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Alyssa A. Goodman • Harvard University

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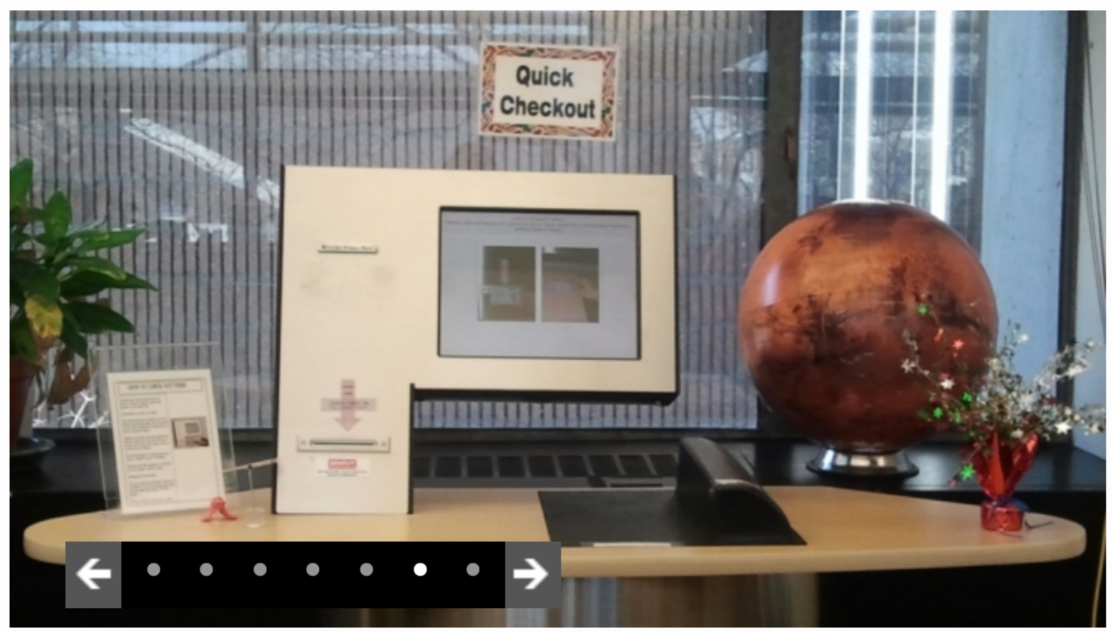

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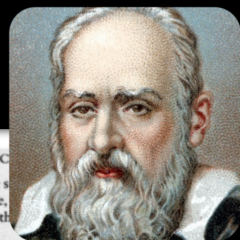
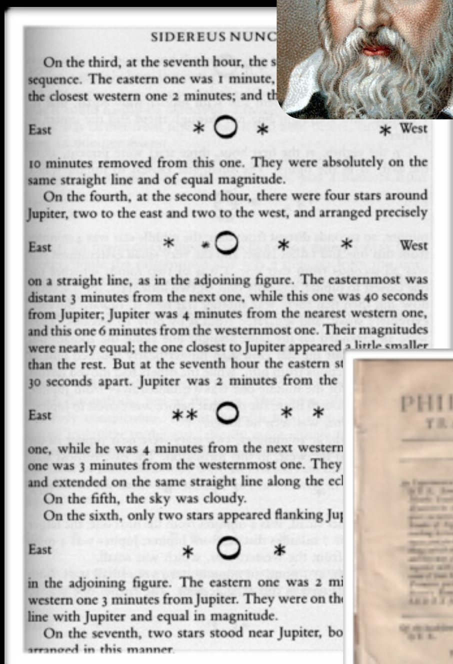
1610

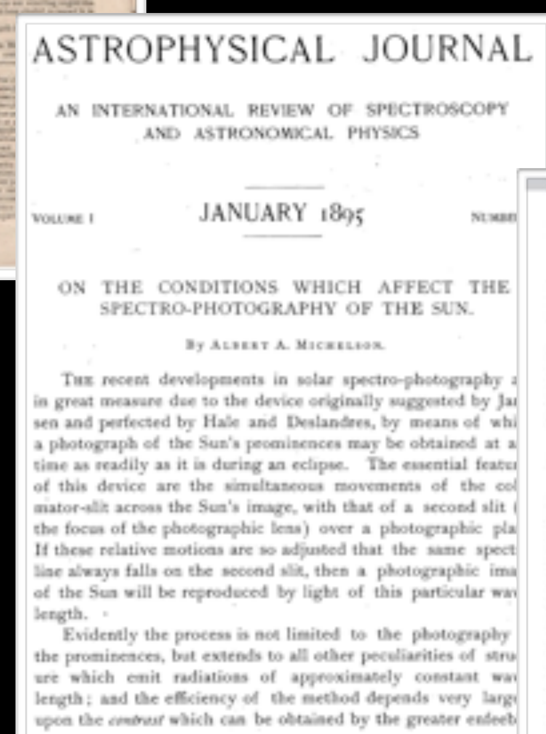



SIDEREUS NUNC
On the third, at the seventh hour, the s
sequence. The eastern one was 1 minute,
the closest western one 2 minutes; and th
East * O * * West
10 minutes removed from this one. They were absolutely on the same straight line and of equal magnitude.
On the fourth, at the second hour, there were four stars around Jupiter, two to the east and two to the west, and arranged precisely
East * *O * * West
on a straight line, as in the adjoining figure. The easternmost was distant 3 minutes from the next one, while this one was 40 seconds from Jupiter; Jupiter was 4 minutes from the nearest western one, and this one 6 minutes from the westernmost one. Their magnitudes were nearly equal; the one closest to Jupiter appeared a little smaller than the rest. But at the seventh hour the eastern st
30 seconds apart. Jupiter was 2 minutes from the
East ** O * *
one, while he was 4 minutes from the next western
one was 3 minutes from the westernmost one. They
and extended on the same straight line along the ecl
On the fifth, the sky was cloudy.
On the sixth, only two stars appeared flanking Jup
East * O *
in the adjoining figure. The eastern one was 2 mi
western one 3 minutes from Jupiter. They were on th
line with Jupiter and equal in magnitude.
On the seventh, two stars stood near Jupiter, bo
arranged in this manner.

1665


PHILOSOPHICAL TRANSACTIONS

1895


ASTROPHYSICAL JOURNAL

AN INTERNATIONAL REVIEW OF SPECTROSCOPY AND ASTRONOMICAL PHYSICS

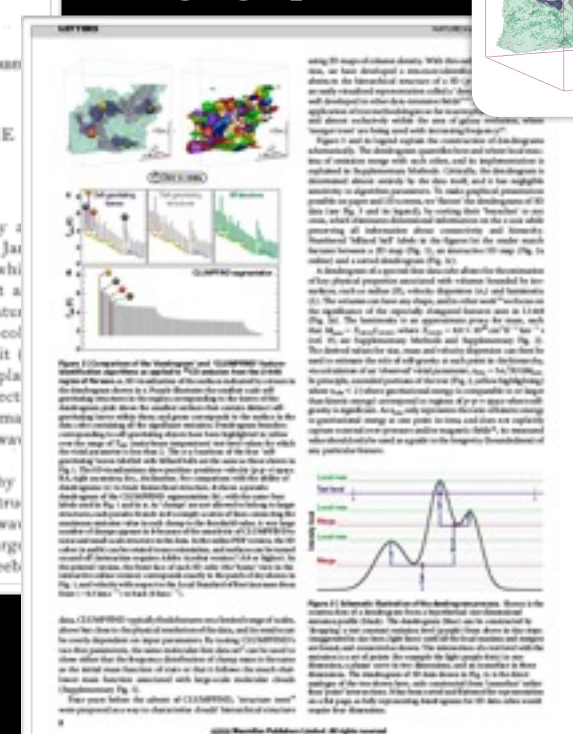
VOLUME I JANUARY 1895 NUMBE

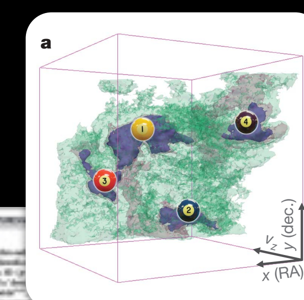
ON THE CONDITIONS WHICH AFFECT THE SPECTRO-PHOTOGRAPHY OF THE SUN.

By Albert A. Michelson.

The recent developments in solar spectro-photography a
in great measure due to the device originally suggested by Ja
sen and perfected by Hale and Deslandres, by means of whi
a photograph of the Sun's prominences may be obtained at a
time as readily as it is during an eclipse. The essential featu
of this device are the simultaneous movements of the col
mator-slit across the Sun's image, with that of a second slit (
the focus of the photographic lens) over a photographic pla
If these relative motions are so adjusted that the same spect
line always falls on the second slit, then a photographic ima
of the Sun will be reproduced by light of this particular wa
length.
Evidently the process is not limited to the photography
the prominences, but extends to all other peculiarities of stru
ure which emit radiations of approximately constant wa
length; and the efficiency of the method depends very larg
upon the *contrast* which can be obtained by the greater enfeeb

2009





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3D PDF

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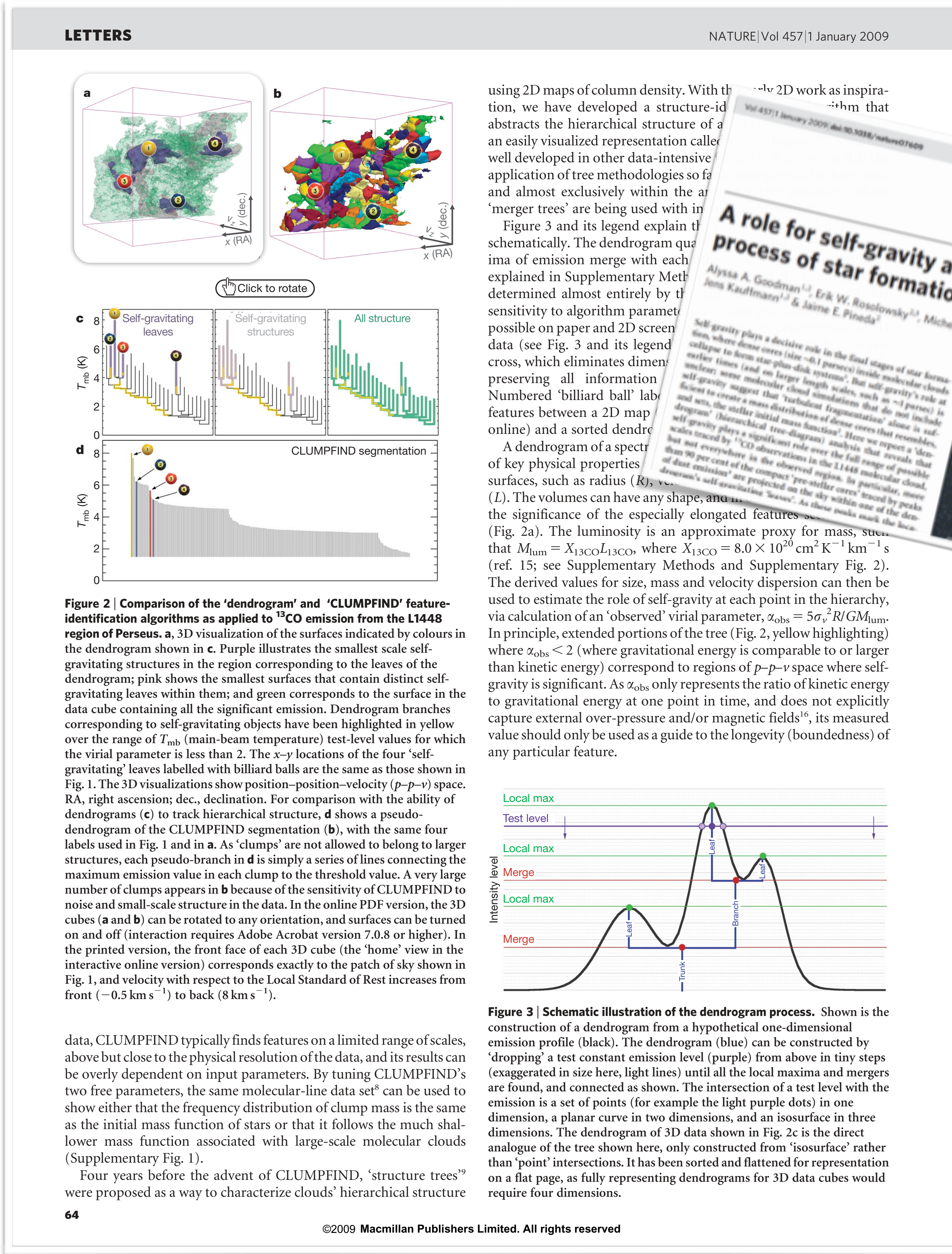

Figure 2 | Comparison of the 'dendrogram' and 'CLUMPFIND' feature-identification algorithms as applied to ^{13}CO emission from the L1448 region of Perseus. a, 3D visualization of the surfaces indicated by colours in the dendrogram shown in **c**. Purple illustrates the smallest scale self-gravitating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

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

Four years before the advent of CLUMPFIND, 'structure trees'[9] were proposed as a way to characterize clouds' hierarchical structure using 2D maps of column density. With th... rly 2D work as inspiration, we have developed a structure-id... rithm that abstracts the hierarchical structure of a ... an easily visualized representation calle... well developed in other data-intensive ... application of tree methodologies so fa... and almost exclusively within the a... 'merger trees' are being used with in...

Figure 3 and its legend explain th... schematically. The dendrogram qua... ima of emission merge with each ... explained in Supplementary Meth... determined almost entirely by th... sensitivity to algorithm paramet... possible on paper and 2D screen... data (see Fig. 3 and its legend... cross, which eliminates dimens... preserving all information ... Numbered 'billiard ball' lab... features between a 2D map ... online) and a sorted dendro...

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

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

Vol 457|1 January 2009|doi:10.1038/nature07609

A role for self-gravity at multiple length scales in the process of star formation

Alyssa A. Goodman[1,2], Erik W. Rosolowsky[2,3], Michelle A. Borkin[1†], Jonathan B. Foster[2], Michael Halle[1,4], Jens Kauffmann[1,2] & Jaime E. Pineda[2]

Goodman et al. 2009, Nature, cf: Fluke et al. 2009

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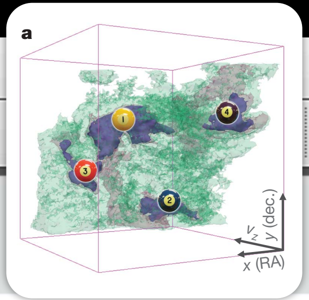

LETTERS

A role for self-gravity at multiple length scales in the process of star formation

Alyssa A. Goodman[1,2], Erik W. Rosolowsky[2,3], Michelle A. Borkin[1]†, Jonathan B. Foster[2], Michael Halle[1,4], Jens Kauffmann[1,2] & Jaime E. Pineda[2]

Self-gravity plays a decisive role in the final stages of star formation, where dense cores (size ∼0.1 parsecs) inside molecular clouds collapse to form star-plus-disk systems[1]. But self-gravity's role at earlier times (and on larger length scales, such as ∼1 parsec) is unclear; some molecular cloud simulations that do not include self-gravity suggest that 'turbulent fragmentation' alone is sufficient to create a mass distribution of dense cores that resembles, and sets, the stellar initial mass function[2]. Here we report a 'dendrogram' (hierarchical tree-diagram) analysis that reveals that self-gravity plays a significant role over the full range of possible scales traced by ^{13}CO observations in the L1448 molecular cloud, but not everywhere in the observed region. In particular, more than 90 per cent of the compact 'pre-stellar cores' traced by peaks of dust emission[3] are projected on the sky within one of the dendrogram's self-gravitating 'leaves'. As these peaks mark the locations of already-forming stars, or of those probably about to form, a self-gravitating cocoon seems a critical condition for their exist-

overlapping features as an option, significant emission found between prominent clumps is typically either appended to the nearest clump or turned into a small, usually 'pathological', feature needed to encompass all the emission being modelled. When applied to molecular-line

