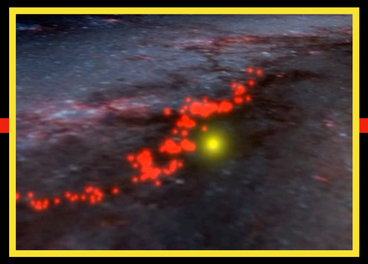
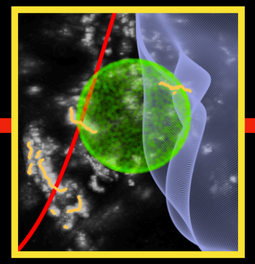
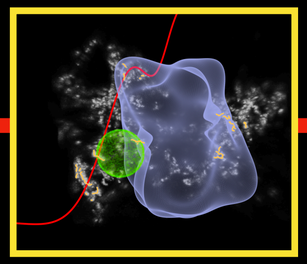
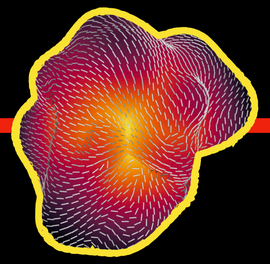
# glue-ing together the Milky Way

Alyssa Goodman, Center for Astrophysics | Harvard & Smithsonian

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)**

- [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

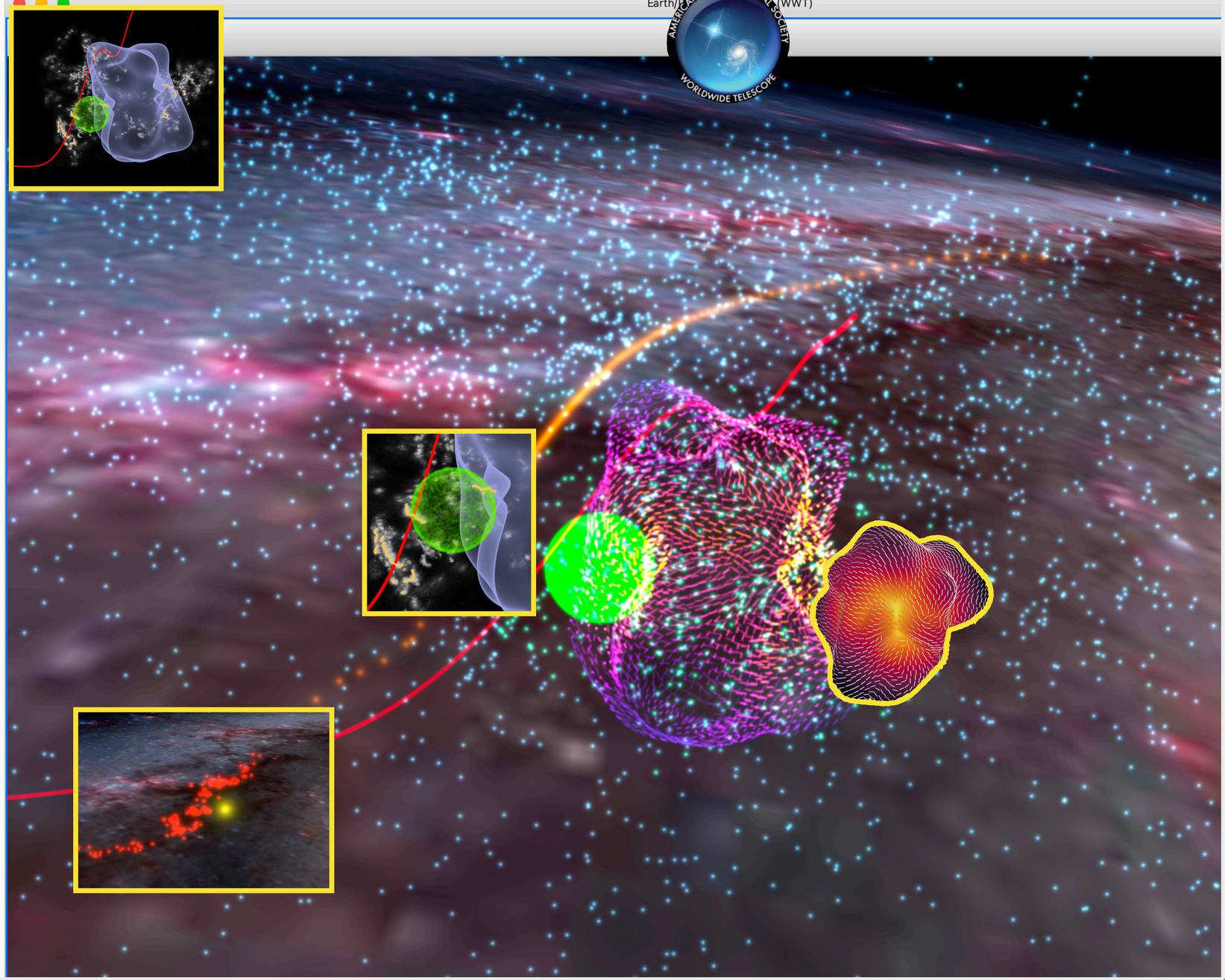
Latitude: GLAT

Distance: Distance

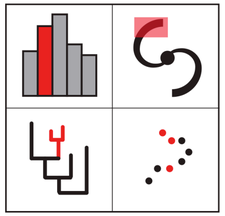
pc

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

Earth/Planet/Sky Viewer (WWT)



