Galaxies in Collision

...the Evolution of Galaxies...

...the Formation of the Elements...

...and how all of it may be necessary for...

YOU

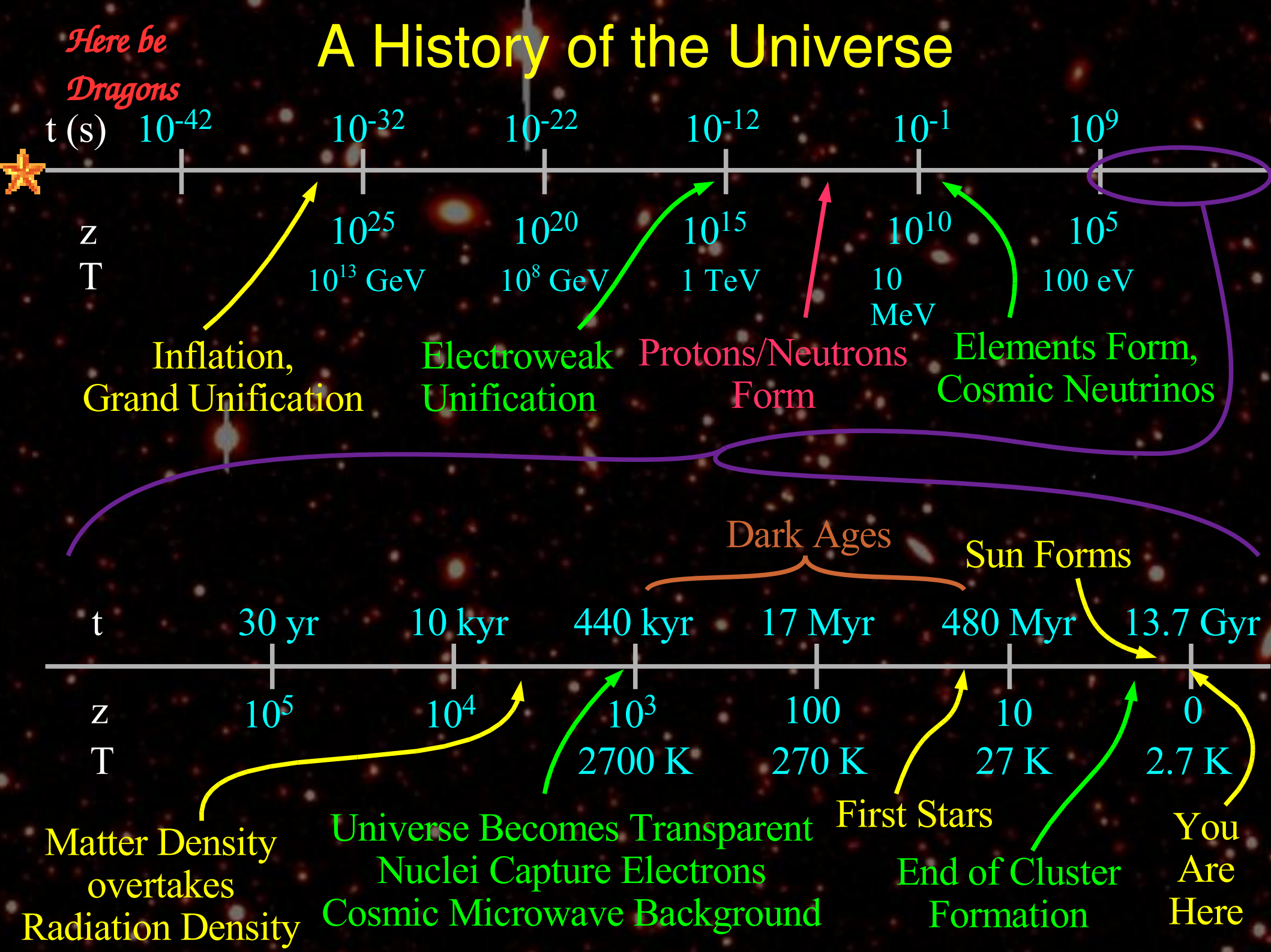
Prof. Robert Knop, Vanderbilt University

