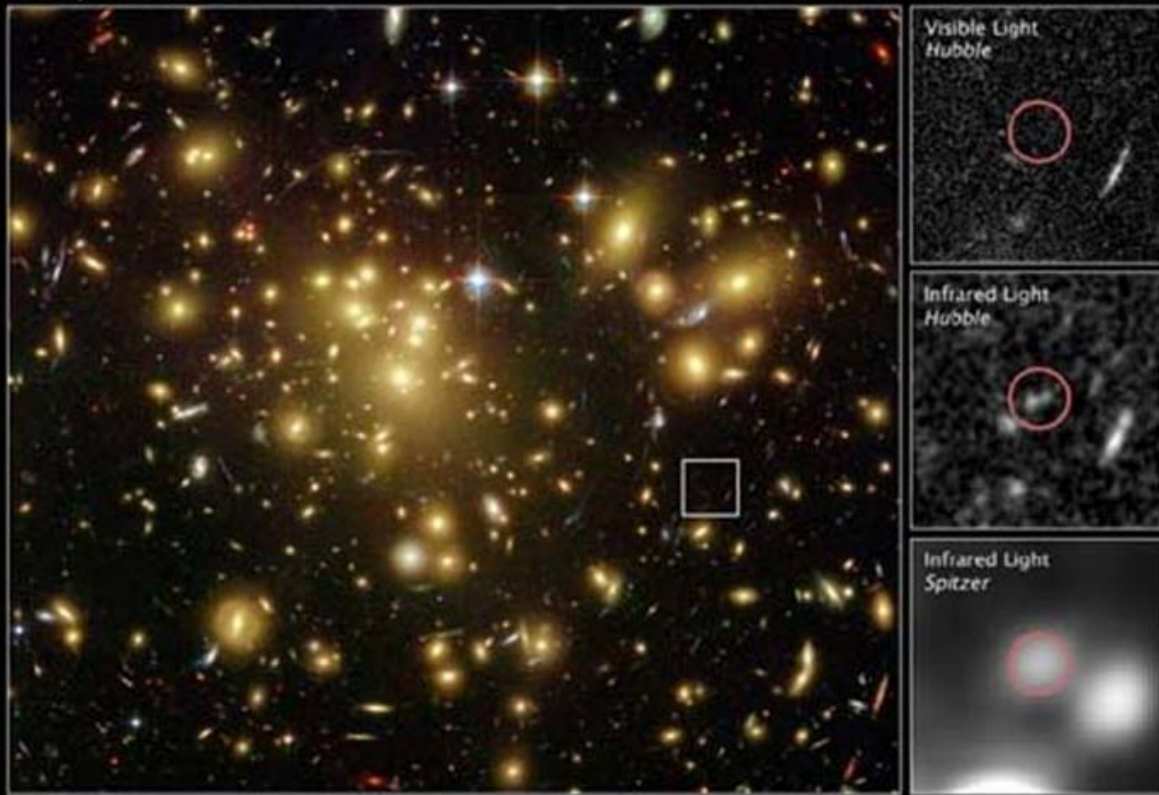


“GALAXIAS EN EL UNIVERSO PRIMITIVO”

Lic. Carlos Guillermo Bornancini

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

Instituto de
Astronomía
Teórica y
Experimental
(IATE)

Las Conferencias se realizan los primeros viernes de cada mes
en el Observatorio Astronómico, calle Laprida 854- Córdoba



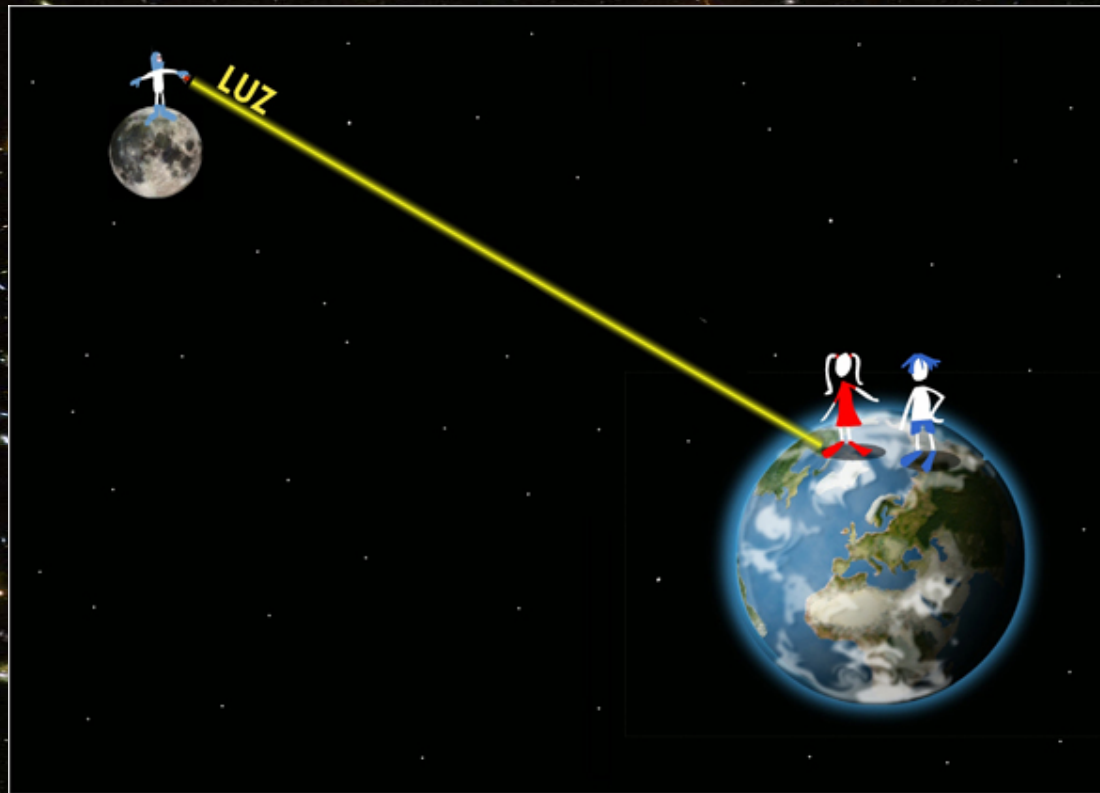
UNIVERSIDAD
NACIONAL
DE CORDOBA

Resumen

- Distancias y medidas de la tierra, los planetas y estrellas
- Standard candles y rulers
- Estrellas Cefeidas
- Distancias a las galaxias: Corrimientos al rojo
- Supernovas Ia
- Lentes gravitacionales
- Gamma Ray Burst, Quásars, radio-galaxias
- Implicancias Cosmológicas

La velocidad de la luz NO es infinita

$$c = 299.792 \text{ km/s}$$



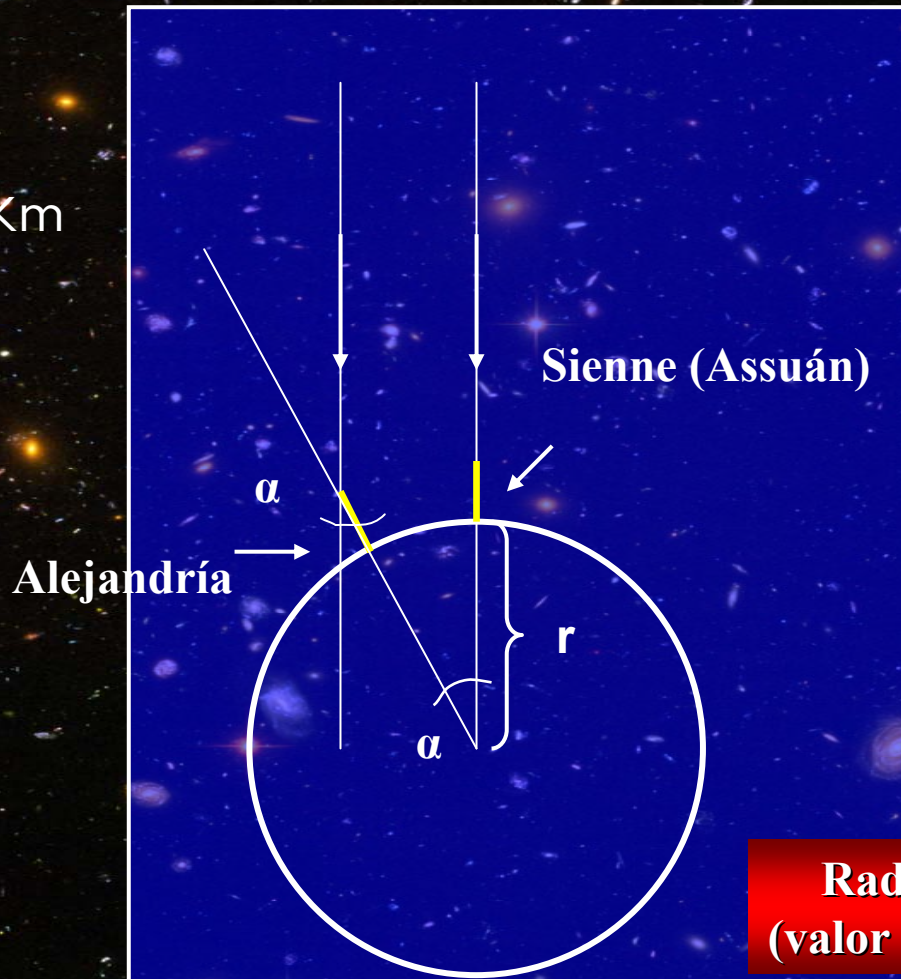
De la Tierra a las galaxias

- Eratóstenes (284-192 a.C): Medición del radio terrestre

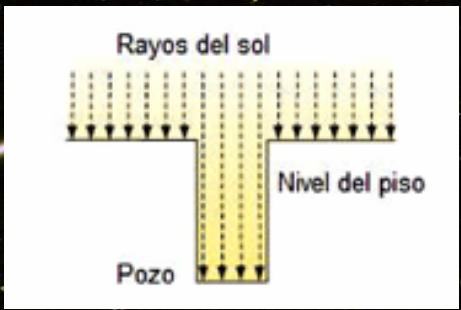
$$\begin{array}{l} 7^\circ \text{ ————— } 800 \text{ Km} \\ 360^\circ \text{ ————— } x \end{array}$$

$$x = \frac{360^\circ \times 800 \text{ km}}{7.2^\circ}$$

$$x = 2\pi r$$

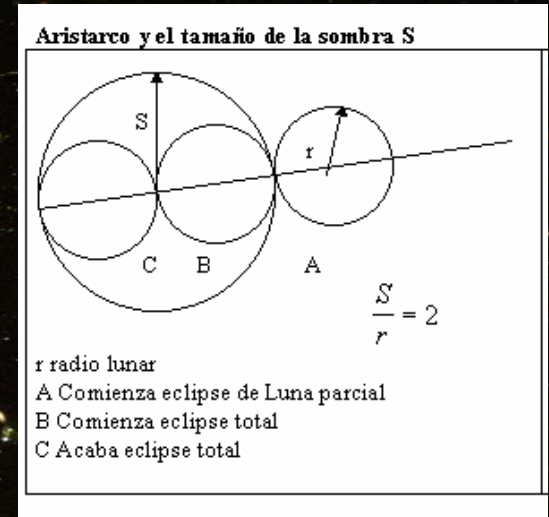
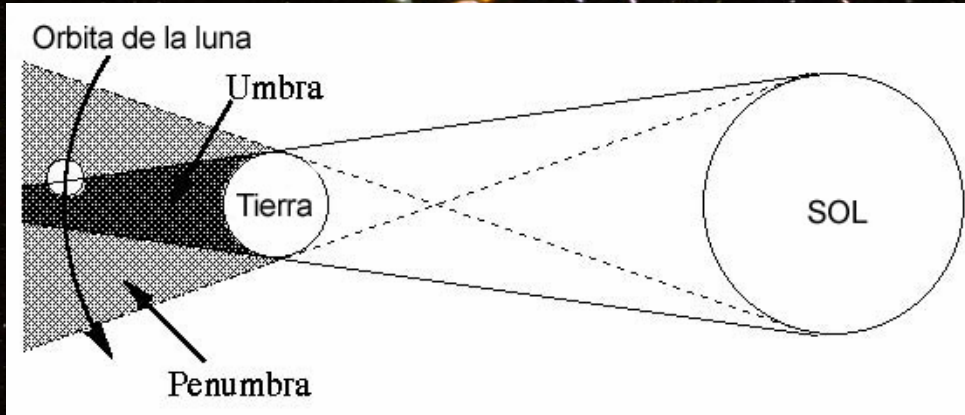


Radio=6271 km.
(valor real 6365 km.)



Distancia Tierra-Luna

Aristarco de Samos (310-230 a.C)

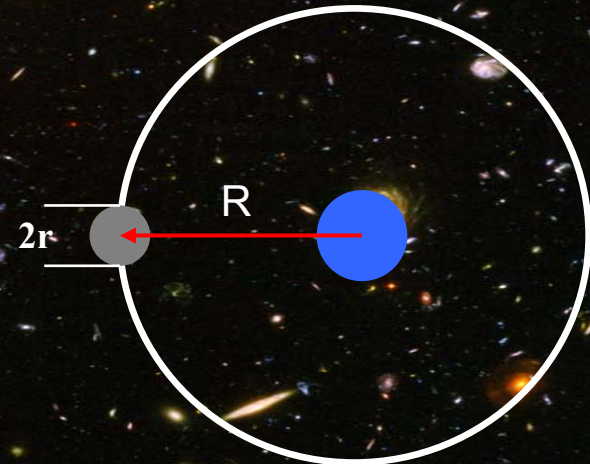


29.5 días → 1 vuelta completa

708 hs ————— $2\pi R$

1 hora ————— $2r$

$$R/r = 225.4$$

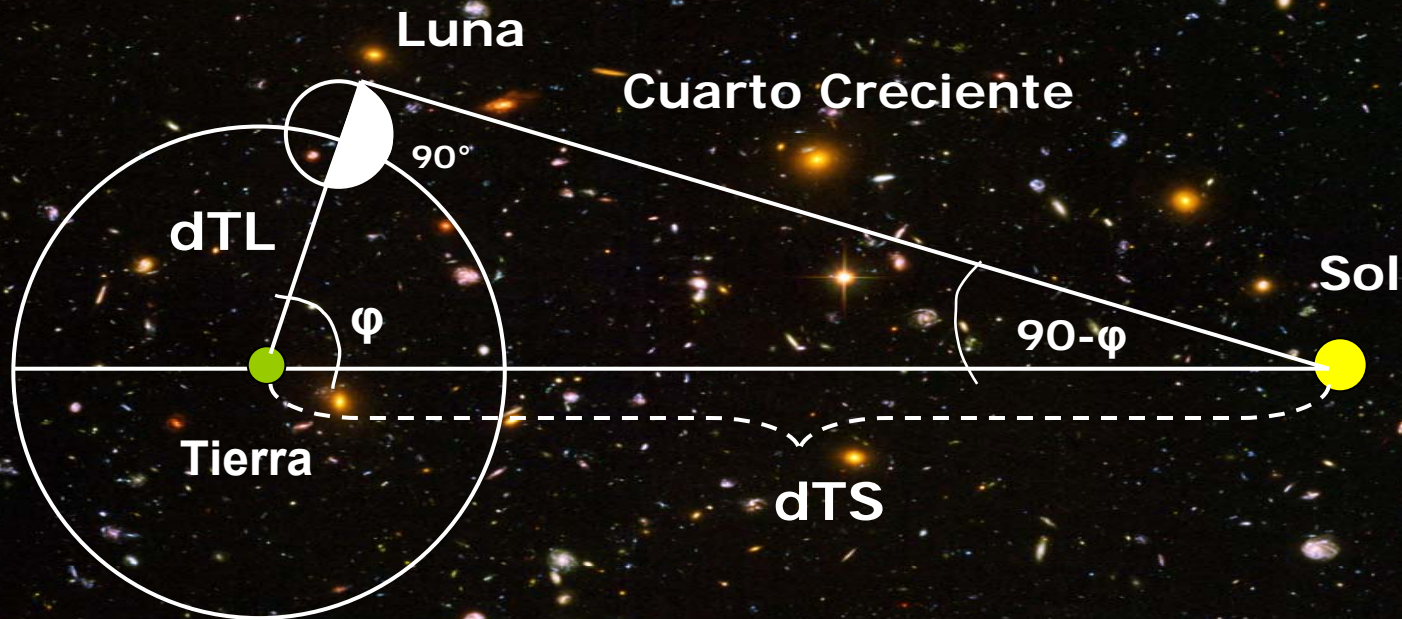


Eclipse de luna



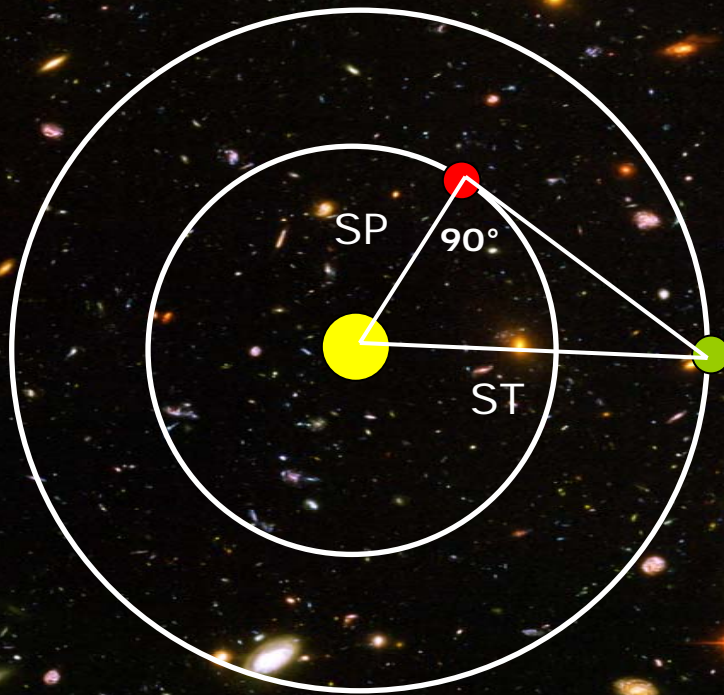
Distancia Tierra-Sol

Aristarco de Samos (310-230 a.C)

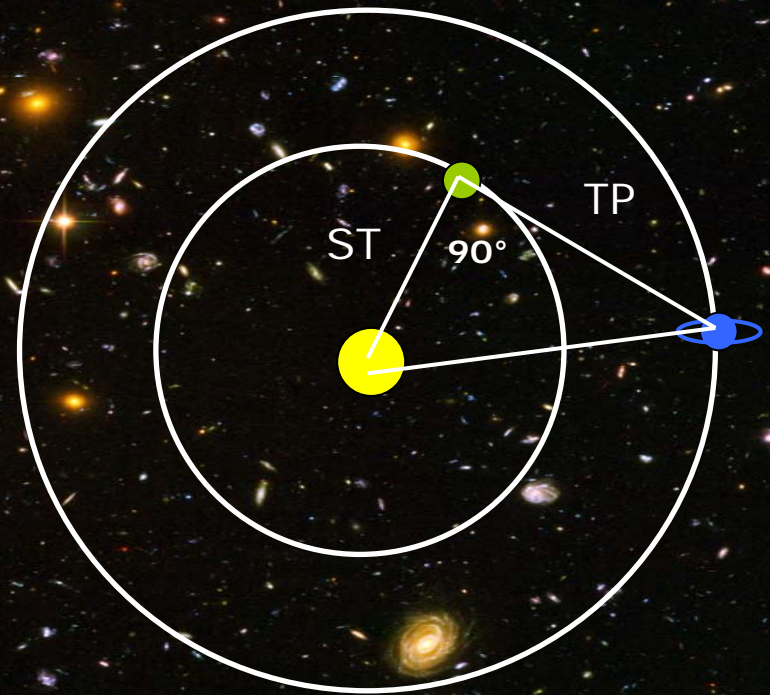


Distancia Tierra-planetas

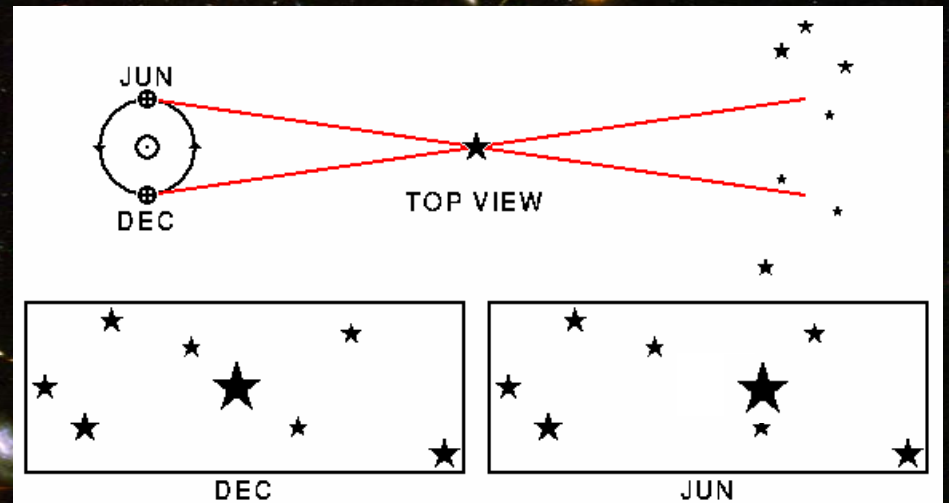
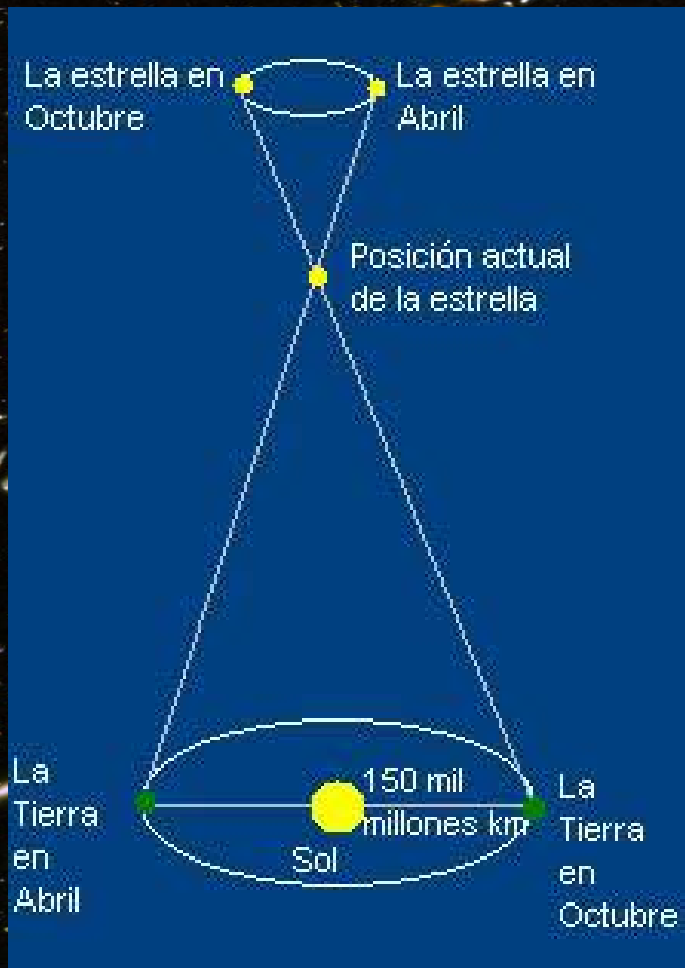
Planeta Interior



