

Sprehod skozi vesolje: Odkrivanje oddaljenega vesolja



MEDNARODNO
LETO SVETLOBE
2015

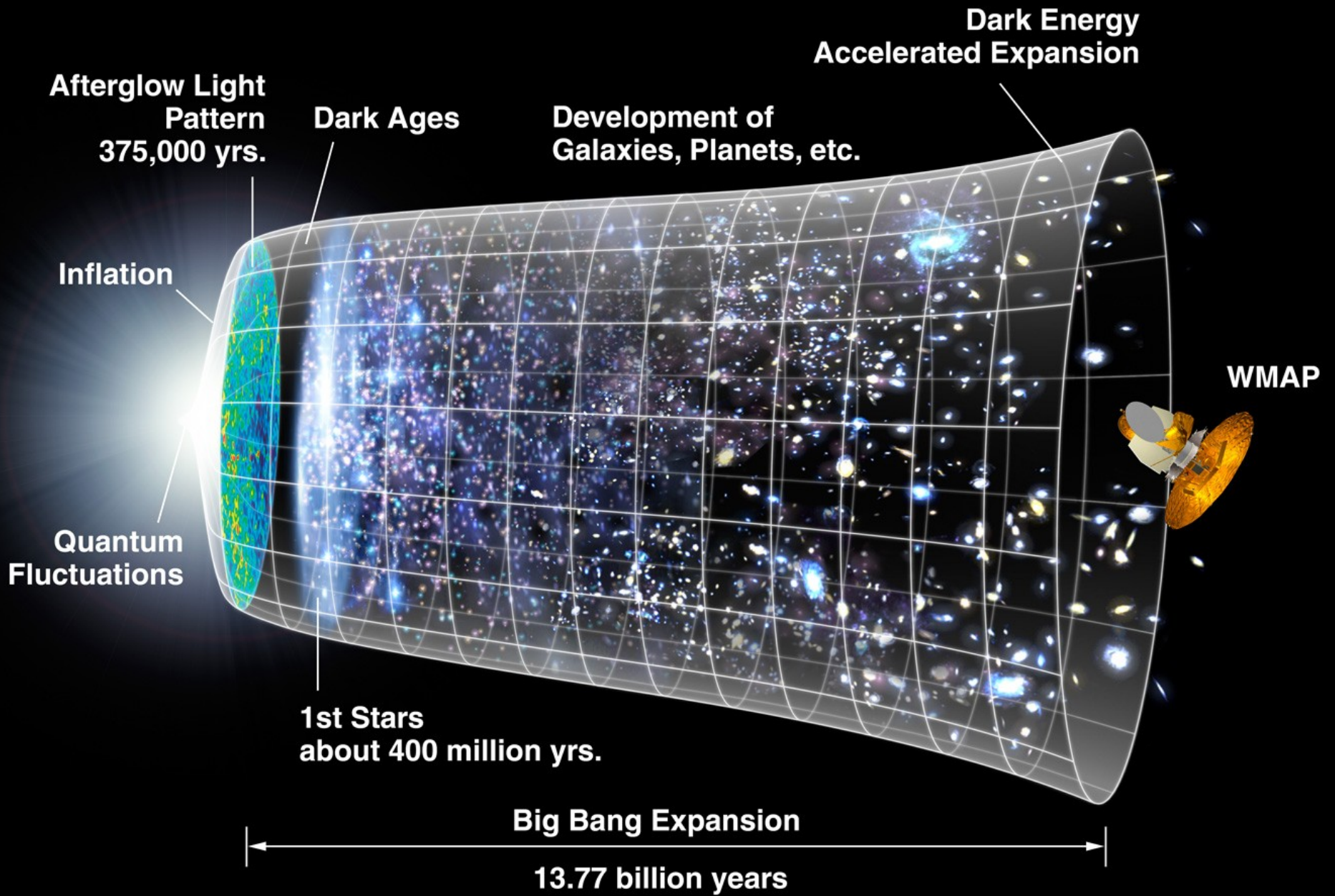
SVETLOBA 
IZ VESOLJA

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Zelo veliki teleskop, Paranal (Čile), Y. Beletsky (LCO)/ESO

Prirodoslovni muzej Slovenije · Ljubljana · 5.2.2015



NASA/WMAP Science Team

NASA/WMAP Science Team



Nick Risinger / NASA

Kako odkrivati oddaljene galaksije?

2024?
Evropski
izjemno veliki teleskop



ESO (Evropski južni observatorij)

Vesoljski teleskop Hubble



Evropska vesoljska agencija ESA



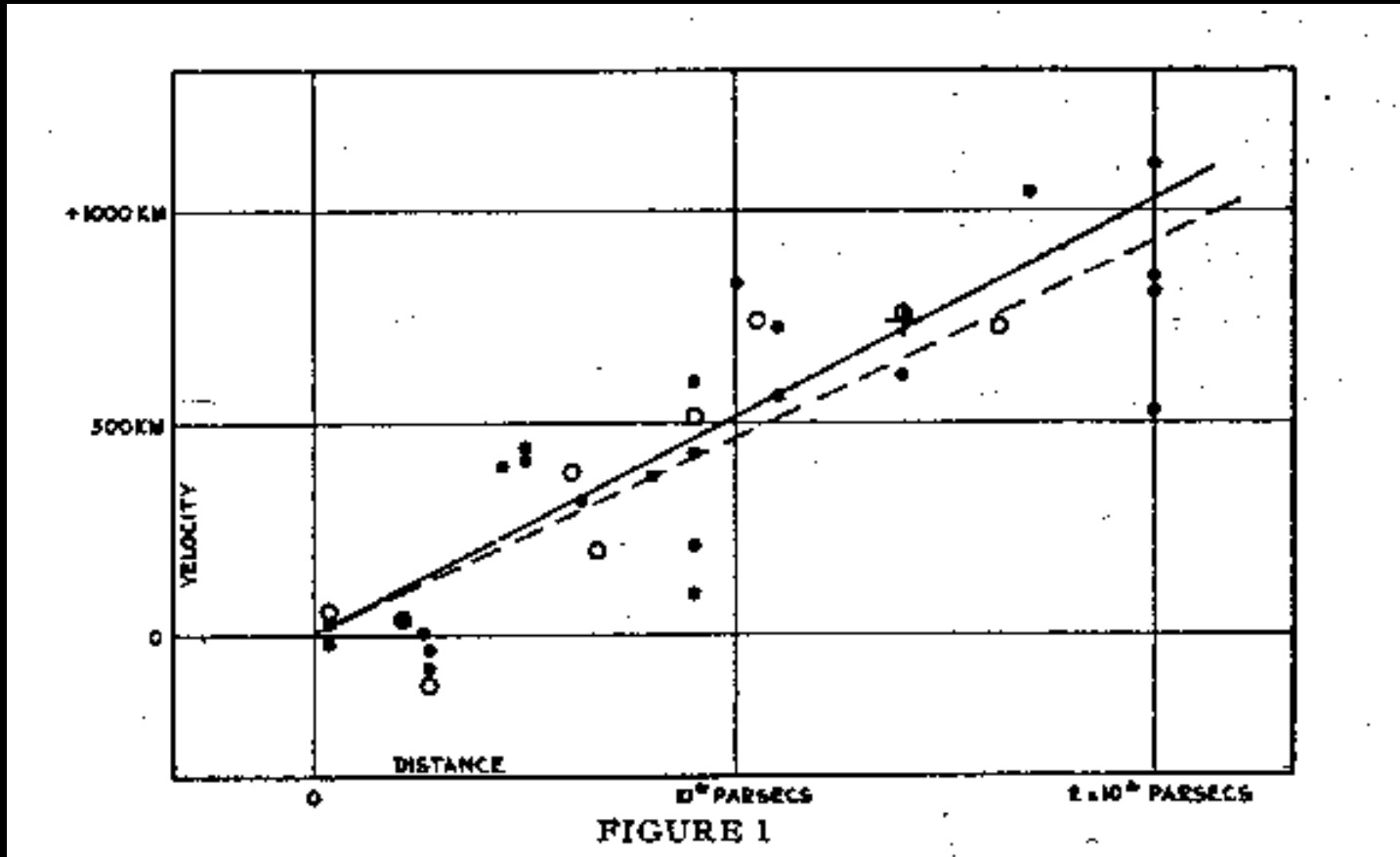
Absorpcijske črte:

← *v Sončevem spektru*

← *v oddaljeni galaksiji
(premaknjene zaradi
rdečega premika)*

Hubblow zakon (1929)

$$v = cz = H_0 d$$



$$H_0 = 100 h^{-1} km s^{-1} Mpc^{-1}, h = 0.67$$

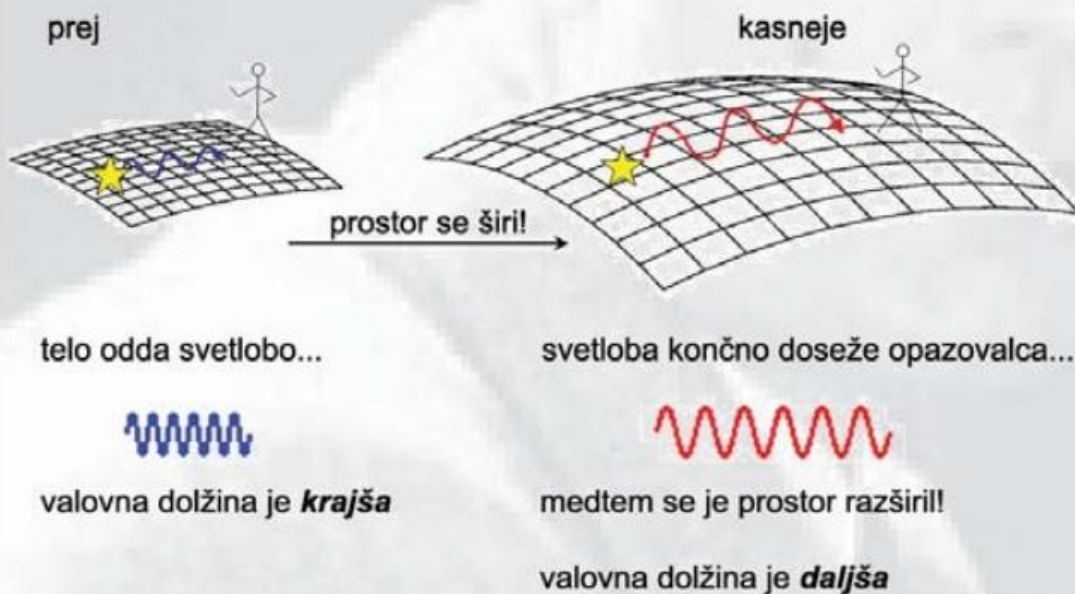
(zadnje meritve satelita Planck)

E. Hubble, PNAS, 1929
Volume 15, Number 3



Dve razlagi rdečega premika:

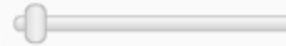
(i) **Dopplerjev pojav.** Zaradi gibanja izvora svetlobe v stran od opazovalca so vrhovi valov videti raztegnjeni – valovna dolžina je daljša, premaknjena k rdečemu delu spektra.



(ii) **Širjenje prostora.** Svetloba z oddaljene galaksije potrebuje dolgo časa, da doseže opazovalca. Med tem potovanjem se je vesolje širilo – in skupaj z njim se je valovna dolžina raztegnila – premaknila proti rdeči.

The spectrum for a galaxy is shown below. As the redshift (z) increases more of the galaxy's light is observed in the infrared and longer wavelengths. Due to the expansion of the universe more distant galaxies have greater redshifts.

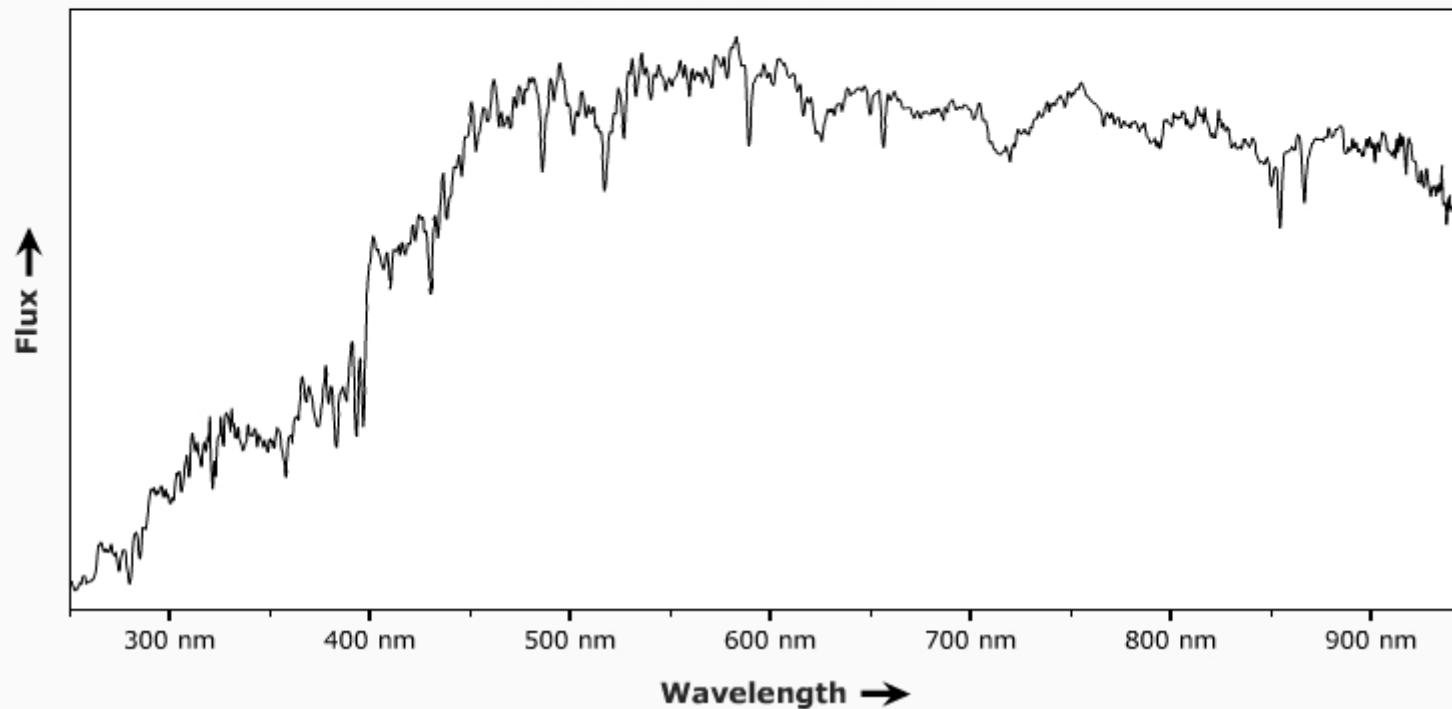
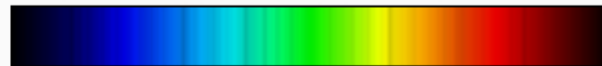
z (redshift):



$$z = \frac{\lambda_{\text{observed}} - \lambda_{\text{emitted}}}{\lambda_{\text{emitted}}}$$

Astronomers observe objects through various filters. As the galaxy's light is redshifted the relative brightness observed through the filters changes.

Visible Spectrum



Animacija na strani:

<http://astro.unl.edu/classaction/animations/cosmology/galacticredshift.html>

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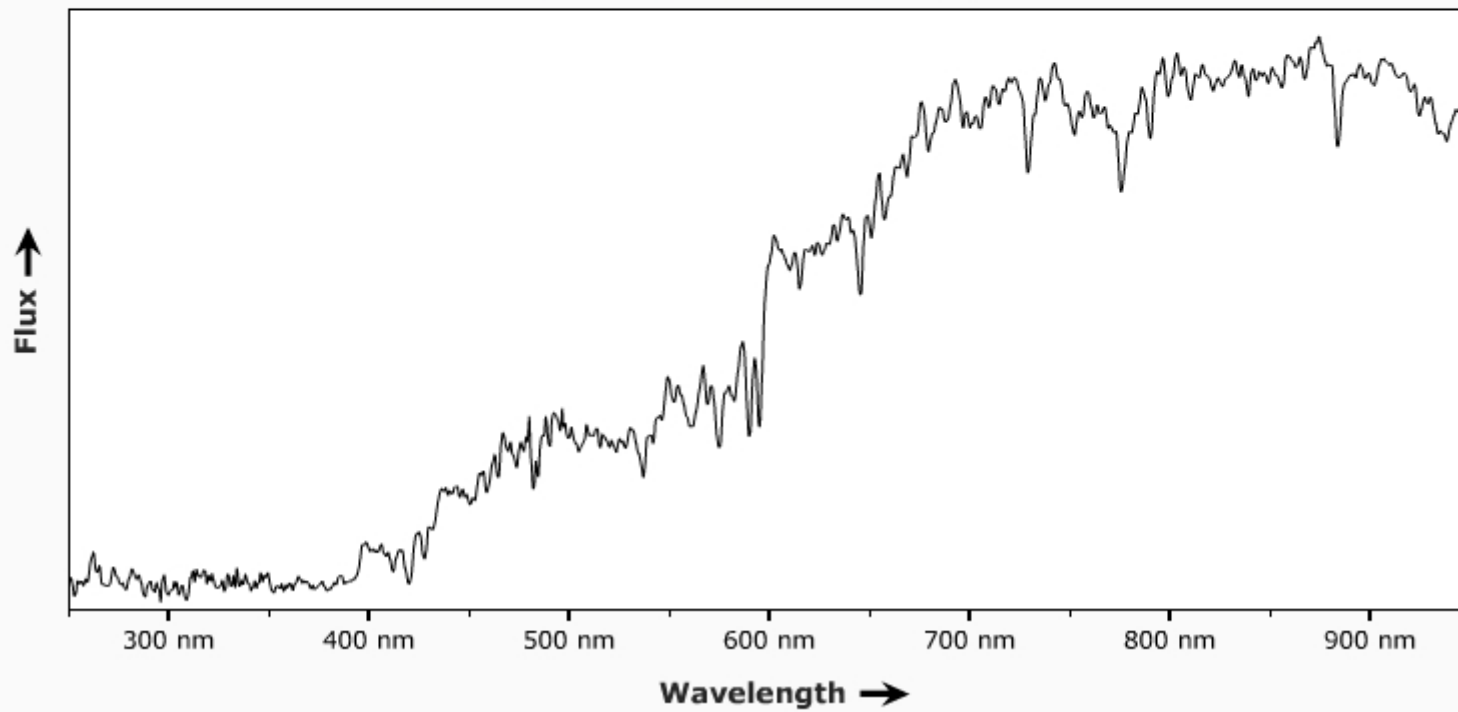