Atlanta Astronomy Club

AAS Shapley Lecture

2006 May 19

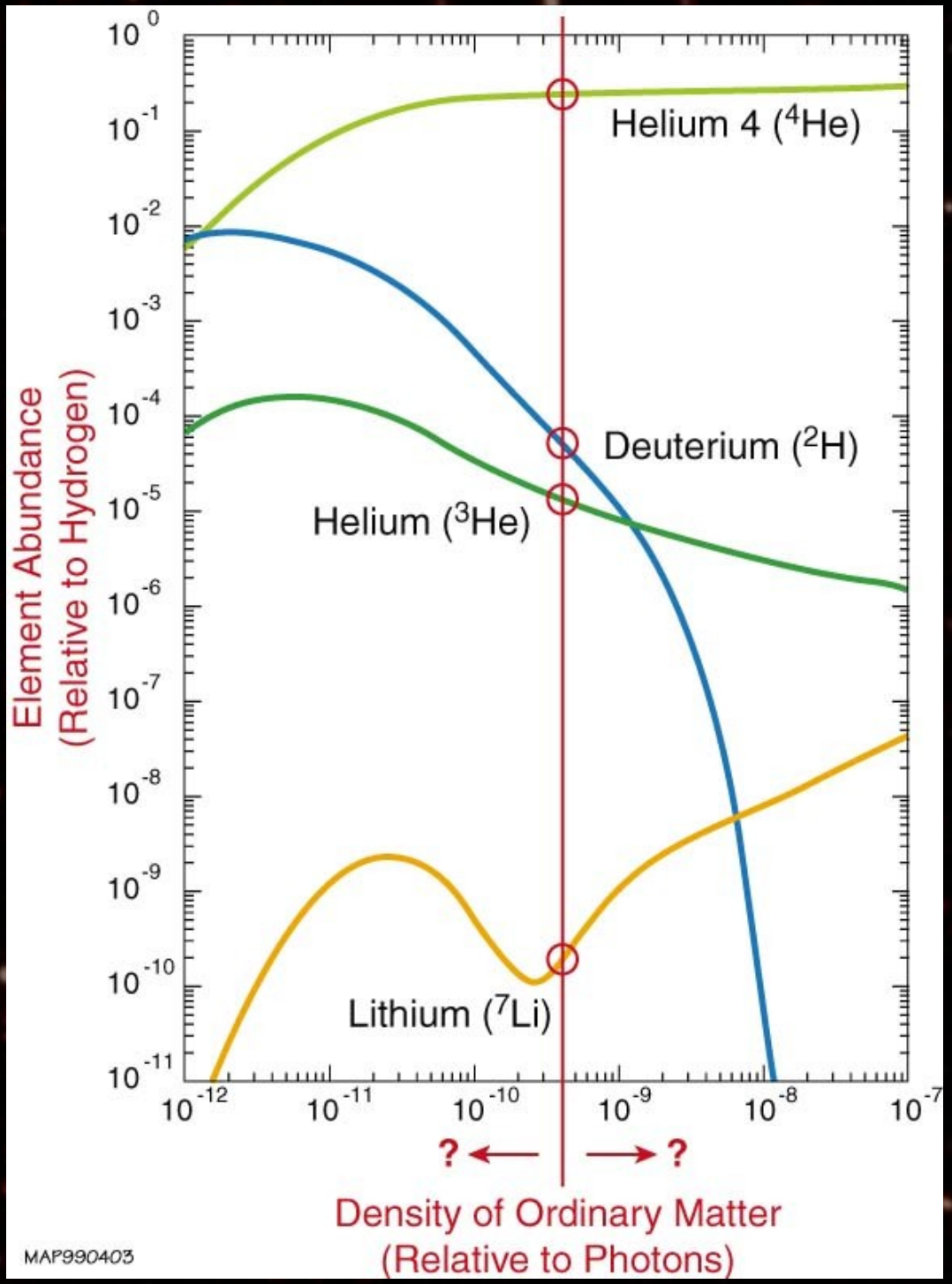
UH 88" Image

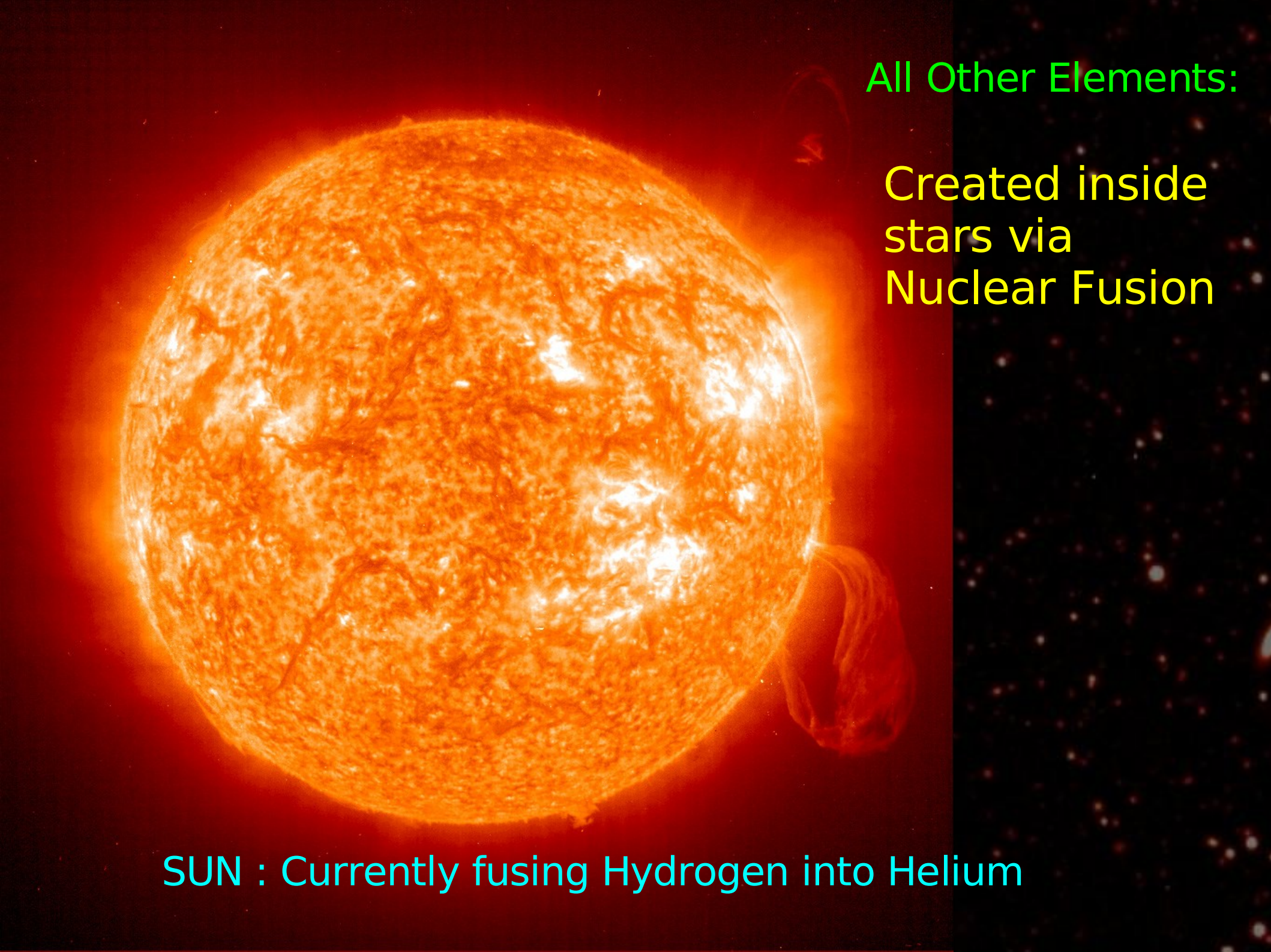

Here be Dragons
A History of the Universe
t (s)
10-42
10-32
10-22
10-12
10-1
109
z
T
1025
1013 GeV
1020
108 GeV
1015
1 TeV
1010
10 MeV
105
100 eV
Inflation, Grand Unification
Electroweak Unification
Protons/Neutrons Form
Elements Form, Cosmic Neutrinos
Dark Ages
Sun Forms
t
30 yr
10 kyr
440 kyr
17 Myr
480 Myr
13.7 Gyr
z
105
104
103
100
10
0
T
2700 K
270 K
27 K
2.7 K
Matter Density overtakes Radiation Density
Universe Becomes Transparent
Nuclei Capture Electrons
Cosmic Microwave Background
First Stars
End of Cluster Formation
You Are Here

Nuclear Alchemy

Produced by the Big Bang:

- Hydrogen
- Helium
- Duterium
- Lithim (a wee bit)




All Other Elements:
Created inside stars via Nuclear Fusion
SUN : Currently fusing Hydrogen into Helium

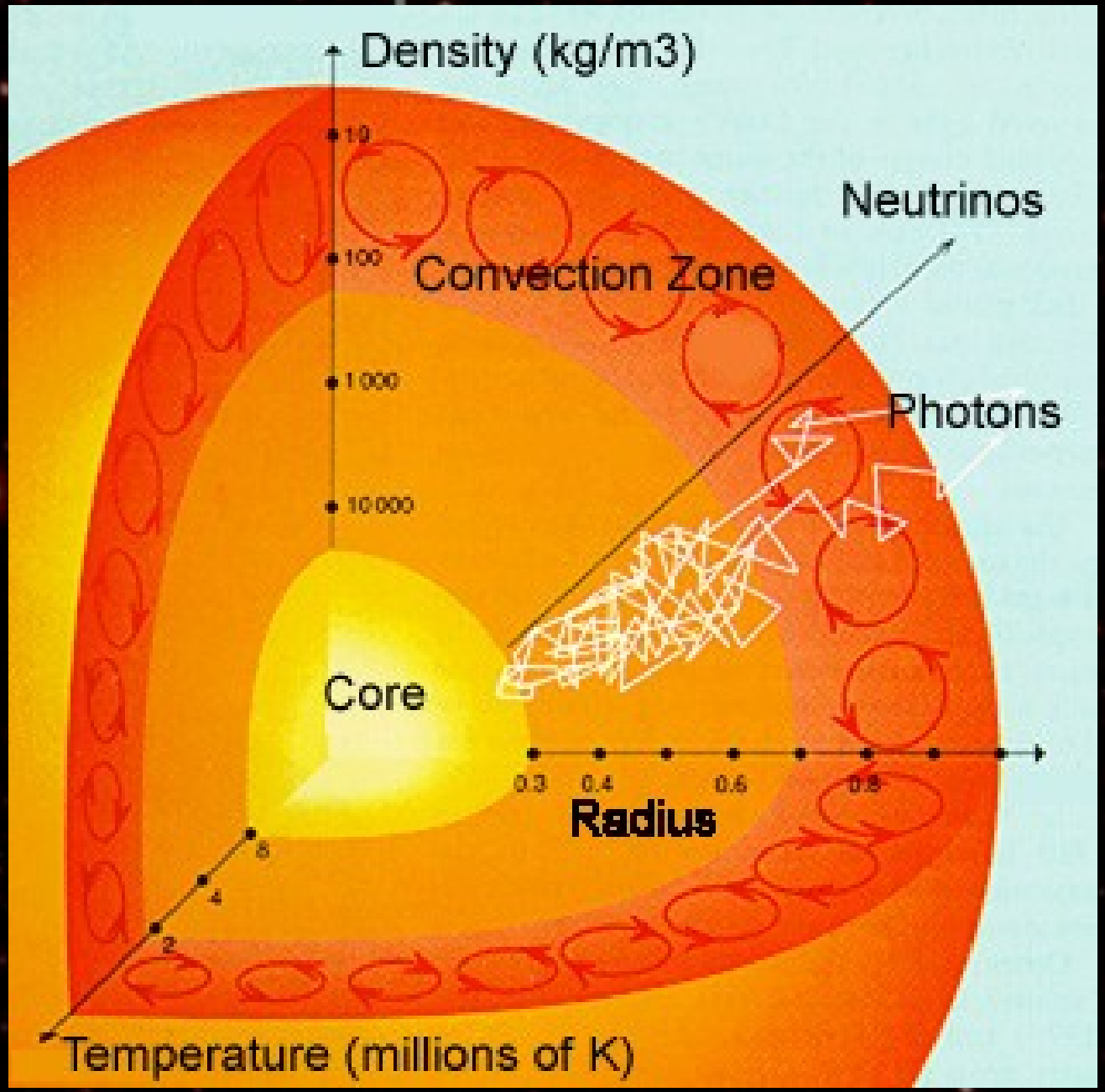
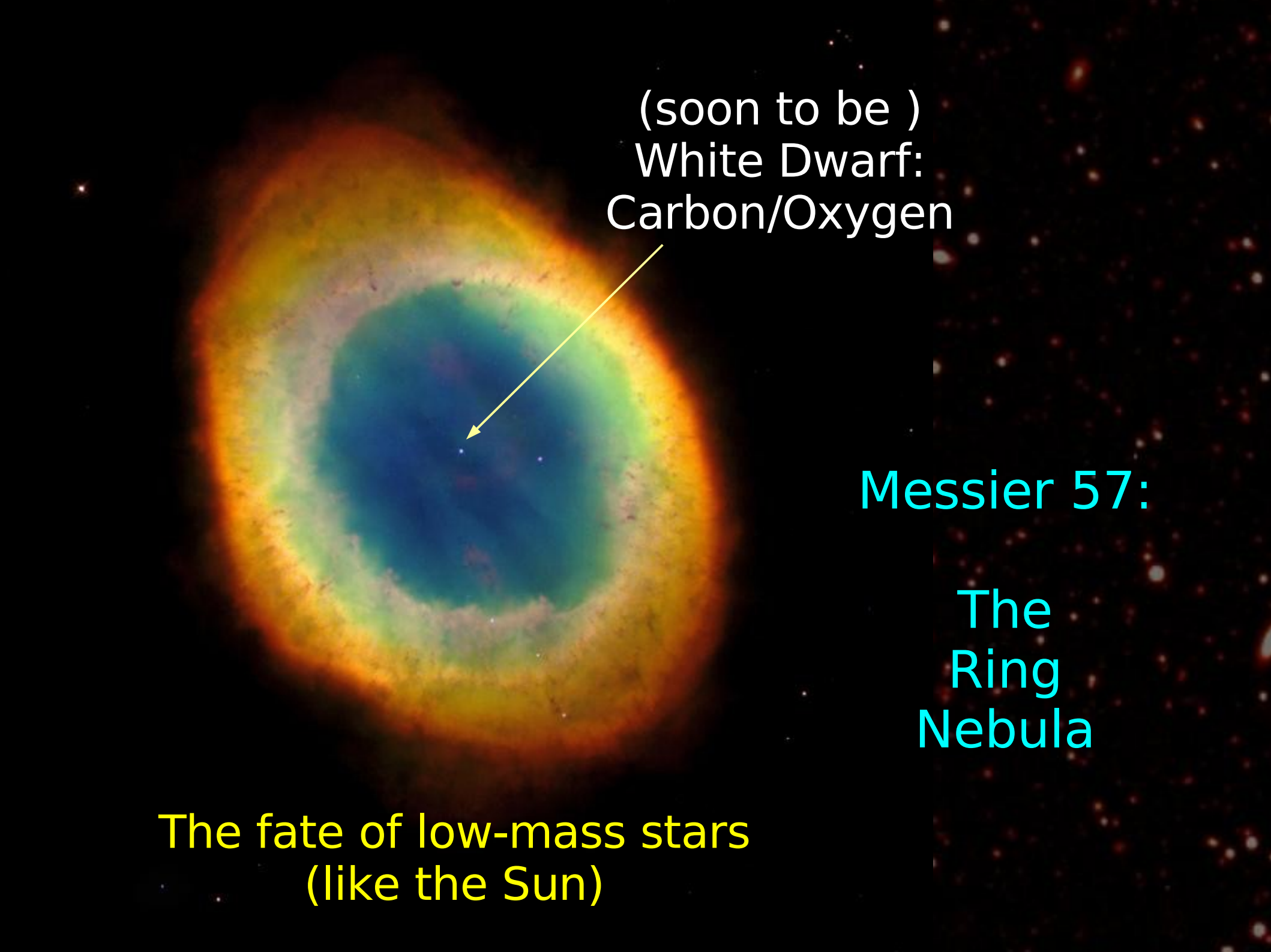


