



# The outer Universe and the inner...

## -What is the connection?

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National Resource Center for Physics Education  
Lund University

# Space 'n stuff



# Space 'n stuff

- Astronomy is exciting regardless of age and background!
- But also hard to understand...

- It is so **BIG** and **EMPTY!**

- **3D** (or 4D?)

- **LOOK UP!**

**DISCERN!**

**CREAT MEANING!**

# Some examples





Don't we just love all these images?!

# Difficulties?



# Difficulties?



- Distance determination!

# Difficulties?



- Distance determination!
- Vision - to see
  - binocular and monocular

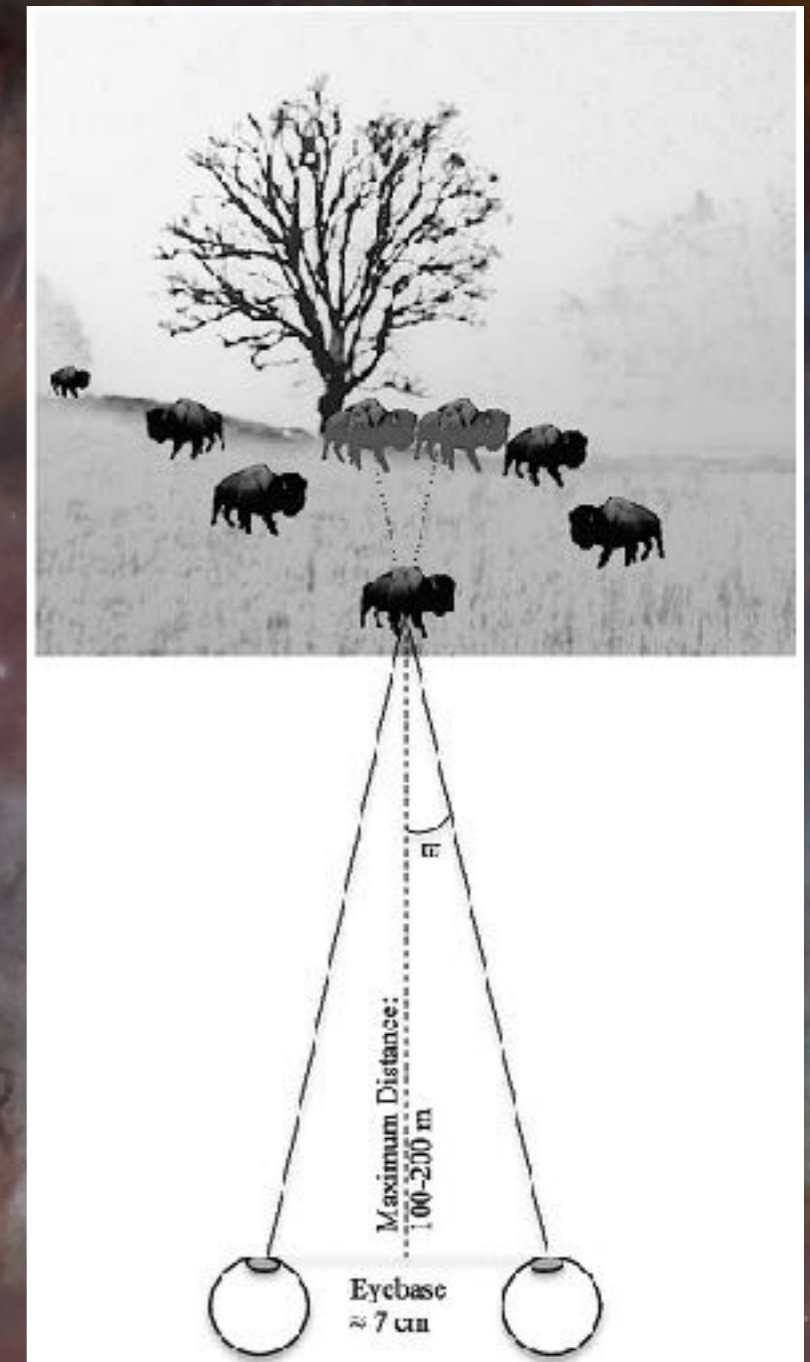




# Difficulties?



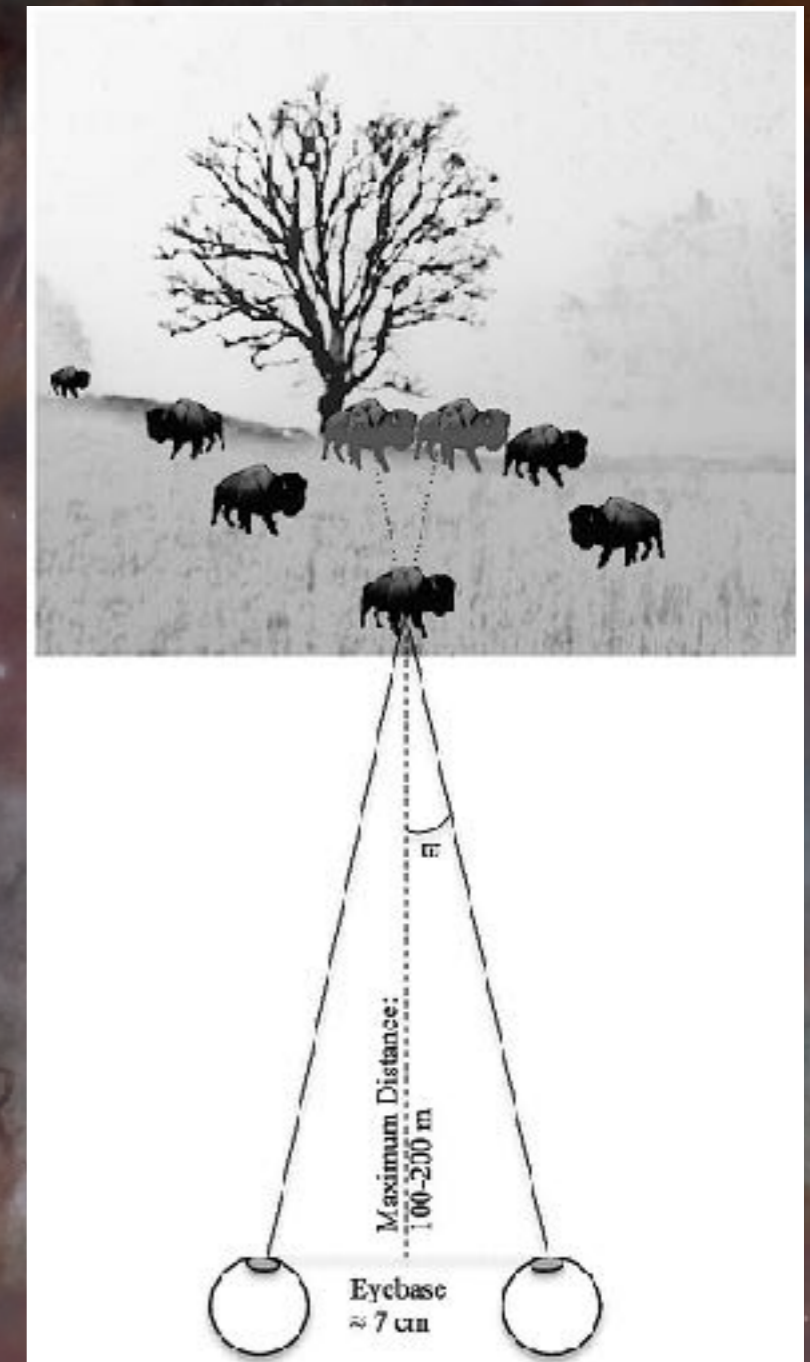
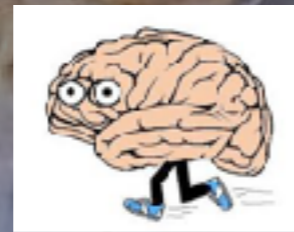
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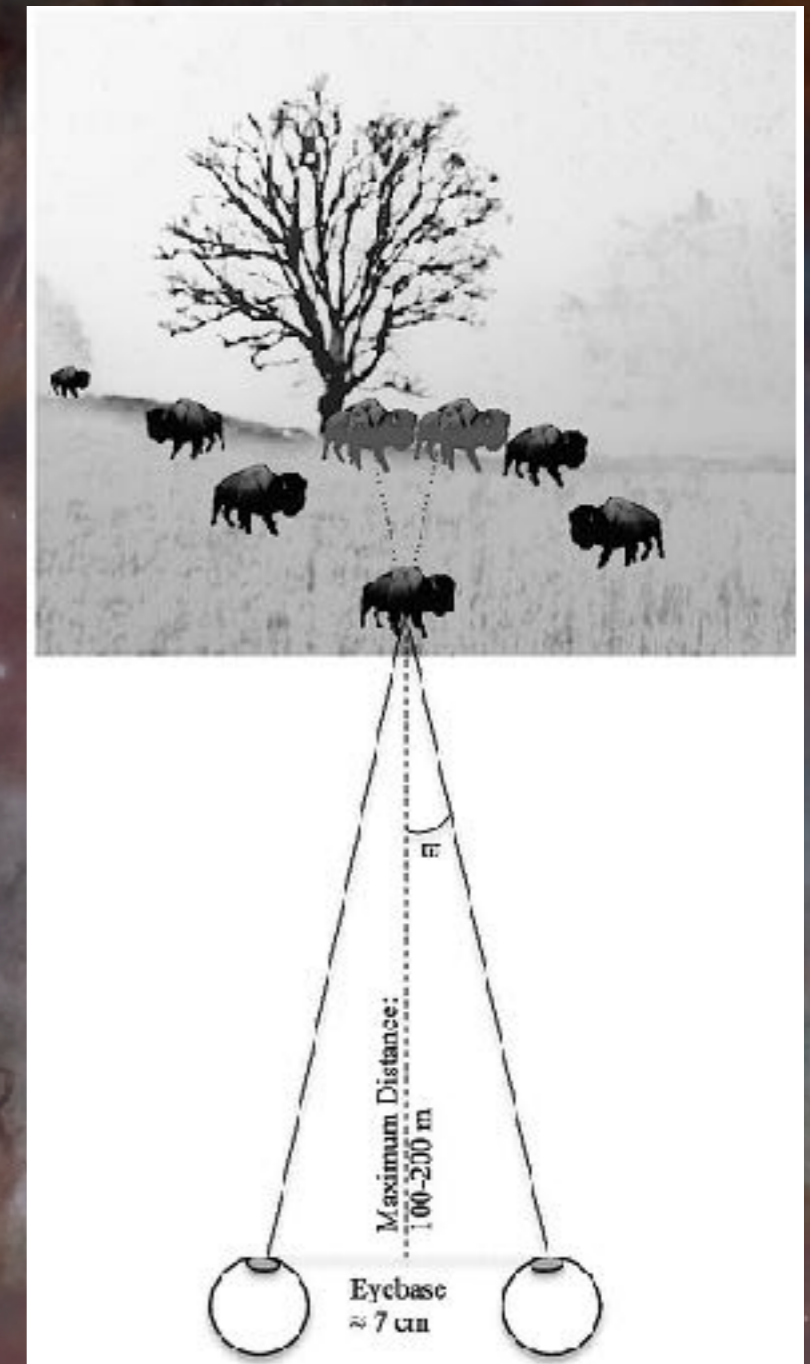
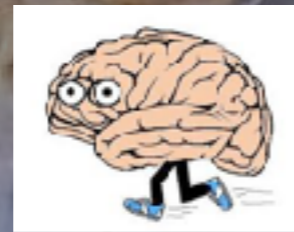
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- The brain



# Difficulties?



- Distance determination!
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- The brain
- Perception!



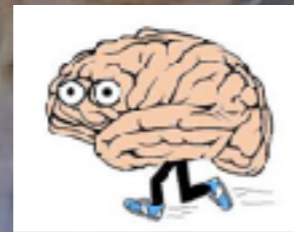
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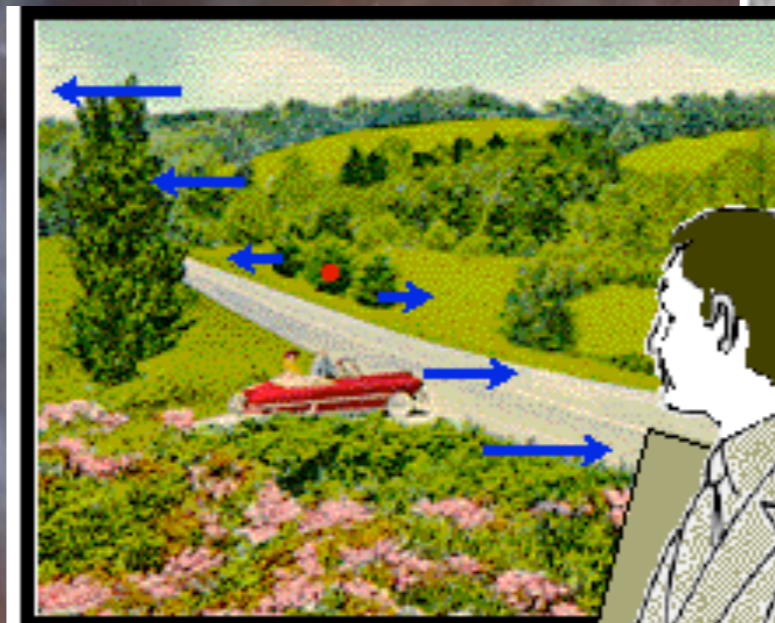


- The brain



- Perception!