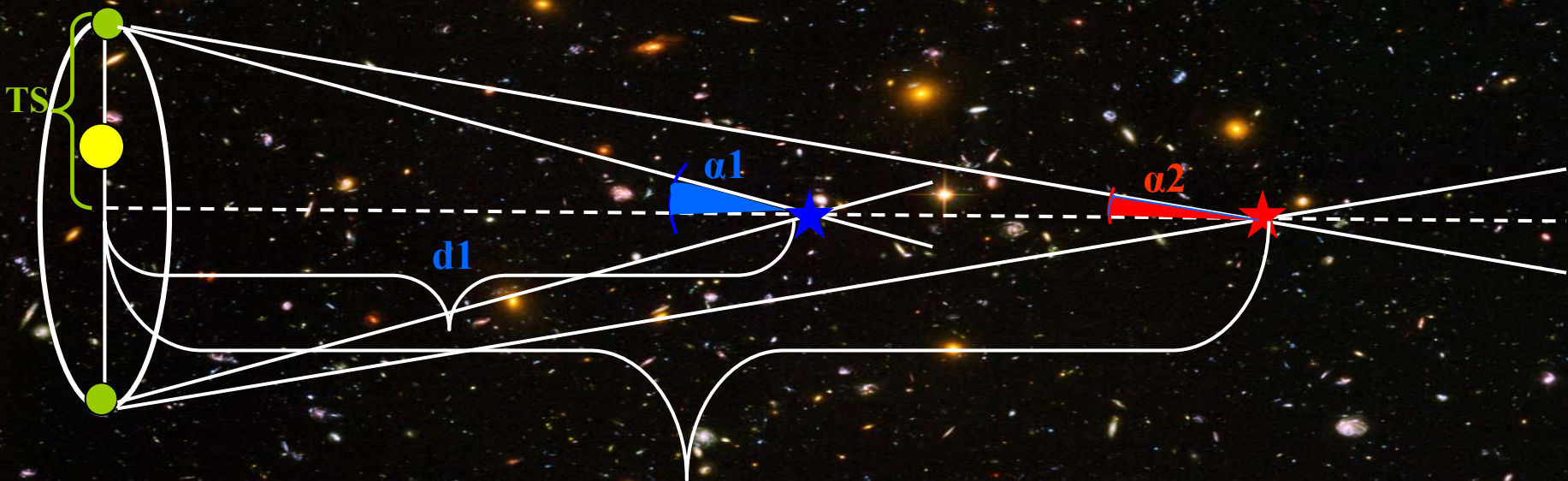
Planeta Exterior



Distancia a las estrellas: Paralaje



$$\text{tg}\alpha_1 = \frac{\text{TS}}{\alpha_1}$$

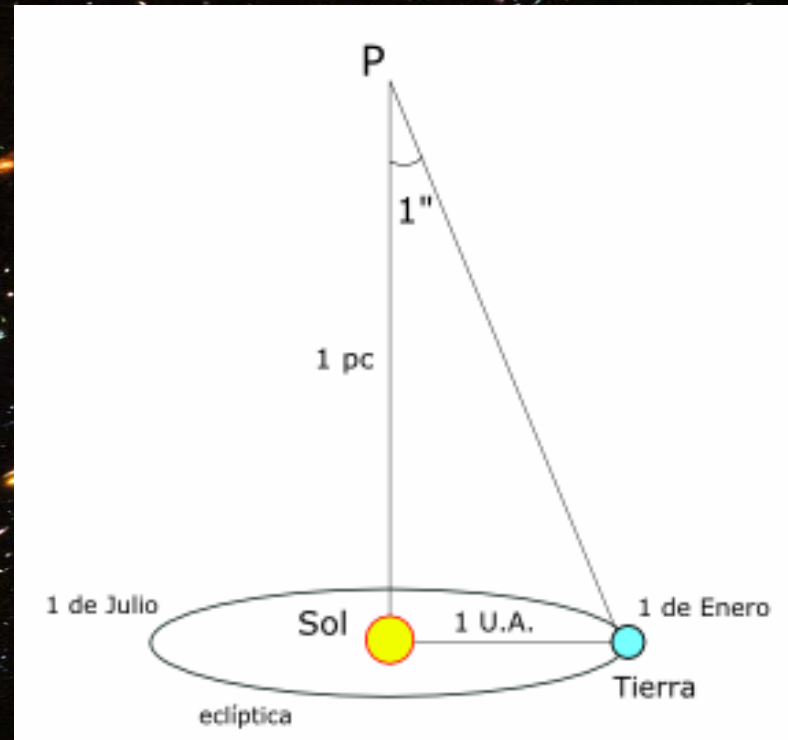


d2

d2 > d1 si $\alpha_2 < \alpha_1$

El pársec : Paralaje Sec segundo

1 Pársec = 3.262 años luz

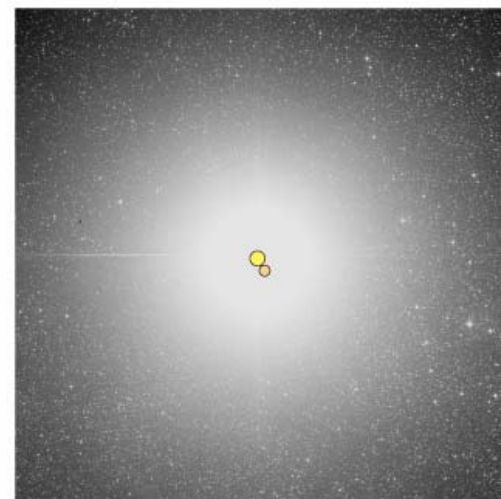


Próxima Centauri, tiene una paralaje de 0"765.
4.26 años luz

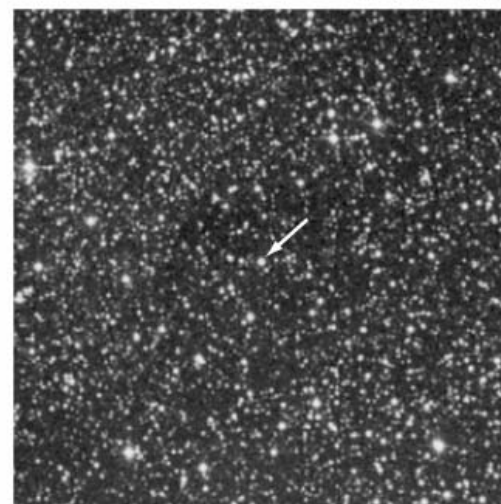
Cruz del Sur: Proxima centauri



© Akira Fujii/DMI



α Cen A & B



Proxima

The Triple Stellar System Alpha Centauri
(ESO 1-m Schmidt Telescope)

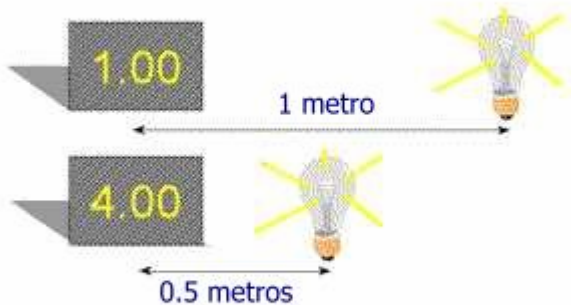
ESO PR Photo 07a/03 (15 March 2003)

© European Southern Observatory



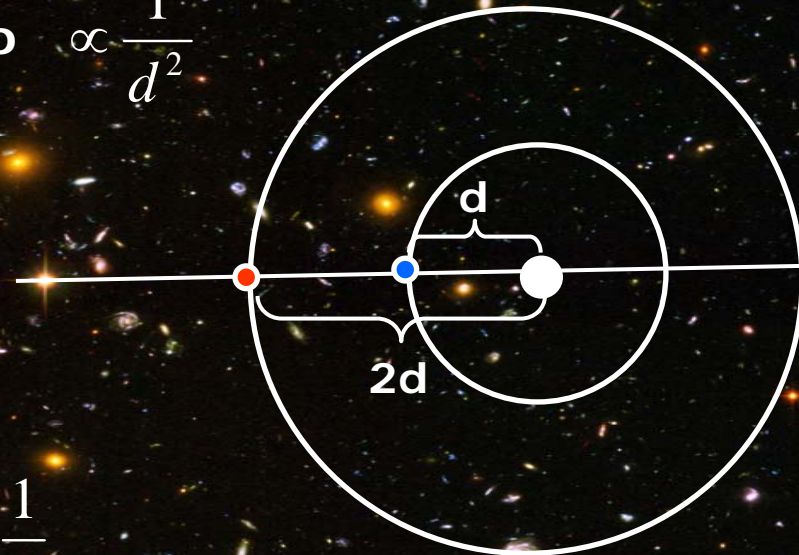
Standard candles y rulers

Midiendo distancia con una candela estándar

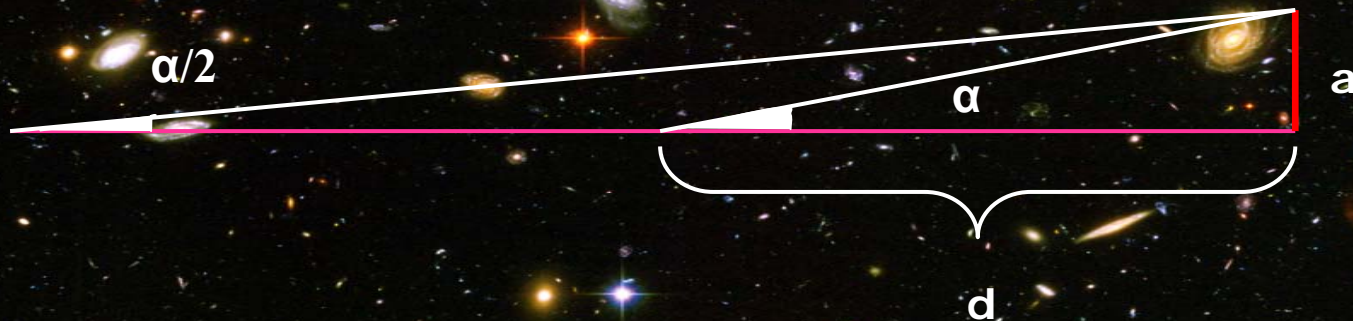


El brillo de un objeto disminuye como el cuadrado de la distancia

Brillo de un objeto $\propto \frac{1}{d^2}$



Tamaño aparente de un objeto $\propto \frac{1}{d}$



Distancias: magnitud aparente y absoluta

$$\bar{m} - \bar{M} = M.D$$



Magnitud
aparente



Magnitud
absoluta

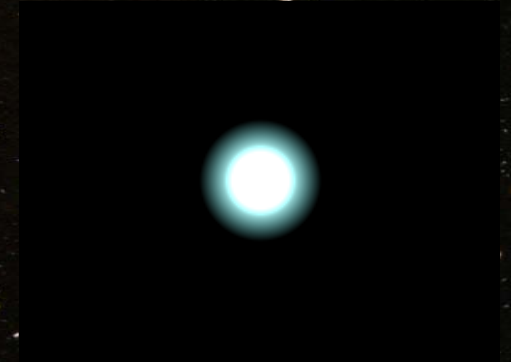


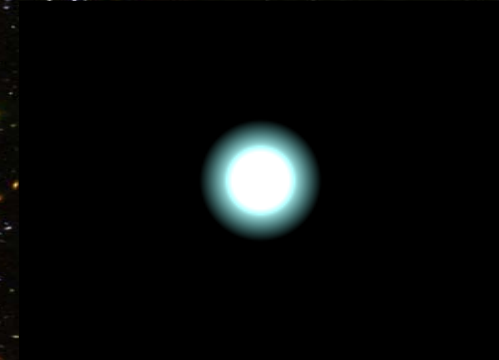
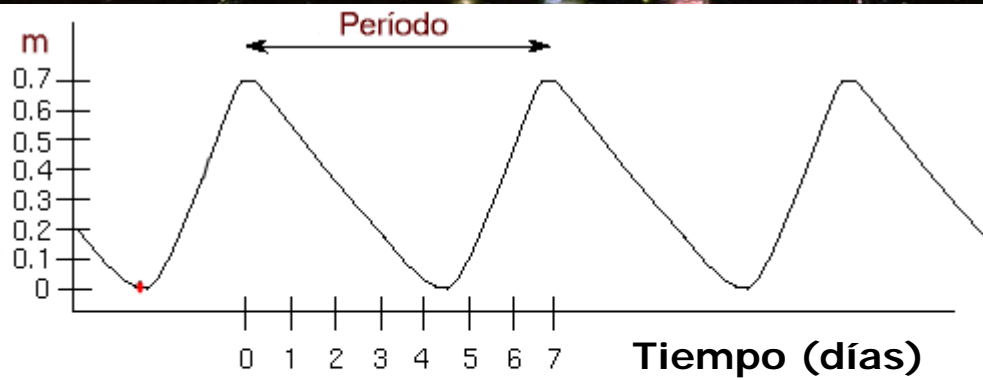
Distancia

Estrellas Variables Cefeidas

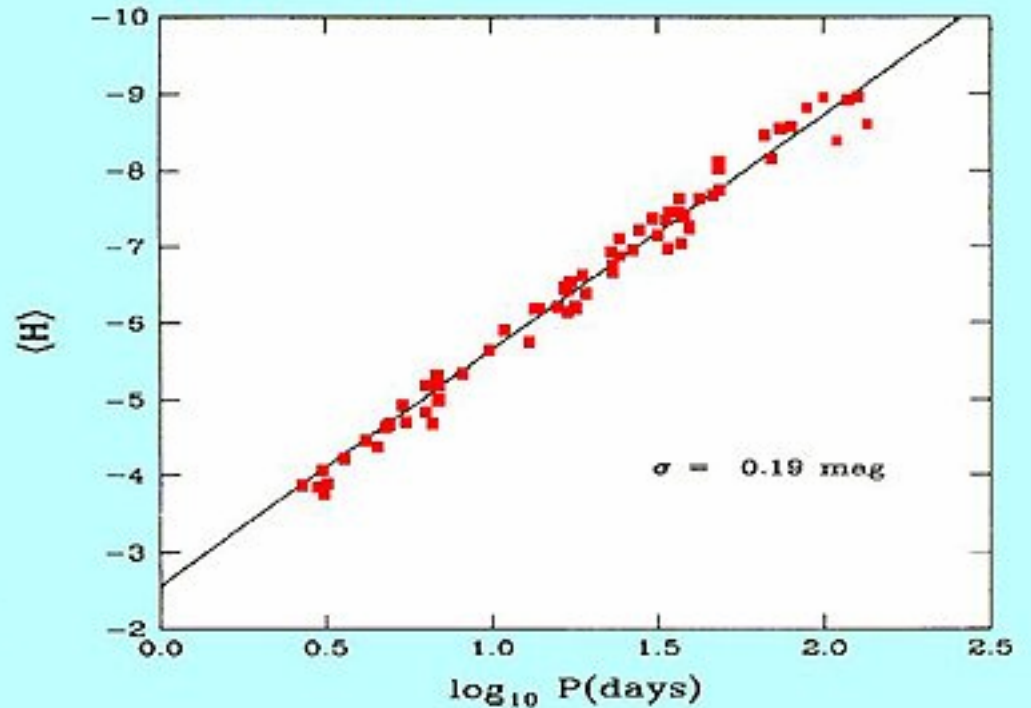
Henrietta Swan Leavitt

(1868-1921).



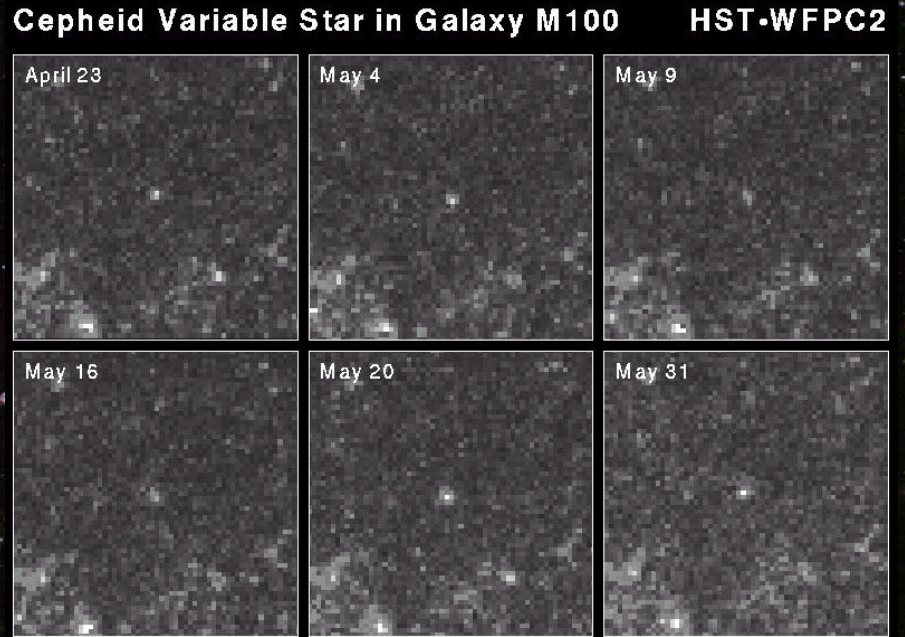
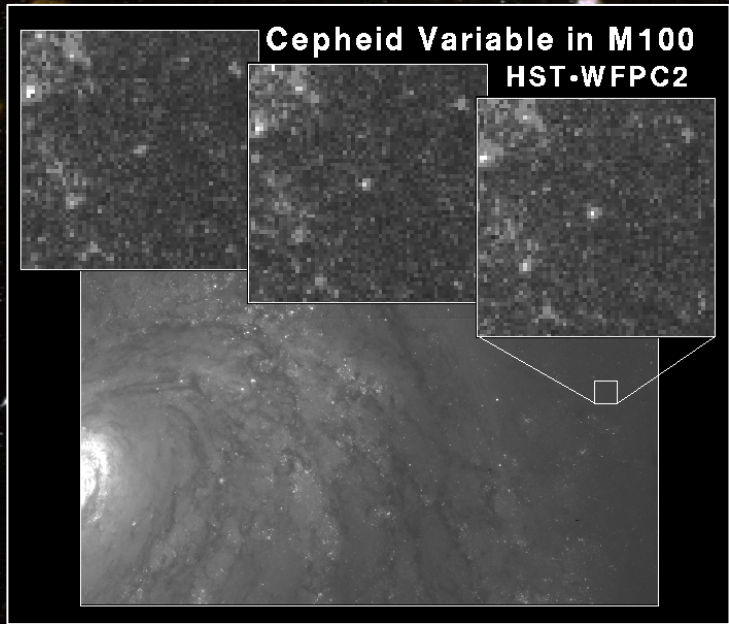