Explore
“The *best* roads are two-way.”
Explain

# 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)

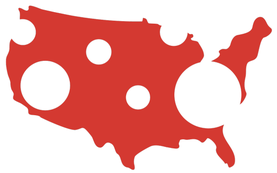
# **data** files' common attributes are **glued**

# avoiding the need to merge data files

# “graphs”

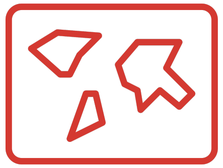
## common statistical graphics

(scatterplots, histograms, tables, curves, overlays)



## maps & images

(greyscale, color, contours, layer control…)

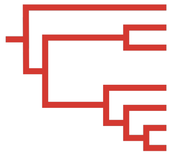


## 3D displays

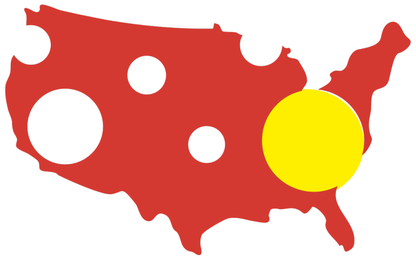
(scatter plots, volumetric rendering, sliders…)

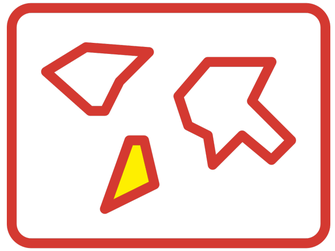
## specialized & custom charts

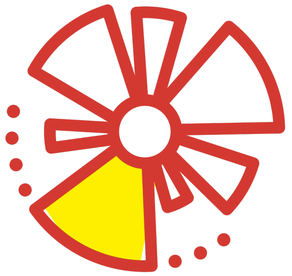
(dendrograms, polar plots, + domain-specific options)



# selections propagate across all graphs



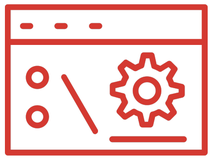




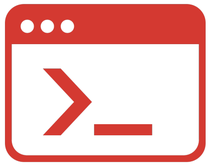
# for real-time data exploration & insight

# tools

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

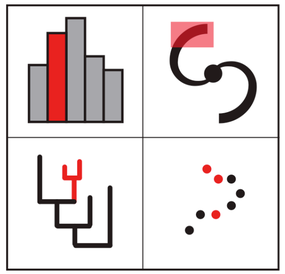


**web services** (across domains)



**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

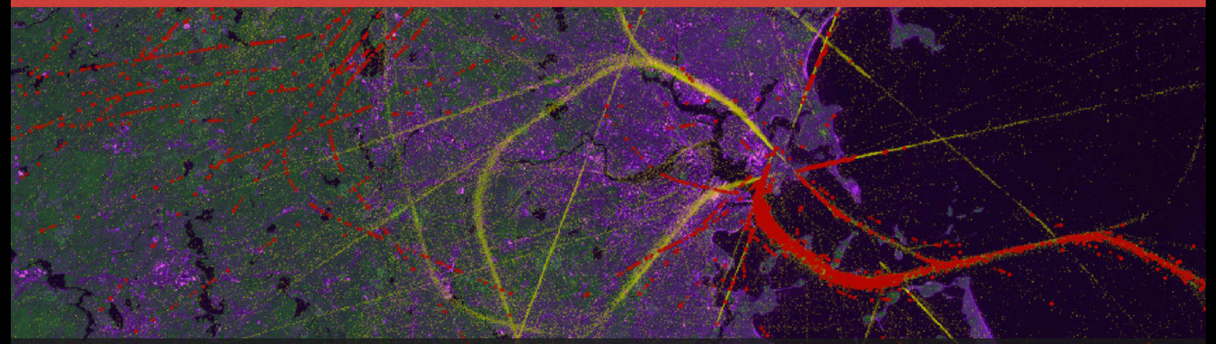
supported by

glue solutions inc.

GORDON AND BETTY MOORE FOUNDATION

**Glue:** multi-dimensional linked-data exploration

Home | Install | Documentation | Team | Get involved | Packages | glue-con events | Consulting services



**Glue** is an open-source Python library to explore relationships within and between related datasets

### Linked Visualizations

With Glue, users can create scatter plots, histograms and images (2D and 3D) of their data. Glue is focused on the brushing and linking paradigm, where selections in any graph propagate to all others.

### Flexible linking across data

Glue uses the logical links that exist between different data sets to overlay visualizations of different data, and to propagate selections across data sets. These links are specified by the user, and are arbitrarily flexible

### Full scripting capability

Glue is written in Python, and built on top of its standard scientific libraries (i.e., Numpy, Matplotlib, Scipy). Users can easily integrate their own python code for data input, cleaning, and analysis.

