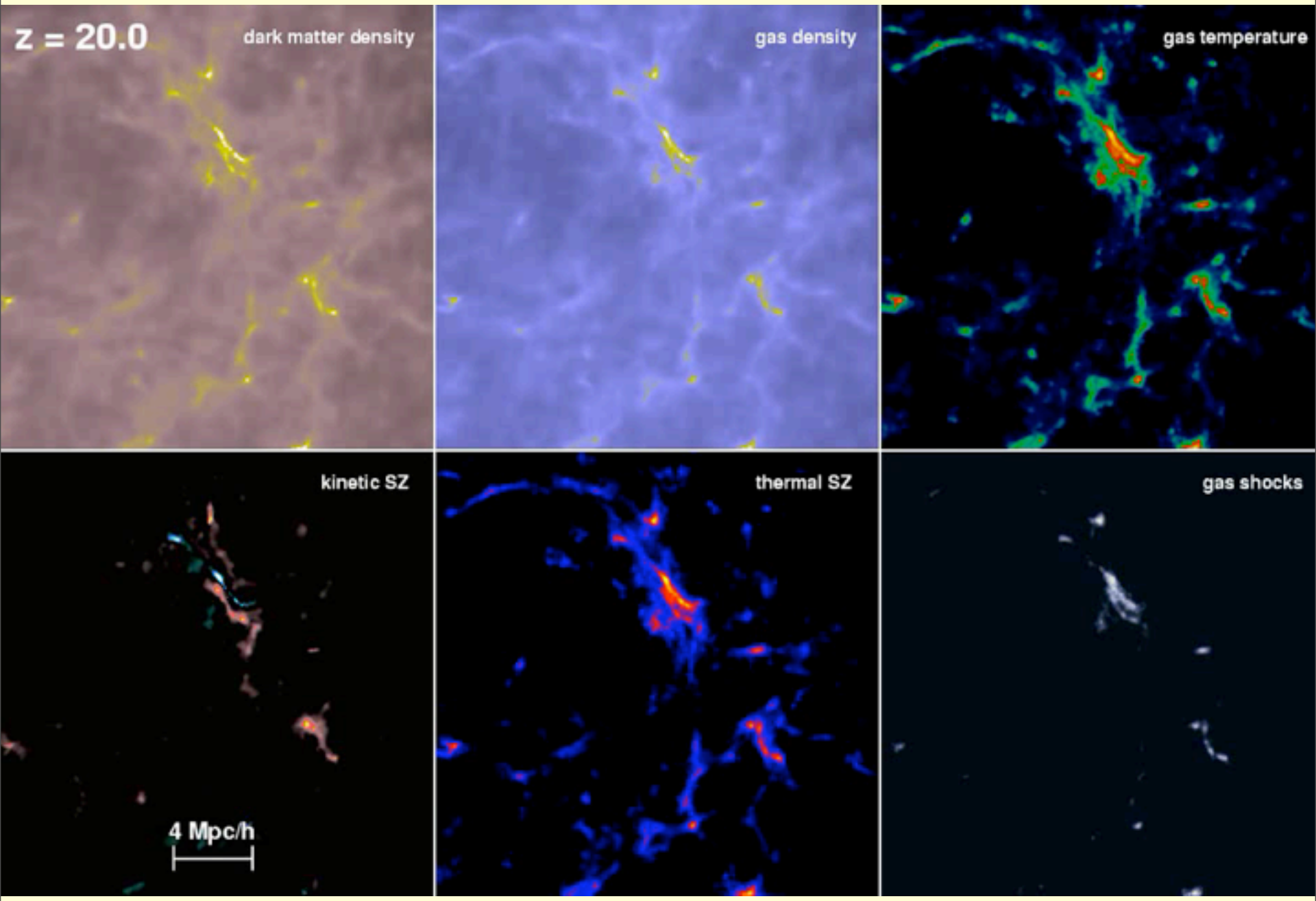
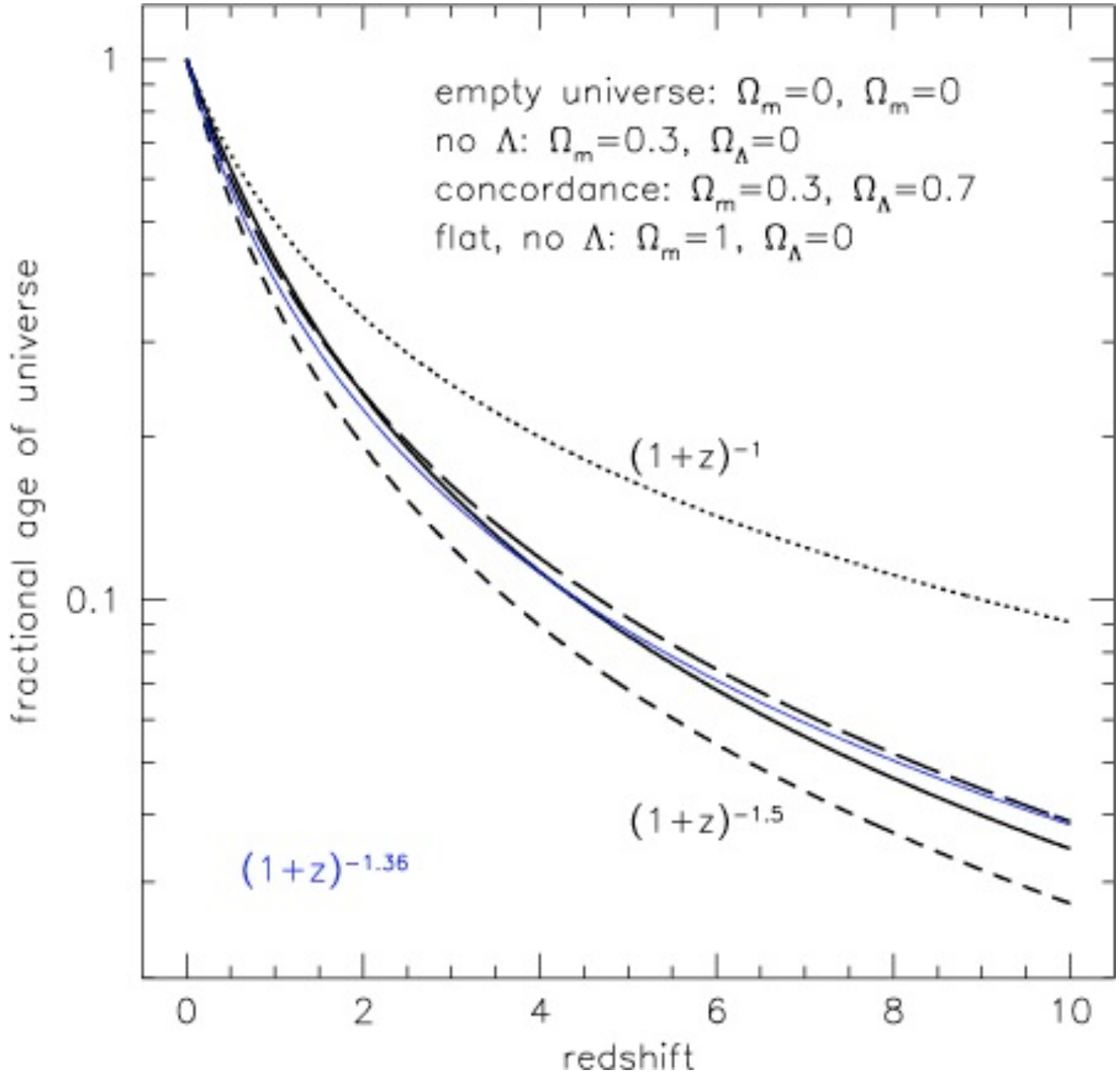