COMPOSITE P-L



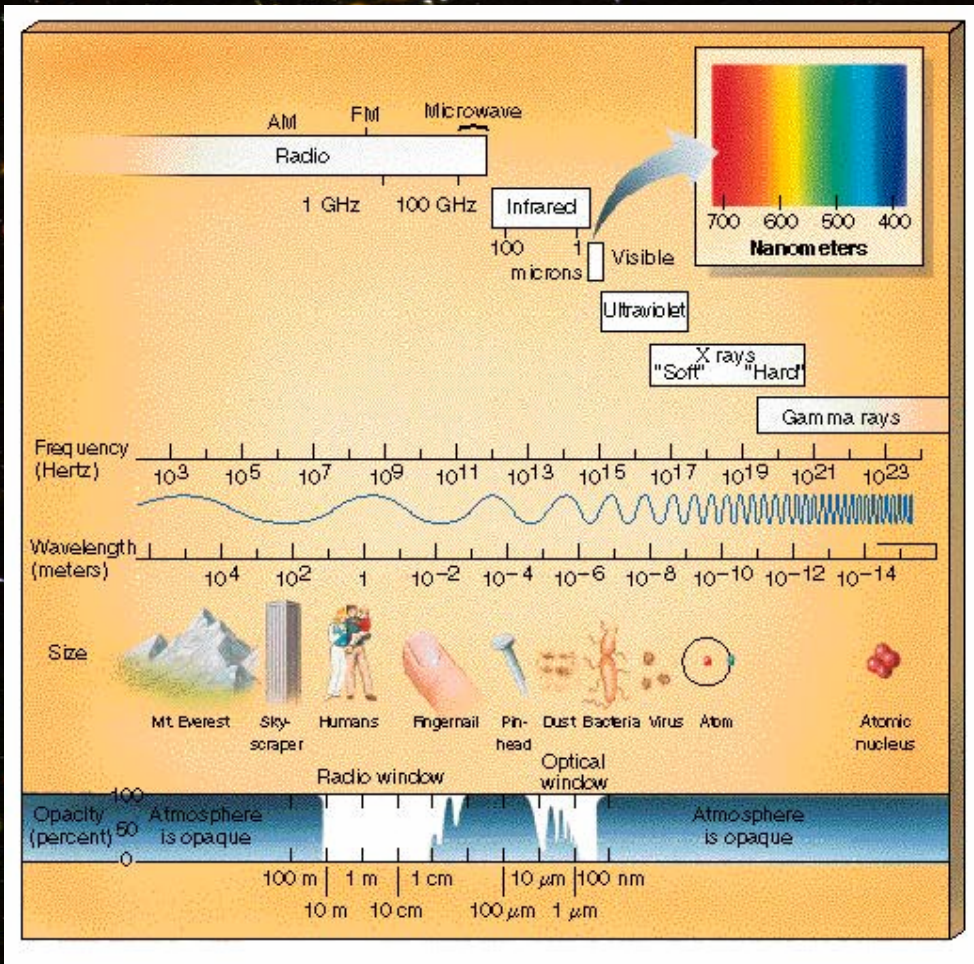
$$M_v = a_6 + b_6 \log P$$

Cefeidas en galaxias

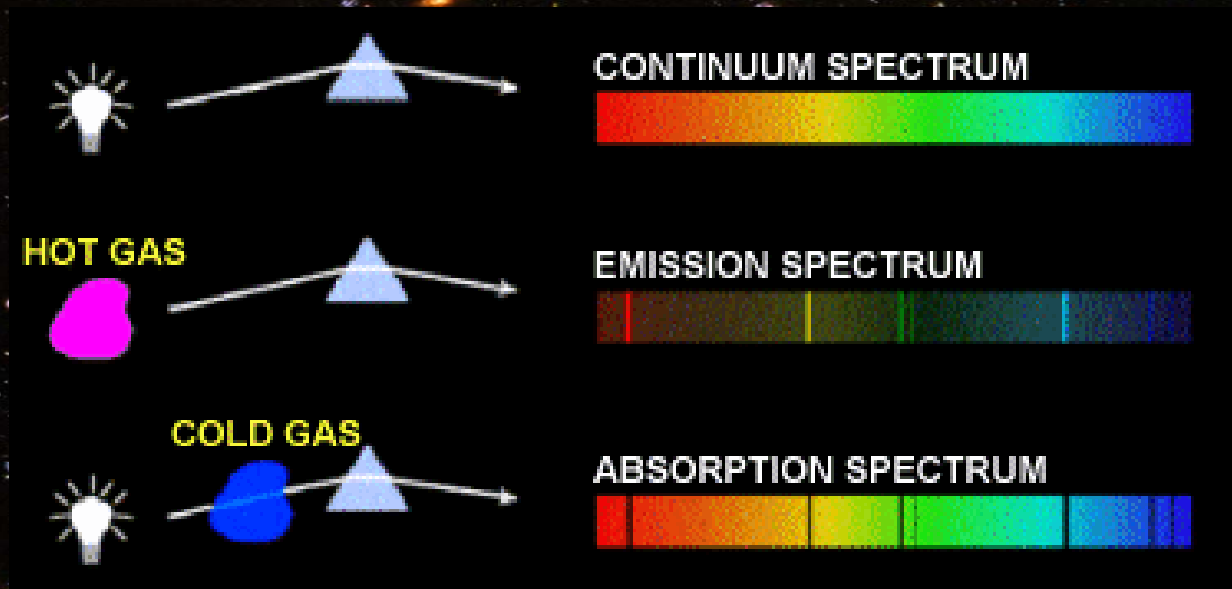


D=50 millones de años luz
HST 80 millones de años luz
2500 galaxias

Distancias a las galaxias: Corrimientos al rojo



Ley de Kirchoff



Espectros de Gases

Hidrógeno

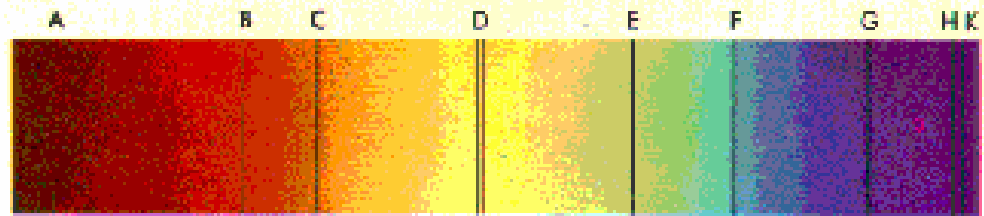


Helio

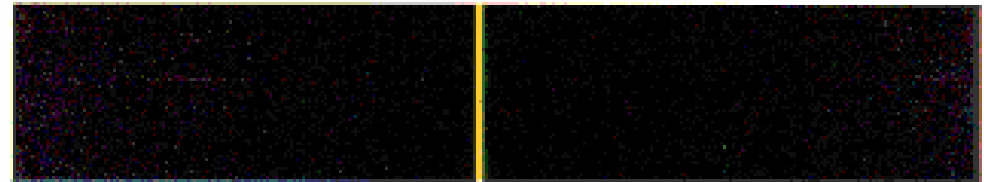


Bright Line Spectra

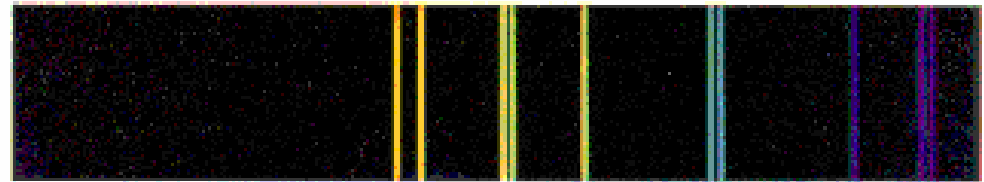
Espectro del Sol



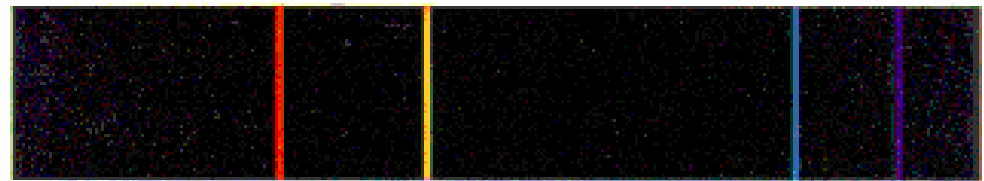
THE SOLAR SPECTRUM



SODIUM



MERCURY

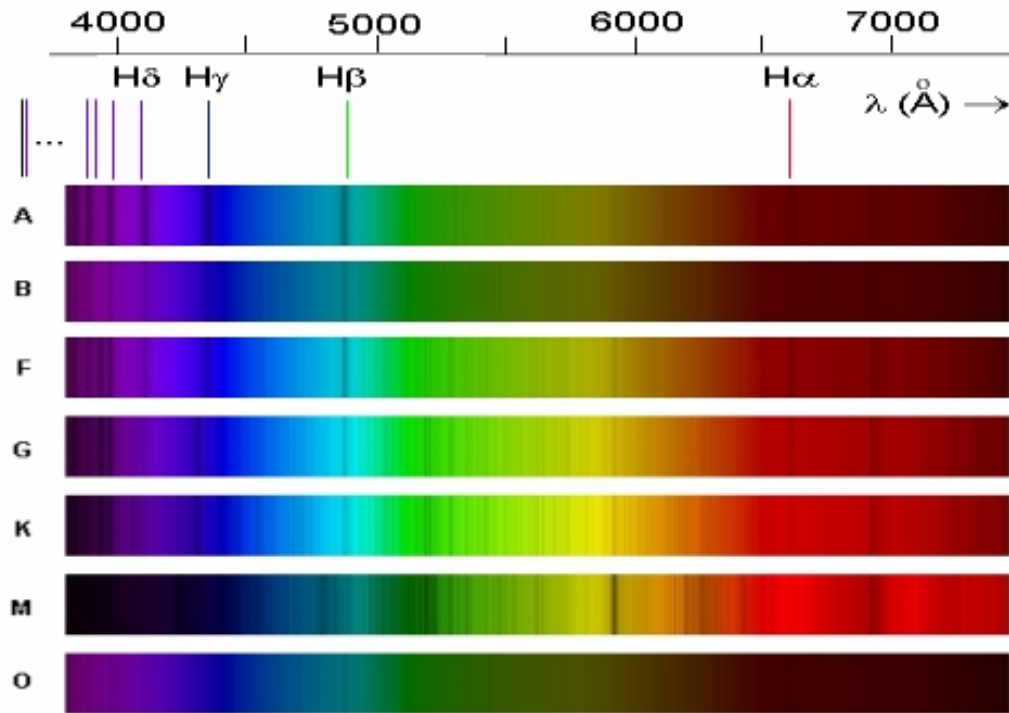


LITHIUM



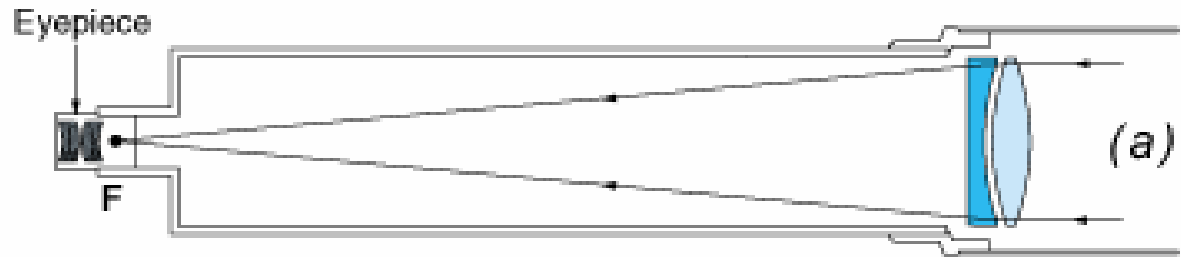
HYDROGEN

Espectros de estrellas

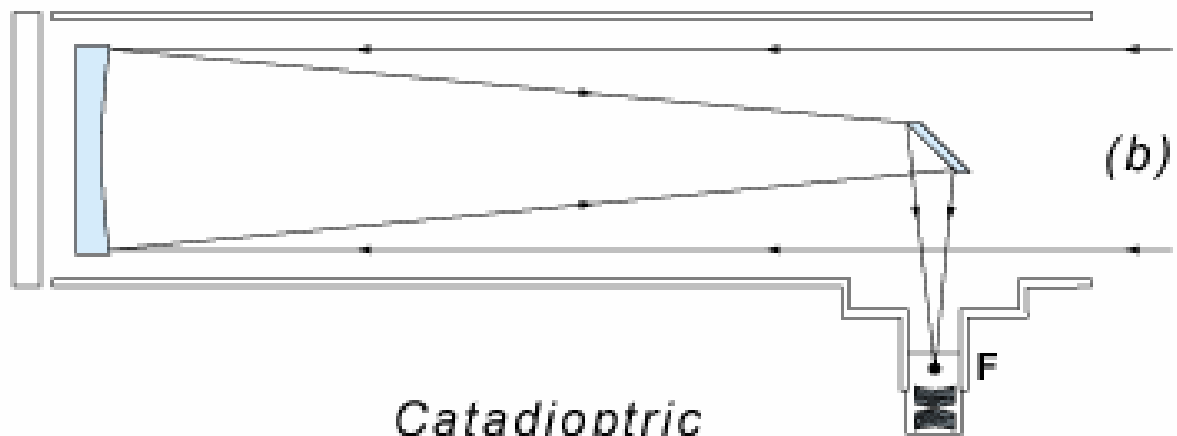


The hydrogen Balmer spectrum is visible for most stars. And astronomers categorized stars according to the strength of the hydrogen absorption lines in the spectrum in the late 19th century.