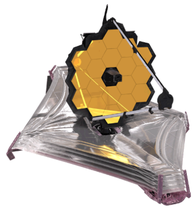
glueviz.org

gluesolutions, inc. | Home | Gallery | Our Team | The Software | glue-con | Social Impact | More

# glupyter (a.k.a. "glue jupyter")

**"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**

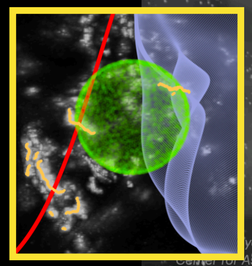
**Sponsors:** The Gordon and Betty Moore Foundation and the National Science Foundation

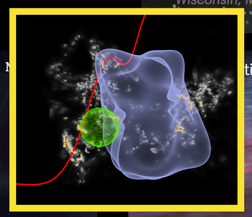
Read more in the justificaiton of the GBF proposal, awarded to Harvard, and watch this 2022 demo video

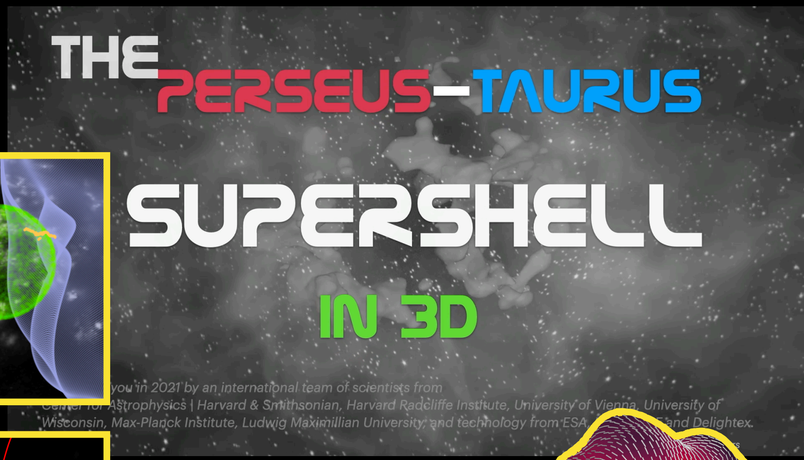
gluesolutions.io/the-software/glupyter

# The “New Milky” Way online
## (early 2023 edition)

2021

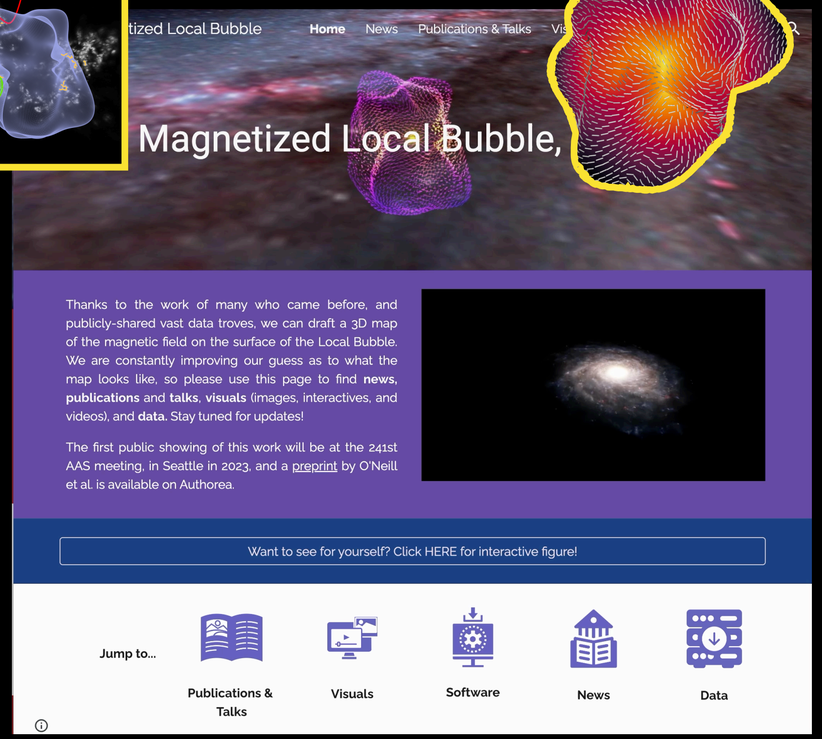






