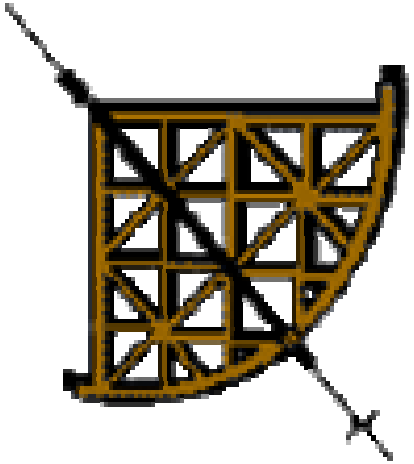
Dal *Sidereus Nuncius* alla cosmologia fisica:
la fecondità del genio galileiano



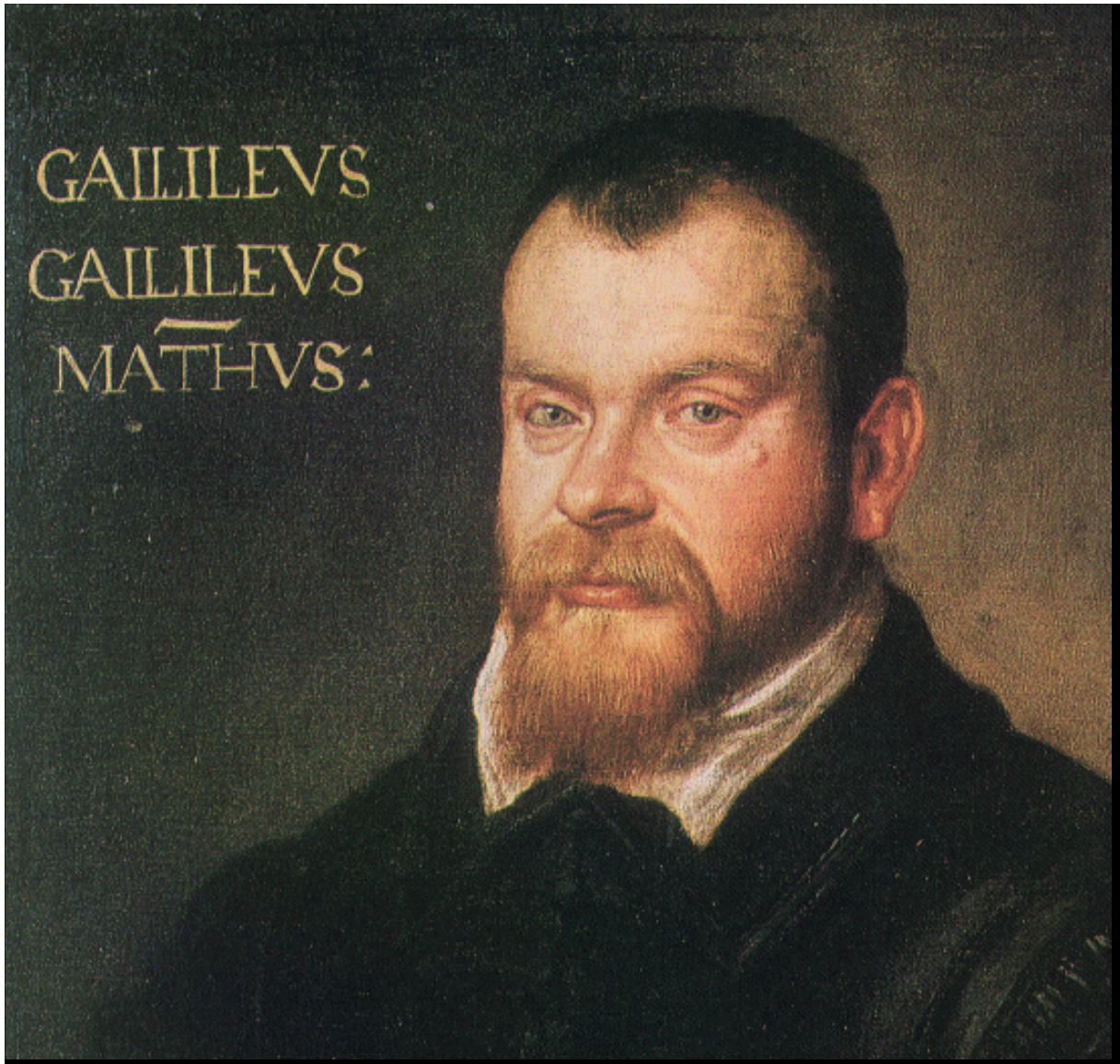
Giorgio G.C. Palumbo

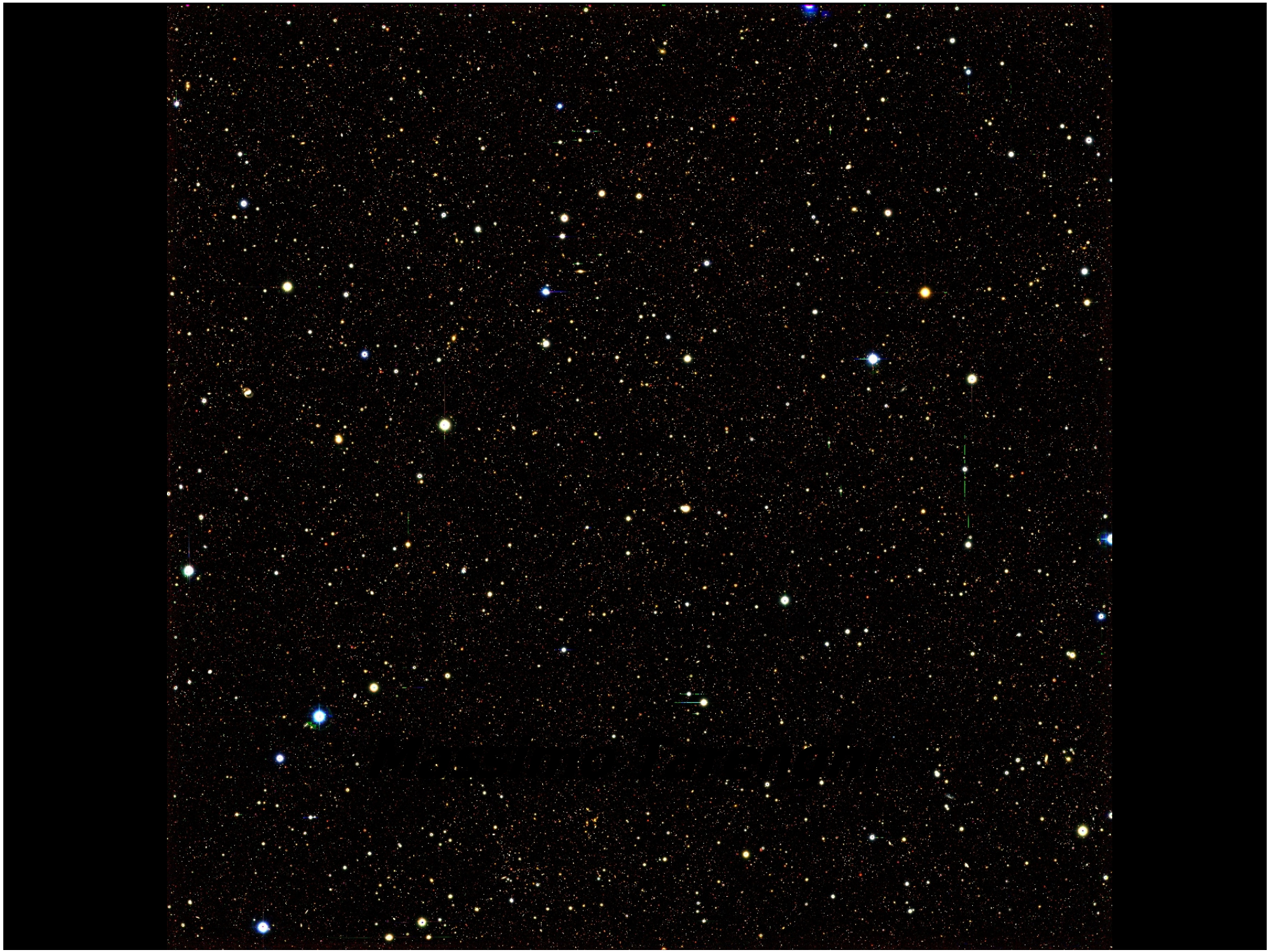
Università degli Studi di Bologna

Dipartimento di Astronomia

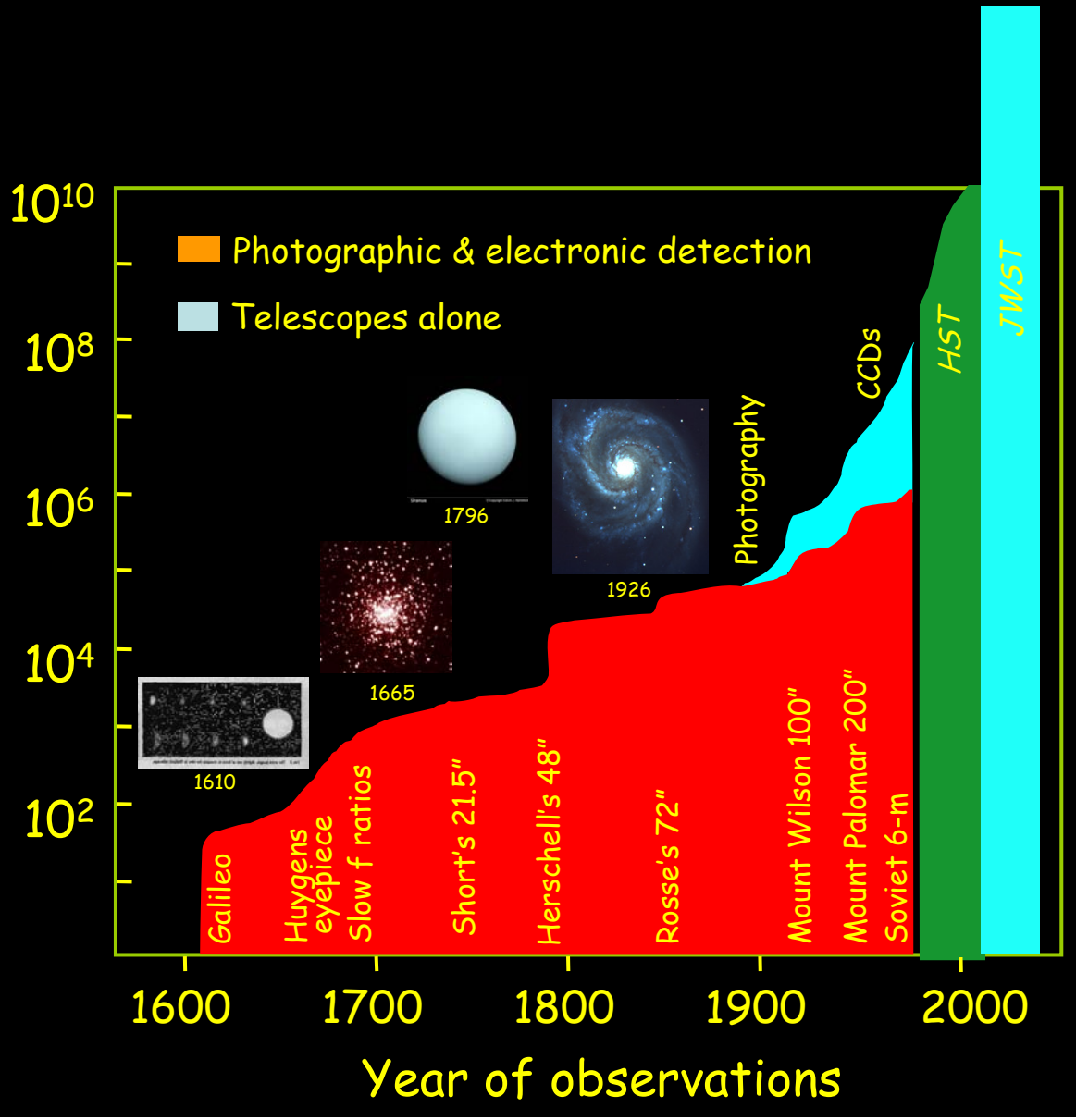
In un documento datato 25 Settembre 1608 del governo di Zeeland ai propri delegati al governo generale delle Netherlands li esorta ad aiutare il consegnatario " che dice di avere un certo aggeggio per mezzo del quale tutte le cose a grandi distanze appaiono come se fossero vicine guardando attraverso vetri che egli afferma essere una nuova invenzione"

Hans Lippersheim (Lippershey) 1570-1619, Wesel, Middelburg

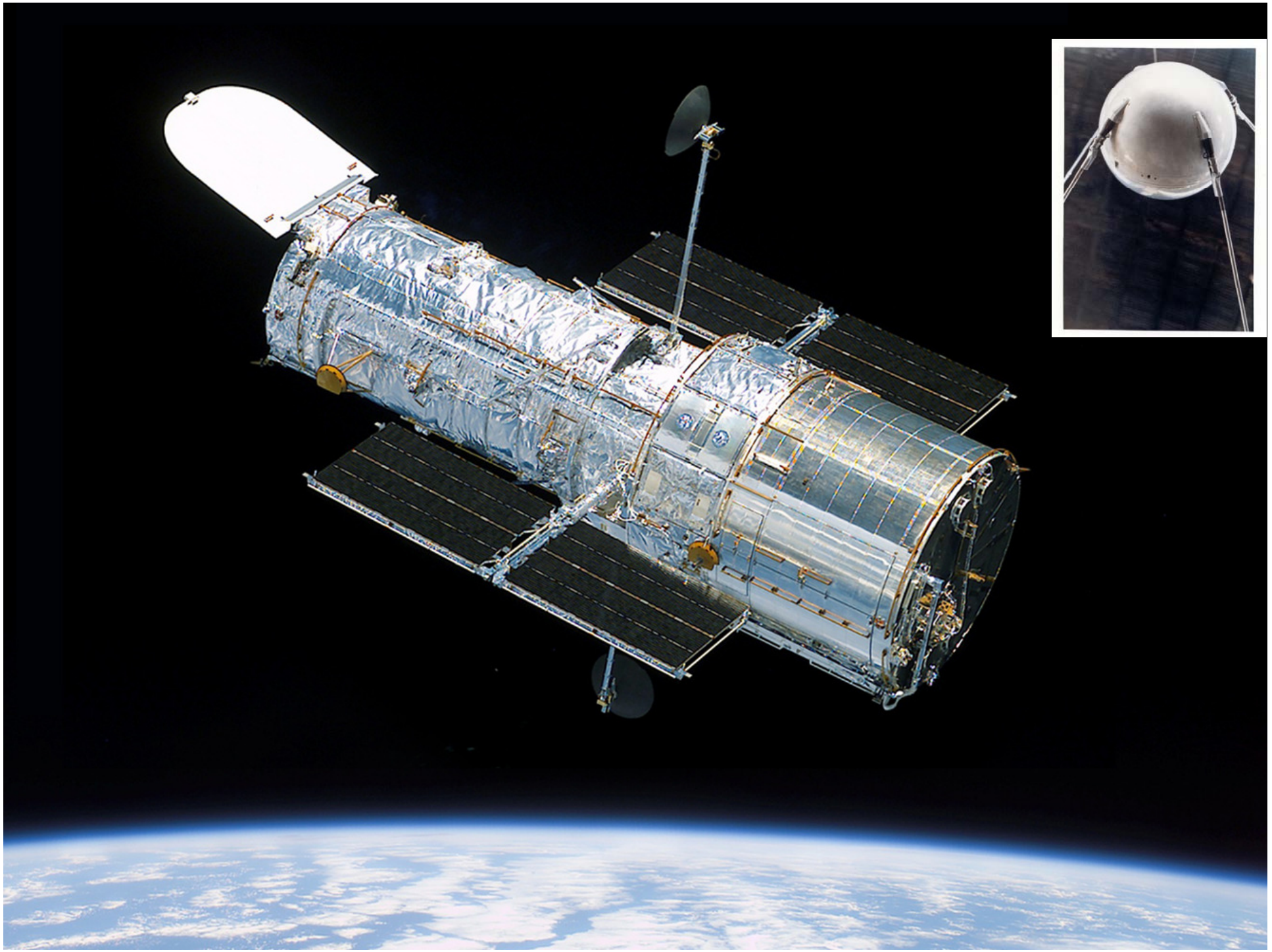

GAILILEVS
GAILILEVS
MATHVS:



Miglioramento rispetto all'occhio umano

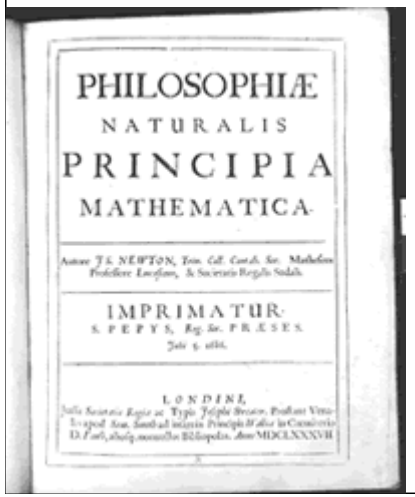


Adapted from *Cosmic Discovery*, M. Harwit



La legge di gravitazione universale

Isaac Newton (1643-1727)


PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA

IMPRIMATUR
S. PEPYS, Reg. Soc. PRÆSES.
Julii 5. 1686.

LONDINI,

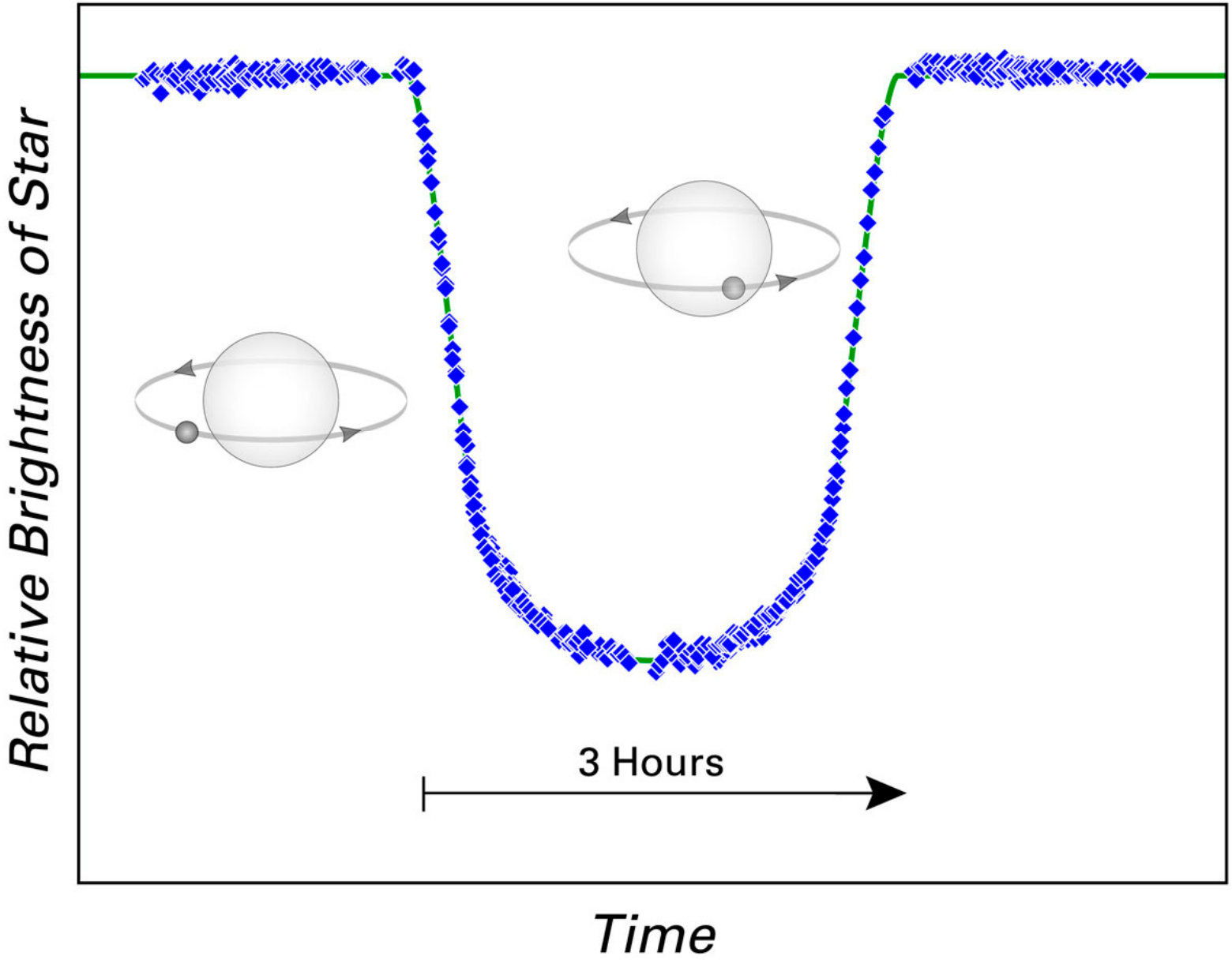
1687

$$F = -G\frac{M_1 M_2}{R^2}$$

Da Newton a Kepler

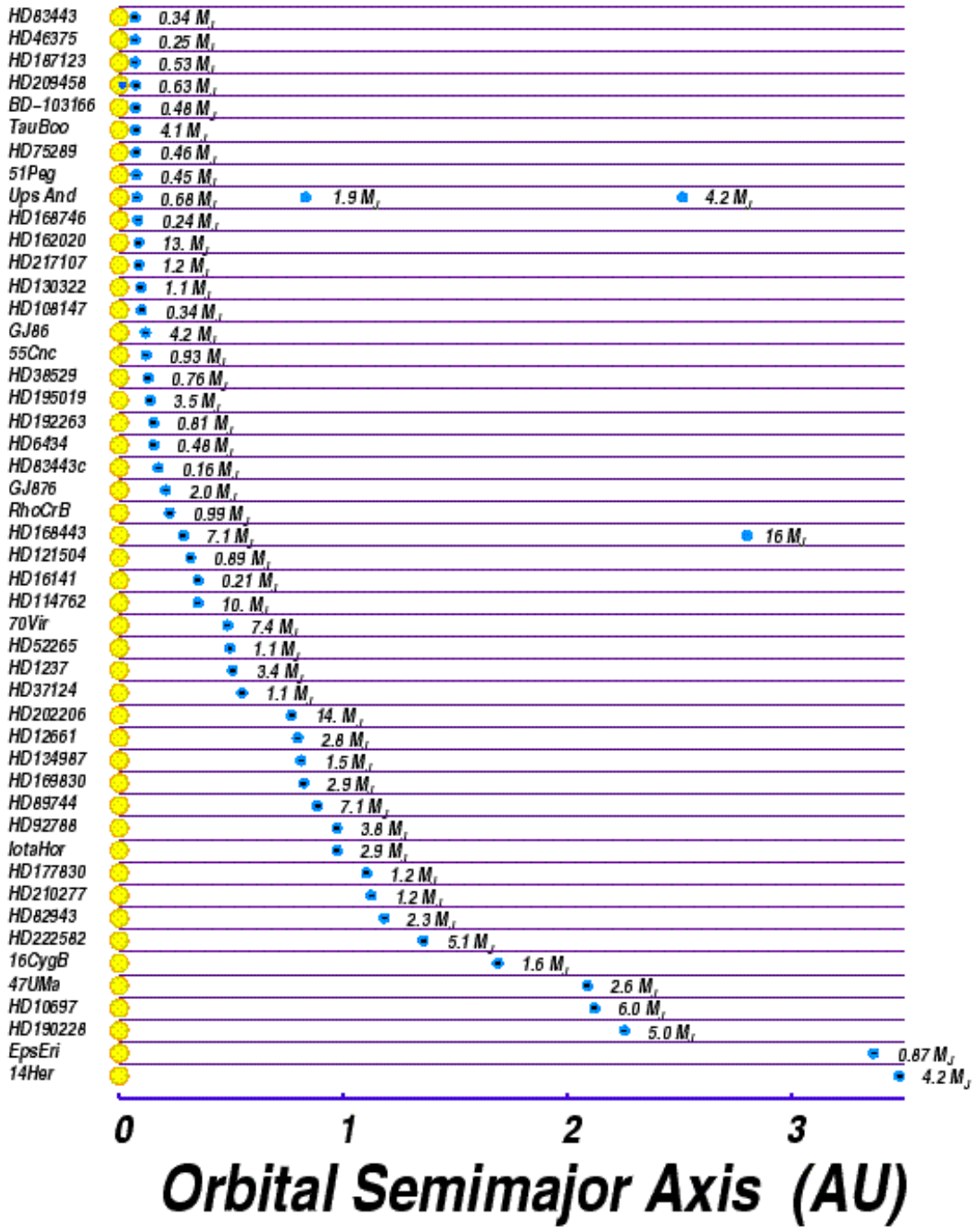
$$\frac{R^3}{P^2} = C$$

Planet Eclipsing Star HD 209458

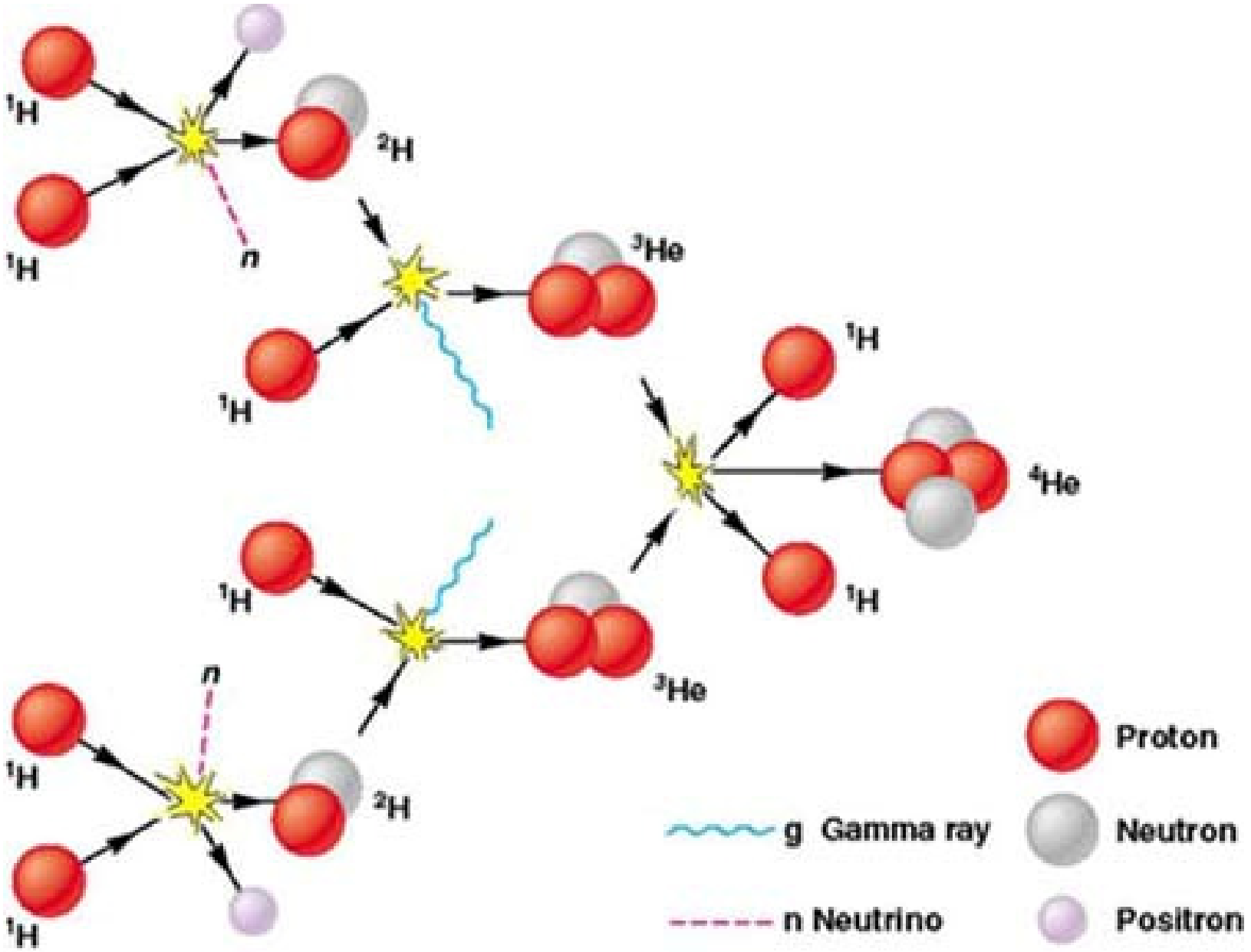


Fino a dieci anni fa non sapevamo neppure se esistessero pianeti orbitanti altre stelle. Oggi se ne conoscono 180....