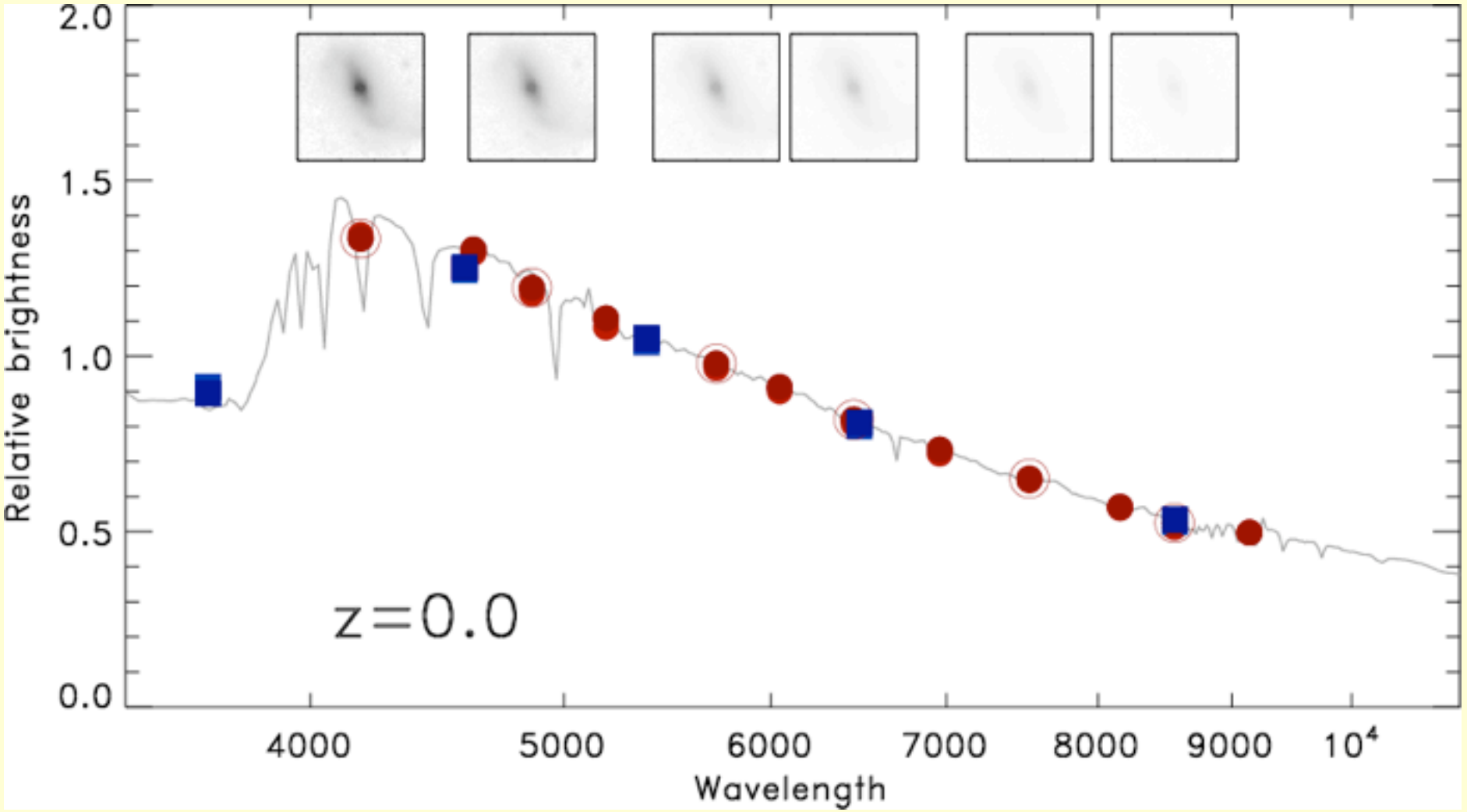