2020

2022




2023

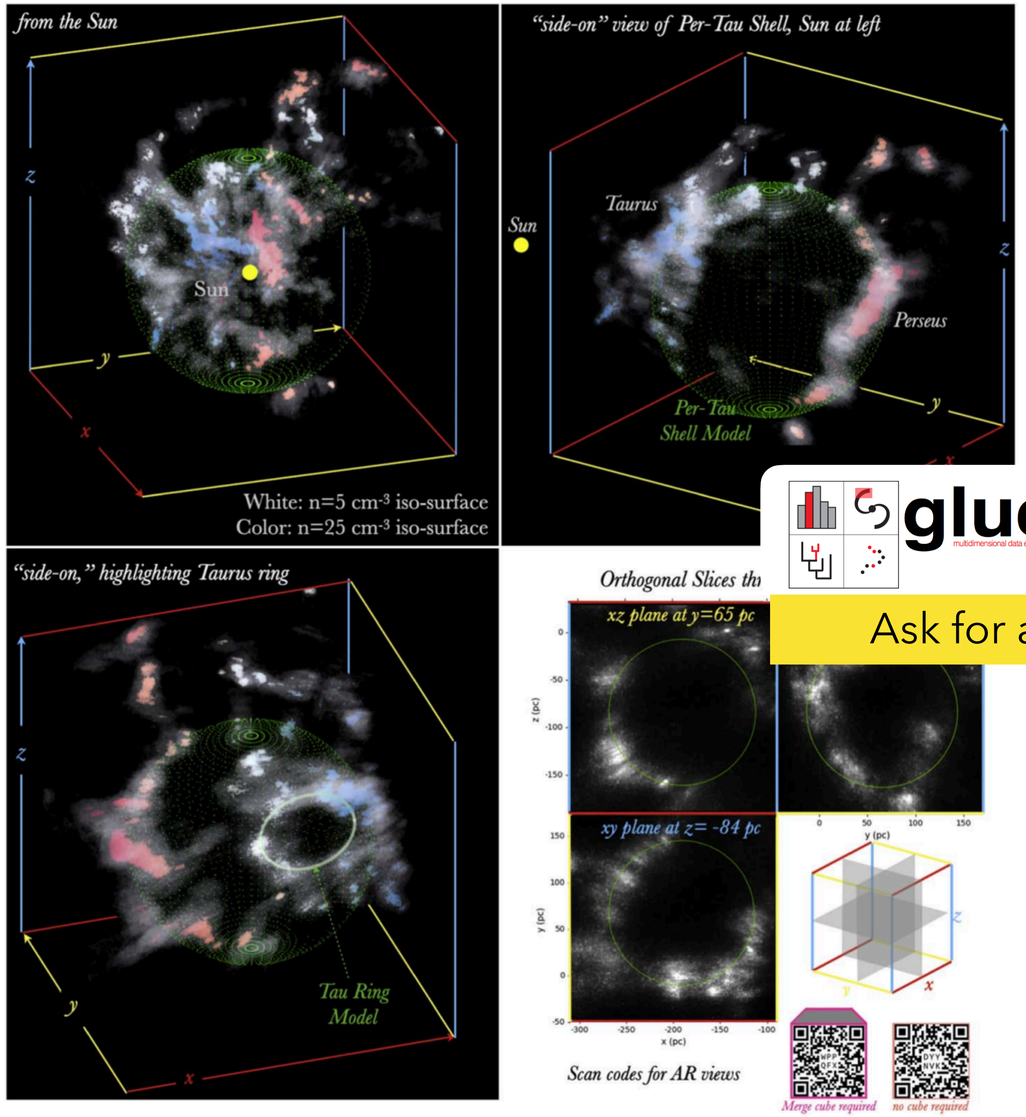



**Figure 2.** 3D views of the Per-Tau shell (for an interactive version[8] of this figure click here [9]; see Figure 5 for more static visualizations). Plotted are density iso-surfaces at levels $n = 5$ cm$^{-3}$ (gray) and $n = 25$ cm$^{-3}$ (color), overlaid with our spherical-shell model, radius $R_s = 78$ 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.

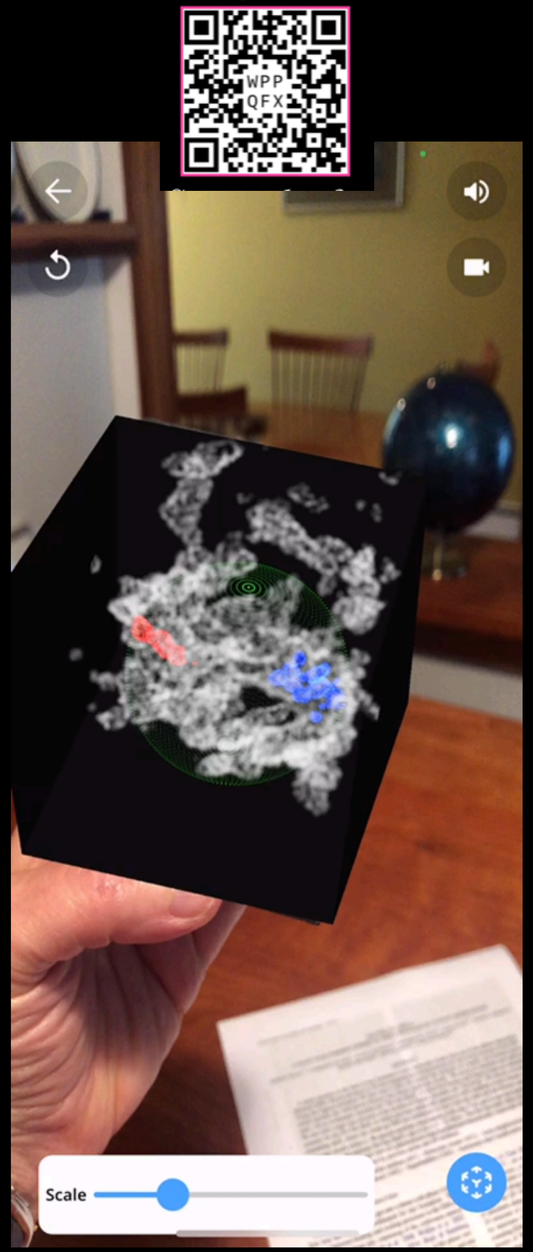
2. *Tau Ring:* in a sky projection the Tau Ring is seen almost edge-on. The near side of the Tau Ring connects with the main body of Taurus at $d \approx 150$ pc, whereas the farthest part extends to $d \approx 220$ pc.

