

From dusty emus to dark energy (and back)

[the evolving visualisation of our universe]

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SWINBURNE
UNIVERSITY OF
TECHNOLOGY



I'll explain how this talk will occur. I decided against Skype-ing in from Australia for various reasons. I have gone with a set of slides- that I hope you have - and I am including some audio/screencast files. Each audio file will match a section of the slides.

This presentation is based on an Introduction to a textbook I am writing on the formation and evolution of cosmic structure. The Introduction gives an overview of how we have visualised and conceptualised our increasing knowledge of the skies. The Introduction is still a work in progress and I expect that as I make this presentation I will be able to improve it further. (Nothing beats speaking out loud your written words to ensure it all makes sense!)

So I will speak to the slides and if you have a laptop you can follow.

Glen.

Outline of Talk

Screencast1 (Intro)

Screencast2

1. Pattern recognition – from humans to machines
2. Palaeolithic examples
3. Of stone and rock ... and dusty emus
4. First star maps
5. From 2D to 3D
6. Lowell and Mars
7. Mysterious nebulae

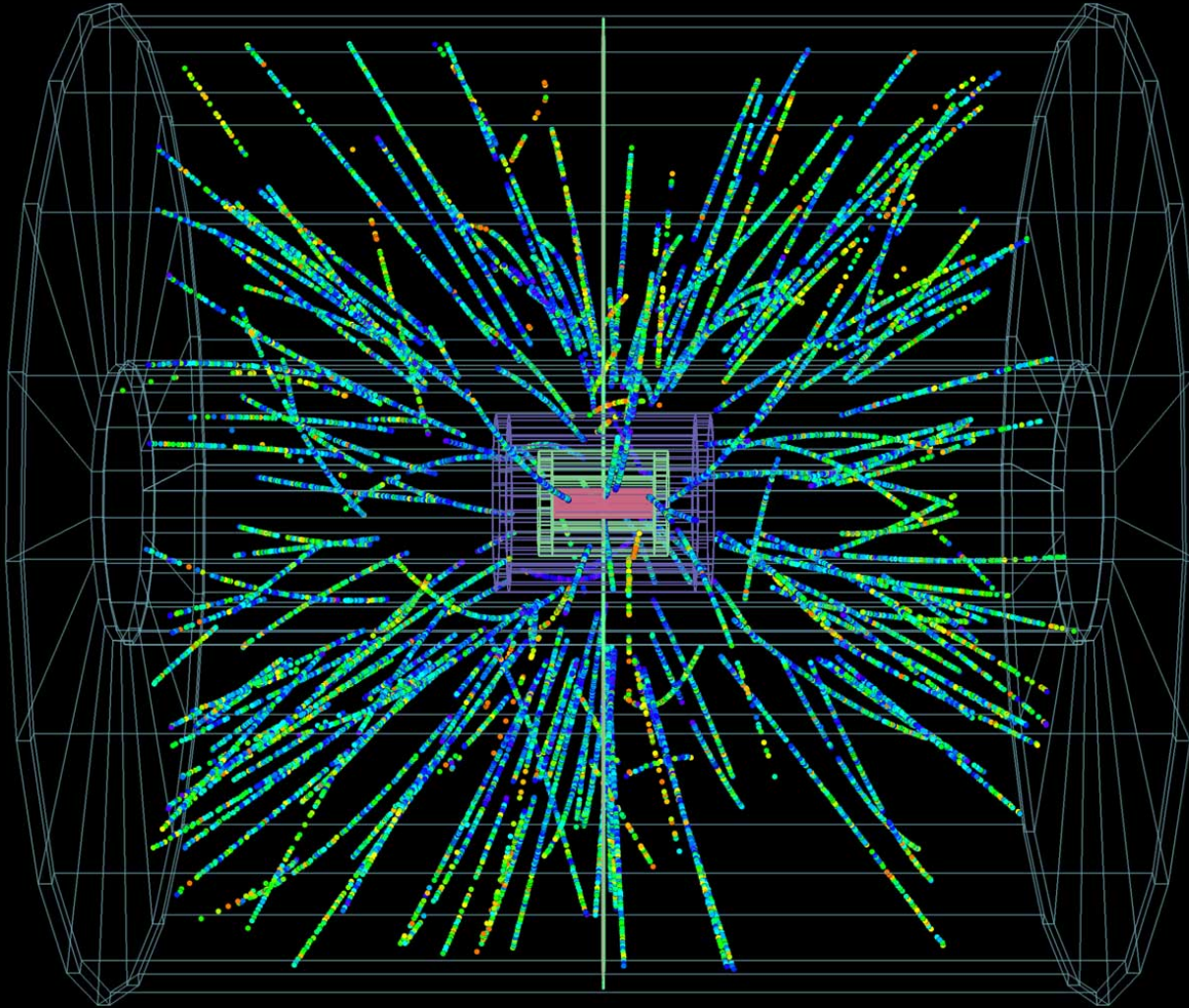
Screencast3

8. Streams, planes and how galaxies form?
9. The CfA 'stick-man' and the reality of filaments
10. Citizen science and classification bias
11. Baryonic Acoustic Oscillations – favoured separation
12. The Cosmological Principle and U1.27
13. State of astronomy visualisation

Screencast4

14. Willem de Sitter , dark energy and emu dust

1. Pattern recognition – from humans to machines



2. Palaeolithic examples



Panel of the Lions – Chauvet-Pont-d'Arc Cave, France
~30-32,000 BP

Lascaux Cave, France
~10-15,000 BP



M45, The Pleiades

<http://www.ancient-wisdom.co.uk>

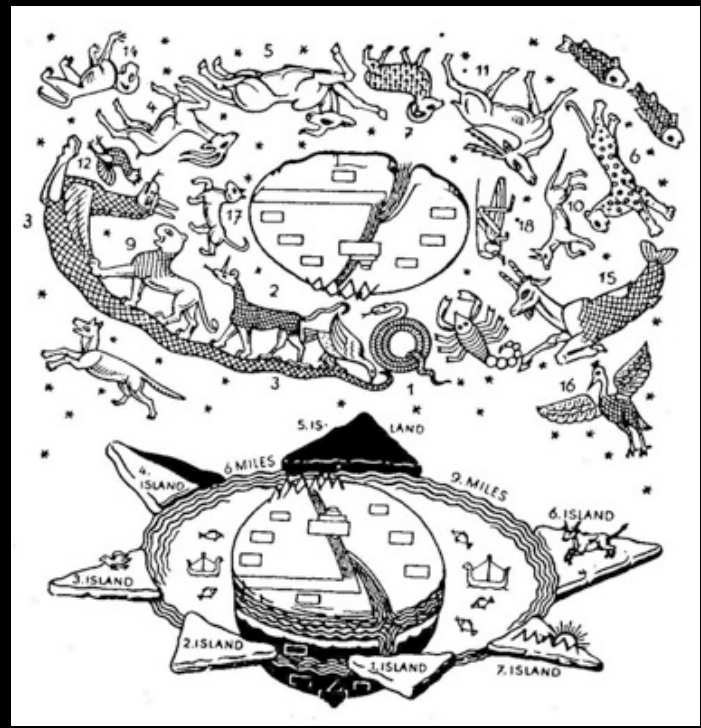
3. Of stone and rock ... and dusty emus

Babylonian clay tablet with cuneiform (~2600 BP) ...

... contains descriptive text (only) of the Heavenly Ocean and its animal constellations



British Museum





Stonehenge (1st phase 5200 BP)
Wiltshire, UK

Credit: *Max Alexander/STFC/SPL*

Credit: GM

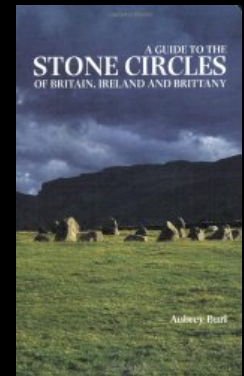


Avebury, Wiltshire, UK (4800 BP)

Credit: GM



Ring of Brodgar, Orkney, Scotland (4700 BP)



A. Burl, 1995

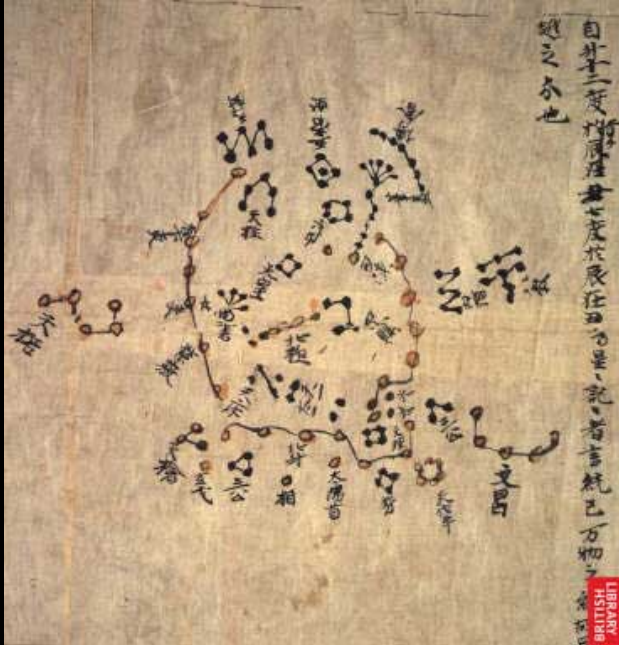
<http://www.megalithic.co.uk>



Ku-ring-gai Chase National Park, NSW, Australia ~5000 BP

Credit: Barnaby Norris

4. First star maps



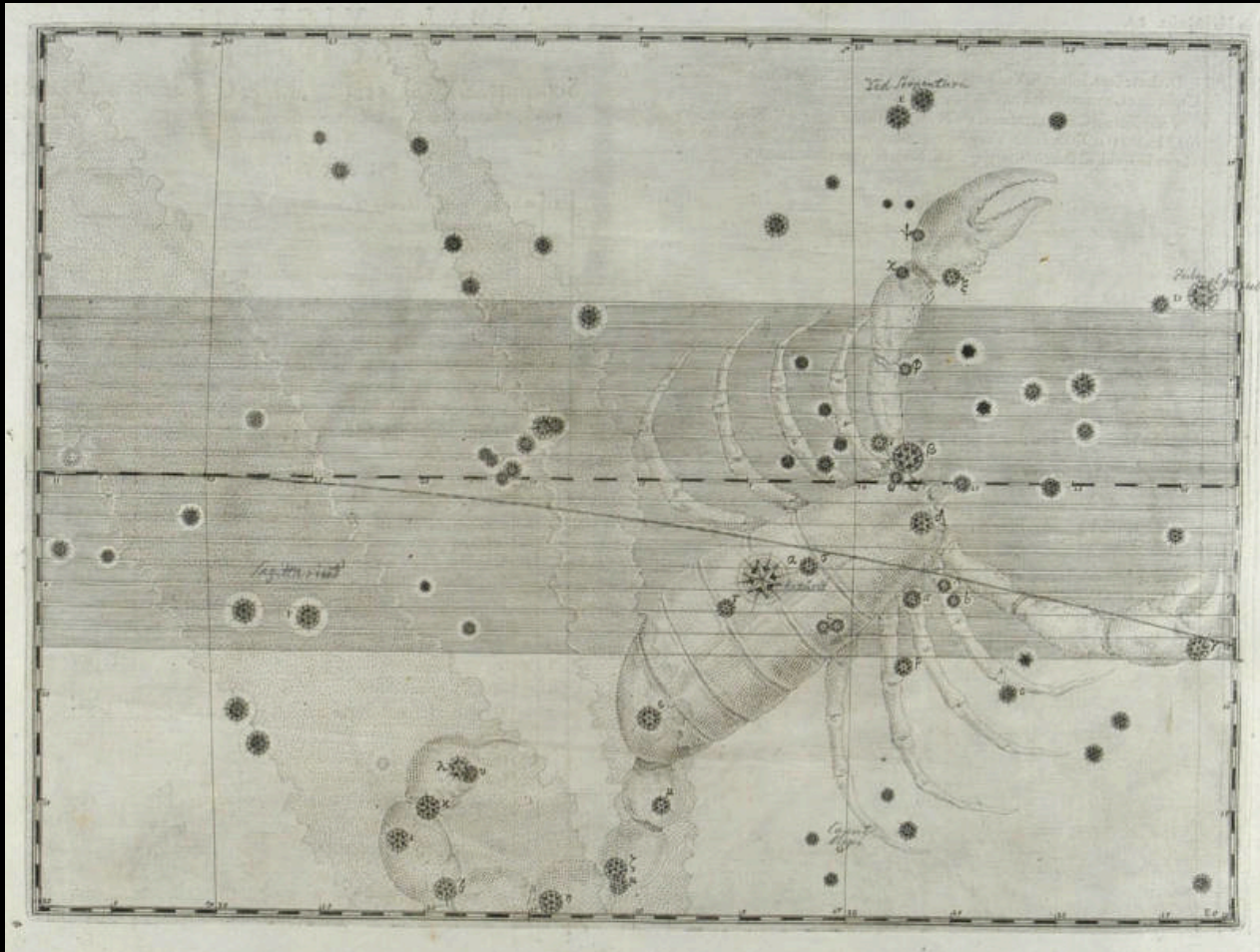
Constellations as seen by
Astronomers in China
(4th-century BC)

British Library



Coelum Stellatum Christianum (1627)
Julius Schiller (c. 1580-1627)

