

Vesoljska zgodba

Sprehodi po vesolju, 1. April 2016
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Starost vesolja:
0 sekund

Kozmološka inflacija



Širjenje ohrani
zgostitve na
makro ravni.

Širjenje, ki ga poganja inflatonsko polje

Kvantno nihanje
vakuma

Starost vesolja:
0 sekund

Kozmološka inflacija

"Veliki Pok"

$\infty^{\circ}\text{C} \approx$

temperatura

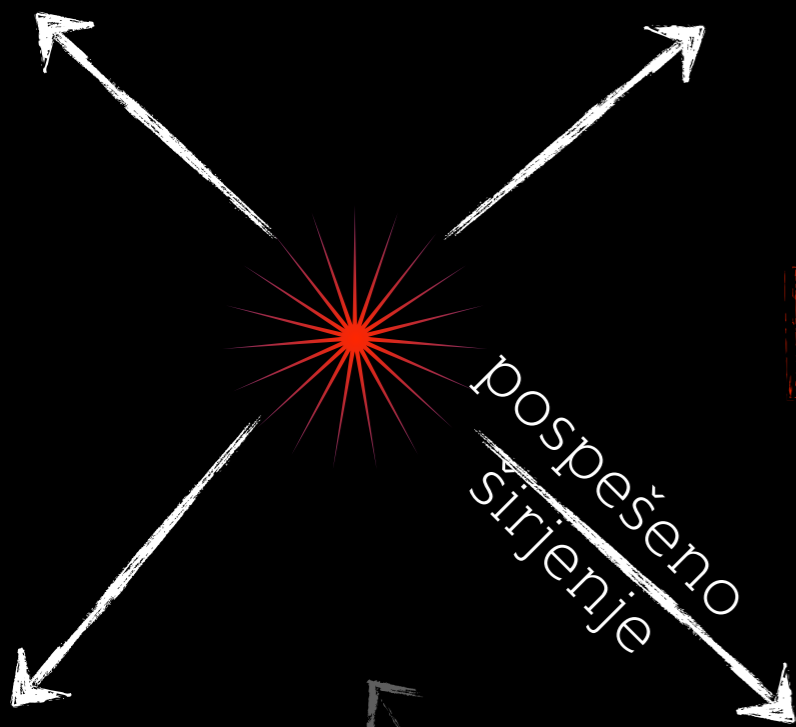
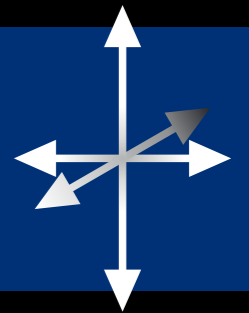
$0 \text{ m} \approx$

velikost vidnega vesolja

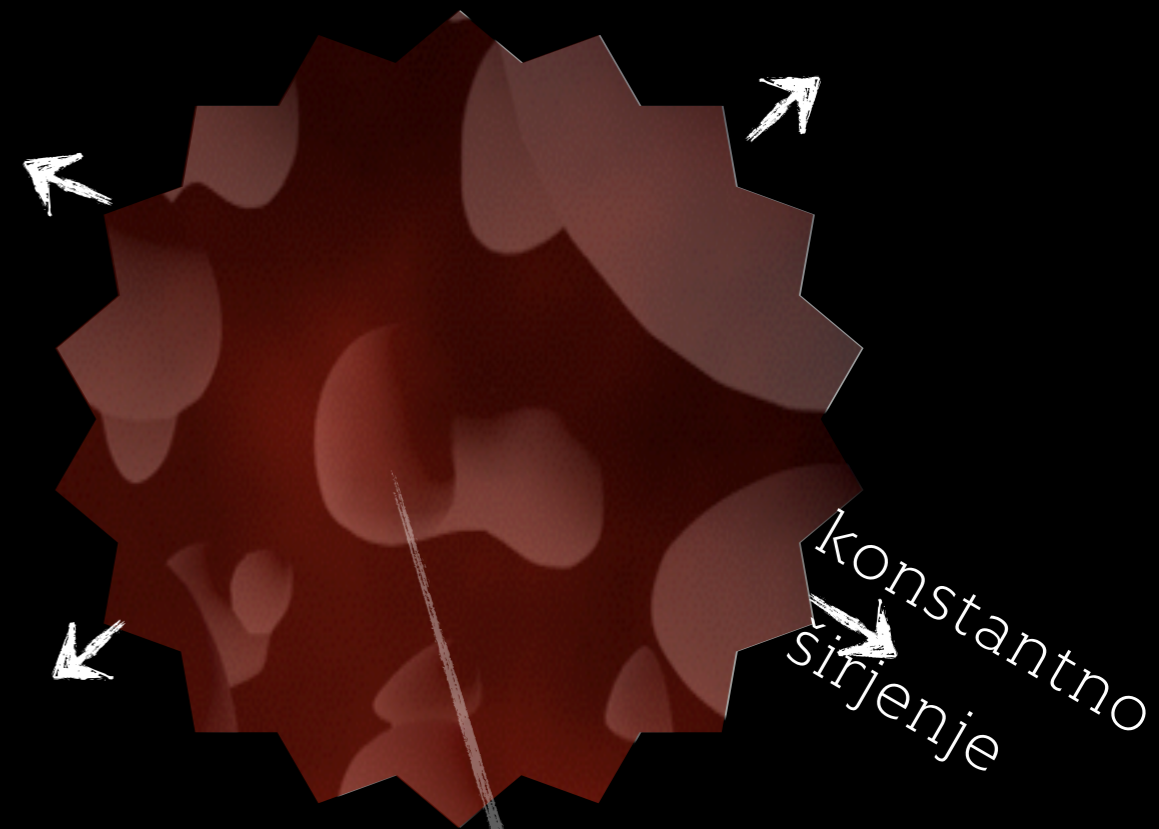
konec inflacije

$\approx 10^{27}^{\circ}\text{C}$

≈ 1 grenivka



redč



vidno vesolje

zgostitve energije oz. "pra-grbine"

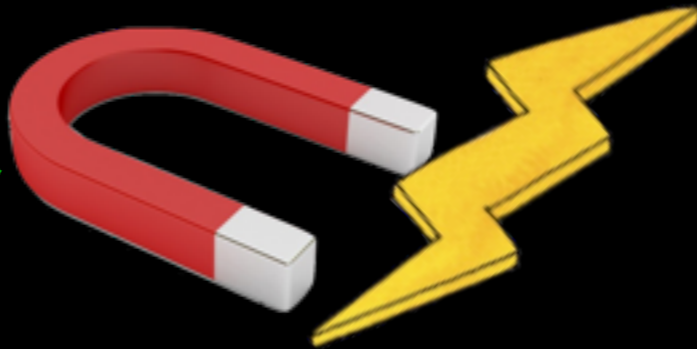
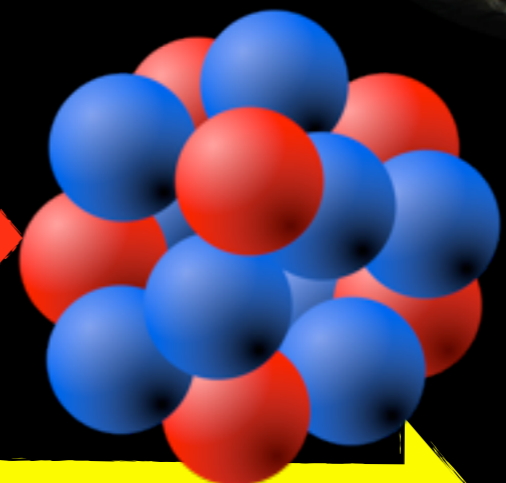
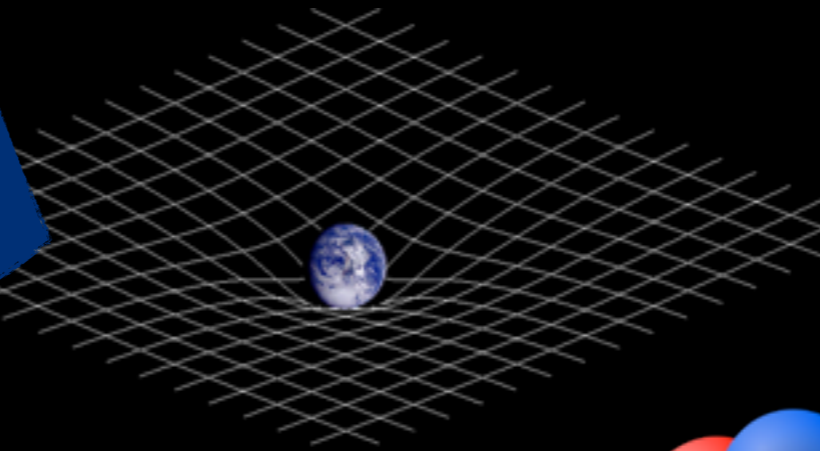
Razlaga: **4 sile narave**

gravitacija

močna jedrska sila

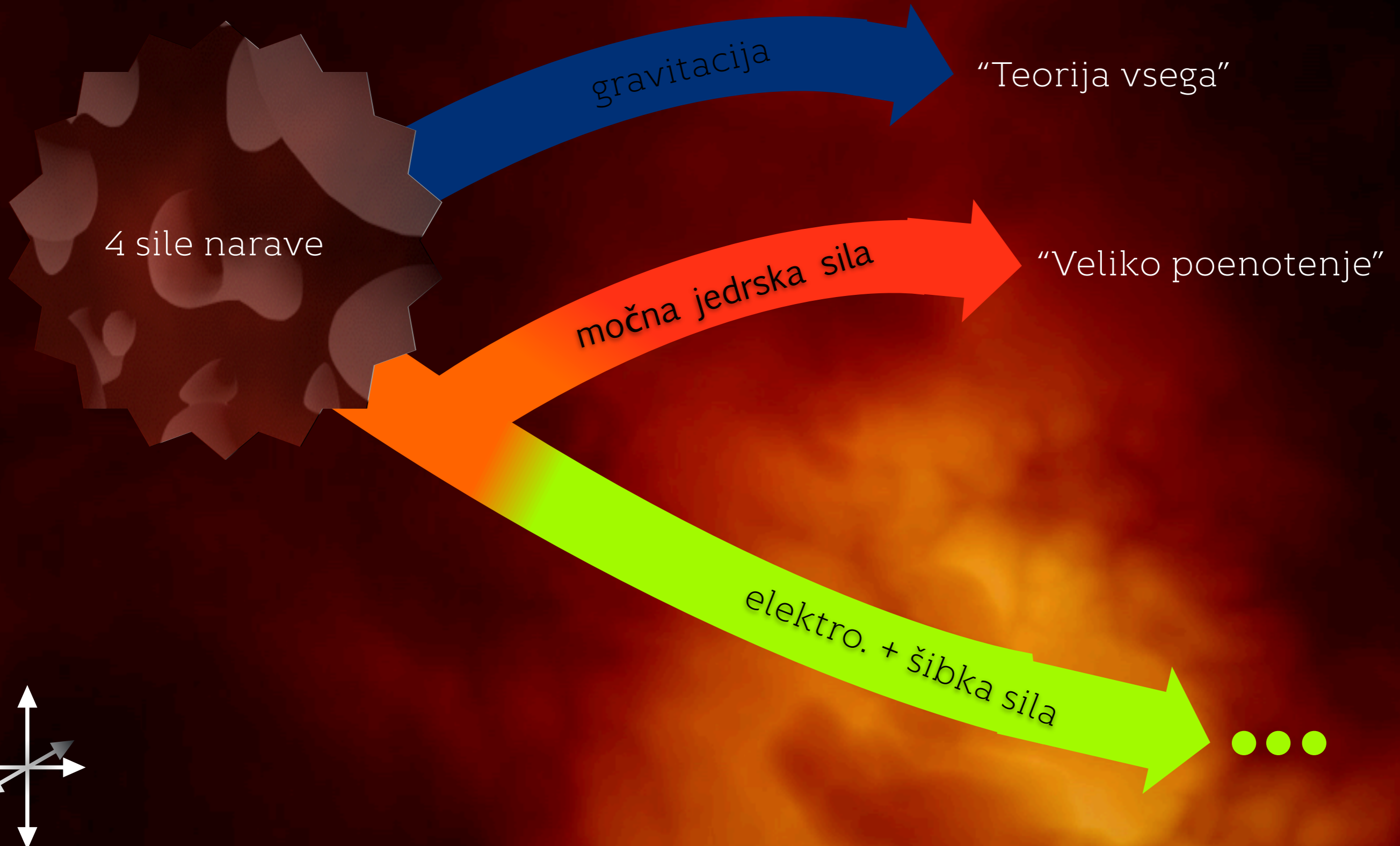
šibka jedrska sila

elektromagnetna sila



Starost vesolja:
 $10^{-42} \rightarrow 10^{-36}$ sek

Veliko poenotenje sil



Starost vesolja:
 10^{-32} sek

Ponovno ogrevanje

pojav
nestabilnih
inflatonskih
delcev

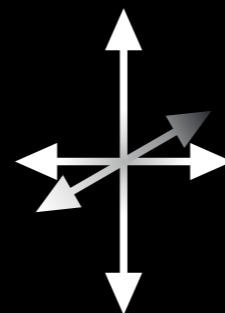
Starost vesolja:
 $10^{-32} \rightarrow 10^{-11}$ sek