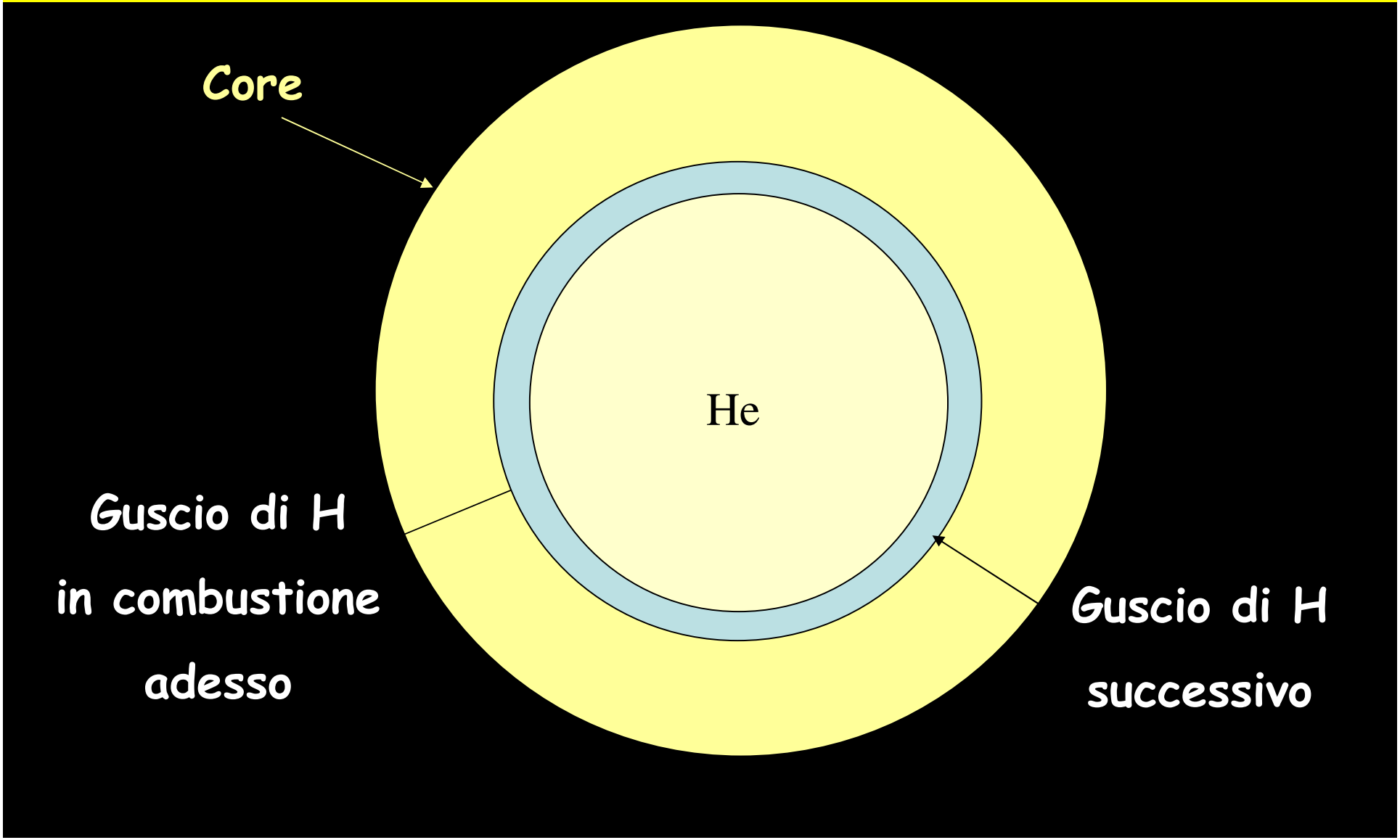
La sfida e' ottenere una immagine del planeta: rapporto del contrasto richiesto $1:10^{-7}$ → $1:10^{-10}$



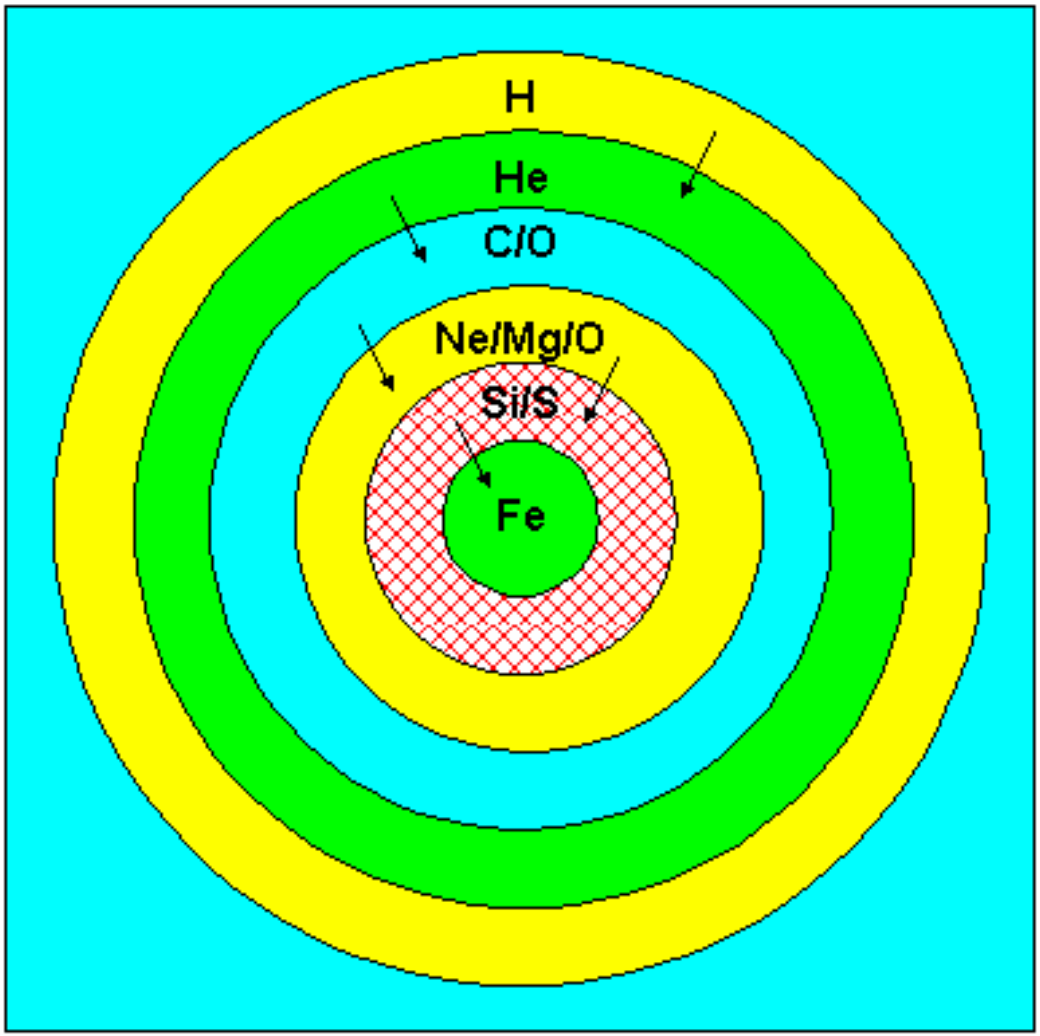
La sorgente di energia delle stelle



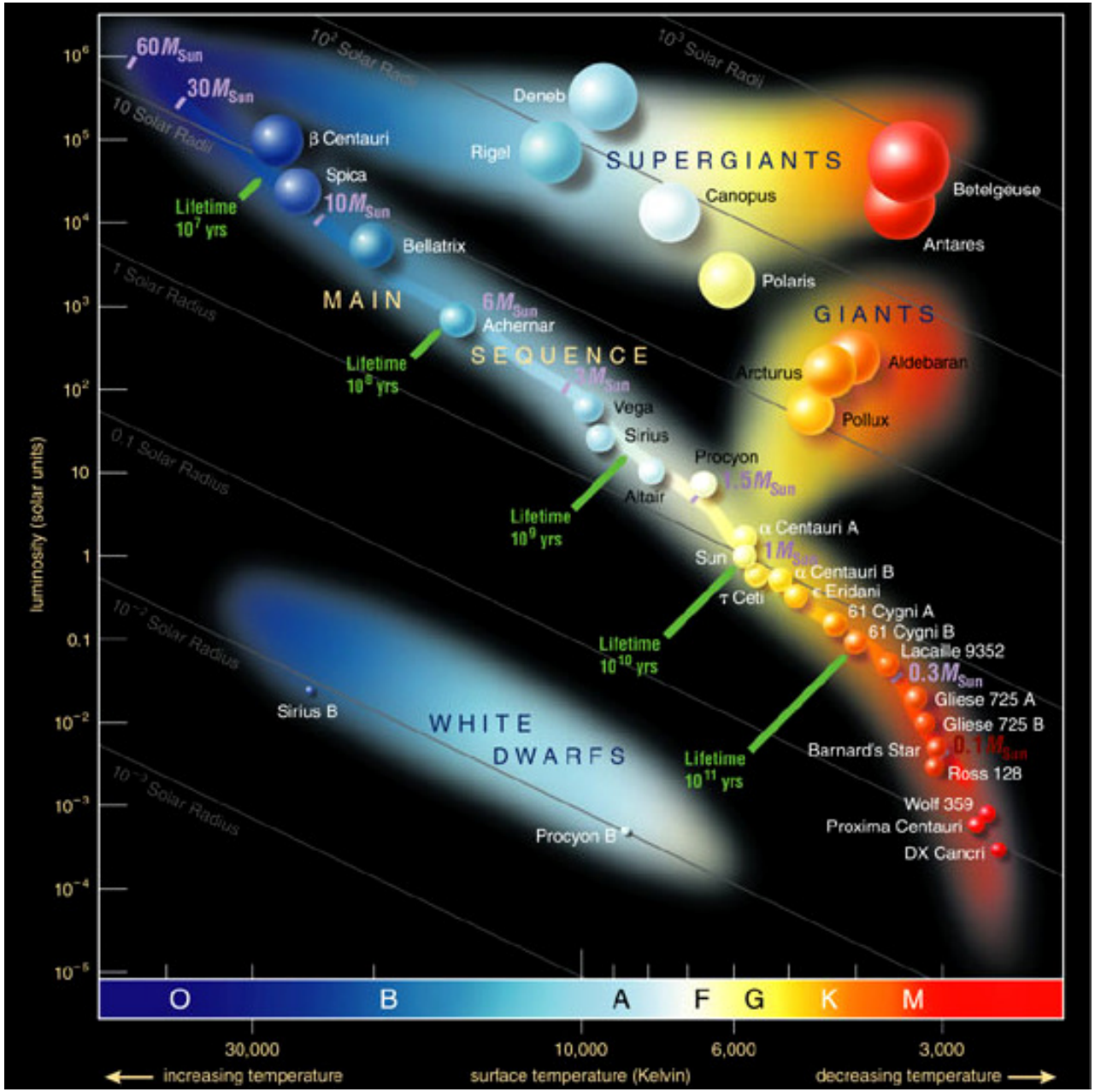
La "cucina" stellare

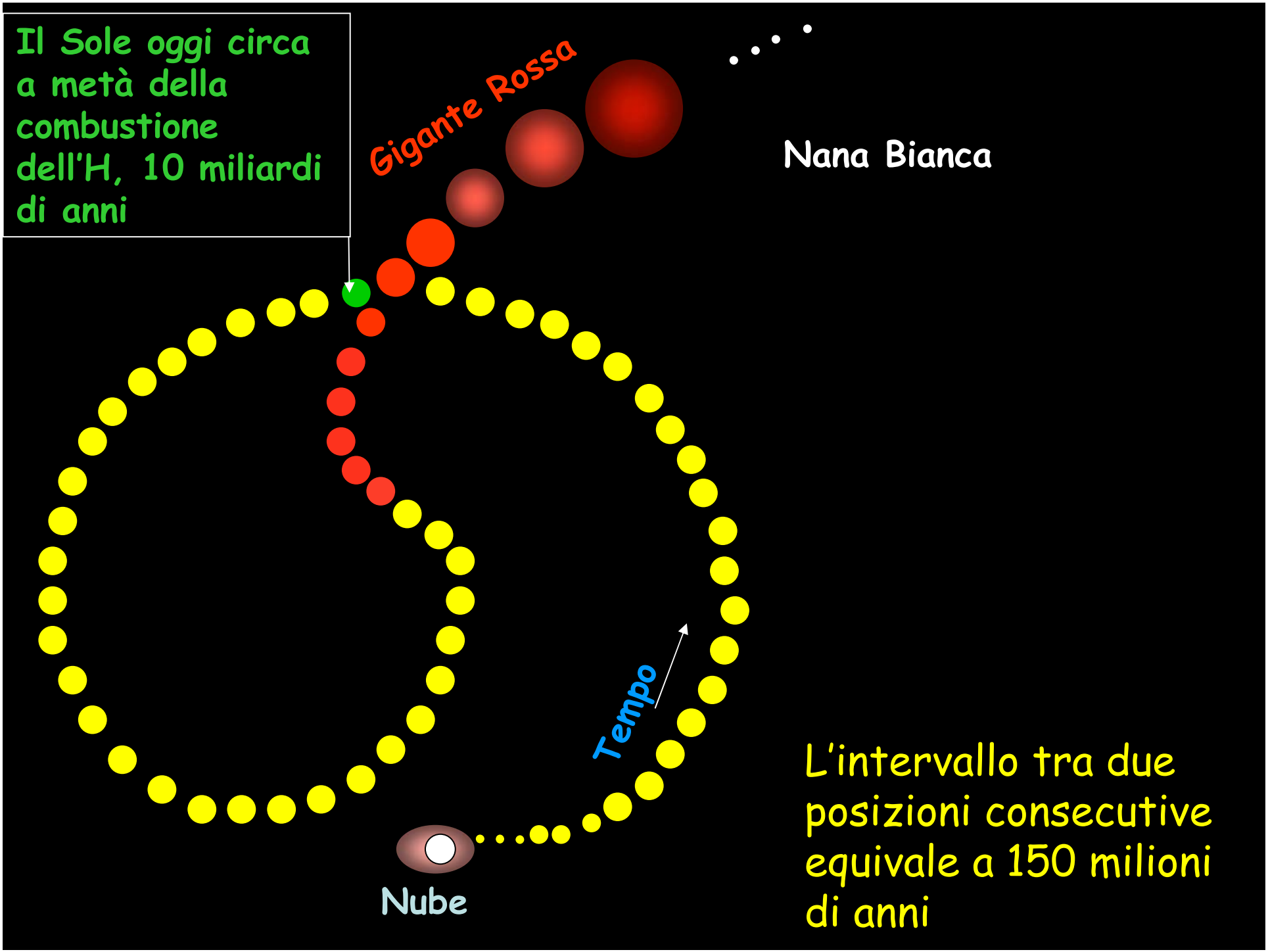


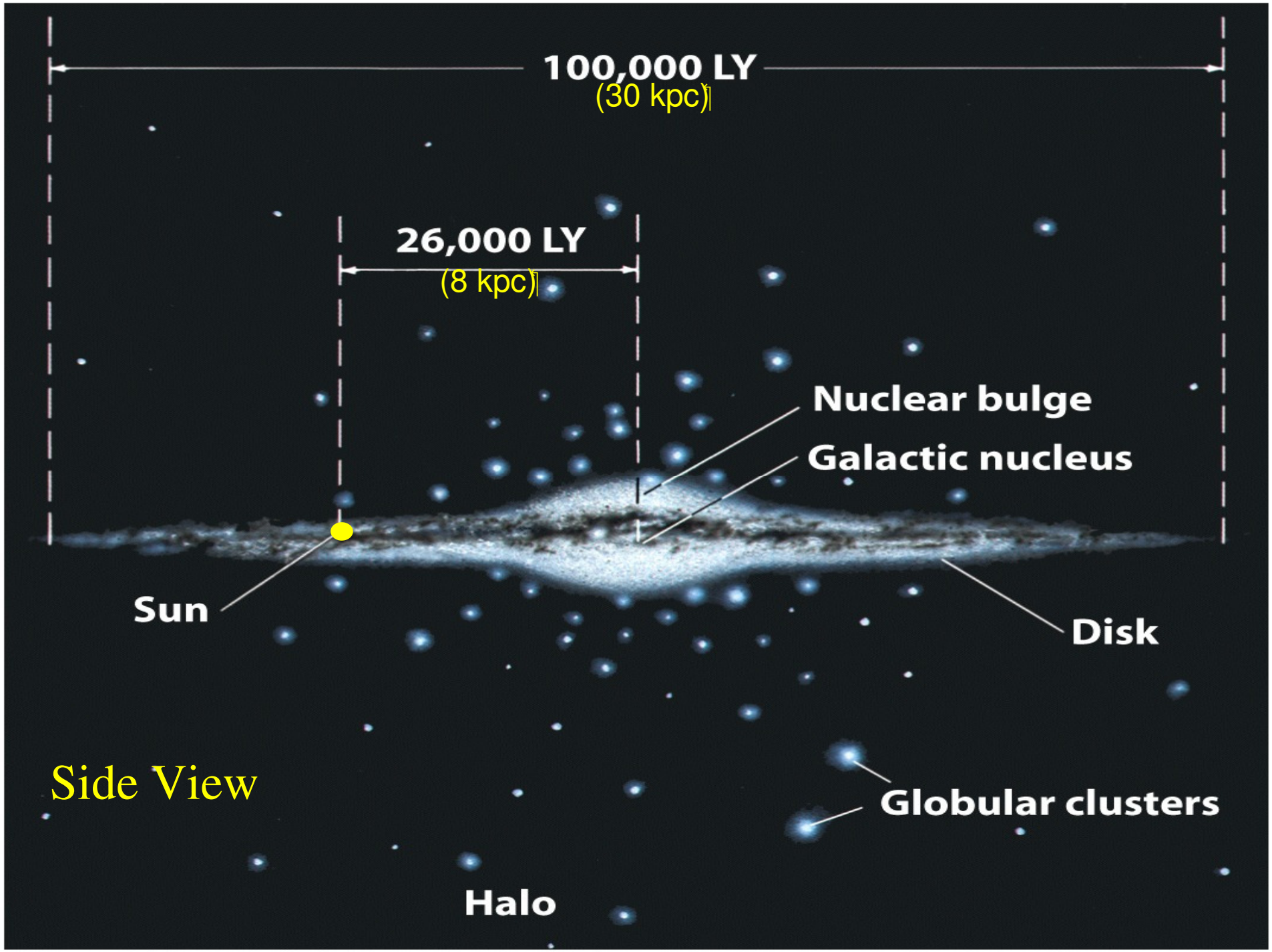
Struttura di una stella Pre-SN di 20 masse solari



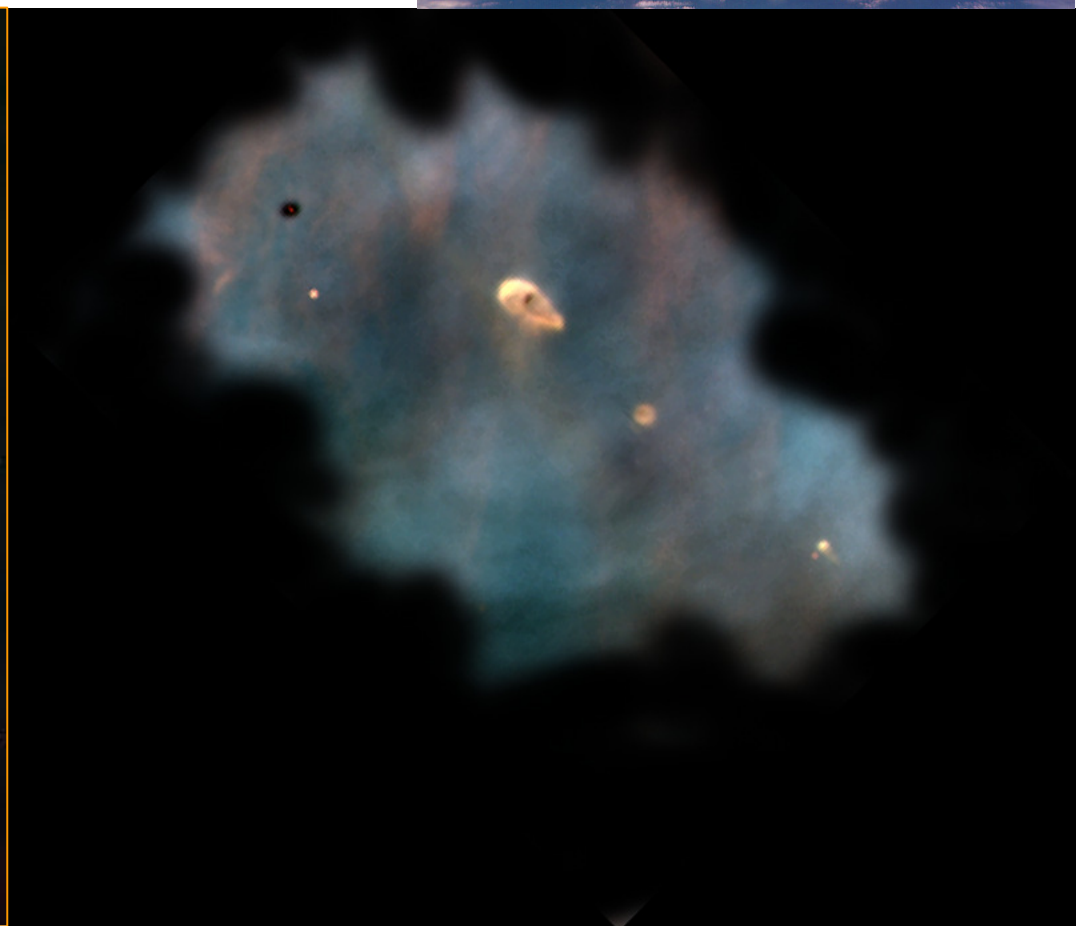
Evoluzione stellare




Il Sole oggi circa a metà della combustione dell'H, 10 miliardi di anni
Gigante Rossa
Nana Bianca
Tempo
Nube
L'intervallo tra due posizioni consecutive equivale a 150 milioni di anni

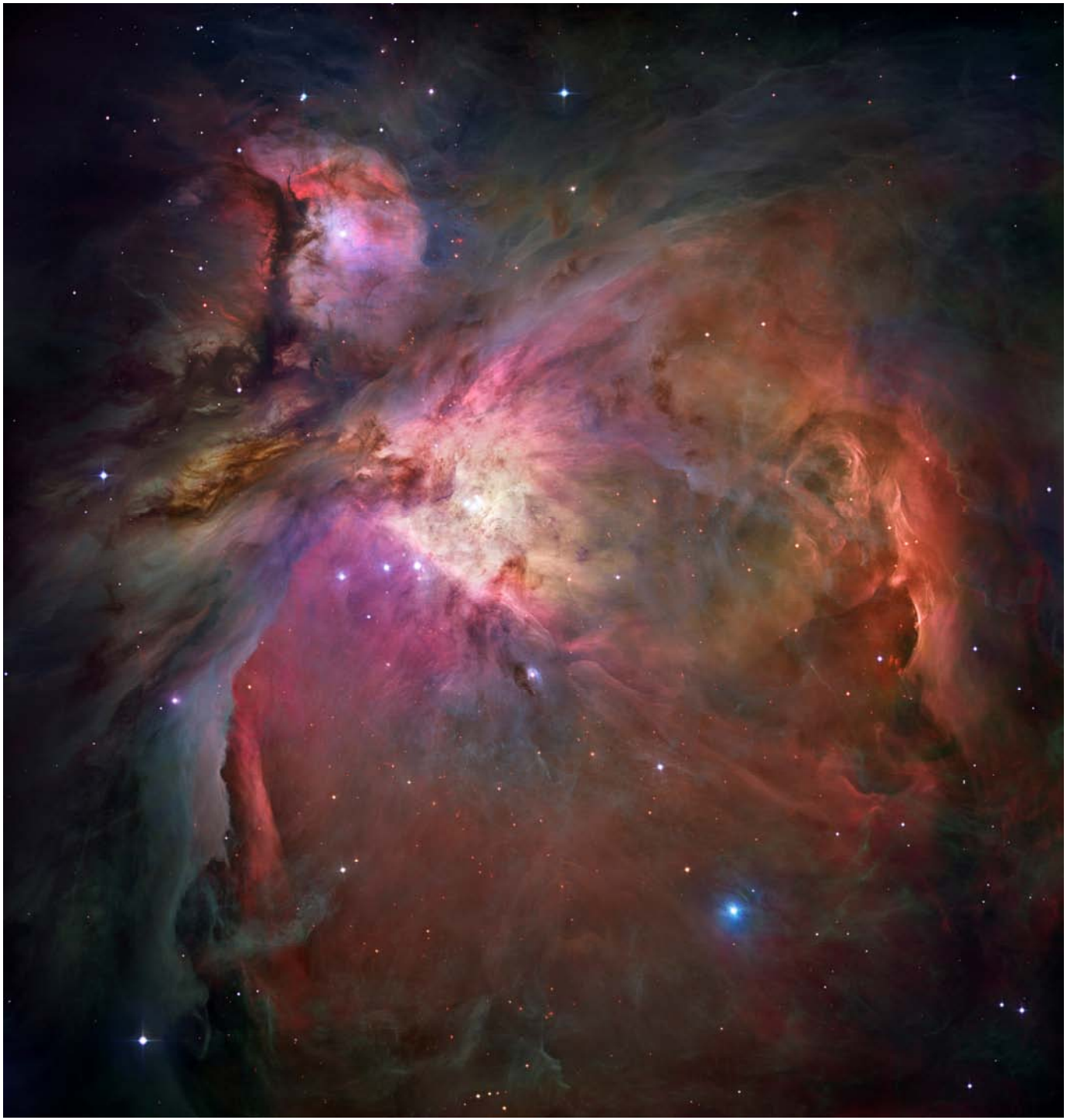

100,000 LY
(30 kpc)
26,000 LY
(8 kpc)
Nuclear bulge
Galactic nucleus
Sun
Disk
Side View
Globular clusters
Halo