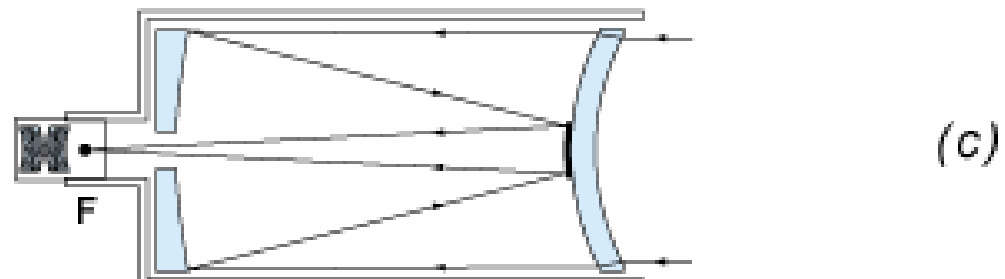
Refracting

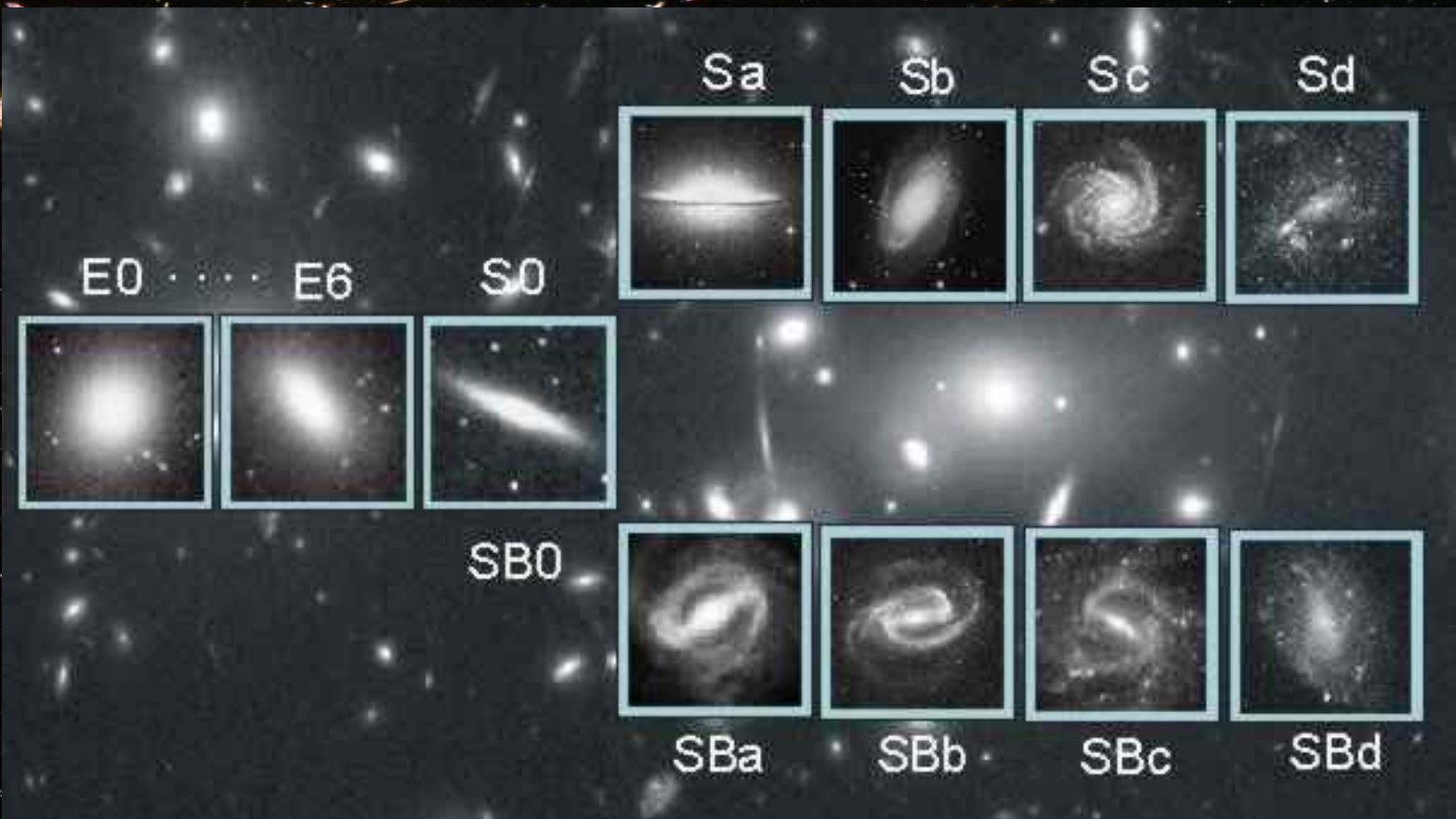


Reflecting

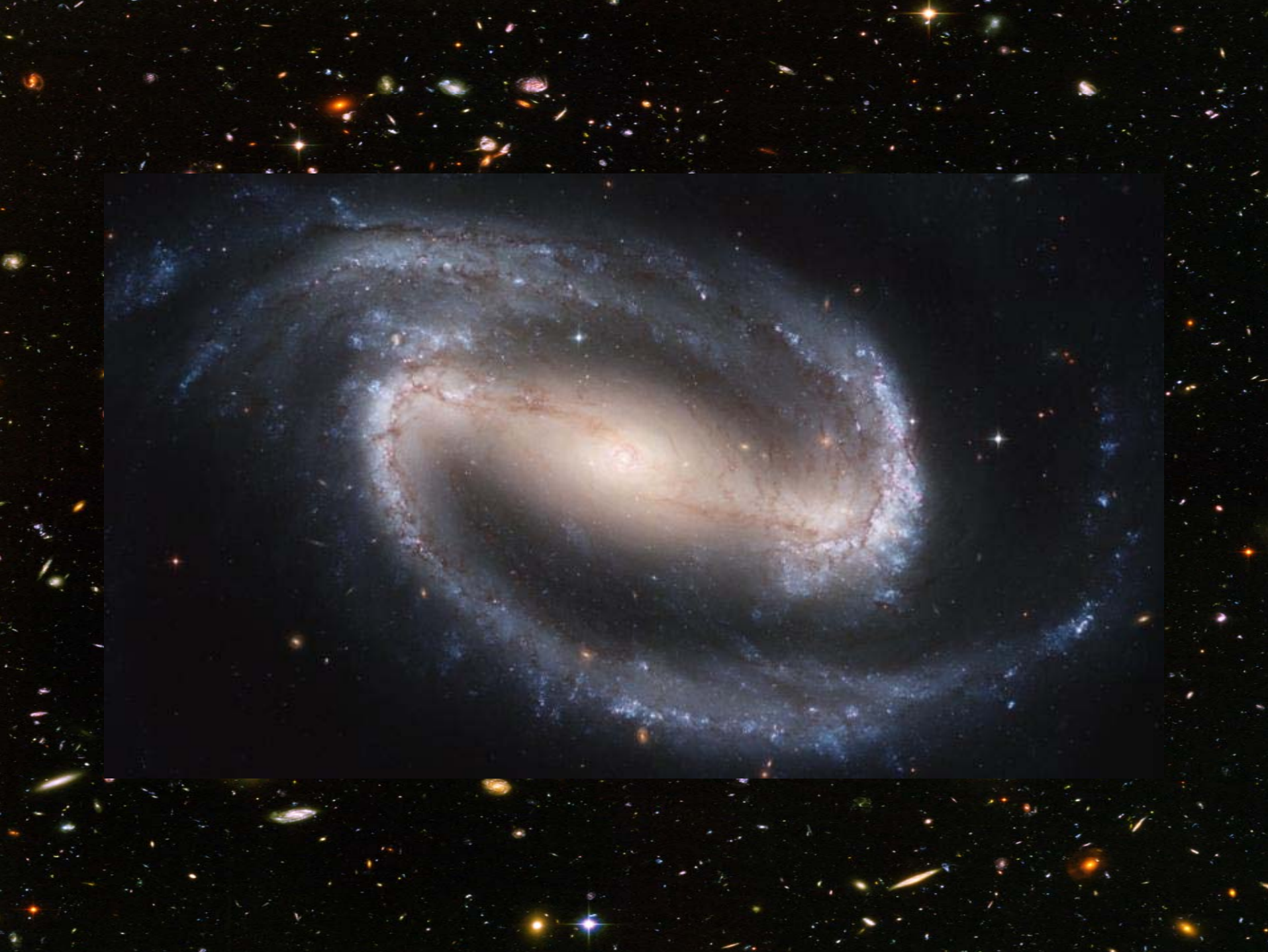


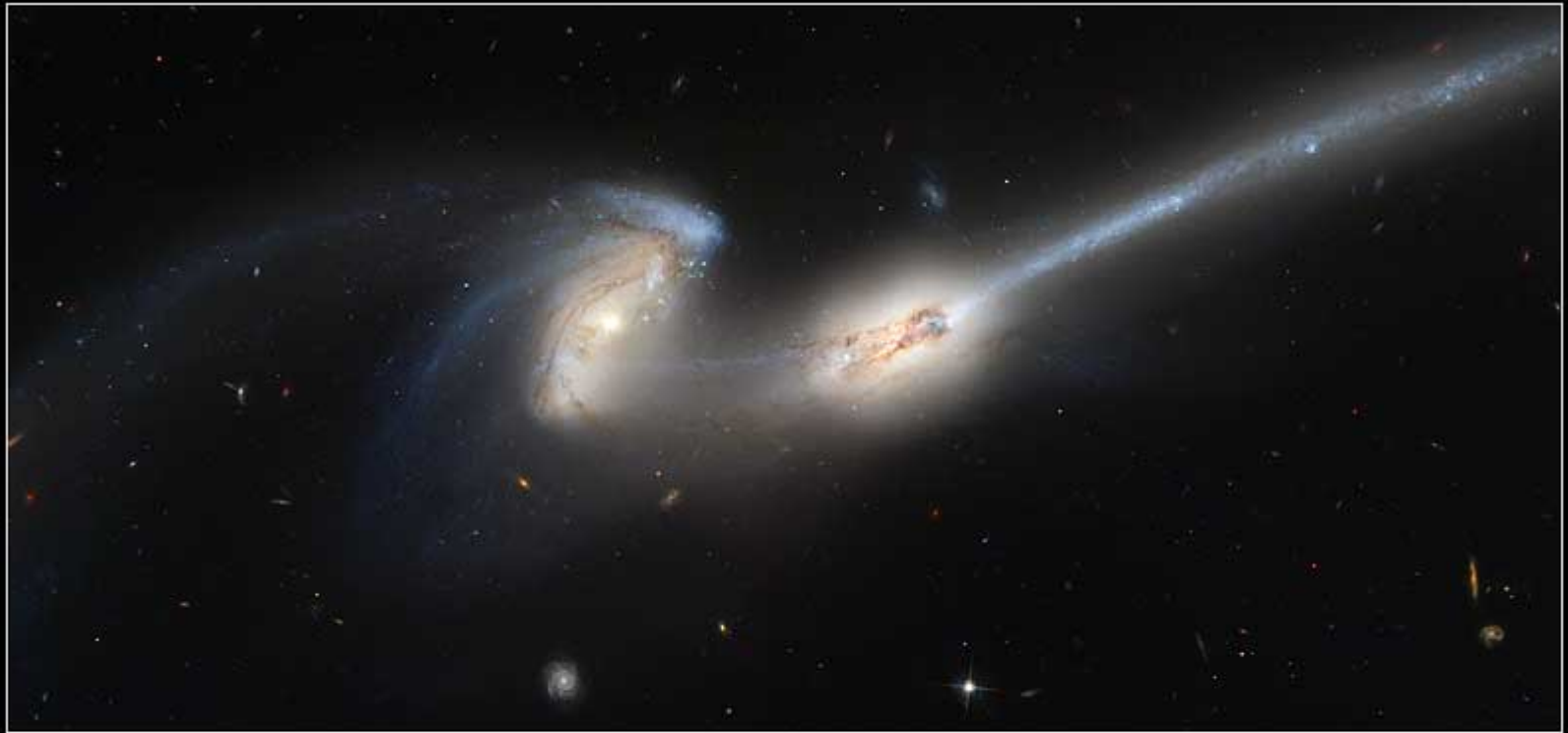
Catadioptric











The Mice • Interacting Galaxies NGC 4676

HST • ACS

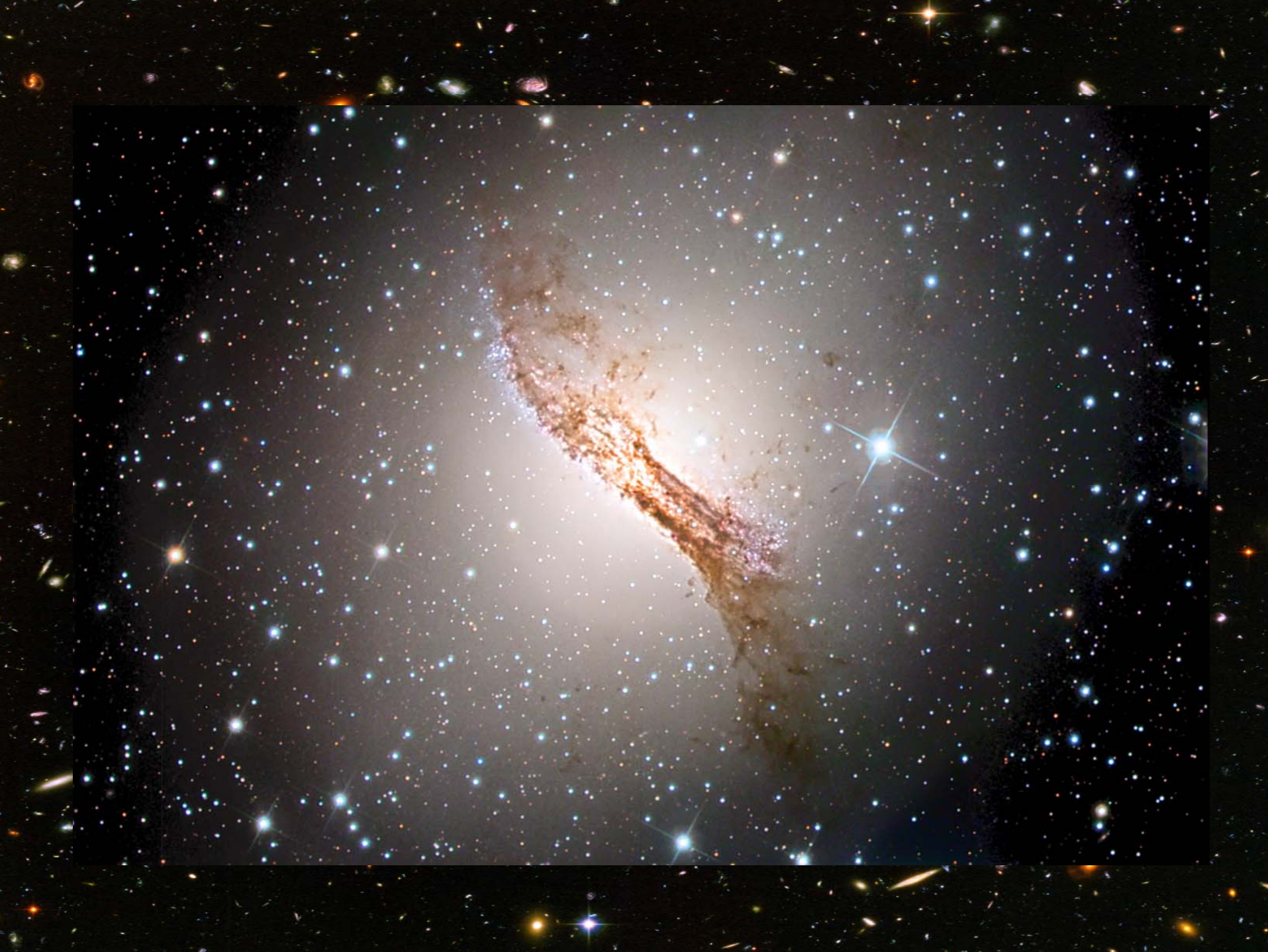
NASA, H. Ford (JHU), G. Illingworth (UCSC/LO), M. Clampin (STScI), G. Hartig (STScI), the ACS Science Team and
ESA • STScI-PRC02-11d



Sombrero Galaxy • M104



Hubble
Heritage

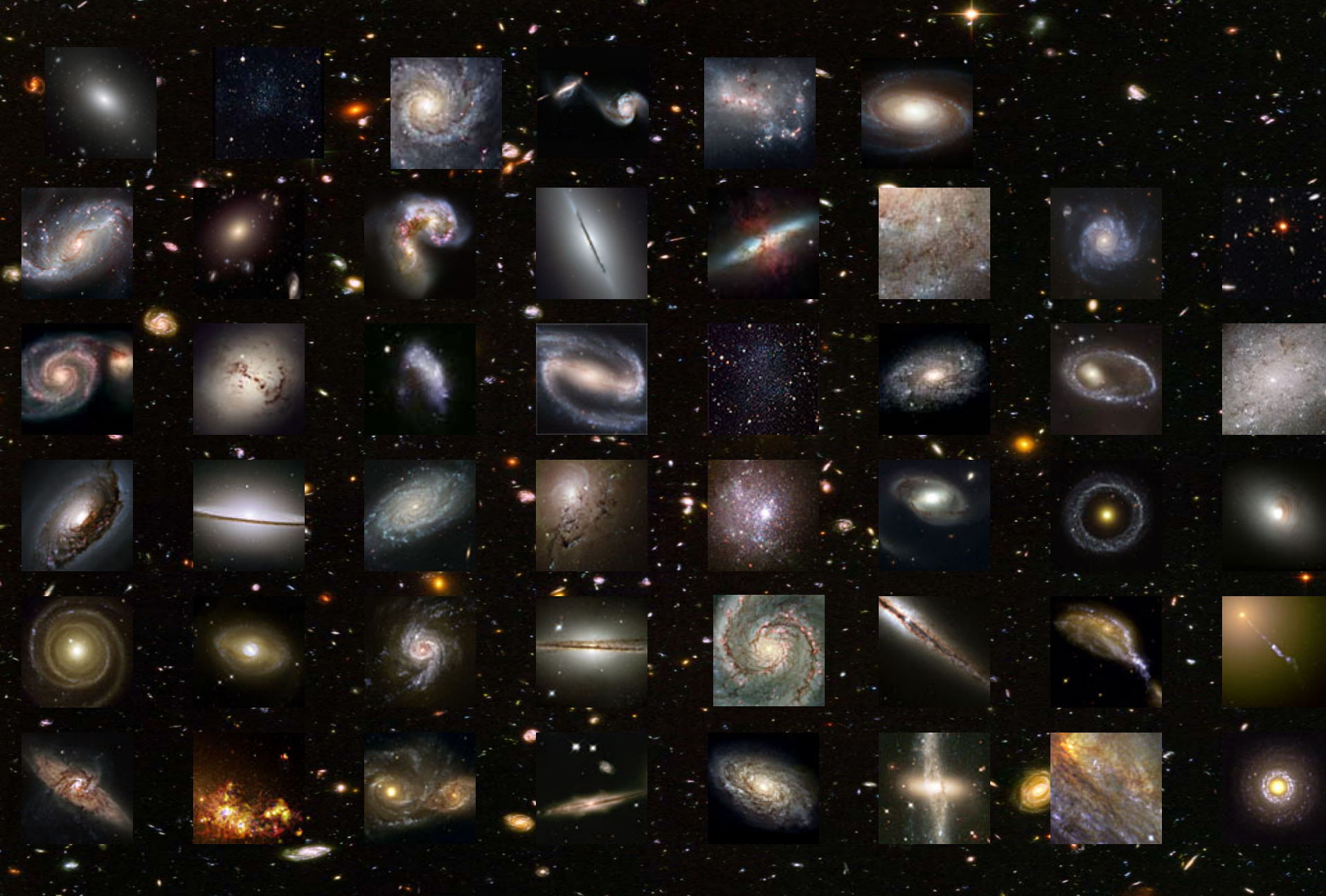


Polar-Ring
Galaxy
NCC 4650A

PRC99-16
Space Telescope
Science Institute
Hubble Heritage Team
(AURA/STScI/NASA)



Hubble
Heritage

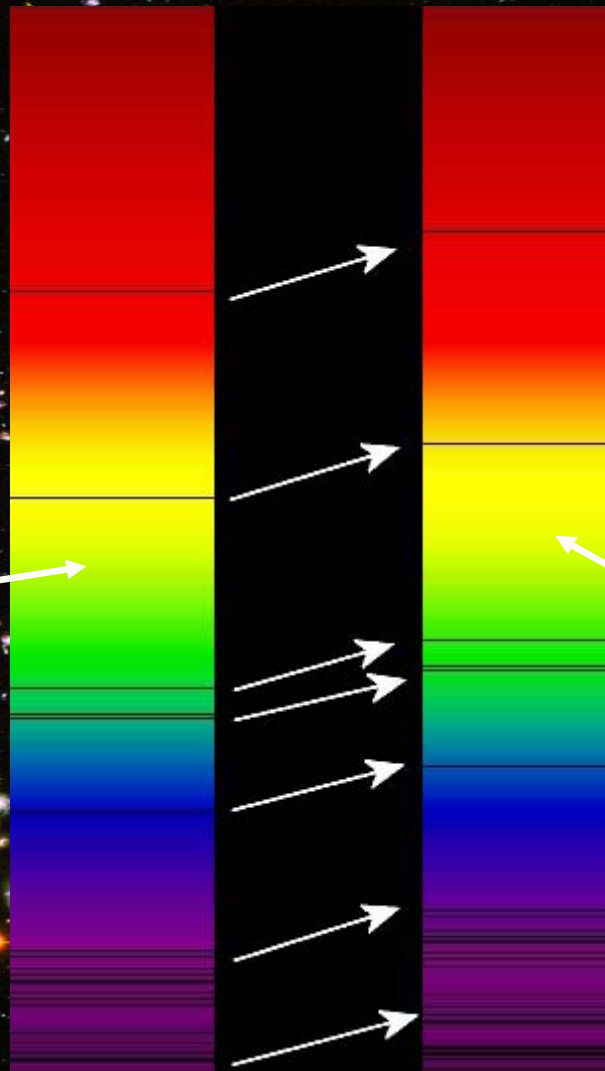


http://heritage.stsci.edu/gallery/gallery_category.html

Corrimiento al rojo

Gas en Laboratorio

Gas en galaxia

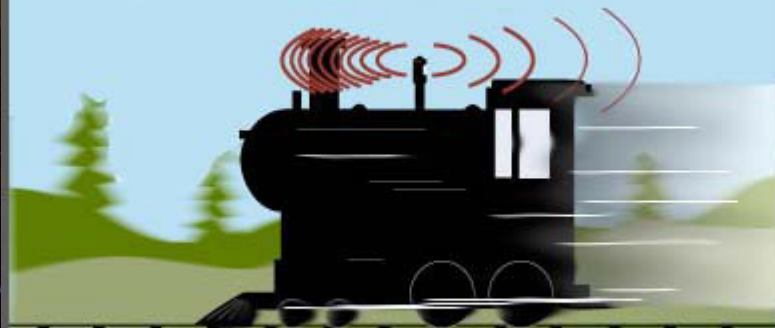


Misma Frecuencia



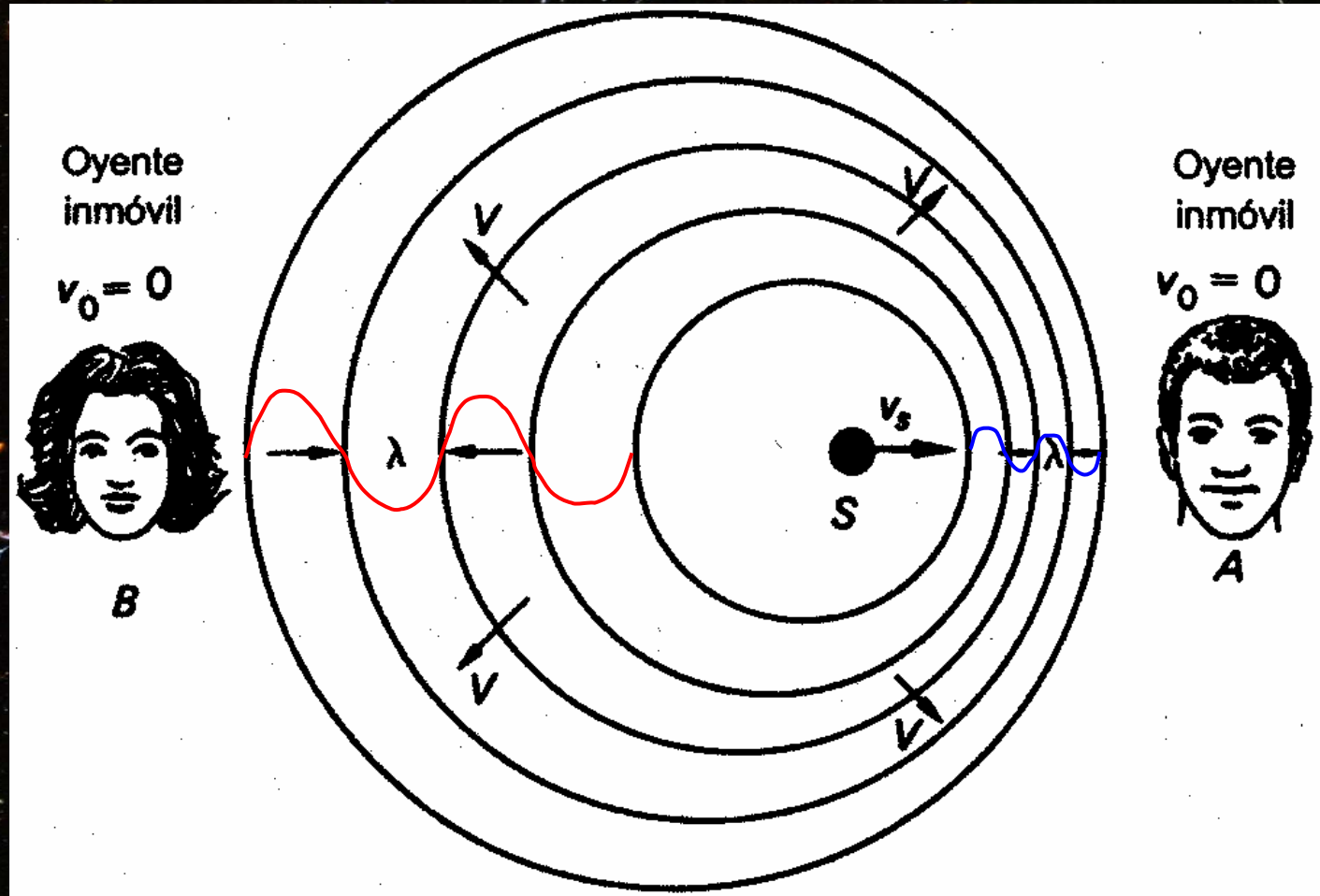
ESTACIONARIO

Frecuencia Mayor Frecuencia Menor



EN MOVIMIENTO

Efecto Doppler



Redshift

Laboratorio
en reposo



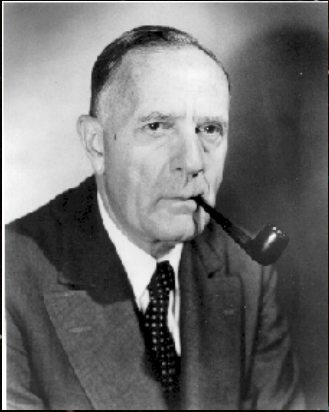
Galaxia



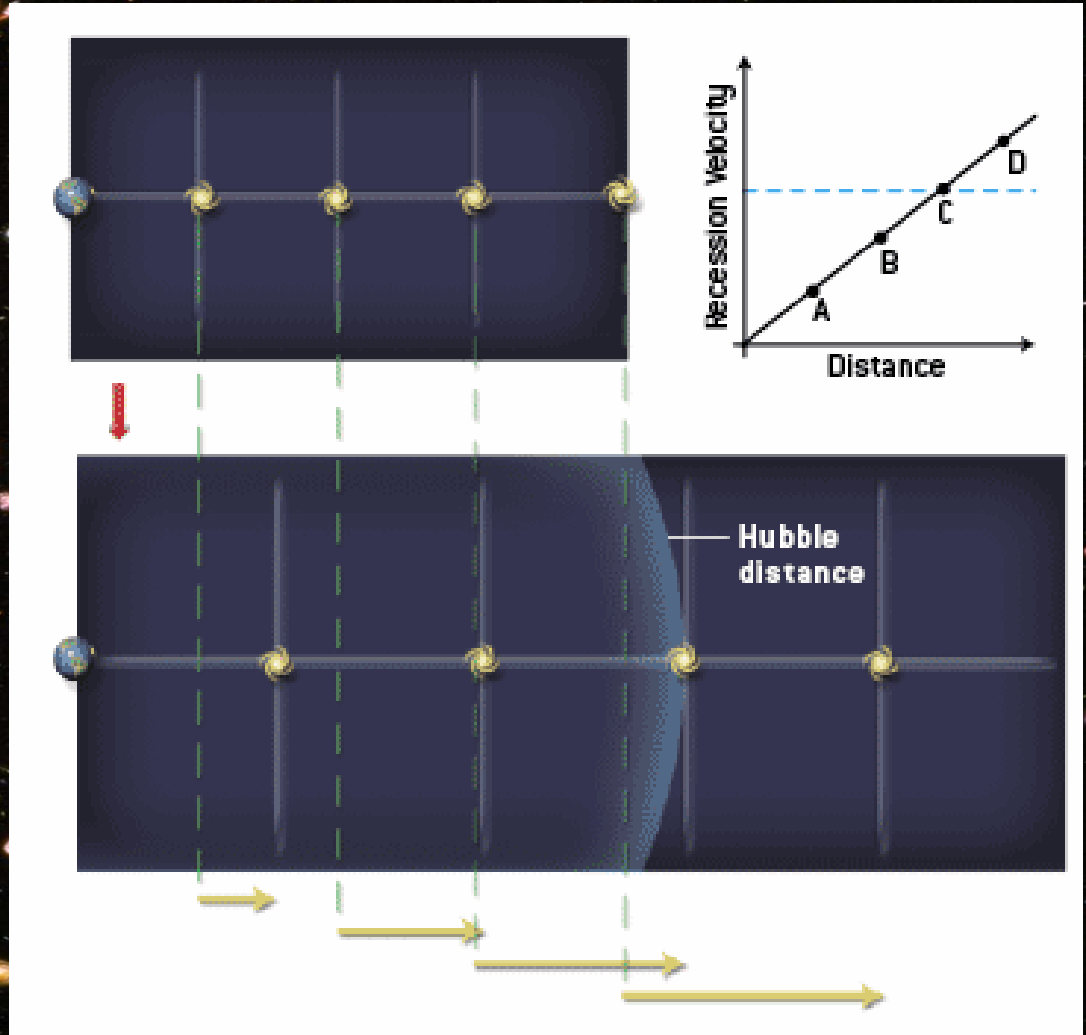
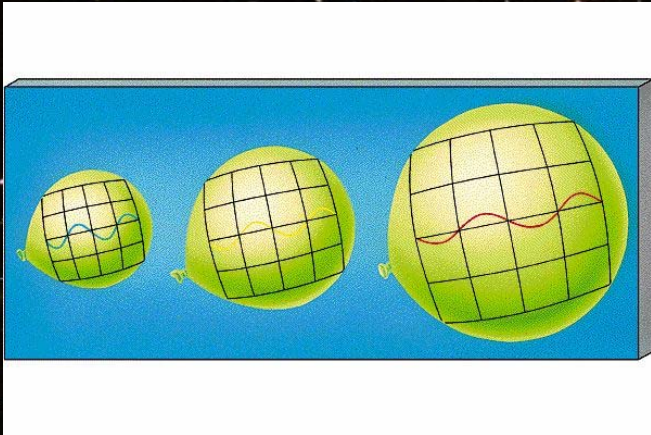
$$z = \frac{\lambda' - \lambda}{\lambda}$$

$$v = c \times z$$

Ley de Hubble



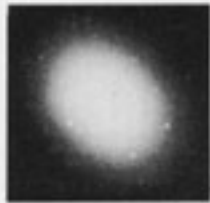
Edwin Hubble



Cluster
nebula in

Distance in
light-years

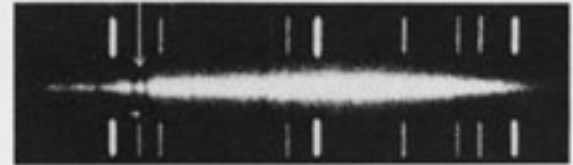
Redshifts



Virgo

78,000,000

H + K



1,200 km s⁻¹



Ursa Major

1,000,000,000

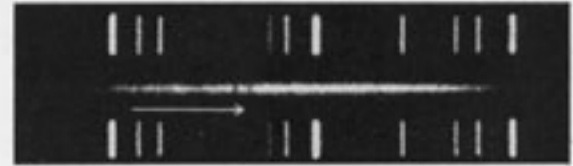


15,000 km s⁻¹



Corona
Borealis

1,400,000,000

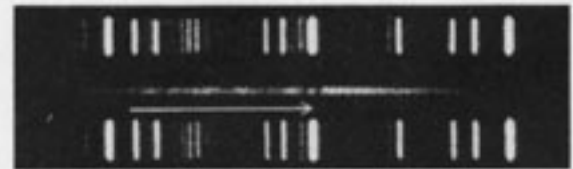


22,000 km s⁻¹



Bootes

2,500,000,000

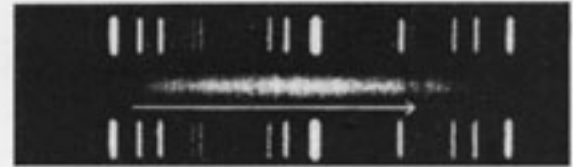


39,000 km s⁻¹



Hydra

3,960,000,000



61,000 km s⁻¹

Expansión del Universo

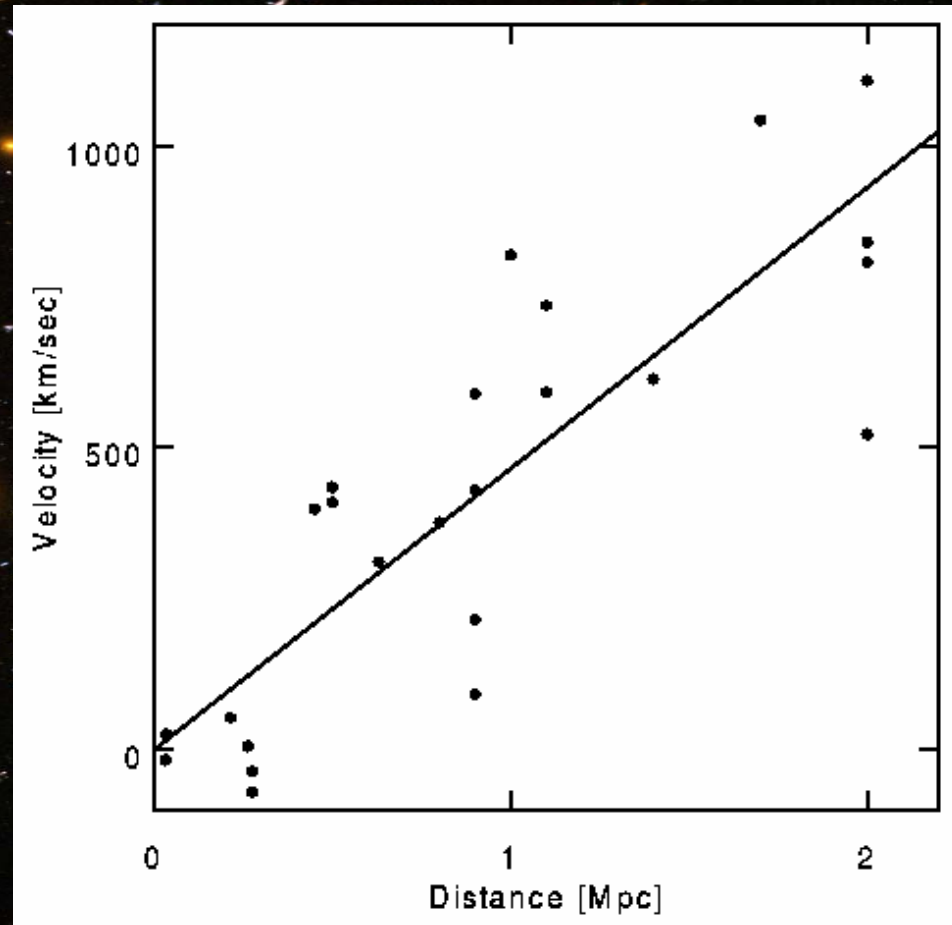
■ Hubble (1926).