Kršitev simetrije



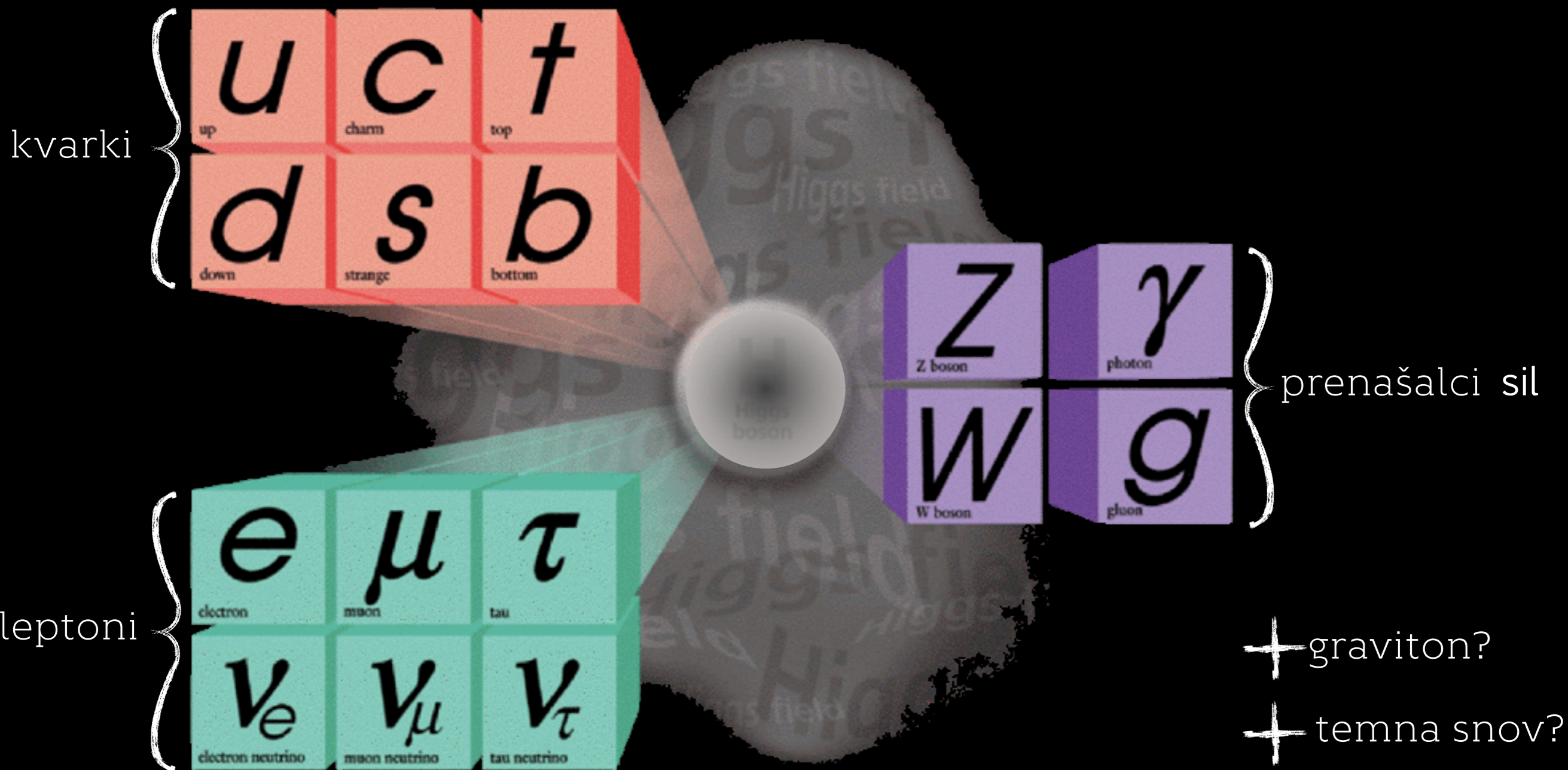
Snov

Antisnov



Razlaga...

