

AUGMENTED REALITY FOR EVERYONE

▲ 3-D trip inside a drawing, via computer graphics

Slip this display device on your head and you see a computer-generated 3-D image of a room before your eyes. Move your head and your perspective changes, just as though you were actually inside the room. Architects could use the device to draw buildings in three dimensions; realtors could use it to show buyers the interiors of homes without even leaving the office. Dr. Ivan Sutherland, University of Utah, invented the device, essentially a computer-graphics version of the old stereoscope.

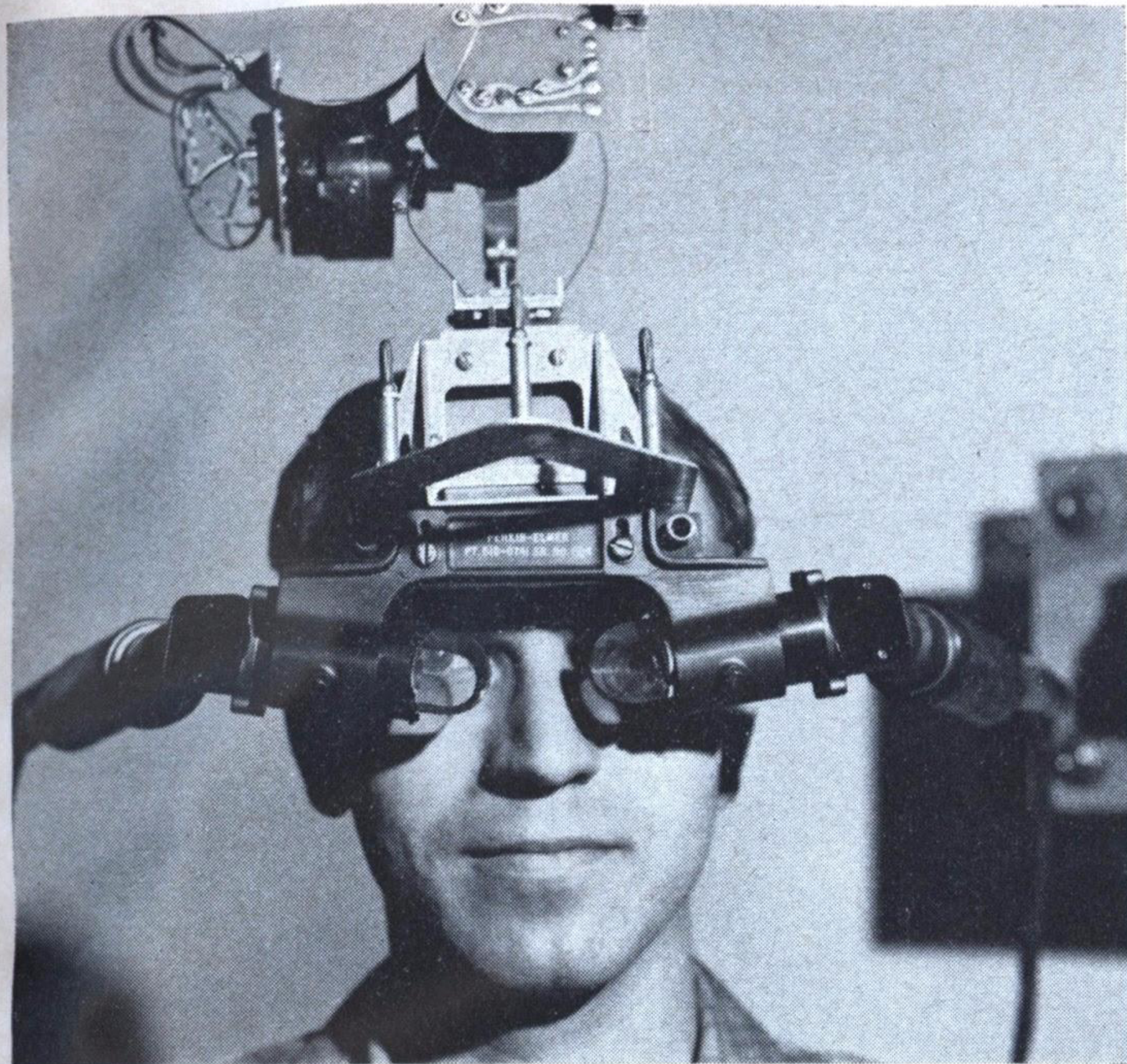
CENTER FOR ASTROPHYSICS | HARVARD & SMITHSONIAN

ALYSSA GOODMAN

COSMIC DATA STORIES & GLUE PI



60 YEARS AGO



▲ 3-D trip inside a drawing, via computer graphics

Slip this display device on your head and you see a computer-generated 3-D image of a room before your eyes. Move your head and your perspective changes, just as though you were actually inside the room. Architects could use the device to draw buildings in three dimensions; realtors could use it to show buyers the interiors of homes without even leaving the office. Dr. Ivan Sutherland, University of Utah, invented the device, essentially a computer-graphics version of the old stereoscope.

NOW



1965

The Ultimate Display

Ivan E. Sutherland

Information Processing Techniques
Office, ARPA, OSD

Proceedings of the IFIP Congress

*We live in a physical world whose properties we have come to know well through long familiarity. We sense an involvement with this physical world which gives us the ability to predict its properties well. For example, we can predict where objects will fall, how well-known shapes look from other angles, and how much force is required to push objects against friction. We lack corresponding familiarity with the forces on charged particles, forces in non-uniform fields, the effects of nonprojective geometric transformations, and high-inertia, low friction motion. **A display connected to a digital computer gives us a chance to gain familiarity with concepts not realizable in the physical world. It is a looking glass into a mathematical wonderland.***

The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming such a display could literally be the Wonderland into which Alice walked.

TODAY'S TERMINOLOGY

Extended Reality **XR**

The entire experience spectrum from completely virtual to completely real

Virtual Reality **VR**

User is completely immersed into a virtual environment



Mixed Reality **MR**

"Environment aware" 2D or 3D content is overlaid onto the physical space



Augmented Reality **AR**

"Non-environment aware" 2D or 3D content is overlaid onto the physical space



Shop HoloLens 2 offerings

Purchase HoloLens 2 from Microsoft Store or an authorized HoloLens 2 reseller.

HEAD-
MOUNTED
DISPLAYS?



HoloLens 2

An ergonomic, untethered self-contained holographic device with enterprise-ready applications to increase user accuracy and output.

\$3,500



HoloLens 2 Industrial Edition

A HoloLens 2 that is designed and tested to support regulated environments such as clean rooms and hazardous locations.

\$4,950



Trimble XR10 with HoloLens 2

A hardhat-integrated HoloLens 2 that is purpose-built for personnel in dirty, loud, and safety-controlled work site environments.

\$5,199

(several thousand dollars for on-board computing as of 2021)

Using a phone is >100x less expensive!!

HEAD-
MOUNTED
DISPLAYS?



\$9



\$50

(using a smartphone, HMD's can be nearly "free")

And who needs a headset?

The entire experience spectrum from completely virtual to completely real

Virtual Reality

VR

User is completely immersed into a virtual environment



Mixed Reality

MR

"Environment aware" 2D or 3D content is overlaid onto the physical space



Augmented Reality

AR

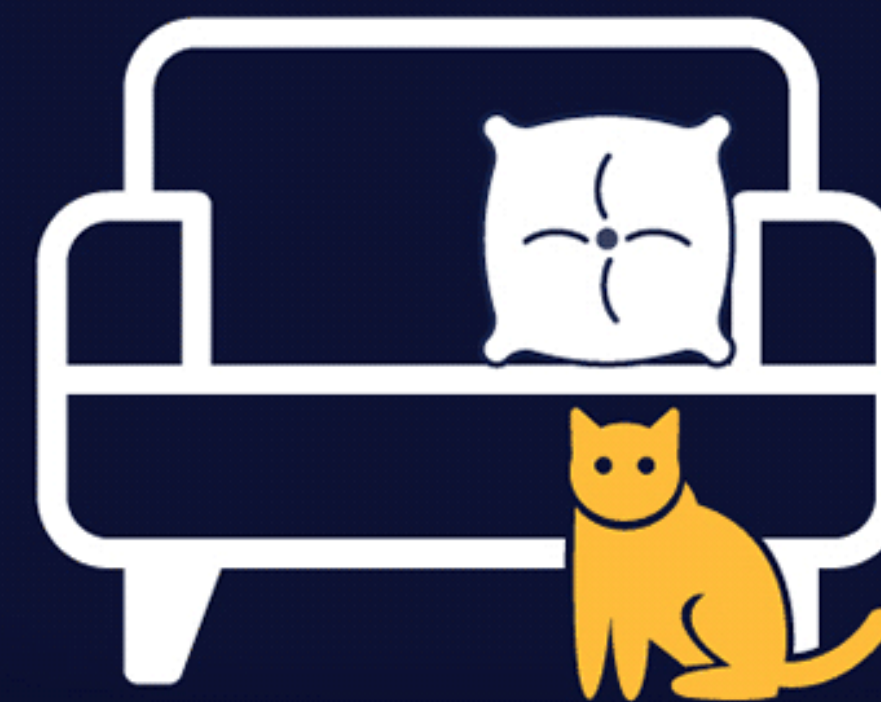
"Non-environment aware" 2D or 3D content is overlaid onto the physical space



Augmented Reality

AR

"Non-environment aware" 2D or 3D content is overlaid onto the physical space



Educational



 FREE 5.0



 FREE 4.0



  FREE 5.0



  FREE 4.5



  FREE 4.0



 FREE 4.0



 FREE 4.5



  FREE 4.0



 FREE 4.5



 FREE 5.0



 [Contact](#)

2021: THE FIRST AUGMENTED REALITY FIGURES IN THE ASTROPHYSICAL JOURNAL (LETTERS)

THE ASTROPHYSICAL JOURNAL
© 2021. The American Astronomical Society

Newsweek

TECH & SCIENCE

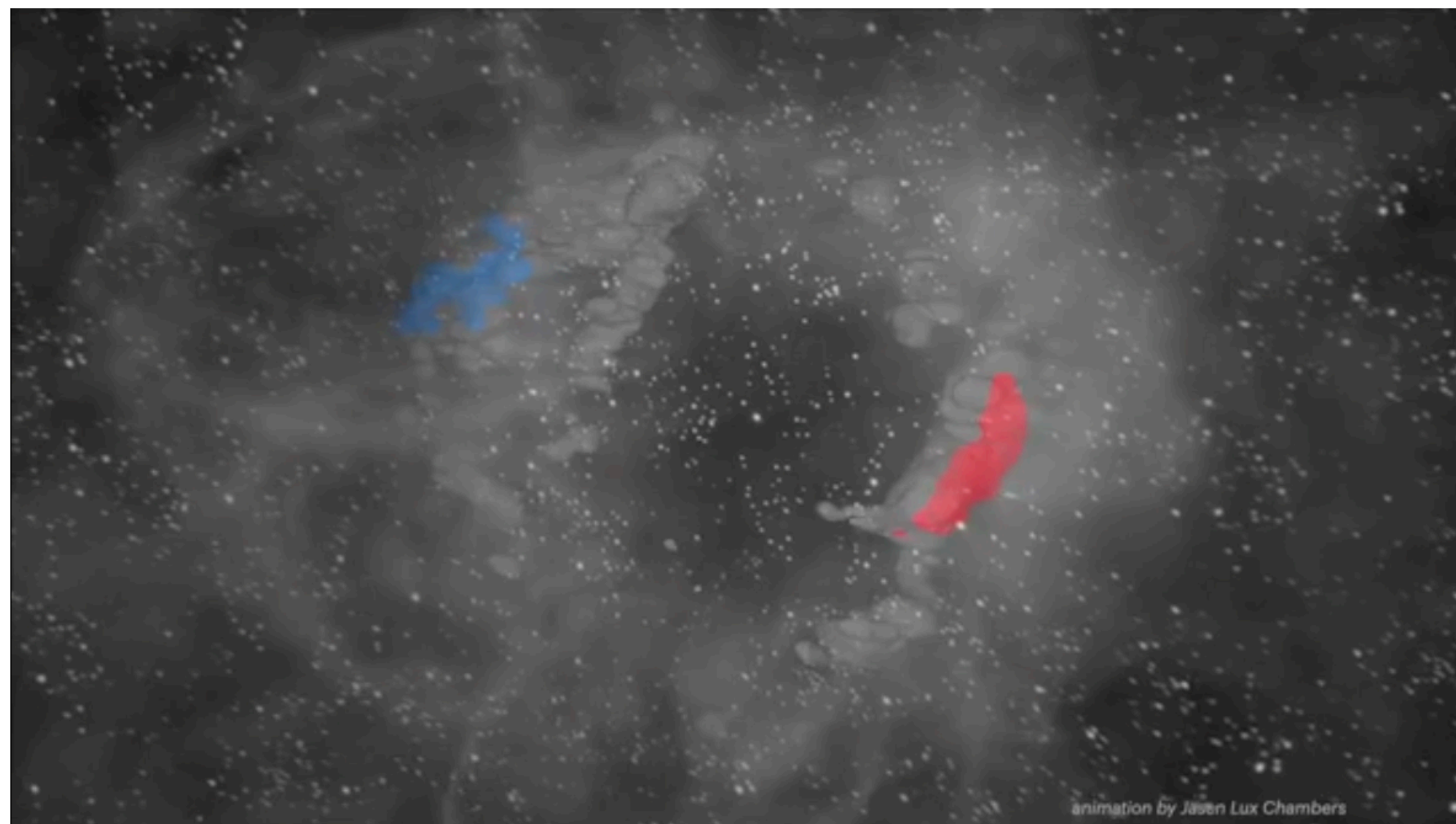
The Per-Tau Shell

Astronomers Discover Mysterious 500-Light-Year-Wide Void in Space: 'Absolutely Shocking'

Shmuel Bialy

BY ROBERT LEA ON 9/22/21 AT 12:08 PM EDT

1 Co



A major (ISM). R highest-r the well-diameter find a la scenario shell, wh within it estimate phenome stellar an Unified A (1509); S Supporti

animation by Jaseen Lux Chambers

THE ASTROPHYSICAL JOURNAL LETTERS, 919:L5 (12pp), 2021 September 20

Bialy et al.

