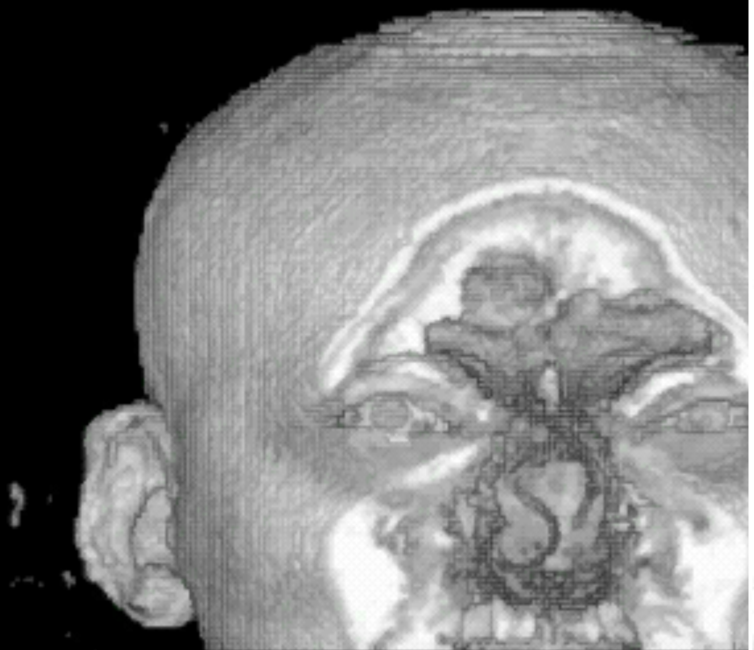
2 quantities | *on 2 Dimensions*

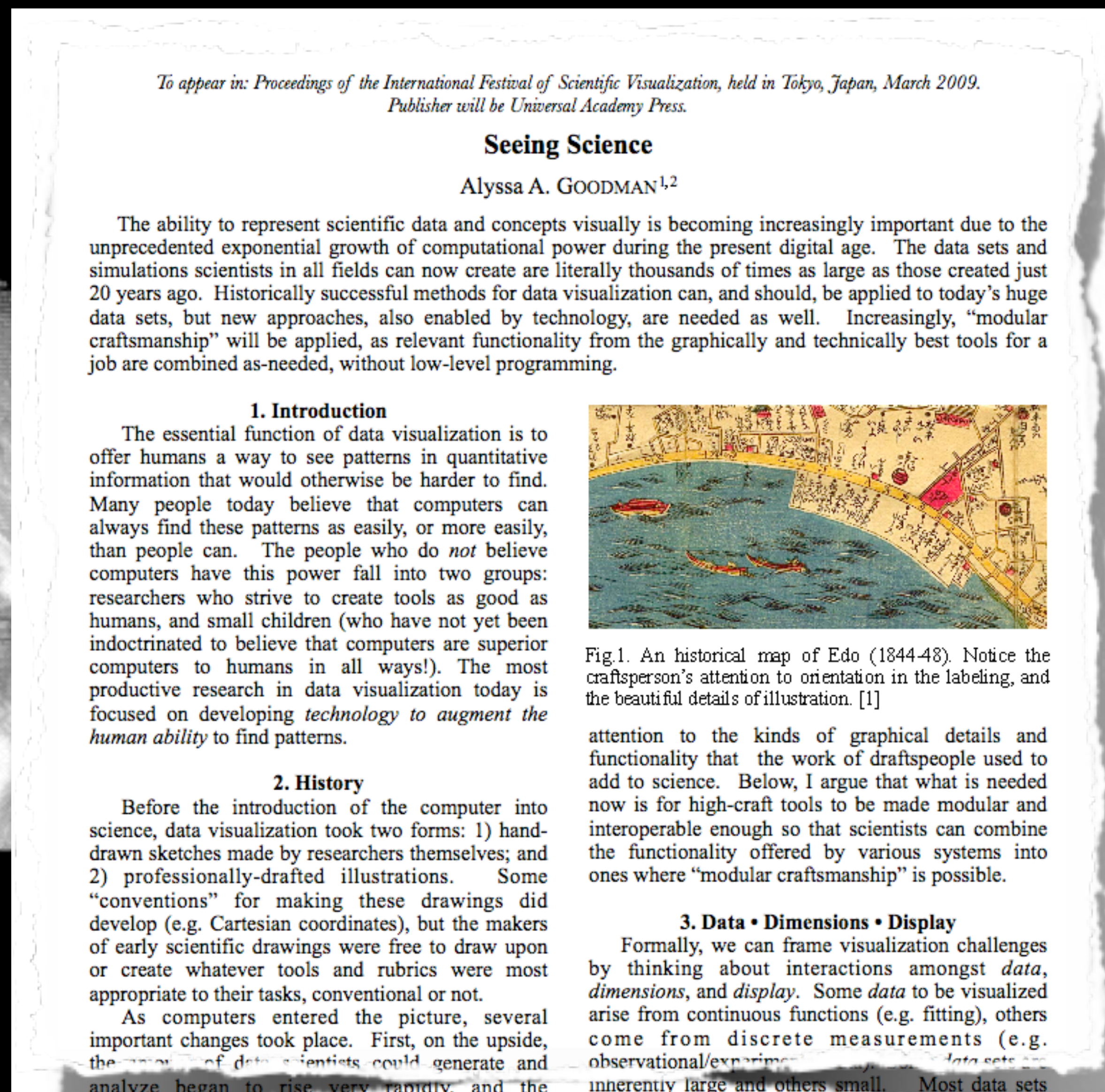


How many "dimensions" at once?

Can/should time (animation) substitute for dimensions?

"KEITH"





To appear in: Proceedings of the International Festival of Scientific Visualization, held in Tokyo, Japan, March 2009. Publisher will be Universal Academy Press.

Seeing Science

Alyssa A. GOODMAN[1,2]

The ability to represent scientific data and concepts visually is becoming increasingly important due to the unprecedented exponential growth of computational power during the present digital age. The data sets and simulations scientists in all fields can now create are literally thousands of times as large as those created just 20 years ago. Historically successful methods for data visualization can, and should, be applied to today's huge data sets, but new approaches, also enabled by technology, are needed as well. Increasingly, "modular craftsmanship" will be applied, as relevant functionality from the graphically and technically best tools for a job are combined as-needed, without low-level programming.

1. Introduction

The essential function of data visualization is to offer humans a way to see patterns in quantitative information that would otherwise be harder to find. Many people today believe that computers can always find these patterns as easily, or more easily, than people can. The people who do *not* believe computers have this power fall into two groups: researchers who strive to create tools as good as humans, and small children (who have not yet been indoctrinated to believe that computers are superior computers to humans in all ways!). The most productive research in data visualization today is focused on developing *technology to augment the human ability* to find patterns.

2. History

Before the introduction of the computer into science, data visualization took two forms: 1) hand-drawn sketches made by researchers themselves; and 2) professionally-drafted illustrations. Some "conventions" for making these drawings did develop (e.g. Cartesian coordinates), but the makers of early scientific drawings were free to draw upon or create whatever tools and rubrics were most appropriate to their tasks, conventional or not.

As computers entered the picture, several important changes took place. First, on the upside, the [illegible] of [illegible] scientists could generate and analyze began to rise very rapidly, and the

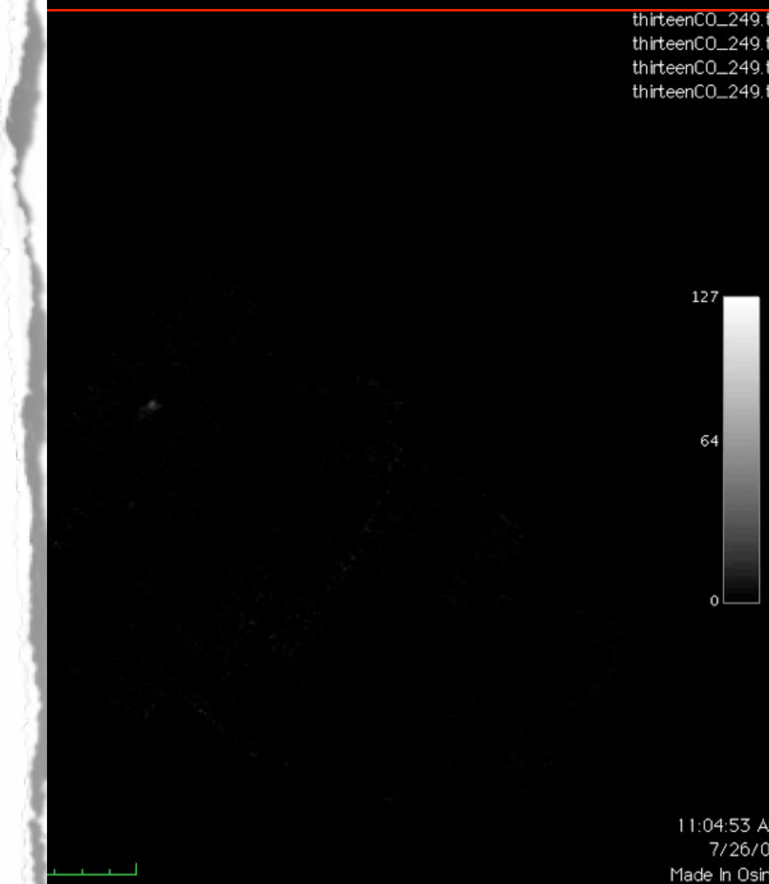
Fig.1. An historical map of Edo (1844-48). Notice the craftsperson's attention to orientation in the labeling, and the beautiful details of illustration. [1]

attention to the kinds of graphical details and functionality that the work of draftspeople used to add to science. Below, I argue that what is needed now is for high-craft tools to be made modular and interoperable enough so that scientists can combine the functionality offered by various systems into ones where "modular craftsmanship" is possible.

3. Data • Dimensions • Display

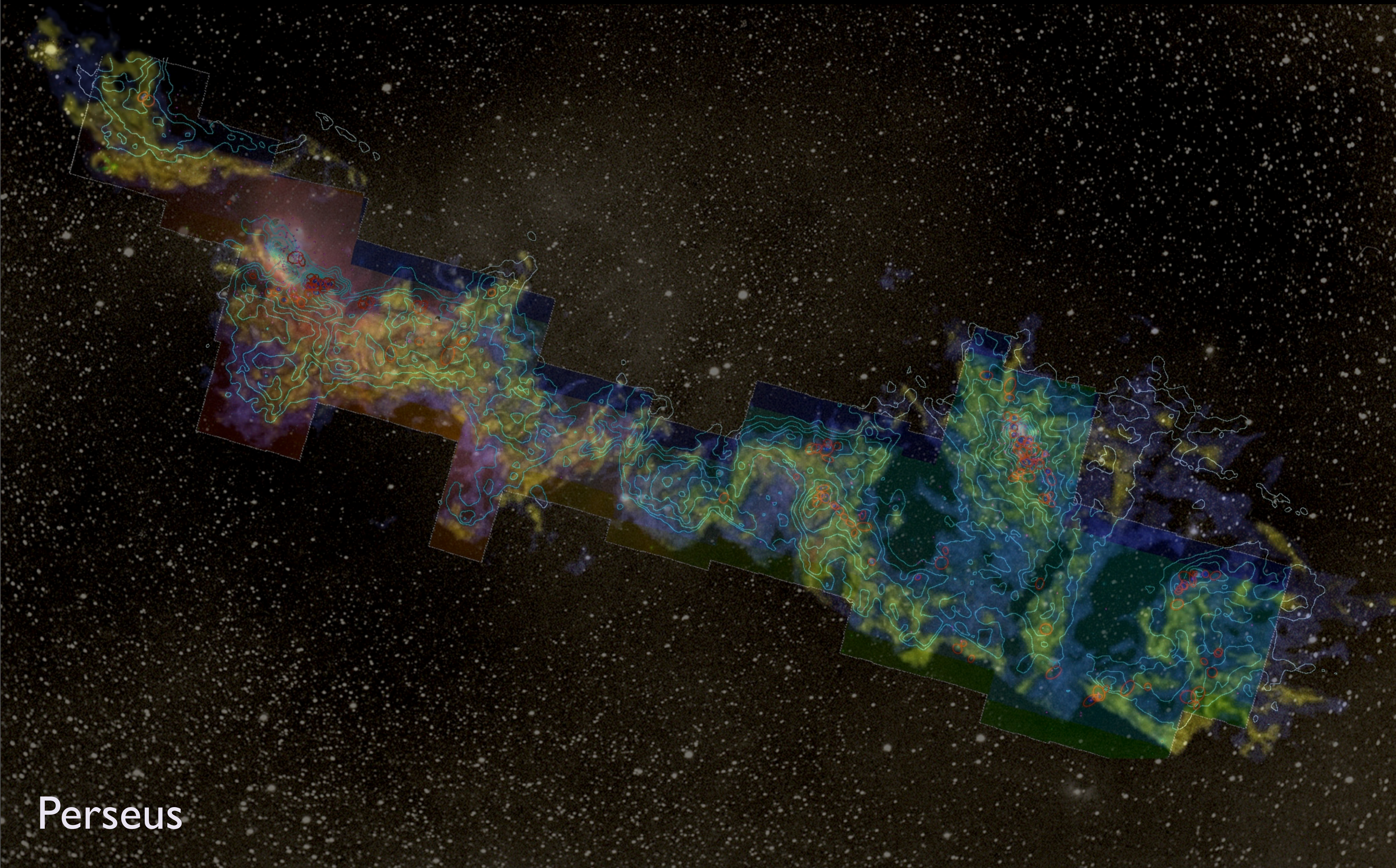
Formally, we can frame visualization challenges by thinking about interactions amongst *data*, *dimensions*, and *display*. Some *data* to be visualized arise from continuous functions (e.g. fitting), others come from discrete measurements (e.g. observational/[illegible] data sets are inherently large and others small. Most data sets

EUS"



"z" is depth into ... -sight velocity

(This kind of "series of 2D slices view" is known in the Viz as "the grand tour")



3D Viz made with VolView

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COMPLETE

What can we observe?

What can we “see”?

What can we imagine?

What can we explain?

