Cosmologie

L. Vacher -

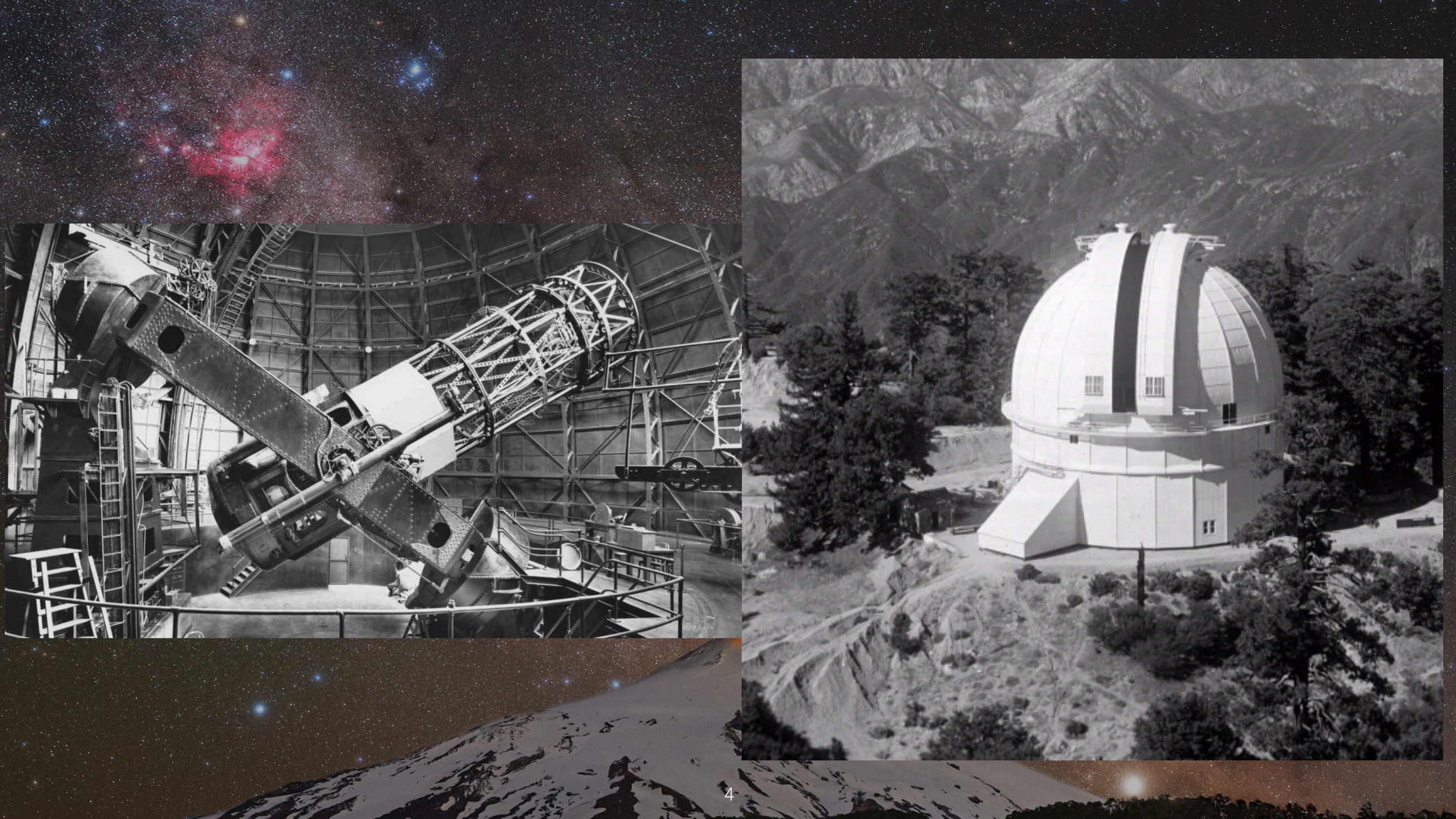
photo: Slovinsky

irap
astrophysique & planétologie

Edwin Hubble

Milton Humason

photo: Slovinsky



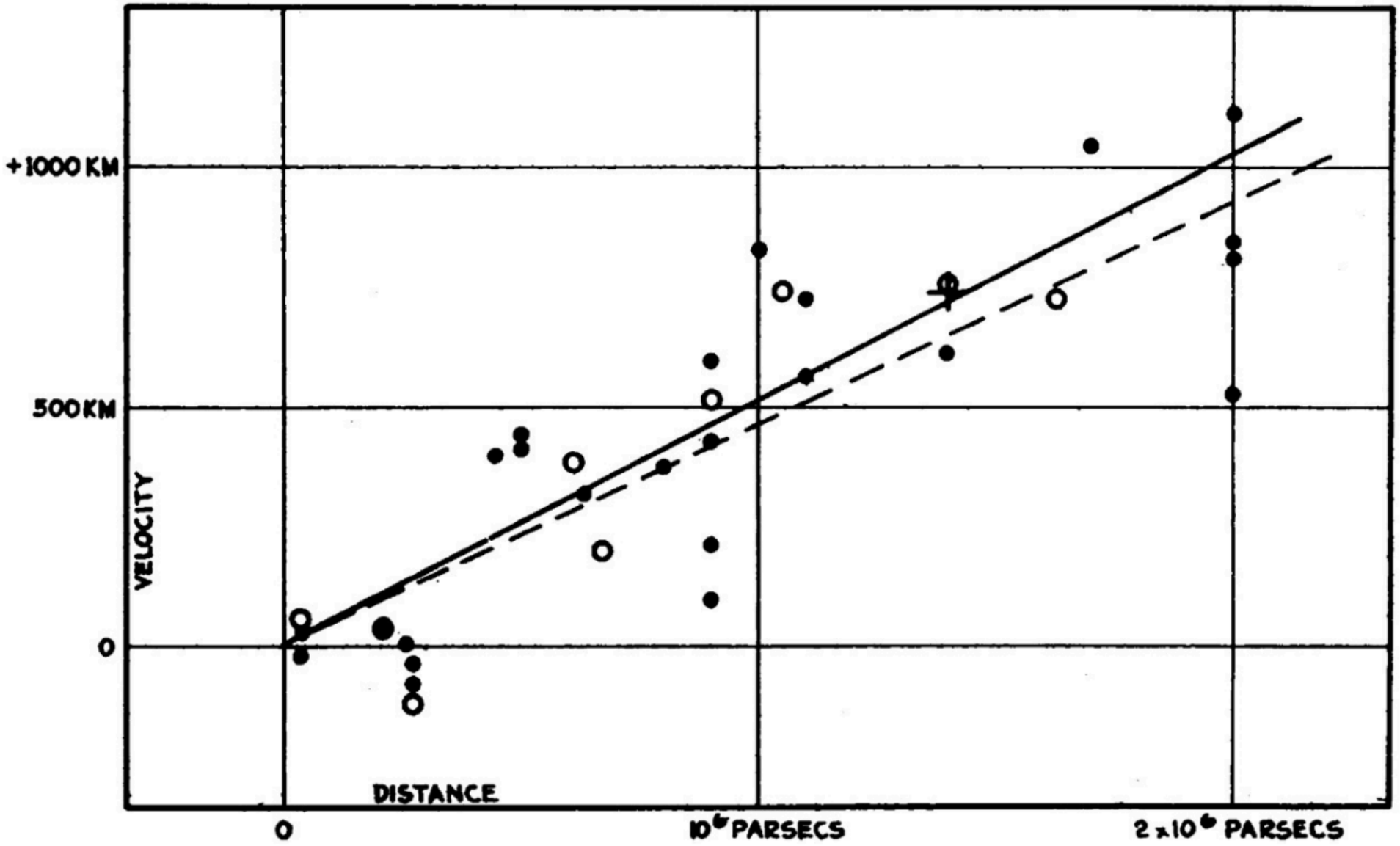


photo: Slovinsky

Vitesse?

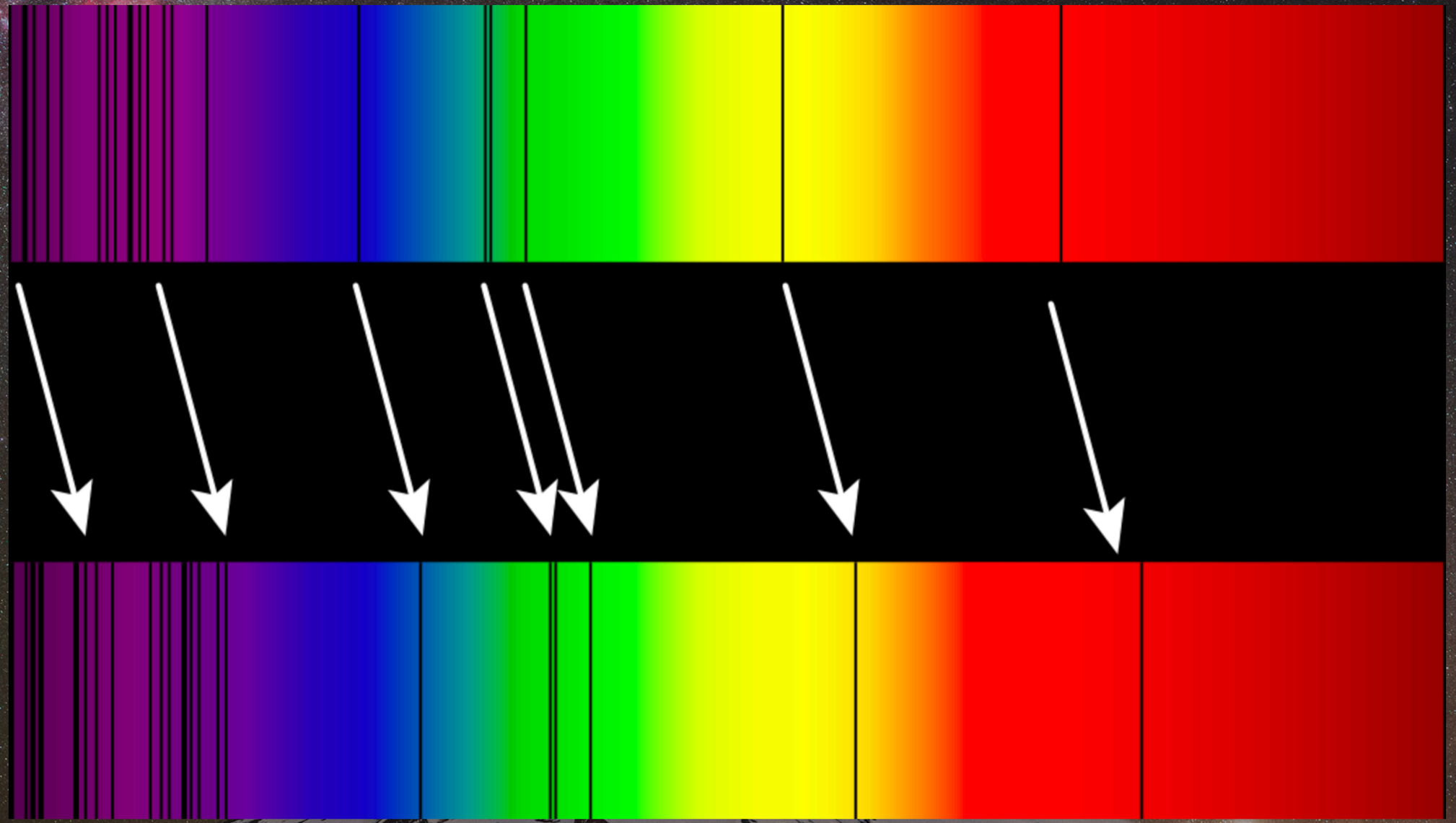


photo: Slovinsky

Distance?