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[show filter details](#)

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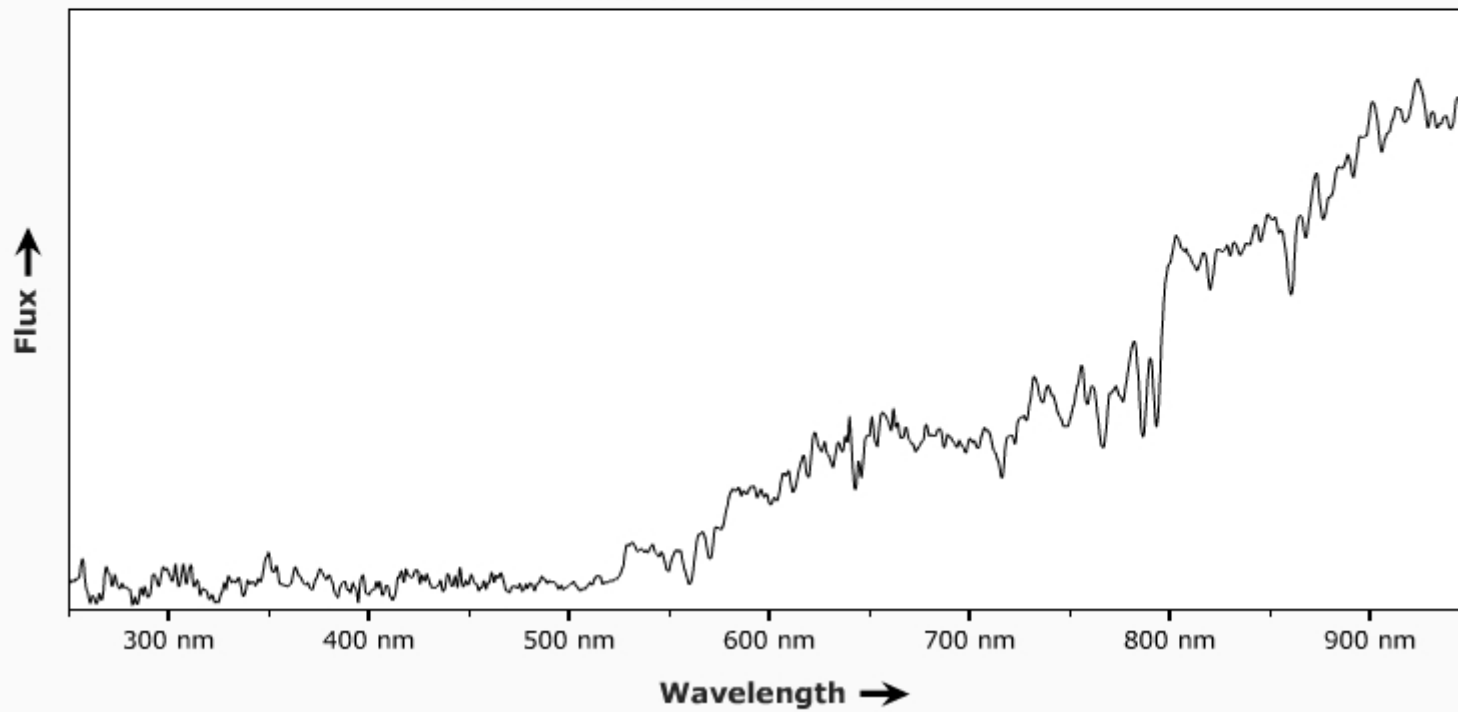
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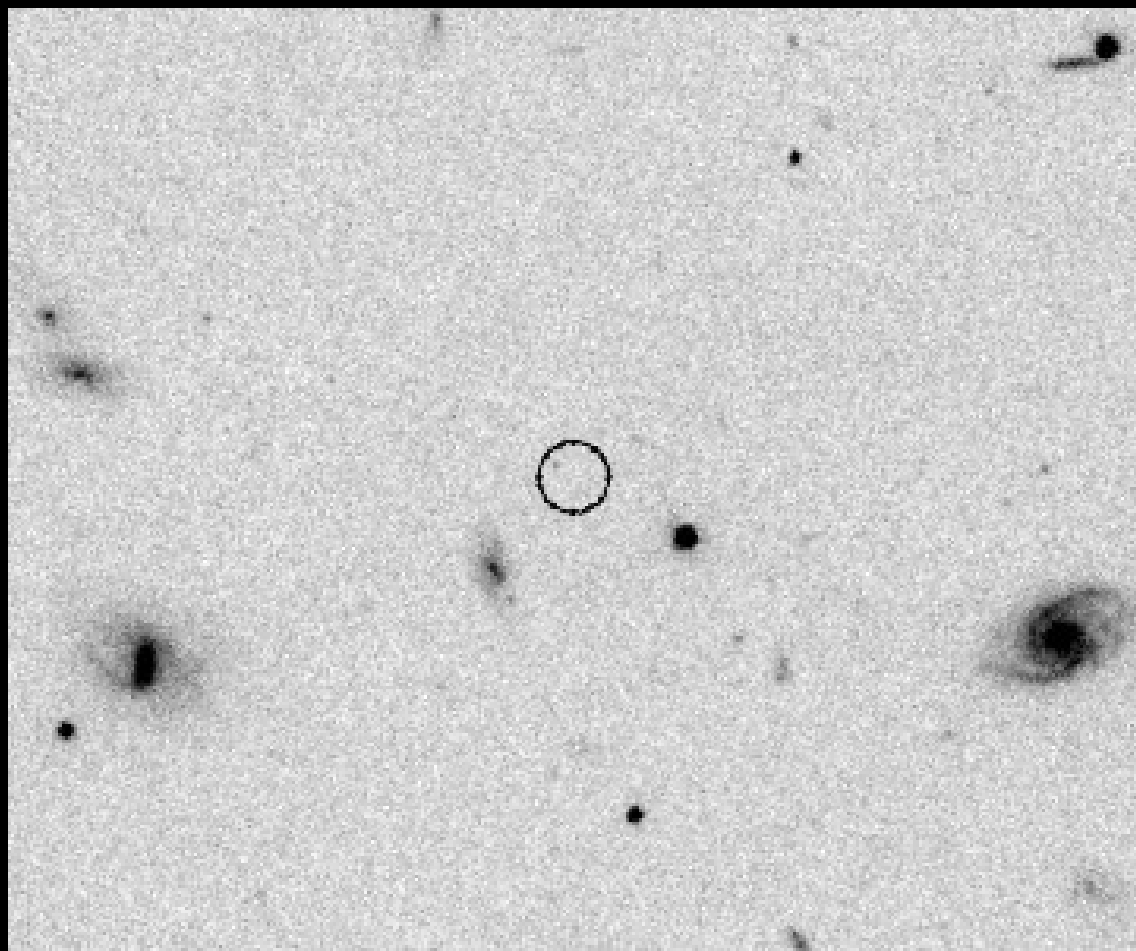
[show filter details](#)

Visible Spectrum



Kako odkrivati oddaljene galaksije?

