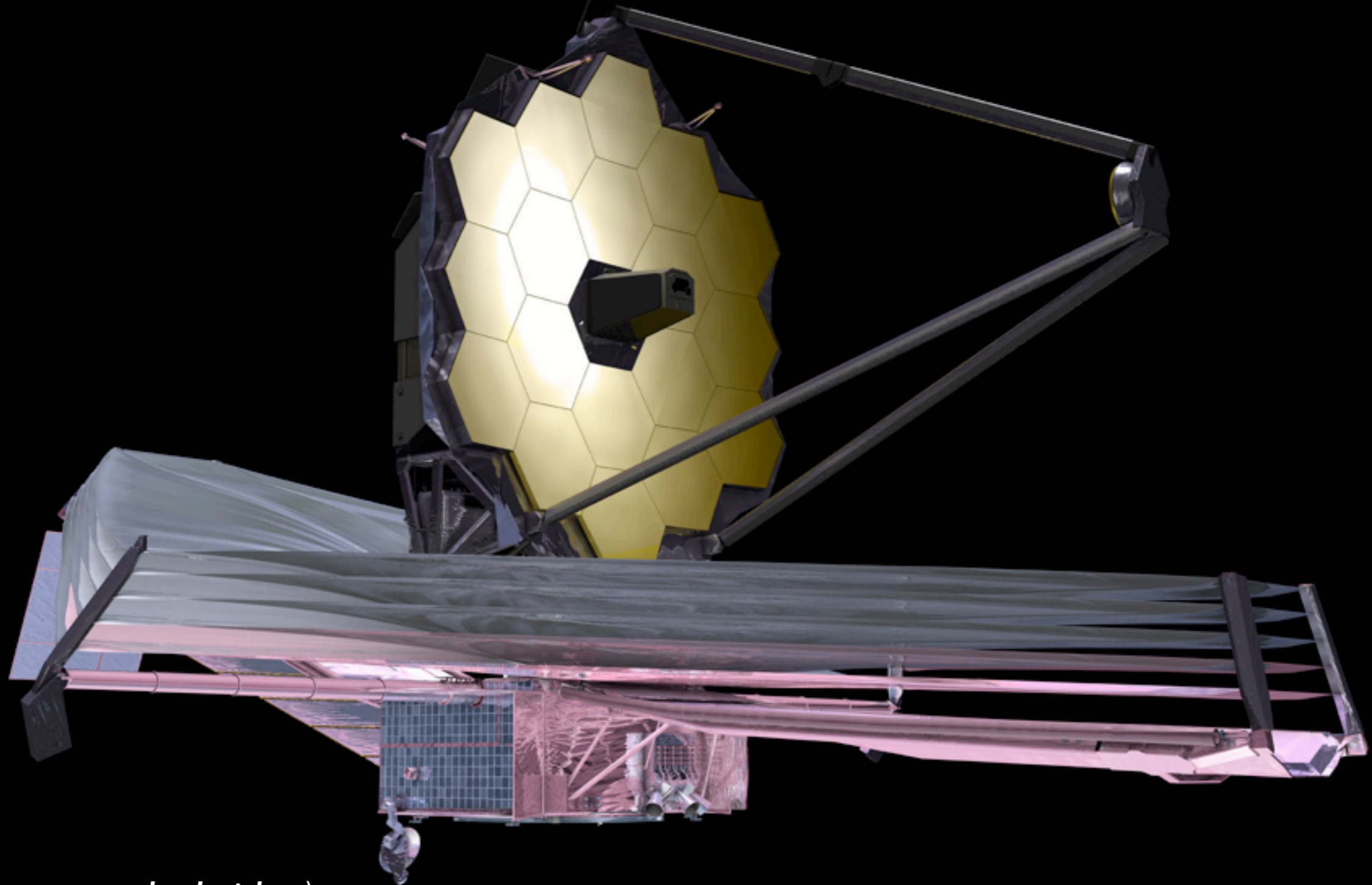


# The James Webb Space Telescope

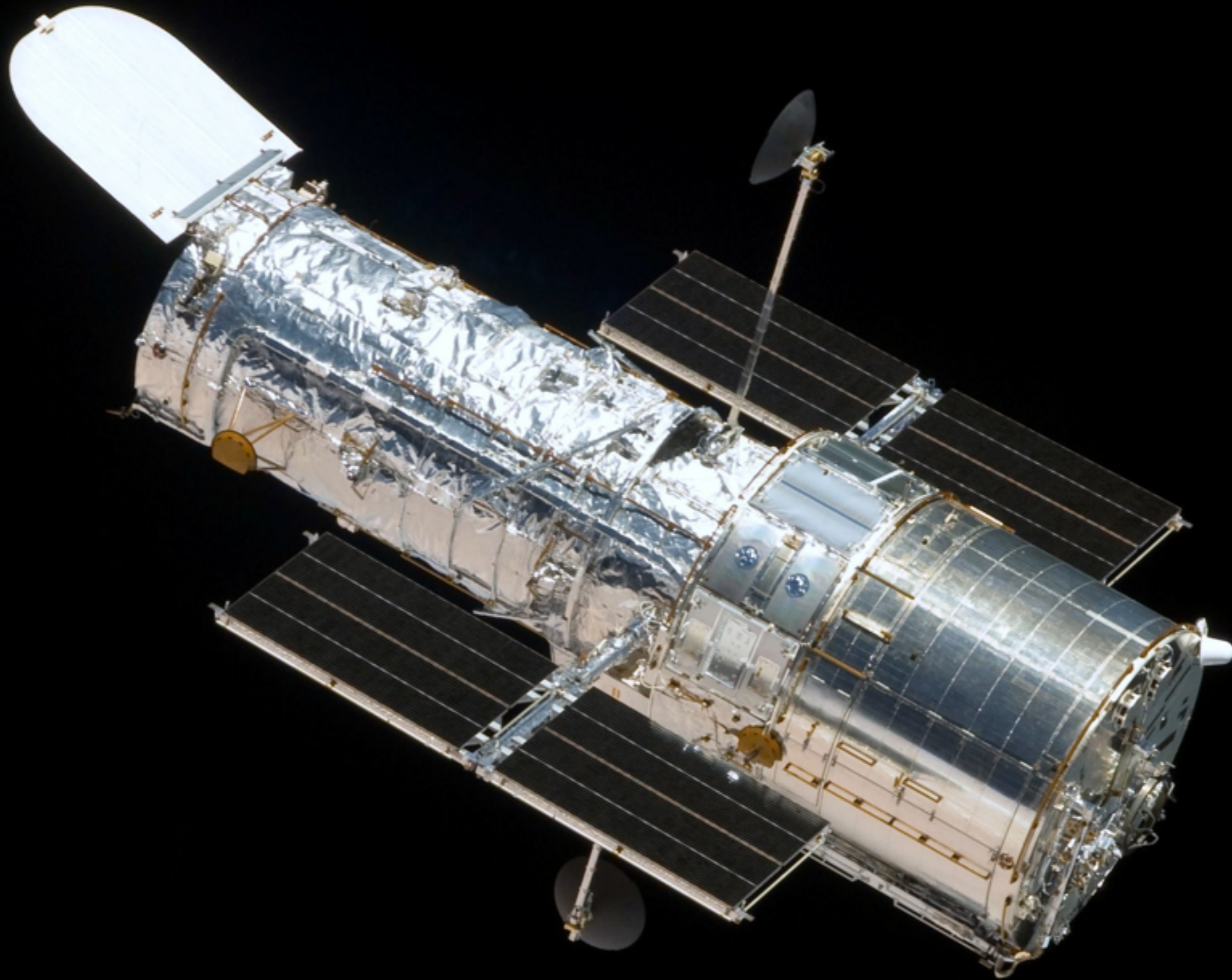
*van het eerste licht in het heelal tot het ontstaan van leven*



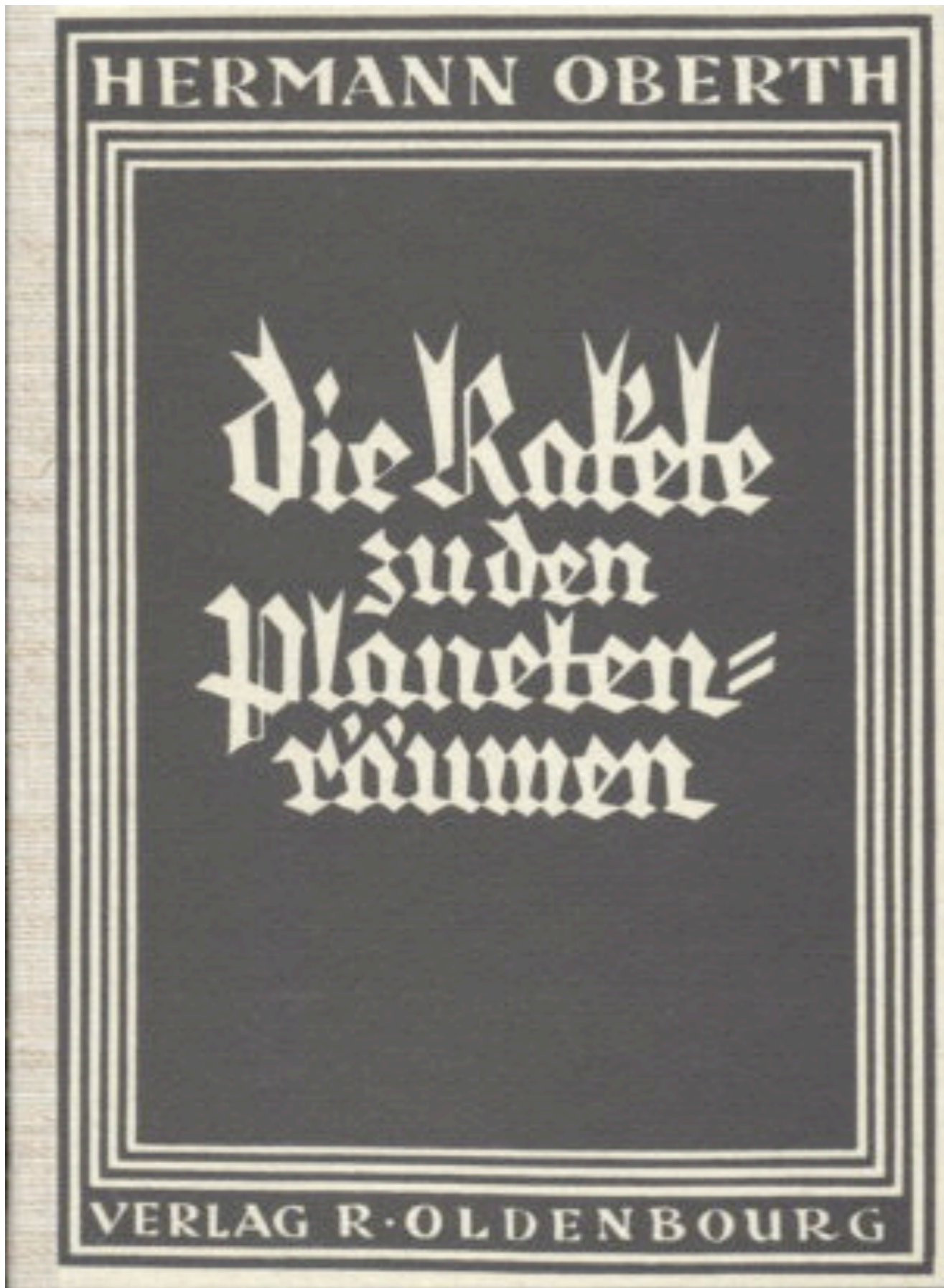
*Ivo Labbé (Sterrewacht Leiden)*

*WDN, 13 dec 2013*

# Hubble Space Telescope

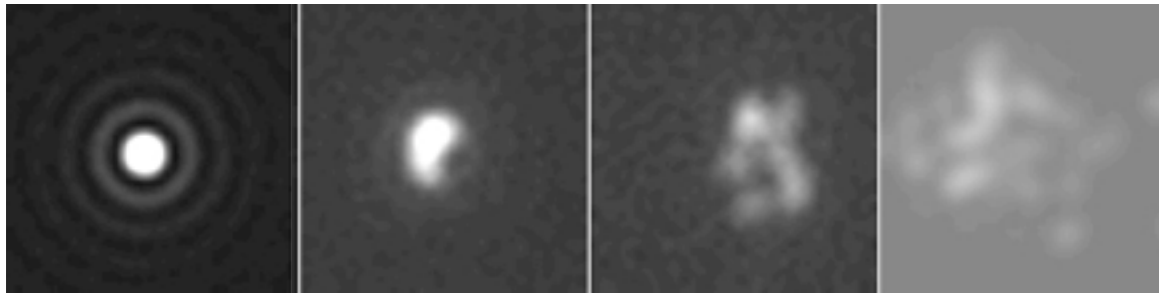
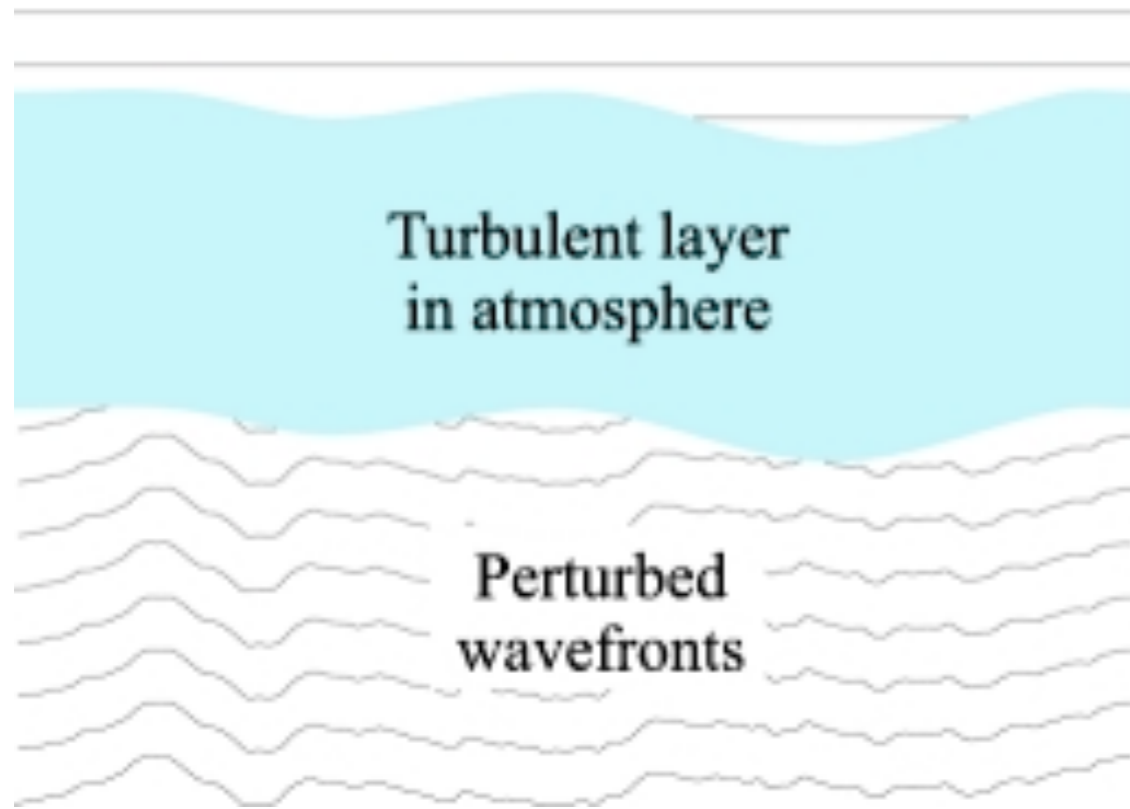






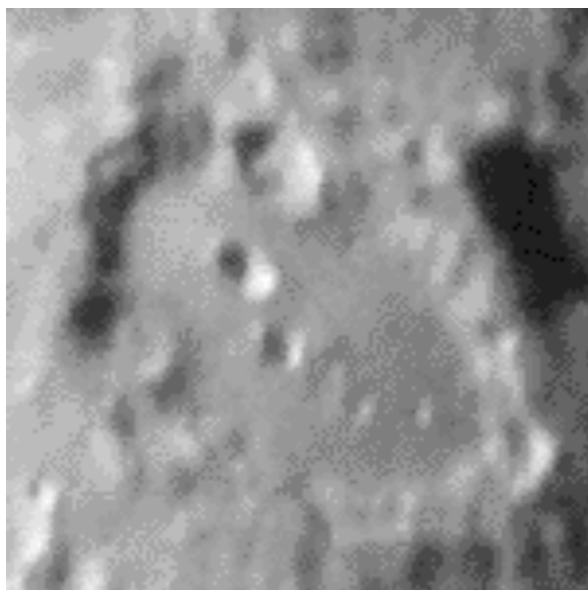
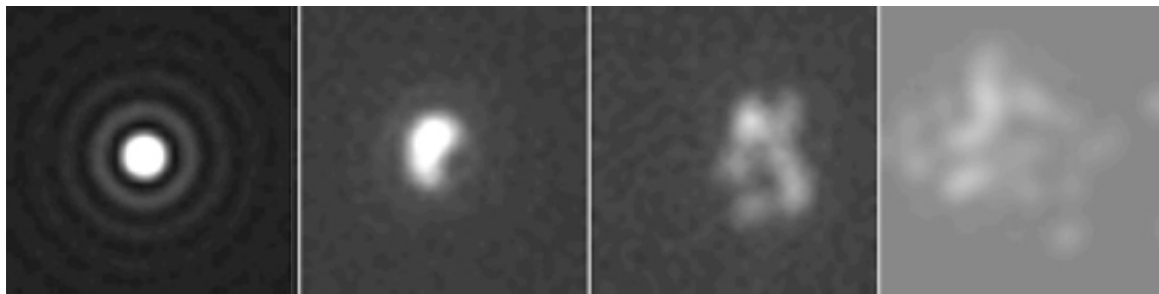
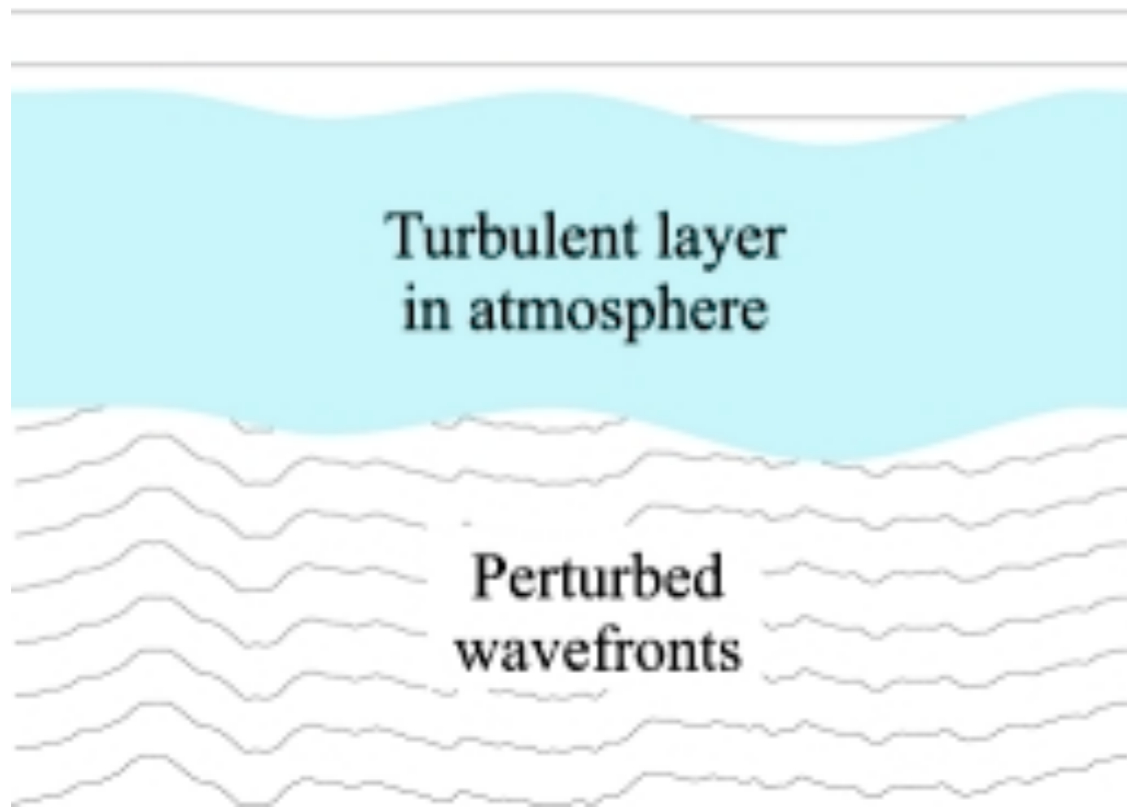
1923