Parallaxes ?

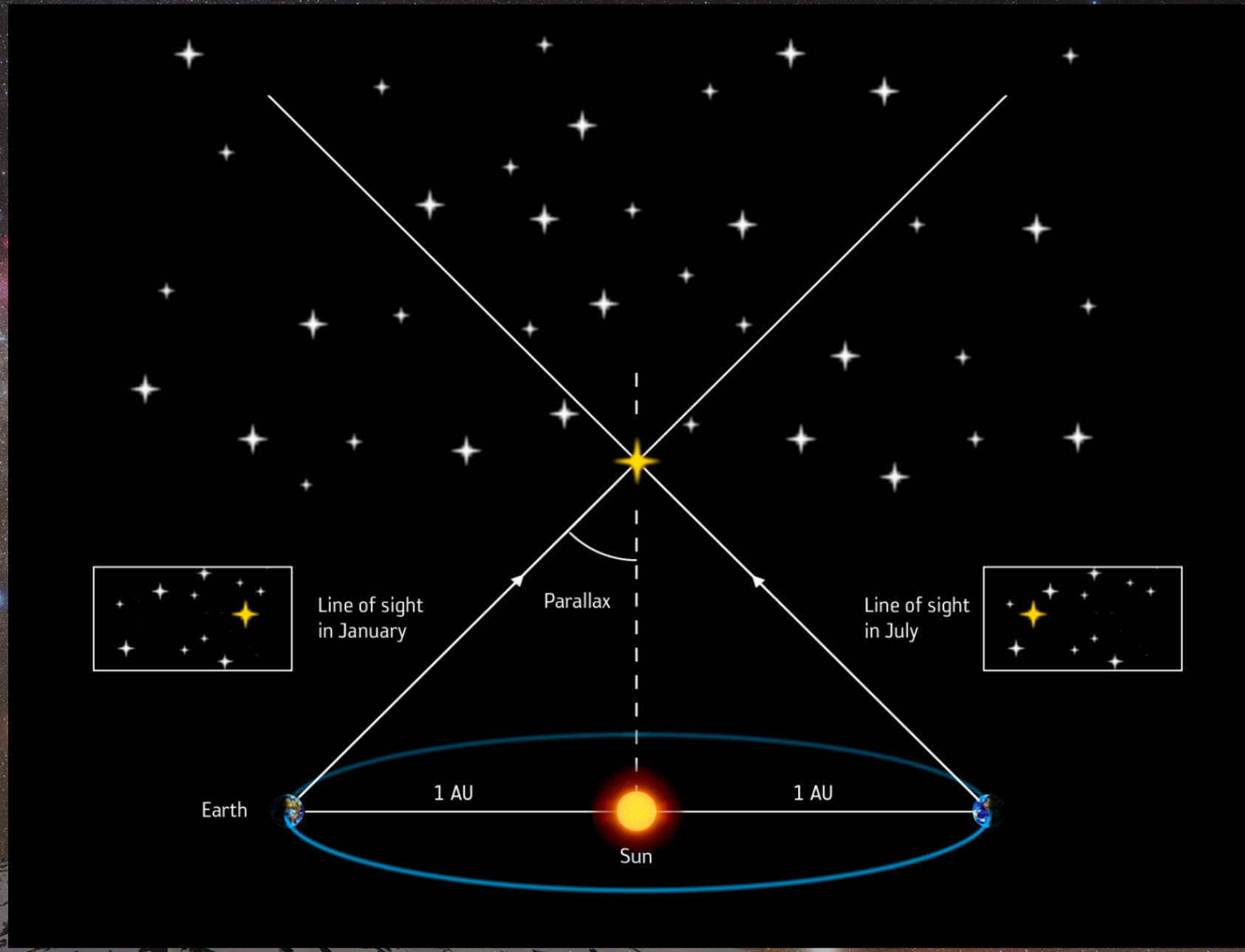
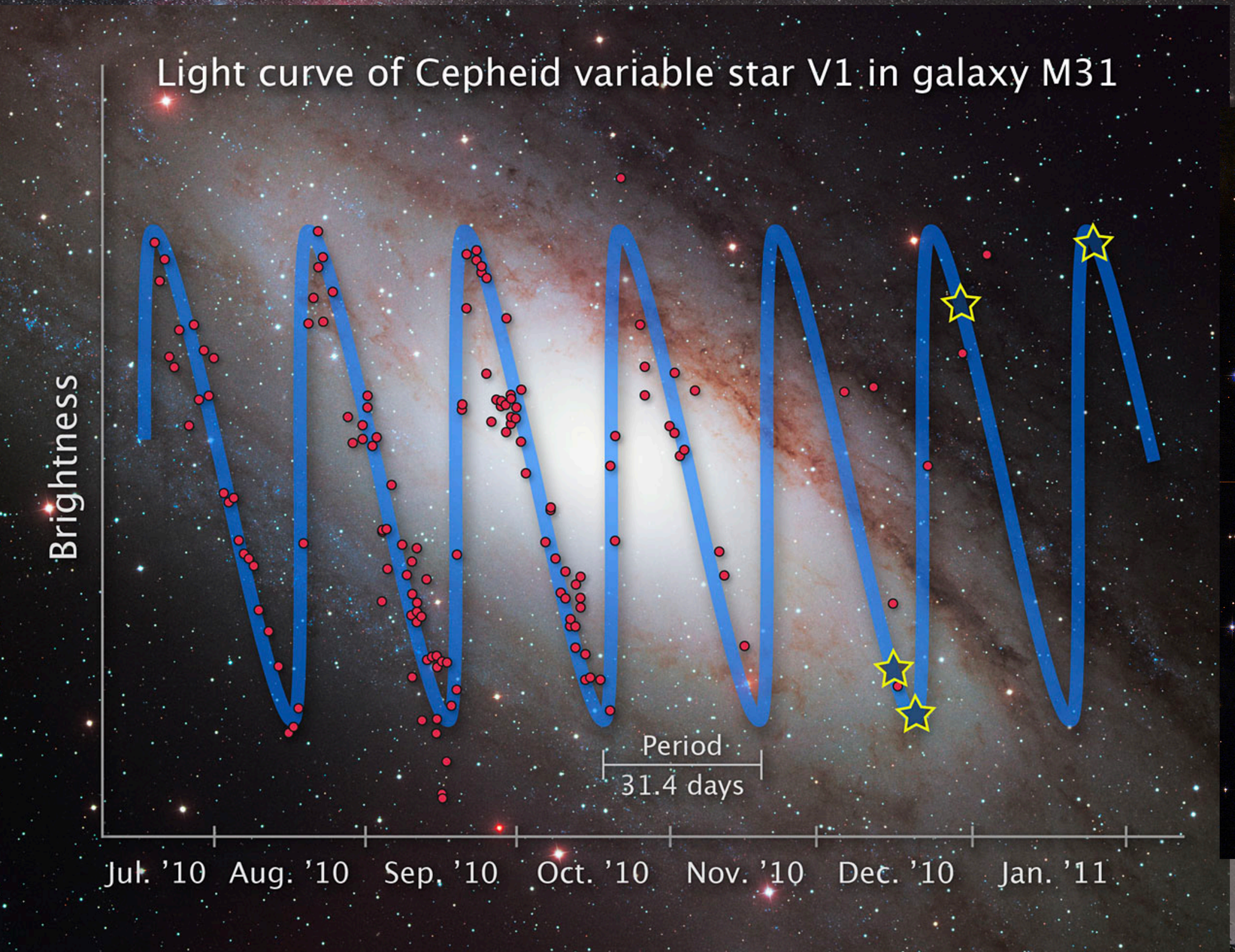
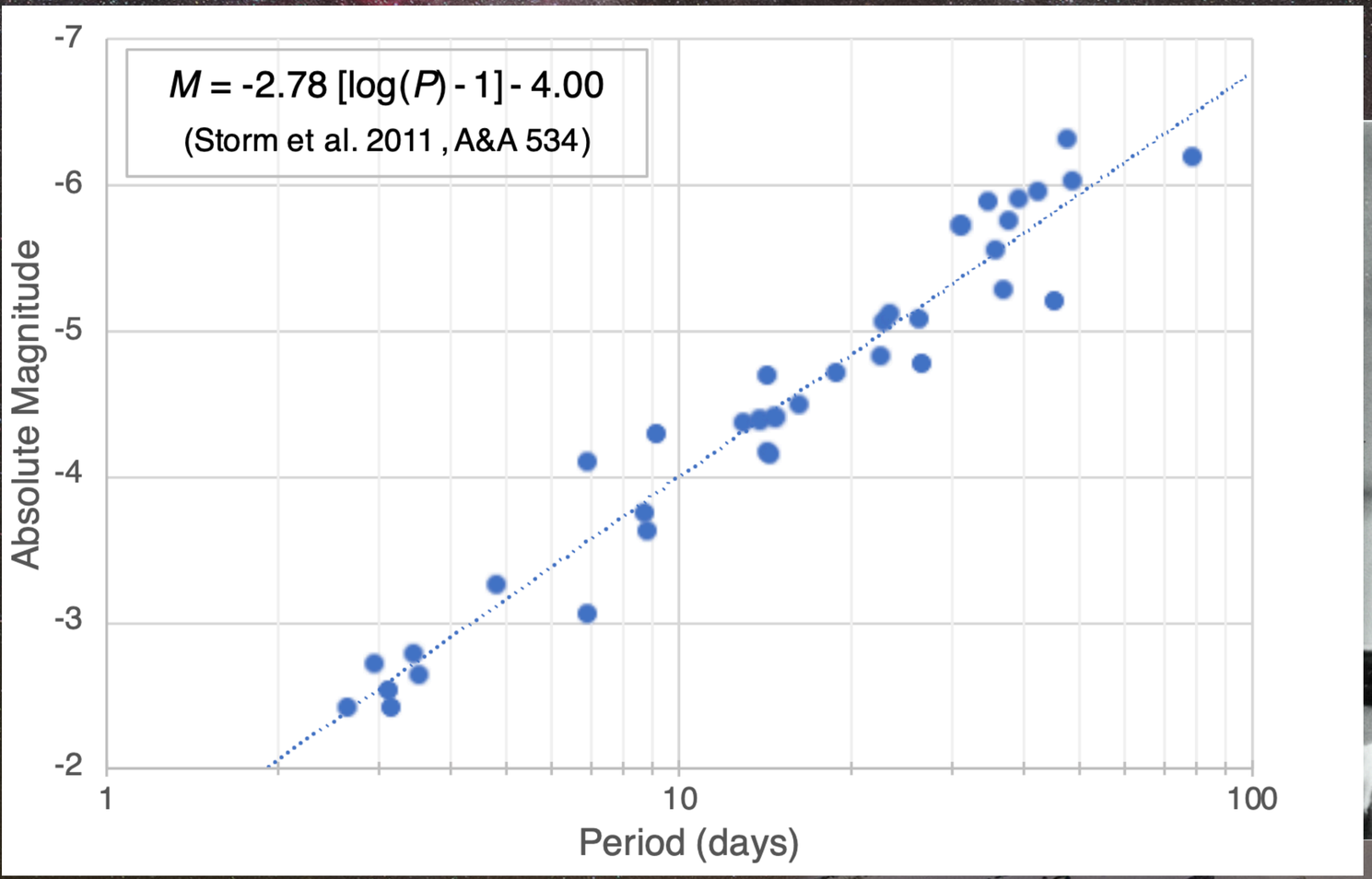


