Dark Matter & Dark Energy

NASA

Peterborough Astronomical Association

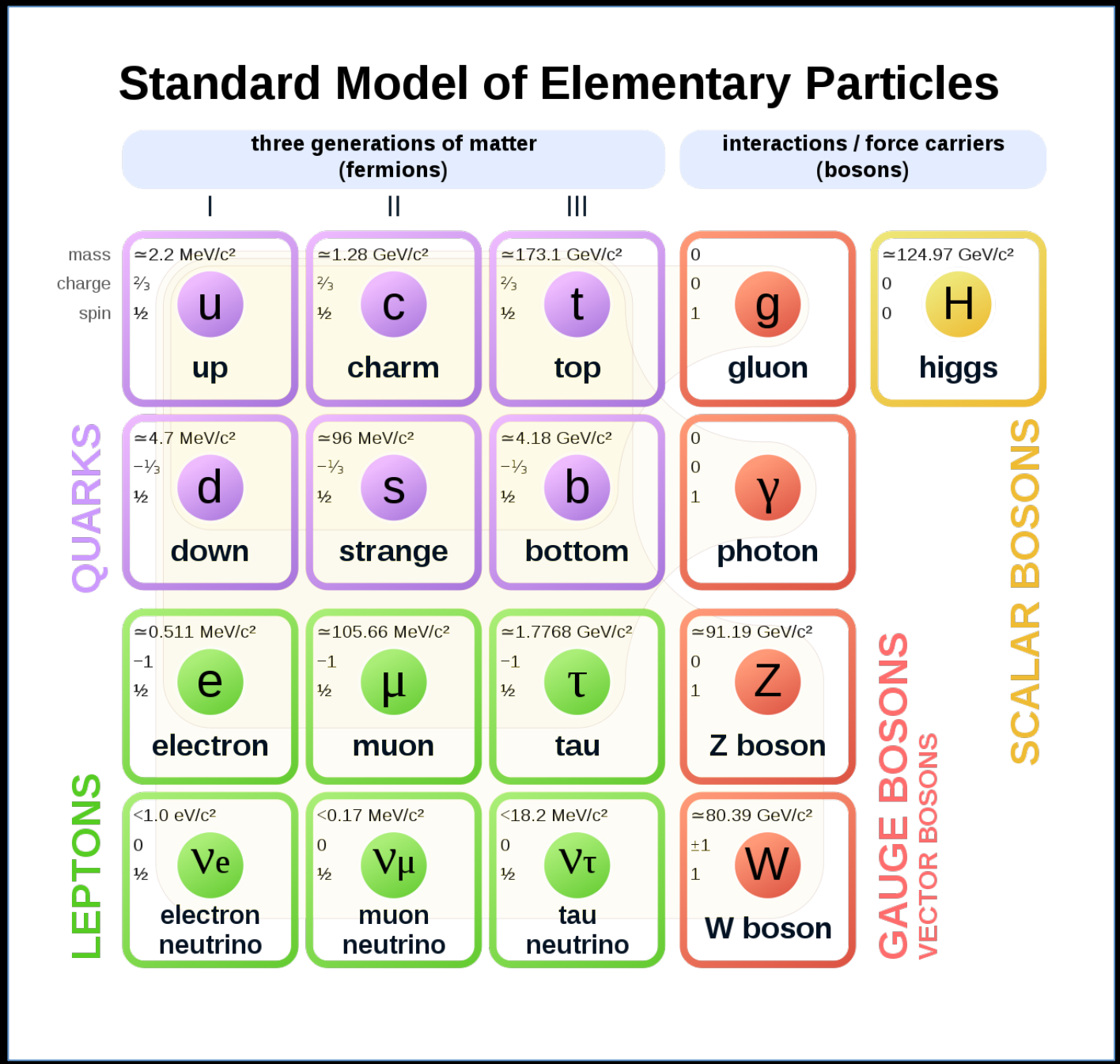
Novice Astronomy Class # 25

October 4, 2024

Brett Hardy

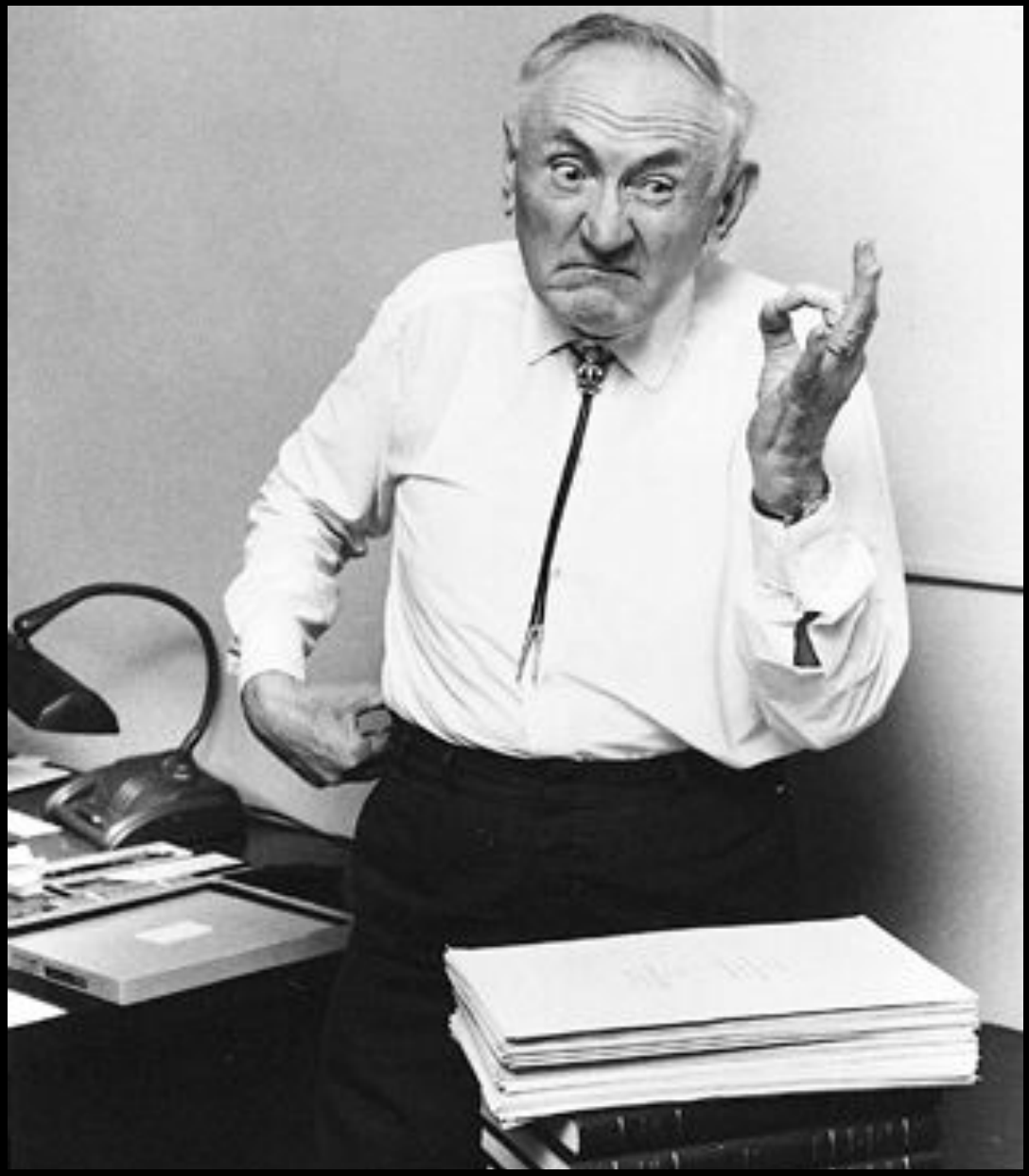
Baryonic Matter

- Protons, neutrons, electrons − oh, my!
- You, me and everything else you can see
- Only 5 %