# Aarde: seeing 1''

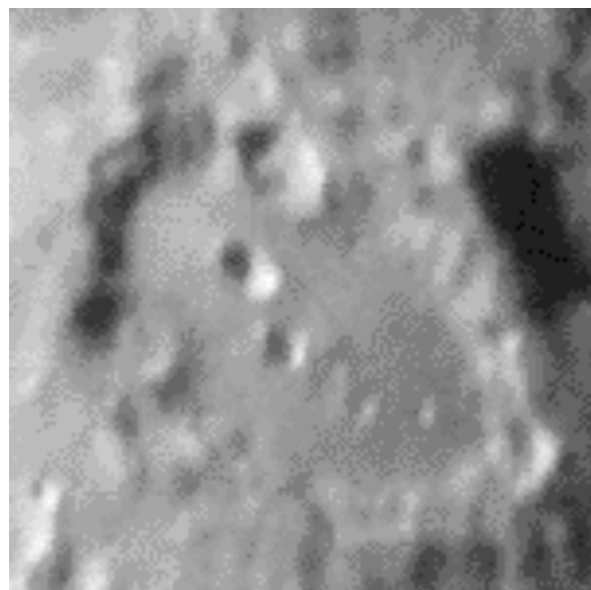
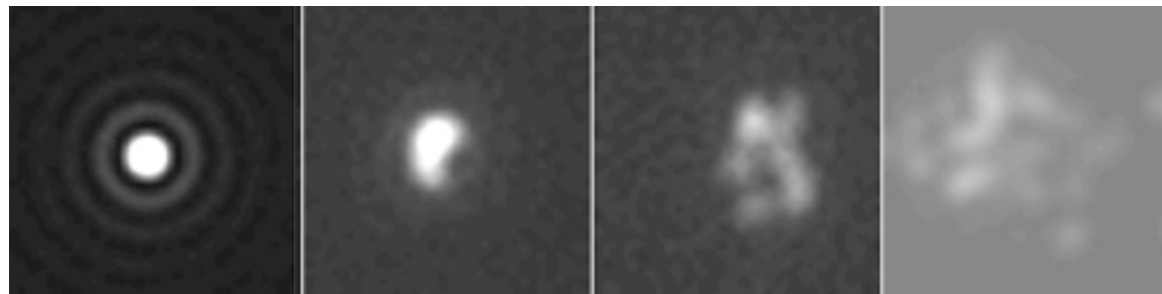
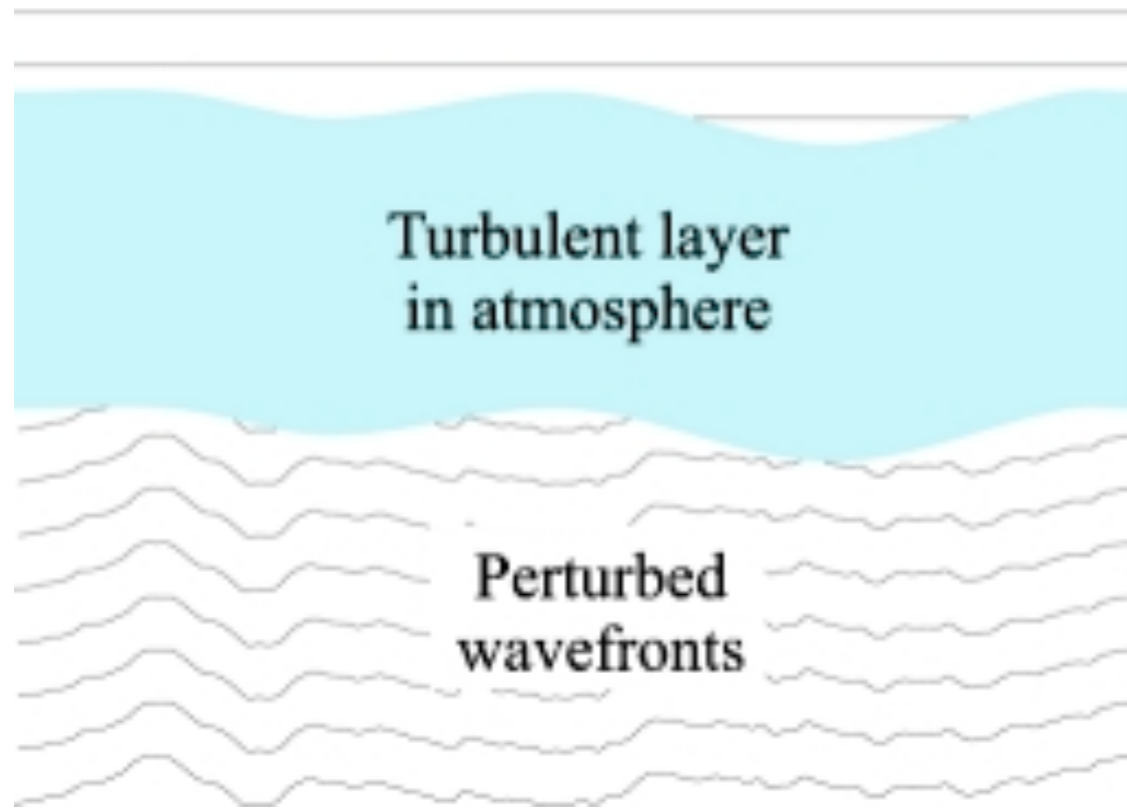




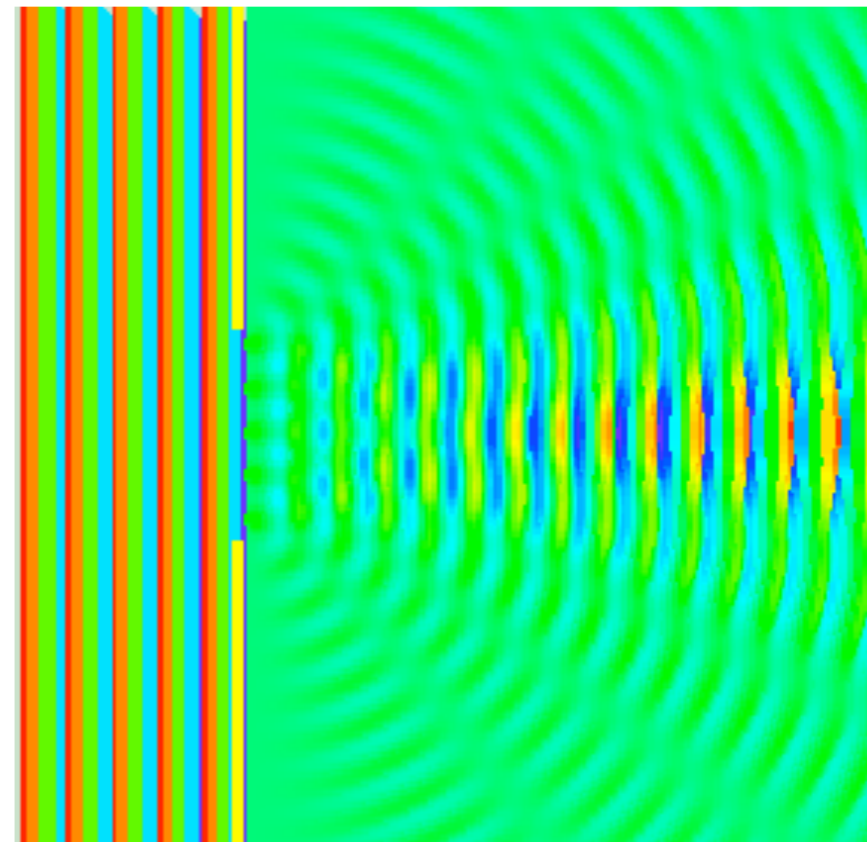
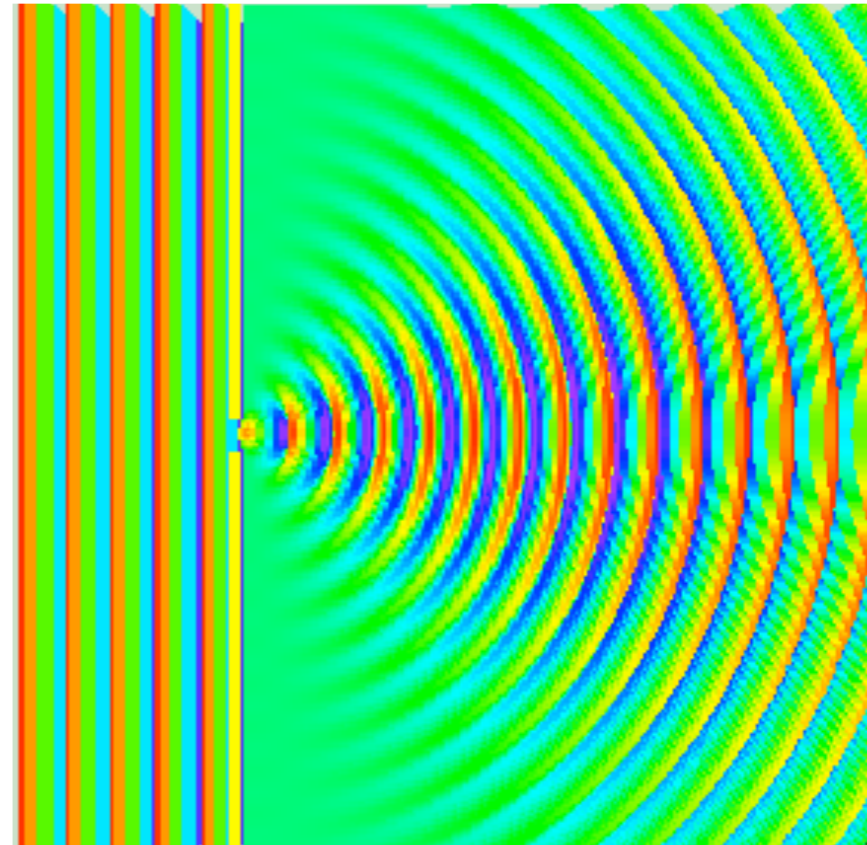
# Aarde: seeing 1''



Aarde: seeing 1''

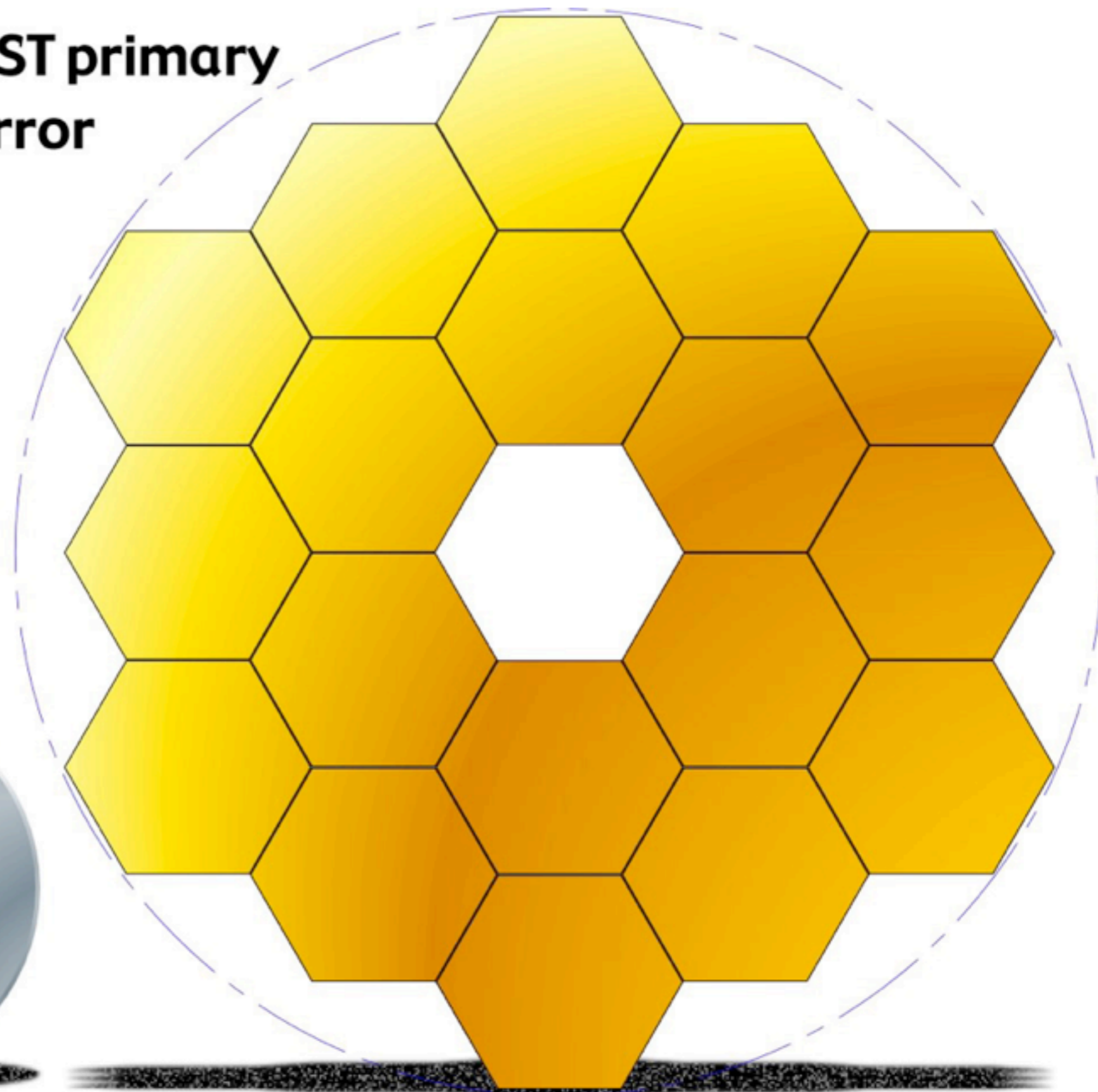


Ruimte: diffractie  $\propto \lambda/D$

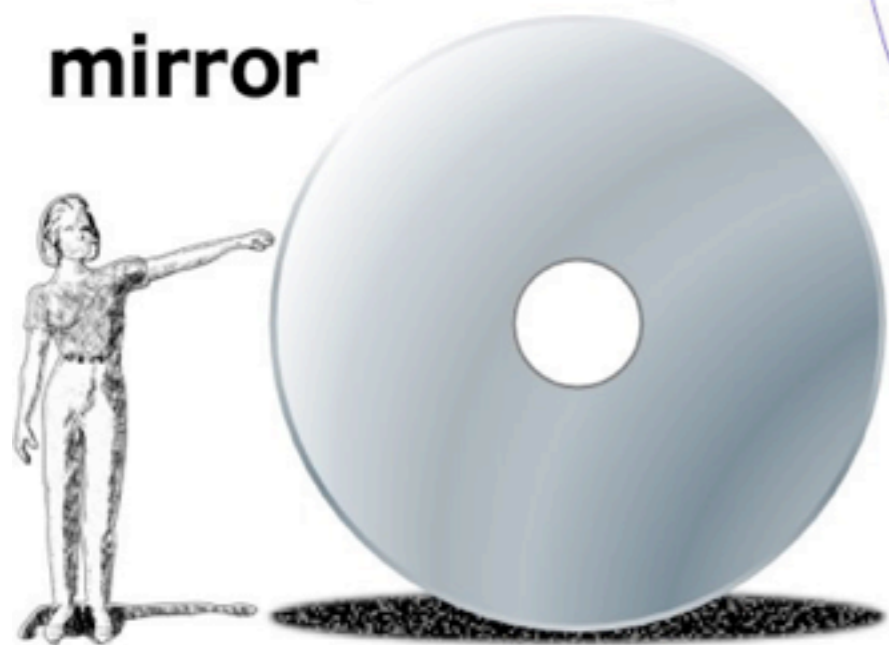


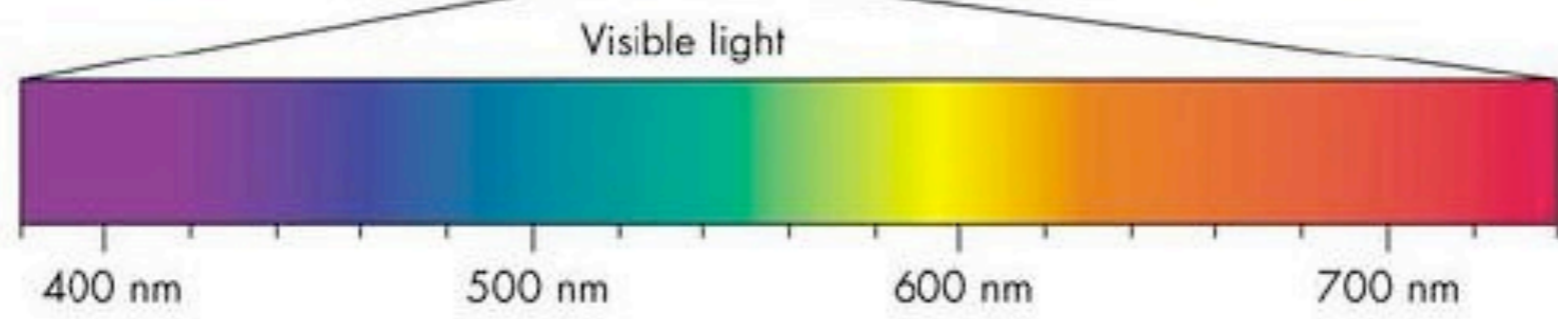
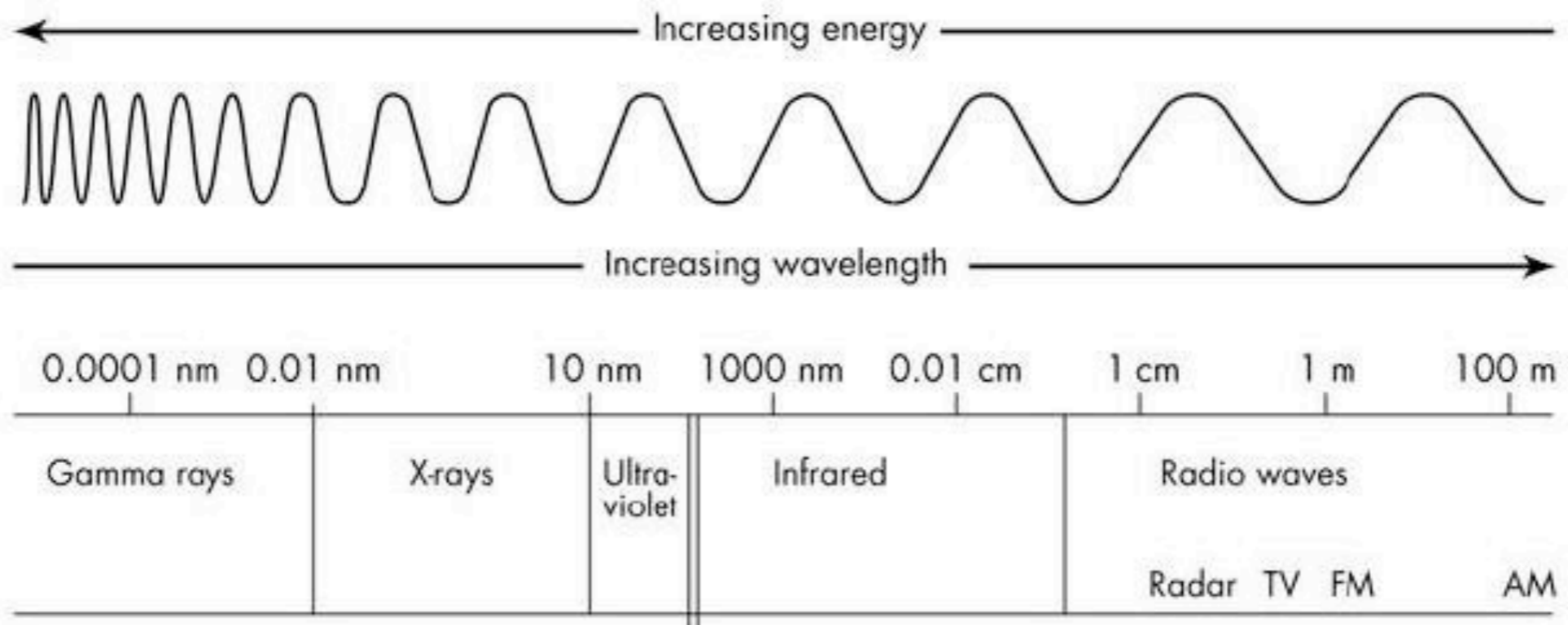