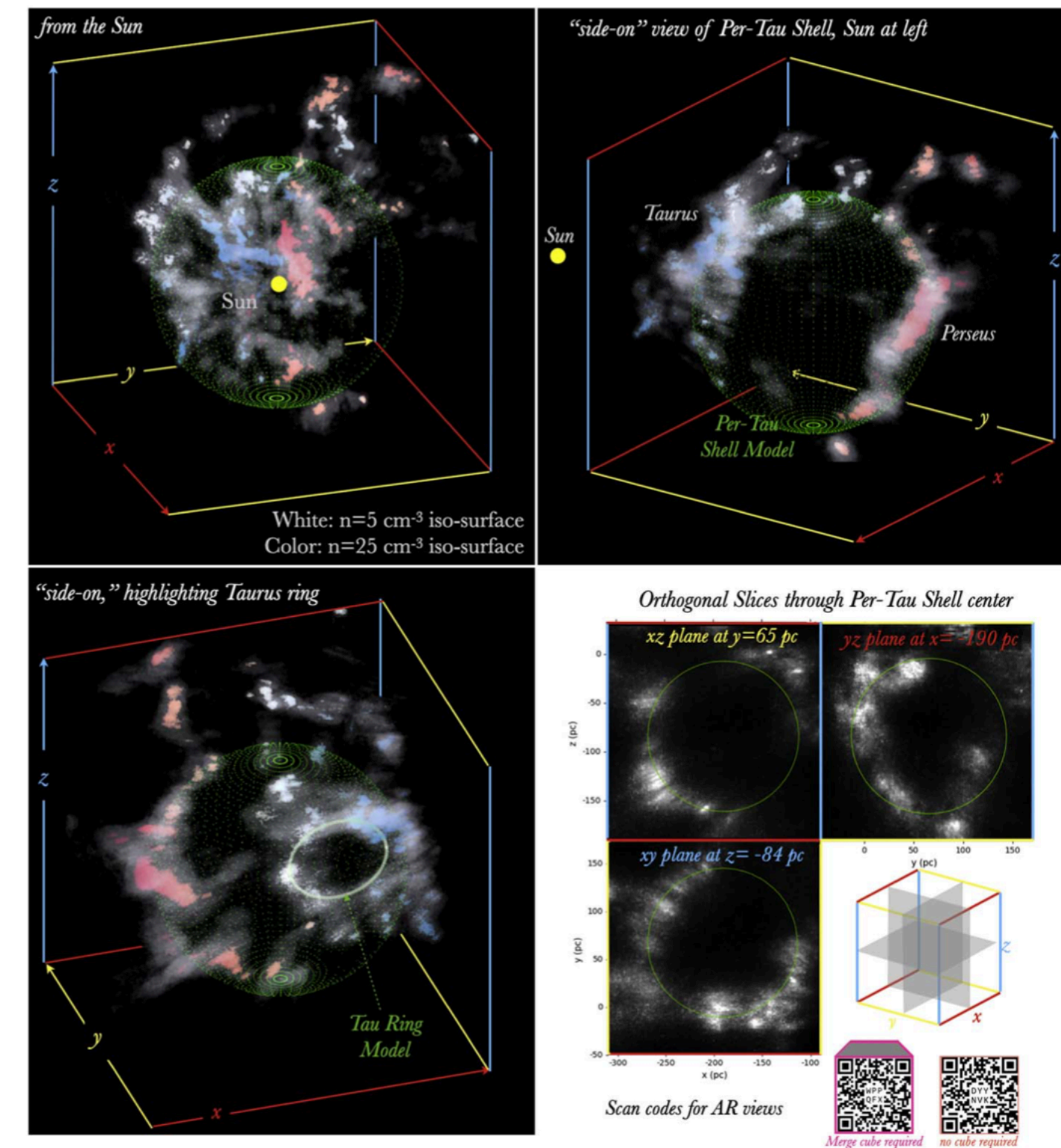


Figure 2. 3D views of the Per-Tau shell (for an interactive version of this figure click [here](#); see Figure 5 for more static visualizations). Plotted are density iso-surfaces at levels $n = 5 \text{ cm}^{-3}$ (gray) and $n = 25 \text{ cm}^{-3}$ (color), overlaid with our spherical-shell model, radius $R_s = 78 \text{ pc}$, distance from the Sun $d = 218 \text{ pc}$. The $n = 25 \text{ cm}^{-3}$ 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.

THE **PERSEUS**-**TAURUS**

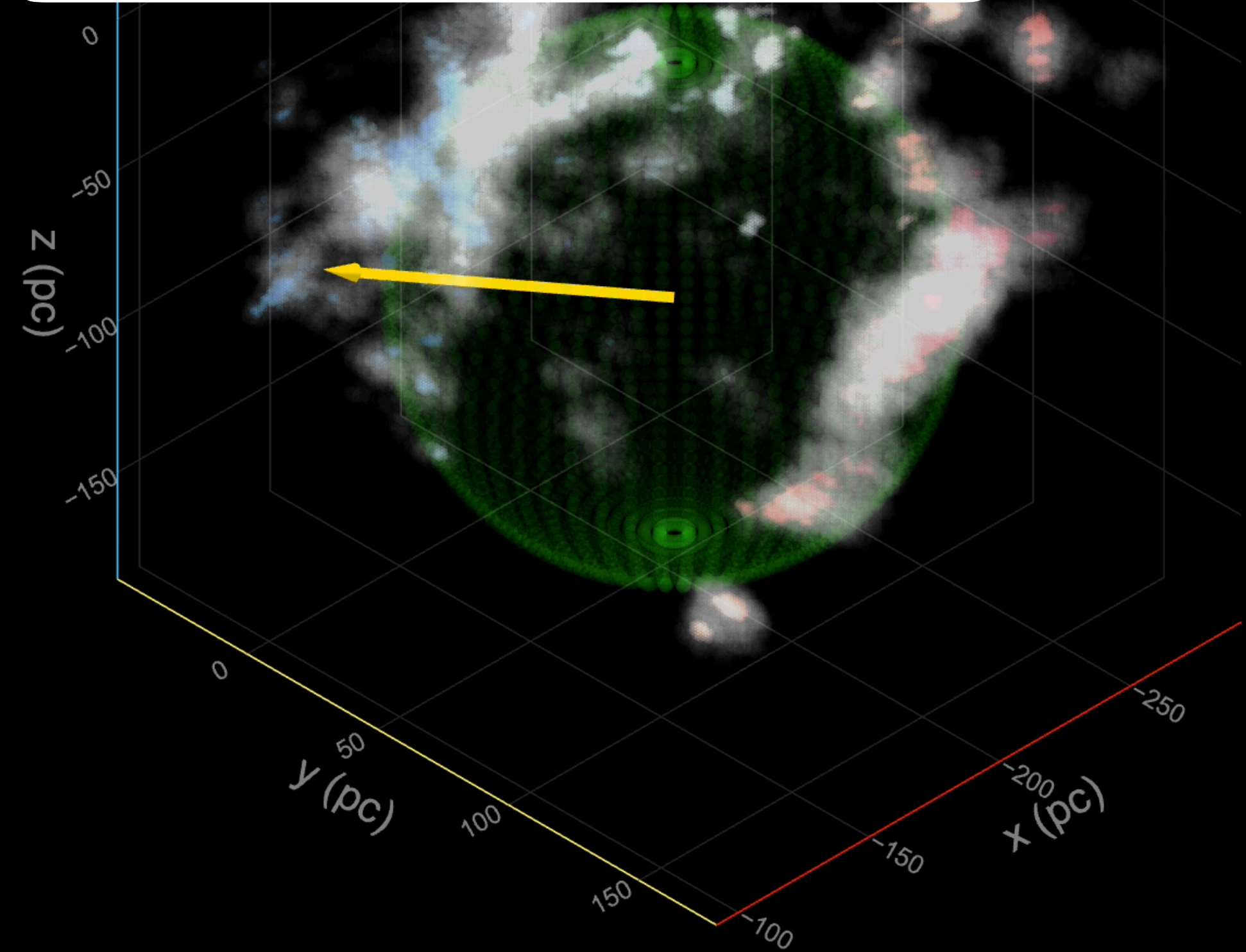
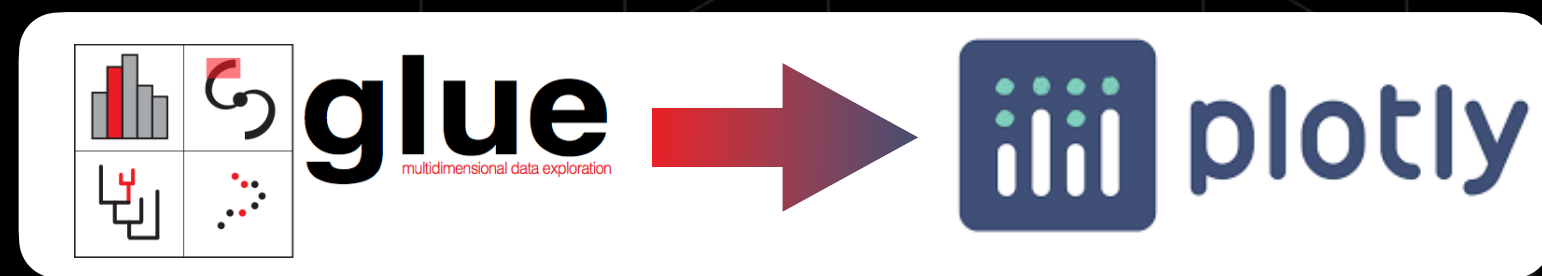
SUPERSHELL

IN 3D

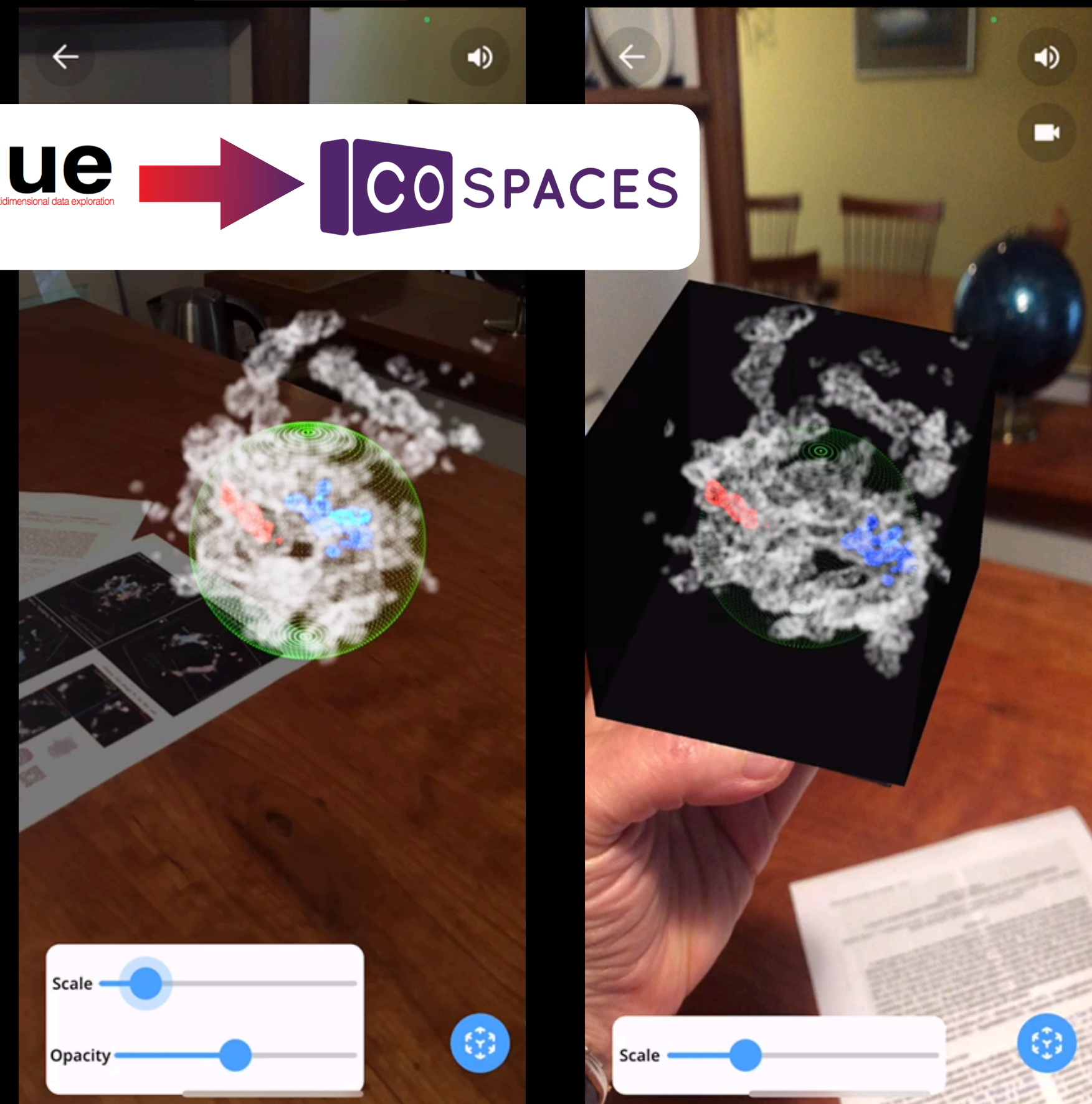
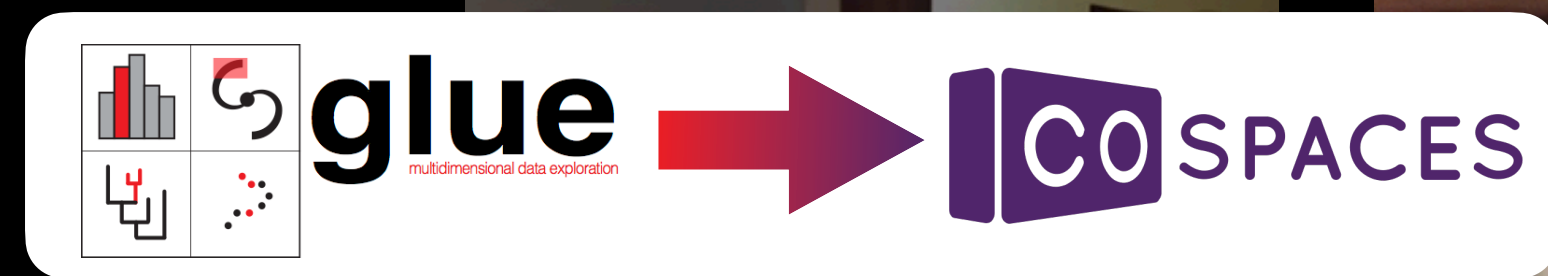
*brought to you in 2021 by an international team of scientists from
Center for Astrophysics | Harvard & Smithsonian, Harvard Radcliffe Institute, University of Vienna, University of
Wisconsin, Max-Planck Institute, Ludwig Maximilian University, and technology from ESA, NASA, NSF and Delightex.*

animation by Jasen Lux Chambers

WANT TO EXPLORE THE PERSEUS-TAURUS SUPERSHELL IN 3D?