$$v = H \times d$$

$$d = v \times T$$

$$d = H \times d \times T$$

$$T = \frac{1}{H}$$



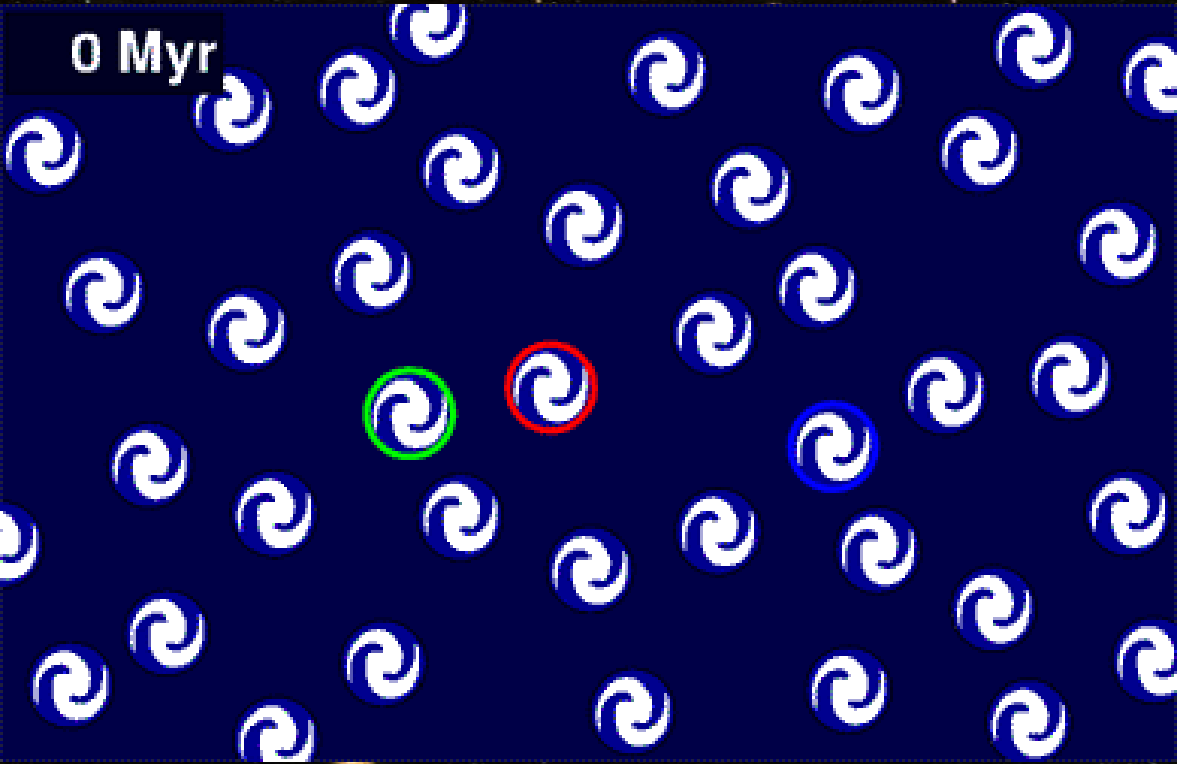
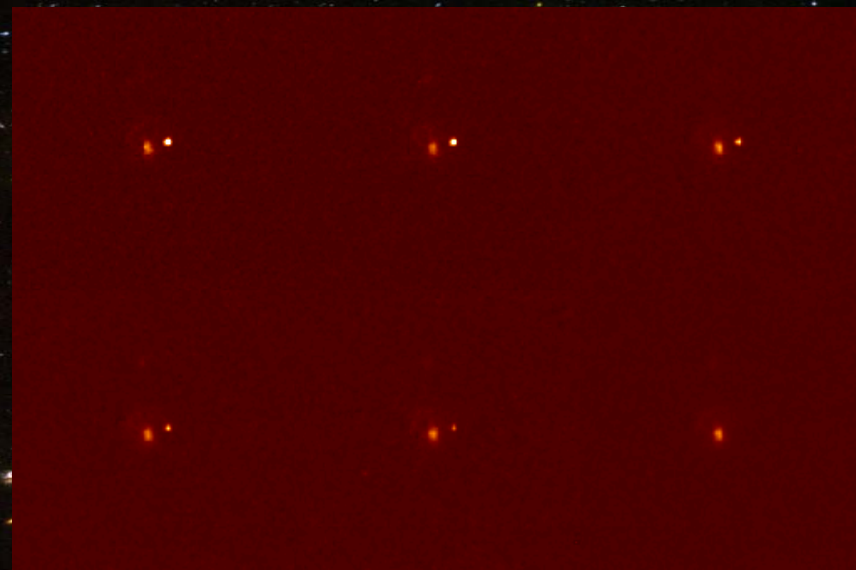
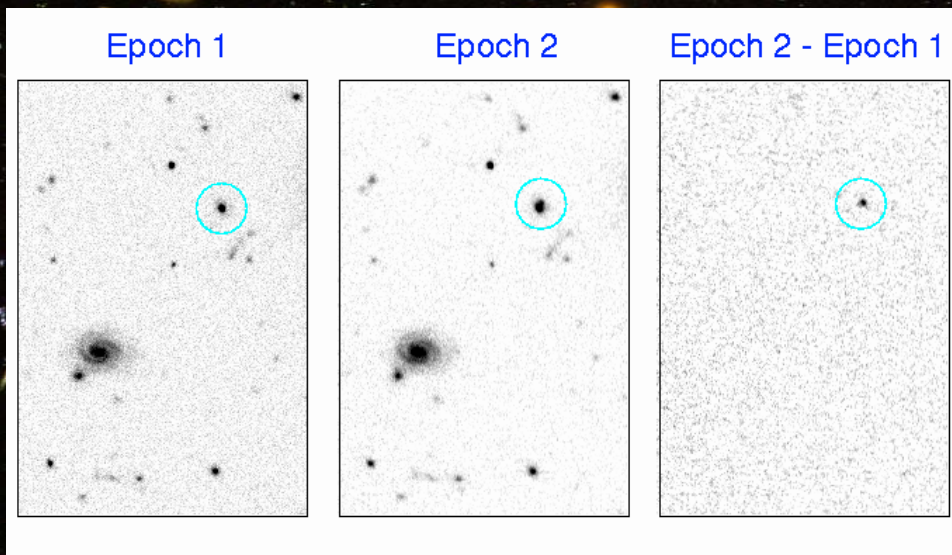
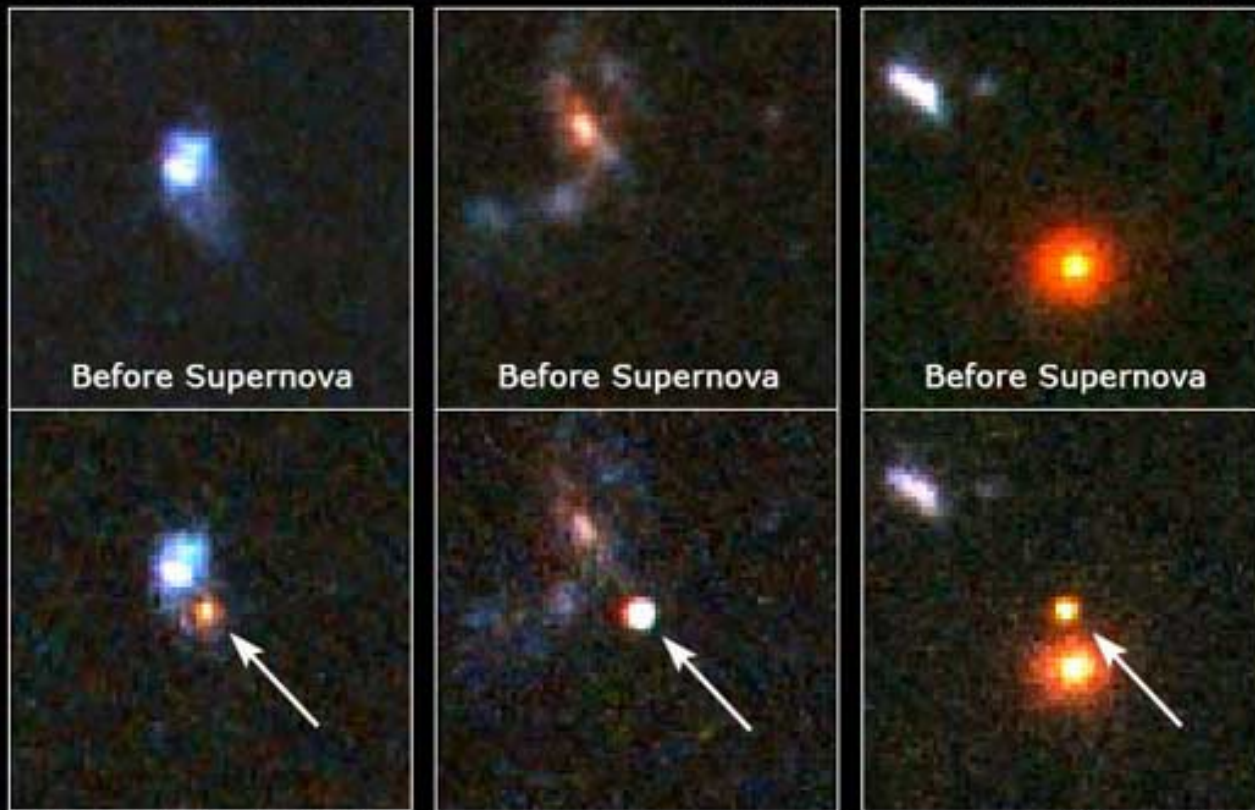


Diagrama de Hubble: Supernovas tipo Ia



Distant Supernovae

Hubble Space Telescope • ACS



Before Supernova

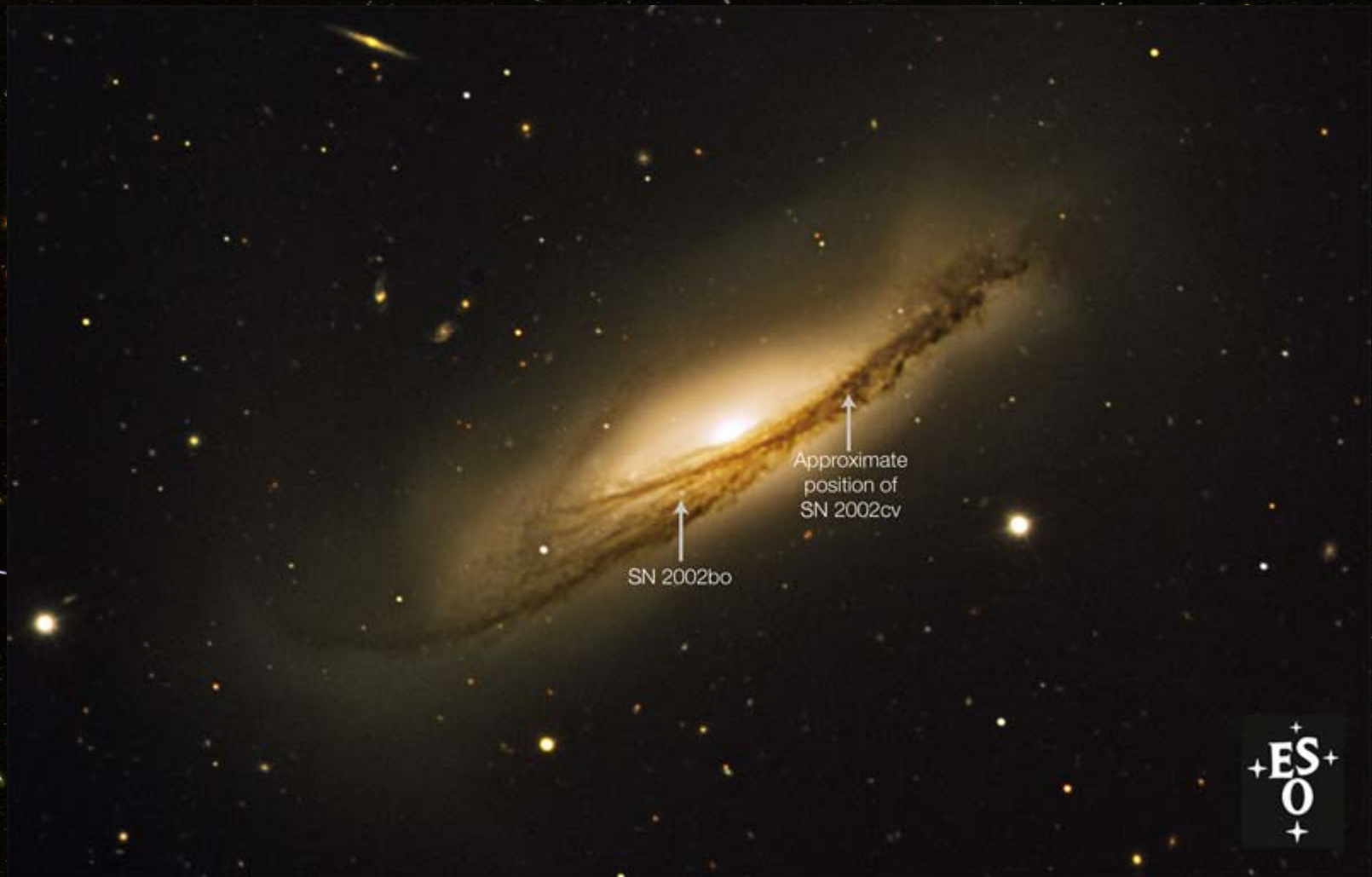
Before Supernova

Before Supernova

NASA and A. Riess (STScI)

STScI-PRC04-12

Explosiones múltiples



Supernovas tipo Ia: Curvas de luz

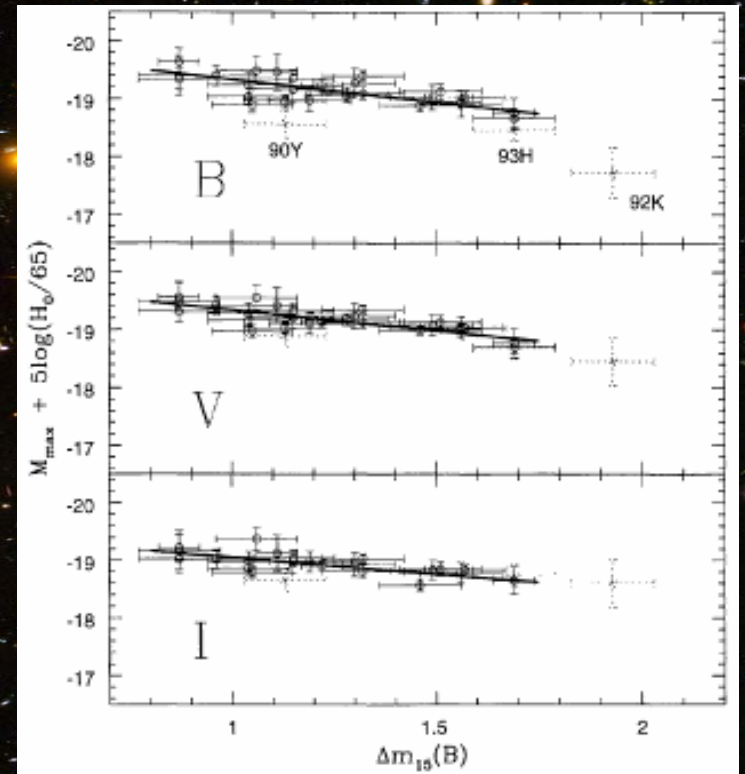
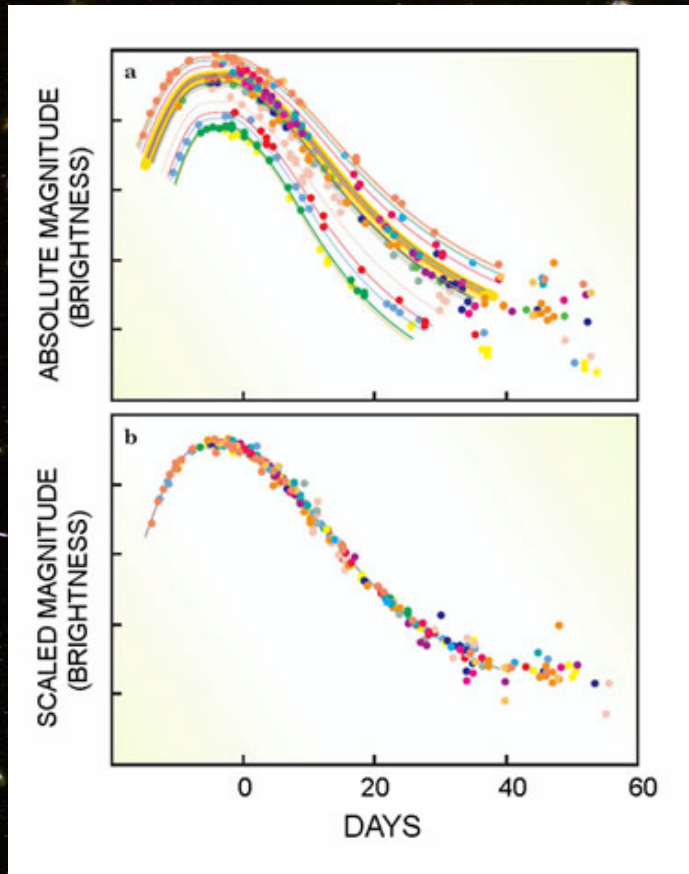


