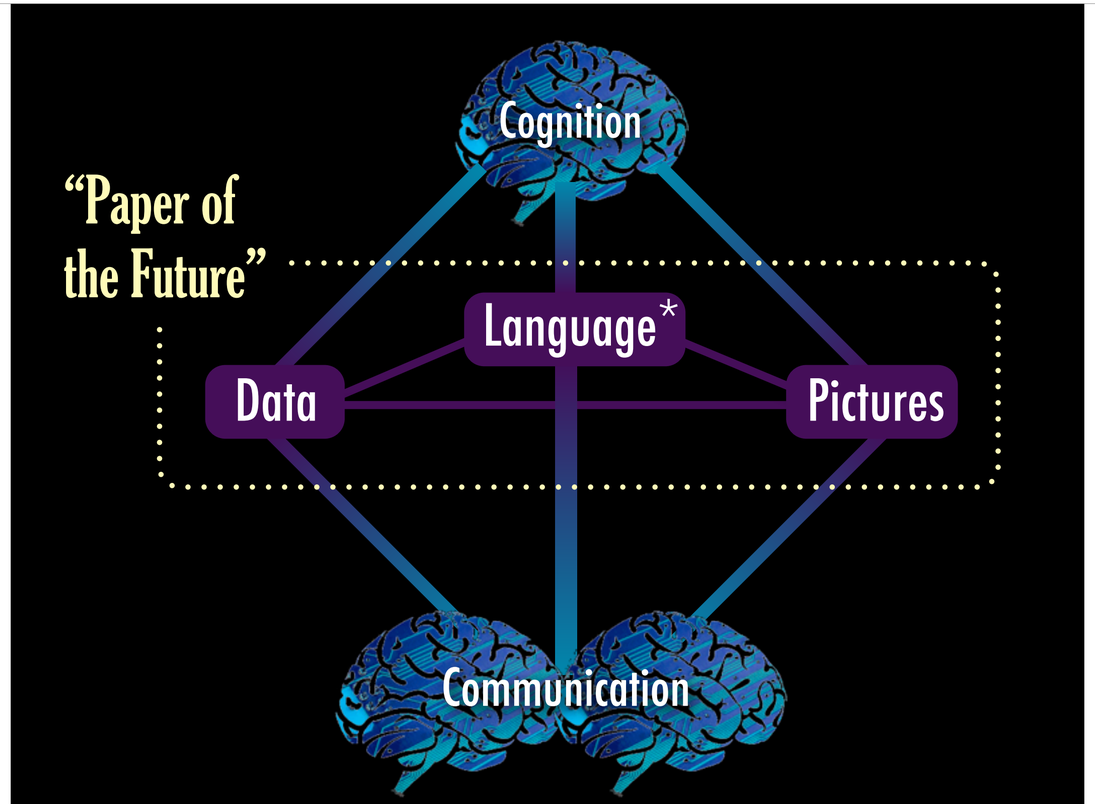
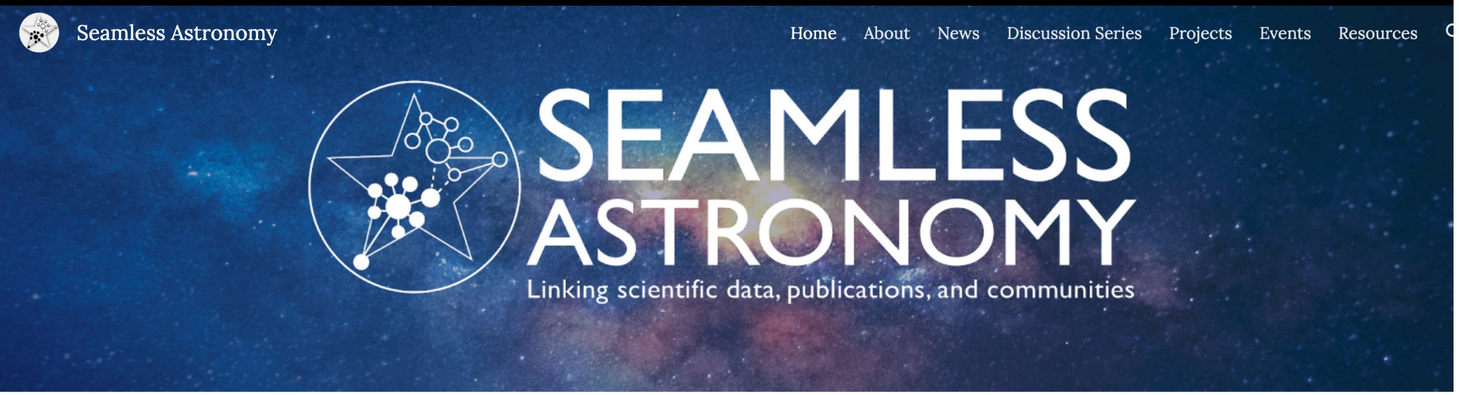
Seamless linkages (between data archives) for visualization and analysis (@AAS 2024)

Alyssa Goodman
Center for Astrophysics
| Harvard & Smithsonian



LIVE Astro

“Linking Scientific Data, Publications, and Communities”

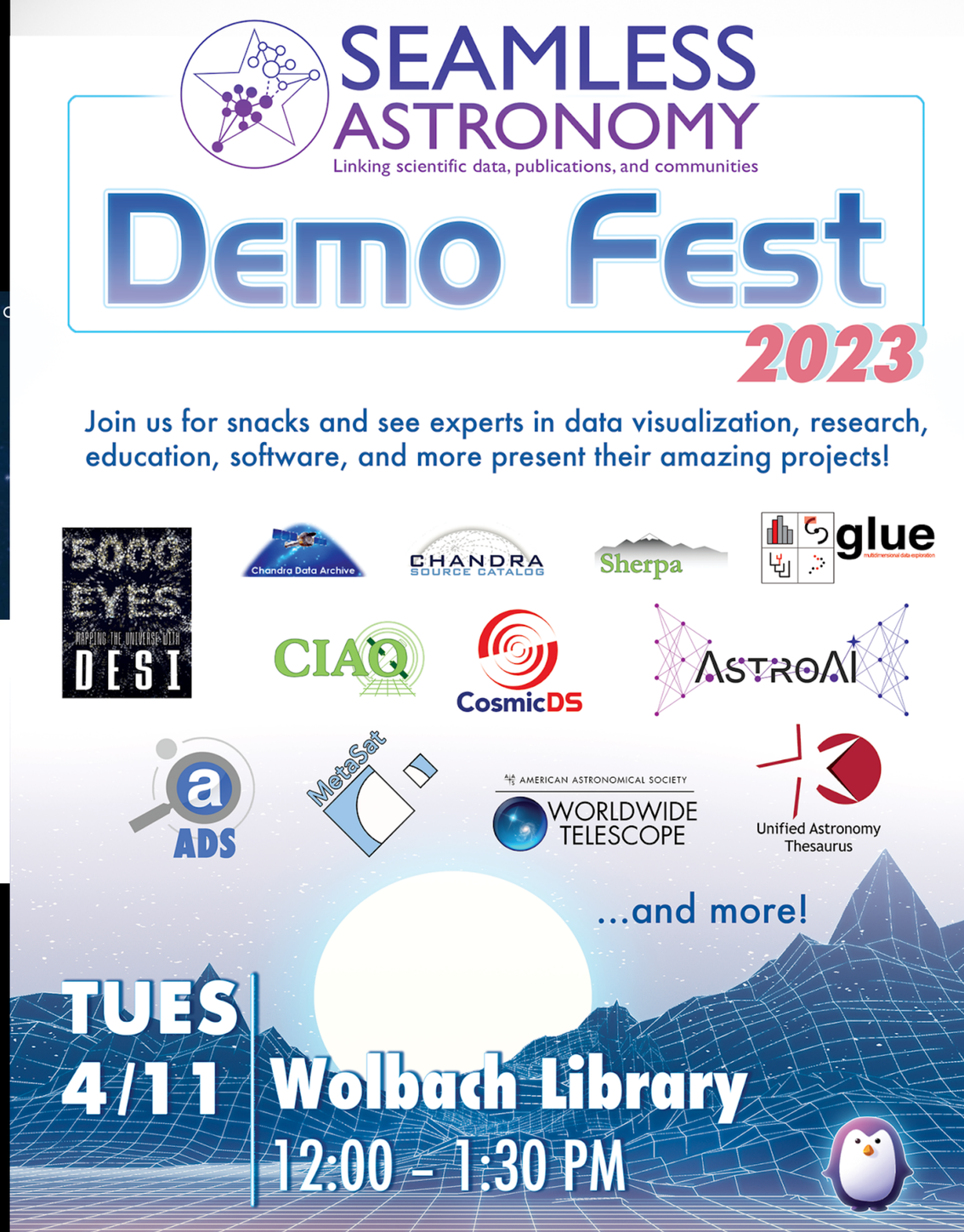


Linking scientific data, publications, and communities

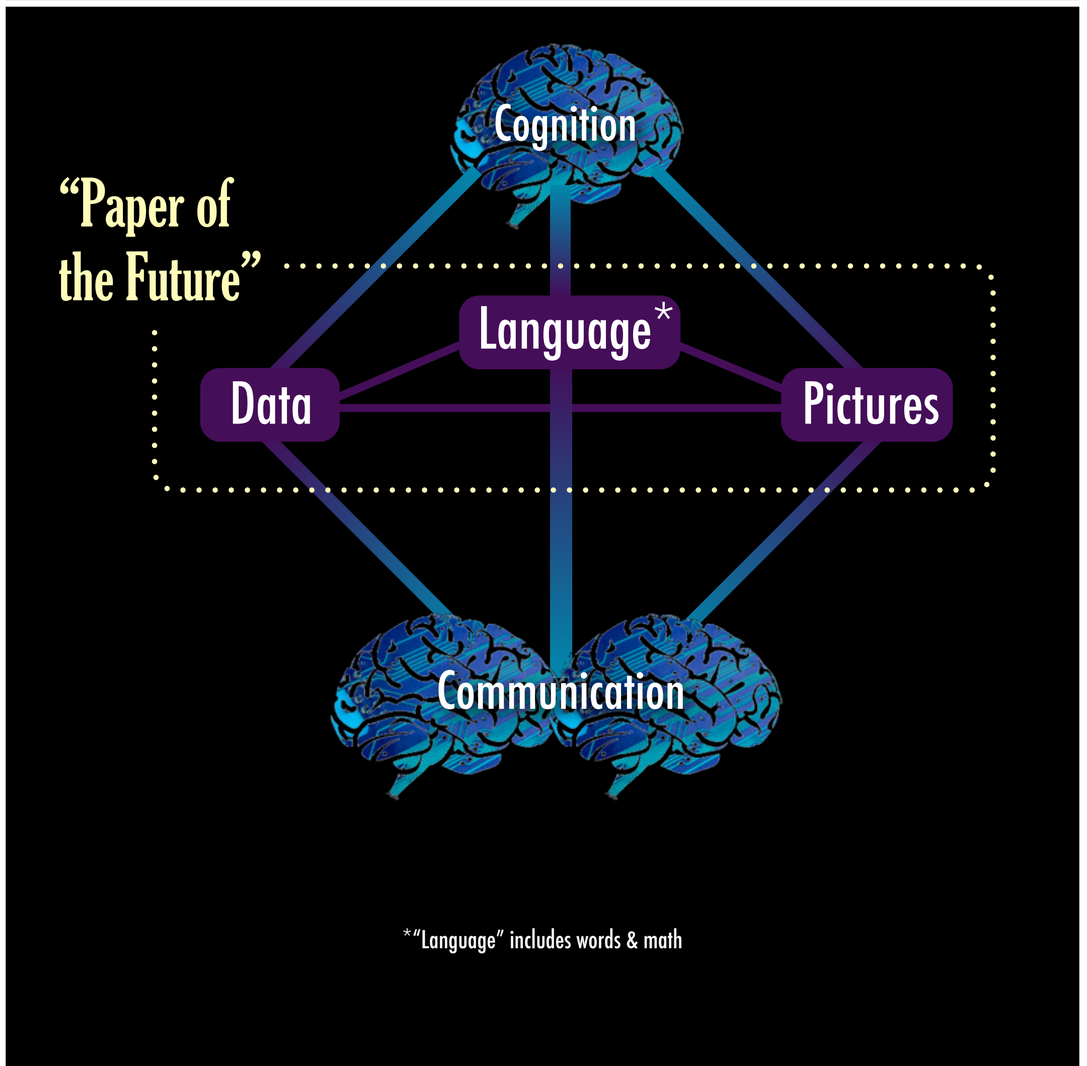
Seamless Astronomy at the Harvard & Smithsonian Center for Astrophysics brings together astronomers, computer scientists, information scientists, librarians and visualization experts involved in developing tools and systems to study and enable the next generation of **online astronomical research.**

Current projects include research on the development of systems that seamlessly integrate scientific data and literature, the semantic interlinking and annotation of scientific resources, the study of the impact of social media and networking sites on scientific dissemination, and the analysis and visualization of astronomical data and research communities.

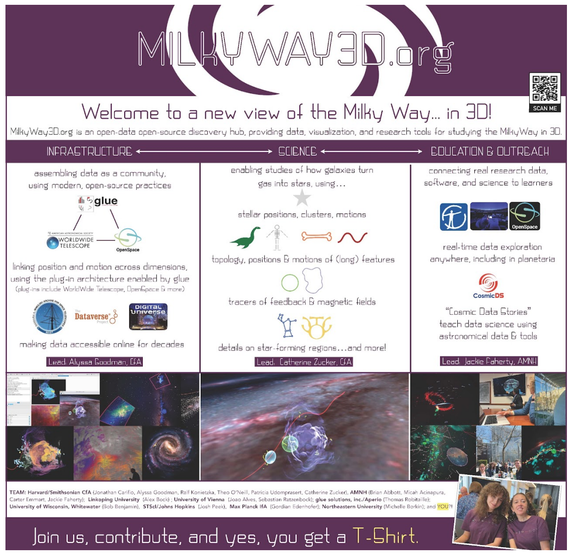
Joining me: Dr. **Eric Koch**
Director of Seamless Astronomy at the CfA
+ expert glue/CosmicDS/WWT dev, Dr. Jon **Carifio**



Key collaborators **Josh Peek, Catherine Zucker, Jackie Faherty** are here at AAS today. **Fernando Perez** is here in spirit, as are many other collaborators!