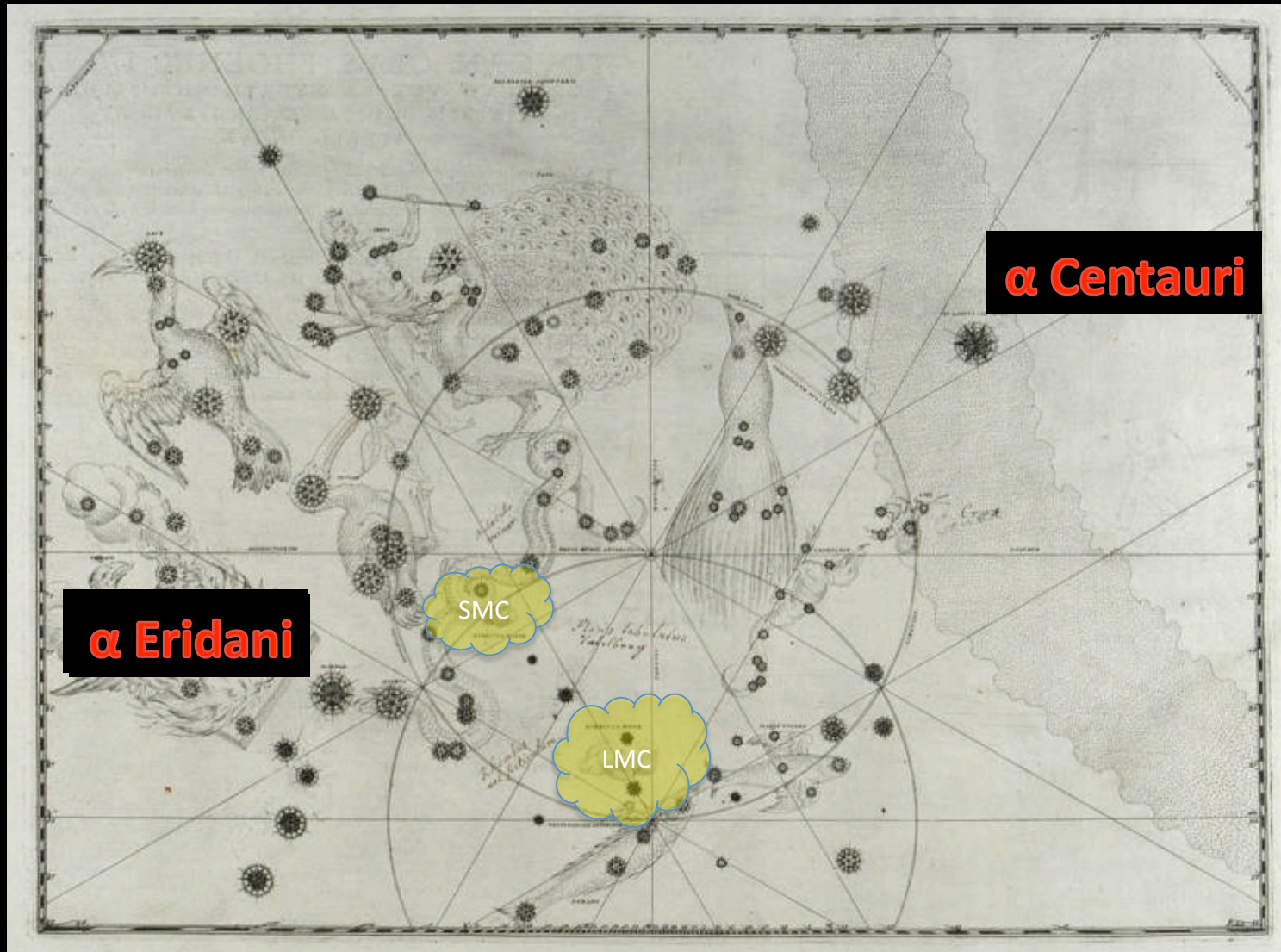
... cant see the stars for the apostles !



Uranometria, Johann Bayer, 1603

Linda Hall Library, LHL Digital Collections

... with southern constellations ...



α Eridani

SMC

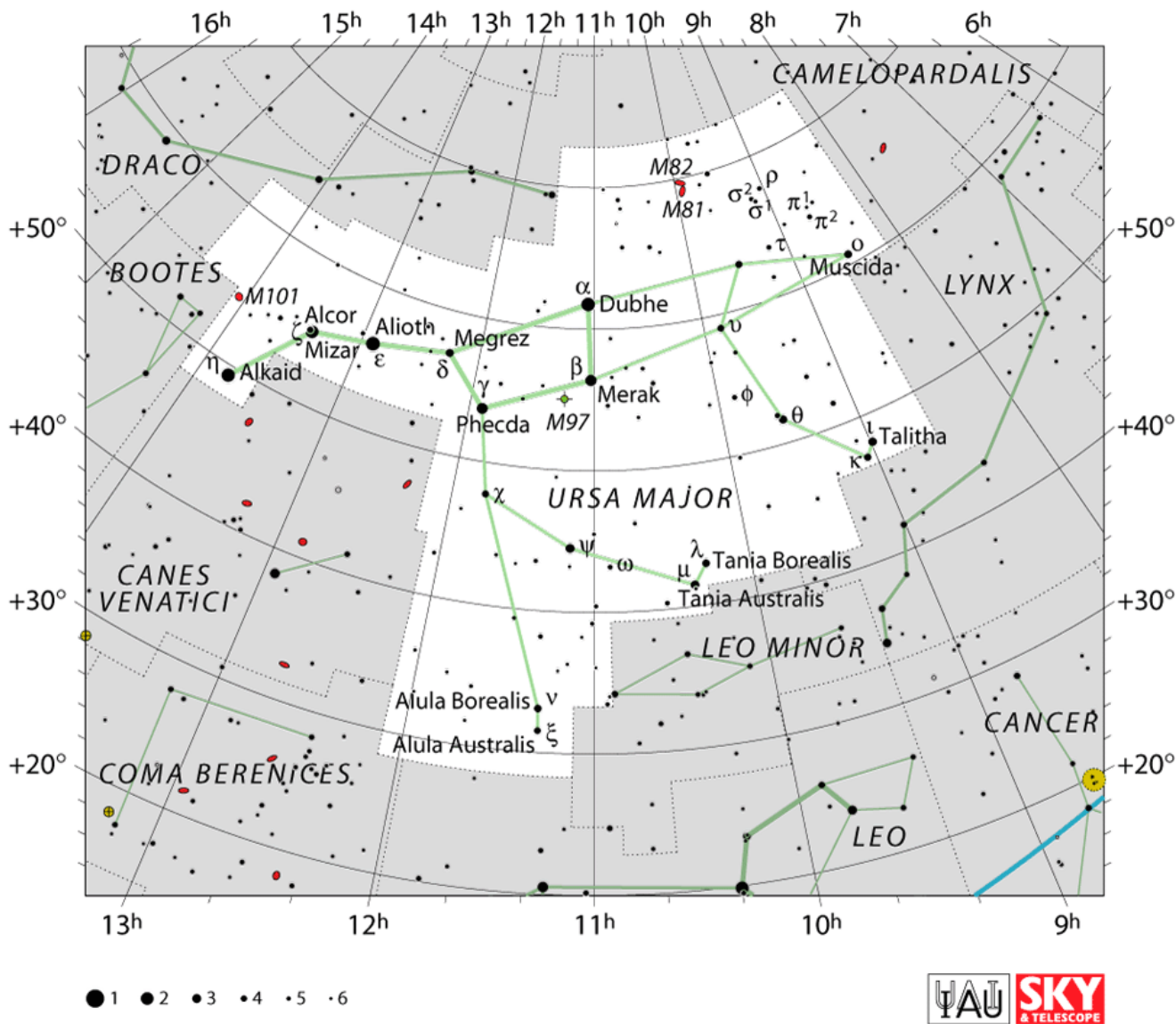
LMC

α Centauri

Uranometria, Johann Bayer, 1603

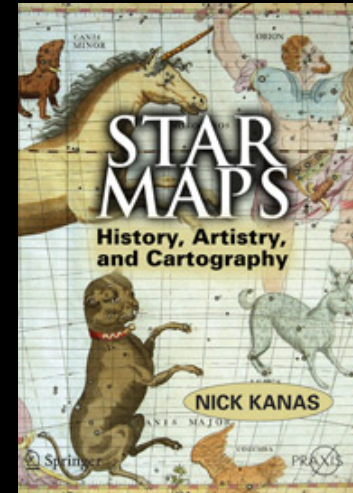
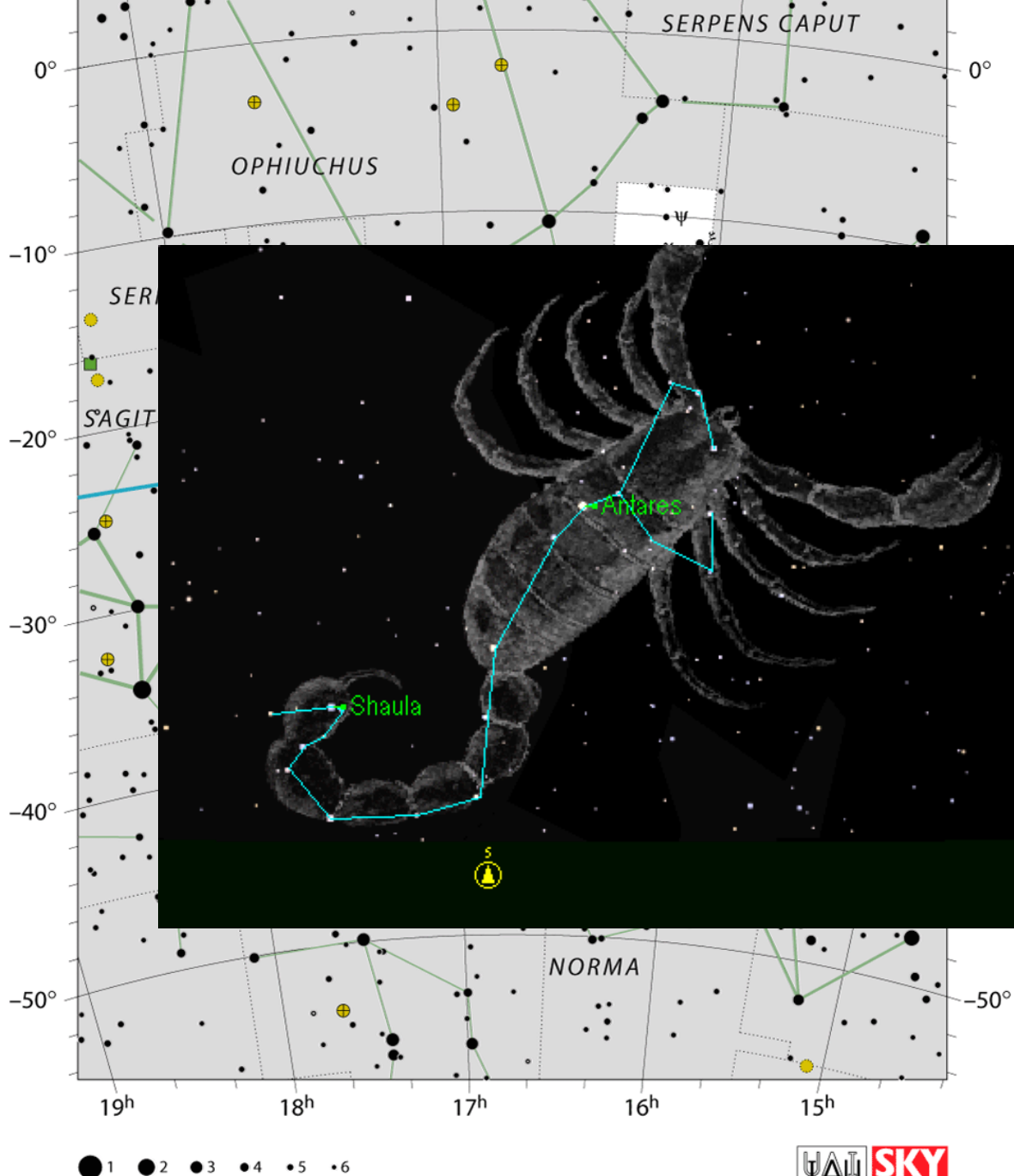
Linda Hall Library, LHL Digital Collections

... including Pavo, Toucan, Grus, Phoenix, Dorado, Piscis Volans, Hydrus, Chameleon, Apis, Apis Indica, and Triangulum Australe.