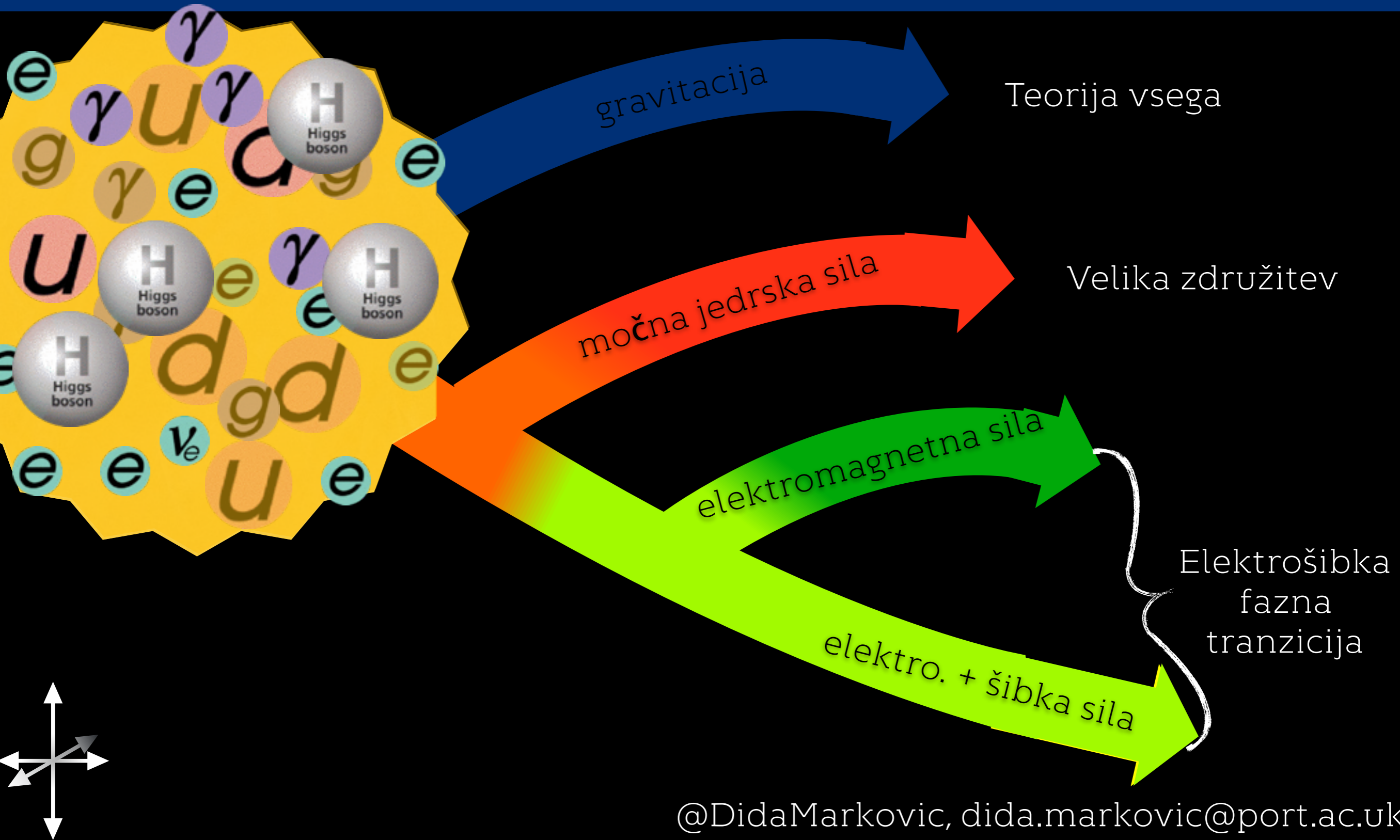
Standardni model delcev



Starost vesolja:
 10^{-11} sekunde

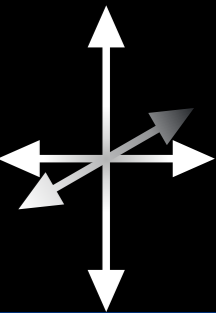
Elektrošibka tranzicija

temperatura $\approx 100\,000\,000\,000\,000\,000^\circ\text{C}$



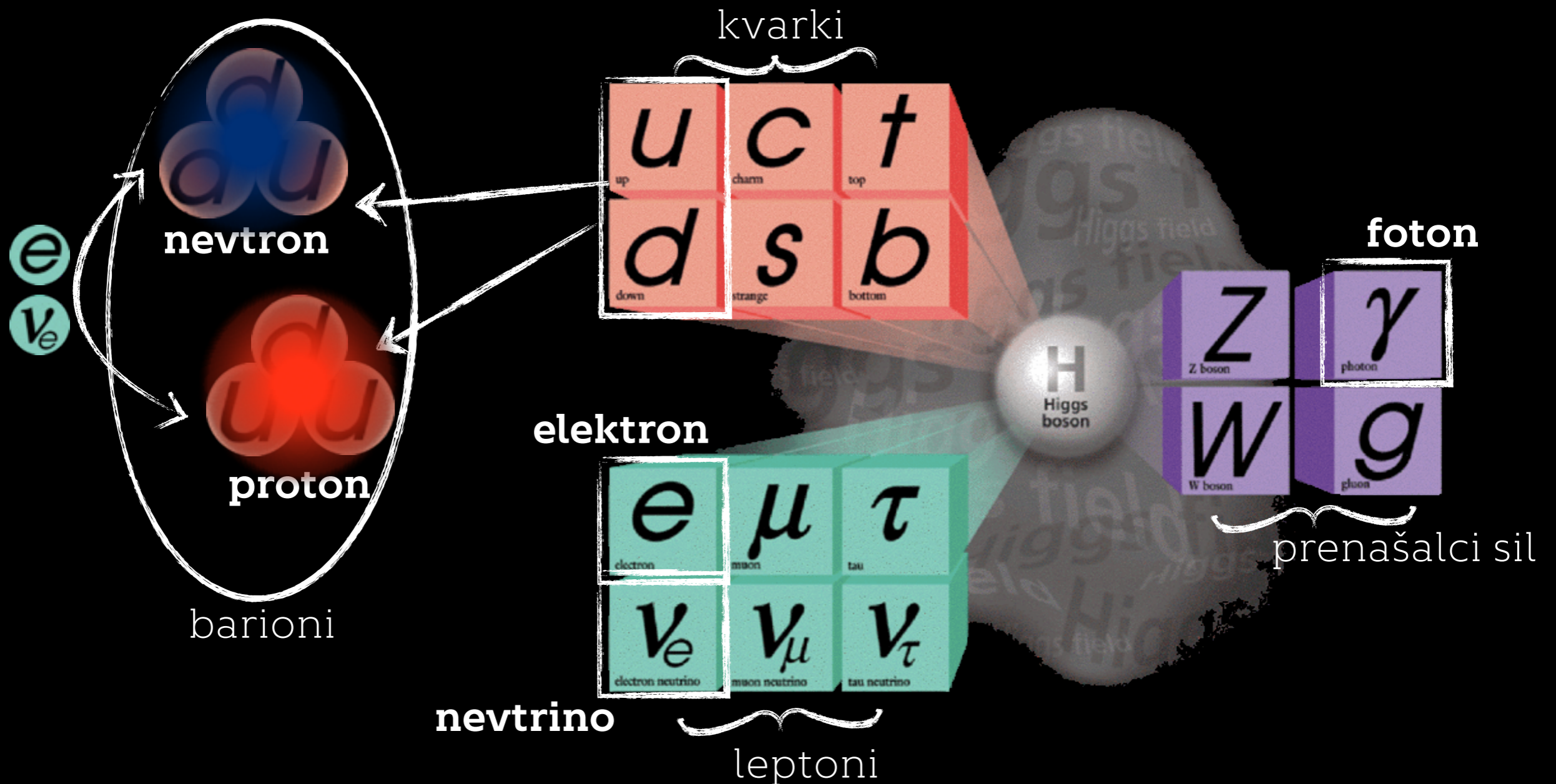
Starost vesolja:
milijoninka sekunde

Rojstvo atomskih jeder



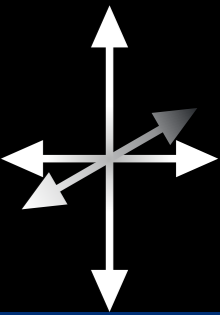
temperatura $\approx 10\,000\,000\,000\,000^\circ\text{C}$

velikost vidnega vesolja \approx velikost jedra naše galaksije

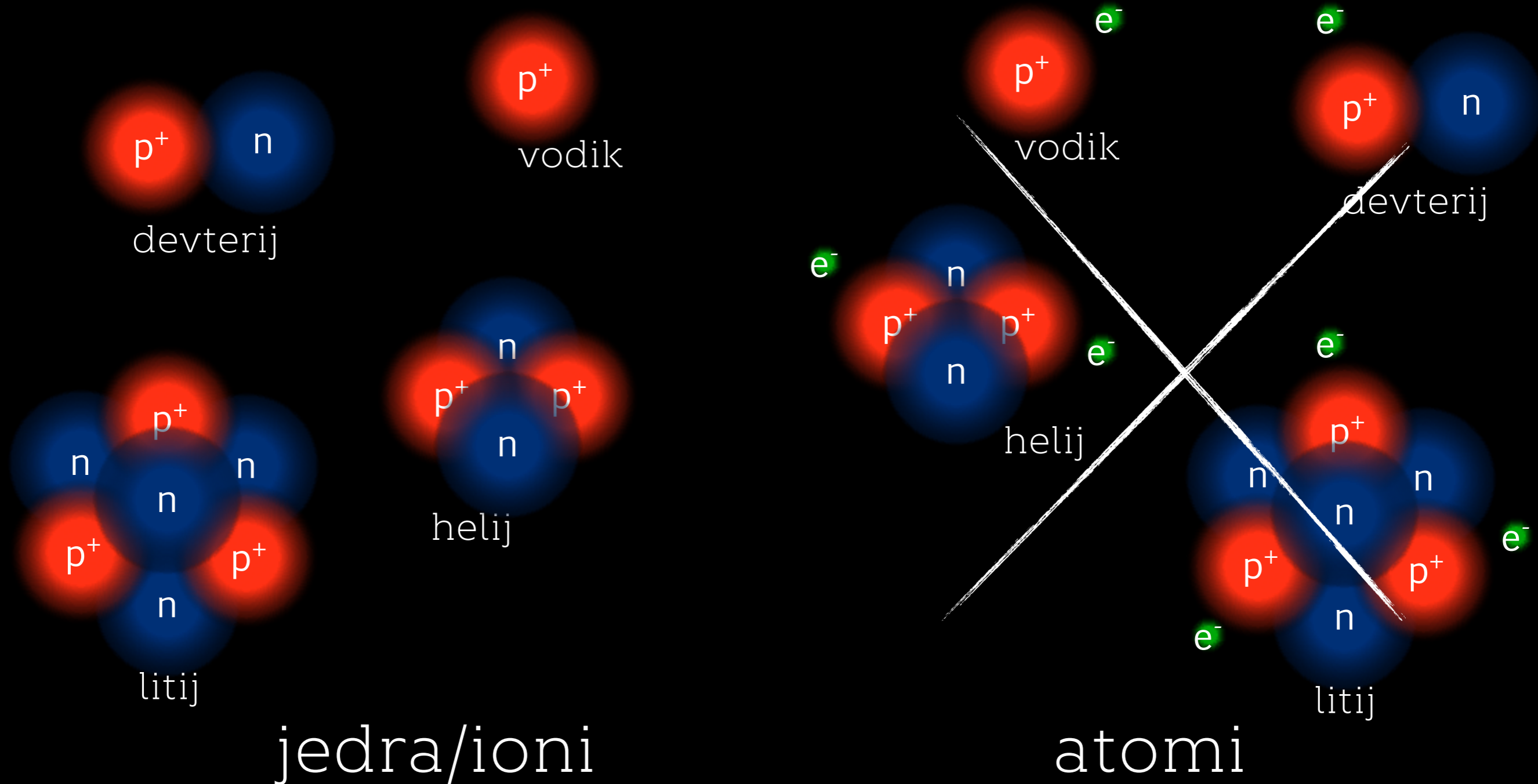


Starost vesolja:
1 minuta

Rojstvo atomskih jeder

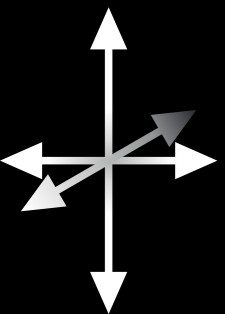
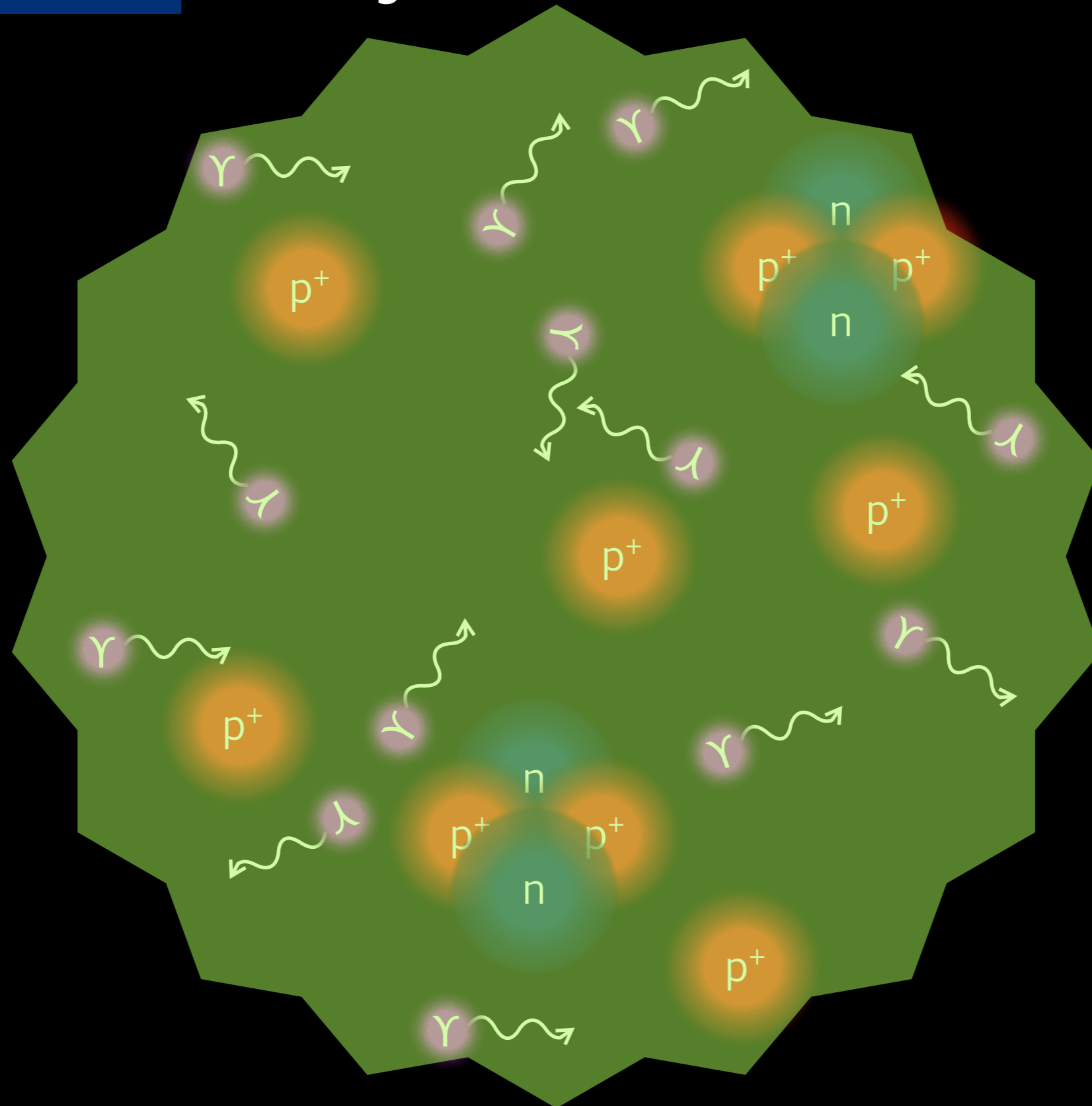


temperatura $\approx 1\,000\,000\,000^\circ\text{C}$
velikost vidnega vesolja \approx velikost galaksije



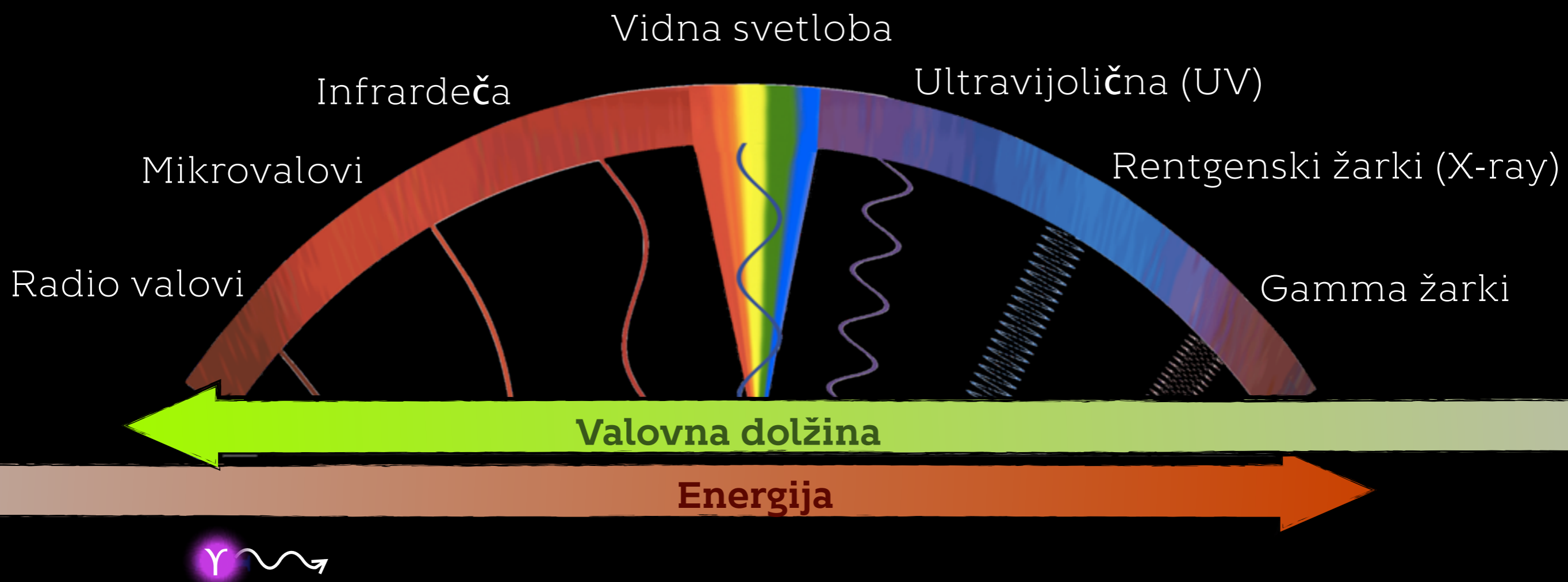
Starost vesolja:
3 minute

Pra-juha delcev



Razlaga...