Standard Model of Elementary Particles
three generations of matter (fermions)
interactions / force carriers (bosons)
I
II
III
mass
charge
spin
≃2.2 MeV/c²
⅔
½
u
up
≃1.28 GeV/c²
⅔
½
c
charm
≃173.1 GeV/c²
⅔
½
t
top
0
0
1
g
gluon
≃124.97 GeV/c²
0
0
H
higgs
QUARKS
≃4.7 MeV/c²
−⅓
½
d
down
≃96 MeV/c²
−⅓
½
s
strange
≃4.18 GeV/c²
−⅓
½
b
bottom
0
0
1
γ
photon
SCALAR BOSONS
≃0.511 MeV/c²
−1
½
e
electron
≃105.66 MeV/c²
−1
½
μ
muon
≃1.7768 GeV/c²
−1
½
τ
tau
≃91.19 GeV/c²
0
1
Z
Z boson
GAUGE BOSONS
VECTOR BOSONS
LEPTONS
<1.0 eV/c²
0
½
νe
electron neutrino
<0.17 MeV/c²
0
½
νμ
muon neutrino
<18.2 MeV/c²
0
½
ντ
tau neutrino
≃80.39 GeV/c²
±1
1
W
W boson

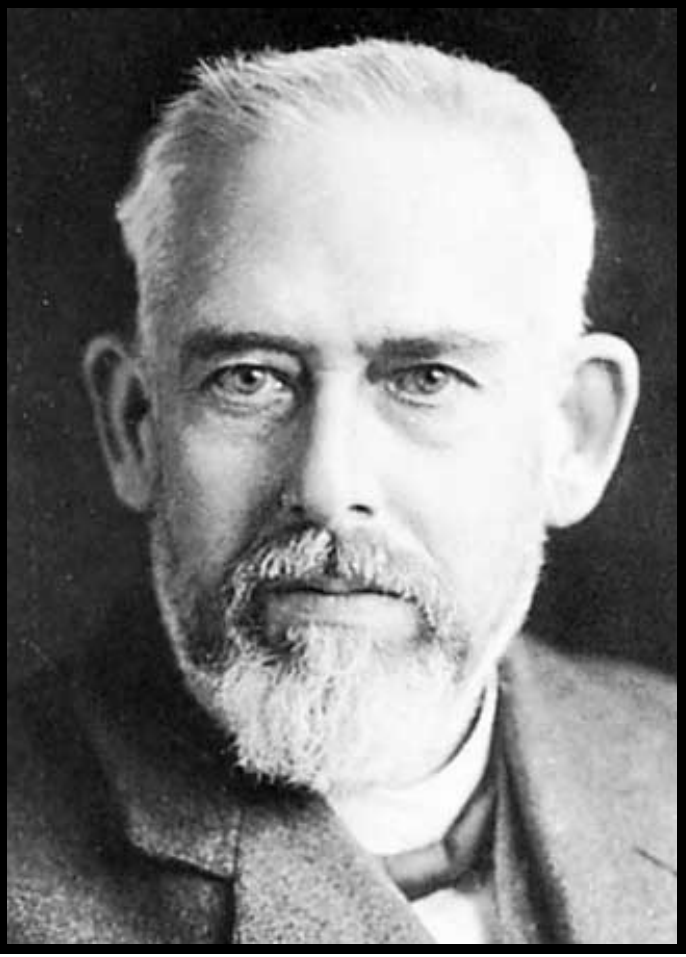
Dark Matter Early History

- Fritz Zwicky, 1933
- Missing mass



Spectroscopy

- Max Wolf & Vesto Slipher
- Andromeda Galaxy
- Orbital speed anomaly

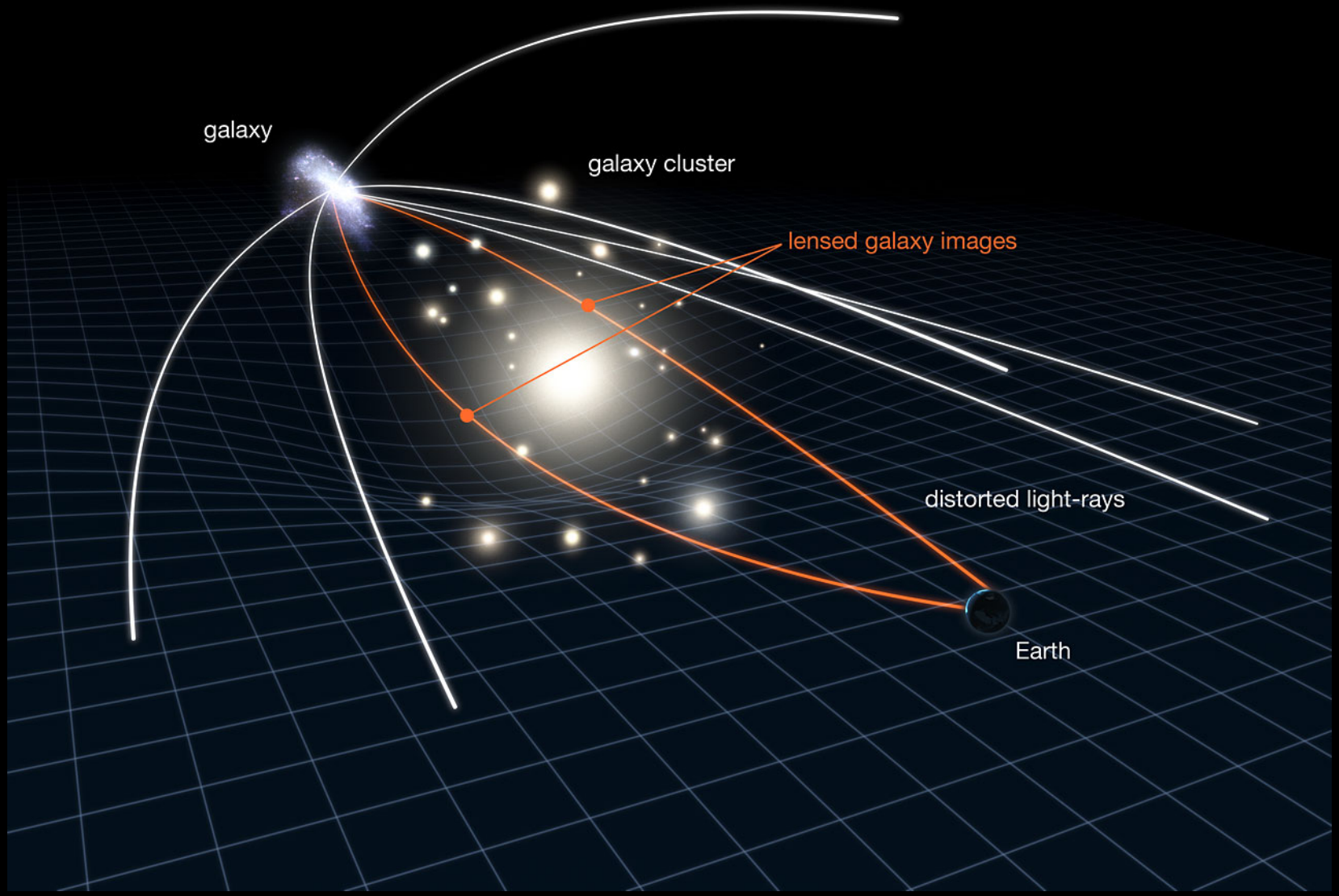


Mounting Evidence

- Vera Rubin
- Galaxy rotation problem