Formazione stellare



Carina Nebula

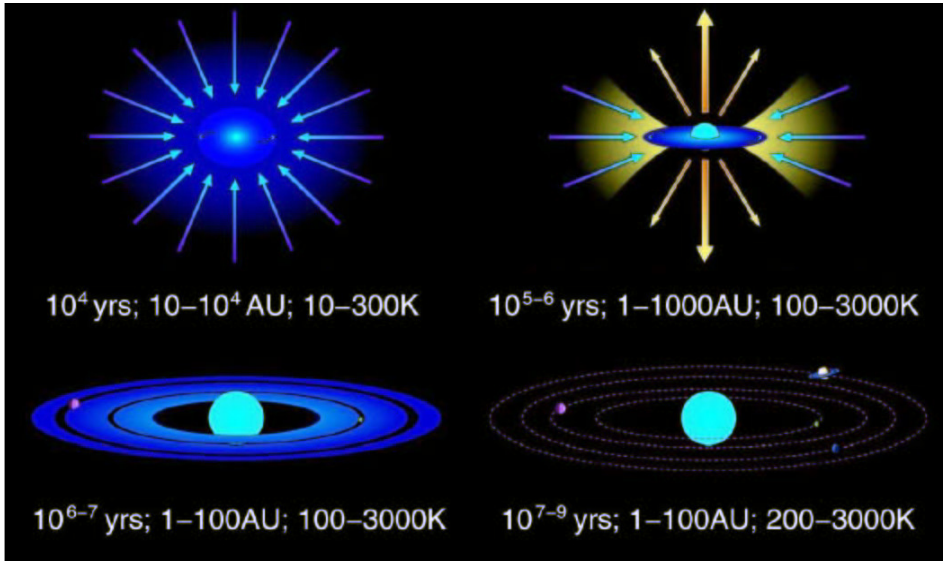
Hubble Heritage

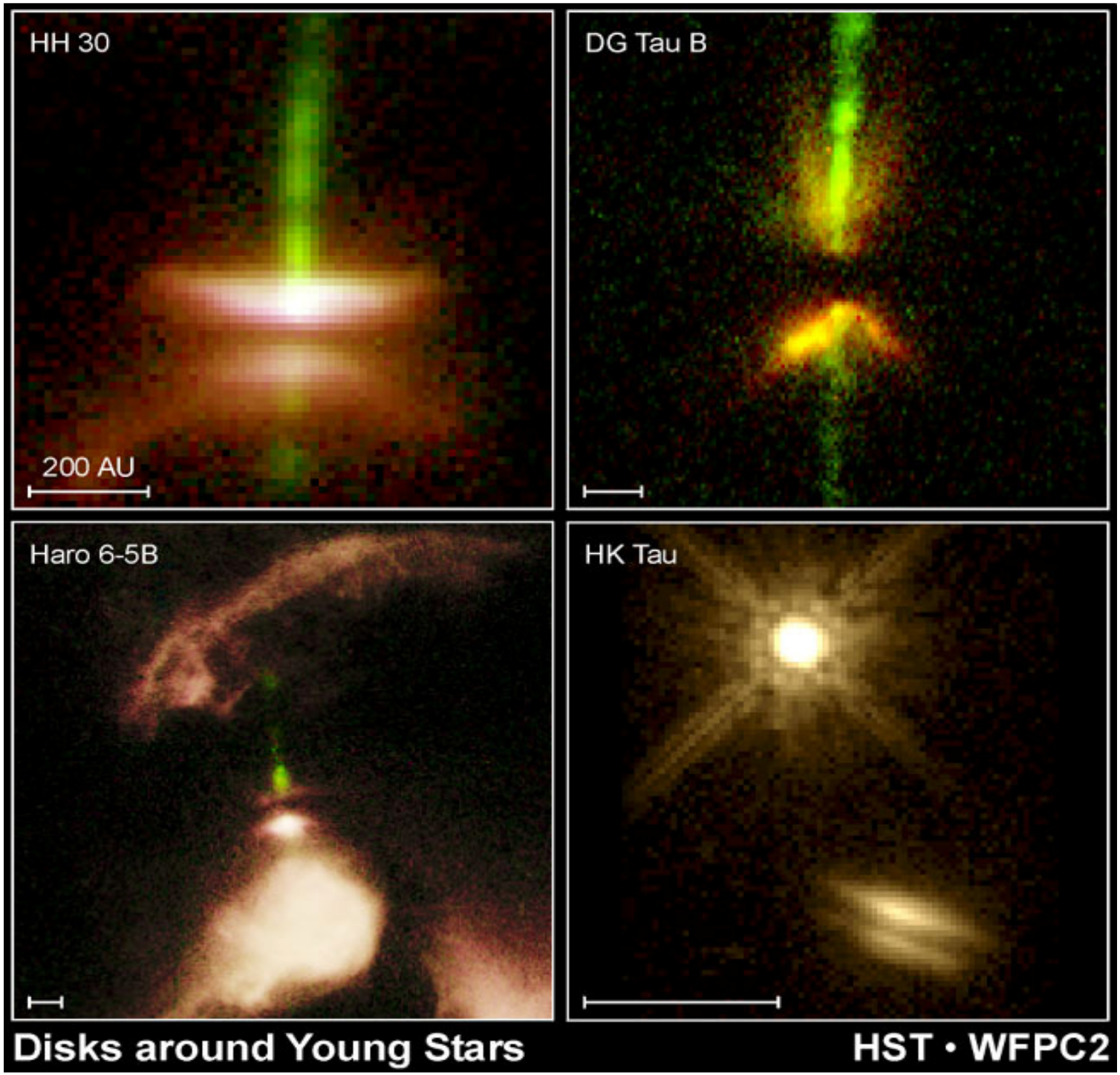


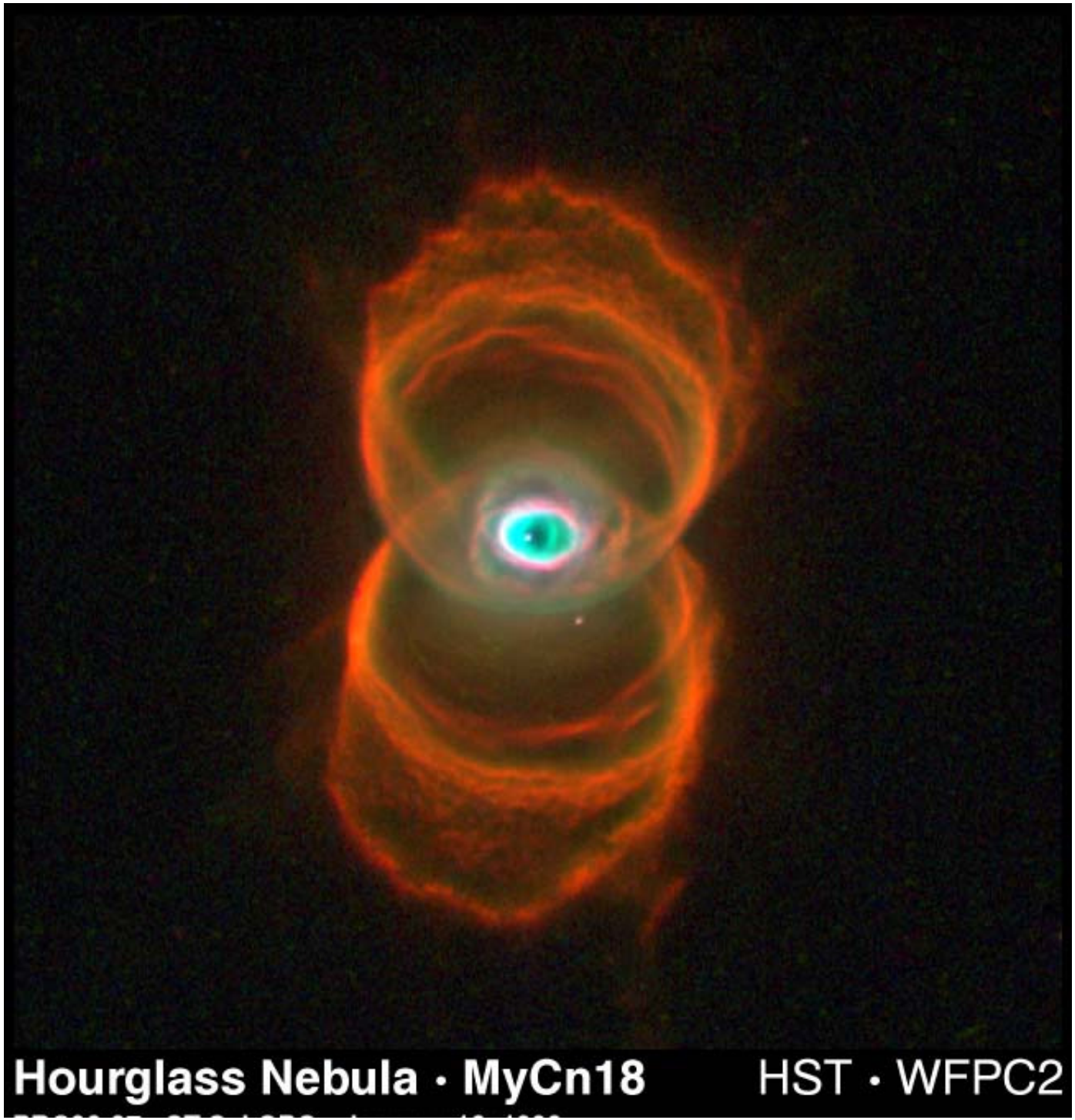

Trifid Nebula • M20
HST • WFPC2

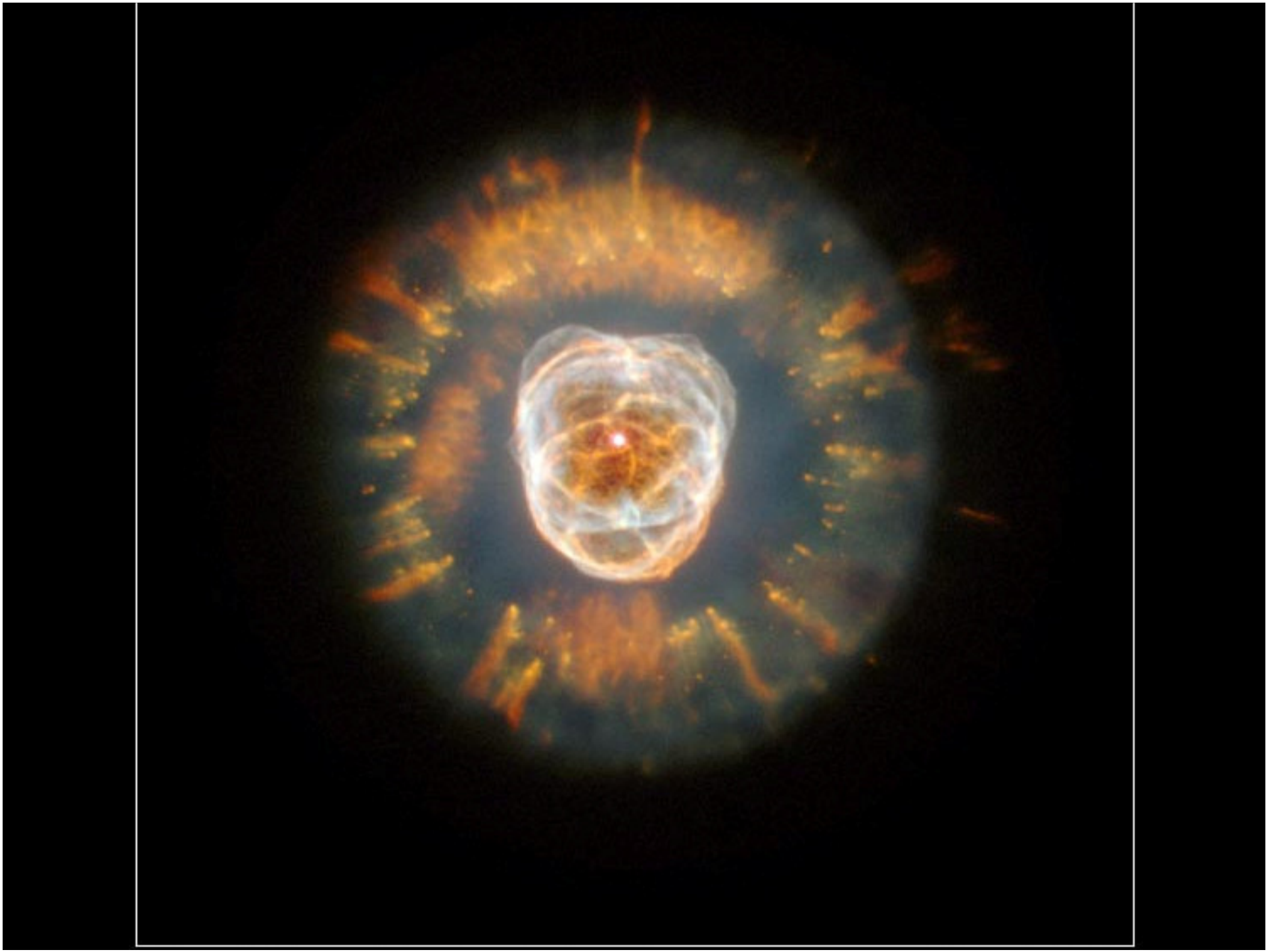
Nascita di stelle e sistemi protoplanetari

Eagle Nebula HST




HH 30
200 AU
DG Tau B
Haro 6-5B
HK Tau
Disks around Young Stars
HST • WFPC2


Hourglass Nebula · MyCn18
HST · WFPC2

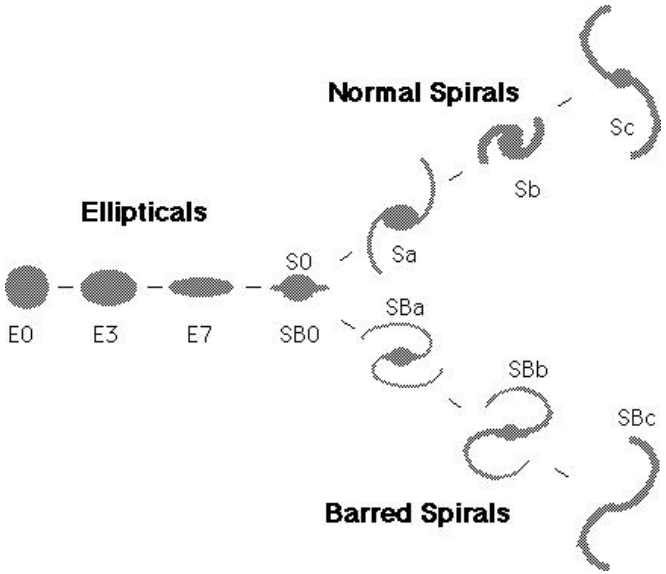


Edwin P. Hubble

(1889-1953)

Mt. Wilson
Observatory
Pasadena, CA

Galassie



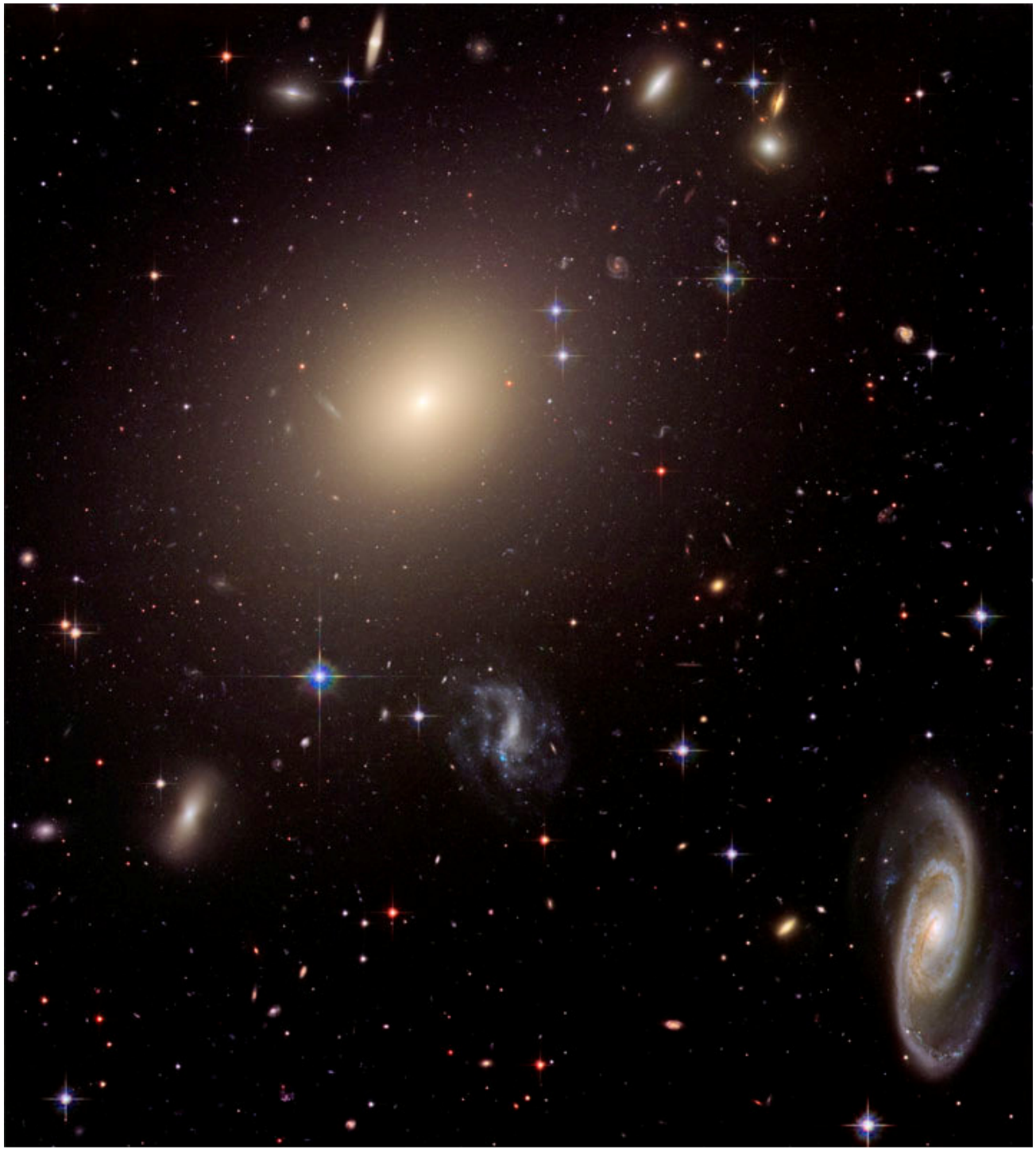
La sequenza di Hubble

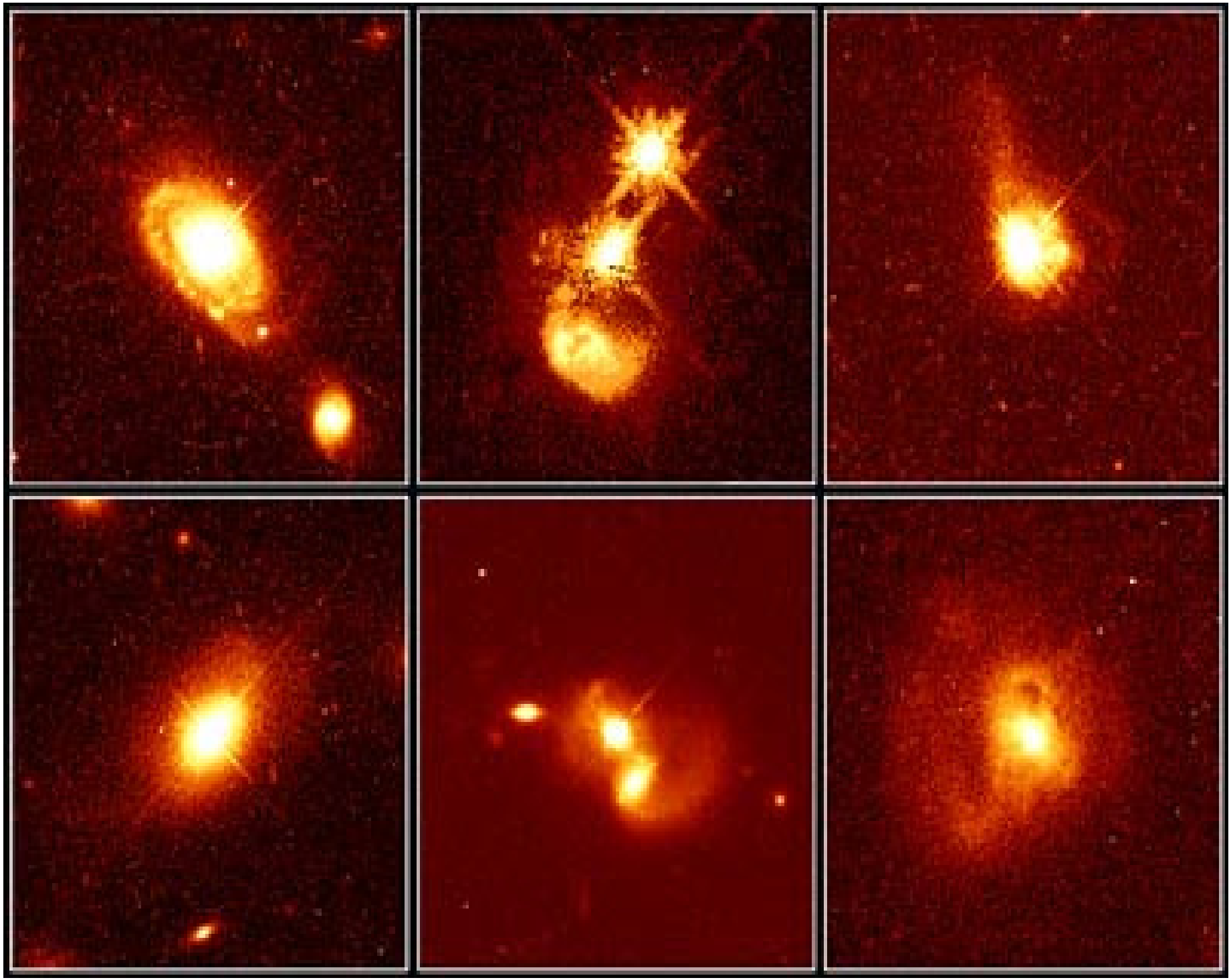
Galaxies NGC 2207 and IC 2163

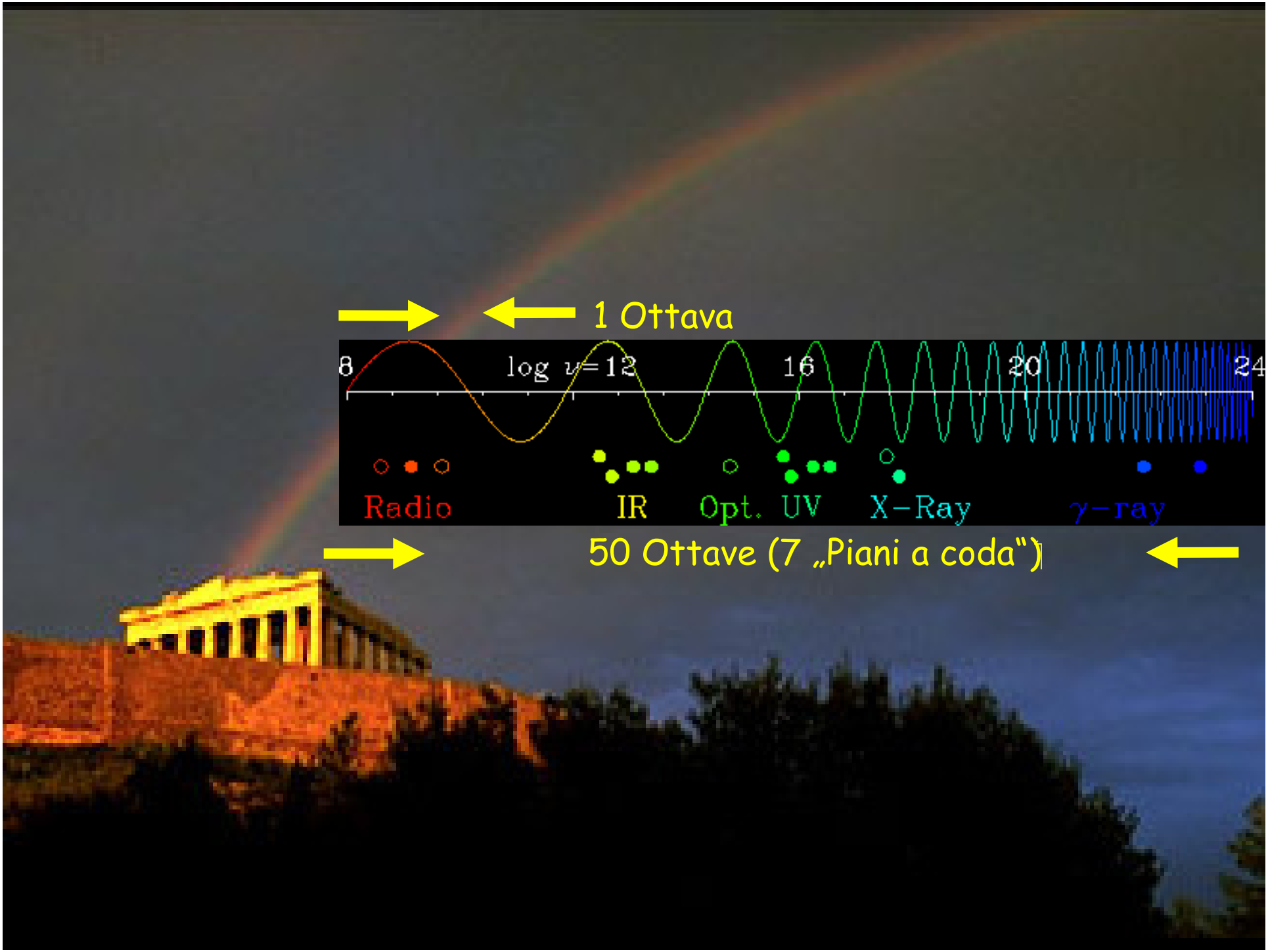
Hubble Heritage

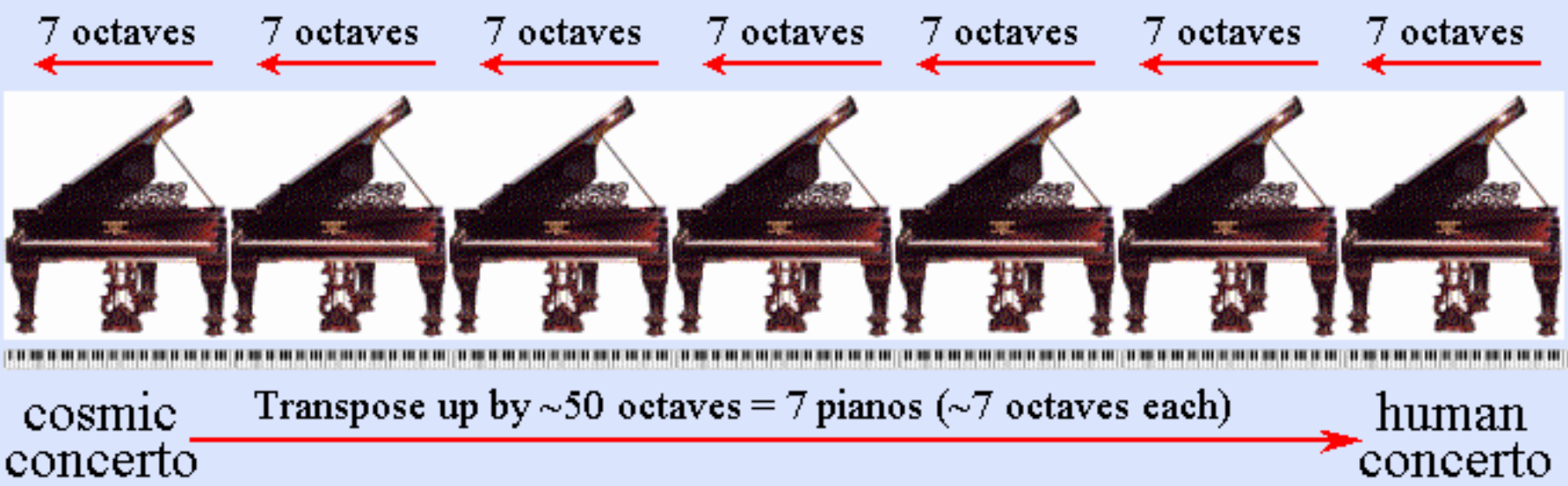
NASA and The Hubble Heritage Team (STScI) • Hubble Space Telescope WFPC2 • STScI-PRC99-41

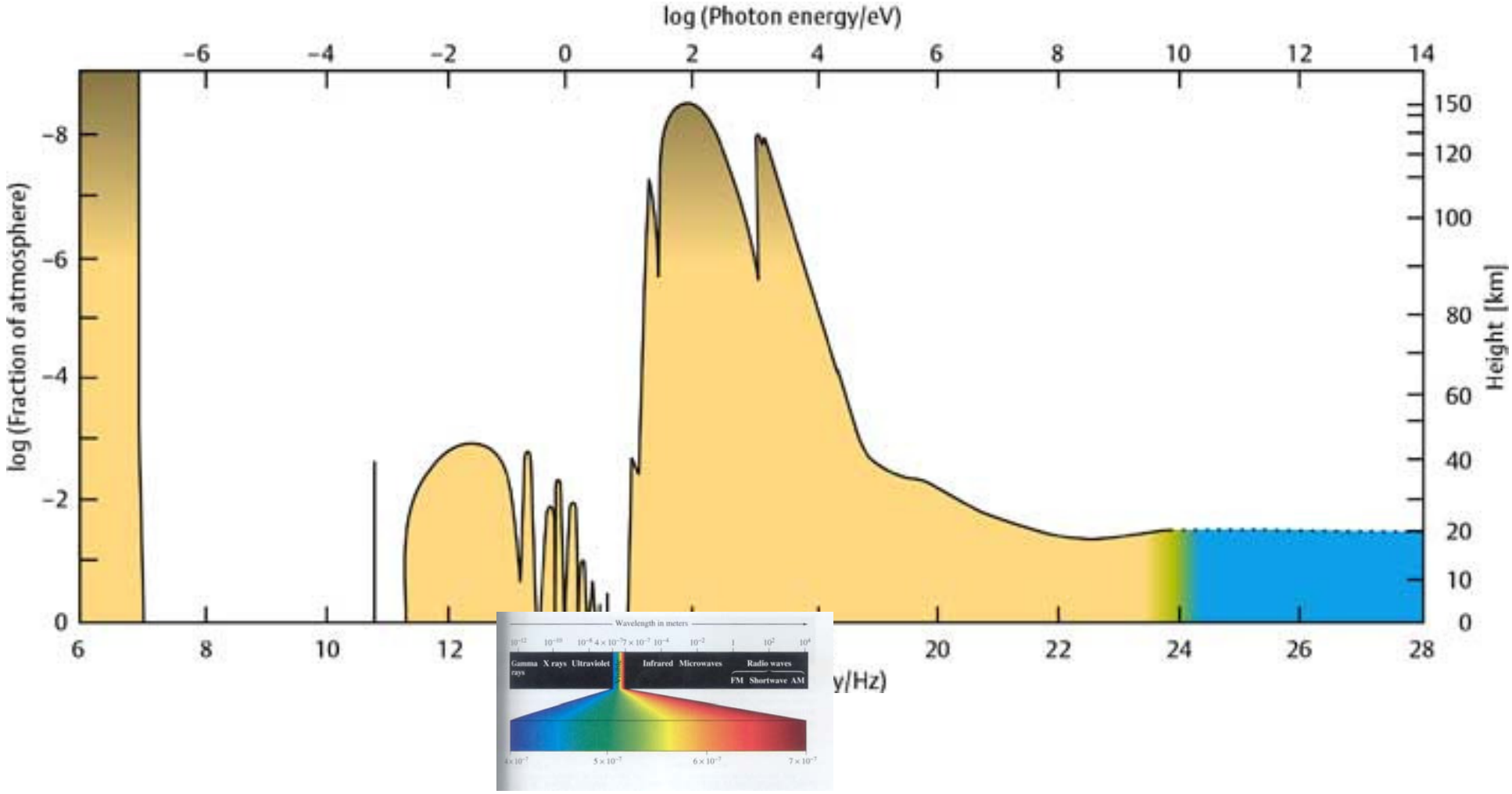
Ammassi di Galassie






1 Ottava
8
log ν=12
16
20
24
Radio
IR
Opt.
UV
X-Ray
γ-ray
50 Ottave (7 „Piani a coda“)


7 octaves
7 octaves
7 octaves
7 octaves
7 octaves
7 octaves
7 octaves
cosmic concerto
Transpose up by ~50 octaves = 7 pianos (~7 octaves each)
human concerto