Spekter svetlobe



Starost vesolja:
3 minute

Akustični vrhovi, BAO

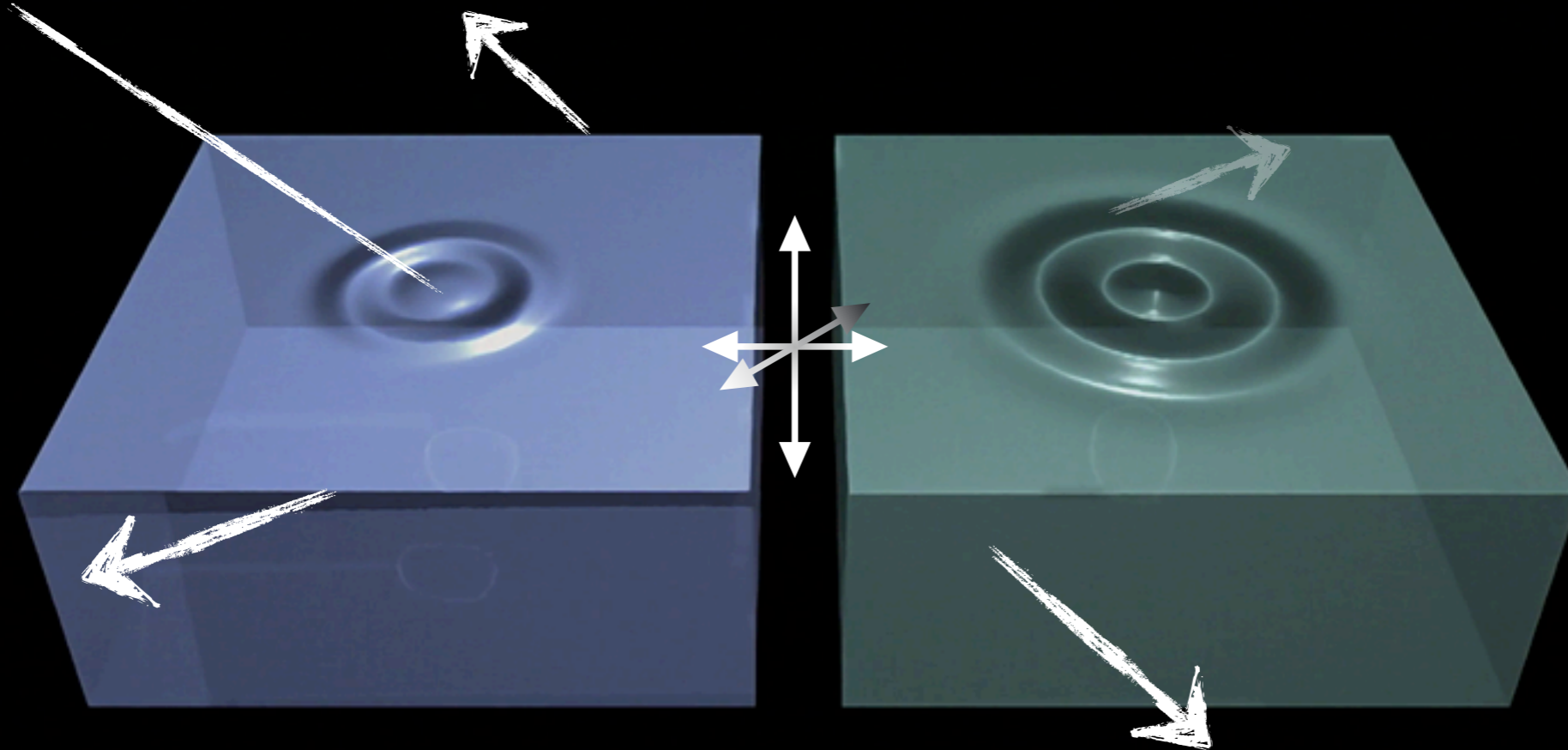


Starost vesolja:
400 000 let

Akustični vrhovi, BAO

$$\begin{aligned} &400\,000 \text{ let} \times \text{zvočna hitrost v pra-juhi} \\ &= 400\,000 \text{ let} \times (\text{hitrost svetlobe})/2 \\ &= 200\,000 \text{ svetlobnih let} \end{aligned}$$

pra-grbina
v pra-juhi



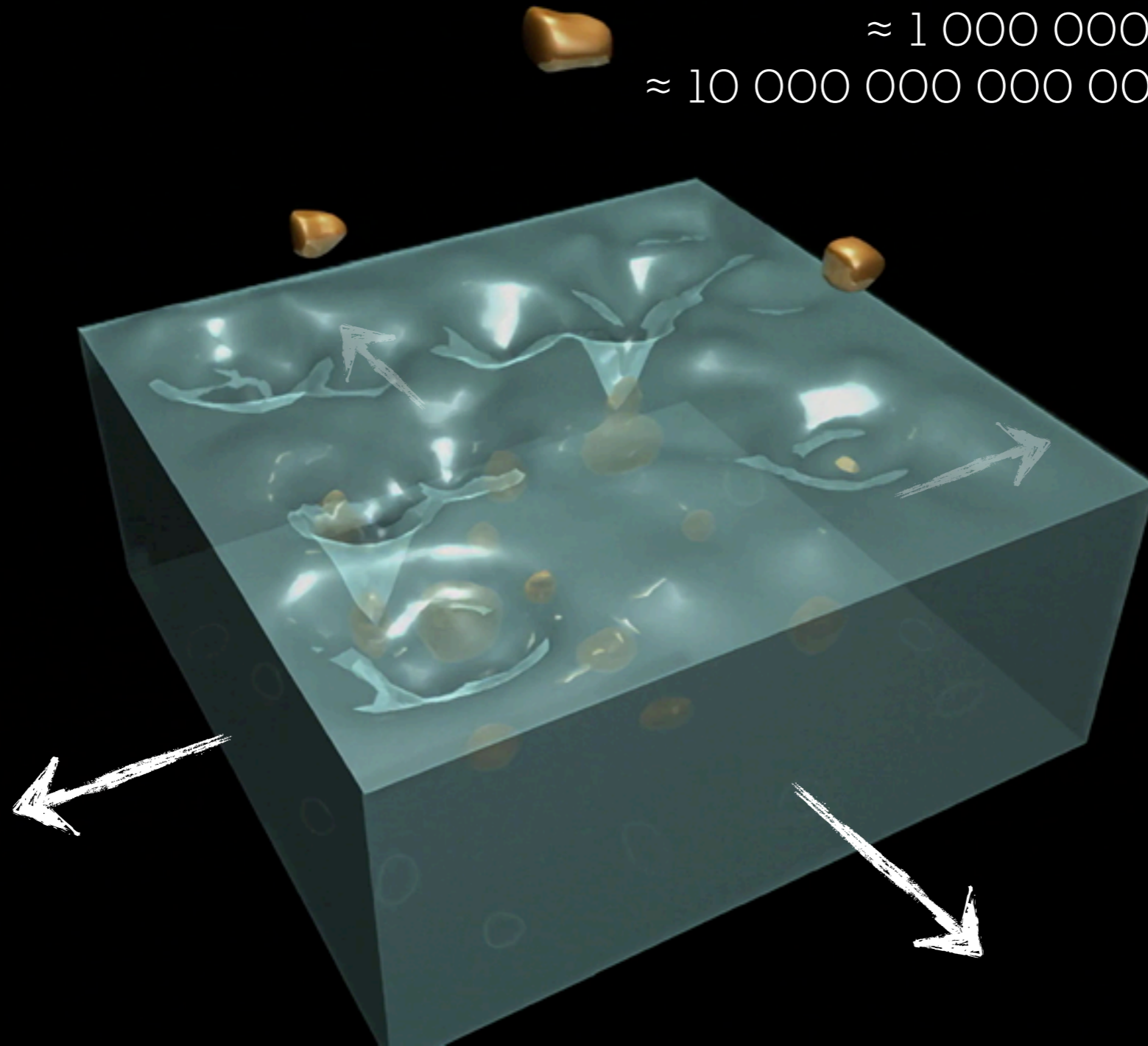
WMAP, NASA

“pra-grbine” → kamenčki v ribnik

Starost vesolja:
400 000 let

Akustični vrhovi, BAO

$\approx 1\,000\,000$ svetlobnih let
 $\approx 10\,000\,000\,000\,000\,000\,000\,000$ km