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



glue multidimensional data exploration → COSPACES

Ask for a demo later, please.




Bialy et al. 2021

The Dataverse® Project

**Embargoed—please do not share—this slide will be removed from slides online.**

# Phase Space Analysis of the Local Interstellar Medium

## *The Oscillation of the Radcliffe Wave*

**Ralf Konietzka**

**Master's Thesis**

at the Faculty of Physics

Ludwig-Maximilians-University of Munich

Submitted by

**Ralf Konietzka**

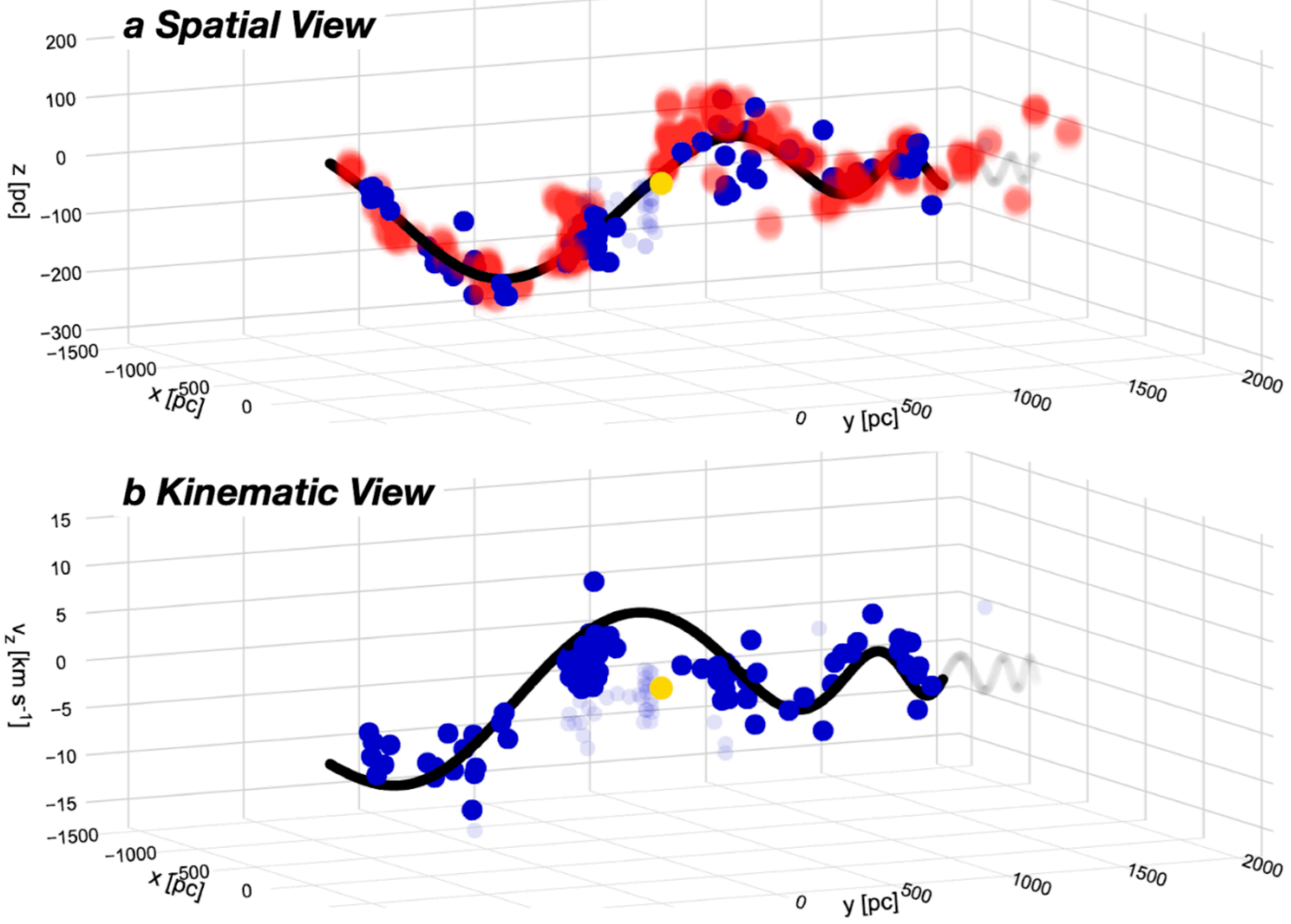
born in Nuremberg

Supervised by

Prof. Dr. Alyssa Goodman

Prof. Dr. Andreas Burkert

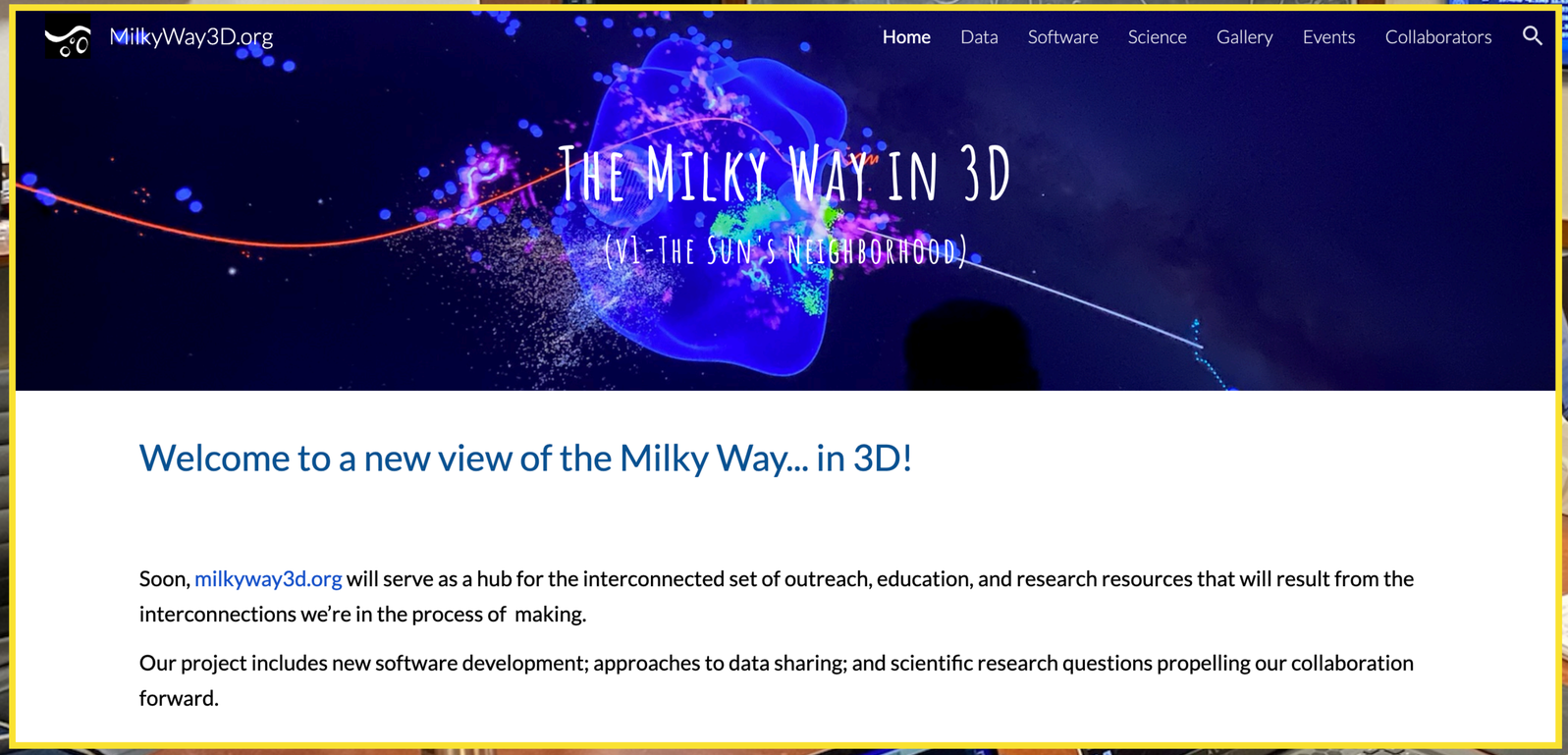
Munich, June 12, 2023

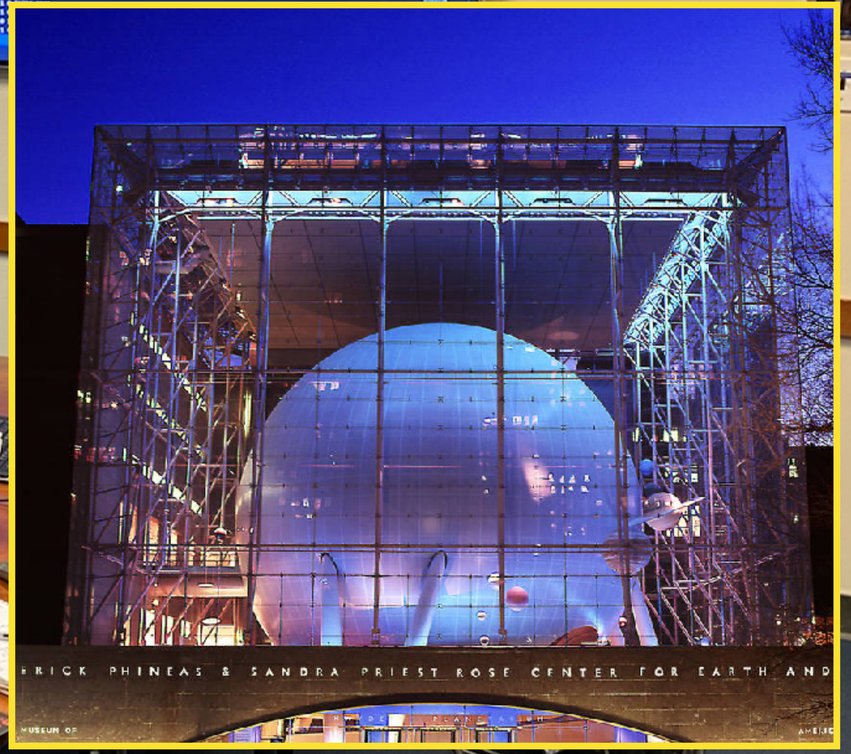



https://ralfkonietzka.github.io/files/RW_final_figures/Figure_1.html