Image: CSE, SSL, UCB


(soon to be)
White Dwarf:
Carbon/Oxygen
Messier 57:
The
Ring
Nebula
The fate of low-mass stars
(like the Sun)

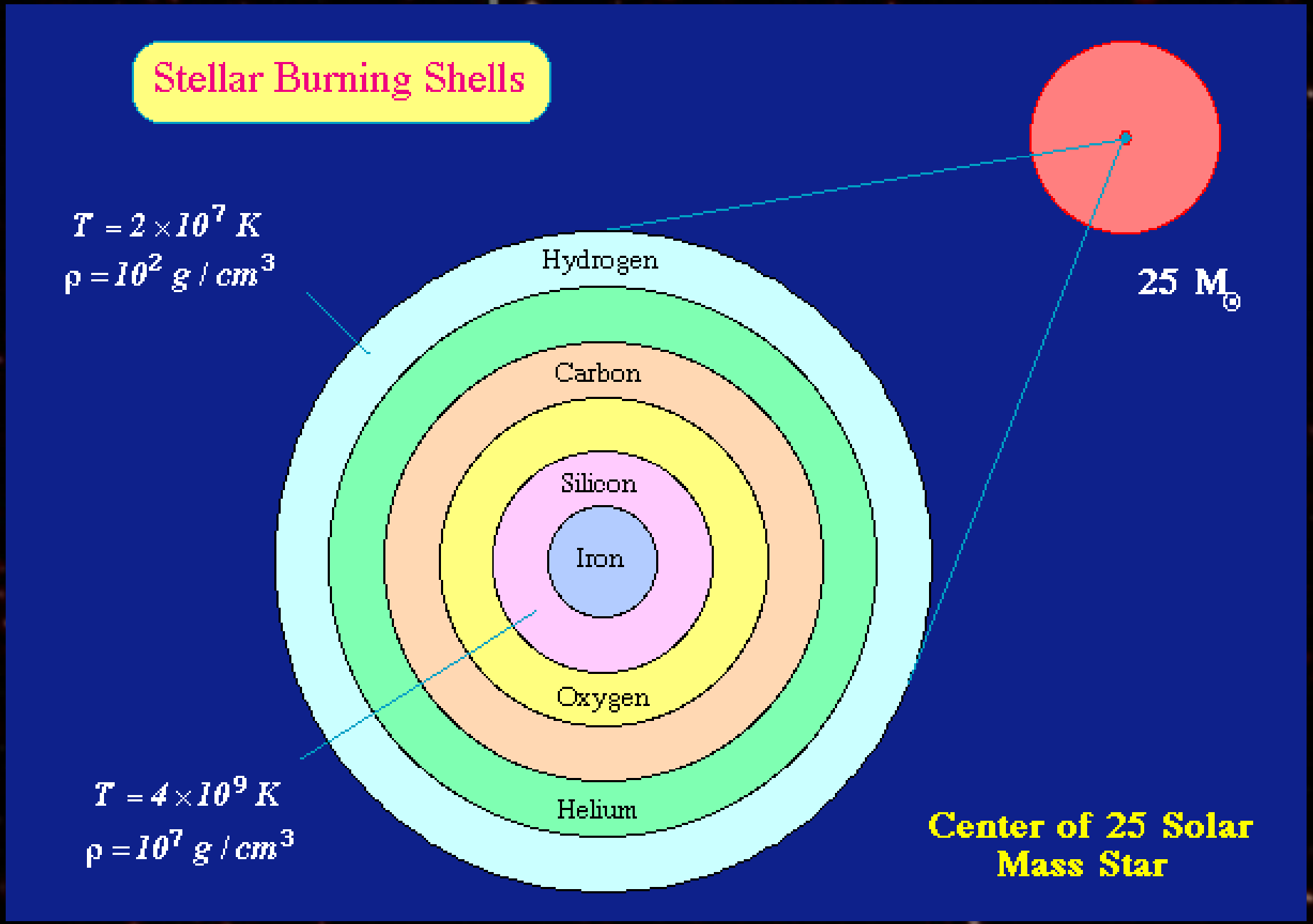
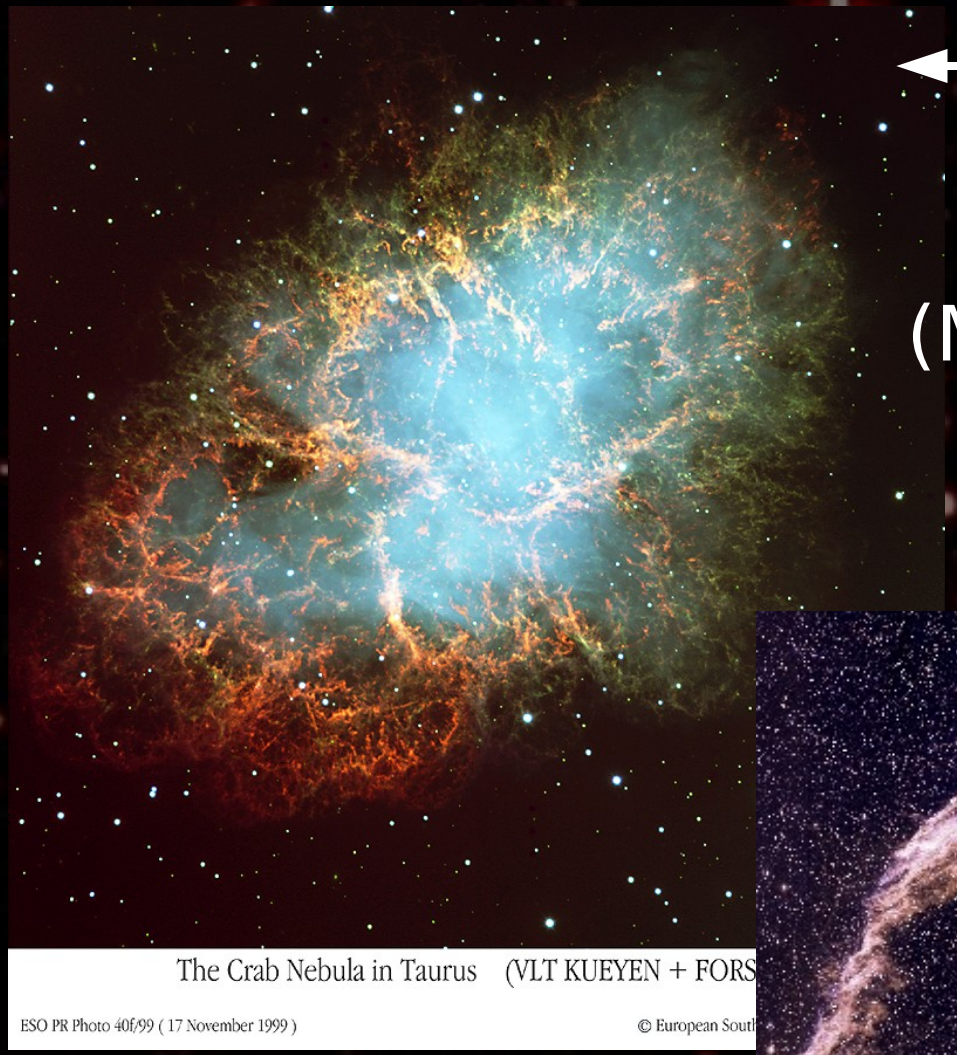


Image: Mike Guidry

Supernova 1987A



1,000 years later:

(Messier 1, the Crab Nebula)

15,000 years later

(The Cygnus Loop)

Obligatory Bullet Points!!

- The Big Bang made only Hydrogen & Helium
- All other elements are created in stars via Fusion
- Supernovae make the most massive elements (including iron)
- *The atoms in you have been inside stars, and have been through supernovae!!! (Yipers)*

Er, wasn't this talk about interacting galaxies??