photo: Slovinsky

Distance? Céphéides



Distance? Céphéides



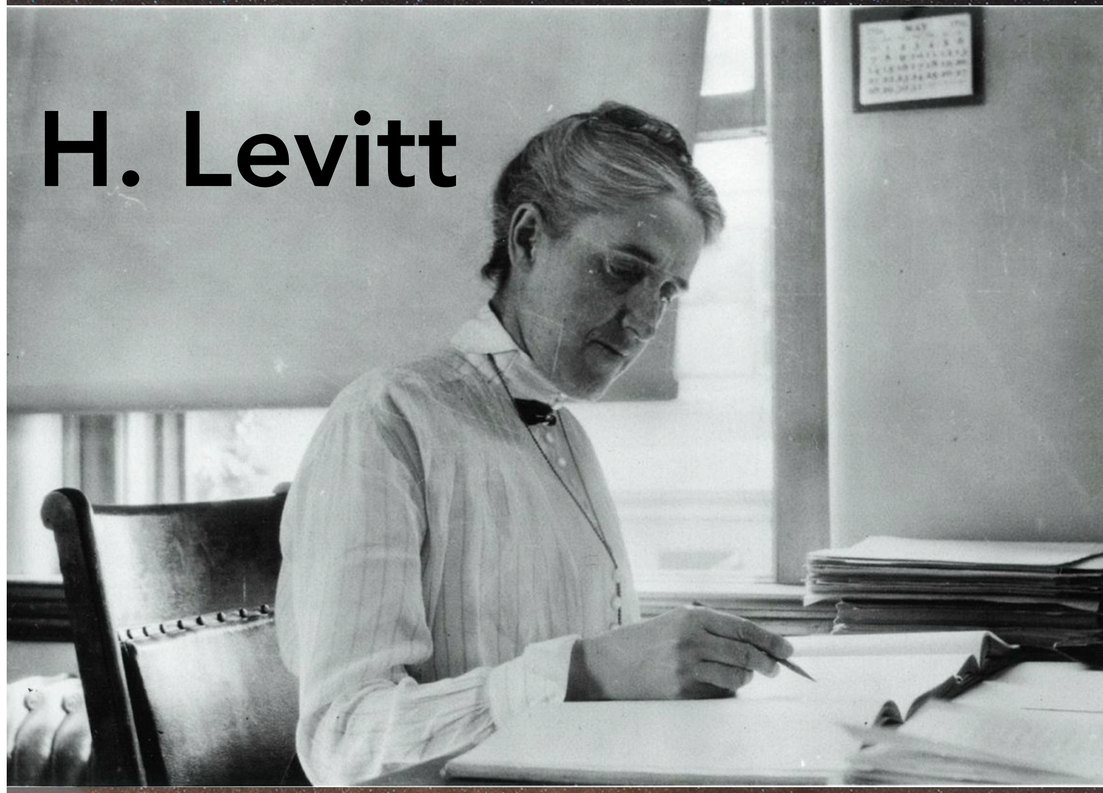
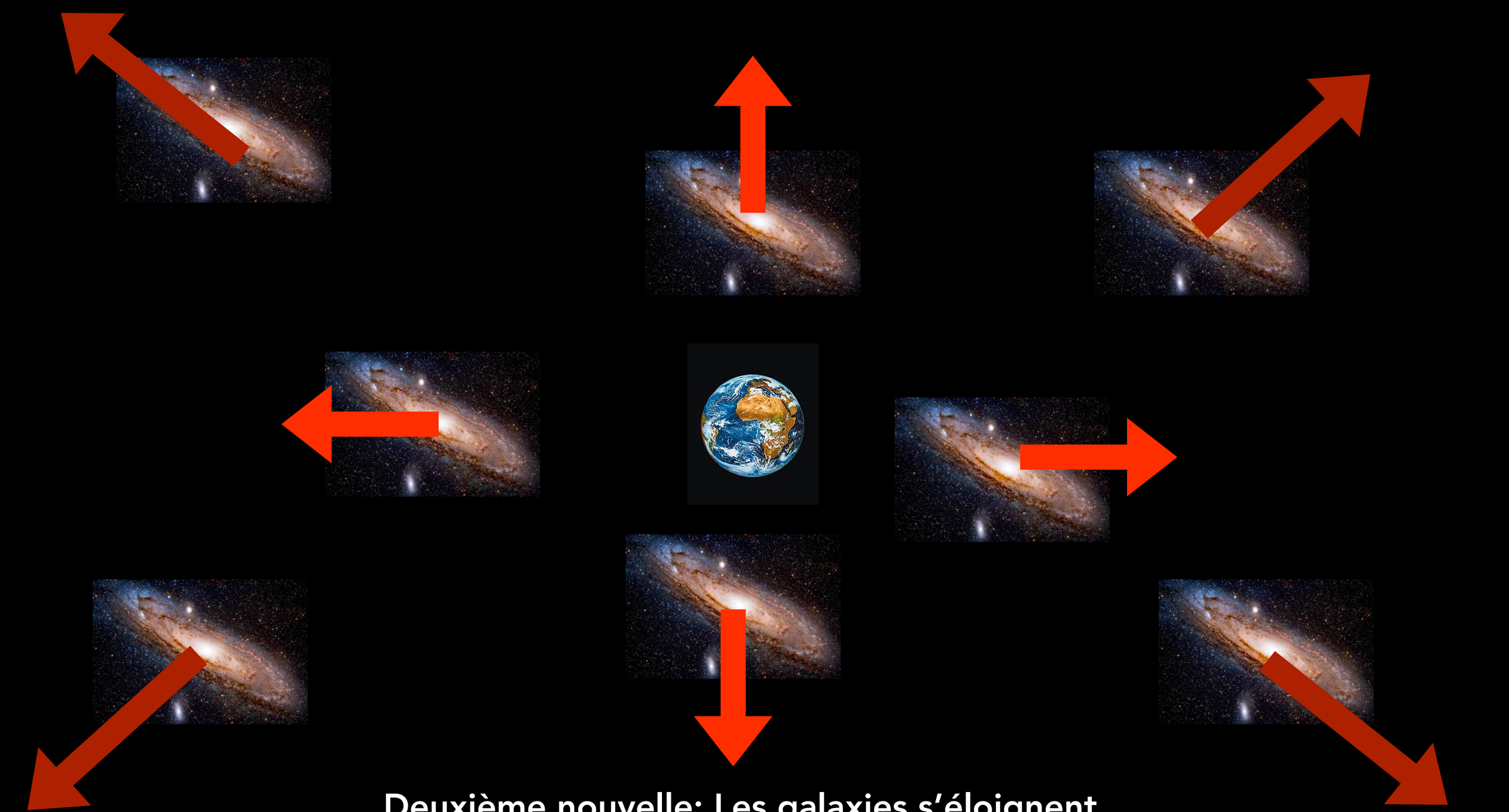