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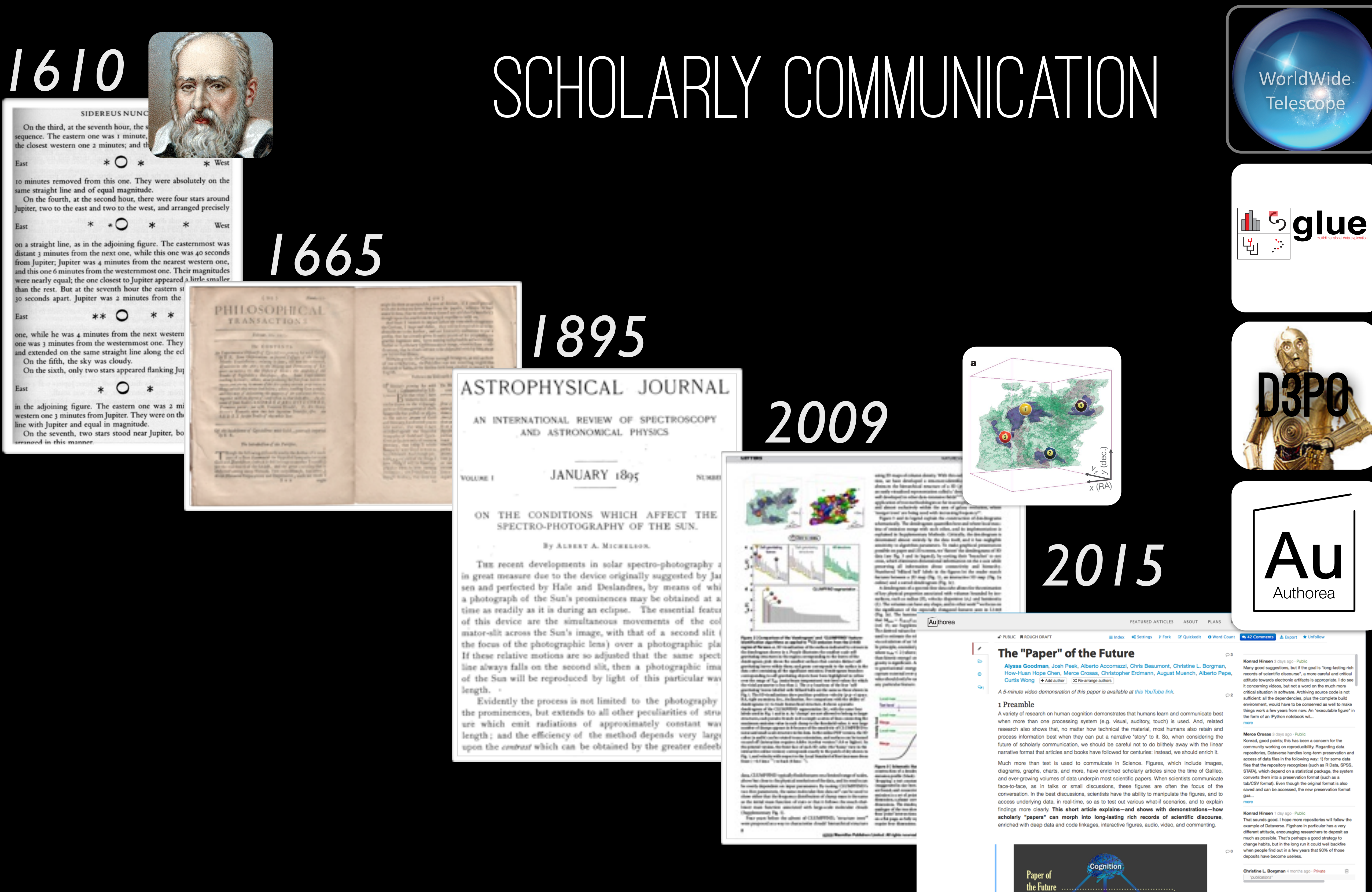

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The "Paper" of the Future

3

Alyssa Goodman, Josh Peek, Alberto Accomazzi, Chris Beaumont, Christine L. Borgman, How-Huan Hope Chen, Merce Crosas, Christopher Erdmann, August Muench, Alberto Pepe, Curtis Wong + Add author Re-arrange authors

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

2

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.

0

Konrad Hinsen 3 days ago · Public
Many good suggestions, but if the goal is "long-lasting rich records of scientific discourse", a more careful and critical attitude towards electronic artifacts is appropriate. I do see it concerning videos, but not a word on the much more critical situation in software. Archiving source code is not sufficient: all the dependencies, plus the complete build environment, would have to be conserved as well to make things work a few years from now. An "executable figure" in the form of an IPython notebook wil...
more

Merce Crosas 3 days ago · Public
Konrad, good points; this has been a concern for the community working on reproducibility. Regarding data repositories, Dataverse handles long-term preservation and access of data files in the following way: 1) for some data files that the repository recognizes (such as R Data, SPSS, STATA), which depend on a statistical package, the system converts them into a preservation format (such as a tab/CSV format). Even though the original format is also saved and can be accessed, the new preservation format gua...
more

Konrad Hinsen 1 day ago · Public
That sounds good. I hope more repositories will follow the example of Dataverse. Figshare in particular has a very different attitude, encouraging researchers to deposit as much as possible. That's perhaps a good strategy to change habits, but in the long run it could well backfire when people find out in a few years that 90% of those deposits have become useless.

Christine L. Borgman 4 months ago · Private
"publications"

d3po/Authorea: Peek, Price-Whelan, Pepe, Beaumont, Borkin, Newton; PoF: Goodman, Peek; WWT: Wong, Fay et al.; Astrometry.net: Hogg, Lang, Roweis et al.

Astrometry.net glue

[video, demos]

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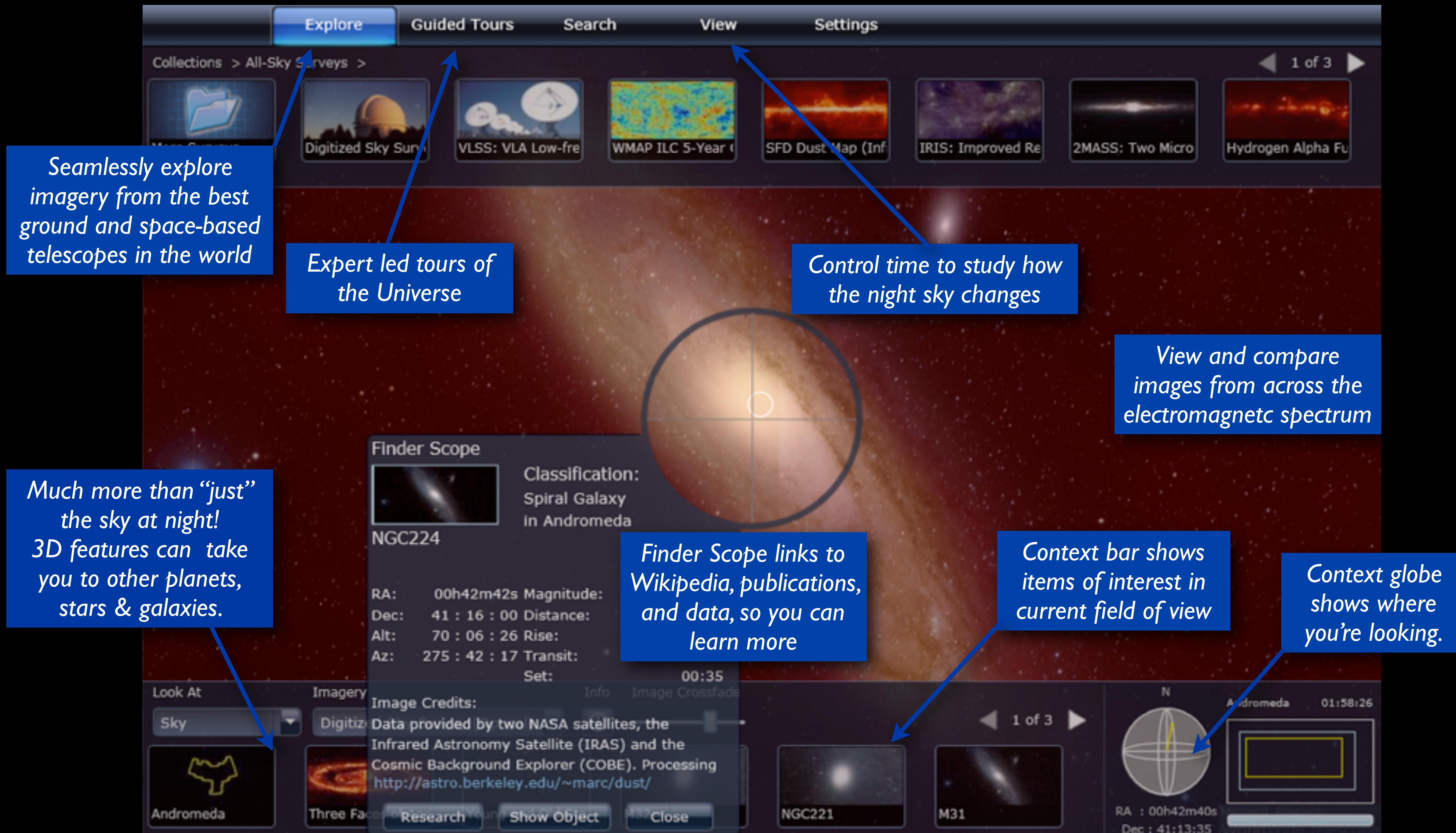

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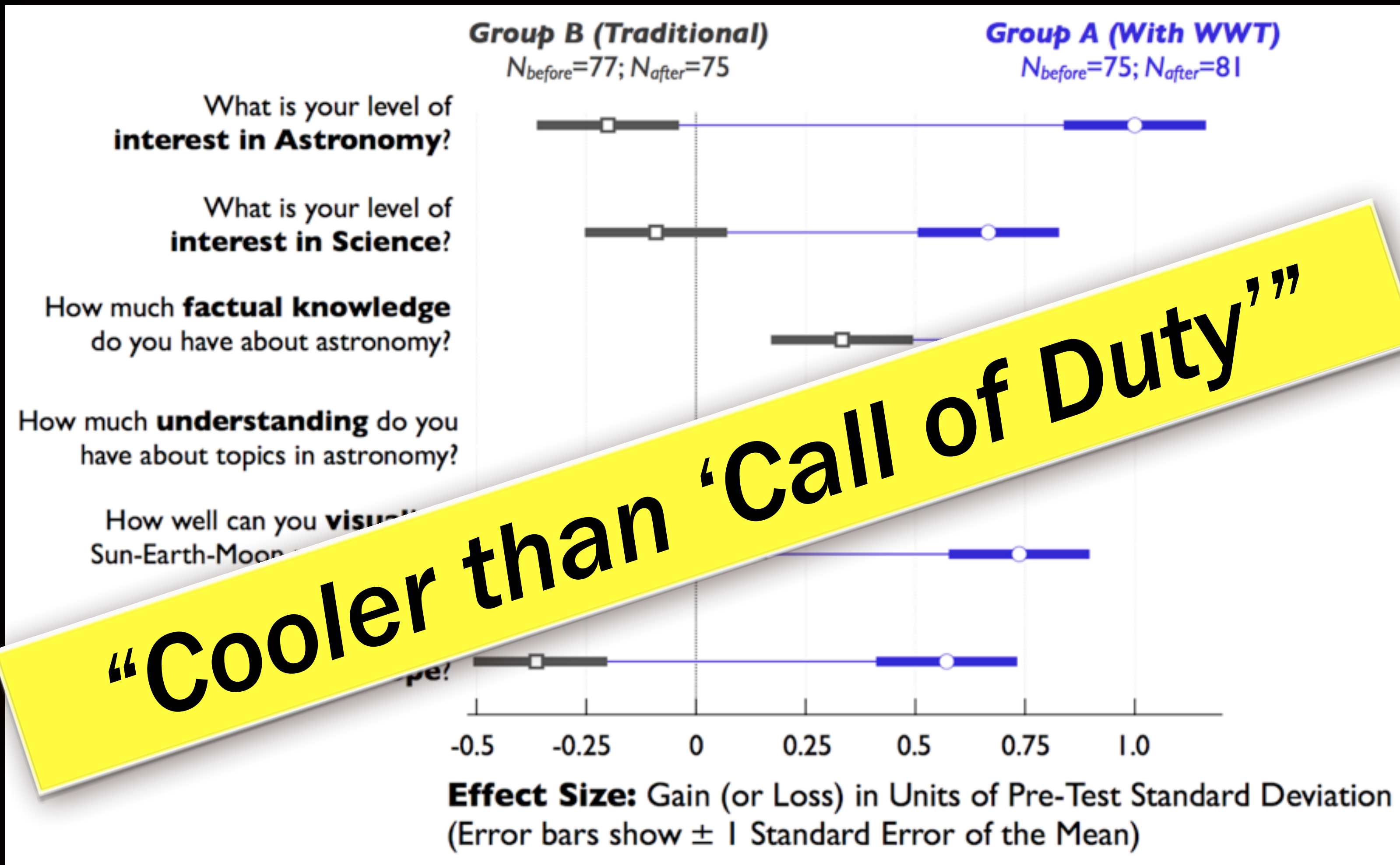

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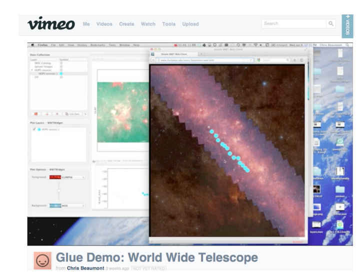

glue

multidimensional data exploration

ADS ALL SKY SURVEY

Viz-e-Lab

KINECT

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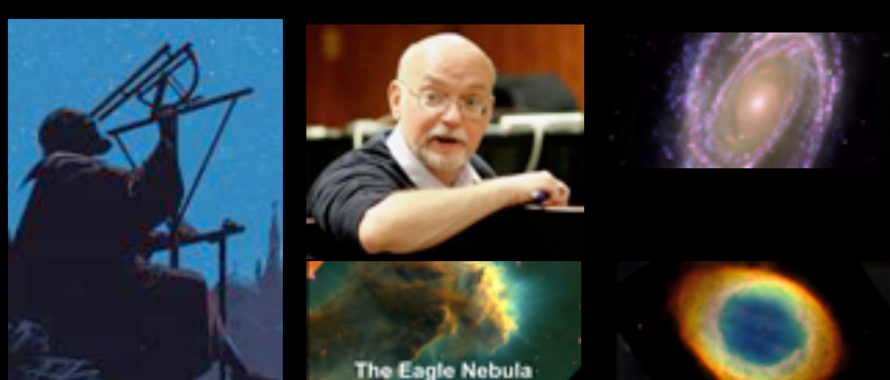

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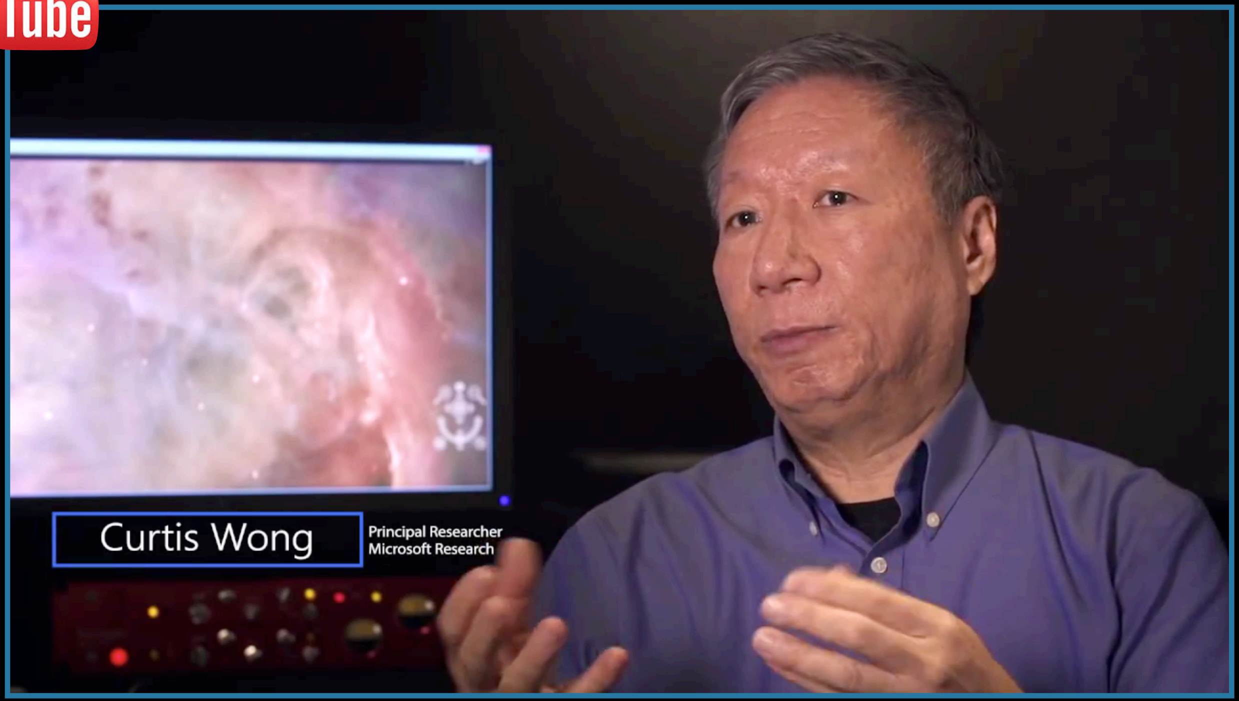