Trasparenza atmosferica alla radiazione elettromagnetica

Edward Hopper

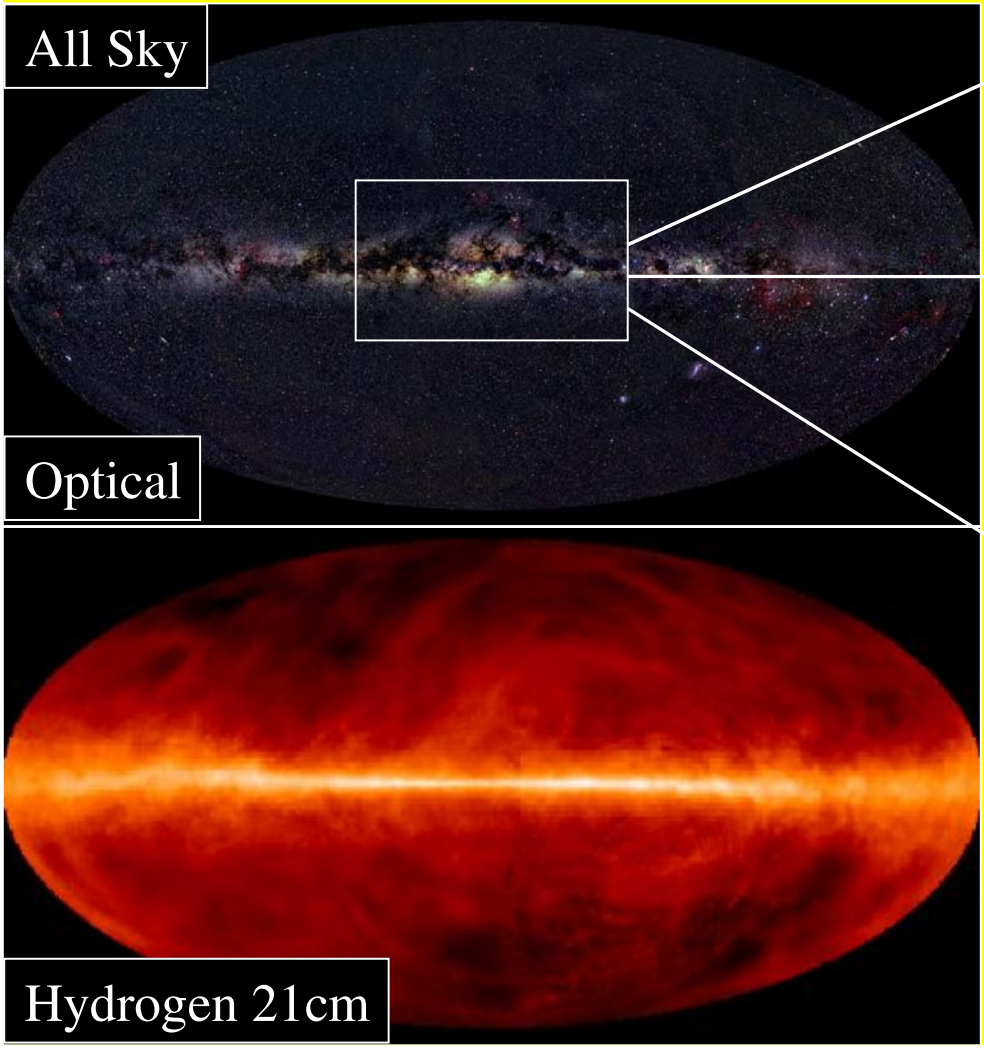
Rooms by the sea

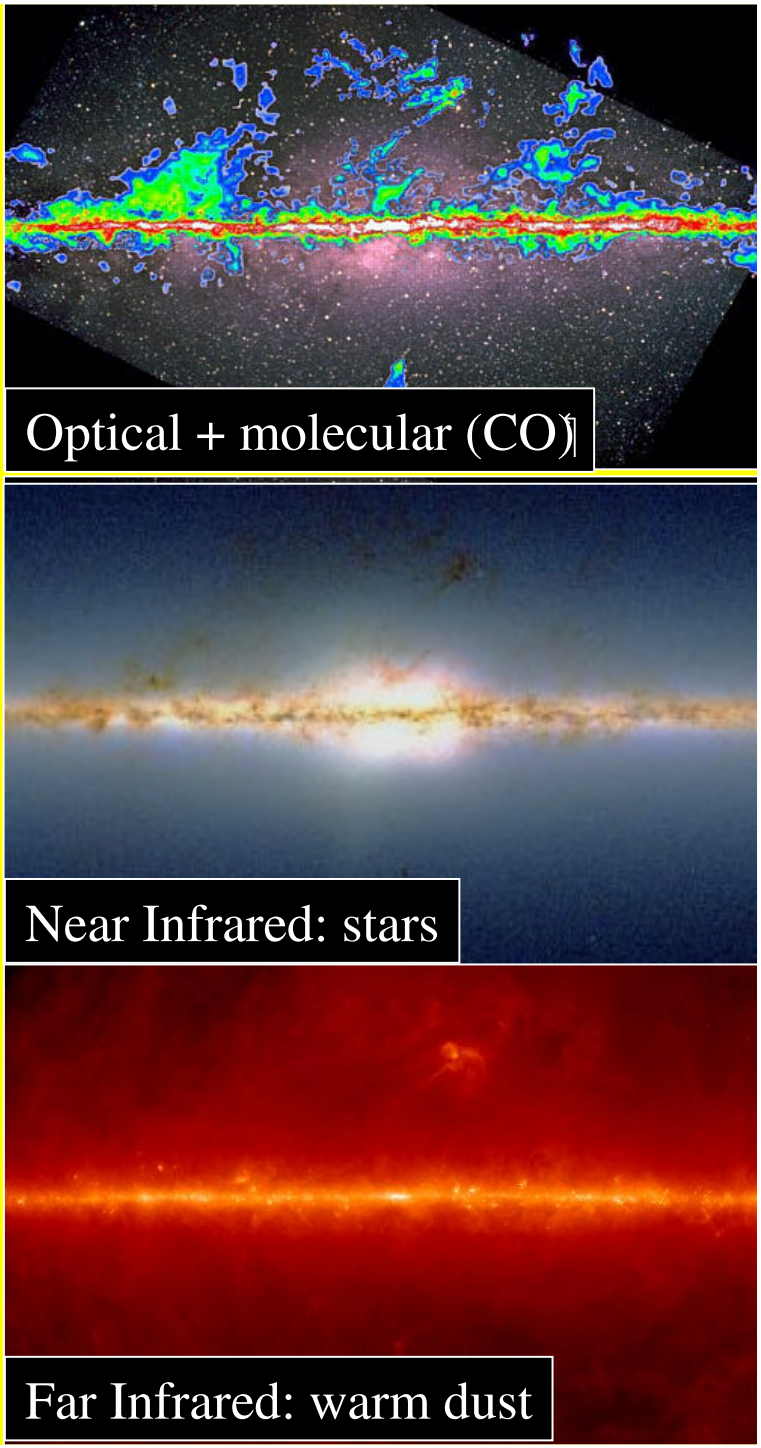
(1951)