Ozkopasovna fotometrija z uporabo posebno močne emisijske črte

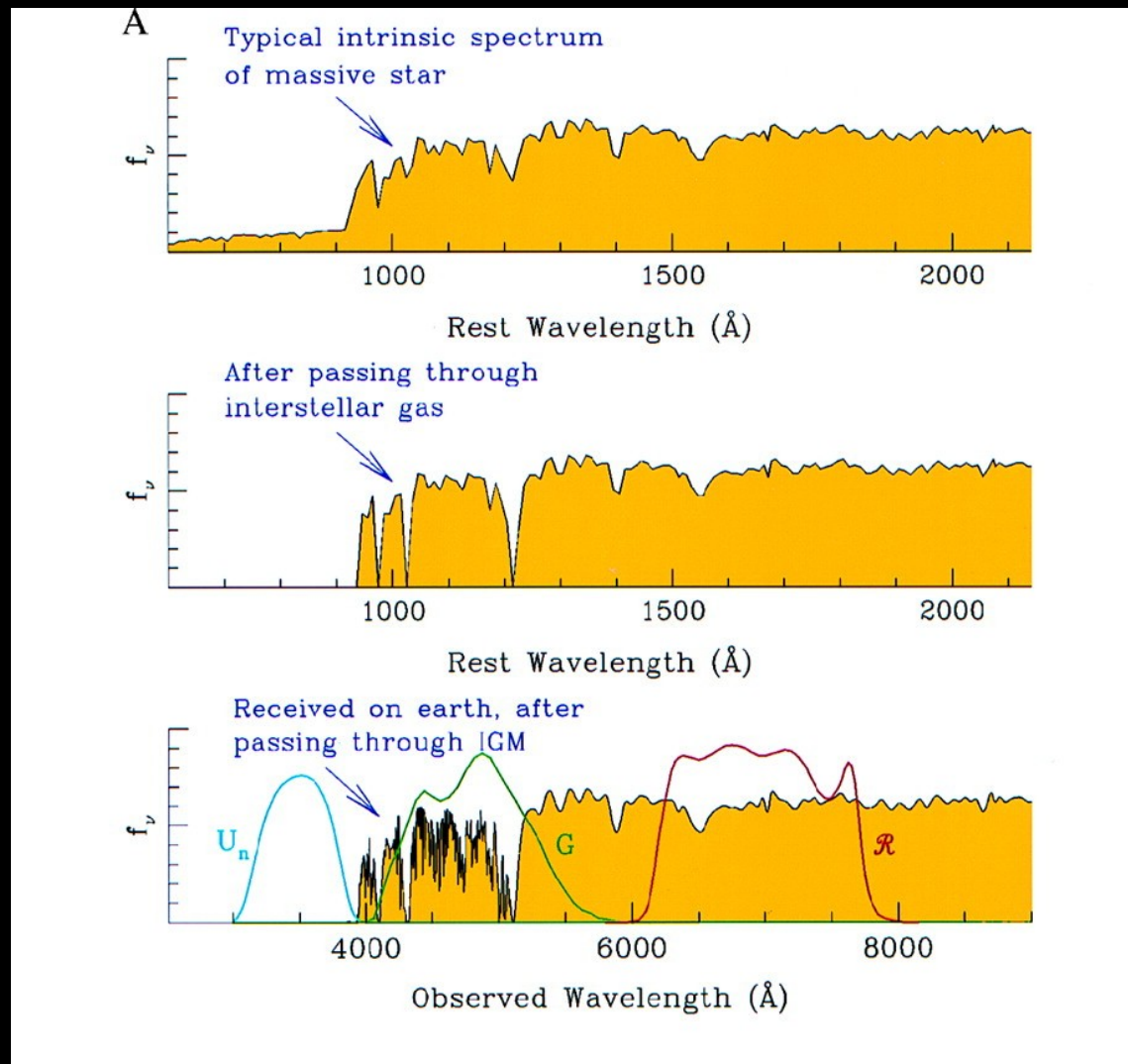


Vesoljski teleskop Hubble
išče emisijo Lyman alpha

Kamera WFPC2, filter F814W
(`wide I'), polje 36×30 arcmin²
Lyman alpha emitter
(označen s krogcem) na $z=4.19$.
Objekt ni zaznaven na 2.6 urnem
posnetku.

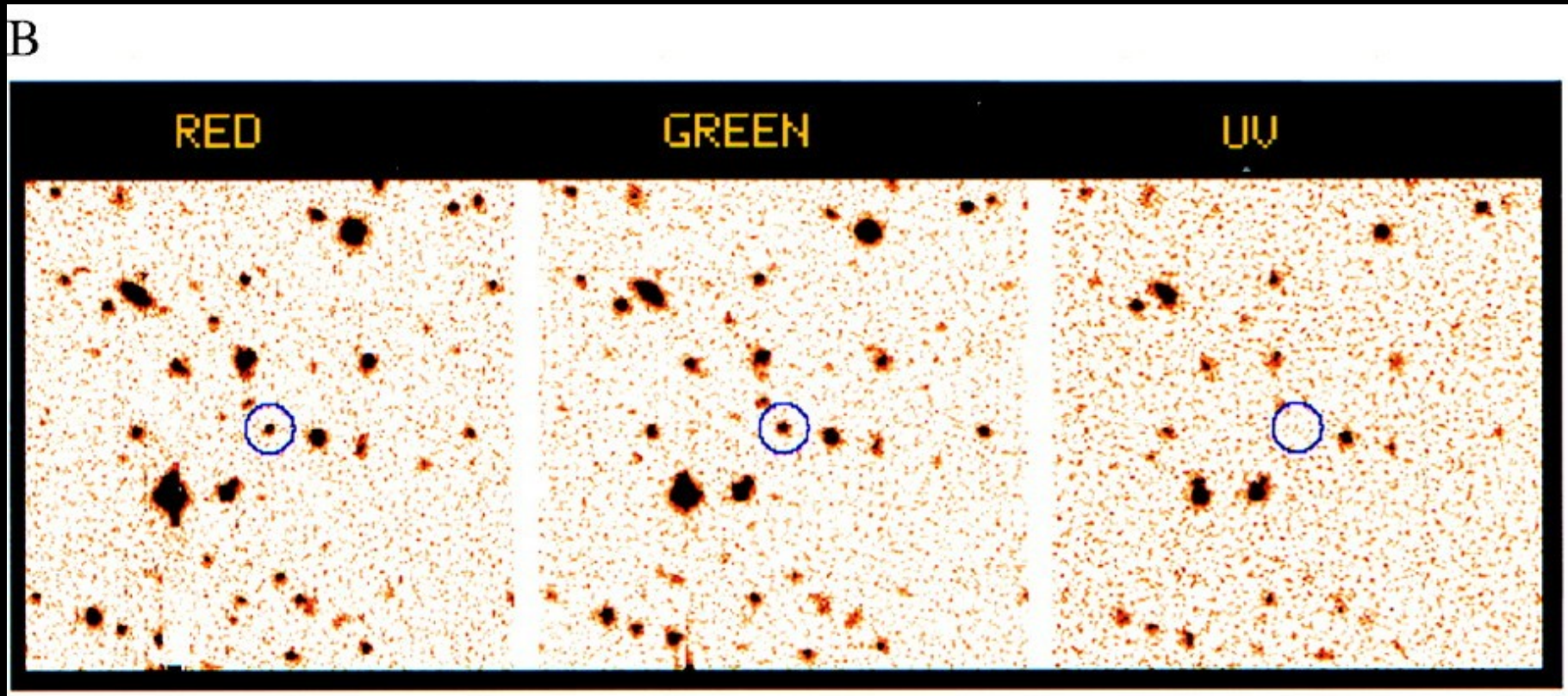
Kako odkrivati oddaljene galaksije?

Tehnika *Lyman break*



Kako odkrivati oddaljene galaksije?

Tehnika *Lyman break*

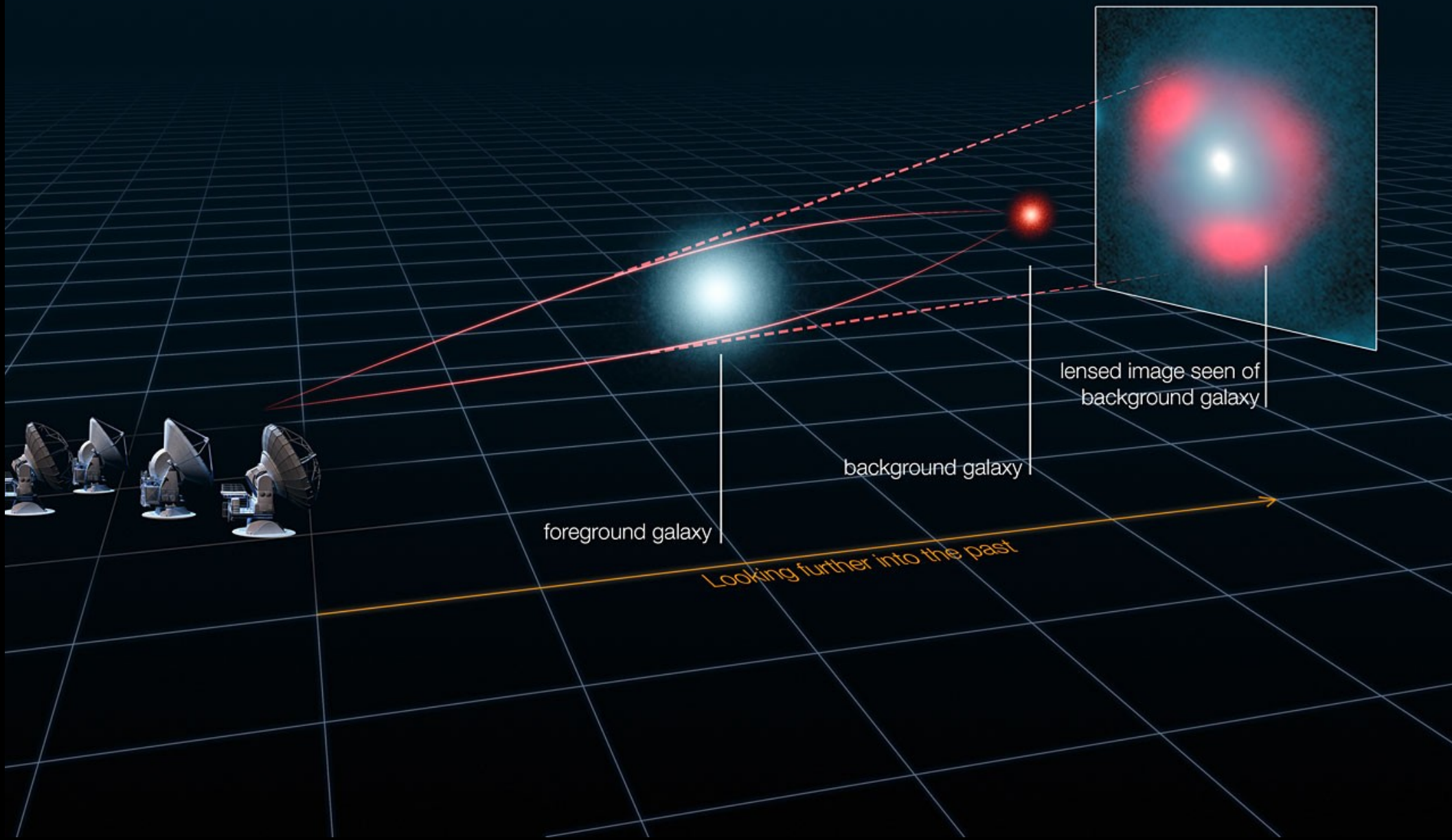


Kako odkrivati oddaljene galaksije?