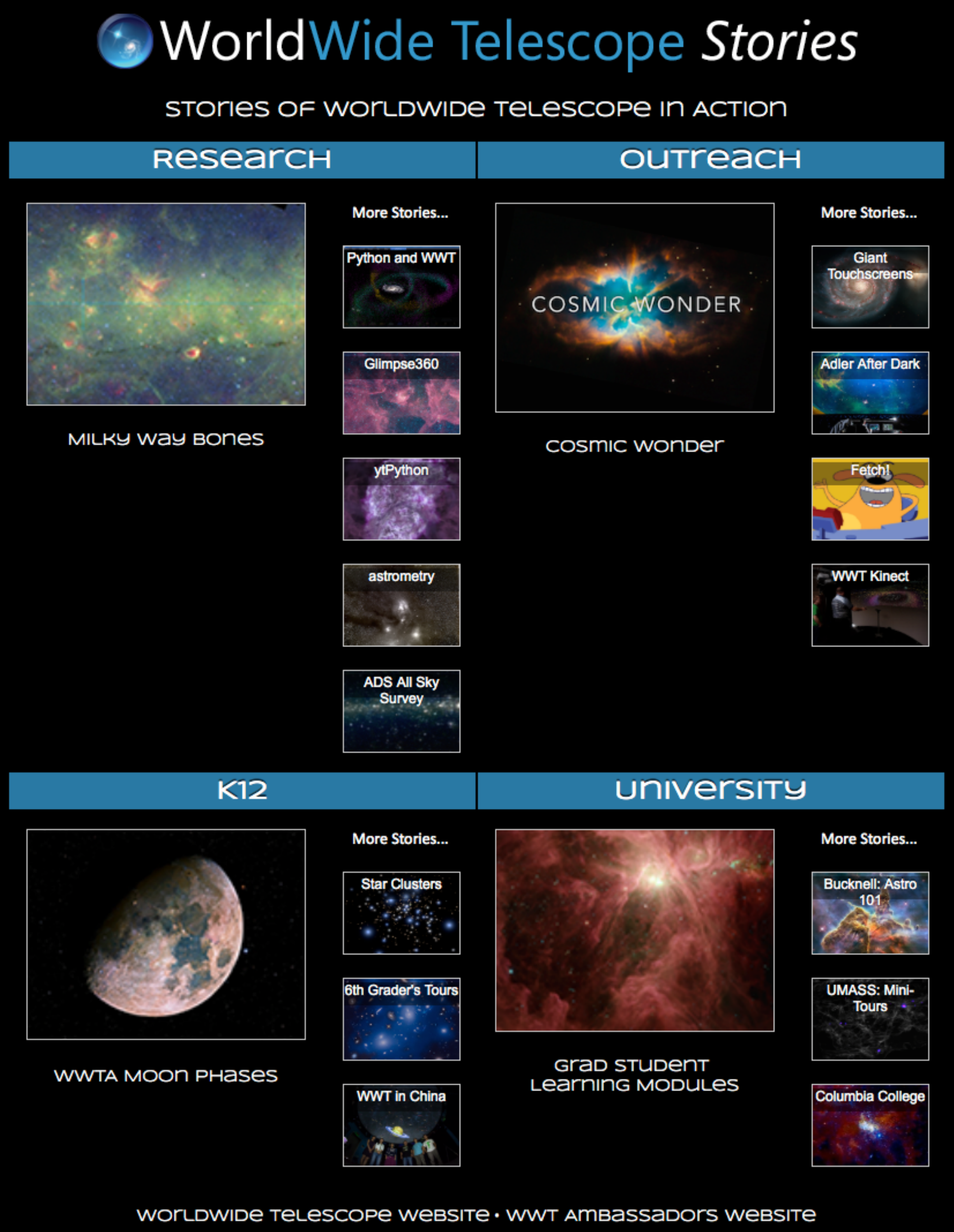

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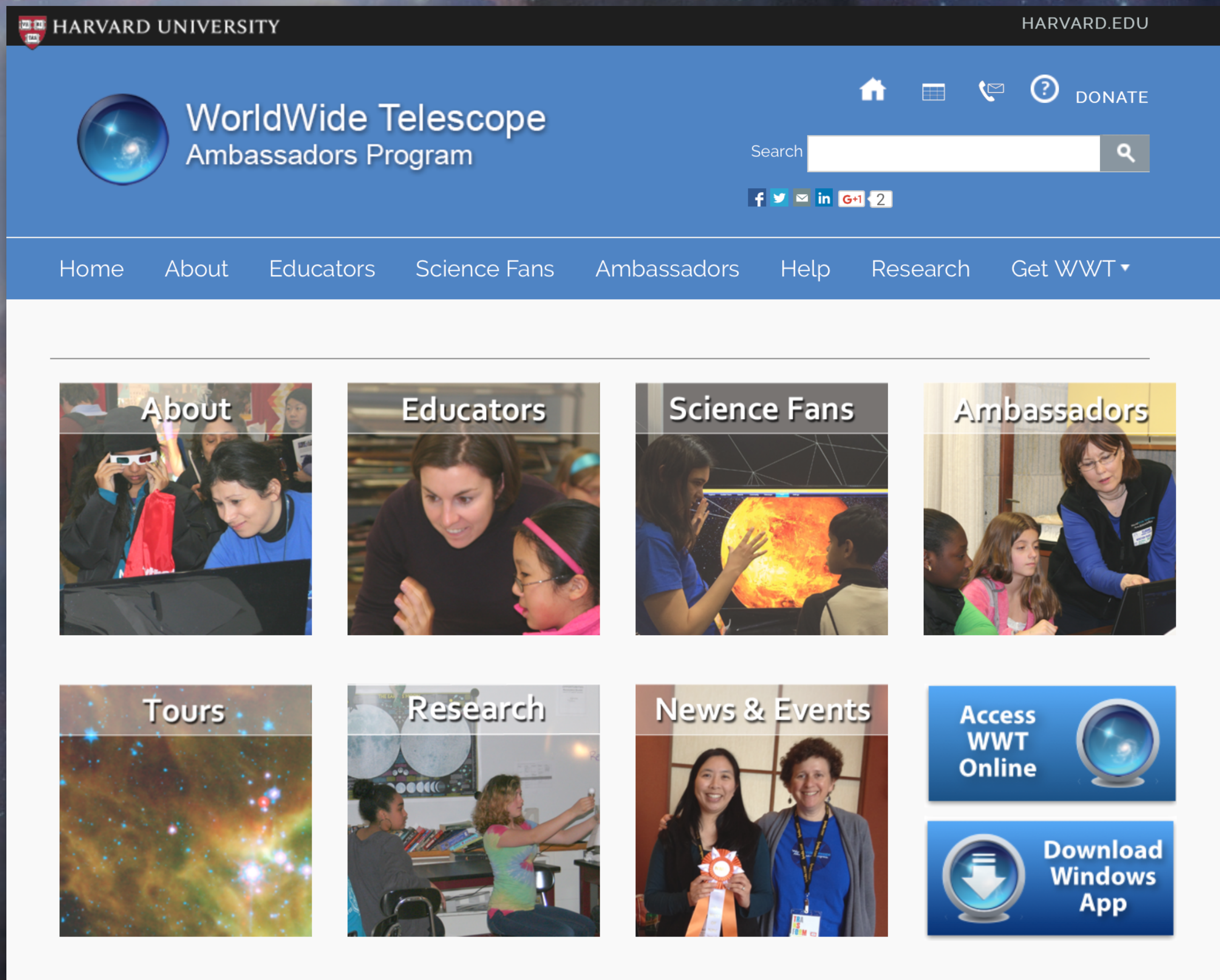

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Think Space

LIFE IN THE UNIVERSE

John Templeton Foundation

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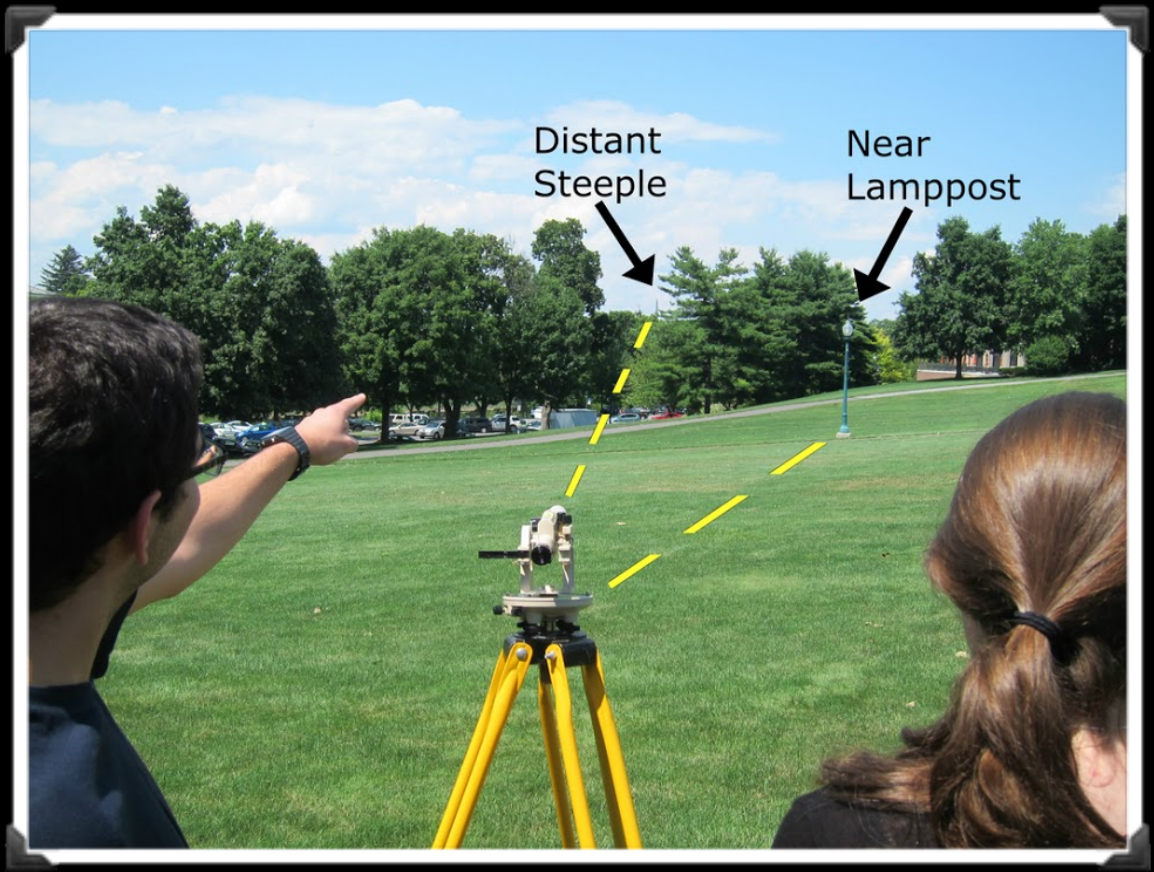
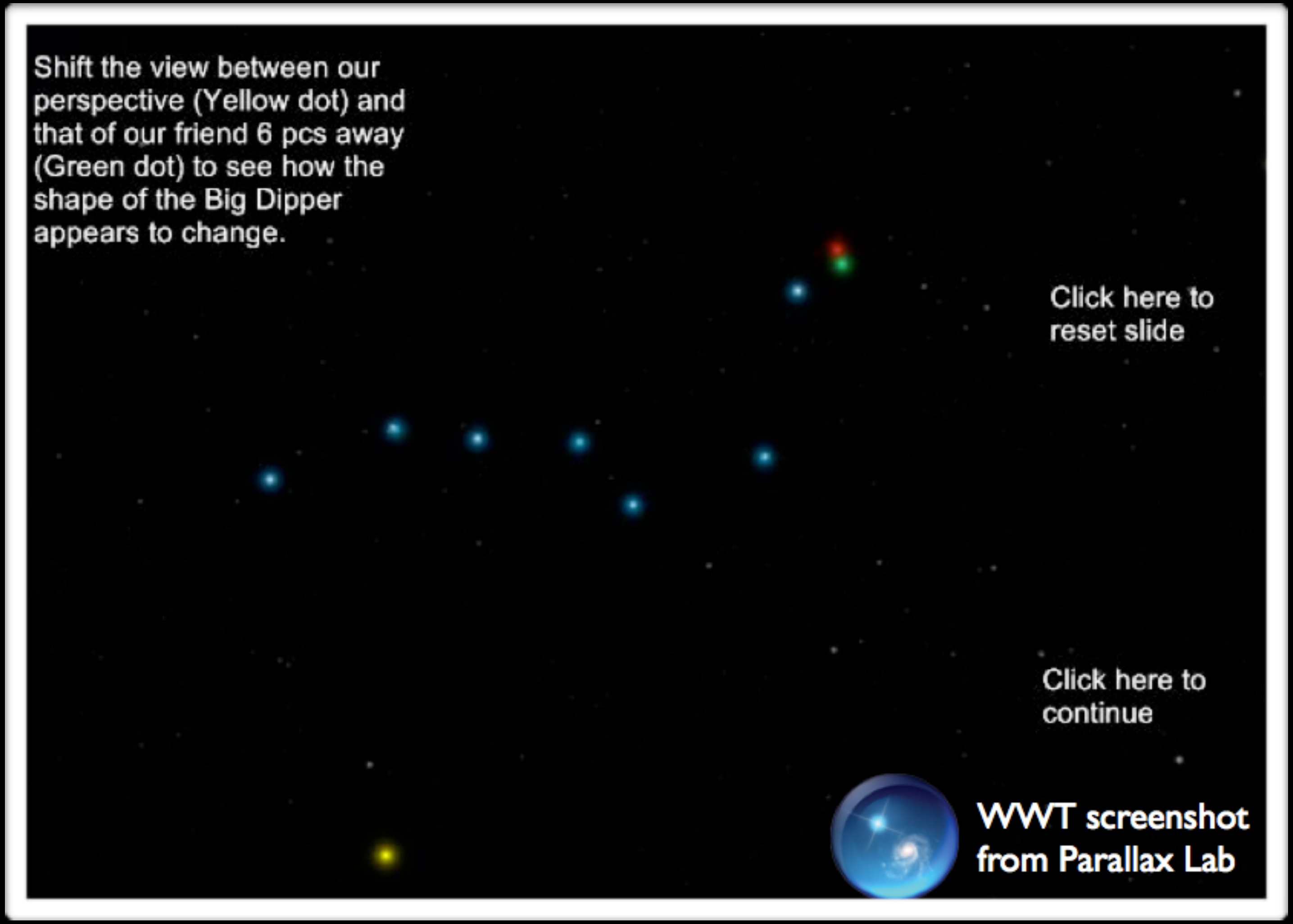

Distant Steeple
Near Lamppost


Shift the view between our perspective (Yellow dot) and that of our friend 6 pcs away (Green dot) to see how the shape of the Big Dipper appears to change.
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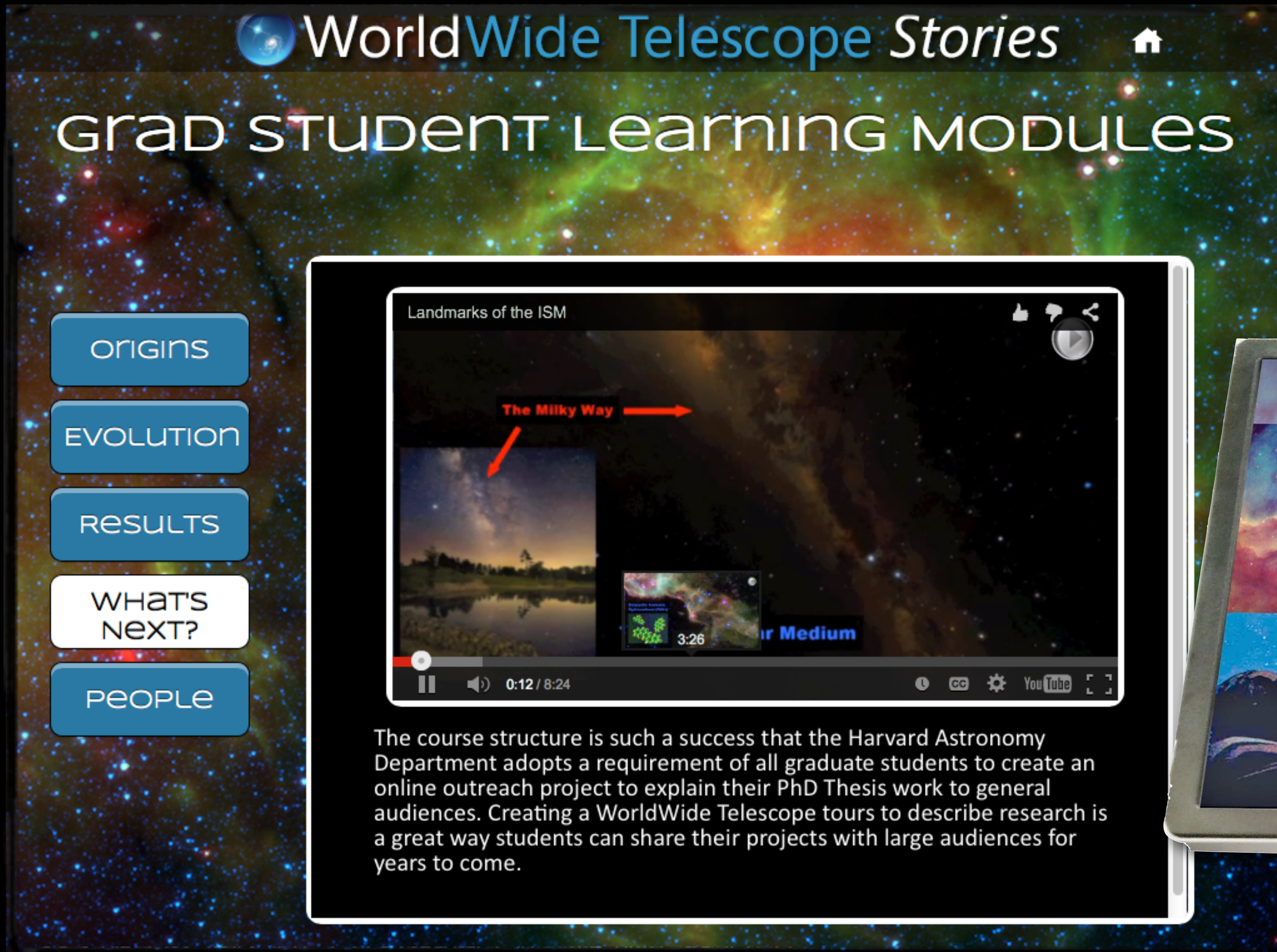
WWT screenshot from Parallax Lab