Diagrama de Hubble Supernovas tipo Ia

$$1 + z = \frac{\lambda'}{\lambda} = \frac{1}{a(t)}$$

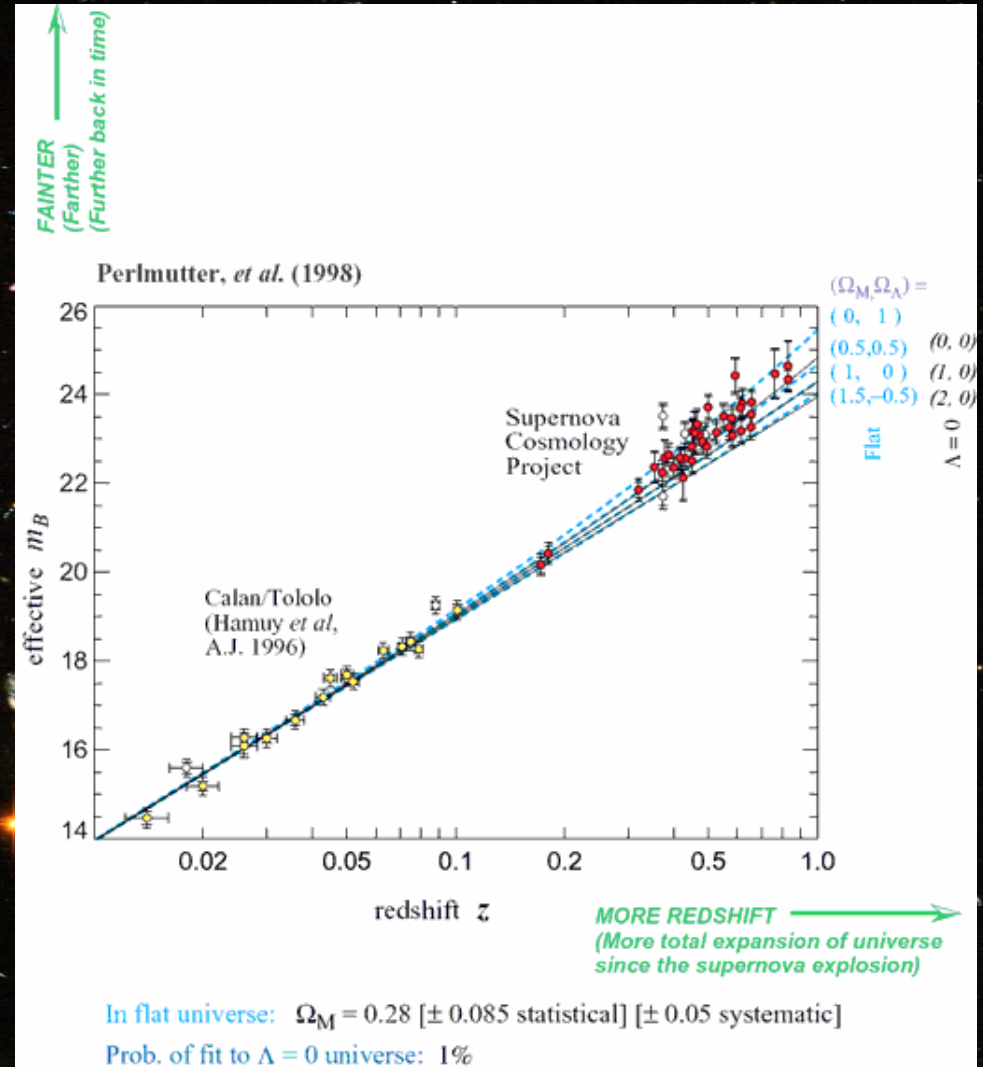
Tamaño del Universo

Constante de Hubble

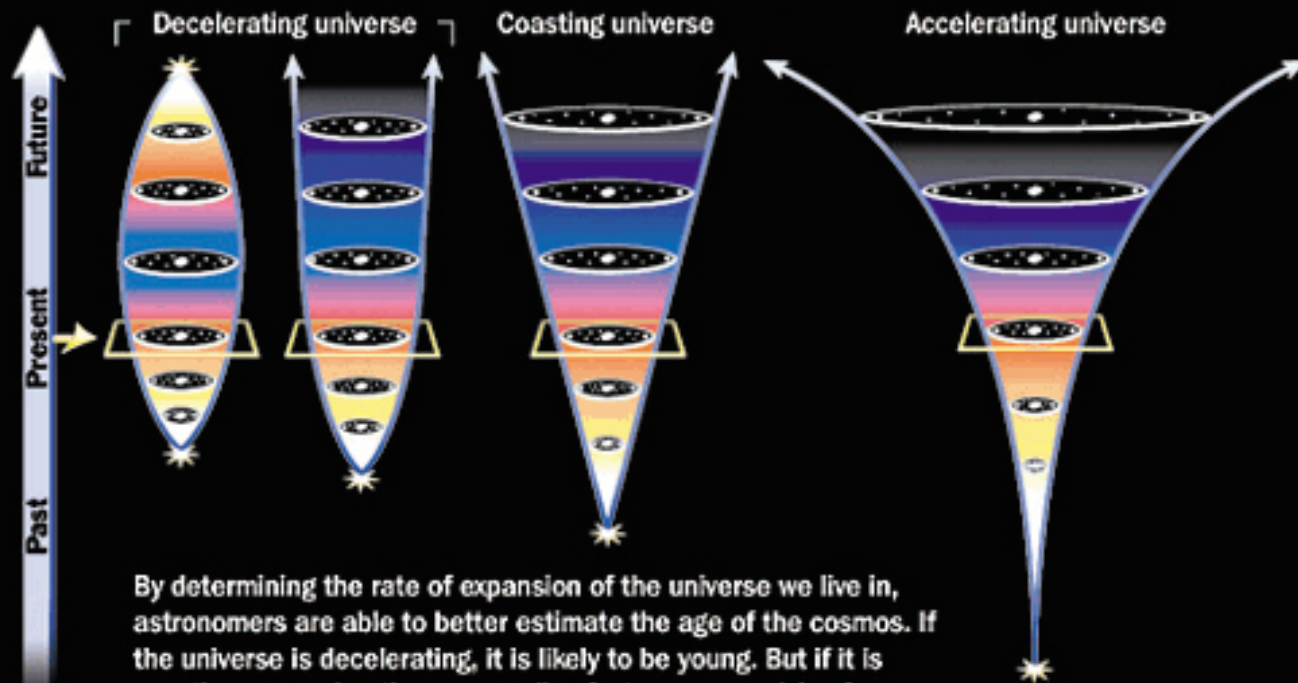
$$H_0 = 64 \pm 6 \text{ km.seg}^{-1} \cdot \text{Mpc}^{-1}$$

Edad del Universo

$$(14.9 \pm 1.4) \times 10^{10} \text{ Años}$$

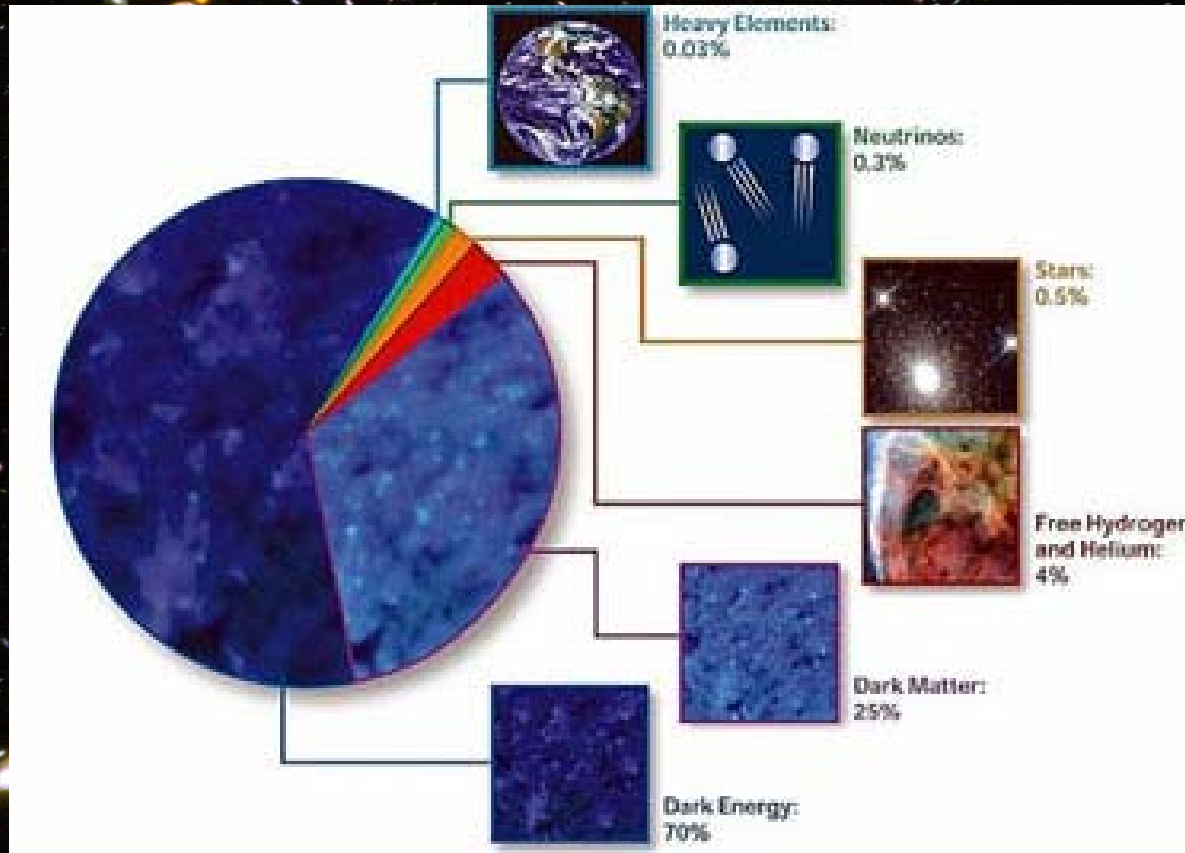


Possible models of the expanding universe



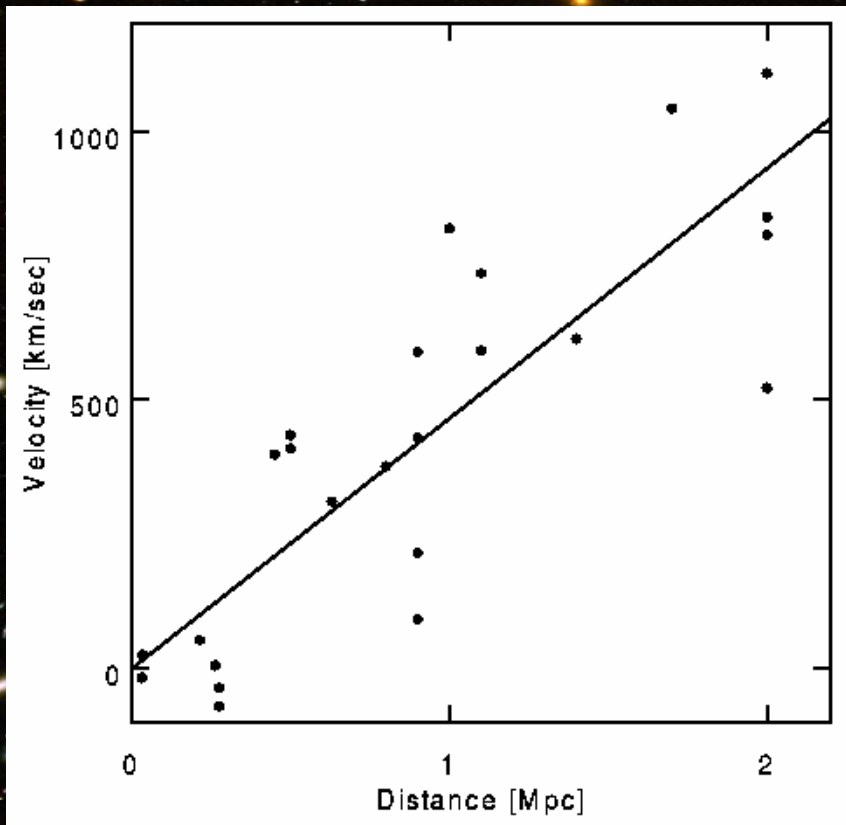
By determining the rate of expansion of the universe we live in, astronomers are able to better estimate the age of the cosmos. If the universe is decelerating, it is likely to be young. But if it is coasting or accelerating – expanding faster as a repulsive force pushes galaxies apart – it is probably older.

Diagrama de Hubble: Energía oscura

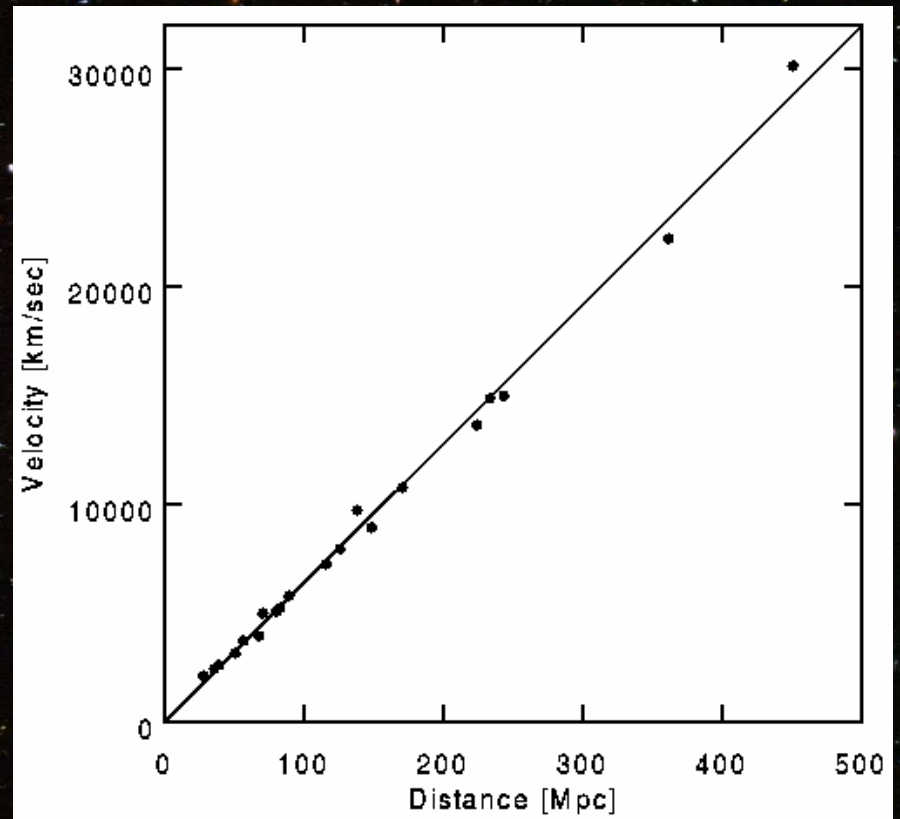


80 años de la Ley de Hubble

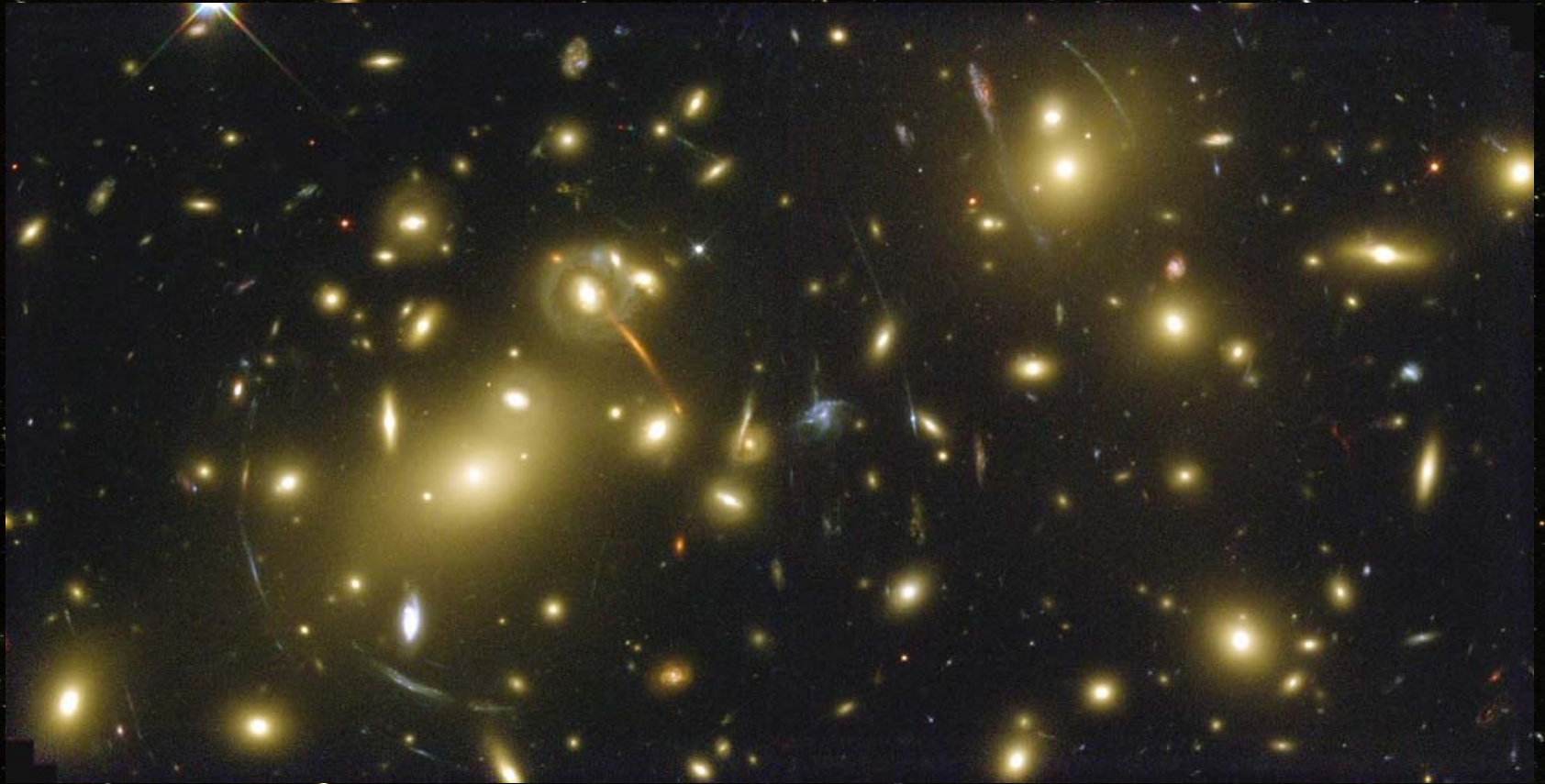
■ Hubble (1926).



■ Supernova Cosmology Project (1998).