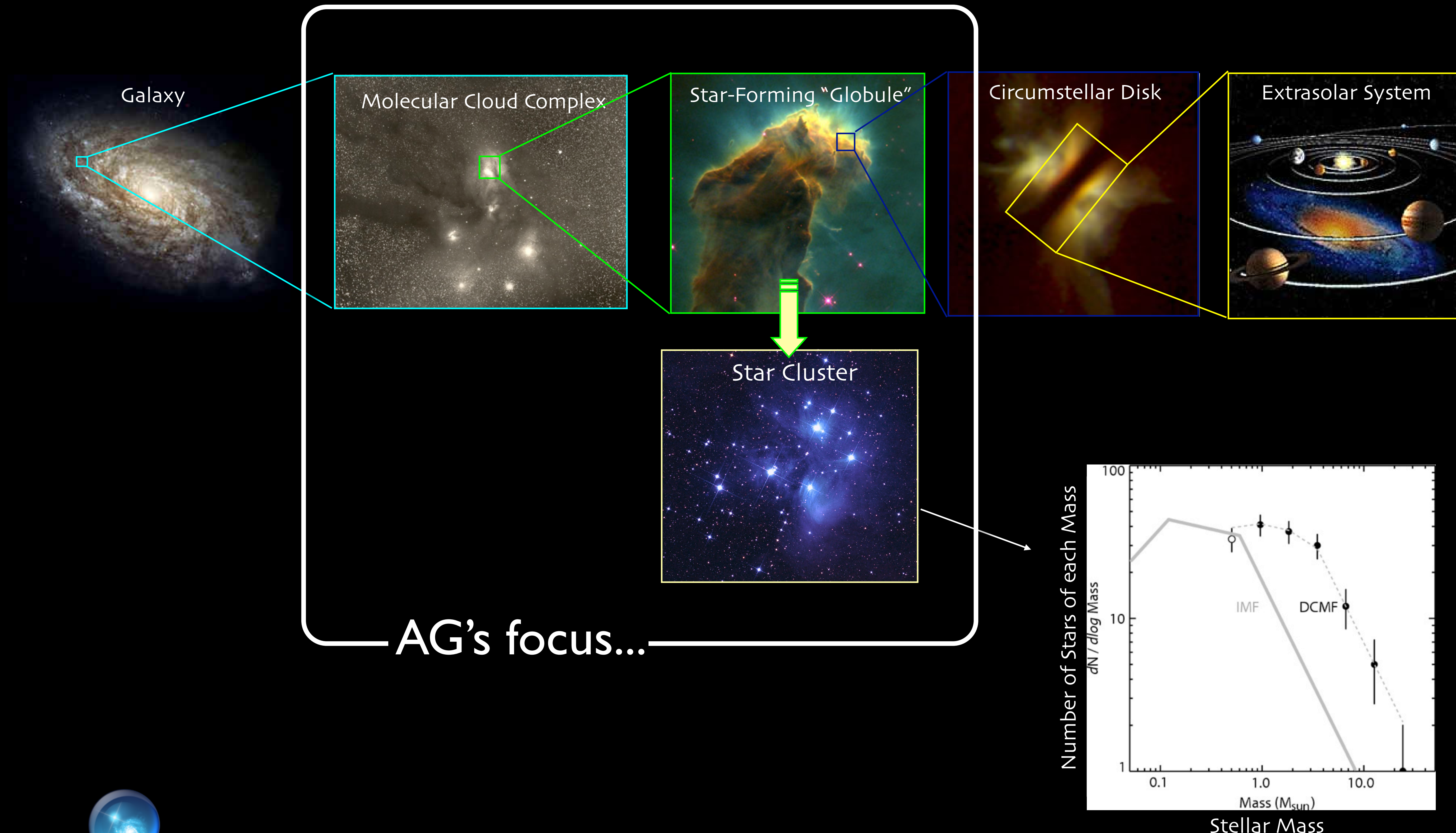
Simulations

The Future

Simulations

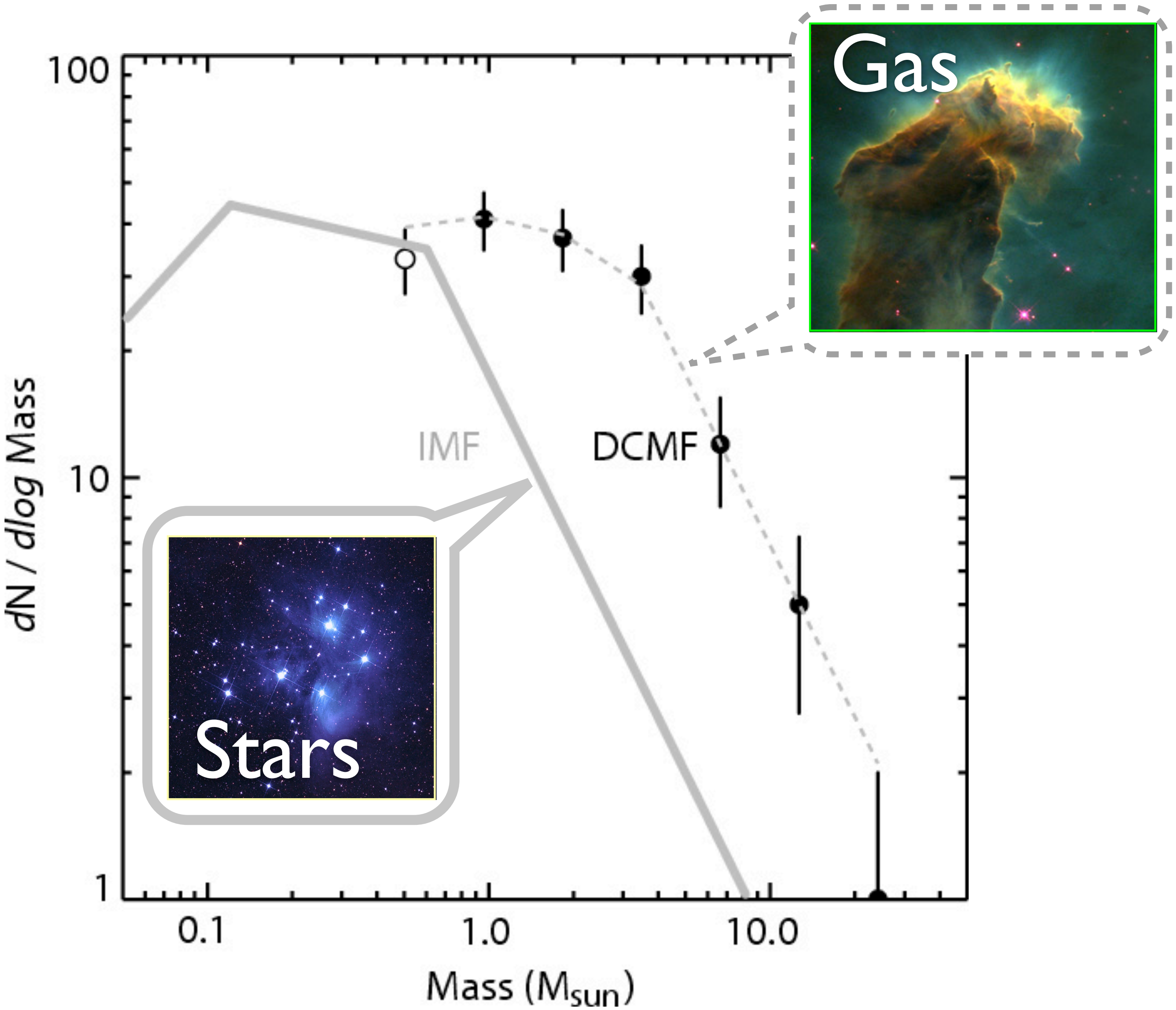
(and “Tasting” them)

Star (and Planet, and Moon) Formation 101



“IMF”? “CMF”?

Note: IMF= “Initial Mass Funciton” of Stars, not “International Monetary Fund.”

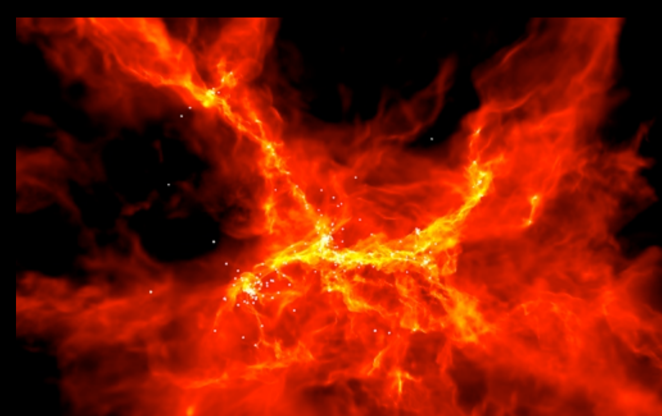


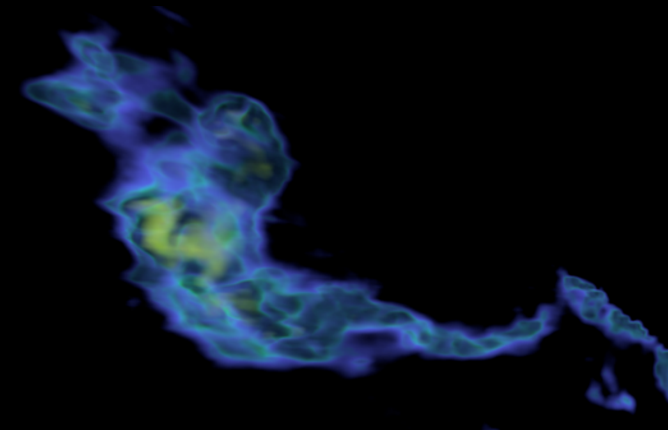
Alves, Lombardi & Lada 2007

BUT: Beautiful images like this do not reveal *internal* structure directly...

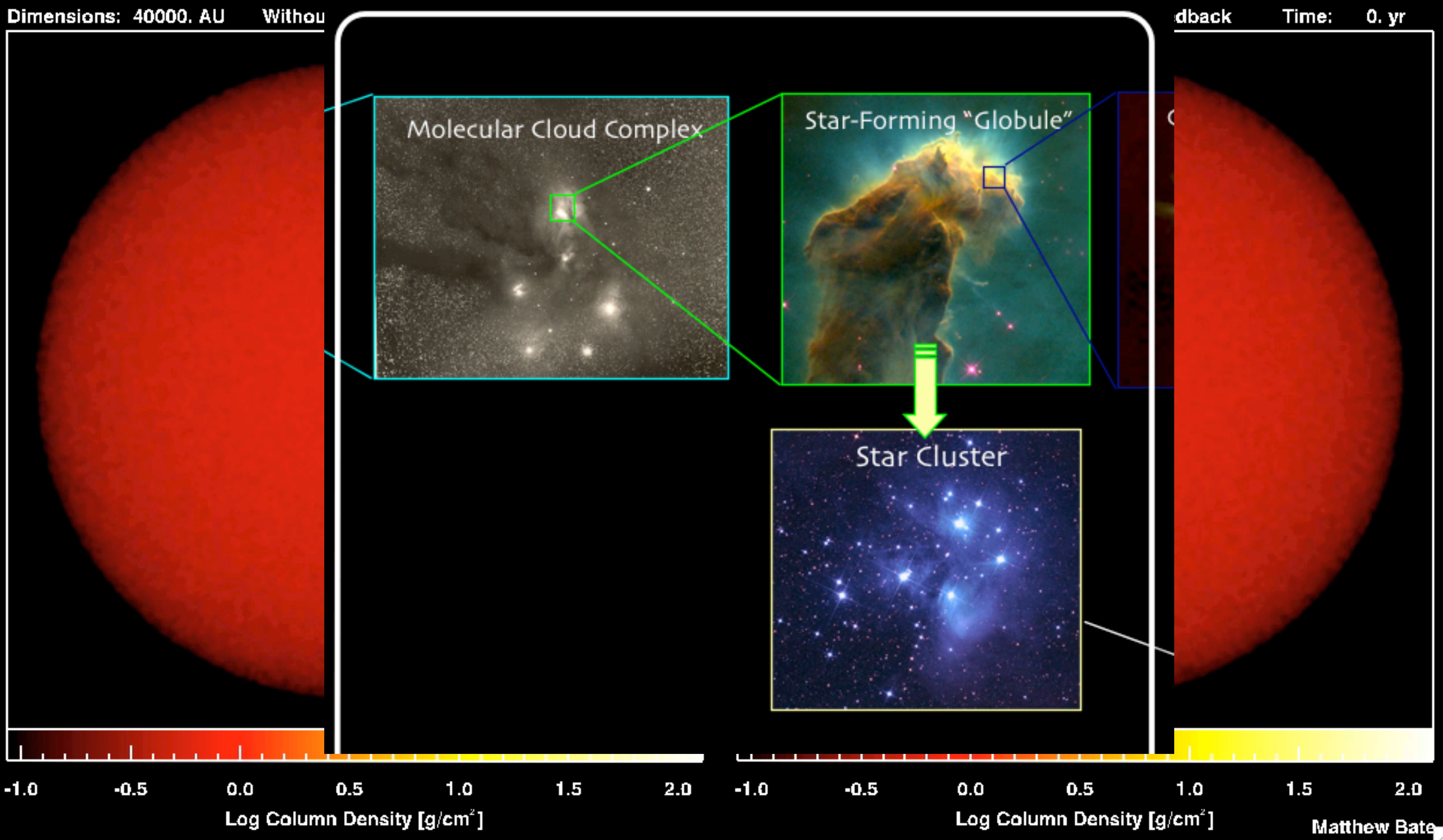
simulations

>2D observations





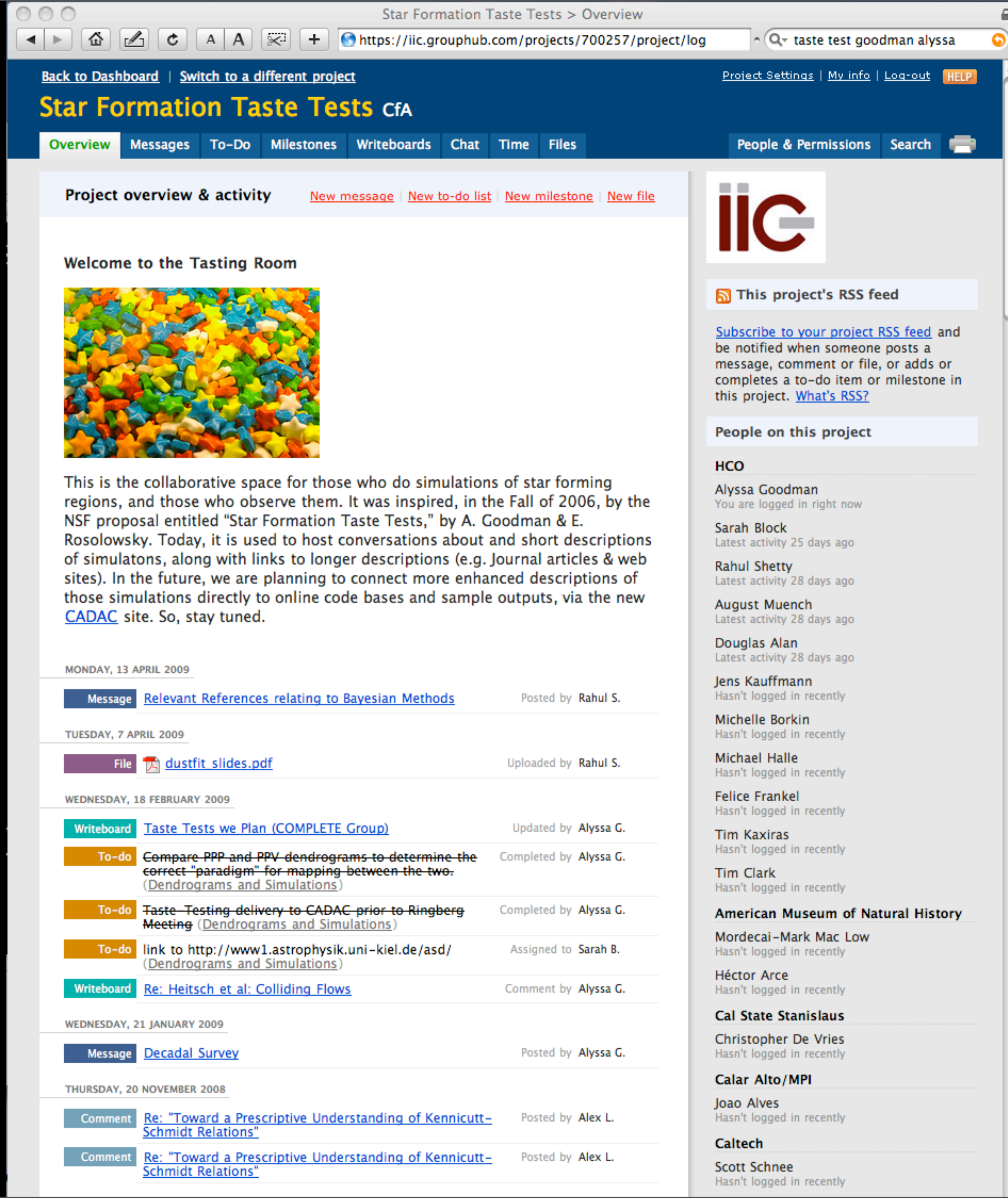
"Tasting" Magnetohydrodynamic Simulations



Simulations of Bate 2009

Tasting

$$I(E, s, \vec{x}, t)$$



Star Formation Taste Tests > Overview

https://iic.grouphub.com/projects/700257/project/log

taste test goodman alyssa

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Star Formation Taste Tests CfA

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Welcome to the Tasting Room

This is the collaborative space for those who do simulations of star forming regions, and those who observe them. It was inspired, in the Fall of 2006, by the NSF proposal entitled "Star Formation Taste Tests," by A. Goodman & E. Rosolowsky. Today, it is used to host conversations about and short descriptions of simulatons, along with links to longer descriptions (e.g. Journal articles & web sites). In the future, we are planning to connect more enhanced descriptions of those simulations directly to online code bases and sample outputs, via the new CADAC site. So, stay tuned.