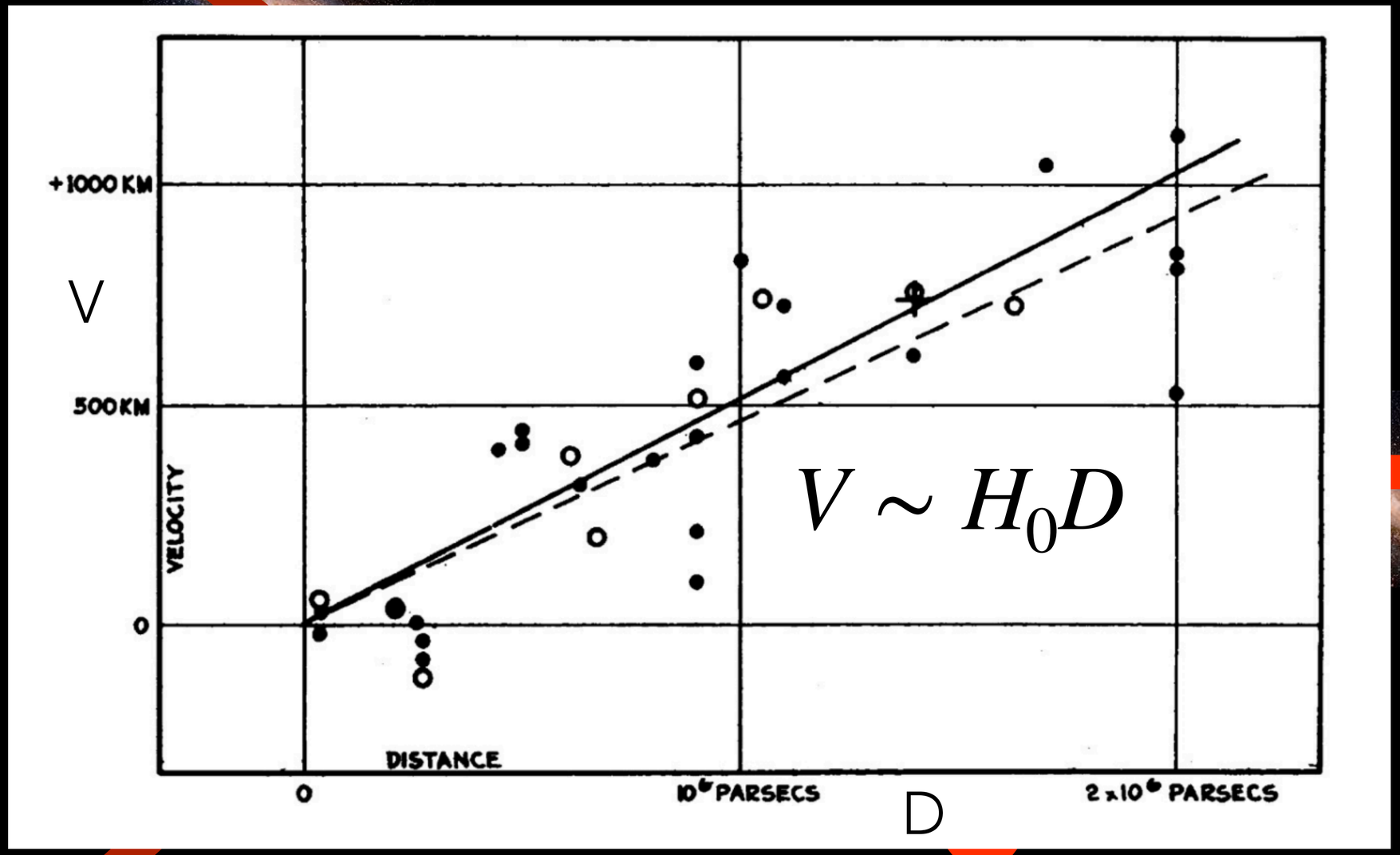
photo: Slovinsky

Première nouvelle: « nébuleuses » vs « galaxies »

Première nouvelle: « nébuleuses » vs « galaxies » (The Hubble extremely deep field)



Deuxième nouvelle: Les galaxies s’éloignent



Deuxième nouvelle: Les galaxies s’éloignent

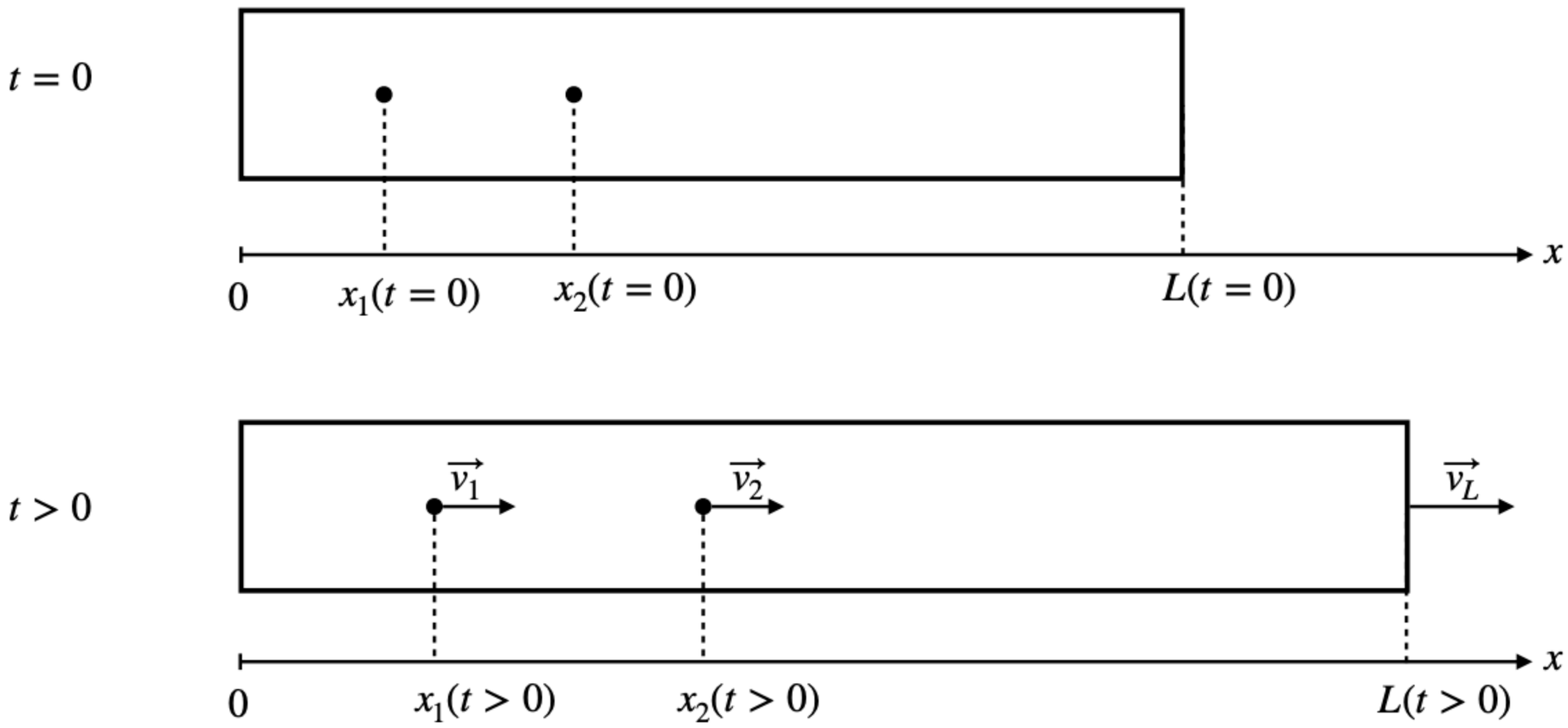
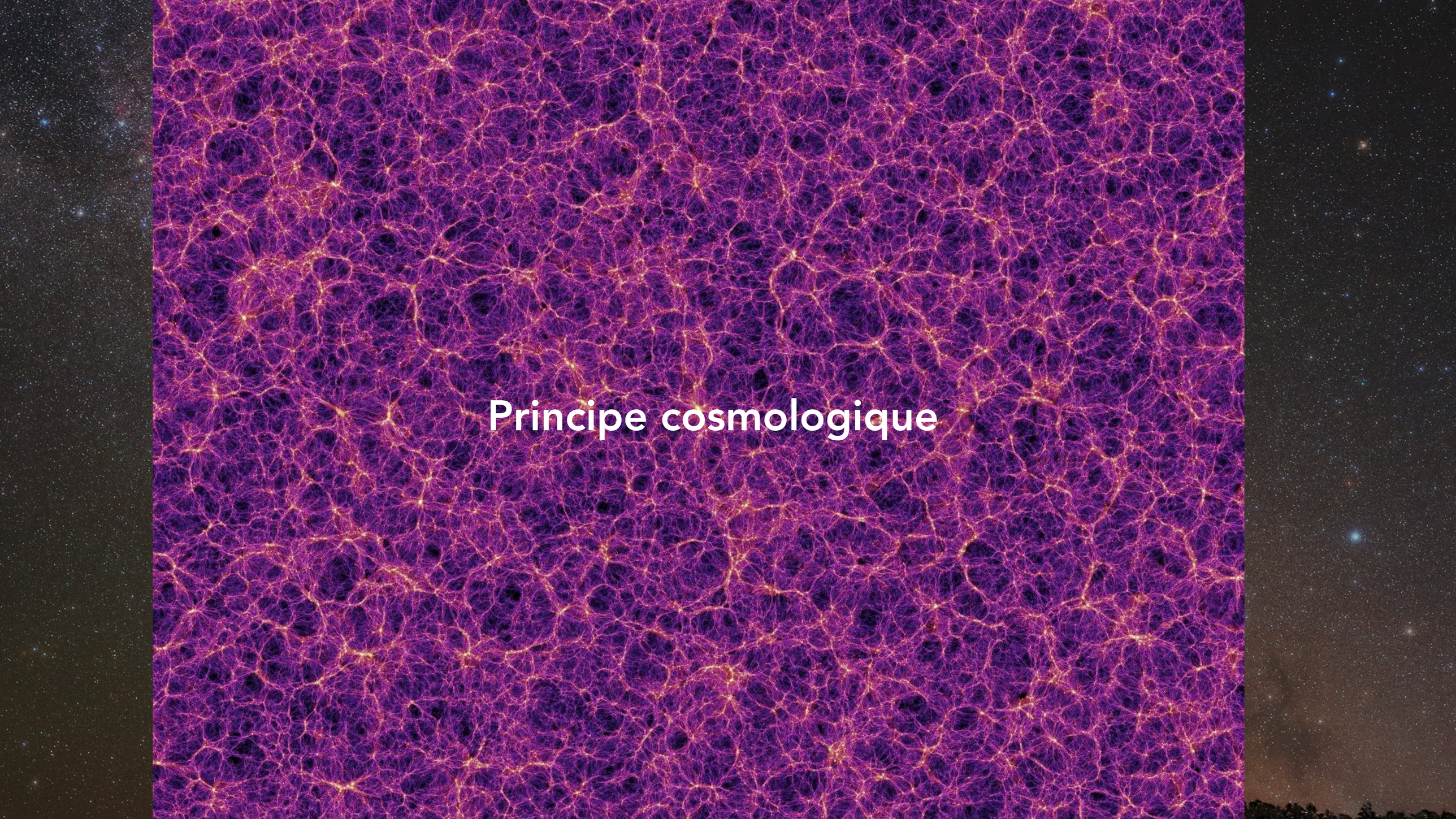