Ursa Major

Scorpius



N. Kanas, 2007

IAU Scorpius chart, IAU and Sky & Telescope magazine (Roger Sinnott and Fick Fienberg)

5. From 2D to 3D



<http://www.famous-mathematicians.com>

(736)

I. *Considerations on the Change of the Latitudes of some of the principal fixt Stars.* By Edmund Halley, R. S. Sec.

HAVING of late had occasion to examine the quantity of the Precession of the Equinoctial Points, I took the pains to compare the Declinations of the fixt Stars delivered by *Ptolomy*, in the 3^d Chapter of the 7th Book of his *Almag.* as observed by *Timocharis* and *Aristyllus* near 300 Years before *Christ*, and by *Hipparchus* about 170 Years after them, that is about 130 Years before *Christ*, with what we now find: and by the result of very many Calculations, I concluded that the fixt Stars in 1800 Years were advanced somewhat more than 25 degrees in Longitude, or that the Precession is somewhat more than 50" *per ann.* But that with so much uncertainty, by reason of the imperfect Observations of

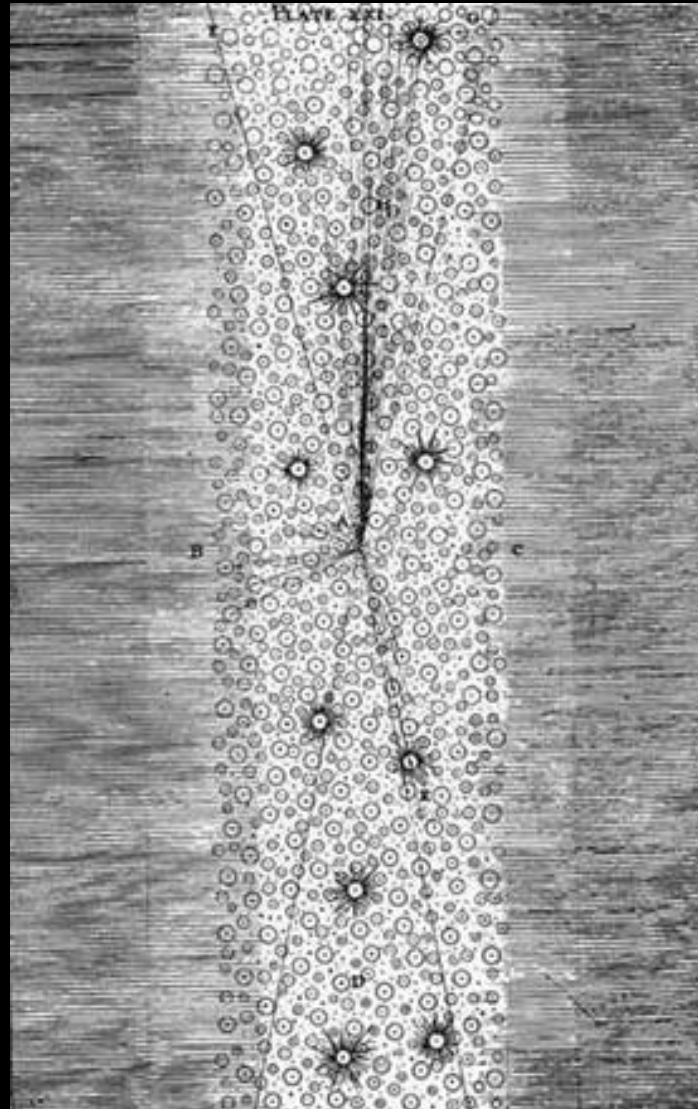
<http://www.jstor.org>

Sirius, Aldebaran, Arcturus had changed their space positions over a 1800 year baseline.

Thomas Wright



<http://images.fineartamerica.com>



from *An Original Theory or New Hypothesis of the Universe* (1750)

Plate XXII: "[The Milky Way] a vast Gulph, or Medium, every way extended like a Plane, and enclosed between two surfaces.



<http://www.lindahall.org>

II. A letter from Professor Bessel to Sir J. Herschel, Bart., dated Königsberg, Oct. 23, 1838.

Esteemed Sir,—Having succeeded in obtaining a long-looked-for result, and presuming that it will interest so great and zealous an explorer of the heavens as yourself, I take the liberty of making a communication to you thereupon. Should you consider this communication of sufficient importance to lay before other friends of Astronomy, I not only have no objection, but request you to do so. With this view, I might have sent it to you through Mr. Baily; and I should have preferred this course, as it would have interfered less with the important affairs claiming your immediate attention on your return to England. But, to you, I can write in my own language, and thus secure my meaning from indistinctness.

After so many unsuccessful attempts to determine the parallax of a fixed star, I thought it worth while to try what might be accomplished by means of the accuracy which my great Fraunhofer Heliometer gives to the observations. I undertook to make this investigation upon the star 61 *Cygni*, which, by reason of its great proper motion, is perhaps the best of all; which affords the ad-

<http://adsabs.harvard.edu/abs/1838MNRAS...4..152B>

Bessel writes “*presuming it will interest so great and zealous an explorer of the heavens as [Herschel], takes the liberty of making a communication to [him] thereupon*”

(if only modern day astronomers spoke so!)

6. Lowell and Mars



<http://www.stampcommunity.org>

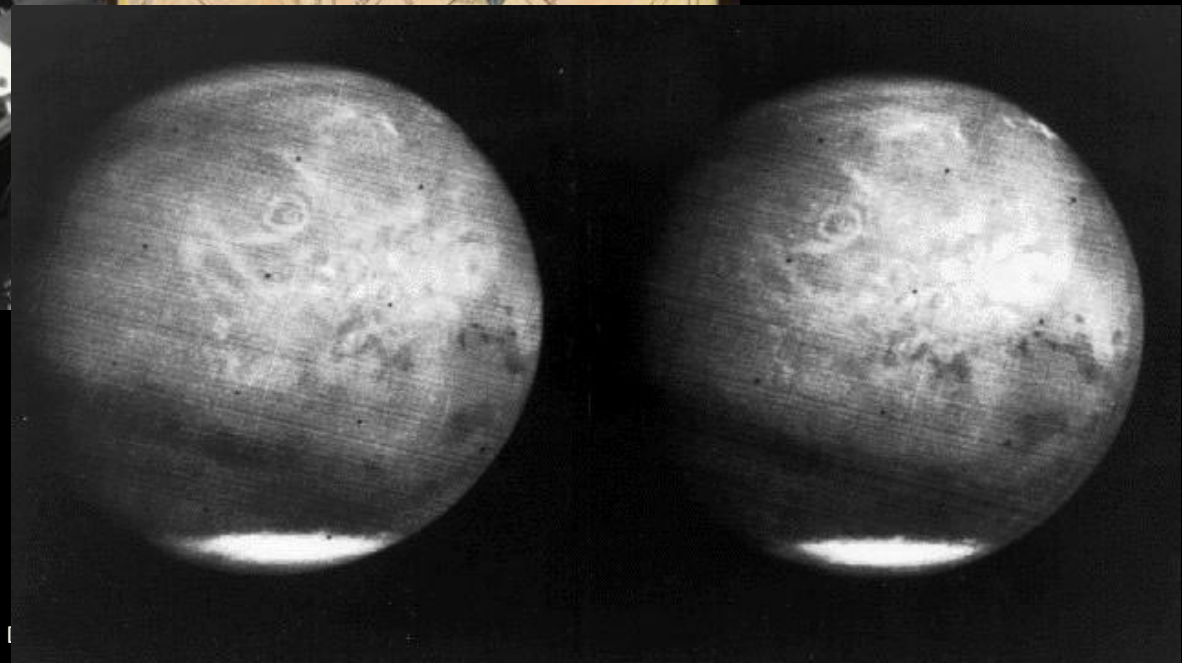
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<http://news.discovery.com>

www.nasa.gov



7. Mysterious nebulae

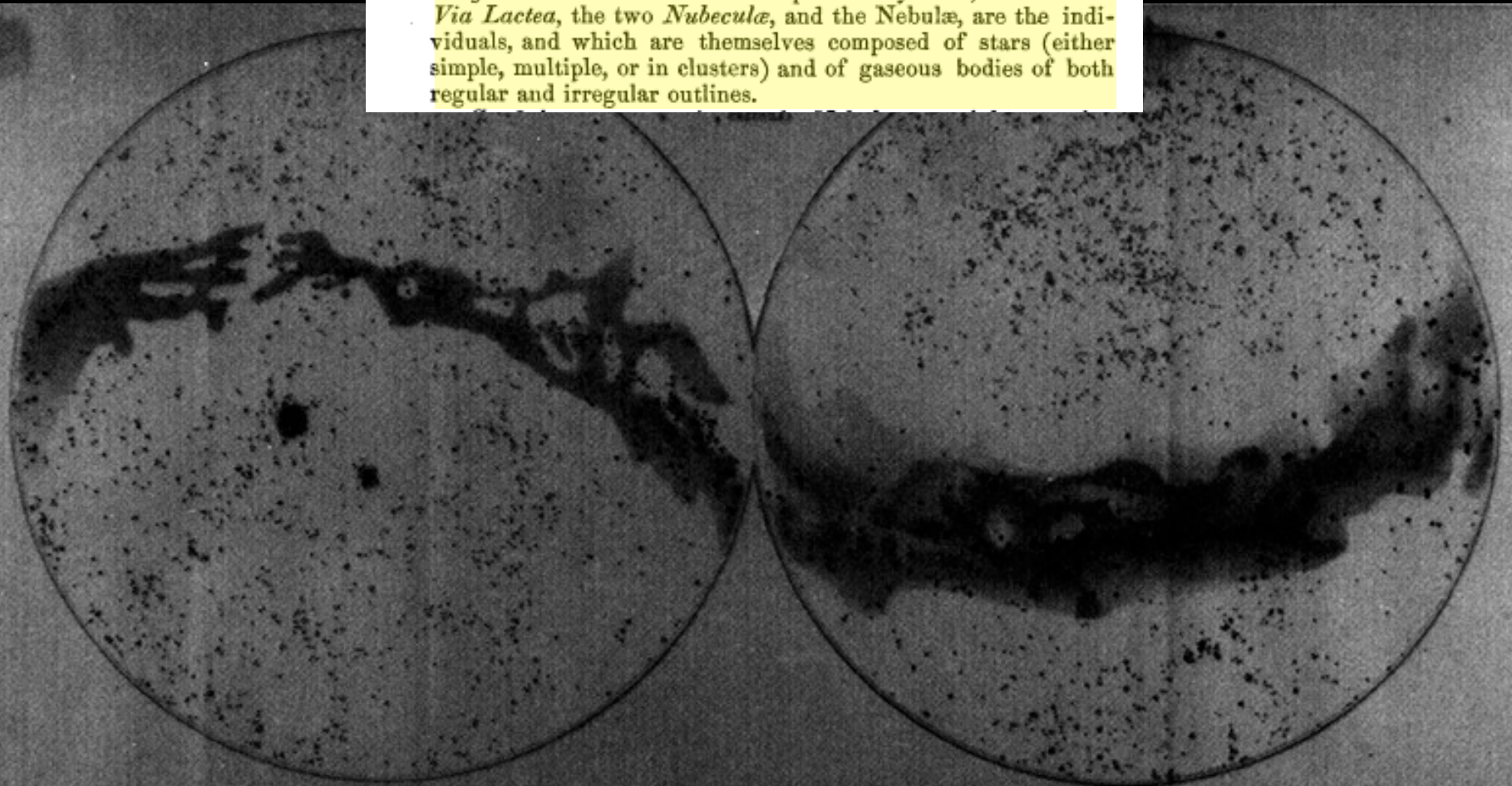


The study of the foregoing Tables may lead to the following conclusions or suggestions:—

1. The Clusters (Cl.) are members of the *Via Lactea*, and are nearer to us than the average of its faint stars.

2. The Nebulæ resolved and unresolved lie in general without the *Via Lactea*, which is therefore essentially stellar.

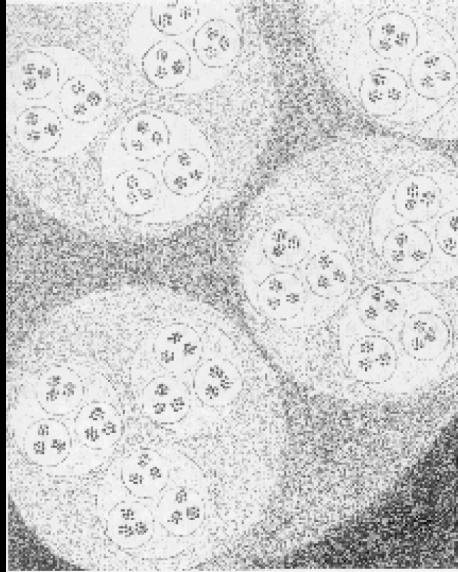
3. The visible universe is composed of systems, of which the *Via Lactea*, the two *Nubeculæ*, and the Nebulæ, are the individuals, and which are themselves composed of stars (either simple, multiple, or in clusters) and of gaseous bodies of both regular and irregular outlines.



Carl Charlier 1922



C. V. Charlier.



A cosmological model in which the galaxies are distributed throughout the universe in a clustering hierarchy. (His motivation was to provide a resolution for Olber's Paradox.)

Shane and Wirtanen mid-1950s



Galaxy counts across the northern galactic hemisphere. (north galactic pole is centred)

The Local Supergalaxy De Vaucouleurs 1953



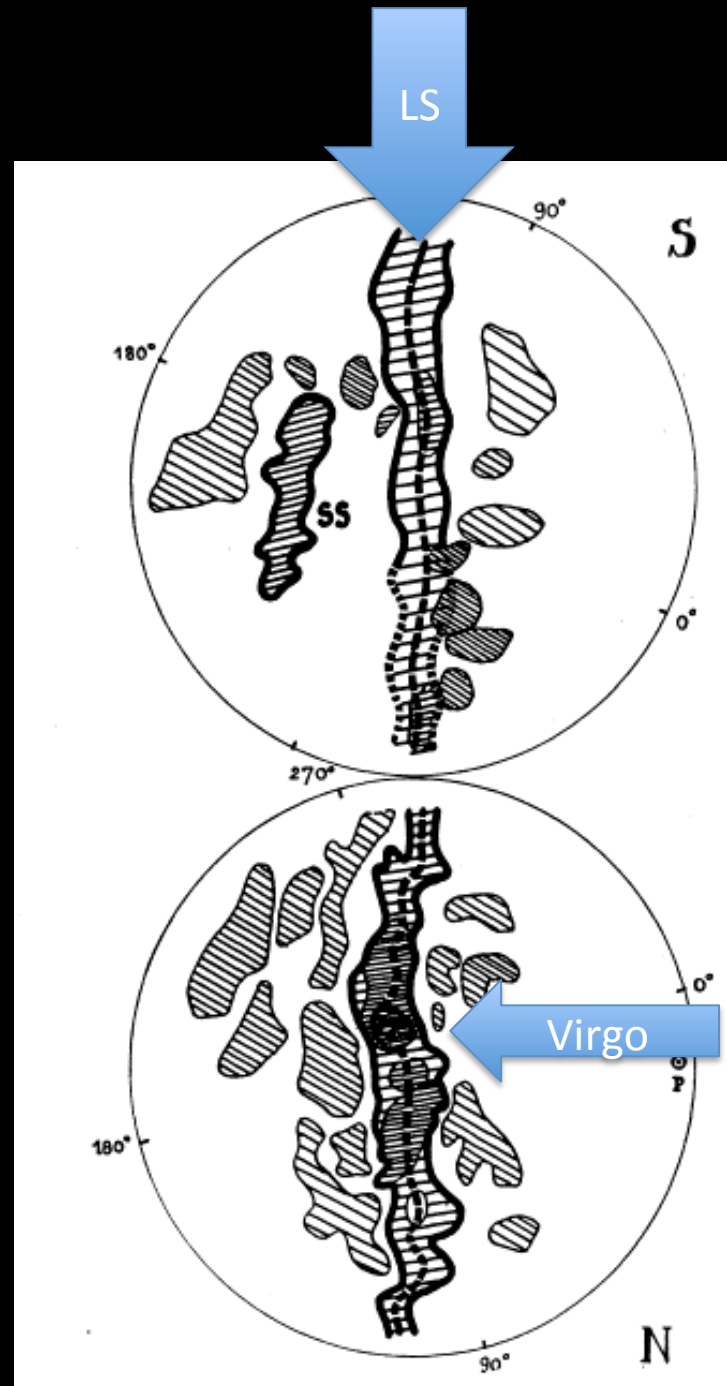
$m < 13$ nebulae density across the southern (top) and northern (bottom) galactic hemispheres.