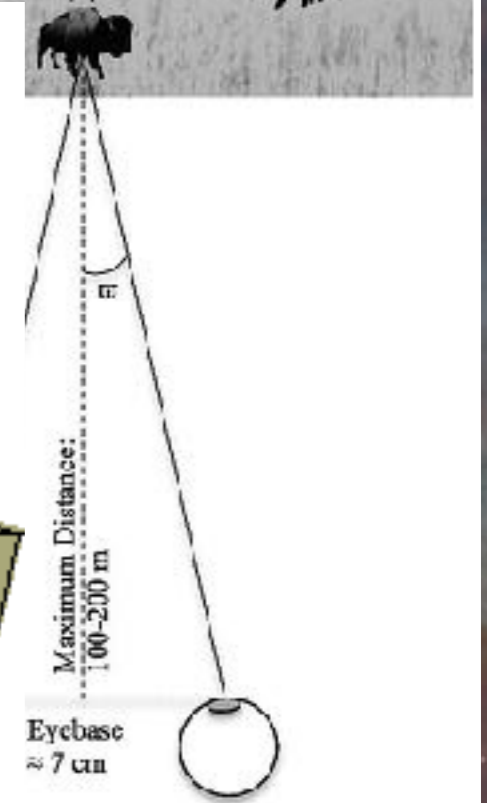
- Motion parallax



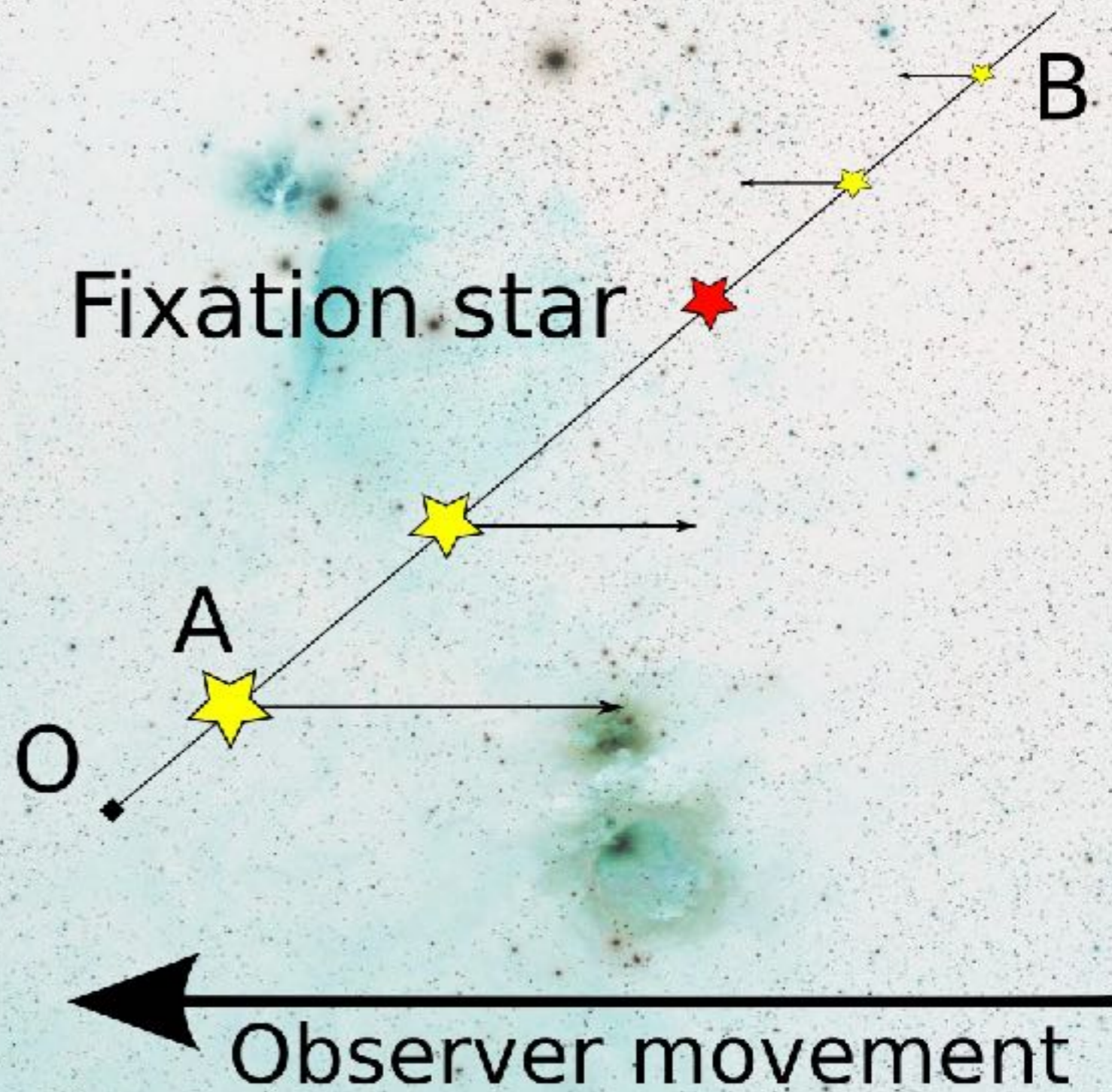
Observer Movement

Motion Parallax

(After Coren & Ward, 1989)



# Motion parallax



# What has been done?

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- Very much research on human difficulties concerning perception connected to the 3D structure of the Universe focusing on The Earth, the Moon and the Sun.

# What has been done?

COGNITIVE SCIENCE **18**, 123–183 (1994)

*British Journal of Educational Psychology* (1998), **68**, 505–516 Printed in Great Britain  
© 1998 The British Psychological Society

## Mental Models of the Day/Night Cycle

STELLA VOSNIADOU

*University of Athens, Greece  
and University of Illinois at Urbana-Champaign*

WILLIAM F. BREWER

*University of Illinois at Urbana-Champaign*

This article presents the results of an experiment which investigated elementary school children's explanations of the day/night cycle. Children were asked to explain certain phenomena: the sun during the night, the disappearance of stars, the movement of the moon, and the alteration of day and night. The majority of the children in our sample used a number of relatively well-defined mental models to explain the day/night cycle. These models were empirically accurate, logically consistent, and a part of the children's issues of simplicity of explanation. The formed initial mental models which provided explanations based on everyday experience (e.g., the sun clouds cover up the sun). The older children constructed (e.g., the sun and the moon revolve around the earth rotates in an up/down direction and opposite sides) which represented attempts to synthesize views with aspects of their initial models. A few children have constructed a mental model of the day/night cycle. A theoretical framework is outlined which distinguishes synthetic, and scientific models of the day/night cycle. A hierarchy of constraints, some of which are life, and others which emerge later out of the structure.