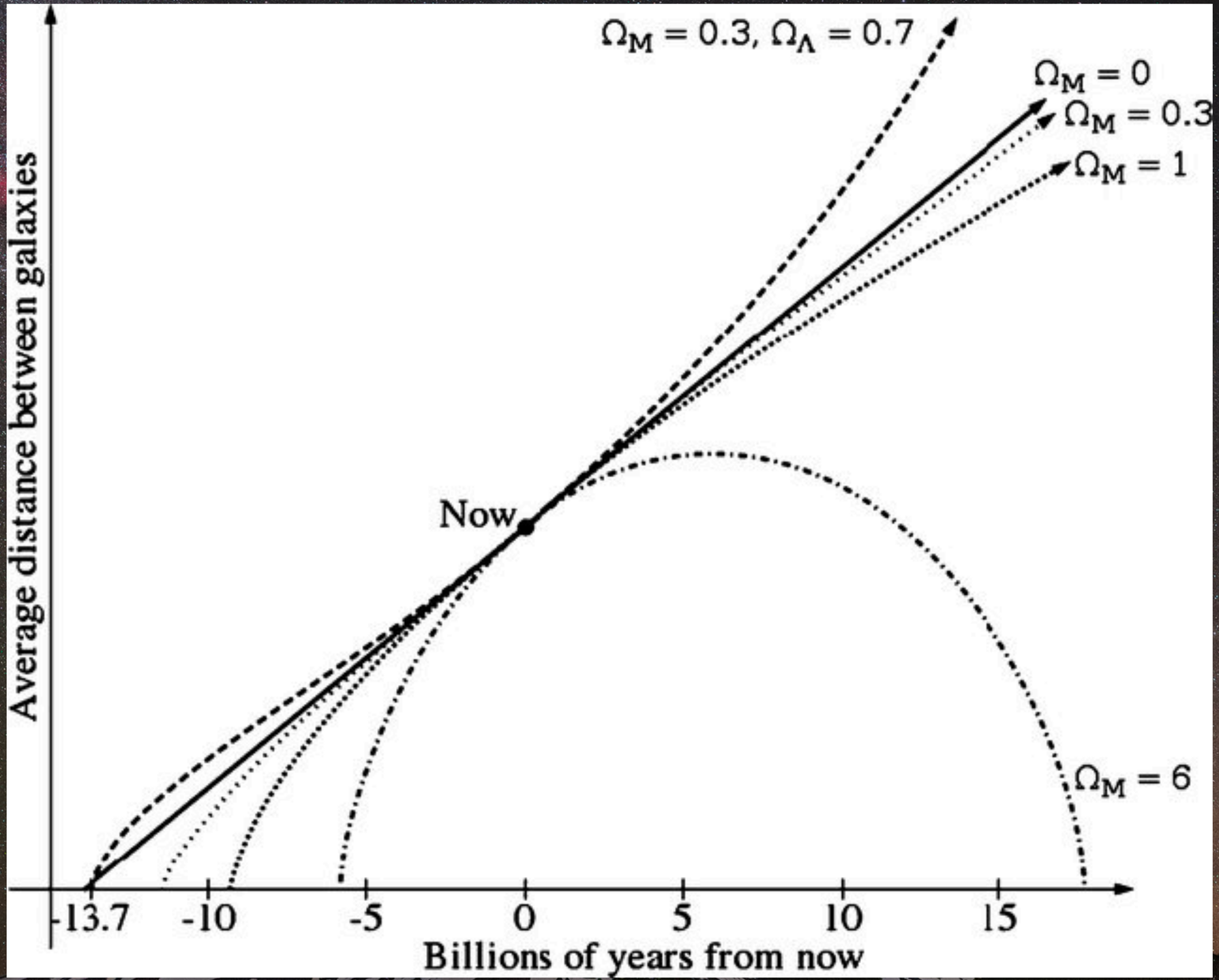
FIGURE 1 – Representations schématiques de l'élastique en expansion à $t = 0$ et à $t > 0$

photo: Slovinsky

A. Friedmann

G. Lemaitre


Principe cosmologique


$\Omega_M = 0.3, \Omega_\Lambda = 0.7$
$\Omega_M = 0$
$\Omega_M = 0.3$
$\Omega_M = 1$
Now
$\Omega_M = 6$
Average distance between galaxies
-13.7
-10
-5
0
5
10
15
Billions of years from now