IN YOUR BROWSER AT [TINYURL.COM/UNIVERSE-IN-MY-HAND](https://tinyurl.com/universe-in-my-hand)



OR IN AUGMENTED REALITY (KEEP WATCHING)...

TO "HOLD THE UNIVERSE IN YOUR HAND"...

1. OBTAIN A "MERGE CUBE"
AVAILABLE ONLINE FOR \$15



2. FIND YOUR **SMARTPHONE**, AND OPEN THE CAMERA APP

3. FOCUS THE CAMERA AT THE
"MERGE CUBE" **QR CODE**

Merge Cube



no cube



Scan codes for augmented reality

4. TAP THE MESSAGE TO "OPEN IN COSPACES" 

[DOWNLOAD COSPACES IF YOU DON'T HAVE IT YET. IT'S FREE.]

5. HOLD THE **CUBE** WHERE YOUR **CAMERA CAN SEE IT**

6. MOVE THE CUBE AROUND & **ENJOY!**



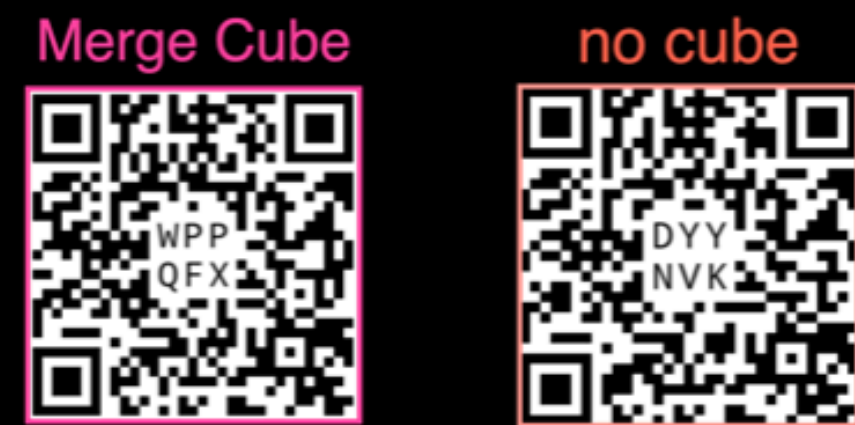
TO FLOAT THE SUPERSHELL ON A FLAT SURFACE...

1. FIND A FLAT SURFACE

[YOU DON'T NEED THE PRINTOUT, THAT'S JUST FOR FUN]

2. FIND YOUR **SMARTPHONE**, AND OPEN THE CAMERA APP

3. FOCUS THE CAMERA AT THE
"NO CUBE" **QR CODE**



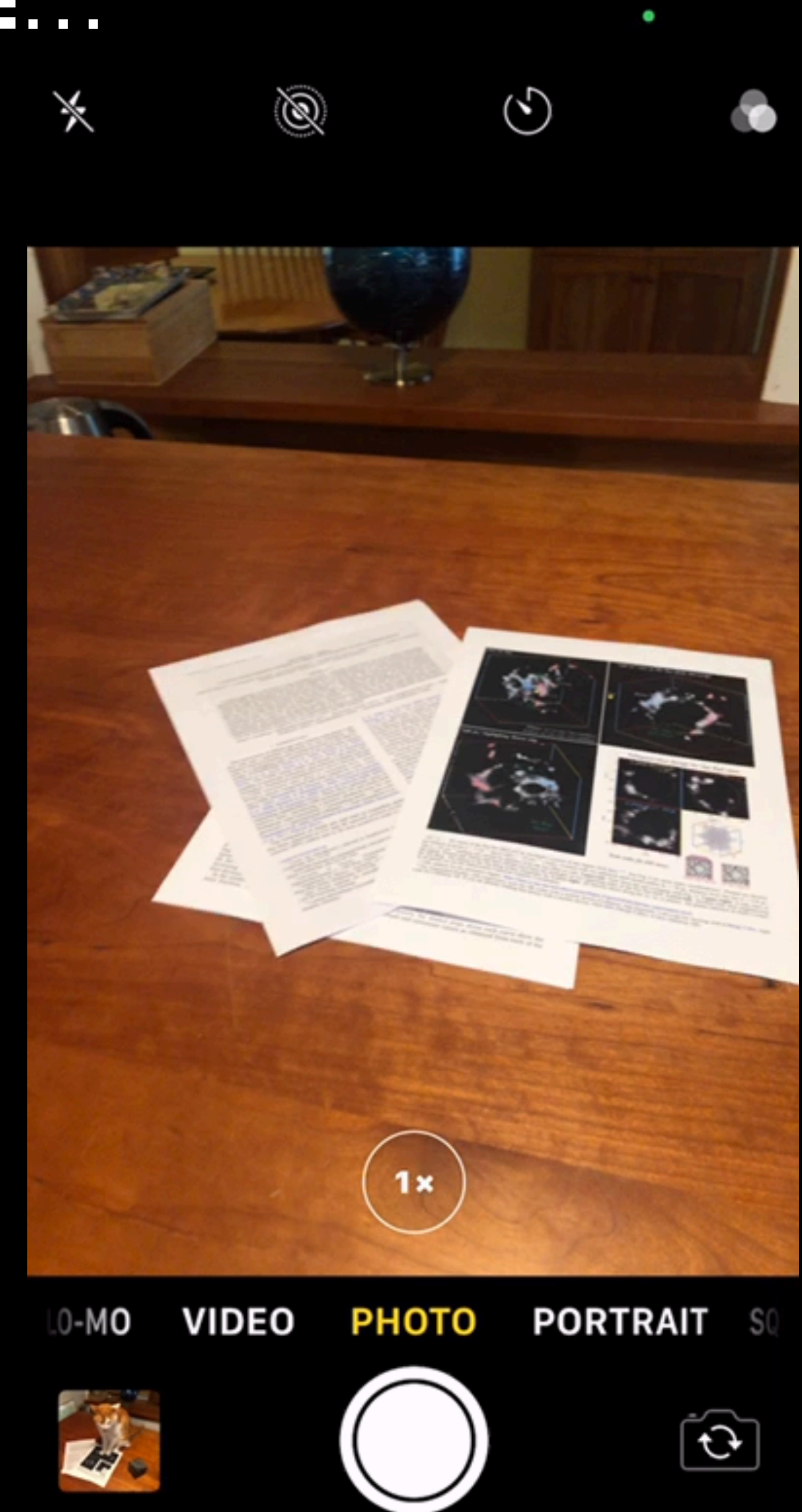
Scan codes for augmented reality

4. TAP THE MESSAGE TO "**OPEN IN COSPACES**" 

[DOWNLOAD COSPACES IF YOU DON'T HAVE IT YET. IT'S FREE.]

