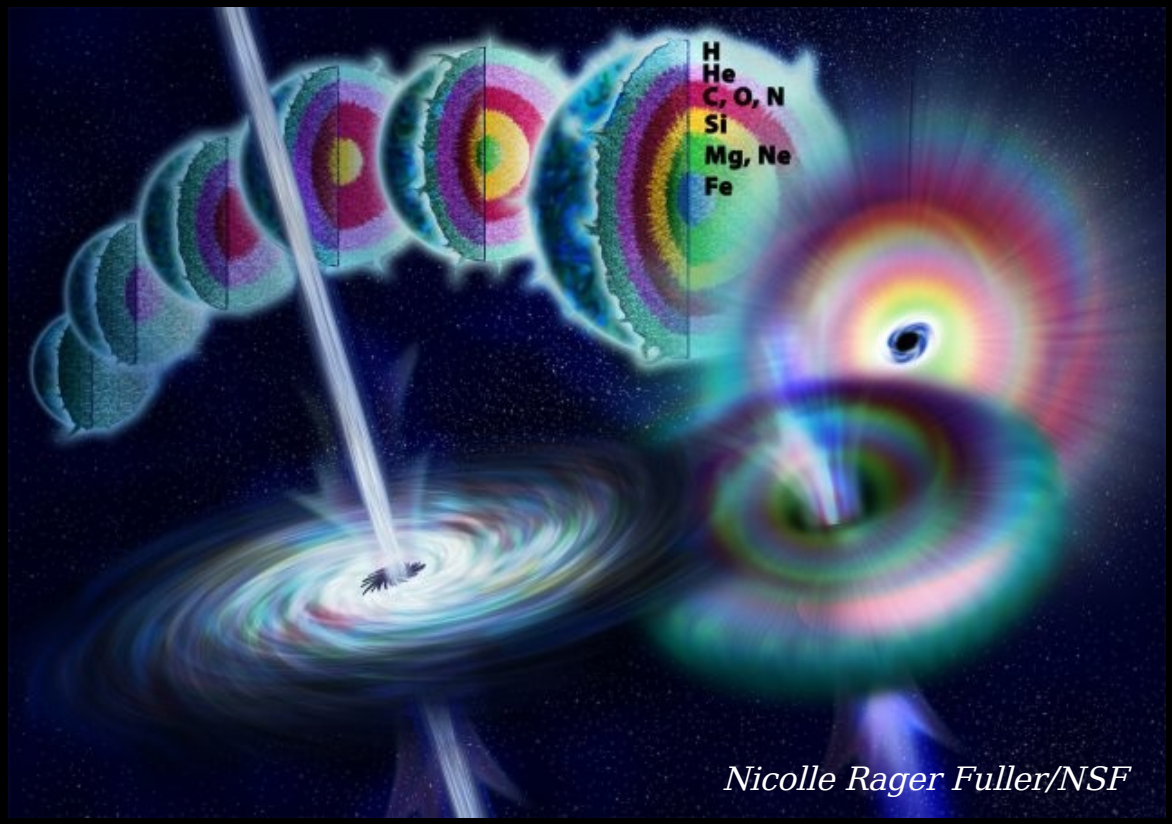
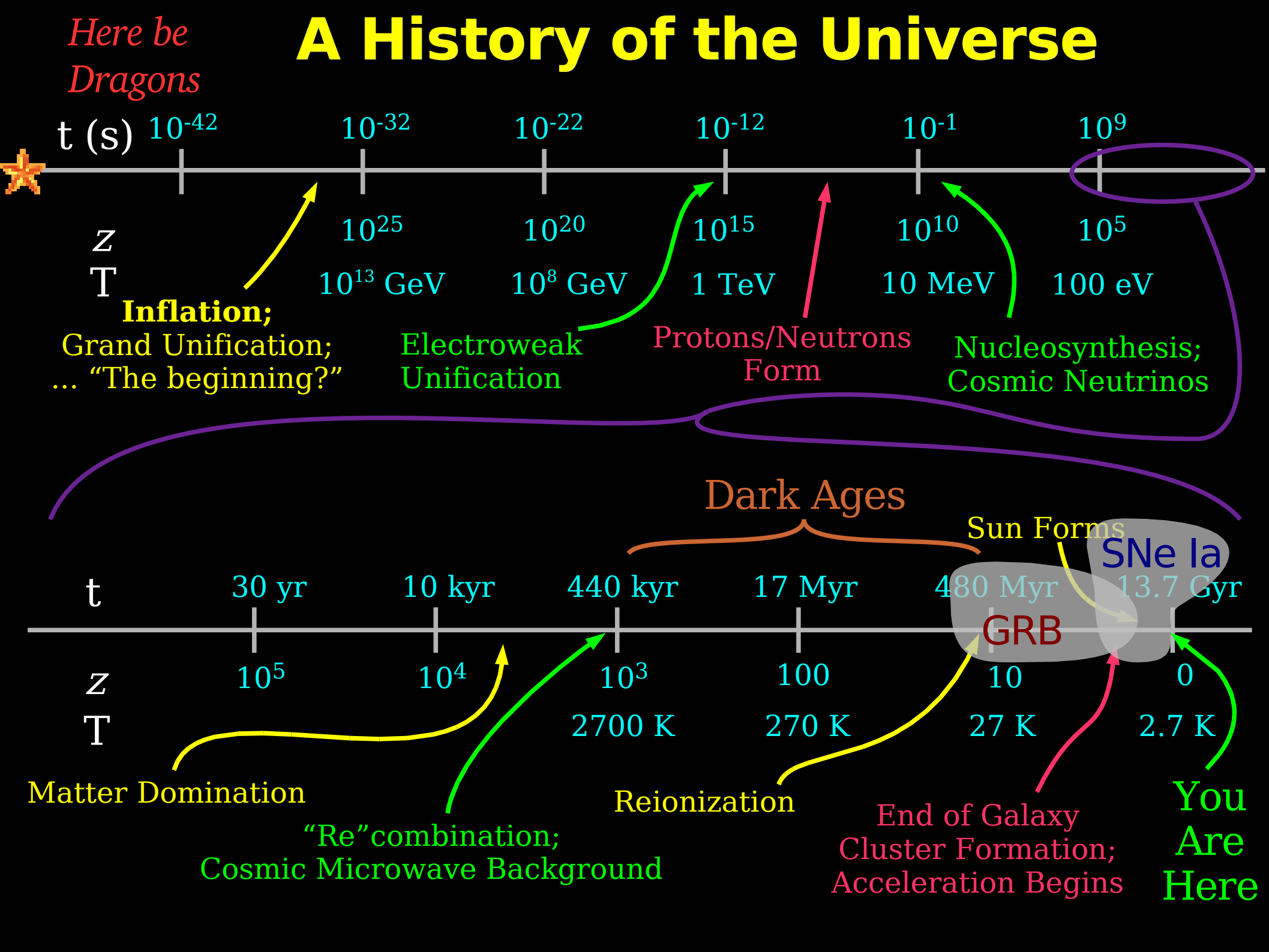