Konietzka, R., Goodman, A., Zucker, C., Burkert, A., Alves, J., Foley, M., Swiggum, C. 2023. To be submitted to Nature, June 2023. The Radcliffe Wave is Oscillating

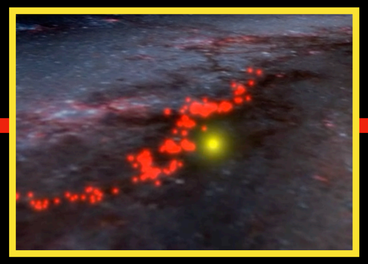
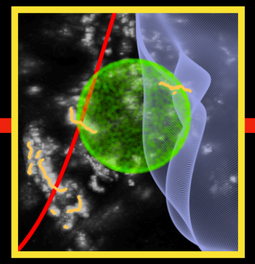
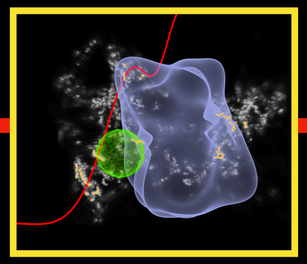
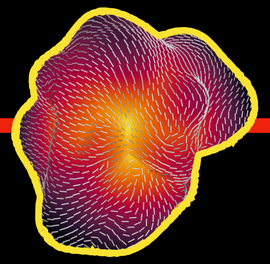
# Putting it all together at MilkyWay3D.org



# glue-ing together the Milky Way

Alyssa Goodman, Center for Astrophysics | Harvard & Smithsonian

***great* 1D, 2D** and **3D** data manipulation, flexible architecture facilitating plug-ins, data transfer, and interactive data exploration; "glupyter" flavor runs in web pages

glue
multidimensional data exploration

CosmicDS

plug-in in-use on Hayden Planetarium dome

AMERICAN ASTRONOMICAL SOCIETY
WORLDWIDE TELESCOPE

plug-in shows WWT images in context in 3.