The research reported in this article was supported by the National Science Foundation, BNS-85-10254, from the Office of Educational Research under Cooperative Agreement No. G0087-CI001-90 with the Center and from the Cognitive Science Group, Beckman Institute. This publication does not necessarily reflect the views of the Office of Educational Research.

We would like to thank the principal, teachers and children at the University of Illinois for their help in carrying out this project. We also thank David Dorfman, and Ann Jolly for their help in testing the children, and Christos Ioannides for their comments, and Delores and beyond the call of duty.

Correspondence and requests for reprints should be sent to Stella Vosniadou, Department of Psychology, University of Illinois at Urbana-Champaign, 61820.

## Pupils' explanations of seasonal changes: age differences and the influence of teaching

Eve Kikas\*

*Department of Psychology, University of Tartu, Estonia*

**Background.** Pupils have consistent everyday astronomical explanations, some of which, e.g., distance theory, are very resistant to change. The reasons

### PHYSICS EDUCATION RESEARCH SECTION

The Physics Education Research Section (PERSES) publishes articles describing important results from the field of physics education research. Manuscripts should be submitted using the web-based system that can be accessed via the American Journal of Physics home page, <http://ajp.dickinson.edu>, and will be forwarded to the PERSES editors for consideration.

### Learning about the scale of the solar system using digital planetarium visualizations

Ka Chun Yu<sup>1</sup>

*Department of Space Science, Denver Museum of Nature and Science, 2001 Colorado Boulevard, Denver, Colorado 80205*

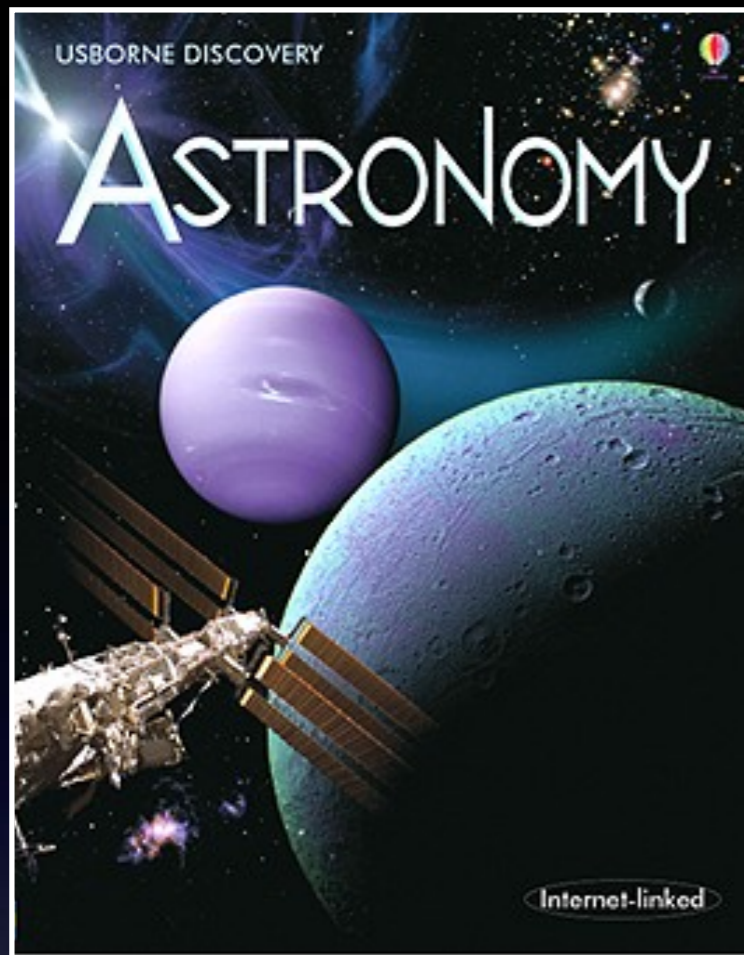
Kamran Sahami<sup>2</sup> and James Dove<sup>3</sup>

*Department of Physics, Metropolitan State University of Denver, Denver, Colorado 80217*

(Received 29 August 2016; accepted 19 March 2017)

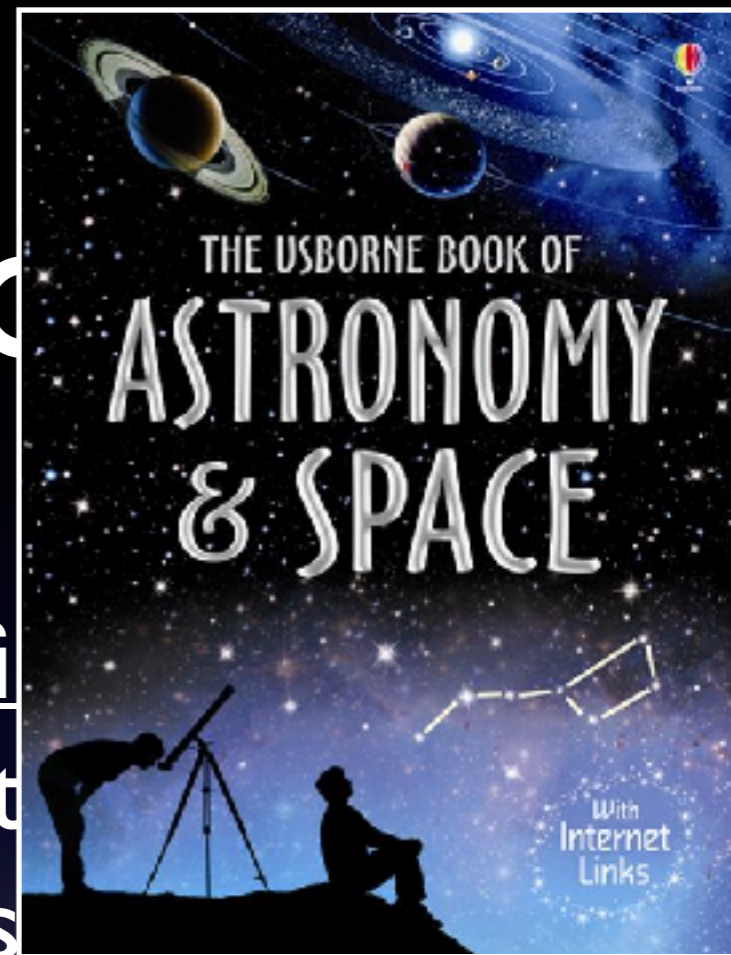
We studied the use of a digital planetarium for teaching relative distances and sizes in introductory undergraduate astronomy classes. Inspired in part by the classic short film *The Powers of Ten* and large physical scale models of the Solar System that can be explored on foot, we created lectures using virtual versions of these two pedagogical approaches for classes that saw either an immersive treatment in the planetarium or a non-immersive version in the regular classroom (with  $N=573$  students participating in total). Students who visited the planetarium had not only the greatest learning gains, but their performance increased with time, whereas students who saw the same visuals projected onto a flat display in their classroom showed less retention over time. The gains seen in the students who visited the planetarium reveal that this medium is a powerful tool for visualizing scale over multiple orders of magnitude. However the modest gains for the students in the regular classroom also show the utility of these visualization approaches for the broader category of classroom physics simulations. © 2017 Author(s). All article content, except where otherwise noted, is licensed under a Creative Commons Attribution 4.0 Unported License. [<http://dx.doi.org/10.1119/1.4984812>]