Sizes and distances of stars

The Sun	A tennis ball (2 ¼" across)
Earth	The head of a pin (1/50" across), 6m away
Jupiter	A small marble (¼" across), 30m away
Alpha Centauri	A tennis ball in *New York* (1000mi away)

Milky Way Galaxy

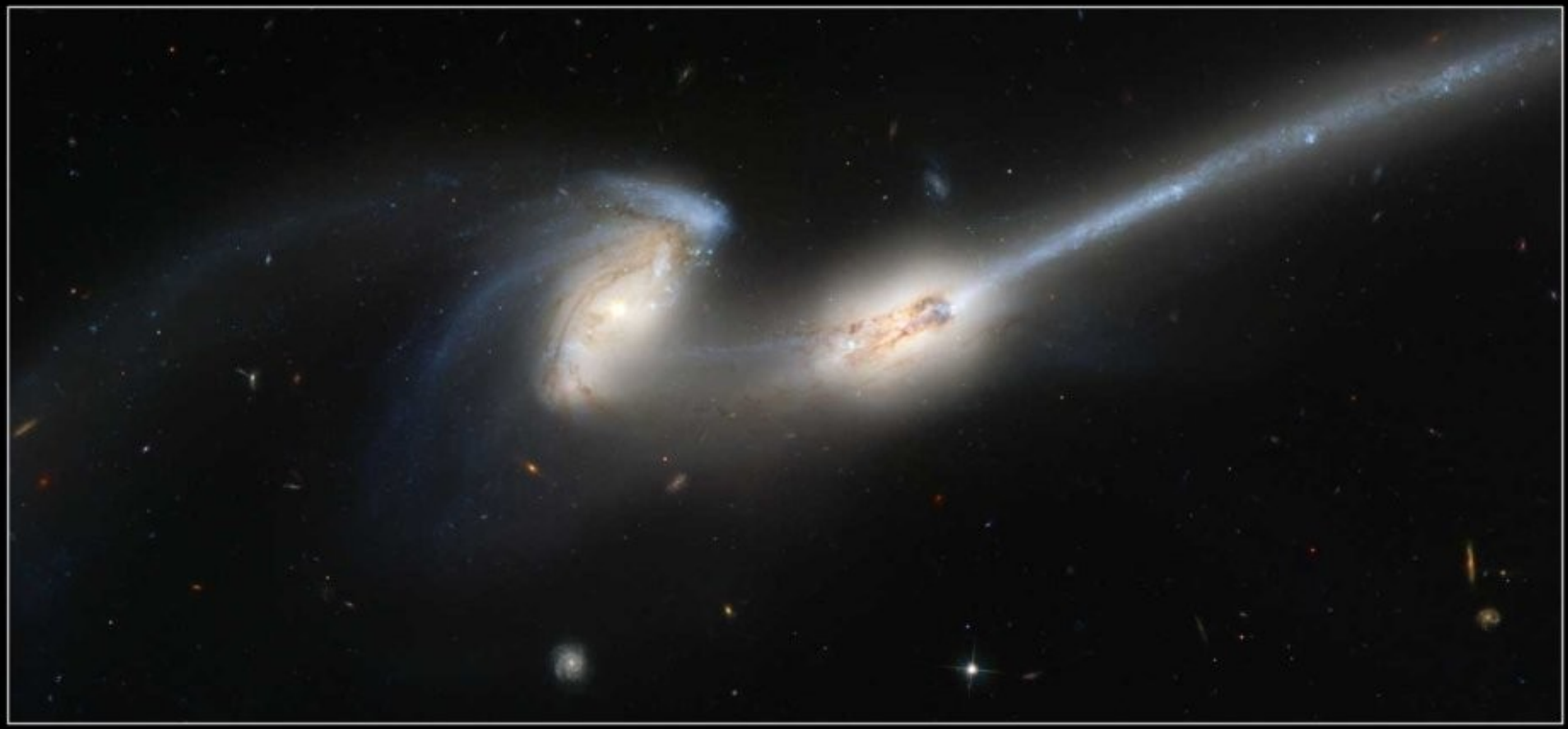
Galaxies are much closer together *compared to their size* than stars within a galaxy are *compared to their size*

Andromeda Galaxy

Galaxies NGC 2207 and IC 2163

Hubble Heritage

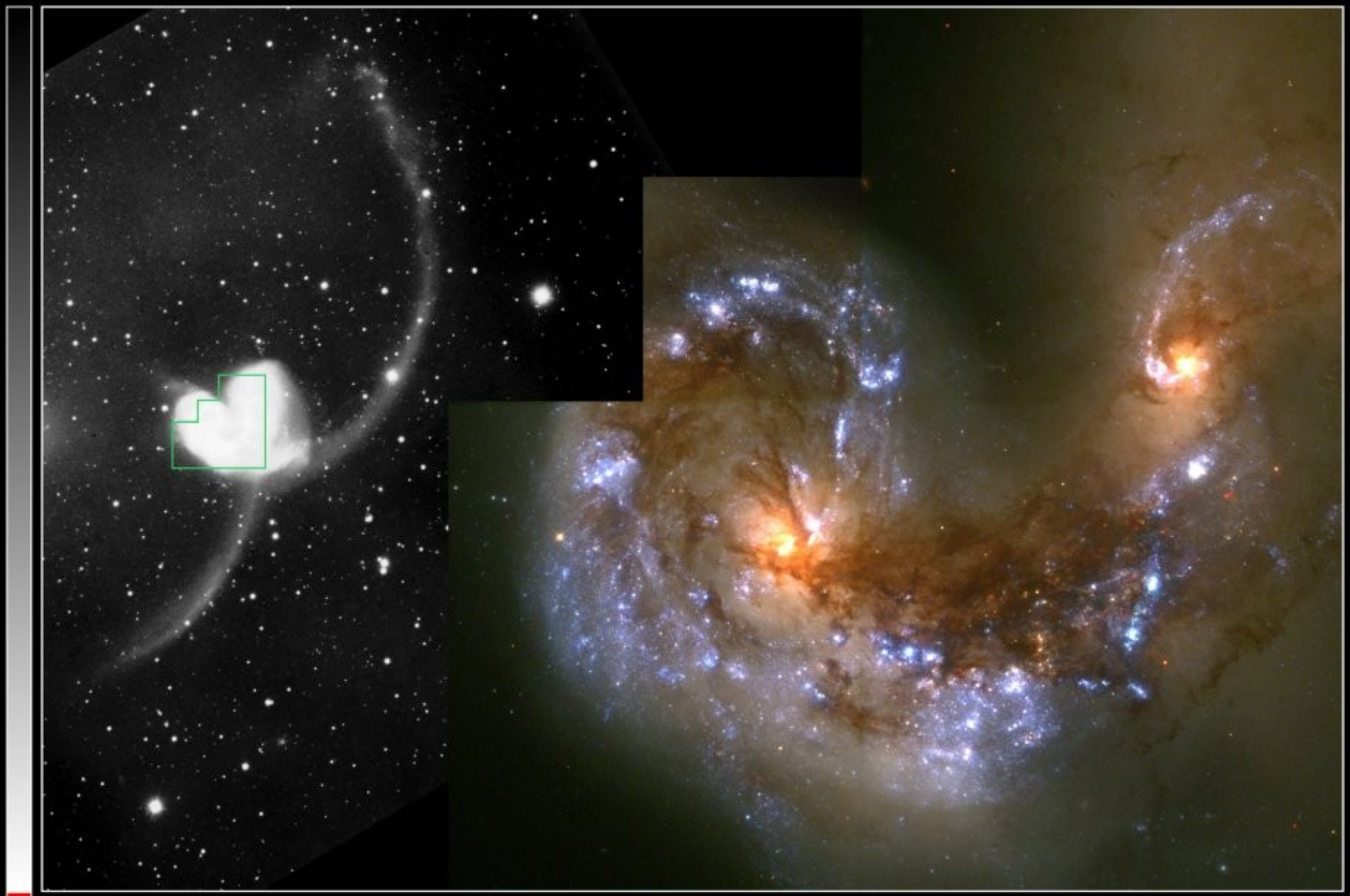
NASA and The Hubble Heritage Team (STScI) • Hubble Space Telescope WFPC2 • STScI-PRC99-41



The Mice • Interacting Galaxies NGC 4676

Hubble Space Telescope • Advanced Camera for Surveys

NASA, H. Ford (JHU), G. Illingworth (UCSC/LO), M. Clampin (STScI), G. Hartig (STScI), the ACS Science Team and ESA • STScI-PRC02-11d