The density of shading is related to the nebulae density.

LS – local supergalaxy

SS – southern supergalaxy

The densest part of the northern hemisphere (in the LS) is the Virgo cluster.



8. Streams, planes and how galaxies form?

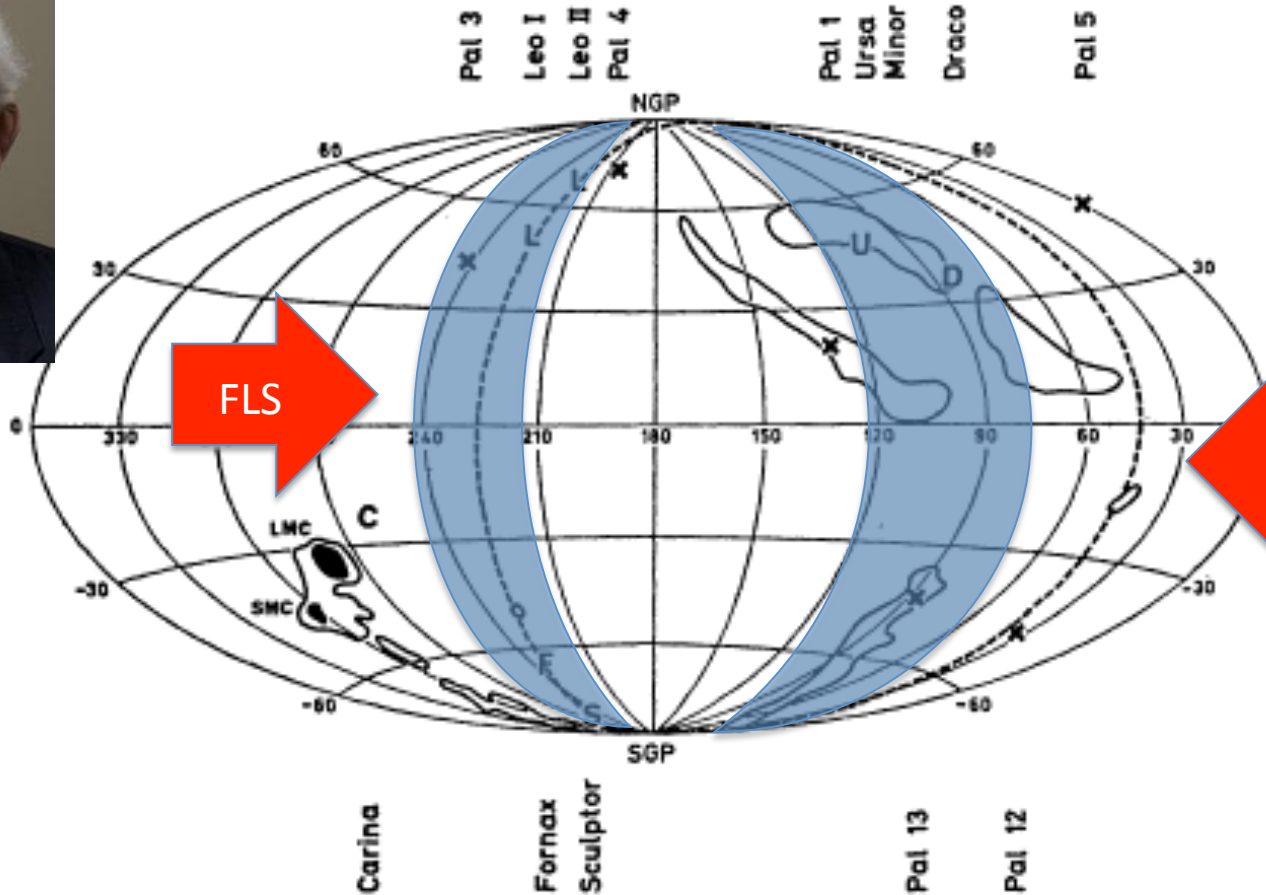
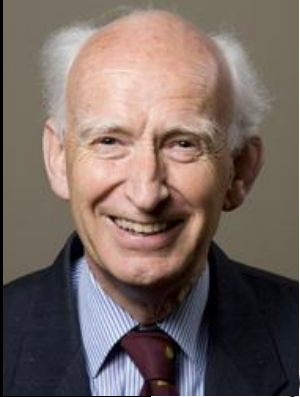
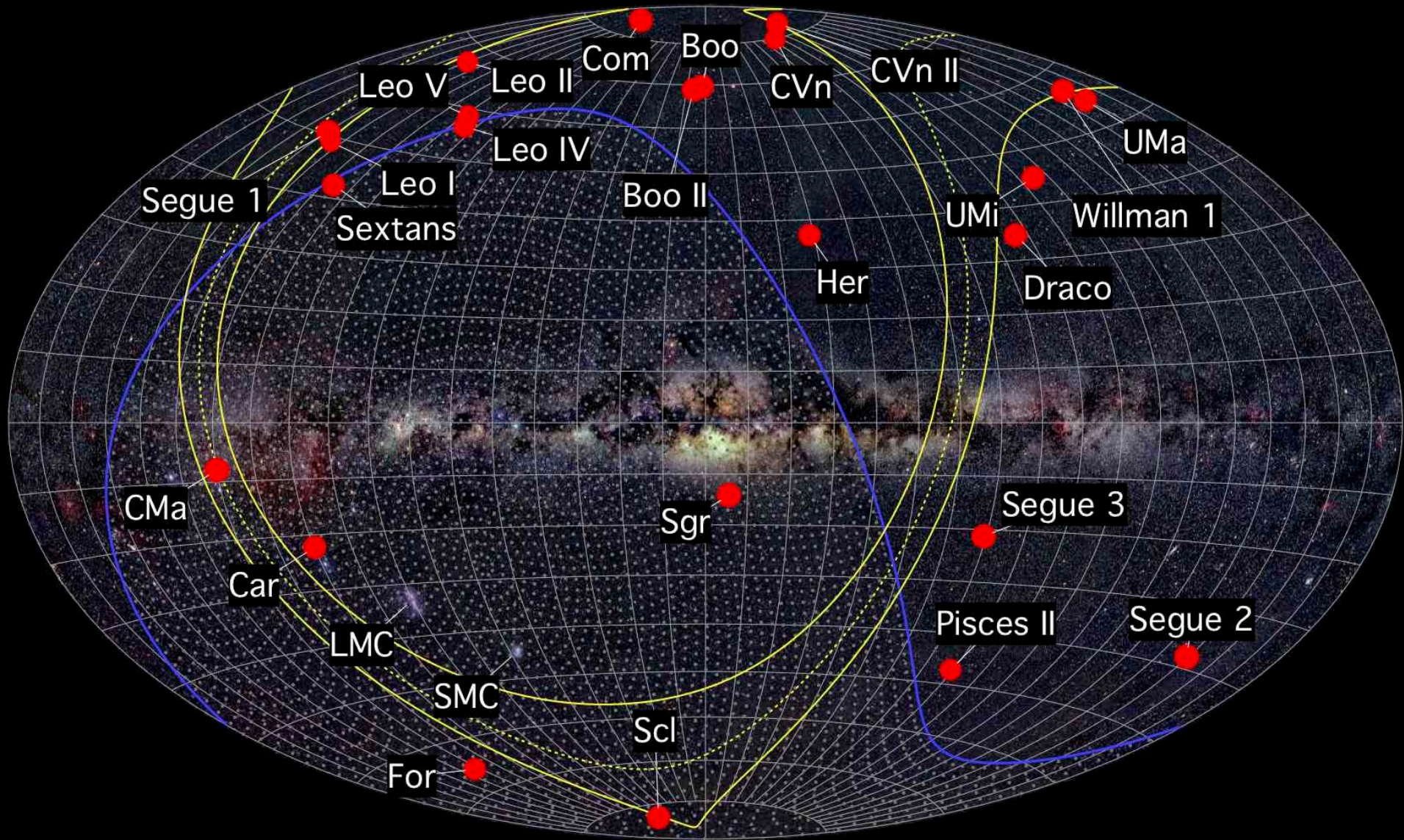


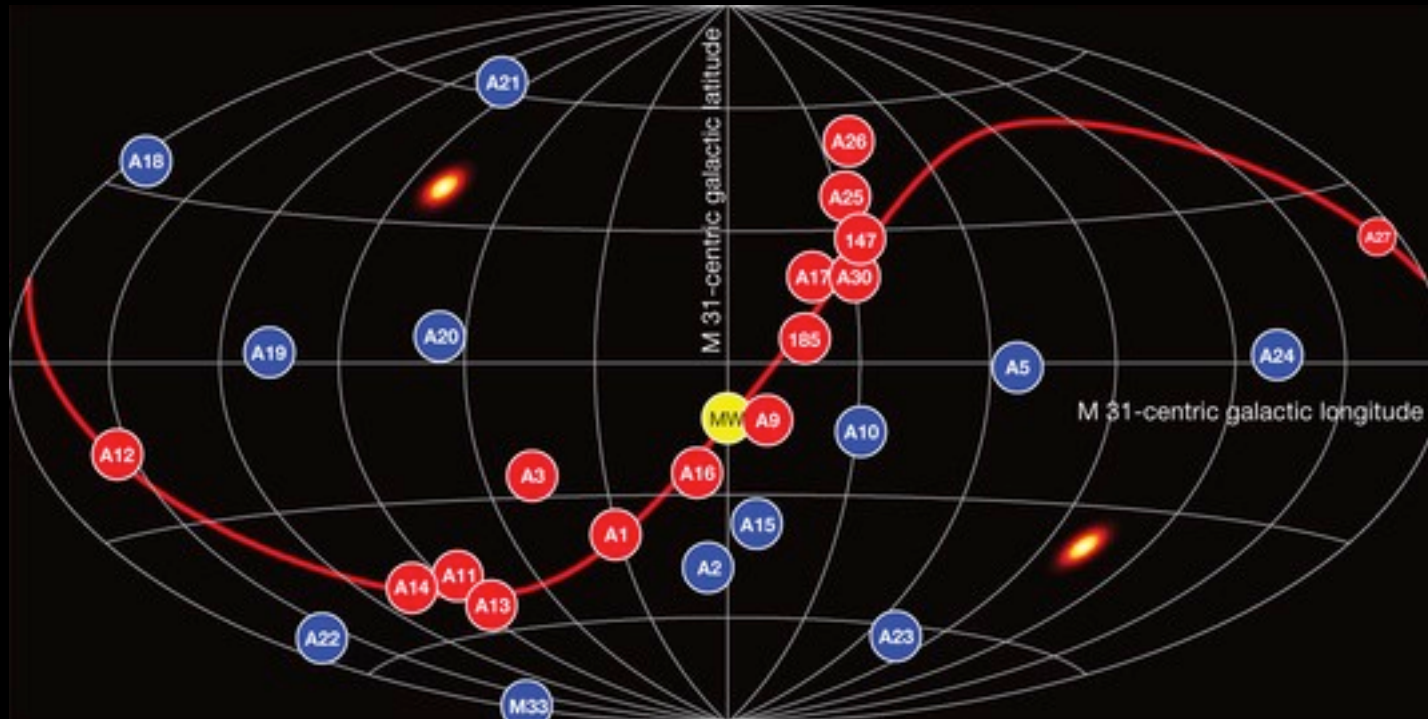
FIG. 1

The Fornax-Leo-Sculptor great circle plotted on a map of high-velocity clouds with the dwarf spheroidal galaxies and diffuse globular clusters. The plot is in Galactic coördinates as observed from the Sun. Correction to the Galactocentric coördinates are minor and are detailed in Table I.