- 5 – 6 times missing mass

Mark Godfrey

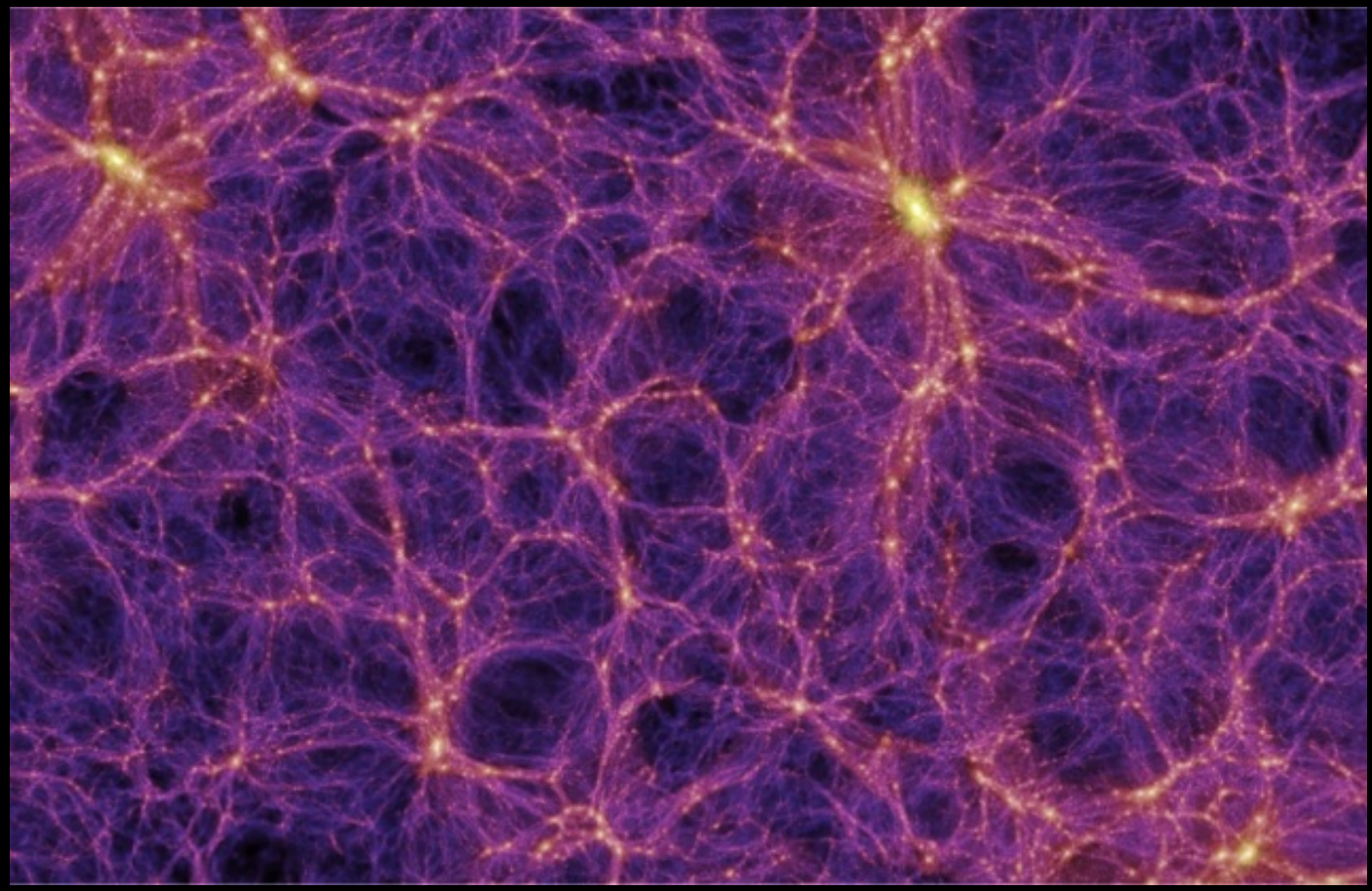
Gravitational Lensing



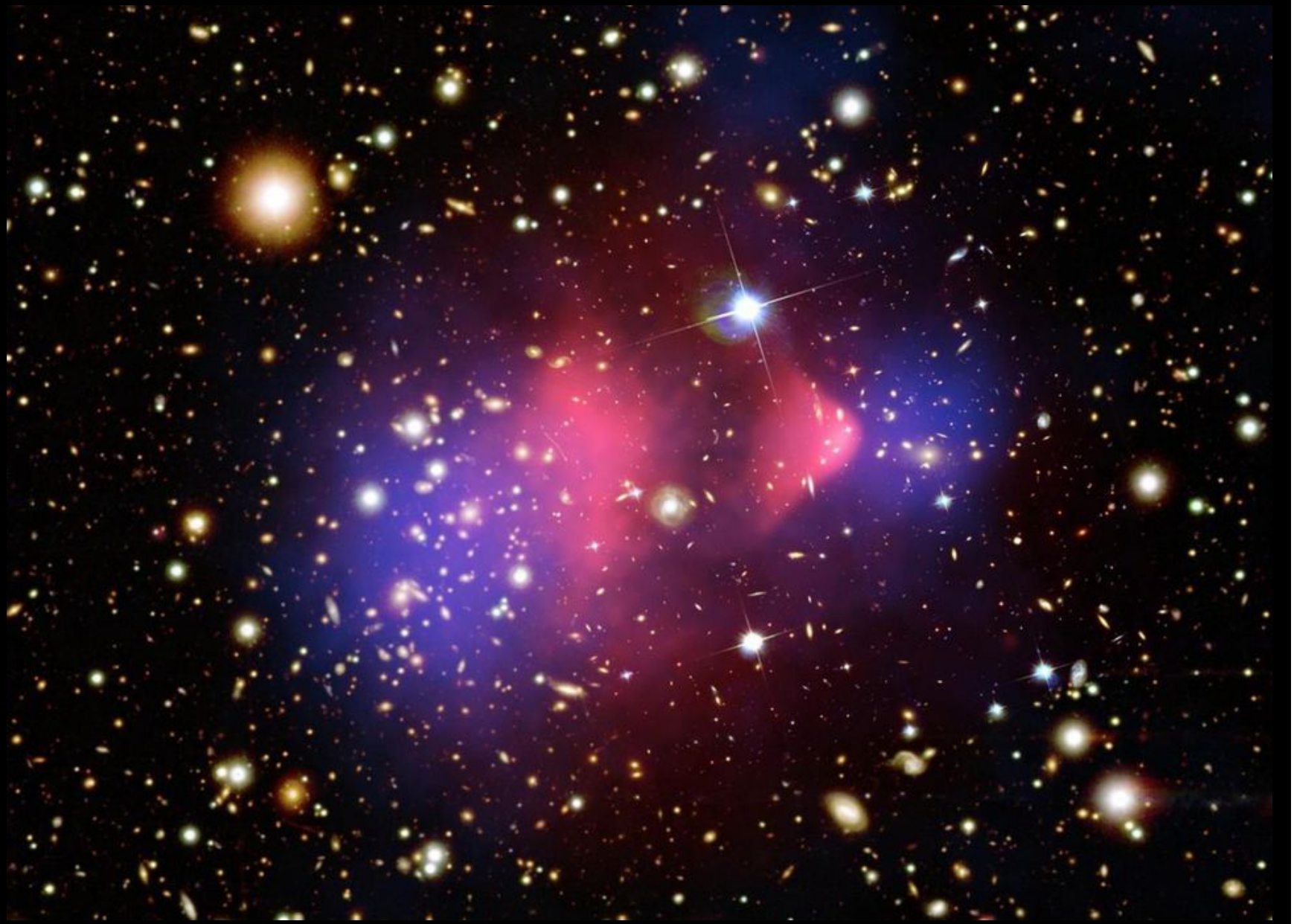
NASA, ESA, L. Calcada

Deep Sky Surveys

- Galaxy distribution
- Large scale patterns



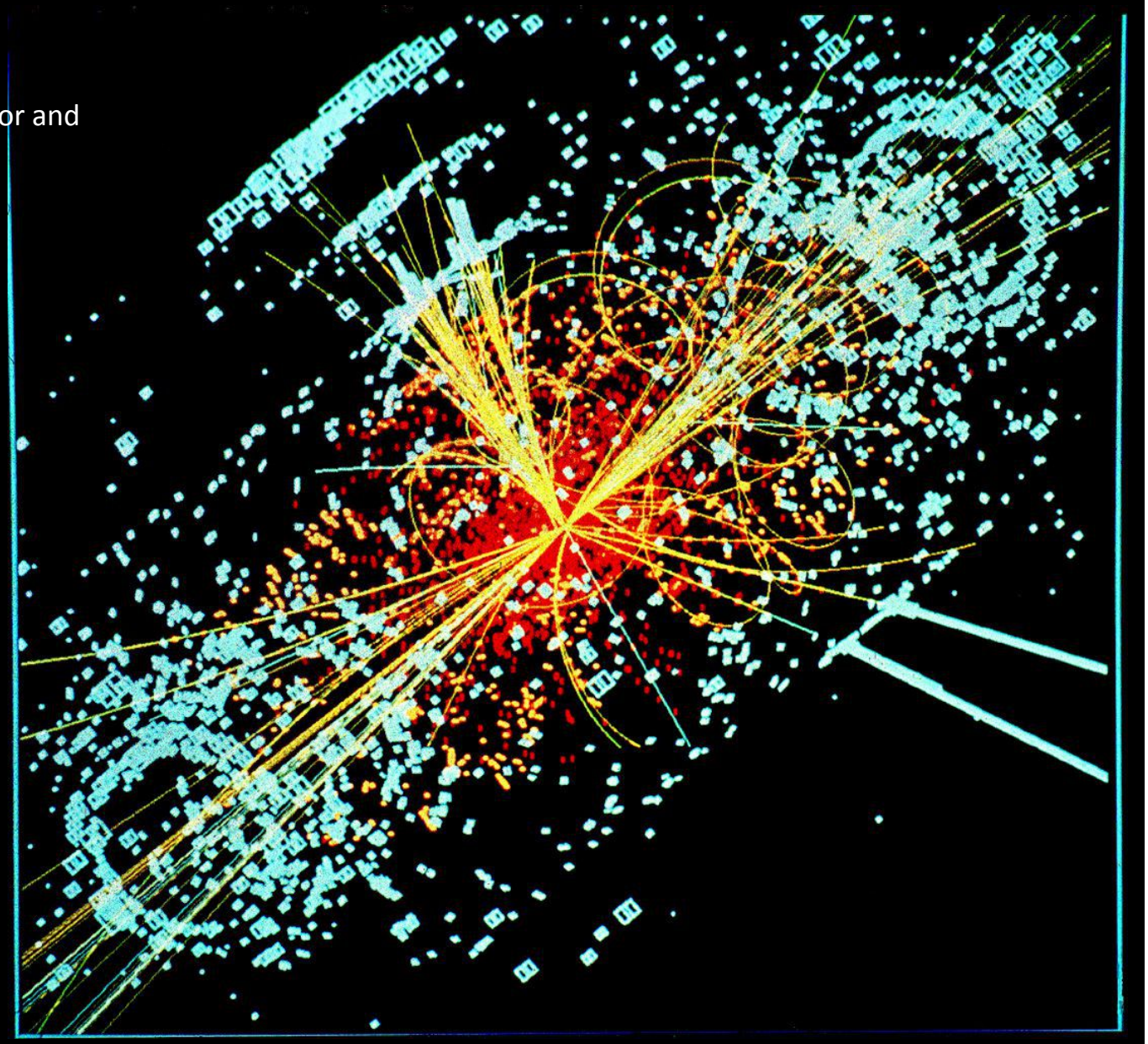
Bullet Cluster



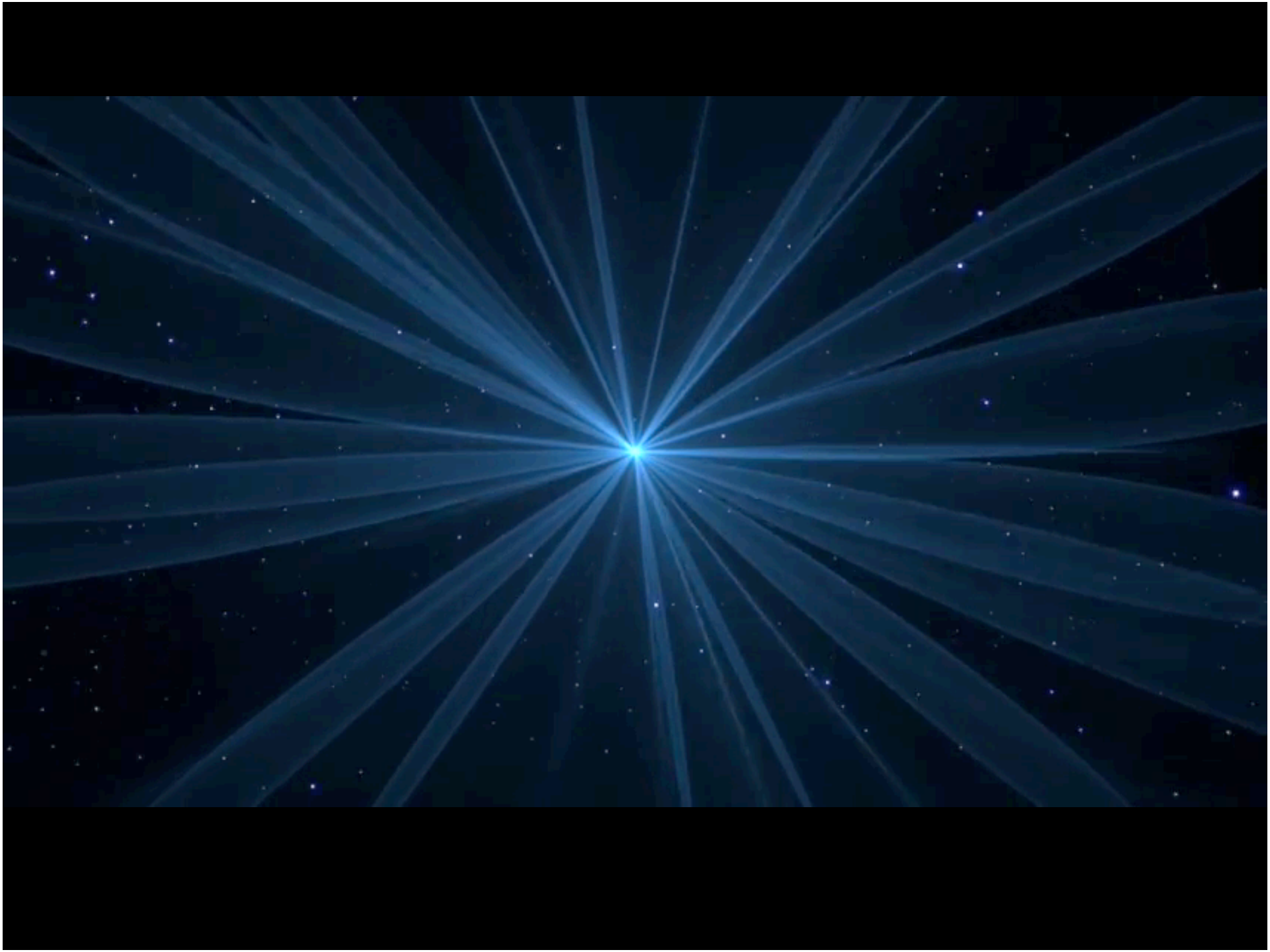
NASA, CXC, CFA, M. Markevitch et al

CERN

- Largest particle accelerator and detectors
- Particle collisions
- Make ‘em
- Break ‘em
- Shake ‘em