Lečenje oddaljenih galaksij



Oddaljena
galaksija
MS 1512-cB58



foreground galaxy

background galaxy

lensed image seen of background galaxy

Looking further into the past

Hubblovo globoko polje



Hubble Deep Field

ST ScI OPO January 15, 1996 R. Williams and the HDF Team (ST ScI) and NASA

HST WFC2

Robert Williams and the Hubble Deep Field Team (STScI) and NASA/ESA



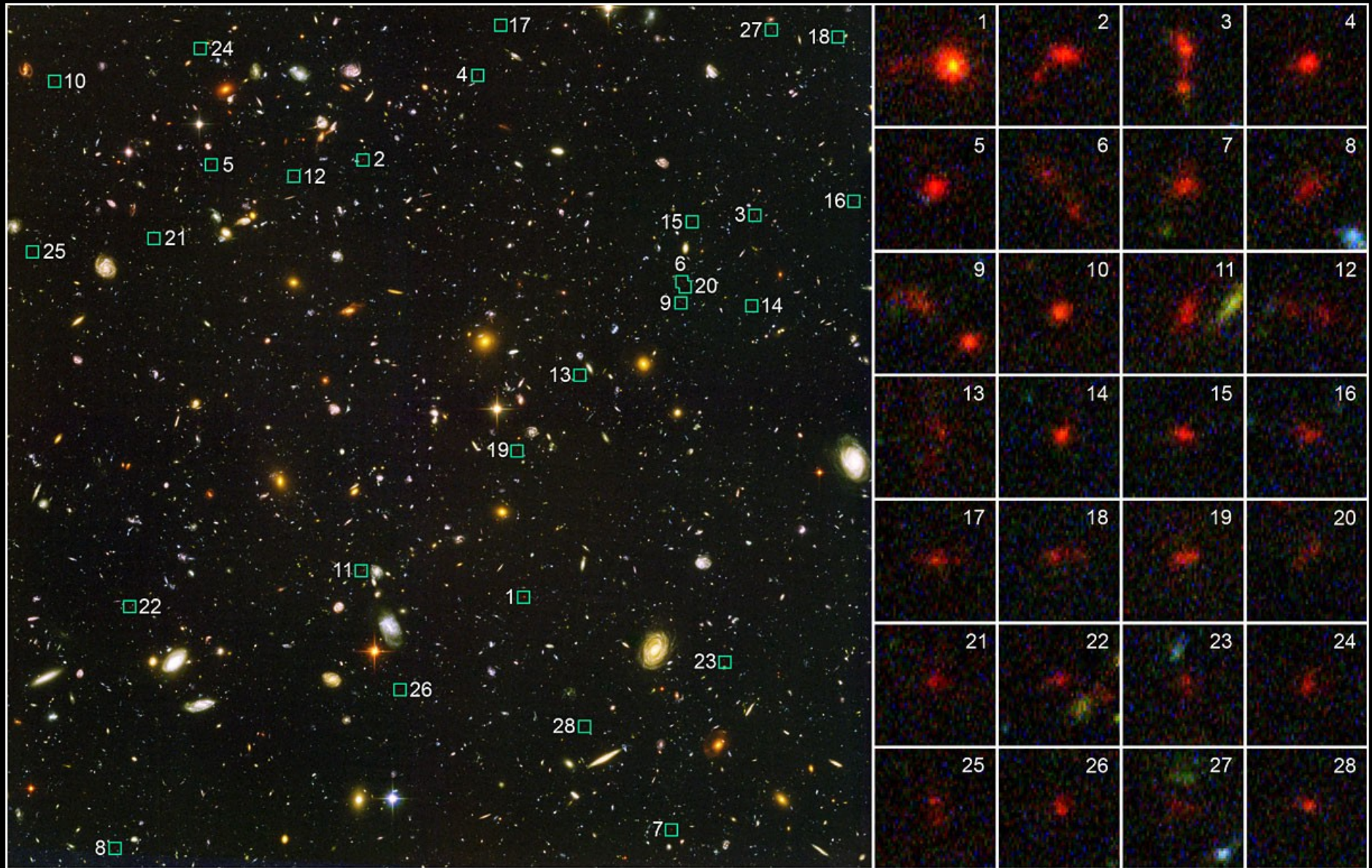
Hubblovo
ultra globoko polje

NASA, ESA, and S. Beckwith (STScI) and the HUDF Team



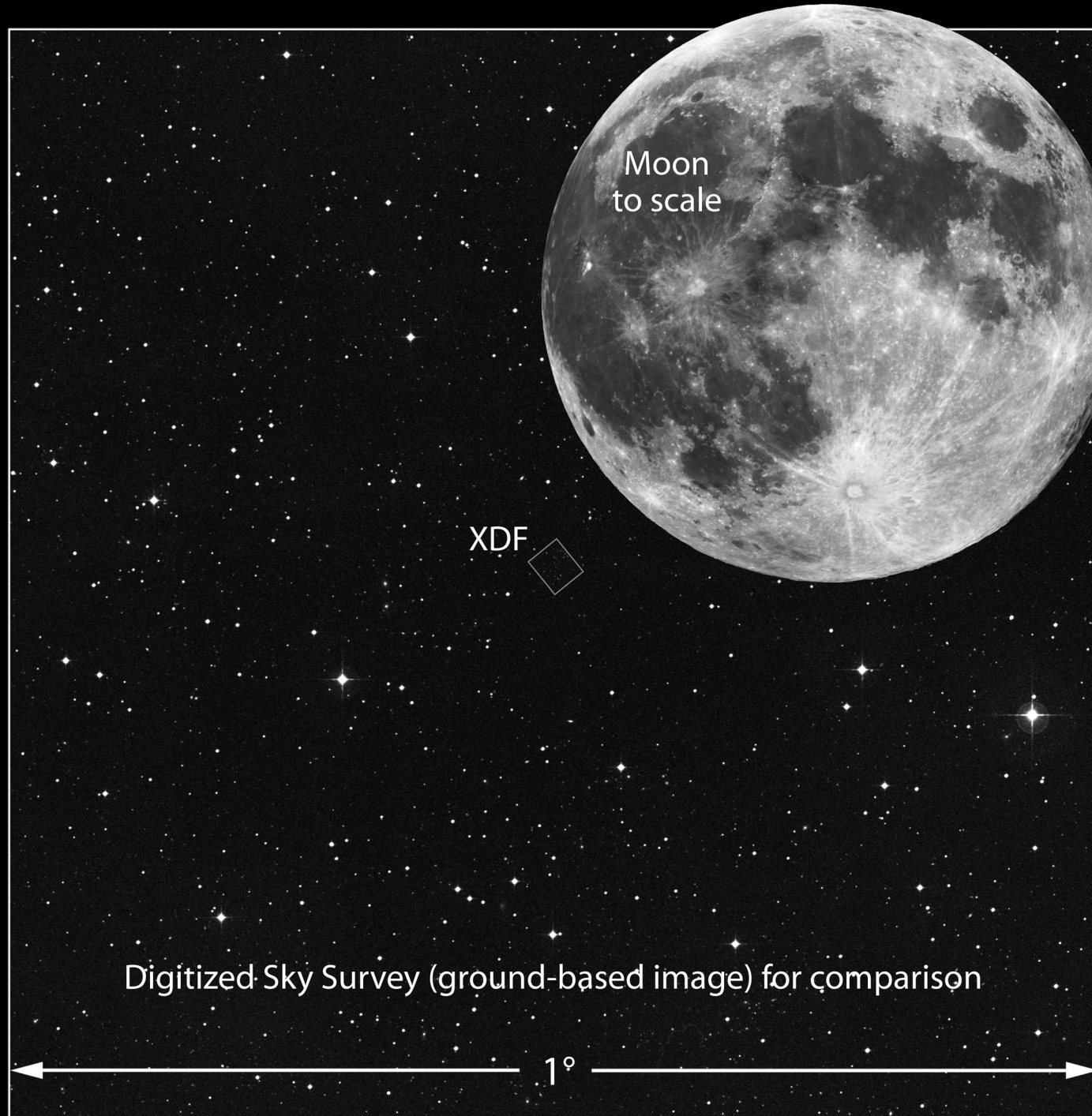
NASA, ESA, F. Summers, Z. Levay, L. Frattare, B. Mobasher, A. Koekemoer and the HUDF Team (STScI)

