

Dimensions of Discovery

Technology in learning and research

Alyssa A. Goodman

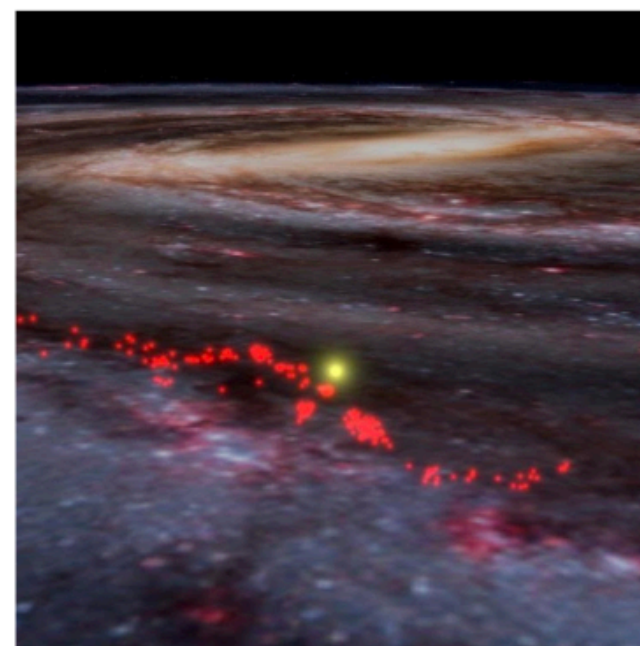
Center for Astrophysics | Harvard & Smithsonian

tinyurl.com/dimensionsofdiscovery

DIMENSIONS OF DISCOVERY

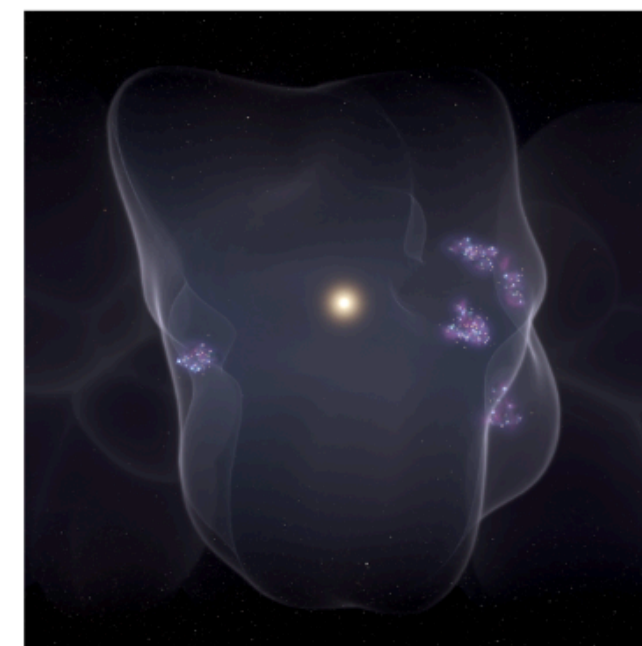
A web page created by [Alyssa Goodman](#) to showcase the use of technology in research, education, and communication, of science and more.

What's happening "these days?" A sampler of ongoing and recent projects.



The Radcliffe Wave

A gigantic "wave" of dense gas that forms the spine of the Local Arm of the Milky Way. ([Alves et al. 2020, *Nature*](#))



The Local Bubble

A 1000-light-year-wide bubble surrounding the Sun and Earth is apparently responsible for the formation of all nearby, young stars. ([Zucker et al. 2022, *Nature*](#))



PredictionX

The best place to learn more about the past, present, and future of the future. Through dynamic online learning, PredictionX uncovers the role of uncertainty in the world around us.



Data + Climate

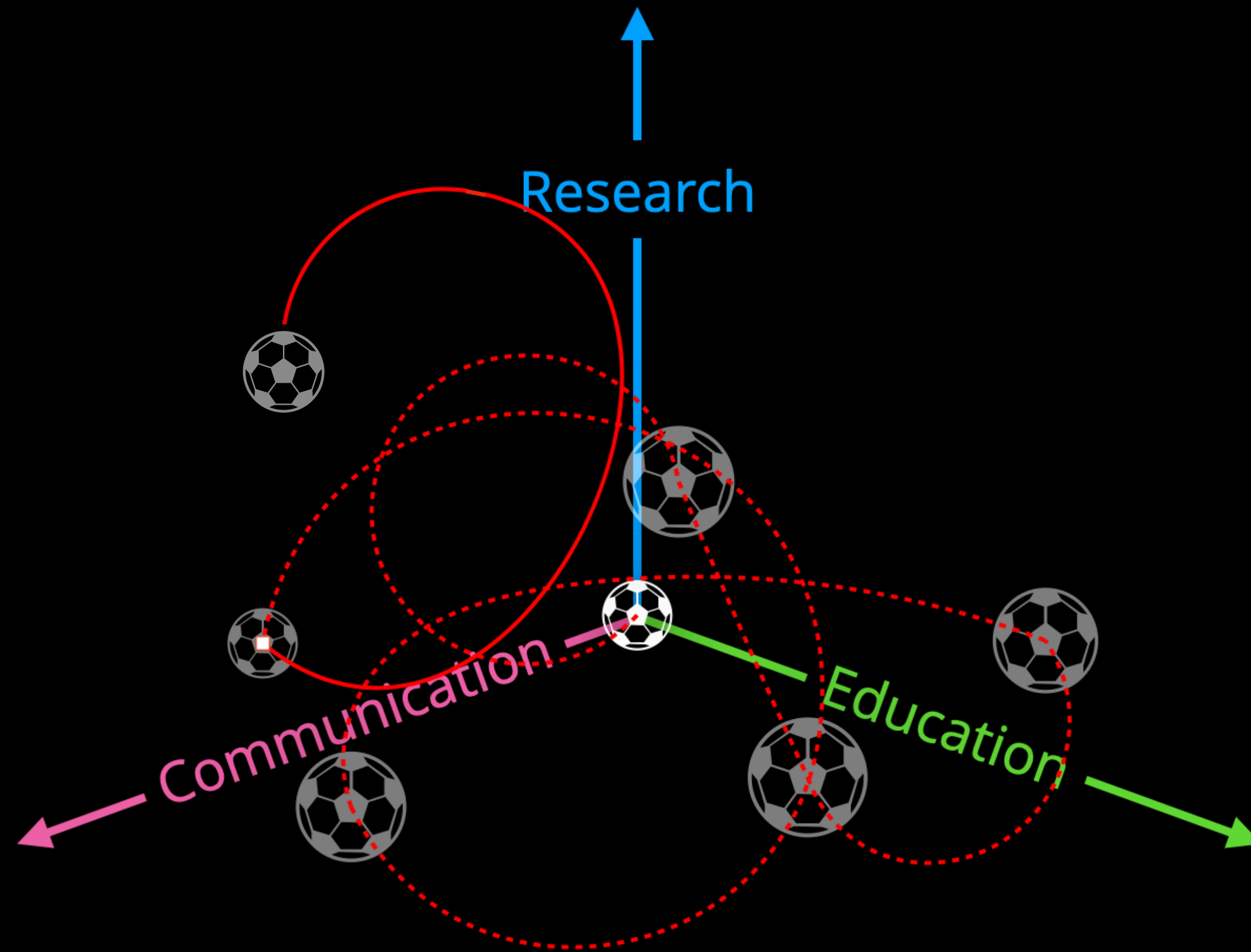
A collaboration of researchers at Harvard and Google, making data discoverable and available to researchers seeking to uncover novel solutions to climate and sustainability challenges.