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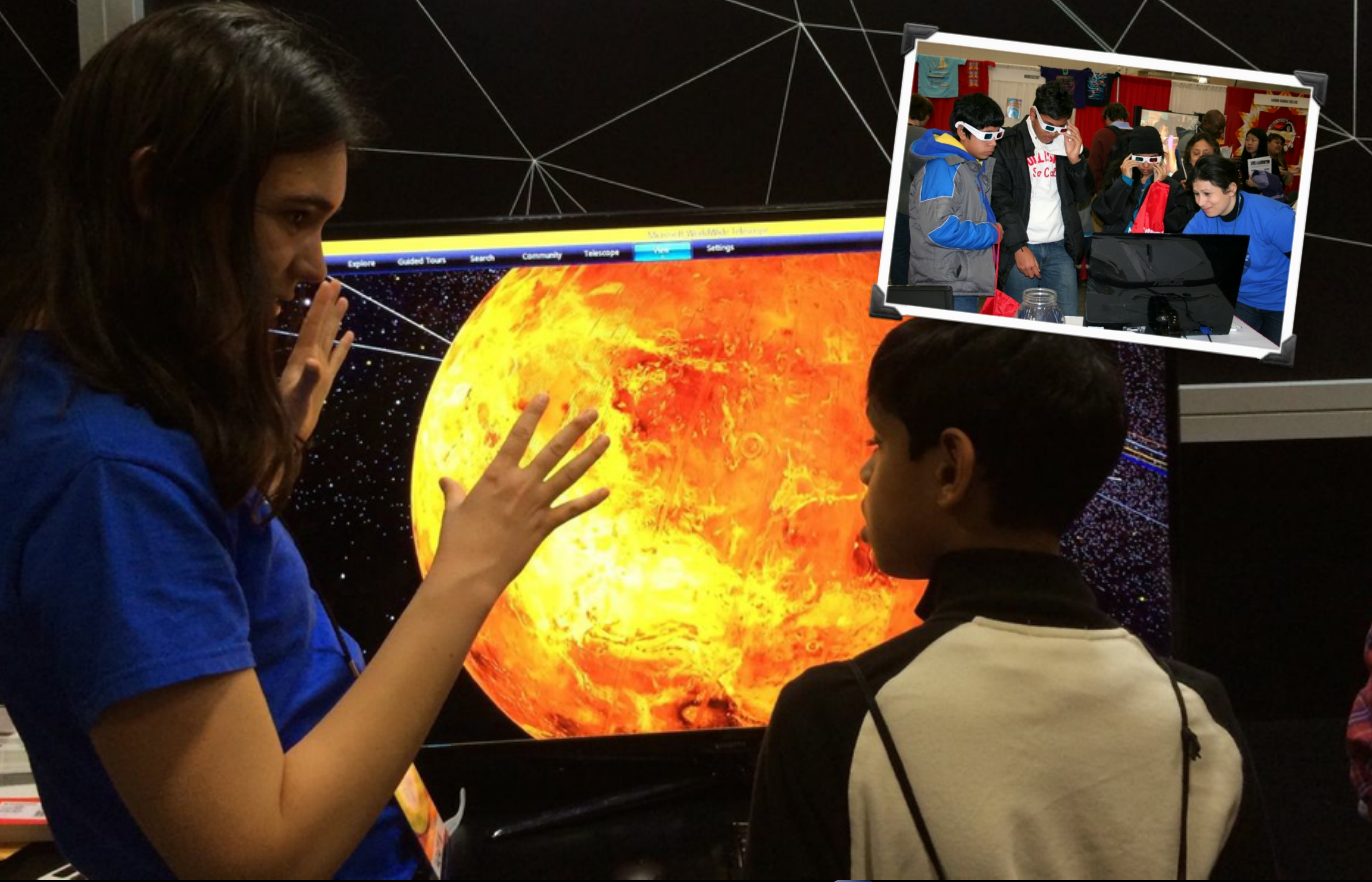

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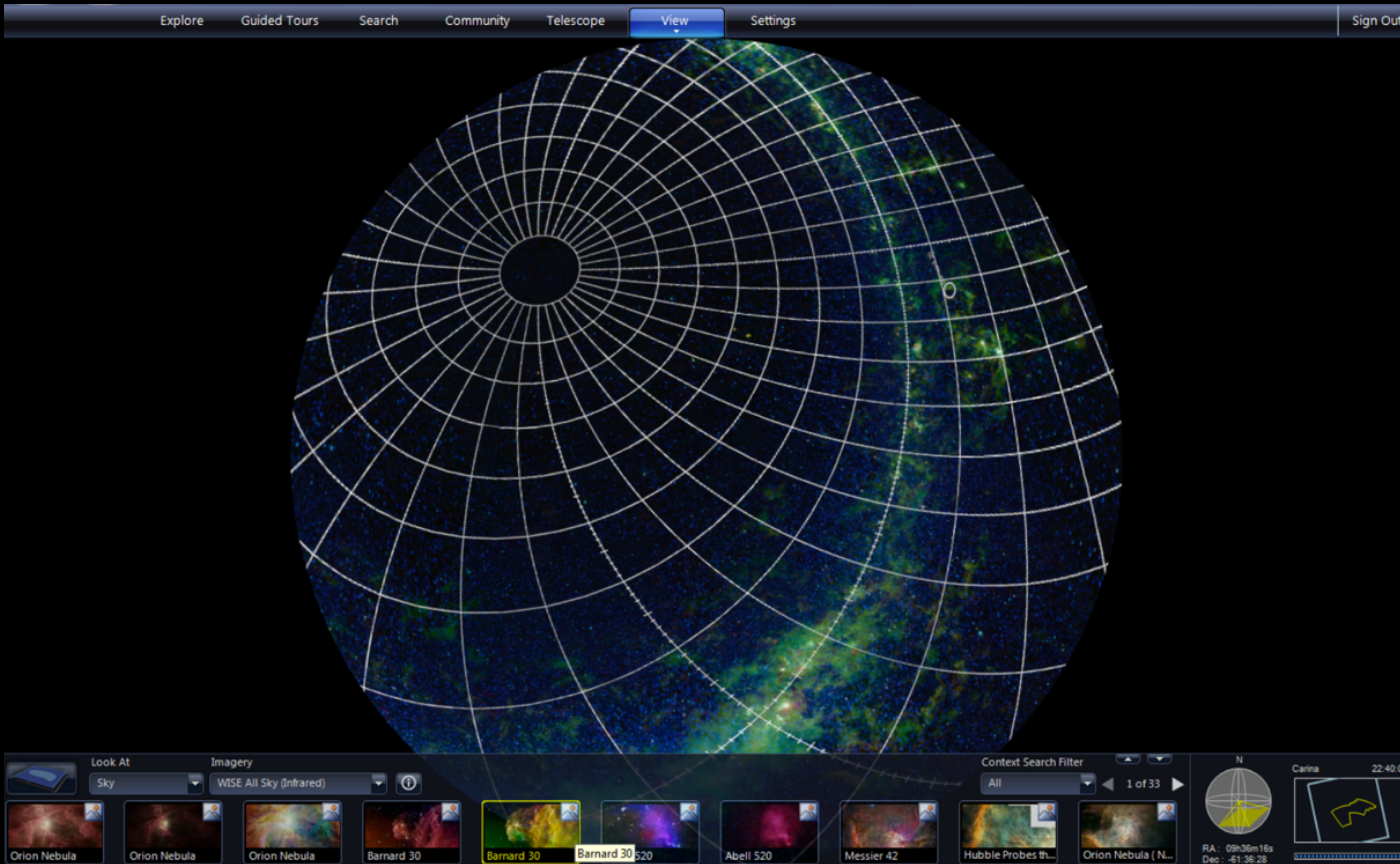

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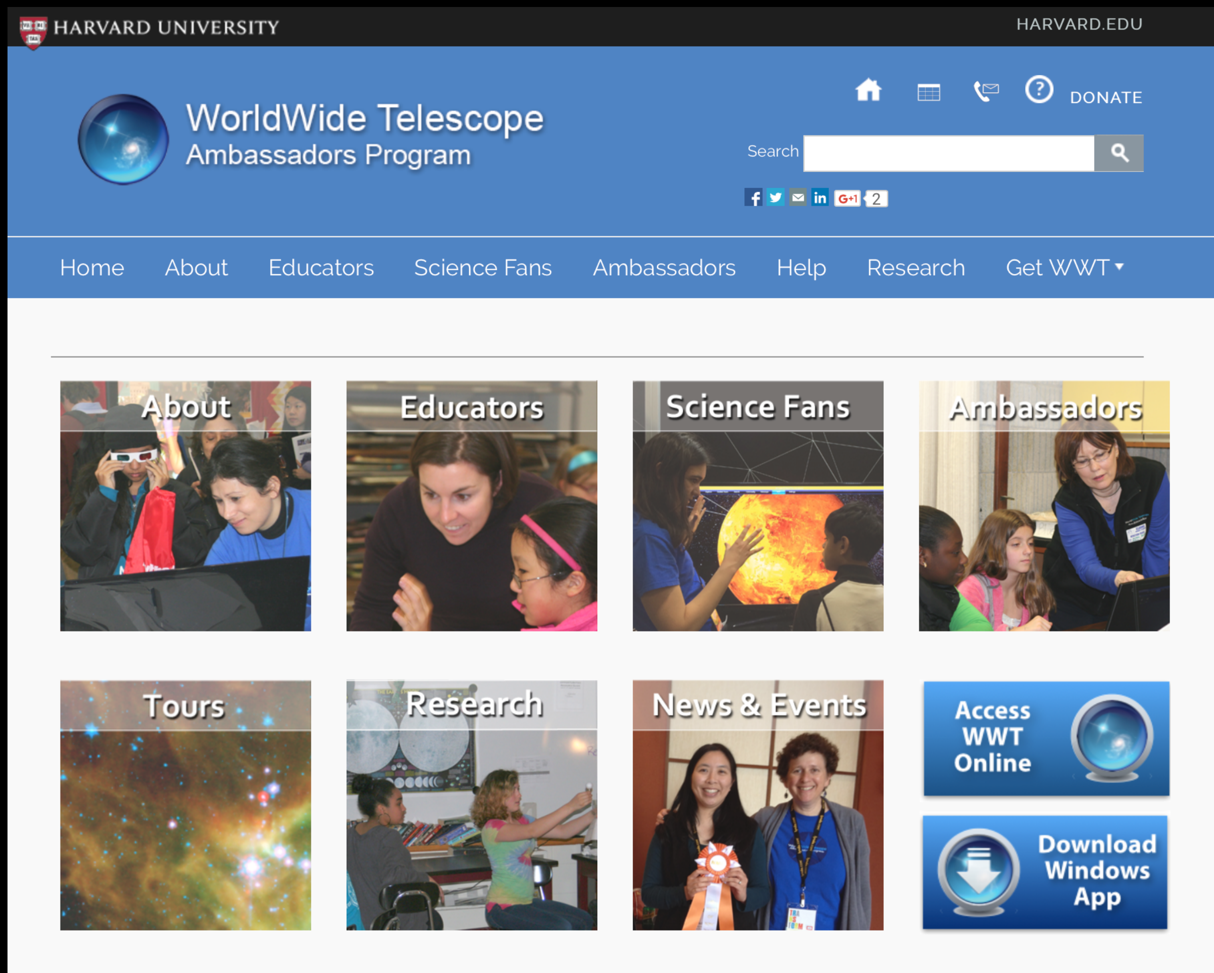

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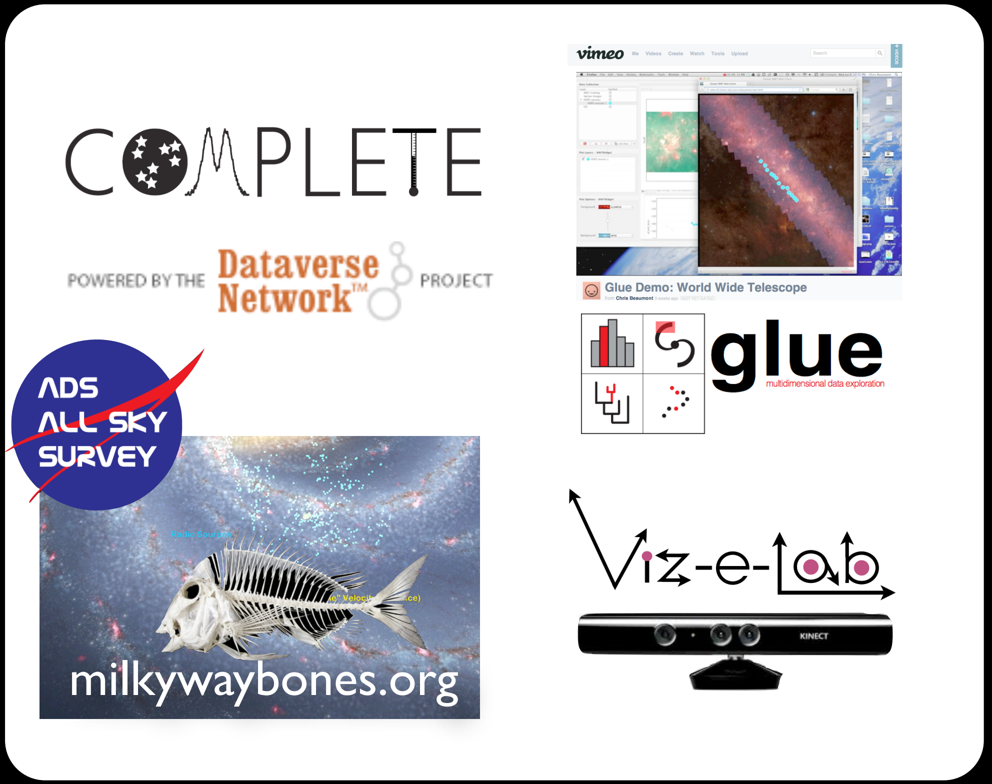

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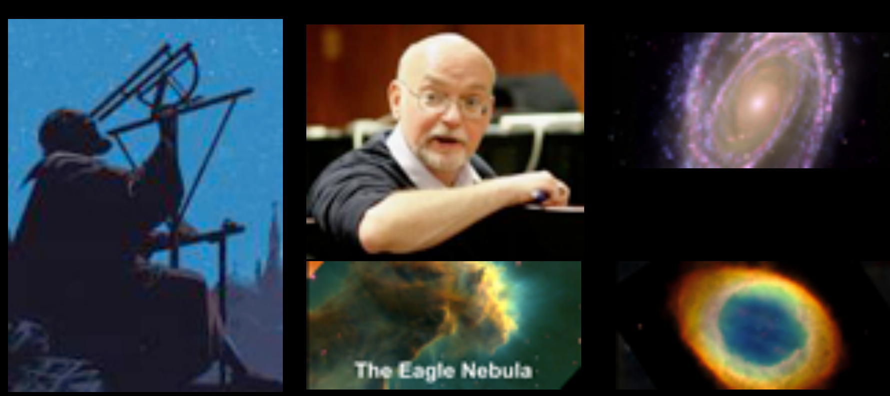