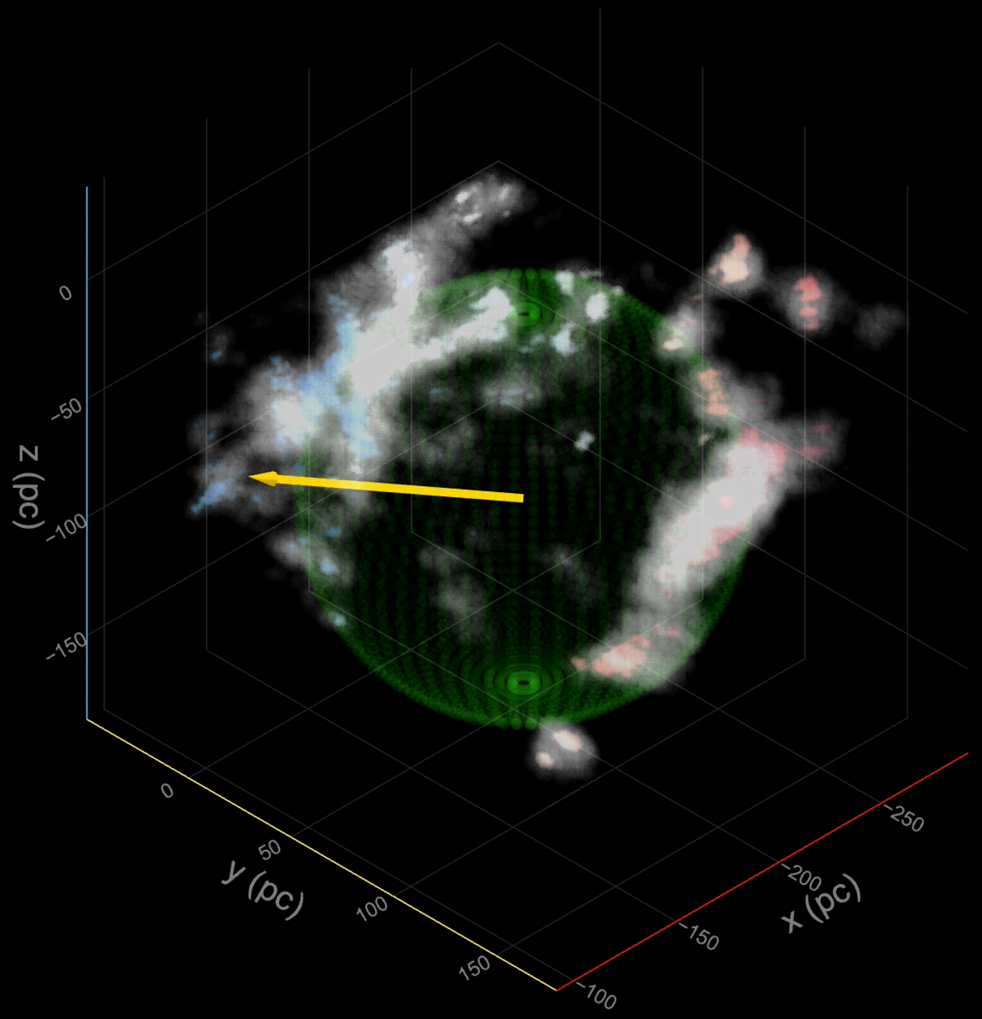
LIVE Astro



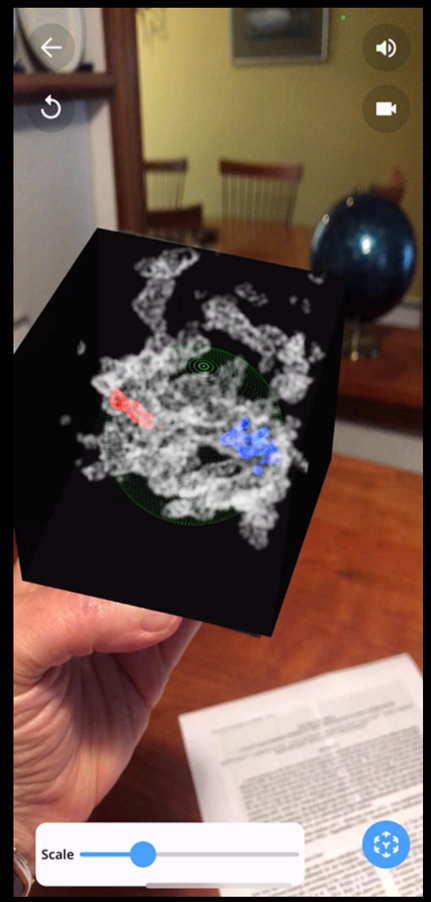
SciX
[SciXplorer.org]
DASK
yt
NASA
CosmicDS
Astronomy
APOD
Picture of the Day
LIVE Astro
astropy
NumPy
Zarr
xarray
WorldWide Telescope Ambassadors
www.tambassadors.org
JWST
PREDICTIONX
glue
genes
glue
multidimensional data exploration

The Future

The Future of Publishing



TINYURL.COM/UNIVERSE-IN-MY-HAND



AUGMENTED REALITY

The Future of Publishing

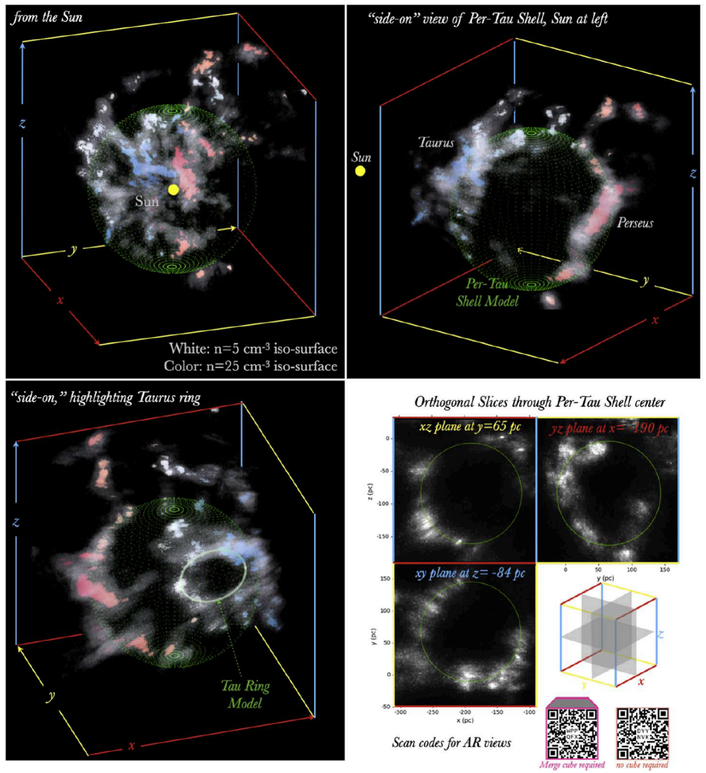
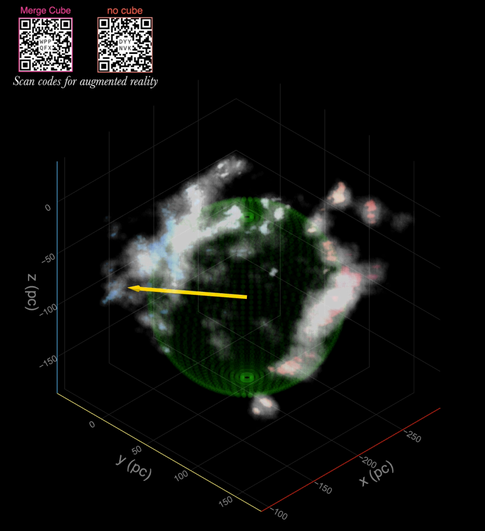
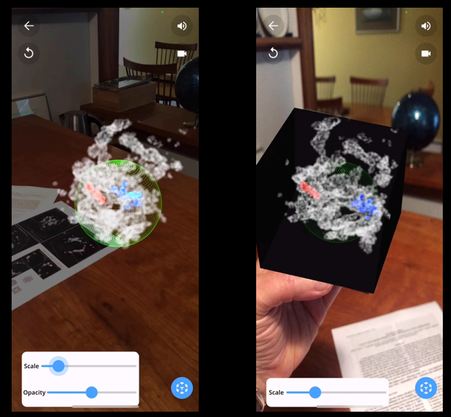


Figure 2. 3D views of the Per-Tau shell (for an interactive version[8] of this figure click here [9]; see Figure 5 for more static visualizations). Plotted are density isosurfaces at levels $n = 5$ cm^{-3} (gray) and $n = 25$ cm^{-3} (color), overlaid with our spherical-shell model, radius $R_s = 78$ pc, distance from the Sun $d = 218$ pc. The $n = 25$ cm^{-3} surfaces are colored by distance from the Sun (blue-to-red). Top-left panel: view from the Sun (compare with Figure 1). Top-right panel: a side view of the region. Perseus and Taurus and their diffuse envelopes are arranged on two opposing sides of the Per-Tau shell. Bottom-left panel: another side view emphasizing the Tau Ring. The ellipse is the Tau Ring model (Appendix B). Bottom-right panel: 2D density slices along the *xy*, *xz*, *yz* planes. All planes intersect at shell's center. In all panels *xyz* are the Heliocentric Cartesian Galactic Coordinates.

2. *Tau Ring:* in a sky projection the Tau Ring is seen almost edge-on. The near side of the Tau Ring connects with the main body of Taurus at $d \approx 150$ pc, whereas the farthest part extends to $d \approx 220$ pc.

3. *The Fictitious Connection*: A filament seems to connect Taurus to Perseus. This connection is only a coincidental projection effect, where in actuality the filament is located at the distance of Taurus, and does not physically connect





The Astrophysical Journal Letters, 919:L5 (12pp), 2021 September 20 https://doi.org/10.3847/2041-8213/ac1f95
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The Per-Tau Shell: A Giant Star-forming Spherical Shell Revealed by 3D Dust Observations

Shmuel Bialy[1], Catherine Zucker[1], Alyssa Goodman[1,2], Michael M. Foley[1], João Alves[2,3], Vadim A. Semenov[1], Robert Benjamin[4], Reimar Leike[5,6], and Torsten Enßlin[5,6]
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[2] Radcliffe Institute for Advanced Study, Harvard University, 10 Garden Street, Cambridge, MA 02138, USA
[3] University of Vienna, Department of Astrophysics, Türken-schanzstrasse 17, 1180 Wien, Austria
[4] Department of Physics, University of Wisconsin-Whitewater, 800 West Main Street, Whitewater, WI 53190, USA
[5] Max Planck Institute for Astrophysics, Karl-Schwarzschildstraße D-1,85748 Garching, Germany
[6] Ludwig-Maximilians-Universität, Geschwister-SchollPlatz1, D-80539 Munich, Germany
Received 2021 April 30; revised 2021 July 8; accepted 2021 July 12; published 2021 September 22

HARVARD Dataverse

The Per-Tau Shell (Bialy et al. 2021)

(Harvard)

Harvard Dataverse > The Per-Tau Shell (Bialy et al. 2021) >

Replication Data for: "The Per-Tau Shell: A Giant Star-Forming Spherical Shell Revealed by 3D Dust Observations" (Bialy et al. 2021)

Version 1.0

Bialy, Shmuel; Zucker, Catherine; Goodman, Alyssa; Alves, Joao; Foley, Michael; Semenov, Vadim; Benjamin, Robert; Leike, Reimer; Ensslin, Torsten, 2021, "Replication Data for: "The Per-Tau Shell: A Giant Star-Forming Spherical Shell Revealed by 3D Dust Observations" (Bialy et al. 2021)", https://doi.org/10.7910/DVN/6ODS8M, Harvard Dataverse, V1, UNF:6:tRun1ZvDwdJze0WTkUBPQg== [fileUNF]

Cite Dataset Learn about Data Citation Standards.

Access Dataset

Contact Owner Share

PerTau_Glue_session.glu
PerTau_Dataverse/glue/
Unknown - 187.4 KB
Published Aug 19, 2021
8 Downloads
MD5: 7c5...b3d

Dataset Metrics

164 Downloads

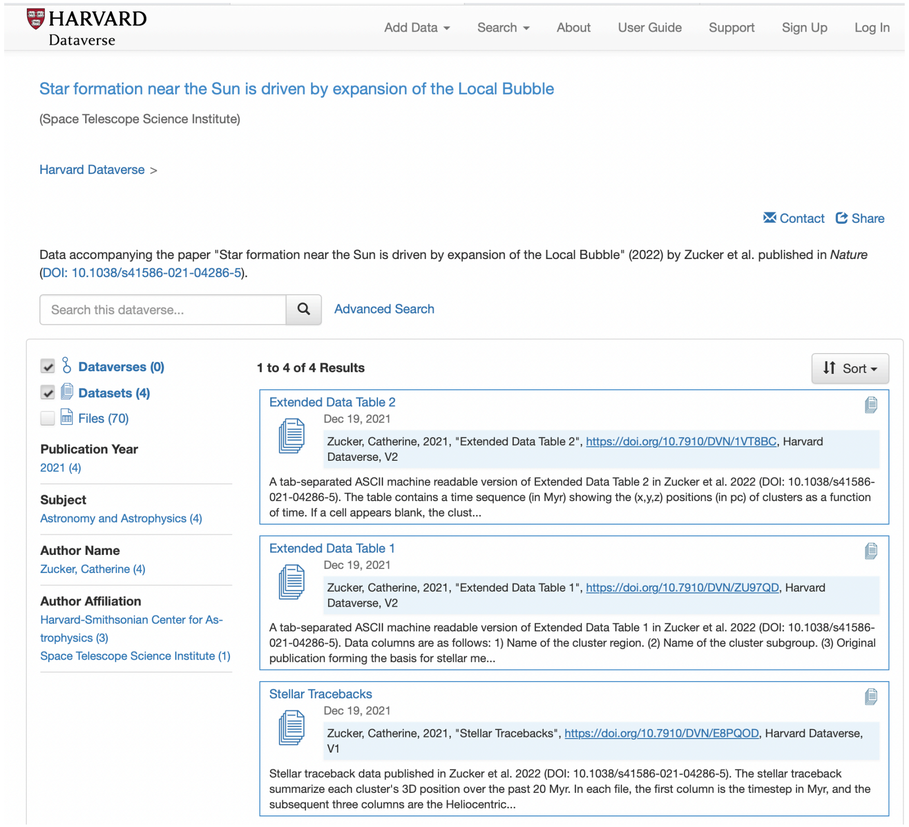
Description

Bialy et al. (2021) presented 2D and 3D observations of the Perseus and Taurus star-forming region, showing that the 3D ISM structure reveals the existence of a very extended shell, R~80 pc, where the Perseus and Taurus molecular clouds lie on the two ends of the shell. This shell was named "the Per-Tau Shell", and it was argued that it may have been produced by a past supernova (SN) and stellar feedback activity, pointing to the potential importance of positive SN feedback.

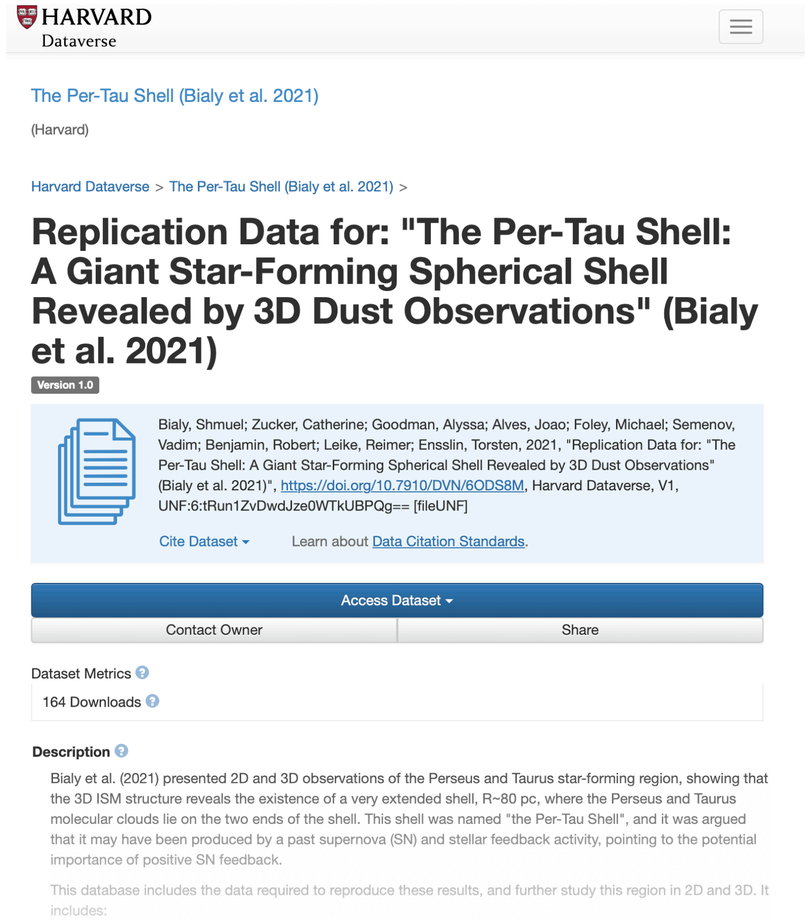
This database includes the data required to reproduce these results, and further study this region in 2D and 3D. It includes:

Examples per DOI discussion earlier…

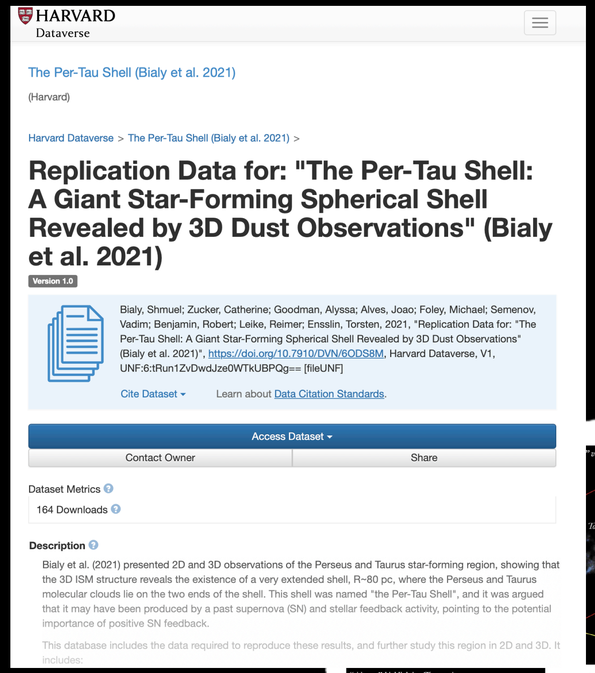
dataverse.harvard.edu/dataverse/local_bubble_star_formation

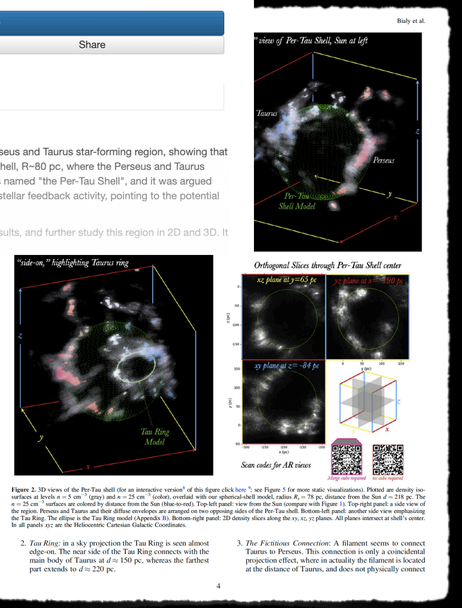


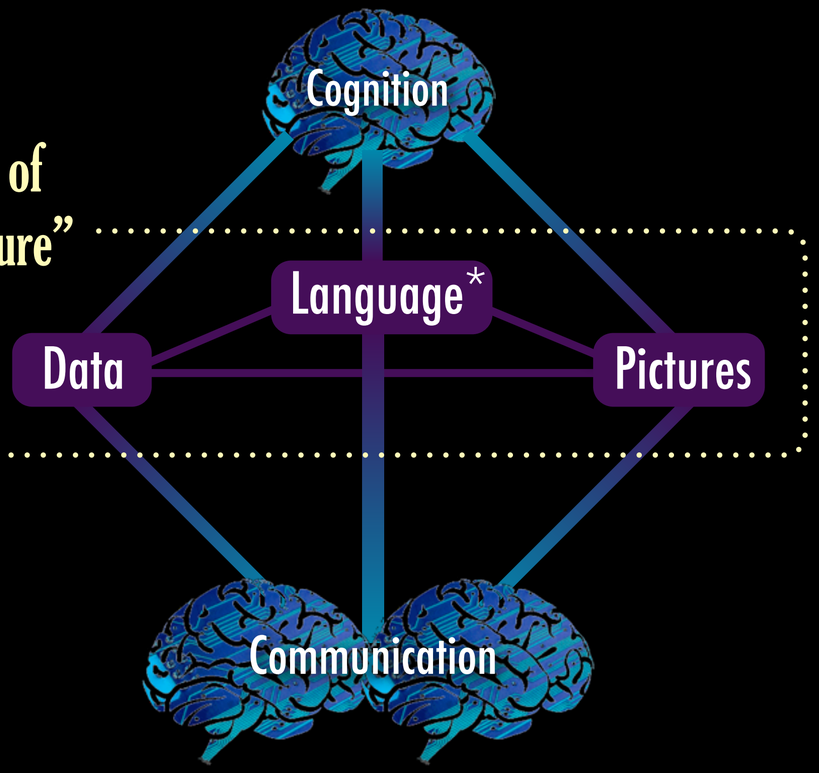
dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/6ODS8M



The time **has** arrived to publish data, words, and images, TOGETHER.





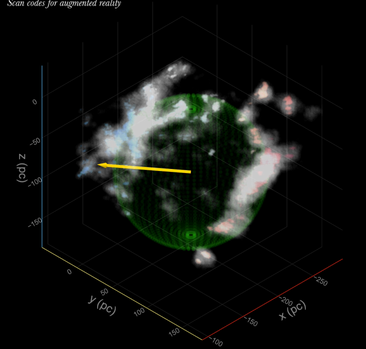


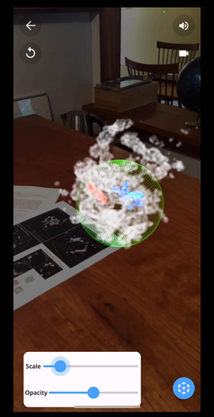
"Paper of the Future"

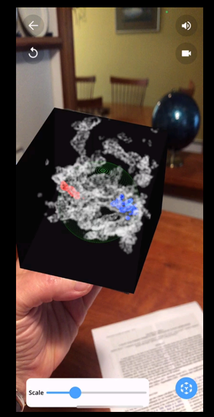
*"Language" includes words & math

Merge Cube
3D Scan

Scan codes for augmented reality







Video too.

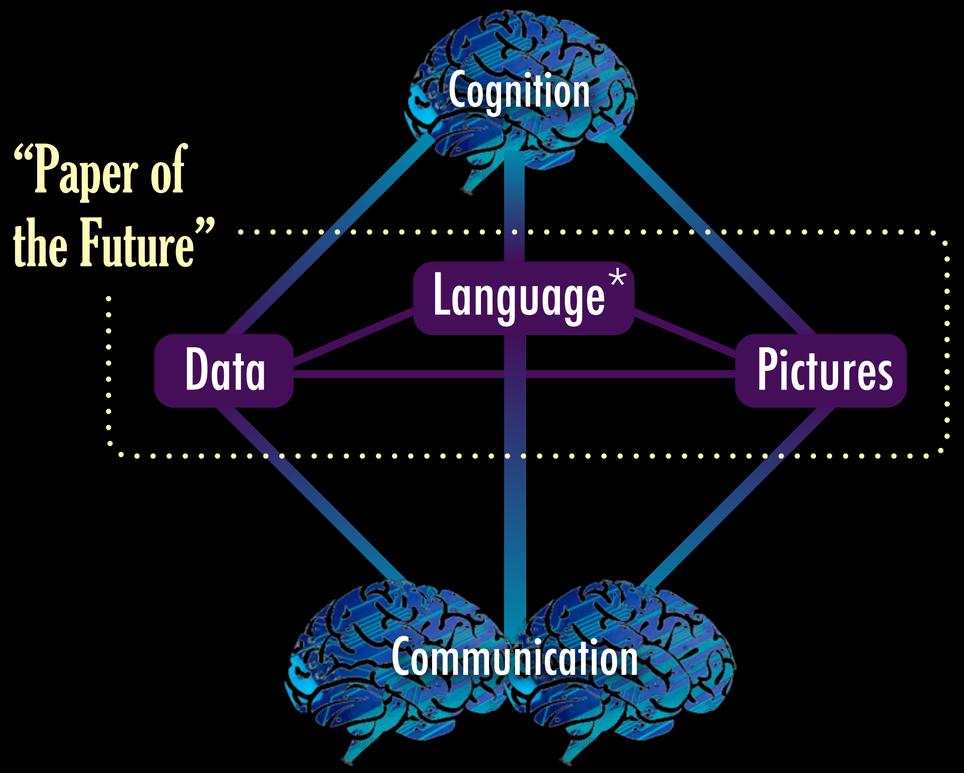
THE PERSEUS-TAURUS SUPERSHELL IN SPACE

brought to you in 2021 by an international team of scientists from Center for Astrophysics | Harvard & Smithsonian, Harvard Radcliffe Institute, University of Vienna, University of Wisconsin, Max-Planck Institute, Ludwig Maximillian University, and technology from ESA, NASA, NSF and Delightex.

animation by Jasen Lux Chambers

2009

2015



*“Language” includes words & math

2024

LIVE Astro

2009 GRC Oxford

July 2009 Oxford, UK [Gordon Research Conferences : Visualization In Science & Education]

From Baby Pictures to Baby Stars: What Scientists /Can/ See" (Zipped keynote files, 244 MB), (pdf)

Visualization in Science and Education
Gordon Research Conference

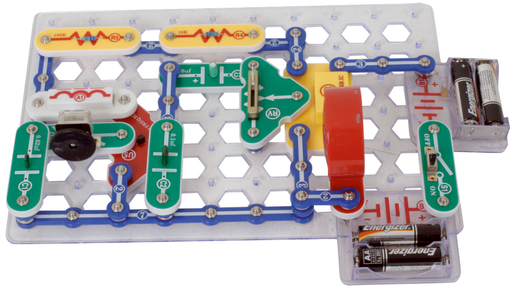
Revealing Nature, Generating Insight

July 26 - 31, 2009

Chairs
Arthur J. Olson and Shaaron Ainsworth

Vice Chairs
Elizabeth M. Dorland and Ghislain Deslongchamps

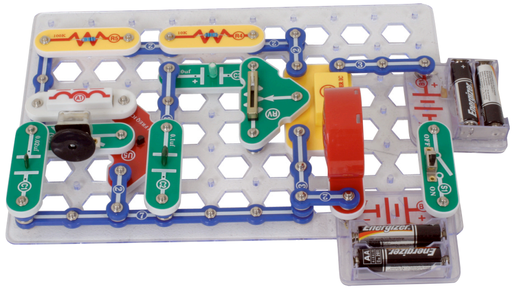
9:00 am - 9:40 am **Alyssa Goodman** (Harvard University, USA)
"From Baby Pictures to Baby Stars: What Scientists /Can/ See"



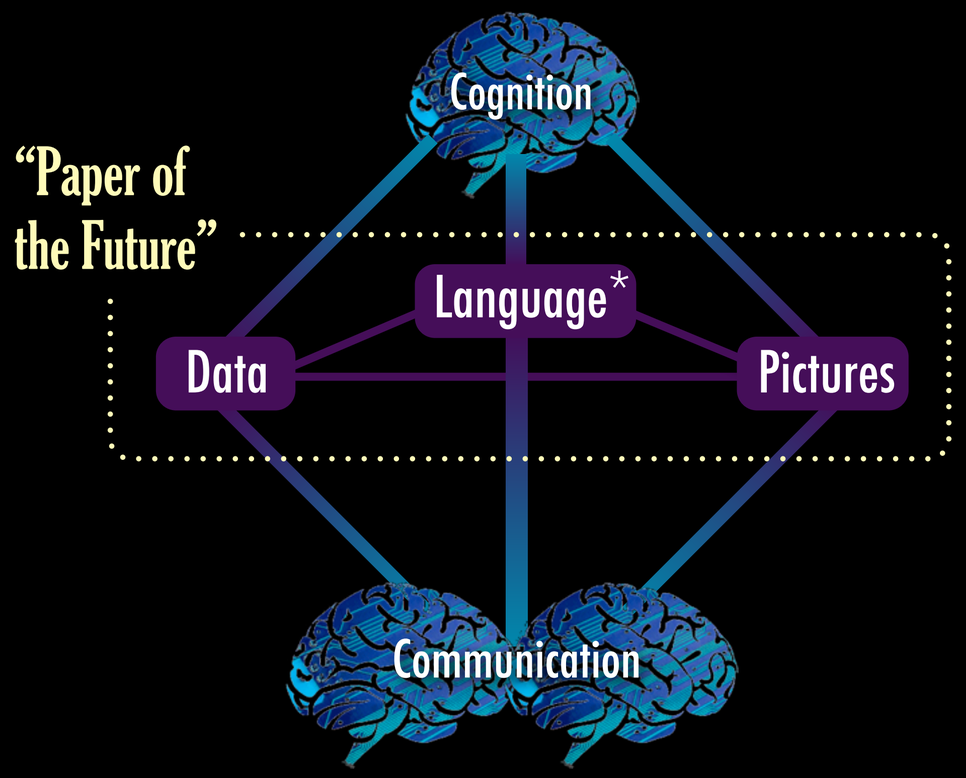
Discussing:

The *Modular, Personalizable,* Approach we "Can", "Could" (& Should!?) Take to *Interactions*

"Customizable Complexity"



2015



*“Language” includes words & math

Authorea Beta 3 HELP EXPLORE

Document Format Insert saved share

markdown

The "Paper" of the Future

Authorea preprint 02/21/2017 DOI: 10.22541/au.148769949.92783646

Alyssa Goodman (Harvard University)
Josh Peek (Space Telescope Science Institute)
Alberto Accomazzi (Harvard-Smithsonian Center for Astrophysics (CFA))
Chris Beaumont (Harvard-Smithsonian Center for Astrophysics (CFA))
Christine L. Borgman (UCLA - University of California, Los Angeles)
Hope How-Huan Chen (Harvard University)
Merce Crosas (Harvard University)
Christopher Erdmann (North Carolina State University)
And 3 more…

Add Collaborator Manage

markdown

A 5-minute video demonstration of this paper is available at this YouTube link.

1 Preamble

A variety of research on human cognition demonstrates that humans learn and communicate best when more than one processing system (e.g. visual, auditory, touch) is used. And, related research also shows that, no matter how technical the material, most humans also retain and process information best when they can put a narrative "story" to it. So, when considering the future of scholarly communication, we should be careful not to do blithely away with the linear narrative format that articles and books have followed for centuries: instead, we should enrich it.

Much more than text is used to commuicate in Science. Figures, which include images, diagrams, graphs, charts, and more, have enriched scholarly articles since the time of Galileo, and ever-growing volumes of data underpin most scientific papers. When scientists communicate face-to-face, as in talks or small discussions, these figures are often the focus of the conversation. In the best discussions, scientists have the ability to manipulate the figures, and to access underlying data, in real-time, so as to test out various what-if scenarios, and to explain findings more clearly. **This short article explains—and shows with demonstrations—how scholarly "papers" can morph into long-lasting rich records of scientific discourse**, enriched with deep data and code linkages, interactive figures, audio, video, and commenting.