MONDAY, 13 APRIL 2009

Message	Relevant References relating to Bayesian Methods	Posted by	Rahul S.

TUESDAY, 7 APRIL 2009

File	dustfit_slides.pdf	Uploaded by	Rahul S.

WEDNESDAY, 18 FEBRUARY 2009

Writeboard	Taste Tests we Plan (COMPLETE Group)	Updated by	Alyssa G.
To-do	~~Compare PPP and PPV dendrograms to determine the correct "paradigm" for mapping between the two.~~ (Dendrograms and Simulations)	Completed by	Alyssa G.
To-do	~~Taste-Testing delivery to CADAC prior to Ringberg Meeting~~ (Dendrograms and Simulations)	Completed by	Alyssa G.
To-do	link to http://www1.astrophysik.uni-kiel.de/asd/ (Dendrograms and Simulations)	Assigned to	Sarah B.
Writeboard	Re: Heitsch et al: Colliding Flows	Comment by	Alyssa G.

WEDNESDAY, 21 JANUARY 2009

Message	Decadal Survey	Posted by	Alyssa G.

THURSDAY, 20 NOVEMBER 2008

Comment	Re: "Toward a Prescriptive Understanding of Kennicutt-Schmidt Relations"	Posted by	Alex L.
Comment	Re: "Toward a Prescriptive Understanding of Kennicutt-Schmidt Relations"	Posted by	Alex L.

This project's RSS feed

Subscribe to your project RSS feed and be notified when someone posts a message, comment or file, or adds or completes a to-do item or milestone in this project. What's RSS?

People on this project

HCO

Alyssa Goodman
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Latest activity 25 days ago

Rahul Shetty
Latest activity 28 days ago

August Muench
Latest activity 28 days ago

Douglas Alan
Latest activity 28 days ago

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Hasn't logged in recently

Michelle Borkin
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Michael Halle
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American Museum of Natural History

Mordecai-Mark Mac Low
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Hasn't logged in recently

Cal State Stanislaus

Christopher De Vries
Hasn't logged in recently

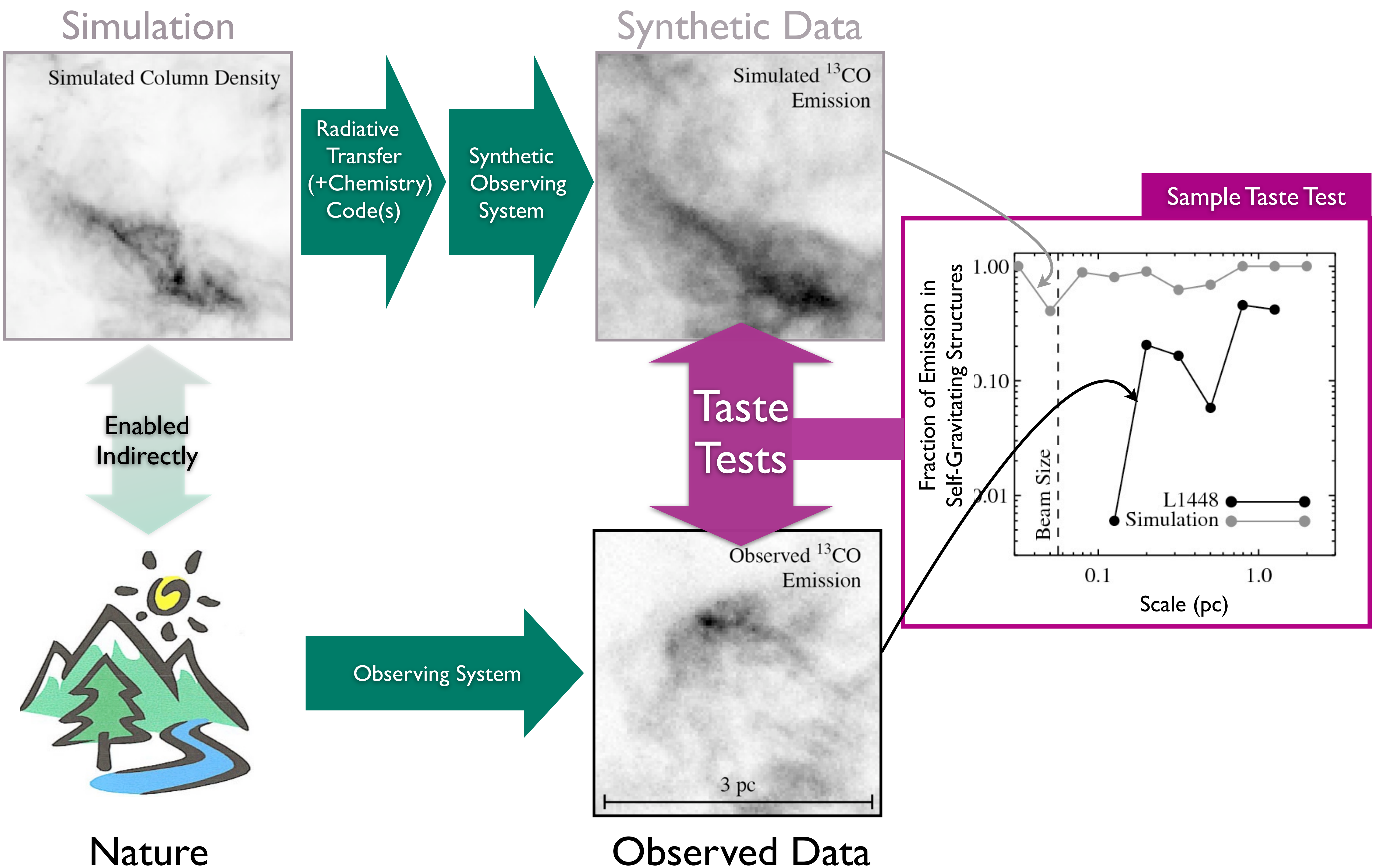
Calar Alto/MPI

Joao Alves
Hasn't logged in recently

Caltech

Scott Schnee
Hasn't logged in recently

The Taste-Testing Process



"Tasting"
The Role Self-Gravity in Star Formation

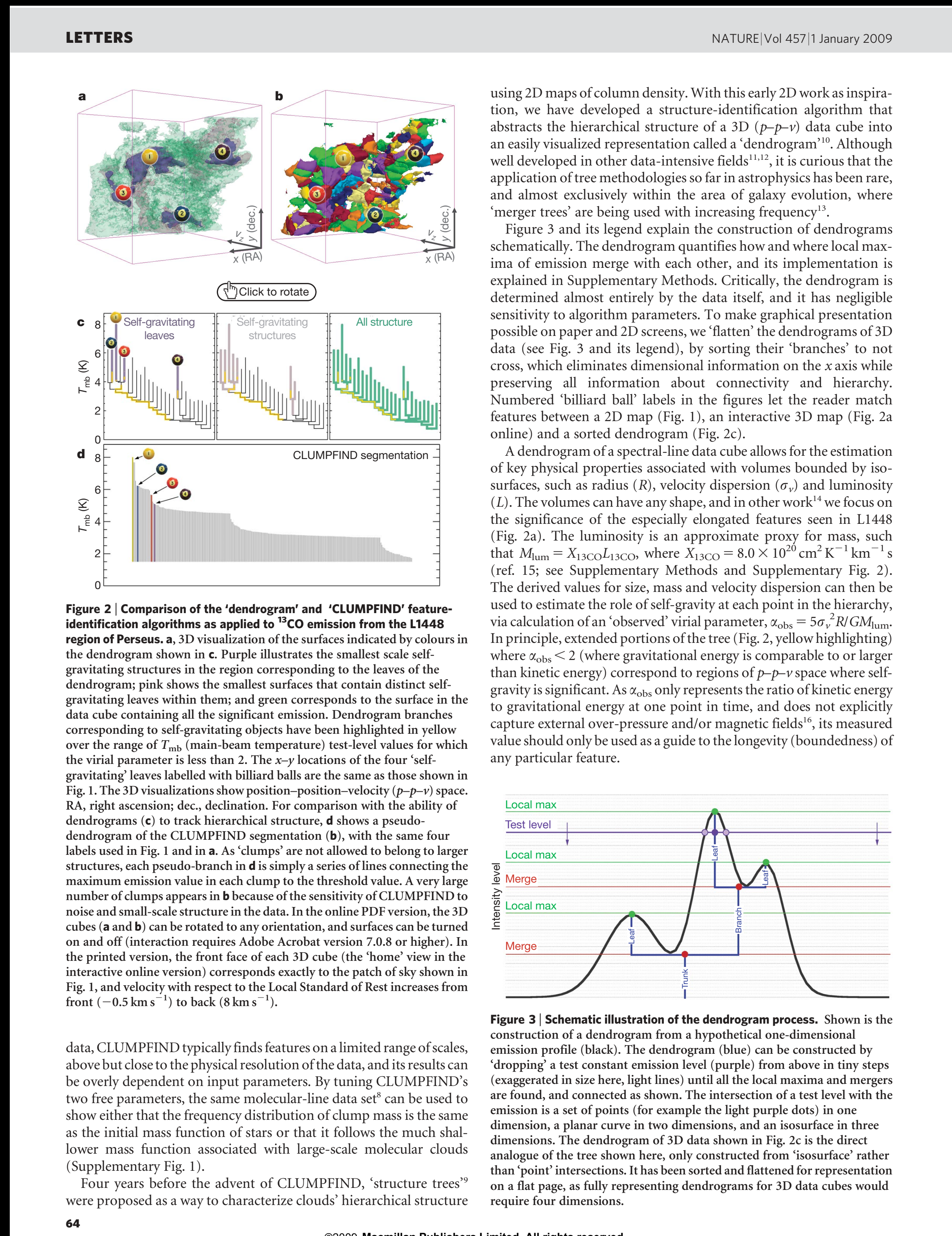


Figure 2 | Comparison of the 'dendrogram' and 'CLUMPFIND' feature-identification algorithms as applied to ^{13}CO emission from the L1448 region of Perseus. a, 3D visualization of the surfaces indicated by colours in the dendrogram shown in **c**. Purple illustrates the smallest scale self-gravitating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

data, CLUMPFIND typically finds features on a limited range of scales, above but close to the physical resolution of the data, and its results can be overly dependent on input parameters. By tuning CLUMPFIND's two free parameters, the same molecular-line data set[8] can be used to show either that the frequency distribution of clump mass is the same as the initial mass function of stars or that it follows the much shallower mass function associated with large-scale molecular clouds (Supplementary Fig. 1).

Four years before the advent of CLUMPFIND, 'structure trees'[9] were proposed as a way to characterize clouds' hierarchical structure using 2D maps of column density. With this early 2D work as inspiration, we have developed a structure-identification algorithm that abstracts the hierarchical structure of a 3D (p–p–v) data cube into an easily visualized representation called a 'dendrogram'[10]. Although well developed in other data-intensive fields[11,12], it is curious that the application of tree methodologies so far in astrophysics has been rare, and almost exclusively within the area of galaxy evolution, where 'merger trees' are being used with increasing frequency[13].

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

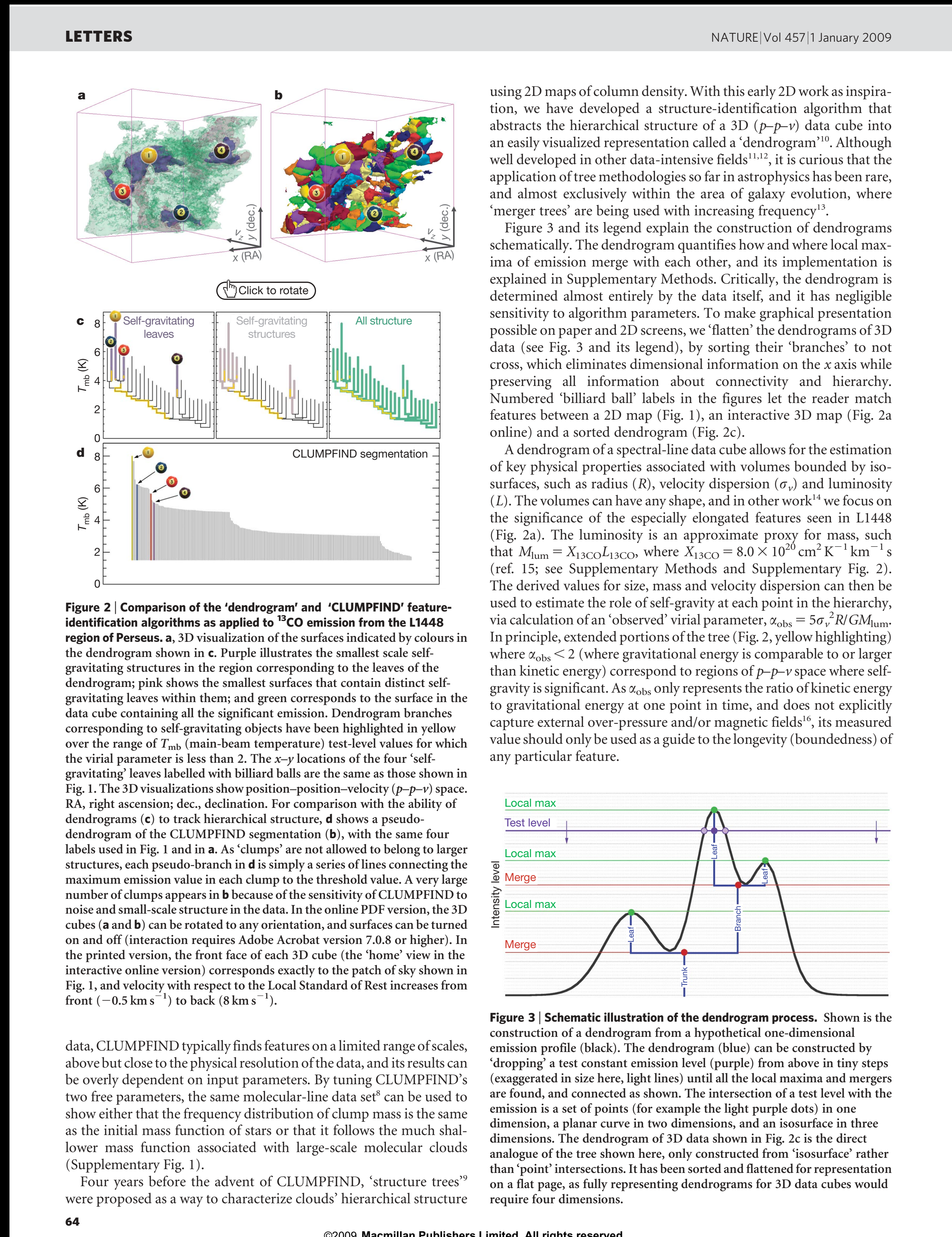
A dendrogram of a spectral-line data cube allows for the estimation of key physical properties associated with volumes bounded by isosurfaces, such as radius (R), velocity dispersion (σ_v) and luminosity (L). The volumes can have any shape, and in other work[14] we focus on the significance of the especially elongated features seen in L1448 (Fig. 2a). The luminosity is an approximate proxy for mass, such that $M_{lum} = X_{13CO}L_{13CO}$, where $X_{13CO} = 8.0 \times 10^{20}$ cm^2 K^{-1} km^{-1} s (ref. 15; see Supplementary Methods and Supplementary Fig. 2). The derived values for size, mass and velocity dispersion can then be used to estimate the role of self-gravity at each point in the hierarchy, via calculation of an 'observed' virial parameter, $\alpha_{obs} = 5\sigma_v^2 R/GM_{lum}$. In principle, extended portions of the tree (Fig. 2, yellow highlighting) where $\alpha_{obs} < 2$ (where gravitational energy is comparable to or larger than kinetic energy) correspond to regions of p–p–v space where self-gravity is significant. As α_{obs} only represents the ratio of kinetic energy to gravitational energy at one point in time, and does not explicitly capture external over-pressure and/or magnetic fields[16], its measured value should only be used as a guide to the longevity (boundedness) of any particular feature.