Hubblovo ultra globoko polje



NASA, ESA, R. Bouwens and G. Illingworth (University of California, Santa Cruz, USA)

Size of Hubble eXtreme Deep Field on the Sky





Hubblovo
izjemno globoko polje

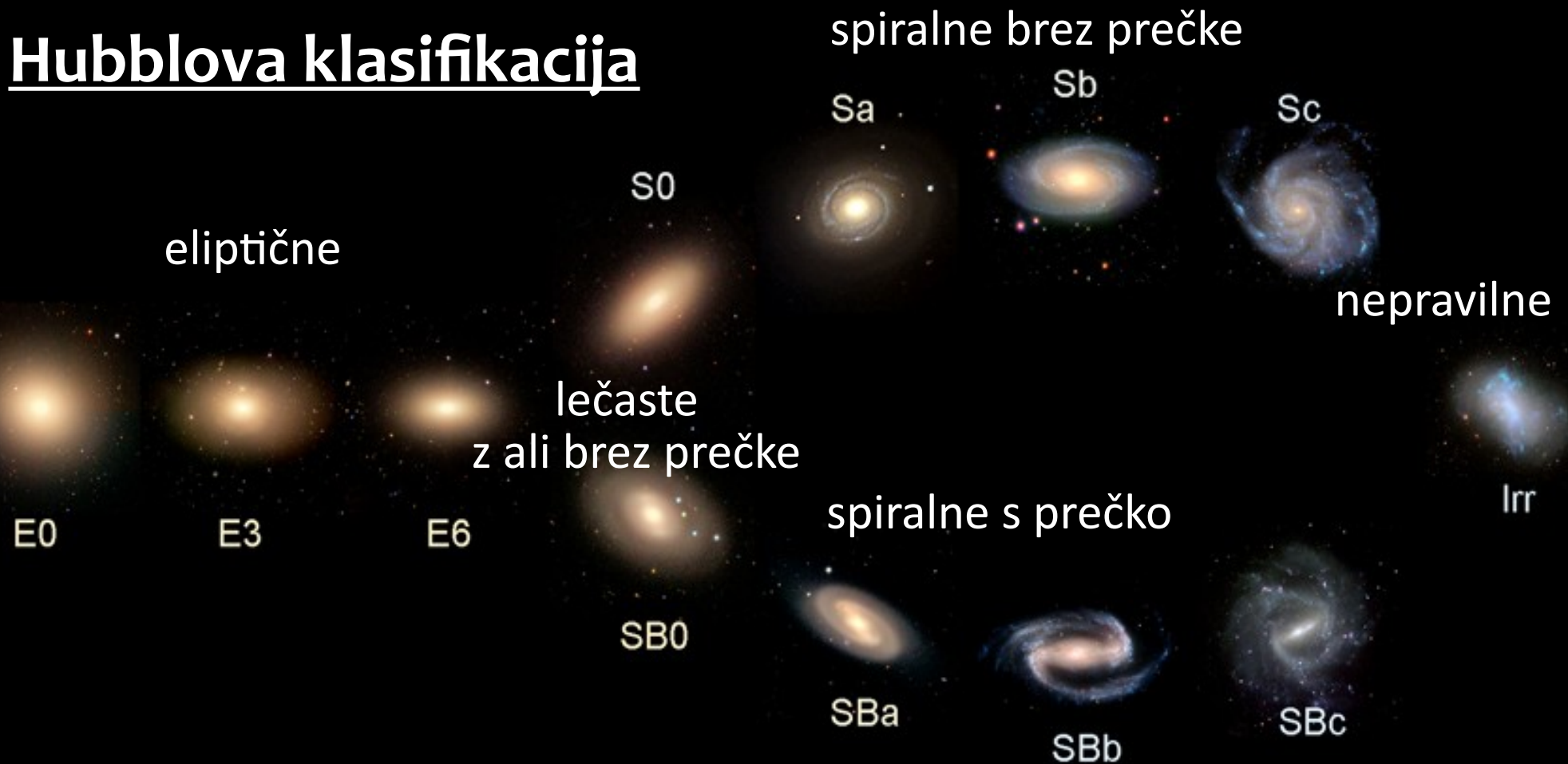
Hubble Probes the Early Universe



Kako izgledajo oddaljene galaksije?

So podobne tem, ki jih poznamo?