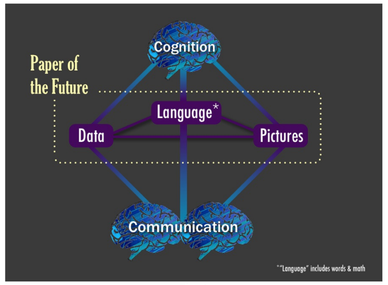


Fig. 1

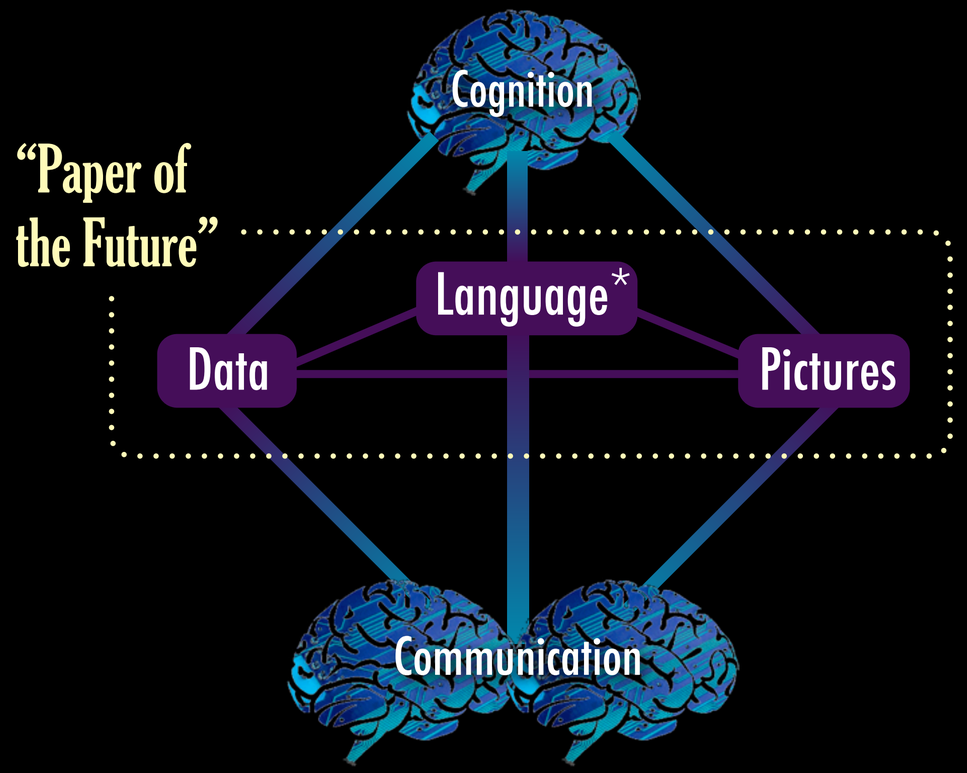
markdown

*The Paper of the Future should include seamless linkages amongst **data**, **pictures**, and **language**, where "language" includes both words and math. When an individual attempts to understand each of these kinds of information, different cognitive functions are utilized: communication is inefficient if the channel is restricted primarily to language, without easy interconnection to data and pictures.*

[demo]

2009

2015



*"Language" includes words & math

2024

LIVE Astro

2024

LIVE Astro

Why use LIVE?

data from **anywhere**, in any format

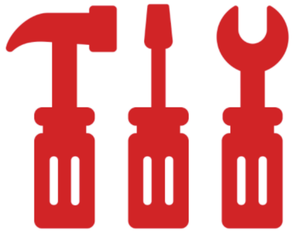
loaded data sets are "**linked**," **not merged**

exploratory data analysis, with selections propagating across data sets

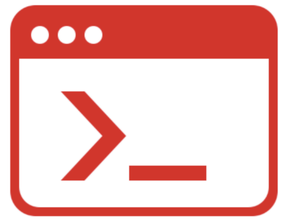
flexible user interface and **output** options that can be **saved** and **shared**

LIVE's modular architecture allows

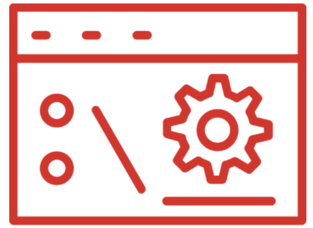
data **loaders** for any format, any data source



custom user or **field-specific** linking



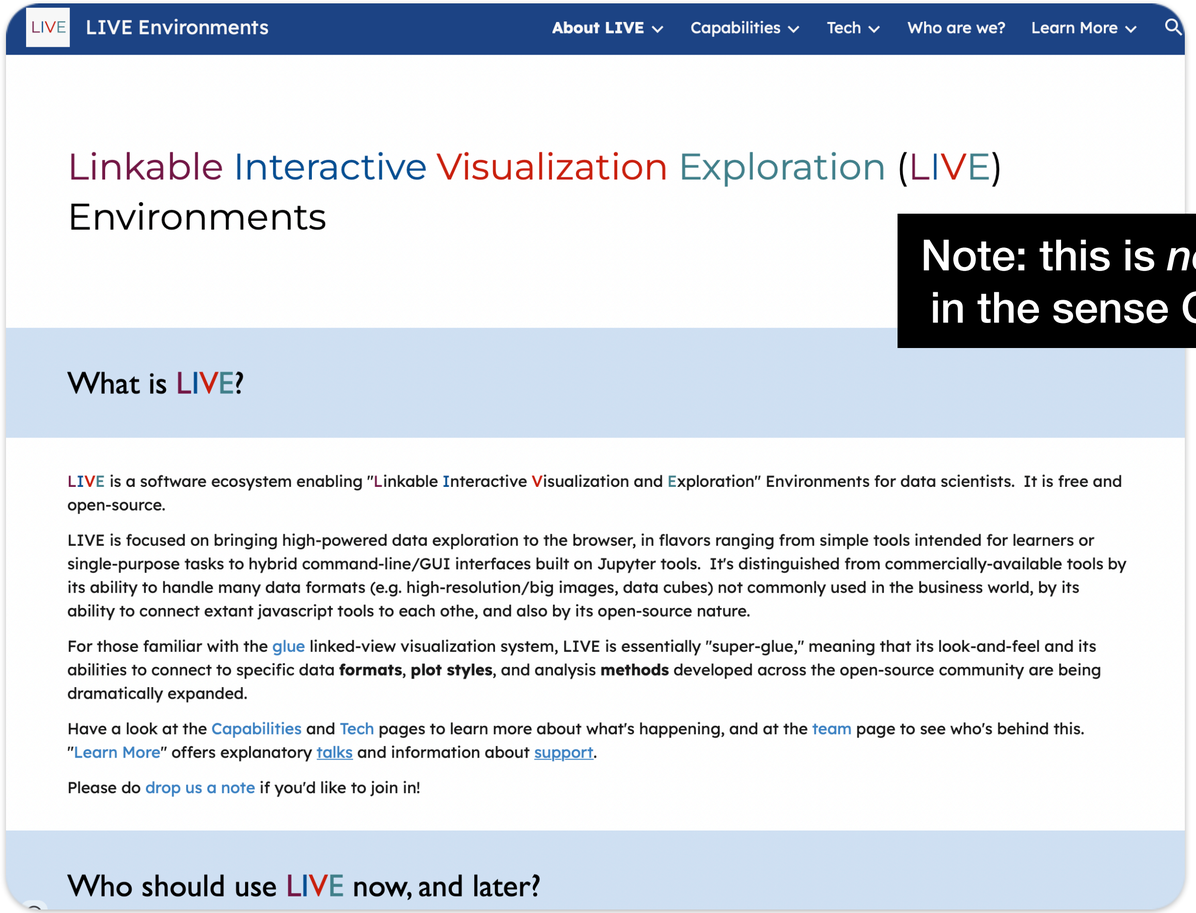
custom analysis & visualization **tools** via plug-ins or **command-line** interactions



custom **dashboards**, **websites**, desktop OS **applications**, or fully command-line (**notebook**) views, and a variety of interactive **export formats**, including **AR**

LIVE Environments

a request to NSF TIP for a research-enabling software infrastructure build-out



Note: this is *not* a "platform," in the sense Gus discussed.

live-env.org

Transforming Surgical Pathology through Digital Functional HistoPathology is the Science Demonstration project for

LIVE Bio

ARPA-H

"**MilkyWay3D.org**" is the Science Demonstration project for

LIVE Astro

NSF

CosmicDS, **Data+Climate,** and more are Science Demonstration projects for

LIVE GIS

NASA

2024

LIVE Astro

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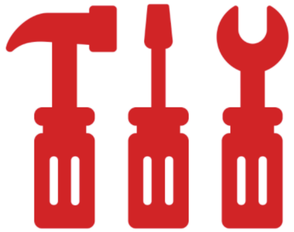

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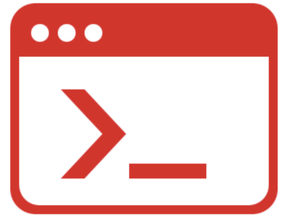

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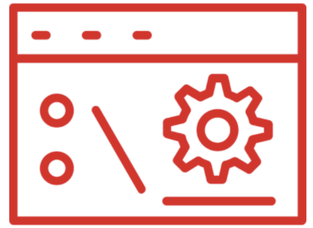
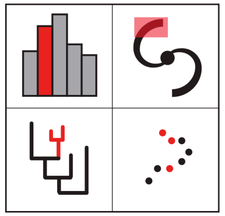


custom **dashboards**, **websites**, desktop OS **applications**, or fully command-line (**notebook**) views, and a variety of interactive **export formats**, including **AR**

What is  glue?

multidimensional data exploration

It’s not an acronym.

It is open-source software that

glues data,

glues graphs &

glues tools.

data

numbers (tables, arrays, spreadsheets)

images & maps (FITS, JPEG, GIS and more)

data cubes (3D, 4D, and more)

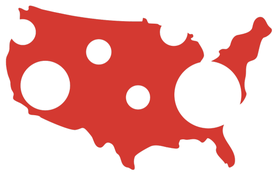
data files' common attributes are **glued**

avoiding the need to merge data files

“graphs”

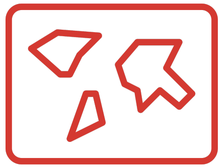
common statistical graphics

(scatterplots, histograms, tables, curves, overlays)



maps & images

(greyscale, color, contours, layer control…)

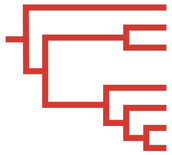


3D displays

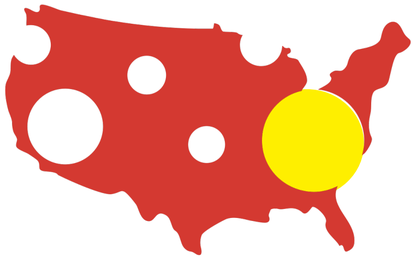
(scatter plots, volumetric rendering, sliders…)

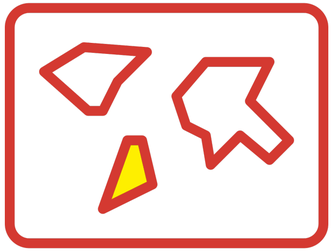
specialized & custom charts

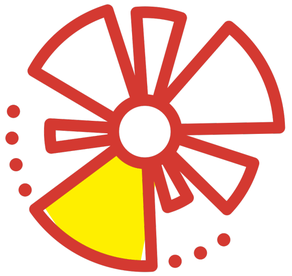
(dendrograms, polar plots, + domain-specific options)



selections propagate across all graphs



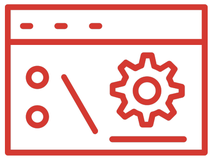




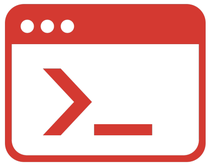
for real-time data exploration & insight

tools

plug-ins (user-defined formats, plots, layouts…)

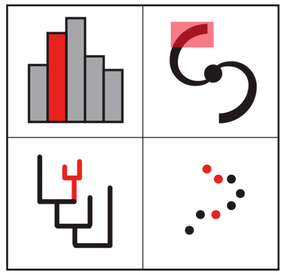


web services (across domains)



command-line (built-in terminal, scriptable)

for easy customization



glue

multidimensional data exploration

glues data,
glues graphs &
glues tools.

glueviz.org

BONUS: **save**, **share**, or **publish** what you learn—

save “sessions” to continue where you left off

export graphics

use/export to Jupyter environments

export to plot.ly (javascript)

export to augmented reality

learn how at glueviz.org.

glueviz.org

supported by

glue solutions inc.

GORDON AND BETTY MOORE FOUNDATION

Glue (/Users/aagoodman/Library/CloudStorage/GoogleDrive-agoodman@cfa.harvard.edu/My Drive/Milky Way Takeover 2020/MilkyWay3D.ORG/Sessions/cfaspf23demowithco.glu)

Open Session | Export Session | Import Data | Export Data/Subsets | Link Data | x^2 Arithmetic attributes | Active Subset: None/Create New (the next selection will create a subset) | Terminal | Preferences | Error Console

Data Collection

- Pelgrims2020_A+A_636_A17_lmax10_MW3D[HDU1]
- Zucker2021_ApJ_919_35_spines_MW3D[HDU1]
- Alves2020_Nat_578_237_MW3D[HDU1]
- Bialy2021_ApJL_919_L5_MW3D[HDU1]
- Foley2022_arXiv_2212.01405_OrionShell_MW3D[HDU1]
- Reid2019_ApJ_885_131_LocalArmFit_MW3D[HDU1]
- Reid2019_ApJ_885_131_SGNArmFit_MW3D[HDU1]
- Reid2019_ApJ_885_131_MW3D[HDU1]
- Hunt2023_arXiv_2303.13424_MW3D[HDU1]
- Lallement2019_A+A_625_A135_Split_MW3D[HDU1]
- Edenhofer_2023_3D_Dust_XYZ_Revised-2

Plot Layers - Earth/Planet/Sky Viewer (WWT)

- [x] distance picker (Bialy2021_ApJL_919_L5_MW3D[HDU1])
- [x] Bialy2021_ApJL_919_L5_MW3D[HDU1]
- [x] distance picker (Hunt2023_arXiv_2303.13424_MW3D[HDU1])
- [x] ONeill2023_LocalBubbleB_VectorPointCloud_MW3D[HDU1]
- [x] Hunt2023_arXiv_2303.13424_MW3D[HDU1]
- [x] Reid2019_ApJ_885_131_SGNArmFit_MW3D[HDU1]
- [x] Reid2019_ApJ_885_131_LocalArmFit_MW3D[HDU1]
- [ ] Lallement2019_A+A_625_A135_Split_MW3D[HDU1]

Size | Color

Fixed

Center view on layer

Plot Options - Earth/Planet/Sky Viewer (WWT)

Mode: Milky Way

Frame: Galactic

Longitude: GLON

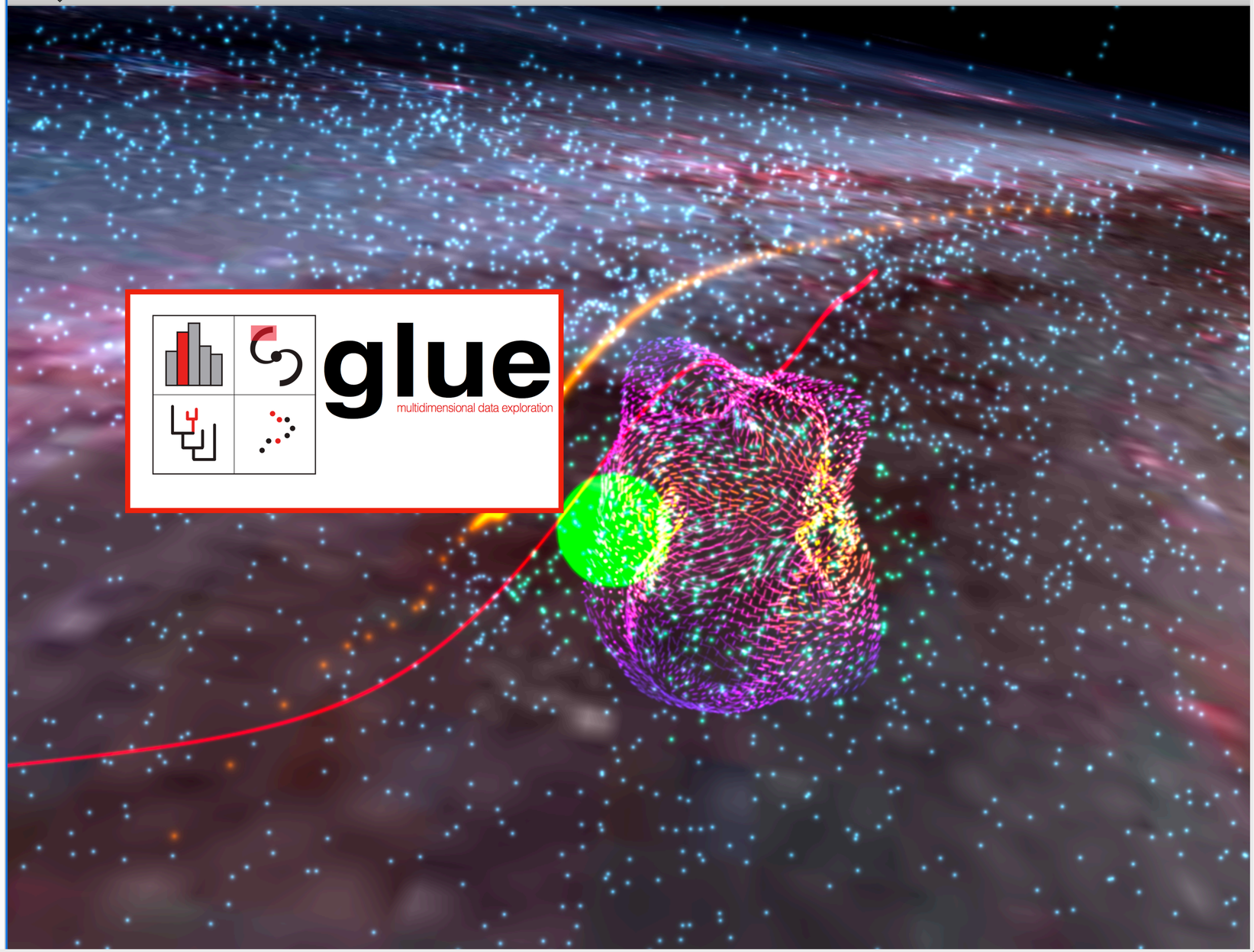
Latitude: GLAT

Distance: Distance

pc

3D overview | WWT 3D | 3D dust stars | WWT overlay | CO

Earth/Planet/Sky Viewer (WWT)