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

Goodman et al. *Nature*, 2009

The Future
(is now)

Data “In” the Literature: 3D PDF



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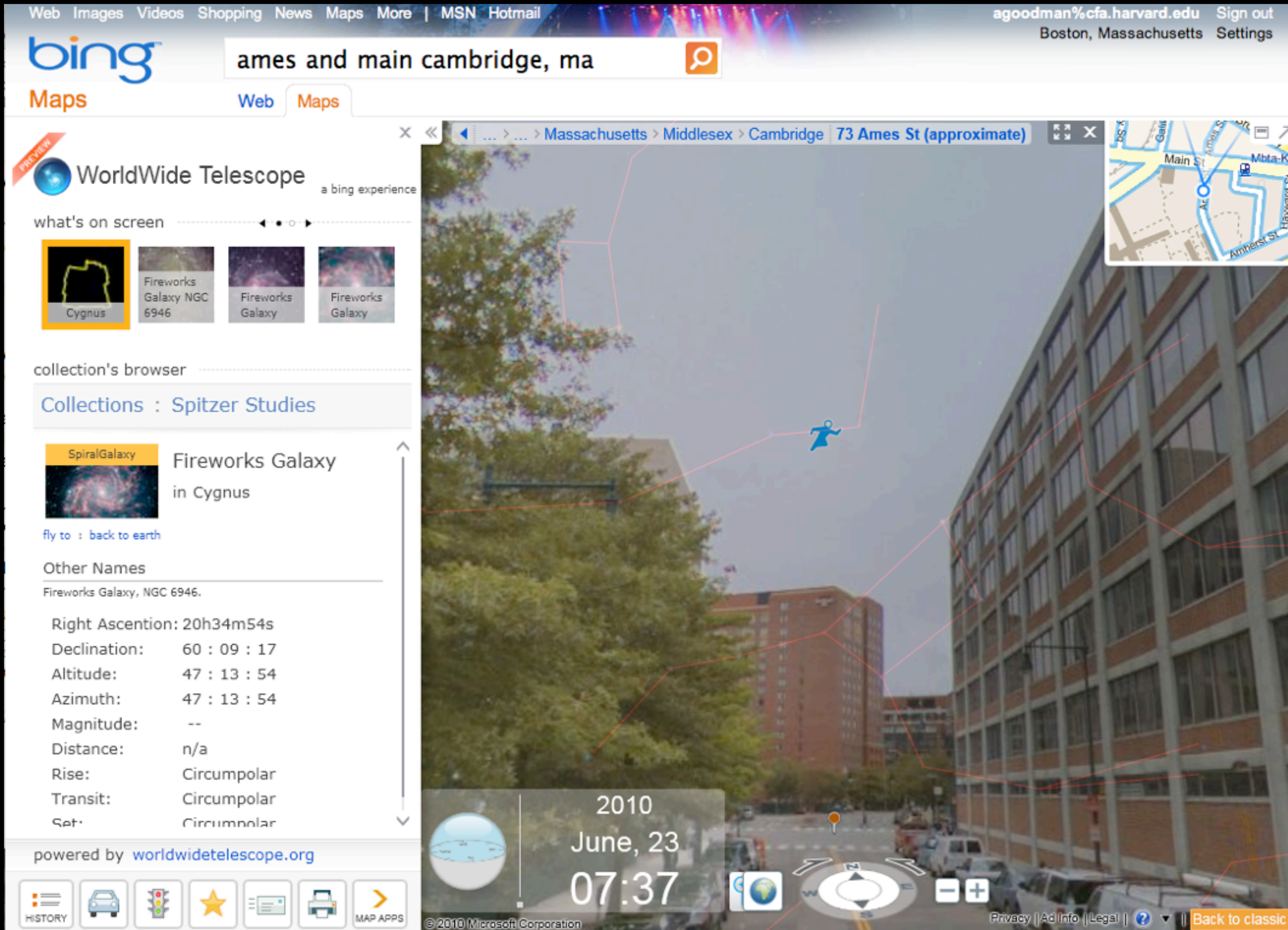
Data Integration, Everywhere



Map apps (25)

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ALL APPS

- virtualglobetrotting.com — Roadside sculptures
- virtualglobetrotting.com — Urban graffiti
- virtualglobetrotting.com — Roadside attractions
- Bing — Hotel finder
- webcams.travel — Travel webcams
- Bing — Oodle Rentals
- Bing — Bing Maps World Tour
- Bing — foursquare Everywhere
- virtualglobetrotting.com — Urban murals
- virtualglobetrotting.com — Signs & billboards
- trafficland.com — TrafficLand
- Bing — Haiti earthquake
- Bing — Current traffic
- Bing — What's nearby
- Bing — Streetside Photos
- Bing — Winter Games
- Bing — Restaurant finder
- Newseum — Today's front pages
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- Microsoft Research — Destination Maps (tech preview)


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scientists' discovery room lab (sdr lab)

Lead investigators
Chia Shen (IIC) and Hanspeter Pfister (SEAS/IIC)

Project staff
Michael Horn, Meekal Bajaj, Matthew Tobiasz and Matthias Lee

Description

The Scientists' Discovery Room (SDR) is a next-generation visual digital laboratory for science discovery, collaborative learning and education. Our research focuses on experimenting with new modalities of human-computer interaction and visualization, to create a new genre of navigation, exploration and detailed analyses in multi-dimensional information spaces. All projects in SDR are in close collaboration with domain scientists and educators.

INVOLV is a generalizable multi-user interactive visualization framework for large hierarchical data sets. In this project, we address the visual layout of both the primary data representation and the overlay of alternate structures of the same data. Our first case study is the visualization of life on earth based on the Encyclopedia of Life (www.eol.org) and Tree of Life (www.tolweb.org). The user interface provides free-form exploration of more than 1.2 million named species while communicating issues of biodiversity and phylogeny. The current visualization combines a Voronoi Treemap tessellation with innovative human-computer interaction designs to support collaborative exploration and learning. Please visit www.involvweb.org for more information on this project.

CThru, a collaborative endeavor with Molecular and Cellular Biology faculty, aims to develop a self-guided learning environment. In CThru, we examine methods for constructing interactive video-based educational modules. Using the animation "The Inner Life of the Cell" as a testbed, CThru addresses research issues of embedding interactive visible objects, extensive multimedia information and manipulatable 3D models within a video flow, replacing sequential video viewing with the experience of exploring and manipulating in a multi-dimentional information space.

WeSpace is a collaborative work space that integrates a large data wall with a multi-user multi-touch table. WeSpace has been developed for a population of scientists who frequently meet in small groups for data exploration and visualization. It provides a low overhead walk-up and share environment for users with their own personal applications and laptops.

LivOlay is an interactive image overlay tool that enables the rapid visual overlay of live data rendered in different applications. Our tool addresses datasets in which visual registration of the information is necessary in order to allow for thorough understanding and visual analysis.

Slideshow: Tabletop Computers *Continued*

By Meredith Ringel Morris

First Published December 2008

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PHOTO: HAO JIANG, DANIEL WIGDOR, CLIFTON FORLINES, AND CHIA SHEN

UBITABLE: Users can interact with surface computers through auxiliary devices, such as laptops, phones, and PDAs. The display on the auxiliary device can convey private or sensitive content to a single user, while group-appropriate content can appear on the tabletop display. Chia Shen and her colleagues at Mitsubishi Electric Research Laboratories, in Cambridge, Mass., have explored auxiliary interactions with surface computers in their UbiTable project, in which two people with laptops collaborate over a tabletop display. Recently, Shen expanded the UbiTable into an interactive room called the WeSpace. People can share data on their laptops with other people in the room, using both a table and a large display wall. Here, three Harvard University astrophysicists discuss radio and IR spectrum images using the WeSpace.

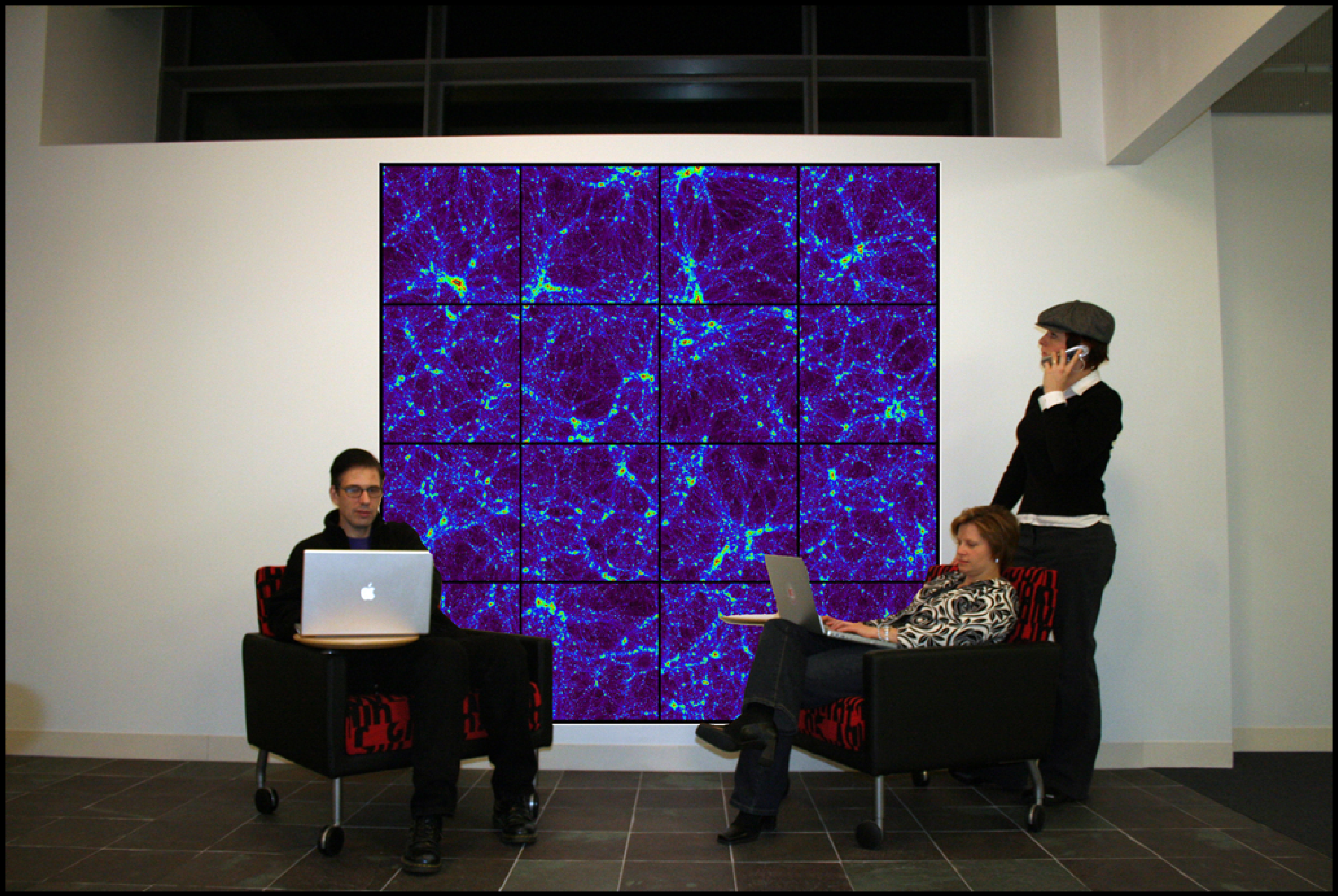
http://iic.harvard.edu/research/scientists-discovery-room-lab-sdr-lab

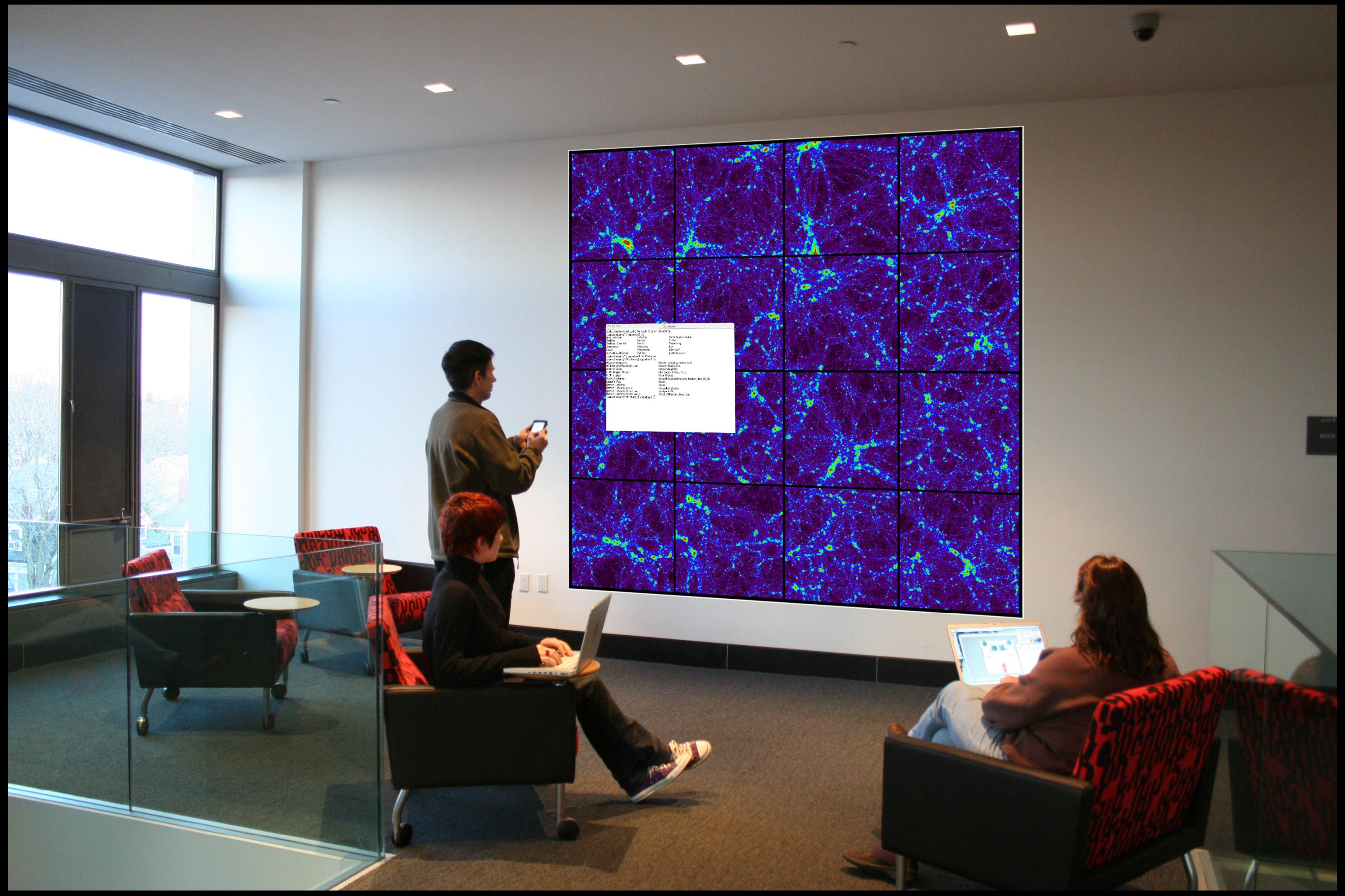
http://spectrum.ieee.org/dec08/6999/9

The Scientists' Discovery Room
(Shen & Pfister)

movie courtesy Daniel Wigdor, equipment now in Chia Shen's SDR lab at Harvard SEAS

"This is not art."