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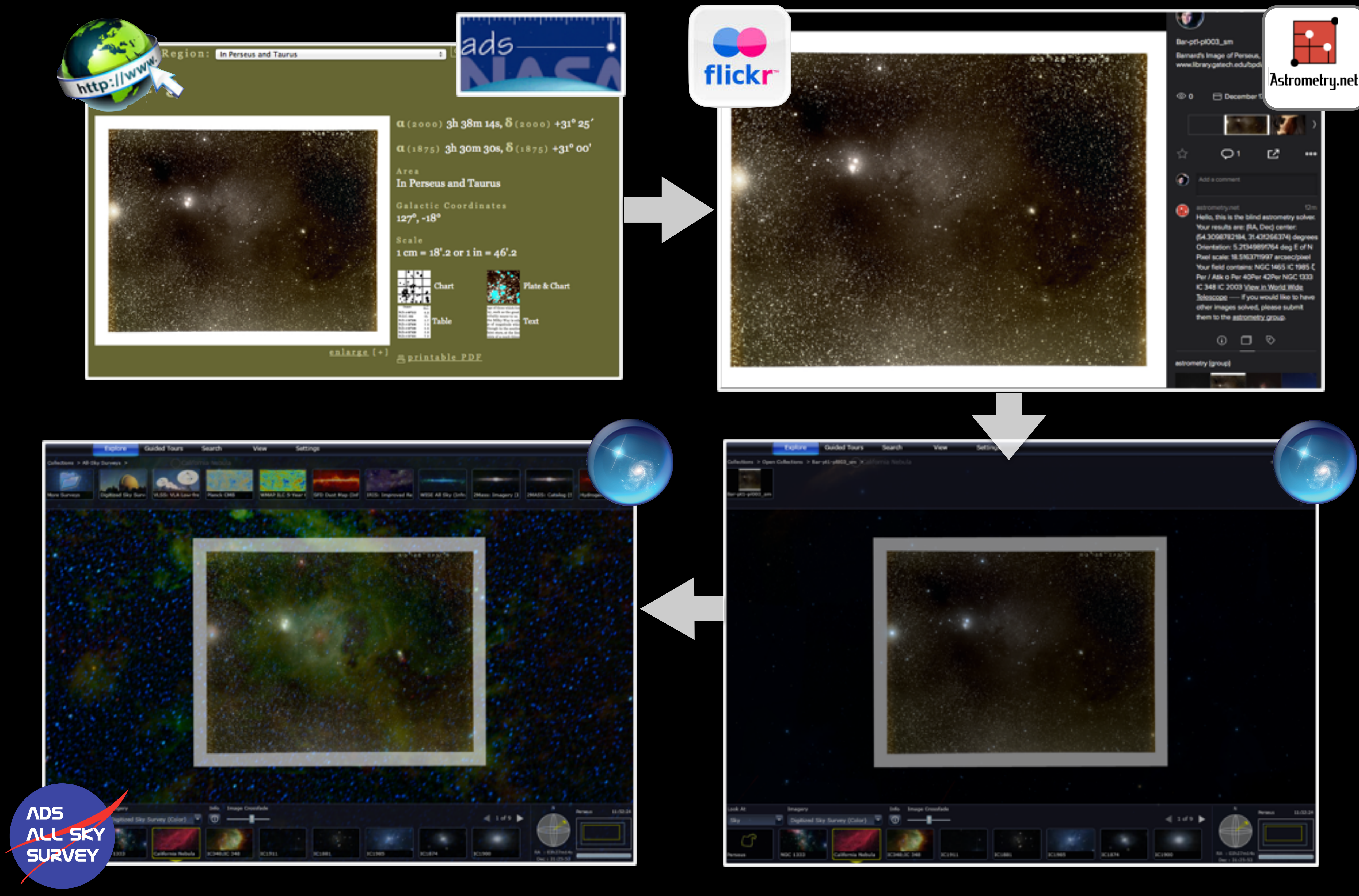

WorldWide Telescope: ADS All-Sky Survey+

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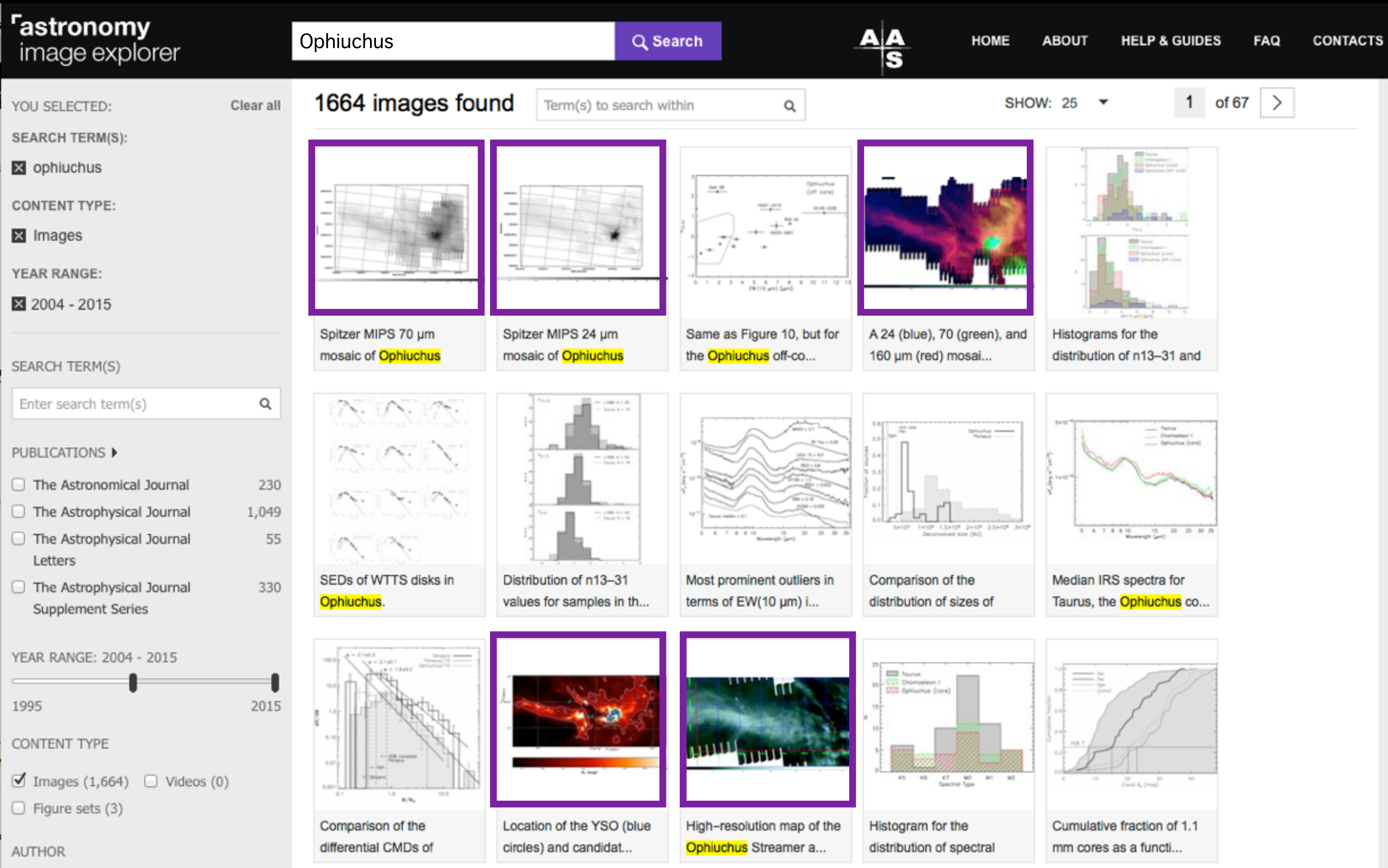

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OLD ASTRONOMY RESEARCH **CLASSIFY** EDUCATION TALK

TABLE 2
CLANS OBSERVATION SUMMARY

Target Name	Observation ID	α (J2000.0)	δ (J2000.0)	Observation Start Date	Exposure[a] (ks)
SWIRE LOCKMAN 5 (center).........	5023	10 46 00.00	+59 01 00.00	2004 Sep 12 21:30:56	67
SWIRE LOCKMAN 1	5024	10 44 46.15	+58 41 55.45	2004 Sep 16 06:53:47	65
SWIRE LOCKMAN 2	5025	10 46 39.44	+58 46 51.24	2004 Sep 17 20:30:04	70
SWIRE LOCKMAN 3	5026	10 48 32.77	+58 51 47.33	2004 Sep 18 16:17:12	69
SWIRE LOCKMAN 4	5027	10 44 06.67	+58 56 05.28	2004 Sep 20 14:40:35	67
SWIRE LOCKMAN 6	5028	10 47 53.44	+59 05 57.00	2004 Sep 23 03:36:12	71
SWIRE LOCKMAN 7	5029	10 43 27.23	+59 10 15.07	2004 Sep 24 03:43:15	71
SWIRE LOCKMAN 8	5030	10 45 20.56	+59 15 11.16	2004 Sep 25 19:47:08	66
SWIRE LOCKMAN 9	5031	10 47 13.85	+59 20 06.95	2004 Sep 26 14:47:00	65

NOTE.—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds.
[a] Total good time with dead-time correction.

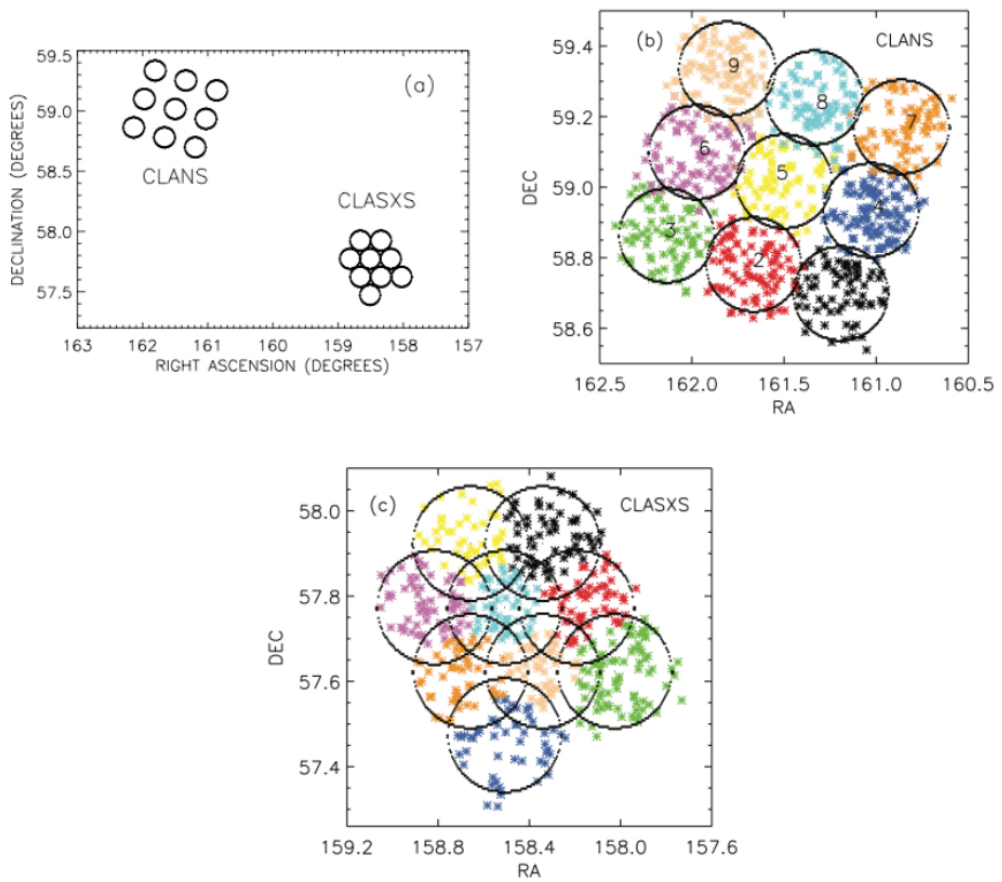

FIG. 1.—(*a*) Location of the CLANS and CLASXS pointings in the Lockman Hole. The circles delimit 5′ from the pointing centers (the area within which the sensitivity of source detection in the ACIS-I images is approximately uniform). Location of the (*b*) CLANS and (*c*) CLASXS X-ray sources are also shown. The circles delimit 8′ from the pointing centers, which is the limiting off-axis angle used in § 8 when calculating the log *N*–log *S* distributions for these fields. The numbers 1–9 in (*b*) correspond to the *Chandra*/SWIRE Lockman pointings listed in Table 2.

How many of the figures on this journal page show a photograph of the sky, a contour map of the sky, or another type of image of the sky *with the axes labeled*?

- 0
- 1
- 2
- 3
- 4
- 5+

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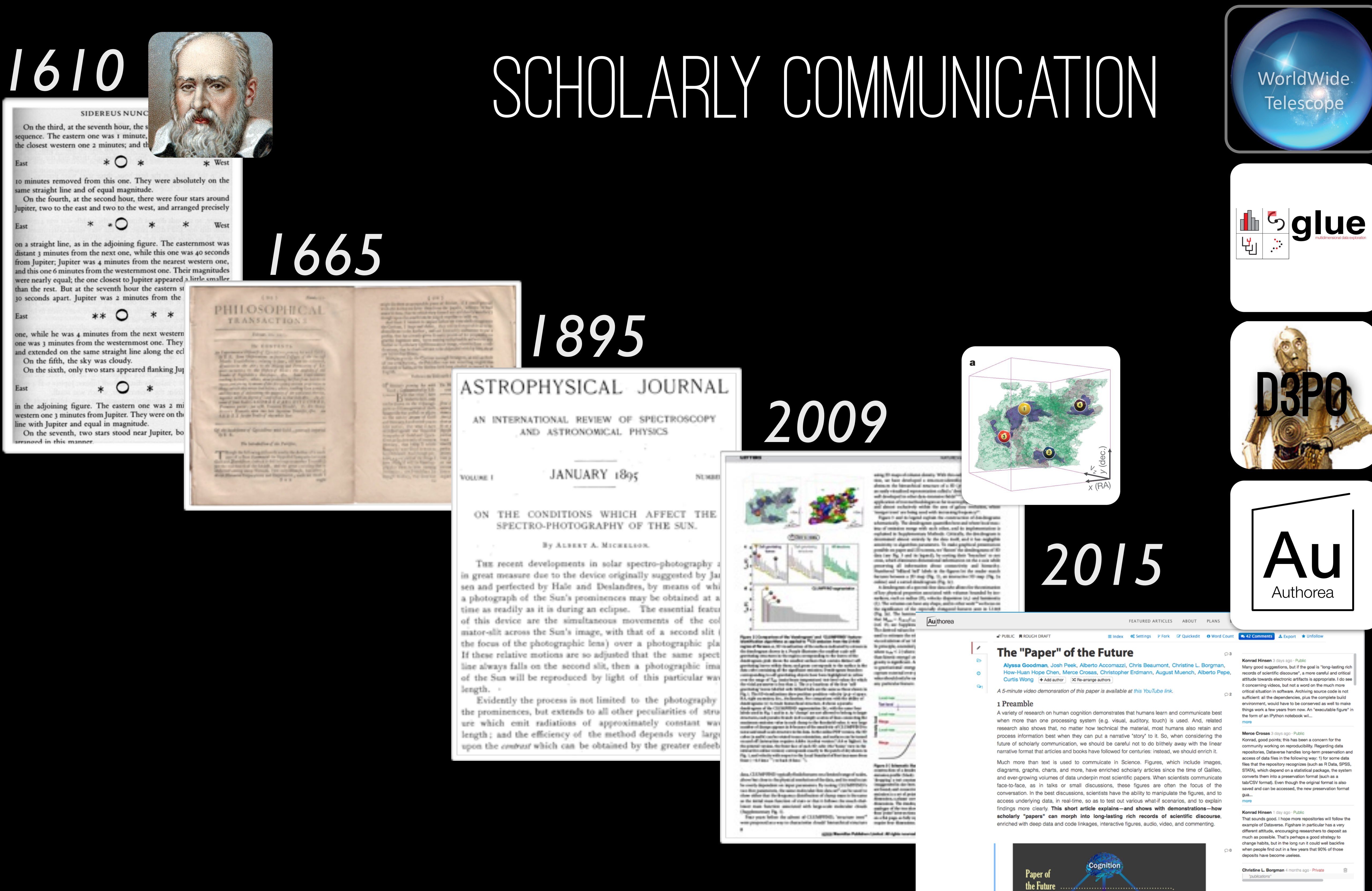
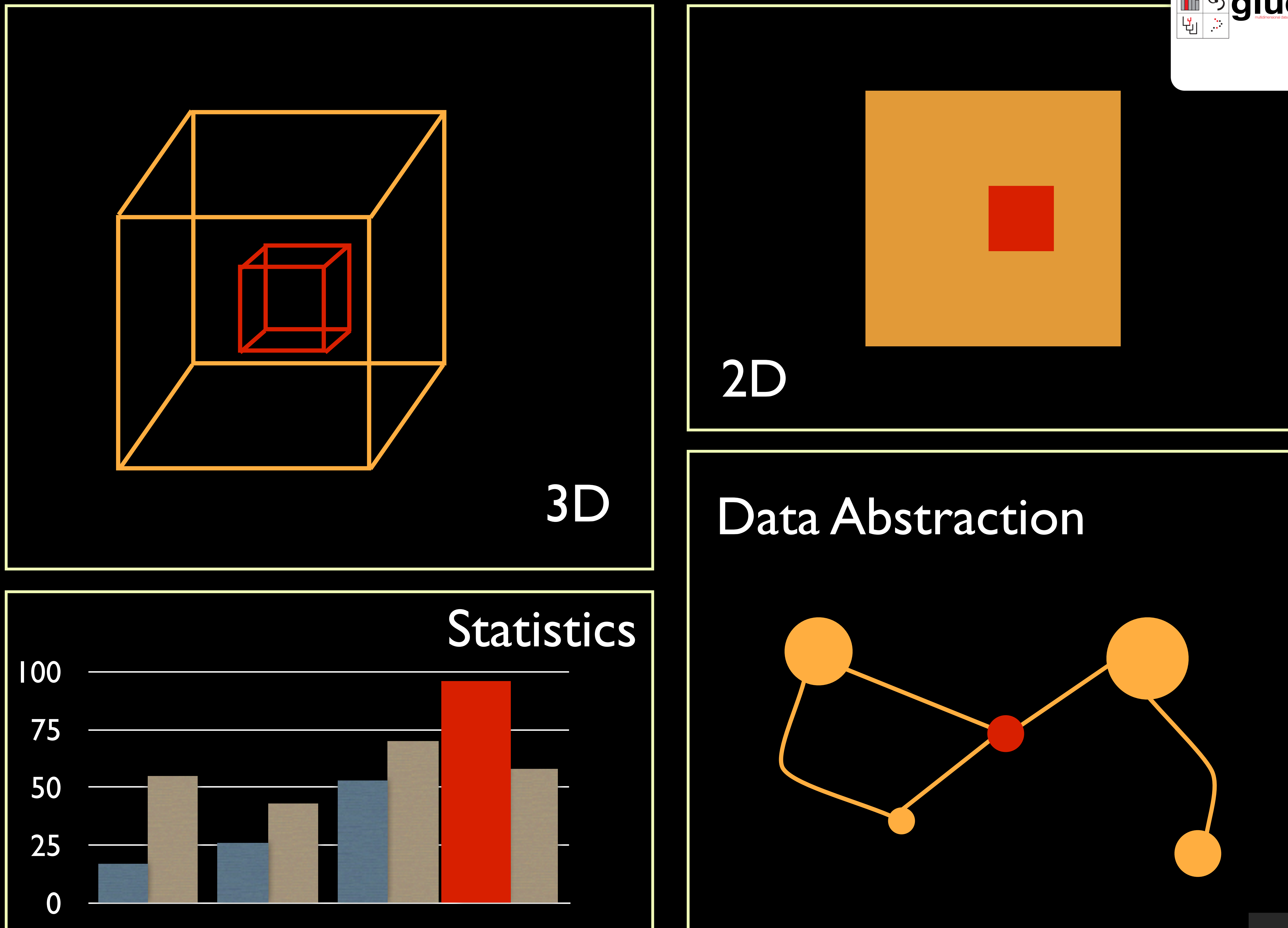