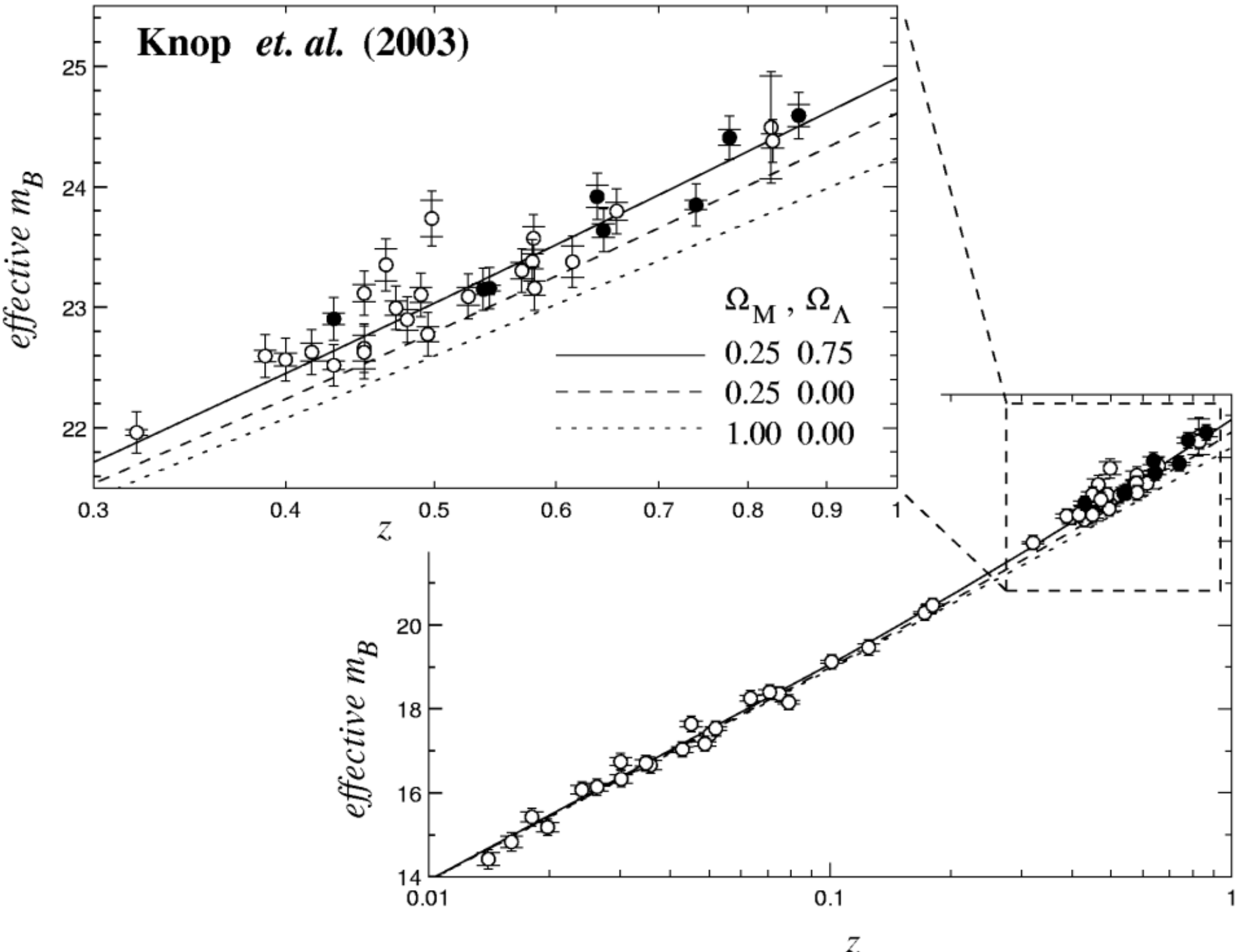
High Hopes for Gamma Ray Burster Cosmology