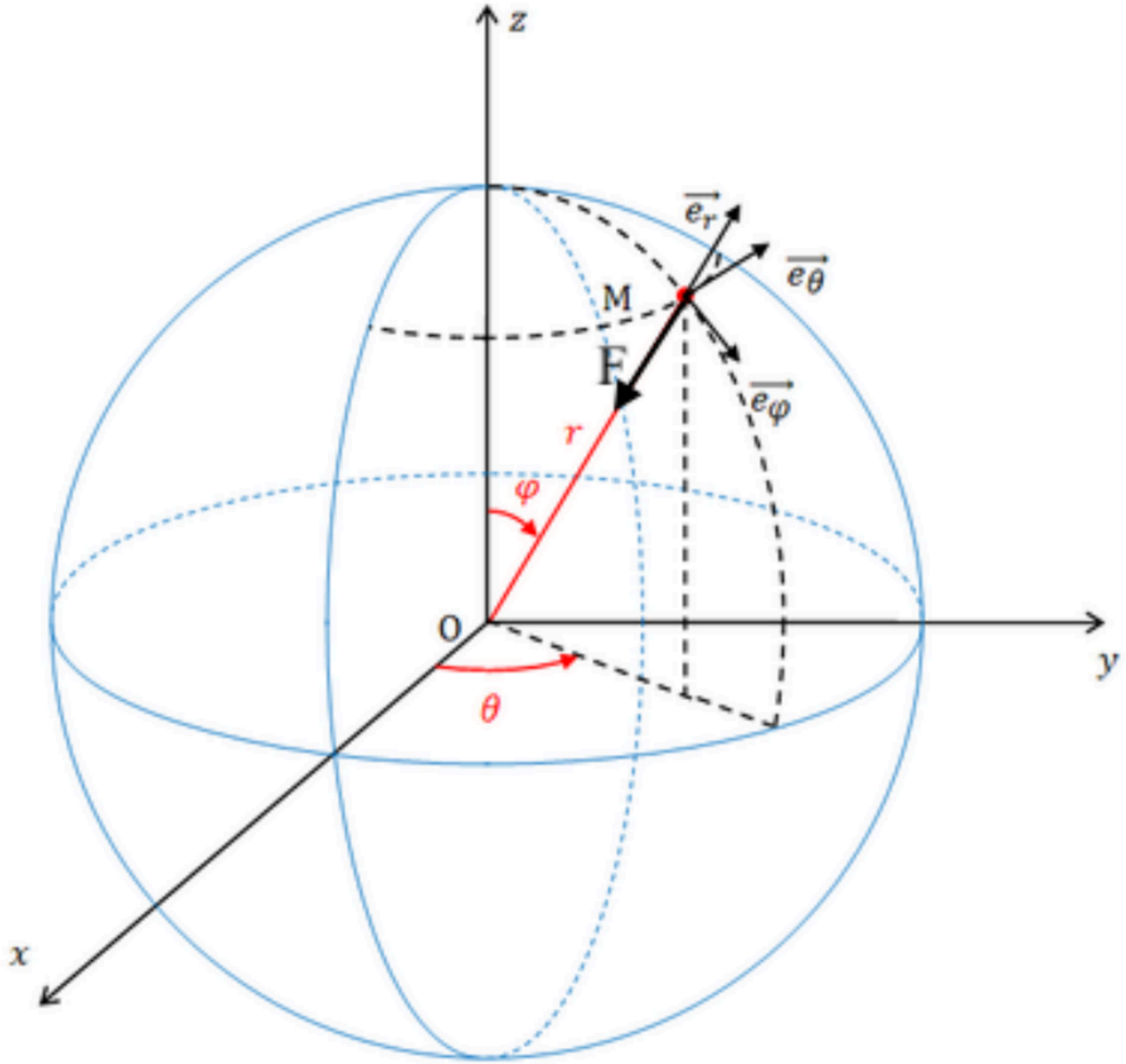


FIGURE 3 –

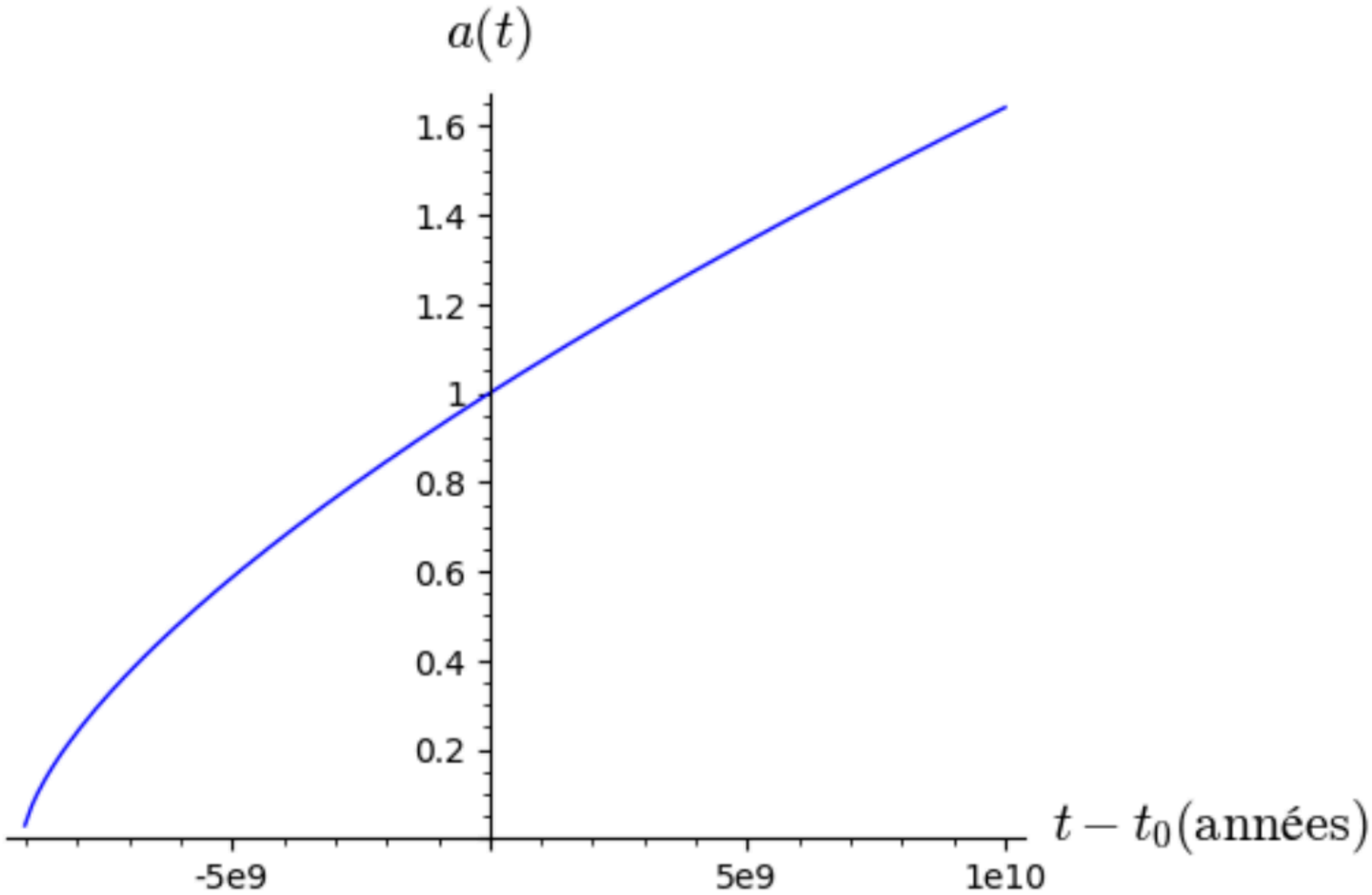


photo: Slovinsky

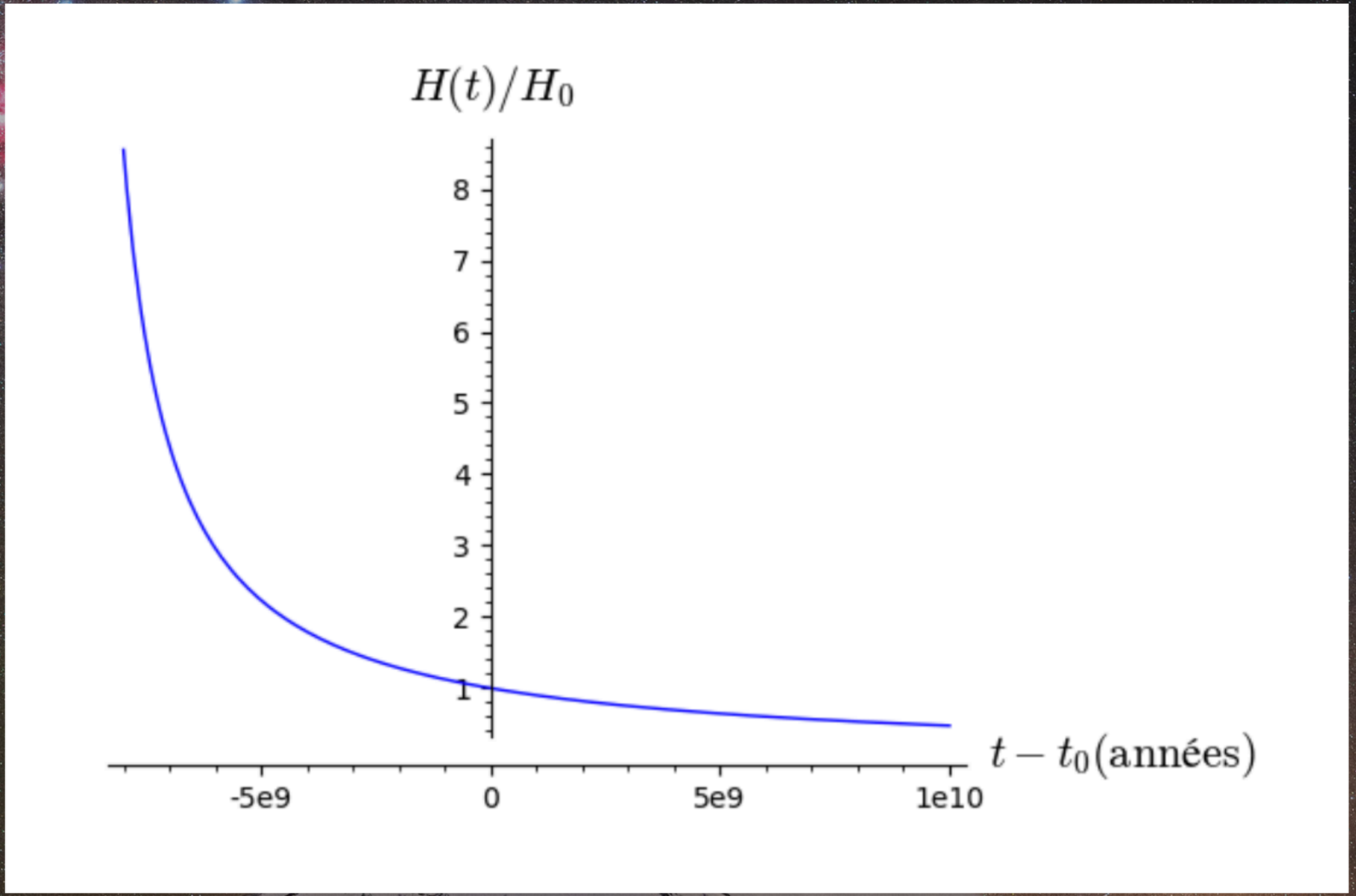


photo: Slovinsky

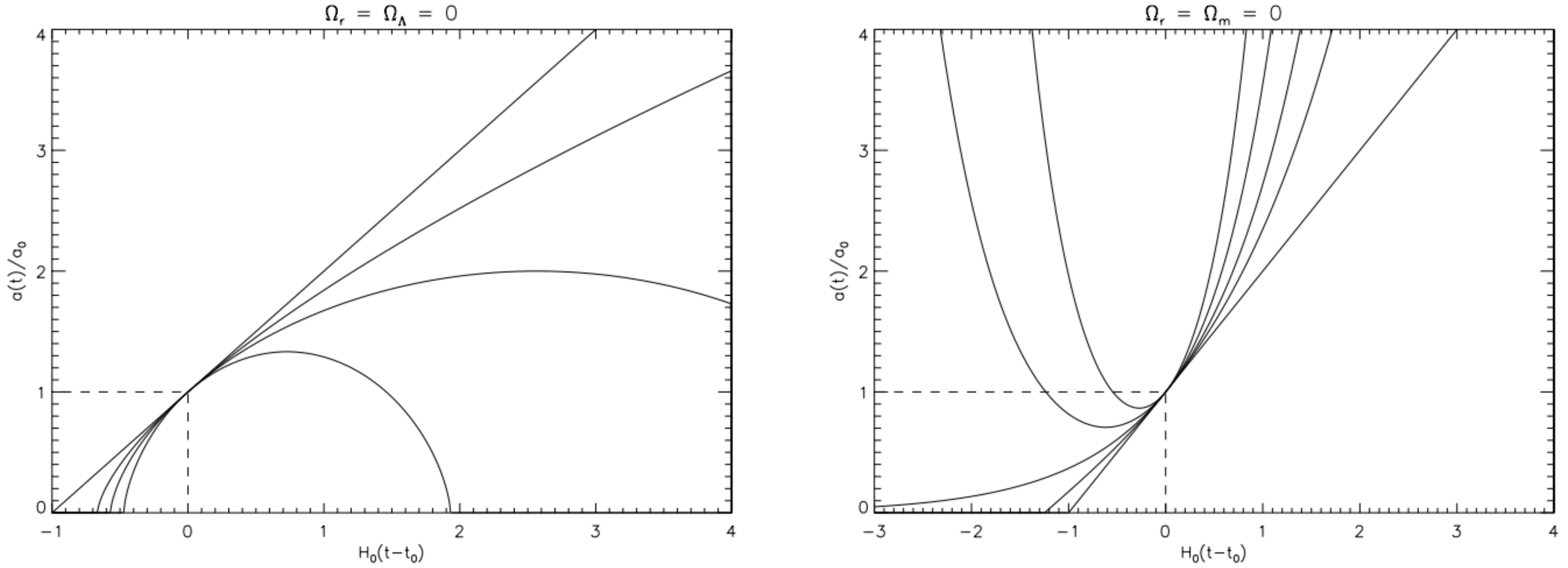


FIGURE 2 – Evolution de l'univers, représentée par son facteur d'échelle a en fonction du temps par rapport à l'époque actuelle. *A gauche :* Univers de matière ($\Omega_r = \Omega_\Lambda = 0$), pour $\Omega_m = 0, 1, 2, 4$. *A droite :* Univers de De Sitter ($\Omega_r = \Omega_m = 0$) pour $\Omega_\Lambda = 0, 0.5, 1, 2, 4$.