5. TAP ON THE GRID OF DOTS ON THE SCREEN TO "PLACE"
THE BUBBLE ABOVE THE SURFACE

6. WALK AROUND WHAT YOU SEE & **ENJOY!**



BROUGHT TO YOU IN 2021 BY

CENTER FOR **ASTROPHYSICS**

HARVARD & SMITHSONIAN

PRODUCER: ALYSSA GOODMAN

WRITER: NADIA WHITEHEAD

NARRATOR: CATHERINE ZUCKER

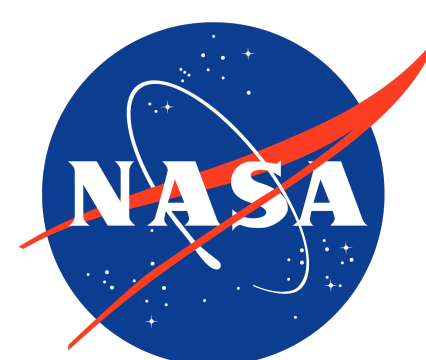
CONTRIBUTORS: CARTER EMMART, CATHERINE ZUCKER, SHMUEL BIALY, MICHAEL FOLEY

3D ANIMATION: JASEN LUX CHAMBERS

MADE POSSIBLE BY... TECHNOLOGY FROM

SUPPORT FROM

AND COLLABORATORS AT



AMERICAN ASTRONOMICAL SOCIETY



GORDON AND BETTY
MOORE
FOUNDATION



universität
wien



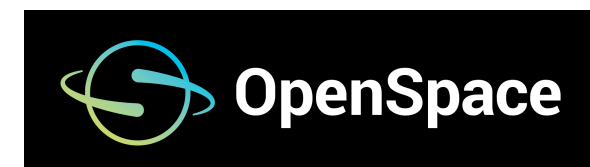
HDSI | Harvard Data
Science Initiative



MAX-PLANCK-GESELLSCHAFT



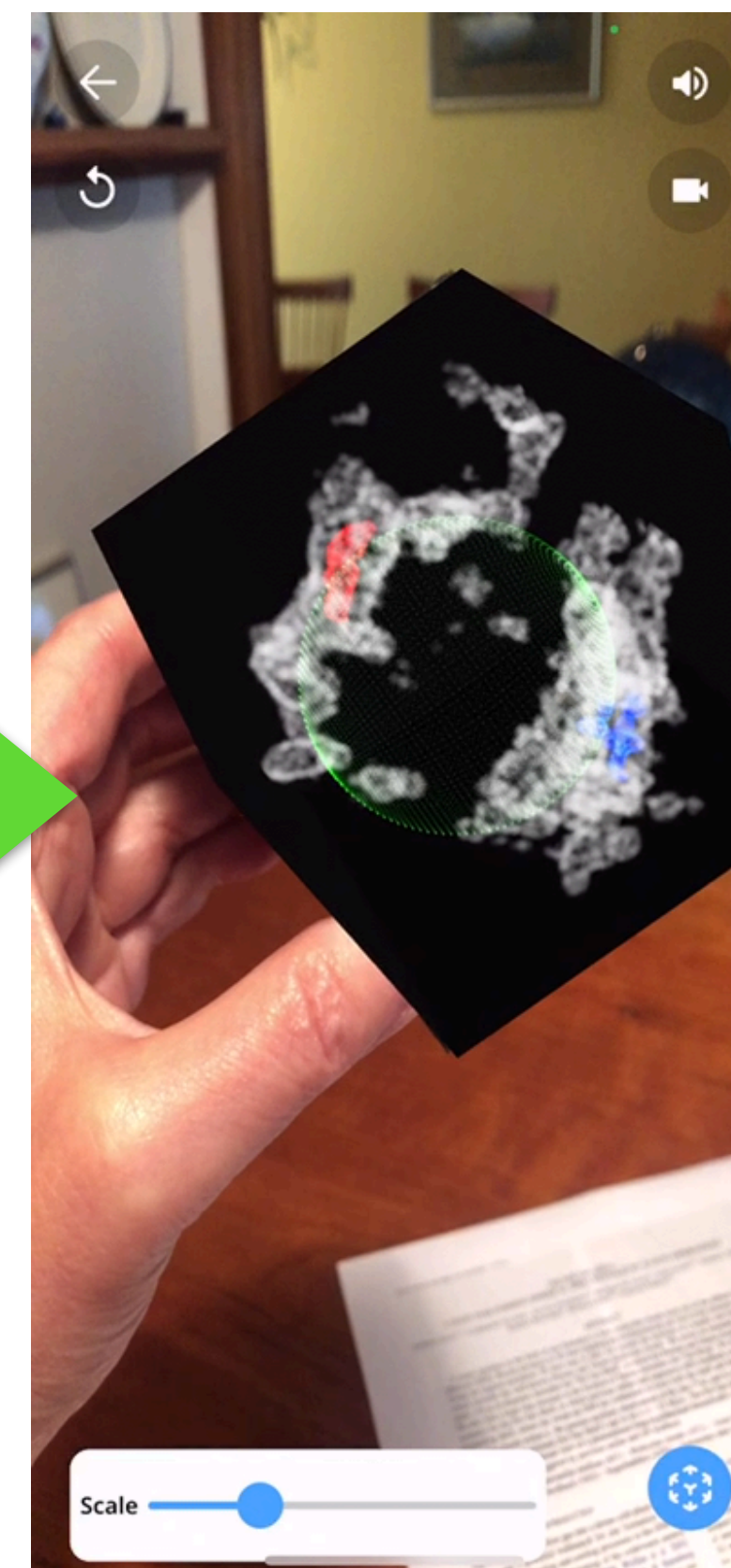
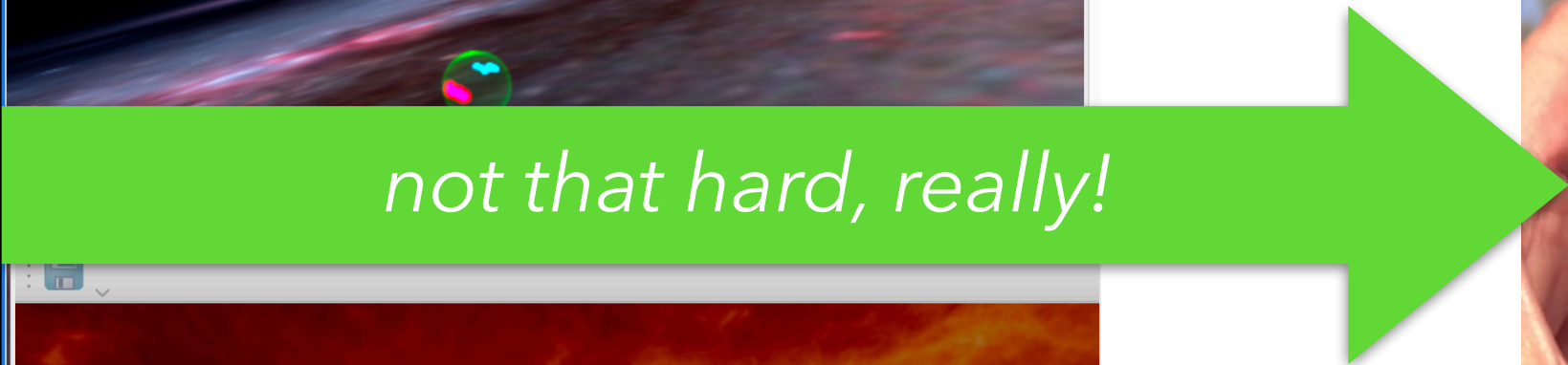
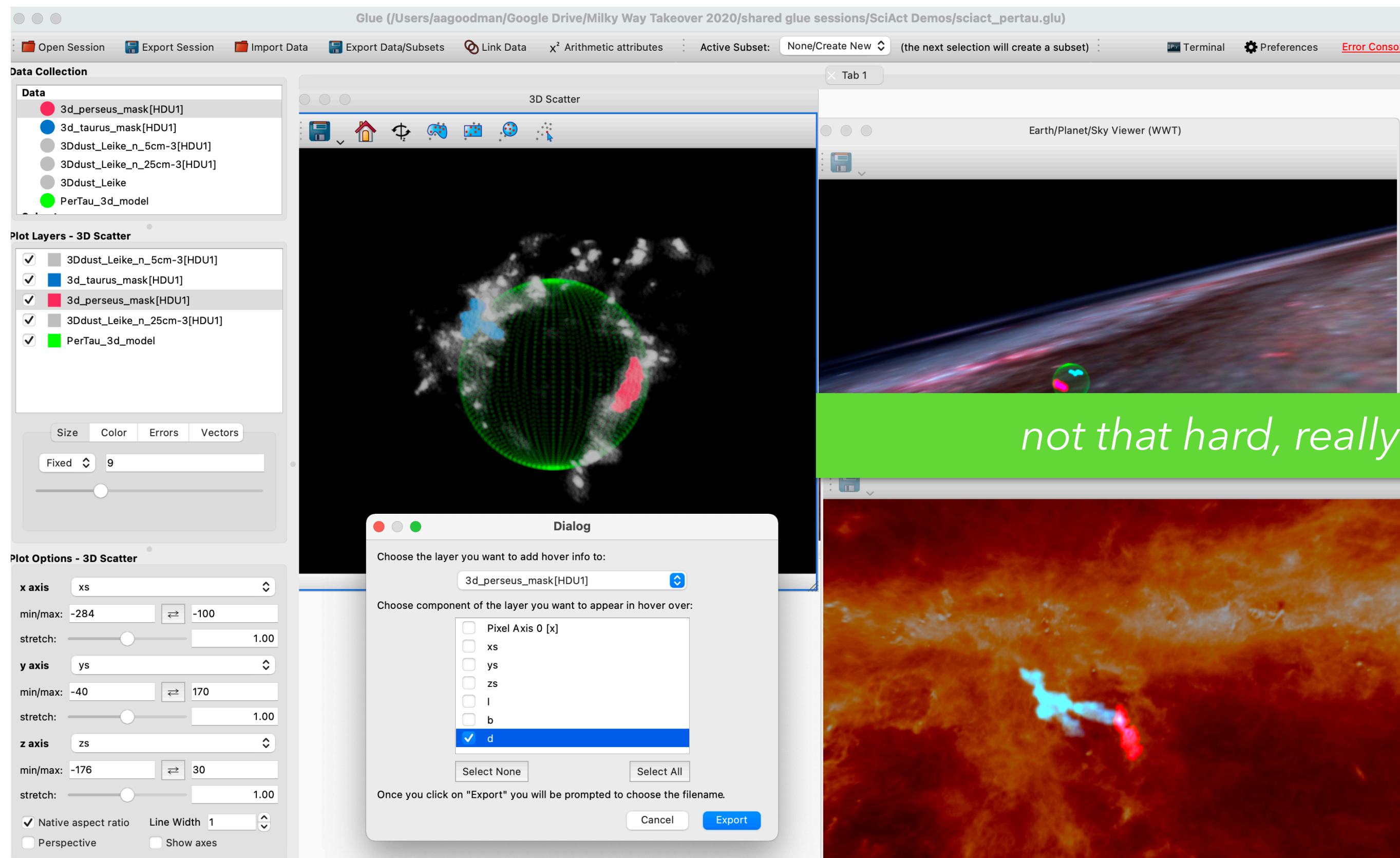
University of Wisconsin
Whitewater



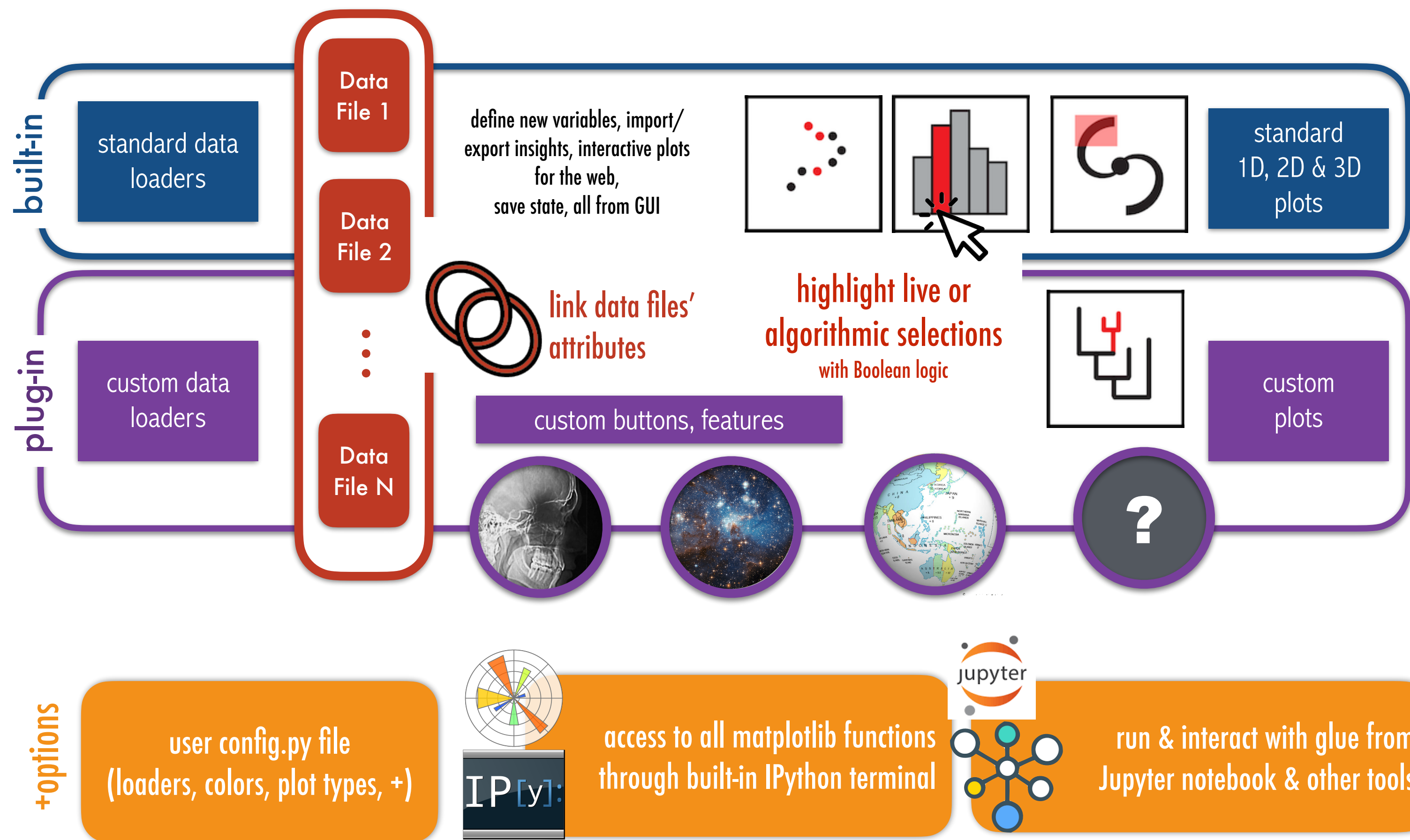
AR MADE POSSIBLE BY... TECHNOLOGY FROM*



click for glue website or intro video

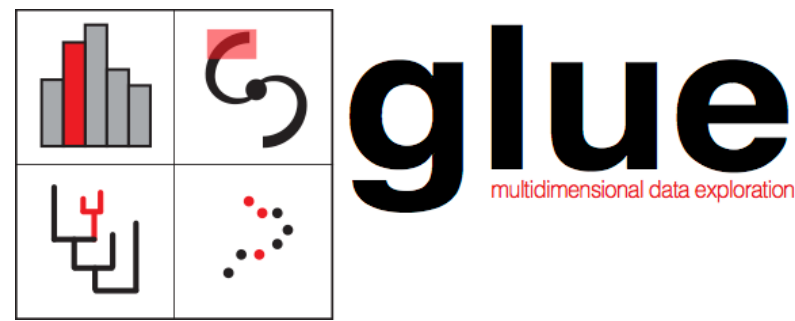


*and extraordinary work by Dr. Catherine Zucker and our collaborators, especially at 



glueviz.org

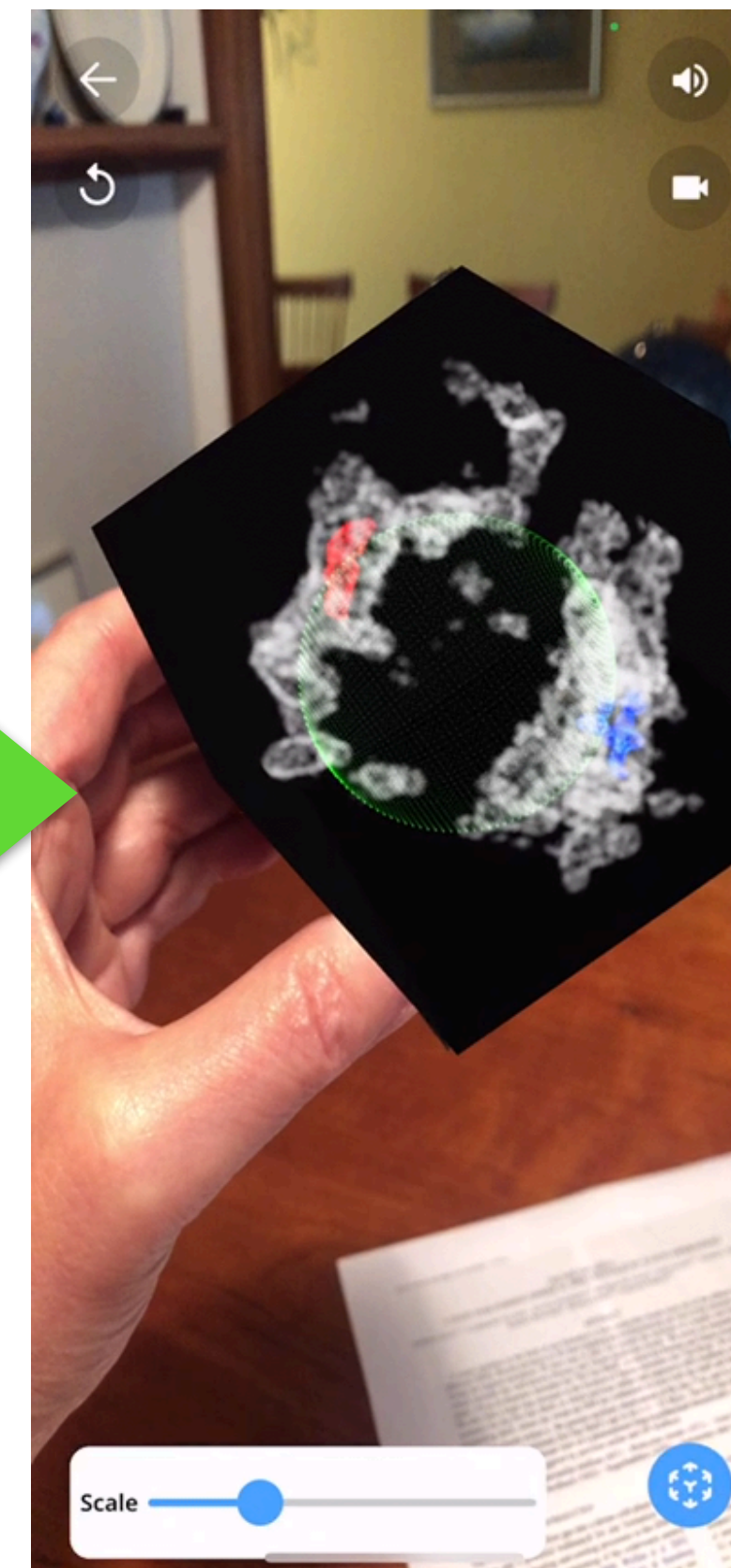
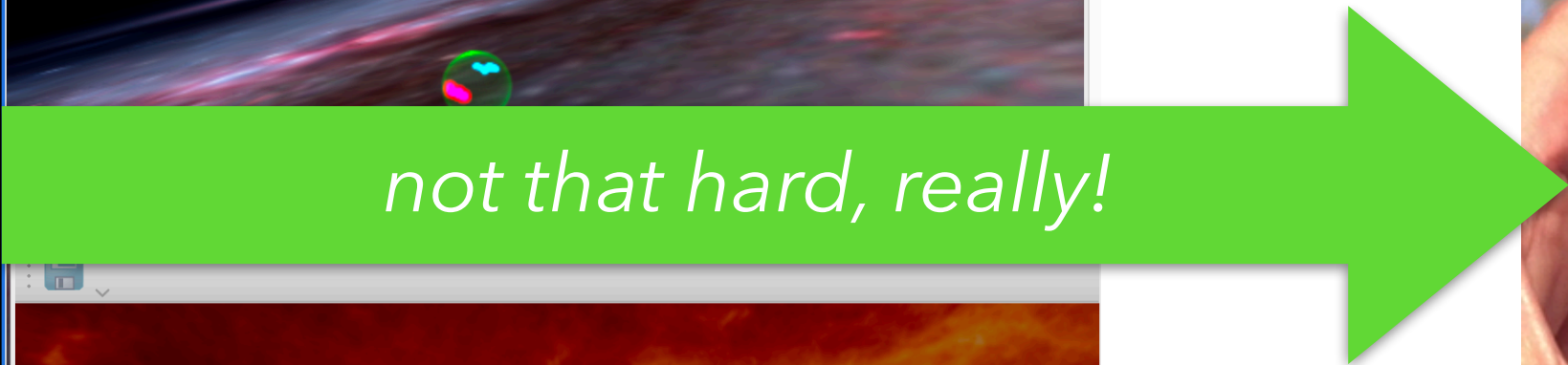
AR MADE POSSIBLE BY... TECHNOLOGY FROM*