Glue (/Users/aagoodman/Library/CloudStorage/GoogleDrive-agoodman@cfa.harvard.edu/My Drive/Milky Way Takeover 2020/MilkyWay3D.ORG/Sessions/cfaspf23demowithco.glu)

Open Session | Export Session | Import Data | Export Data/Subsets | Link Data | Arithmetic attributes | Active Subset: None/Create New (the next selection will create a subset) | Terminal | Preferences | Error Console

Data Collection

- Pelgrims2020_A+A_636_A17_lmax10_MW3D[HDU1]
- Zucker2021_ApJ_919_35_spines_MW3D[HDU1]
- Alves2020_Nat_578_237_MW3D[HDU1]
- Bialy2021_ApJL_919_L5_MW3D[HDU1]
- Foley2022_arXiv_2212.01405_OrionShell_MW3D[HDU1]
- Reid2019_ApJ_885_131_LocalArmFit_MW3D[HDU1]
- Reid2019_ApJ_885_131_SGNArmFit_MW3D[HDU1]
- Reid2019_ApJ_885_131_MW3D[HDU1]
- Hunt2023_arXiv_2303.13424_MW3D[HDU1]
- Lallement2019_A+A_625_A135_Split_MW3D[HDU1]
- Edenhofer_2023_3D_Dust_XYZ_Revised-2

Plot Layers - Earth/Planet/Sky Viewer (WWT)

- distance picker (Bialy2021_ApJL_919_L5_MW3D[HDU1])
- Bialy2021_ApJL_919_L5_MW3D[HDU1]
- distance picker (Hunt2023_arXiv_2303.13424_MW3D[HDU1])
- ONeill2023_LocalBubbleB_VectorPointCloud_MW3D[HDU1]
- Hunt2023_arXiv_2303.13424_MW3D[HDU1]
- Reid2019_ApJ_885_131_SGNArmFit_MW3D[HDU1]
- Reid2019_ApJ_
- Lallement2019_

Fixed

Center view on layer

"classic" (Qt)

Plot Options - Earth/Planet/Sky Viewer (WWT)

Mode: Milky Way

Frame: Galactic

Longitude: GLON

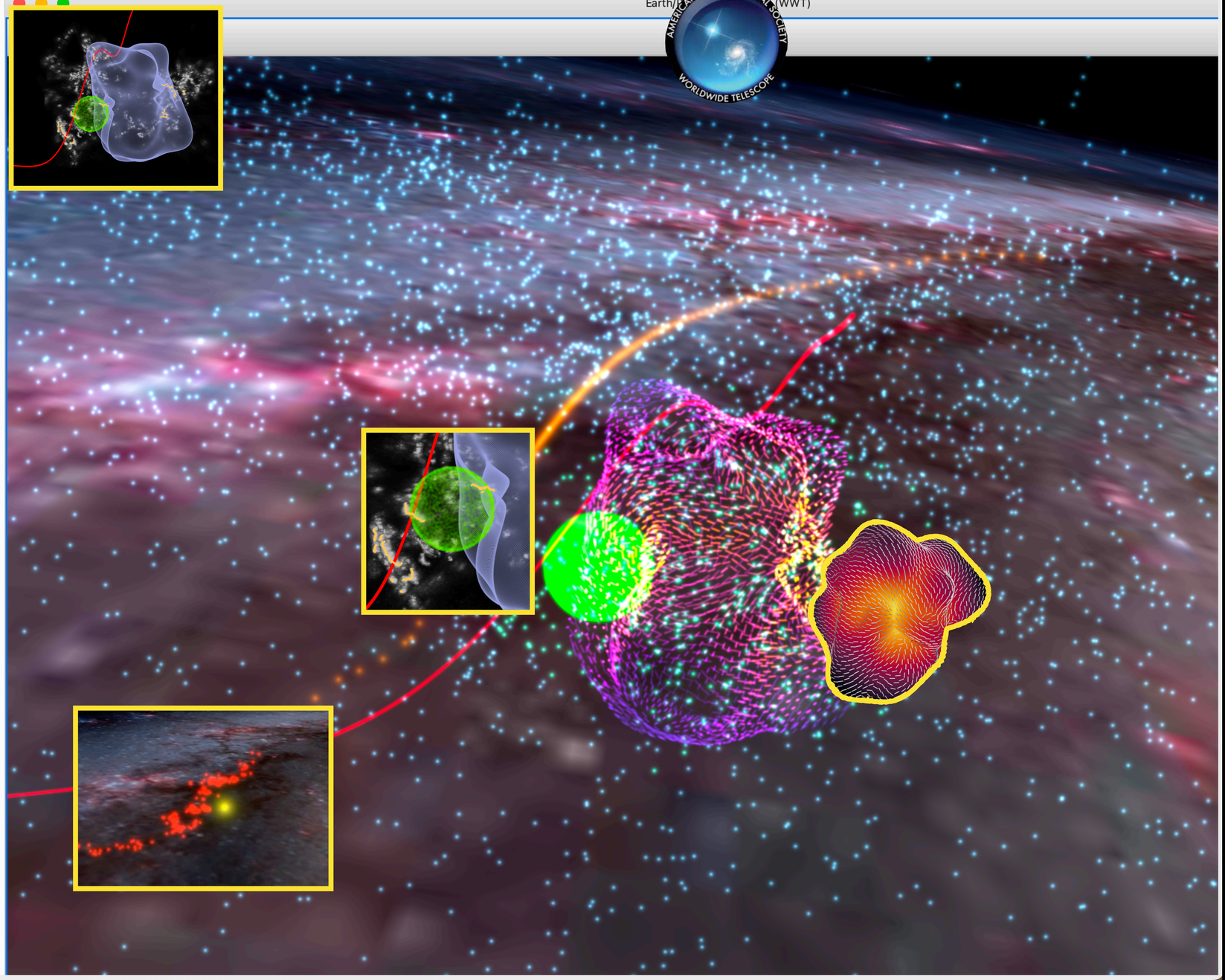
Latitude: GLAT

Distance: Distance

pc

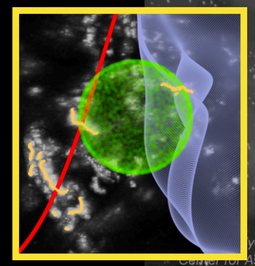
3D overview | WWT 3D | 3D dust stars | WWT overlay | CO

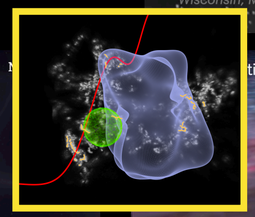
Earth/ (WWT)



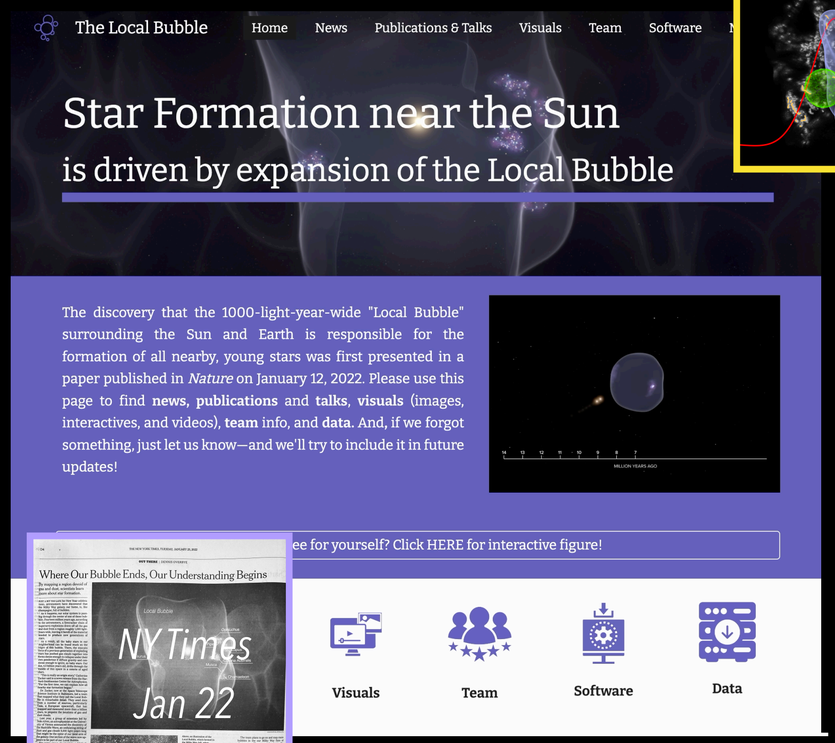
The *New* Milky Way made possible by glue (& 3D dust mapping)

2021

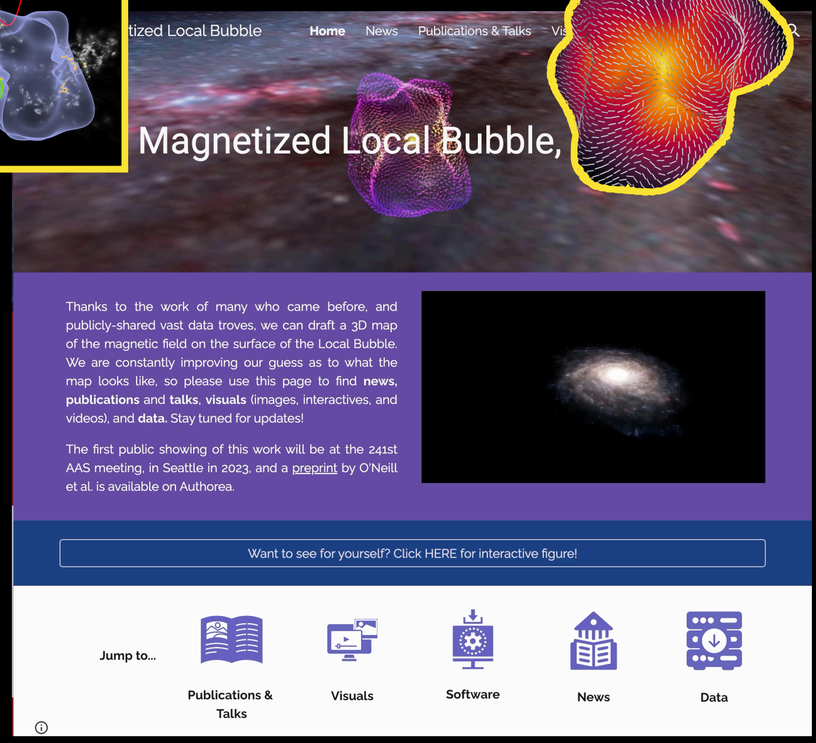




2020



2022



2023

"MilkyWay3D.org" is the Science Demonstration project for LIVE Astro

MILKYWAY3D.org

SCAN ME

Welcome to a new view of the Milky Way... in 3D!

MilkyWay3D.org is an open-data open-source discovery hub, providing data, visualization, and research tools for studying the MilkyWay in 3D.

INFRASTRUCTURE ⟷ SCIENCE ⟷ EDUCATION & OUTREACH

assembling data as a community, using modern, open-source practices

glue

THE AMERICAN ASTRONOMICAL SOCIETY WORLDWIDE TELESCOPE — OpenSpace

linking position and motion across dimensions, using the plug-in architecture enabled by glue (plug-ins include WorldWide Telescope, OpenSpace & more)

MAST — The Dataverse Project — DIGITAL universe

making data accessible online for decades

Lead: Alyssa Goodman, CfA

enabling studies of how galaxies turn gas into stars, using...

stellar positions, clusters, motions

topology, positions & motions of (long) features

tracers of feedback & magnetic fields

details on star-forming regions...and more!

Lead: Catherine Zucker, CfA

connecting real research data, software, and science to learners

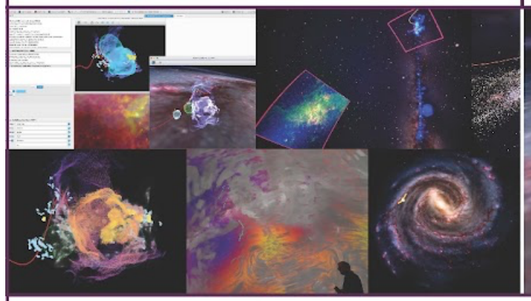
OpenSpace

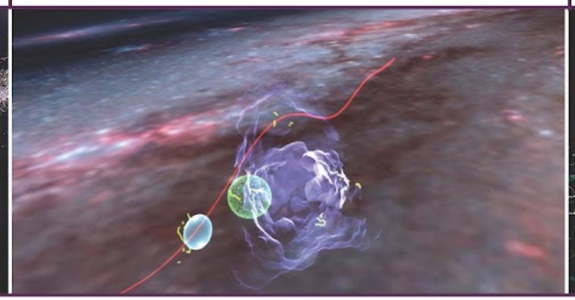
real-time data exploration anywhere, including in planetaria

CosmicDS

"Cosmic Data Stories" teach data science using astronomical data & tools

Lead: Jackie Faherty, AMNH

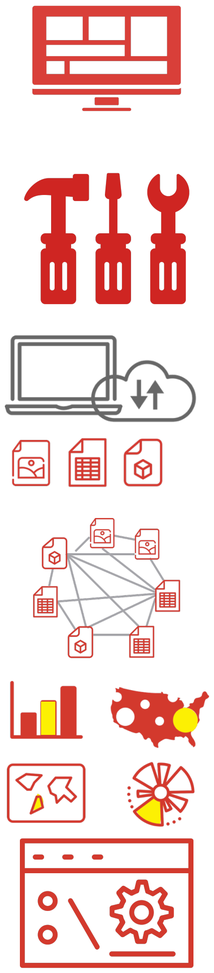




TEAM: **Harvard/Smithsonian CfA** (Jonathan Carifio, Alyssa Goodman, Ralf Konietzka, Theo O'Neill, Patricia Udomprasert, Catherine Zucker), **AMNH** (Brian Abbott, Micah Acinapura, Carter Emmart, Jackie Faherty); **Linkoping University** (Alex Bock) ; **University of Vienna** (Joao Alves, Sebastian Ratzenbock); **glue solutions, inc./Aperio** (Thomas Robitaille); **University of Wisconsin, Whitewater** (Bob Benjamin), **STScI/Johns Hopkins** (Josh Peek), **Max Planck IfA** (Gordian Edenhofer); **Northeastern University** (Michelle Borkin); and YOU?!

Join us, contribute, and yes, you get a T-Shirt.

Creating a
Linkable Interactive Visualization Exploration (LIVE) Environment
in real-time



1. choose a **framework**
   - choose a **template** *(or not)*
   - add **tools** *(as-needed)*
2. access/add **data**
3. **link** data
4. **explore**, using **linked visualizations**
5. share your **interactive** environment

see live-env.org for details

Capabilities

- Data Access
- Linking Data
- Linking Tools
- Exploratory Analysis
- Interactive Exports
- UI Options
- Command line interac...

A few minutes on where

Linkable Interactive Visualization Exploration (LIVE) Environments

came from & what “or not” & “as-needed” mean

...at Jupytercon 2023

"glupyter" is a union of glue and Jupyter software environments. We think it may well be the future of glue, or "glue-qt" as experts sometimes call the desktop app version of glue. This webpage, hosted openly and freely by glue solutions, inc., serves as a clearinghouse for current information about open-source glupyter-related projects. Some of these projects are funded by government agencies (notably NSF and NASA), others by private foundations (e.g. The Gordon and Betty Moore Foundation), some as part of corporate collaborations (e.g. Harvard+Google Data+Climate), and some by open-source consulting work carried out by glue solutions, inc.

The glue-jupyter GitHub repository is fully open,
and more detail can be found on this Read the Docs page.

Quick insights for Images, Spectra

JDAViz

includes: ImViz, CubeViz, SpecViz, MOSViz

Sponsor: NASA, James Webb Space Telescope

Read more (blog post at 10QViz.org)...

GitHub

Open-Source GIS Data Exploration

SAVE

Search-Analysis-Visualization-Environment

Sponsors: Harvard+Google Data+Climate

Read more at Data+Climate site...