tinyurl.com/dimensionsofdiscovery

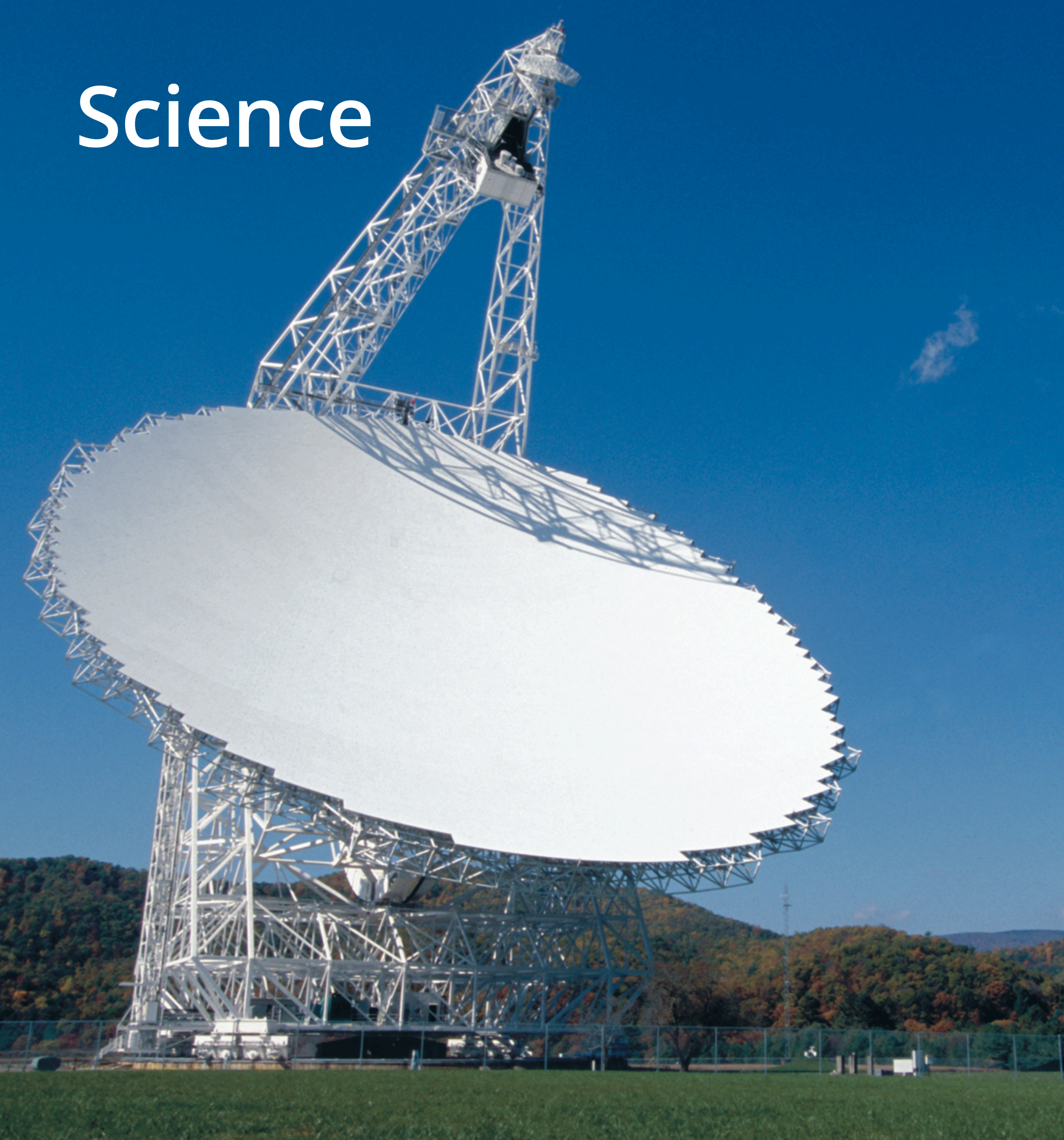
When to use what technology?