ASTR 220
Nov 29 2010

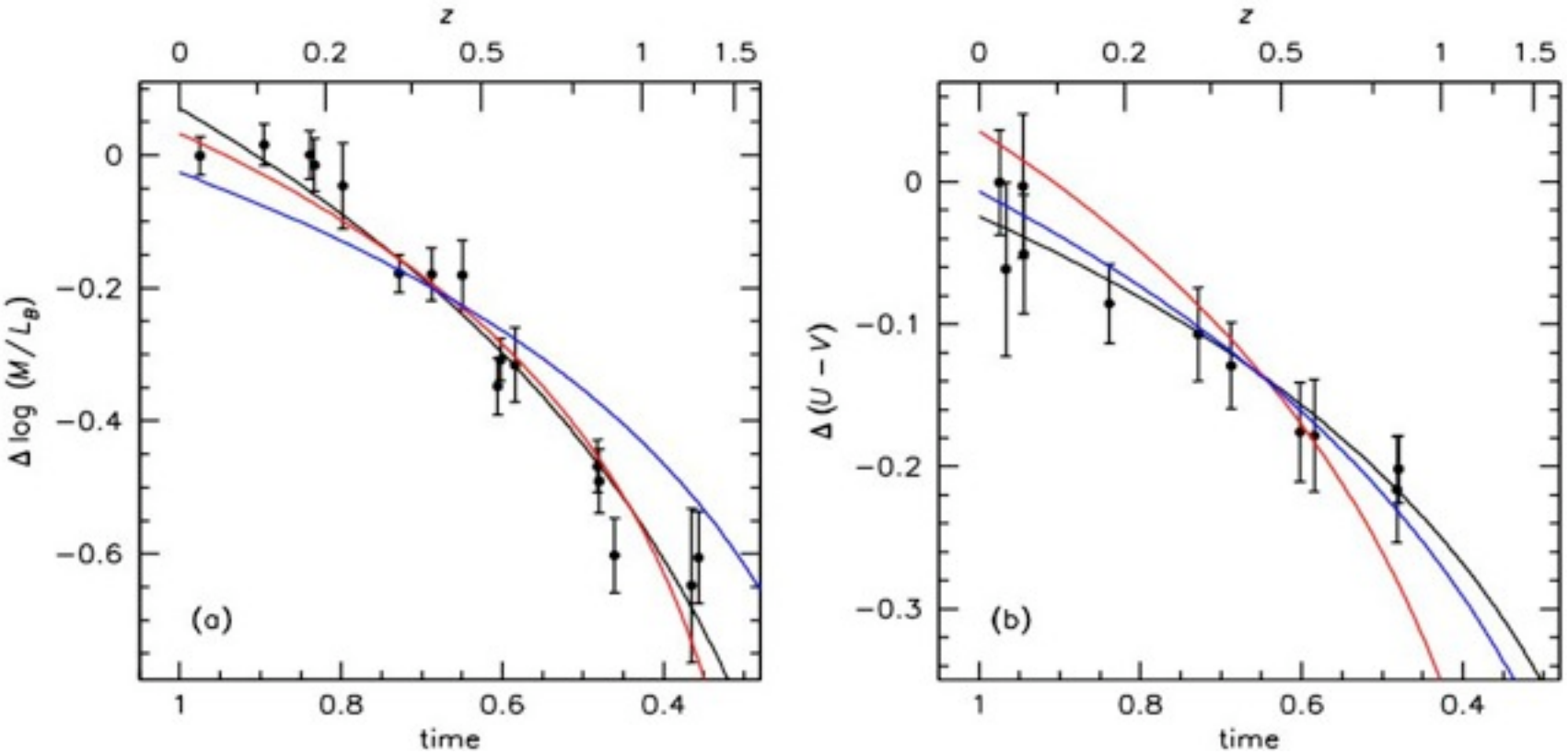

z = 20.0
dark matter density
gas density
gas temperature
kinetic SZ
thermal SZ
gas shocks
4 Mpc/h


empty universe: Ω_m=0, Ω_m=0
no Λ: Ω_m=0.3, Ω_Λ=0
concordance: Ω_m=0.3, Ω_Λ=0.7
flat, no Λ: Ω_m=1, Ω_Λ=0
$(1+z)^{-1}$
$(1+z)^{-1.5}$
$(1+z)^{-1.36}$
fractional age of universe
redshift
1
0.1
0
2
4
6
8
10

Galaxy Cluster Abell 2218 **HST • WFPC2**

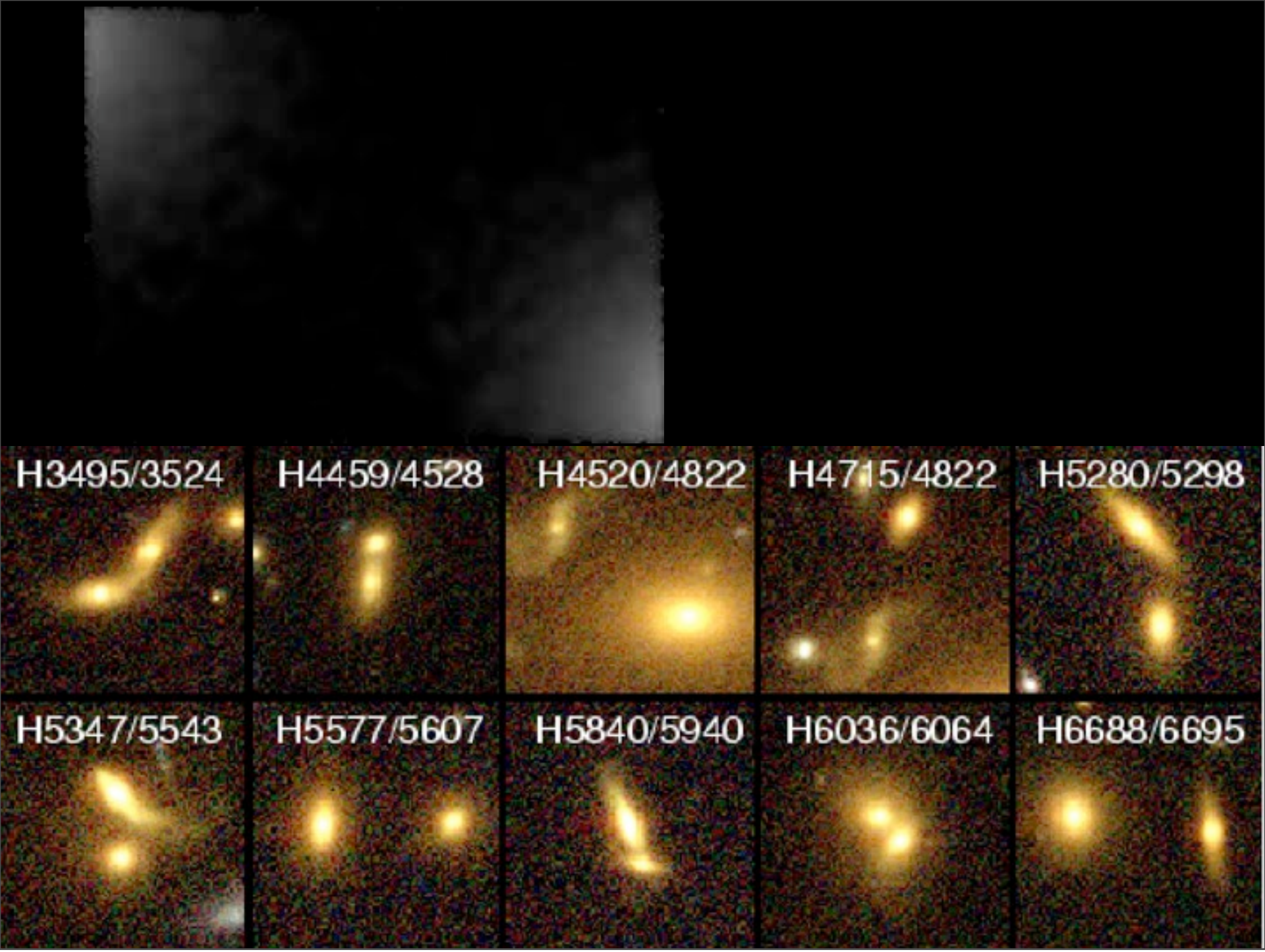
NASA, A. Fruchter and the ERO Team (STScI) • STScI-PRC00-08


2.0
1.5
1.0
0.5
0.0
Relative brightness
z=0.0
4000
5000
6000
7000
8000
9000
10⁴
Wavelength