GitHub

CosmicDS

Data Science Education

Cosmic Data Stories

Sponsor: NASA, Science Activation Program (funded proposal)

Read more at CosmicDS website...

GitHub

glupyter

bringing glue to JupyterLab

glupyter prototype

Sponsors: The Gordon and Betty Moore Foundation and the National Science Foundation

Read more in the justificaiton of the GBF proposal, awarded to Harvard, and watch this 2022 demo video

tinyurl.com/dimensionsofdiscovery

"LEVELS" of interaction/users

CosmicDS — **guided** experience for learners, no coding, only interactive webpages

Jdaviz — **dashboard**-style

glupyter — fully **flexible**, **scriptable**, **extensible**.

"Customizable Complexity"

CosmicDS

guided experience for learners, no coding, only interactive webpages

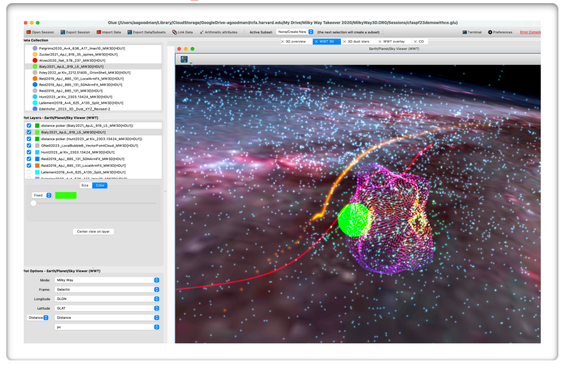
Jdaviz

dashboard-style

glue
multidimensional data exploration

fully **flexible**, **scriptable**, **extensible**.

"simple" ⟷ *"complicated"*



...at Cape Code 2023 (with Maarten Breddels et al.)

"flavors" of glue

"glupyter" means glue running in any flavor of Jupyter, EITHER locally or on the web.

"glue" eventually means glue running anywhere (including in a browser) , now it means glue in Qt either locally or on the web

Qt

glue
multidimensional data exploration

glue genes

jupyter

Jdaviz

CosmicDS

Principal GitHub Repositories (glue-viz)

"glue" -- github.com/glue-viz/glue
Tom Robitaille is separating glue-core from glue-qt (this repo name will go away)

"glue-core" -- github.com/glue-viz/glue
The core (frontend-agnostic) glue functionality

"glue-Qt" -- github.com/glue-viz/glue-qt
Qt front-ends to glue-core (desktop client)

glue-Jupyter -- github.com/glue-viz/glue-jupyter
Jupyter front-ends (notebook & lab) to glue-core (aka "glupyter")

"glue-jupyter.lab_app" -- github.com/QuantStack/glue-jupyterlab
*prototype QT-glue-like experience inside of JupyterLab, this will become a **sub-package** of glue-jupyter*

GitHub Repositories (Special Purpose Apps using glue-jupyter))

"CosmicDS" -- github.com/cosmicds/cosmicds
Interactive online educational software which uses glue to teach learners about data science and astronomy

"Jdaviz" -- github.com/spacetelescope/jdaviz
*special-purpose tools for astronomy -- quick insights for images and spectra (**SEPARATE** REPO)*

GitHub Repositories (glue plug-ins)

glue-vispy-viewers - github.com/glue-viz/glue-vispy-viewers
3D viewers for glue powered by vispy

glue-wwt - github.com/glue-viz/glue-wwt
Use WWT as a viewer in glue (Qt and Jupyter)

glue-plotly -github.com/glue-viz/glue-plotly
export to plot.ly as html

glue-geospatial -- github.com/glue-viz/glue-geospatial
GIS tools in glue

glue-map-- github.com/jfoster17/glue-map
map viewer for glue using ipyleaflet (Jupyter only)

"SAVE" - github.com/jfoster17/SAVE
GIS-style environment useful especially for climate and climate change mitigation data

glue-astronomy -- github.com/glue-viz/glue-astronomy
collection of additional plug-ins making glue most useful to astronomy

glue-genes -- github.com/gluesolutions/glue-genes
glue tailored for genomics--currently Qt-only, future versions will offer Jupyter/web versions

glue-solar -- github.com/glue-viz/glue-solar
glue for Solar physics (experimental)

glue-medical --
glue for medical imaging (experimental)

Imagine an MSWD-style “templates” paradigm

glue (Qt), new session = “Blank Document”

glue (Qt), existing session = Existing Document

glue genes (Qt), with custom plug-ins
= Blank Document, with user plug-ins

Jdaviz dashboards

glupyter Imviz = Imviz *Template*

glupyter MOSviz = Mosviz *Template*

glupyter Specviz = Specviz *Template*

glupyter Cubeviz = Cubeviz *Template*

Cosmic Data Story = CosmicDS Template (site)

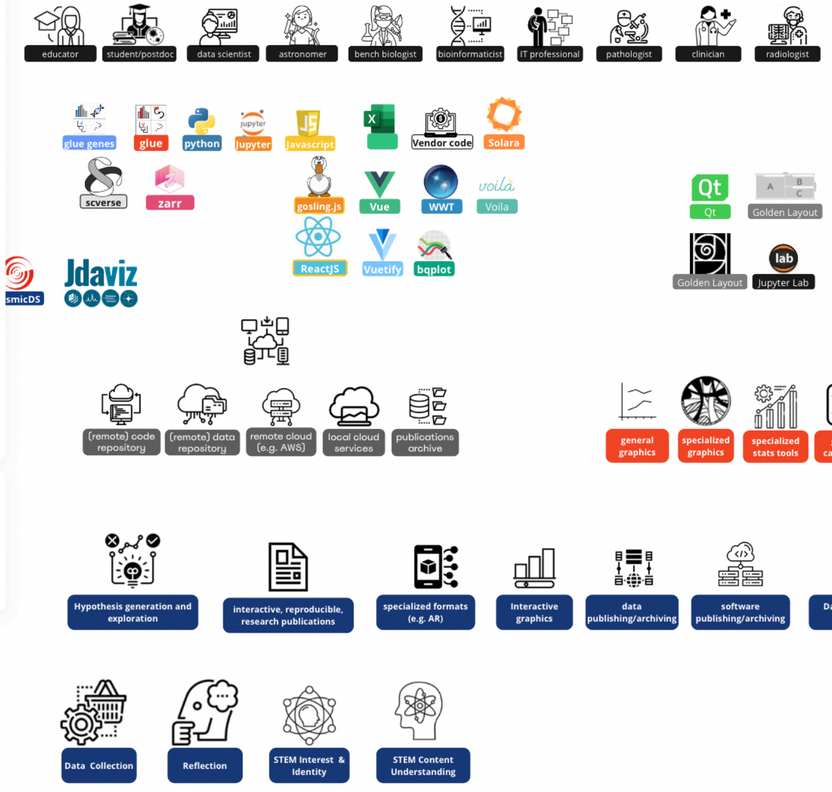
Data+Climate (GIS-featured) site
= GIS Story Template (site)

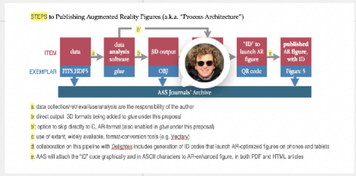
And other special-purpose uses can rely on new “templates,” fuilt from scratch or by combining existing templates.

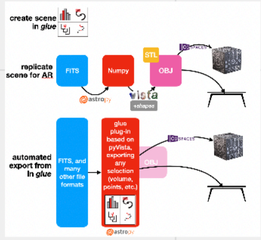
Present | Share

eroglyphs for glue

This board is the start of a glyphs system to be used in explaining different "flavors" and uses of glue, now and in the future.

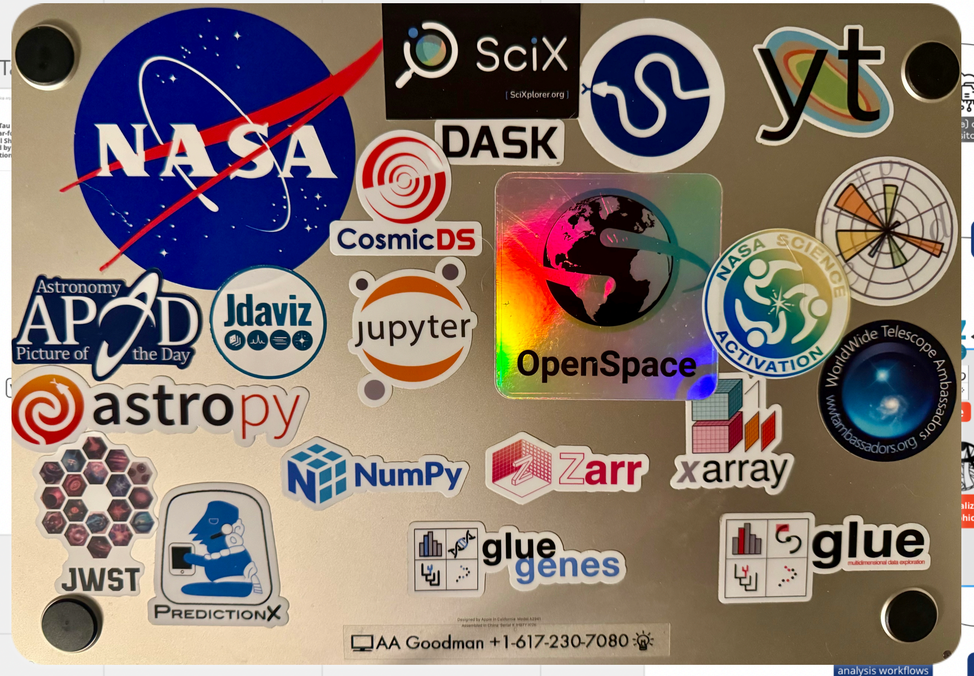




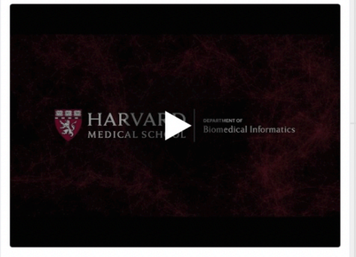


Per T

Jdaviz



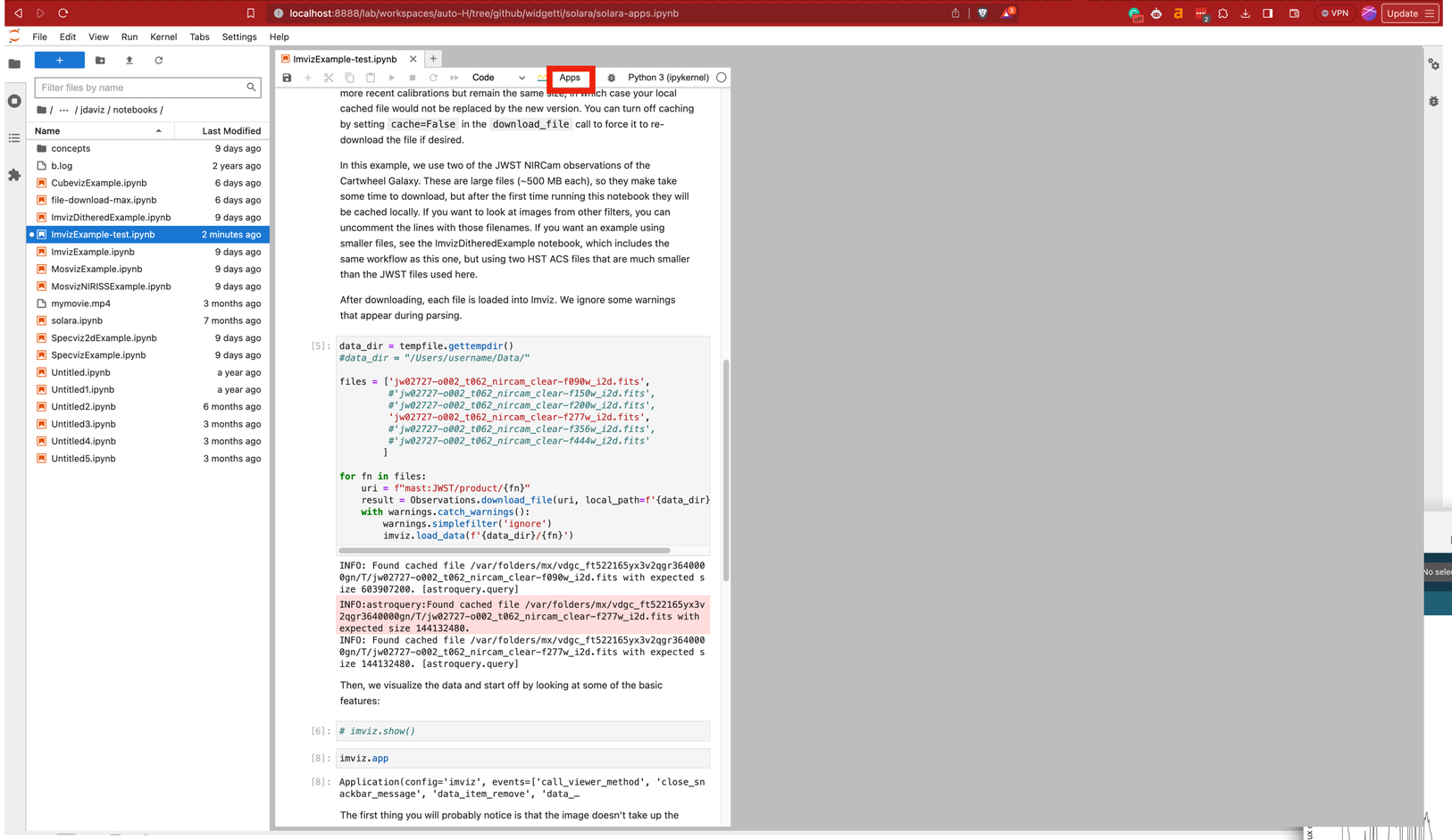
Notebook-



29%

Imagine *'Jupyter apps'*

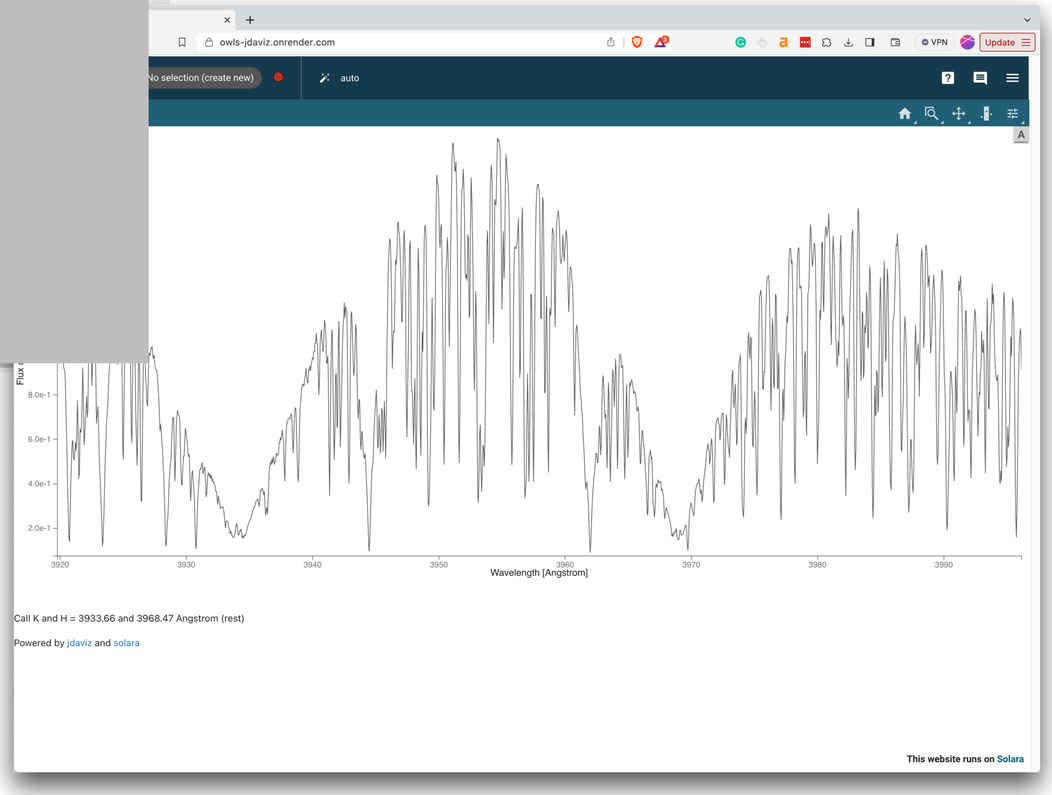
(built using Solara, which has already been tested re:Imviz & is planning stages re:CosmicDS HubbleDS)