**JWST primary  
mirror**



**Hubble primary  
mirror**

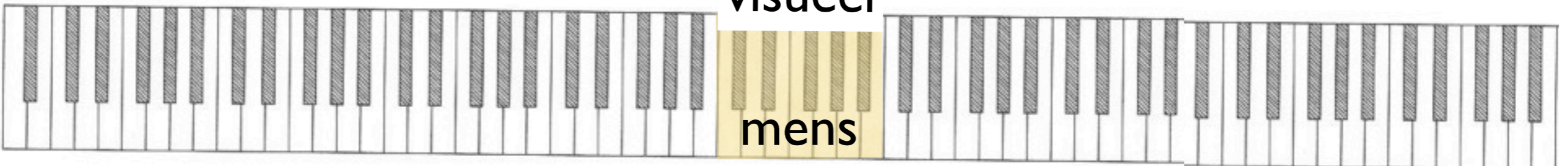
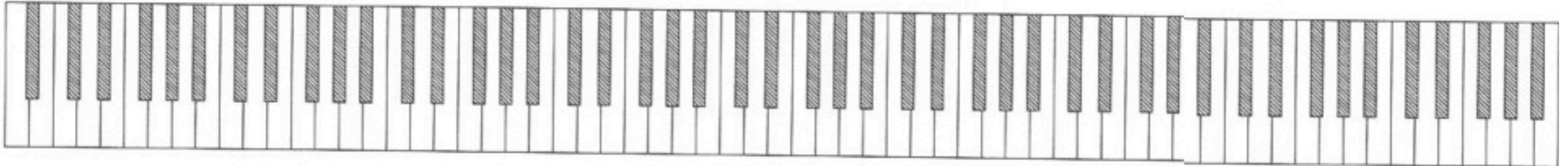
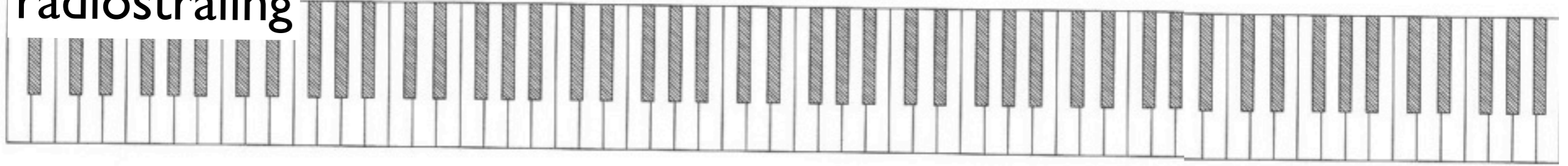






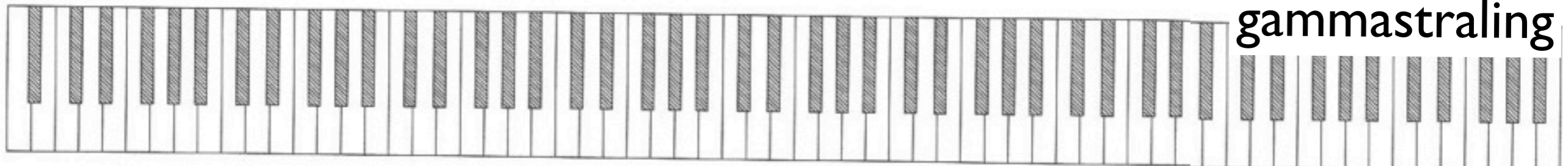
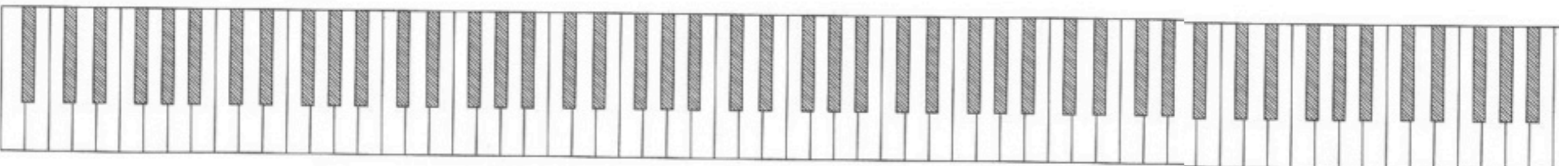
# Muziek der sferen

radiostraling



visueel

mens

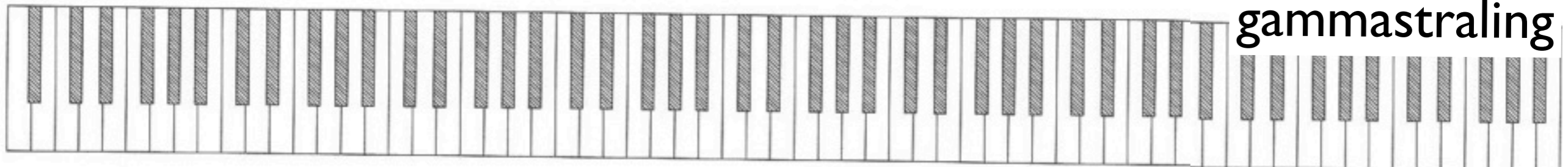
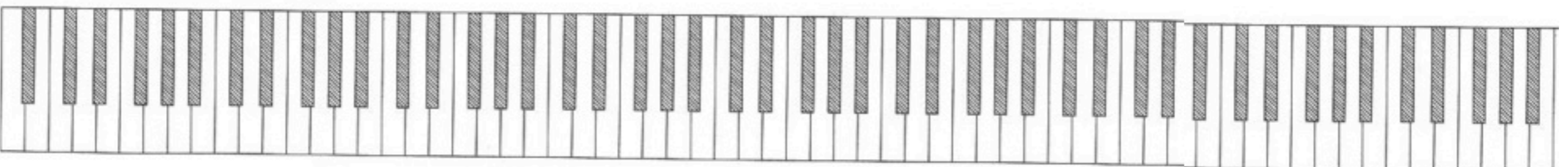
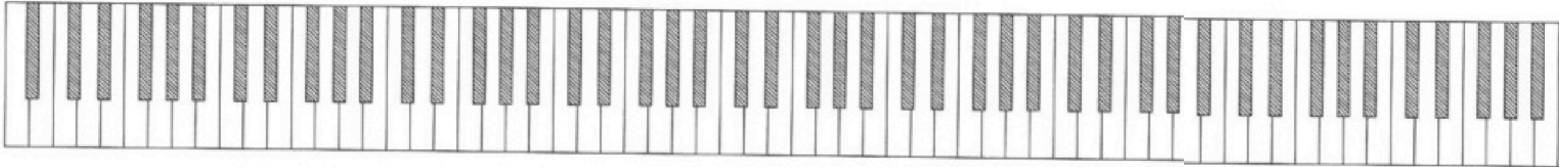
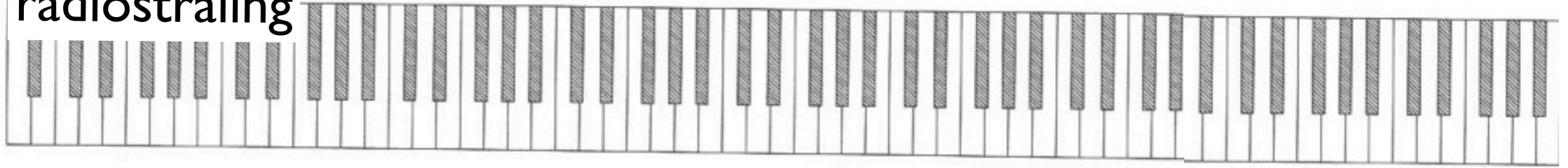


gammastraling



# Muziek der sferen

radiostraling



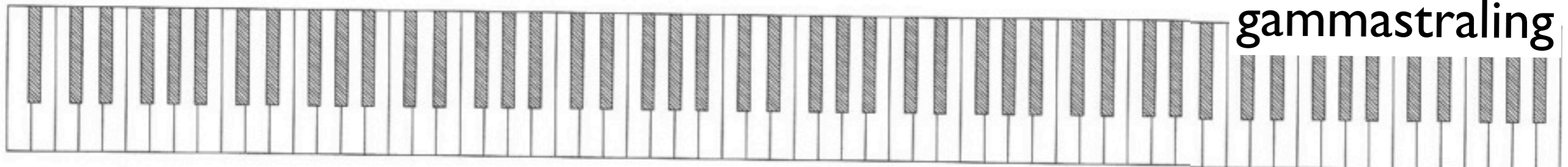
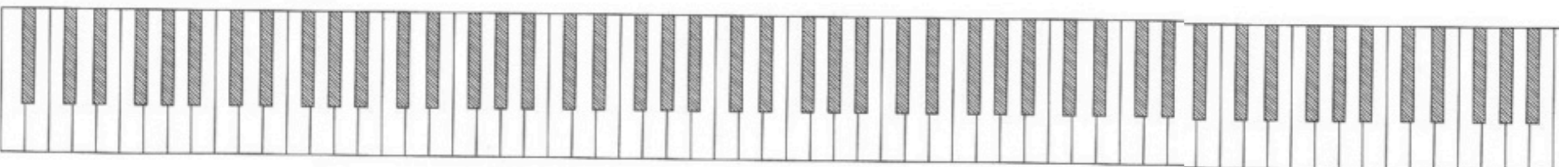
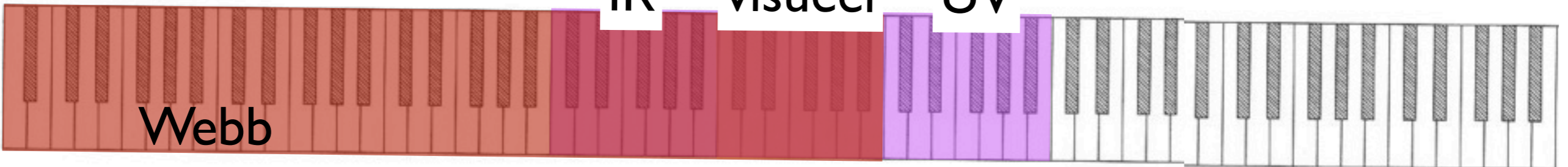
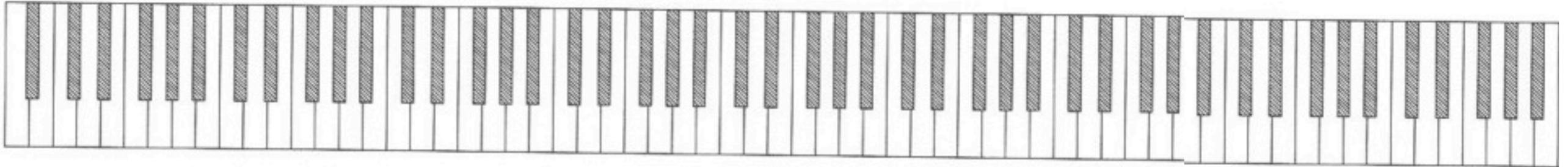
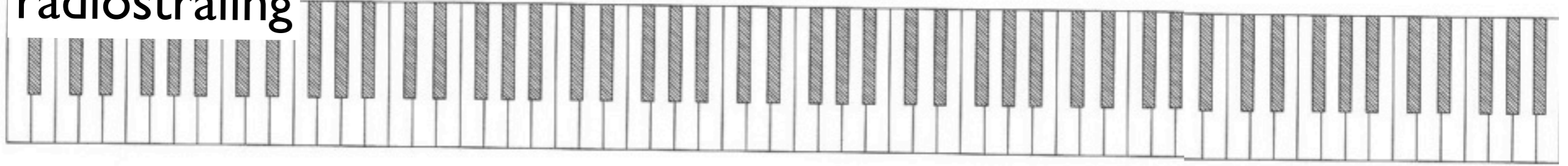
IR visueel UV  
Hubble