It has been de

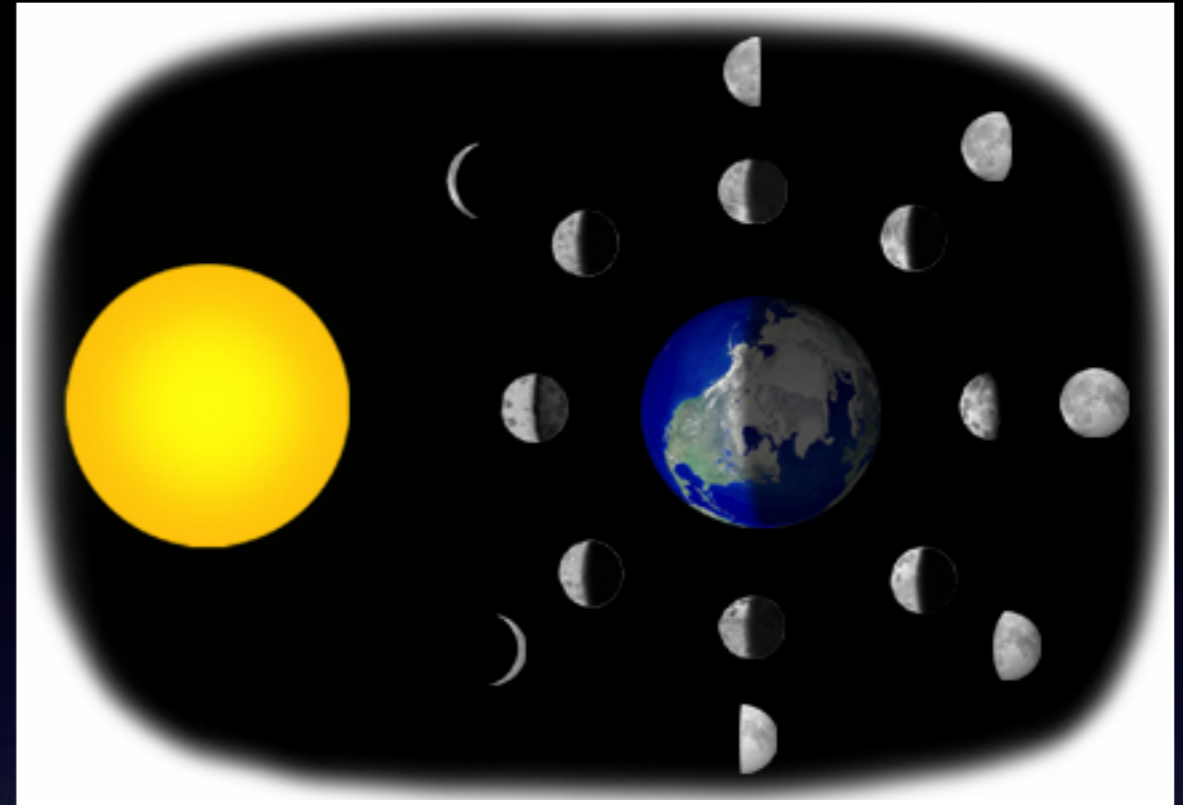
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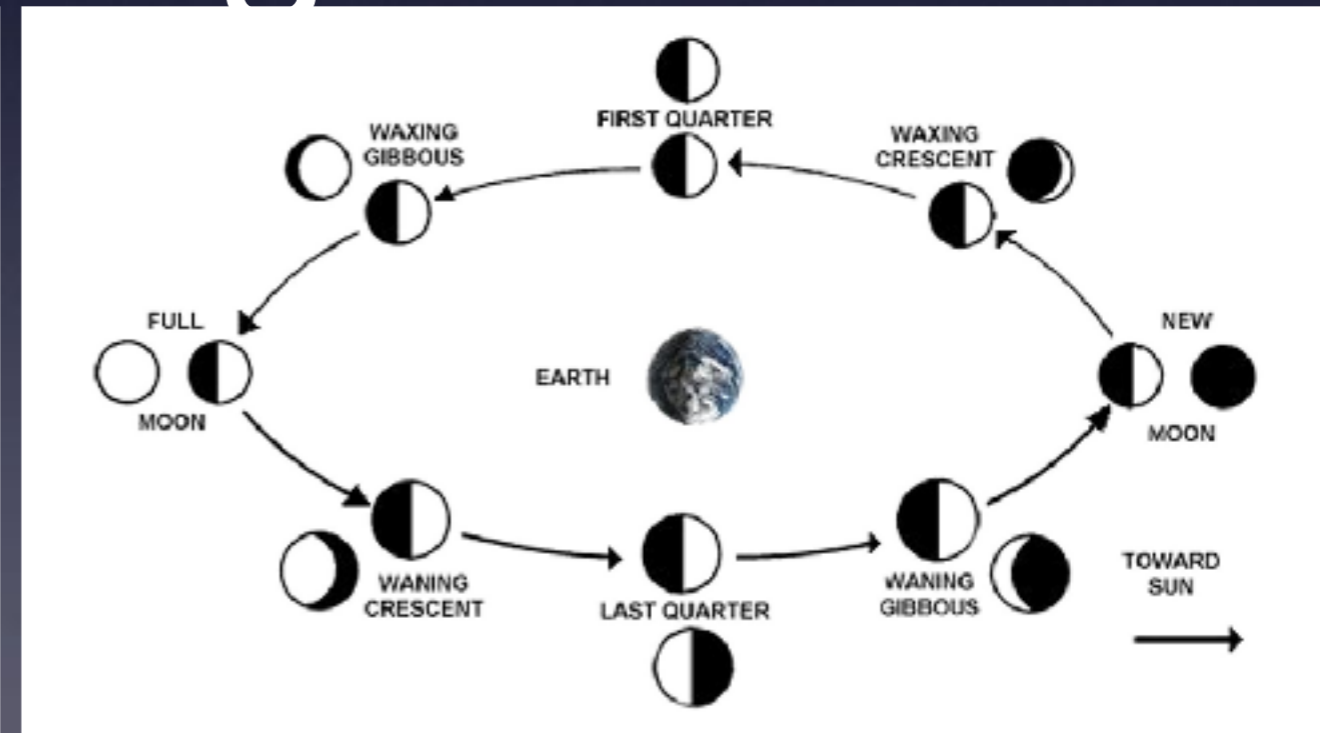
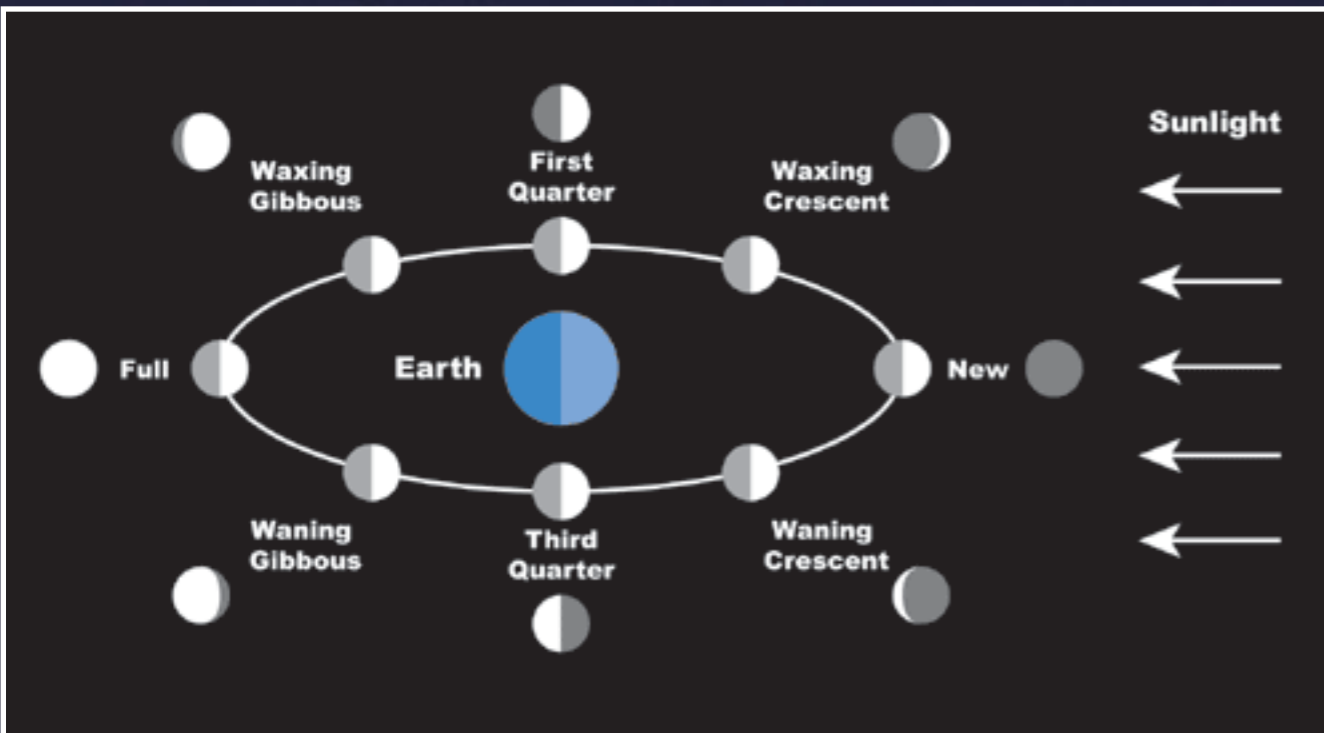
## The Earth, the Moon and the Sun.