Jupyter apps can be started from the notebook

Side by side (ala Sidecar)

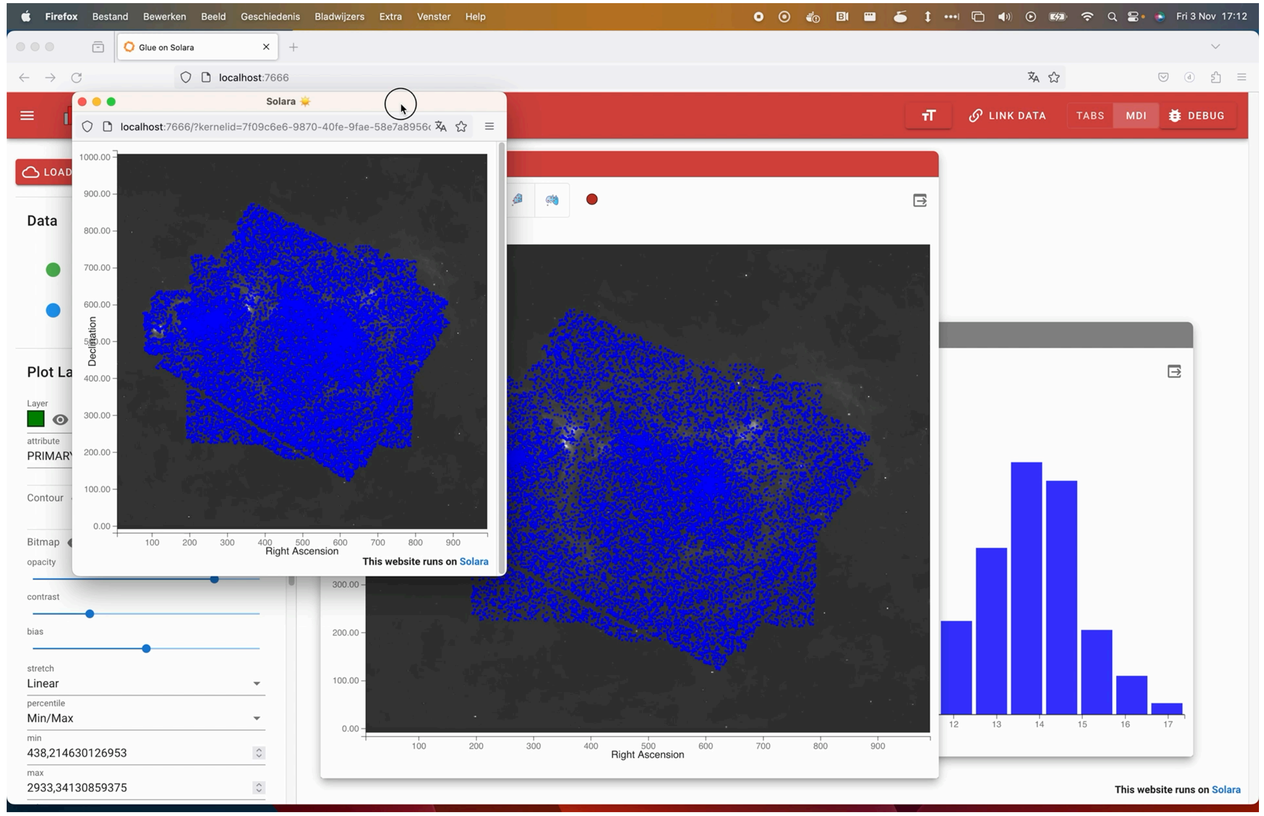
Can be shown in a separate browser tab



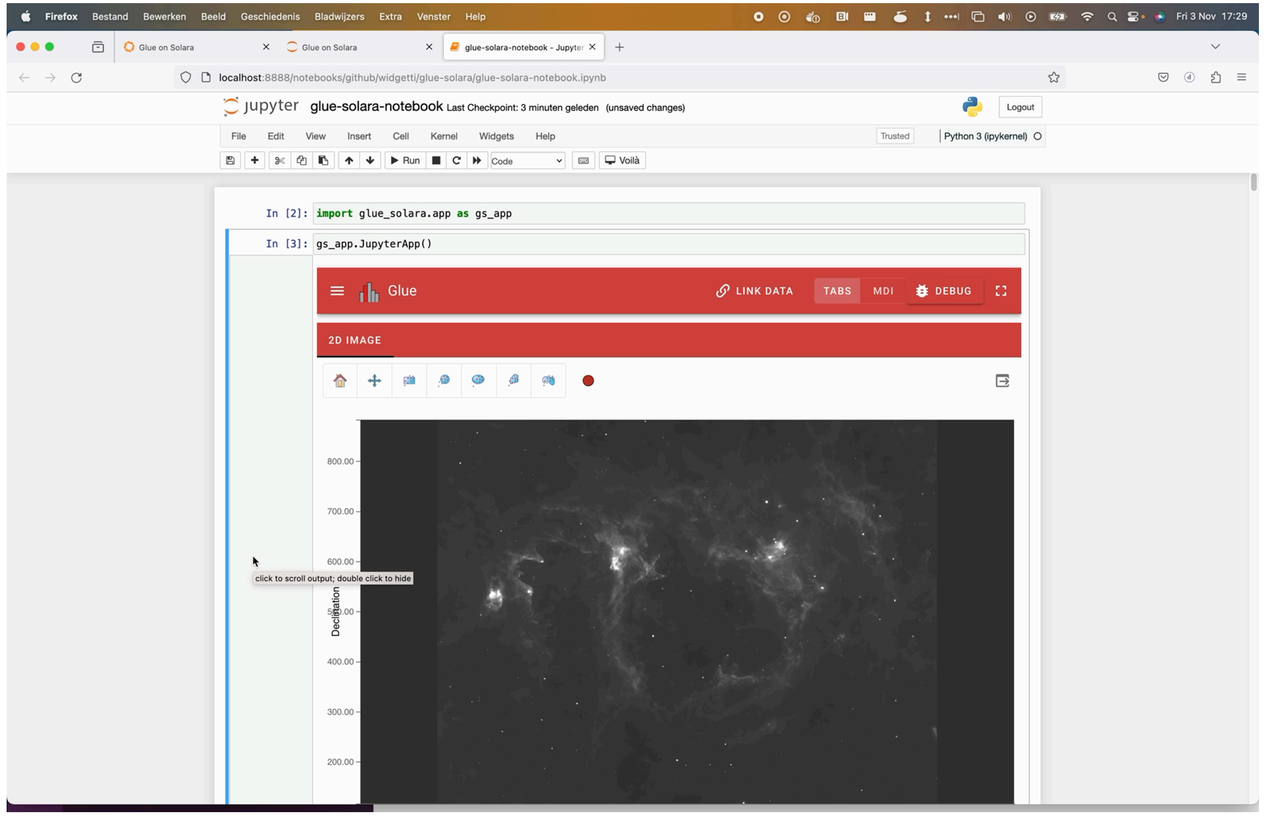
October 2023 experiment after Cape Code

...and now, glupyter in Solara is already working...

MDI allows for tear-off in-browser



also good for Jupyter Notebooks



thanks to Maarten Breddels/Widgetti & Jon Carifio!

“But wait, there’s more!”

Slack message from Maarten Breddels to Jon Carifio & Alyssa Goodman, 1/10/24

very early prototype/POC, showing the google-modelviewer in glue-Solara, then on the phone, and on the quest 3…

LIVE Astro 2024

for discussion??

LIVE | About LIVE | Capabilities | Tech | Who are we? | Learn More

VE Astro Gallery

Interactive Research Figures in the Browser
LIVE Astro for the Public
MilkyWay3D in a Planetarium
Cosmic Data Stories
Examples beyond glue, OpenSpace and WWT

Interactive Research Figures in the Browser

***Excerpt, not Export:* Rich Interactive presentations and publications**

Given glue's astronomical capabilities, many interactive figures used both in **research** and **communication** have been produced by exporting data sets that have been linked, explored, and visualized n the downloadable desktop (Qt) version of glue to Plotly (semi-automatically).
One of the goals of LIVE Astro is to **unify** the data exploration environment (e.g. glue in the browser as glupyter) with the presentation/publication environment, avoiding the need for export. So, in the fully-realized LIVE Astro environment, interactive figures could be a ***direct excerpt, rather than an export*, from a researcher's work.**

SPECIAL NOTICE FOR AAS 224 ATTENDEES IN NEW ORLEANS

The LIVE Astro talk Google Slideshow here was delivered by Jackie Faherty at the AAS Visualization Workshop on 1/7/24 in New Orleans, on behalf of Alyssa Goodman (who was stranded by Delta Airlines that day!). If you've reached this site on 1/7 itself, please note that it's so new that it's only "almost" ready for priimetime, so "pardon our dust" on unfinished sections!

The Future of Publishing

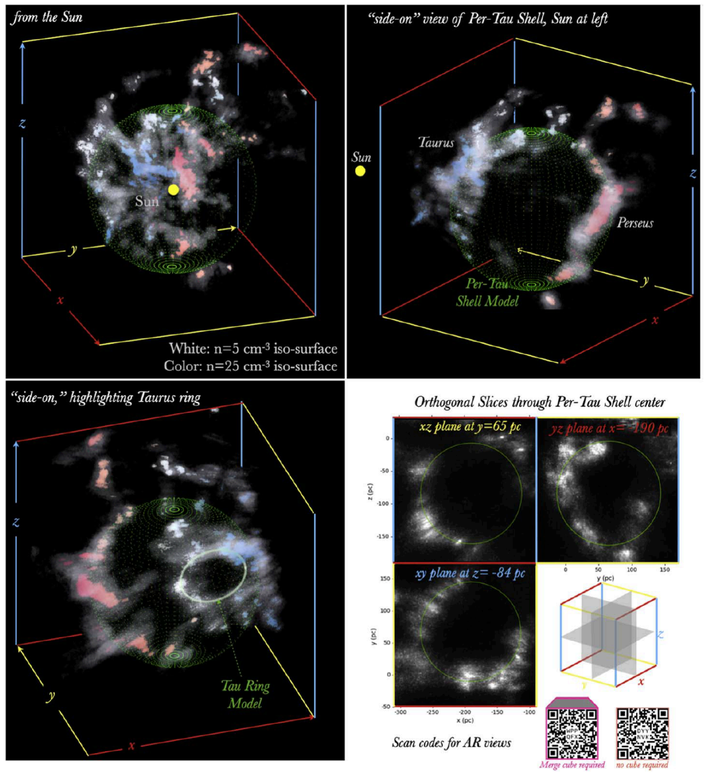
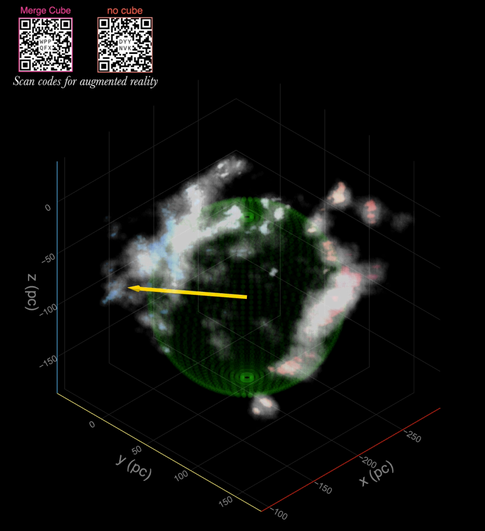
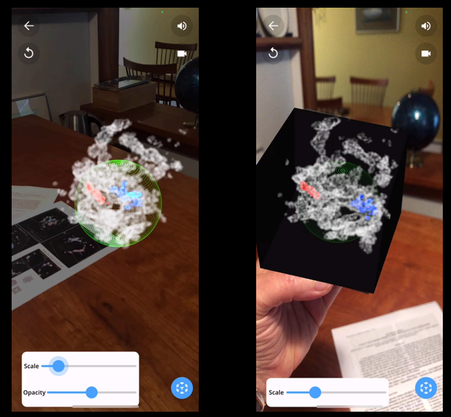


Figure 2. 3D views of the Per-Tau shell (for an interactive version[8] of this figure click here [9]; see Figure 5 for more static visualizations). Plotted are density isosurfaces at levels $n = 5$ cm^{-3} (gray) and $n = 25$ cm^{-3} (color), overlaid with our spherical-shell model, radius $R_s = 78$ pc, distance from the Sun $d = 218$ pc. The $n = 25$ cm^{-3} surfaces are colored by distance from the Sun (blue-to-red). Top-left panel: view from the Sun (compare with Figure 1). Top-right panel: a side view of the region. Perseus and Taurus and their diffuse envelopes are arranged on two opposing sides of the Per-Tau shell. Bottom-left panel: another side view emphasizing the Tau Ring. The ellipse is the Tau Ring model (Appendix B). Bottom-right panel: 2D density slices along the *xy*, *xz*, *yz* planes. All planes intersect at shell's center. In all panels *xyz* are the Heliocentric Cartesian Galactic Coordinates.

2. *Tau Ring:* in a sky projection the Tau Ring is seen almost edge-on. The near side of the Tau Ring connects with the main body of Taurus at $d \approx 150$ pc, whereas the farthest part extends to $d \approx 220$ pc.

3. *The Fictitious Connection*: A filament seems to connect Taurus to Perseus. This connection is only a coincidental projection effect, where in actuality the filament is located at the distance of Taurus, and does not physically connect





The Astrophysical Journal Letters, 919:L5 (12pp), 2021 September 20 https://doi.org/10.3847/2041-8213/ac1f95
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The Per-Tau Shell: A Giant Star-forming Spherical Shell Revealed by 3D Dust Observations

Shmuel Bialy[1], Catherine Zucker[1], Alyssa Goodman[1,2], Michael M. Foley[1], João Alves[2,3], Vadim A. Semenov[1], Robert Benjamin[4], Reimar Leike[5,6], and Torsten Enßlin[5,6]
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HARVARD Dataverse

The Per-Tau Shell (Bialy et al. 2021)

(Harvard)

Harvard Dataverse > The Per-Tau Shell (Bialy et al. 2021) >

Replication Data for: "The Per-Tau Shell: A Giant Star-Forming Spherical Shell Revealed by 3D Dust Observations" (Bialy et al. 2021)

Version 1.0

Bialy, Shmuel; Zucker, Catherine; Goodman, Alyssa; Alves, Joao; Foley, Michael; Semenov, Vadim; Benjamin, Robert; Leike, Reimer; Ensslin, Torsten, 2021, "Replication Data for: "The Per-Tau Shell: A Giant Star-Forming Spherical Shell Revealed by 3D Dust Observations" (Bialy et al. 2021)", https://doi.org/10.7910/DVN/6ODS8M, Harvard Dataverse, V1, UNF:6:tRun1ZvDwdJze0WTkUBPQg== [fileUNF]

Cite Dataset Learn about Data Citation Standards.

Access Dataset

Contact Owner Share

PerTau_Glue_session.glu
PerTau_Dataverse/glue/
Unknown - 187.4 KB
Published Aug 19, 2021
8 Downloads
MD5: 7c5...b3d

Dataset Metrics

164 Downloads

Description

Bialy et al. (2021) presented 2D and 3D observations of the Perseus and Taurus star-forming region, showing that the 3D ISM structure reveals the existence of a very extended shell, R~80 pc, where the Perseus and Taurus molecular clouds lie on the two ends of the shell. This shell was named "the Per-Tau Shell", and it was argued that it may have been produced by a past supernova (SN) and stellar feedback activity, pointing to the potential importance of positive SN feedback.