Science

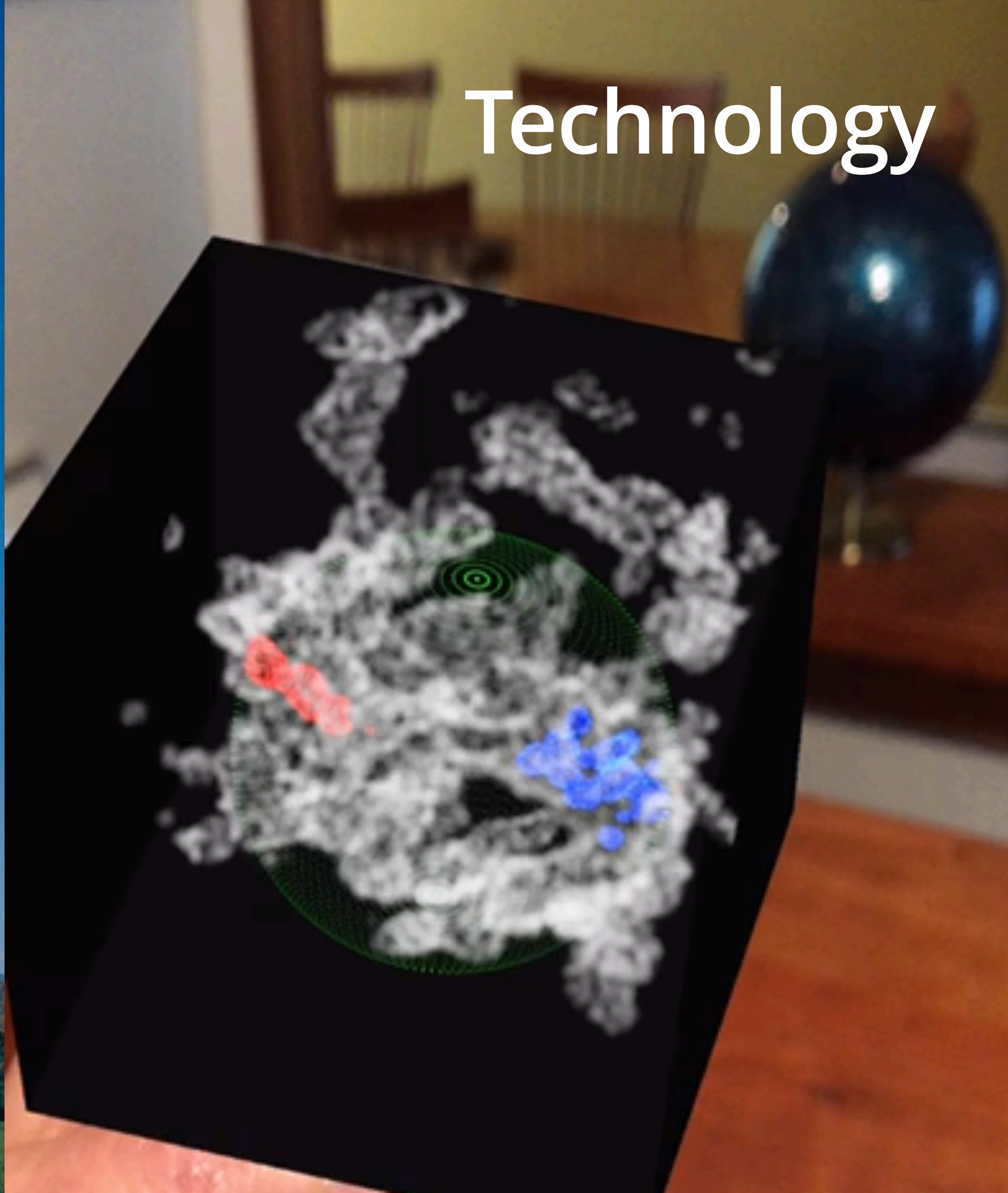
Technology



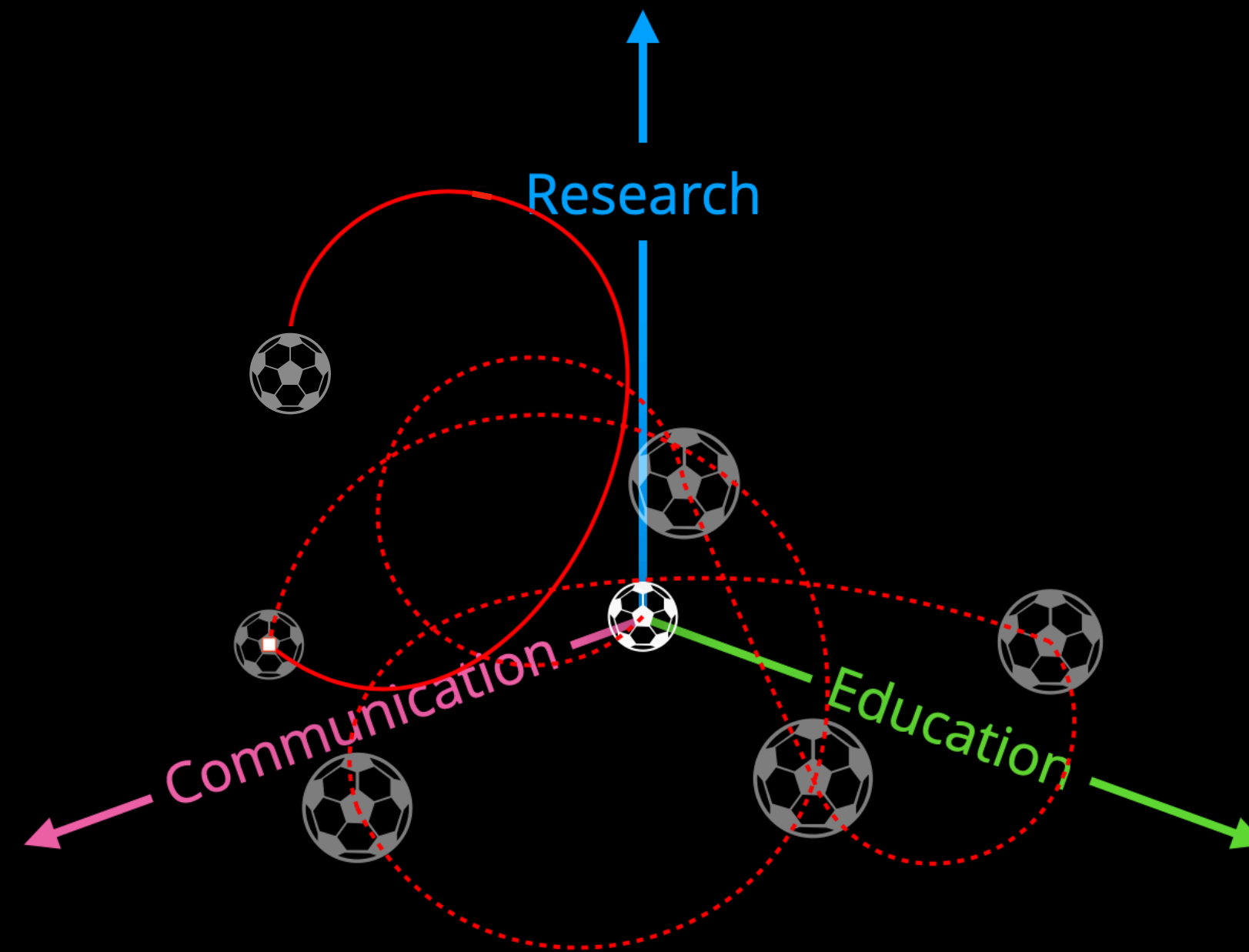
Science



Technology



Science + Technology = { Fun, Discovery }



"The Heavy Red Bag" Technology

1993ApJ...407..175C

THE ASTROPHYSICAL JOURNAL, 407:175–184, 1993 April 10
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OH ZEEMAN OBSERVATIONS OF DARK CLOUDS
R. M. CRUTCHER,¹ T. H. TROLAND,² A. A. GOODMAN,³ C. HEILES,⁴ I. KAZÈS,⁵ AND P. C. MYERS³
Received 1992 August 3; accepted 1992 October 7

ABSTRACT

We have made measurements with the **Green Bank 43 m telescope** of the Zeeman effect in the 1665 and 1667 MHz lines of OH toward dark clouds. The typical 1σ sensitivity was $3\mu\text{G}$. The only certain detection of a magnetic field was toward B1, for which we measured a line-of-sight component $|B|\cos\theta = -19.1 \pm 3.9\mu\text{G}$. Comparison with our earlier measurement of the field toward B1 with the Arecibo telescope provided evidence for a 40% enhancement in field strength between the molecular envelope and core of the B1 cloud, which is consistent with quasi-static contraction of the cloud driven by ambipolar diffusion. Because the Zeeman effect is only sensitive to the line-of-sight component of the magnetic field, a statistical analysis of the total (not line-of-sight) field strength and upper limits was necessary. This analysis indicated that the total (not line-of-sight) field strength was $|B| \approx 16\mu\text{G}$ toward the central regions of dark clouds were approximately magnetic and gravitational energy and (2) the supersonic line widths found to be consistent with the hypotheses that (1) dark clouds are in approximate subcritical clouds evolving on the ambipolar diffusion