present

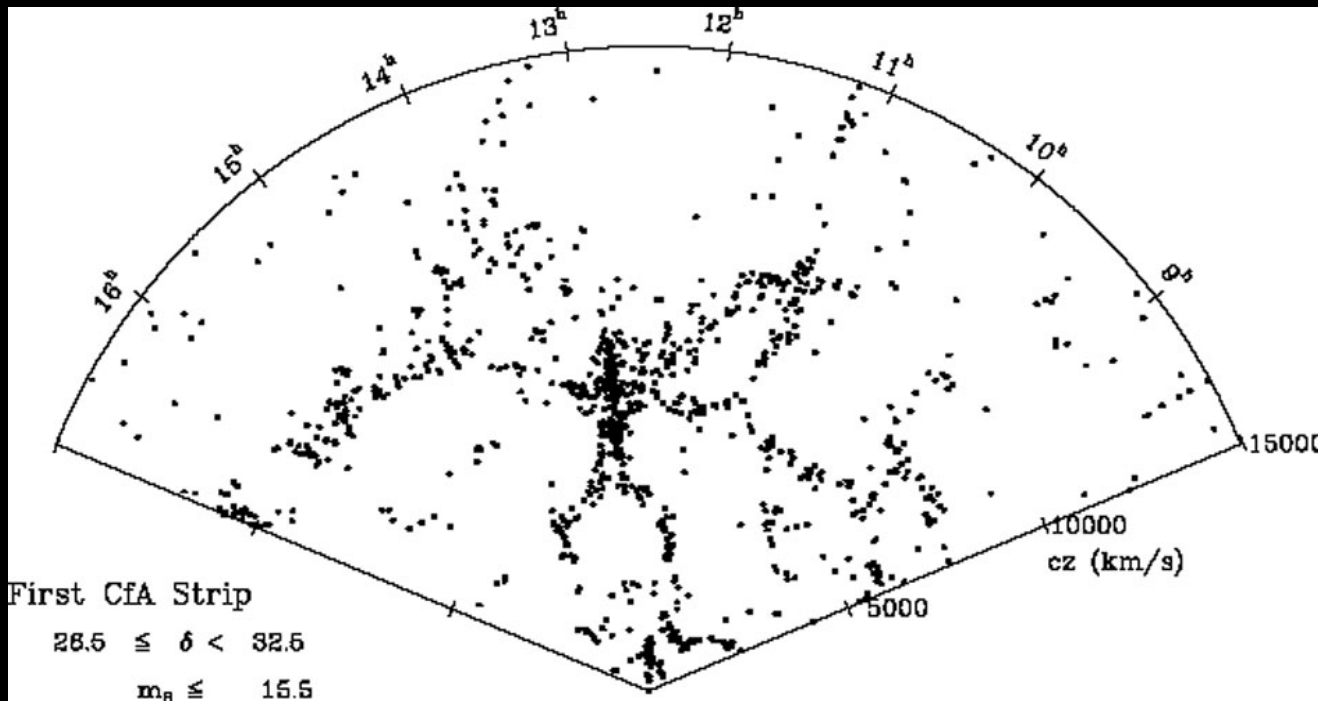


All-sky image showing the locations of known dwarf galaxies associated with the Galaxy.



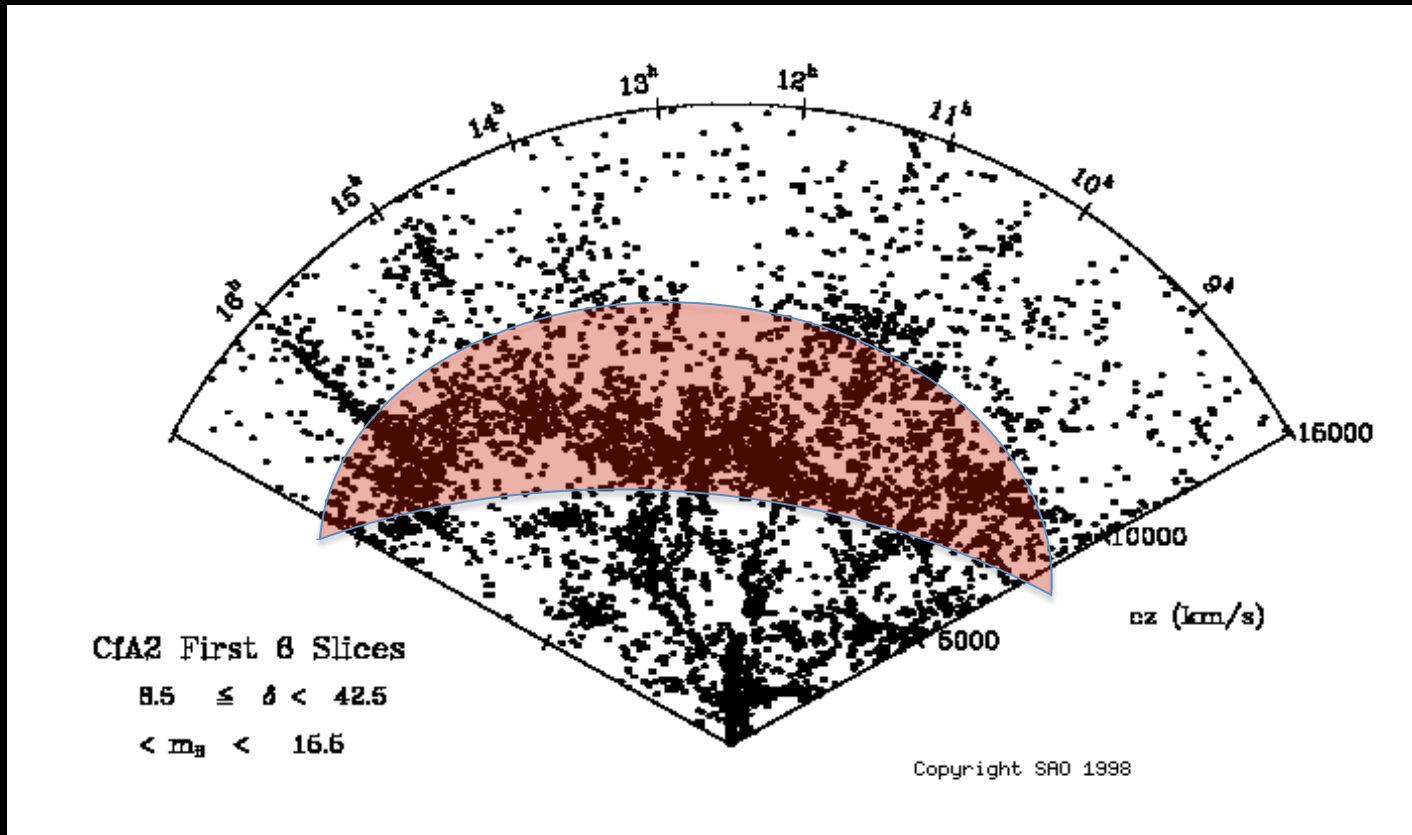
The sample of 27 satellite dwarf galaxies as they would be seen from the centre of the Andromeda galaxy, M31.

9. The CfA 'stick-man' and the reality of filaments

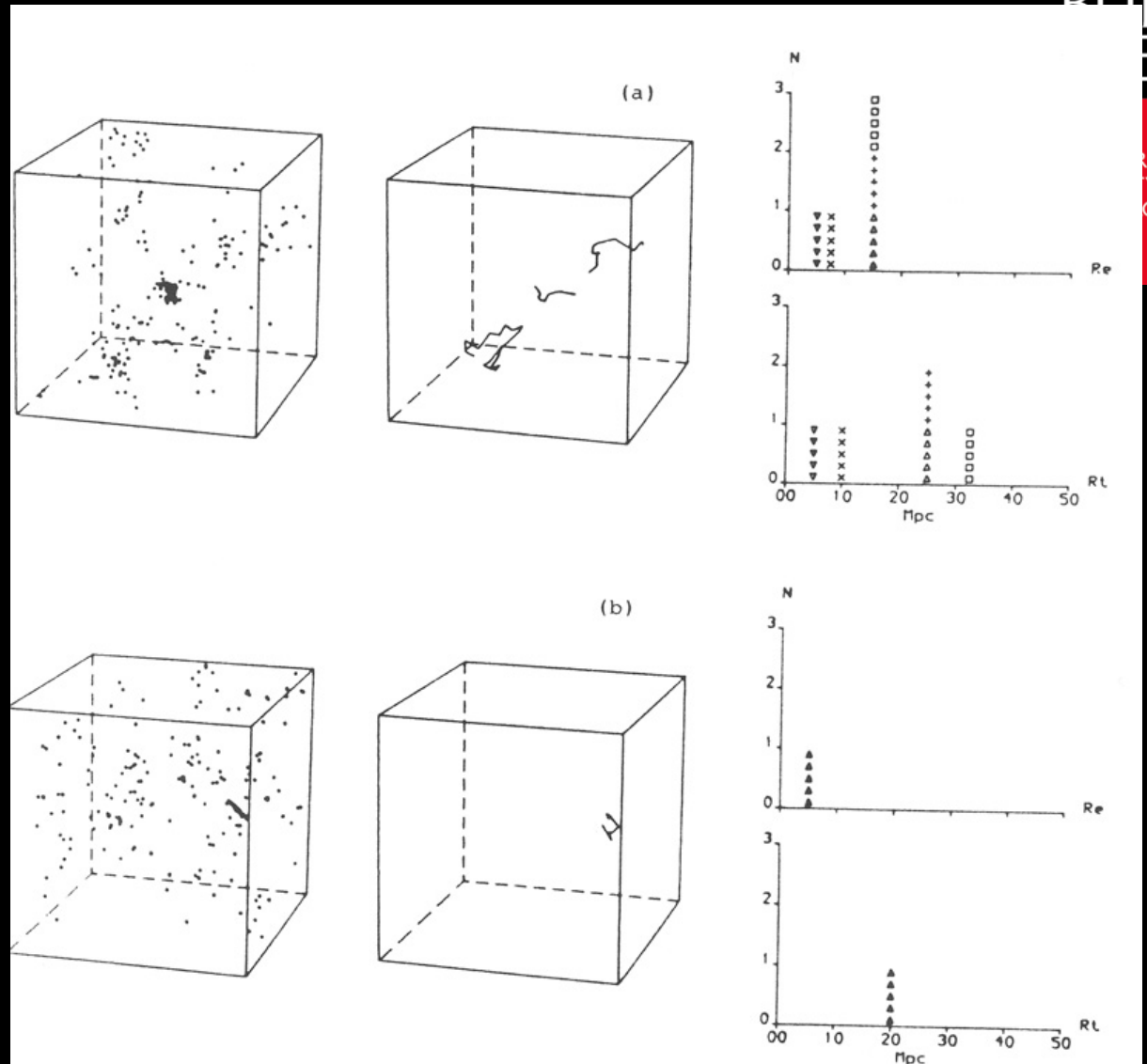
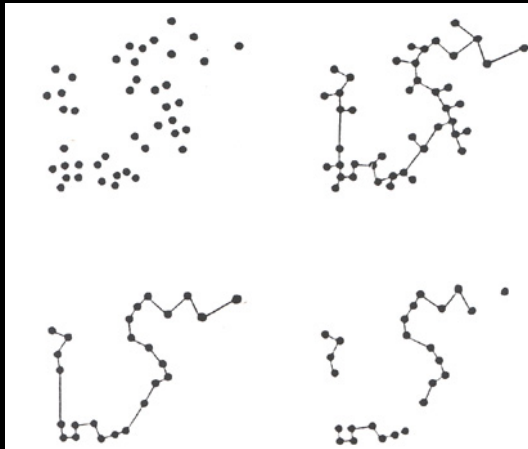


CfA galaxy survey 'stick-man'

Expanded CfA galaxy survey 'stick-man' replaced by 'Great Wall'



The structure between 8 - 17 hours RA and 5,000 -10,000 km/s is called the 'Great Wall'.
It's dimensions are ~600x250x30 million light years.



Minimal Spanning Tree (MST) technique

10. Citizen science and classification bias

CLASSIFY

STORY

SCIENCE



DISCUSS

PROFILE

LANGUAGE



Few have witnessed what you're about to see

Experience a privileged glimpse of the distant universe as observed by the SDSS, the Hubble Space Telescope, and UKIRT

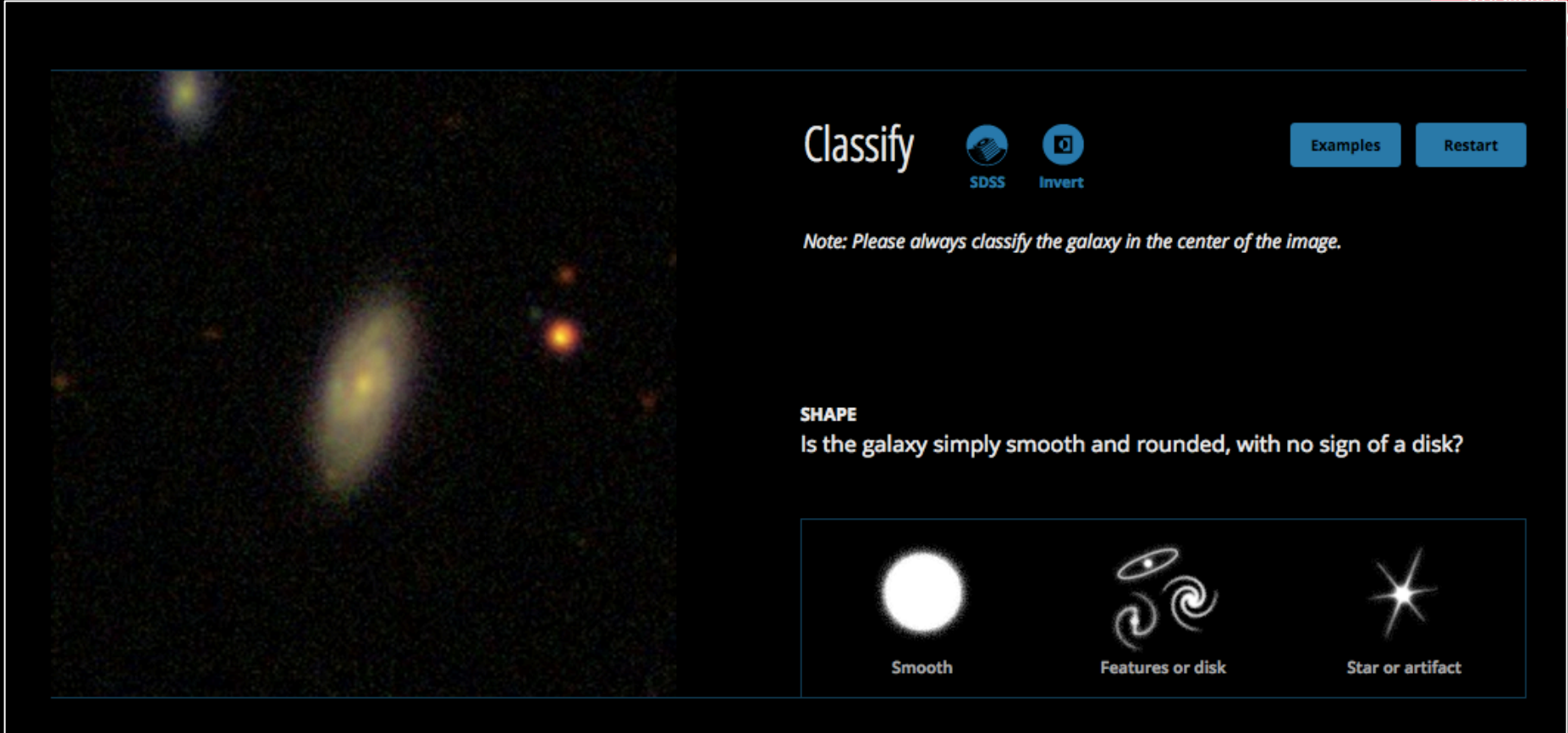
Classify Galaxies

To understand how galaxies formed we need your help to classify them according to their shapes. If you're quick, you may even be the first person to see the galaxies you're asked to classify.