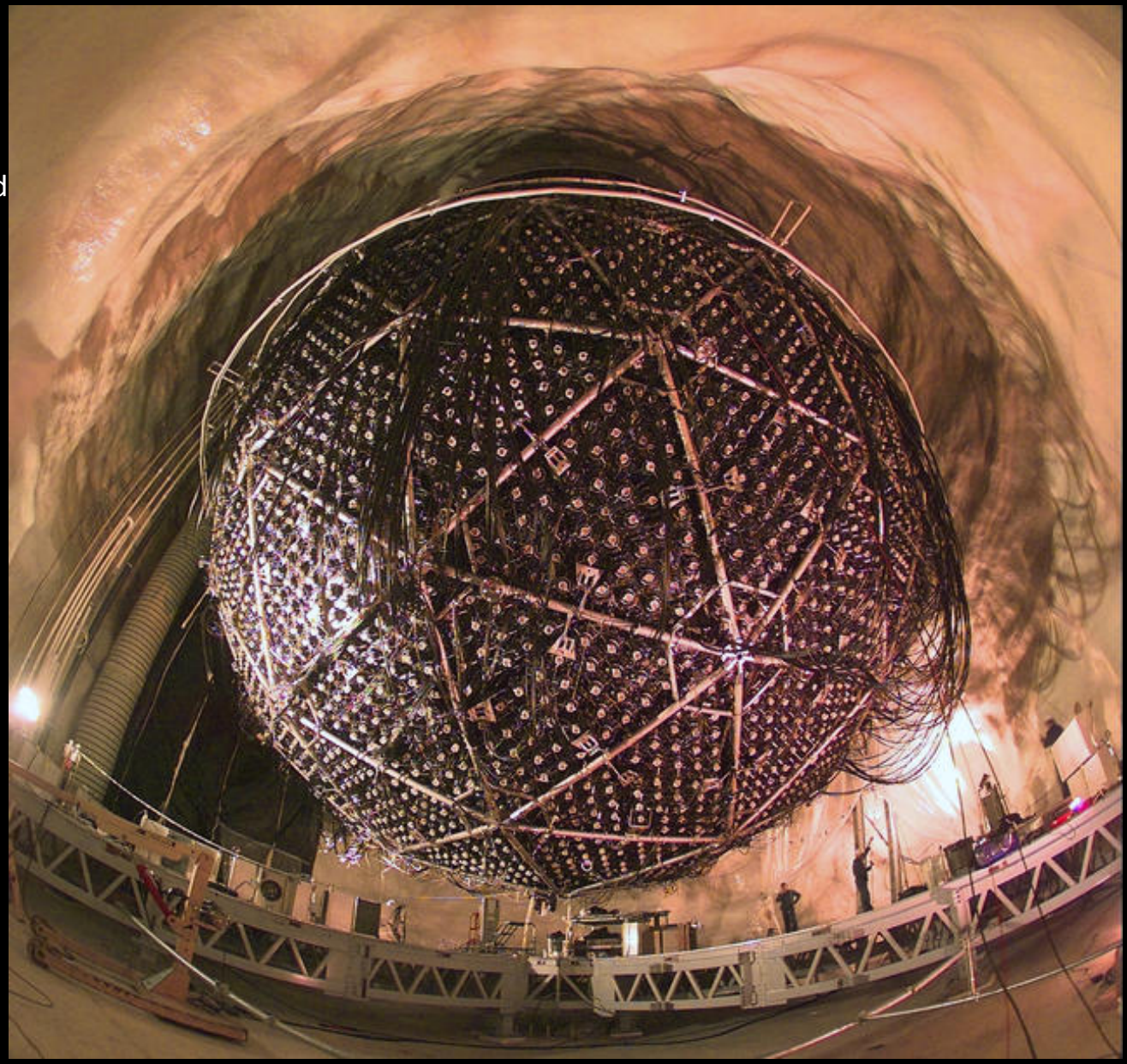


CERN

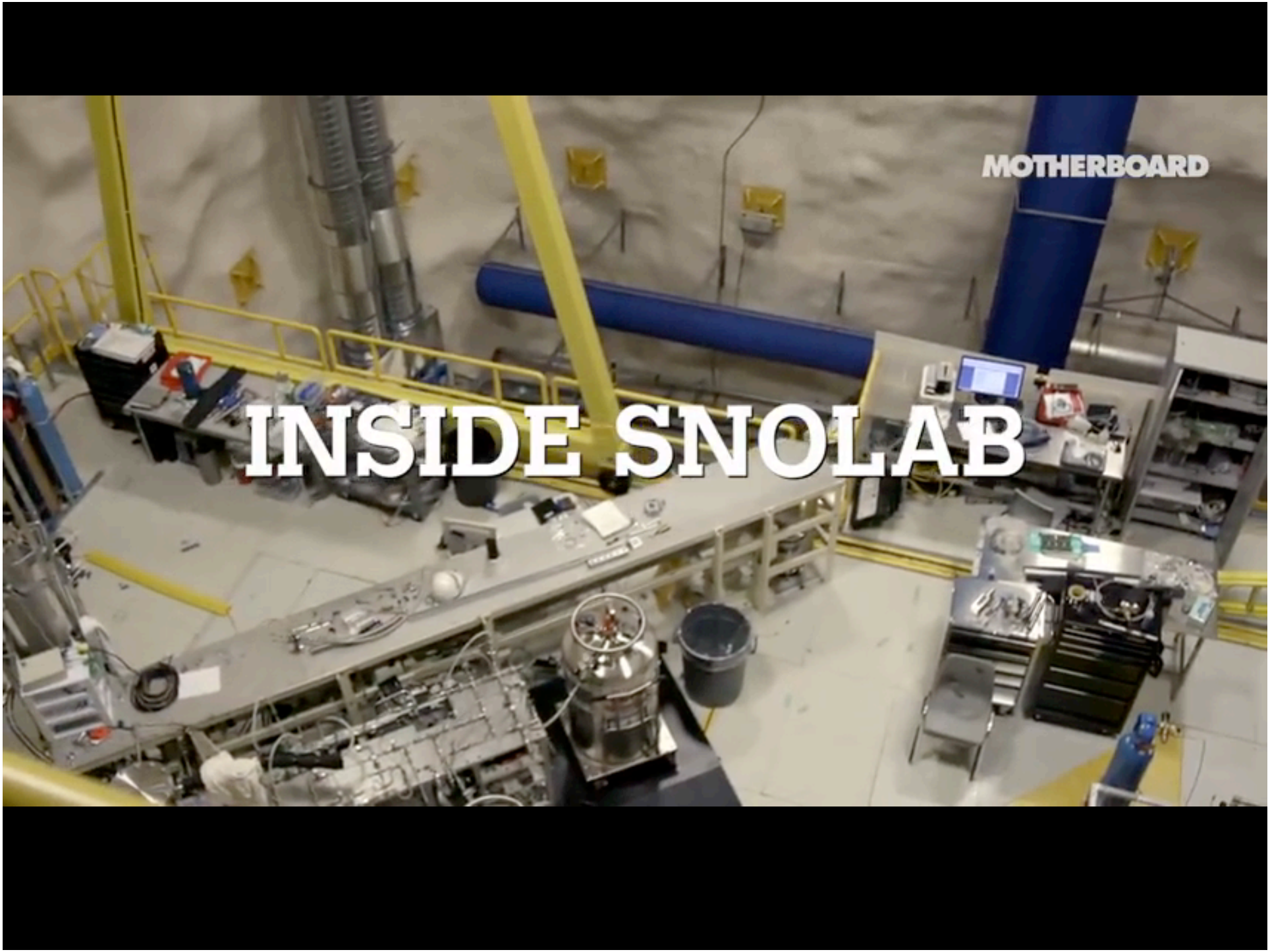


SNOLAB

- Sudbury, Ontario
- 2 kilometres below ground

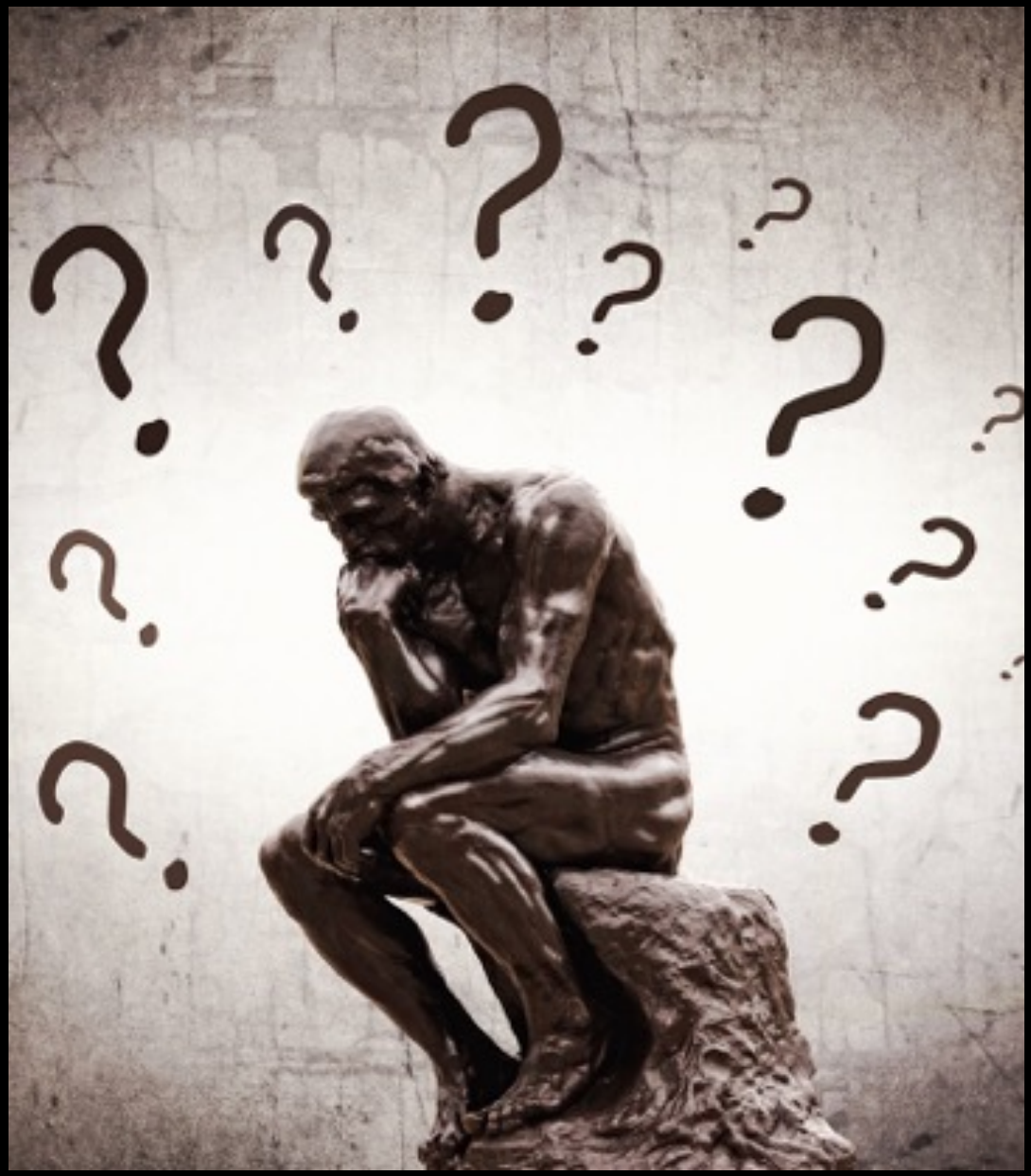


SNOLAB


MOTHERBOARD
INSIDE SNOLAB

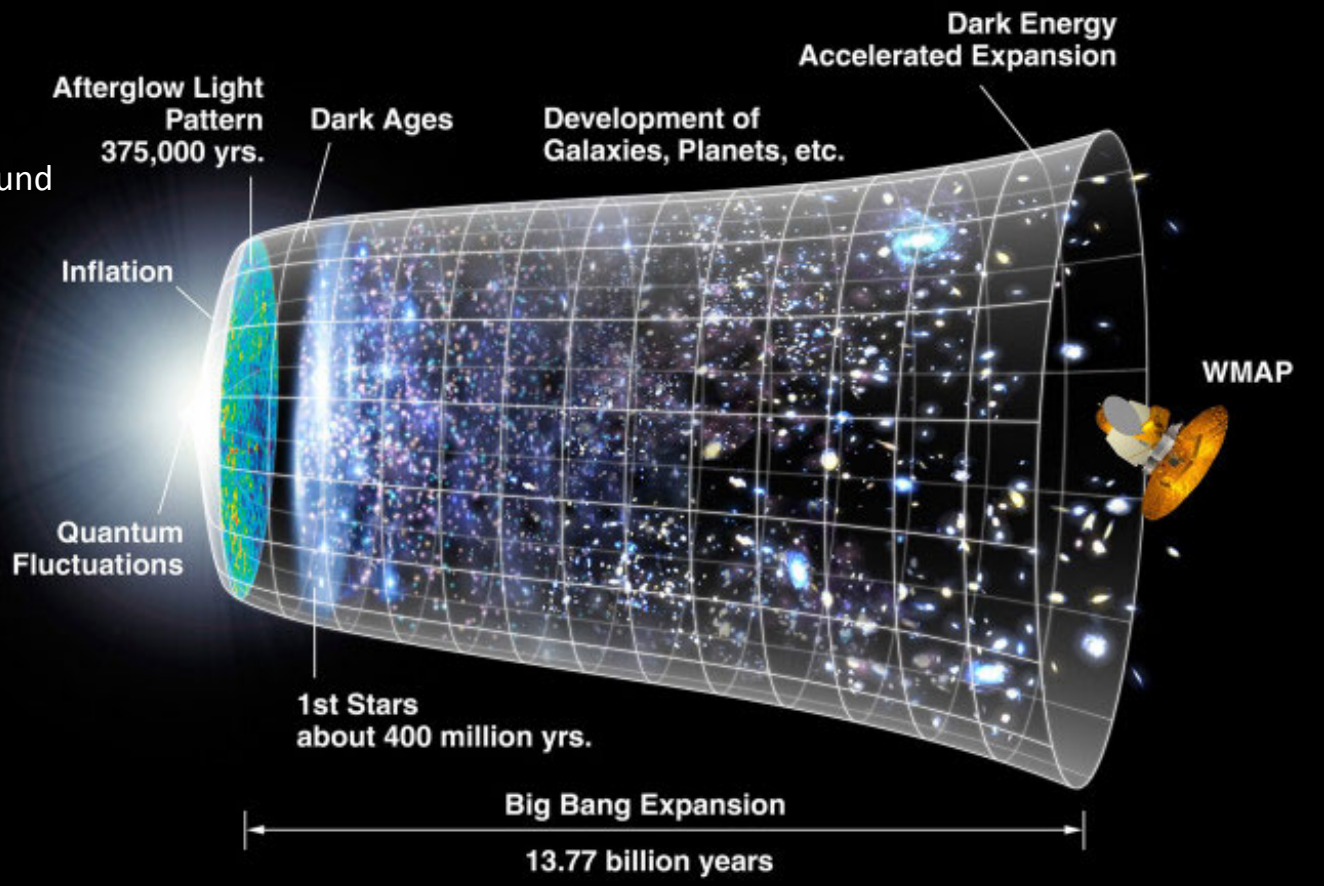
Dark Matter Candidates

- 26 %
- AXIONS
- WIMP (Weakly Interacting Massive Particle)
- MACHO (Massive Astrophysical Compact Halo Object)
- Kaluza-Klein particle
- Gravitino



The Standard Model

- Big Bang
- Hubble Constant
- Cosmological Constant
- WMAP
- Cosmic Microwave Background (CMB)