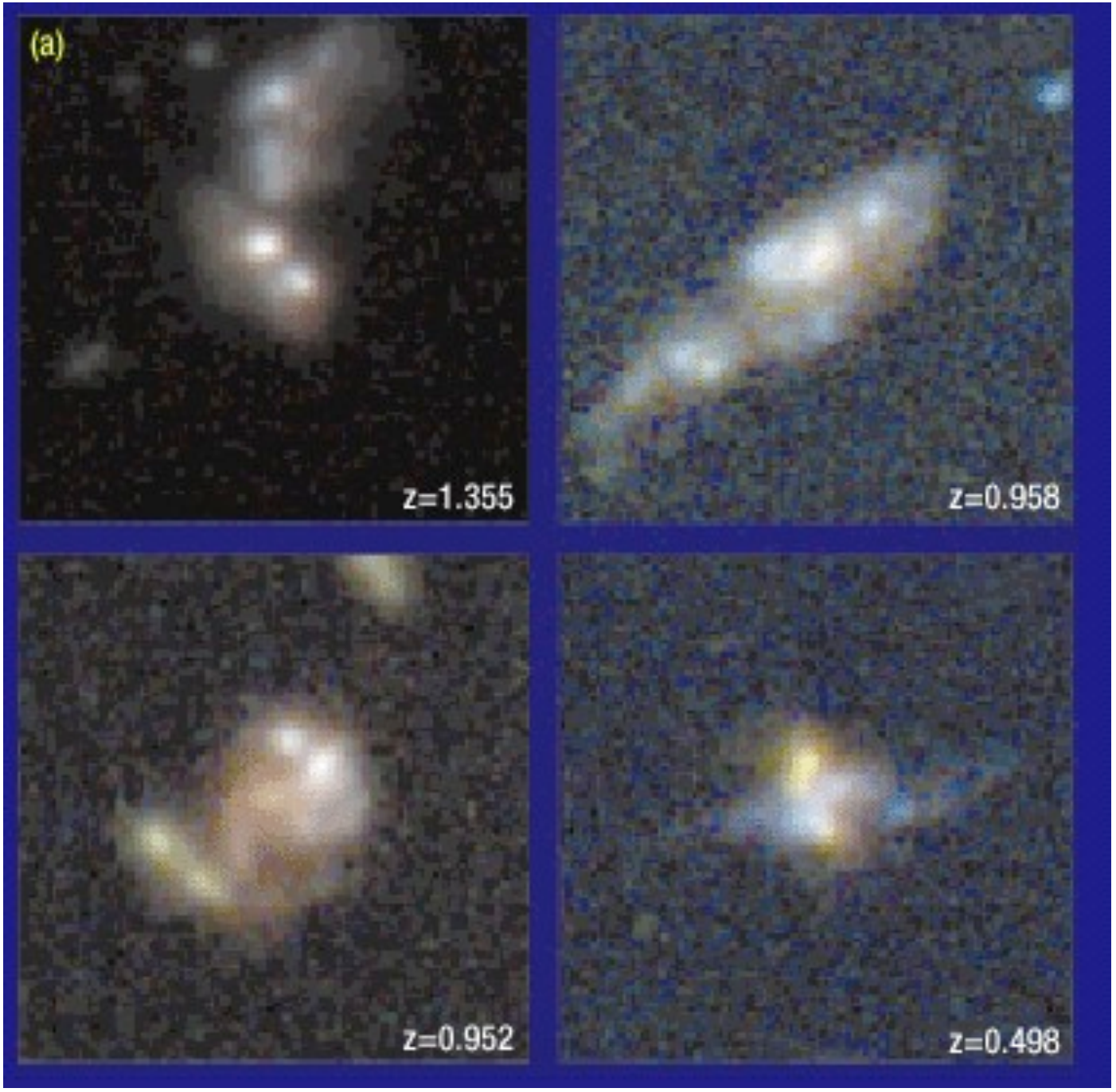


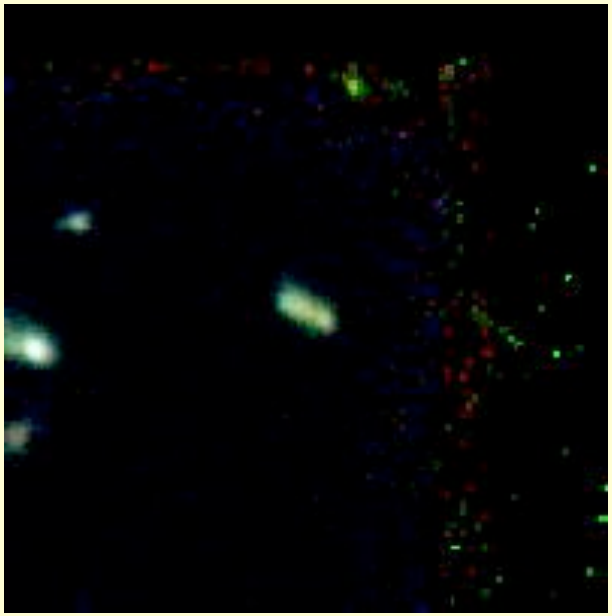
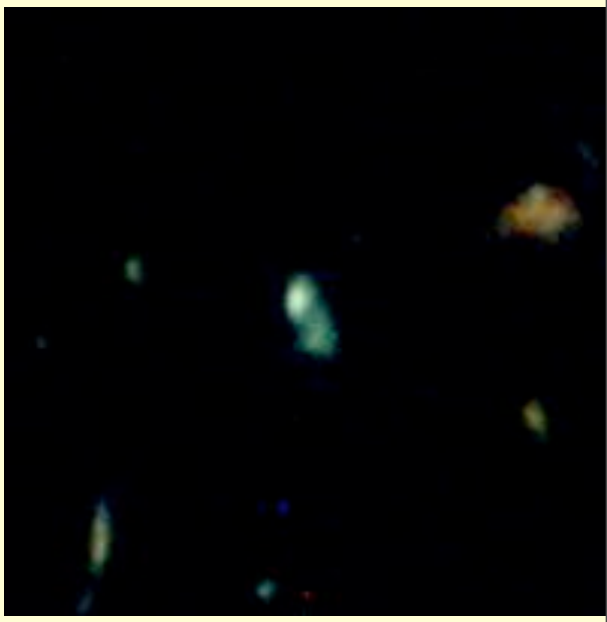
Elliptical galaxies were more luminous, and bluer, in the past: due to younger stellar populations