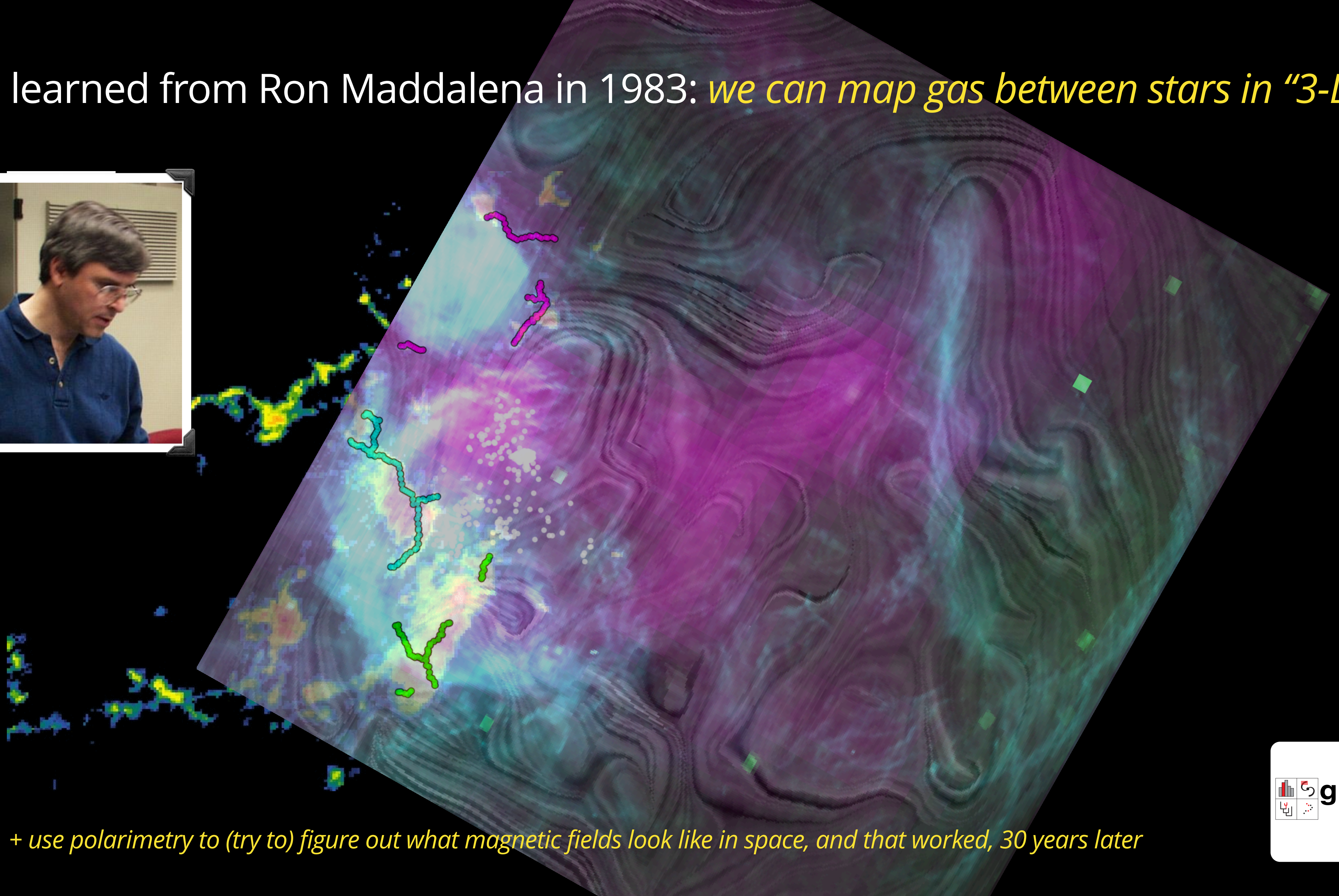
THE ASTROPHYSICAL JOURNAL, 338:L61–L64, 1989 March 15
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MEASUREMENT OF MAGNETIC FIELD STRENGTH IN THE DARK CLOUD BARNARD 1
A. A. GOODMAN,^{1,2} R. M. CRUTCHER,³ C. HEILES,⁴ P. C. MYERS,² AND T. H. TROLAND⁵
Received 1988 August 30; accepted 1988 December 13