photo: Slovinsky

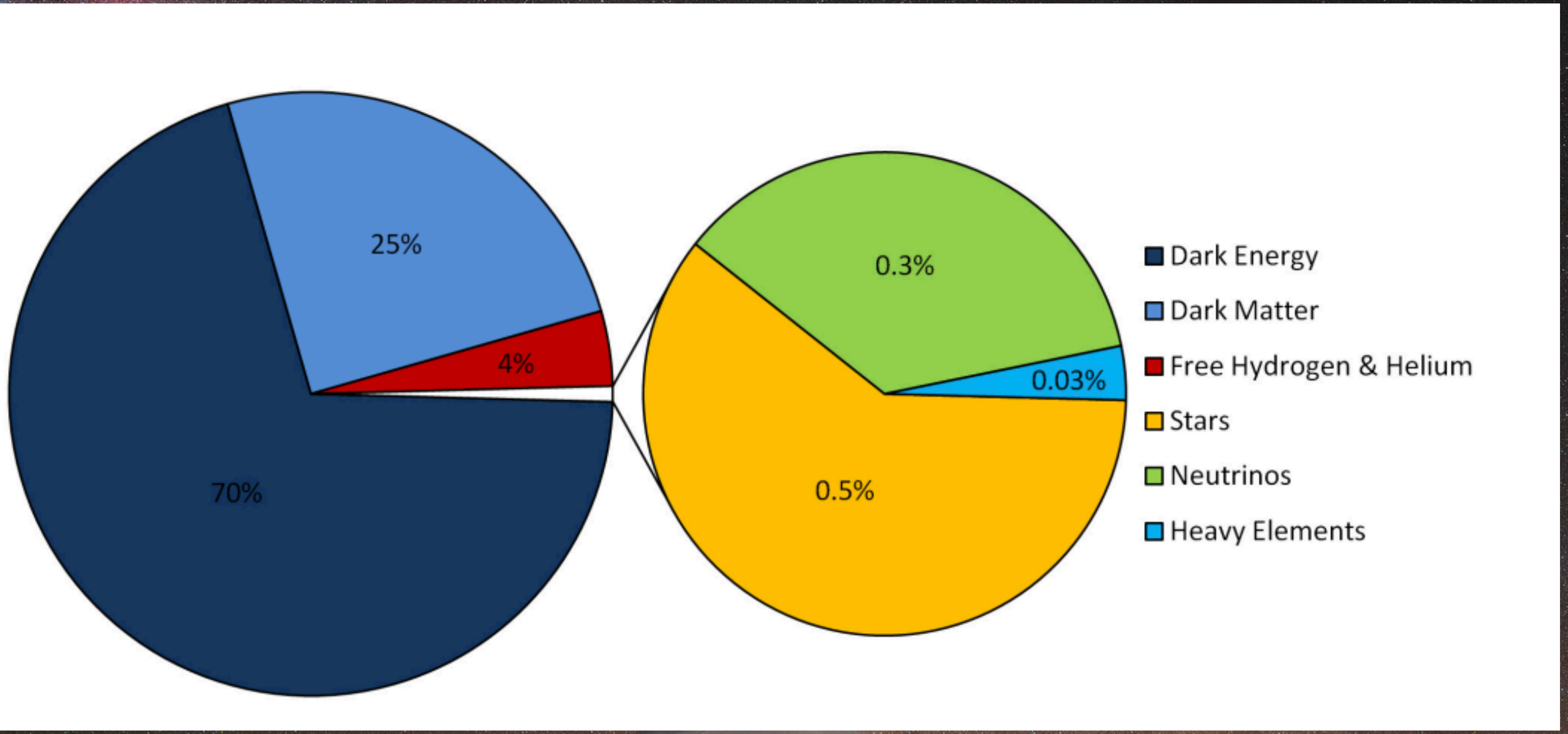
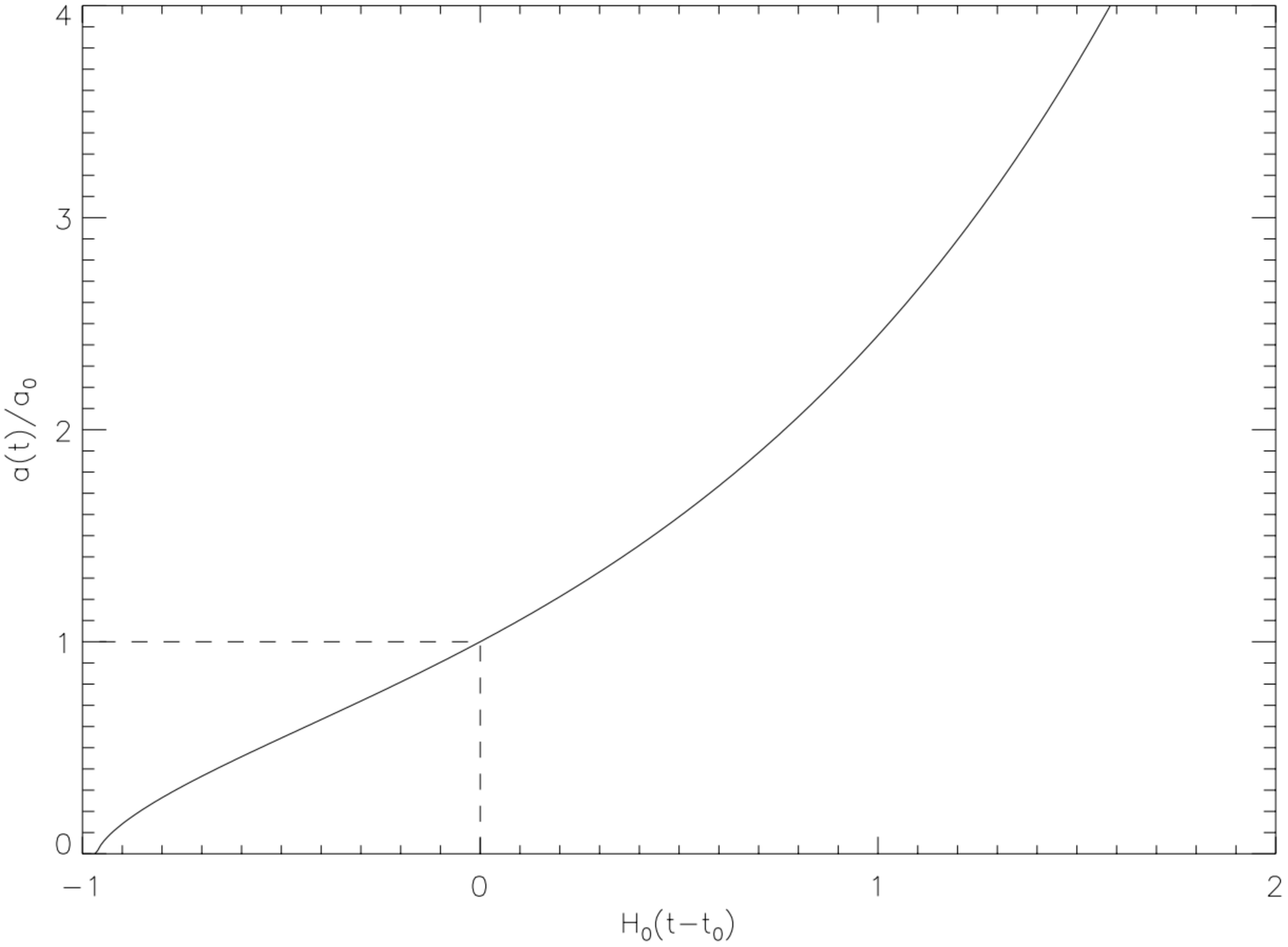


photo: Slovinsky


4
3
2
1
0
a(t)/a0
−1
0
1
2
H0(t−t0)

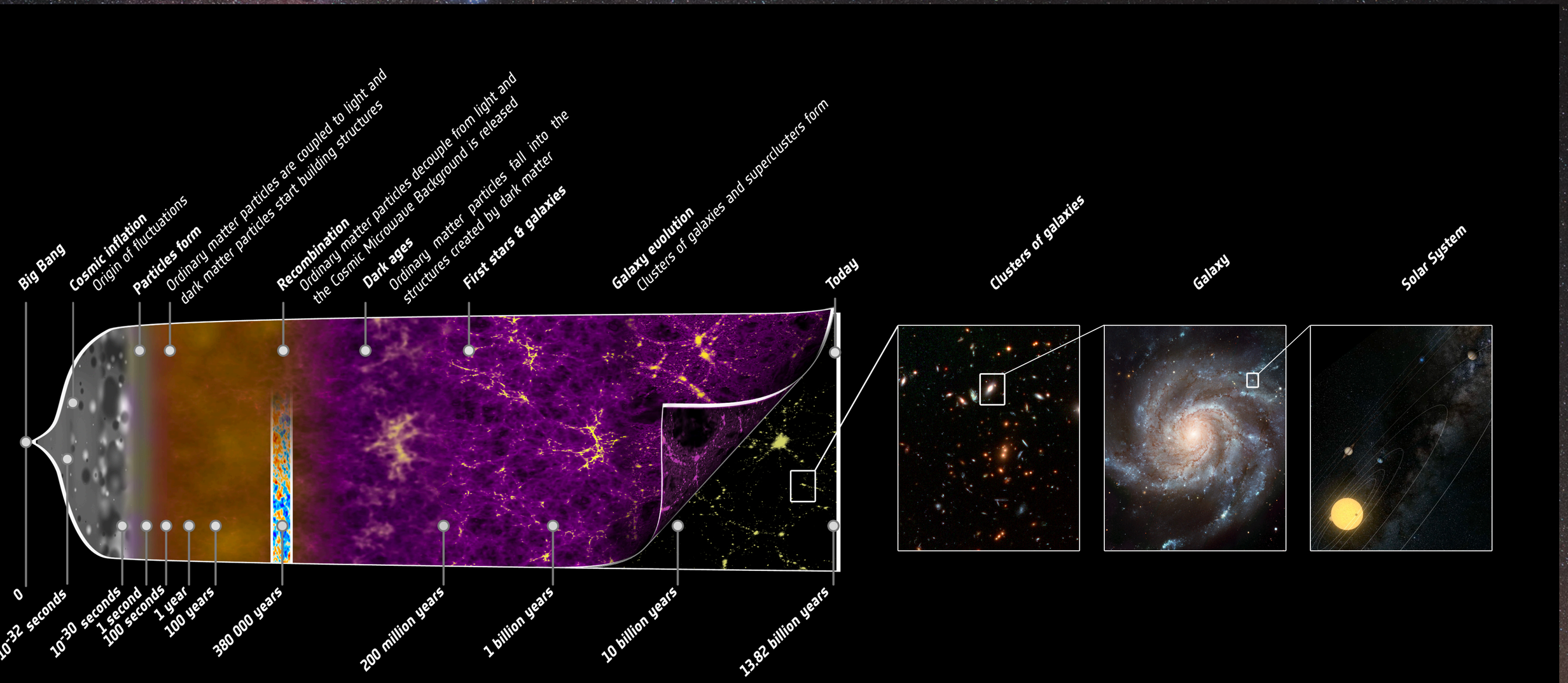
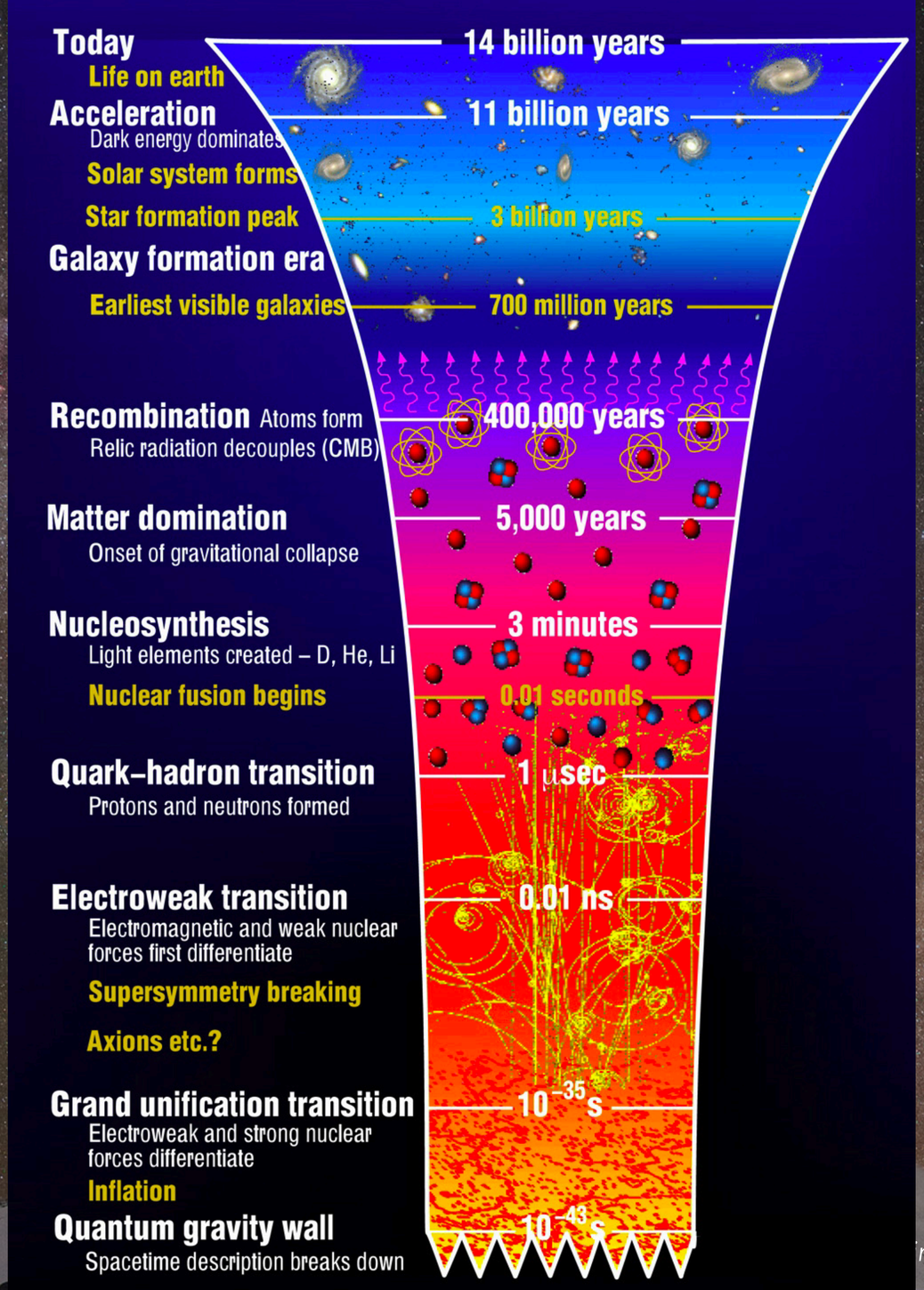