gammastraling



# Muziek der sferen

radiostraling



Webb

IR

visueel

UV

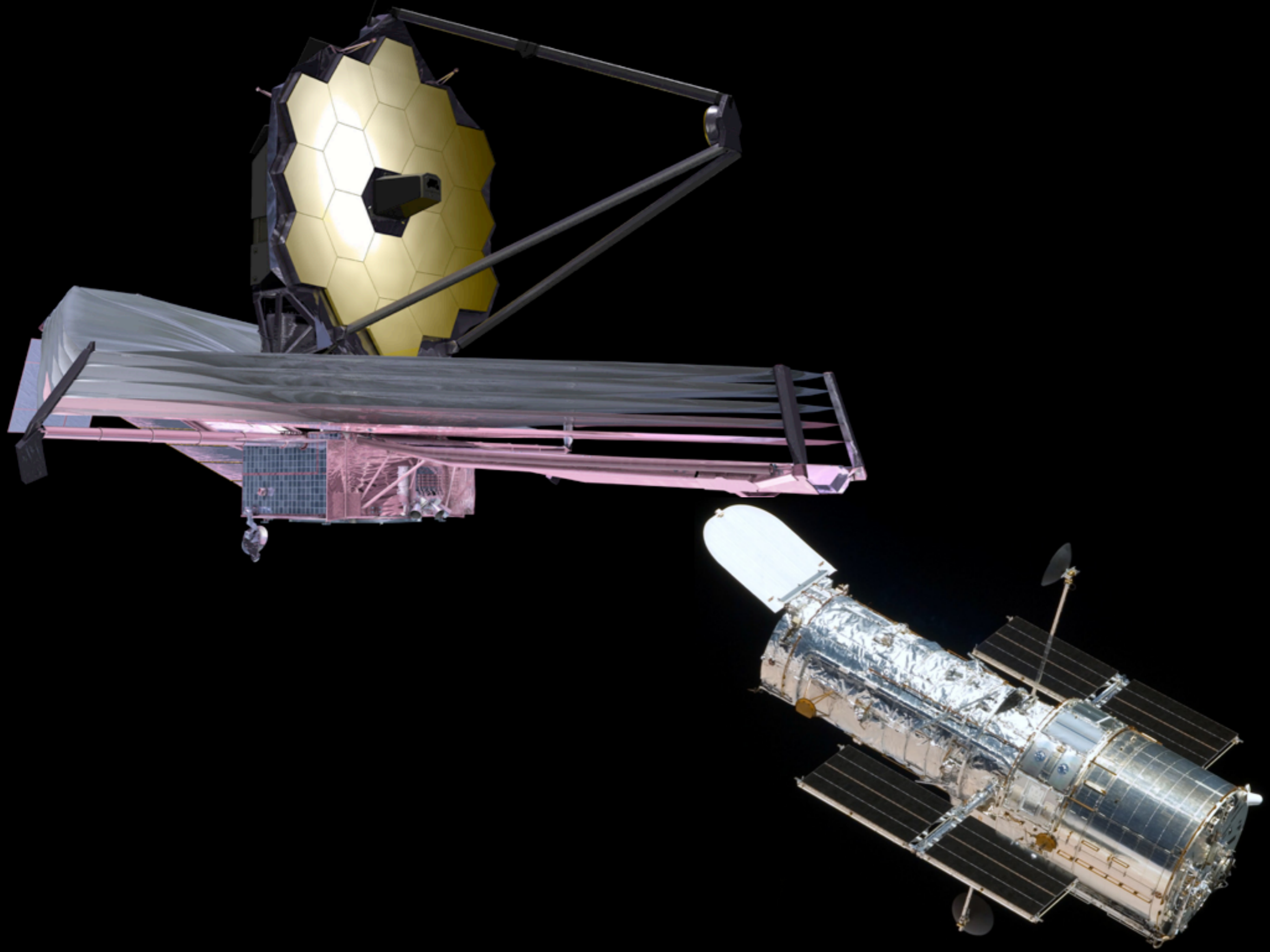
gammastraling











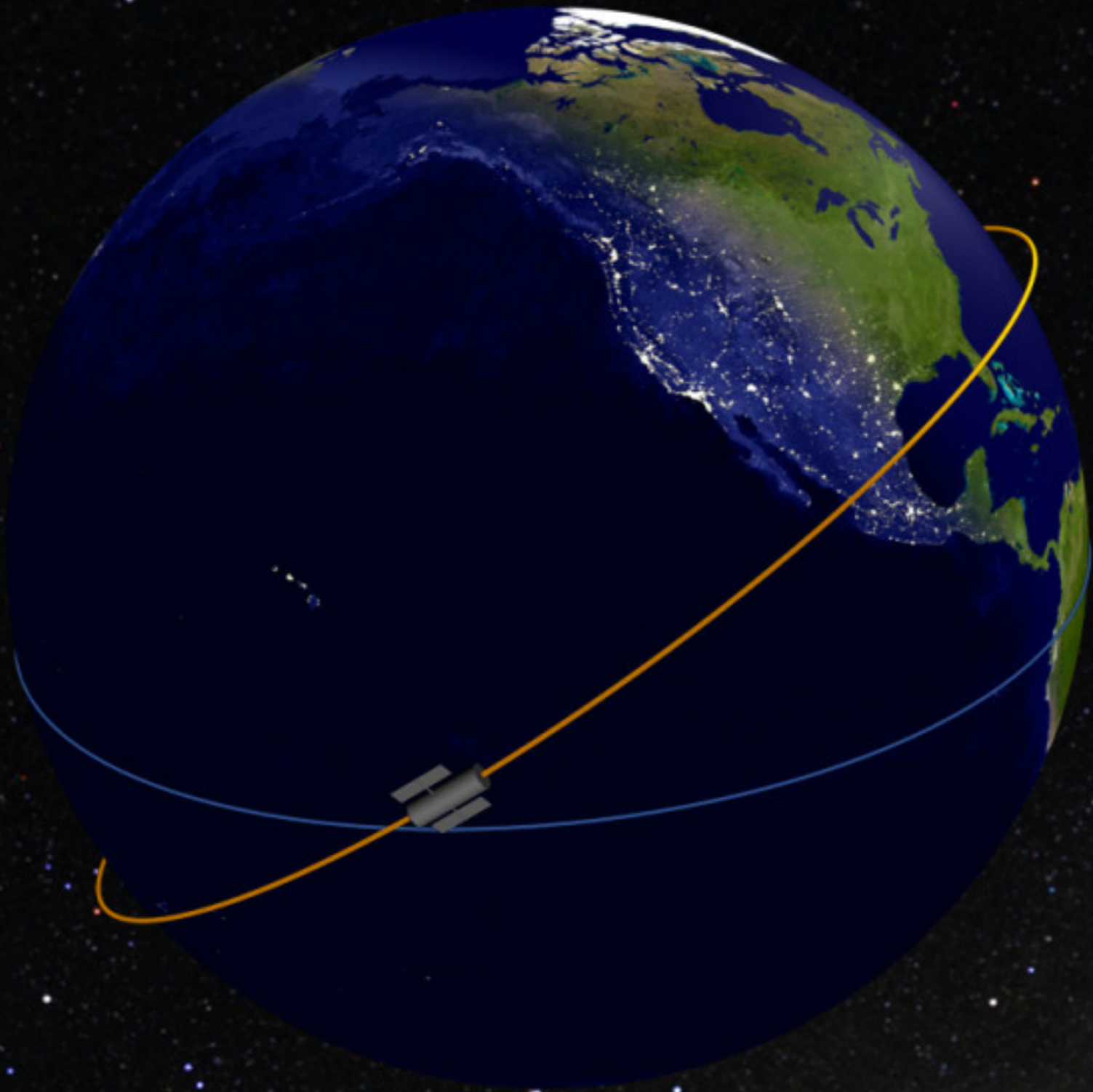
















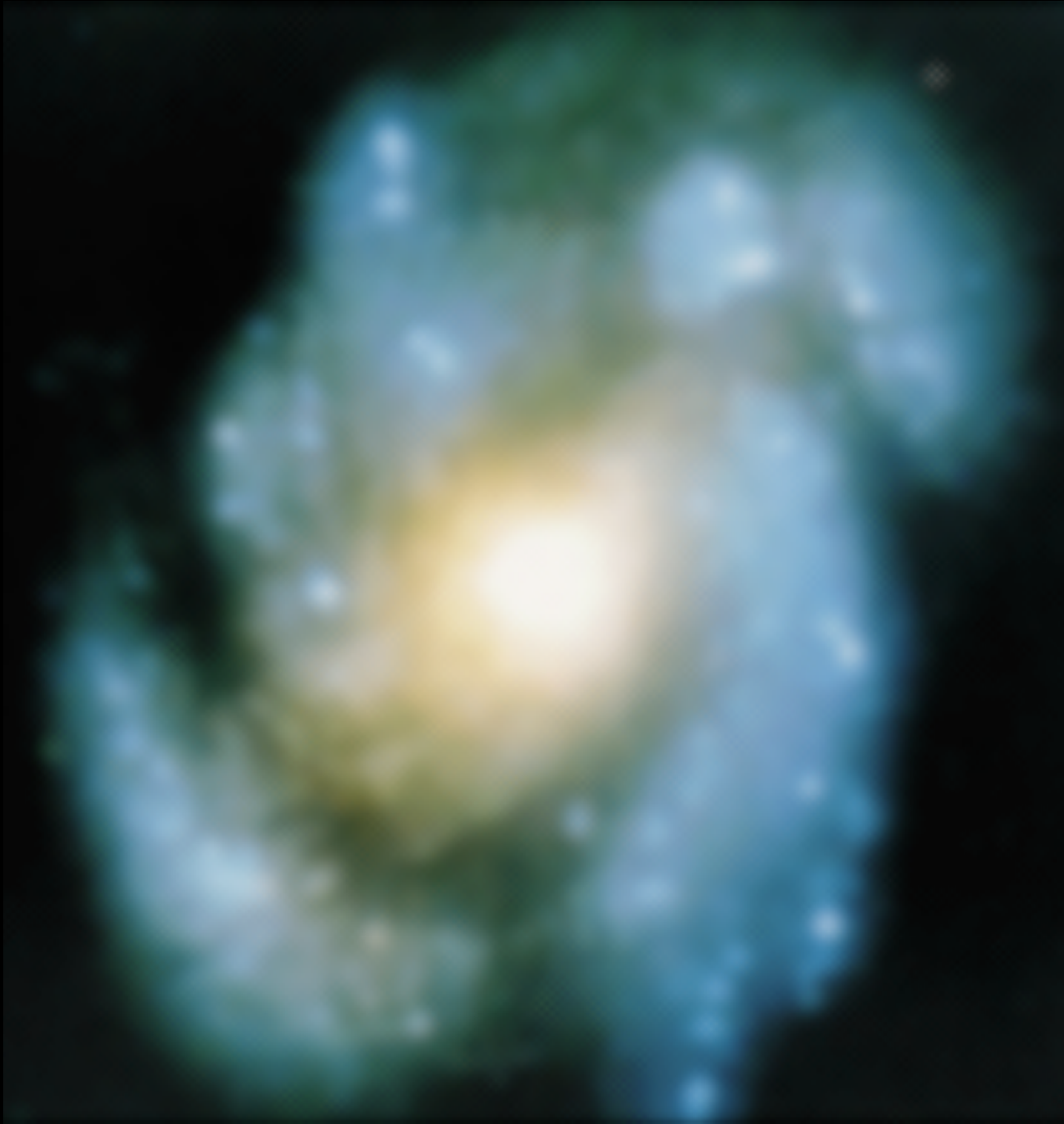
















NASA

JPL

Electric Optics  
Designs  
Inc.