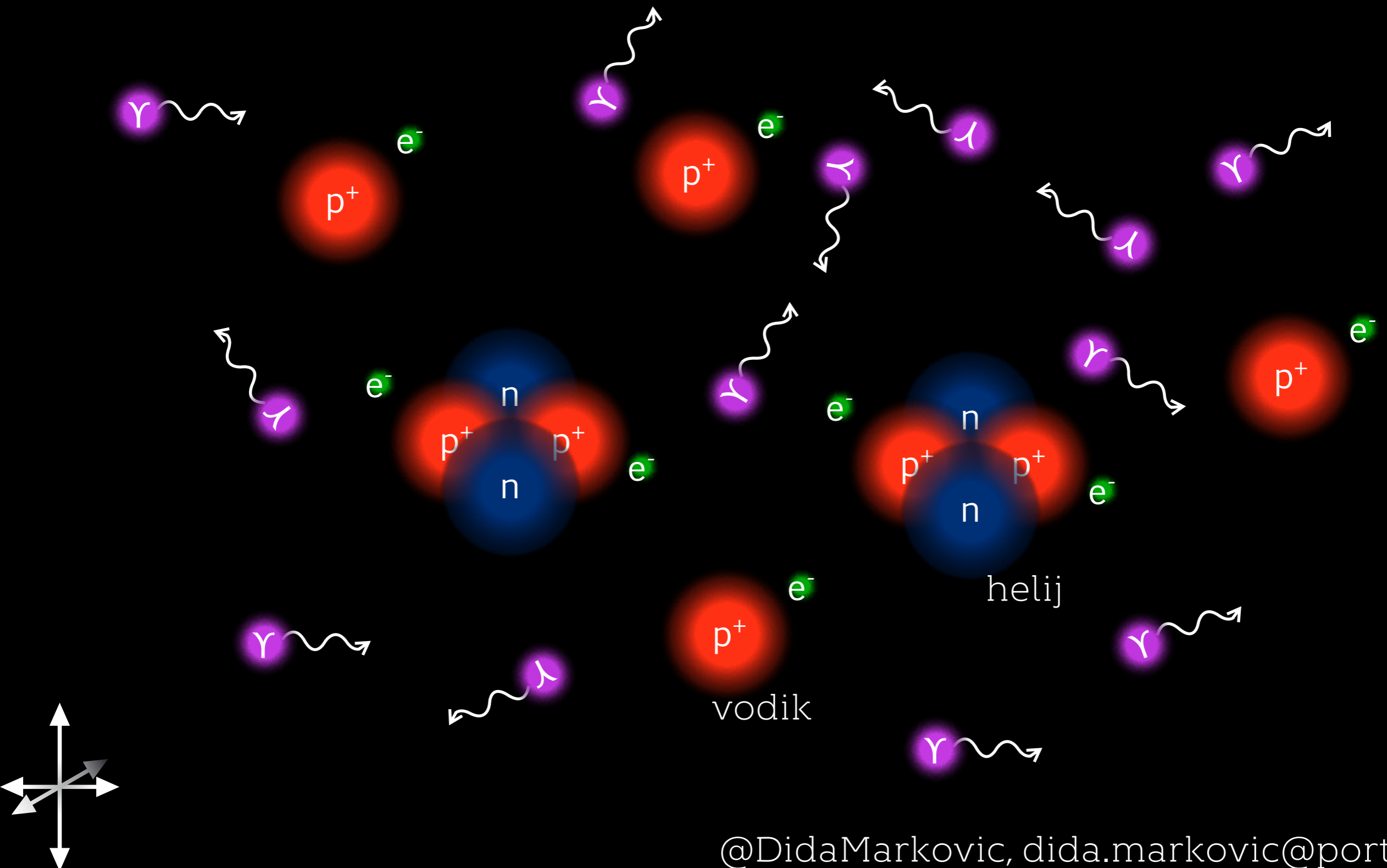
WMAP, NASA

“pra-grbine” → kamenčki v ribnik

Starost vesolja:
400 000 let

Mikrovalovno pra-sevanje

temperatura $\approx 3000\text{K} = 2727^\circ\text{C}$

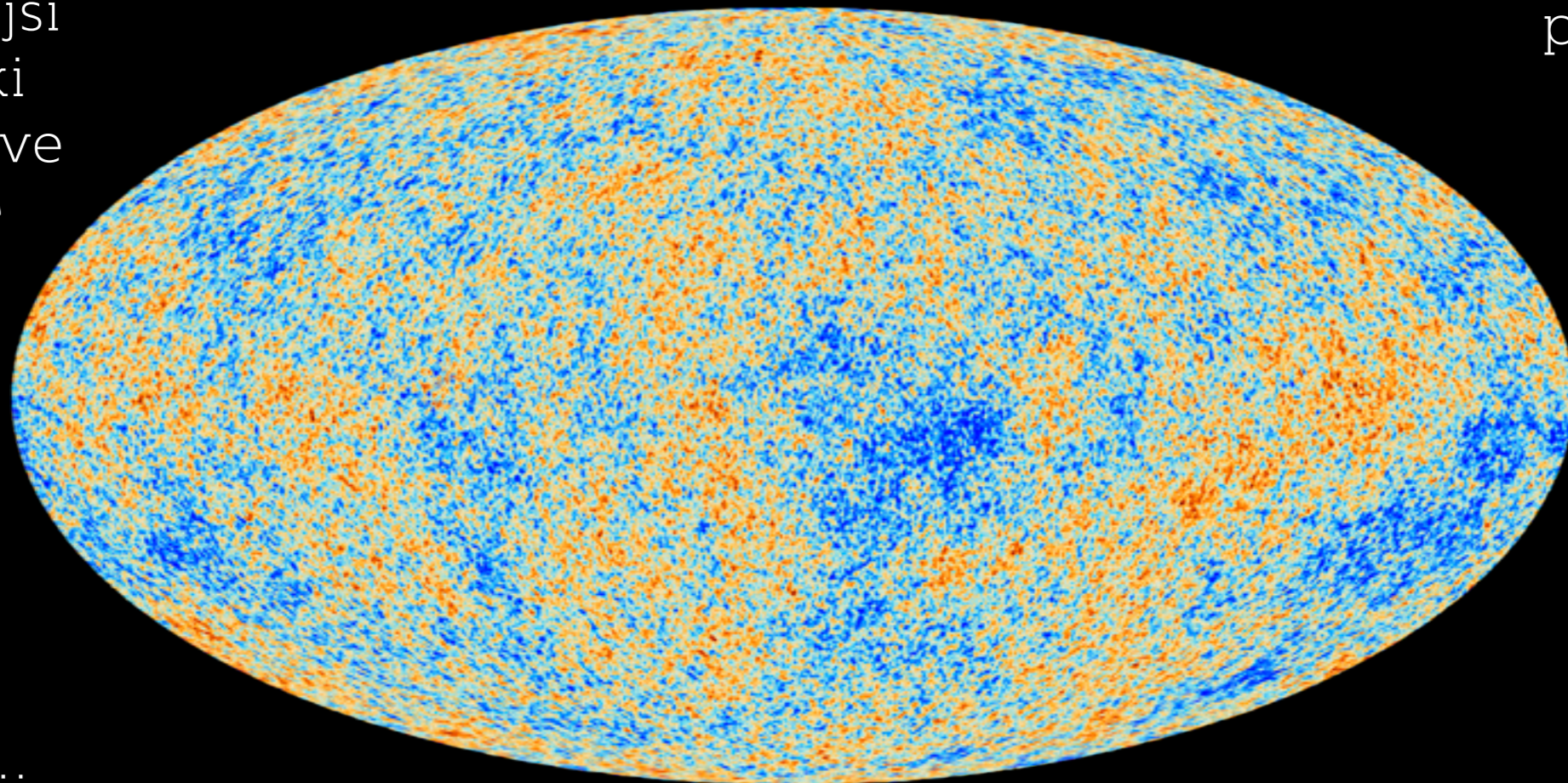


Starost vesolja:
400 000 let

Mikrovalovno pra-sevanje

najnovejši
podatki
Planckove
sonde

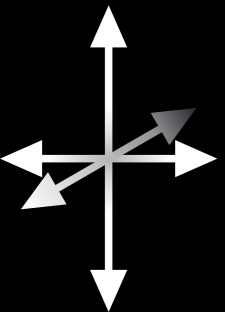
projekcija
neba na
ekran



sij
velikega
poka

sprostitev fotonov
zaradi rekombinacije

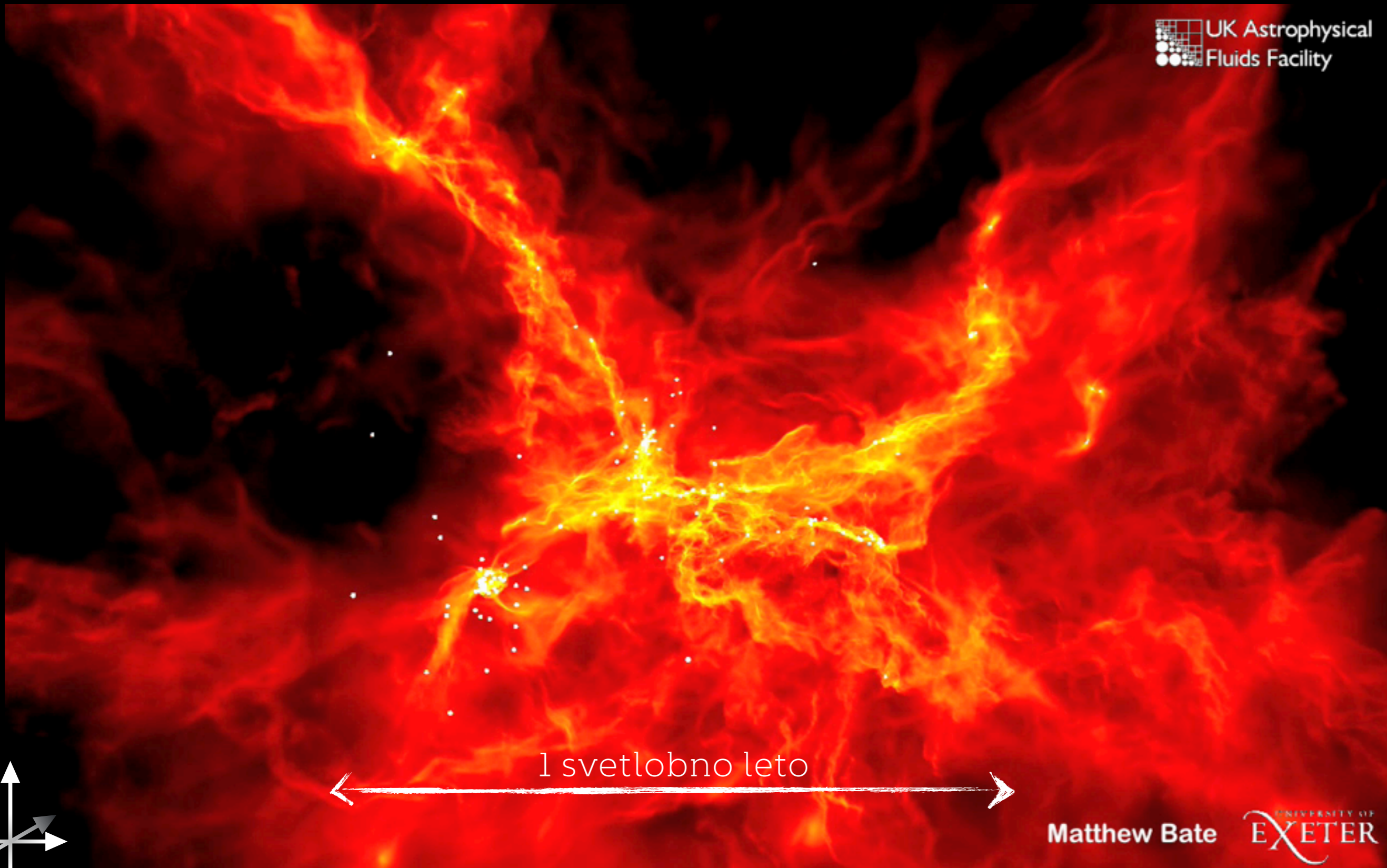
Planck, ESA



Starost vesolja:
100 milijonov let

Rojstvo prvih zvezd

UK Astrophysical
Fluids Facility