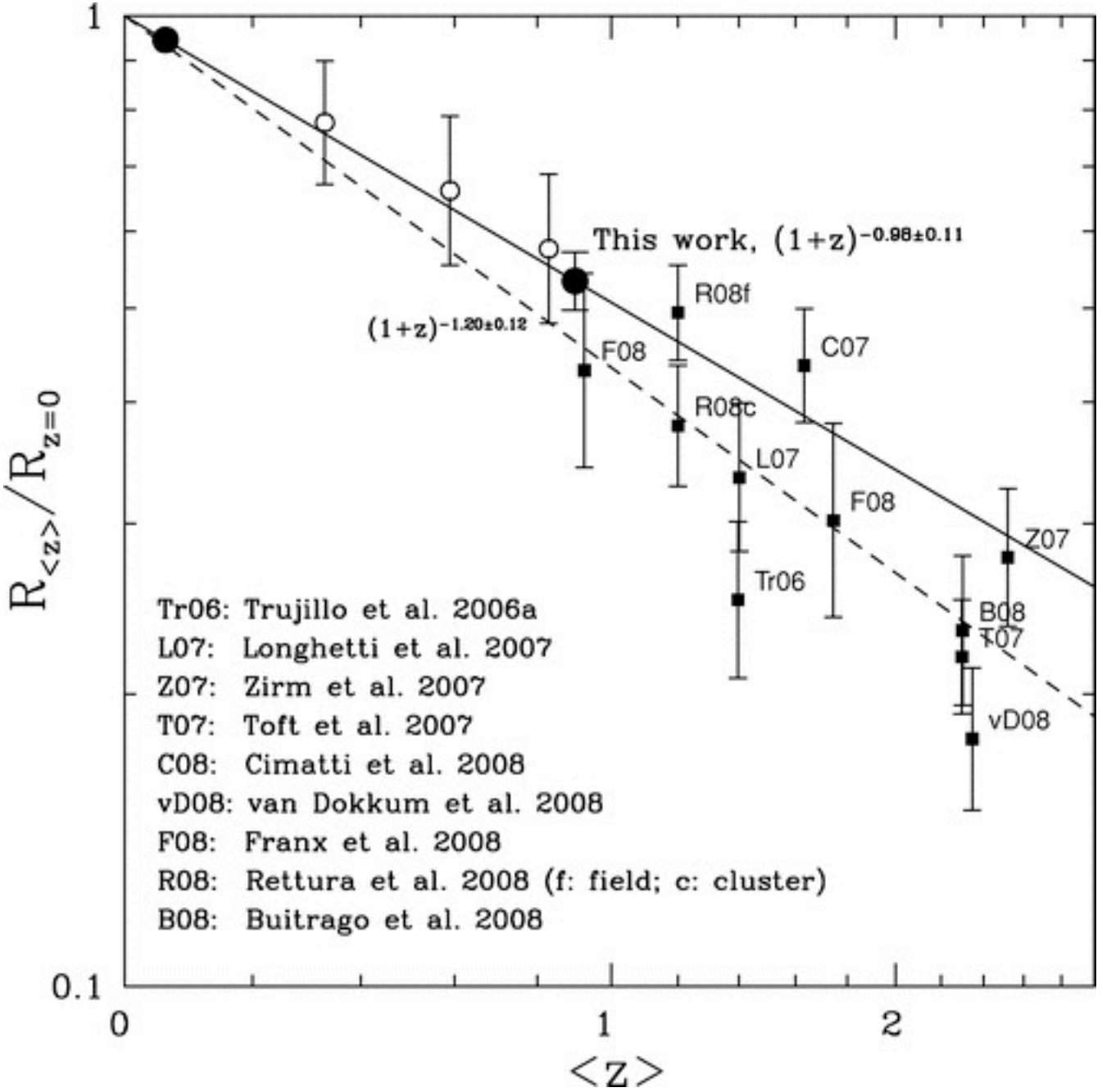

H3495/3524
H4459/4528
H4520/4822
H4715/4822
H5280/5298
H5347/5543
H5577/5607
H5840/5940
H6036/6064
H6688/6695

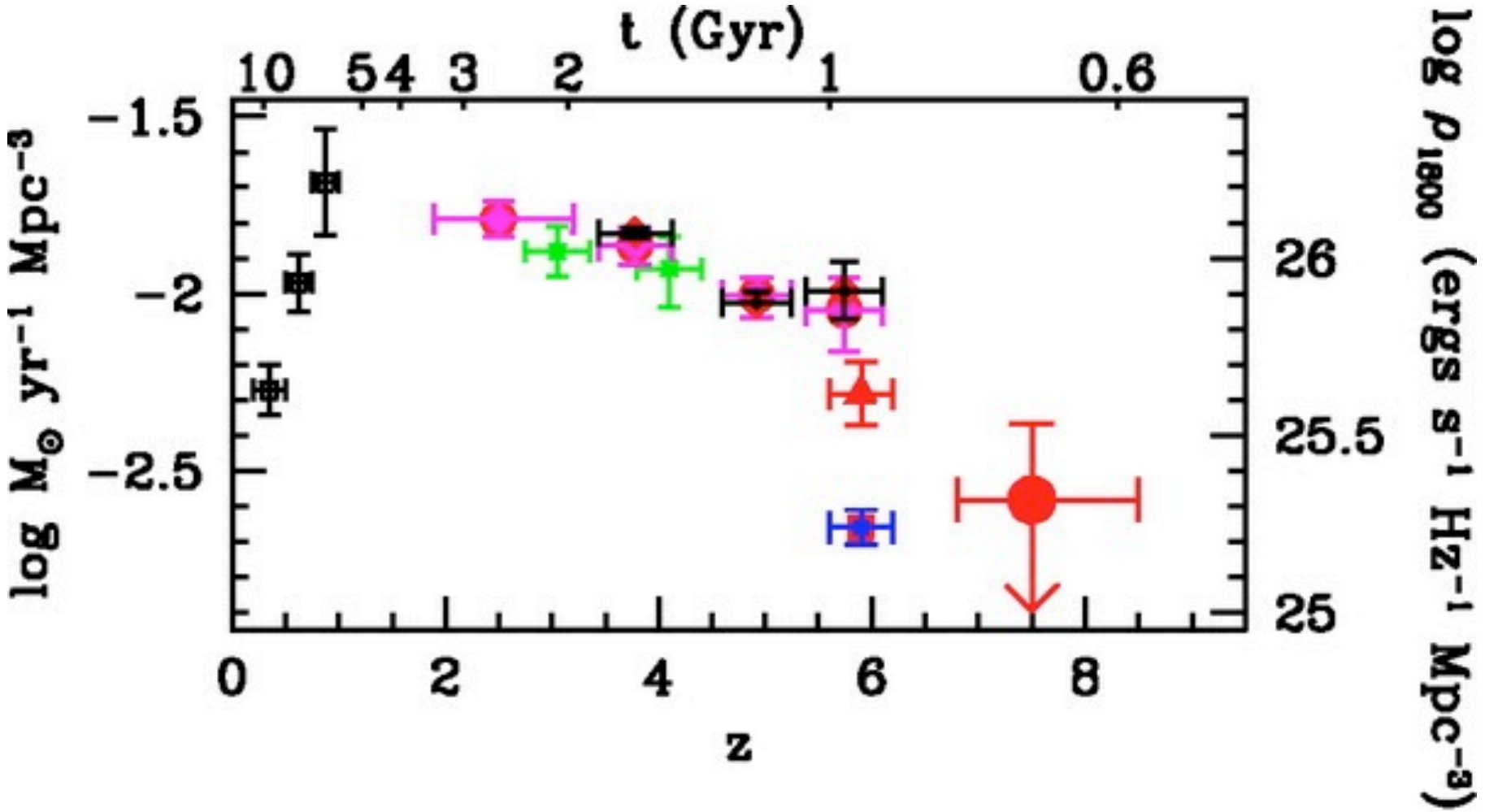

H3495/3524
H4459/4528
H4520/4822
H4715/4822
H5280/5298
H5347/5543
H5577/5607
H5840/5940
H6036/6064
H6688/6695


(a)
(b)
(c)
(d)