Il caso favorisce solo le menti preparate

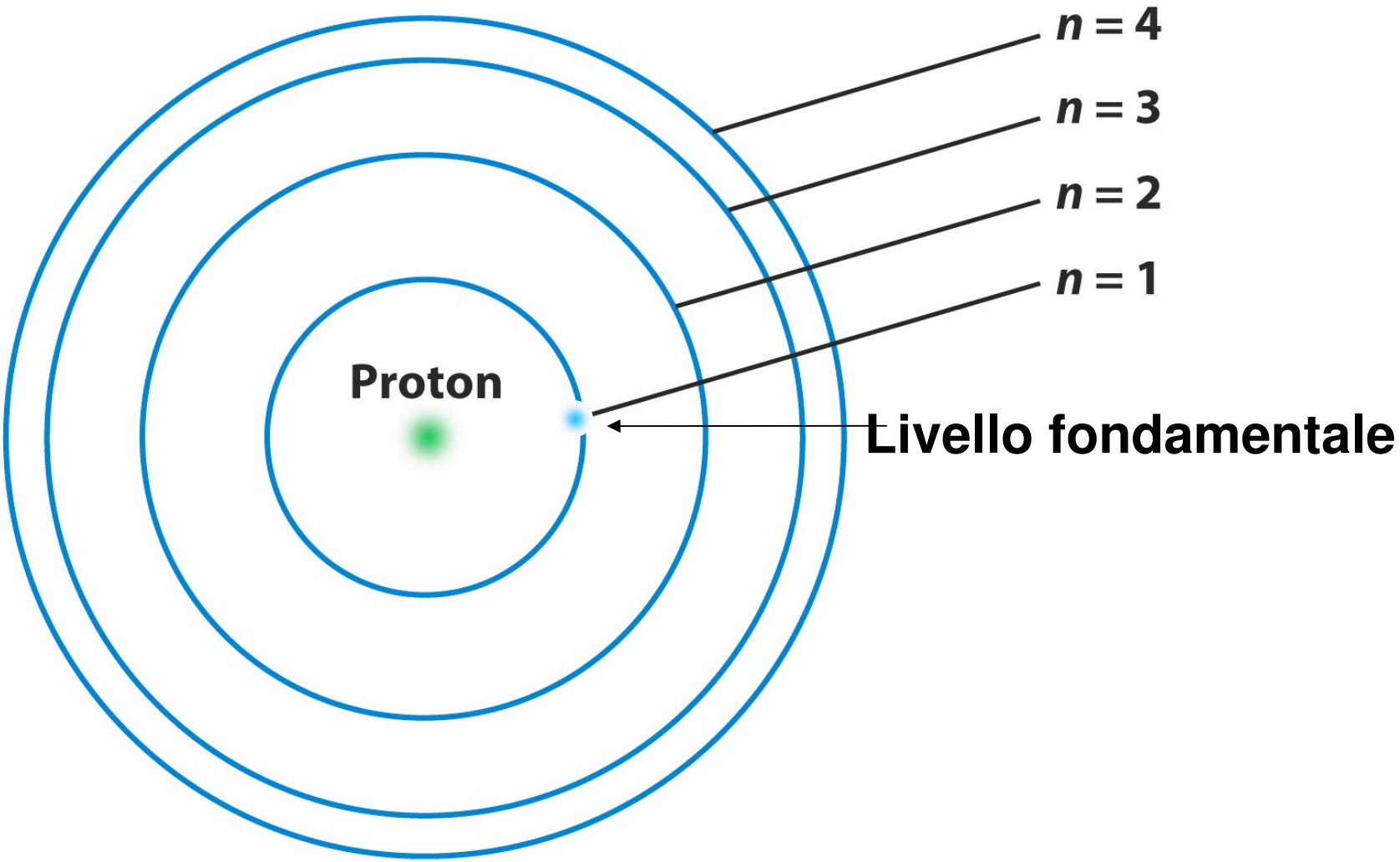
Louis Pasteur

Ottico/Infrarosso/Radio



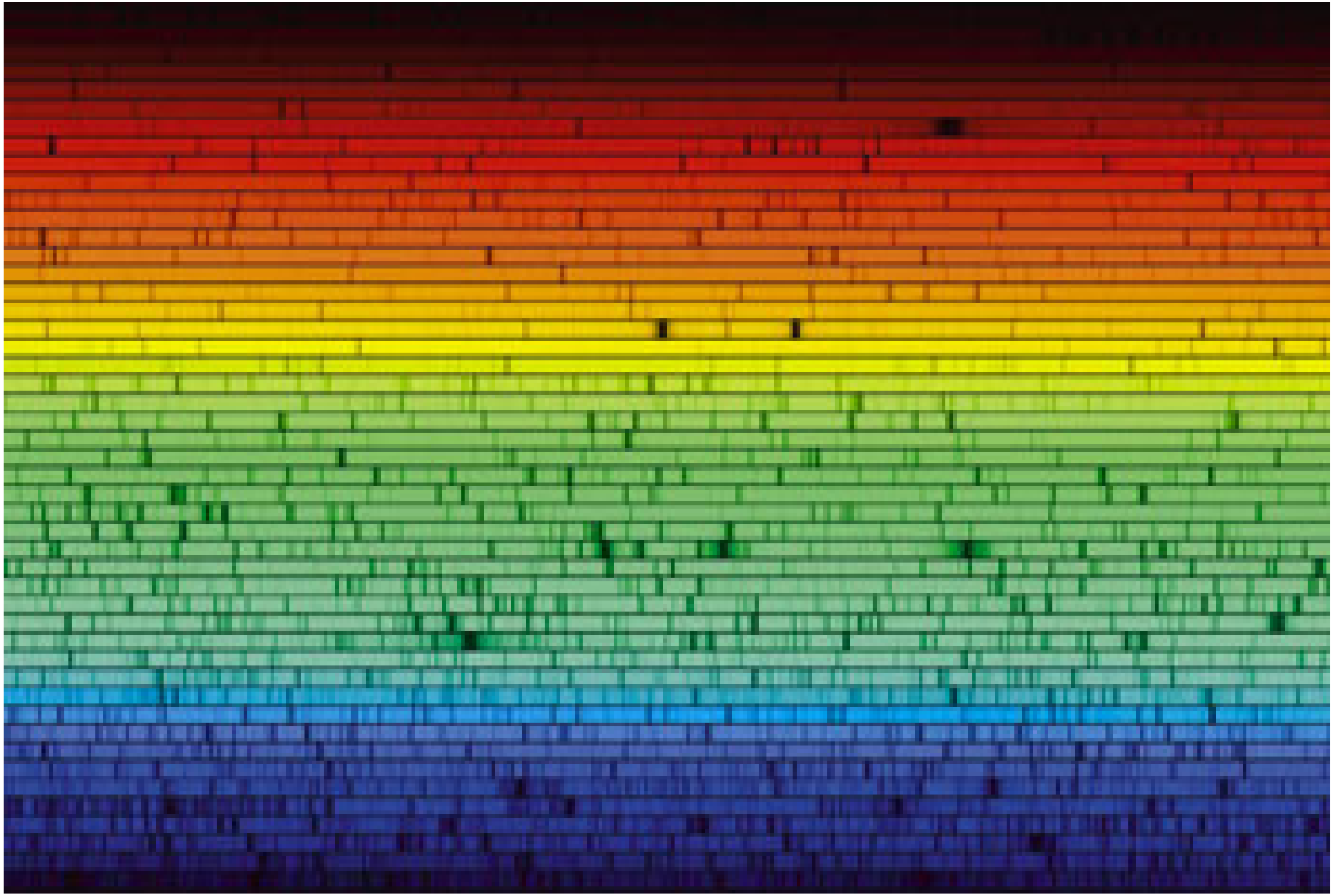


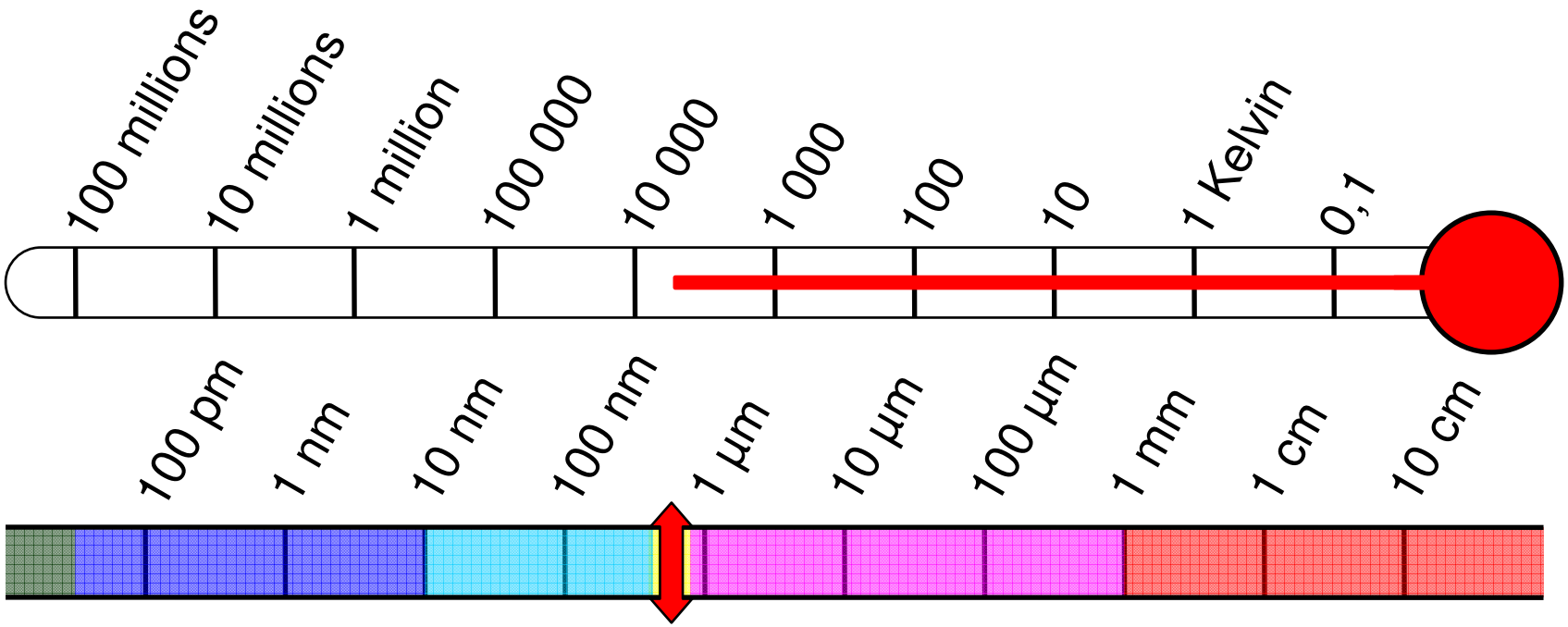
Struttura Atomica



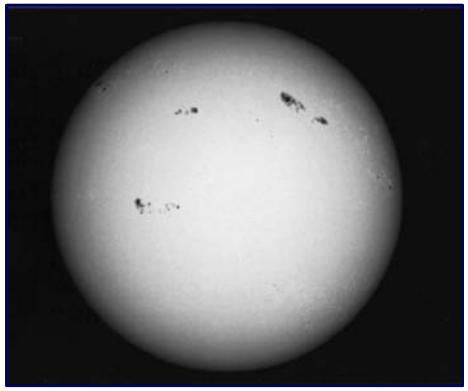
Atomo di H

Fine dell' 800 lo spettro del Sole

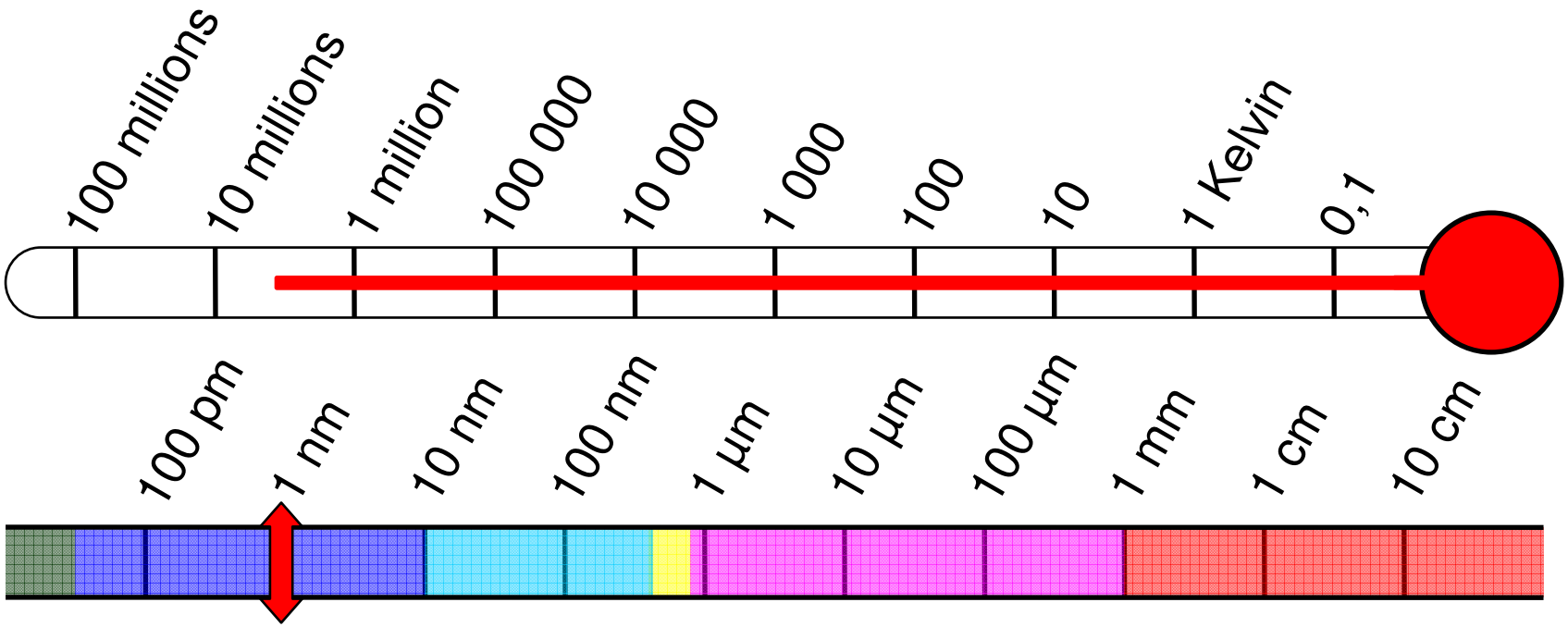




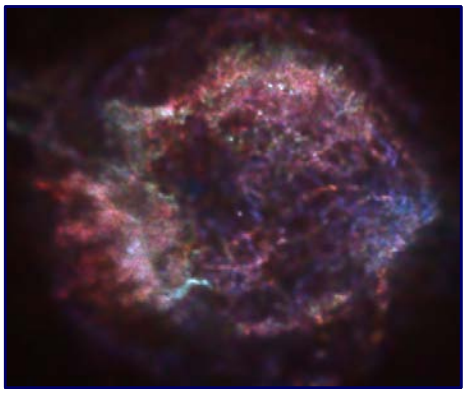
Il VISIBILE



Il SOLE

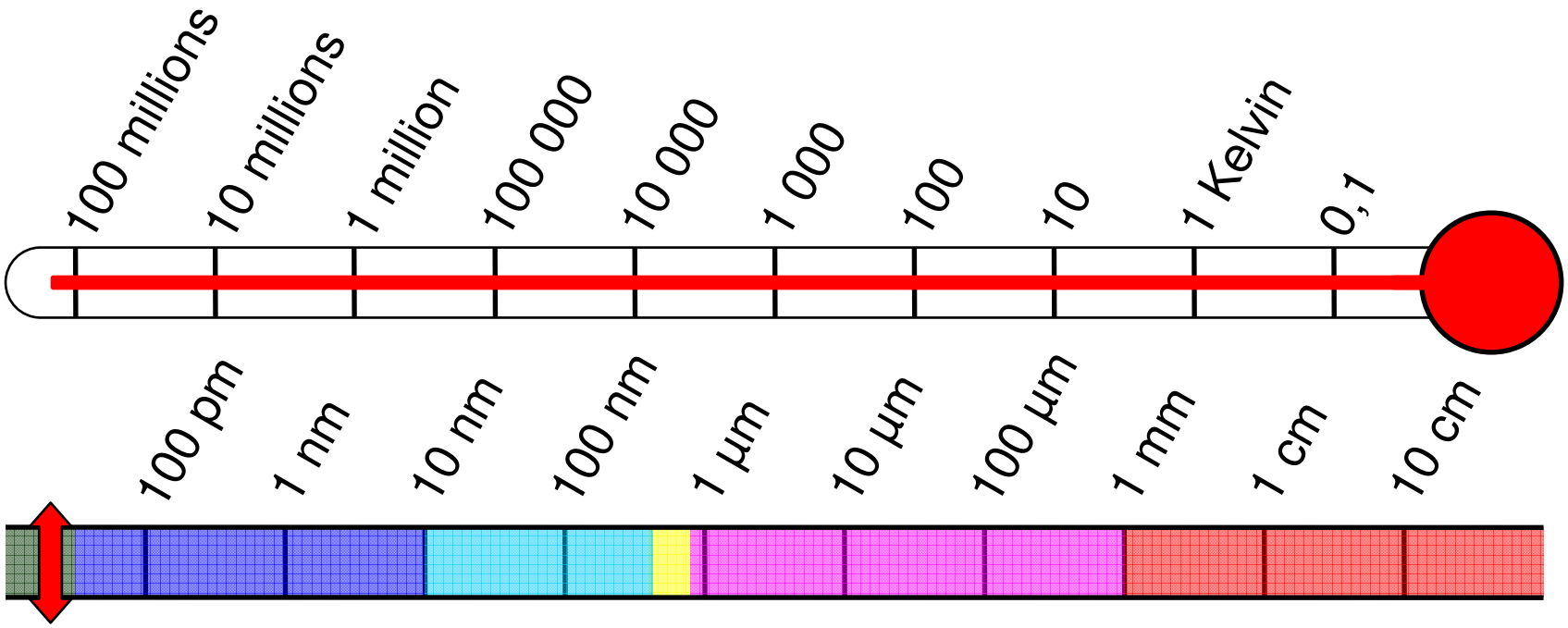


I RAGGI X

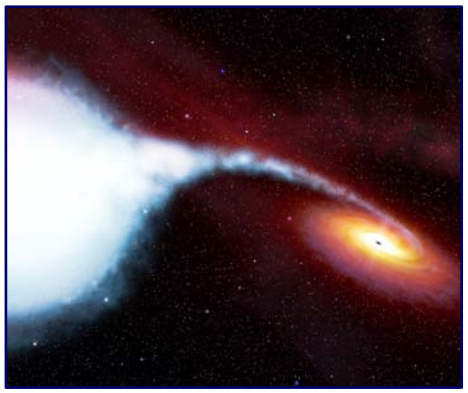


L'Universo Caldo

Resti di Supernova



I raggi γ

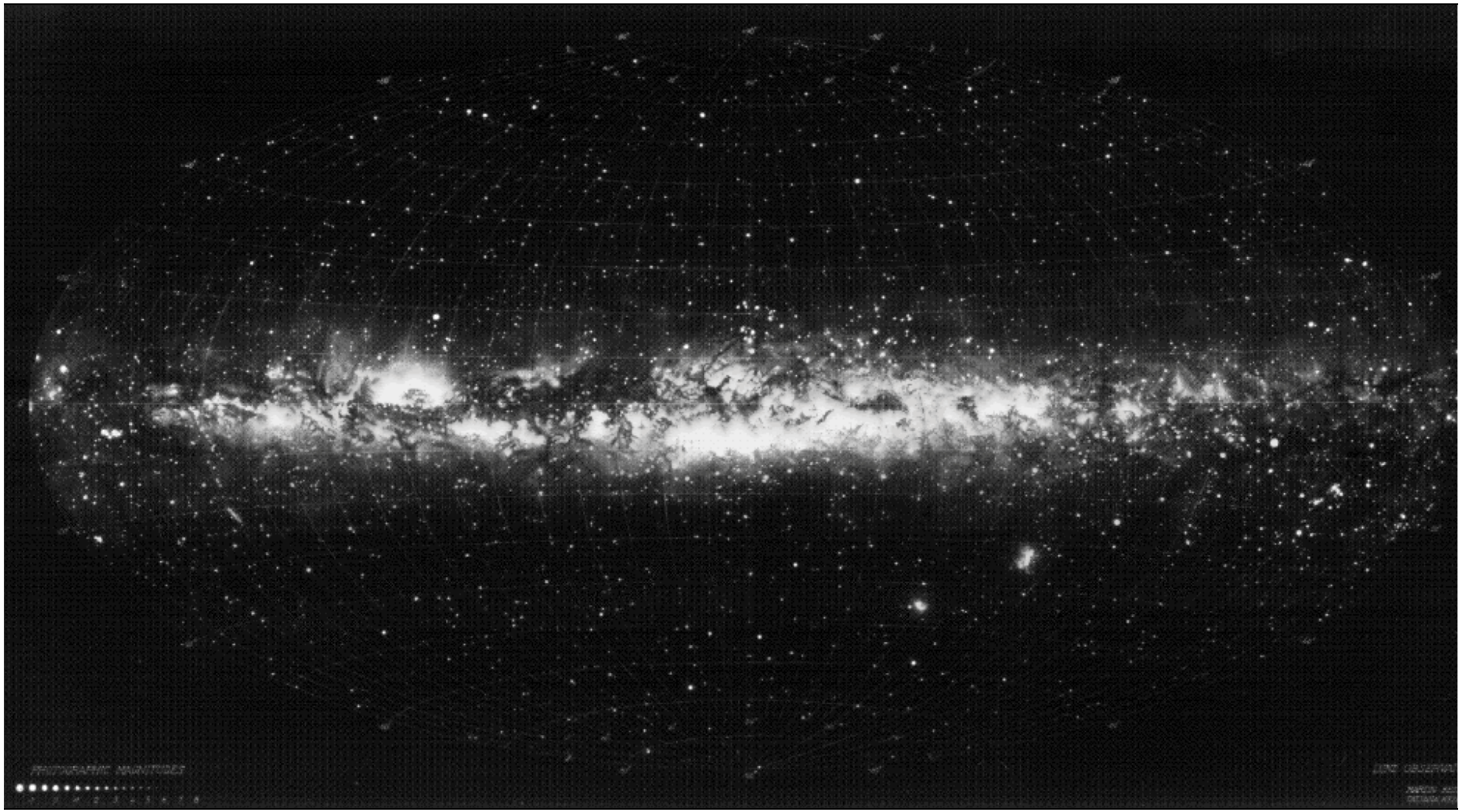


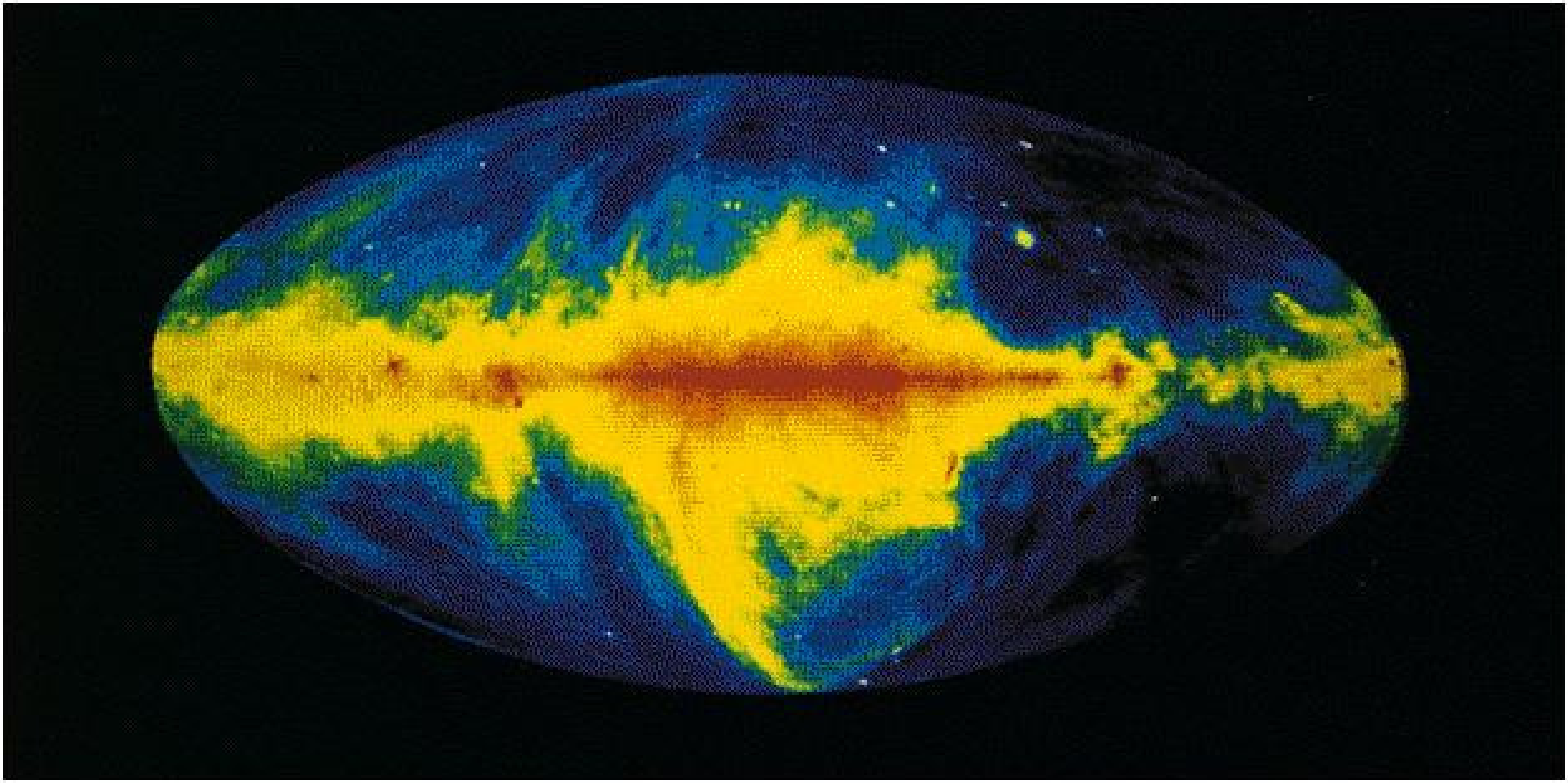
L'Universo estremo

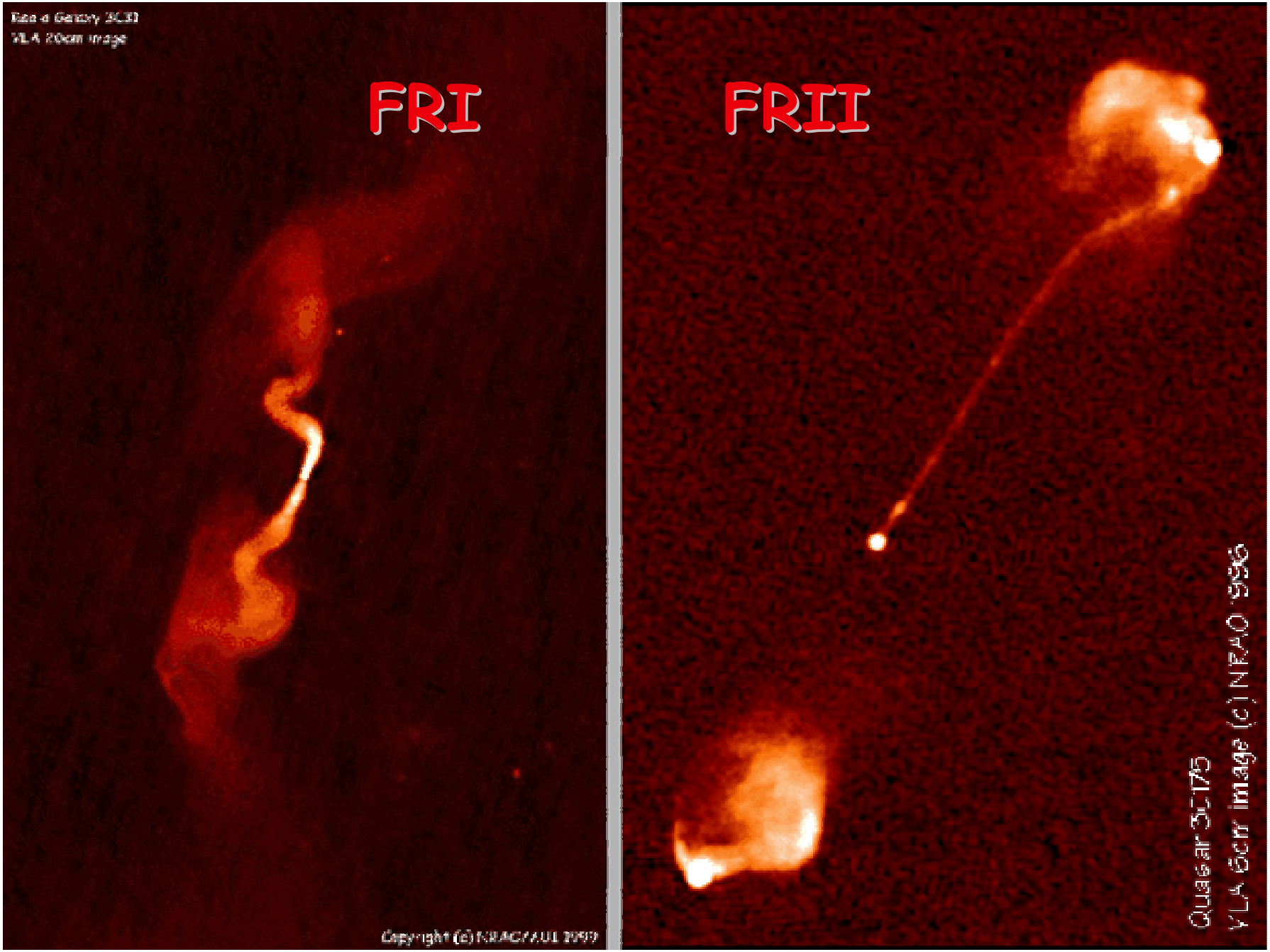
I buchi neri

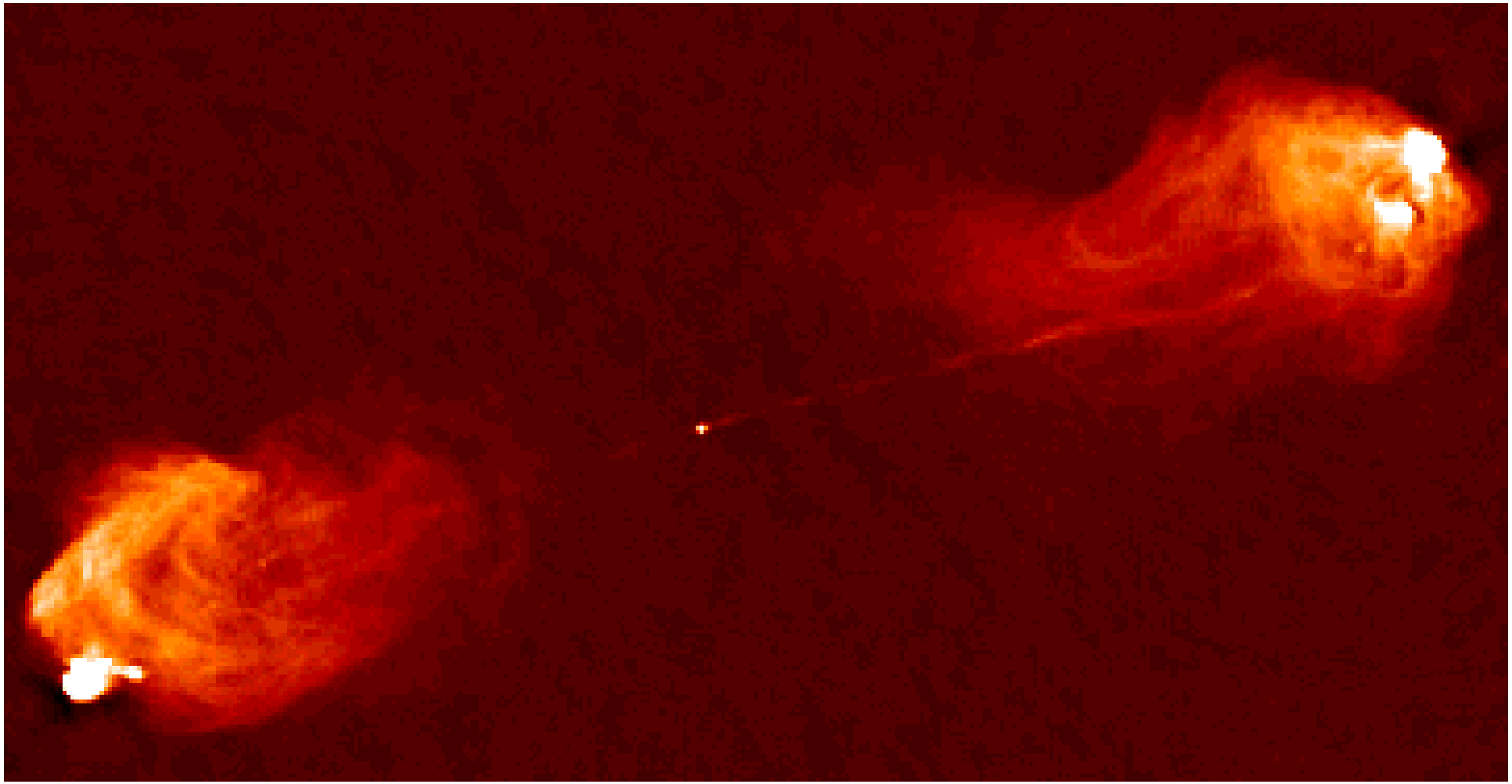
I radiotelescopi

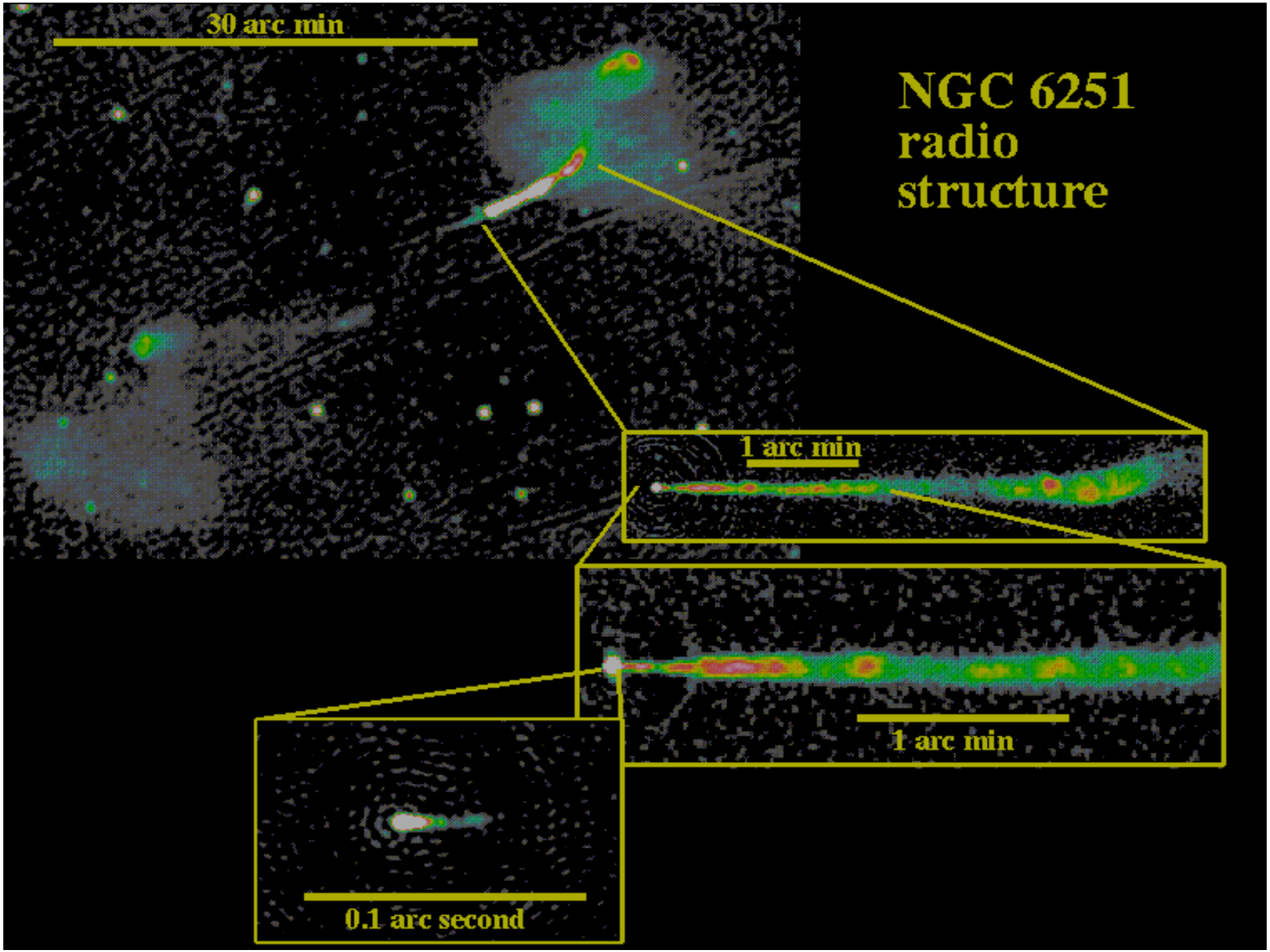
La Via Lattea

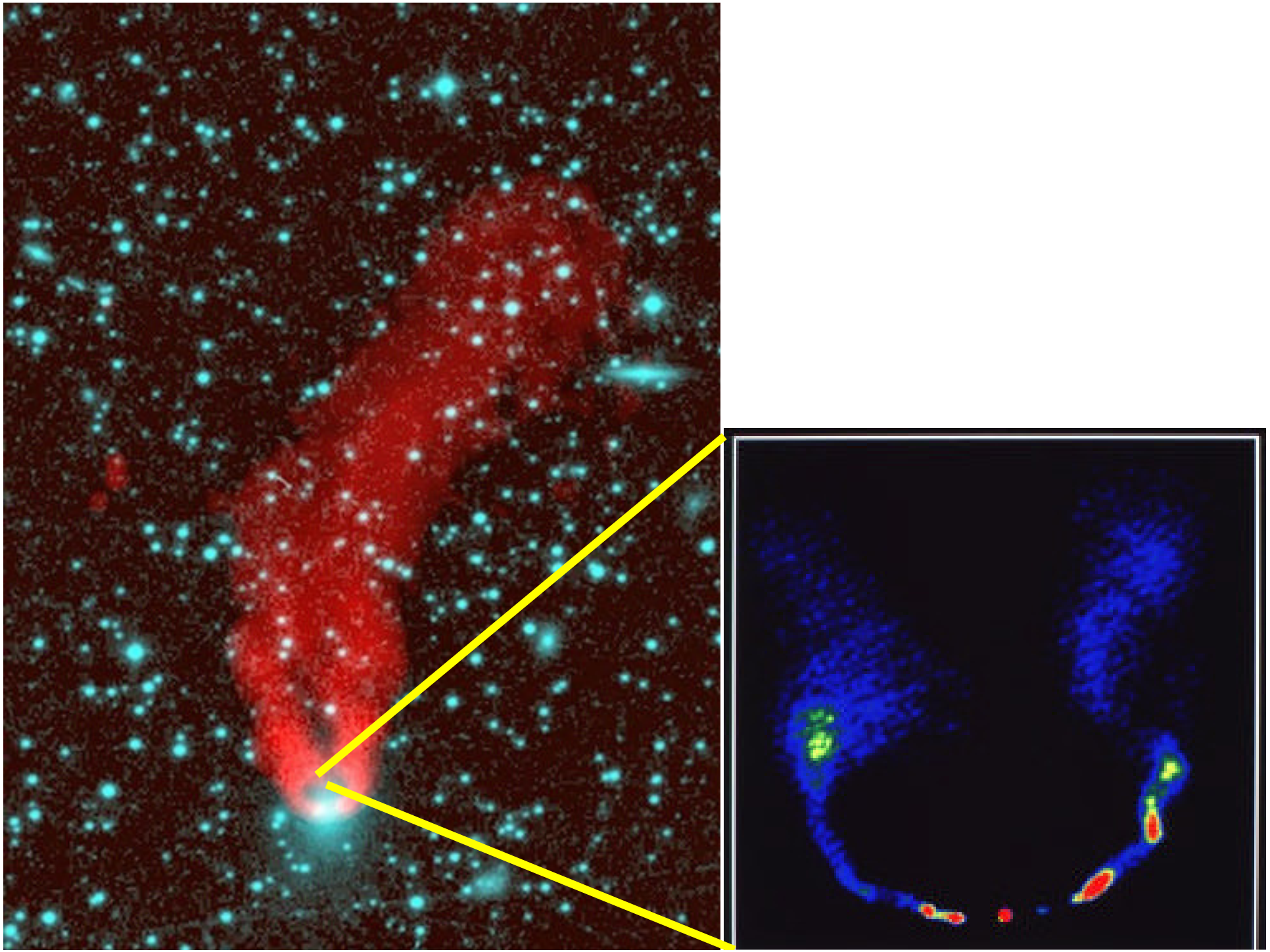




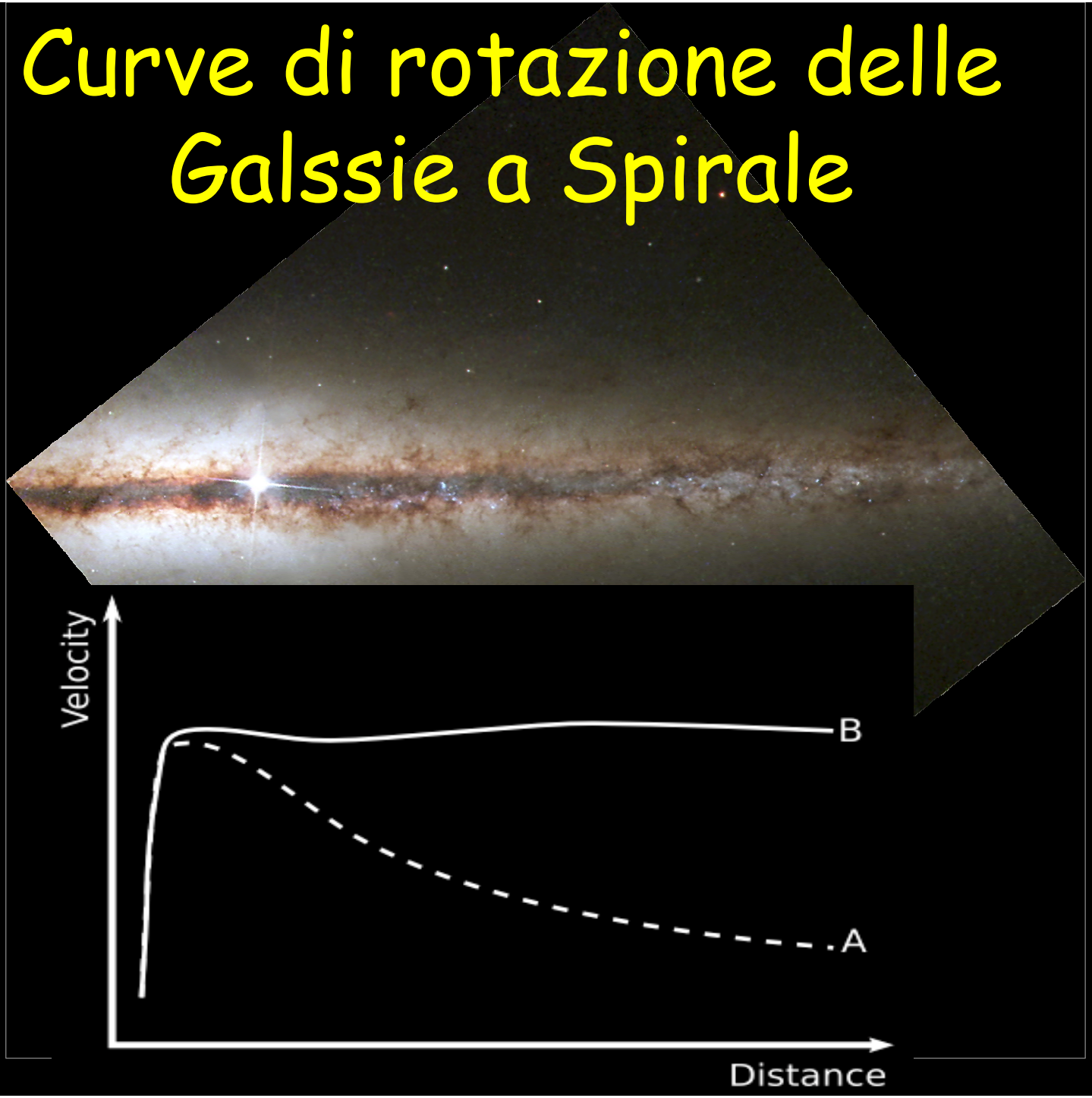

FRI
FRII
Quasar 3C175
VLA 6cm image (c) NRAO 1996



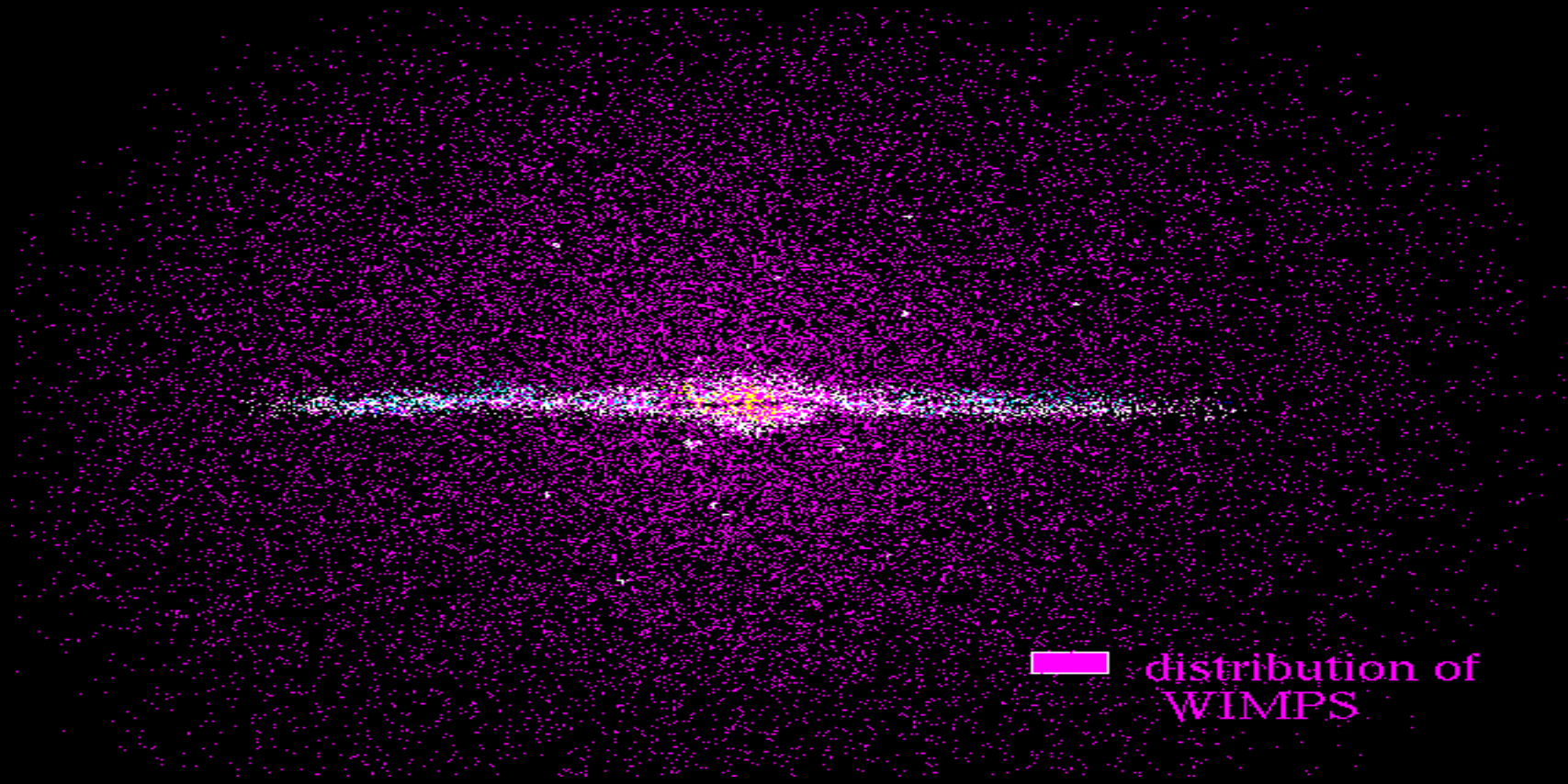

30 arc min
NGC 6251
radio
structure
1 arc min
1 arc min
0.1 arc second

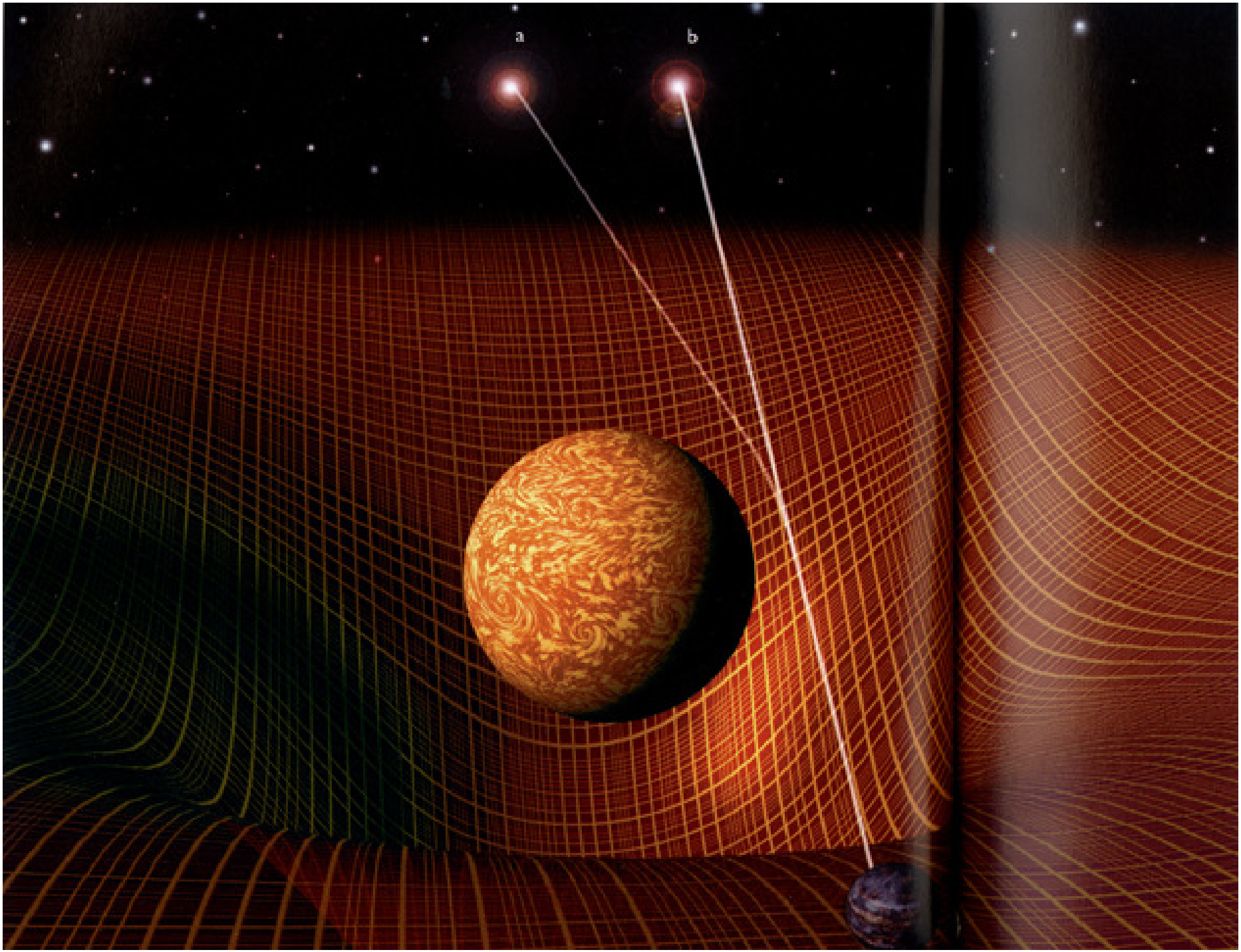


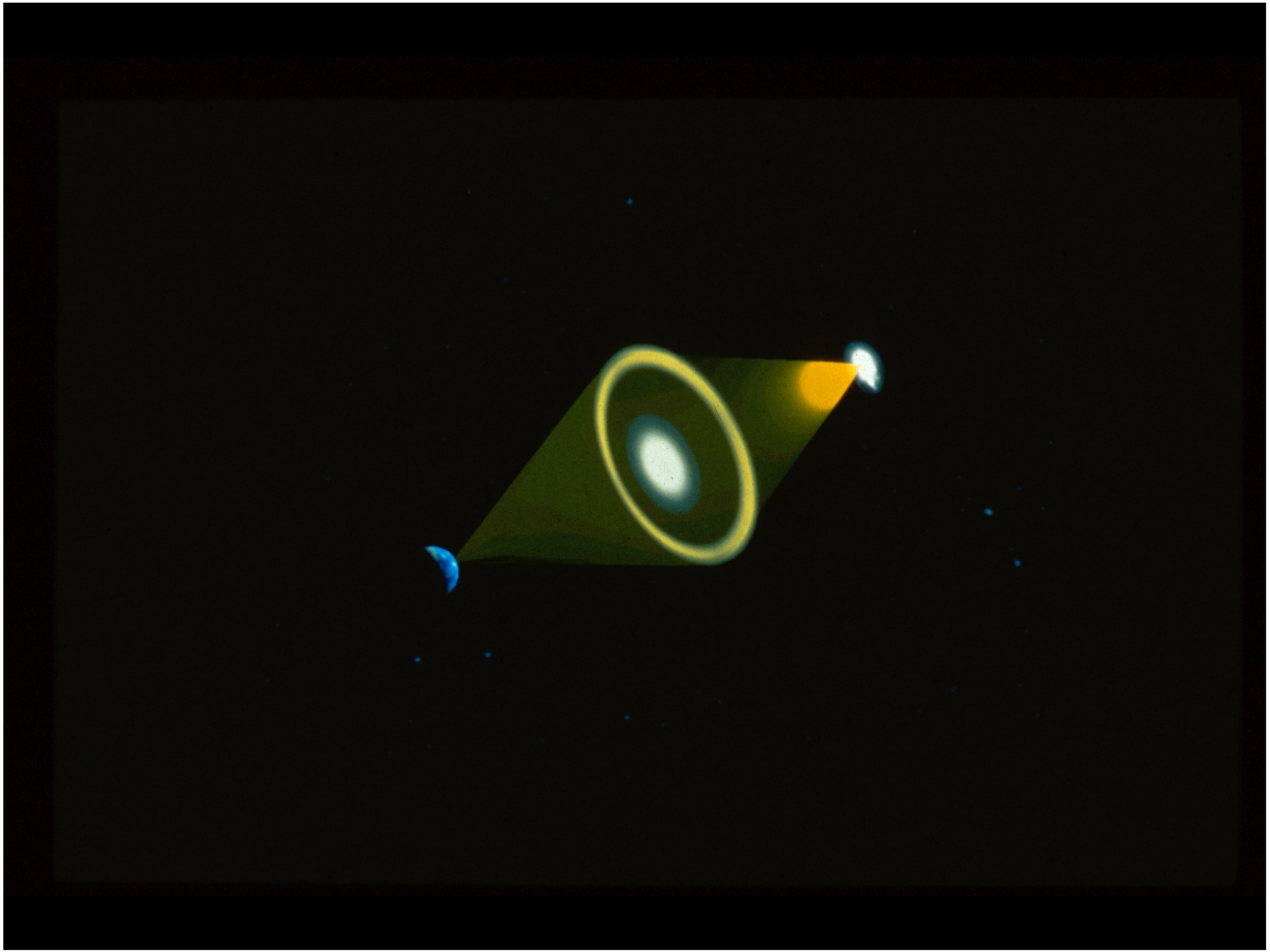
Curve di rotazione delle Galssie a Spirale