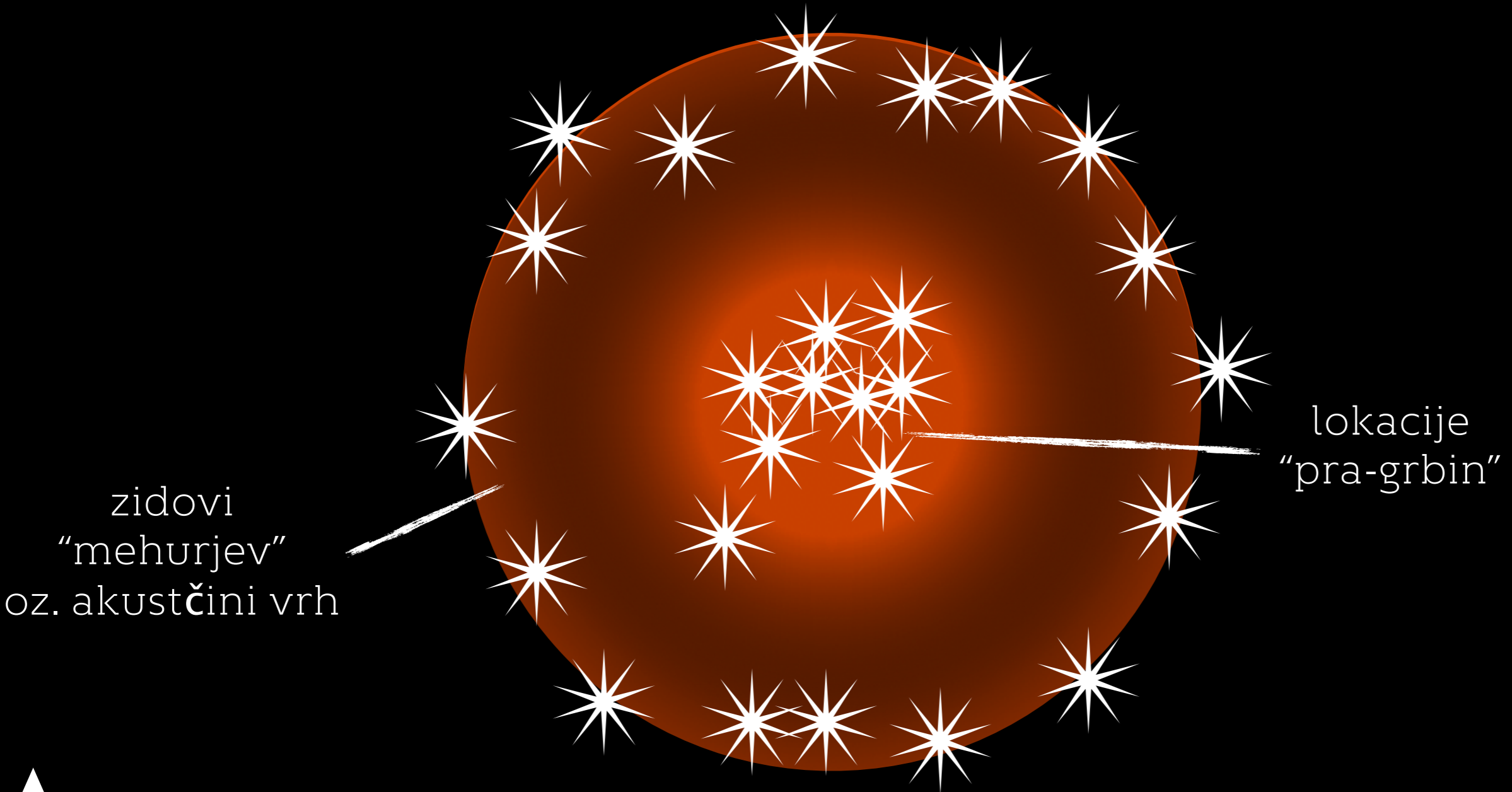


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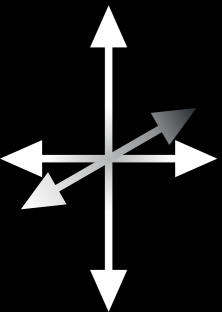
Starost vesolja:
70 000 let

Doba temne snovi

←—————→
kot na nebu ~ 1°

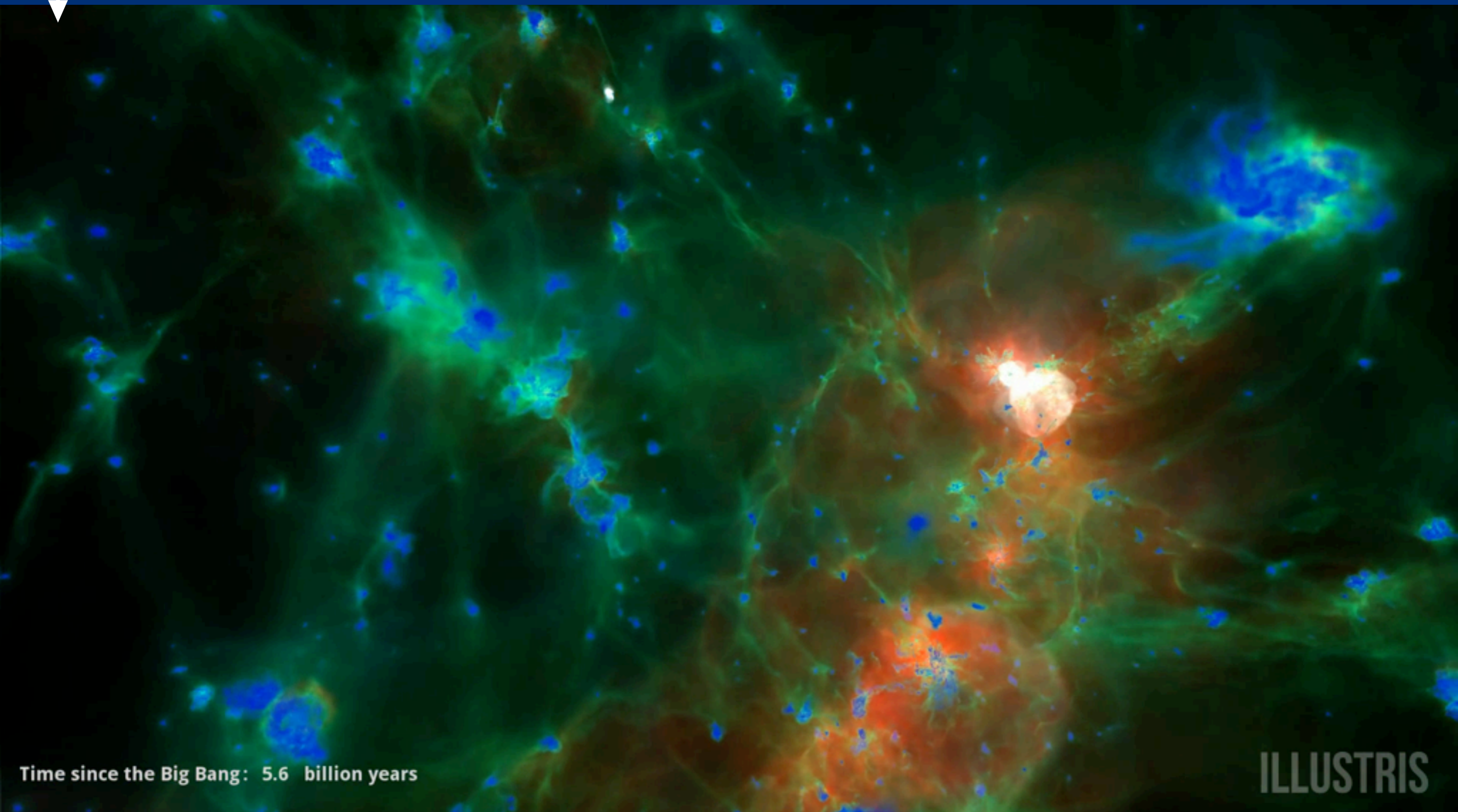
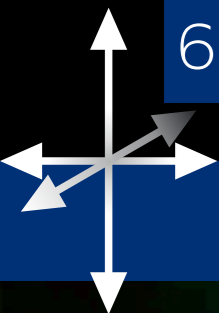


←—————→
1 milijon svetlobnih let v času rekombinacije



Starost vesolja:
600 milijonov let...

Doba temne snovi



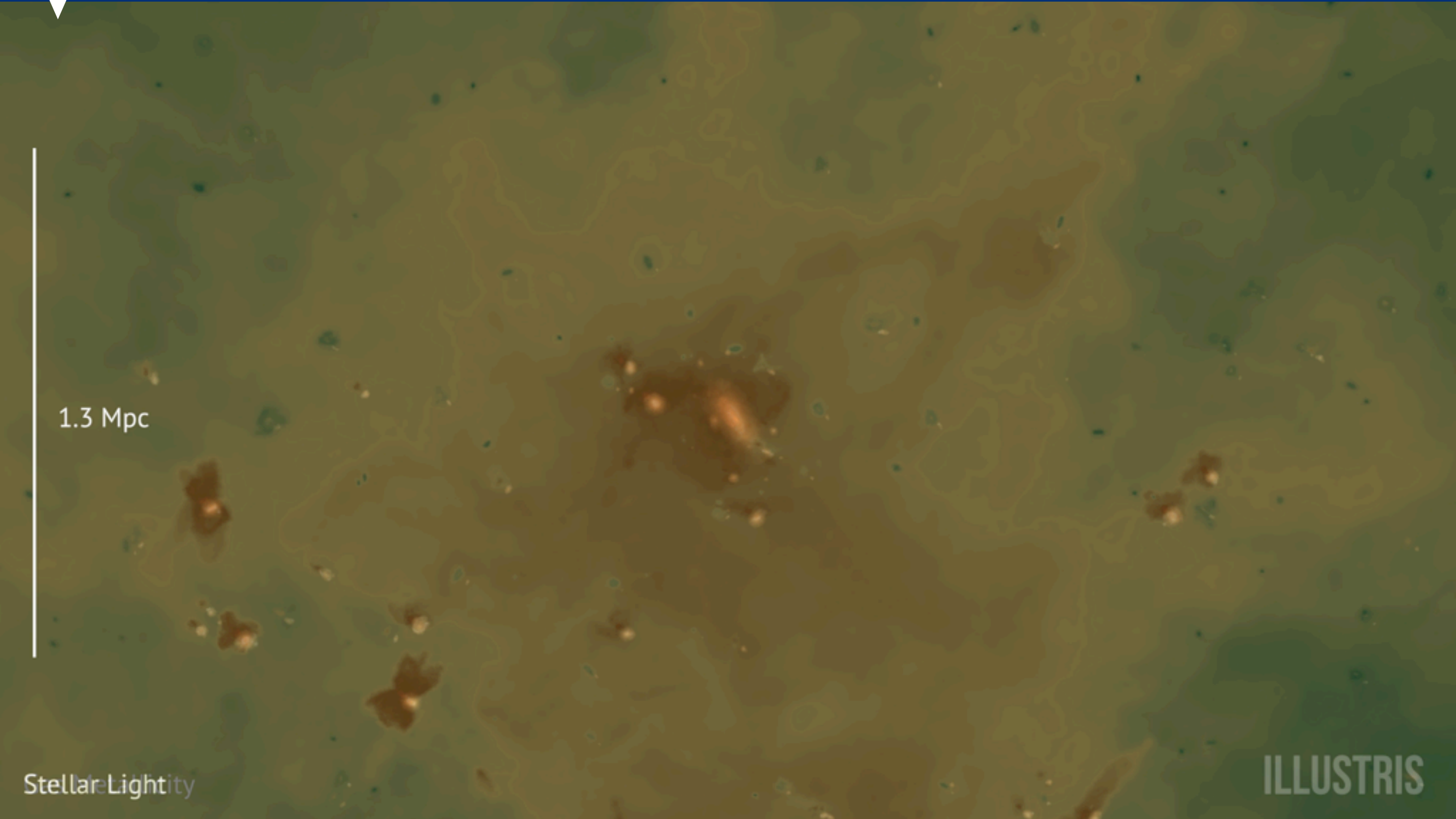
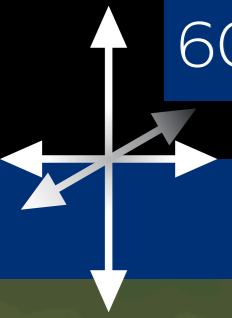
Time since the Big Bang: 5.6 billion years

ILLUSTRIS

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Starost vesolja:
600 milijonov let...