Hubblova klasifikacija





Optical



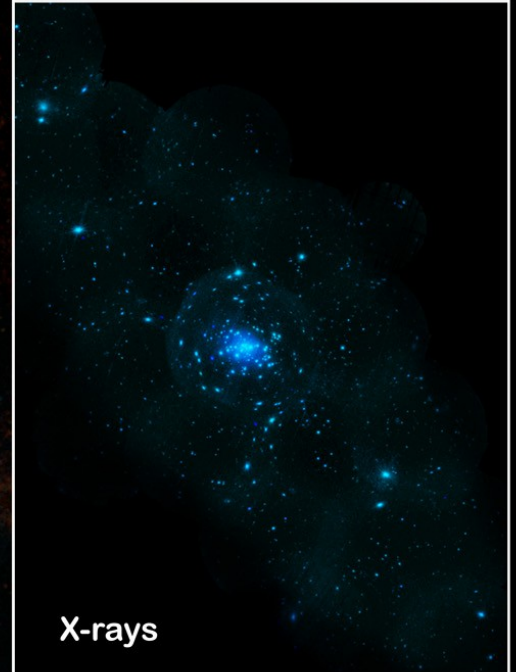
Infrared & X-rays



Infrared



Composite



X-rays

Galaksije z izbruhi nastajanja zvezd

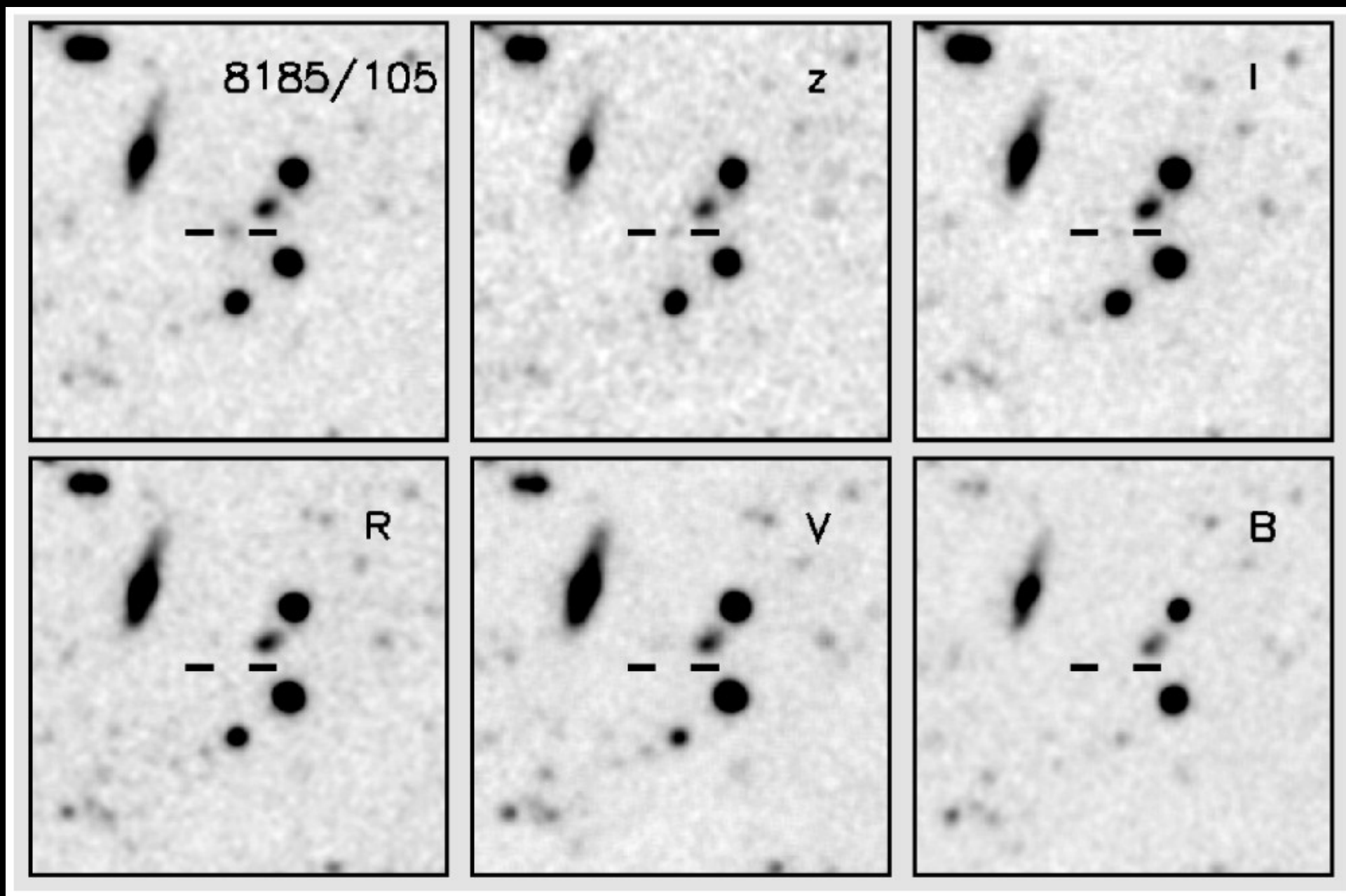


NASA/ESA



ALMA (ESO/NAOJ/NRAO) in HST

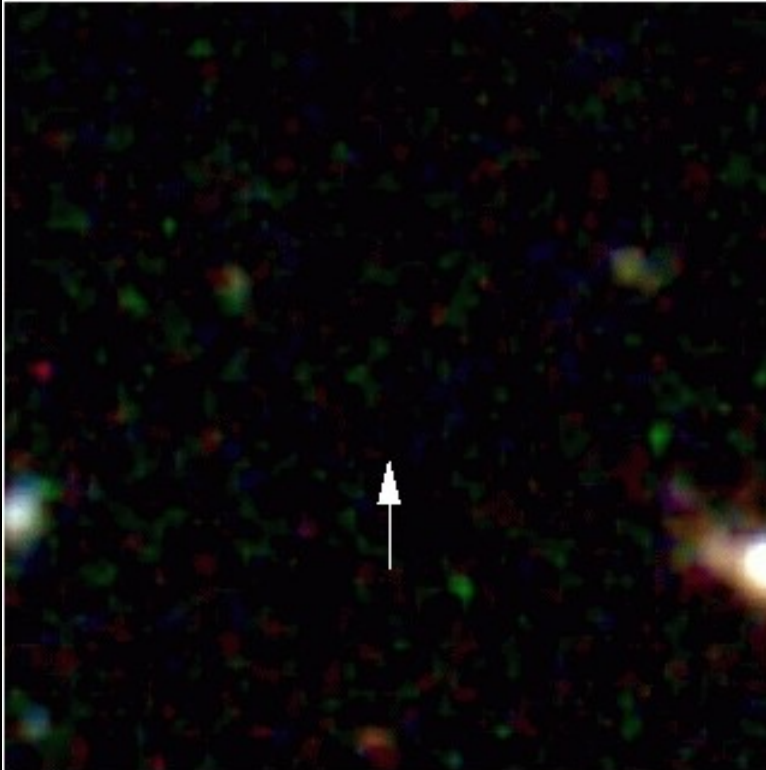
Galaksije *Lyman break*



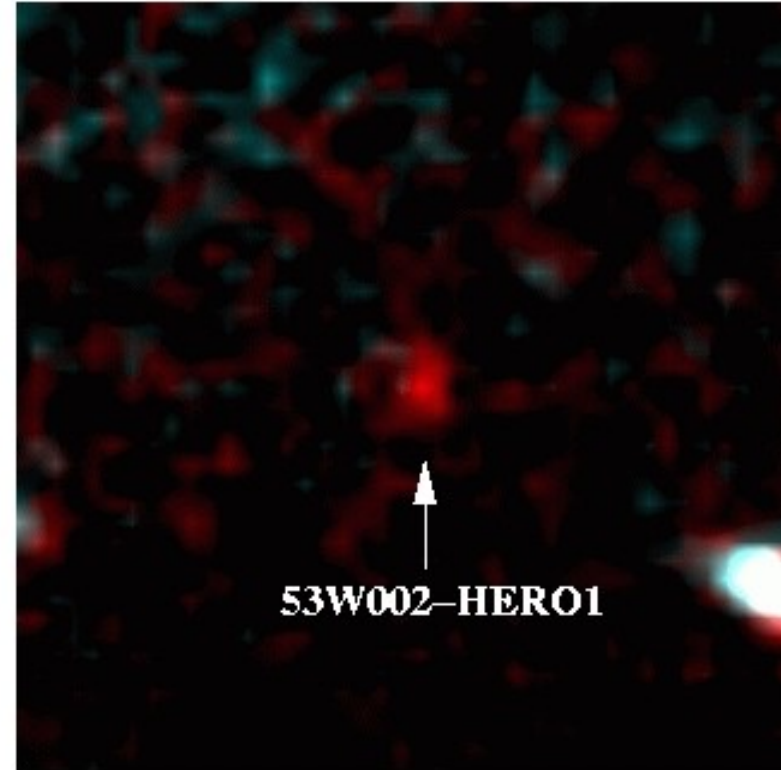
Galaksije *ERO* (*Extremely Red Objects*)

HERO J171412+501542 (a.k.a, 53W002-HERO1)

In Visible Light



In Near Infrared



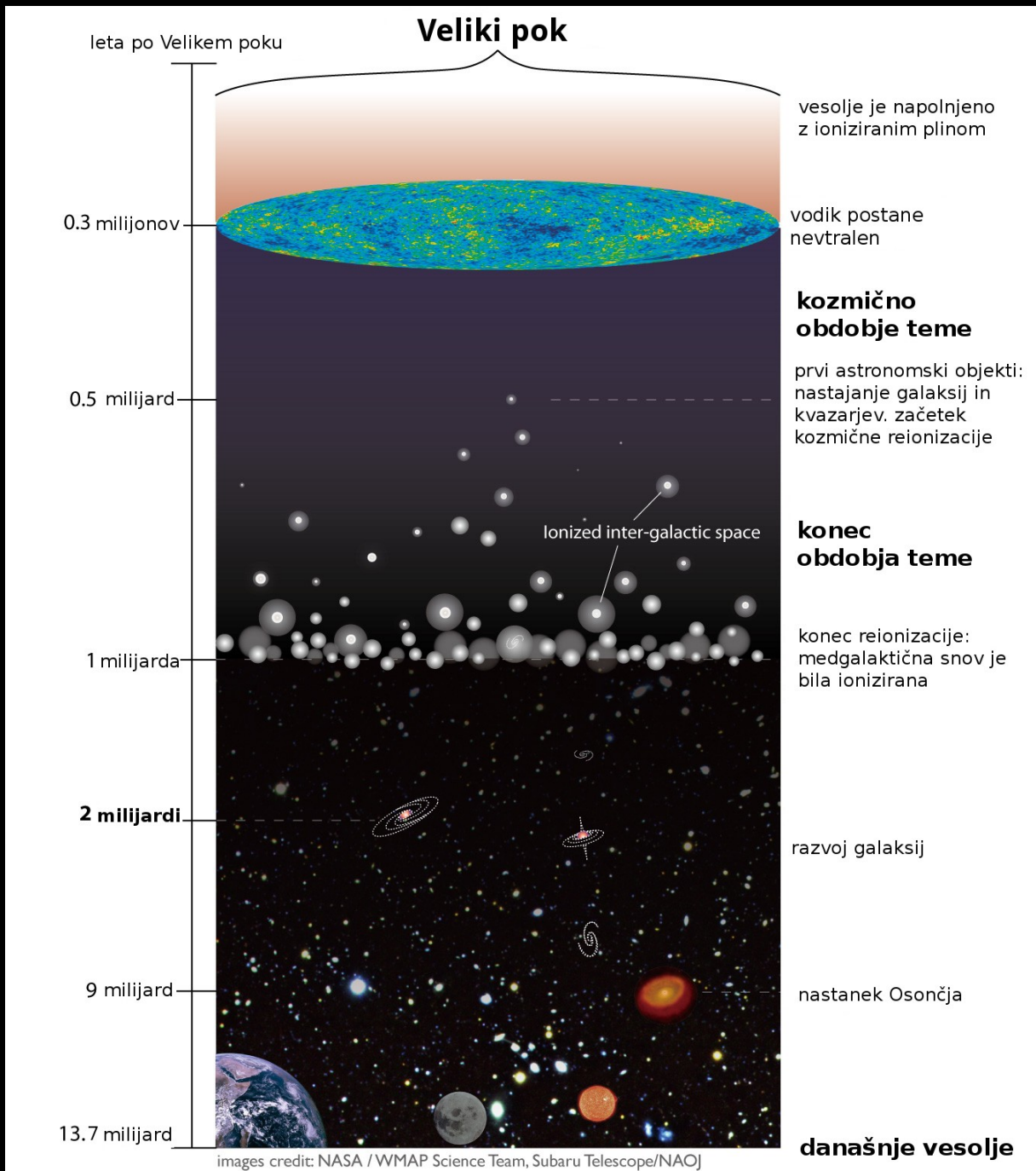
8 arcsecond

Galaksije *ERO* (*Extremely Red Objects*)



Ultraluminous Infrared Galaxies **HST • WFPC2**

NASA and K. Borne (Raytheon ITSS and NASA Goddard Space Flight Center), H. Bushouse (STScI), L. Colina (Instituto de Fisica de Cantabria, Spain) and R. Lucas (STScI)