click for glue website or intro video



The screenshot shows the glue software interface. On the left, the 'Data Collection' panel lists several data series: 3d_perseus_mask[H DU1], 3d_taurus_mask[H DU1], 3Ddust_Leike_n_5cm-3[H DU1], 3Ddust_Leike_n_25cm-3[H DU1], 3Ddust_Leike, and PerTau_3d_model. Below this is the 'Plot Layers - 3D Scatter' panel with checkboxes for each data series. At the bottom left is the 'Plot Options - 3D Scatter' panel with settings for x, y, and z axes, including min/max values and stretch sliders. A 'Dialog' window is open in the center, prompting the user to 'Choose the layer you want to add hover info to:' (3d_perseus_mask[H DU1]) and 'Choose component of the layer you want to appear in hover over:' (d). The main window shows a 3D scatter plot of a star cluster with a green wireframe sphere overlaid.



*and extraordinary work by Dr. Catherine Zucker and our collaborators, especially at 

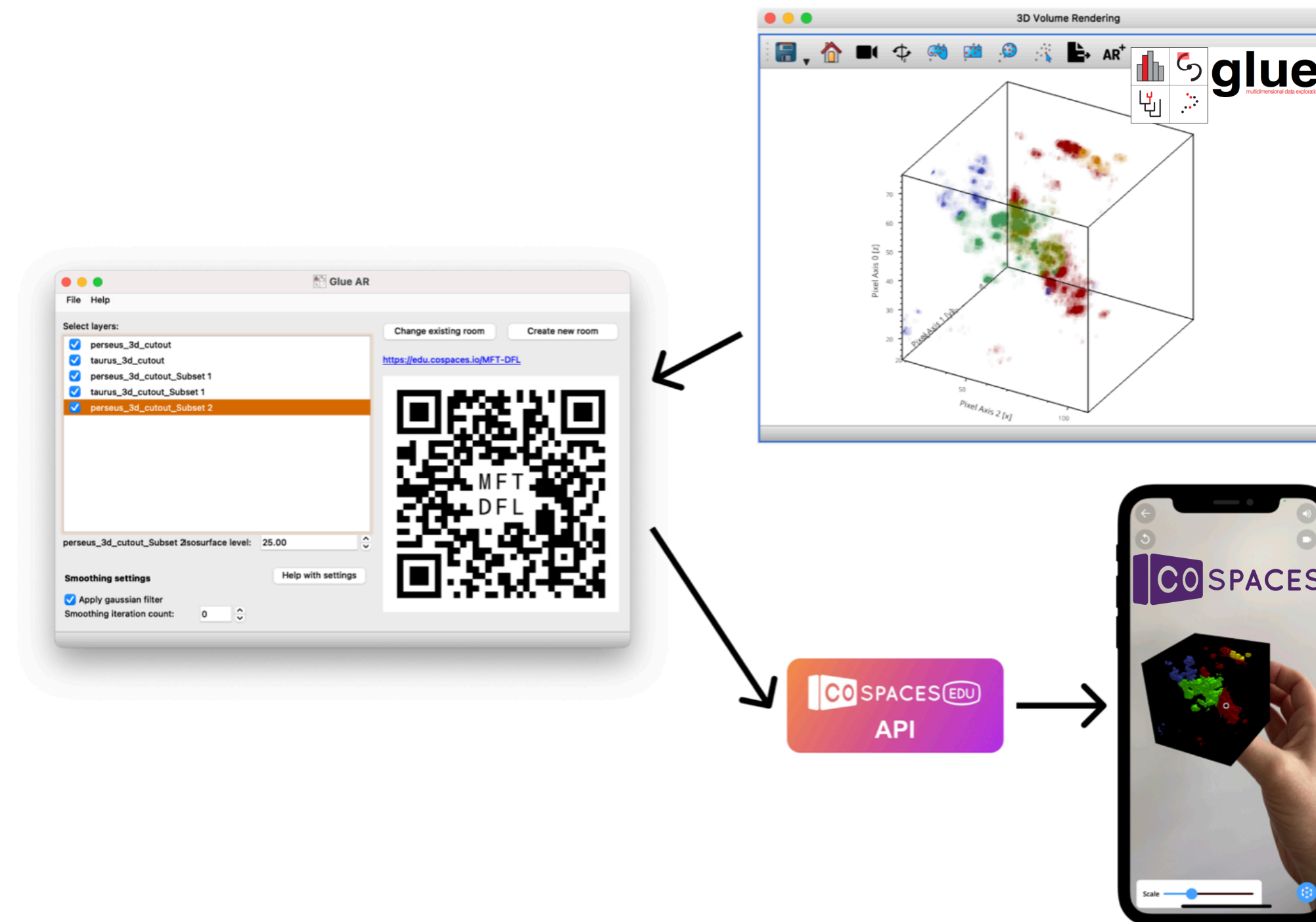
AR PROTOTYPE AUTOMATED OUTPUT FROM GLUE...*



Hochschule für Technik
Studierendenprojekte im Studiengang Informatik

Startseite
Glue
CoSpaces
Repository

Space in 3D: Immersive Analytics Module for a Python Based Visual Analytics Software



VIDEO DEMO

*thanks again to Delightex, Dr. Catherine Zucker plus Prof. Arzu Çöltekin & her students Luca Fluri and Andreas Ambühl at Fachhochschule Nordwestschweiz

AR PROTOTYPE AUTOMATED OUTPUT FROM GLUE...*

The screenshot displays a software interface with several components:

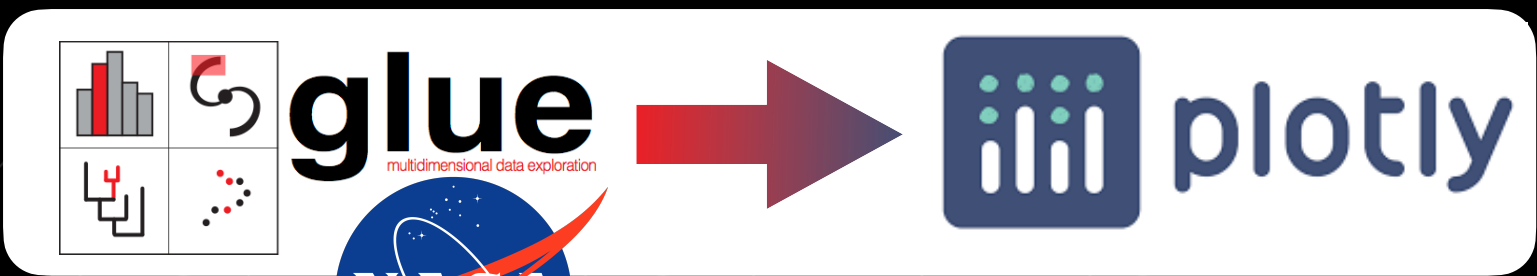
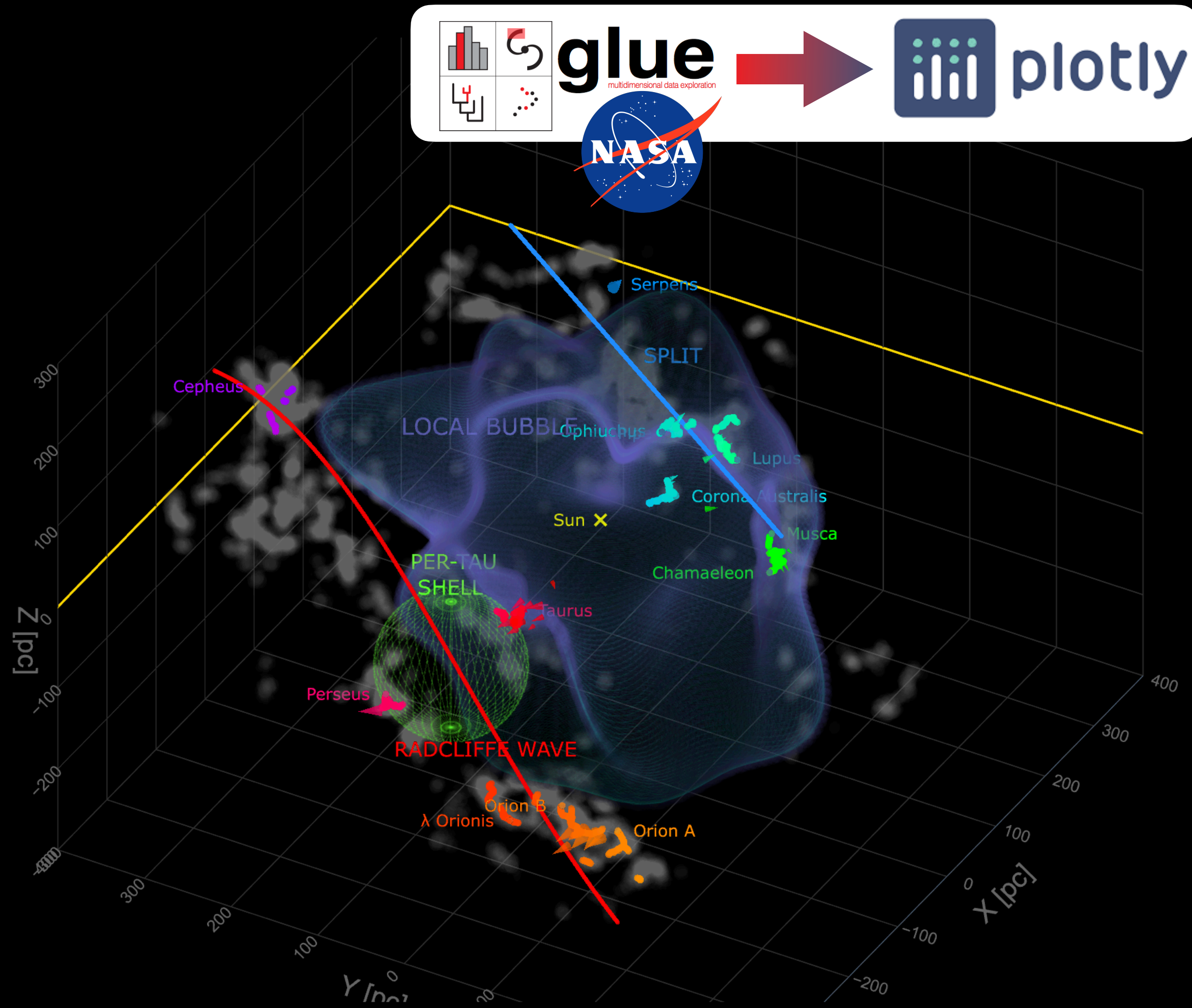
- Data Collection:** Lists data subsets: 'perseus_3d_cutout' (red), 'taurus_3d_cutout' (blue), 'Subset 1' (green), and 'Subset 2' (yellow).
- Plot Layers - 3D Volume Rendering:** A list of layers with checkboxes, including 'Subset 2 (perseus_3d_cutout)', 'Subset 1 (taurus_3d_cutout)', 'Subset 1 (perseus_3d_cutout)', 'taurus_3d_cutout', and 'perseus_3d_cutout'.
- Plot Options - 3D Volume Rendering:** Configuration for axes (x, y, z), min/max values, stretch, reference, and resolution (256).
- 3D Volume Rendering:** A central window showing a 3D visualization of data points within a wireframe box.
- 1D Histogram:** A window showing a histogram with a peak at 1.2e6.
- Glue AR Dialog:** A modal window for configuring an AR room. It includes a 'Select layers' list, a 'Change existing room' dialog with a QR code, and 'Smoothing settings' (Apply gaussian filter, Smoothing iteration count).