Doba temne snovi



1.3 Mpc

StellarLightity

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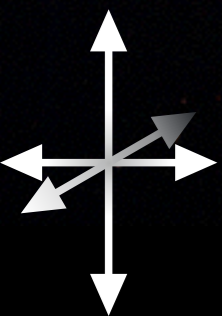
Starost vesolja:
600 milijonov let

Rojstvo galaksij



HST, NASA

spiralna galaxija M81



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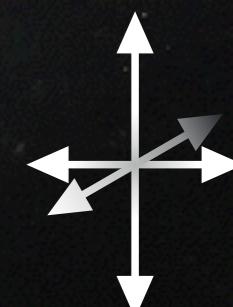
Starost vesolja:
600 milijonov let

Rojstvo galaksij



HST, NASA

spiralna galaxija M106 (Hubblor teleskop)



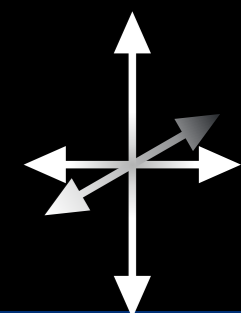
Starost vesolja:
600 milijonov let

Rojstvo galaksij



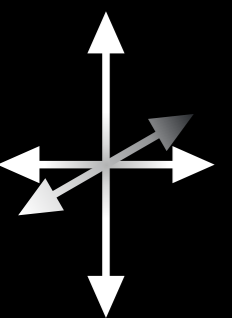
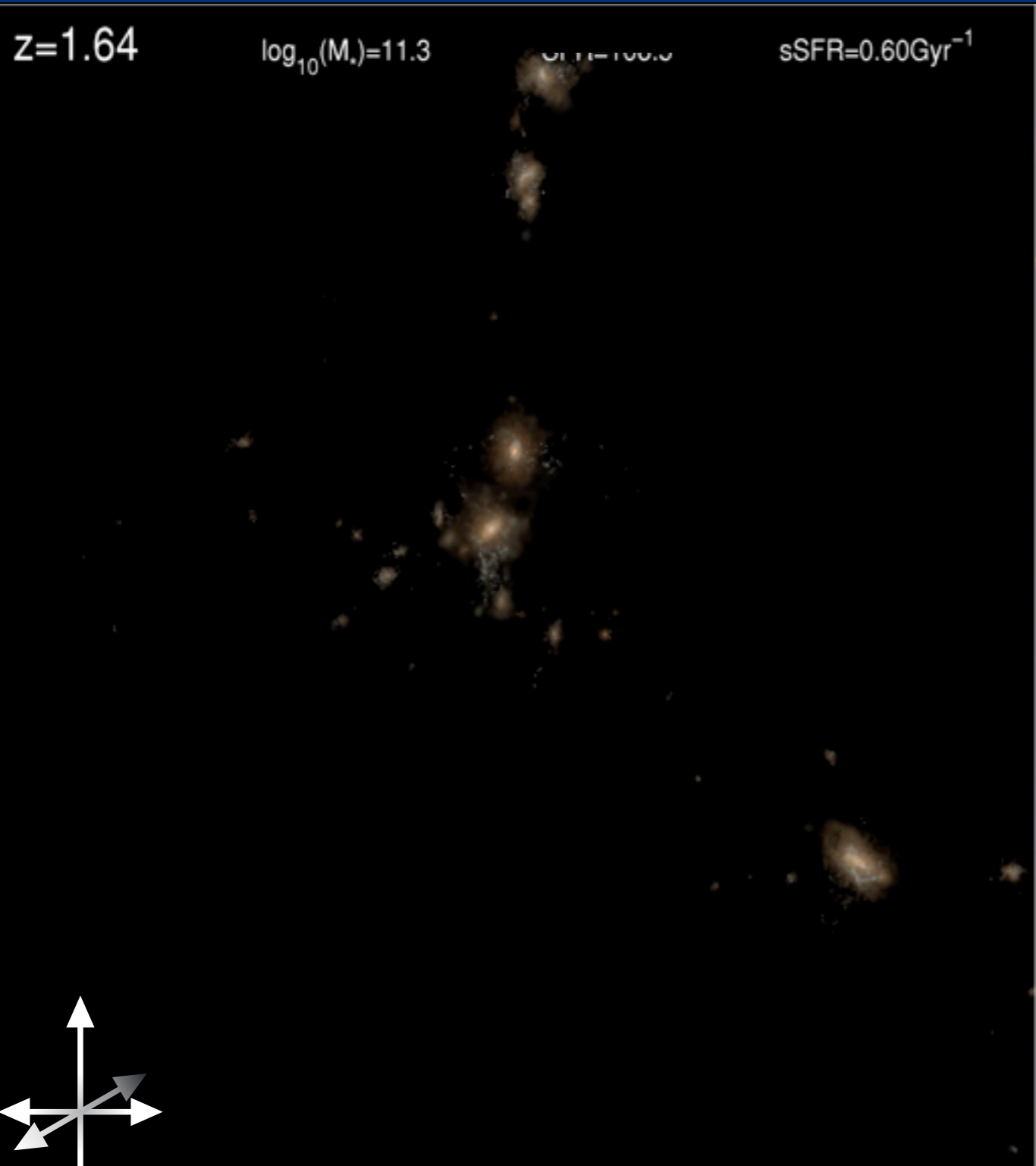
HST, NASA

galaxiji v interakciji, ARP 273 (Hubbllov teleskop)



Starost vesolja:
600 milijonov let...

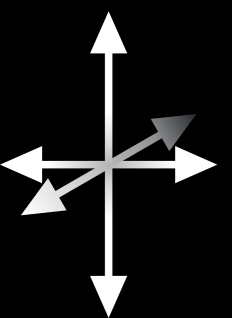
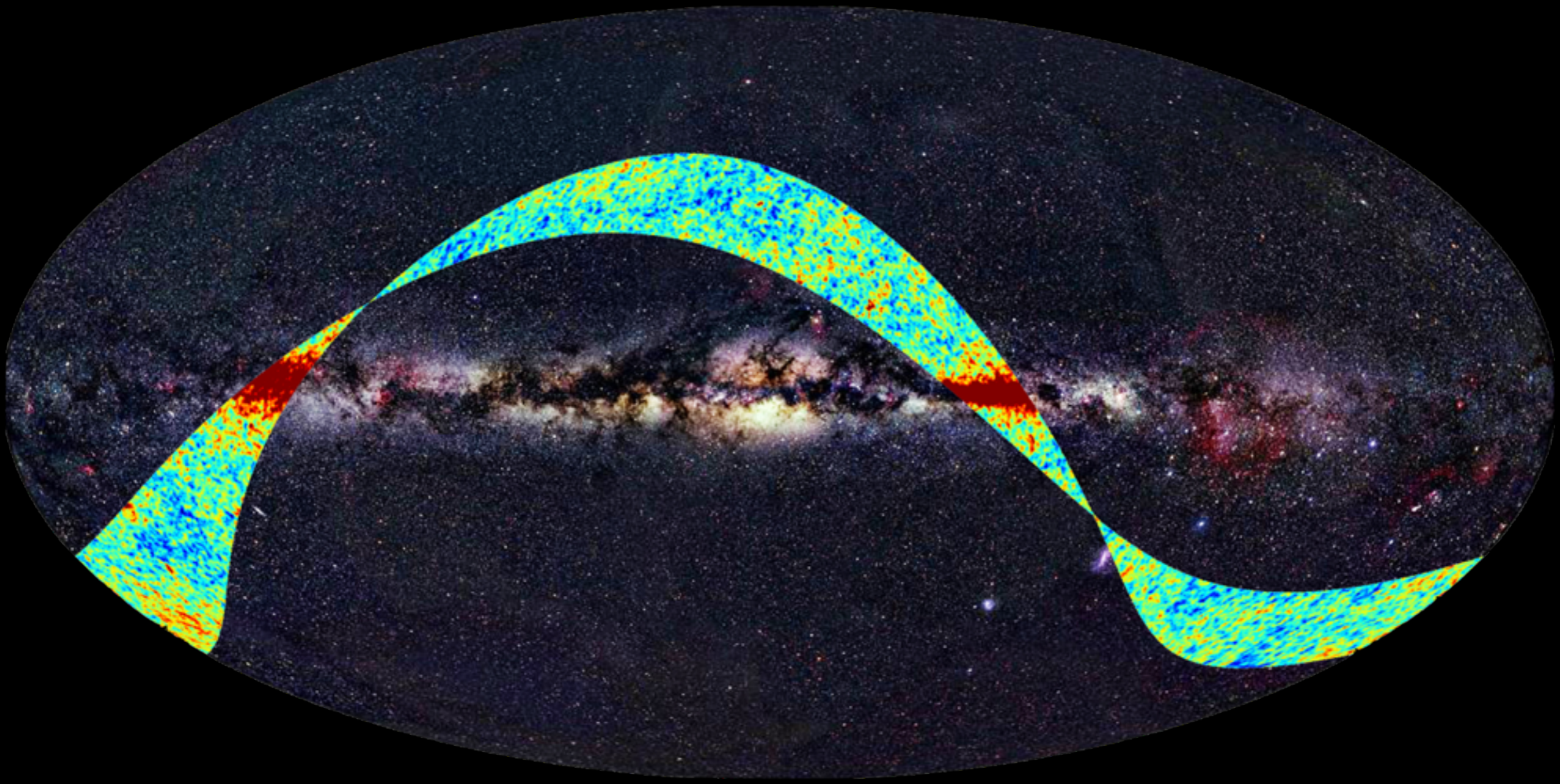
Doba temne snovi



ILLUSTRIS

Starost vesolja:
600 milijonov let...

Doba temne snovi



nasa galaxija, Rimska Cesta (Planck sonda)

Starost vesolja:
12 milijard let...

Doba temne energije

temna energija
vnovično pospešeno
širjenje

mikrovalovno
pra-sevanje
(CMB)

temni
vek

tvorjenje galaksij
zvezd, planetov...

inflacija
(prvi spomin
vesolja)