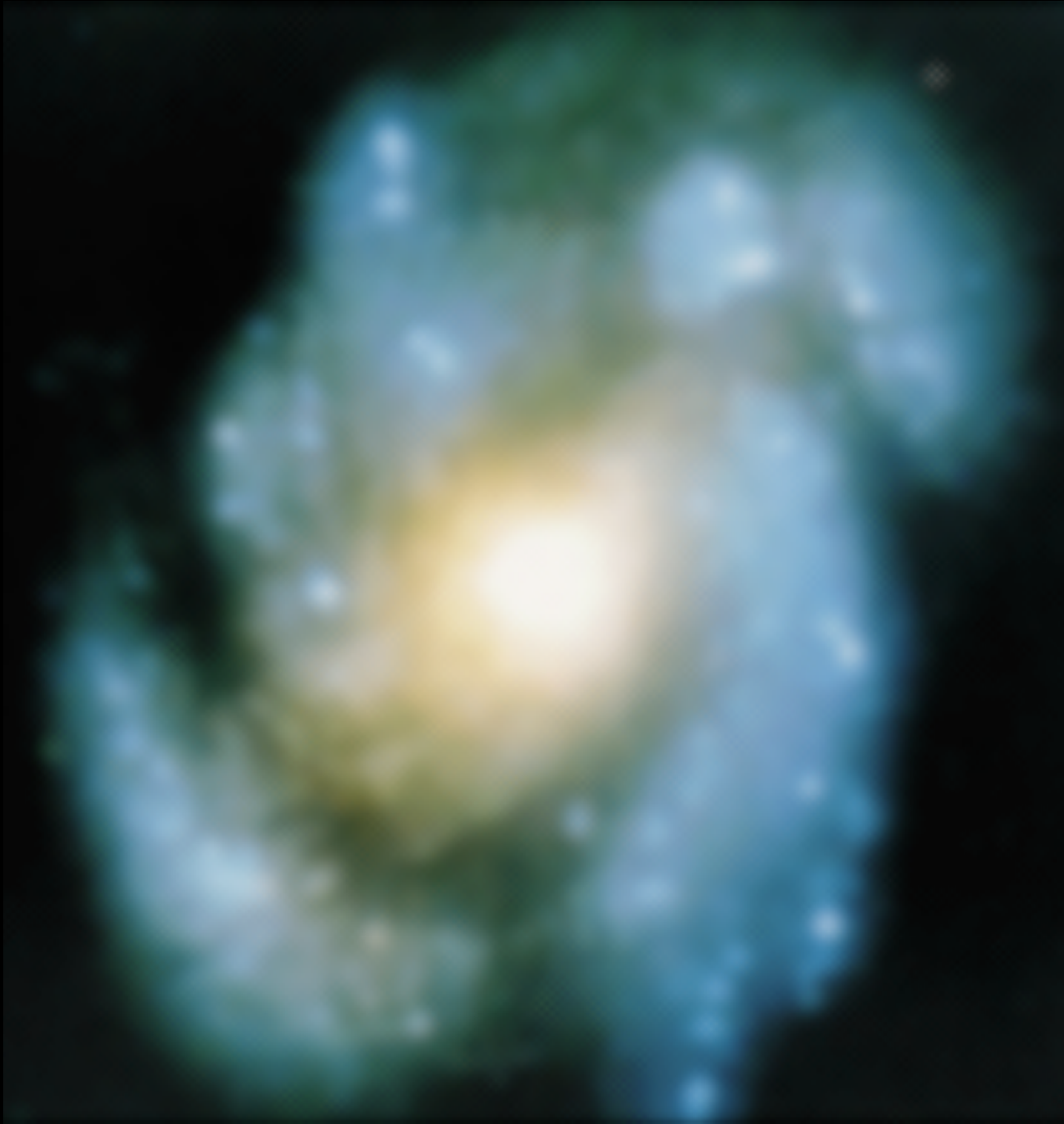
NASA JOHNS HOPKINS  
APPLIED PHYSICS LABORATORY



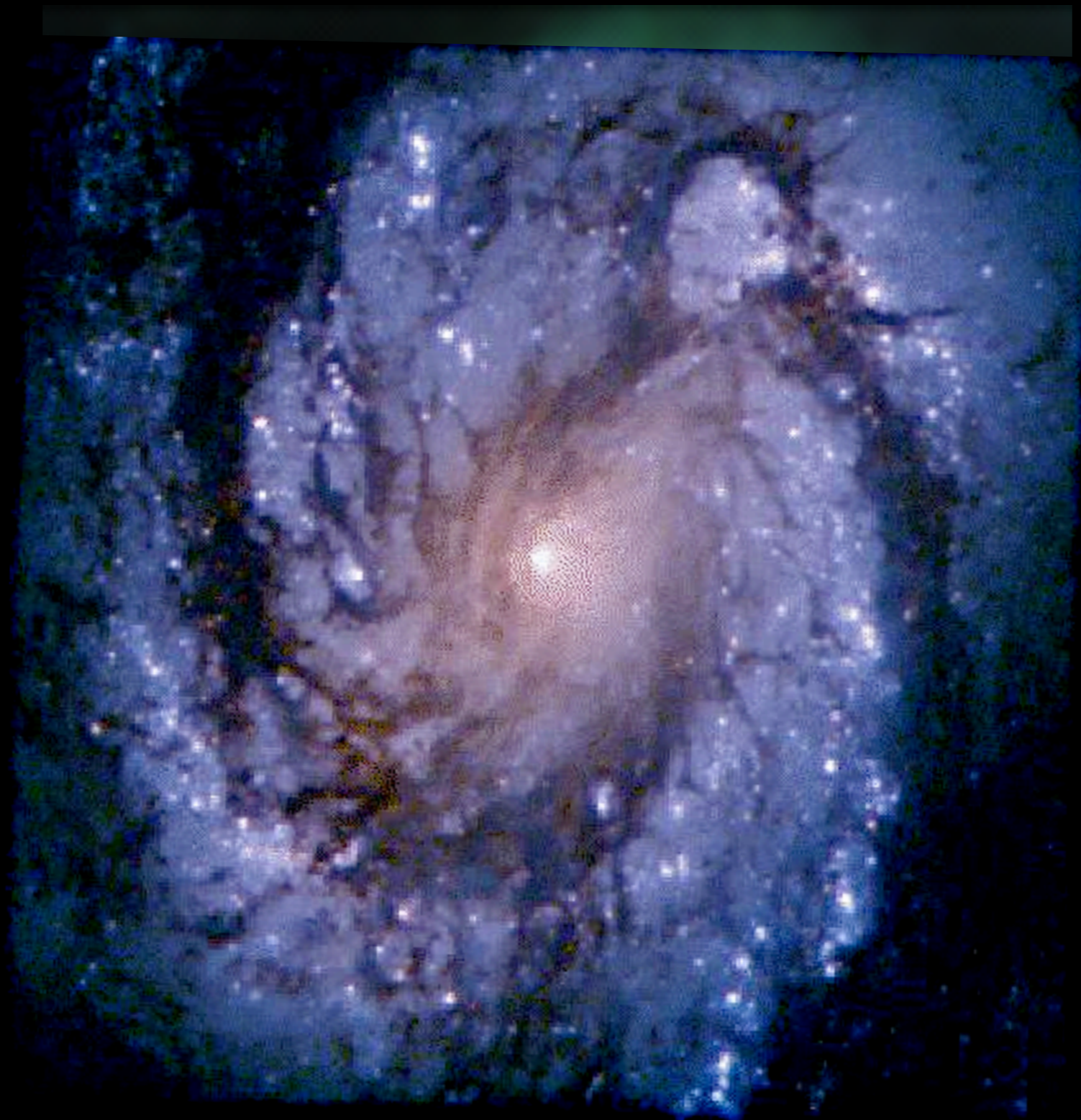
FAIRCHILD  
CORPORATION

LOCKHEED

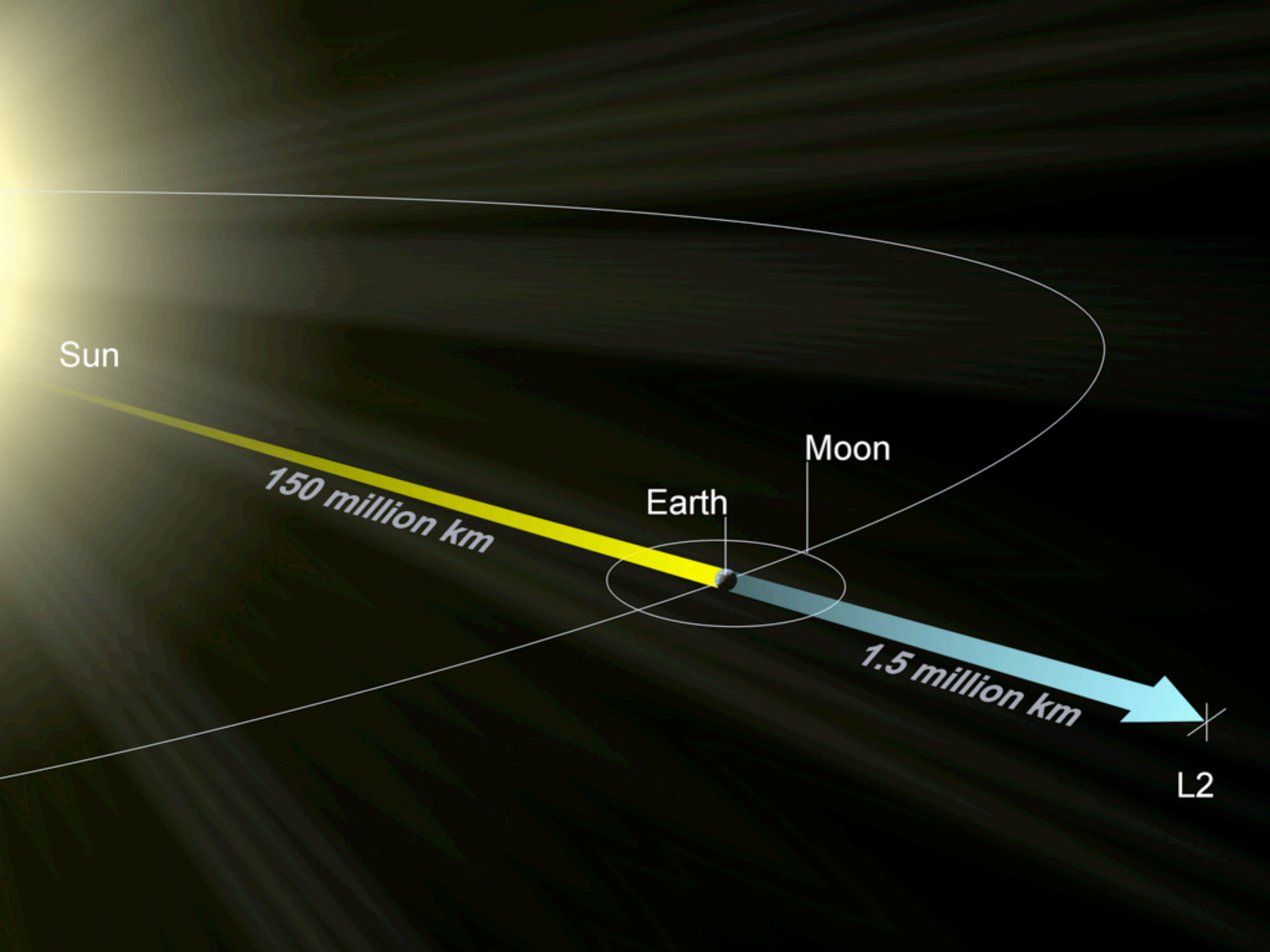




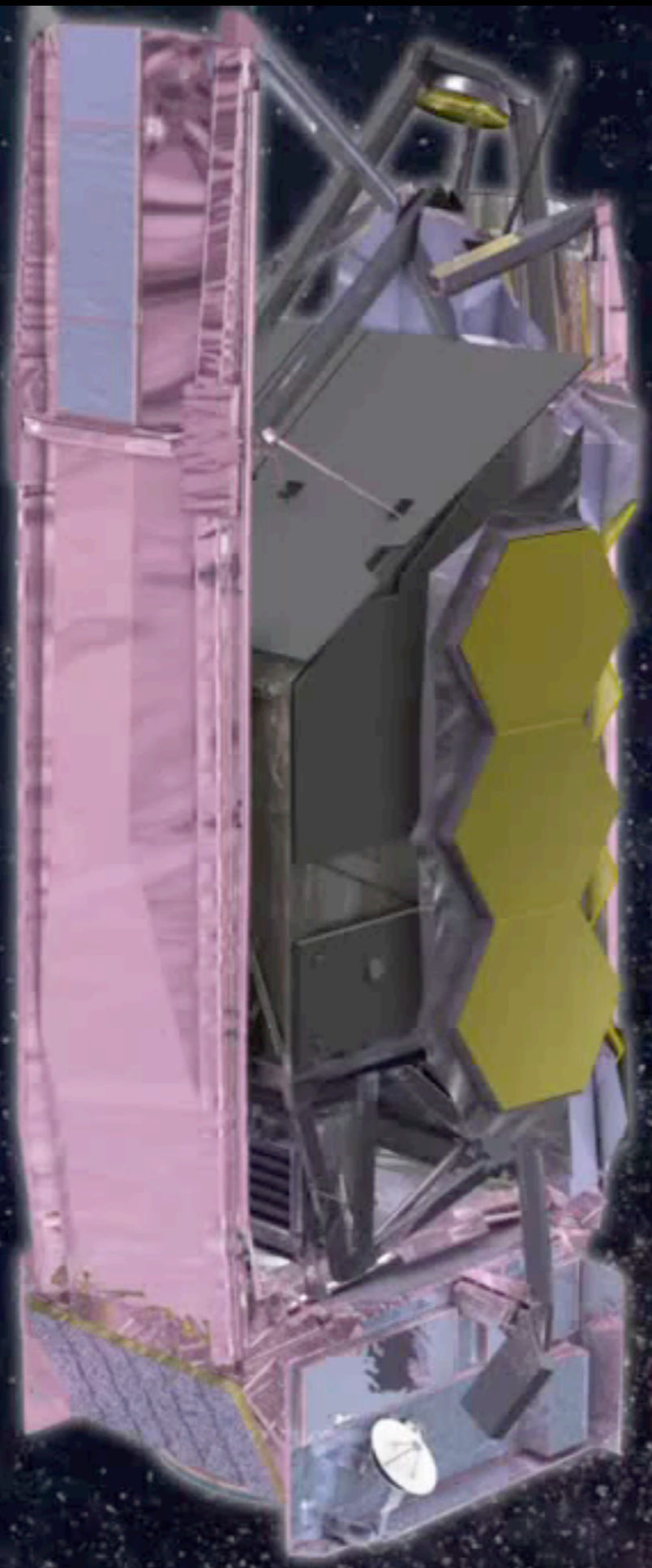








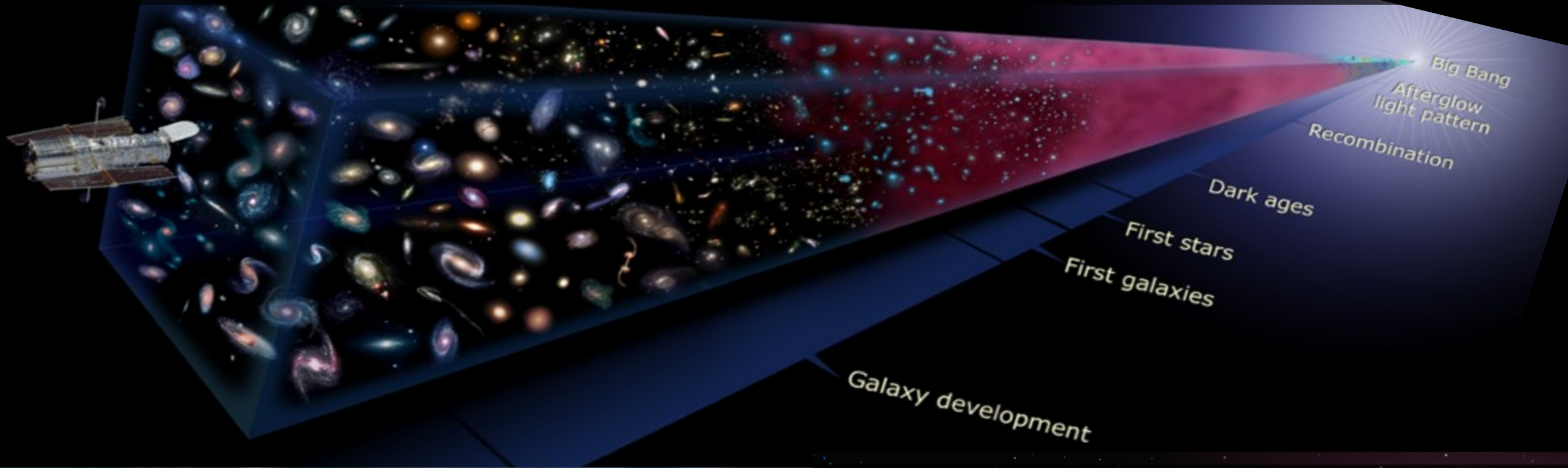






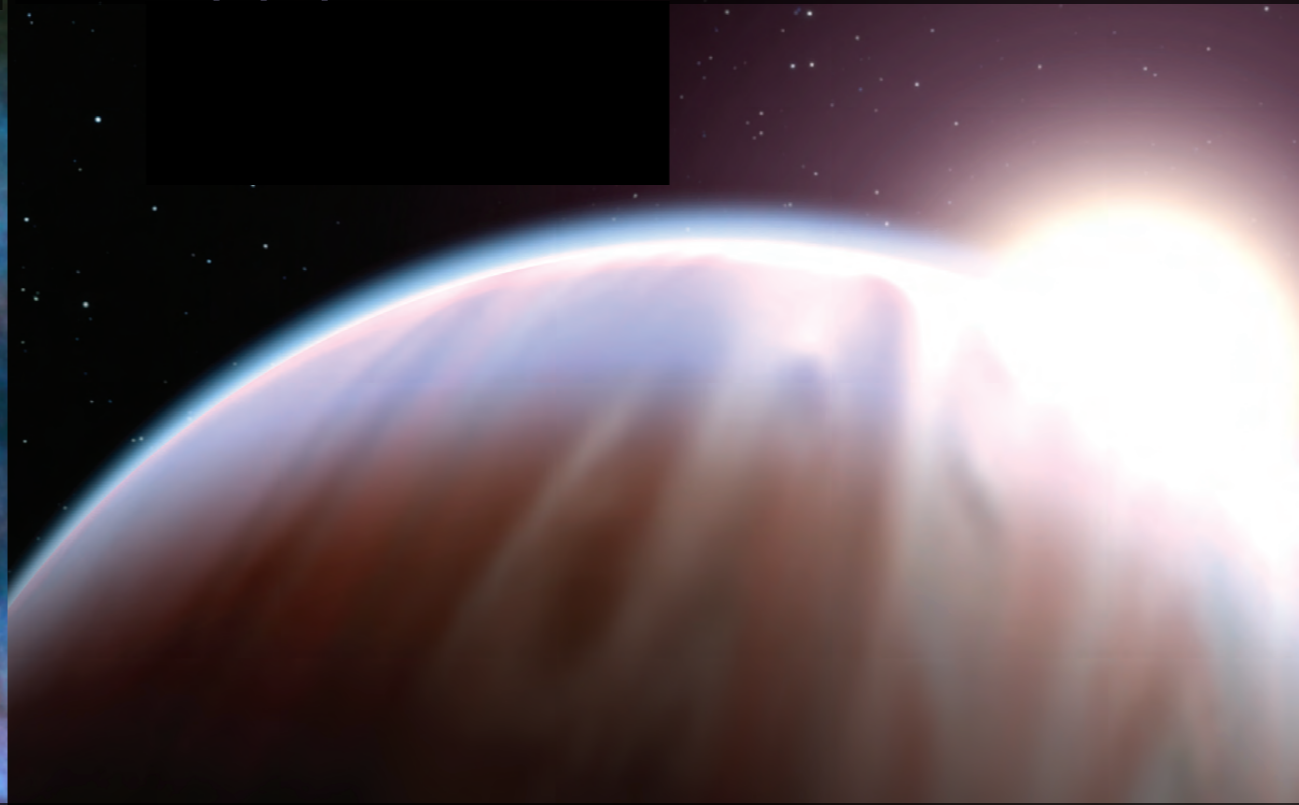
het eerste licht in het heelal

evolutie van sterrenstelsels



onstaan van sterren en planeten

levende planeten



zie: prof dr. A. de Koter

zie: prof dr. I. Snellen

Artist's rendering of extrasolar planet  
its parent star peeking from  
IMAGE CREDIT: NASA, E

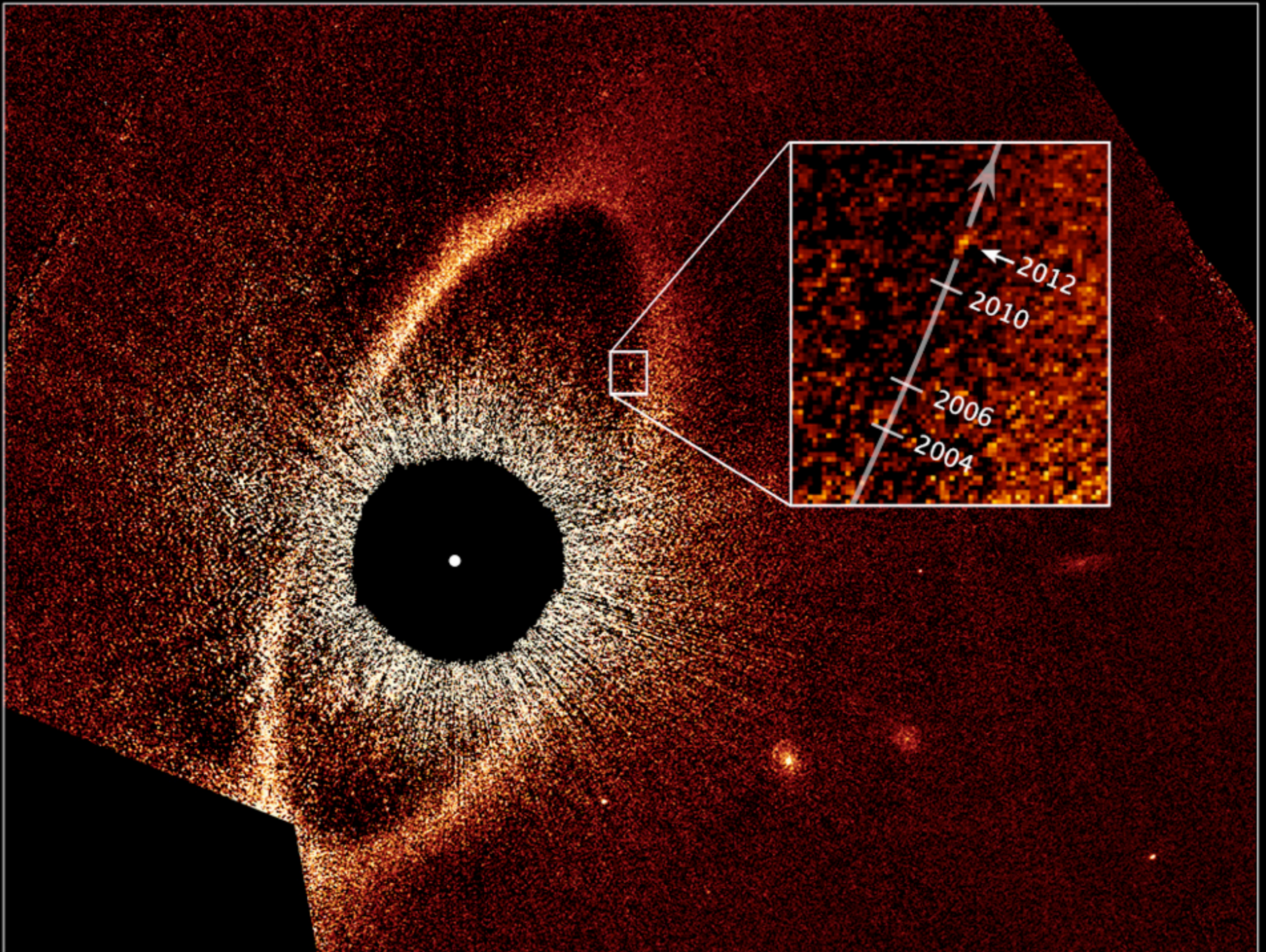














# Living PLANETS

Artist's rendering of extrasolar planet HD 189733b with  
its parent star peeking from behind the top.

IMAGE CREDIT: NASA, ESA, and G. Bacon (STScI)



# Kepler







**BRIGHTNESS**

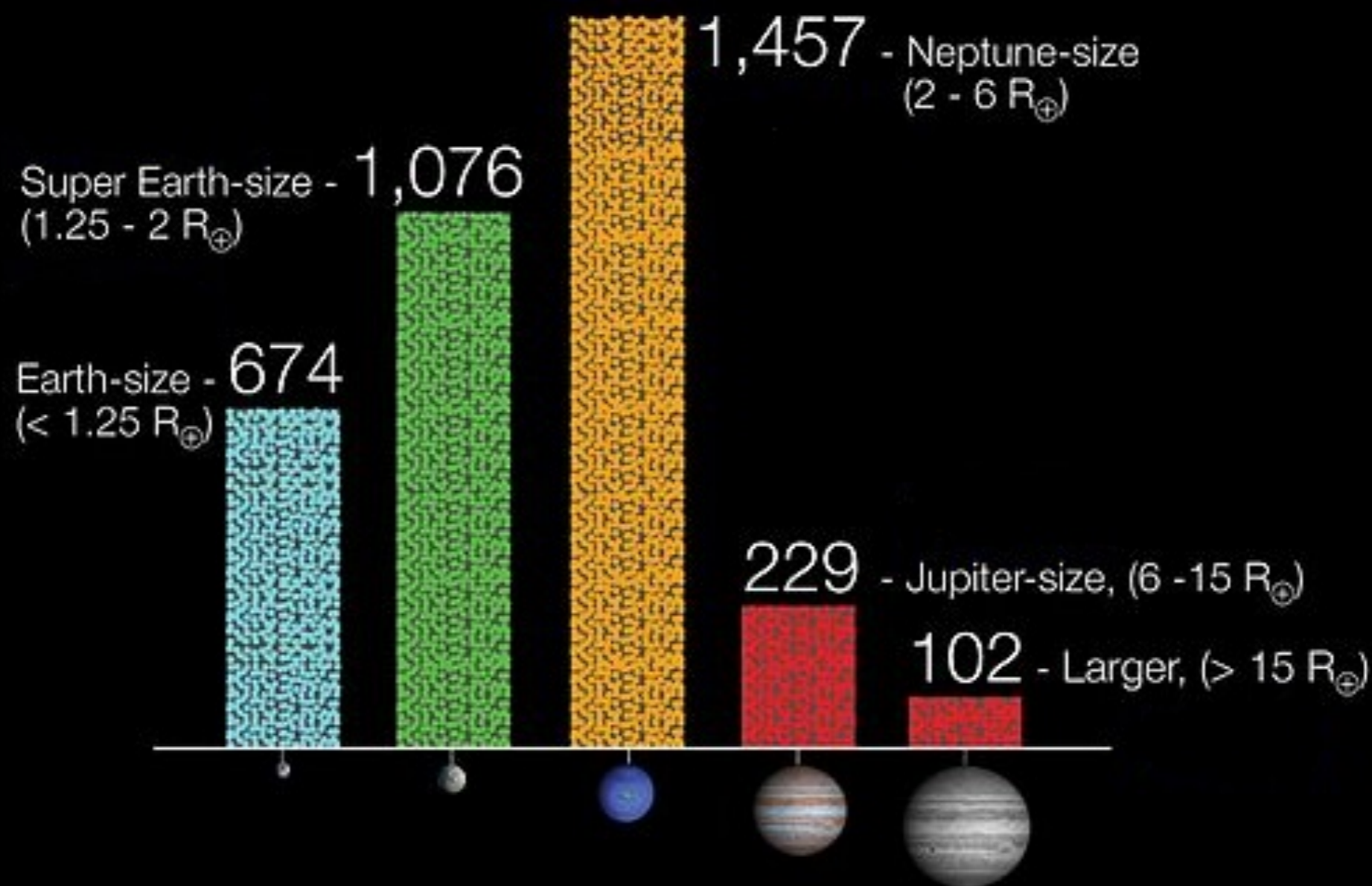


**TIME IN HOURS**



# Sizes of Planet Candidates

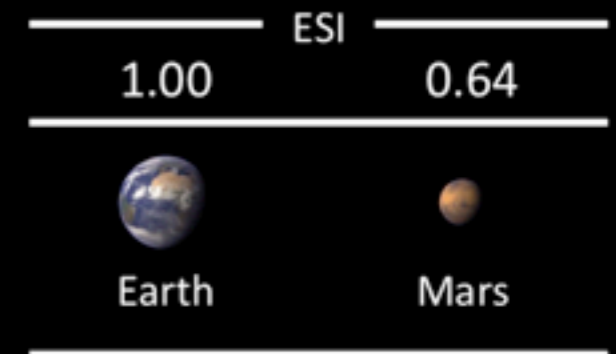
Totals as of November, 2013


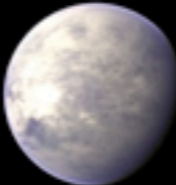




# Current Potential Habitable Exoplanets

Compared with Earth and Mars and Ranked in Order of Similarity to Earth



#1	#2	#3	#4	#5	#6	#7	#8	#9
Earth Similarity Index (ESI)								
0.82	0.82	0.79	0.75	0.74	0.69	0.68	0.67	0.50
								
<b>NEW</b>					<b>NEW</b>			
Kepler-62 e	Gliese 581 g*	Gliese 667C c	Kepler-22 b	Tau Ceti e*	Kepler-62 f	Gliese 163 c	HD 40307 g*	Gliese 581 d
Discovery Date								
Apr 2013	Sep 2010	Nov 2011	Dec 2011	Dec 2012	Apr 2013	Sep 2012	Nov 2012	Apr 2007

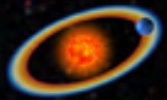
\*planet candidates

CREDIT: PHL @ UPR Arcibo (phl.upr.edu) April 18, 2013

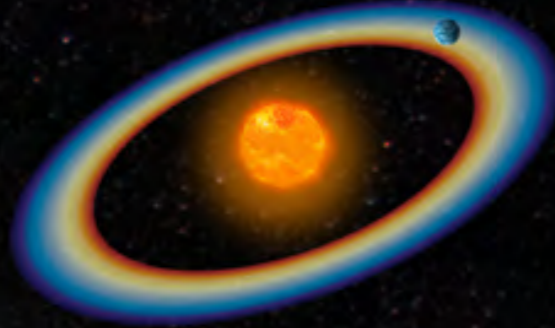


# Habitable Zone by Stellar Type

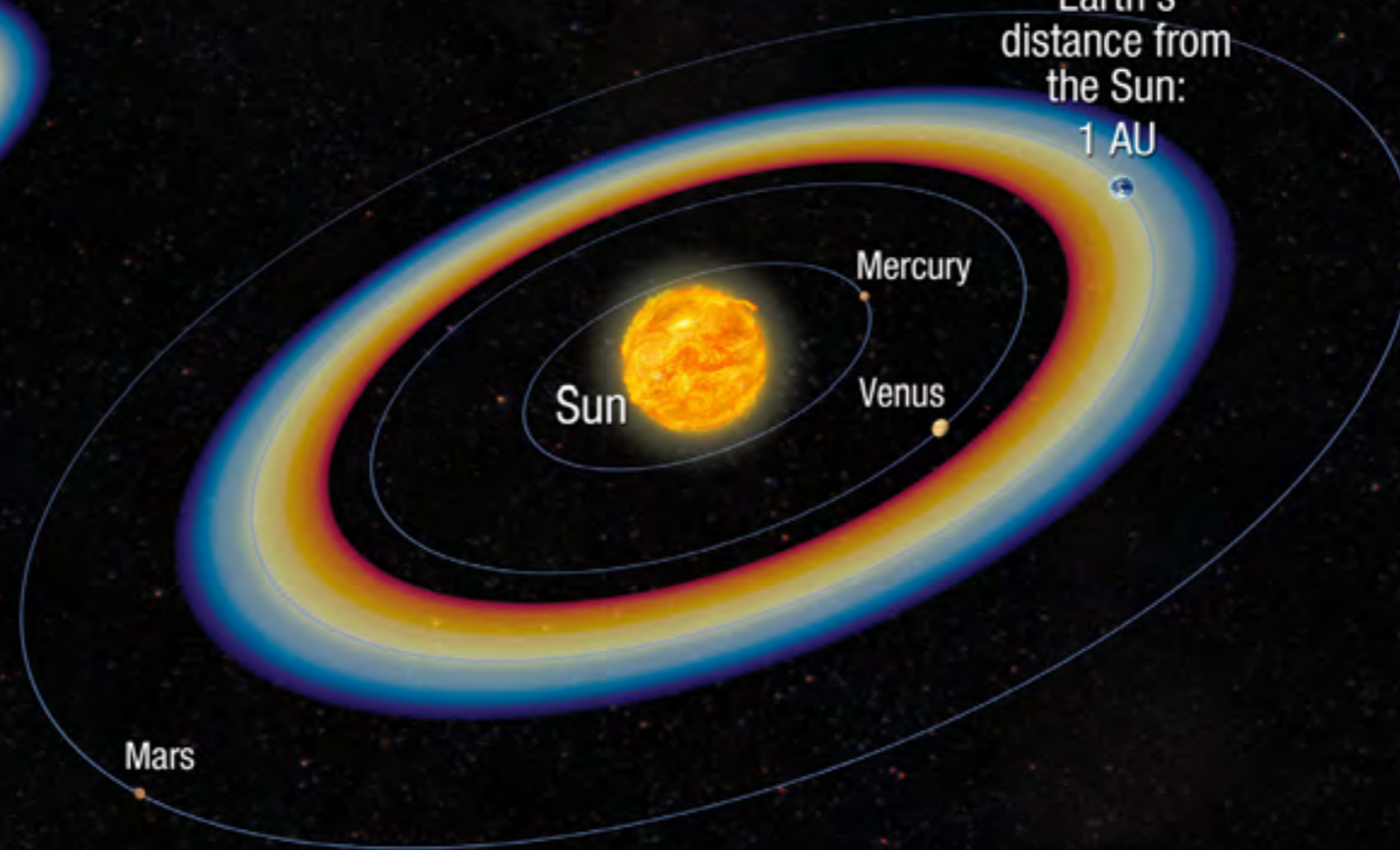
Planet's  
distance from  
red dwarf:  
.3 AU



Planet's  
distance from  
orange dwarf:  
.5 AU



Earth's  
distance from  
the Sun:  
1 AU



*1 AU  $\approx$  93,000,000 miles*

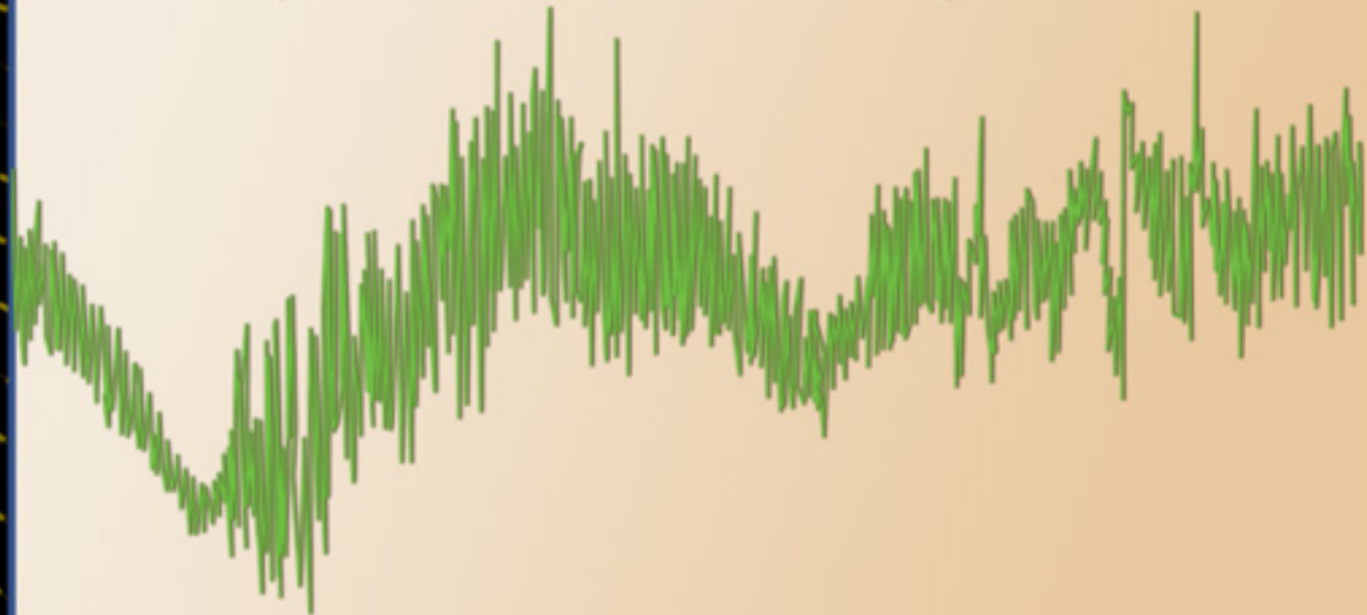
**Habitable zone models.** Depending on stellar mass and luminosity, planets on which liquid water could exist on the surface will be at different distances from their parent star.