- All results show that the *representations* used in eg. books are insufficient, inadequate (2D) and incorrect...

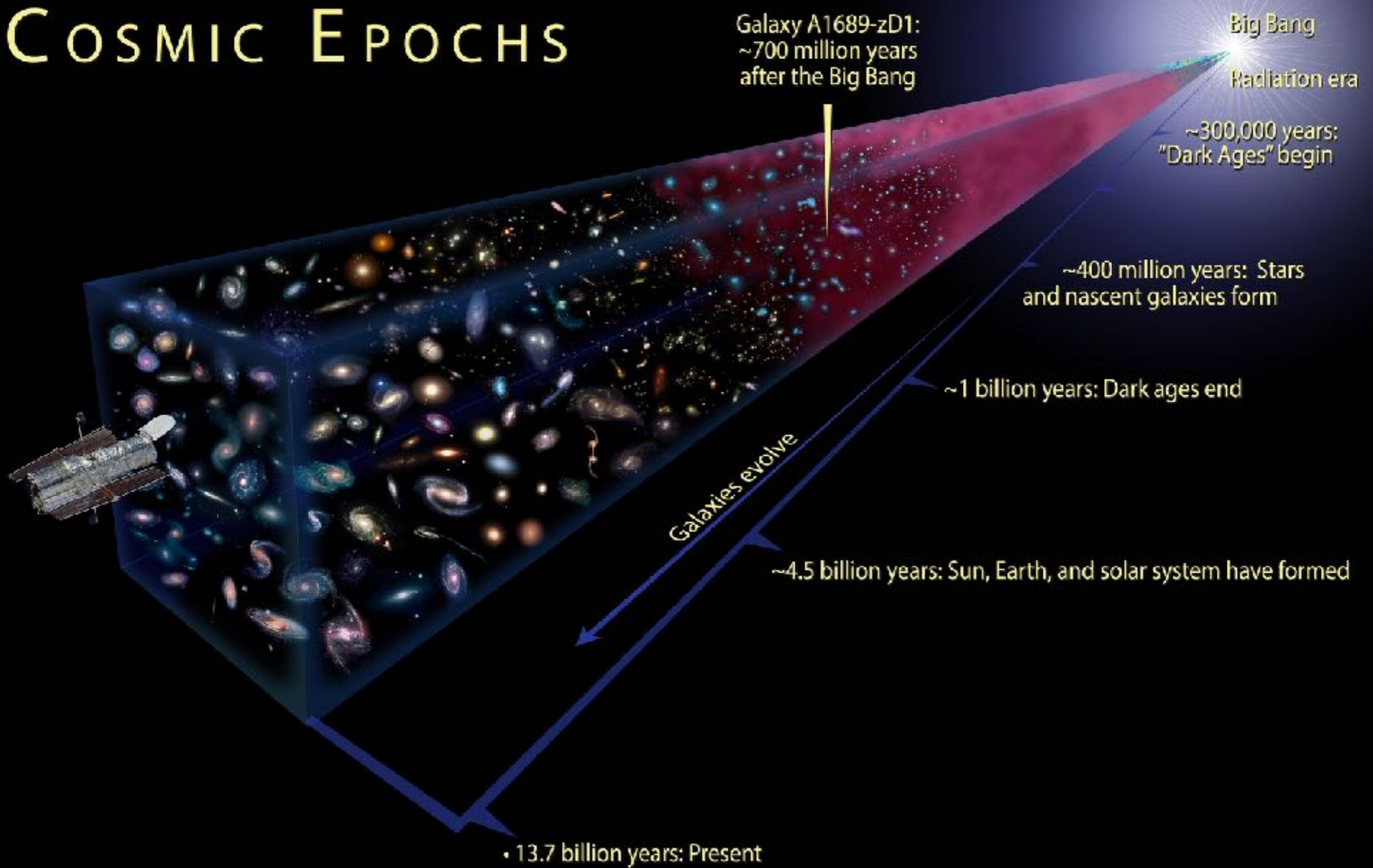
Sometimes it gets really  
confusing...