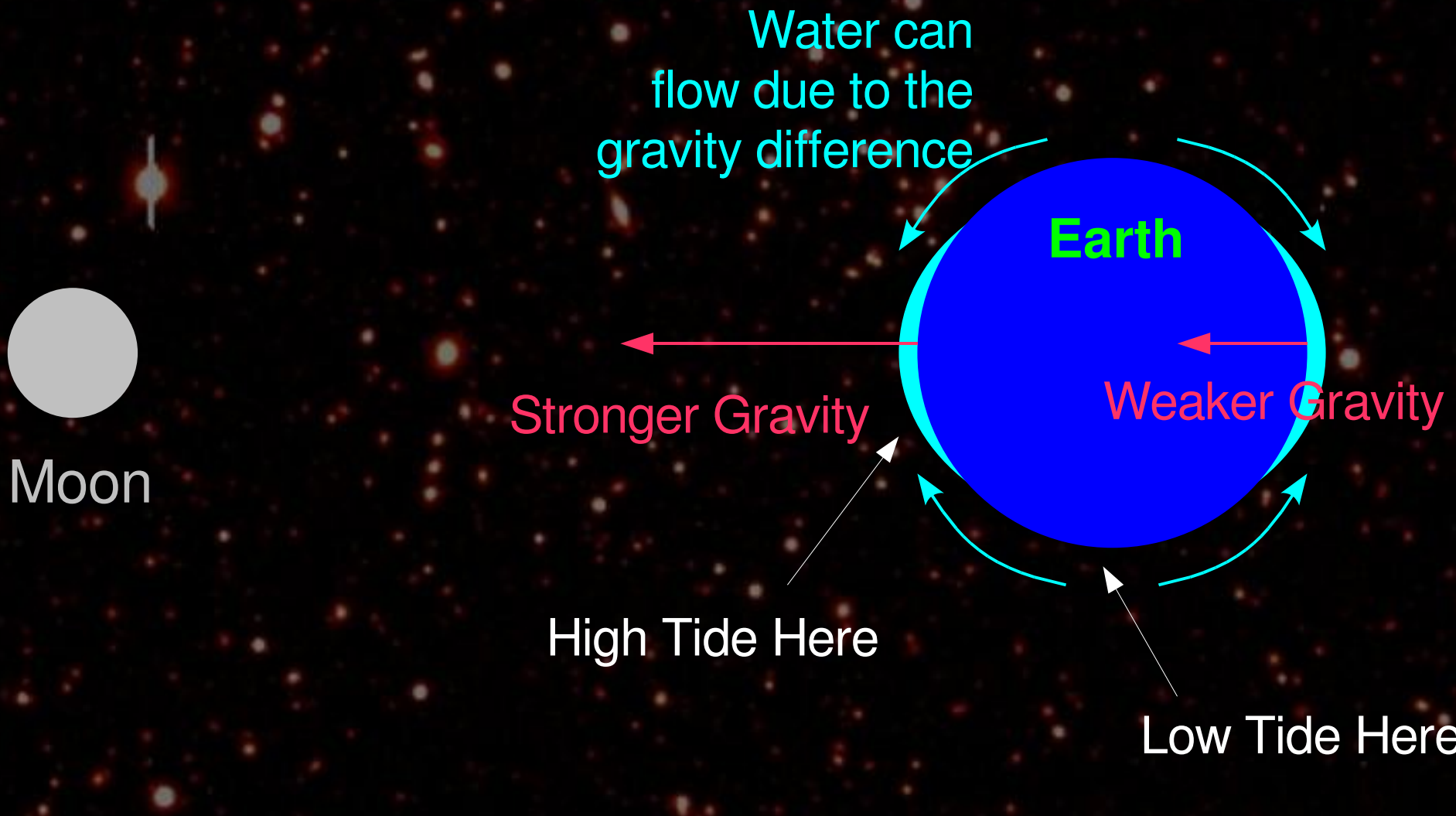
Colliding Galaxies NGC 4038 and NGC 4039

Hubble Space Telescope • Wide Field Planetary Camera 2

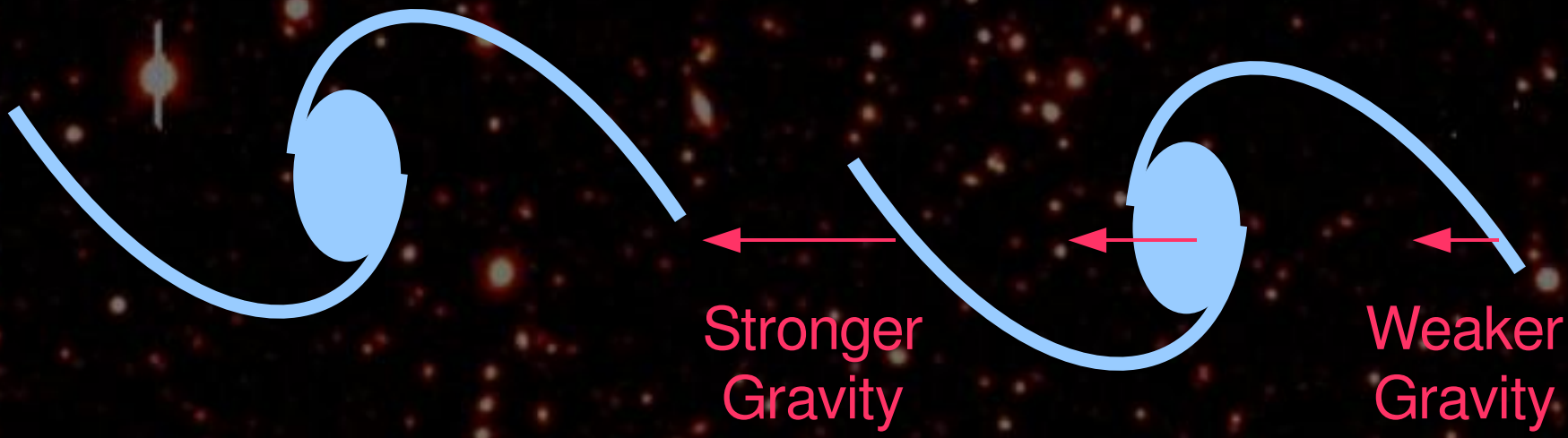
PRC97-34a • ST ScI OPO • October 21, 1997 • B. Whitmore (ST ScI) and NASA

Tidal Forces

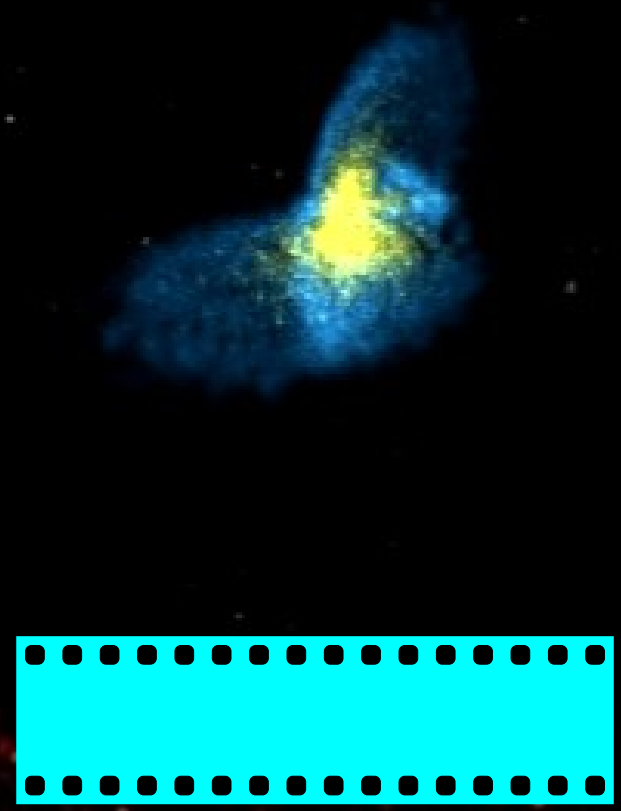
...result from a *difference* in gravity from one side of an object to the other



Tidal Tails in Interacting Galaxies



Galaxy Collision Simulation Movie



Simulation Data: Chris Mihos, Case Western ; Lars Hernquist, Harvard

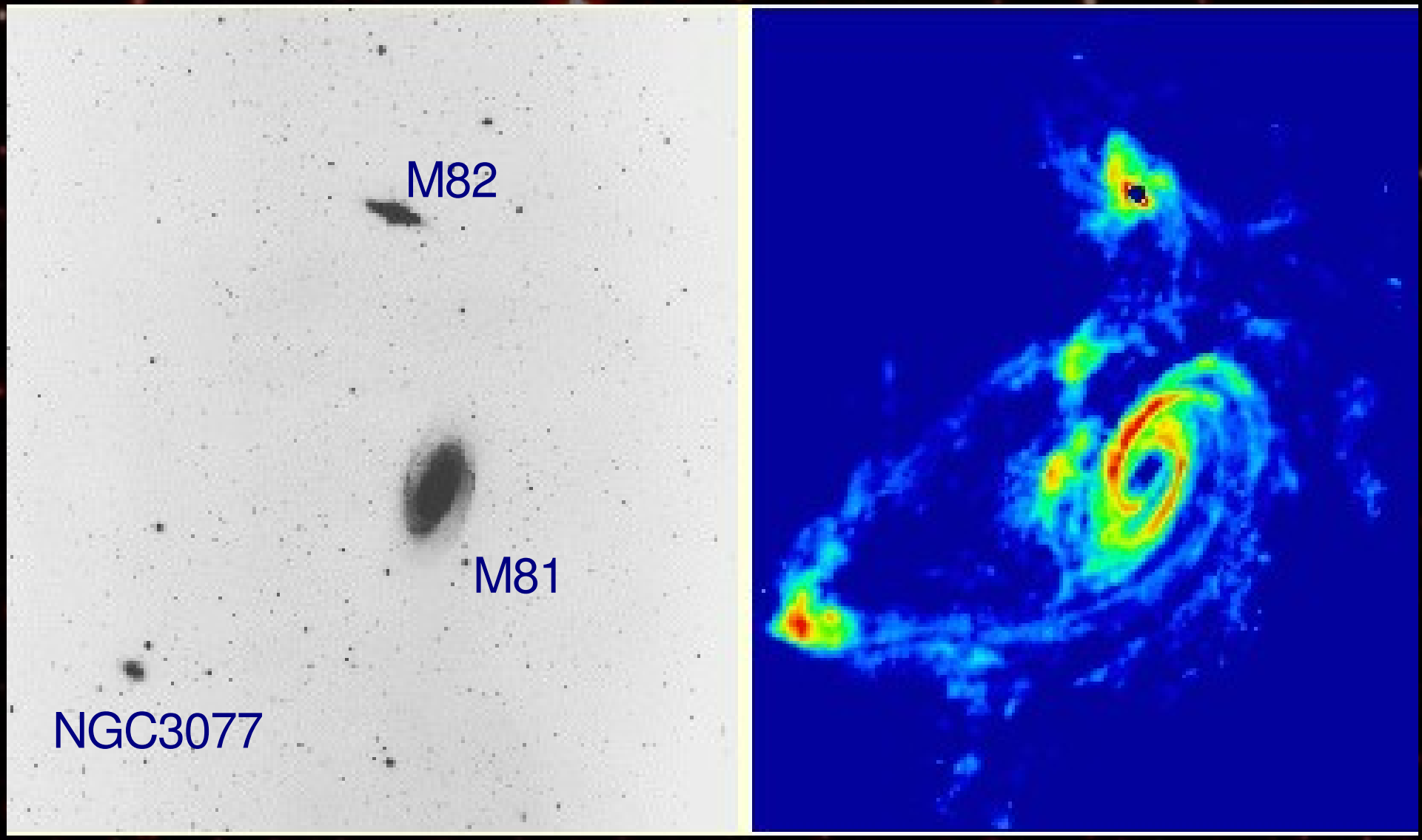
Visualization: Frank Summers, STScI

“Galaxy Crash”