Starlight  
filters through  
planetary  
atmosphere



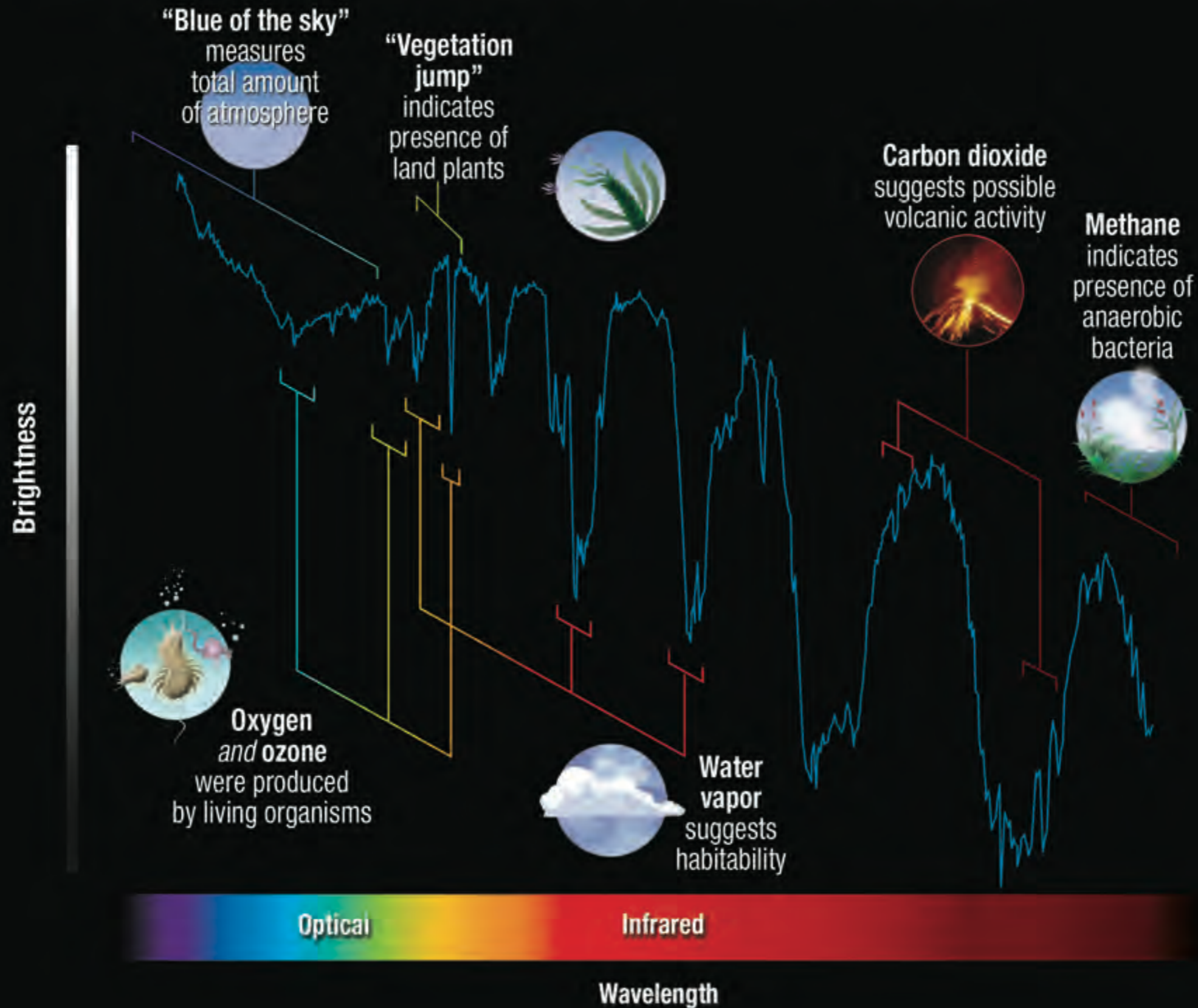
Methane in the planet's  
atmosphere absorbs starlight





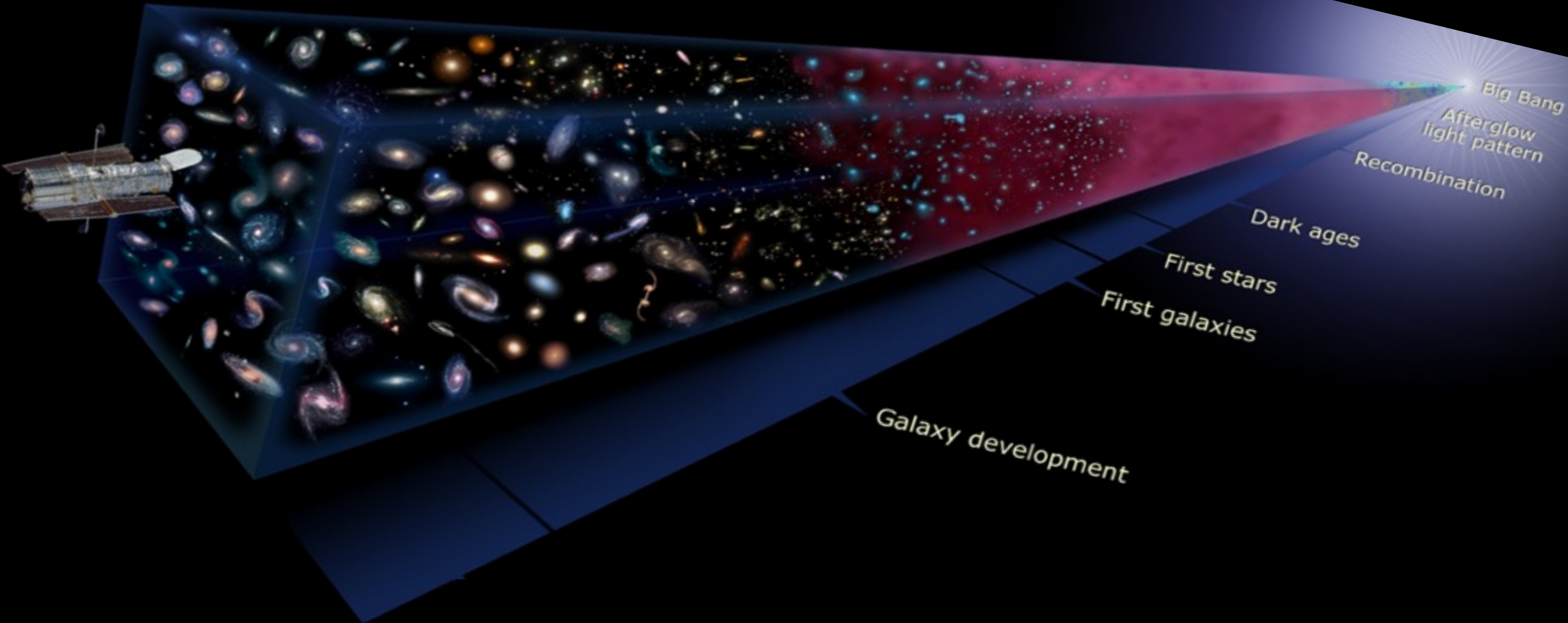
# Earth's Spectrum

Spectroscopic signatures indicate the possible conditions conducive to life



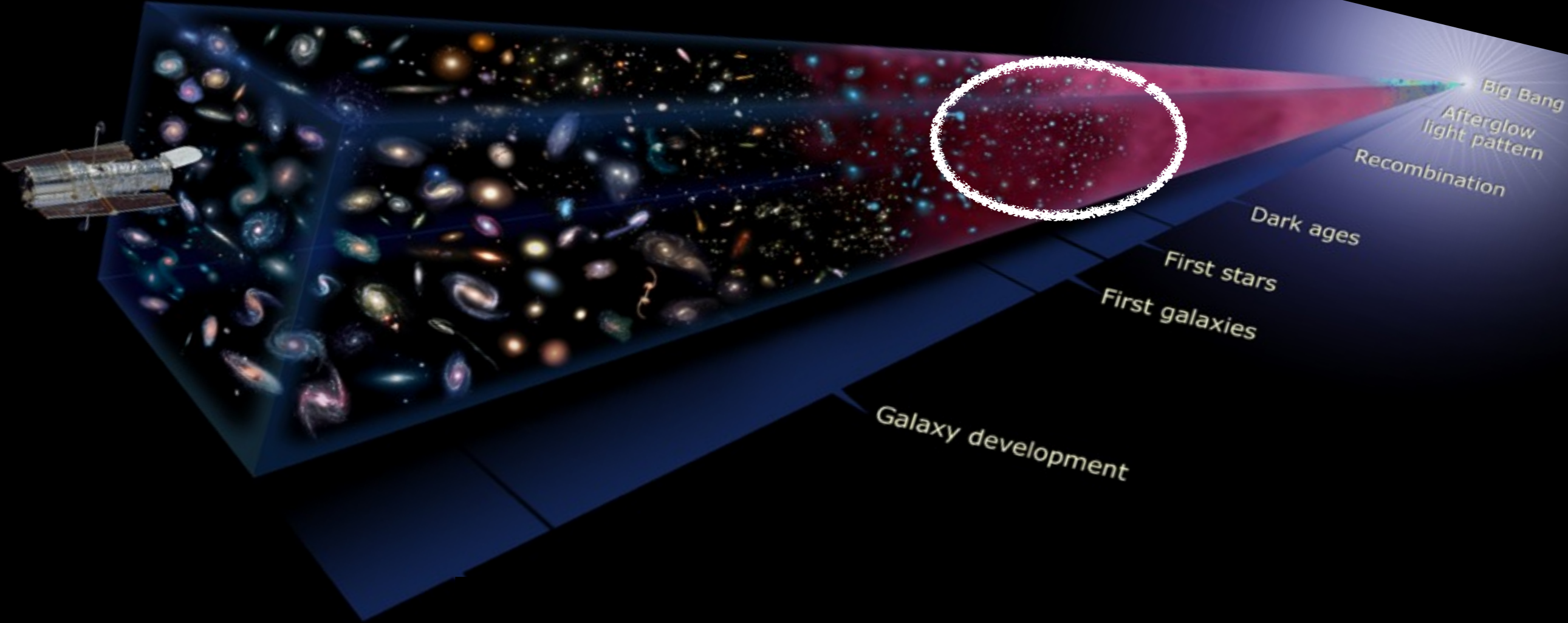


# EVOLUTION OF GALAXIES



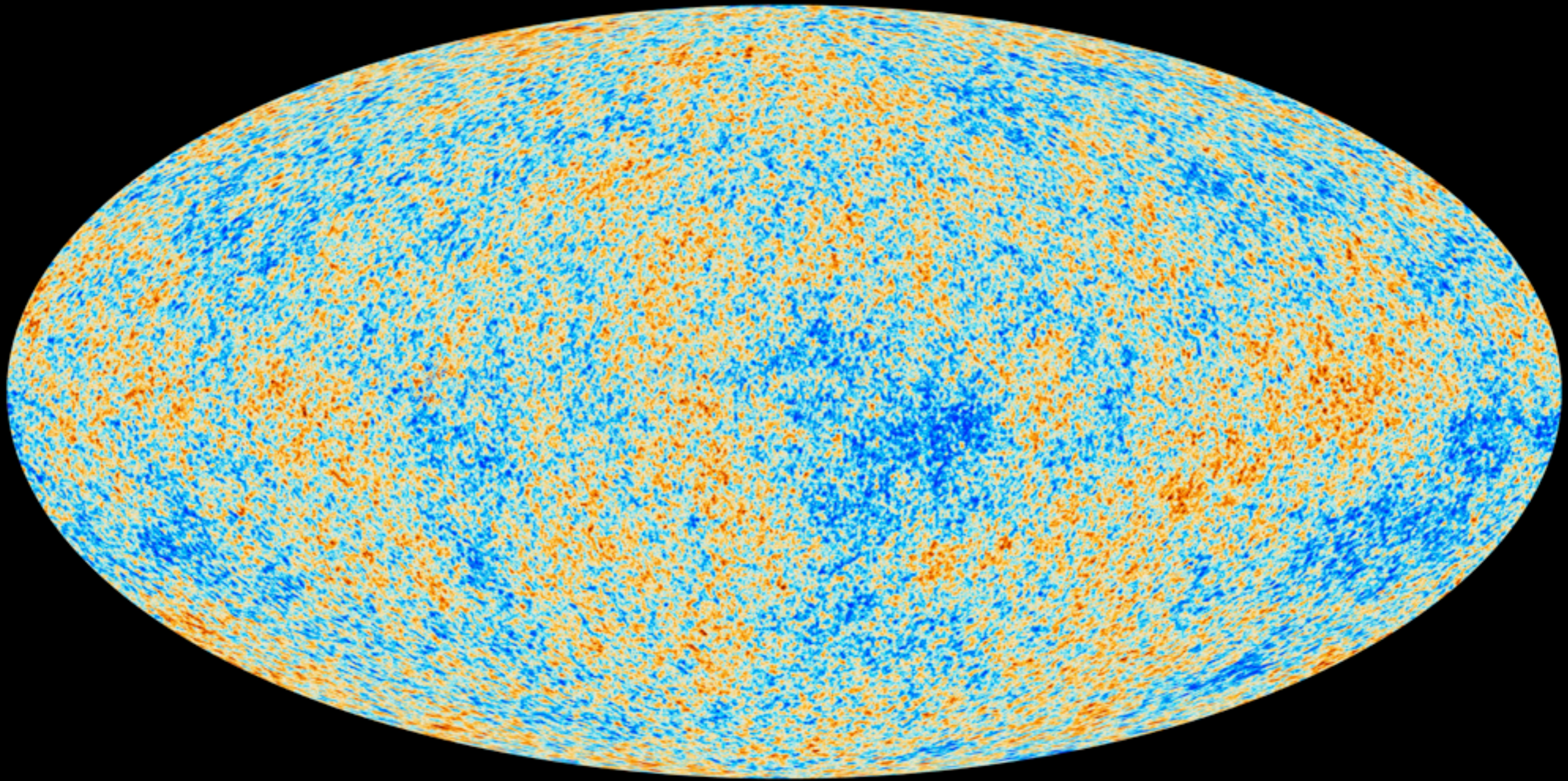


# EVOLUTION OF GALAXIES



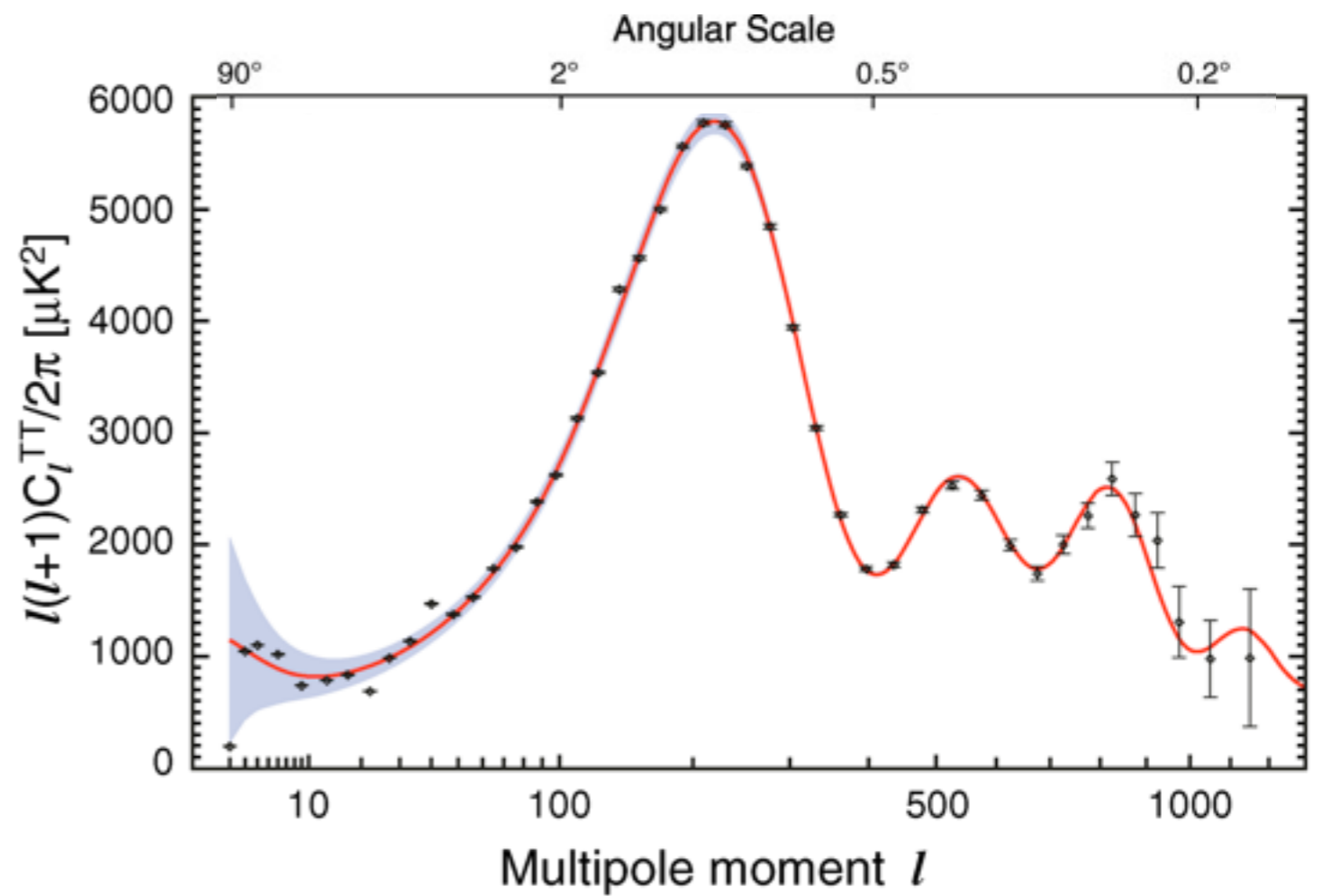
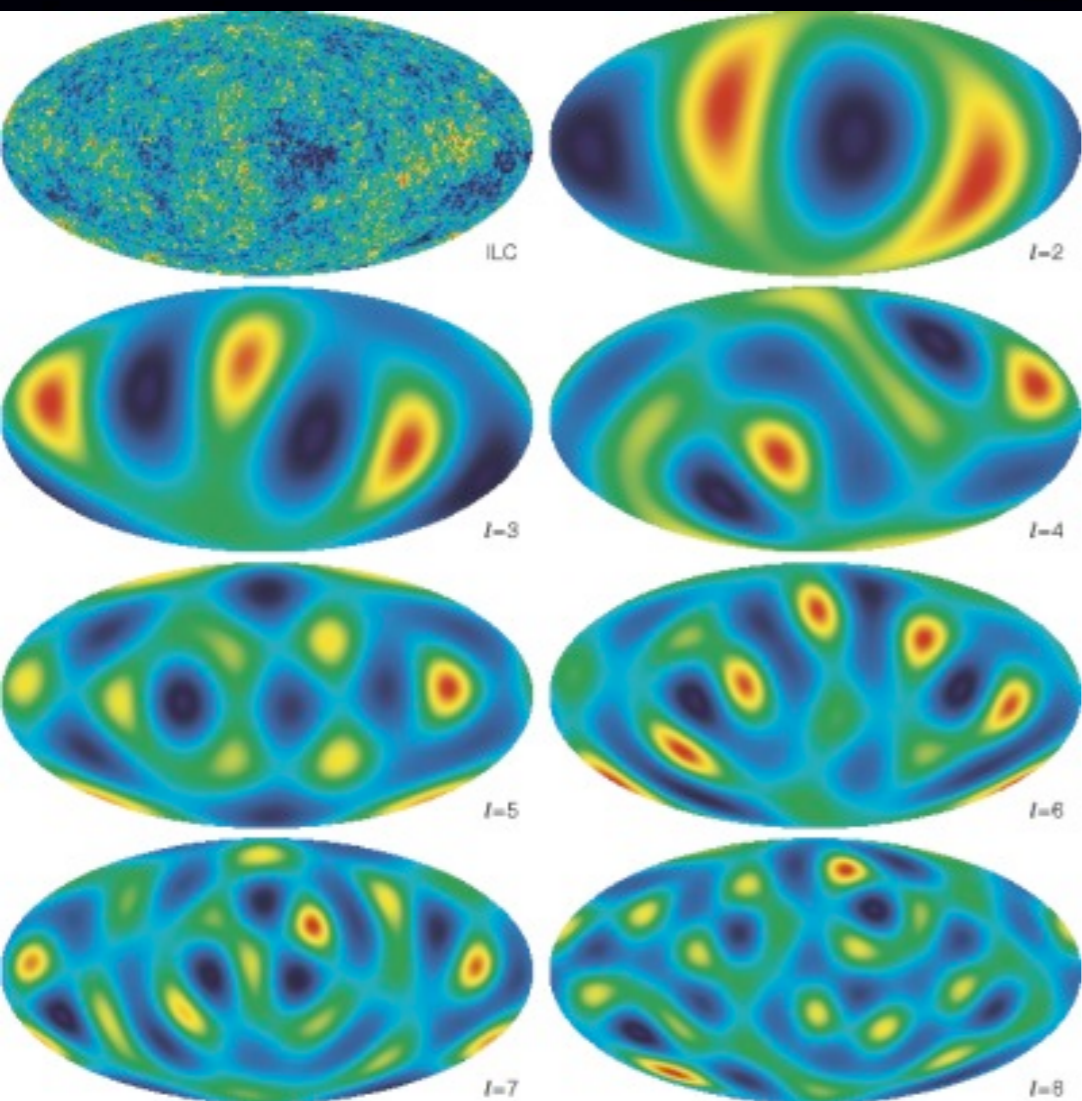