What can we observe?

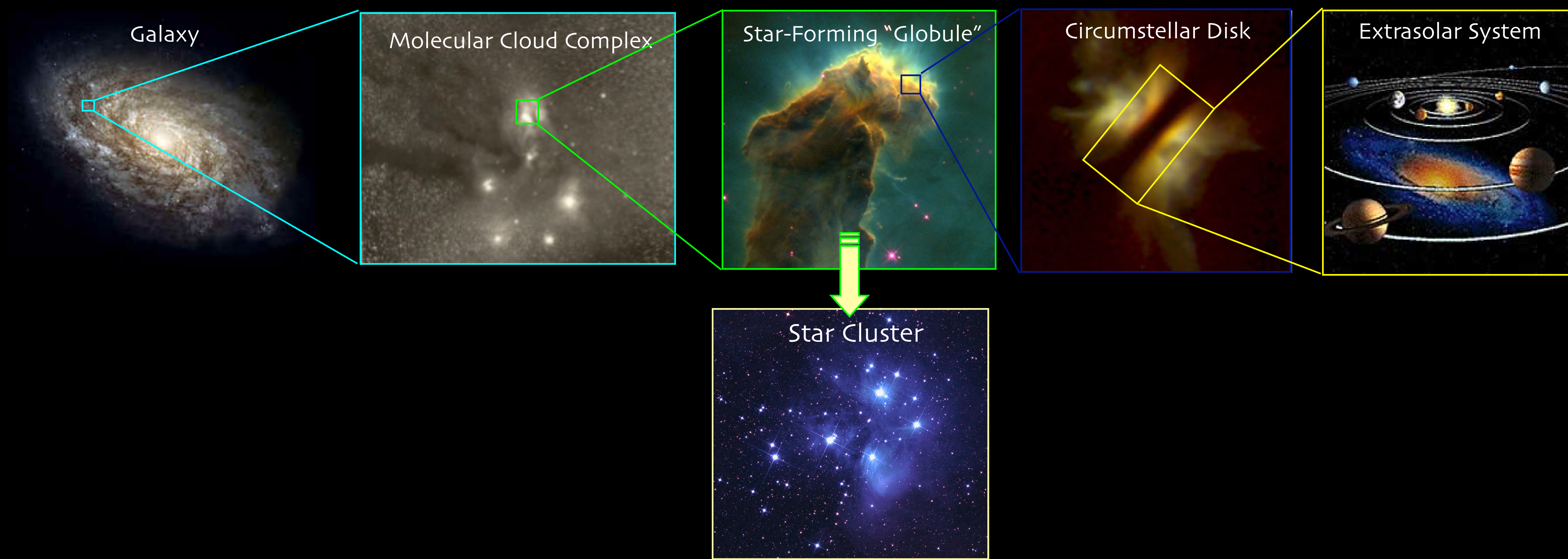
What can we “see”?

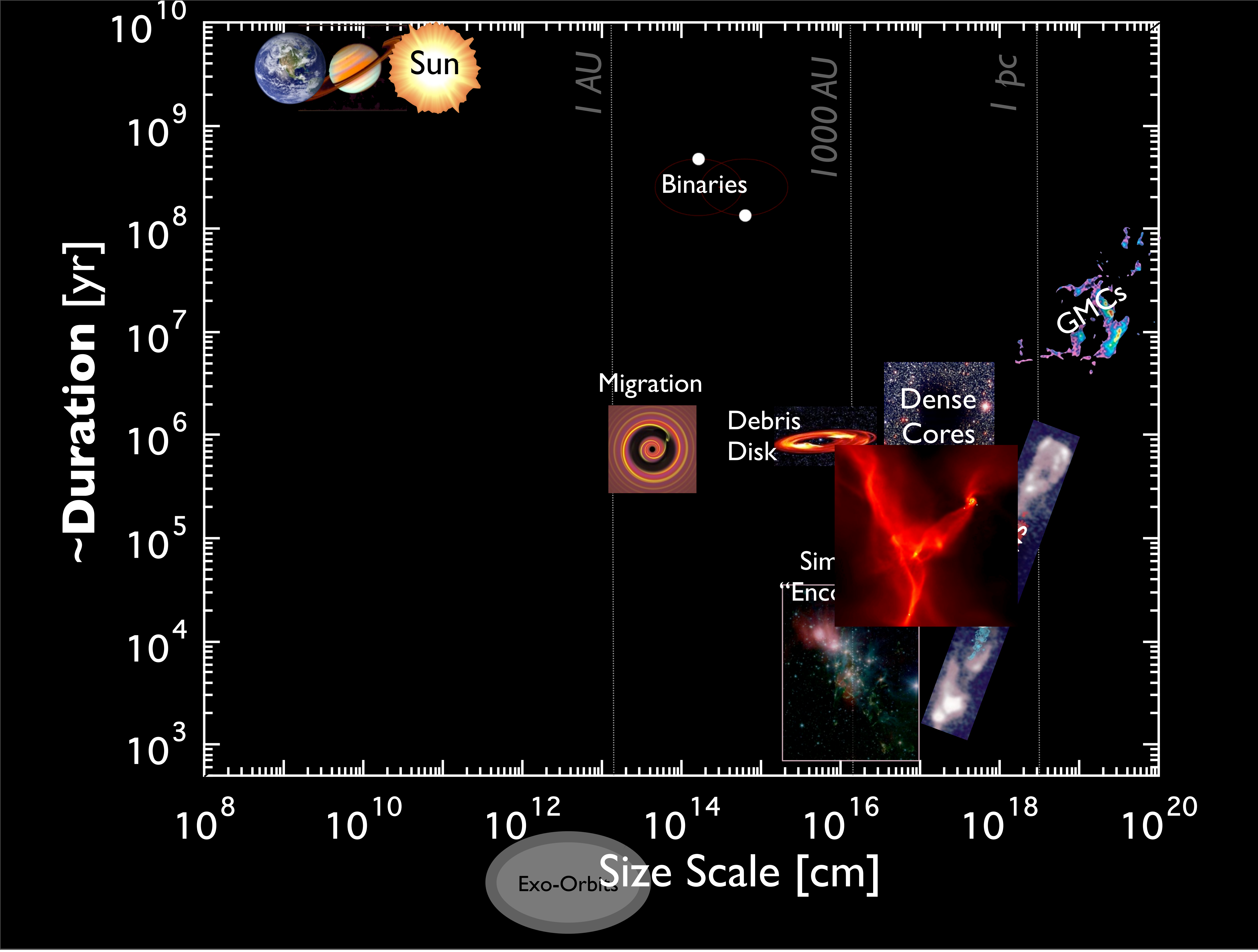
What can we imagine?

What can we explain?

Info(rmation) Graphics

Star (and Planet, and Moon) Formation 101

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Sun
Binaries
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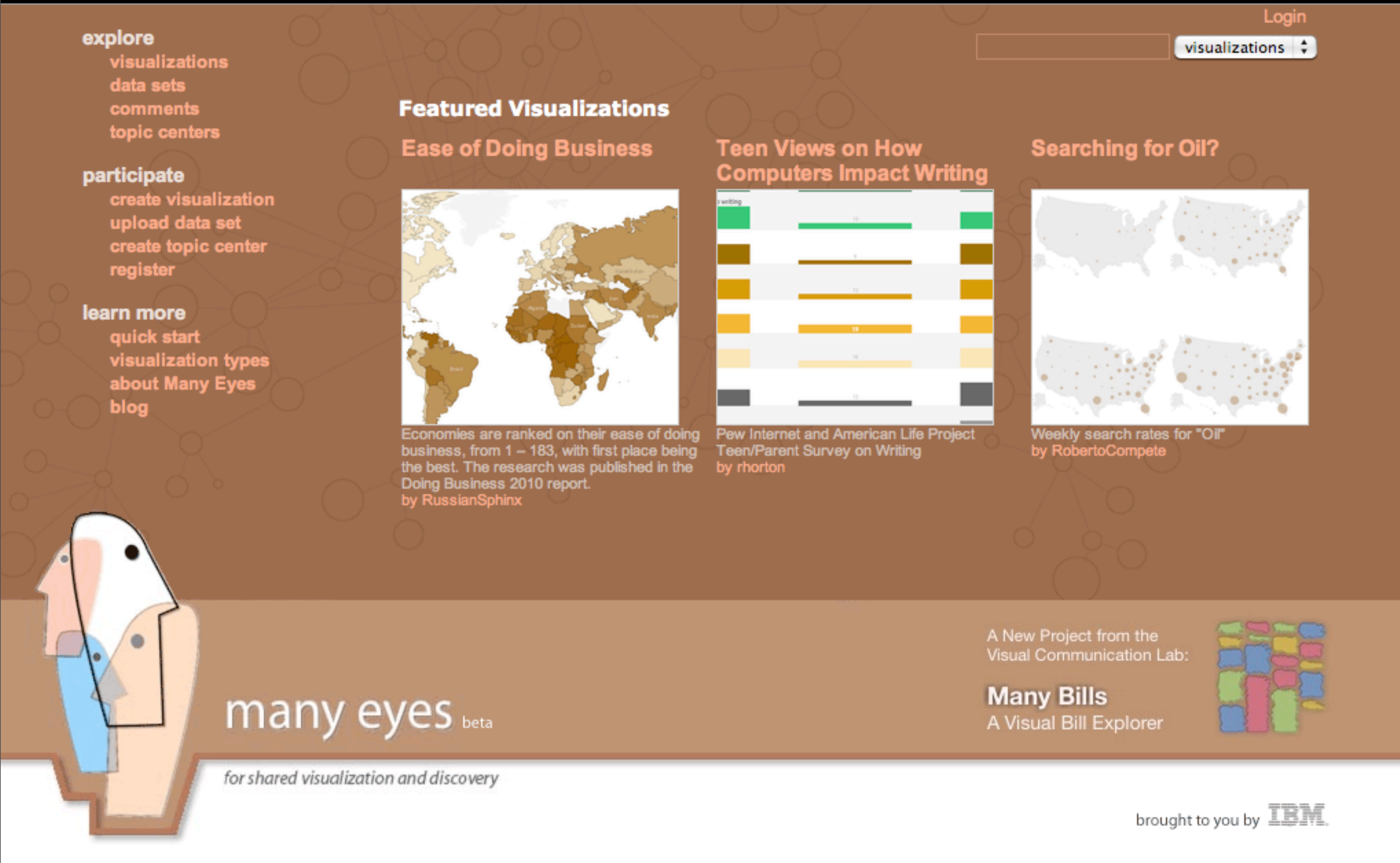
Migration
Dense Cores
Debris Disk
Exo-Orbits