is  
confusing...



# COSMIC EPOCHS





**3D**

**is what it takes!**



# 3D

is what it takes!

3D models or simulations.

Preferably both!

Planetaria provides these  
possibilities!

# Possibilities!

- Astronomical objects must be possible to see from different angles and in motion  
=> Motion parallax!
- Planetaria provides!
- Not to forget: Physical 3D objects...

# Possibilities?

- What about 3D renderings in planetaria using 3D glasses?
- Not much research on that jet...



# Simulating 3D in planetaria



# Simulating 3D in planetaria

- Easy to simulate e.g. the Sun, the Earth and the Moon
- Phases of the Moon...
- Seasons...



- ... but only few have experienced our universe's 3D structure firsthand...

# Simulating 3D in planetaria



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# Simulating 3D in planetaria

- But is it really 3D?
- 2D on a curved surface
- Immersive
- So, the visitor will need to extrapolate three-dimensionality in their minds from the 2D immersive input.

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- But is it really 3D?
- 2D on a curved surface
- Immersive
- So, the visitor will need to extrapolate three-dimensionality in their minds from the 2D immersive input.
- How good are people at doing that?

# The inner Universe

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- What do people notice, or ***discern***, when looking at our planetarium presentations?
- Very little...
- Motion; Distance; Relative sizes; Structural detail; Change of perspective; and 3D.



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# The inner Universe

- What do people notice, or ***discern***, when looking at our planetarium presentations?
- Very little...
- **Motion; Distance; Relative sizes; Structural detail; Change of perspective; and 3D.**
- BUT! With a little help (scaffolding) people discern much more and build a better understanding of the multidimensional structure of the Universe.

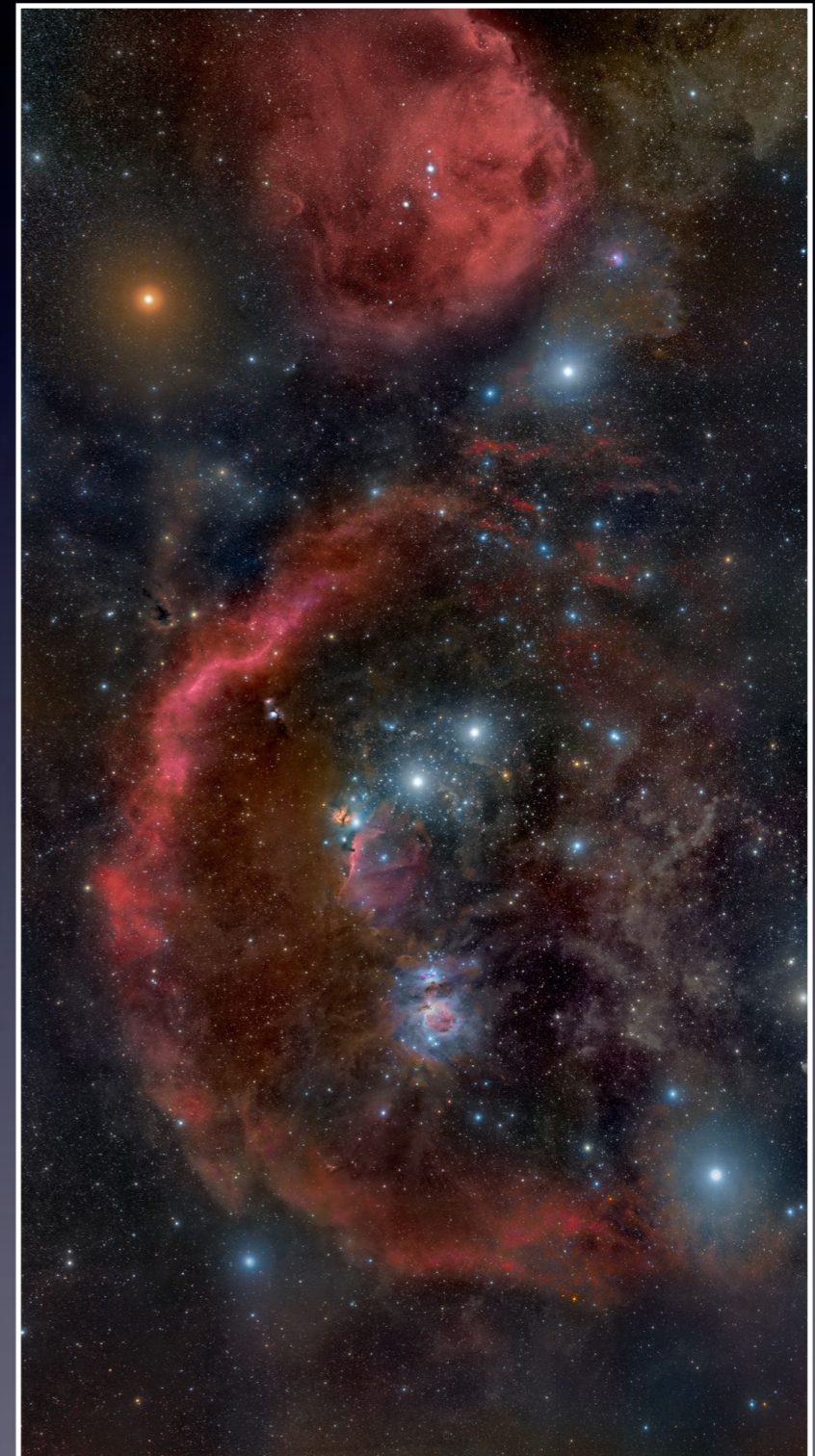
# Disciplinary discernment

- What is important to look at and discern?
- How do one know?
- Very large differences in what movies and experts discern
- The Anatomy of Disciplinary Discernment (ADD) (Eriksson et al. 2014)