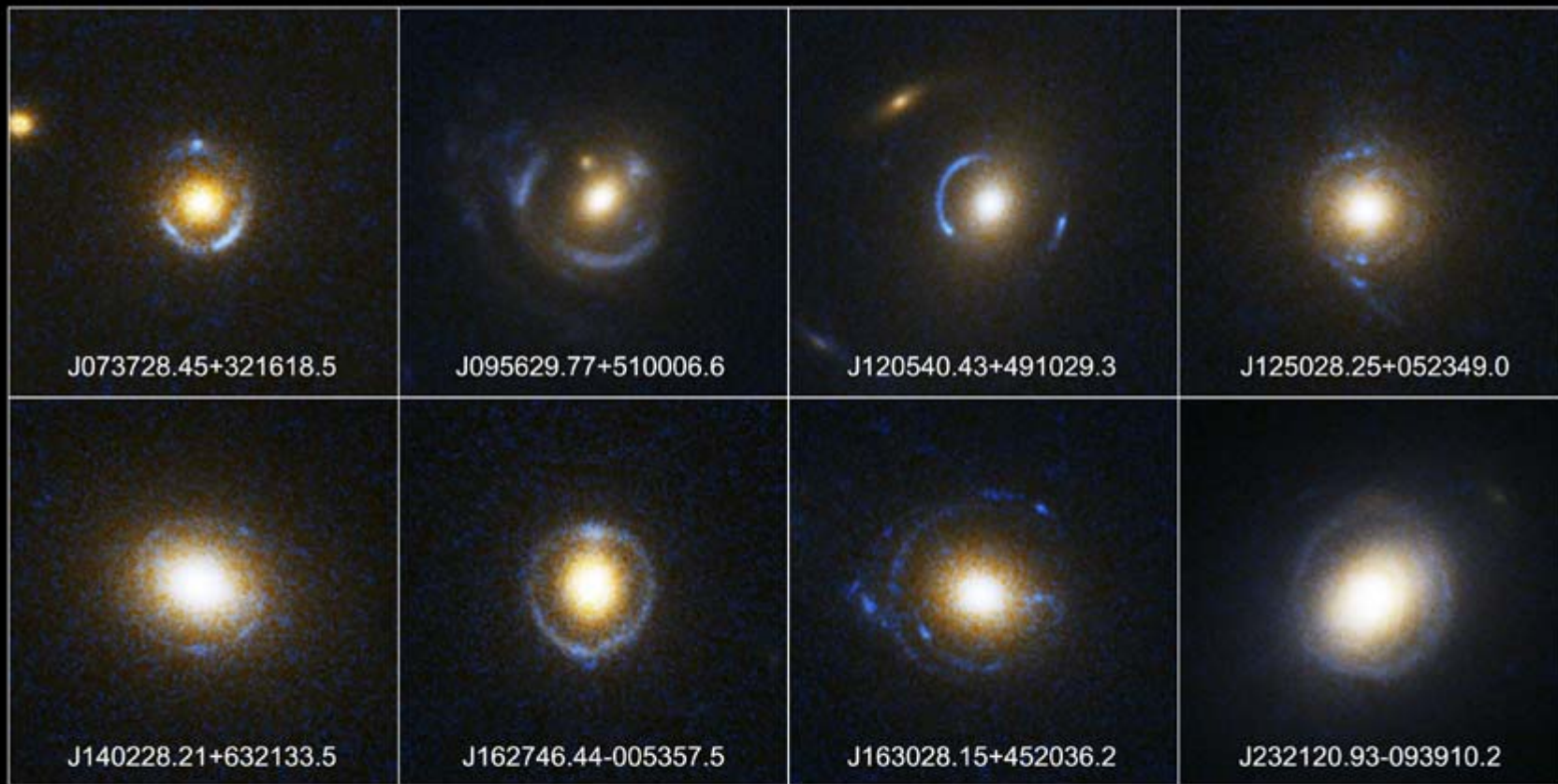


Cúmulos de galaxias como lentes gravitacionales

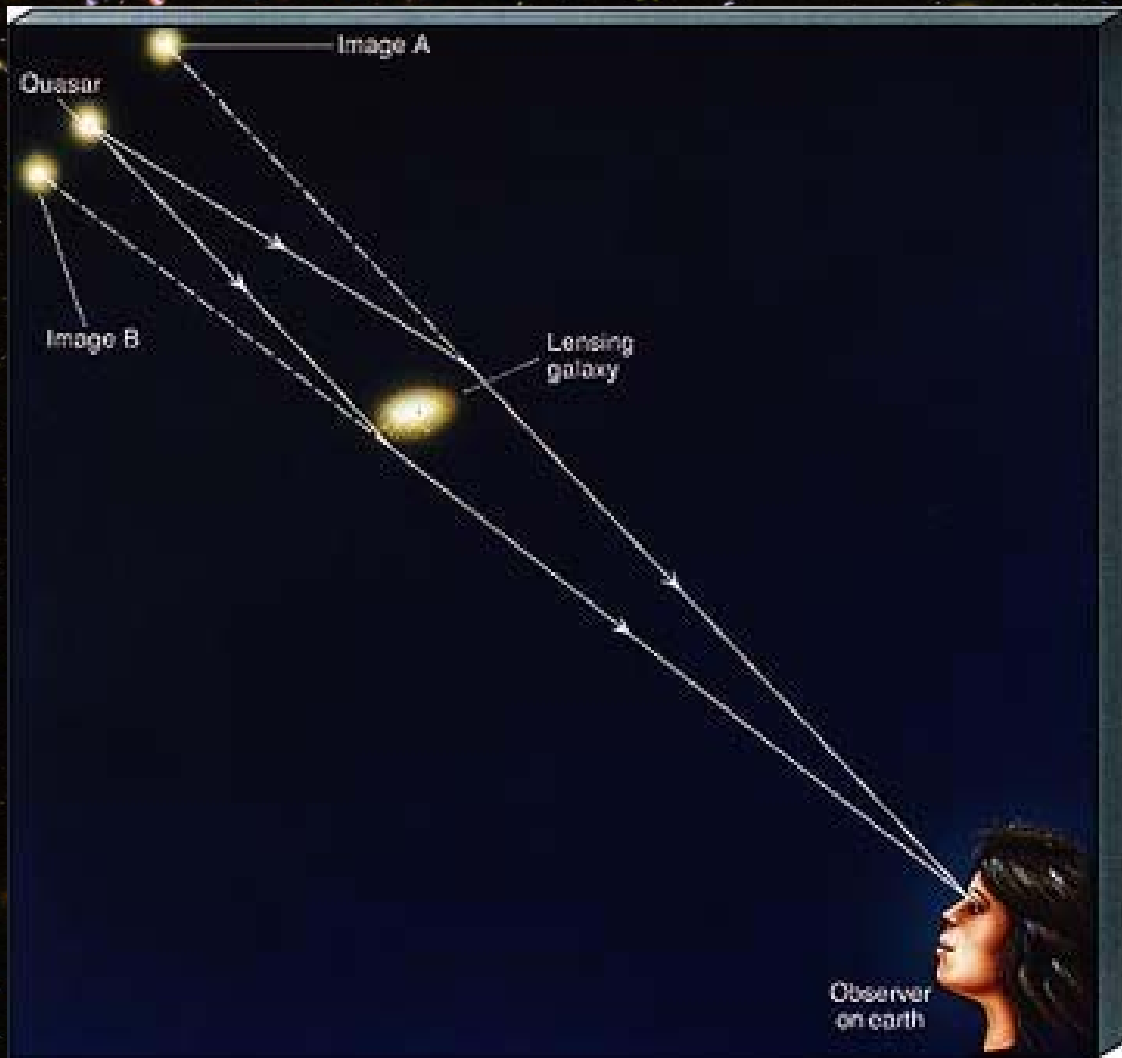






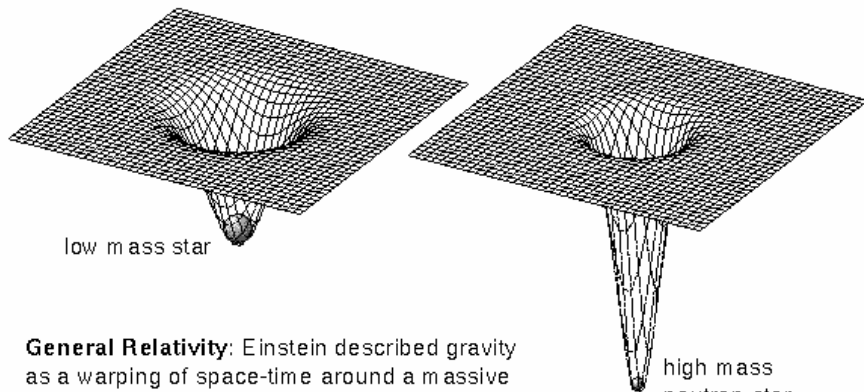


Einstein Ring Gravitational Lenses
Hubble Space Telescope • Advanced Camera for Surveys





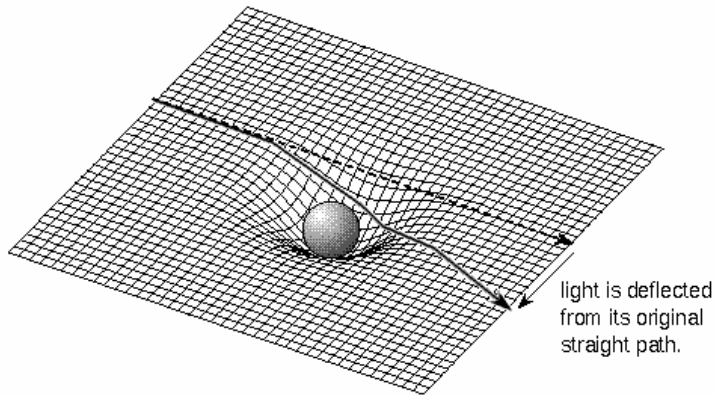
Deformación del Espacio-tiempo



low mass star

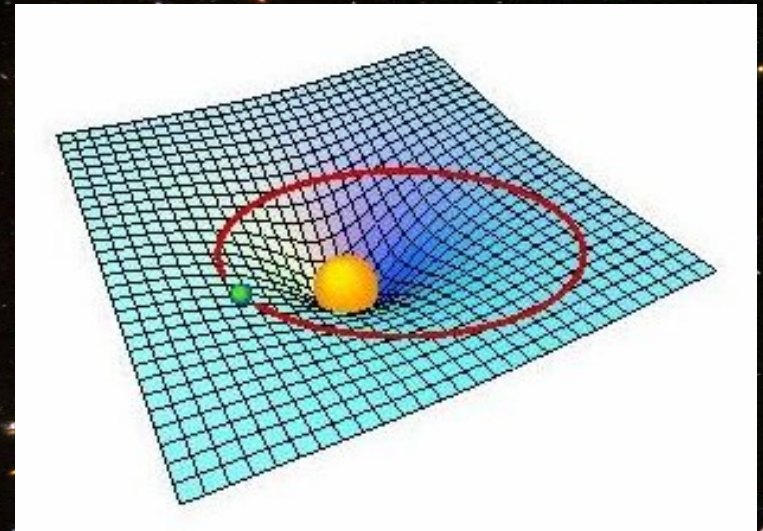
high mass
neutron star

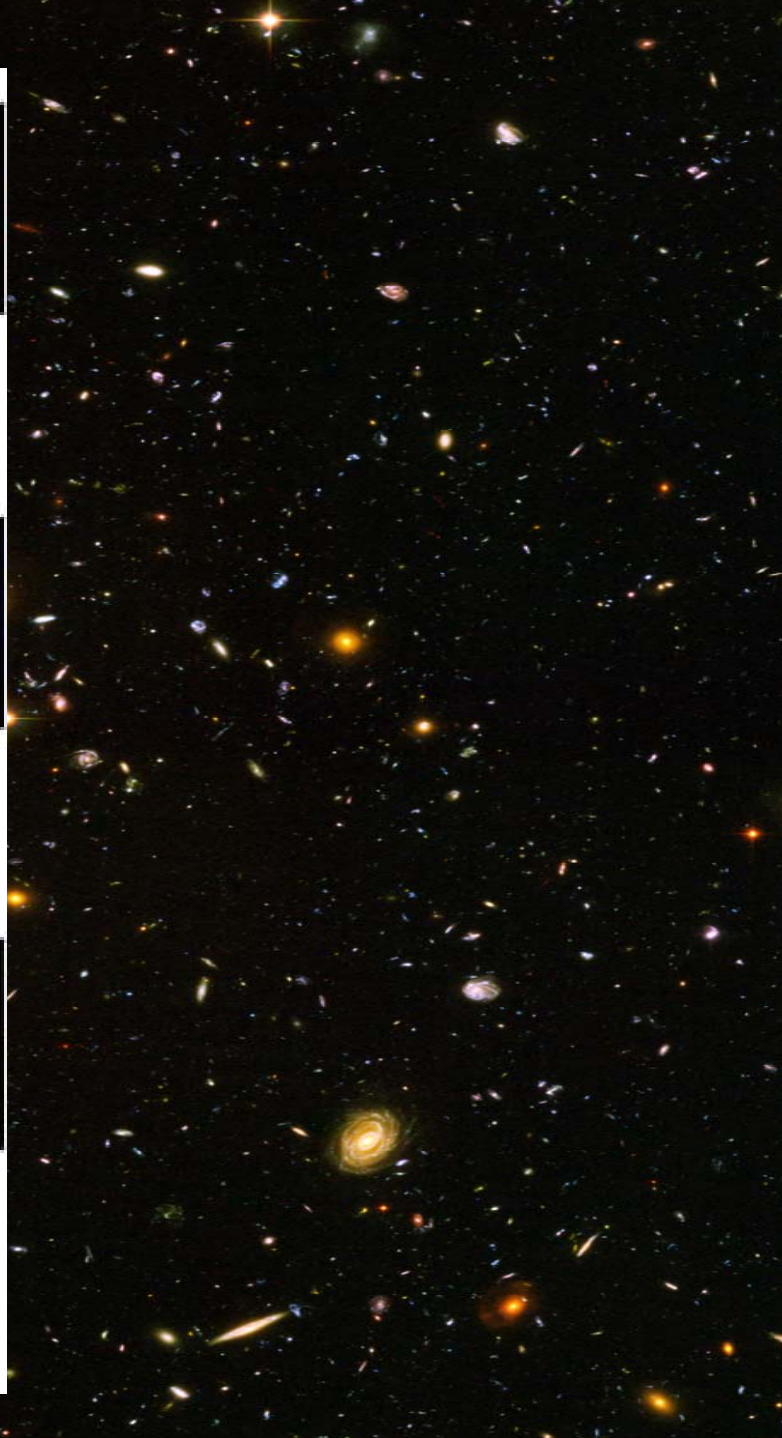
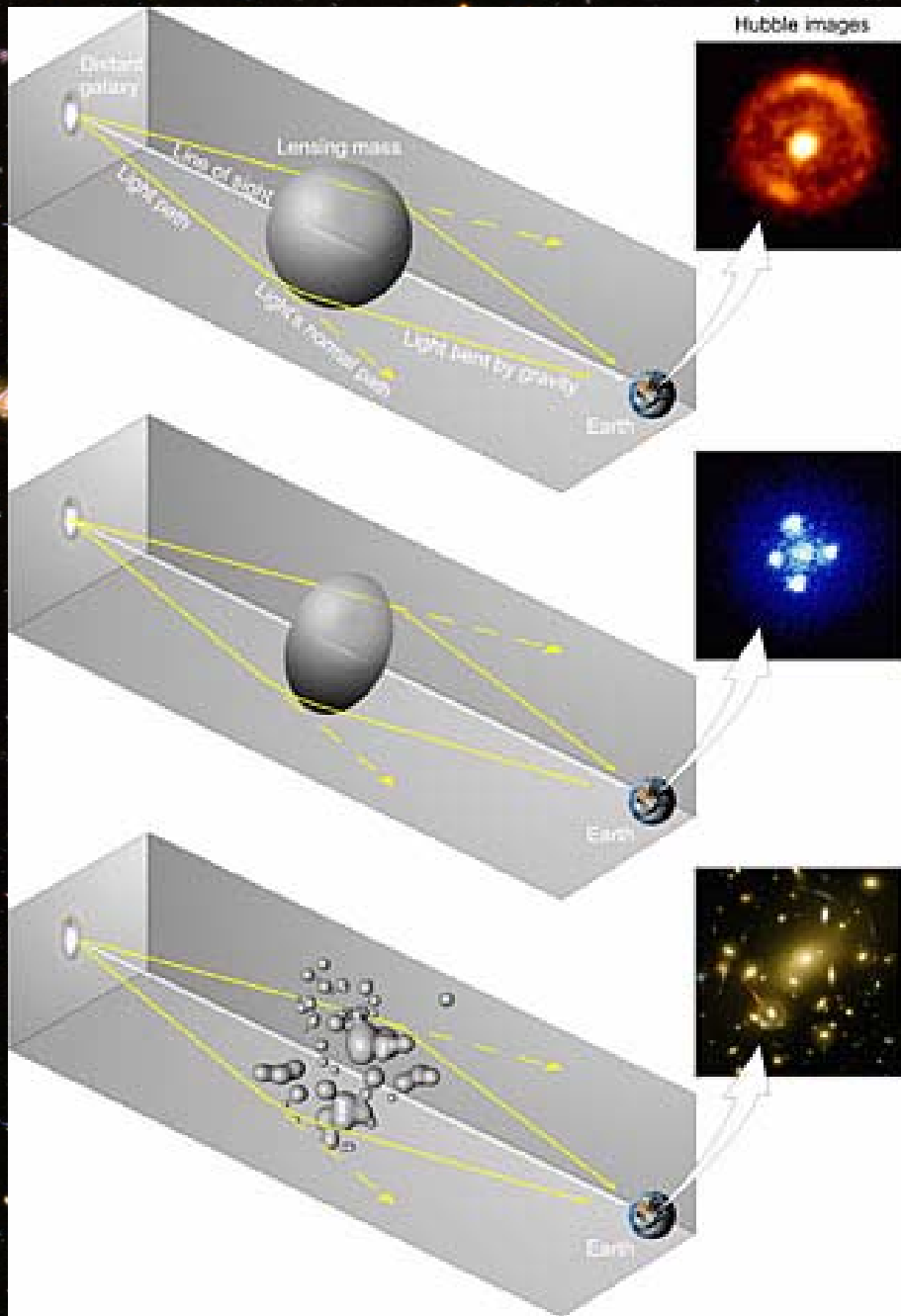
General Relativity: Einstein described gravity as a warping of space-time around a massive object. The stronger the gravity, the more space-time is warped.



light is deflected
from its original
straight path.

General Relativity: Light travels along the curved space taking the shortest path between two points. Therefore, light is deflected toward a massive object! The stronger the local gravity is, the greater the light path is bent.





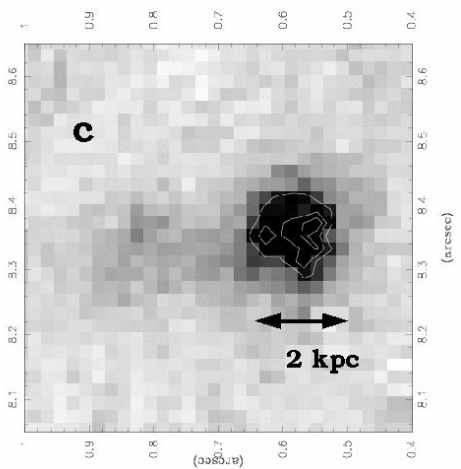
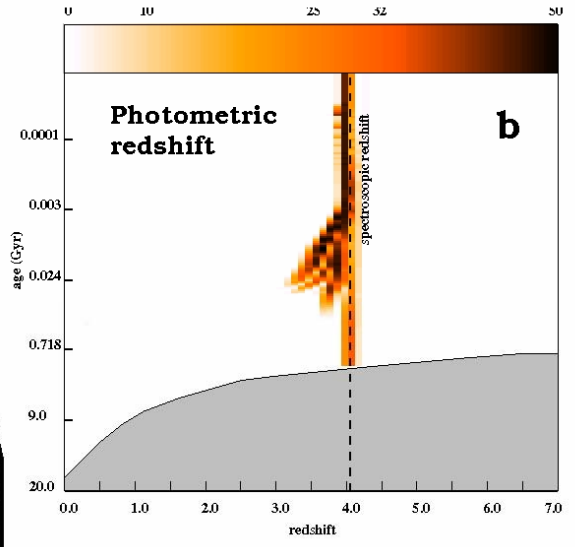
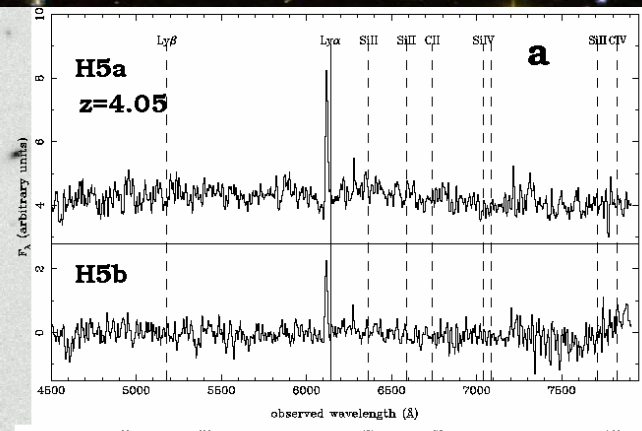
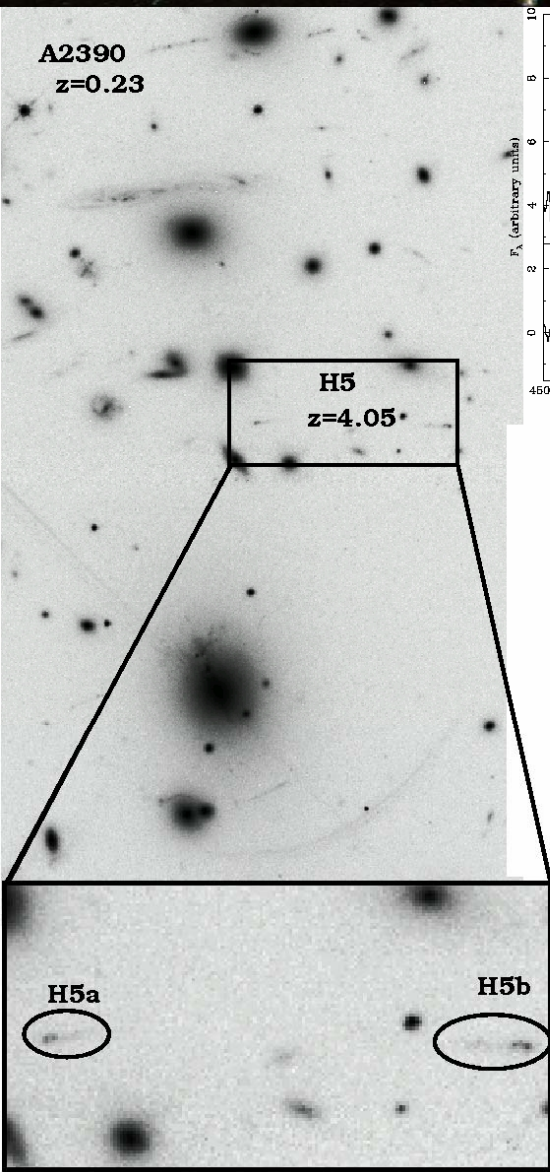
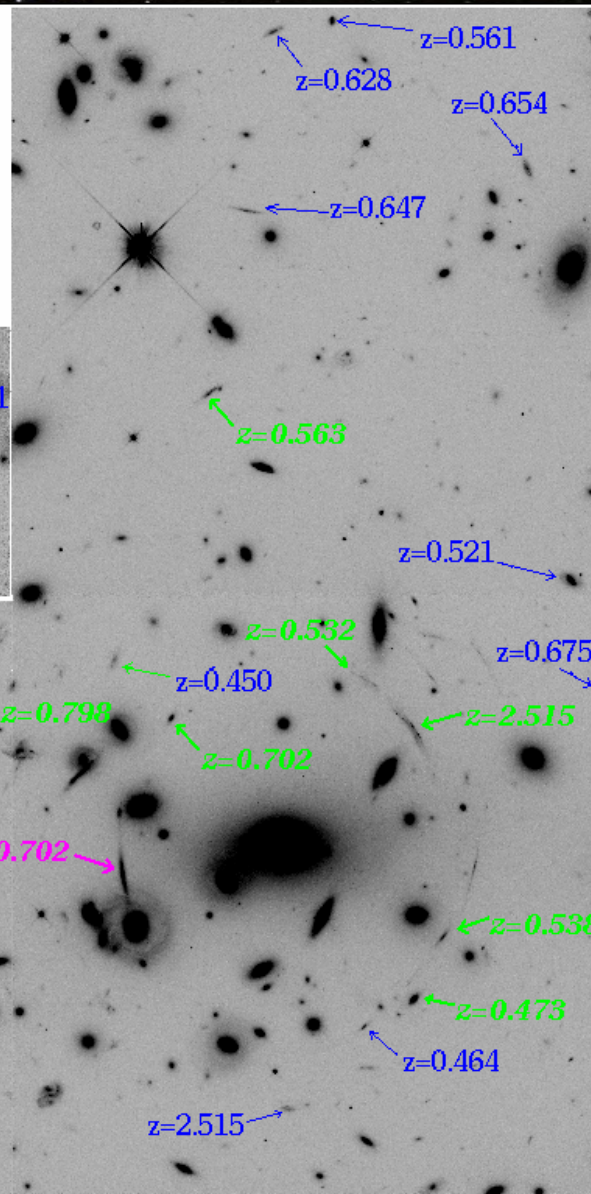
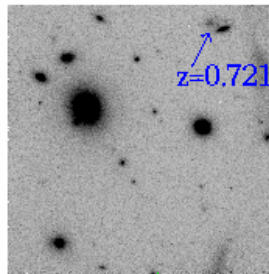
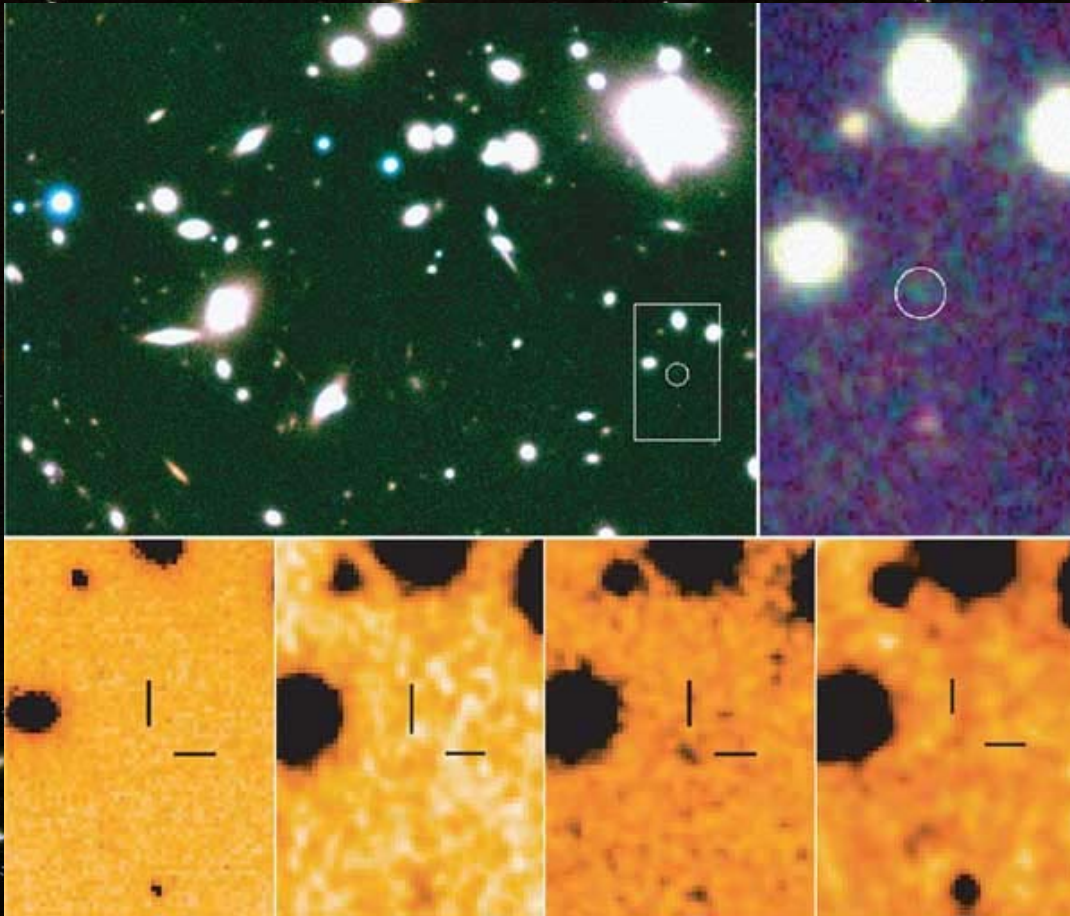