VIDEO DEMO

*thanks again to Delightex, Dr. Catherine Zucker plus Prof. Arzu Çöltekin & her students Luca Fluri and Andreas Ambühl at Fachhochschule Nordwestschweiz

LINKS FROM WITHIN 3D, 2D "BILLBOARDS"



Items Drawings

All Items

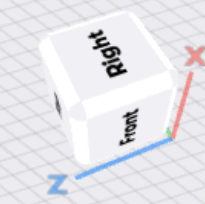
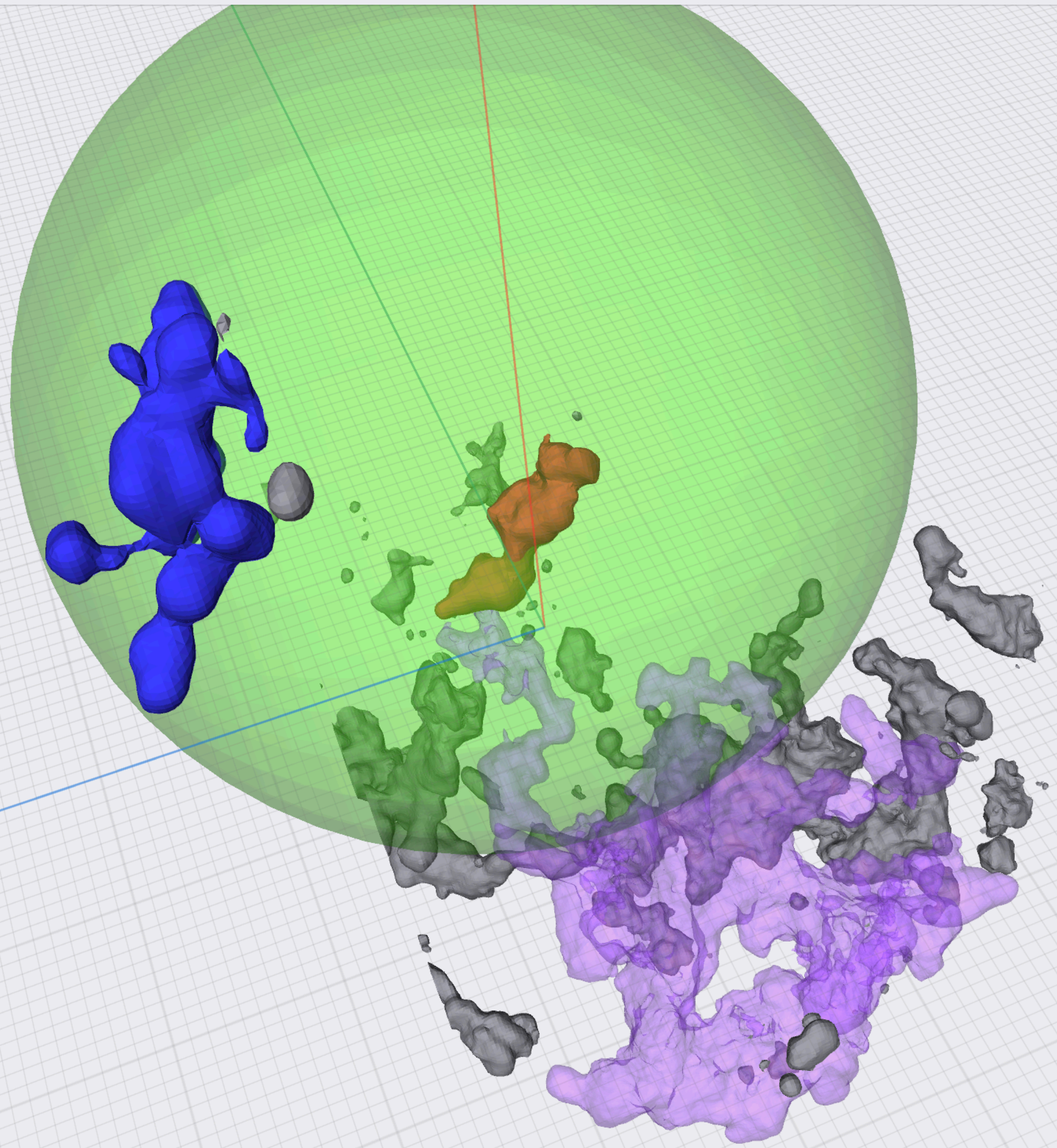
Items

- > Imported
- > Imported
- > Imported
- > Imported



Shapr3D

- 🖌 Sketch
- ➕ Add
- ↕ Transform
- 🔧 Tools



Video call interface showing two participants:

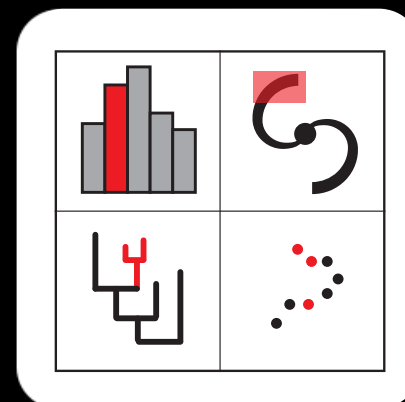
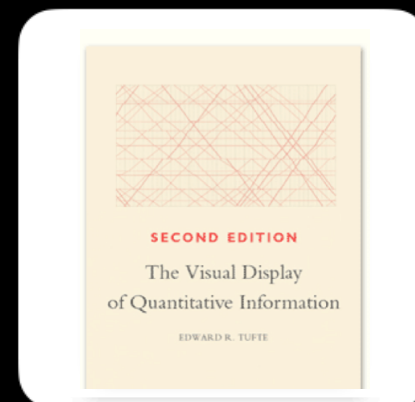
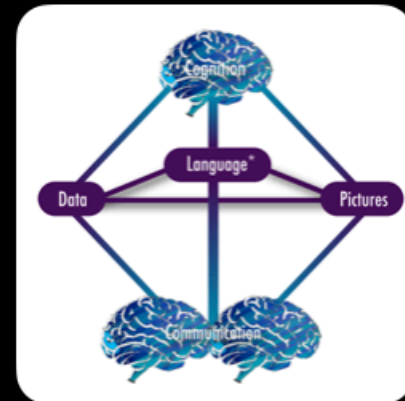
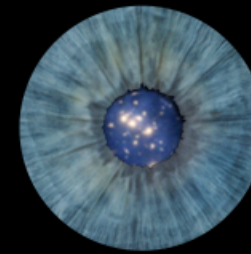
- Alyssa Goodman
- Catherine Zucker



AUGMENTED REALITY FOR SCIACT

Some quick thoughts on what you'd like to do now with AR & SciAct...

SEEING MORE OF THE UNIVERSE



Explore

Explain

FIND THE FULL
SERIES ON



TINYURL.COM/
10QVIZVIDEOS

AUGMENTED REALITY FOR EVERYONE

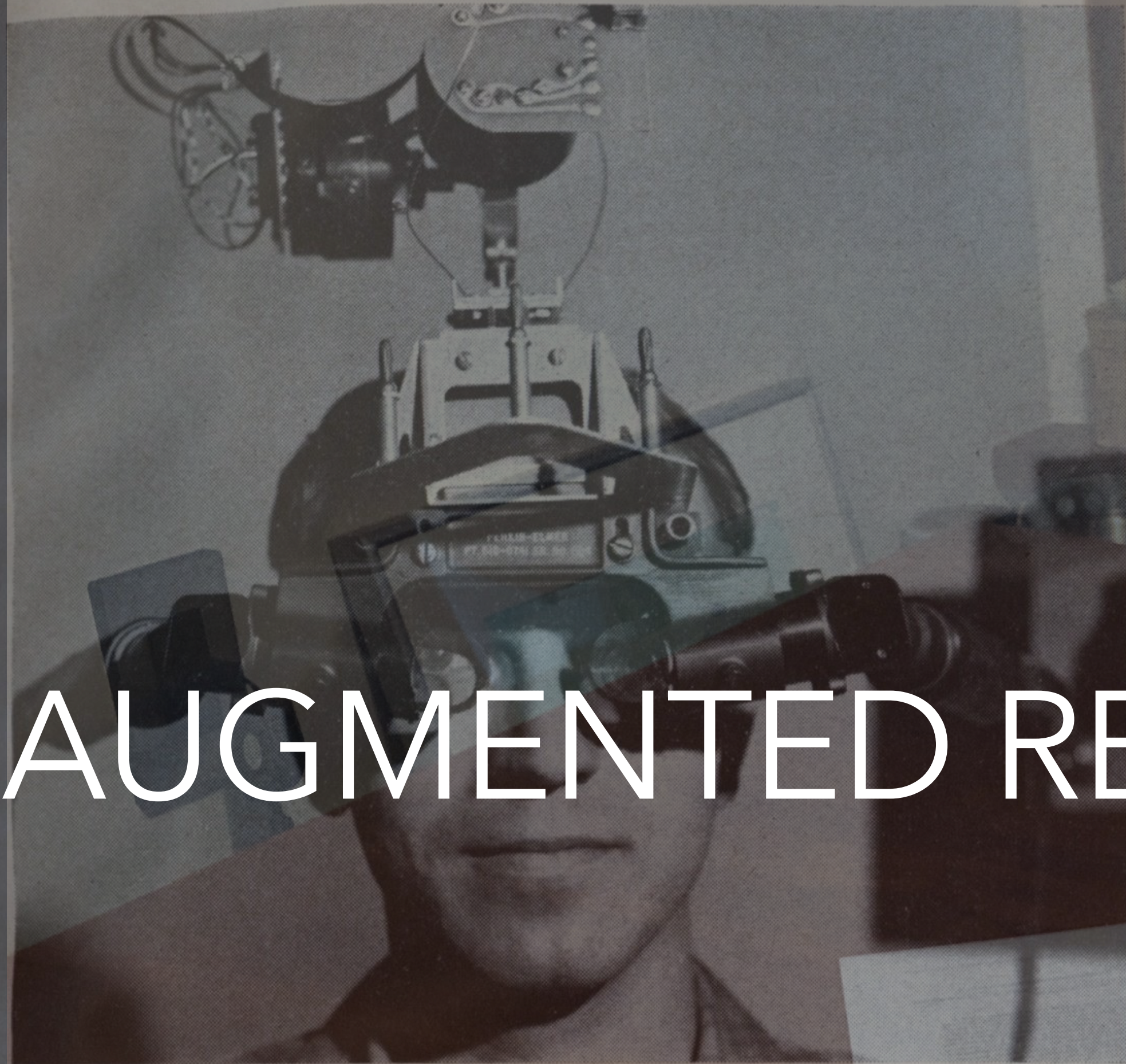
▲ 3-D trip inside a drawing, via computer graphics

Slip this display device on your head and you see a computer-generated 3-D image of a room before your eyes. Move your head and your perspective changes, just as though you were actually inside the room. Architects could use the device to draw buildings in three dimensions; realtors could use it to show buyers the interiors of homes without even leaving the office. Dr. Ivan Sutherland, University of Utah, invented the device, essentially a computer-graphics version of the old stereoscope.