(a)
z=1.355
z=0.958
z=0.952
z=0.498


1
0.1
0
1
2
$R_{<z>}/R_{z=0}$
<z>
This work, $(1+z)^{-0.98\pm0.11}$
$(1+z)^{-1.20\pm0.12}$
R08f
C07
F08
R08c
L07
F08
Z07
Tr06
B08
T07
vD08
Tr06: Trujillo et al. 2006a
L07: Longhetti et al. 2007
Z07: Zirm et al. 2007
T07: Toft et al. 2007
C08: Cimatti et al. 2008
vD08: van Dokkum et al. 2008
F08: Franx et al. 2008
R08: Rettura et al. 2008 (f: field; c: cluster)
B08: Buitrago et al. 2008


t (Gyr)
10
5
4
3
2
1
0.6
−1.5
−2
−2.5
log $M_\odot$ yr^{-1} Mpc^{-3}
0
2
4
6
8
z
26
25.5
25
log ρ_{1800} (ergs s^{-1} Hz^{-1} Mpc^{-3})

Gravitationally Lensed Image of Highest Redshift Galaxy

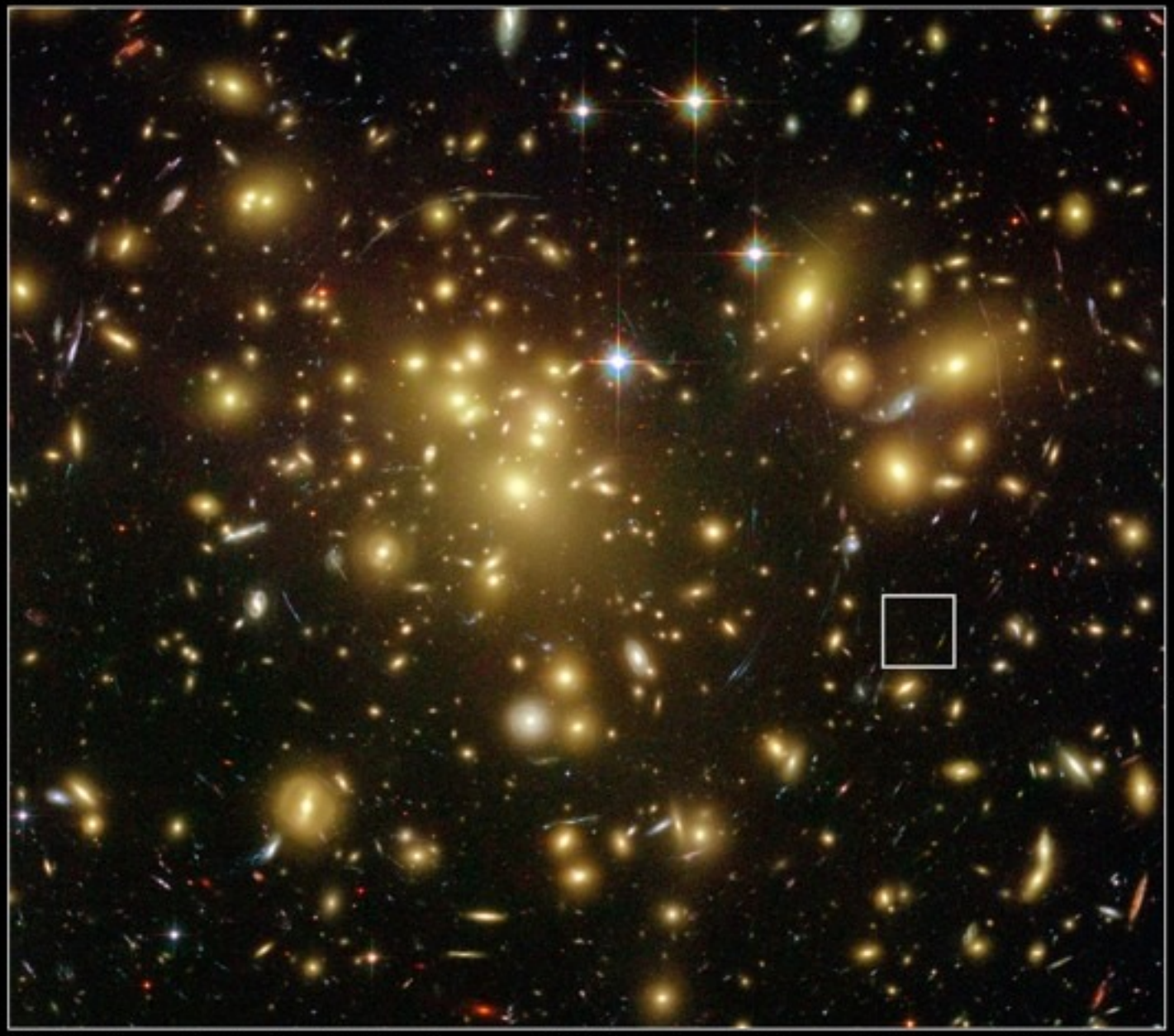
HST
WFPC2

PRC97-25 • ST ScI OPO • July 30, 1997

M. Franx (Kapteyn Astronomical Institute), G. Illingworth (Lick Observatory) and NASA

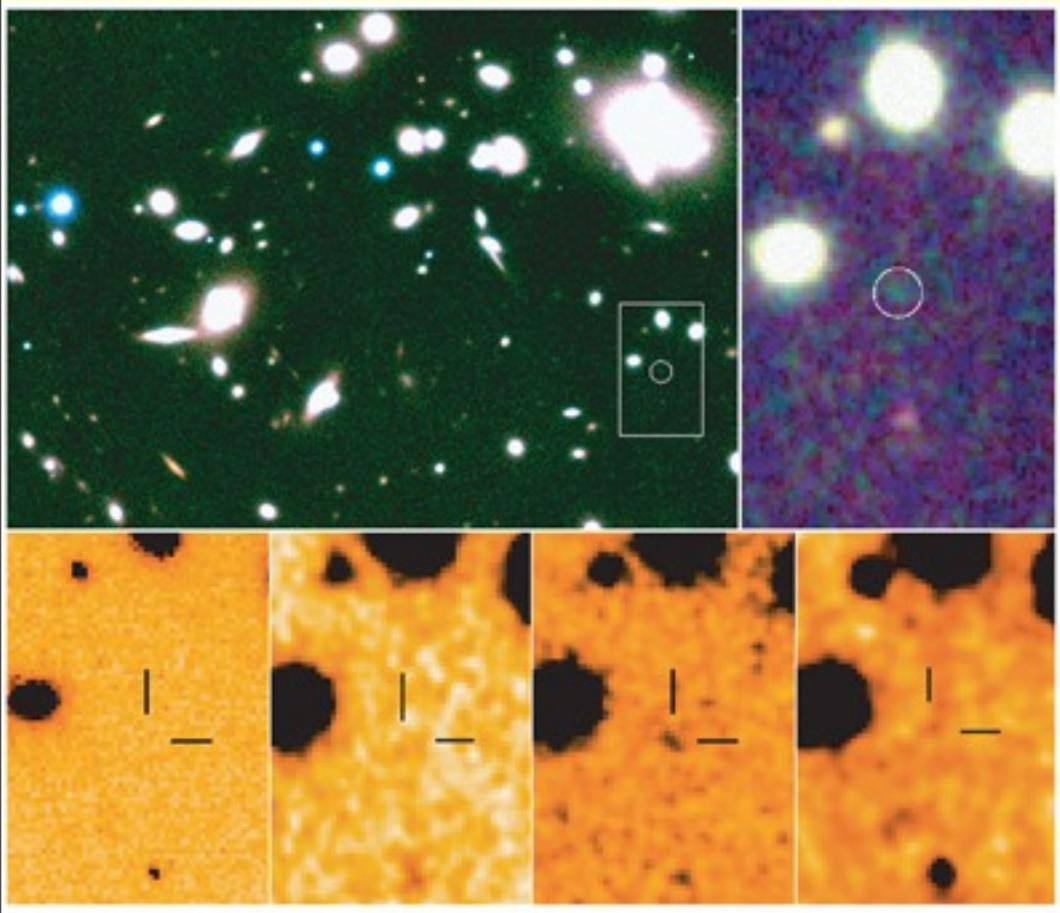
Distant Gravitationally Lensed Galaxy
Galaxy Cluster Abell 1689

Hubble Space Telescope
ACS/WFC NICMOS



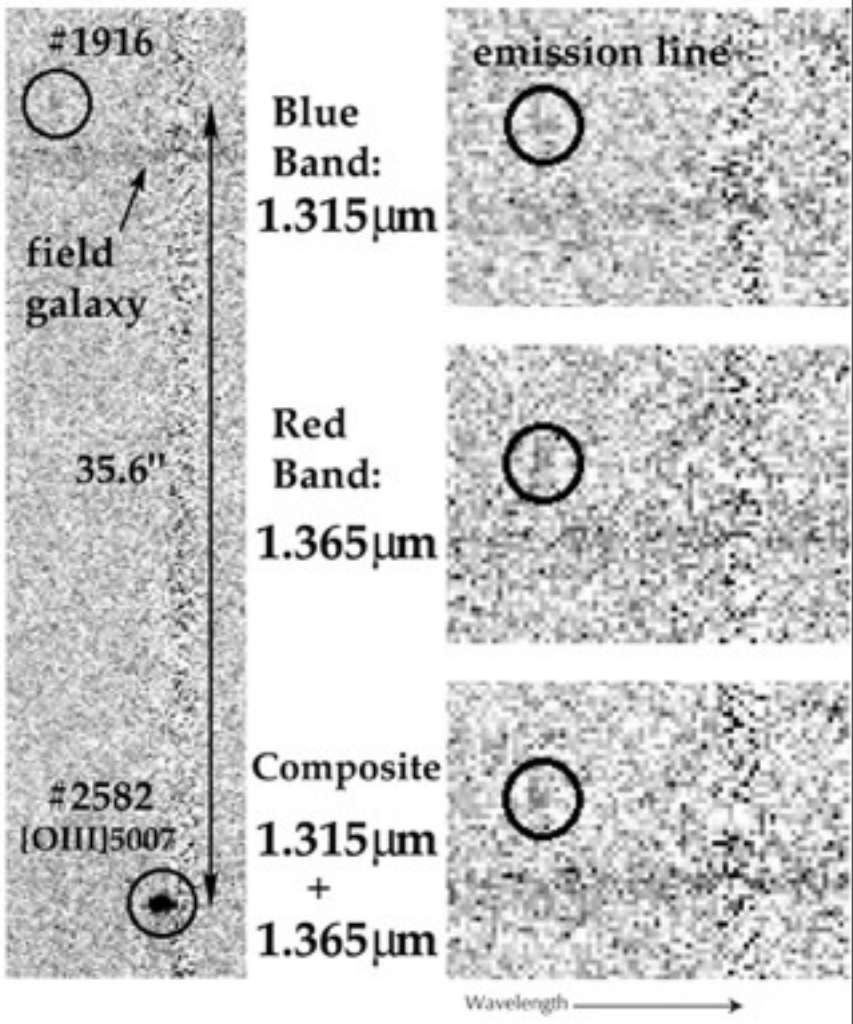
NASA, ESA, and L. Bradley (JHU), R. Bouwens (UCSC), H. Ford (JHU), and G. Illingworth (UCSC)