ABSTRACT

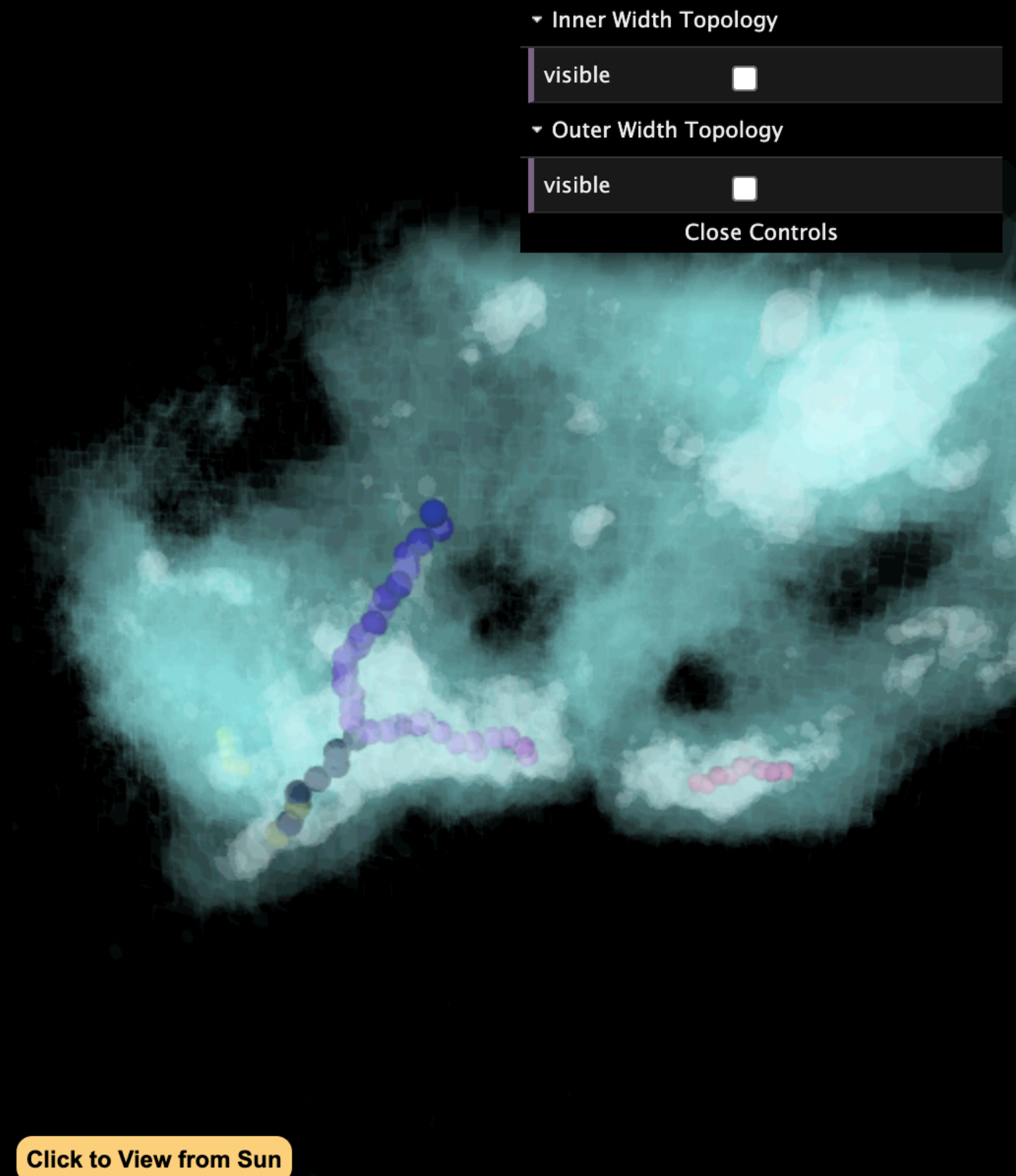
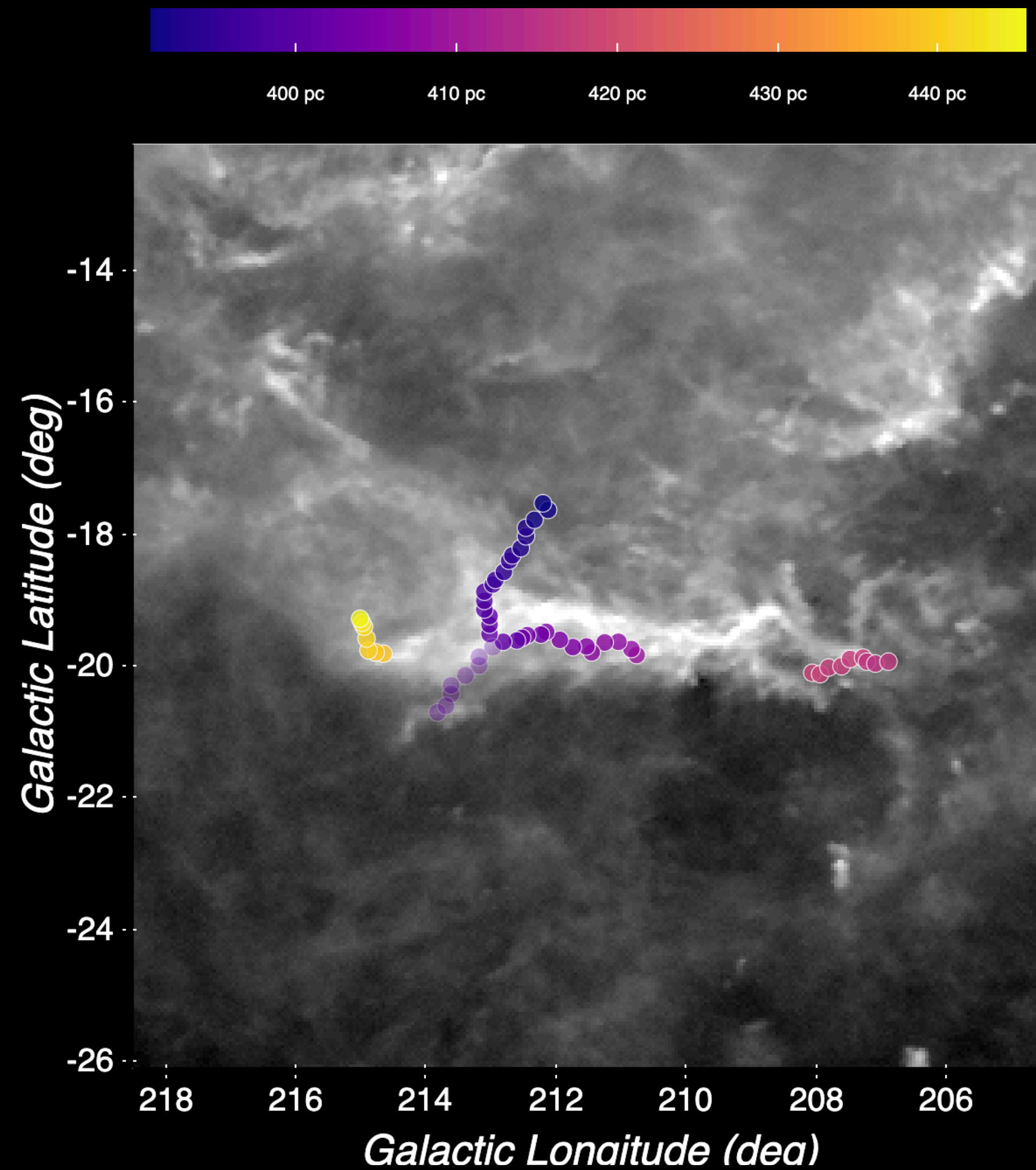
We report the detection of a $-27 \pm 4\mu\text{G}$ magnetic field in the molecular cloud Barnard 1 (B1), via observations of the Zeeman effect in the 1665 and 1667 MHz lines of OH at the Arecibo 305 m telescope. The

What I learned from Ron Maddalena in 1983: *we can map gas between stars in “3-D”**



+ *use polarimetry to (try to) figure out what magnetic fields look like in space, and that worked, 30 years later*

Update since 1983, just for Ron Maddalena: *we can map gas between stars in true 3-D*



What I learned from James Hansen in 1983: *a computer (simulation) can save humanity*

28 August 1981, Volume 213, Number 4511

SCIENCE

Climate Impact of Increasing Atmospheric Carbon Dioxid

**J. Hansen, D. Johnson, A. Lacis, S. Lebedev
P. Lee, D. Rind, G. Russe**

Atmospheric CO₂ increased from 280 to 300 parts per million in 1880 to 335 to 340 ppm in 1980 (1, 2), mainly due to burning of fossil fuels. Deforestation and changes in biosphere growth may also

The major difficulty in theory has been the absence of a warming coincident with the CO₂ increase. In fact, the temperature in the Northern Hemisphere

Summary. The global temperature rose by 0.2°C between the middle 1980, yielding a warming of 0.4°C in the past century. This temperature is consistent with the calculated greenhouse effect due to measured atmospheric carbon dioxide. Variations of volcanic aerosols and solar luminosity appear to be primary causes of observed fluctuations about the mean of increasing temperature. It is shown that the anthropogenic carbon dioxide should emerge from the noise level of natural climate variability by the middle of the 21st century, and there is a high probability of warming in the 1980's. Potential effects on climate in the 21st century include the creation of drought-prone regions in North America and central Asia as part of a shifting of climatic zones, erosion of the West Antarctic ice sheet with a consequent worldwide rise in sea level, and opening of the fabled Northwest Passage.