kvantno
valovanje

prve zvezde

širjenje velikega poka





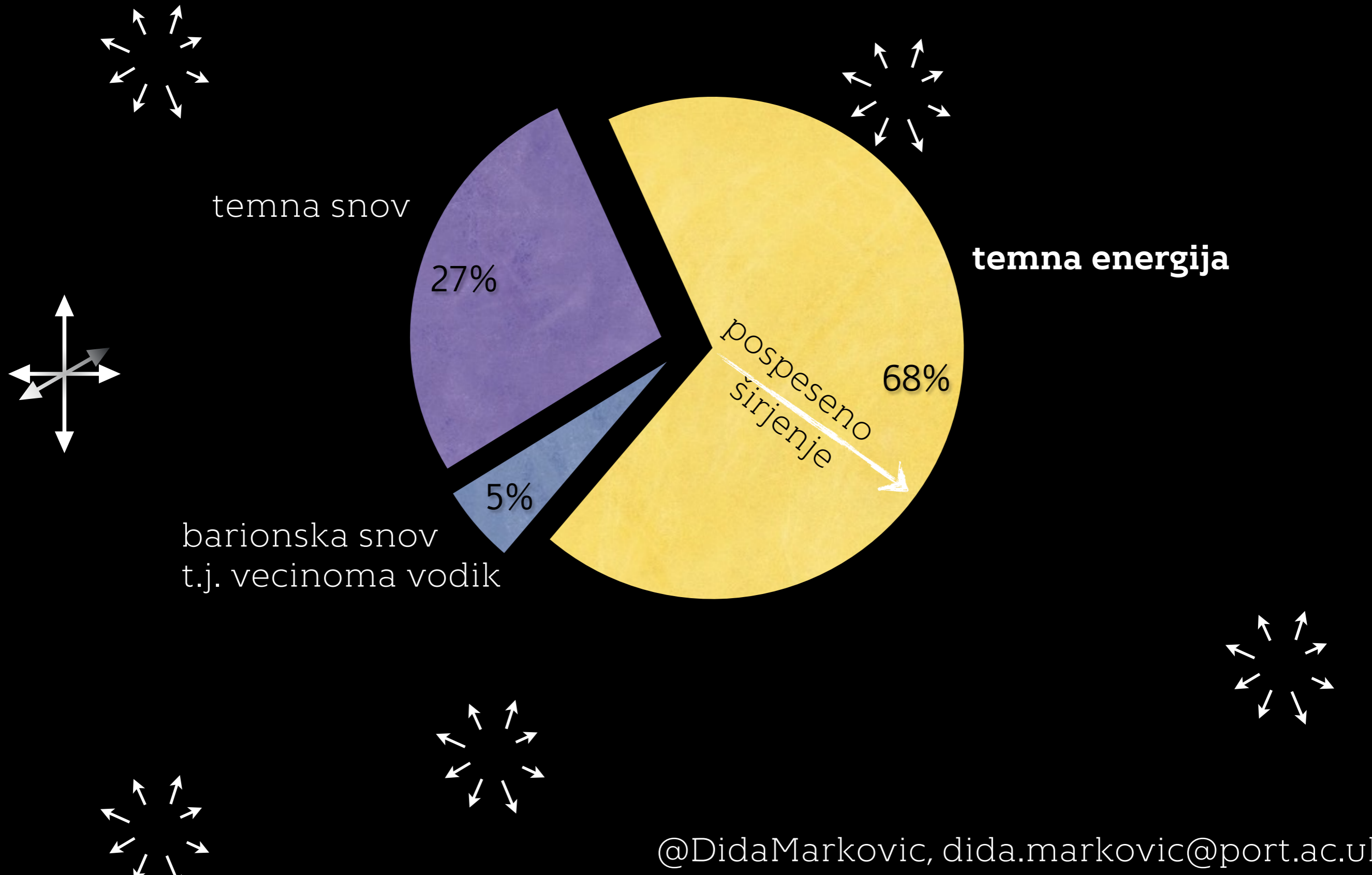
Starost vesolja:
13,8 milijard let

Kozmološke strukture

kolaps struktur se
ustavlja

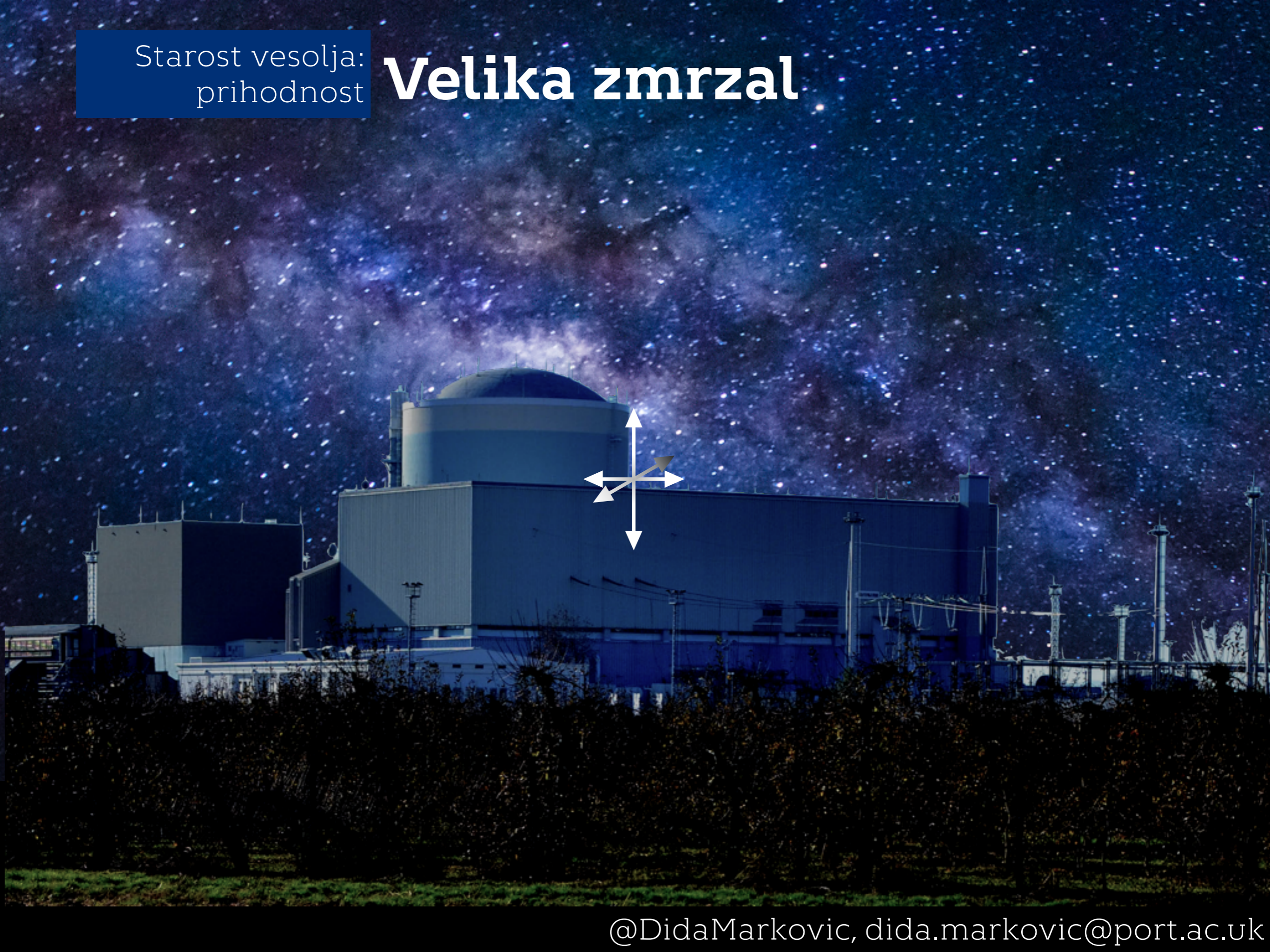
Starost vesolja:
13,8 milijard let

Doba temne energije

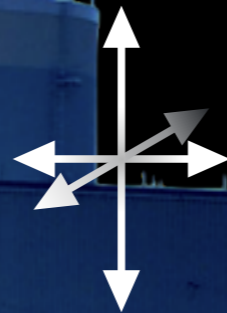


Starost vesolja:
prihodnost

Velika zmrzal



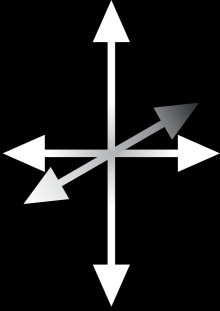
Hvala, za pozornost!



Zdaj pa se vrnimo...

Starost vesolja:
13,8 milijard let

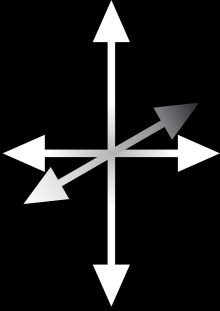
Zahvala



- Pomoč pri vsebini: dr. Stephen Appleby, dr. Michael Kopp, prof. Filipe Abdala, prof. Jochen Weller in drugi
- Pomoč pri prevodu v slovenščino: Radovan Markovič, dr. Vid Iršič, slovar fraz FMFja in slovenska Wikipedia
- Tehnicna pomoč: Milan Kreuzschitz
- Izbrani viri:
 - hubblesite.org - Hubblov telescop
 - map.gsfc.nasa.gov/resources - Wilkinson Microwave Anisotropy Probe
 - www.illustris-project.org - Illustris Simulacije

Starost vesolja:
13,8 milijard let

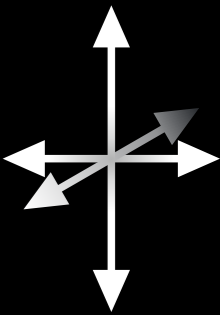
Vsi viri multimedijev



- p. 1: AMNH, <https://www.youtube.com/watch?v=17jymDn0W6U>
- p. 4, 5, 10, 18: <http://www.physics.adelaide.edu.au/theory/staff/leinweber/VisualOCD/Nobel/index.html>
- p. 8: Wikimedia...,
<http://www.dvdsreleasedates.com/covers/gravity-dvd-cover-28.jpg>
http://upload.wikimedia.org/wikipedia/commons/2/22/Spacetime_curvature.png
http://upload.wikimedia.org/wikipedia/commons/thumb/f/f0/Nucleus_drawing.svg
<http://upload.wikimedia.org/wikipedia/commons/thumb/b/b5/Radioactive.svg>
<http://www.turningpointmagazine.com/wp-content/uploads/Magnet-small.jpg>
- p. 11-14: Wikimedia
- p. 17: <http://chandra.harvard.edu/graphics/resources/illustrations/xlightSpectrum-300.gif> (prirejeno)
- p. 19, 21: WMAP, NASA, http://map.gsfc.nasa.gov/media/030658/030658_Ripples_1080p.mov
- p. 22: Planck & Wikimedia
http://www.esa.int/var/esa/storage/images/esa_multimedia/images/2013/03/planck_cmb
<http://upload.wikimedia.org/wikipedia/commons/thumb/7/78/Mollweide-projection.jpg>
- p. 24: http://www.astro.ex.ac.uk/people/mbate/Cluster/Animations/ClusterXT1810Z_H264B.mov
- p. 25: <http://kipac.stanford.edu/kipac/research/reionization>
- p. 27, 28, 32: Illustris simulacija, <http://www.illustris-project.org>
- p. 29-31: Hubble Space Telescope, <http://hubblesit.org/gallery>
- p. 33: Planck, ESA, http://www.esa.int/var/esa/storage/images/esa_multimedia/images/2009/09/planck_first_light_survey/10198835-2-eng-GB/Planck_first_light_survey.jpg
- p. 34: American Museum of Natural History (via www.bloomberg.com)
- p. 35: WMAP, http://upload.wikimedia.org/wikipedia/commons/thumb/6/6f/CMB_Timeline300_no_WMAP.jpg
- p. 37: Jeff Goldberg, Starry Night

Starost vesolja:
13,8 milijard let

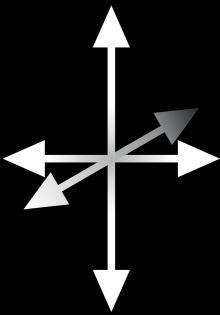
Dodatni poljudni viri



- Multiverzum: <http://news.nationalgeographic.com/news/2014/03/140318-multiverse-inflation-big-bang-science-space/>
- Inflacija (prof. Copeland) <http://www.youtube.com/watch?v=03vIkZR2hNY&feature=youtu.be>
- <http://scienceblogs.com/startswithabang/2010/04/14/the-greatest-story-ever-told-8/>
- <http://www.astro.ucla.edu/~wright/BBhistory.html>
- BICEP: <http://www.youtube.com/watch?v=PCxOEyyzmvQ>
- Kozmicni valovi: <http://www.scientificamerican.com/article/dark-energy-cosmic-distances/>
- Vecna inflacija: <http://vimeo.com/22101494>
- Vidno vesolje: http://en.wikipedia.org/wiki/Observable_universe

Starost vesolja:
13,8 milijard let

Dodatni poljudni viri



- Simulacije: <http://hipacc.ucsc.edu/v4/gallery.php?mode=newest-media&id=MGI2M2Q4NjFhMjM=&page=4>
- Skale: <http://htwins.net/scale2/lang.html>
- <http://arstechnica.com/science/2013/03/first-planck>
- http://www.spacetelescope.org/videos/hst15_big_bang_to_hubble/
- <http://ircamera.as.arizona.edu/NatSci102/NatSci102/lectures/eraplanck.htm>
- <http://quantum-bits.org/?p=233>
- gravity: wikipedia-results-the-universe-is-still-weird-and-interesting/
- http://en.wikipedia.org/wiki/Graphical_timeline_from_Big_Bang_to_Heat_Death
- http://www.staff.science.uu.nl/~proko101/DoruSticlet_pt2.pdf
- <http://www.astro.ucla.edu/~wright/BBhistory.html>