[Begin Classifying](#)



<http://www.galaxyzoo.org/>



Classify

SDSS Invert

Examples Restart

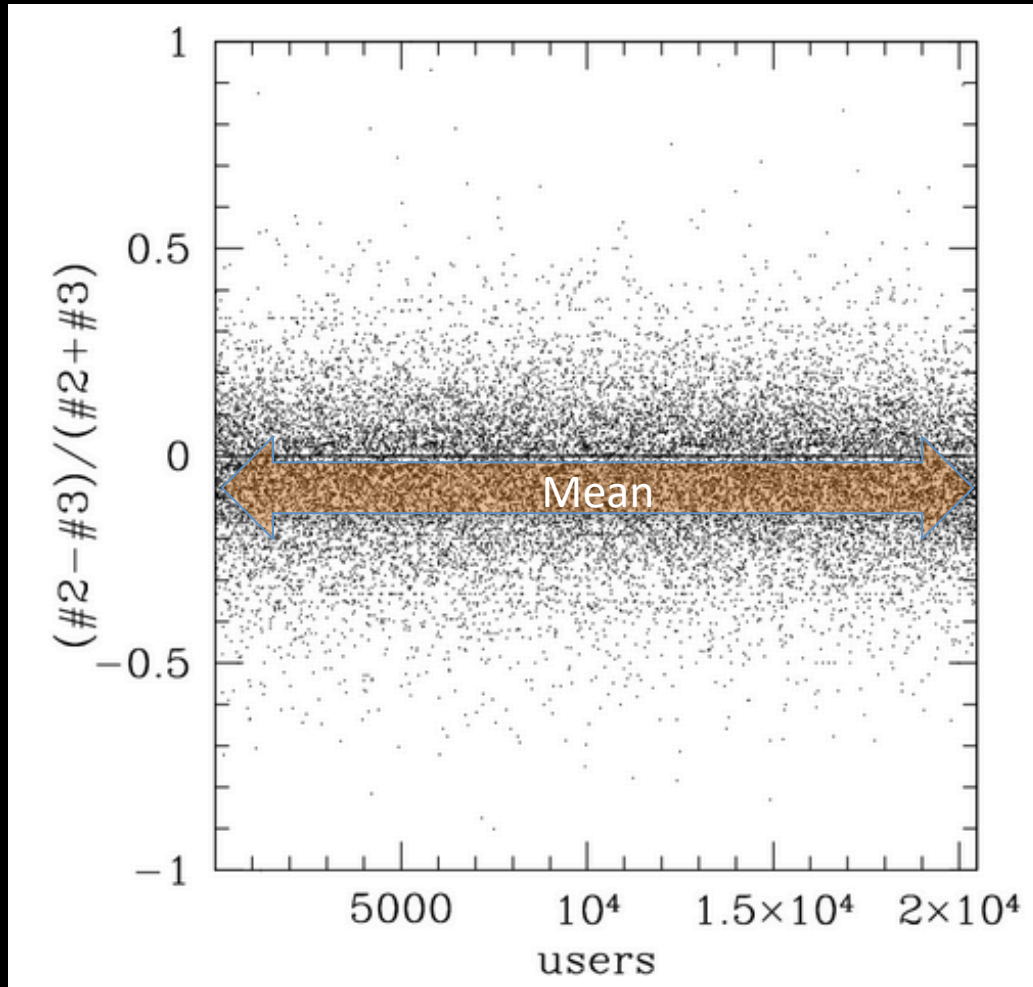
Note: Please always classify the galaxy in the center of the image.

SHAPE
Is the galaxy simply smooth and rounded, with no sign of a disk?

Smooth Features or disk Star or artifact

<http://www.galaxyzoo.org/>

Galaxy Zoo – a preference (bias) to classify rotation as anti-clockwise??



Clockwise arm rotation

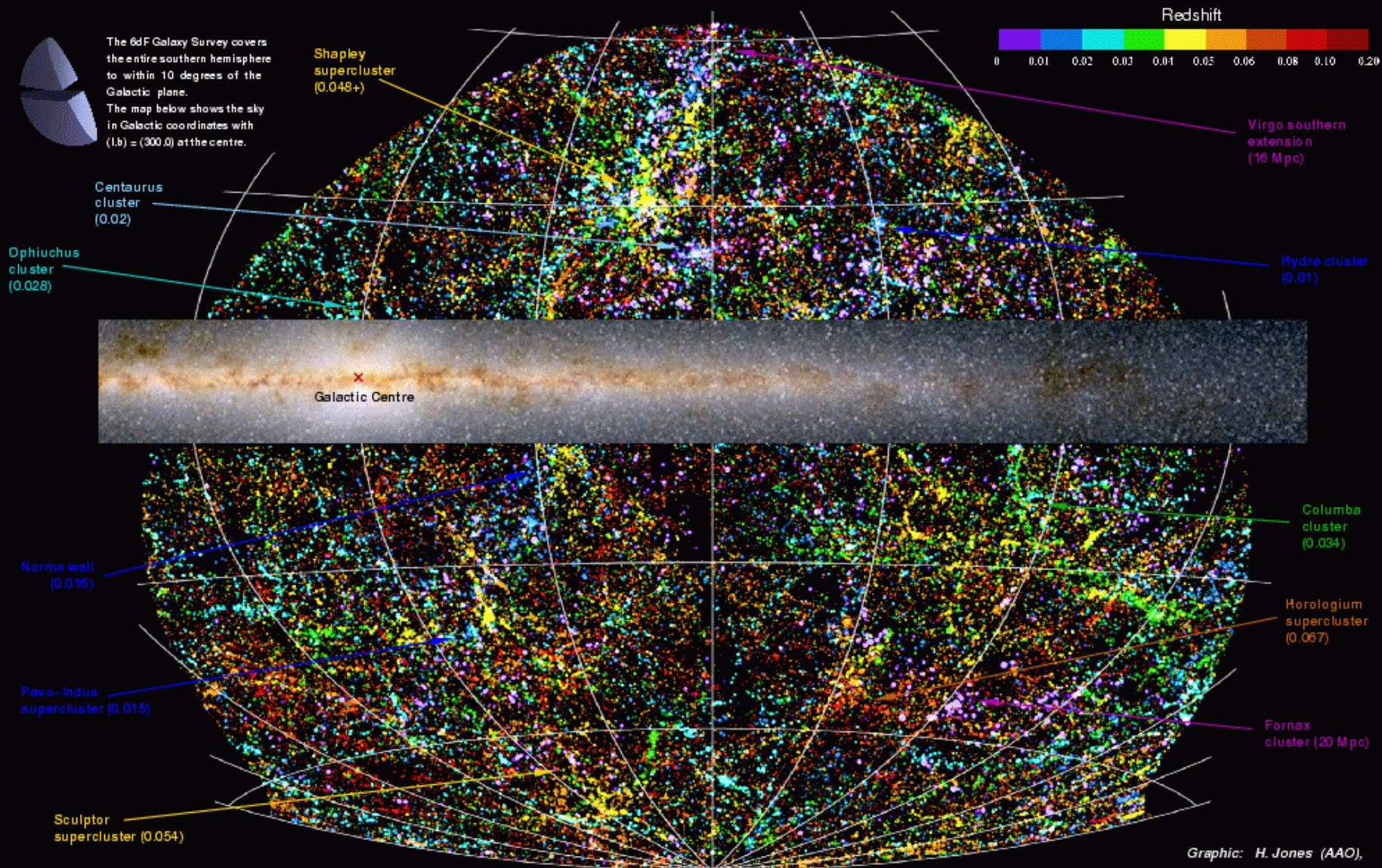
Anti-clockwise arm rotation

Land et al. 2008

<http://blog.galaxyzoo.org/2008/01/10/in-the-eye-of-the-beholder/>

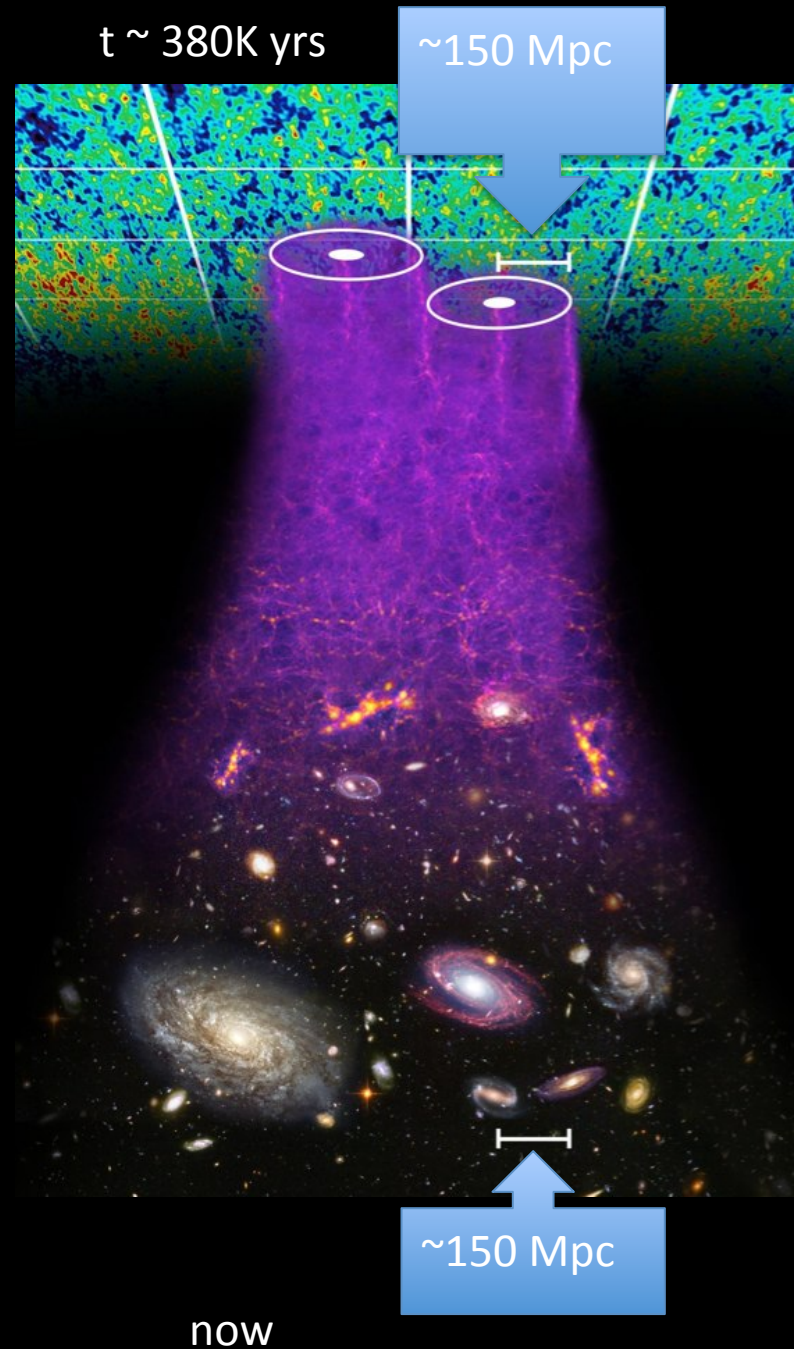
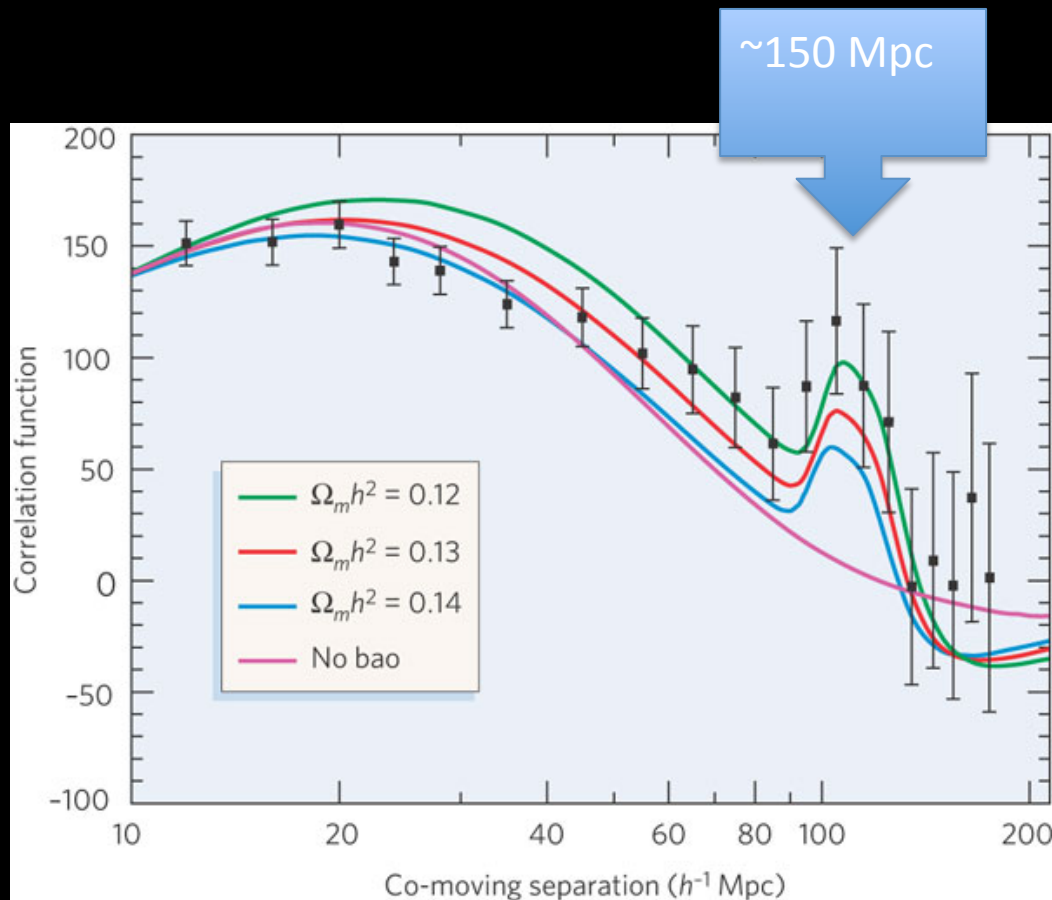
11. Baryonic Acoustic Oscillations – favoured separation