WMAP Collaboration

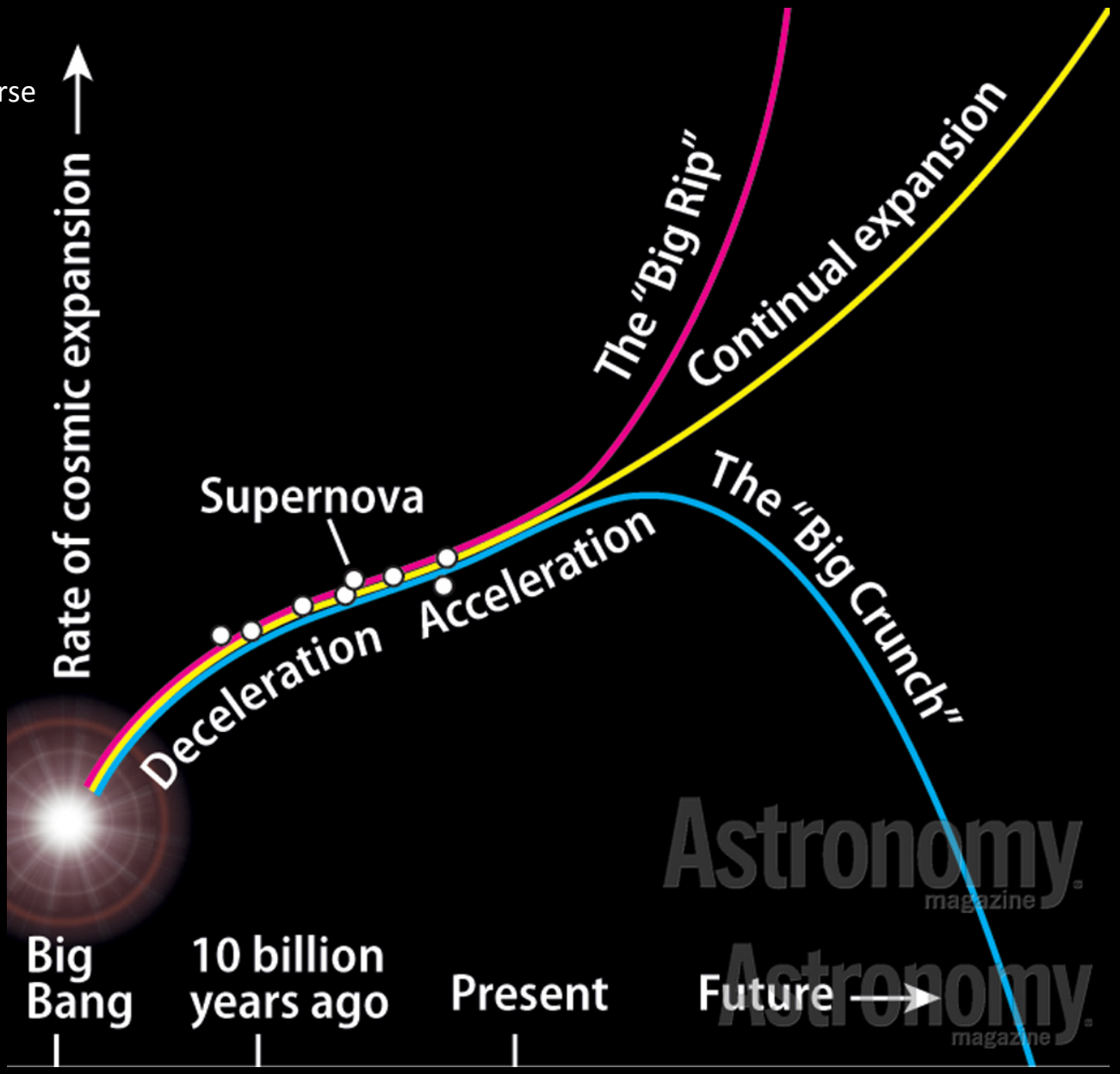
Dark Energy Discovery

- Type 1a supernovae observations
- Saul Perlmutter, Adam Riess & Brian Schmidt
- 69 %