An interactive Java galaxy collision simulator on the web that you can play with.

http://burro.astr.cwru.edu/JavaLab/GalCrashWeb/main.html

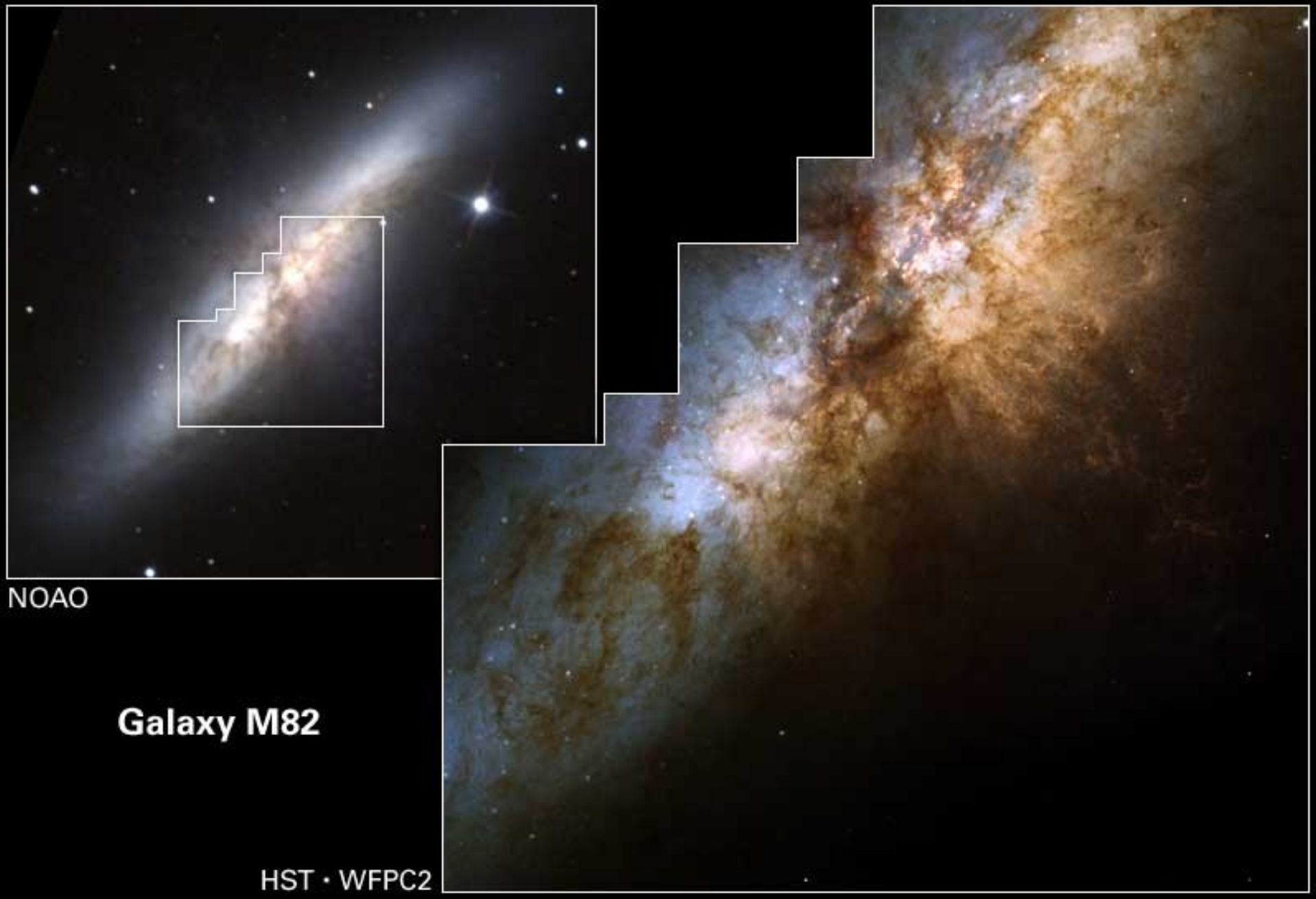
(or search for “Galaxy Crash” in Google)



Telescope Picture

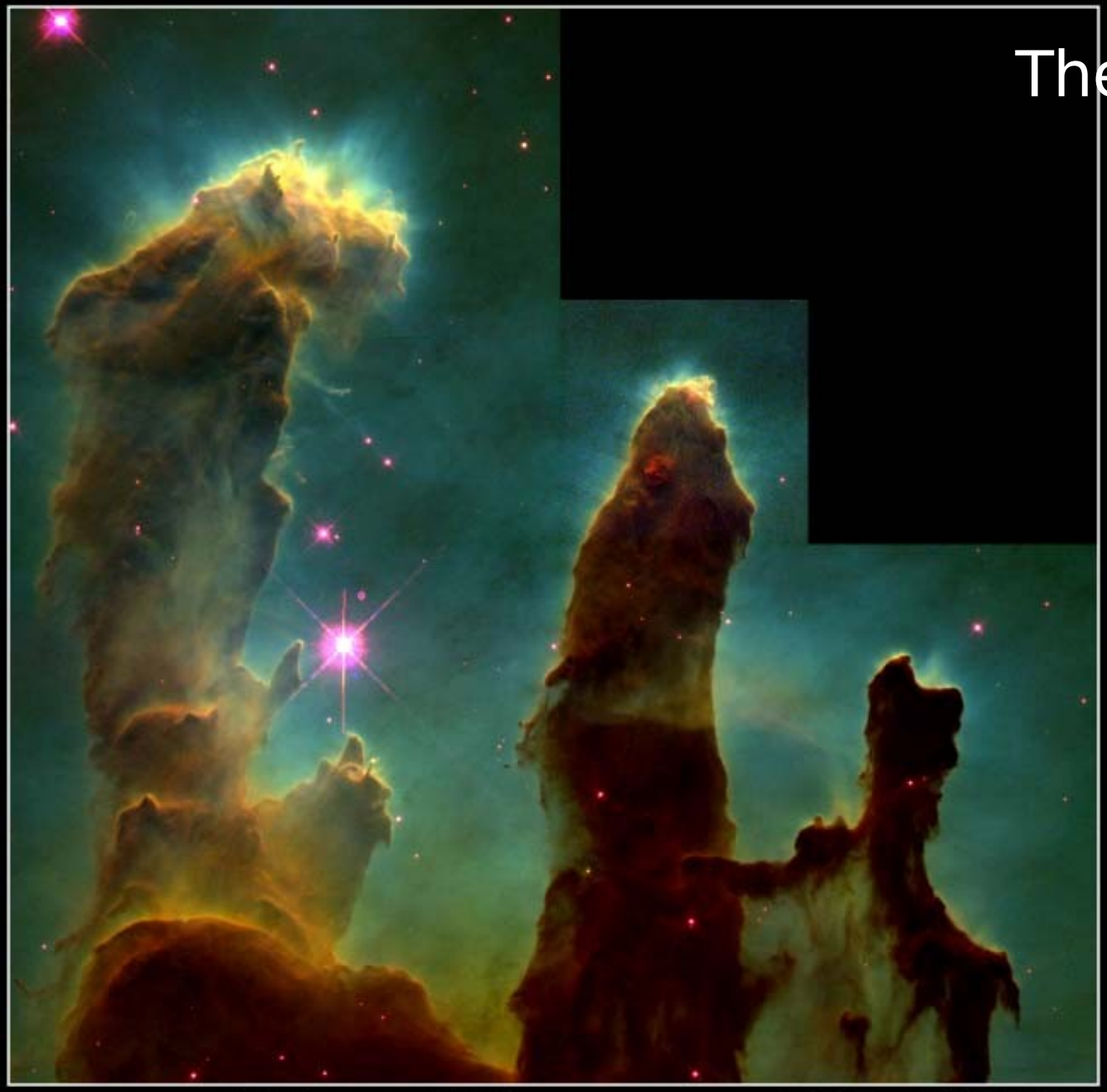
Hydrogen Gas
(Radio Telescope Picture)

Min Yun, NRAO



NASA, ESA, and R. de Grijs (Institute of Astronomy, Cambridge UK) • STScI-PRC01-08a

The Eagle Nebula



Stars form from dense molecular clouds

Gaseous Pillars · M16 HST · WFPC2

PRC95-44a · ST ScI OPO · November 2, 1995
J. Hester and P. Scowen (AZ State Univ.), NASA