The 6dFGS View of the Local Universe

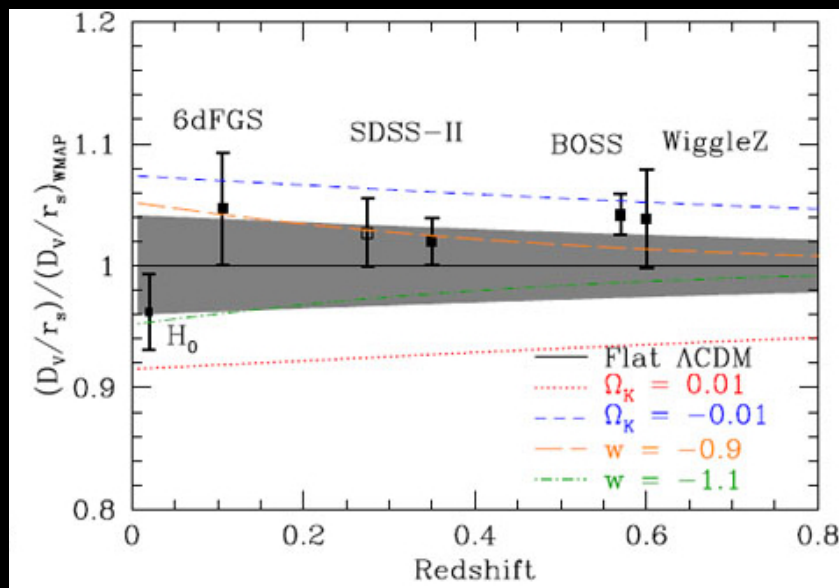


Graphic: H. Jones (AAO),
T. Jarrett (IPAC/Caltech).

Galactic Plane image courtesy of 2MASS.



Deviation from an anti-gravity type of dark energy

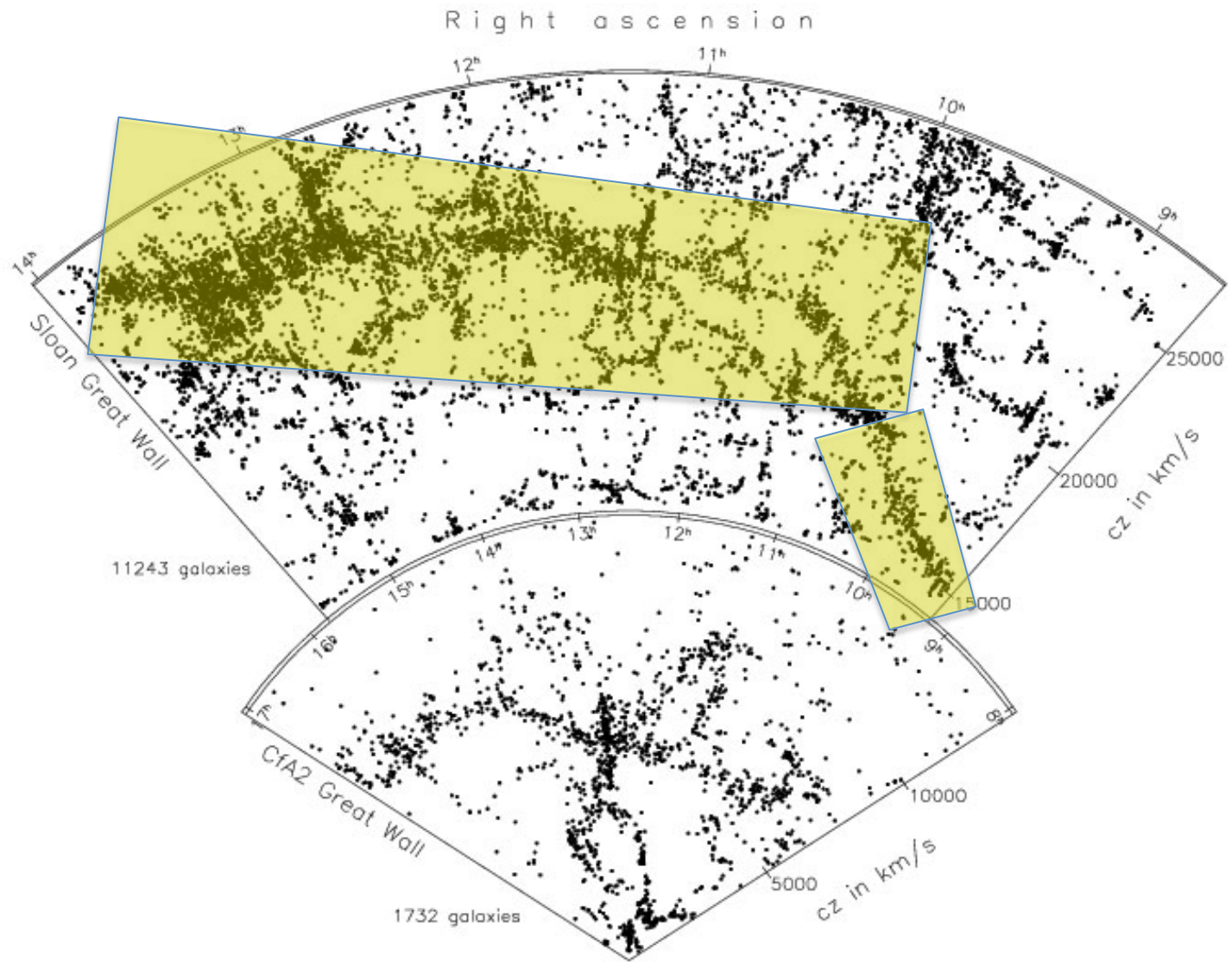


Redshift, z

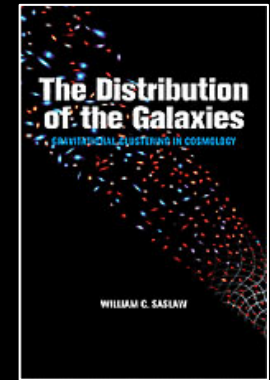
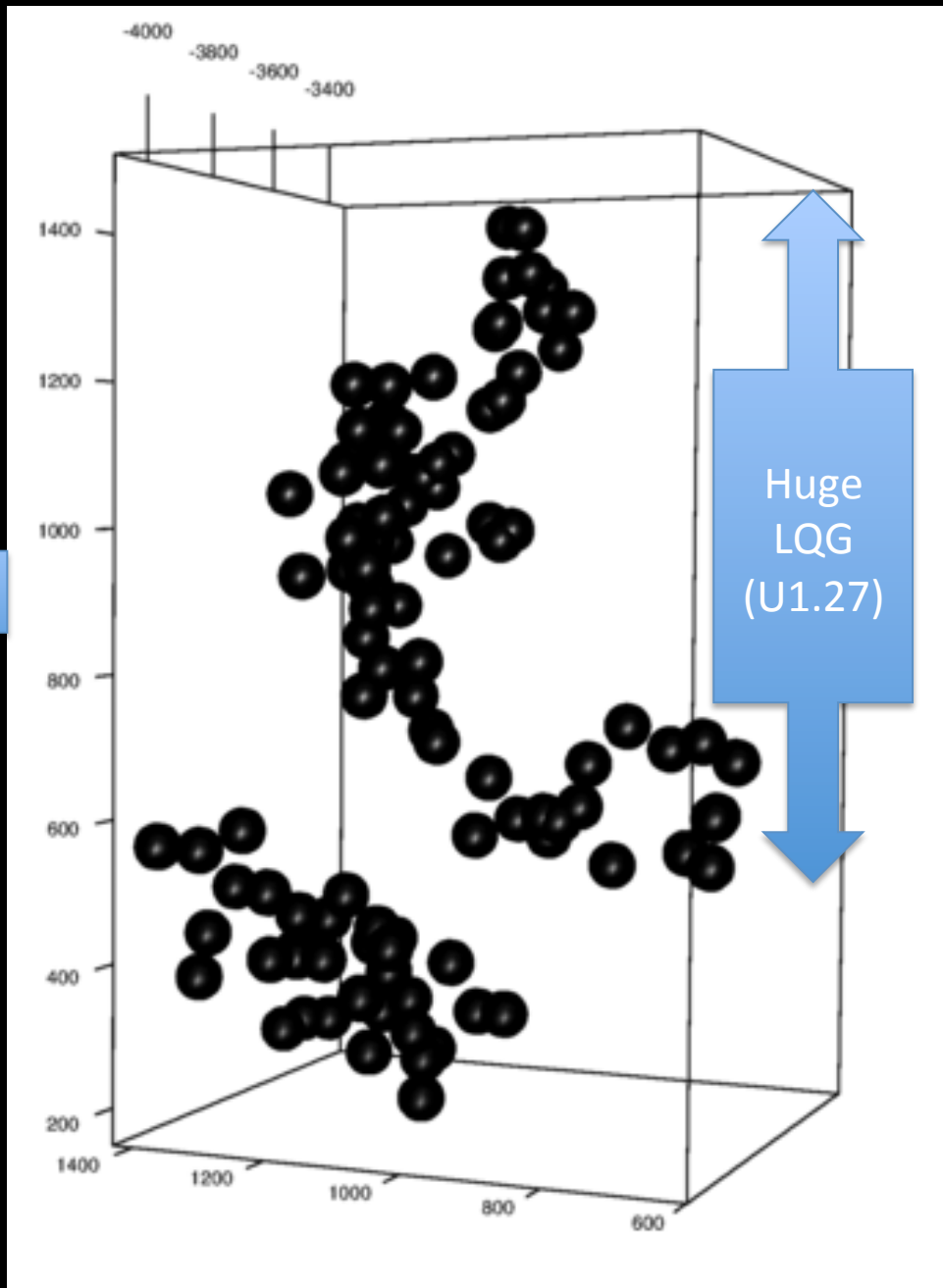
12. The Cosmological Principle and U1.27

Gott et al. 2005

Sloan Great Wall



200 Mpc

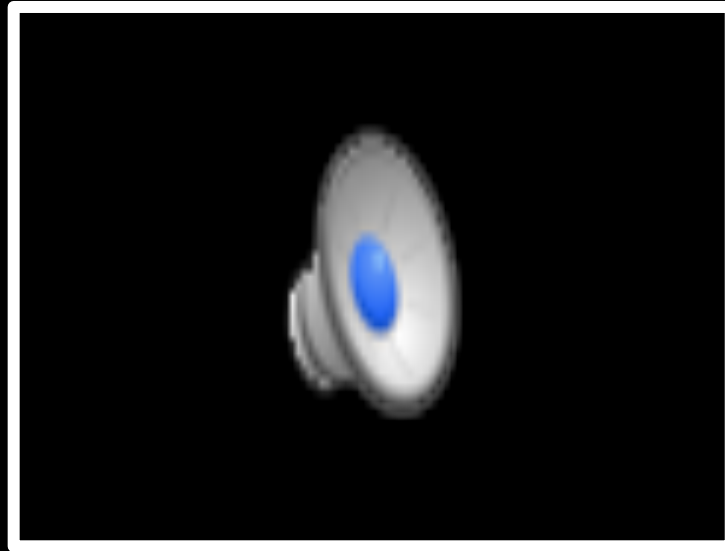


Saslaw 2008

13. State of astronomy visualisation

S2PLOT PDFs – exploration in 3D from 2D page images – Christopher Fluke, David Barnes et al.

http://astronomy.swin.edu.au/~gmackie/CUP/CW/6dF_sample.pdf



Download the pdf file above, and open it in Adobe Reader version 8.0 or higher. Mouse clicking on the panels will allow interaction with a 3D representation of the survey data.