Many Eyes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Economies are ranked on their ease of doing business, from 1 – 183, with first place being the best. The research was published in the Doing Business 2010 report.
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Searching for Oil?
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A Visual Bill Explorer
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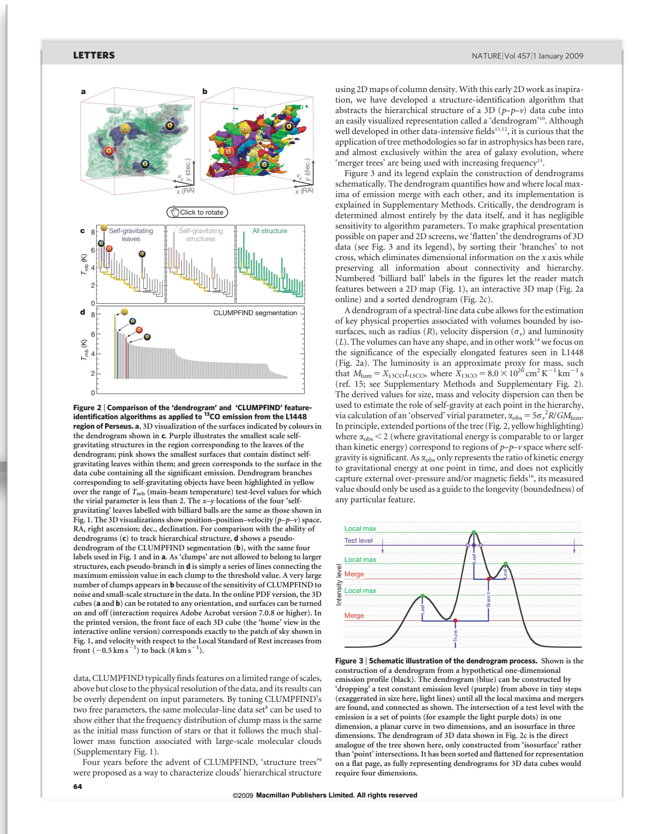
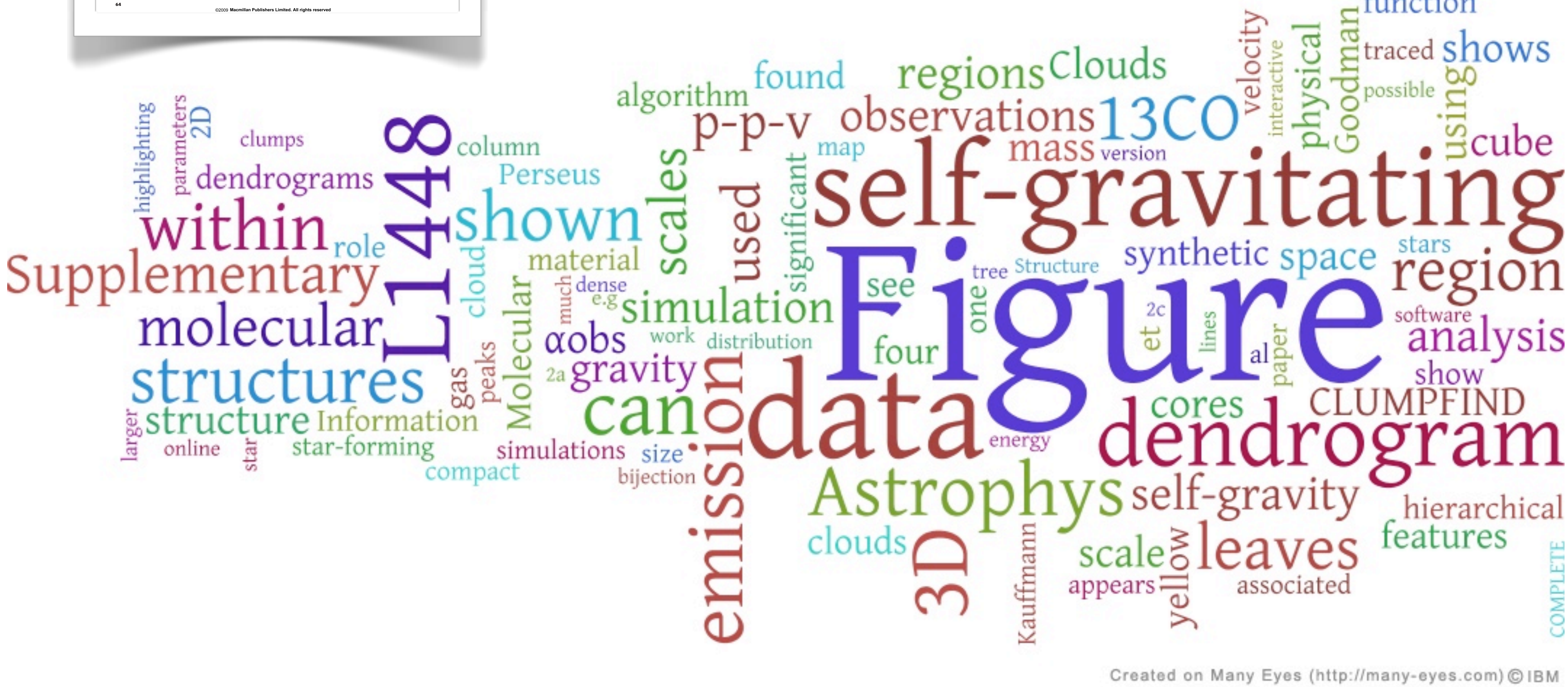
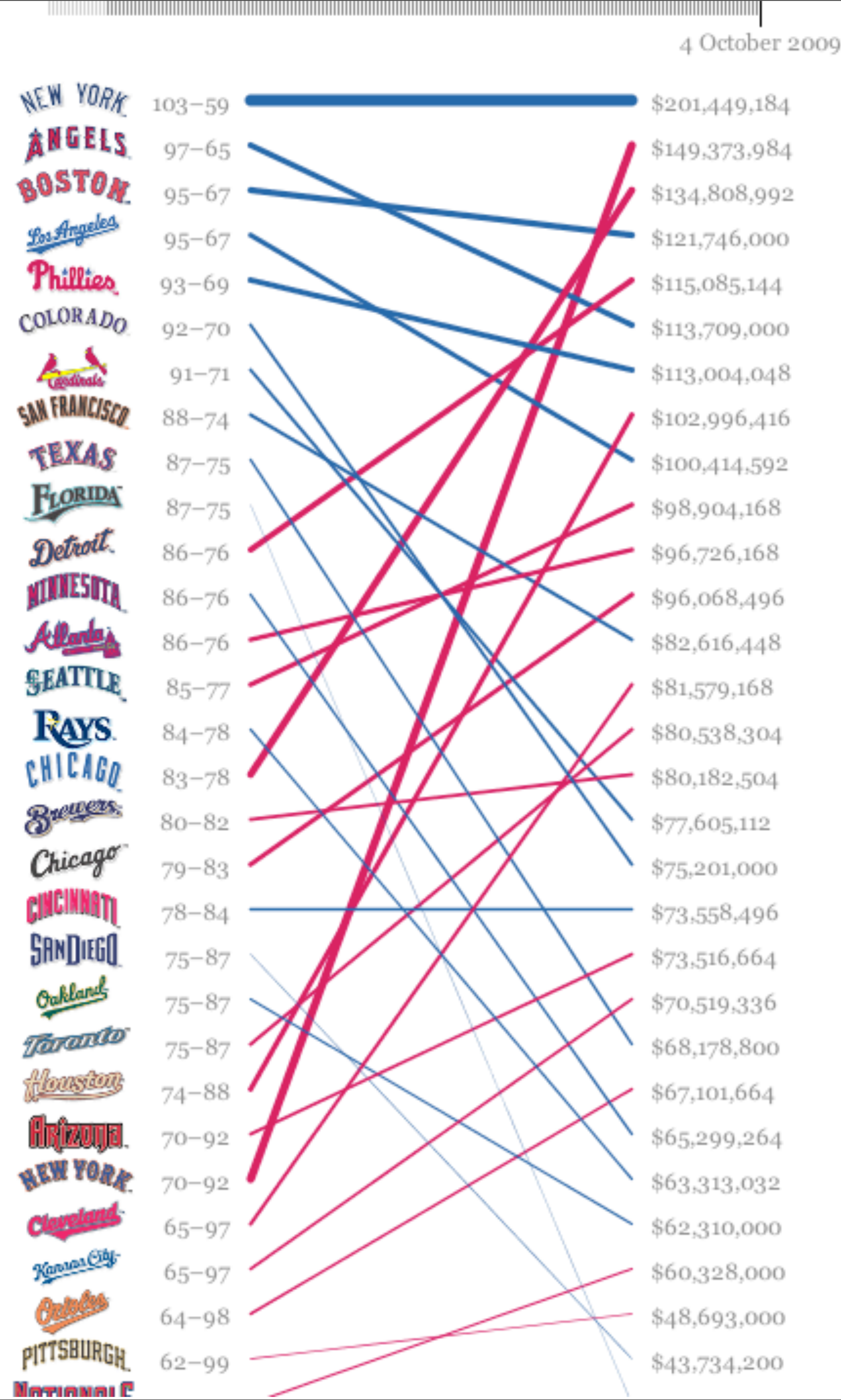
What Many Eyes thinks our "3D PDF" paper on self-gravity in hierarchical star-forming regions is about...





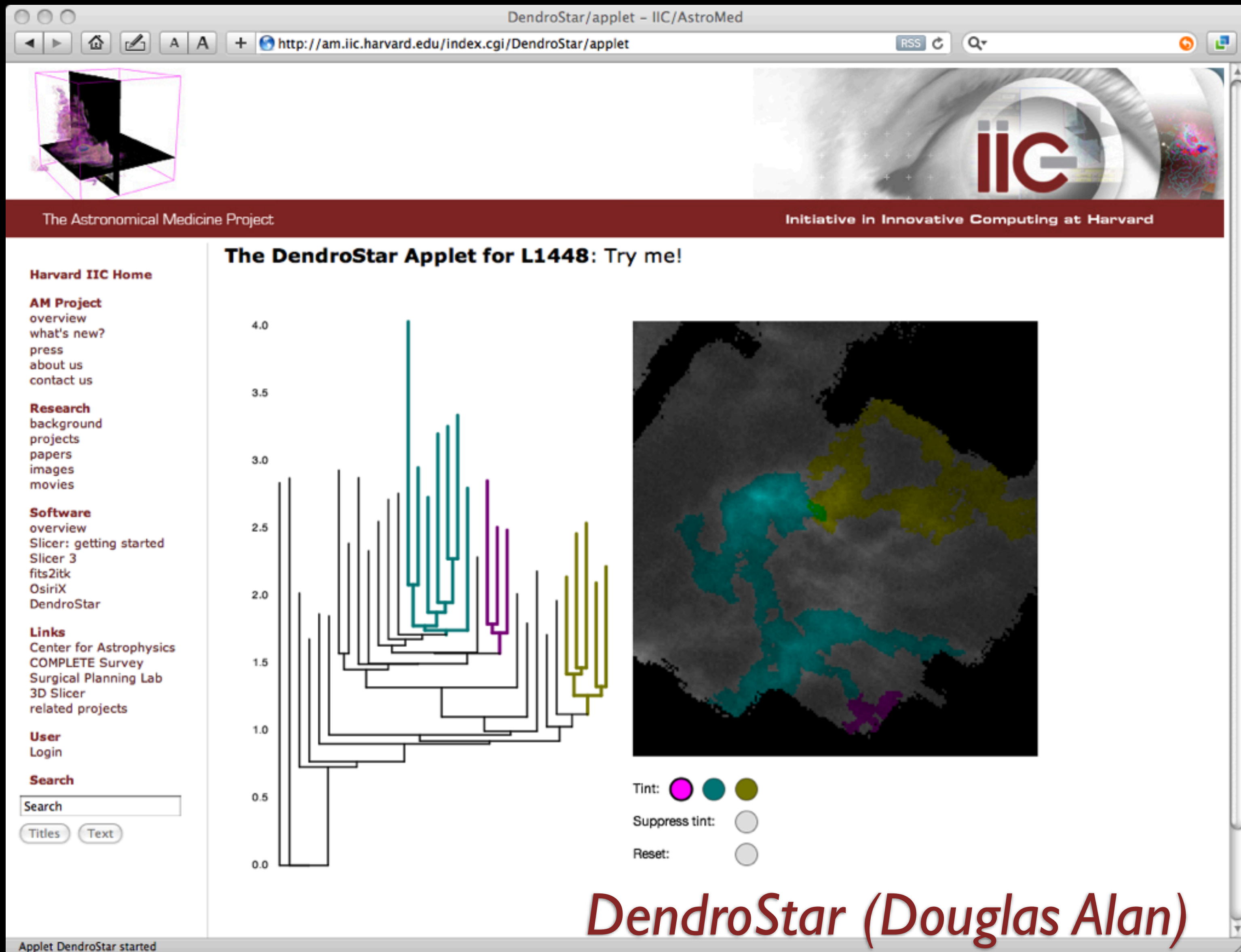
Ben Fry's MLB 2009

benfry.com

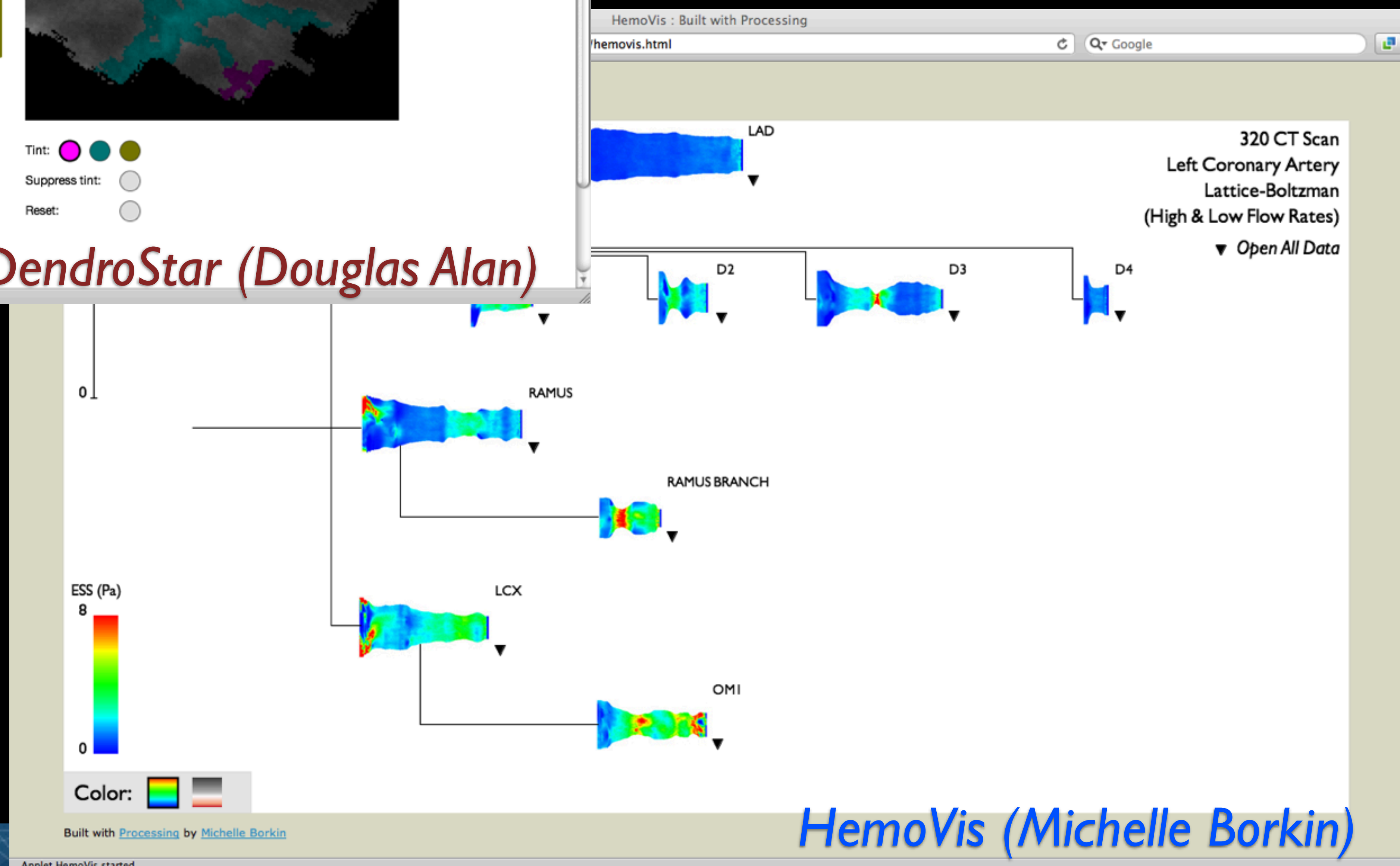


“Made with *Processing*”

(see Reas & Fry 2006)

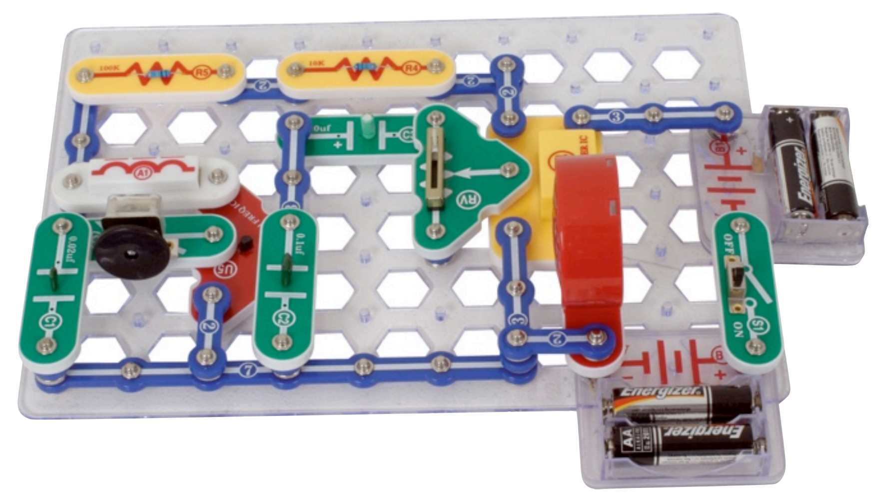


DendroStar (Douglas Alan)



HemoVis (Michelle Borkin)