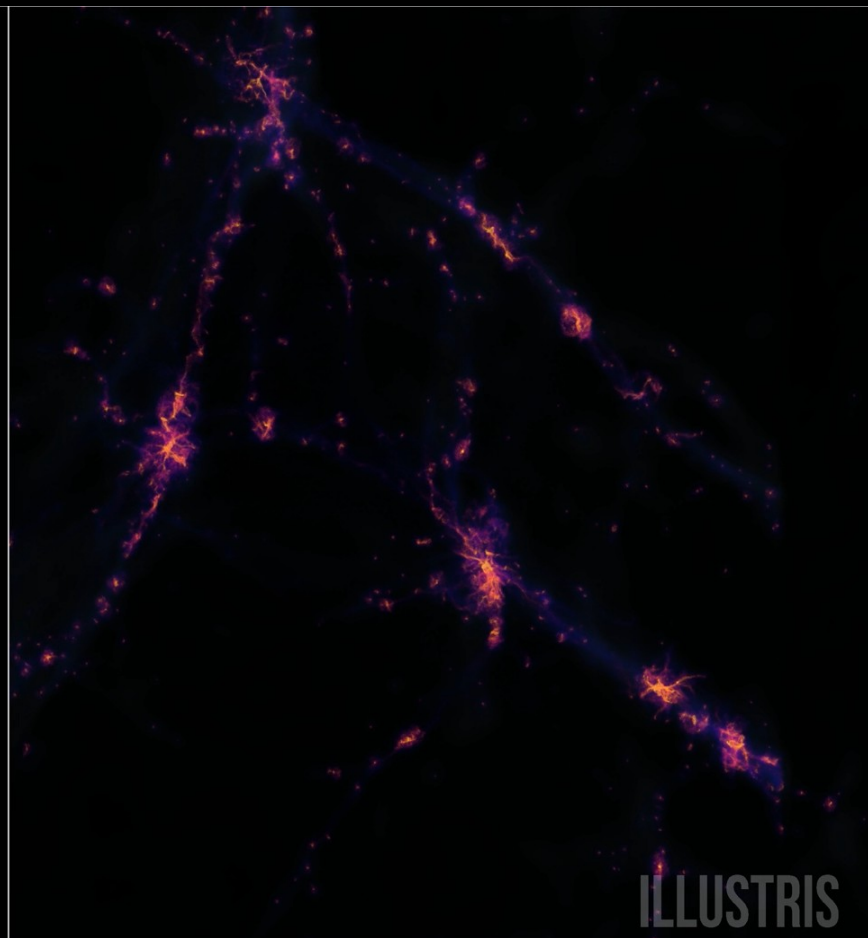
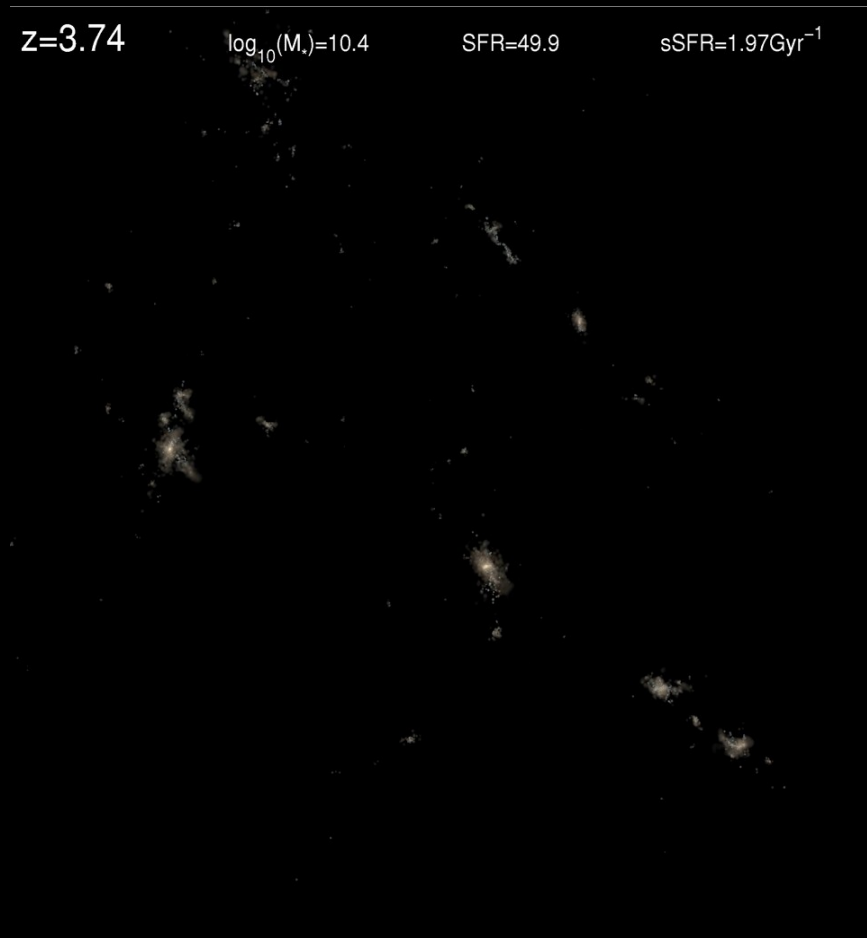


$z=3.74$

$\log_{10}(M_*)=10.4$

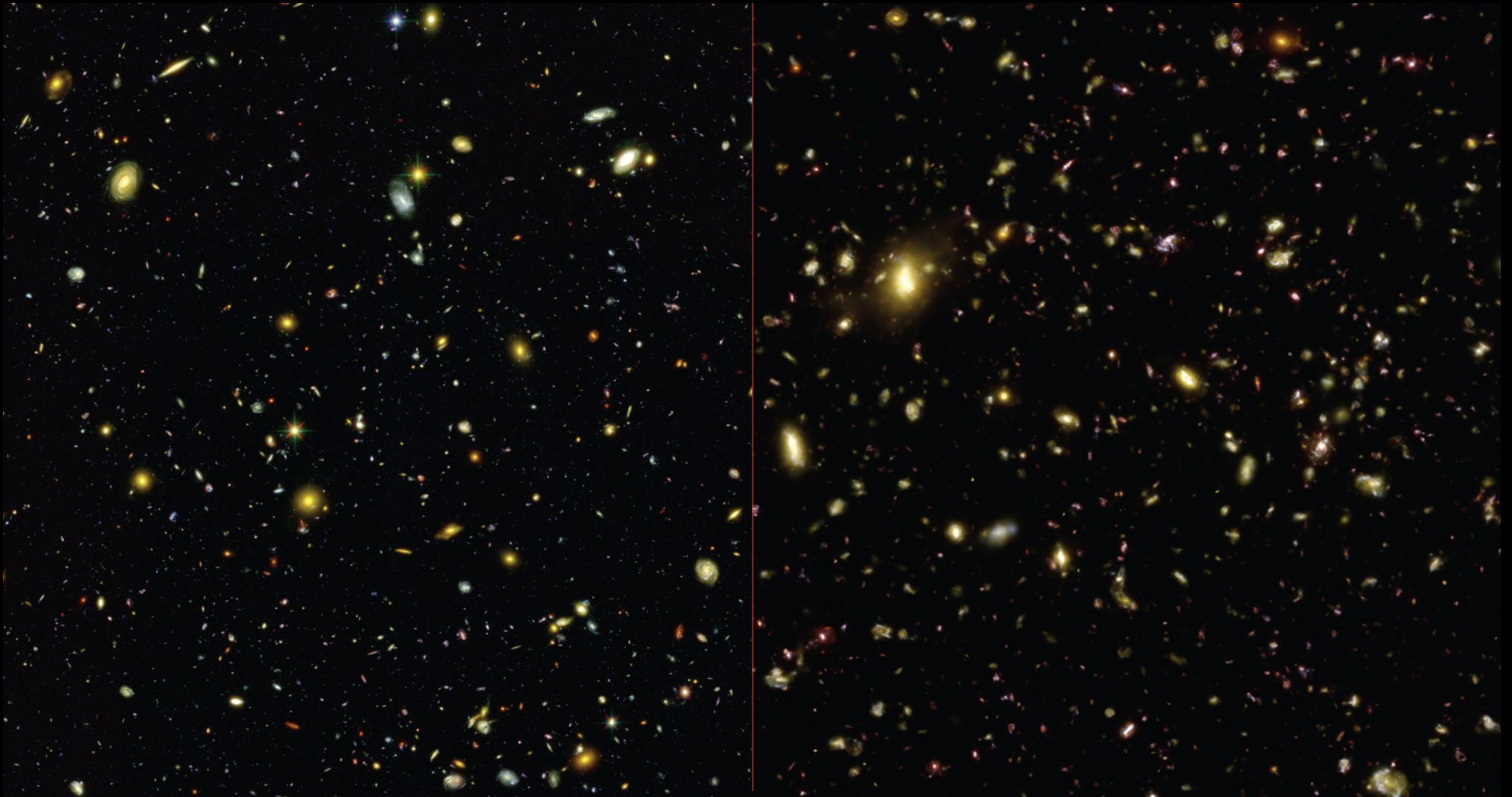
SFR=49.9

sSFR=1.97Gyr⁻¹



ILLUSTRIS

Katero je pravo vesolje?



640601