This database includes the data required to reproduce these results, and further study this region in 2D and 3D. It includes:

for discussion?!?

c. 2017

plotly

en… …cript) outputs, in 2013

d3po

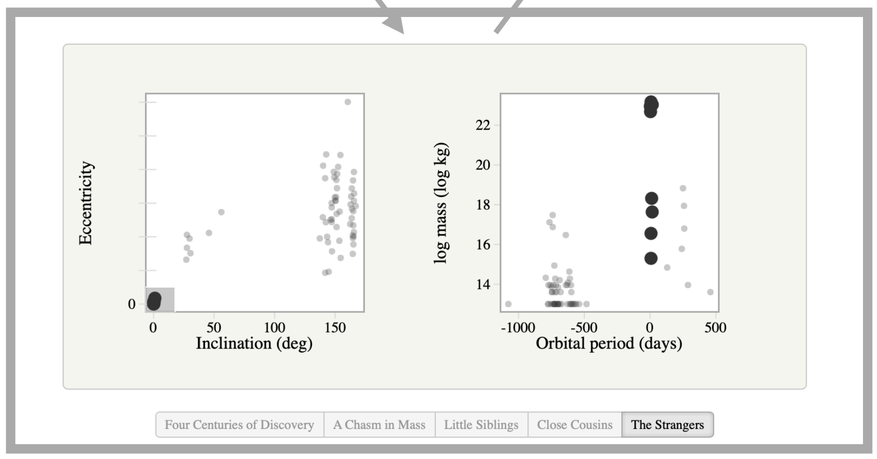
d3po is a project designed to allow an astronomer (or anyone), with no special data visualization skills, to make an interactive, publication-quality figure that has staged builds and linked brushing through scatter plots. Our current version can be previewed at d3po.org, and represents a figure from upcoming work by graduate student Elisabeth Newton. The figure describes how metalicity affects color in cool stars, and represents a nice use case for d3po. Try clicking and dragging in the scatter plots to understand the power of linked brushing in published figures.

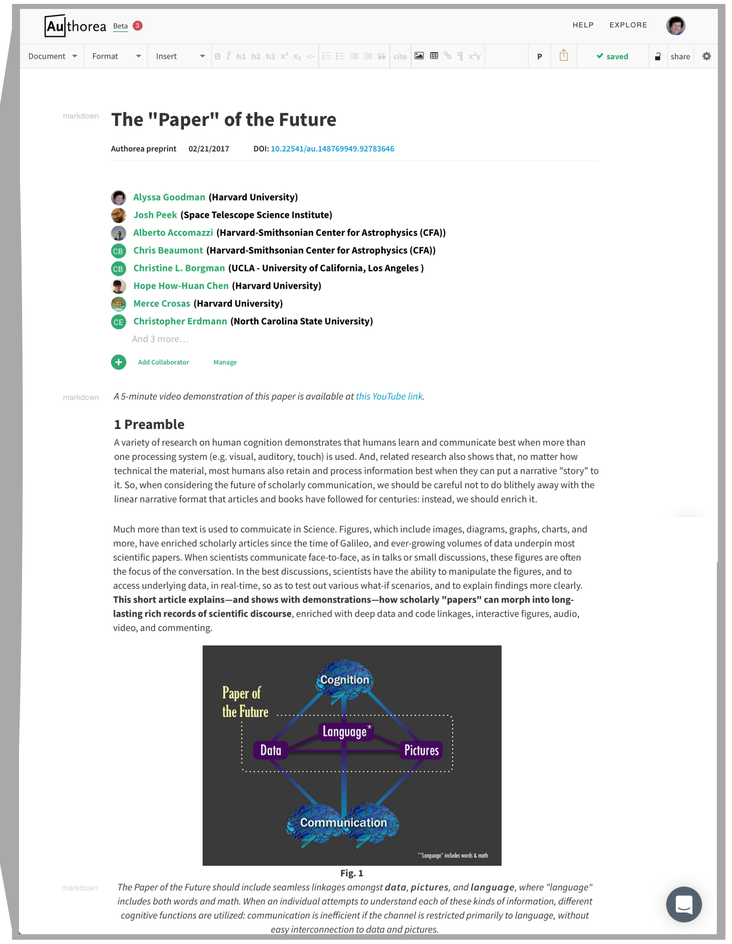
Right now we are in search of alpha testers, who have figures that could be made interactive and who are willing to get their hands a little dirty (No javascript skills needed). In future versions, we plan to link to glue to allow the creation of d3po figures interactively. We are also exploring implementation of d3po within presentations and within authorea. Full 1.0 version expected in January 2014.

Installing your own d3po server

```
git clone git@github.com:adrn/d3po.git
cd d3po
virtualenv --no-site-packages venv
source venv/bin/activate
pip install -r pip-requirements.txt
python run.py
```

Authorea





[demo]

Many thanks to Alberto Pepe, Josh Peek, Chris Beaumont, Tom Robitaille, Adrian Price-Whelan, Elizabeth Newton, Michelle Borkin & Matteo Cantiello for making this posible.

for discussion??

LIVE Astro 2024

LIVE Environments | About LIVE | Capabilities | Tech | Who are we? | Learn More

Data Access

Data sets can be local or remote (e.g. cloud storage), and a wide variety of file formats are supported. The large, multidimensional, datasets required for modern scientific analysis are supported natively. Adding completely new data formats requires only a few lines of code.

Data can be anywhere

Local data

Remote data

Oh, and yes, we already have AI-enabled data set linking working...

Data ca (More AI for metadata too??)

🧬 A large (~60 GB) multi-resolution image can be interactively panned and zoomed while remaining entirely on disk.

your faves?

glue is an open-source Pyt… explore r… …thin and be… …datasets

Vaex is a … …or lazy Out-of-Core … …milar to Pandas), to vis… …ore **big** tabular datasets.

…oes what you want with **tables**

…e overall goal of **Astro Data Lab** is to enable efficient exploration and analysis of the **large datasets** now being generated by instruments on NOIRLab and other wide-field telescopes

Aladin lite is a lightweight version of the Aladin tool, running in the browser and geared towards **simple** visualization of a sky region

ESASky is an application that allows you to visualise and **download** public astronomical **data**.

yt is an open-source, permissively-licensed python package for analyzing and visualizing **volumetric** data.

JS9 brings astronomical **image** display to your browser and desktop

The **Mikulski Archive for Space Telescopes** is an astronomical **data** archive focused on the optical, ultraviolet, and near-infrared.

AAS **WorldWide Telescope** is a tool for showcasing astronomical **data** and **knowledge**.

CARTA is the **Cube** Analysis and Rendering Tool for Astronomy, a new image visualization and analysis tool designed for the ALMA, the VLA, and the SKA pathfinders.

OpenSpace is open source interactive data visualization software designed to visualize the entire known universe and portray our ongoing efforts to investigate the **cosmos**.

A 2[illegible]NCE PLATFORM": PLUG-INS, CODE-SHARING & HUBS

for discussion??

ENABLED BY

The Astropy Project

GitHub jupyter

NumPy

pandas

matplotlib

...

esa Sky

yt

vaex

glue
multidimensional data exploration

SAMP Hub

ASTRO DATALAB

Jdaviz

js9

NOTE: I know this diagram has missing links! Please suggest via Slack & I'll add them during this session—slides will update online.

ChatGPT 4

AI agrees it's time!

You

explain why designing an integrated visualization system using modular elements is so much easier today than it was 15 years ago

ChatGPT

Designing an integrated visualization system using modular elements has become significantly easier today compared to 15 years ago due to several key developments:

1. **Advancements in Technology:** Modern computing power has dramatically increased, enabling the handling of complex visualizations and large datasets with ease. This was a significant limitation 15 years ago.

2. **Availability of Specialized Tools and Libraries**: Today, there is a plethora of tools and libraries specifically designed for visualization, such as D3.js, Plotly, and Matplotlib. These tools offer modular components that can be easily integrated and customized, making the process of creating complex visualizations much simpler.

3. **Widespread Adoption of Open Standards and APIs**: The growth of open standards and APIs has made it easier to integrate different software modules and services. This interoperability was much more limited in the past, making it challenging to combine elements from different sources.

4. **Improved Software Development Practices:** Modern software development practices, like Agile and DevOps, encourage modular design, continuous integration, and testing. This was not the standard approach 15 years ago, making modular development more cumbersome.

5. **Greater Community and Support:** The open-source community has grown exponentially, offering extensive resources, tutorials, and forums for troubleshooting and support. This community-driven support system was less developed 15 years ago.

6. **Cloud Computing and Virtualization**: The advent of cloud computing and virtualization has made it easier to deploy and scale visualization systems. These technologies provide flexibility and scalability that were not available or were very expensive 15 years ago.

7. **Enhanced User Interface (UI) Frameworks:** Modern UI frameworks and design languages have made it easier to create intuitive and interactive visualizations. These frameworks are often modular, allowing developers to integrate and customize components efficiently.

8. **Data Availability and Big Data Technologies**: There is now an abundance of data available for visualization, and big data technologies have made it possible to process and visualize this data in real-time, something that was much more challenging 15 years ago.

Overall, the combination of technological advancements, better tools, open standards, modern development practices, and a supportive community has made the task of designing integrated visualization systems using modular elements much more accessible and efficient today.

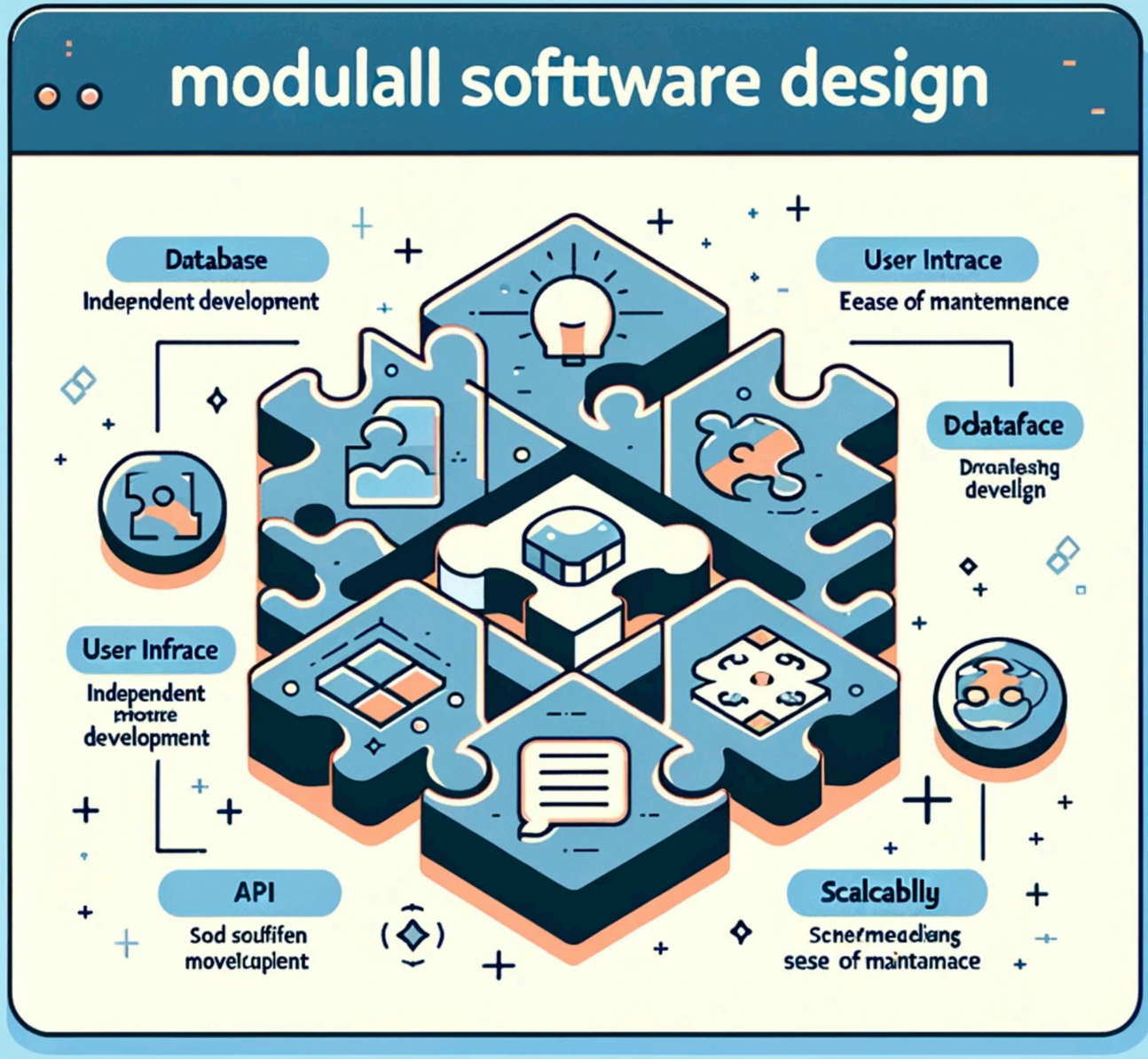
(but, AI is not so great at visualization, yet...)

ChatGPT 4

You
make 5 slides explaining how modular software elements can be fit into a Jupyter framework using composable philosophy

ChatGPT
Creating a five-slide presentation to explain how modular software elements can be integrated into a Jupyter framework using a composable philosophy involves breaking down the concept into digestible parts. Here's a suggested outline for the slides:

1. **Introduction to Modular Software Design:** This slide can explain the basics of modular software design, emphasizing the importance of creating software in smaller, manageable pieces that can be developed, tested, and maintained independently.
2. **Understanding the Jupyter Framework:** This slide should introduce the Jupyter framework, highlighting its features, capabilities, and why it's a suitable platform for integrating modular software elements.
3. **Principles of Composability in Software:** Here, the focus will be on the composable philosophy, explaining how it allows for the flexible combination of independent software modules to create more complex systems.
4. **Integrating Modular Elements in Jupyter:** This slide can delve into the practical aspects of integrating modular software elements into the Jupyter framework, possibly includ ode examples or architecture diagrams.



You

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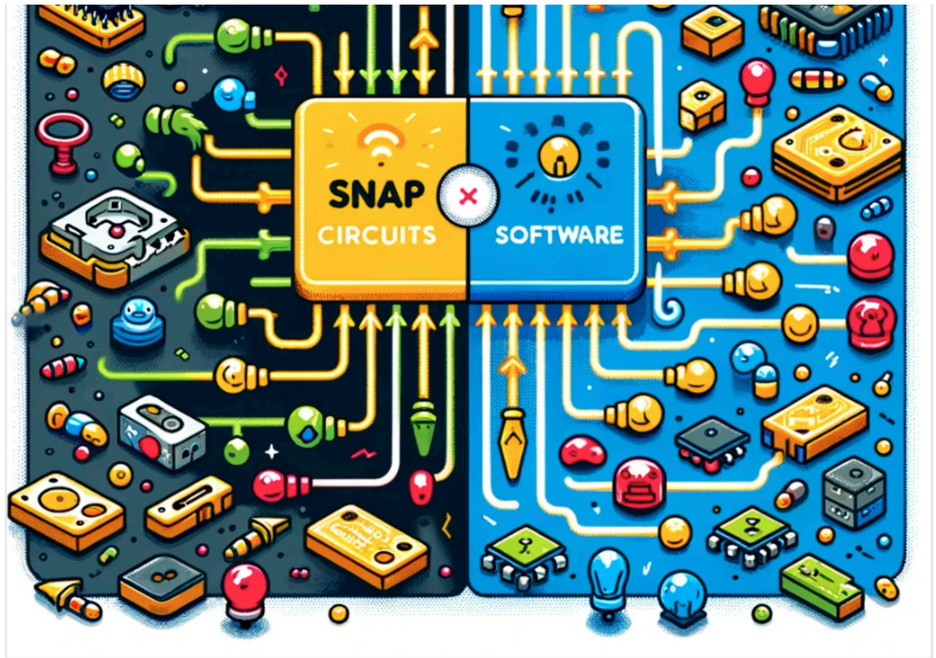
ChatGPT

Designing an integrated visualization system using modular elements has become significantly easier today compared to 15 years ago due to several key developments:



Here's the graphic that demonstrates the analogy between snap circuits and composable software. It visually compares the concept of snap circuits on one side to software components on the other, illustrating the modularity and interconnectivity present in both systems. This should help in understanding how these two concepts are related in terms of their modular and composable nature.