La materia scura




a
b

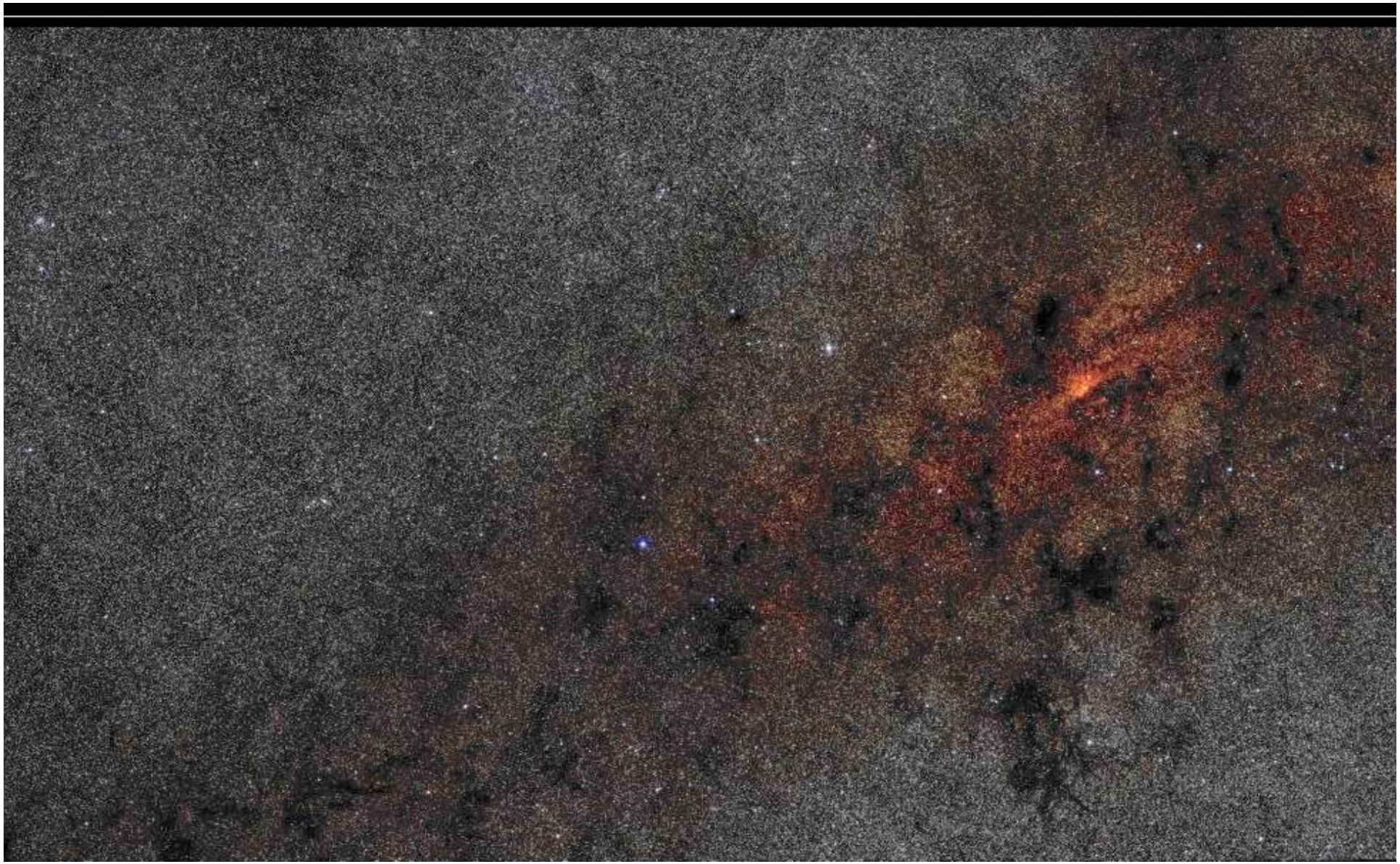


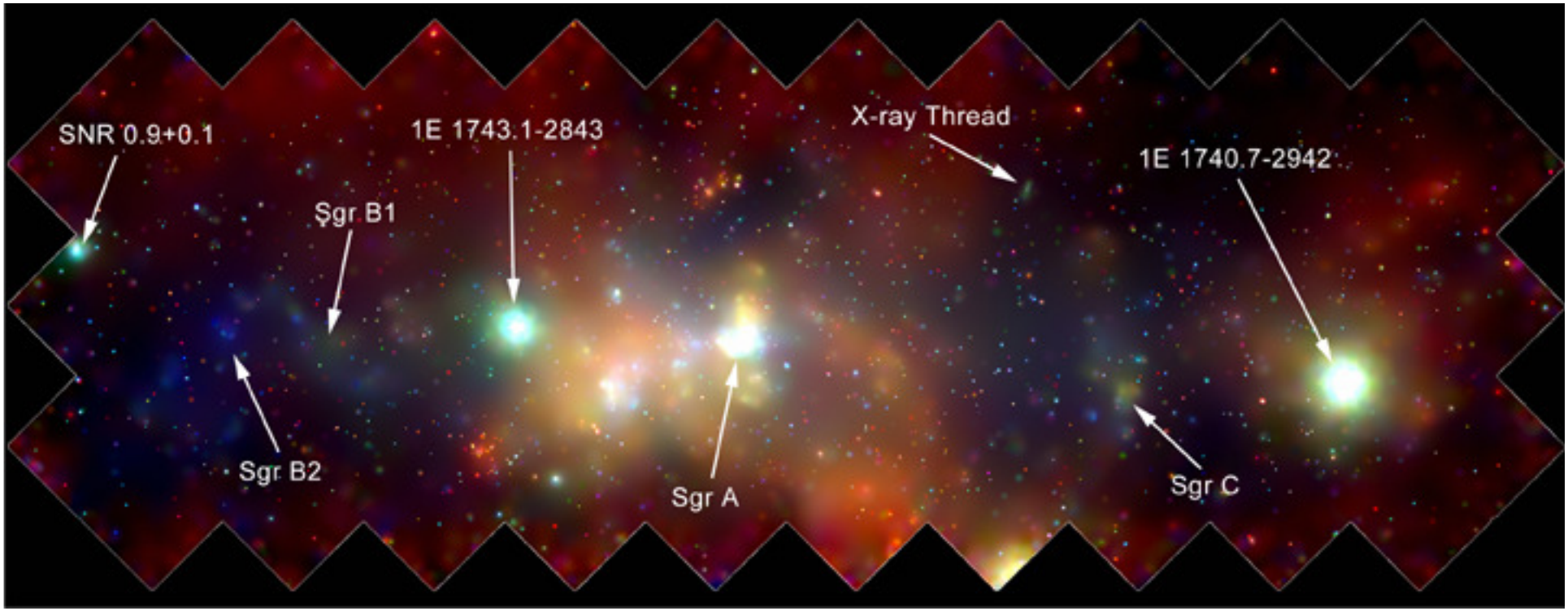
~90% della massa dell'Universo è di un qualche tipo di materia scura (dark), probabilmente di natura diversa da quella di cui siamo fatti noi.

90% materia scura ?
questi astronomi devono essere pazzi !

Emissione X da un AGN

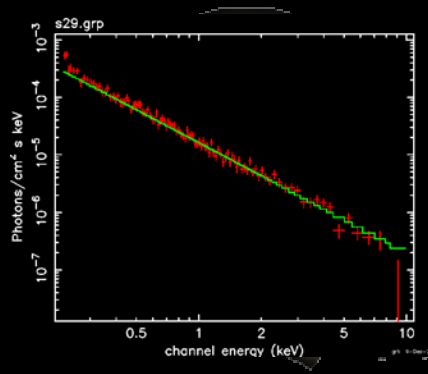
Il centro della nostra Galassia



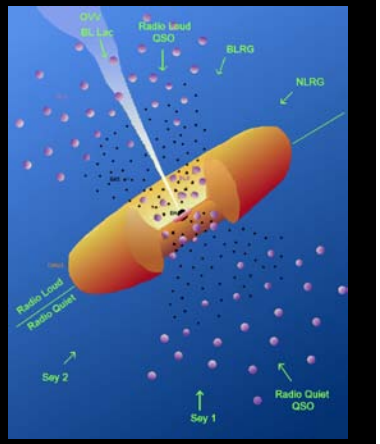


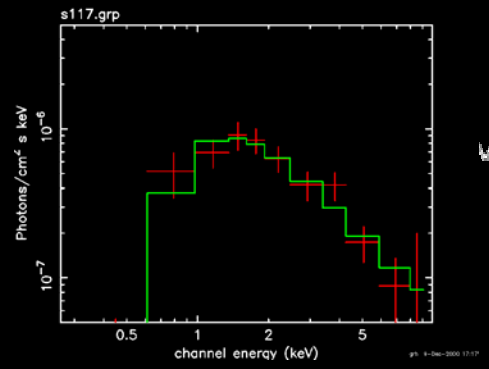
Il centro della Galassia in raggi-X (Chandra)

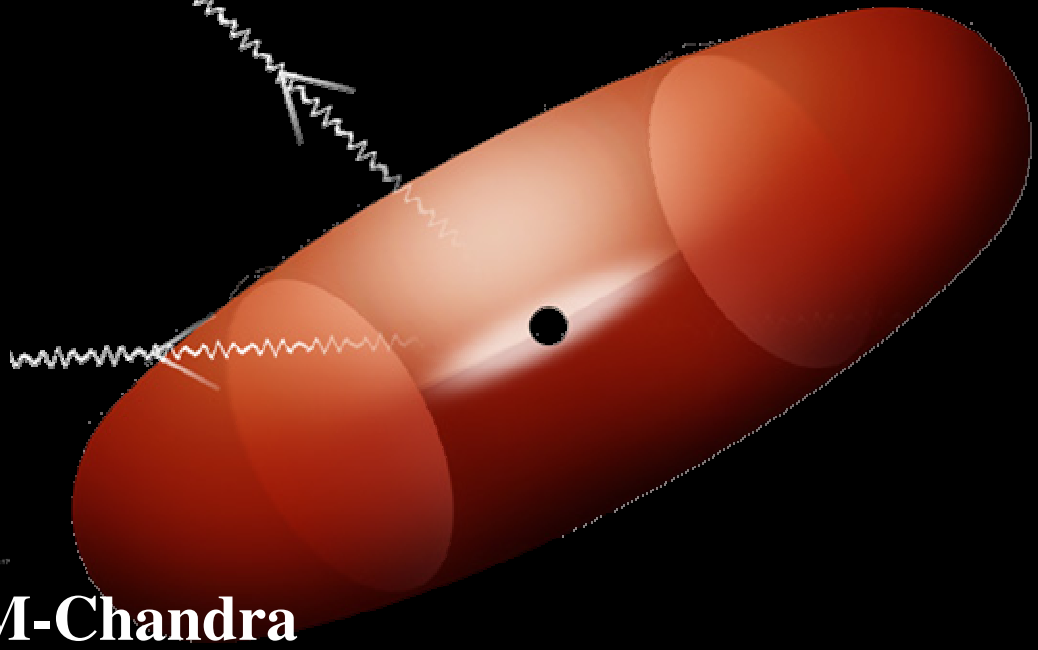
Spettri X e il Modello Unificato degli AGN