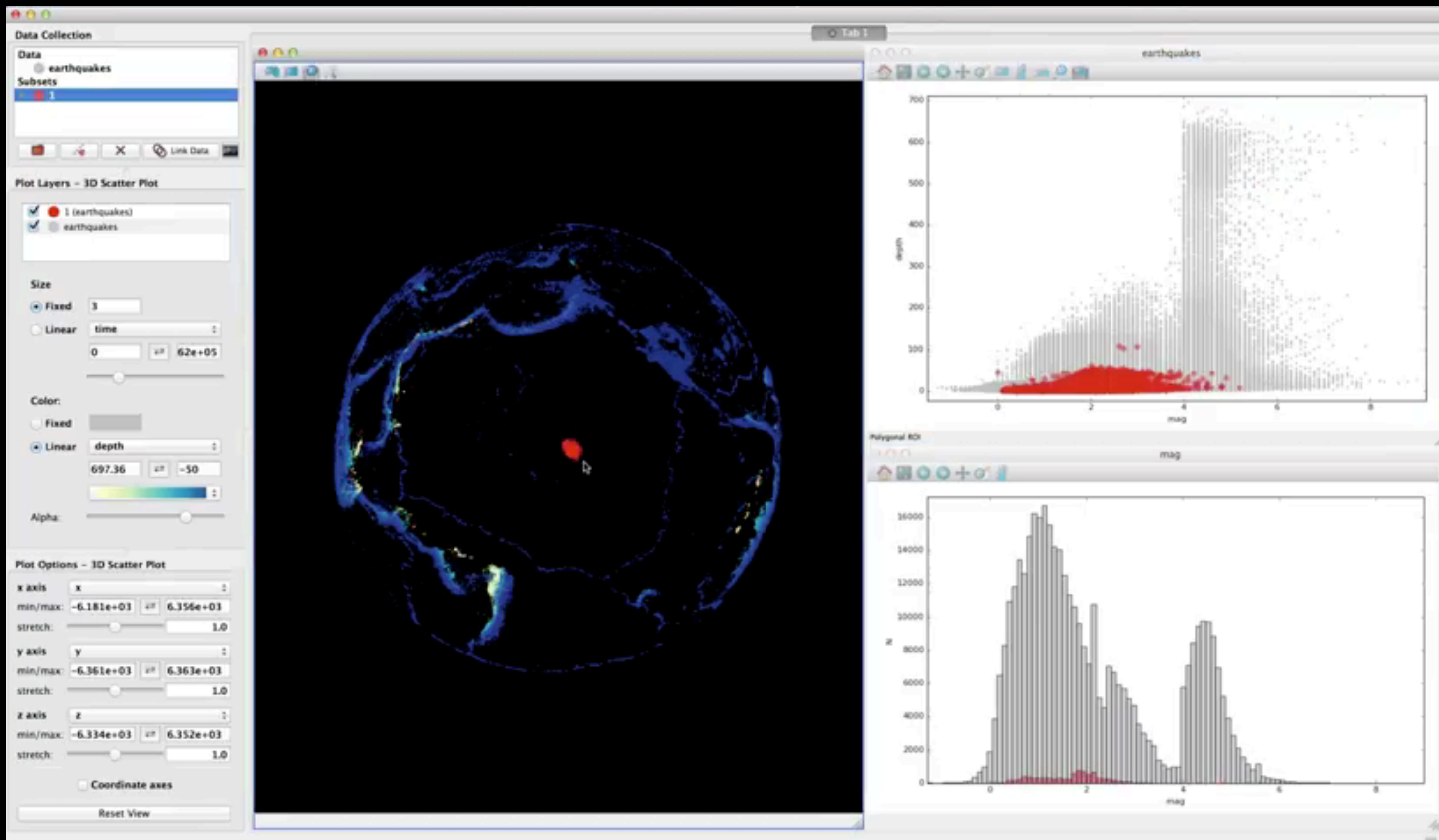
LINKED VIEWS OF HIGH-DIMENSIONAL DATA



figure, by M. Borkin, reproduced from Goodman 2012, "Principles of High-Dimensional Data Visualization in Astronomy"

LINKED VIEWS OF HIGH-DIMENSIONAL DATA (IN PYTHON)

GLUE

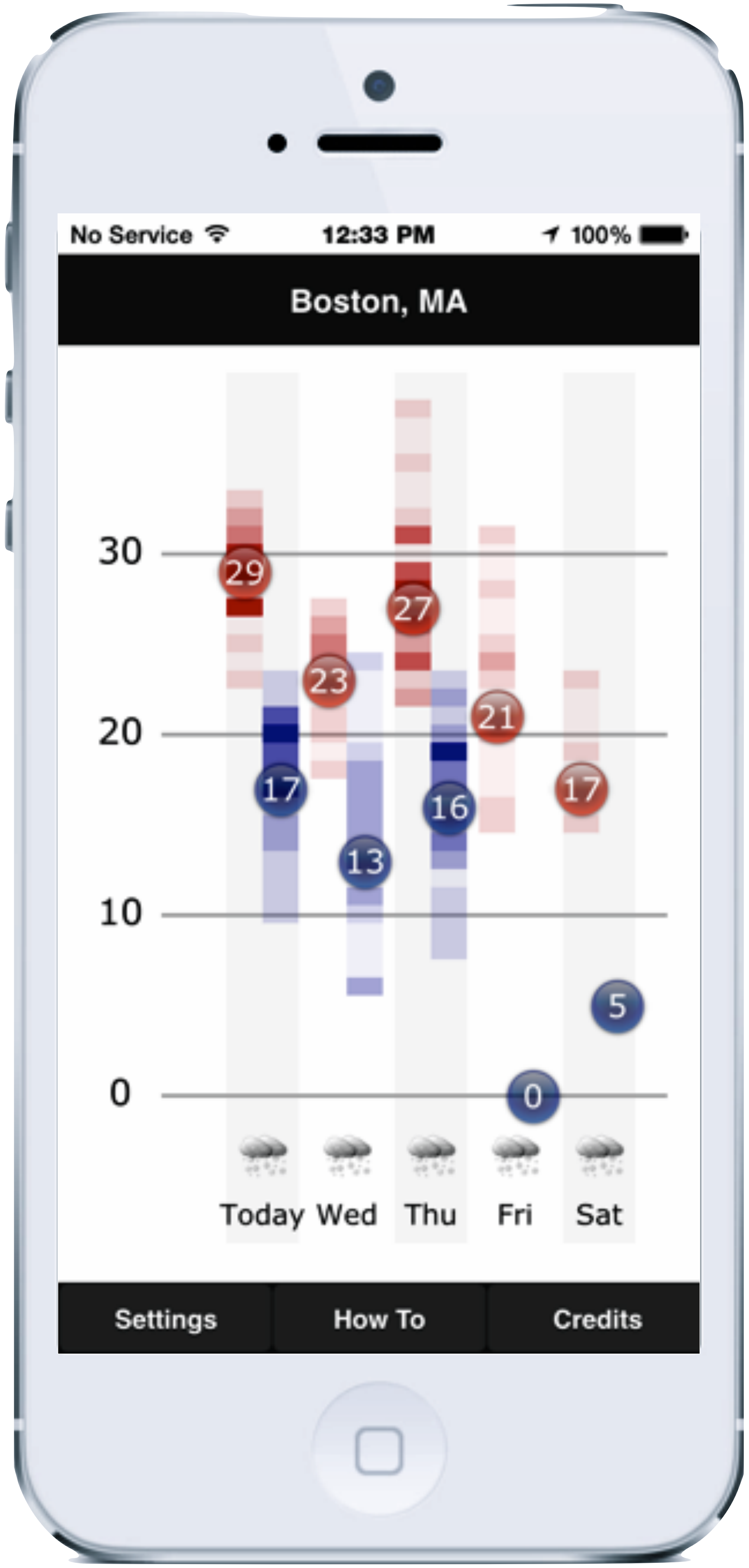


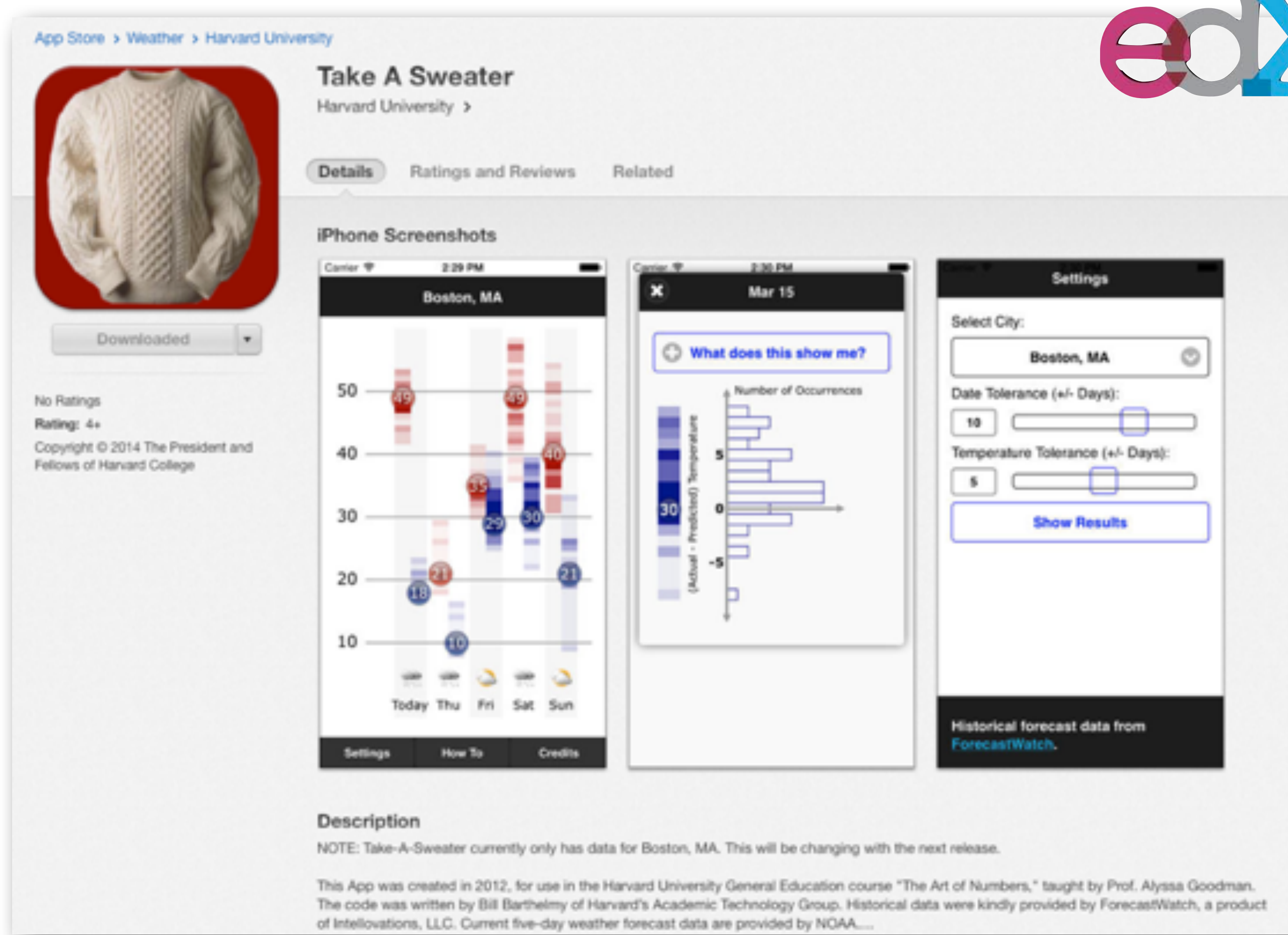
video by Tom Robitaille, lead glue developer

glue created by: C. Beaumont, M. Borkin, P. Qian, T. Robitaille, and A. Goodman, PI

What am I doing tomorrow?