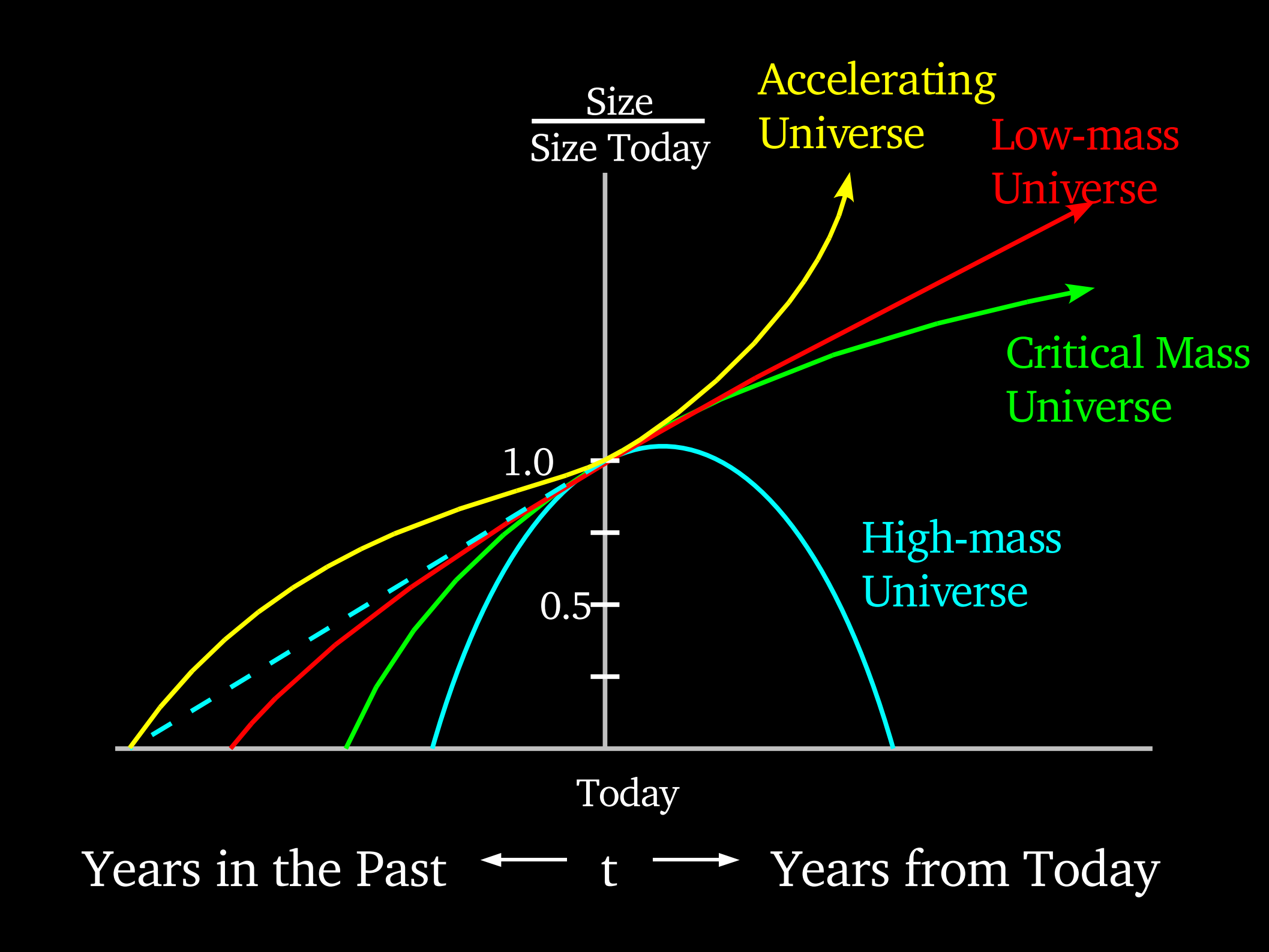


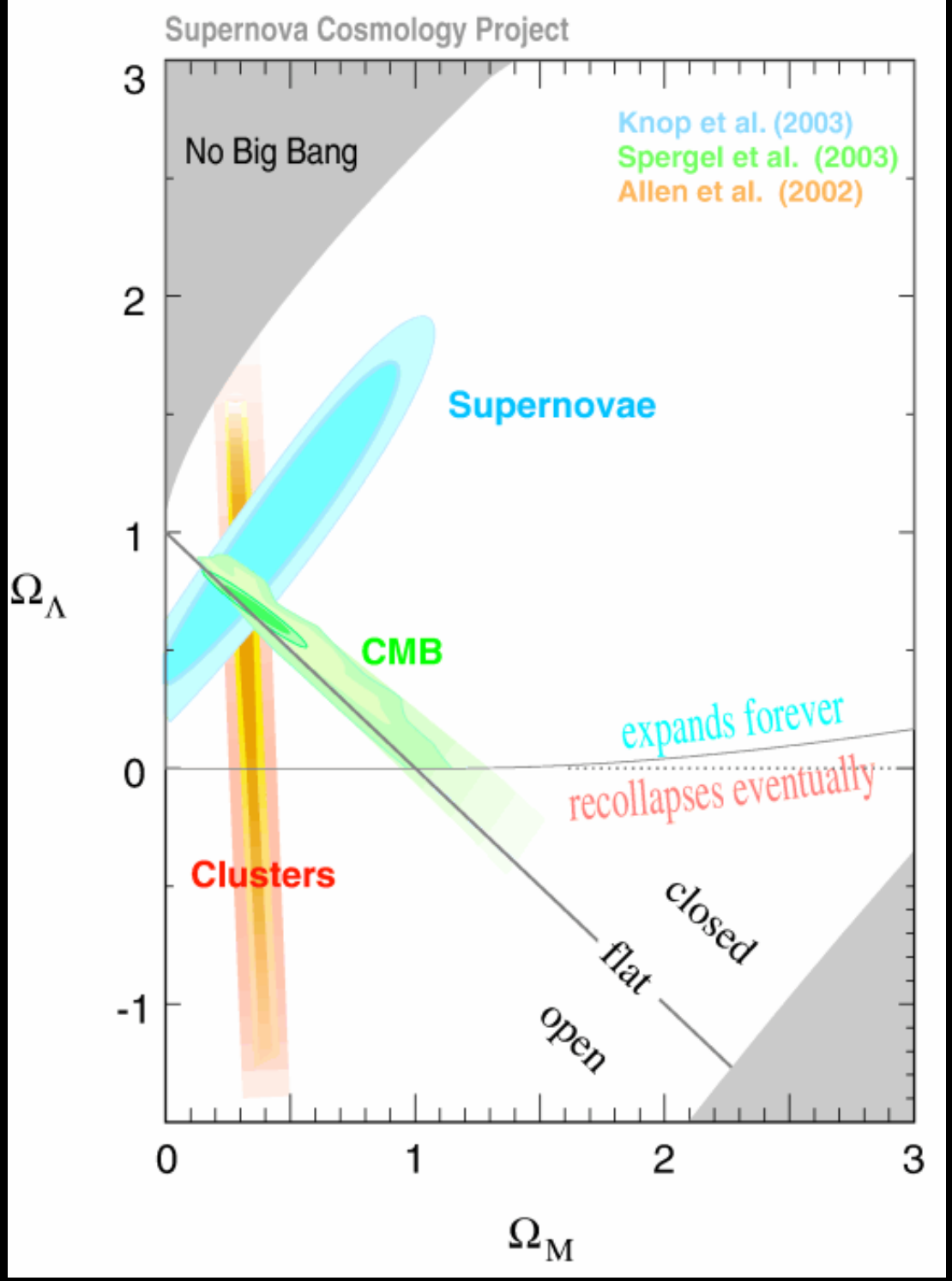
Rob Knop
Asst. Prof. of Physics and Astronomy
Vanderbilt University

VU Prize Awards Dinner
2006 June 29


Here be Dragons
A History of the Universe
t (s)
10-42
10-32
10-22
10-12
10-1
109
z
T
1025
1013 GeV
1020
108 GeV
1015
1 TeV
1010
10 MeV
105
100 eV
Inflation;
Grand Unification;
... "The beginning?"
Electroweak Unification
Protons/Neutrons Form
Nucleosynthesis; Cosmic Neutrinos
Dark Ages
Sun Forms
SNe Ia
t
30 yr
10 kyr
440 kyr
17 Myr
480 Myr
13.7 Gyr
GRB
z
T
105
104
103
2700 K
100
270 K
10
27 K
0
2.7 K
Matter Domination
"Re"combination; Cosmic Microwave Background
Reionization
End of Galaxy Cluster Formation; Acceleration Begins
You Are Here