Einstein - ROSAT
E<3 keV

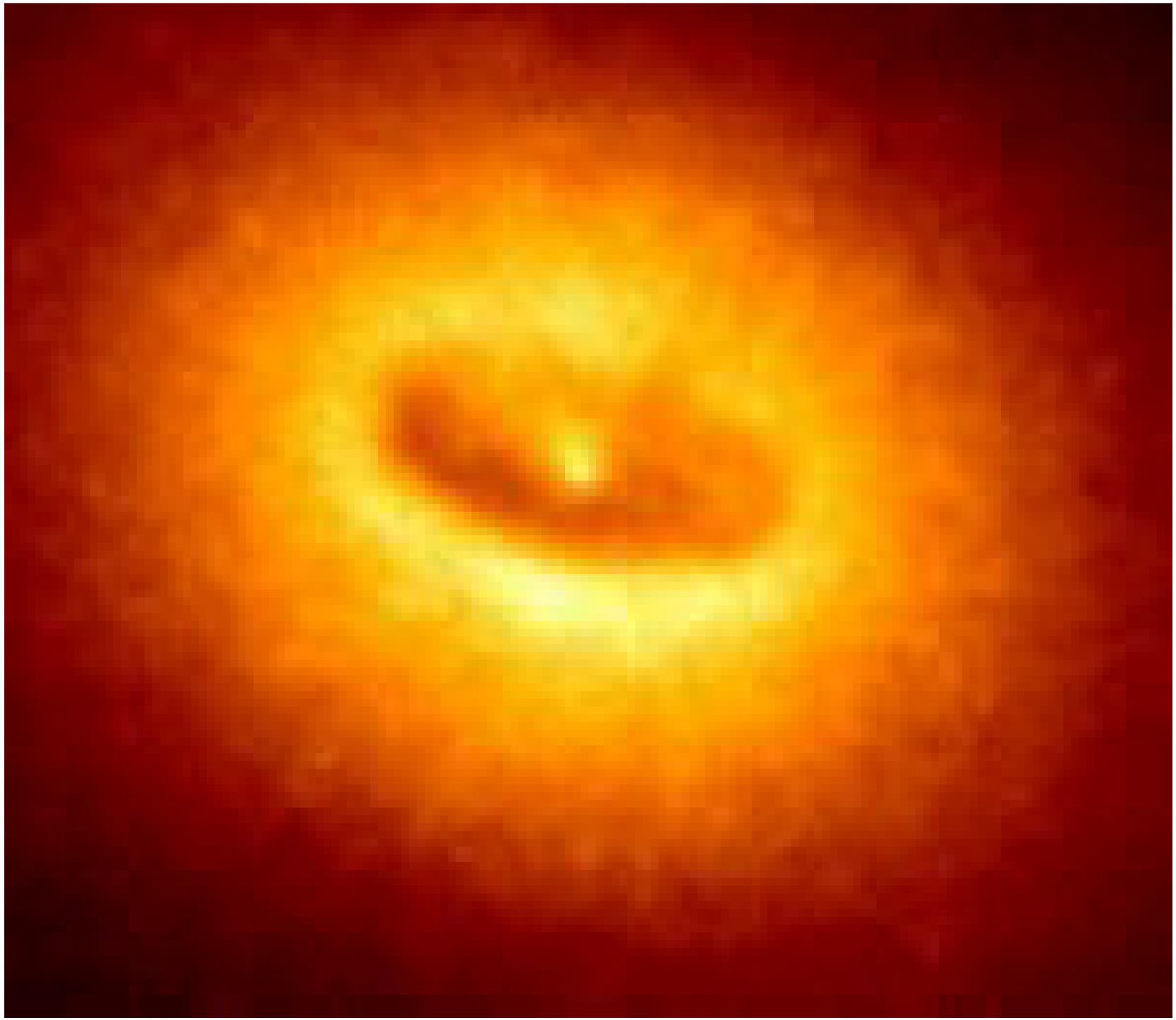


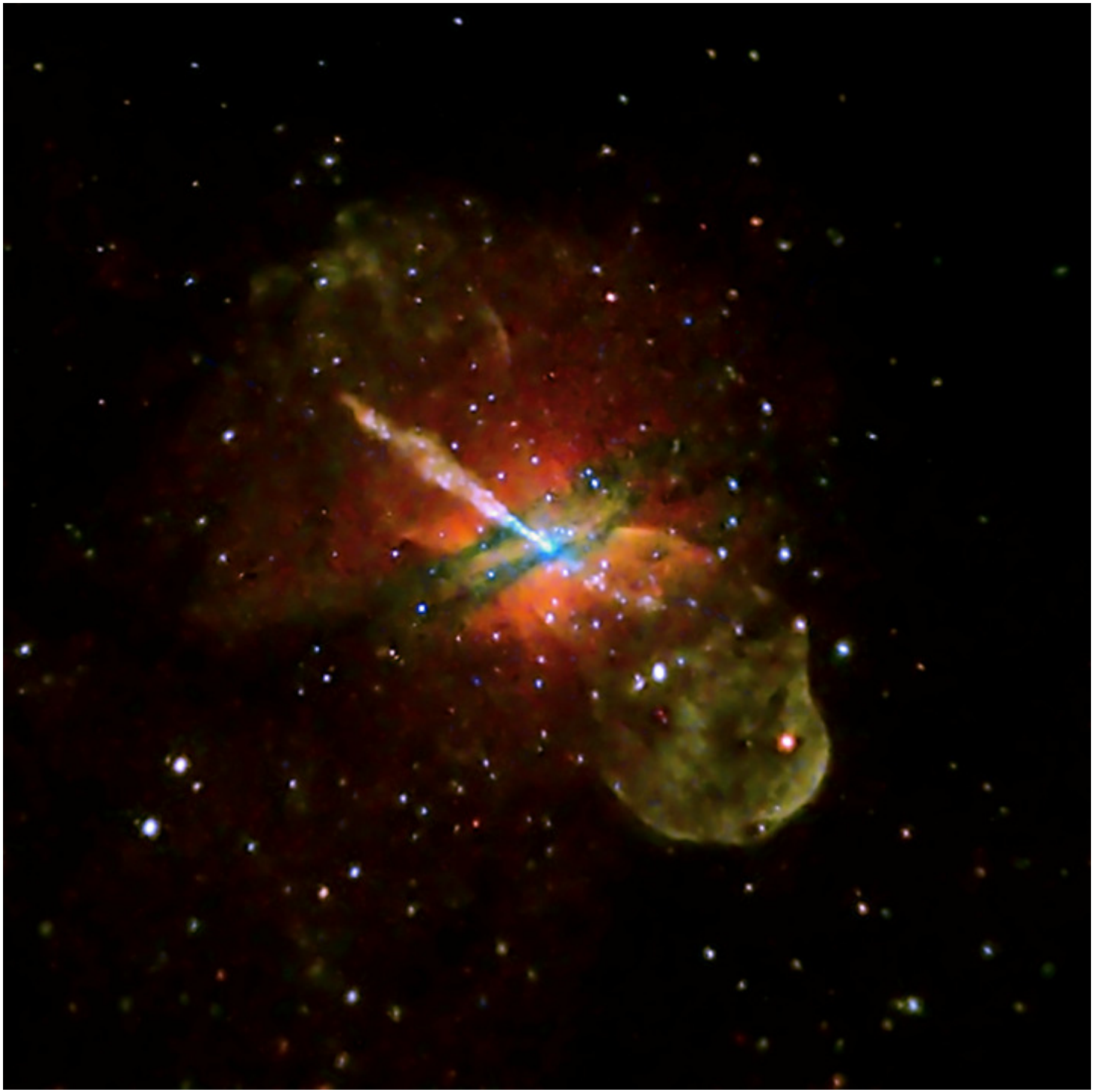




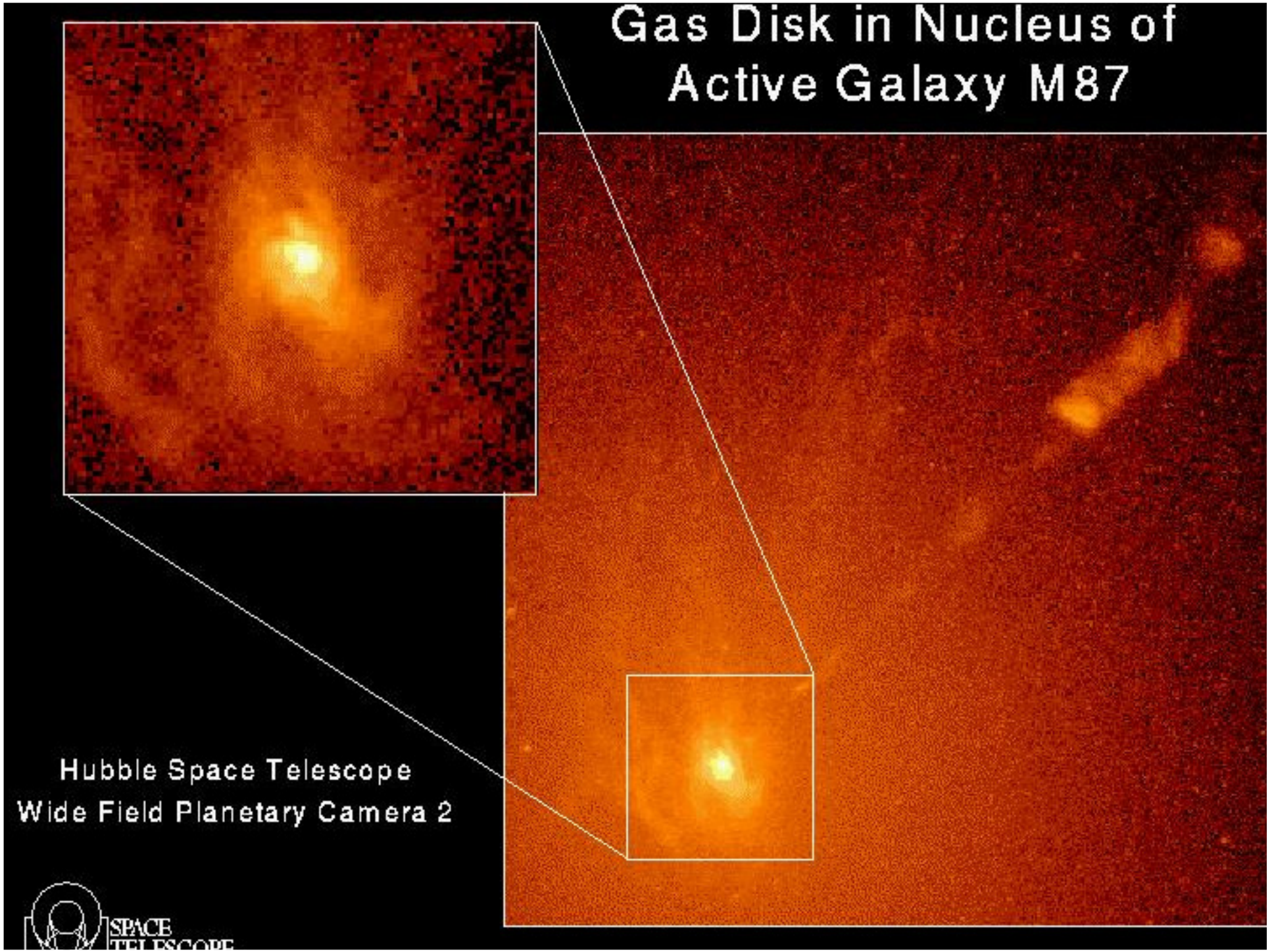
ASCA-SAX-XMM-Chandra
E>3 keV

Adapted from G. Hasinger

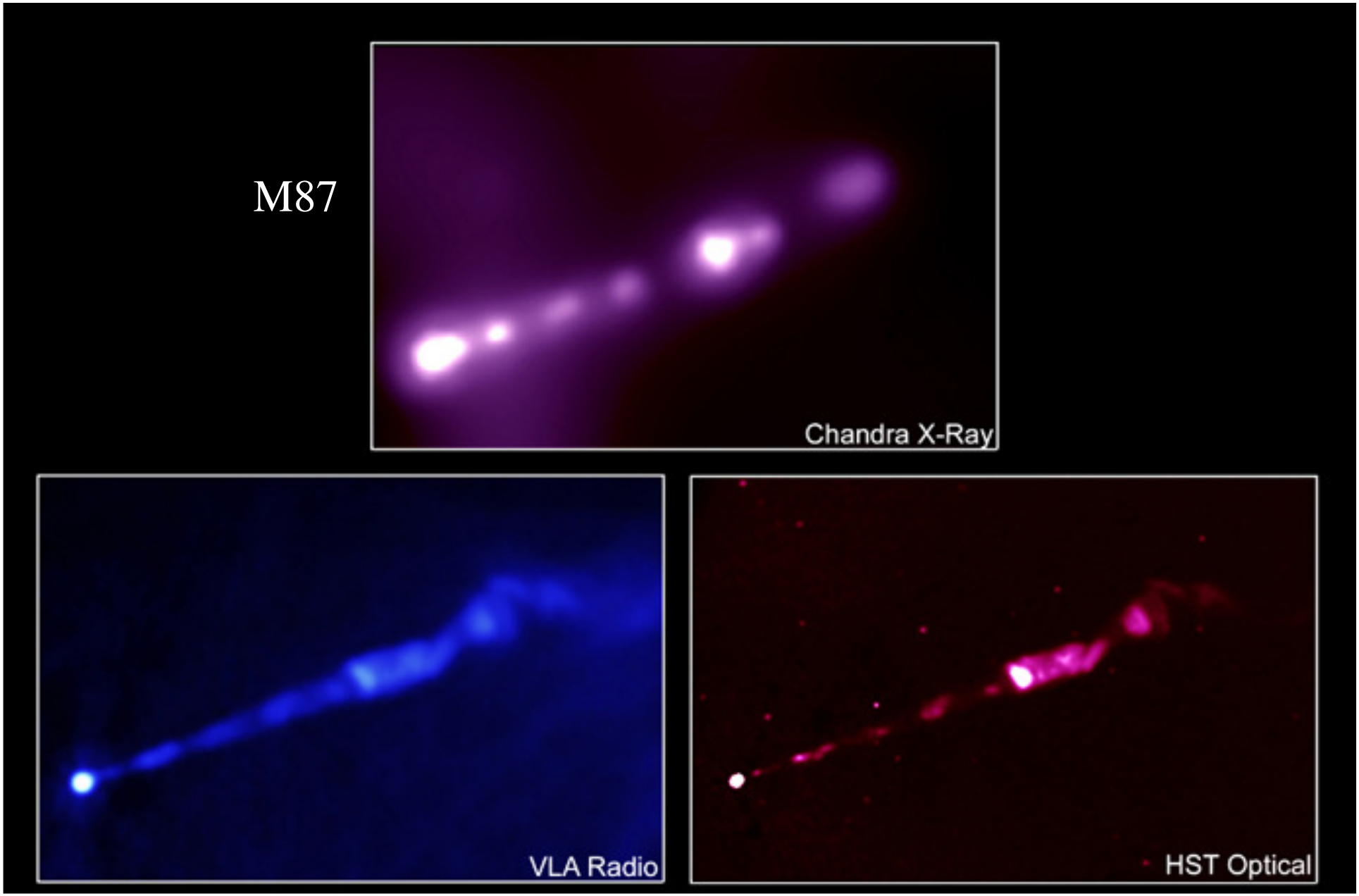


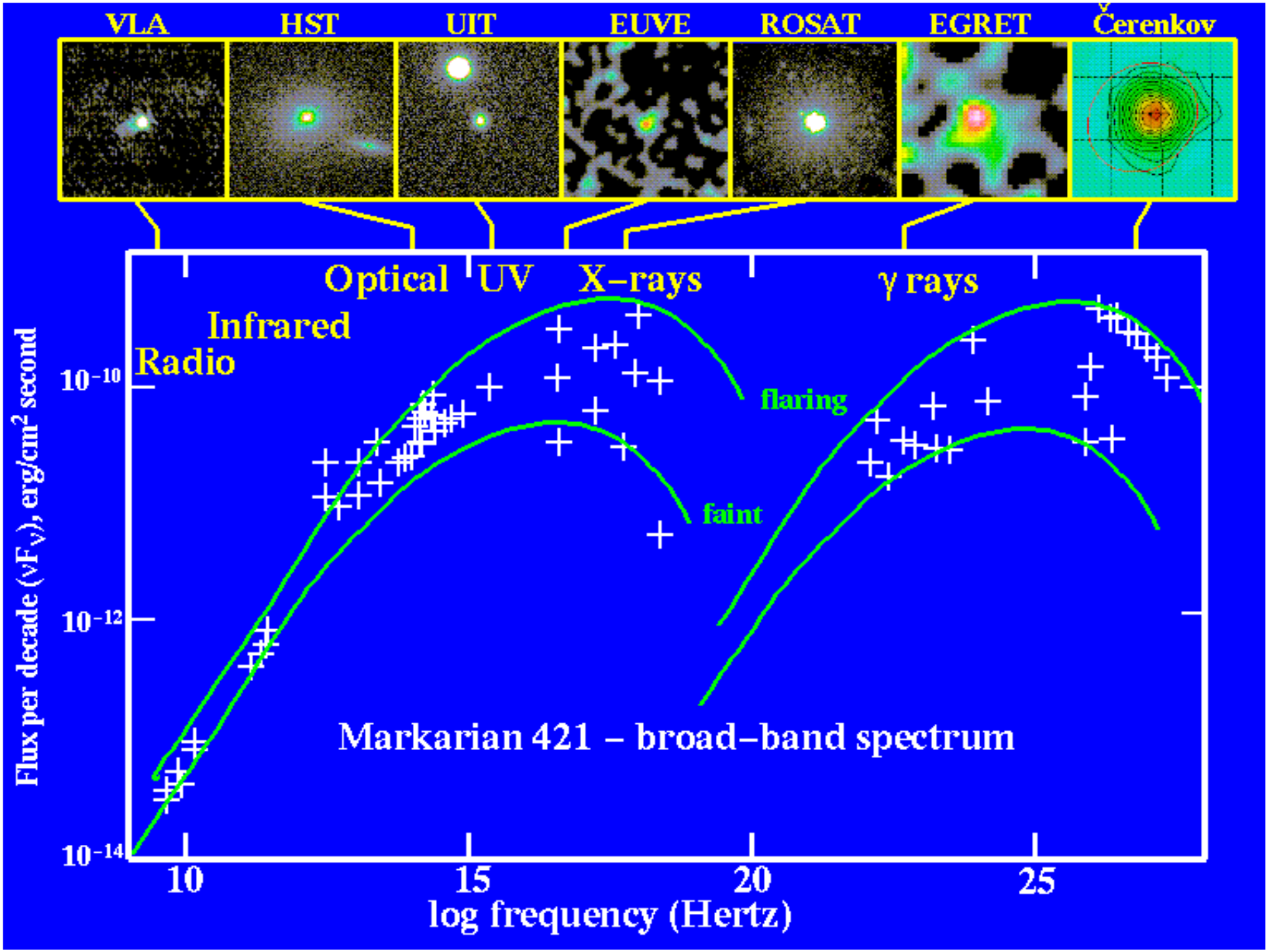


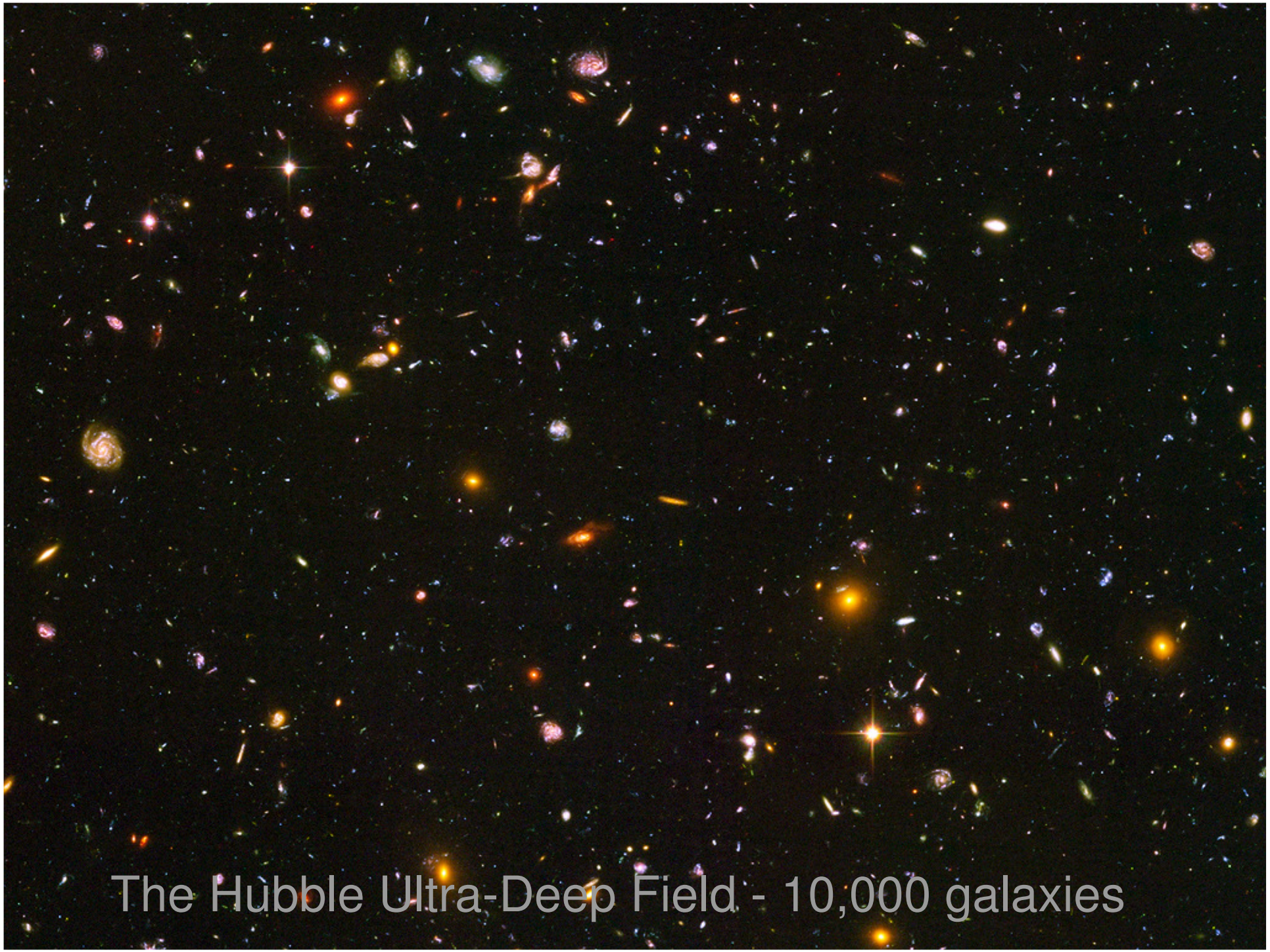
CEN A

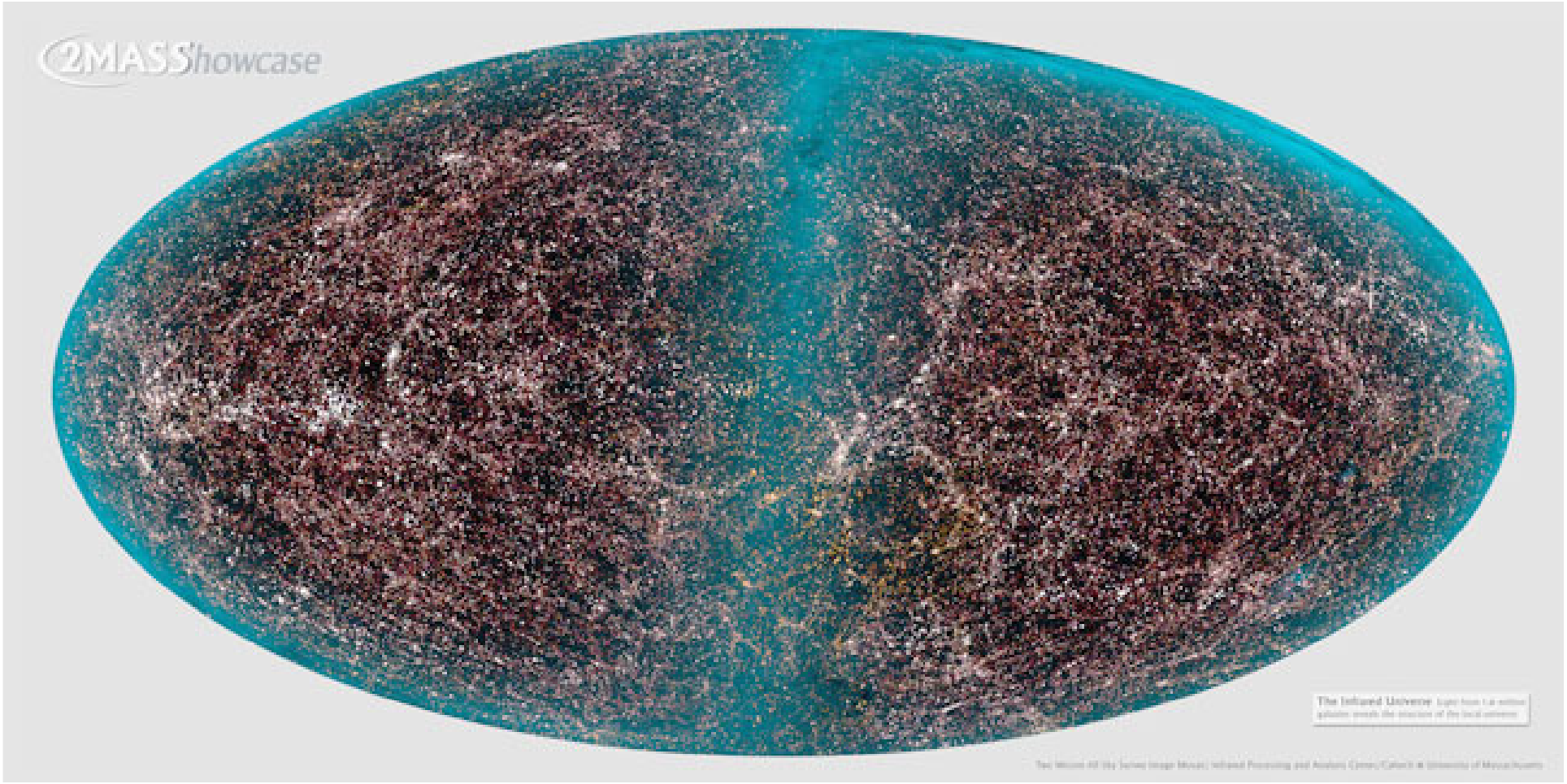

Gas Disk in Nucleus of
Active Galaxy M87
Hubble Space Telescope
Wide Field Planetary Camera 2
SPACE
TELESCOPE

Getti in raggi-O/X/R

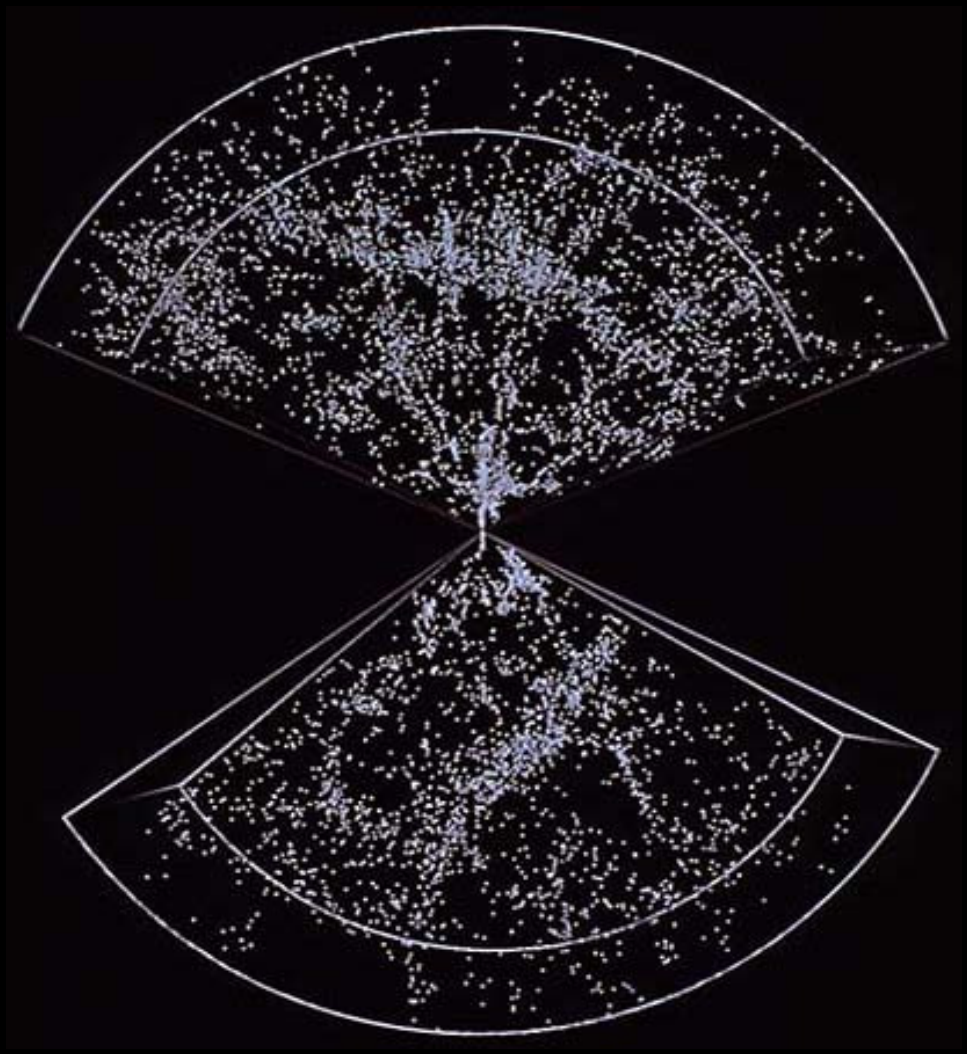


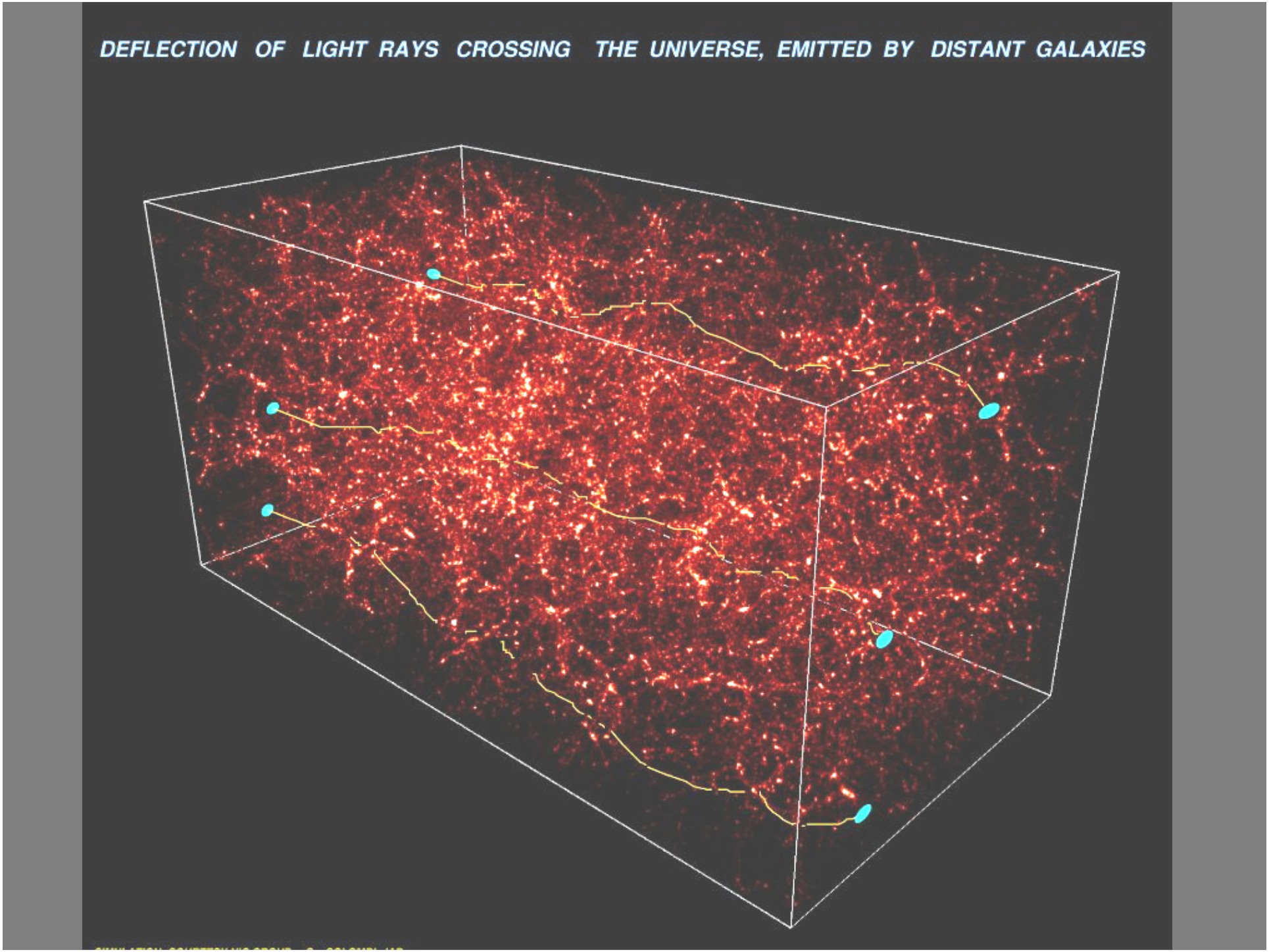

VLA
HST
UIT
EUVE
ROSAT
EGRET
Čerenkov
Optical
UV
X–rays
γ rays
Infrared
Radio
flaring
faint
Markarian 421 – broad–band spectrum
Flux per decade (νF_ν), erg/cm² second
10⁻¹⁰
10⁻¹²
10⁻¹⁴
10
15
20
25
log frequency (Hertz)


The Hubble Ultra-Deep Field - 10,000 galaxies


2MASShowcase
The Infrared Universe

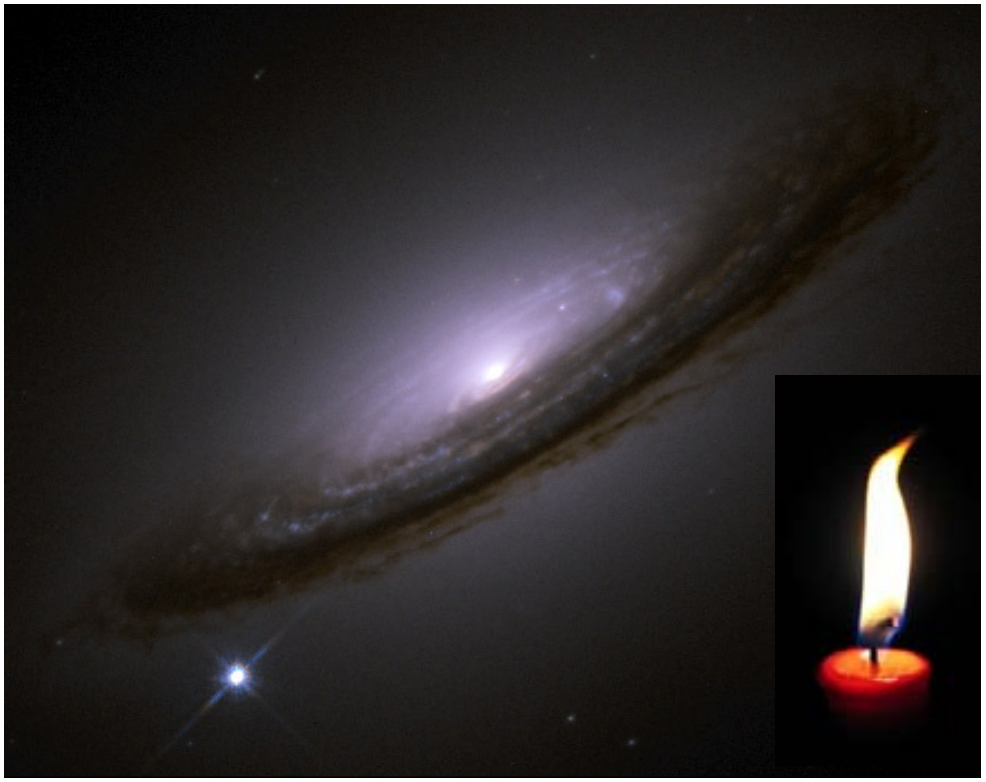
Le grandi strutture




DEFLECTION OF LIGHT RAYS CROSSING THE UNIVERSE, EMITTED BY DISTANT GALAXIES

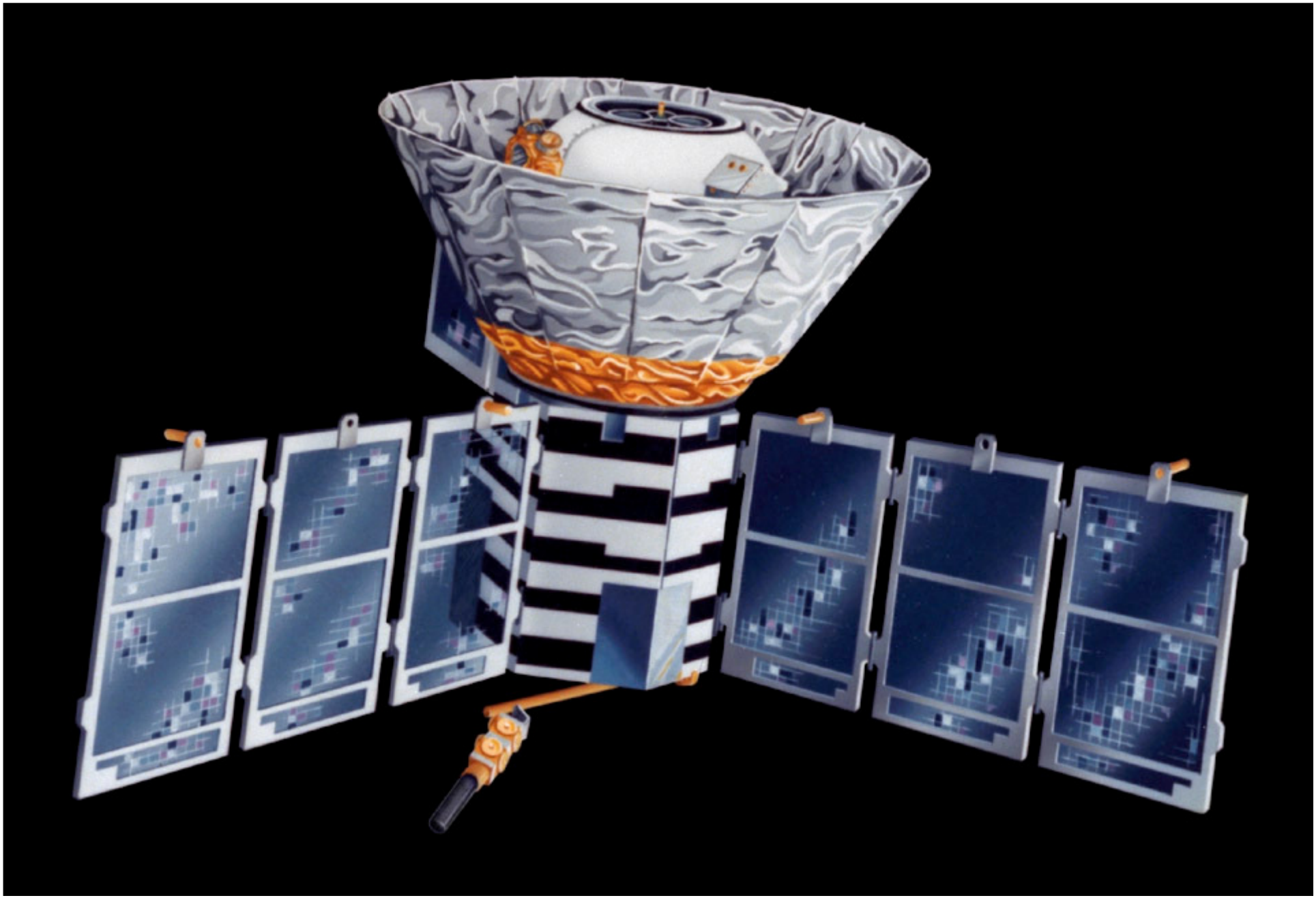
Supernovae lontane non sono facilmente distinte dalle galassie che le ospitano

Supernovae le "candele standard"

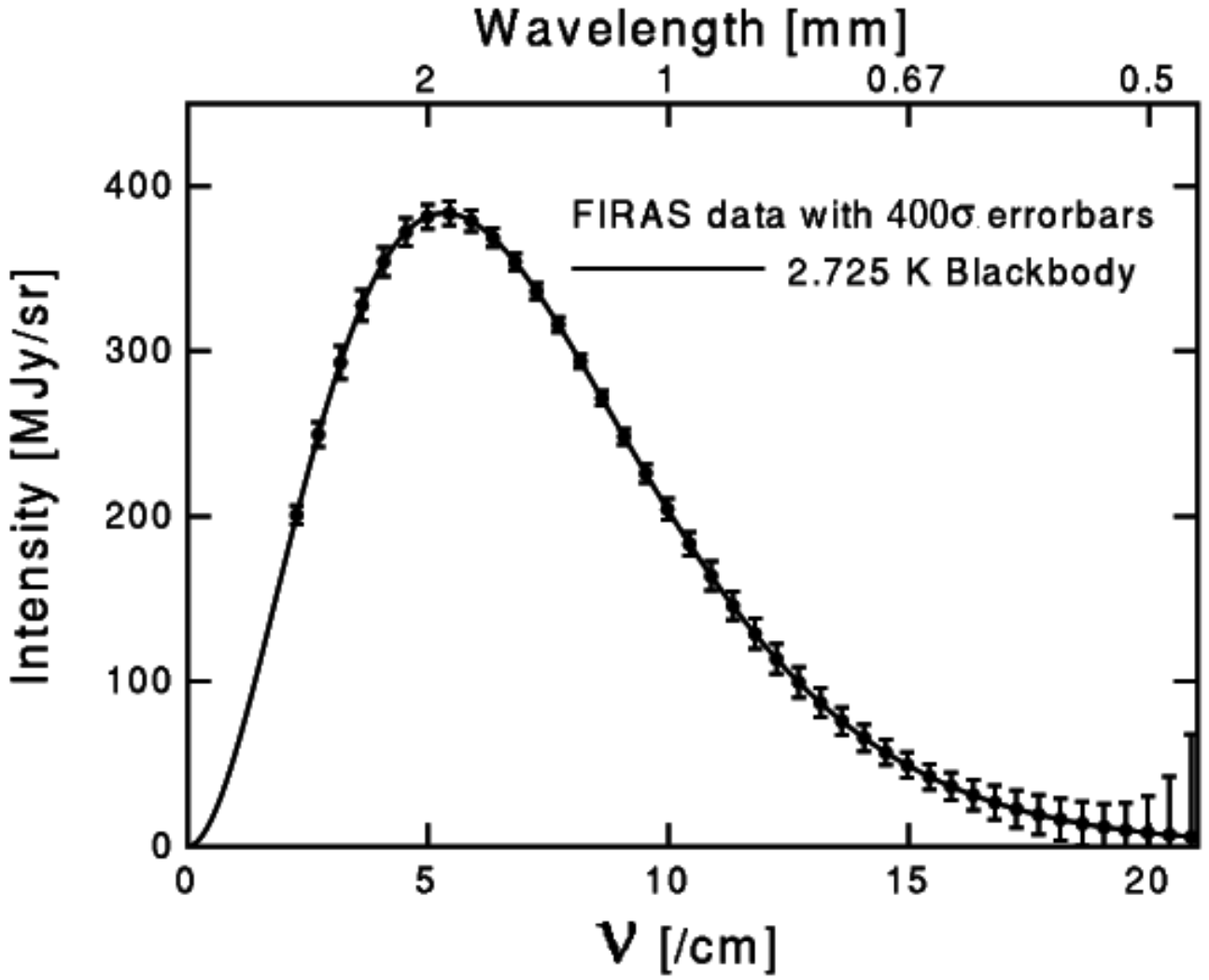


-Da misure di velocità e distanza si può calcolare il tempo….e graficare la Storia dell'Universo

In che UNIVERSO viviamo?



COBE


Wavelength [mm]
2
1
0.67
0.5
400
300
200
100
0
Intensity [MJy/sr]
FIRAS data with 400σ errorbars
2.725 K Blackbody
0
5
10
15
20
ν [/cm]

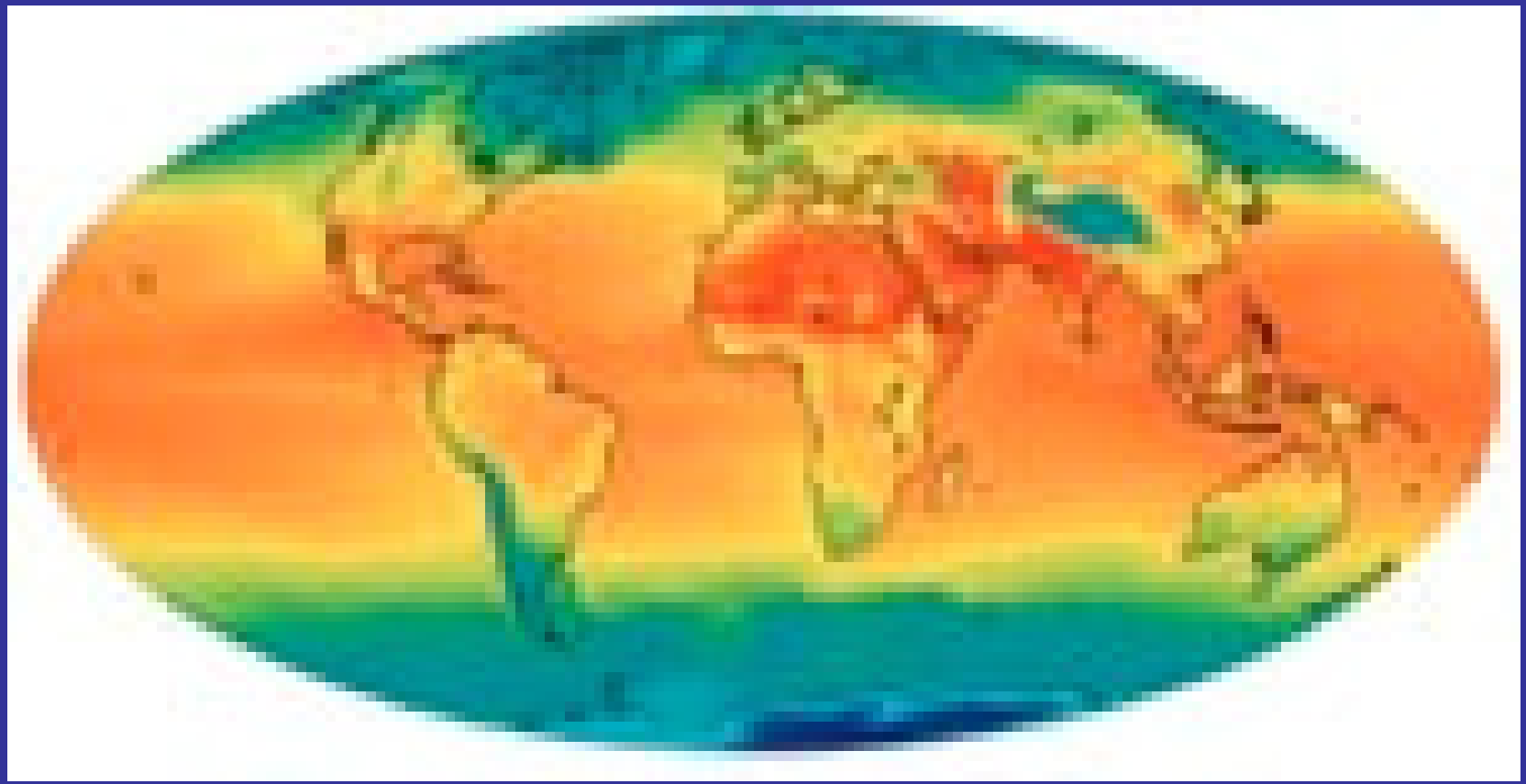
La temperatura dell'Universo

T = 2,725 K temperatura della "luce" che ha viaggiato verso di noi per il 90% del tempo dal Big Bang a oggi.