# Kosmische achtergrondstraling



Planck 2013

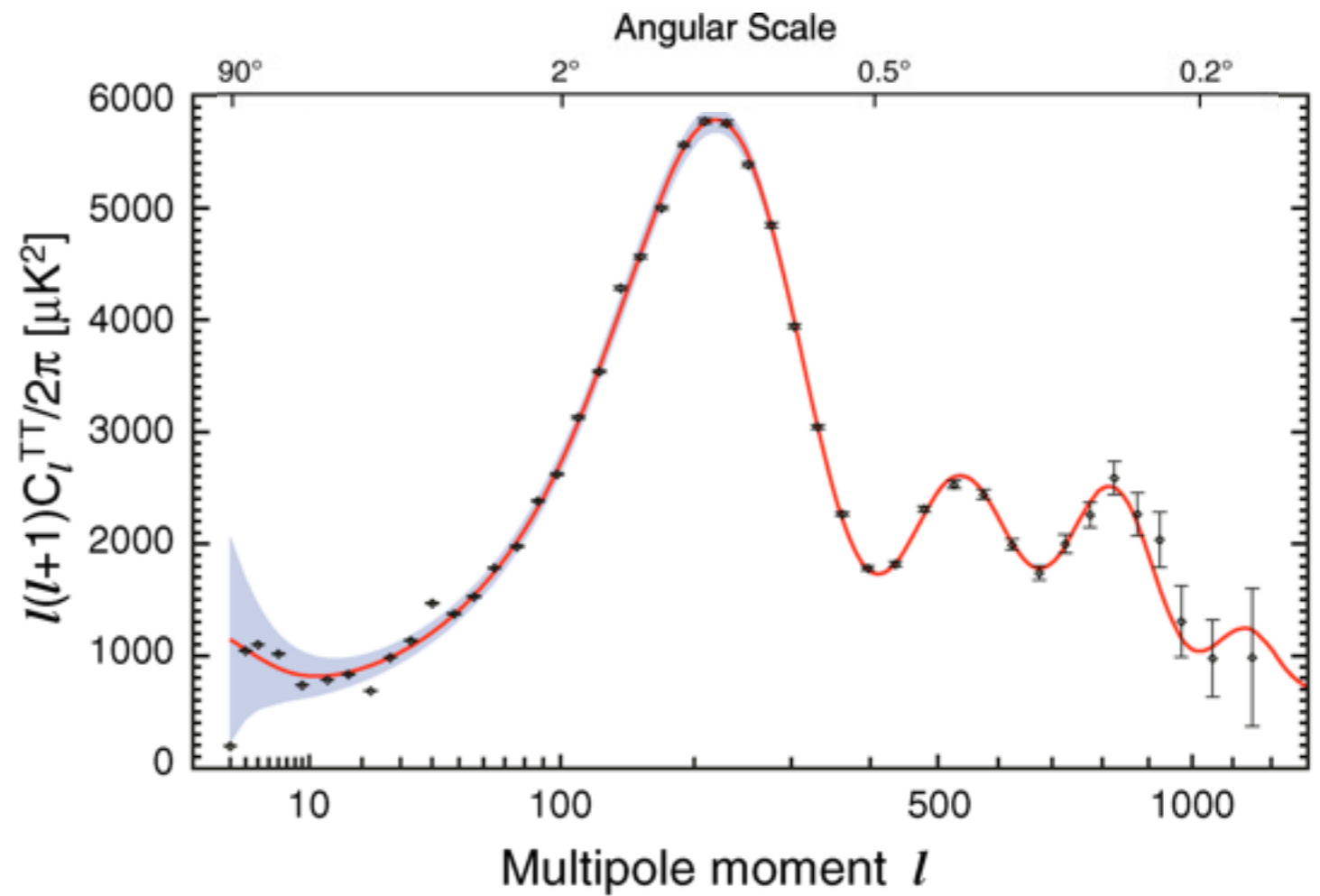
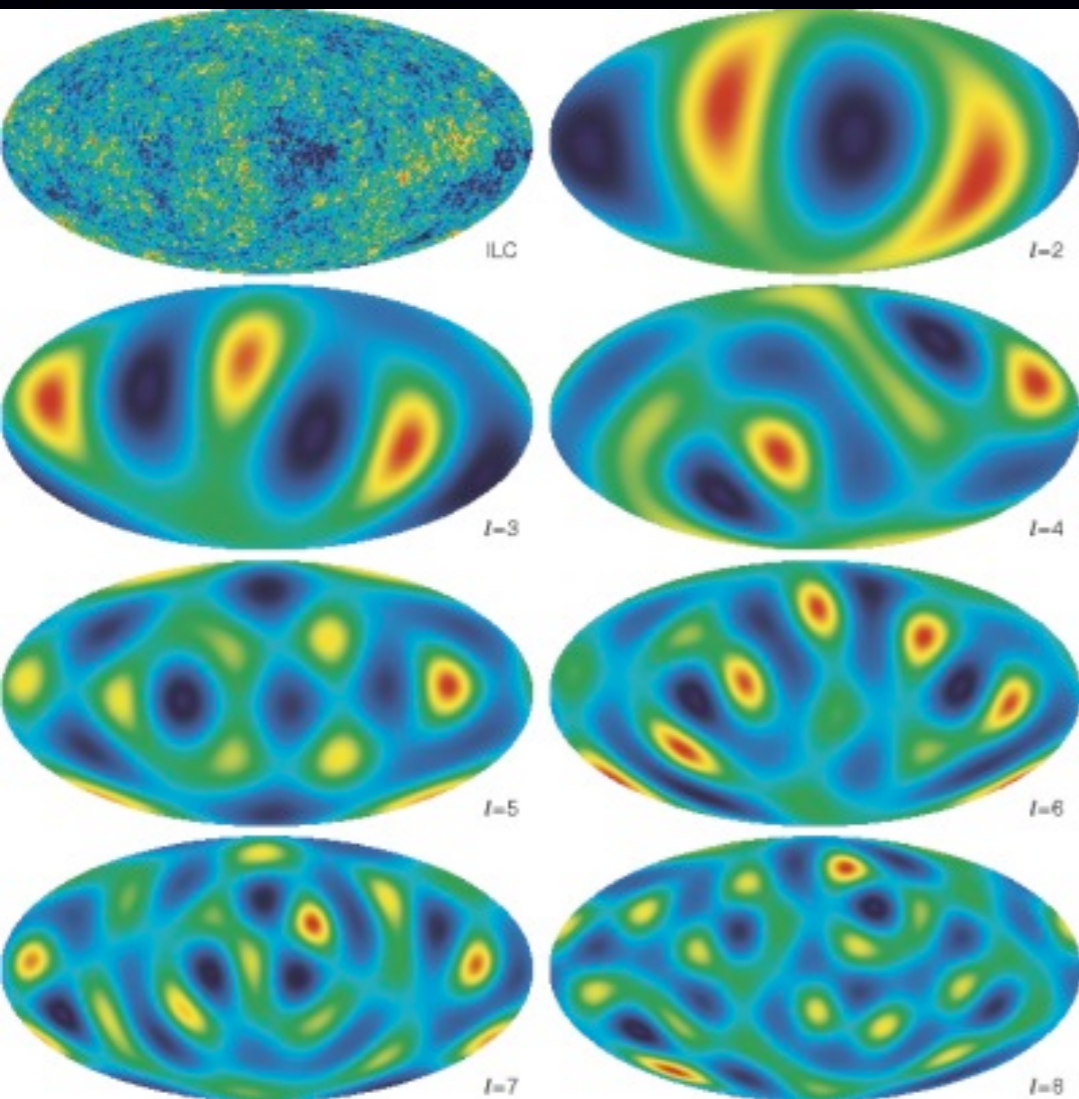




akoestische golven in vroege gas



# Seven-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations:



akoestische golven in vroege gas



...to here?

Spiral Galaxy M64



Hubble Heritage

Elliptical Galaxy ESO 325-G004 in the Abell Cluster S0740



Hubble Heritage

NCC 4038-4039 • Antennae Galaxies



Hubble Heritage

Barred Spiral Galaxy NGC 1300



Hubble Heritage

Sombrero Galaxy • M104



Hubble Heritage

NASA, ESA, and The Hubble Heritage Team (STScI/AURA) • Hubble Space Telescope ACS/WFC • STScI PR1026-14a

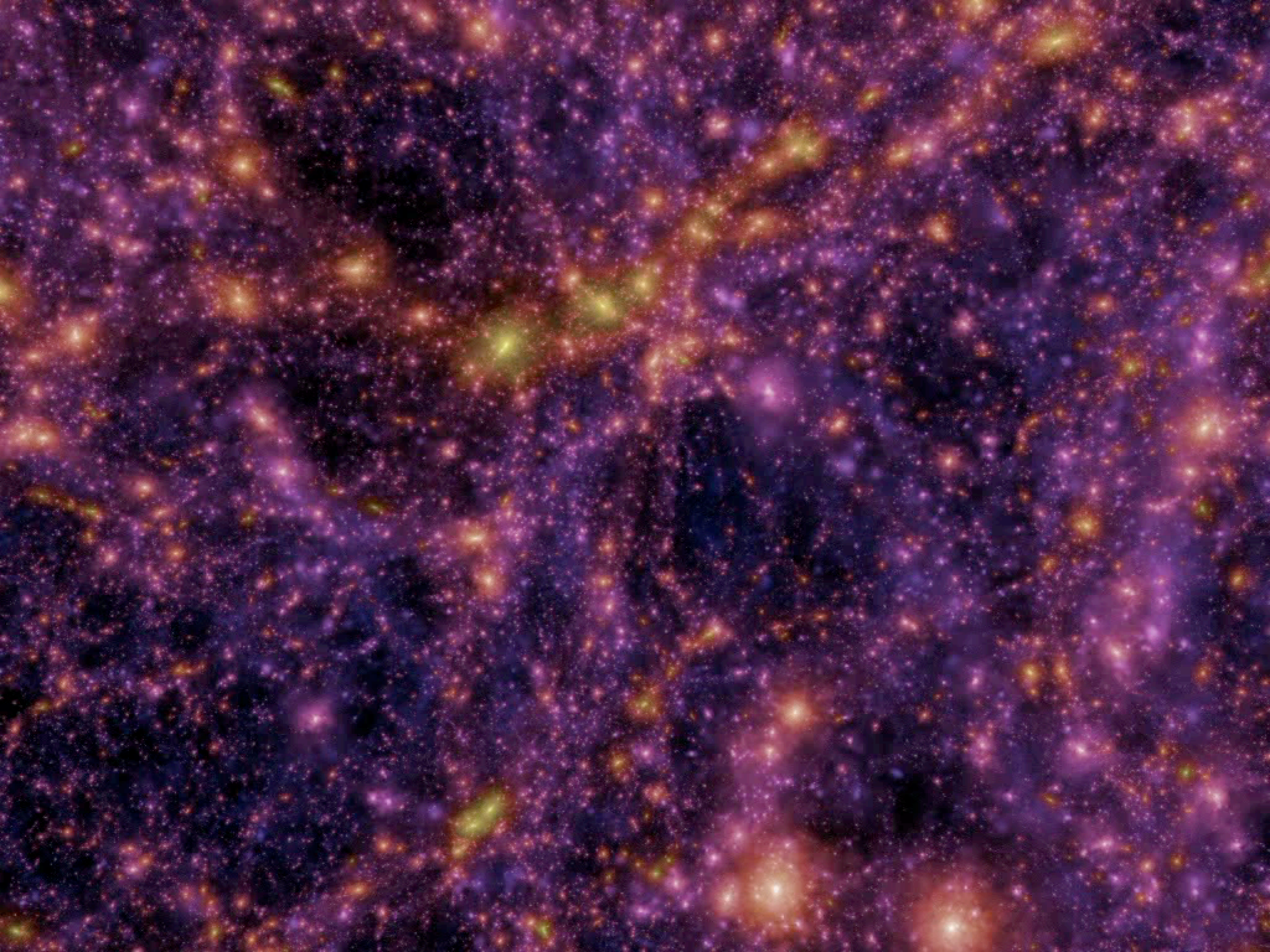


Active Galaxy M81









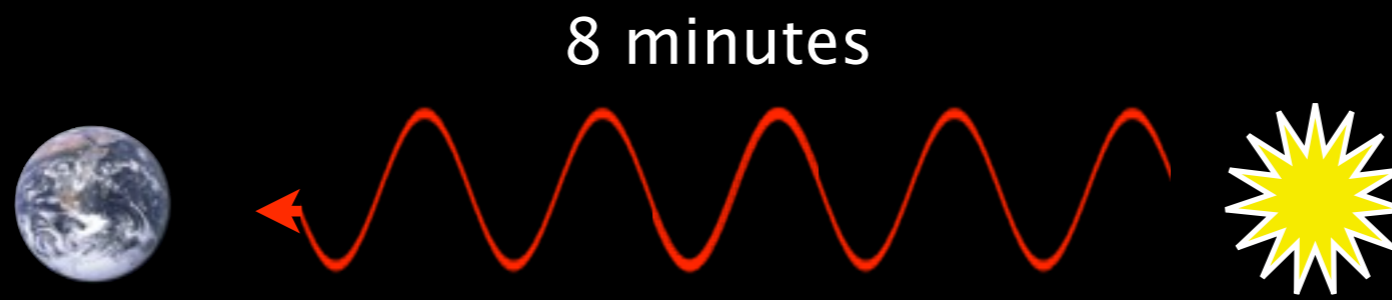


# Time machine basics





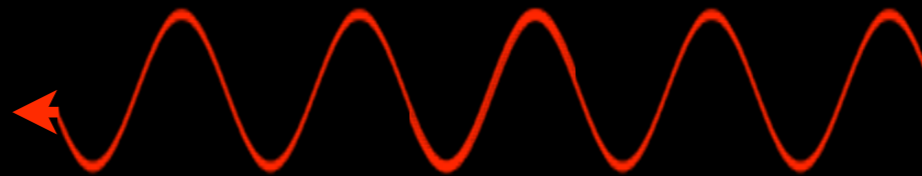
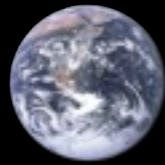
# Time machine basics



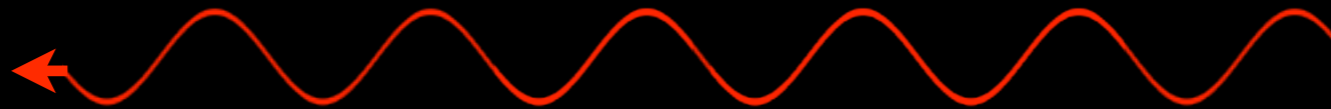


# Time machine basics

8 minutes



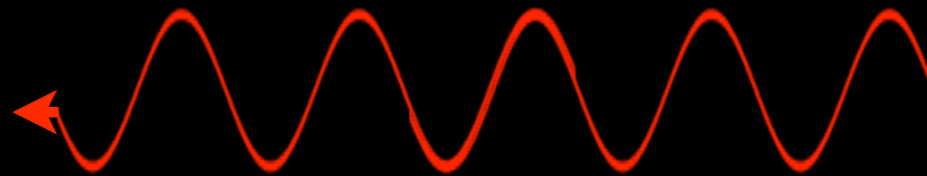
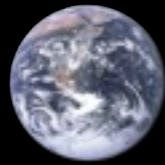
3.5 years