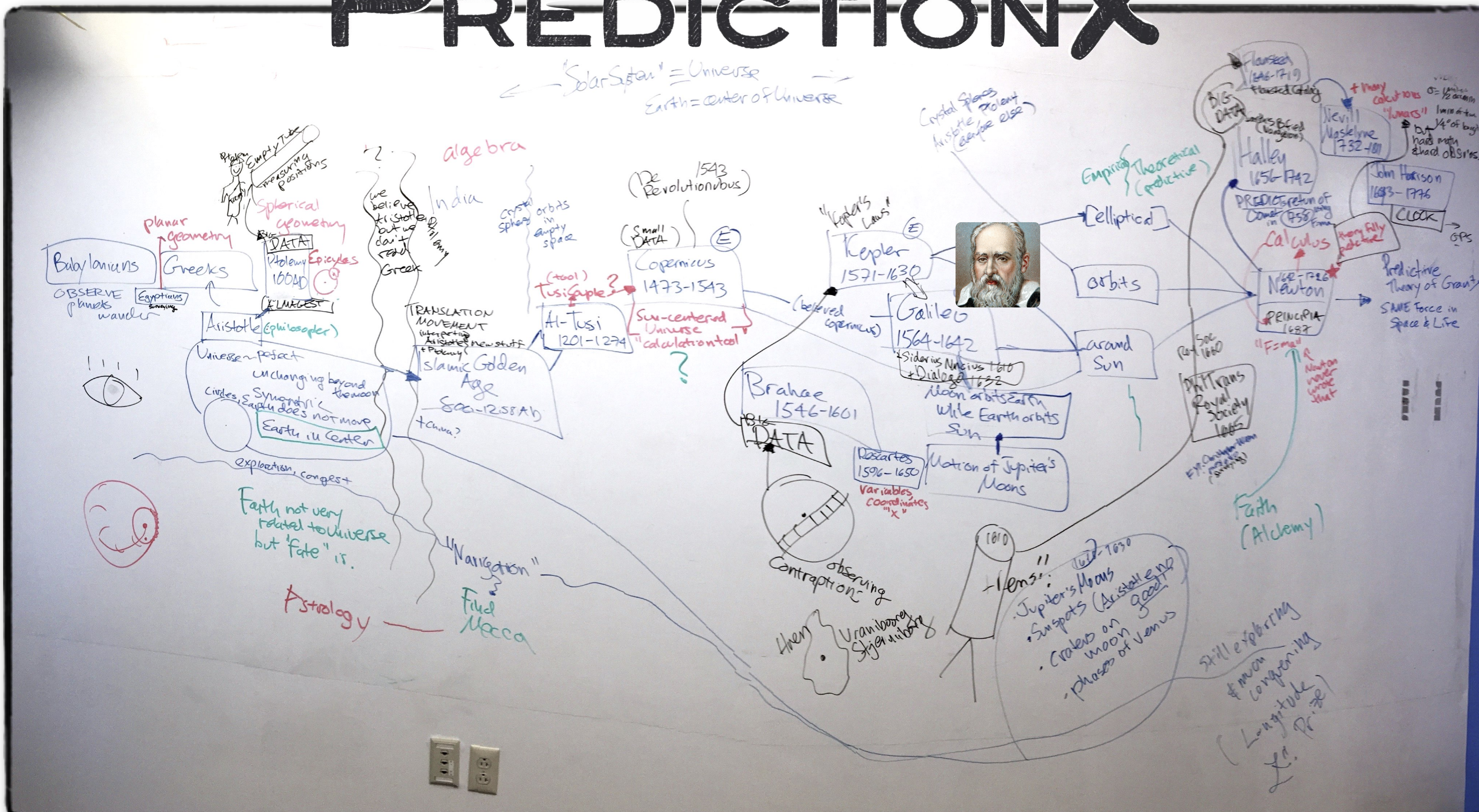
PredictionX





takeasweater.com, and "TakeASweater" in the Apple App Store

PredictionX



PREDICTIONX

Should I invite Smithsonian to our timeline collaboration?

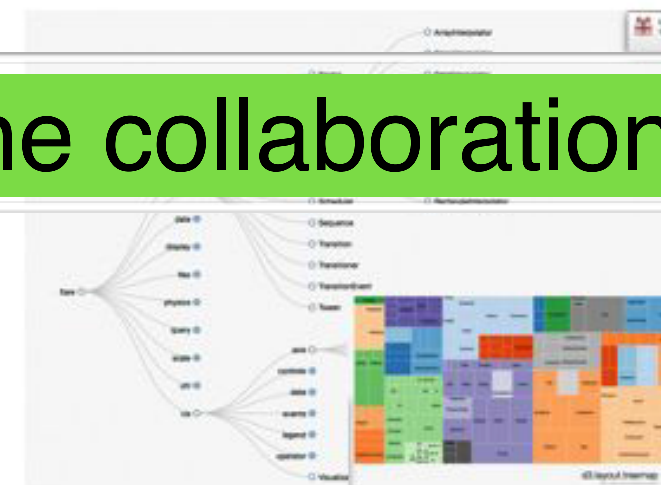
Geographic Region Picker

selected region(s) is (are) highlighted

400
500
700
800
900
1000
1100
1200

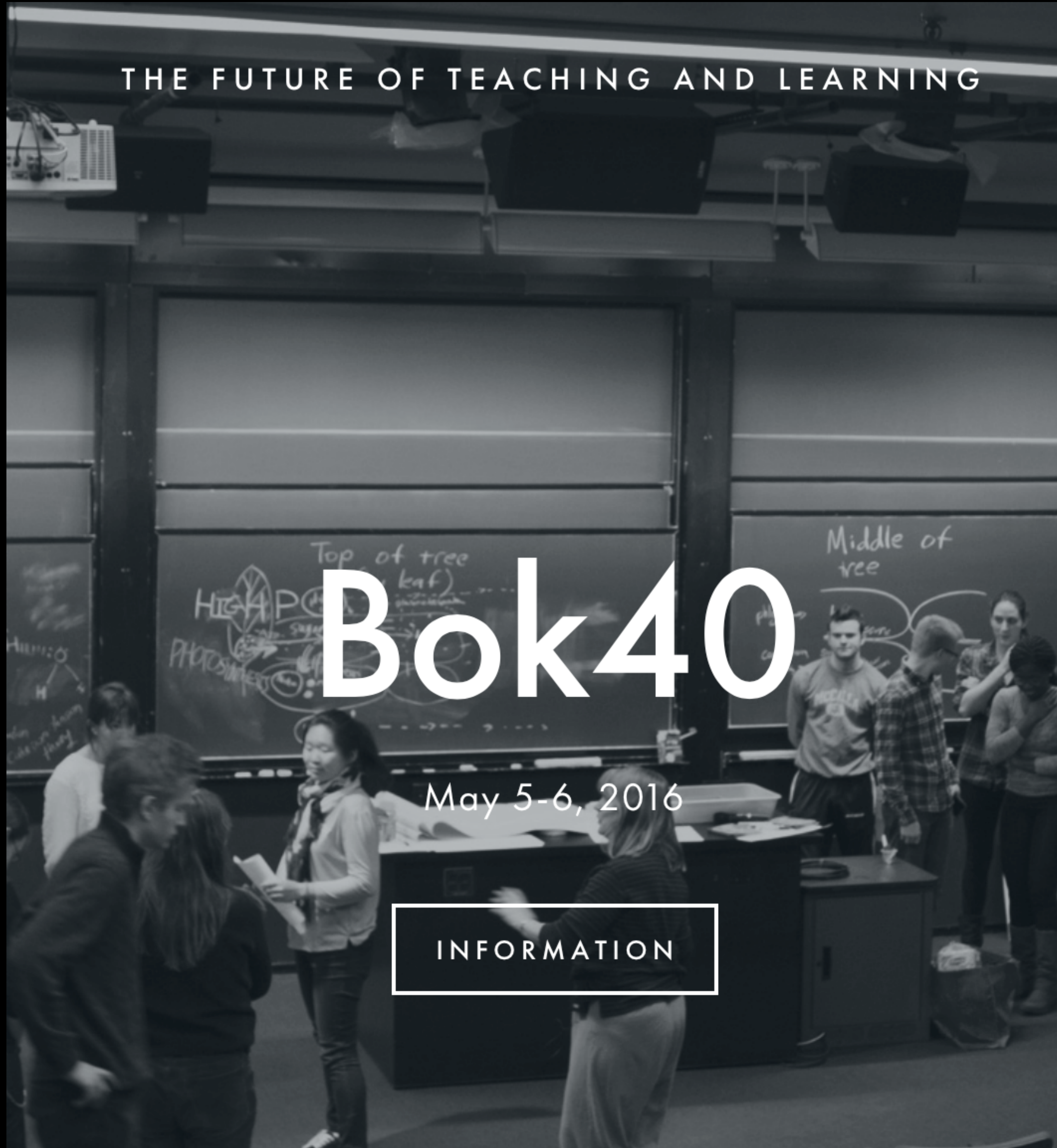
Dynamic Hyerplinked Parallel Timelines, shown as scrolling bands for (several) Region–Topic–Provider Combinations
(scroll direction is time & scale is zoomable)

Topic Picker
(interfaces could be selectable, and toggleable, options shown here are dendrogram–style or treemap)

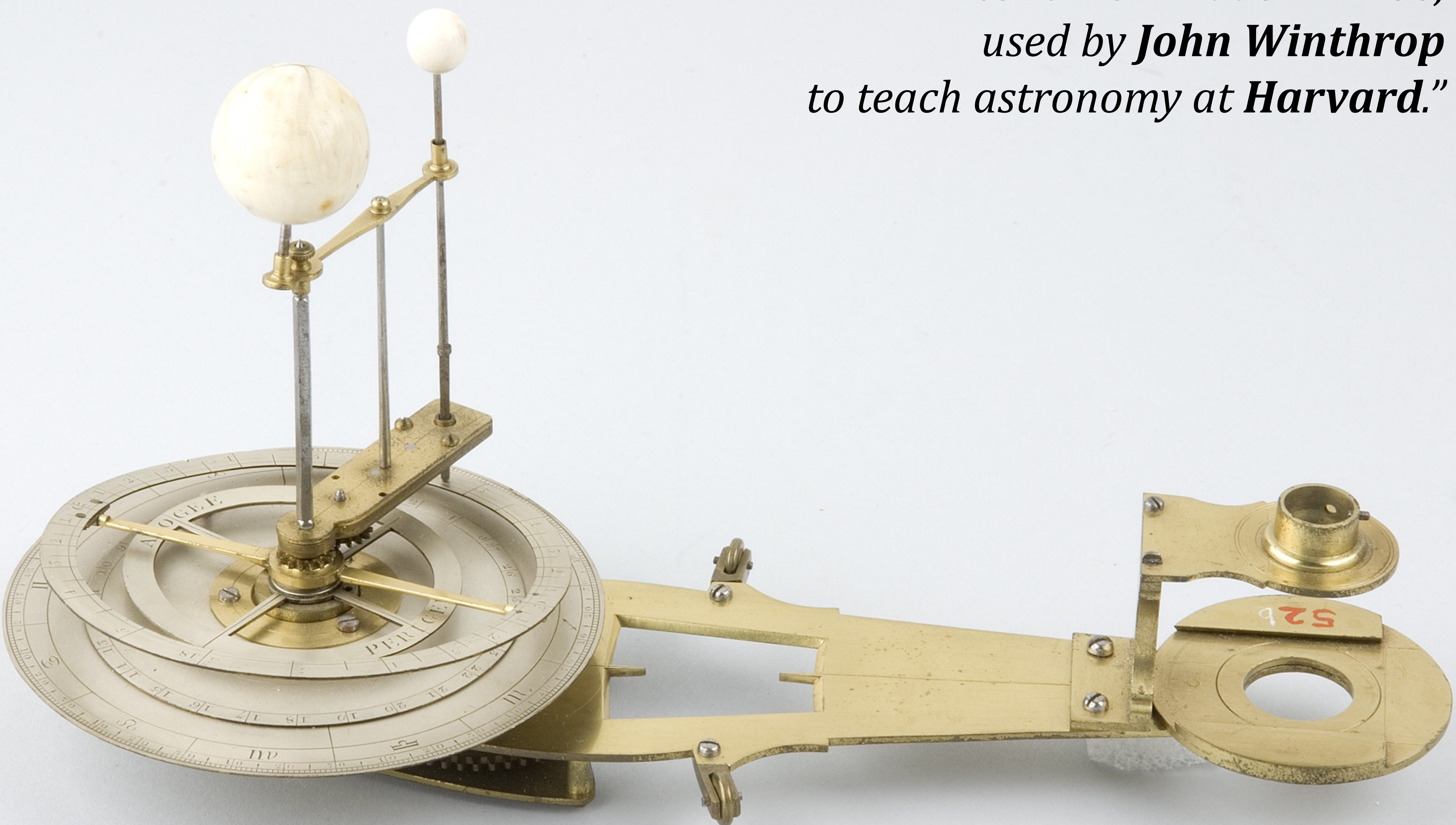


Content Providers
(in the long view, these would be any who comply with location and time metadata standards)

✓ Wikipedia
HarvardX

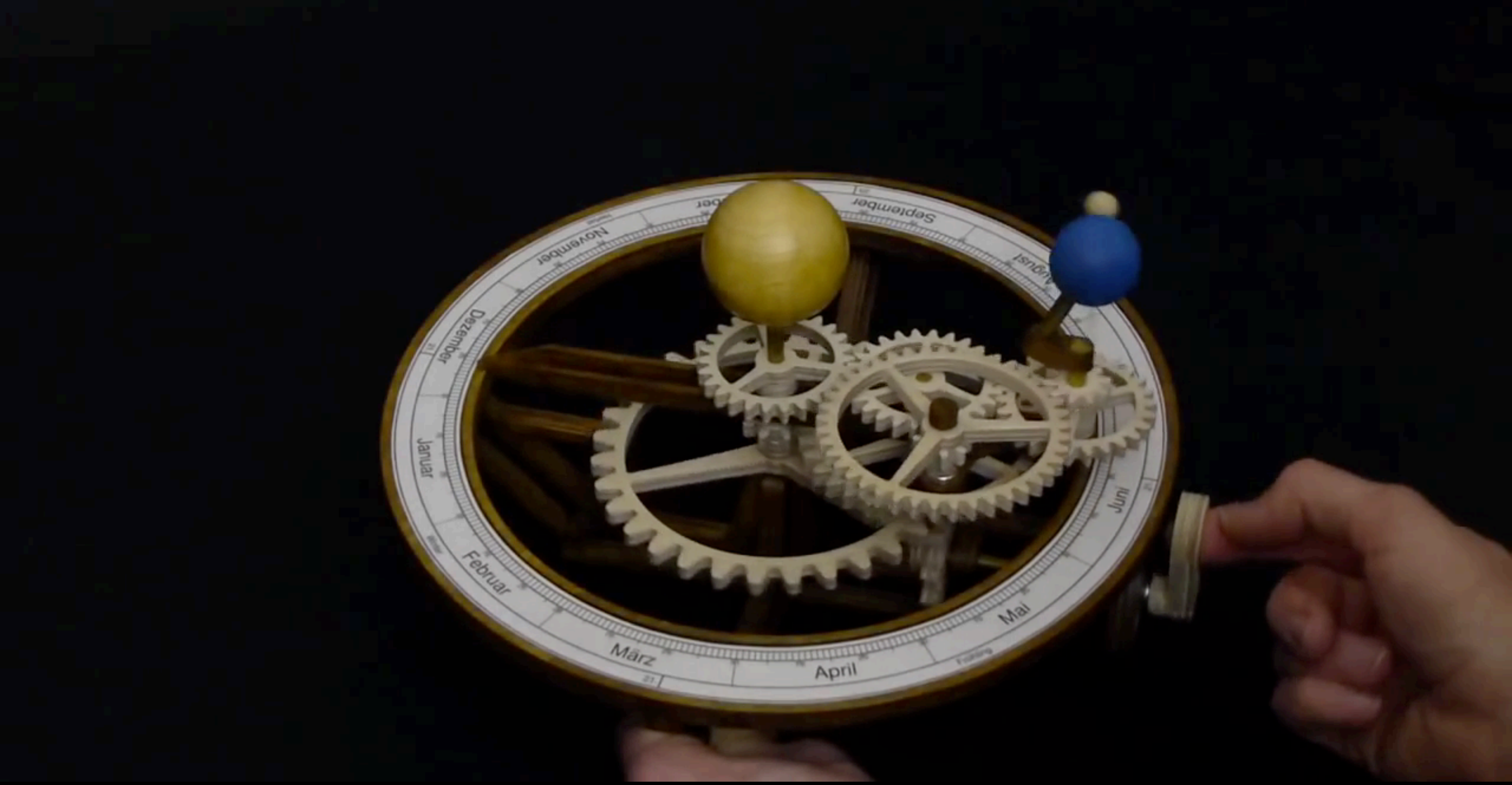

THE FUTURE OF TEACHING AND LEARNING
Bok40
May 5-6, 2016
INFORMATION

*“A **tellurion** made in 1766,*
*used by **John Winthrop***
*to teach astronomy at **Harvard**.”*