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ALYSSA GOODMAN

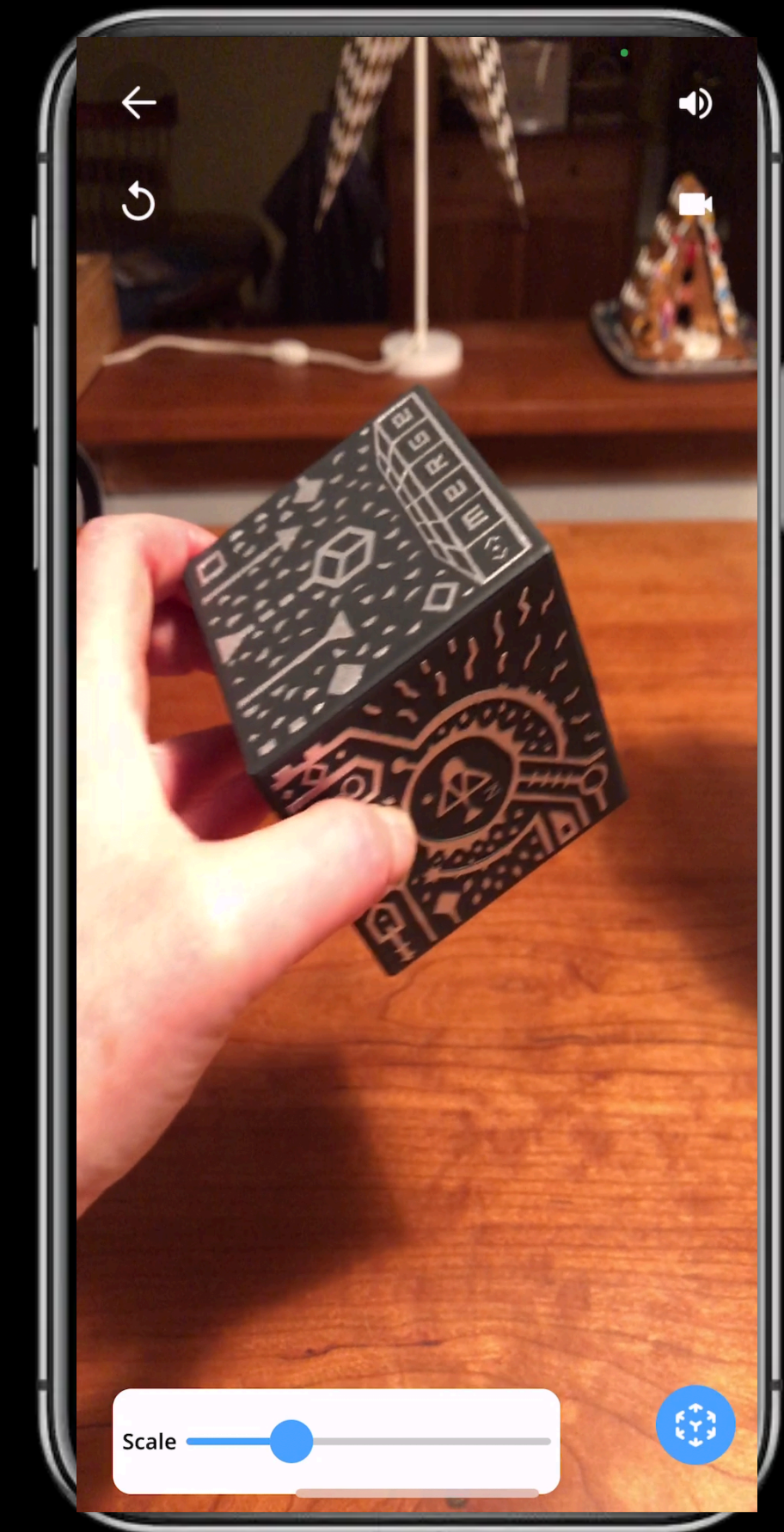
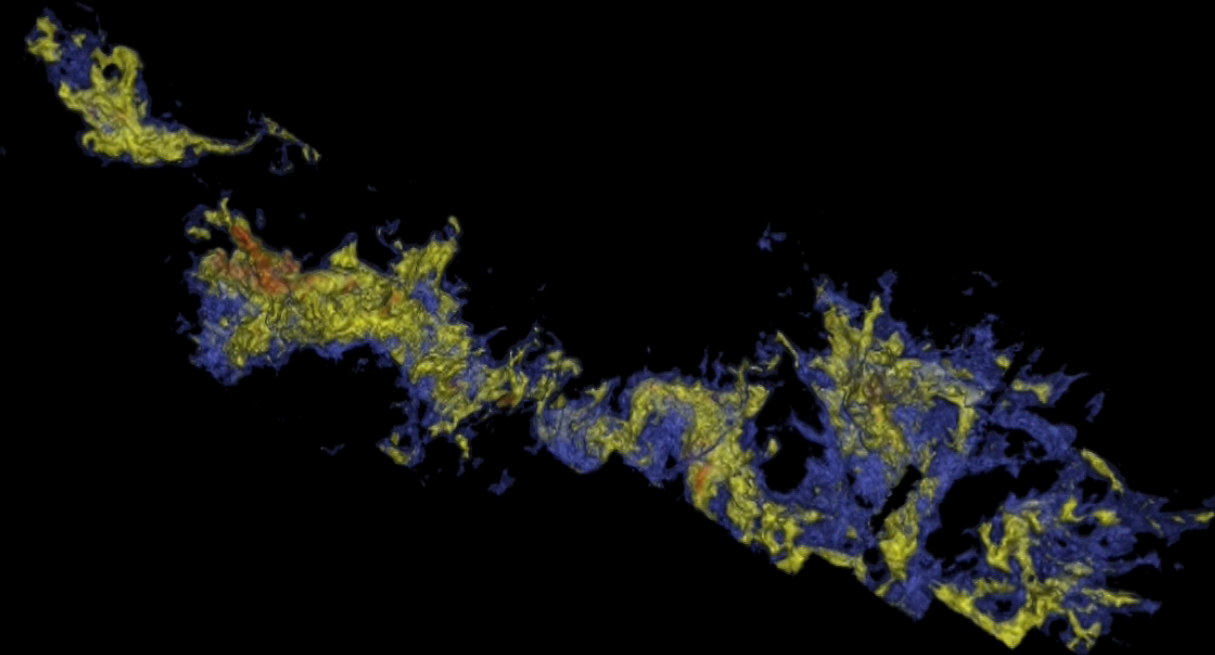
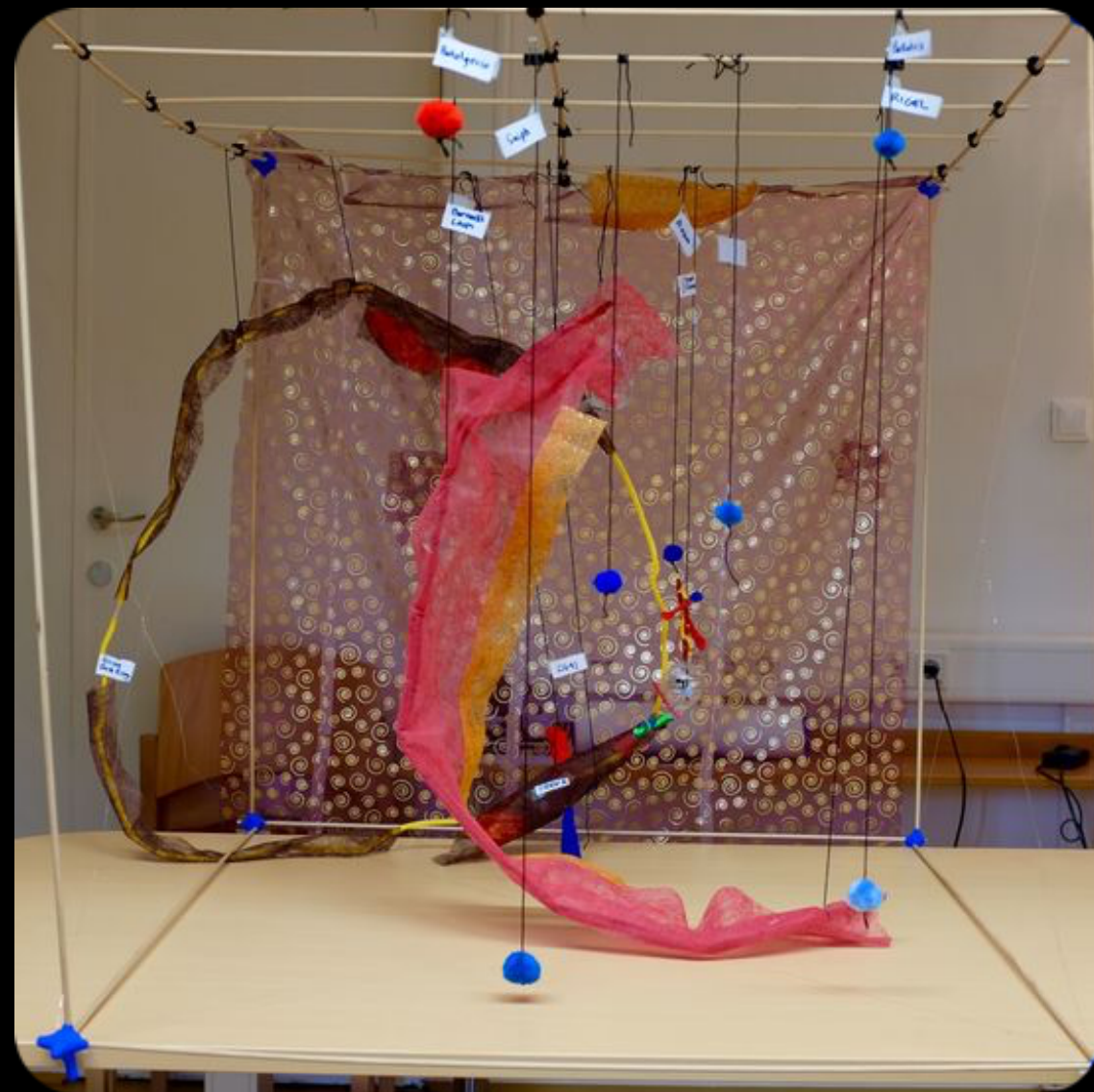
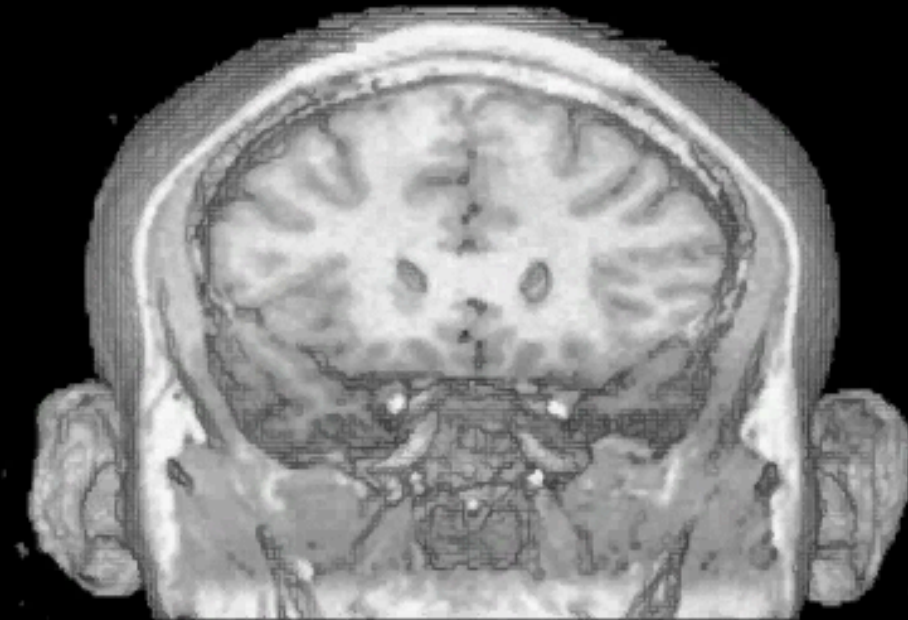
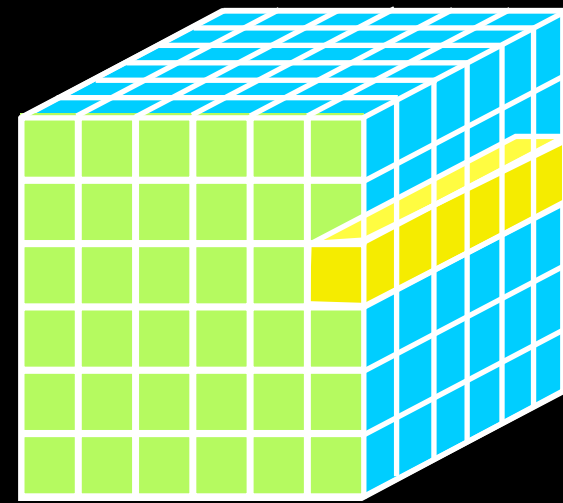
COSMIC DATA STORIES & GLUE PI

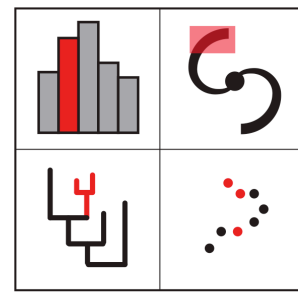


Some quick thoughts on what you'd like to do now with AR & SciAct...

EXTRA SLIDES

"DATA, DIMENSIONS, DISPLAY" (MY PERSONAL QUEST)





glue
multidimensional data exploration

enabled by d3.js (javascript) outputs

plotly

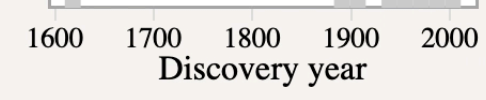
d3po

d3po is a project designed to allow an astronomer (or an interactive, publication-quality figure that has staged build can be previewed at d3po.org, and represents a figure from figure describes how metallicity affects color in cool stars, dragging in the scatter plots to understand the power of lin

Right now we are in search of alpha testers, who have figure their hands a little dirty (No javascript skills needed). In future figures interactively. We are also exploring implementation of version expected in January 2014.

Installing your own d3po server

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



- Four Centuries of Discovery
- A Chasm in Mass
- Little Siblings
- Close Cousins
- The Strangers

After Galileo discovered the first four moons of Jupiter, it took nearly three hundred years to discover the next one.

WATCH a DEMO video, and find S/W links, on YouTube at tinyurl.com/PotF-Demo

many thanks to Alberto Pepe, Josh Peek, Chris Beaumont, Tom Robitaille, Adrian Price-Whelan, Elizabeth Newton, Michelle Borkin & Matteo Cantiello for making the PotF possible.