STScI-PRC08-08a



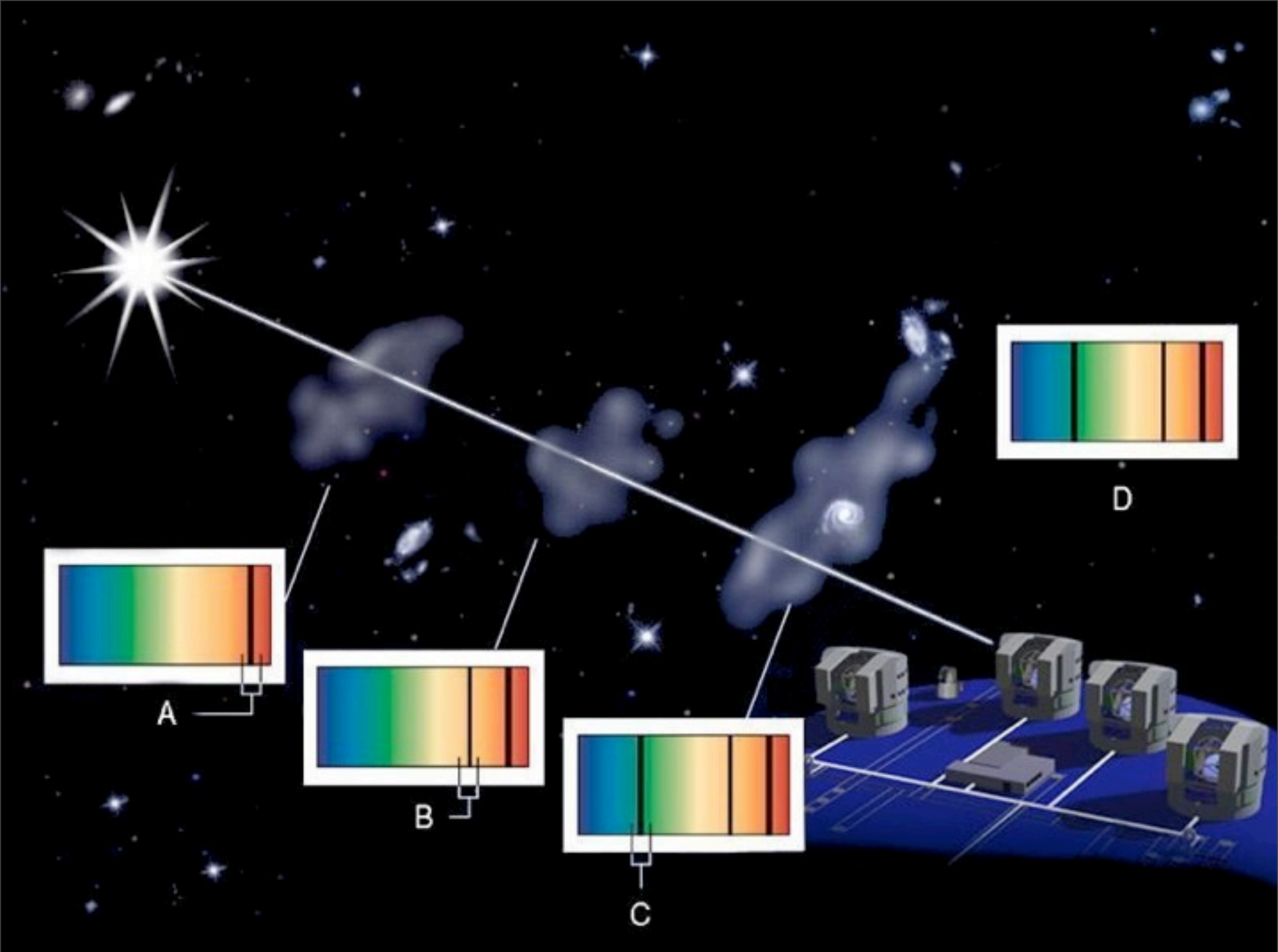
Abell 1835 IR1916 - the Farthest Galaxy - Seen in the Near-Infrared
(VLT ANTU + ISAAC)

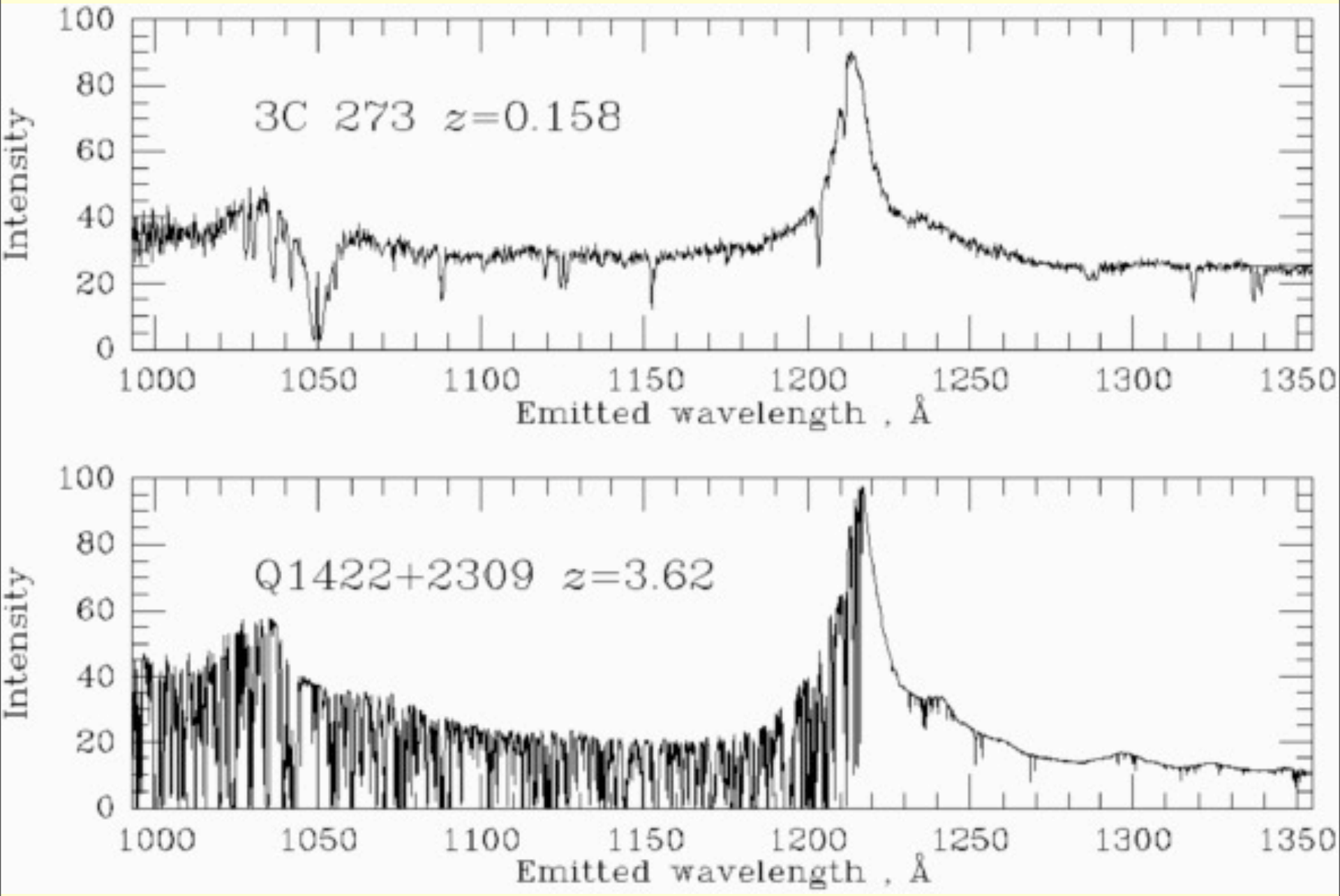
ESO PR Photo 05a/04 (1 March 2004) © European Southern Observatory



Two-dimensional Spectra of Abell 1835 IR1916
(VLT ANTU + ISAAC)

ESO PR Photo 05b/04 (1 March 2004) © European Southern Observatory


A
B
C
D


3C 273 z=0.158
Intensity
Emitted wavelength , Å
Q1422+2309 z=3.62
Intensity
Emitted wavelength , Å