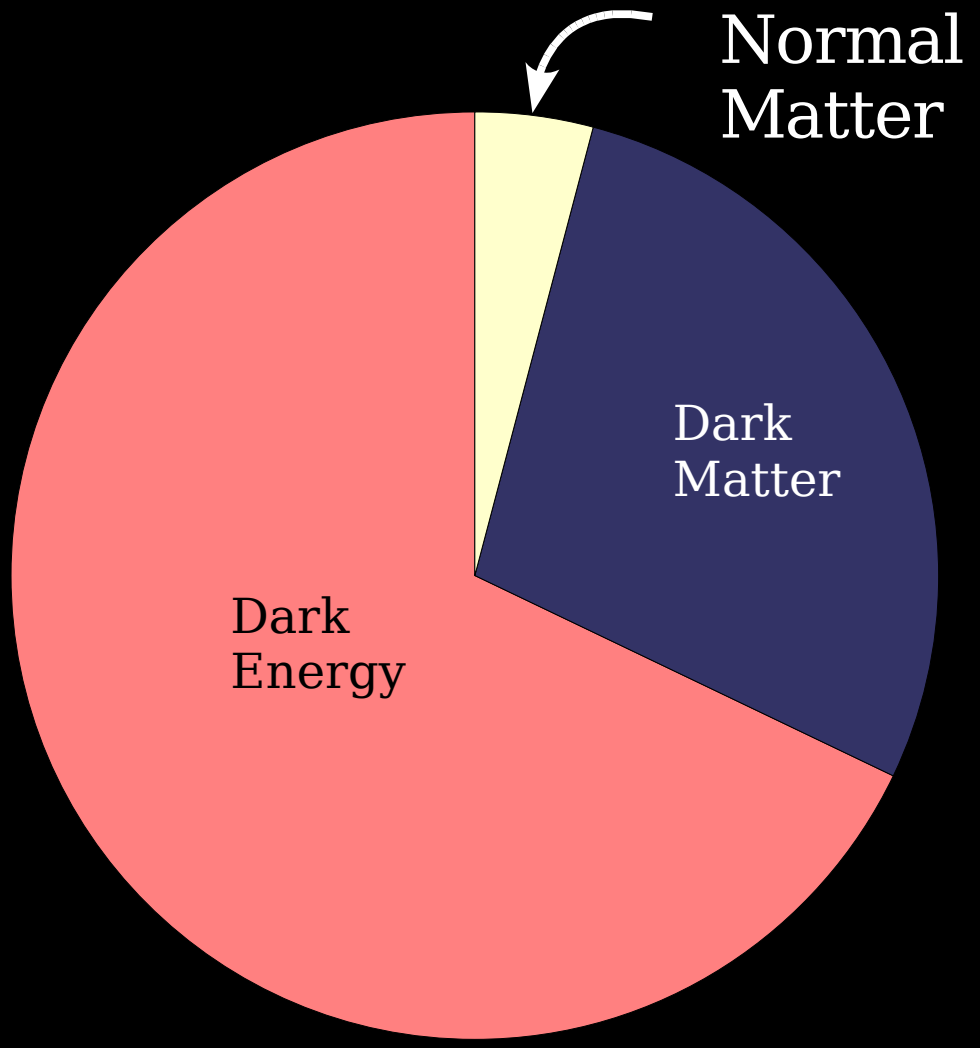

Knop et. al. (2003)
effective m_B
z
Ω_M , Ω_Λ
0.25 0.75
0.25 0.00
1.00 0.00
25
24
23
22
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
20
18
16
14
0.01
0.1
1

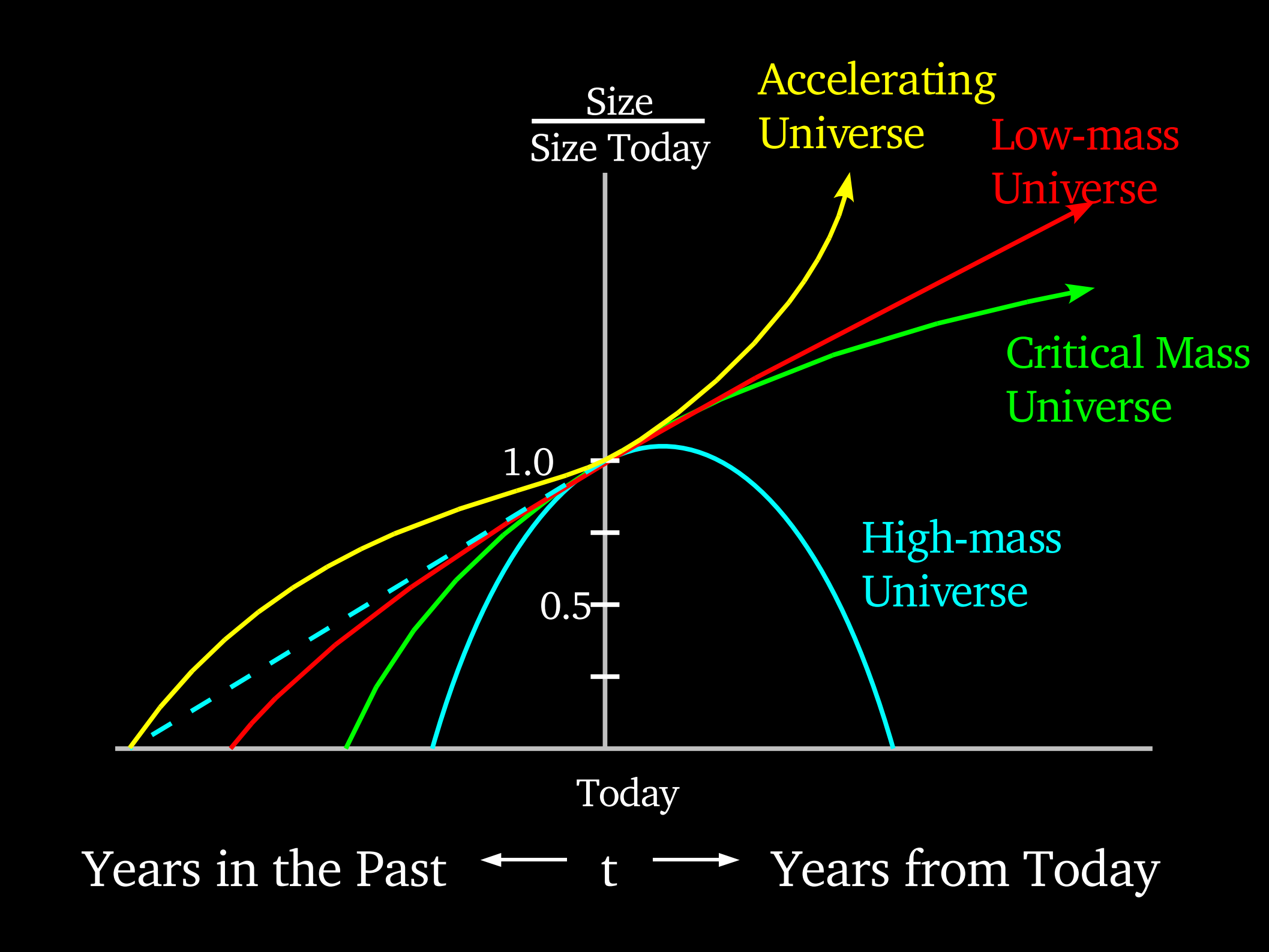

Size
Size Today
Accelerating
Universe
Low-mass
Universe
Critical Mass
Universe
High-mass
Universe
1.0
0.5
Today
Years in the Past
t
Years from Today