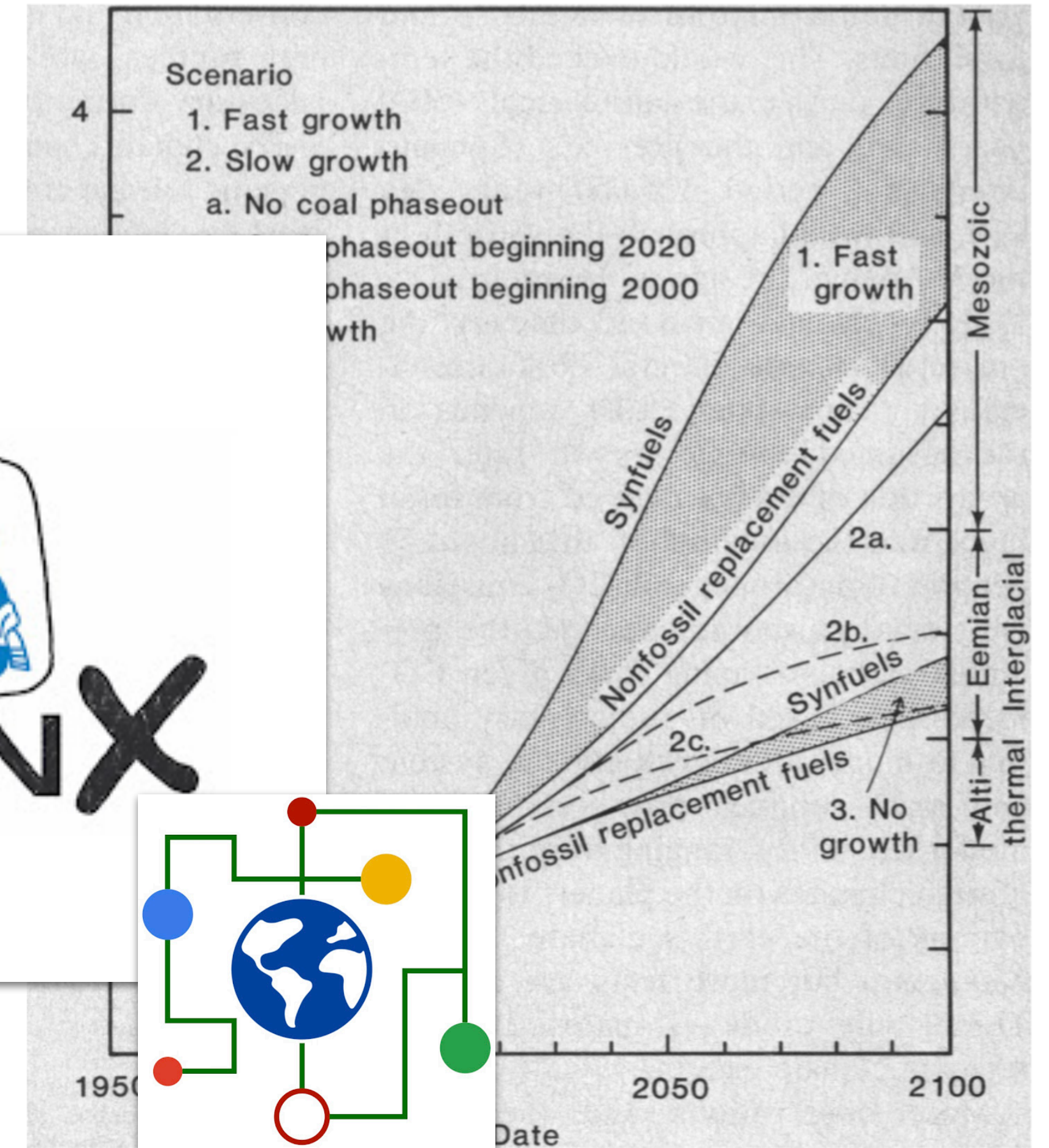
Greenhouse Effect

The effective radiating temperature of the earth, T_e , is determined by the need for infrared emission from the planet to balance absorbed solar radiation:

$$\pi R^2(1 - A)S_0 = 4\pi R^2\sigma T_e \quad (1)$$



temperature gradient is convectively unstable, giving rise to atmospheric motions that contribute to vertical transport of heat and result in $\Gamma \sim 5^\circ$ to 6°C per kilometer. The mean lapse rate is less than the dry adiabatic value because of latent heat release by condensation as



Seamless integration of technologies is part of life in 2022—it should be part of learning, research, and communication too.

1 (Delta)

WiFi ONBOARD Help

2 (Gogo)

Have a Gogo account? Sign in

Payment

Fast checkout payment

3 (PayPal)

4 (Amazon pay)

PayPal amazon pay

OR

5, 6, 7, 8 (4 credit card companies)

Pay with a credit card

AMERICAN EXPRESS VISA MasterCard DISCOVER

Name on card

Enter name on card...

Card number Month Year

Enter card number... Select month... Select year...