photo: Slovinsky


Today
14 billion years
Life on earth
Acceleration
Dark energy dominates
11 billion years
Solar system forms
Star formation peak
3 billion years
Galaxy formation era
Earliest visible galaxies
700 million years
Recombination Atoms form
Relic radiation decouples (CMB)
400,000 years
Matter domination
Onset of gravitational collapse
5,000 years
Nucleosynthesis
Light elements created – D, He, Li
3 minutes
Nuclear fusion begins
0.01 seconds
Quark–hadron transition
Protons and neutrons formed
1 μsec
Electroweak transition
Electromagnetic and weak nuclear forces first differentiate
0.01 ns
Supersymmetry breaking
Axions etc.?
Grand unification transition
Electroweak and strong nuclear forces differentiate
10 -35 s
Inflation
Quantum gravity wall
Spacetime description breaks down
10 -43 s

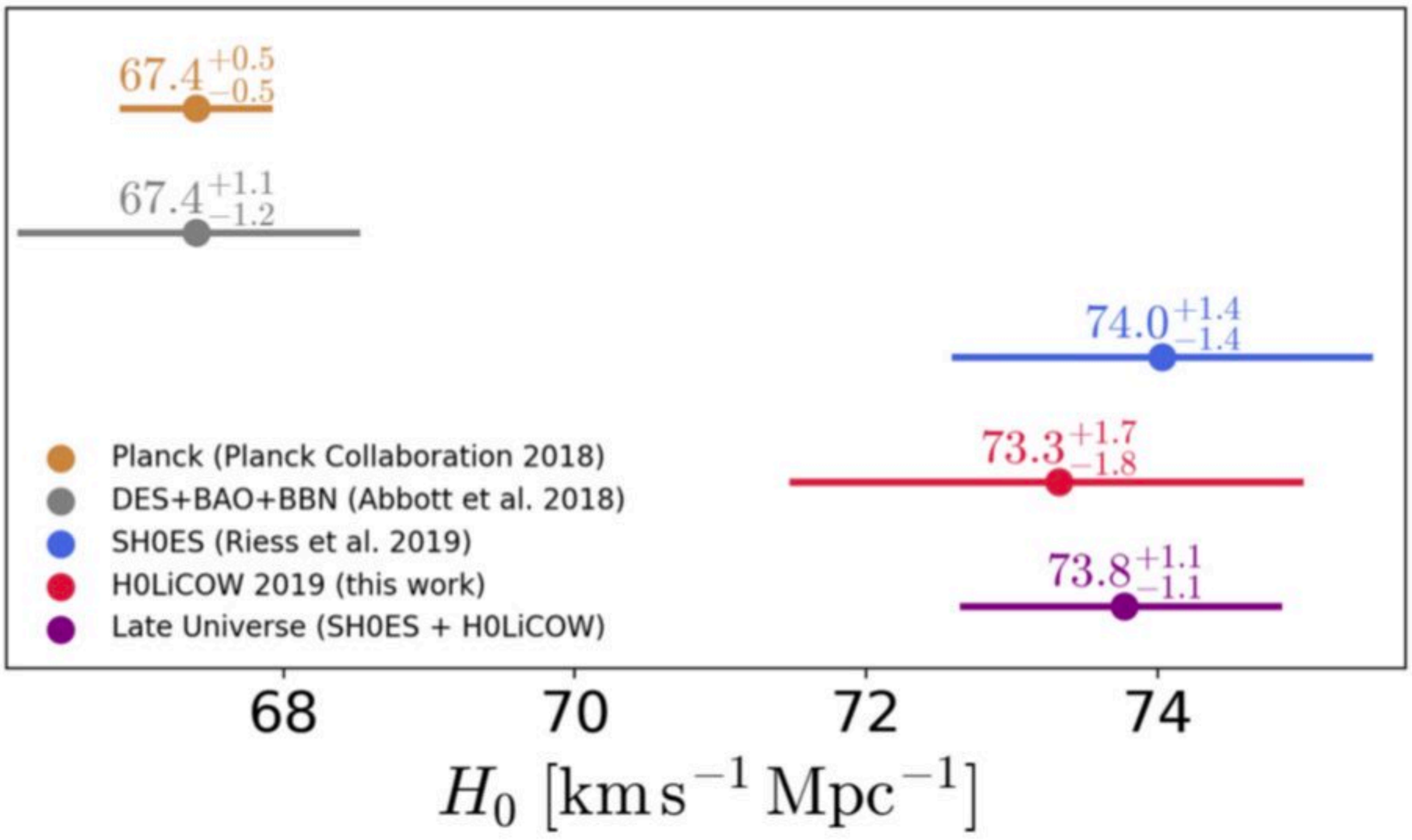
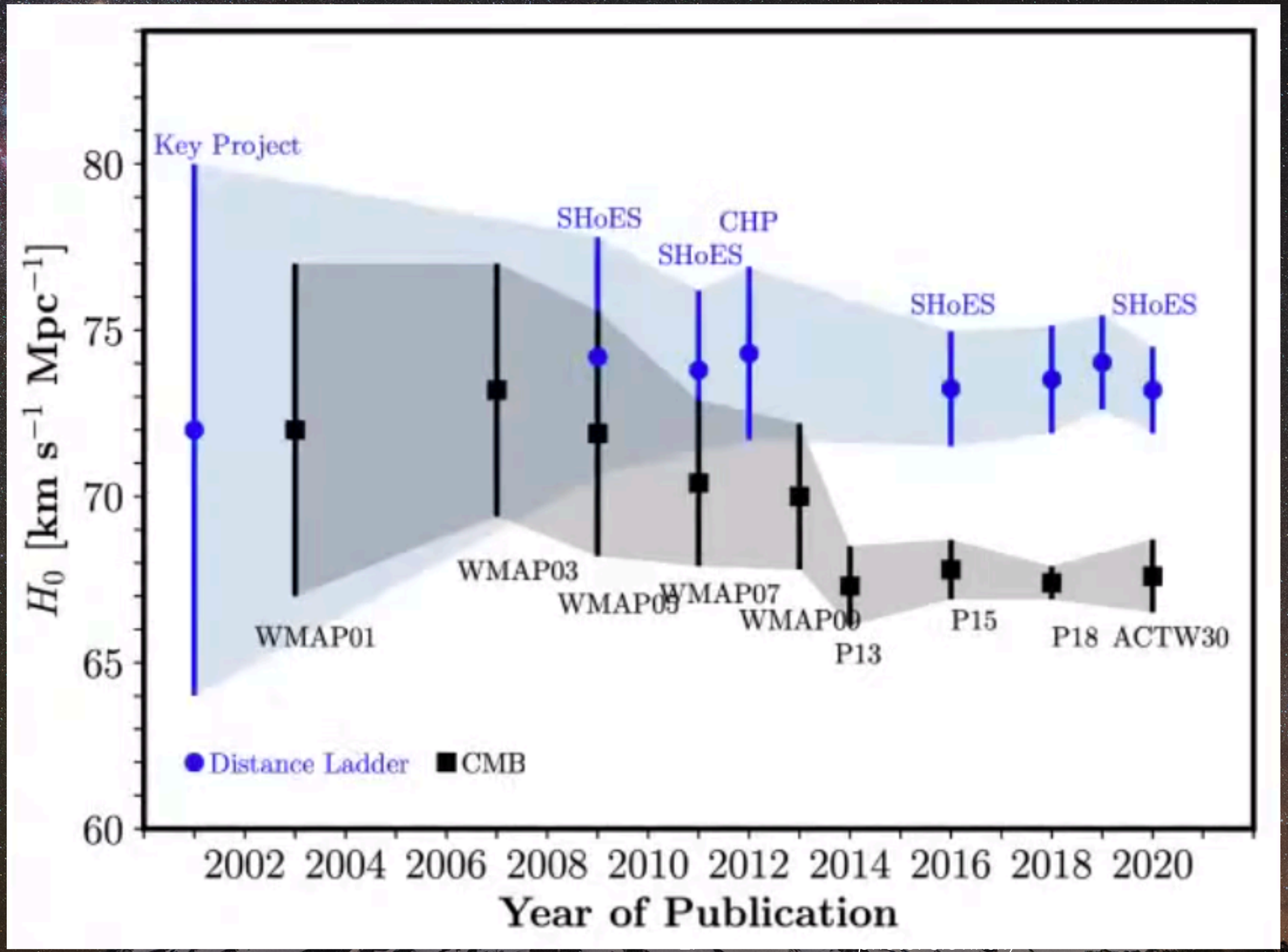


photo: Slovinsky


Key Project
SHoES
CHP
SHoES
SHoES
SHoES
WMAP03
WMAP05
WMAP07
WMAP09
WMAP01
P13
P15
P18
ACTW30
Distance Ladder
CMB
H_0 [km s^{-1} Mpc^{-1}]
80
75
70
65
60
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Year of Publication