← Processing



The Future: A *Modular, Personalizable*, Approach

Image ssc2003-06f

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

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Media Contacts

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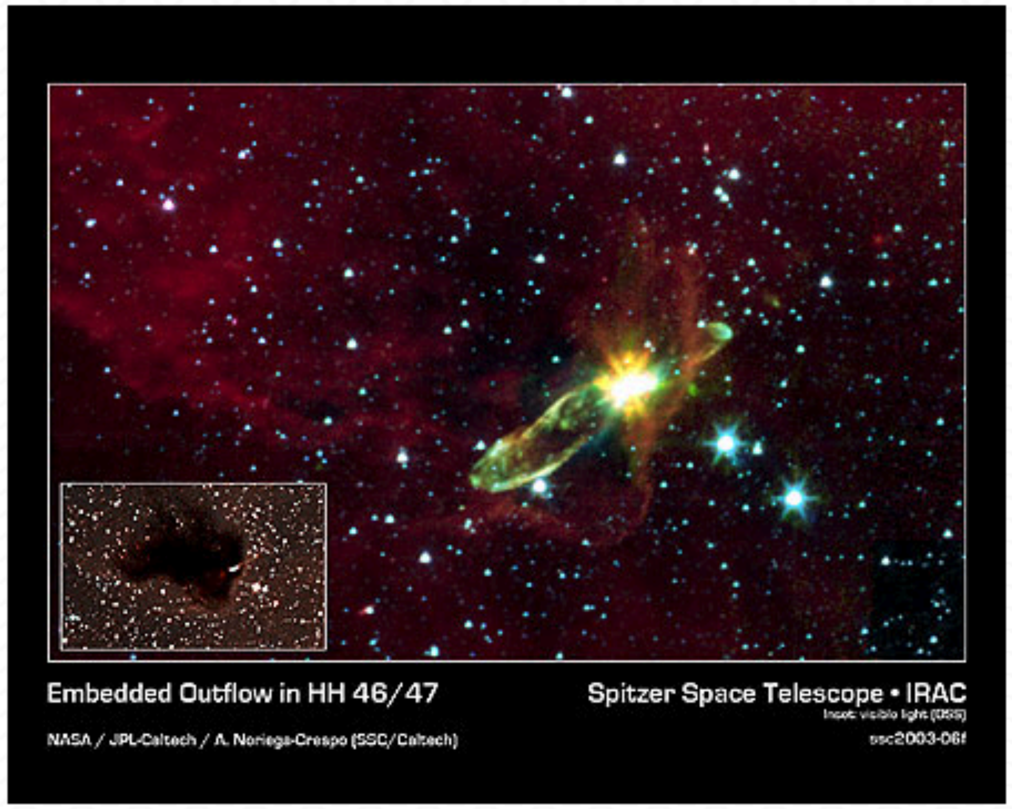


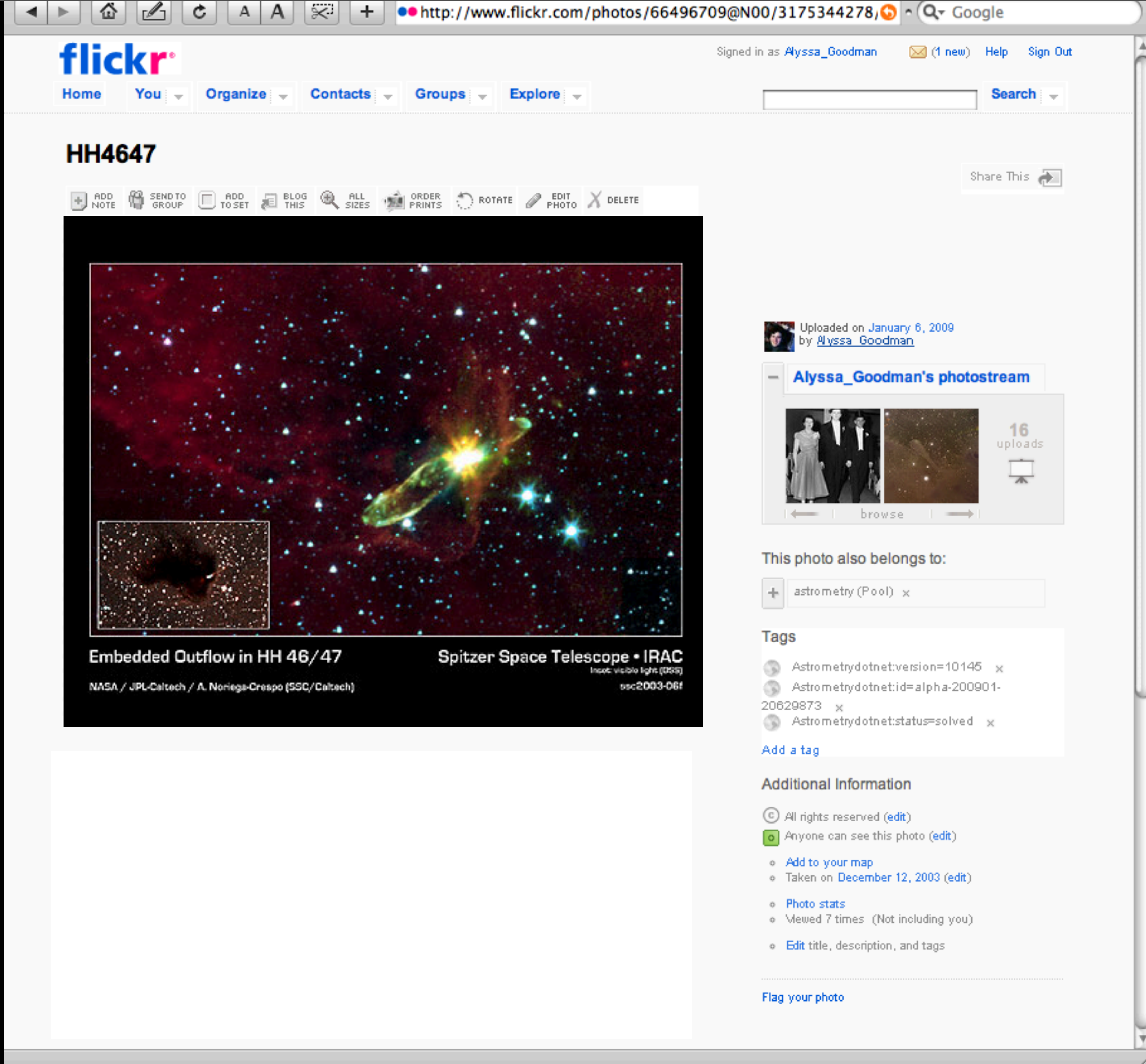
Credit: NASA/JPL-Caltech/A. Noriega-Crespo (SSC/Caltech), Digital Sky Survey

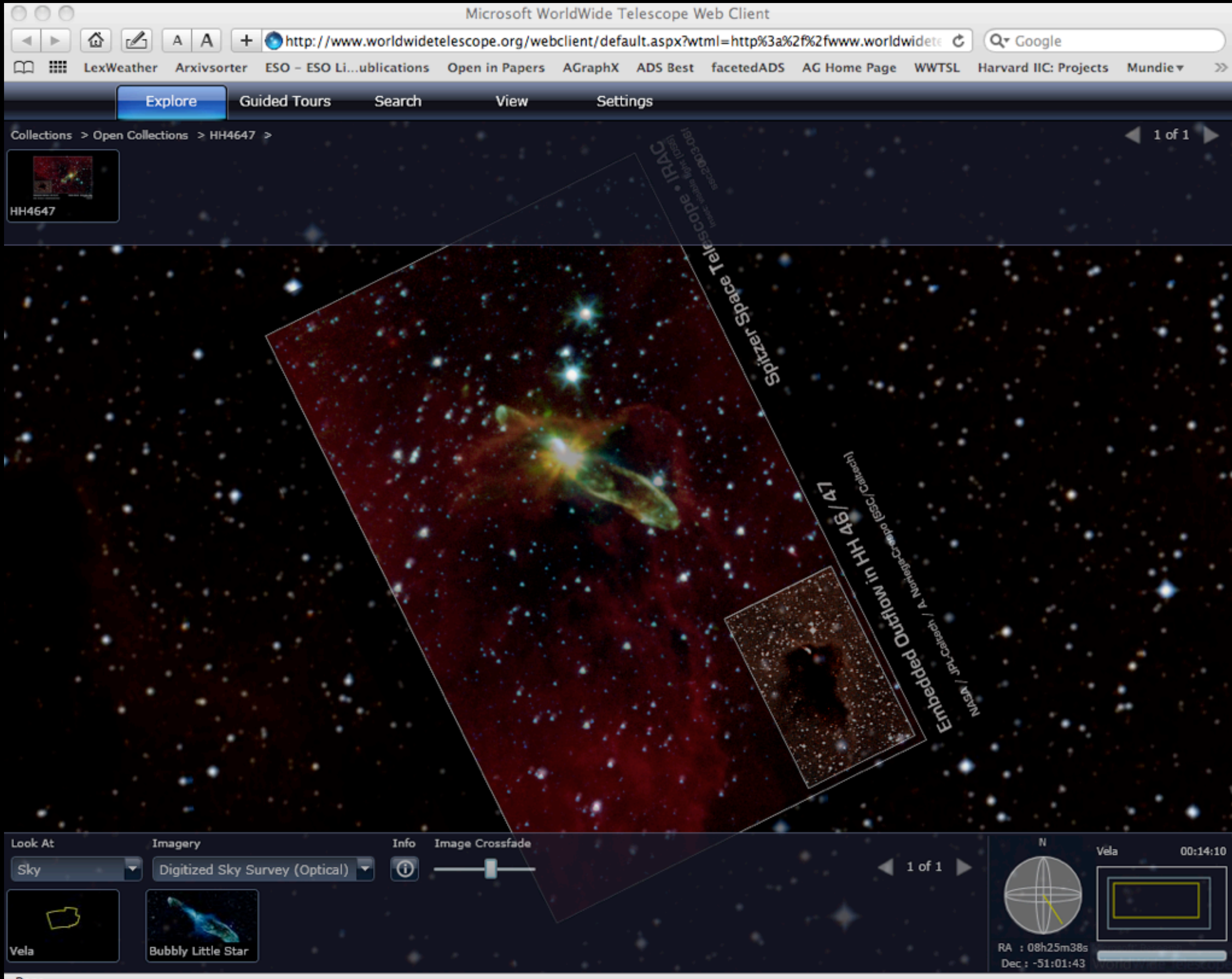
HH46/47

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

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

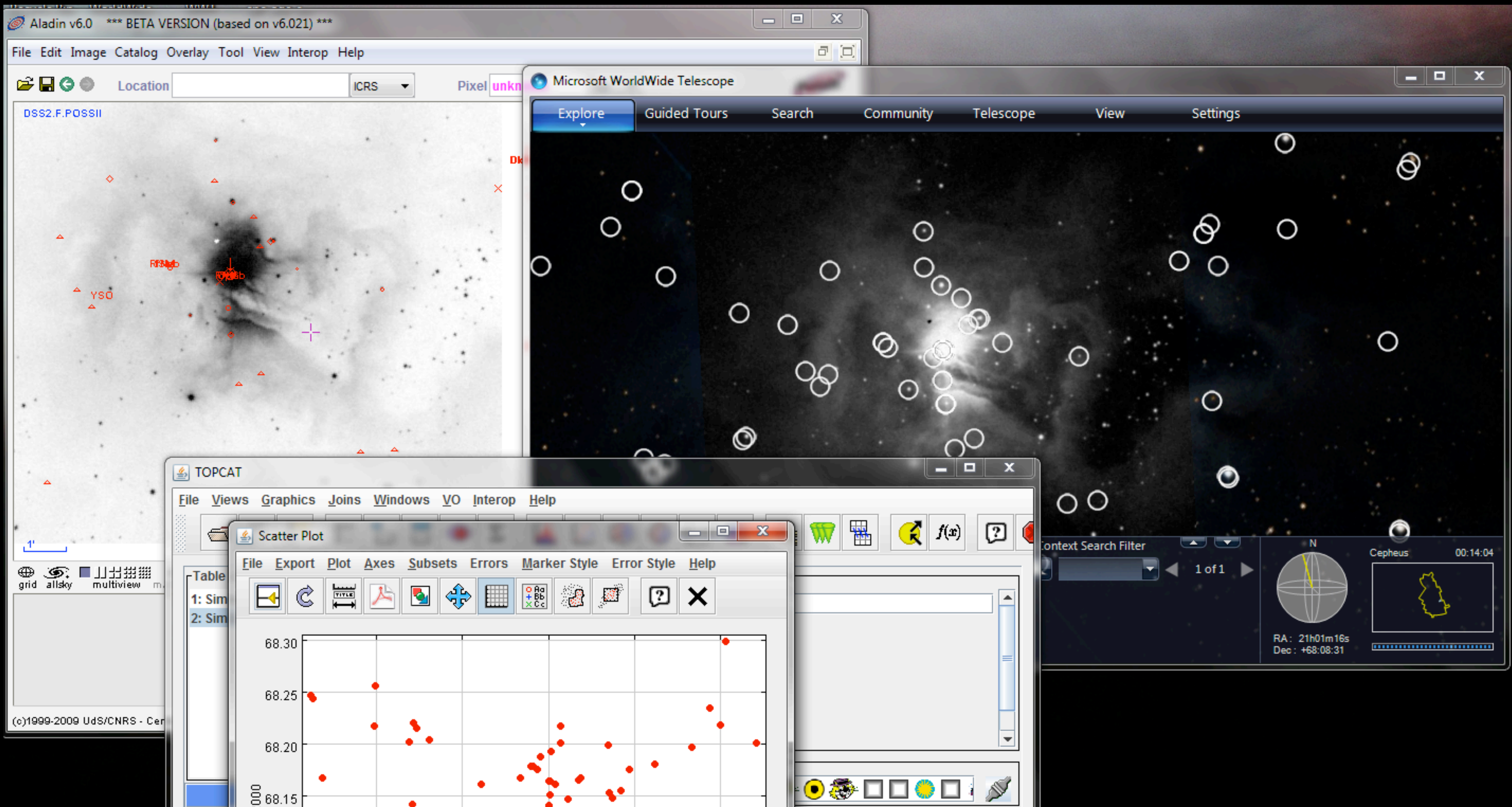
HH 46/47 is a striking example of a low-mass protostar ejecting a jet and creating a bipolar, or two-sided, outflow. The central


http://www.flickr.com/photos/66496709@N00/3175344278/
Google
flickr
Signed in as Alyssa_Goodman
(1 new)
Help
Sign Out
Home
You
Organize
Contacts
Groups
Explore
Search
HH4647
Share This
ADD NOTE
SEND TO GROUP
ADD TO SET
BLOG THIS
ALL SIZES
ORDER PRINTS
ROTATE
EDIT PHOTO
DELETE
Embedded Outflow in HH 46/47
Spitzer Space Telescope • IRAC
NASA / JPL-Caltech / A. Noriega-Crespo (SSC/Caltech)
ssc2003-06f
Uploaded on January 6, 2009
by Alyssa_Goodman
Alyssa_Goodman's photostream
16 uploads
browse
This photo also belongs to:
astrometry (Pool)
Tags
Astrometrydotnet:version=10145
Astrometrydotnet:id=alpha-200901-20629873
Astrometrydotnet:status=solved
Add a tag
Additional Information
All rights reserved (edit)
Anyone can see this photo (edit)
Add to your map
Taken on December 12, 2003 (edit)
Photo stats
Viewed 7 times (Not including you)
Edit title, description, and tags
Flag your photo