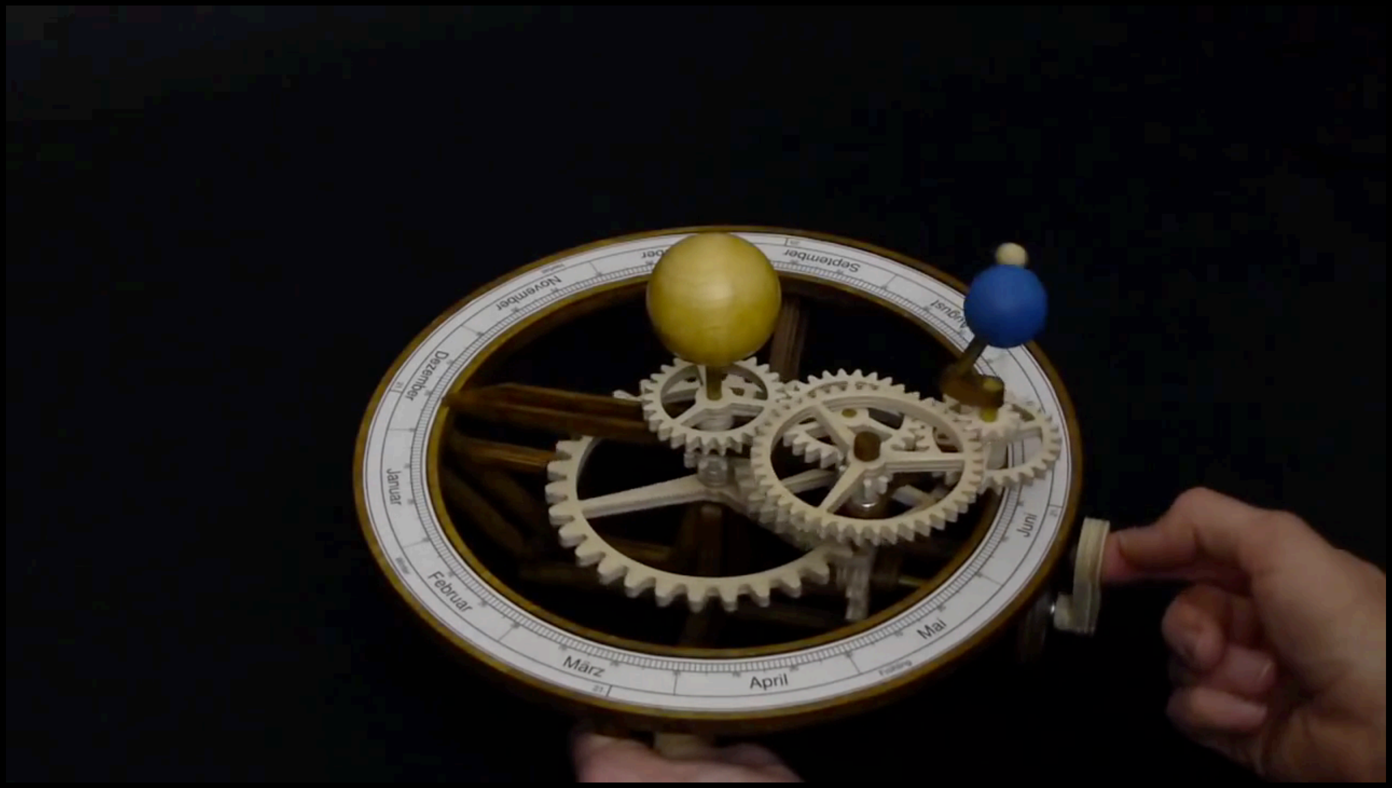


[part of the Collection of Historical Scientific Instruments in the Harvard University Science Center]

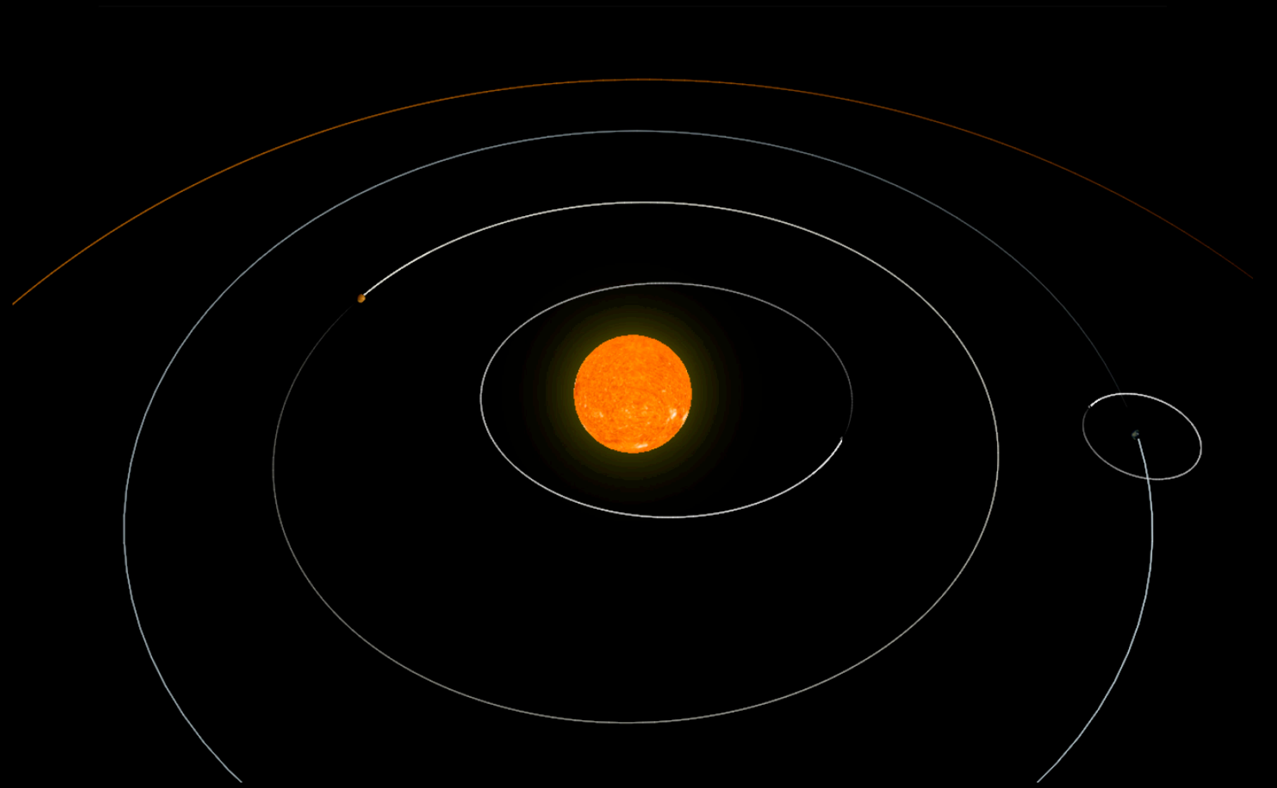
Tellurion, Holz Mechanik



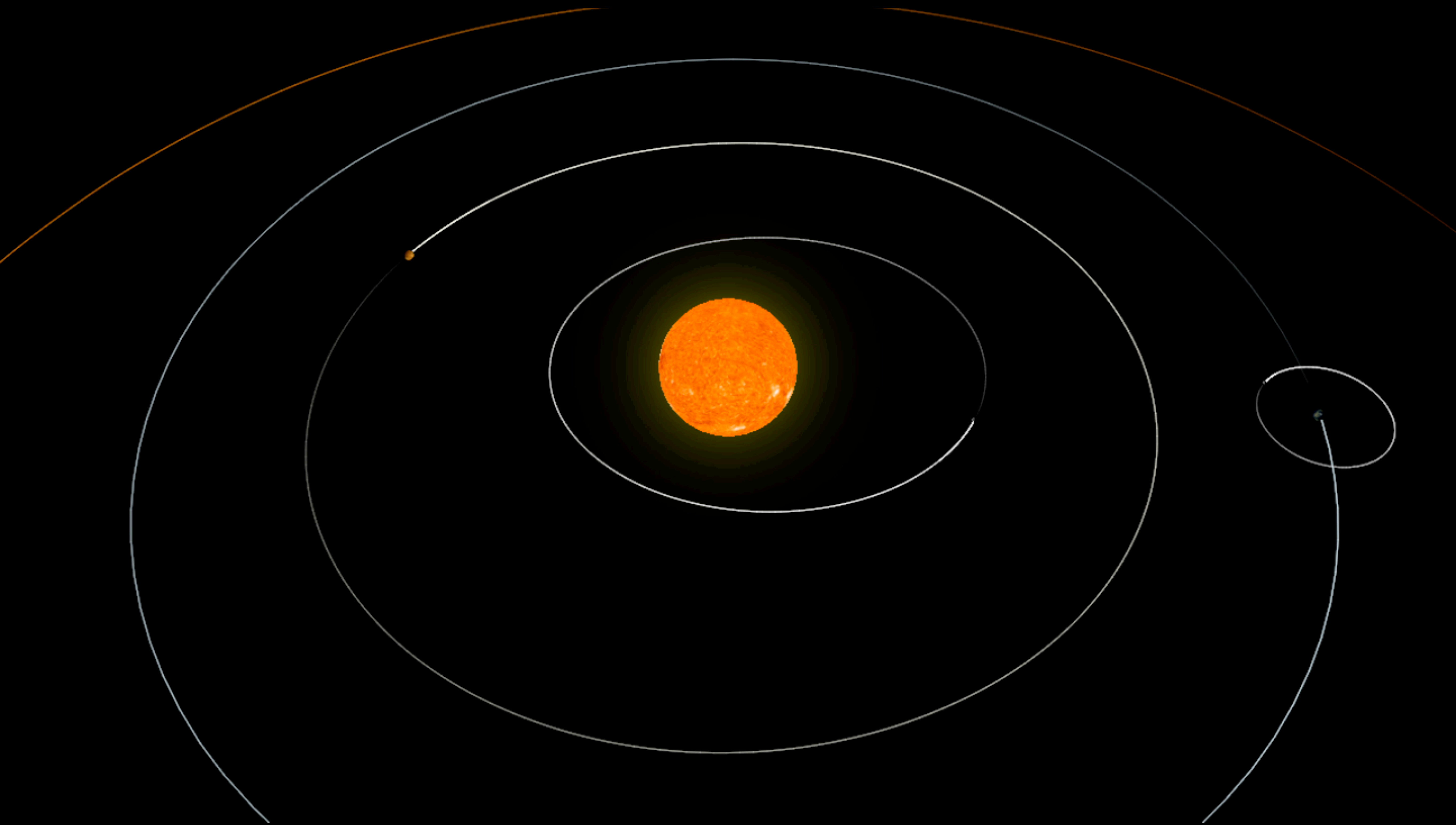
Tellurion, Holz Mechanik



WorldWide Telescope



WorldWide Telescope



How to Mix "Design"

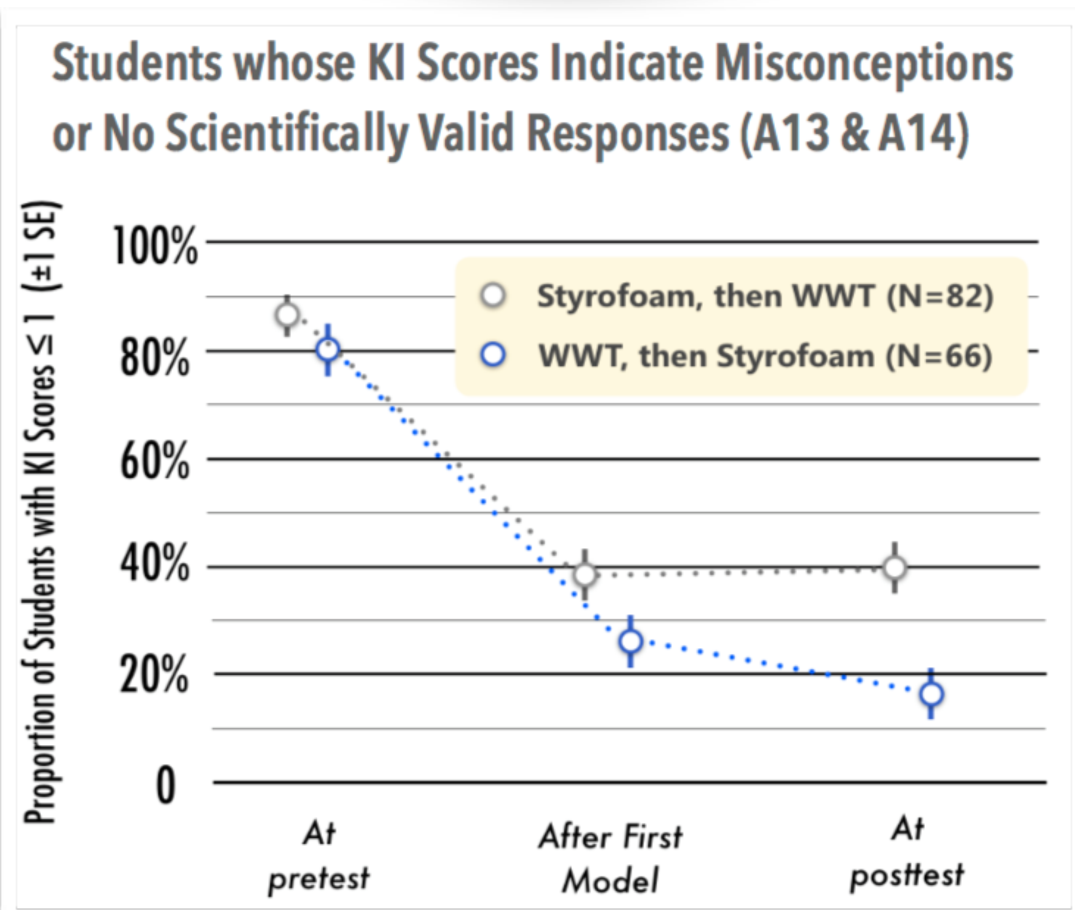
Sample Student Drawing

Sample Student Response

We see a half Moon on this day because:

(Pre) *"The earth is blocking part of the moon from the sun and it casts a shadow on the moon, making half of it dark."*

(Post) *"We are seeing 1/2 of the lit up part of the moon. If a line is drawn on the moon to show our perspective, we see half of the light of the moon."*

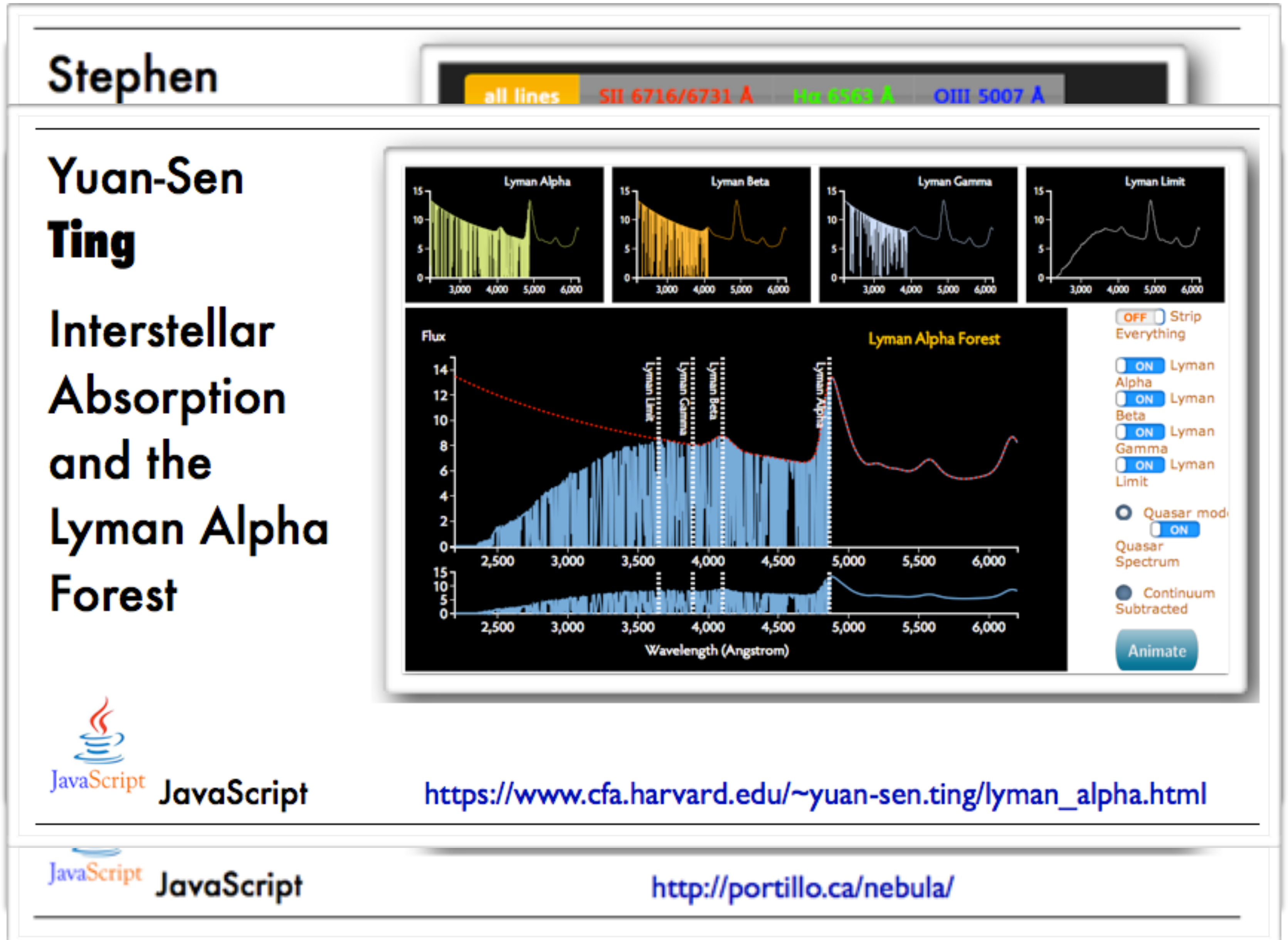


Model Preference	Proportion of Students with that Preference (All Phase 2, N=294)
Models helped equally	37% ± 3%
Computer helped more	**40% ± 3%**
Styrofoam helped more	13% ± 2%

excerpts from the work of Udomprasert et al. as part of the WWT Ambassadors Program

How to Mix "Design"

peer instruction



online learning

virtual environments

see: A New Approach to Developing Interactive Software Modules through Graduate Education, Sanders, Faesi & Goodman 2013