Supernova Cosmology Project
No Big Bang
Knop et al. (2003)
Spergel et al. (2003)
Allen et al. (2002)
Supernovae
CMB
Clusters
expands forever
recollapses eventually
closed
flat
open
3
2
1
0
-1
0
1
2
3
Ω_Λ
Ω_M

A Consistent Picture of the Universe

- 13.7 Billion Years Old
- Flat (Euclidean) Spatial Geometry
- Critical Mass+Energy Density
- Expansion Accelerating




Size
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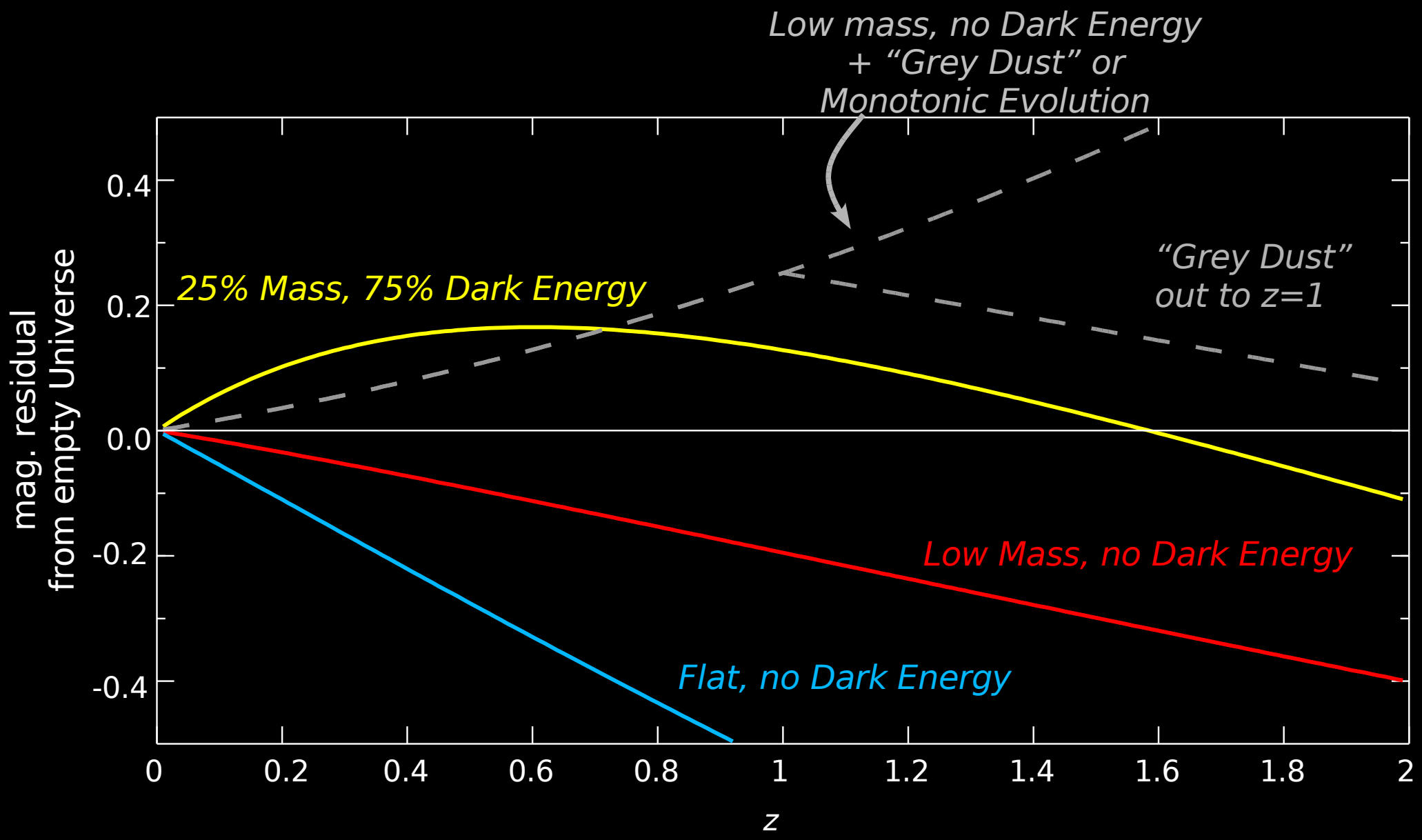
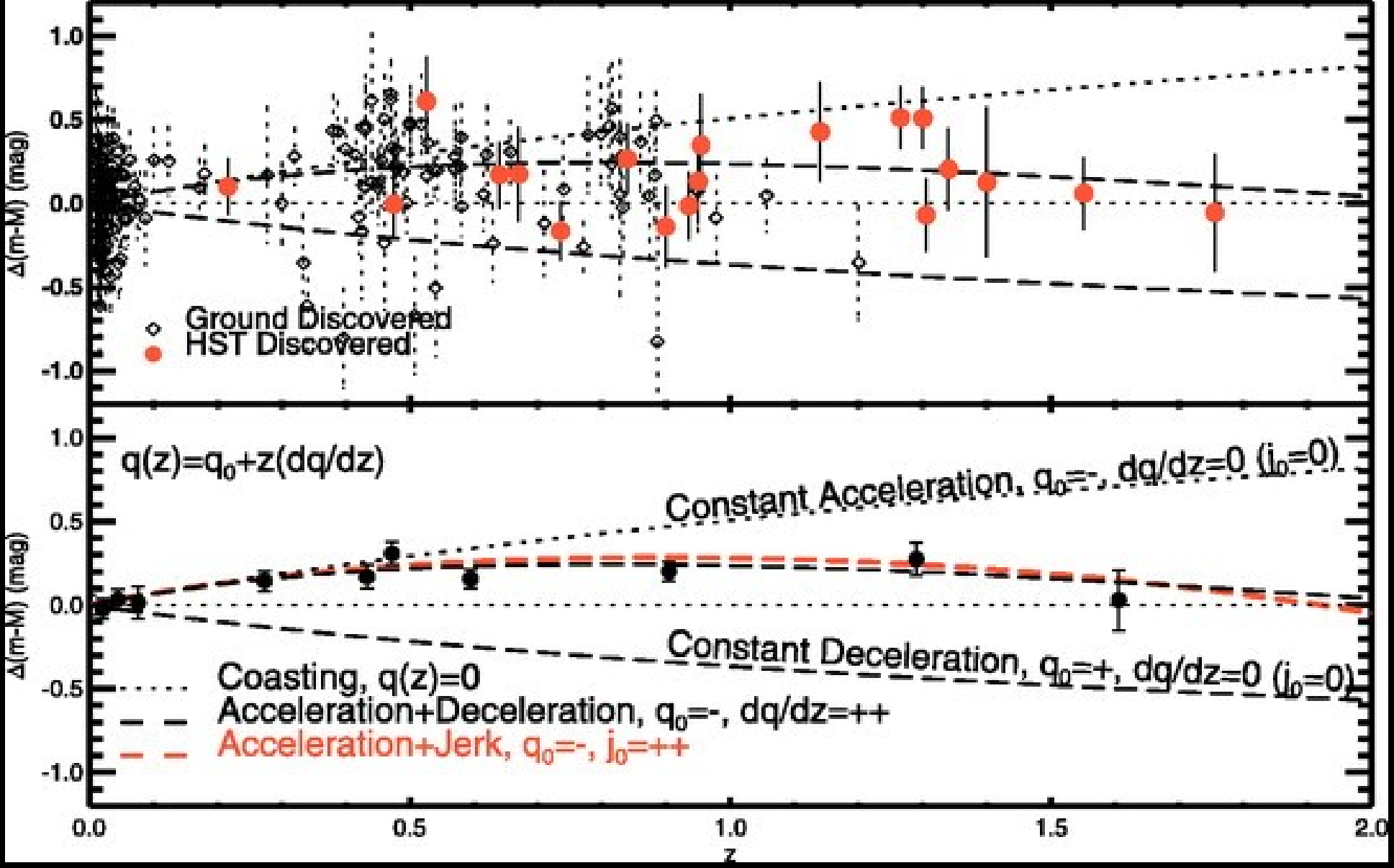
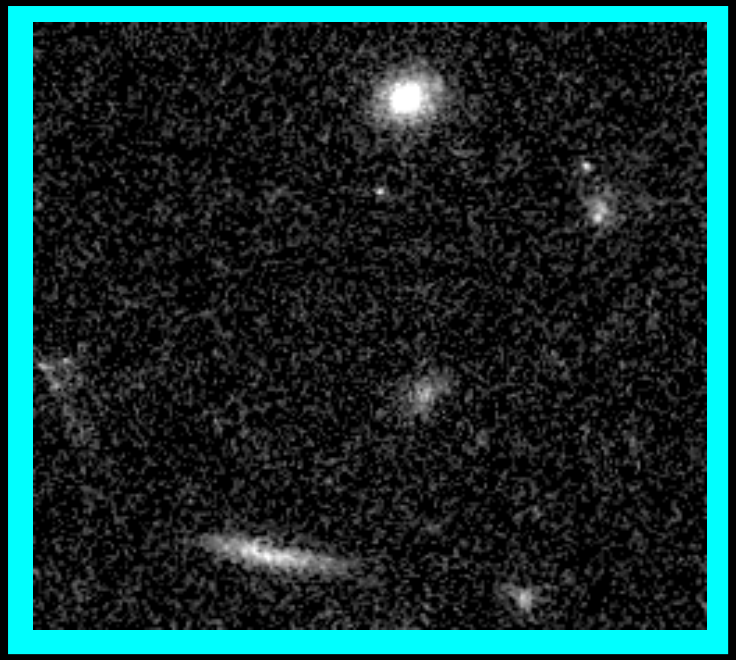
1.0
0.5
Today
Years in the Past
t
Years from Today

Going out to extremely high redshift allows us to explore the “era of deceleration”.