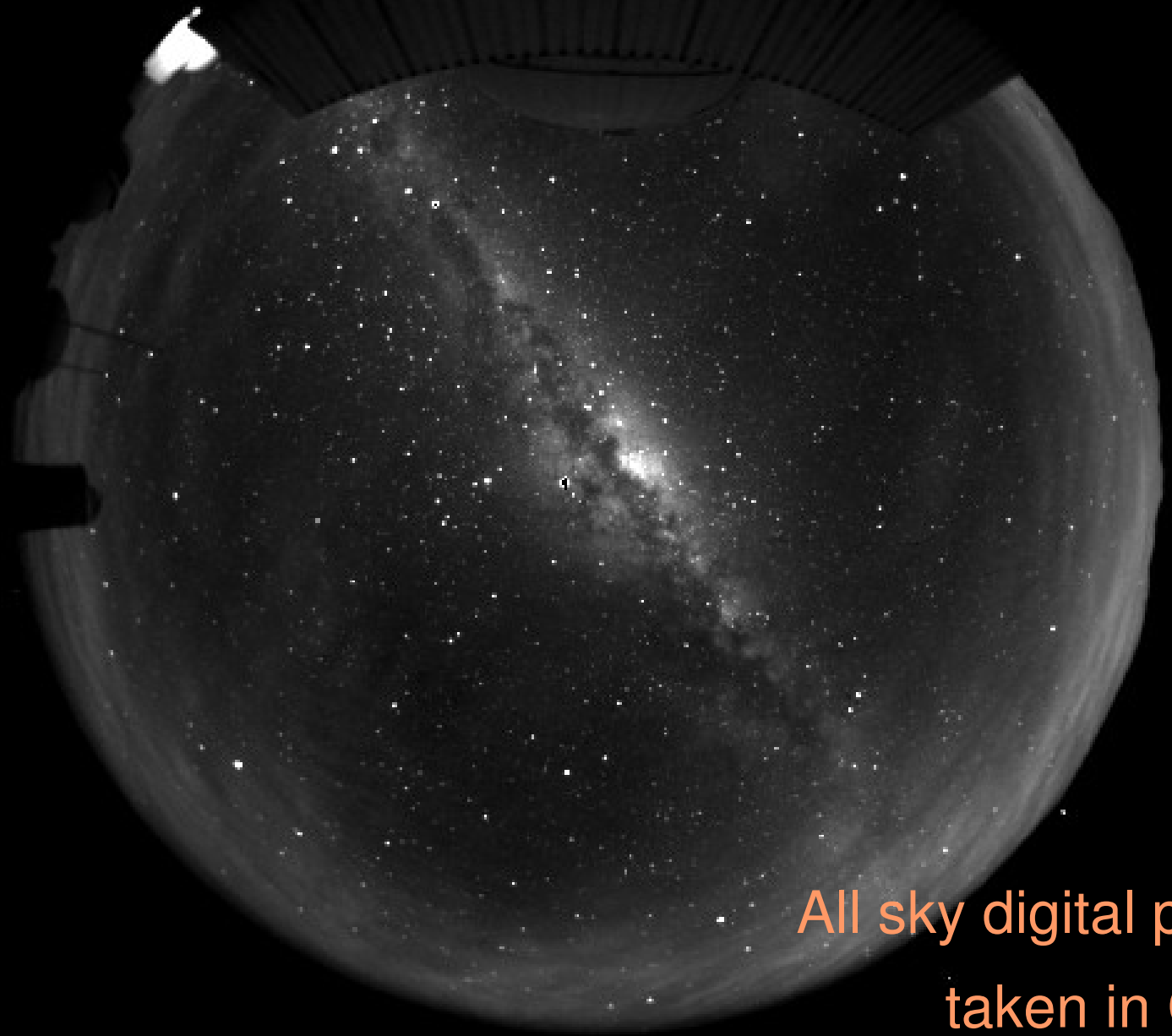
Orion Nebula Mosaic HST · WFPC2

PRC95-45a · ST ScI OPO · November 20, 1995
C. R. O'Dell and S. K. Wong (Rice University), NASA