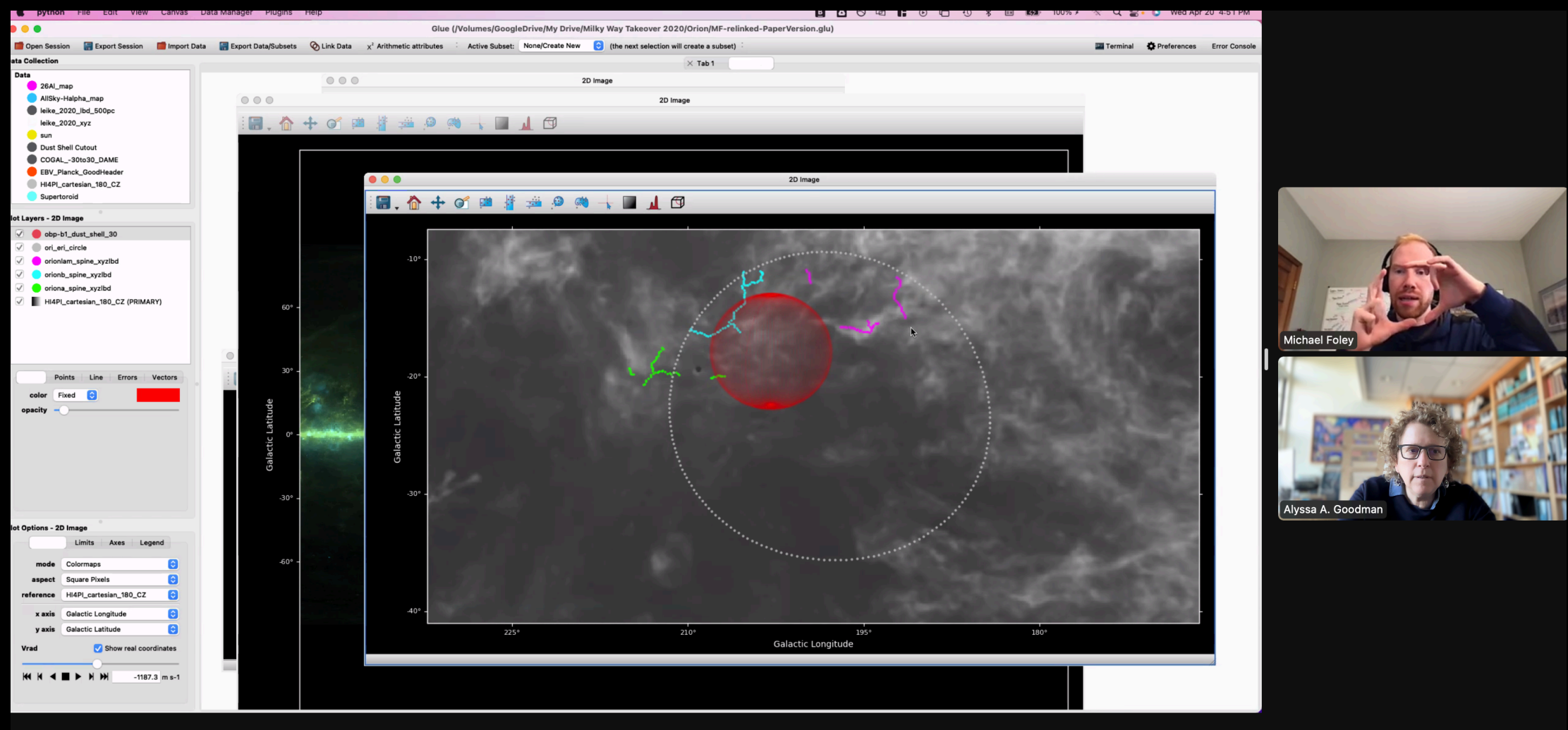
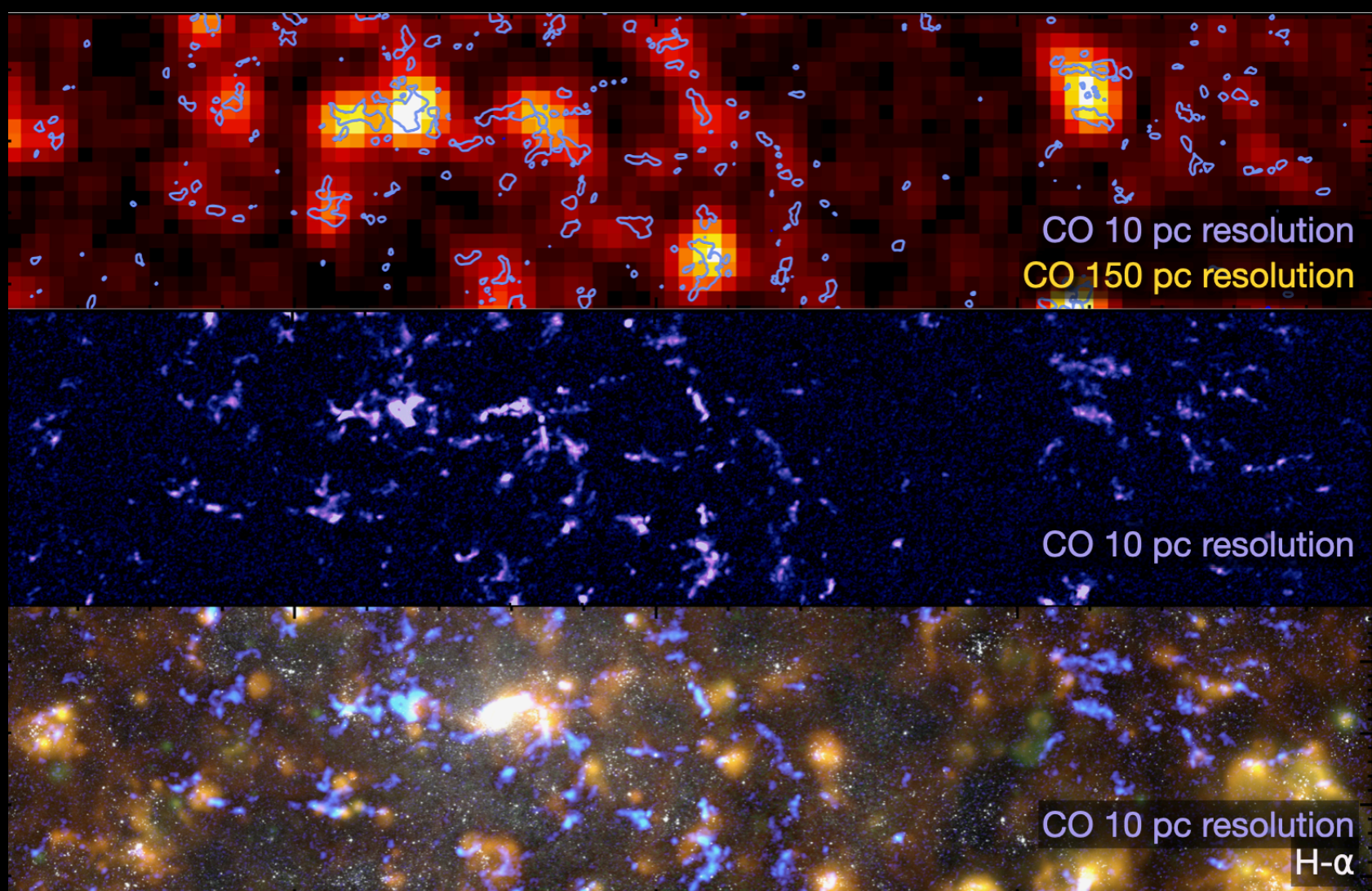
(+ Google, 1Password, etc. services that can auto-fill these fields)

Email address

Enter email address...

Screenshot of Delta Airlines' WiFi purchase page, on a very small plane, BOS:RIC, 4/22/22.

Dimensions of Discovery: “this Wednesday”



Localization (finding page objects)

Ongoing Model updates:

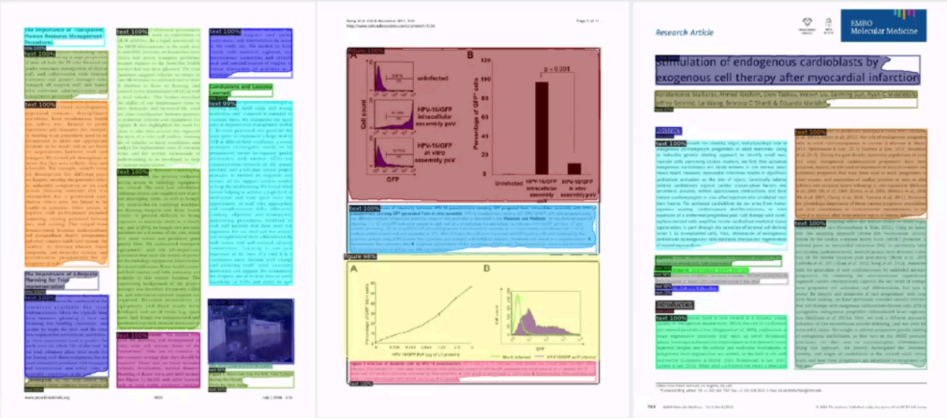
1. We don't know what we get “wrong”
2. The model is computationally expensive (rely on OCR)



Shantanu Pagare
(MSIM, iSchool)

Is there an inexpensive way to detect which pages will work well in our model and which will not (and can maybe be sent to Zooniverse for humans to look at?)