Riess et al., 2004, ApJ, 607, 665



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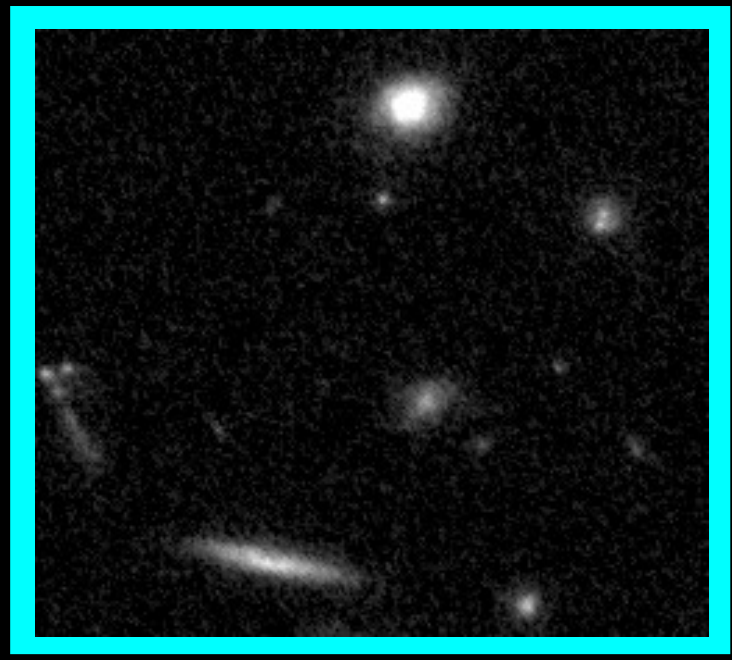

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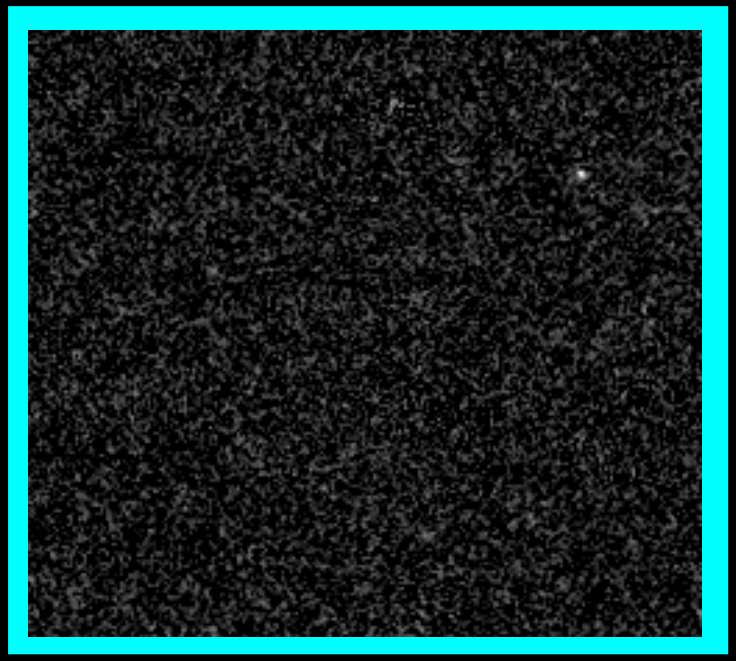

SN “Mingus”

at z=1.7
(photometric z)

GRB 050904 at z=6.39 (photometric)

Near IR
4.1m SOAR

Optical
0.4m PROMPT

Optical composite
3 days later
8m Gemini

Haislip et al., 2006

LETTERS

A photometric redshift of $z = 6.39 \pm 0.12$ for GRB 050904

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Gamma-ray bursts (GRBs) and their afterglows are the most brilliant transient events in the Universe. Both the bursts themselves and their afterglows have been predicted to be visible out to redshifts of $z \approx 20$, and therefore to be powerful probes of the early Universe[1,2]. The burst GRB 000131, at $z = 4.50$, was hitherto the most distant such event identified[3]. Here we report the discovery of the bright near-infrared afterglow of GRB 050904 (ref. 4). From our measurements of the near-infrared afterglow, and our failure to detect the optical afterglow, we determine the photometric redshift of the burst to be $z = 6.39^{+0.11}_{-0.12}$ (refs 5–7). Subsequently, it was measured[8] spectroscopically to be $z = 6.29 \pm 0.01$, in agreement with our photometric estimate. These results demonstrate that GRBs can be used to trace the star formation, metallicity, and reionization histories of the early Universe.

At 01:51:44 Universal Time (UT) on 4 September 2005, Swift's Burst Alert Telescope (BAT) detected GRB 050904 and 81 seconds later a 4′-radius localization was distributed to observers on the ground. Swift's X-Ray Telescope (XRT) automatically slewed to the BAT localization and 76 minutes after the burst a 6′-radius XRT localization was distributed.[9]

Over the next few hours, we observed the XRT localization at both

GRB Cosmology?

- GRBs probe a redshift range that is otherwise only probed by Quasars.
- GRBs fade away, so we can see what else is there. Quasars continue to glare.
- Can GRBs be calibrated for use as a distance indicator? If so, they can extend the Hubble diagram far past the Supernova range!!
- Some GRBs come from supernovae. Do we have a hope of sometime soon watching the deaths of the first stars, and probing the epoch of reionization?
- The future's so bright, I gotta have a redshift to protect my eyes.