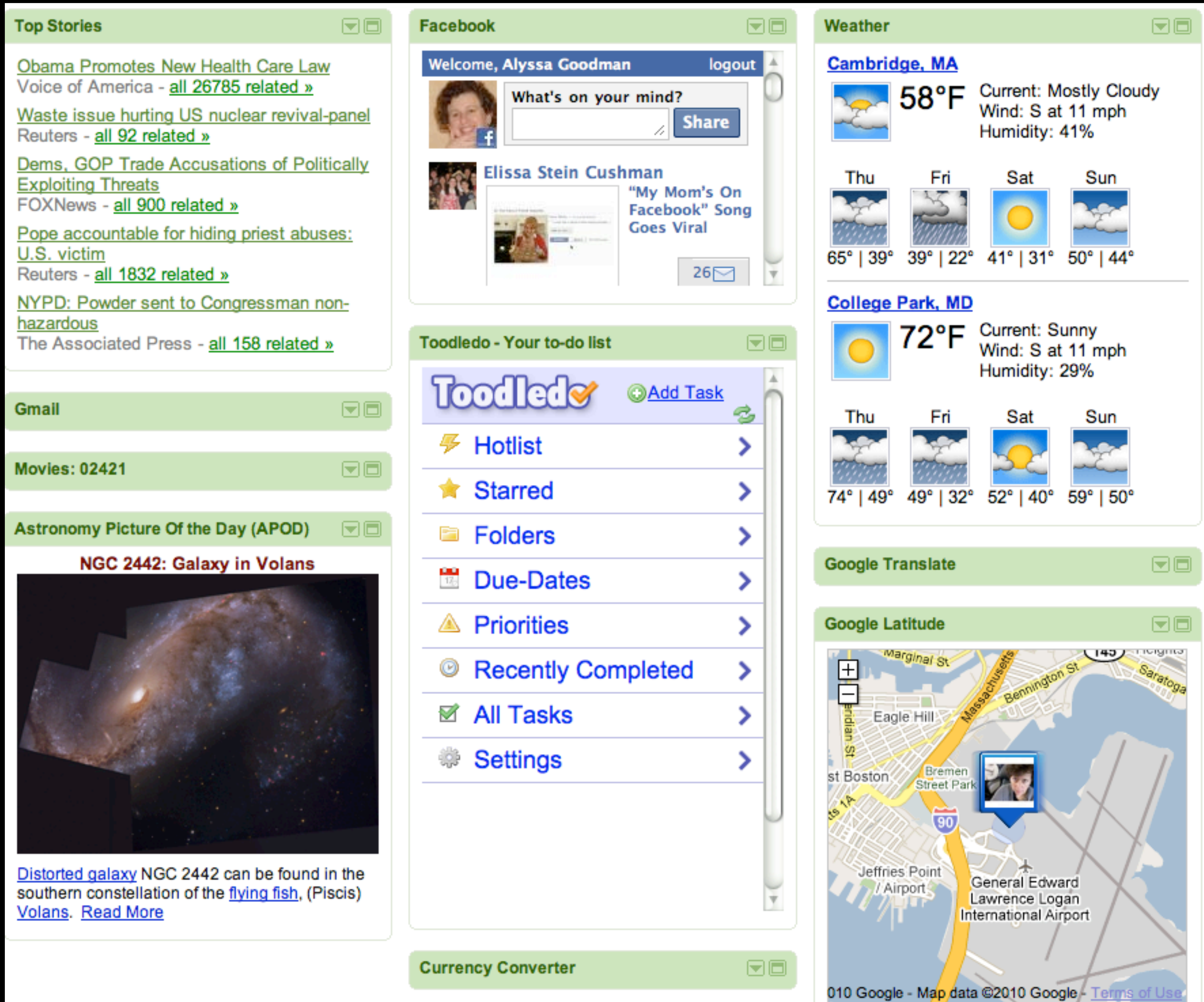

Microsoft WorldWide Telescope Web Client
http://www.worldwidetelescope.org/webclient/default.aspx?wtml=http%3a%2f%2fwww.worldwide
LexWeather Arxivsorter ESO - ESO Li...ublications Open in Papers AGraphX ADS Best facetedADS AG Home Page WWTSL Harvard IIC: Projects Mundie
Explore Guided Tours Search View Settings
Collections > Open Collections > HH4647 >
1 of 1
HH4647
Spitzer Space Telescope • IRAC
Embedded Outflow in HH 46/47
Look At
Sky
Imagery
Digitized Sky Survey (Optical)
Info
Image Crossfade
Vela
Bubbly Little Star
N
RA : 08h25m38s
Dec : -51:01:43
00:14:10
Done

SAMP

(message-passing enabling apps to hear each other)



iGoogle



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Hotlist
Starred
Folders
Due-Dates
Priorities
Recently Completed
All Tasks
Settings
Currency Converter
Weather
Cambridge, MA
58°F
Current: Mostly Cloudy
Wind: S at 11 mph
Humidity: 41%
Thu Fri Sat Sun
65° | 39° 39° | 22° 41° | 31° 50° | 44°
College Park, MD
72°F
Current: Sunny
Wind: S at 11 mph
Humidity: 29%
Thu Fri Sat Sun
74° | 49° 49° | 32° 52° | 40° 59° | 50°
Google Translate
Google Latitude
Marginal St
Bennington St
Saratoga
Massachusetts
Eagle Hill
Bremen Street Park
90
Jeffries Point / Airport
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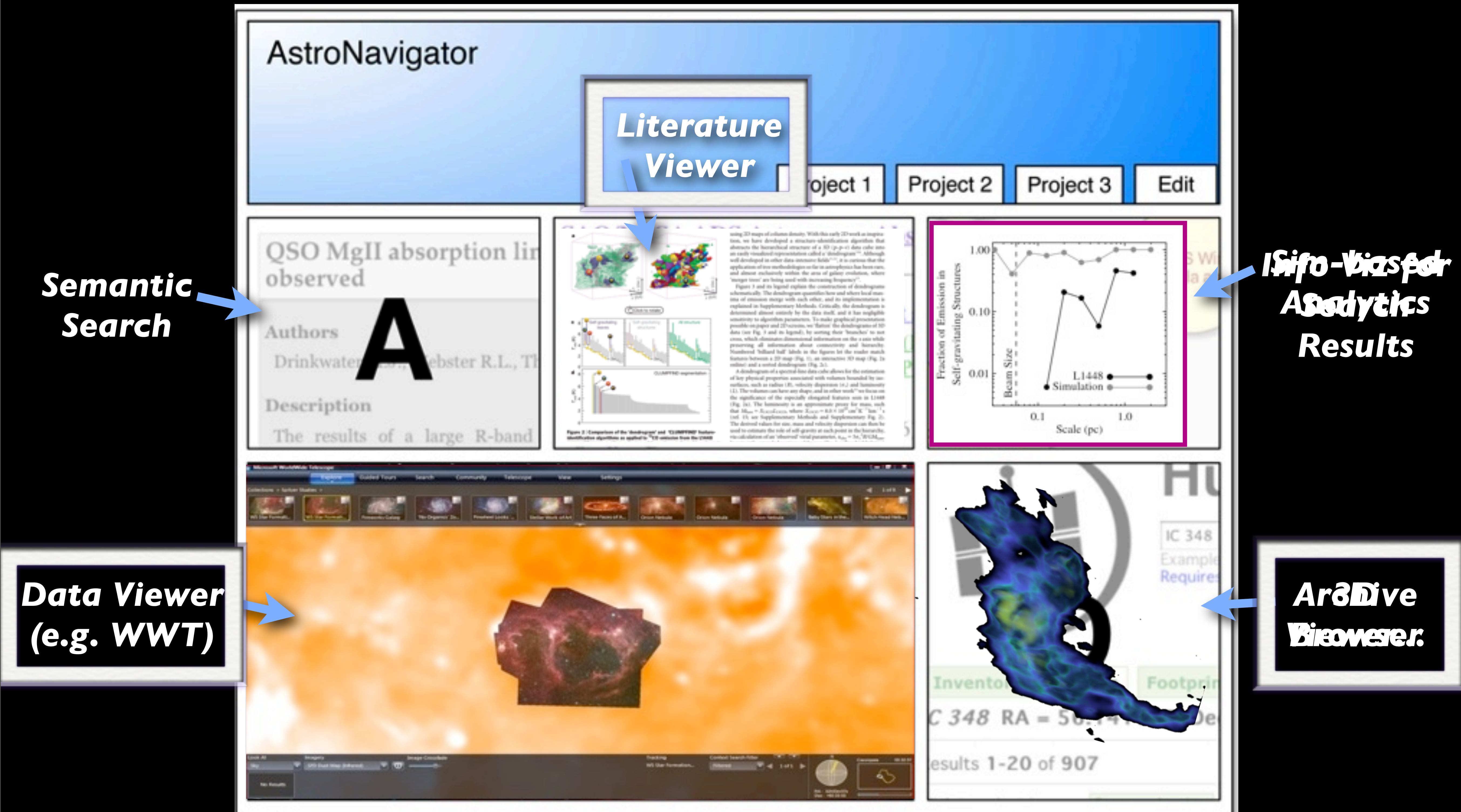
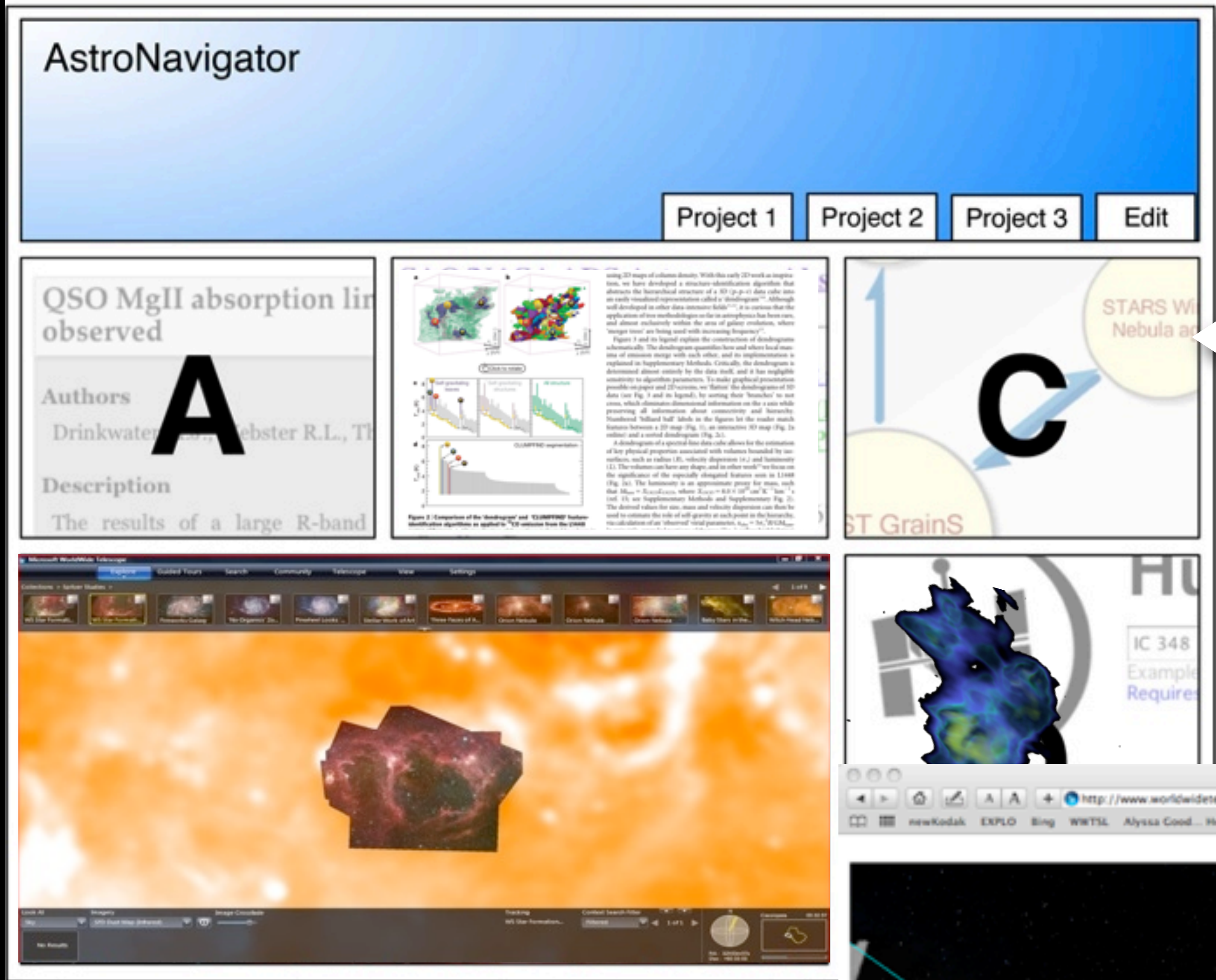
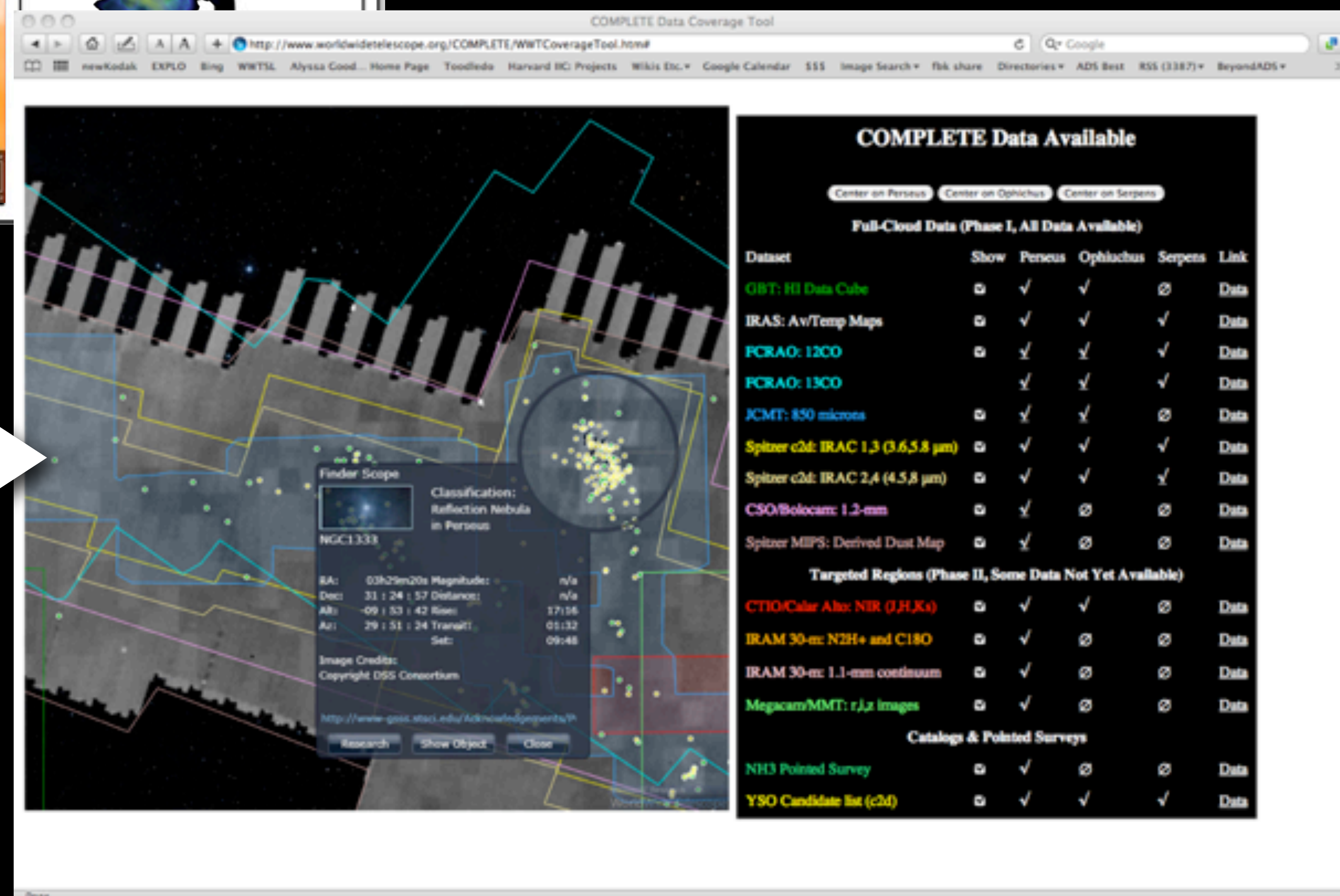
Seamless Astronomy



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



Fiction
(for now)



Fact
(right now)

WorldWide Telescope Ambassadors Program

Happy to talk about this too...

Alyssa Goodman

Harvard University Professor of Astronomy,
WGBH Scholar-in-Residence, Microsoft Academic Partner

Annie Valva

WGBH Interactive, Director of Research & Development

Pat Udomprasert

WWT Program Coordinator

Cognition

"Tools"

Nature

Cognition — "Tools" — Nature