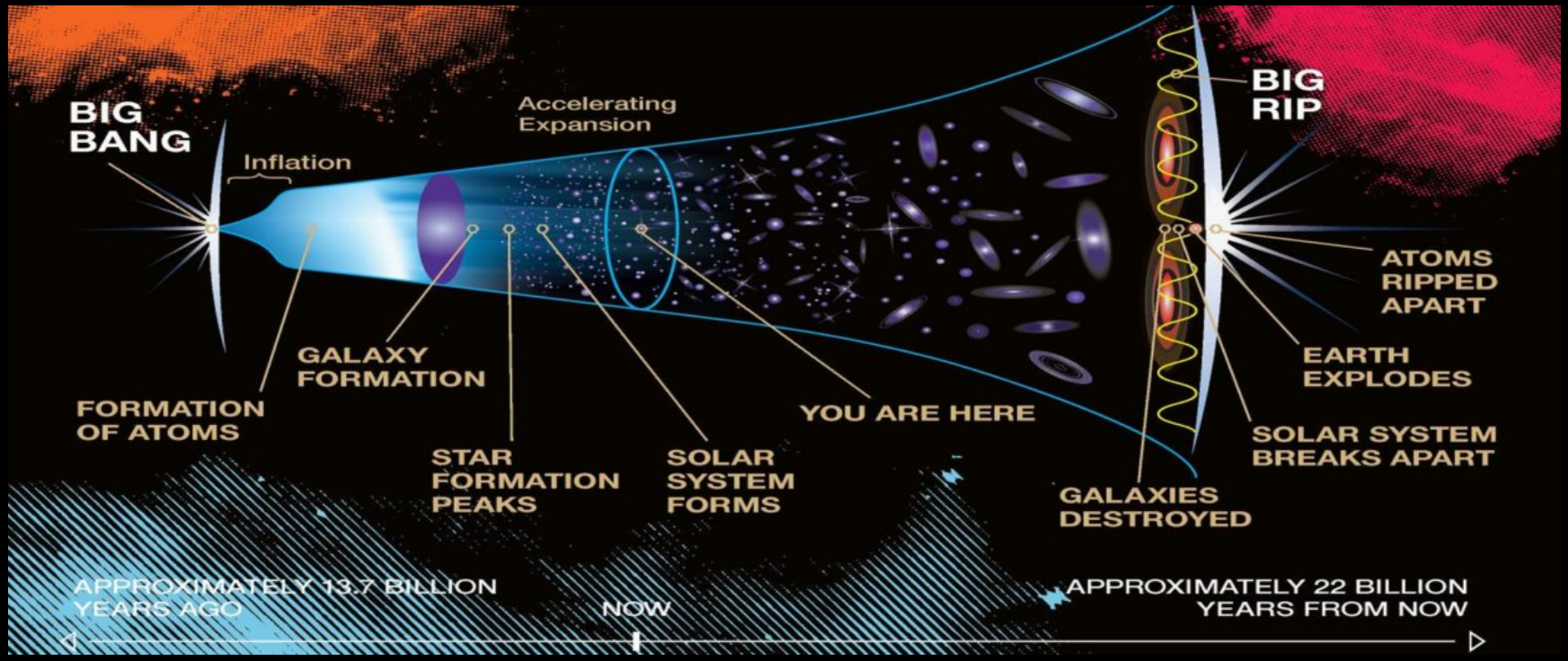
Brett Hardy

Fate of the Universe

- Matter density of the Universe
- 5 scenarios

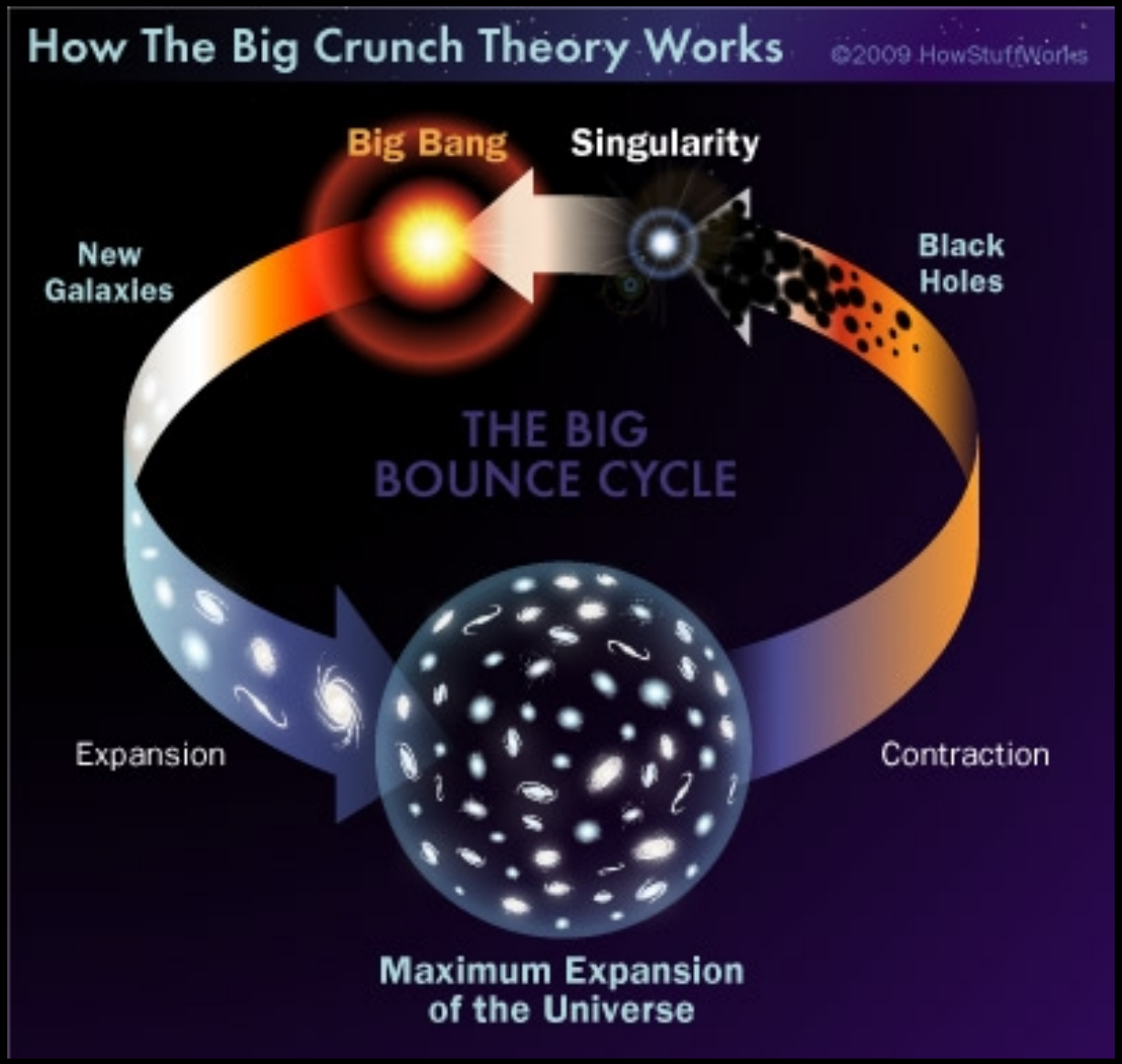


Big Rip



Jeremy Teaford

Big Crunch


How The Big Crunch Theory Works
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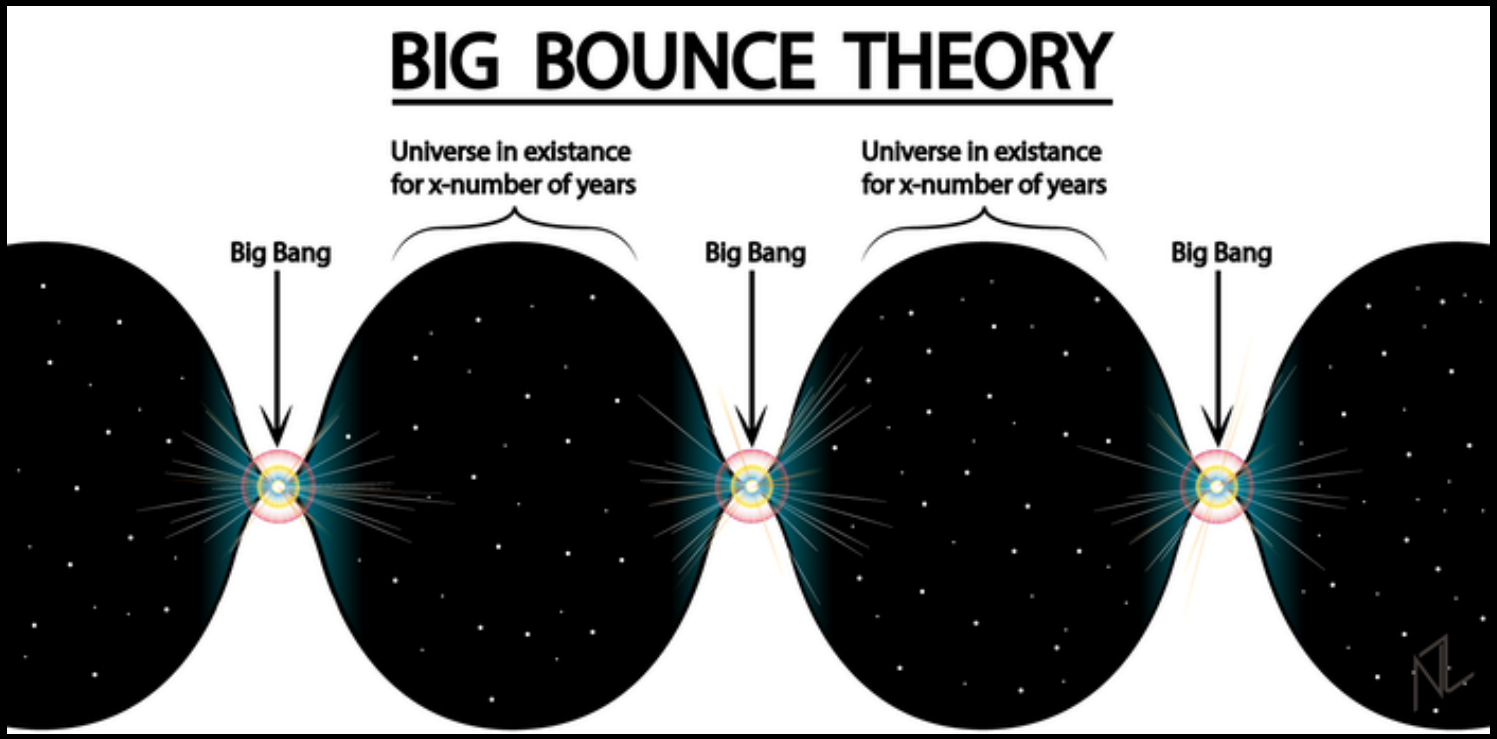
Big Bang
Singularity
New Galaxies
Black Holes
THE BIG BOUNCE CYCLE
Expansion
Contraction
Maximum Expansion of the Universe

Big Bounce



Neng Thao

Vacuum Decay

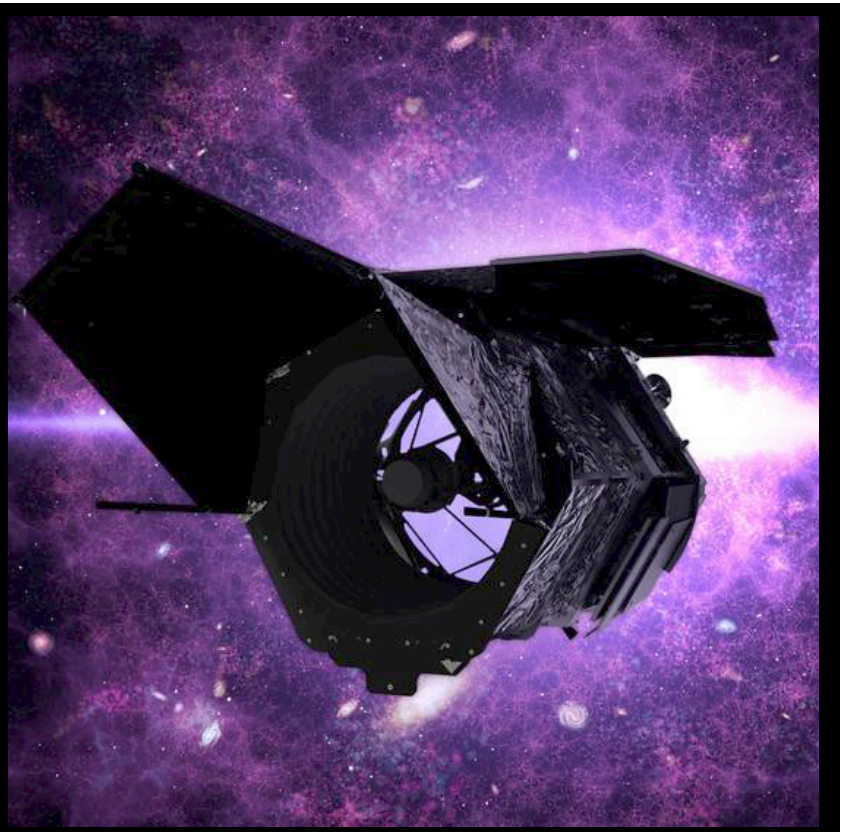
Monsterworks

Heat Death

- Currently most favoured

The Future

- Vera C. Rubin Telescope
- Nancy Grace Roman Space Telescope



Roman Space Telescope NASA

Vera C. Rubin Telescope NSF/AURA

Novice Astronomy Class # 26

Electronically Assisted Astronomy

November 1, 2024