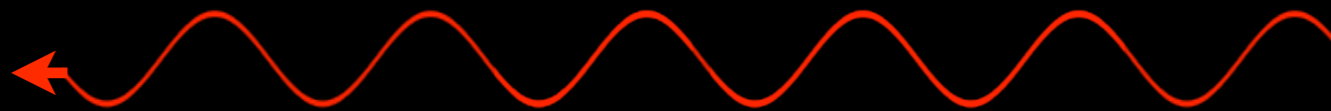


# Time machine basics

8 minutes



3.5 years



13 billion years





In an expanding universe light is redshifted





In an expanding universe light is redshifted



we need to look **far away** and in **infrared**









JWST: leeftijd sterren, gas, rotatiesnelheid



# op jacht naar de eerste sterren

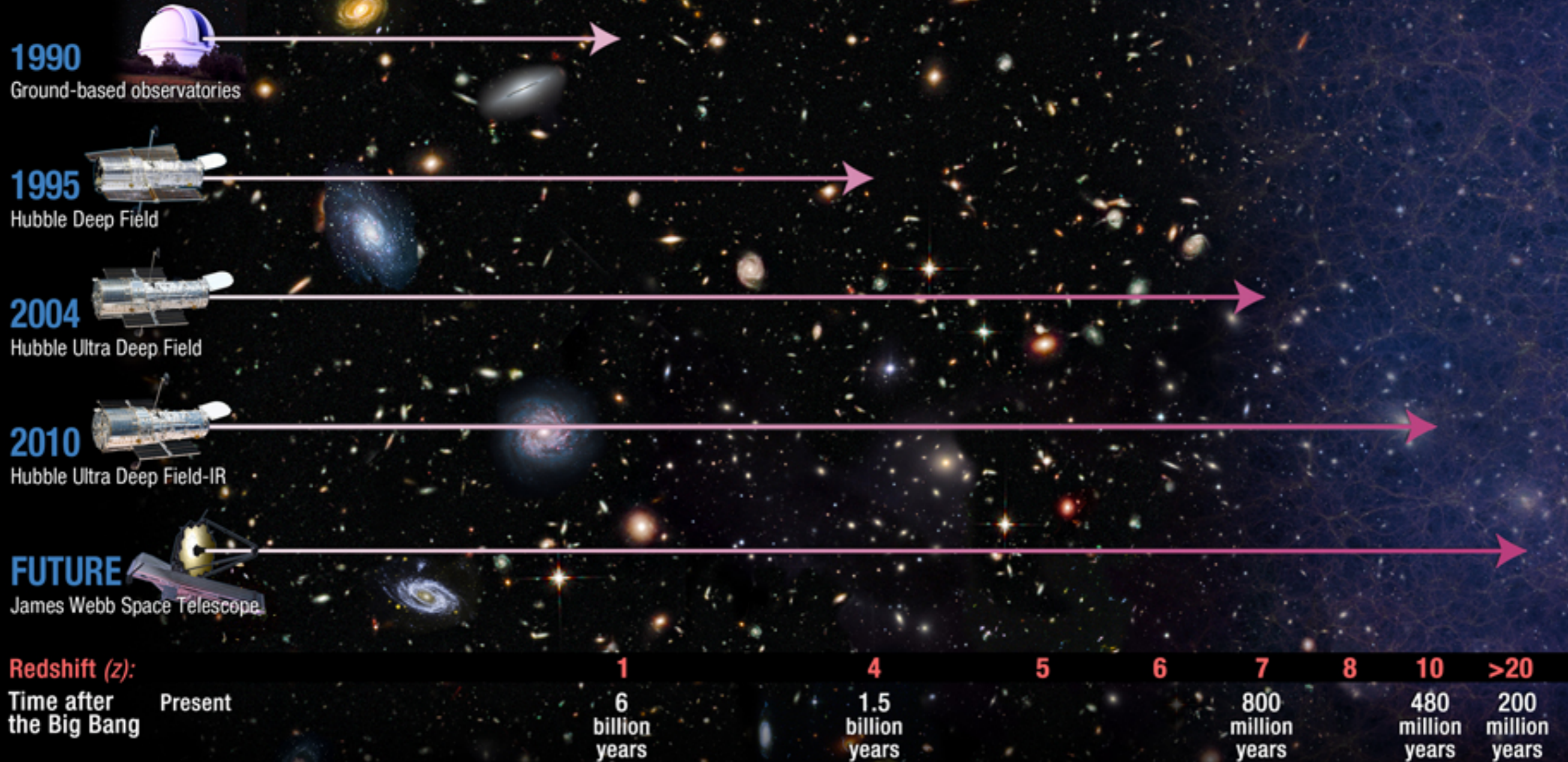


500 miljoen jaar  $z=10$

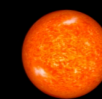
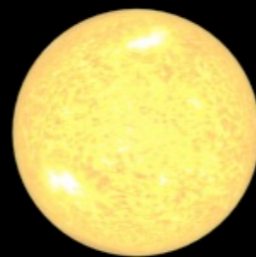
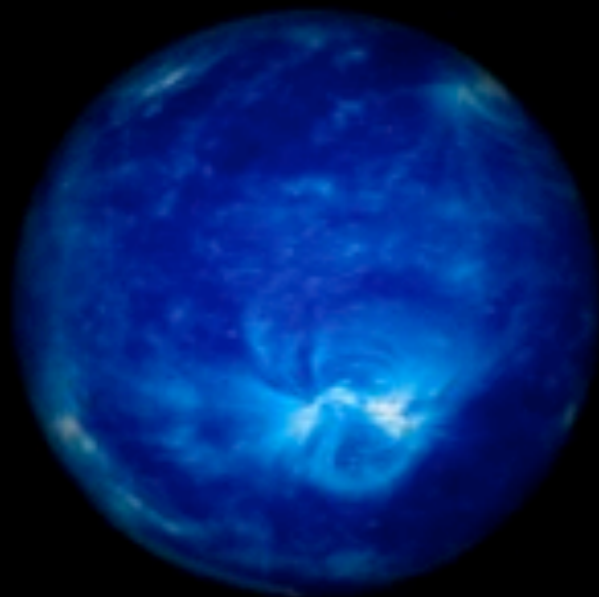
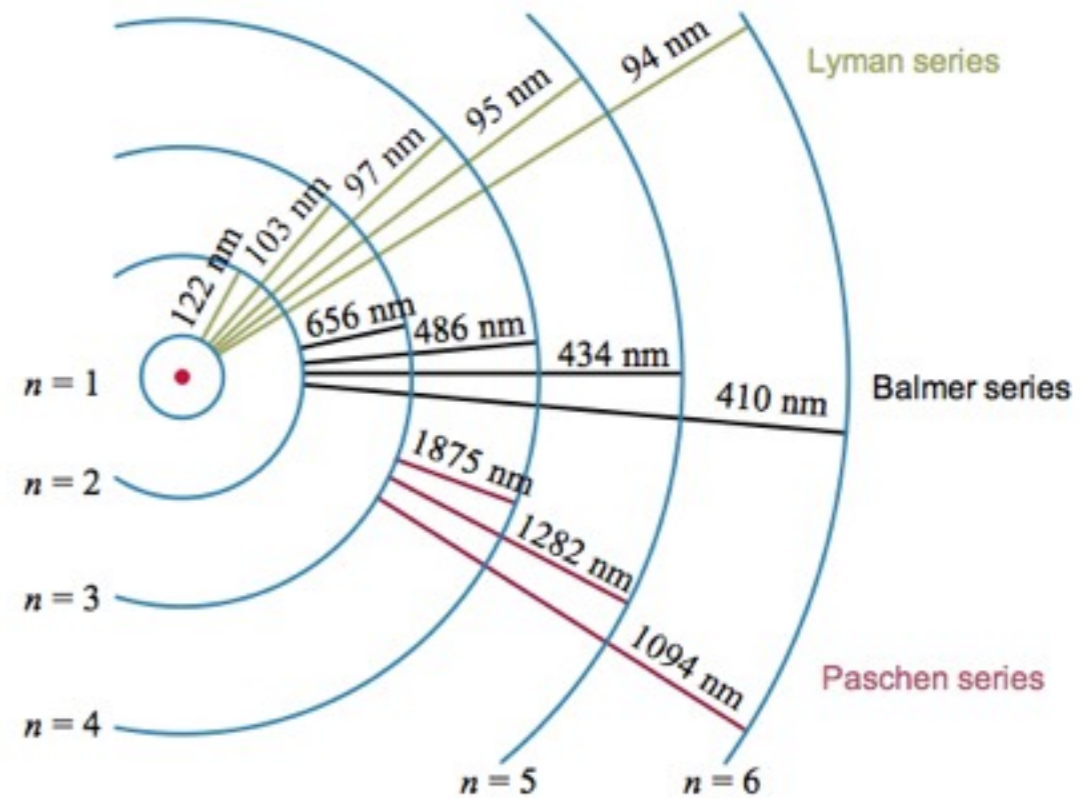
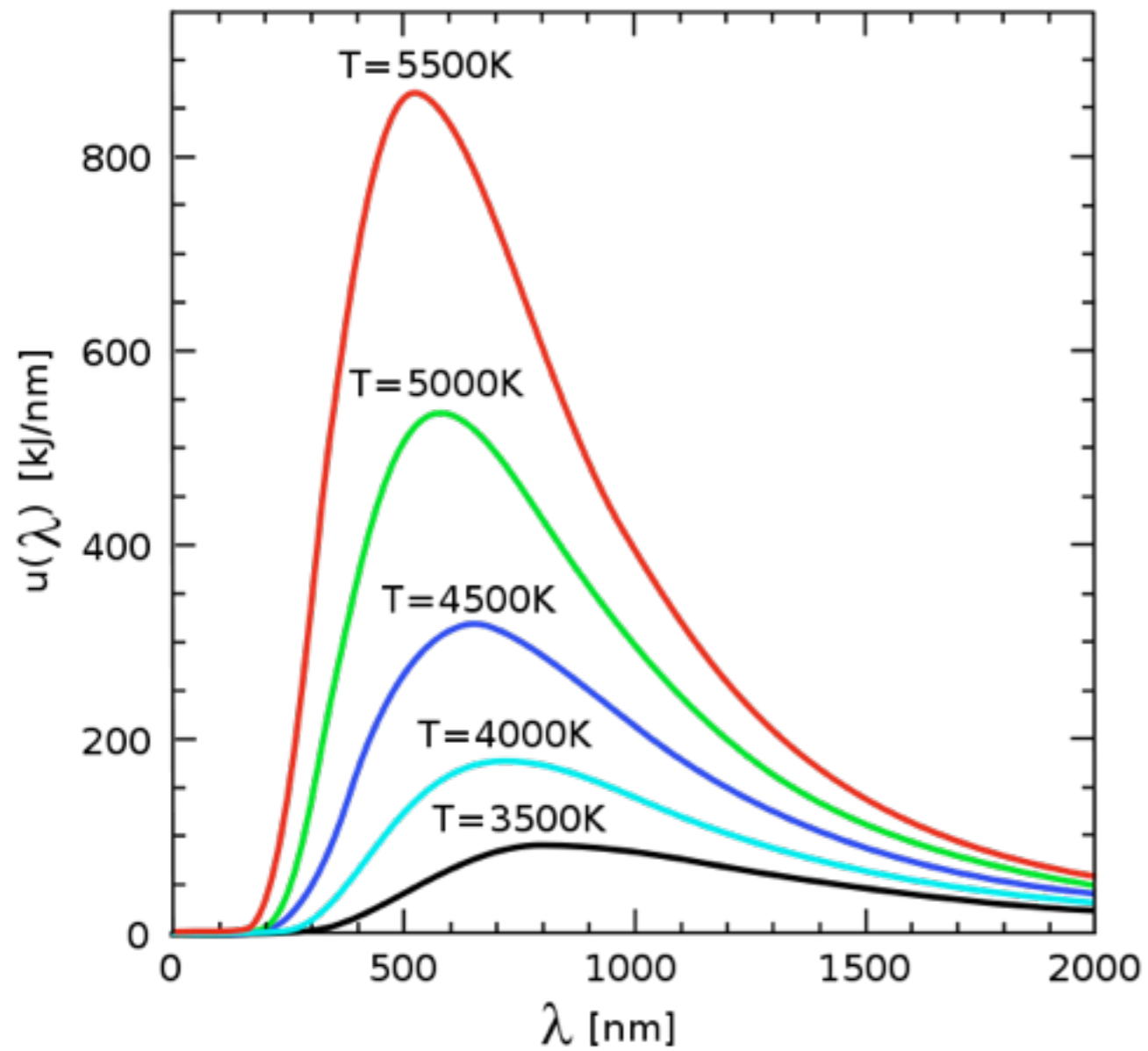


# Hubble heeft zijn limiet bereikt

## Hubble Probes the Early Universe



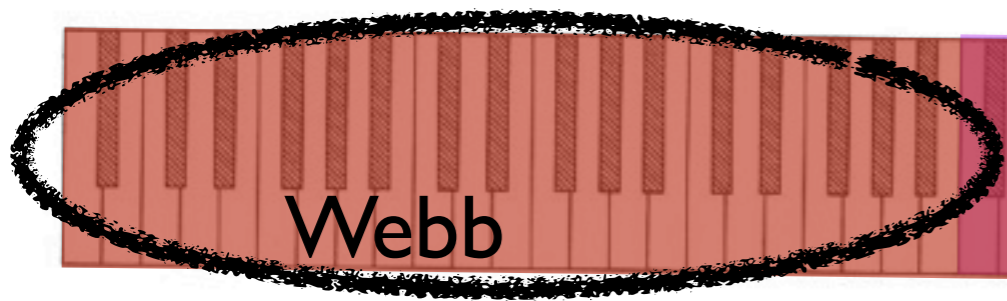
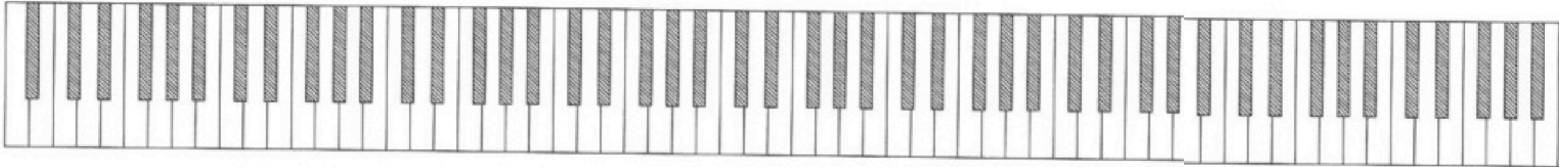
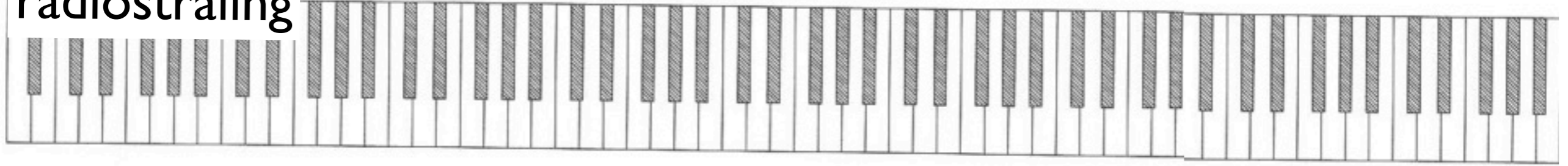






# Muziek der eerste sterren

radiostraling

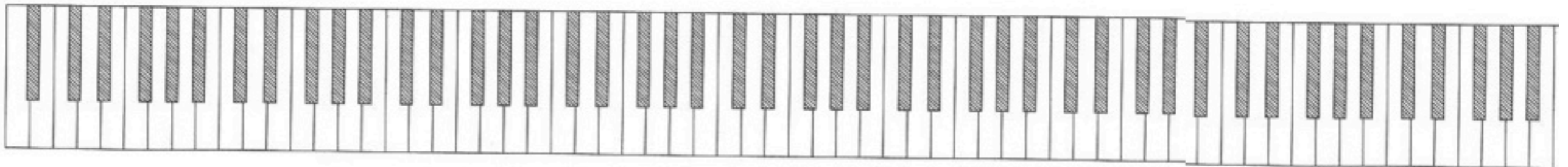
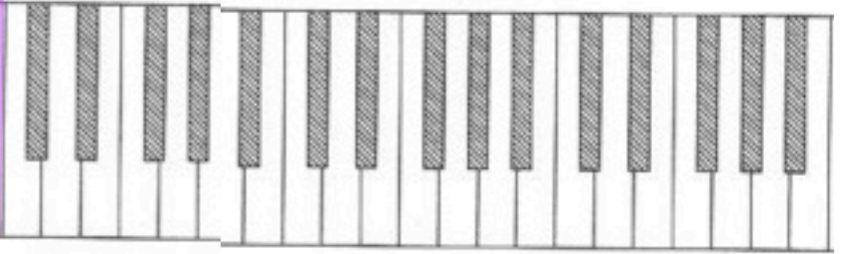
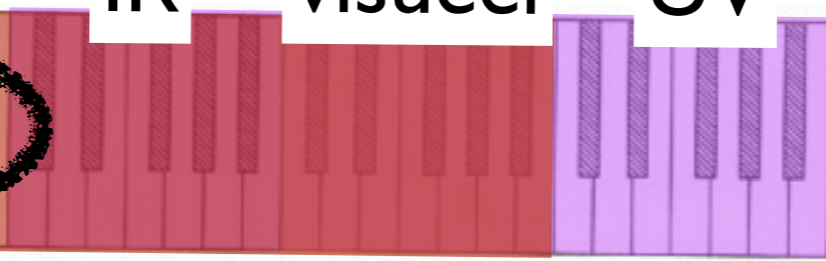


IR

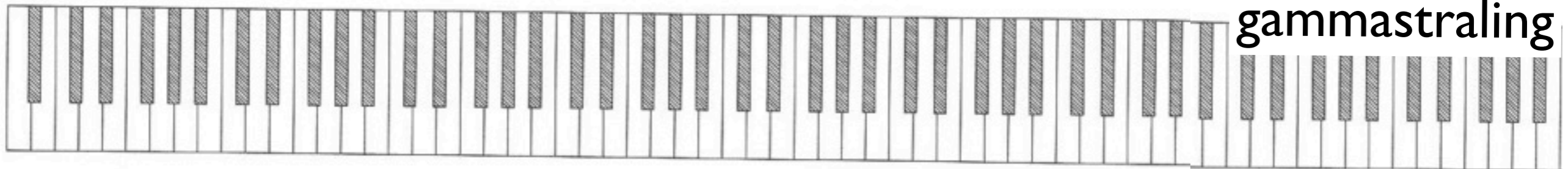
visueel

UV

Webb



gammastraling







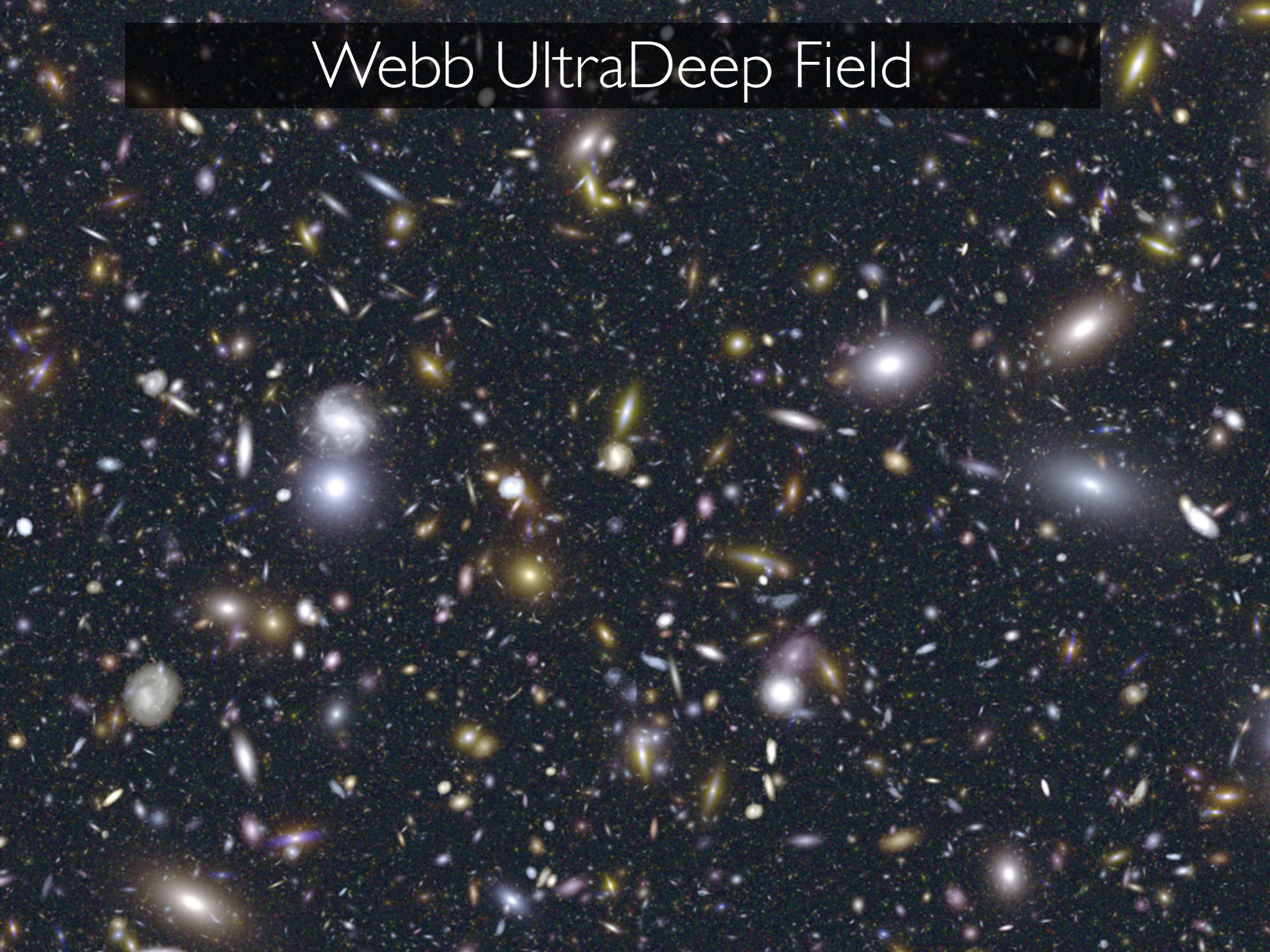


# Hubble UltraDeep Field





# Webb UltraDeep Field





Webb wordt vervolgd in 2018!