Extract from "Sun's Lost Sibling," by Dr Graham Phillips, aired on ABC TV on 2015 March 3, and features the Monash CAVE2 as a backdrop for interview segments with Monash University astrophysicist Dr Daniel Price.



From <http://irfu.cea.fr/cosmography>

"Cosmography of the Local Universe", H.M. Courtois et al., 2013, The Astronomical Journal, 146, 69

IMAX Hidden Universe 3D



<http://hiddenuniversemovie.com>

3D printable models

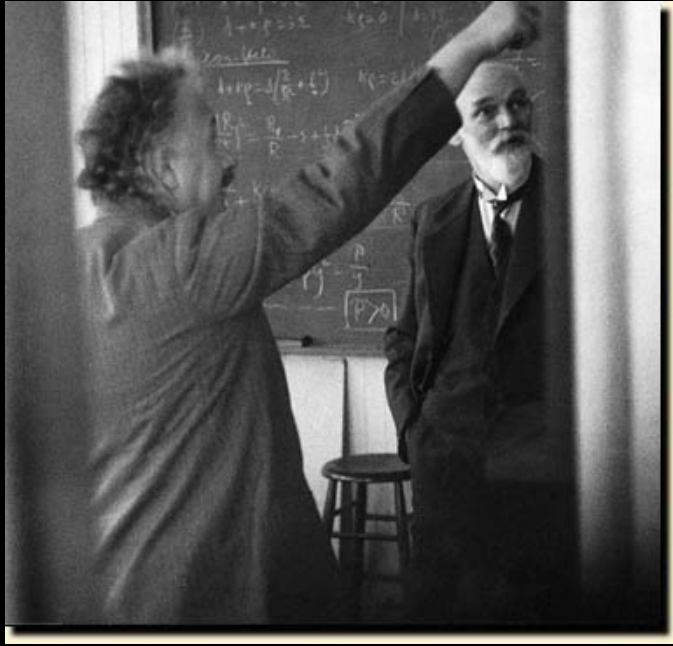


Curiosity rover
landing spot

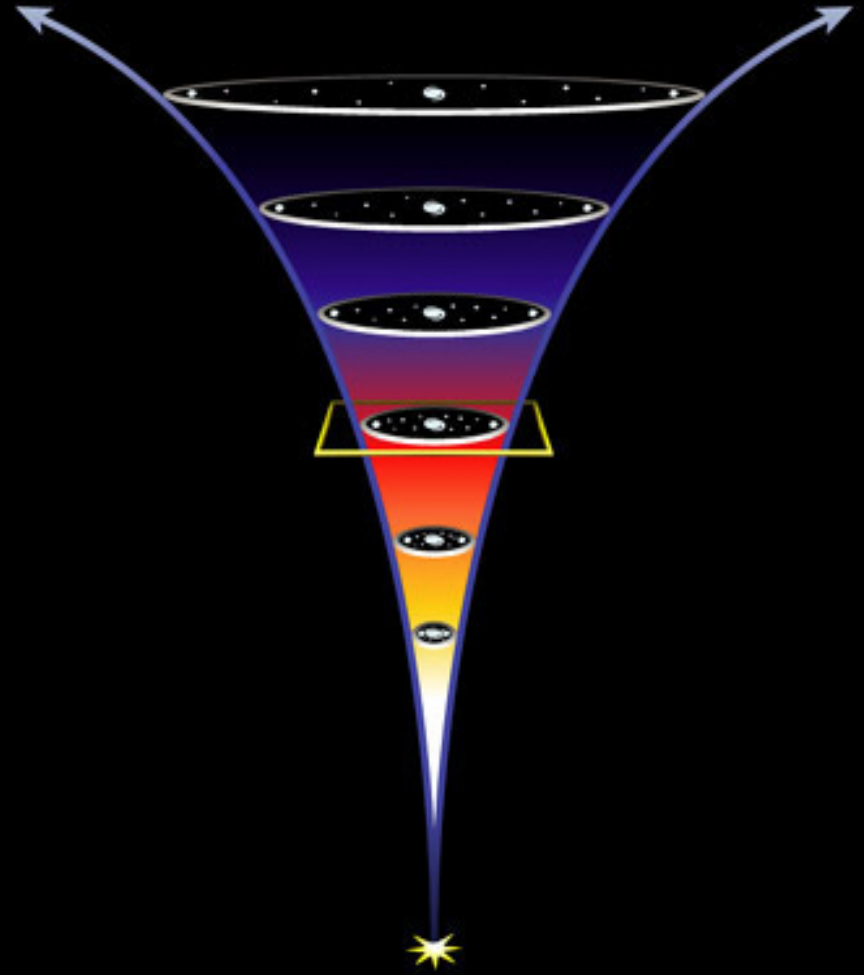
<http://nasa3d.arc.nasa.gov/models>

14. Willem de Sitter , dark energy and emu dust

Universo De Sitter

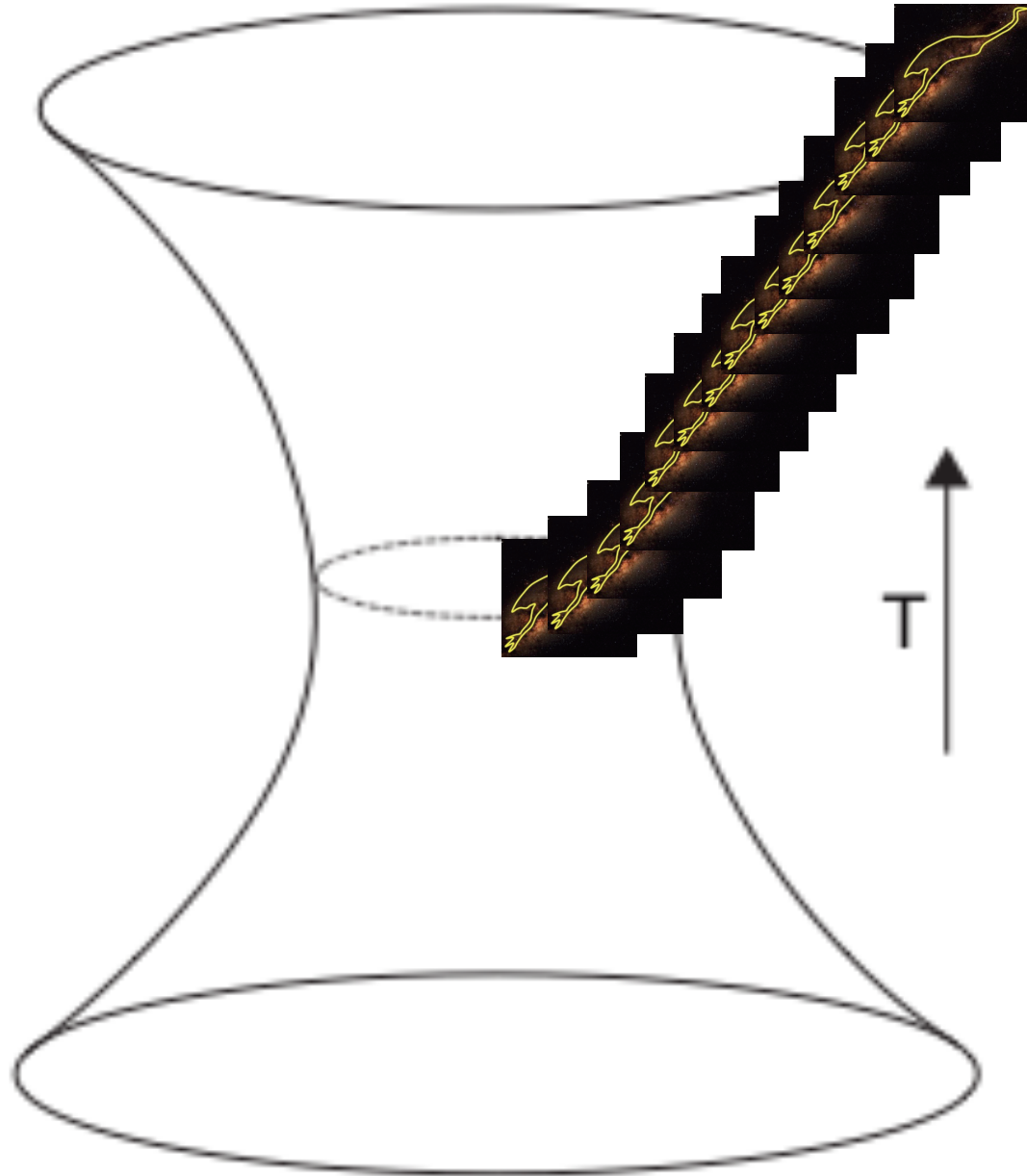


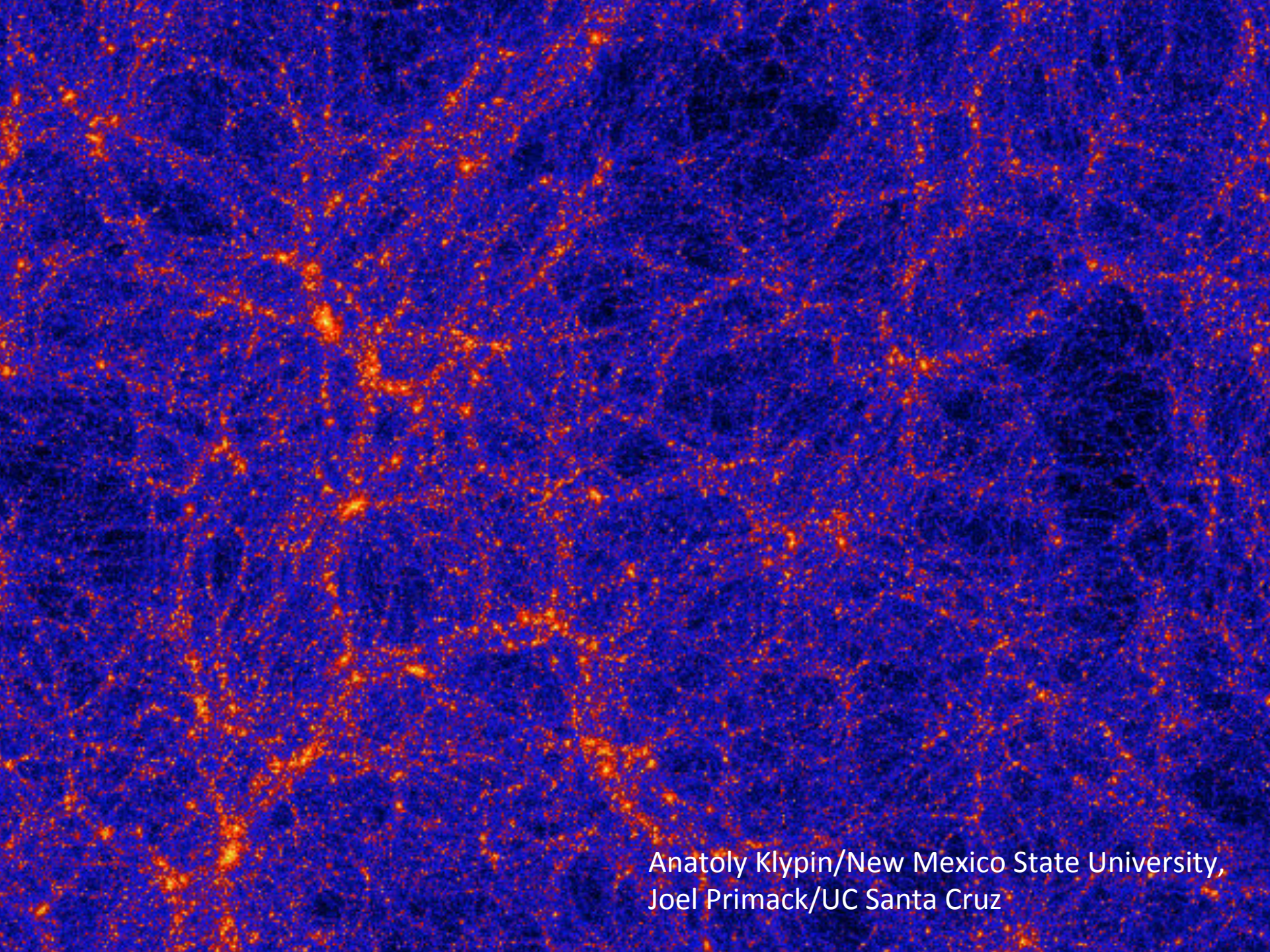
Willem de Sitter
(1872-1934)



de Sitter space

$$R(t) \sim e^{Ht}$$





Anatoly Klypin/New Mexico State University,
Joel Primack/UC Santa Cruz

References

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G. de Vaucouleurs, 1953, Evidence for a local supergalaxy, A. J., 58, 30.

Galaxy Zoo blog

<http://blog.galaxyzoo.org/2008/01/10/in-the-eye-of-the-beholder/>

M.J. Geller and J.P. Huchra, 1989, Mapping the universe, Science, 246, 897.

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Resources

S2Plot <http://astronomy.swin.edu.au/s2plot/index.php?title=S2PLOT>
*D.G.Barnes, C.J.Fluke, P.D.Bourke & O.T.Parry, 2006, Publications of the
Astronomical Society of Australia, 23(2), 82-93.*

Monash University CAVE2

[http://monash.edu/mivp/index.php?
option=com_content&view=article&id=3&Itemid=104](http://monash.edu/mivp/index.php?option=com_content&view=article&id=3&Itemid=104)

Cosmic Flows <http://irfu.cea.fr/cosmography>

Hidden Universe <http://hiddenuniversemovie.com>