PUBLISHING'S INTERACTIVE CUTTING-EDGE & (AUGMENTED) FUTURE

nature

PUBLISHED IN
NATURE
1-2020
ALVES ET AL.
(THE RADCLIFFE WAVE)



AUGMENTED REALITY
PROPOSED TO NSF
11-2020

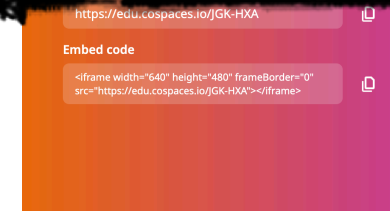
The Radcliffe Wave

To learn more about
AAS WorldWide Telescope:
Visit tinyurl.com/wwt-homepage
See the overview video:
tinyurl.com/wwt-overview
To learn about the Radcliffe Wave:
Visit tinyurl.com/radwave

CLICK, DRAG, ZOOM

Credit: Catherine Zucker, Alyssa Goodman, Curtis Wong

This interactive 3D visualization of the Radcliffe Wave is available in the online version of the published *Nature* article. It was built using the plotly exporter plugin inside the glue visualization software. Click on any layer in the legend (at right) to turn it on and off, and see how the



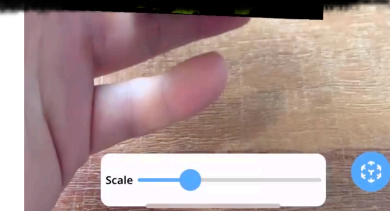
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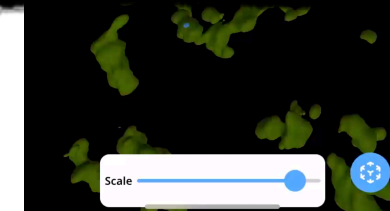
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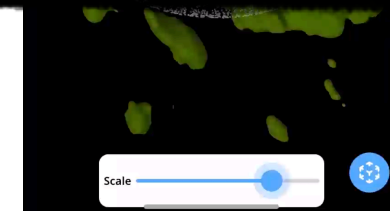
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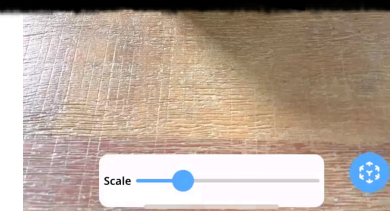
d



e

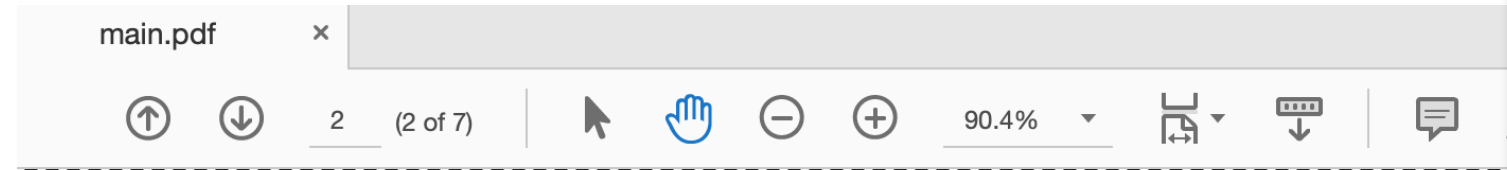


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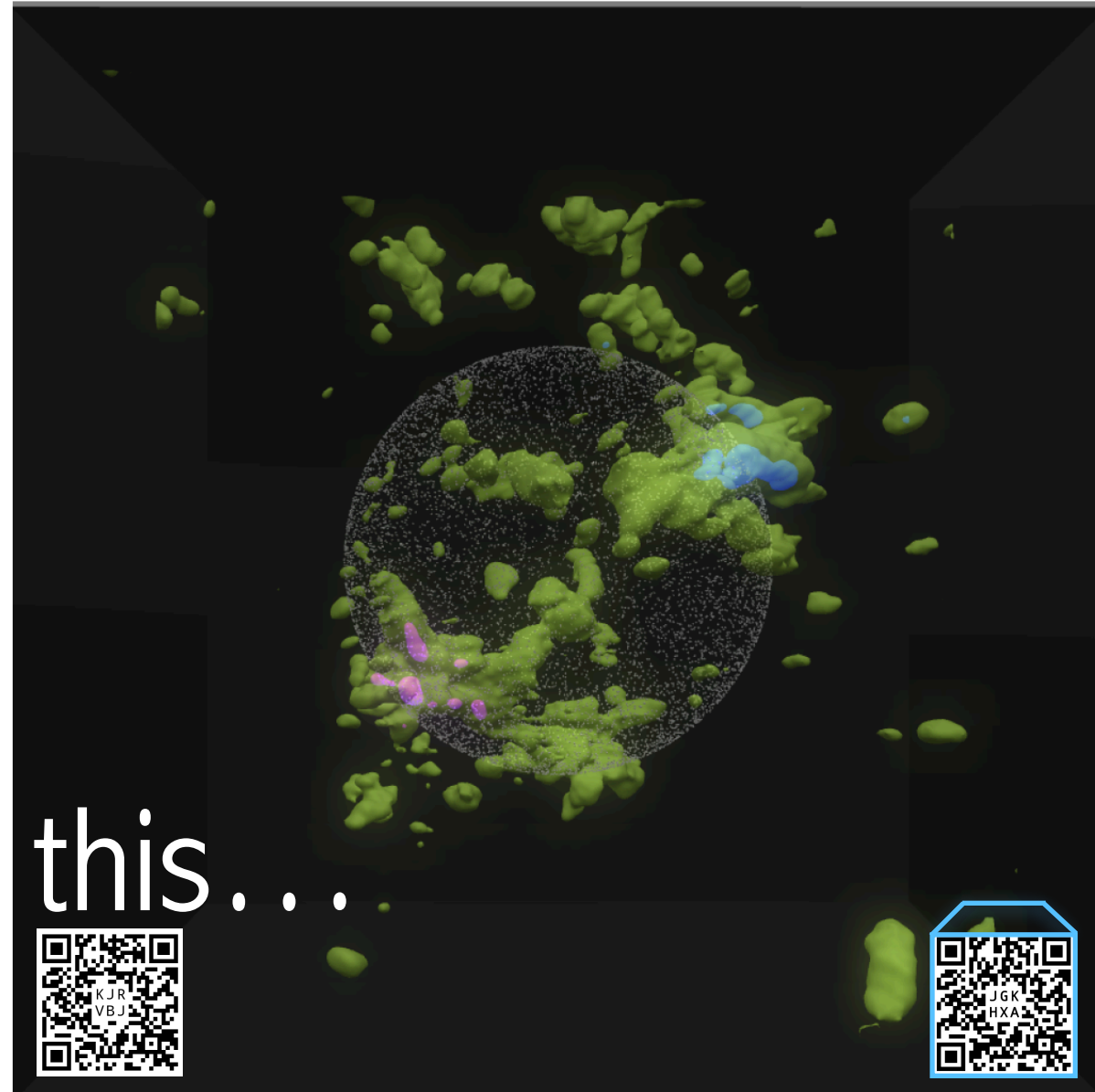


g

PUBLISHING'S INTERACTIVE CULTURE (AUGMENTED) FUTURE



2



scan this...

...see this

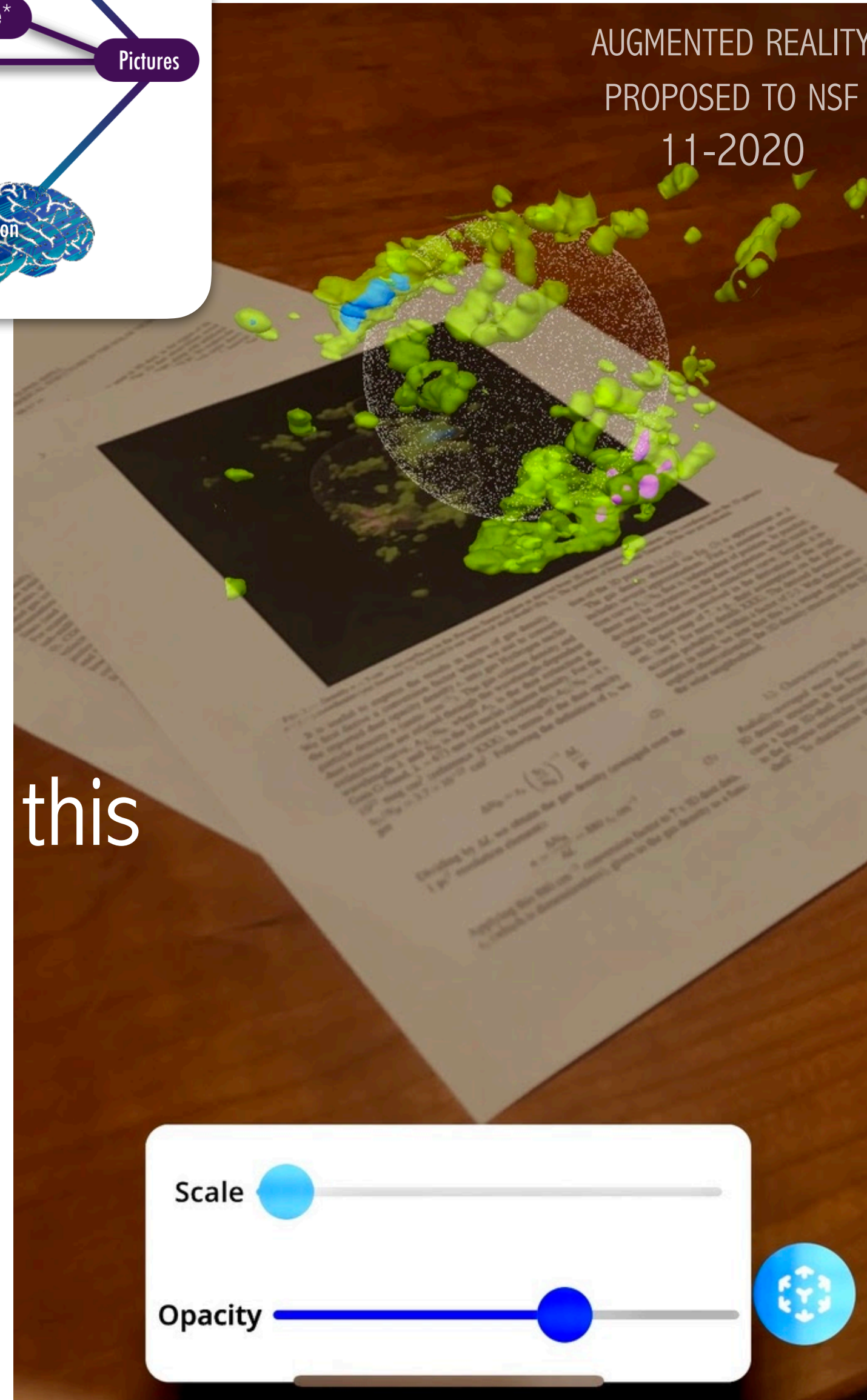
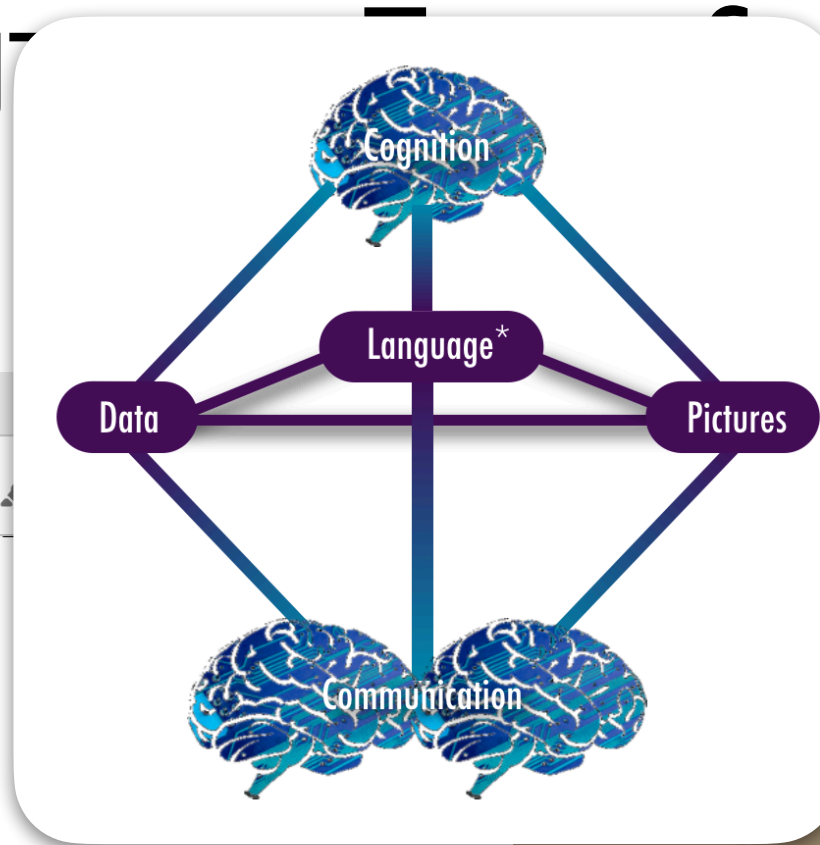


FIG. 1.— Density $n = 5 \text{ cm}^{-3}$ iso-surfaces in the Perseus-Taurus region as derived from 3D-dust extinction observations. The coordinates are the 3D galactic $x-y-z$ coordinates (see footnote 1). Overlaid is our spherical shell model (Eq. 5). The positions of Perseus and Taurus and the sun are indicated.

It is useful to express the results in terms of gas density. We first derive a conversion factor which we use to convert the reported dust opacity density s , into gas Hydrogen nuclei particle density n (units: cm^{-3}). The gas column density and dust extinction are related through the wavelength-dependent extinction curve, A_λ/N_H , where A_λ is the dust extinction at wavelength λ and N_H is the H nuclei column density. For the Gaia G-band, $\lambda = 673 \text{ nm}$ (central wavelength), $A_G/N_H = 4 \times 10^{22} \text{ mag cm}^{-2}$ (reference XXX). In terms of the dust opacity $\tau_G/N_H = 3.7 \times 10^{-22} \text{ cm}^2$. Following the definition of s_x we get

$$\Delta N_H = s_x \left(\frac{\tau_G}{N_H} \right)^{-1} \frac{\Delta L}{\text{pc}}. \quad (2)$$

Dividing by ΔL we obtain the gas density (averaged over the 1 pc^3 resolution element):

$$n = \frac{\Delta N_H}{\Delta L} = 880 s_x \text{ cm}^{-3}. \quad (3)$$

tion of the 3D position, (x, y, z) .

The gas density obtained via Eq. (3) is approximate as it includes several approximations. First, it assumes an extinction curve A_λ/N_H that is independent of position. In practice, there may be variations in the dust properties which result in deviation from the canonical extinction curve. Second, it includes uncertainties involved in the derivation of the original 3D dust map of ?, e.g., their assumptions on the priors, etc. (see ? for more details XXX). The derived densities are accurate probably to within a factor of 2-3. With these uncertainties in mind, we note that this is a unique opportunity to explore observationally the 3D density structure of the ISM in the solar neighborhood.

3.2. Characterizing the shell profile

Radially-averaged mean density: In §4 we explore the 3D density structure in the Perseus-Taurus region, and discuss a large 3D-shell structure, extending from the Taurus

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