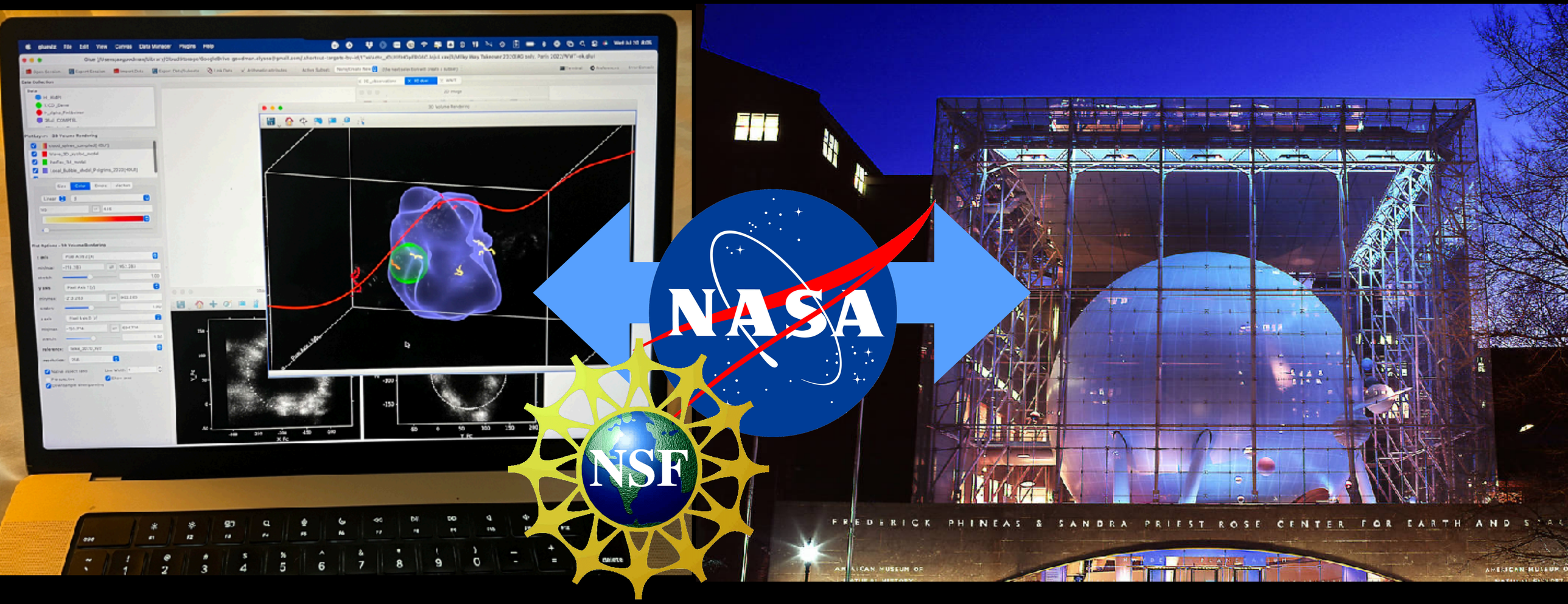
OpenSpace

***great* 2D** object and all-sky images
*limited* 3D functionality

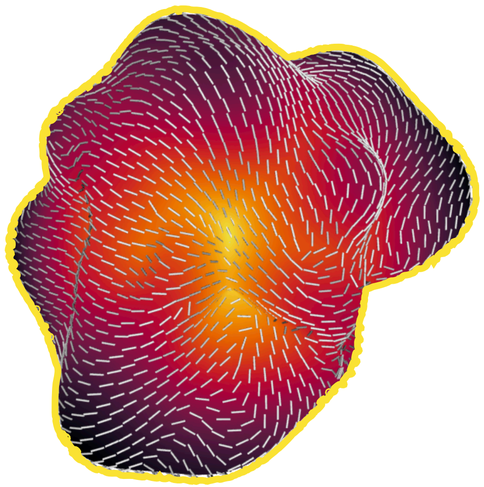
*limited* 2D all-sky images
***great* 3D** functionality

The "Perseus-Taurus Superbubble"
*a demo of the need for 2D-3D contextualization functionality*

*This video was composited using the WWT and OpenSpace, making some use of prototype plug-ins, but 2D and 3D imagery was aligned manually by experts. As a generalizable STEM concept, it explains the deceptive "forced perspective" made possible in when objects at very different distances, in 3D, appear to touch in 2D.*


glue