Sono pochi gradi ma una sorprendente quantità di calore.

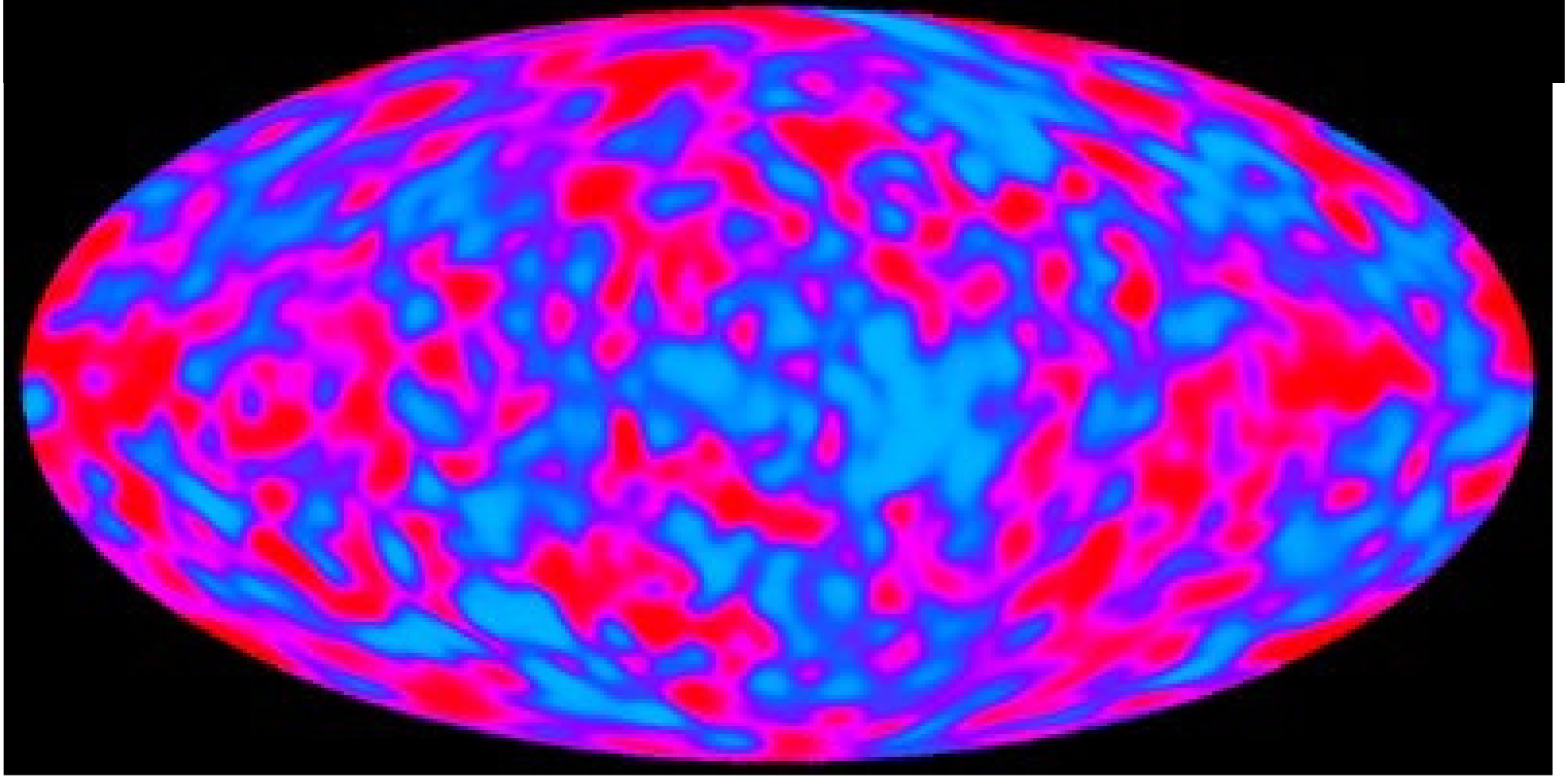
2 miliardi di fotoni per ogni atomo

La temperatura della Terra

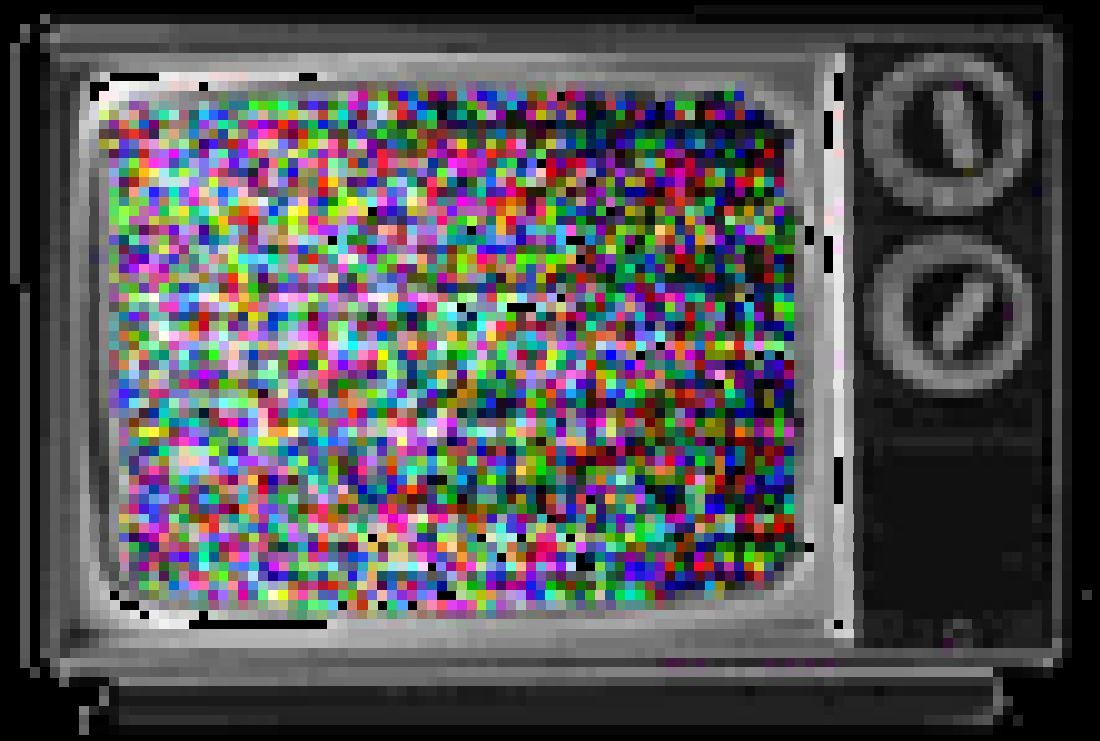


Fluttuazioni della radiazione cosmica di fondo

Nella radiazione cosmica di fondo vediamo le tracce delle fluttuazioni di densità che hanno dato origine alle strutture che osserviamo oggi.

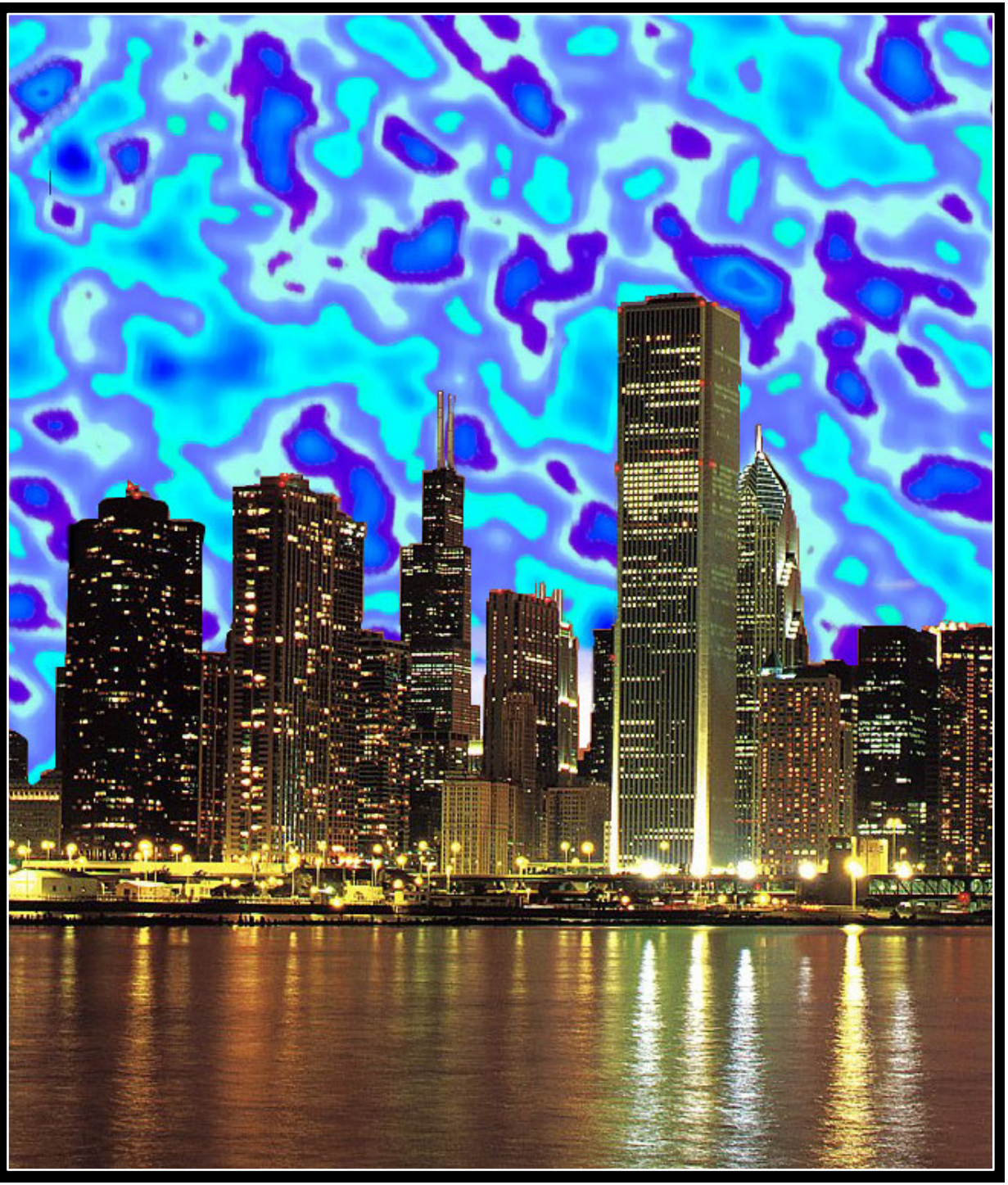


- 400 fotoni per cm cubo !

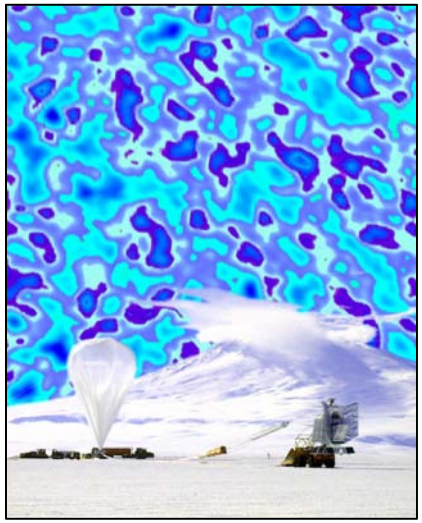


Graphic by Wayne Hu, http://background.uchicago.edu/~whu/beginners/introduction.html

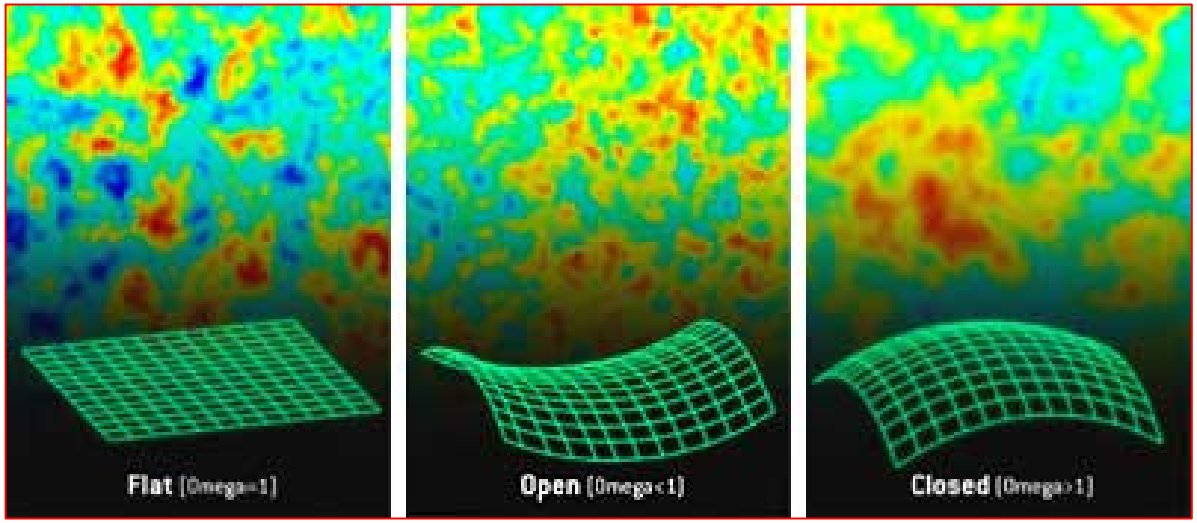
Se i nostri occhi vedessero le microonde, il cielo ci apparirebbe così



La geometria dell'universo



Boomerang

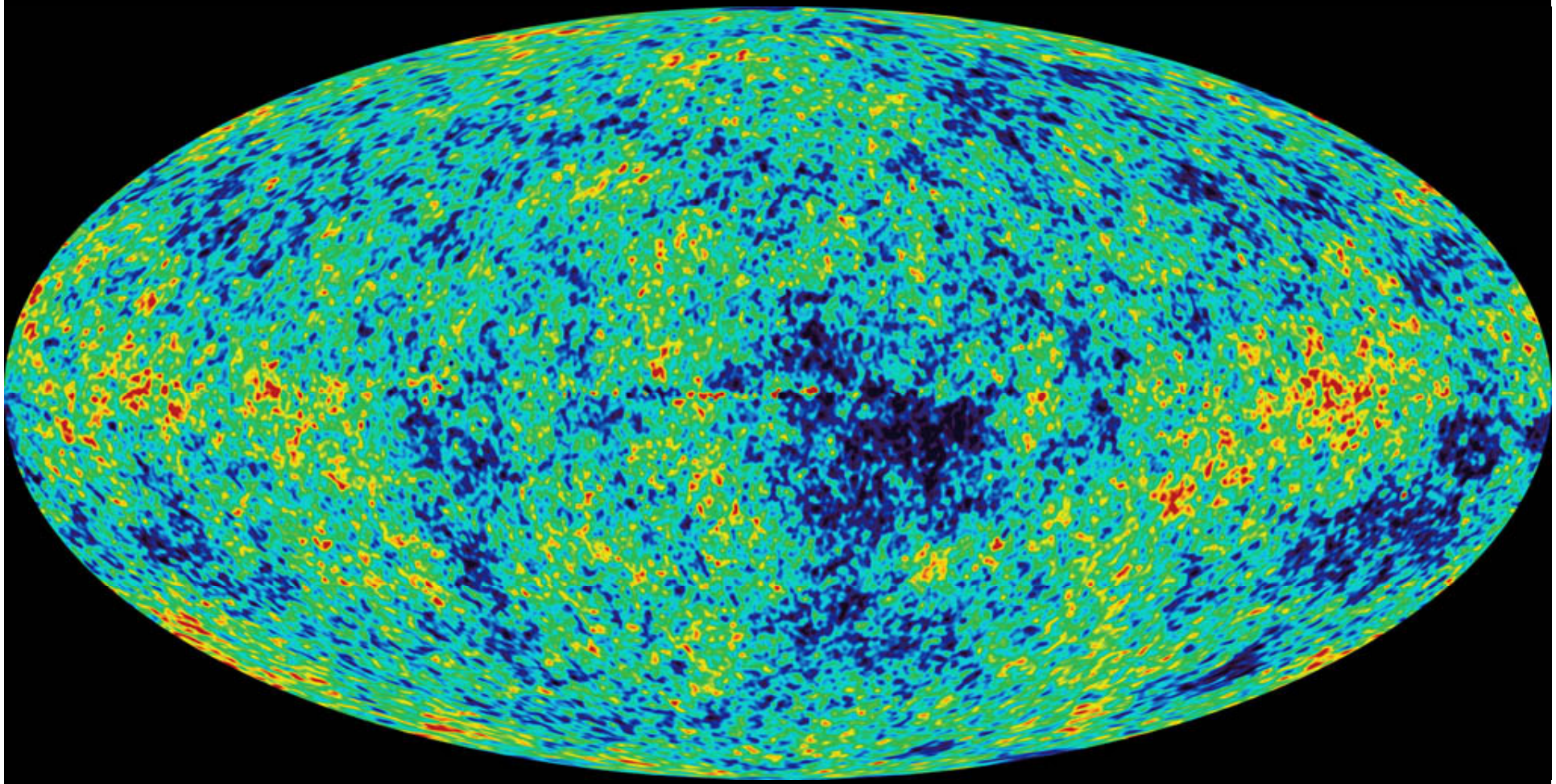


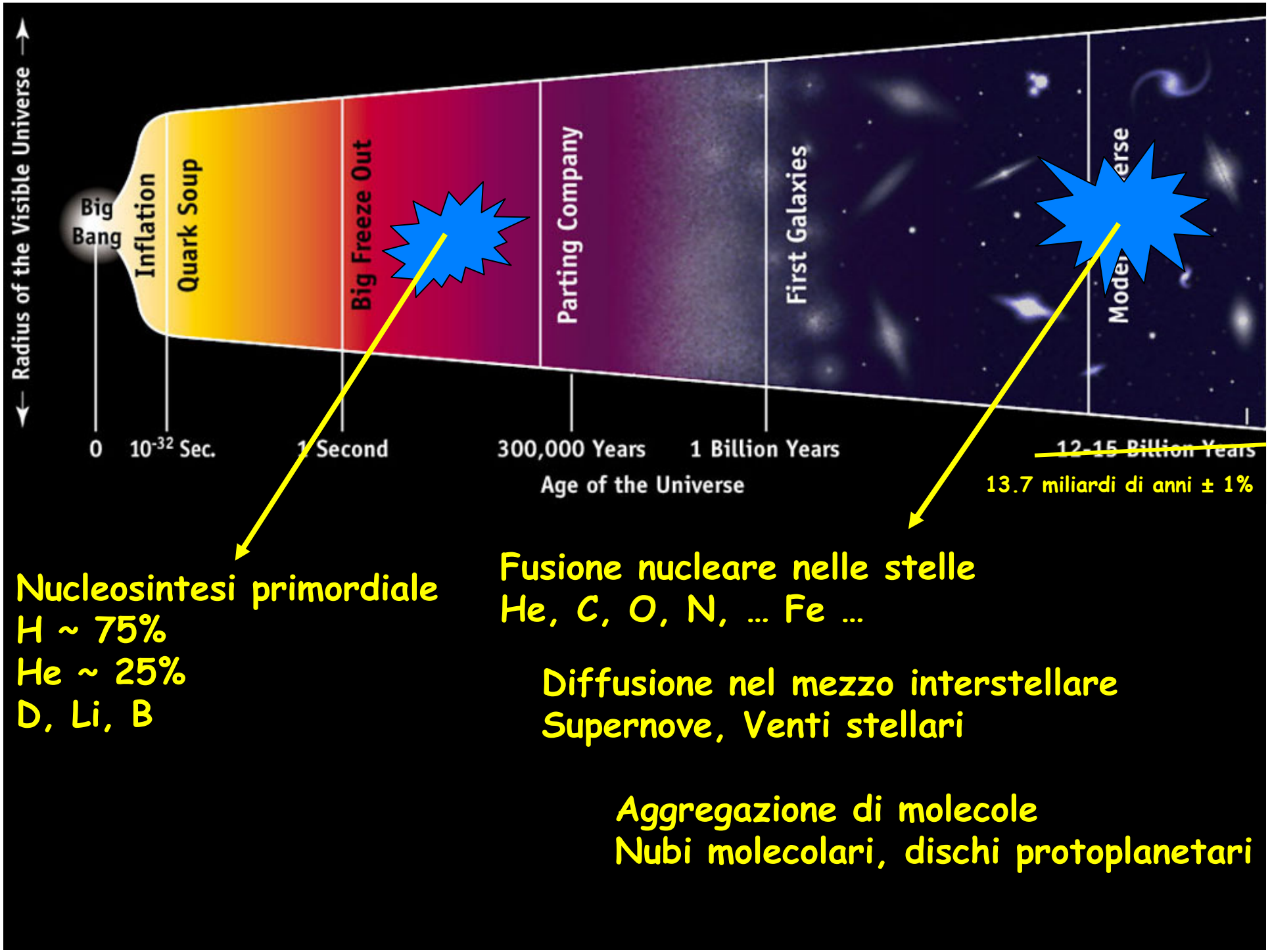
Piatto

Aperto

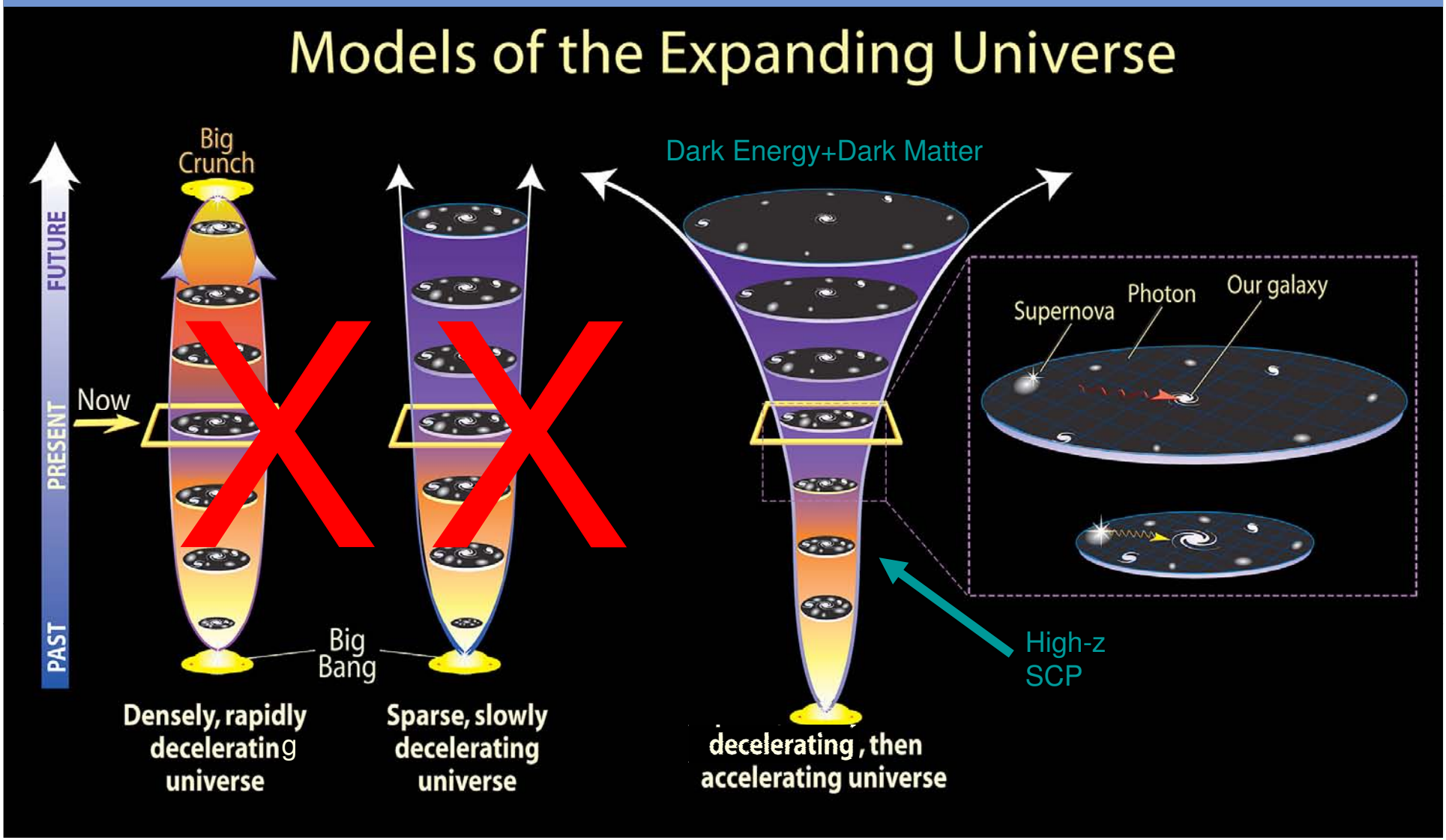
Chiuso

L' Universo 380,000 anni dopo il Big Bang

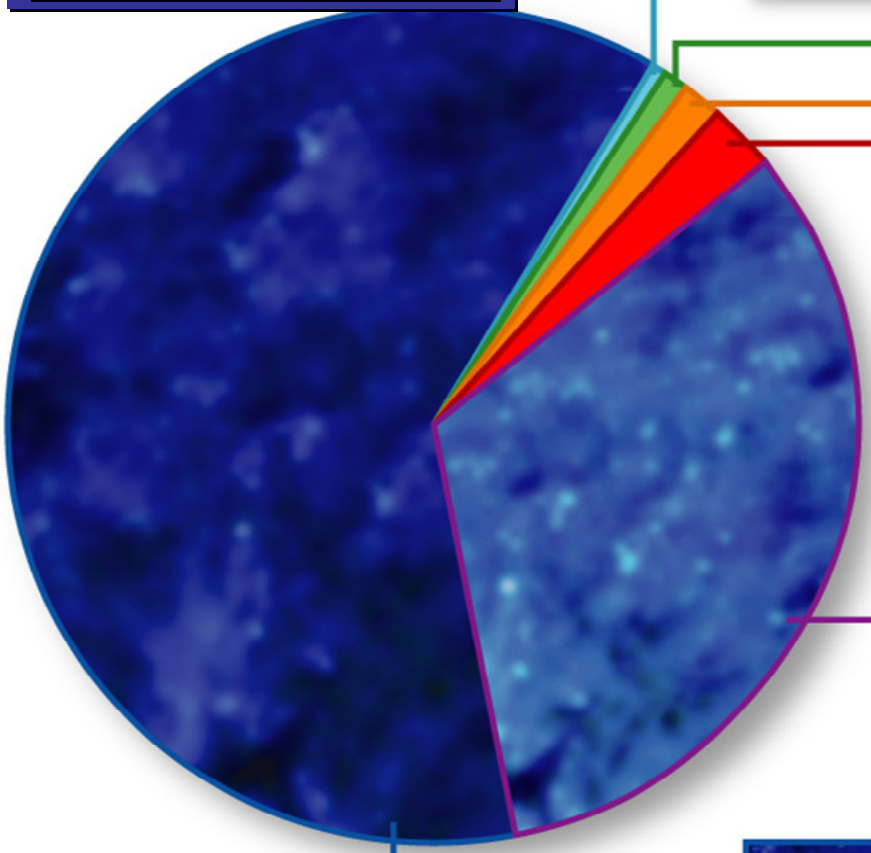



Radius of the Visible Universe
Big Bang
Inflation
Quark Soup
Big Freeze Out
Parting Company
First Galaxies
Modern
0
10-32 Sec.
1 Second
300,000 Years
1 Billion Years
12-15 Billion Years
Age of the Universe
13.7 miliardi di anni ± 1%
Nucleosintesi primordiale
H ~ 75%
He ~ 25%
D, Li, B
Fusione nucleare nelle stelle
He, C, O, N, … Fe …
Diffusione nel mezzo interstellare
Supernove, Venti stellari
Aggregazione di molecole
Nubi molecolari, dischi protoplanetari

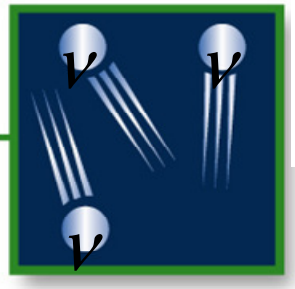
La storia dell'Espansione rivela: un UNIVERSO in espansione



Pizza cosmica

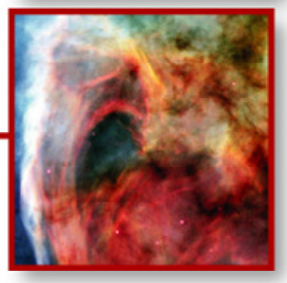


Elementi pesanti:
0.03%

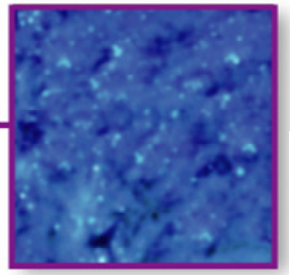


Neutrini:
0.47%

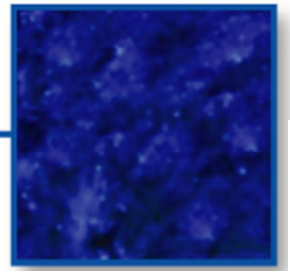
Stelle
0.5%



H & He
4%



Materia scura:
25%



Energia scura:
70%

95% mistero

- “Grandissima mi par l’innezzia di coloro che vorrebbero che Iddio avesse fatto l’Universo più proporzionato alla piccola capacità del loro discorso…”

Galileo Galilei
Opere VII, 397

L'Astronomia

Una necessità primaria

Ulterius progredi temporis angustia inhibet; plura de his brevi candidus Lector expectet

La ristrettezza del tempo mi impedisce di procedere oltre; il benigno Lettore aspetti tra breve una piu' ampia trattazione di questo argomento

Galileo Galilei

Sidereus Nuncius