Messier 51 : The Whirlpool Glaxy

Image: NOAO

The Milky Way Galaxy

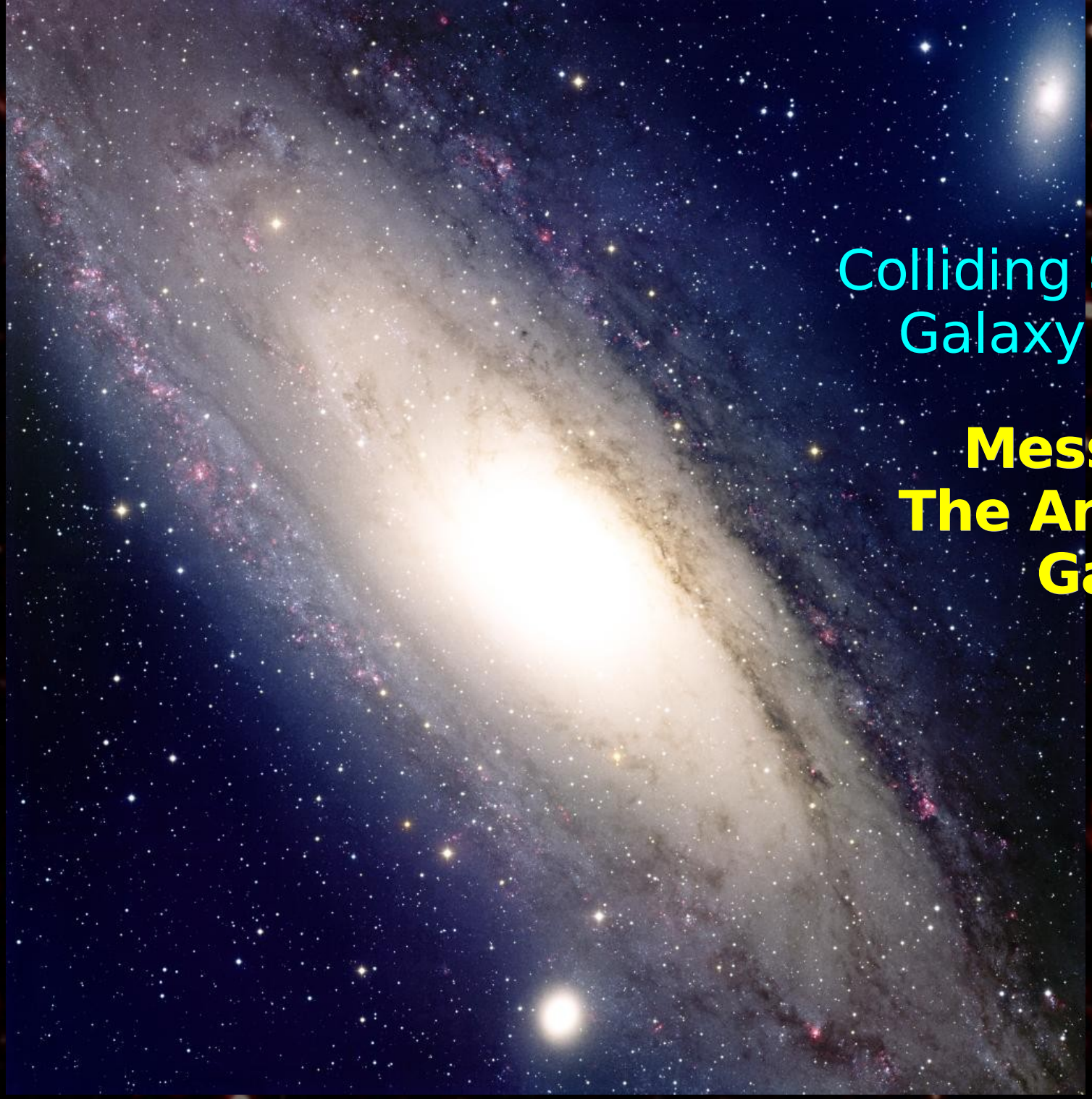


All sky digital photograph
taken in Chile

Galactic Cannibalism

The Saggitarius Dwarf Tidal Stream

Image: D. Martinez-Delgado & G. Perez

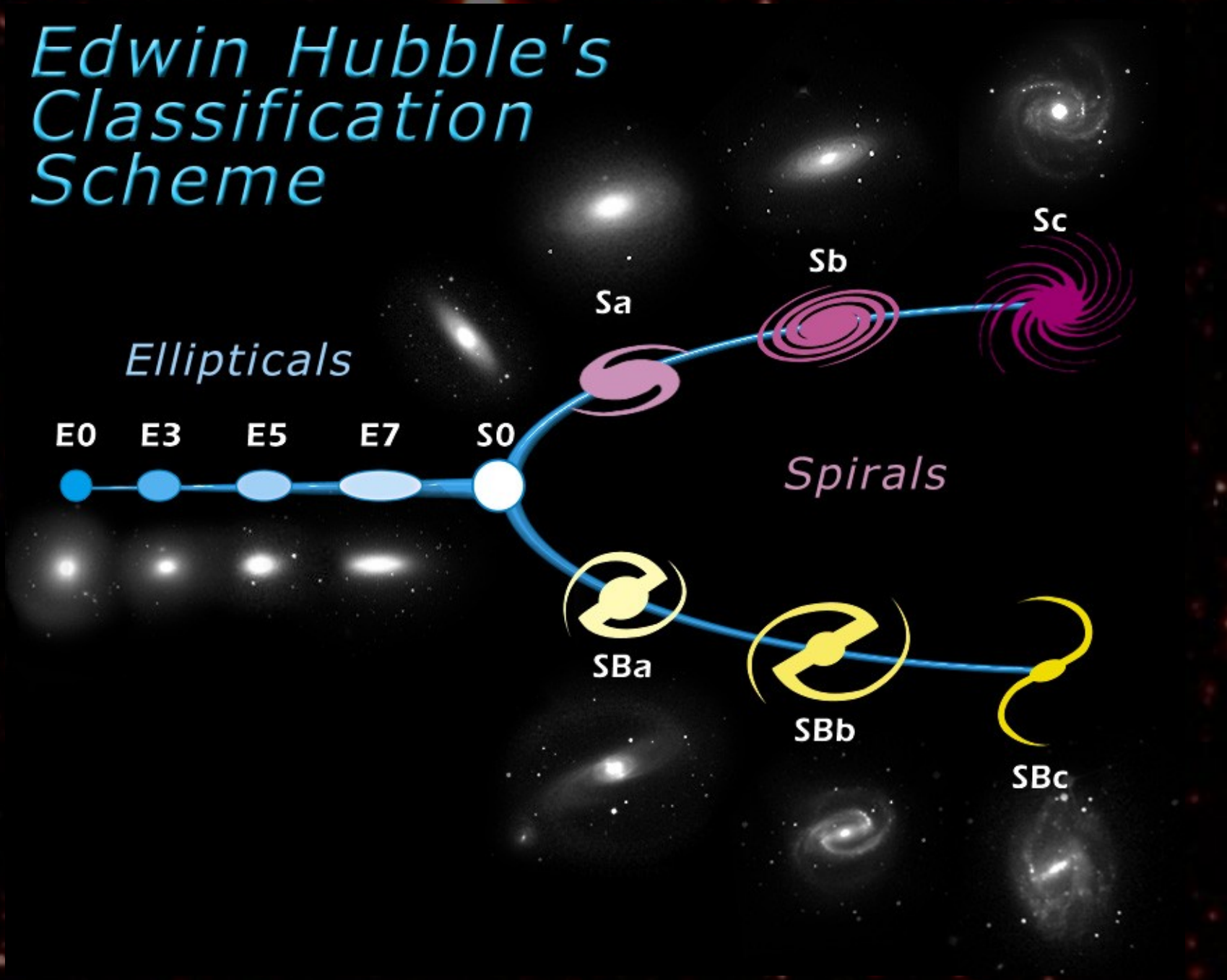


Colliding Soon* with a Galaxy Near You!

Messier 31: The Andromeda Galaxy

(* well, in several billion years....)

Image: T.A.Rector and B.A.Wolpa/NOAO/AURA/NSF


Edwin Hubble's Classification Scheme
Ellipticals
E0
E3
E5
E7
S0
Sa
Sb
Sc
Spirals
SBa
SBb
SBc

(Image: STScI)

M86 (E3)

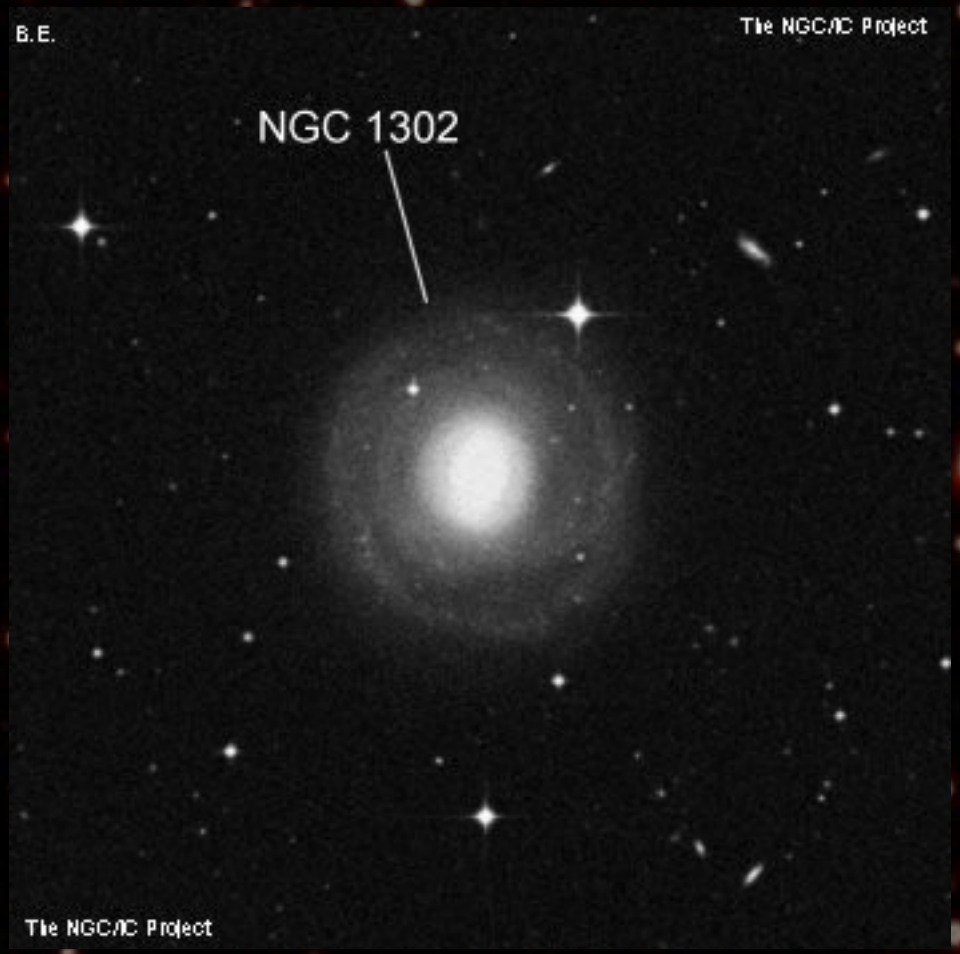
NGC 3115 (S0)

M104
Sombrero Galaxy (Sa)

The Sombrero Galaxy (VLT ANTU + FORS1)

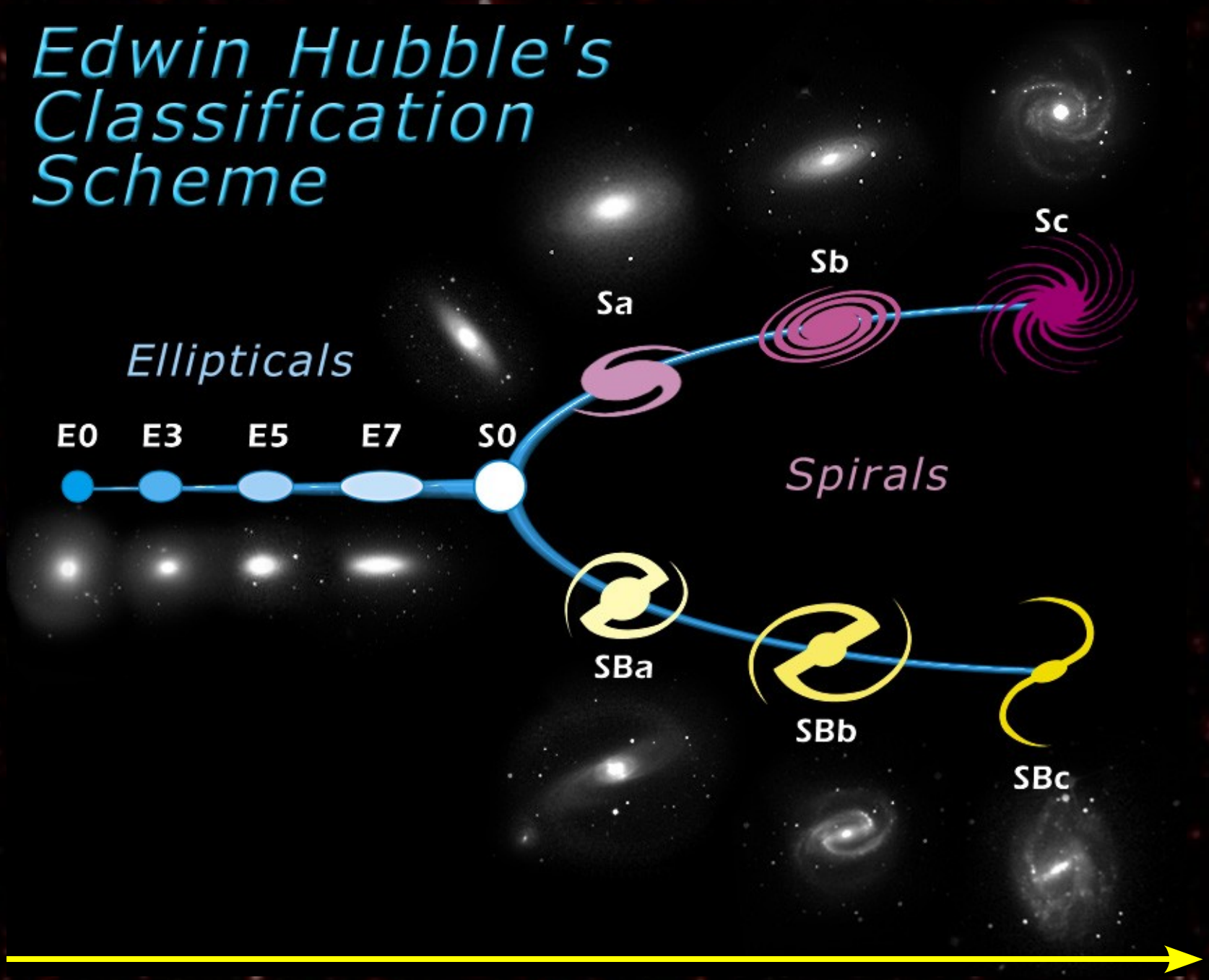
ESO PR Photo 07a/00 (22 February 2000)

NGC 1302 (Sa)



NGC 891 (Sc)

NGC 6946 (Sc)



Sequence of decreasing merger damage?

Galaxy Collisions and You

- Galaxies are seen running into each other!
- Galaxies make a mess out of each other when they collide: twisted shapes, long tails.
- Galaxy collisions are potentially tied to emphasizing spiral arms and galaxy evolution.
- Galaxy collisions condense gas, can trigger bursts of star formation.
- All elements heavier than Helium are made in stars... the heaviest ones in supernovae.
- How much of the star formation of the Universe happens in these "starbursts"???