multidimensional data exploration
OpenSpace
AMERICAN ASTRONOMICAL SOCIETY
WORLDWIDE TELESCOPE
NASA
NSF
FREDERICK PHINEAS & SANDRA PRIEST ROSE CENTER FOR EARTH AND

# A 3D Map of the Local Bubble's Magnetic Field



Explore Interactive Figures from the paper

Figure 1: Local-to-total Extinction Ratio

Figure 3: 3D Vector Field

Figure 4: Environment

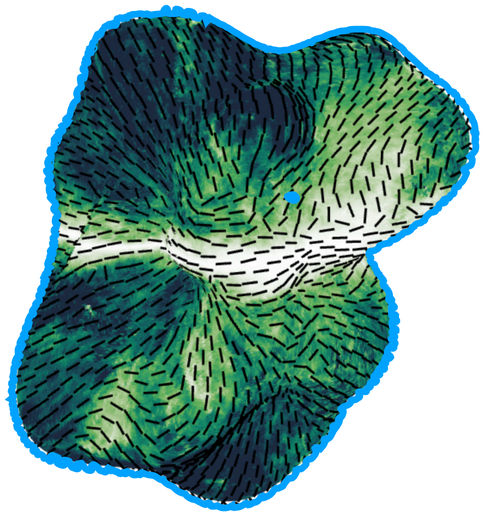
Figure 5: Distance

Figure 6: Inclination from plane-of-the-sky, Gamma

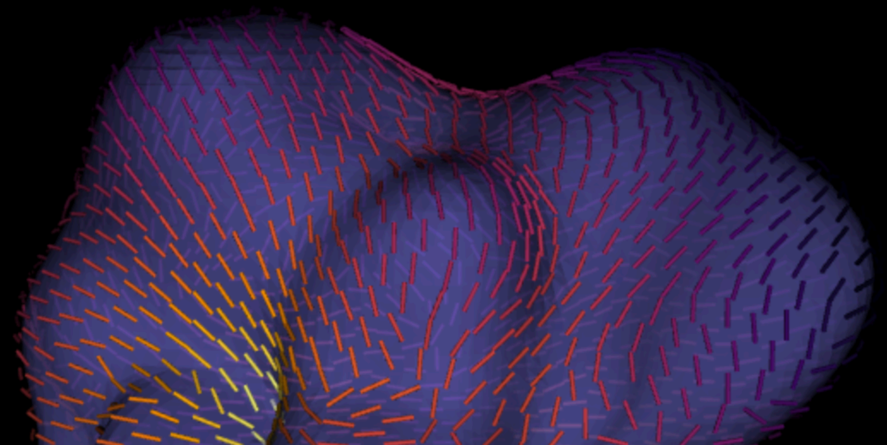
Figure 7: Polarization fraction p

Figure 8: Dispersion S

Figure 12: Background Starlight



https://theo-oneill.github.io/magneticlocalbubble/



O'Neill et al. 2023