# Spatial thinking

- Very hard to imagine what an object in space look like in 3D(4D).
- Again large differences between novice and expert
- Extrapolating 3D in ones mind from a 2D representation
- Motion parallax may be the key to success!



# An example from the planetarium -the Solar System

# Exempel på vad man kan göra

- Från simuleringsprogrammet Uniview
  - Solsystemet
  - Galaxen
- Planetariebesök



An example from the planetarium  
-Our galaxy







# Intergalactic journey



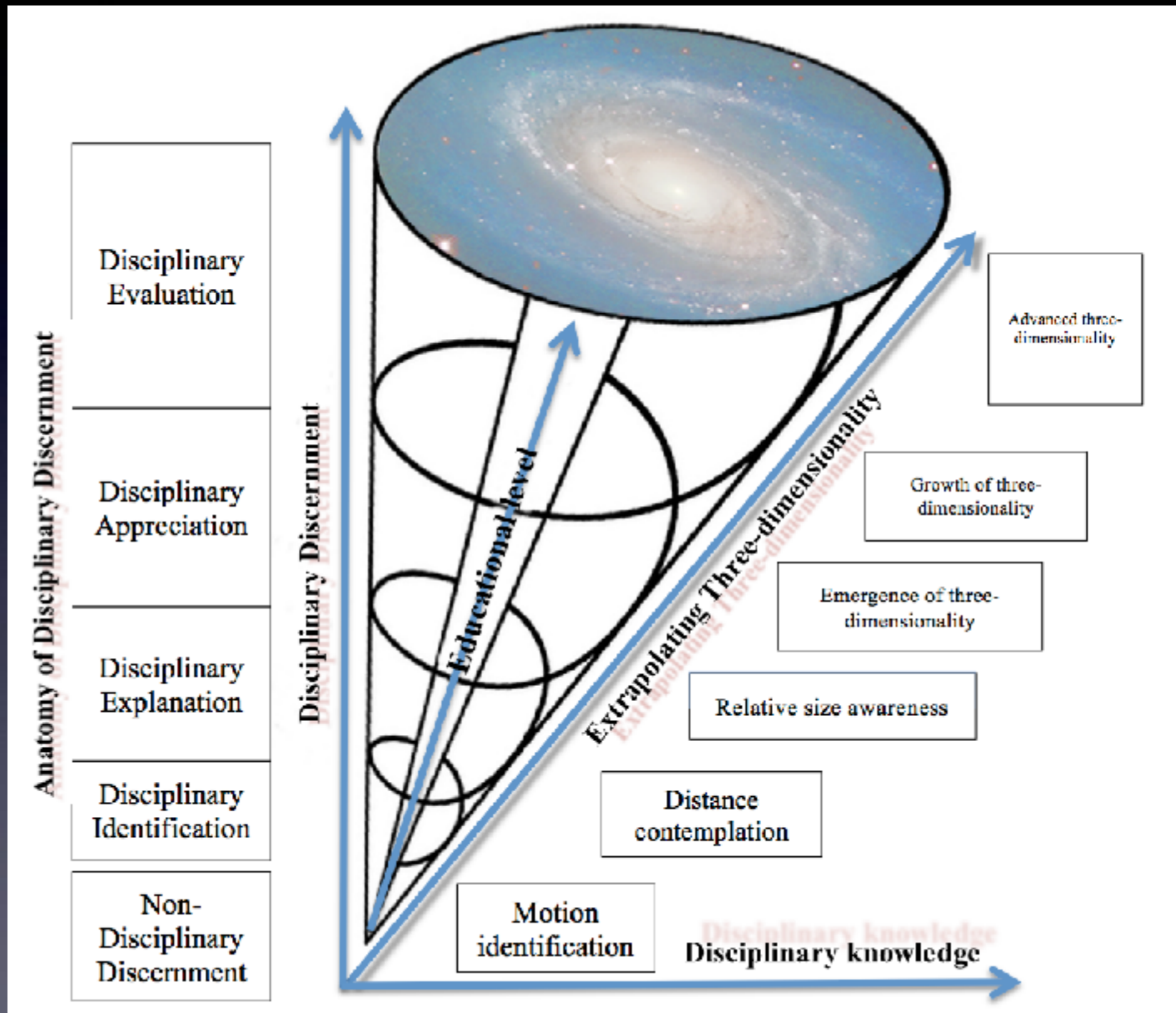
# Intergalactic journey



# What did *you* discern?

- What does a planetarium visit offer?
  - Astronomical object?
  - Properties?
  - 3D?
  - 4D?
- Differences between inner and outer universe?

# The Spiral of Teaching and Learning



# Discussion

- How can planetaria be used for formal learning of astronomy and astrophysics?
  - Research informed approaches exist (Eriksson, 2014; Yu et al., 2015, 2016, 2017)
- Astronomy education research (AER) is a growing field - However, not much done on formal learning in planetaria.
- The question is how to use the technology in the best possible way to create learning experiences and avoid cognitive overload (Mayer, 2009) - the "Star War" effect...

# Conclusions



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- To experience the Universe one need to open ones' mind and **"look up"**!
- It is first then that one starts to notice things and differences between things and build a 3(4)D understanding of the Universe in ones mind.

# Conclusions

- It is not easy to understand either the outer or the inner Universe!
- To understand the Universe one need **experiences** and **disciplinary knowledge**!
- To experience the Universe one need to open ones' mind and **"look up"**!
- It is first then that one starts to notice things and differences between things and build a 3(4)D understanding of the Universe in ones mind.
- Then the gap between the outer and inner Universe diminishes.

# Finally...



Finally...

**KEEP LOOKING UP!**



# Thanks for discerning!

[urban.eriksson@fysik.lu.se](mailto:urban.eriksson@fysik.lu.se)