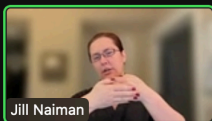
Detectron2+PubLayNet dataset



Classes: figures, text, tables, lists

	ScanBank No PP fig cap	ScanBank w/PP fig cap	detectron2* No PP fig cap [†]	detectron2* w/PP fig cap [†]	Ours No PP fig cap	Ours w/PP fig cap
TP	69.9 29.0	69.3 52.8	72.0 46.4	81.0 80.9	58.2 23.2	85.7 86.7
FP	71.4 28.8	43.6 8.7	41.8 68.2	27.1 22.4	45.3 82.3	13.7 8.6
FN	1.7 42.8	2.5 40.7	0.6 1.6	1.2 4.9	3.1 5.1	3.5 6.0
Prec	49.5 50.2	61.4 85.9	63.3 40.5	74.9 78.3	56.2 22.0	86.2 90.9
Rec	97.6 40.4	96.5 56.5	99.2 96.6	98.5 94.3	95.0 81.9	96.1 93.6
F1	65.7 44.8	75.0 68.1	77.2 57.1	85.1 85.6	70.6 34.7	90.9 92.2

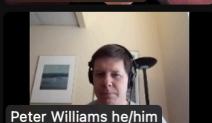
- Does poorly at localizing at high IOU (high overlap between true and found box)
- Does not detect captions directly
- Does much better at lower IOU (for text, figures, tables, lists)
- Uses scanned grayscale pages — runs much more quickly than our model



Jill Naiman



Alyssa A. Goodman



Peter Williams

Hubble's Law Cosmic Data Stories

Collect Galaxy Data
Perhaps a small blurb about this stage

SELECT 5 GALAXIES **FILL DATA POINTS** **STATE**

Select Five Galaxies

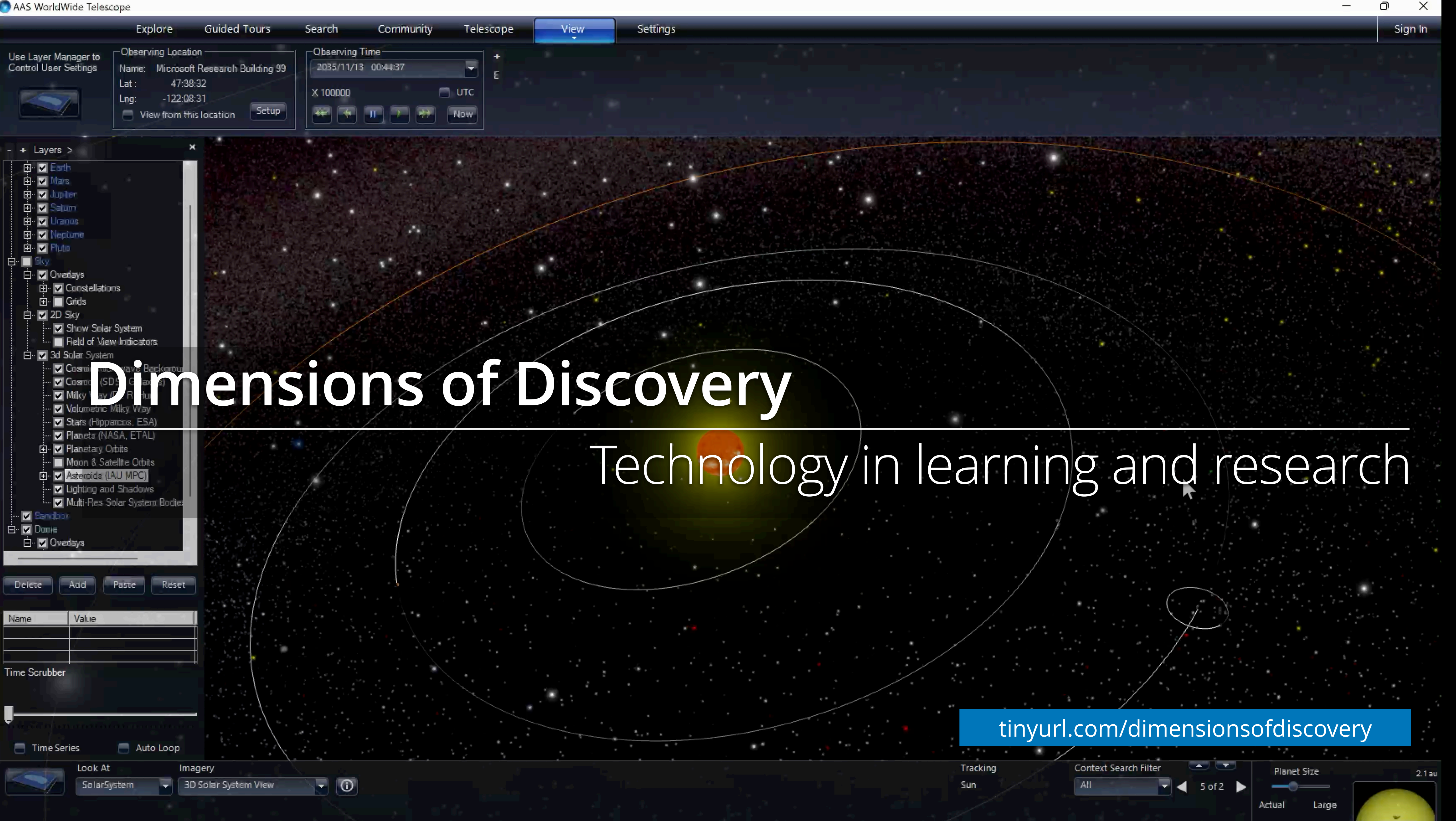
This is a view of the night sky, like the one you explored earlier. This view shows a more modern data set from the Sloan Digital Sky Survey (SDSS), which has collected imaging and spectral data for millions of galaxies. This Data Story will focus on a nearby subset of galaxies.

NIGHT SKY VIEWER

MY GALAXIES

Galaxy Name	Element	Rest Wavelength (Å)	Observed Wavelength (Å)	Velocity (km/s)
No data available				

FIND VELOCITY **LEARN MORE**

Use Layer Manager to
Control User Settings

Observing Location

Name: Microsoft Research Building 99

Lat: 47:38:32

Lng: -122:08:31

View from this location

Setup

Observing Time

2035/11/13 00:44:37

X 100000

UTC

Now

Layers

- ☒ Earth
- ☒ Mars
- ☒ Jupiter
- ☒ Saturn
- ☒ Uranus
- ☒ Neptune
- ☒ Pluto
- ☒ Sky
- ☒ Overlays
 - ☒ Constellations
 - ☐ Grids
- ☒ 2D Sky
 - ☒ Show Solar System
 - ☐ Field of View Indicators
- ☒ 3d Solar System
 - ☒ Cosmic Microwave Background
 - ☒ Cosmic (SDSS, G, etc.)
 - ☒ Milky Way (2D, 3D)
 - ☒ Volumetric Milky Way
 - ☒ Stars (Hipparcos, ESA)
 - ☒ Planets (NASA, ETAL)
 - ☒ Planetary Orbits
 - ☐ Moon & Satellite Orbits
 - ☒ Asteroids (IAU MPC)
 - ☒ Lighting and Shadows
 - ☒ Multi-Res Solar System Bodies
- ☒ Sandbox
- ☒ Domes
- ☒ Overlays

Delete Add Paste Reset

Name	Value

Time Scrubber



Time Series Auto Loop



Look At

Imagery

SolarSystem

3D Solar System View

i

Tracking

Sun

Context Search Filter

All

5 of 2

Planet Size

Actual

Large

2.1 au



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Technology in learning and research

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