Image reconstruction

**Testing
Lens Inversion
with
Abell 2218
HST - WFPC2**

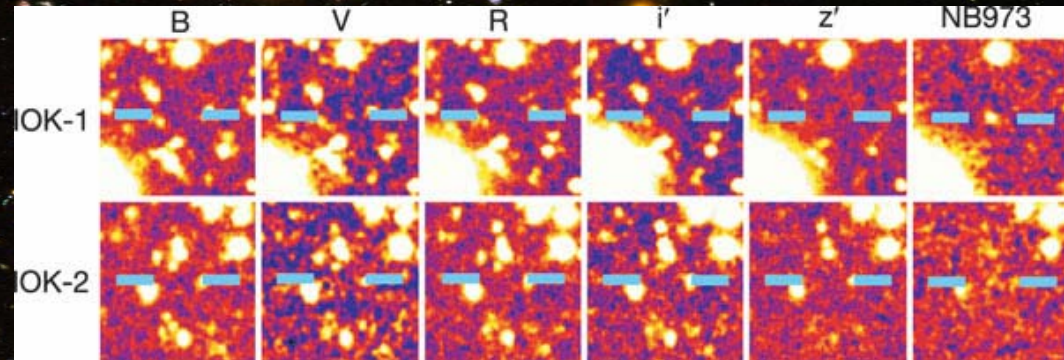
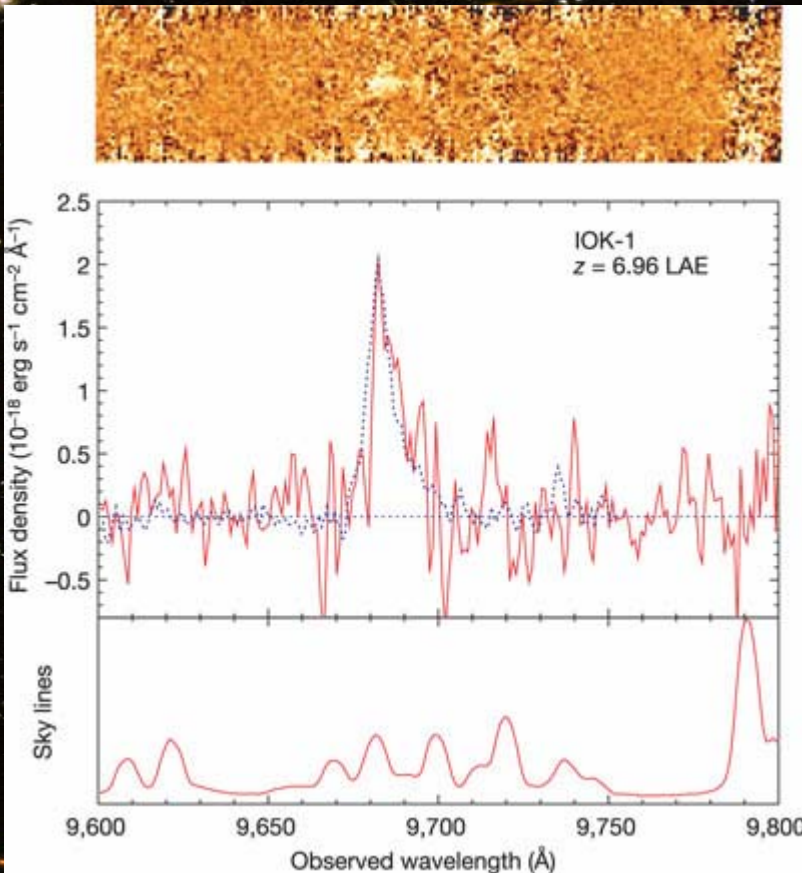


Una galaxia a $z=10$?



Una galaxia a $z=7$

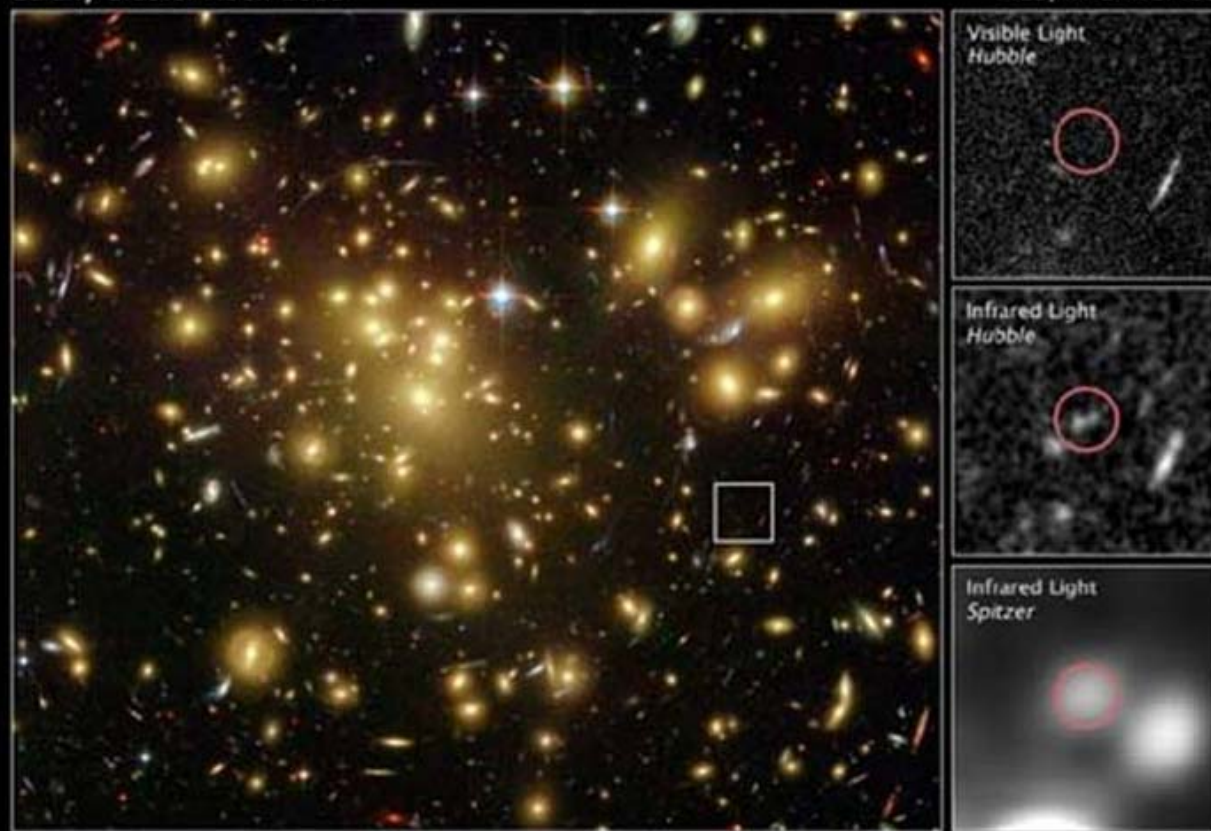
Masaroni et al. 2007



Descubrimiento de una galaxia a $z \sim 7.4$ detrás del cúmulo A1689

Distant Gravitationally Lensed Galaxy
Galaxy Cluster Abell 1689

Hubble Space Telescope
ACS/WFC NICMOS

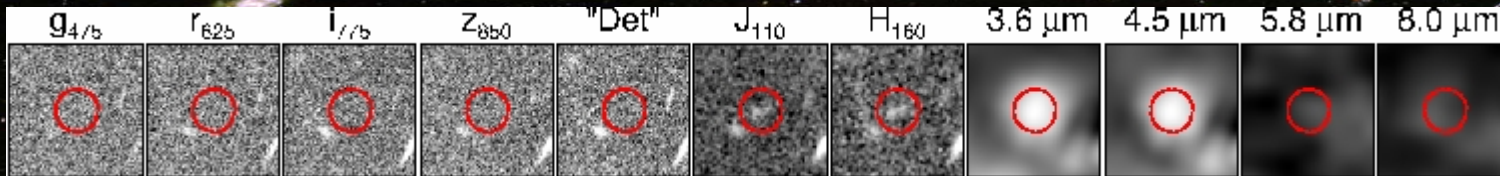


NASA, ESA, and L. Bradley (JHU), R. Bouwens (UCSC), H. Ford (JHU), and G. Illingworth (UCSC)

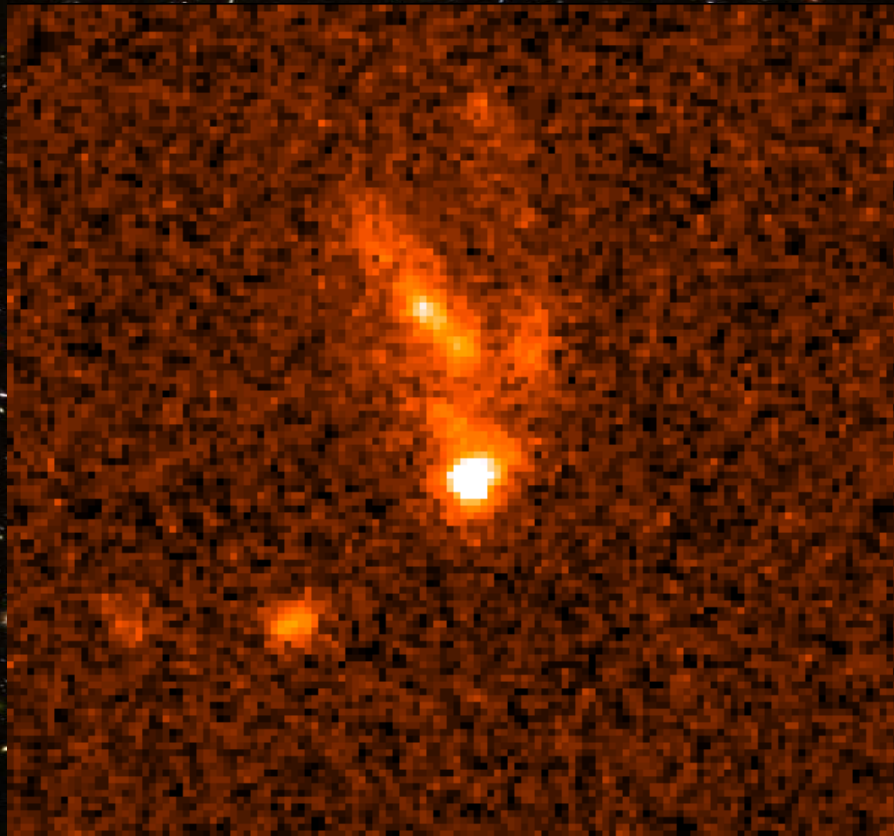
STScI-PRC08-08a

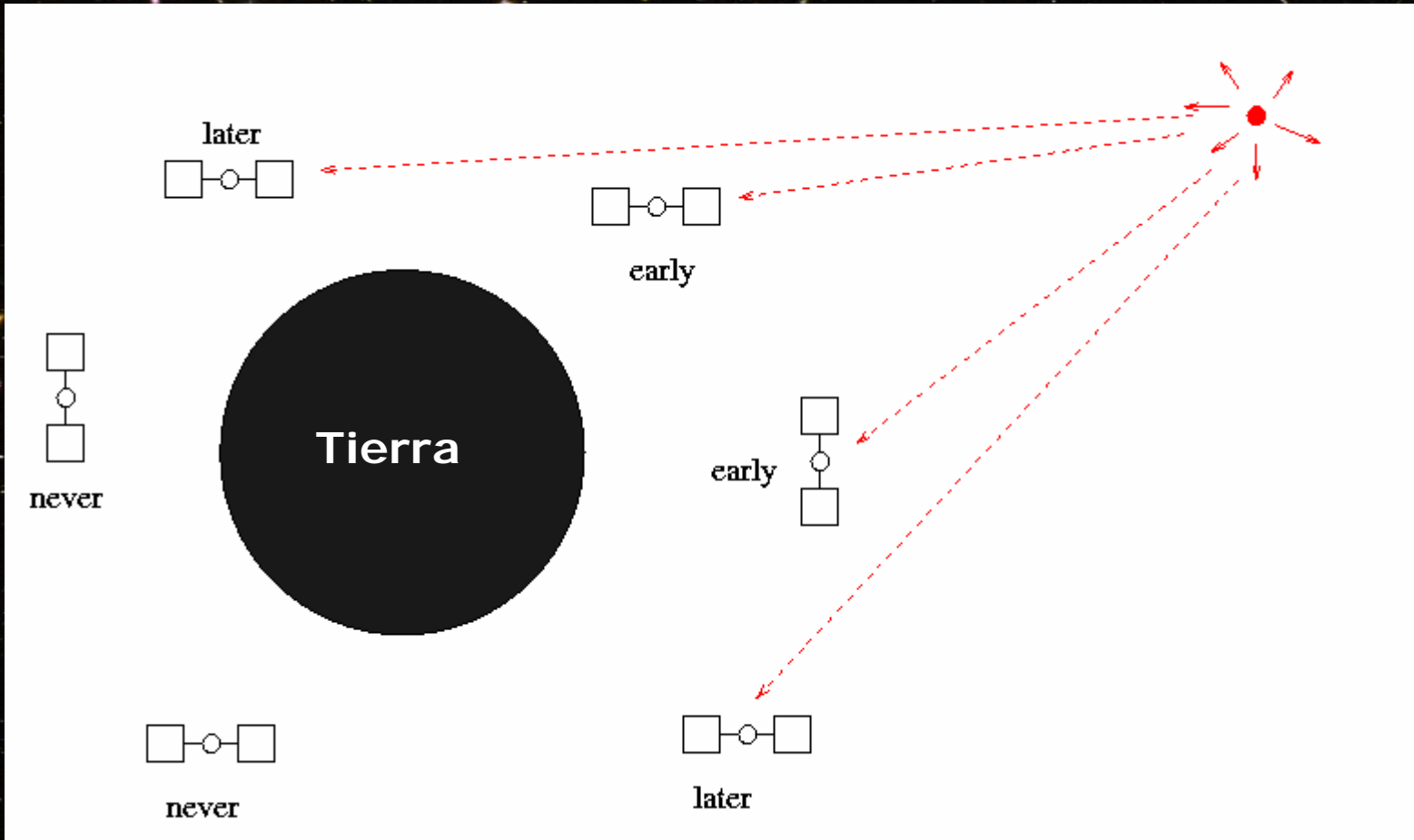
2.5 magnitudes
Más brillante

Magnificación
de 9

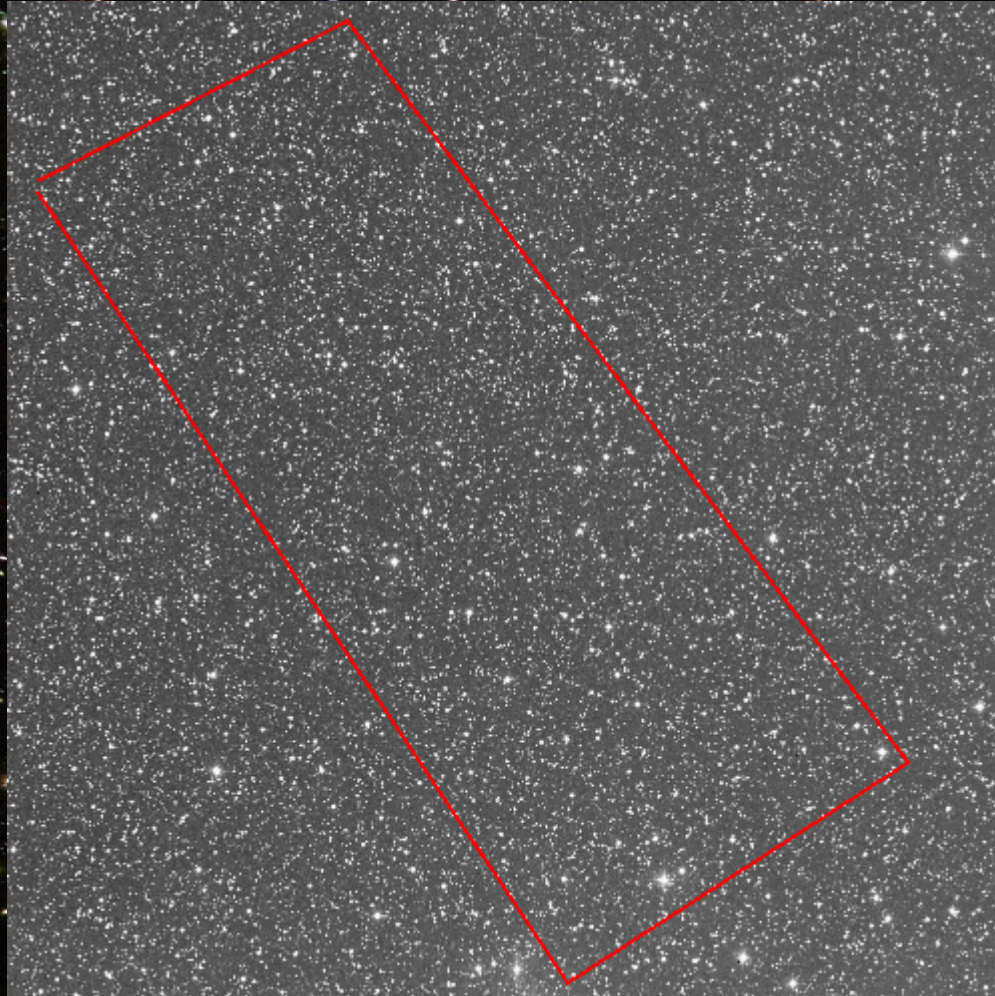


Gamma Ray Burst. **Explosiones en el Universo** **primitivo**



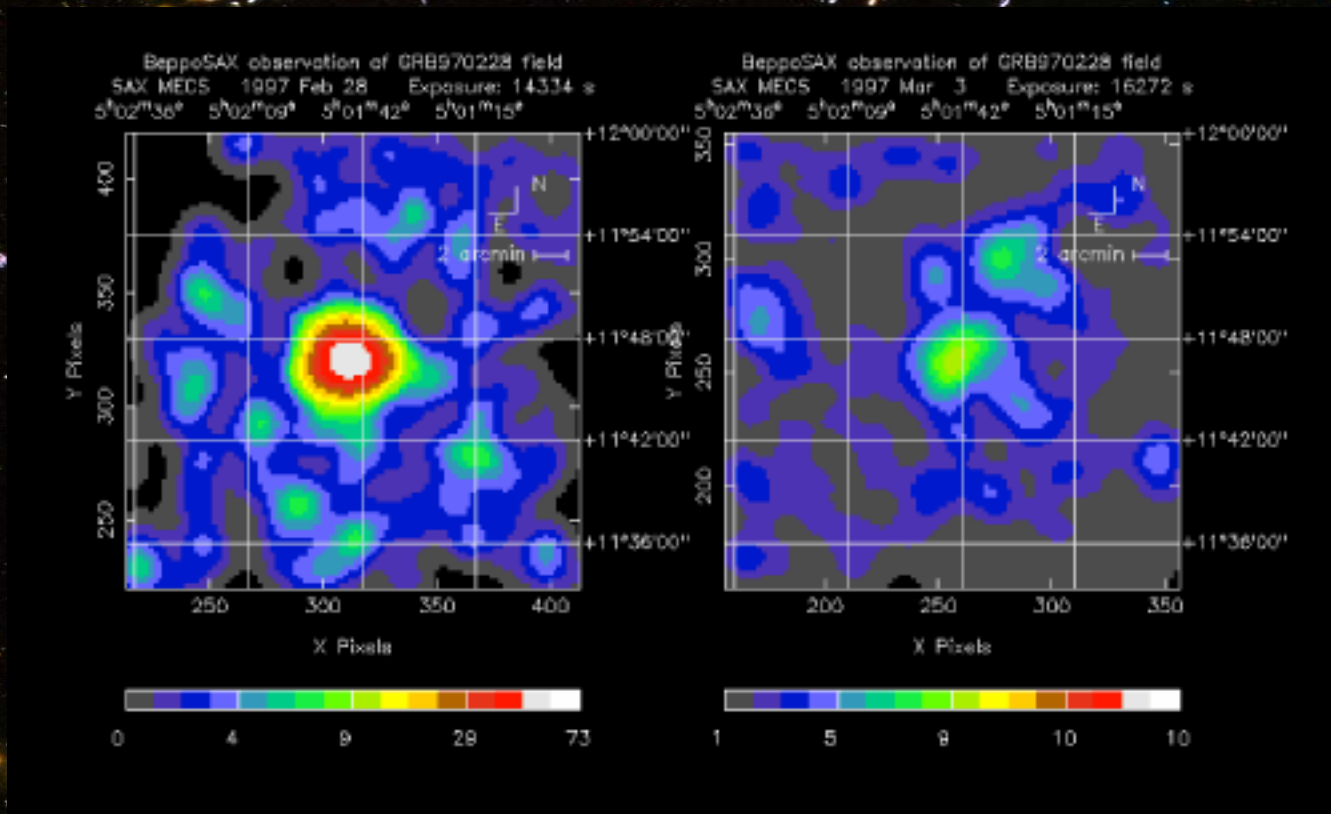


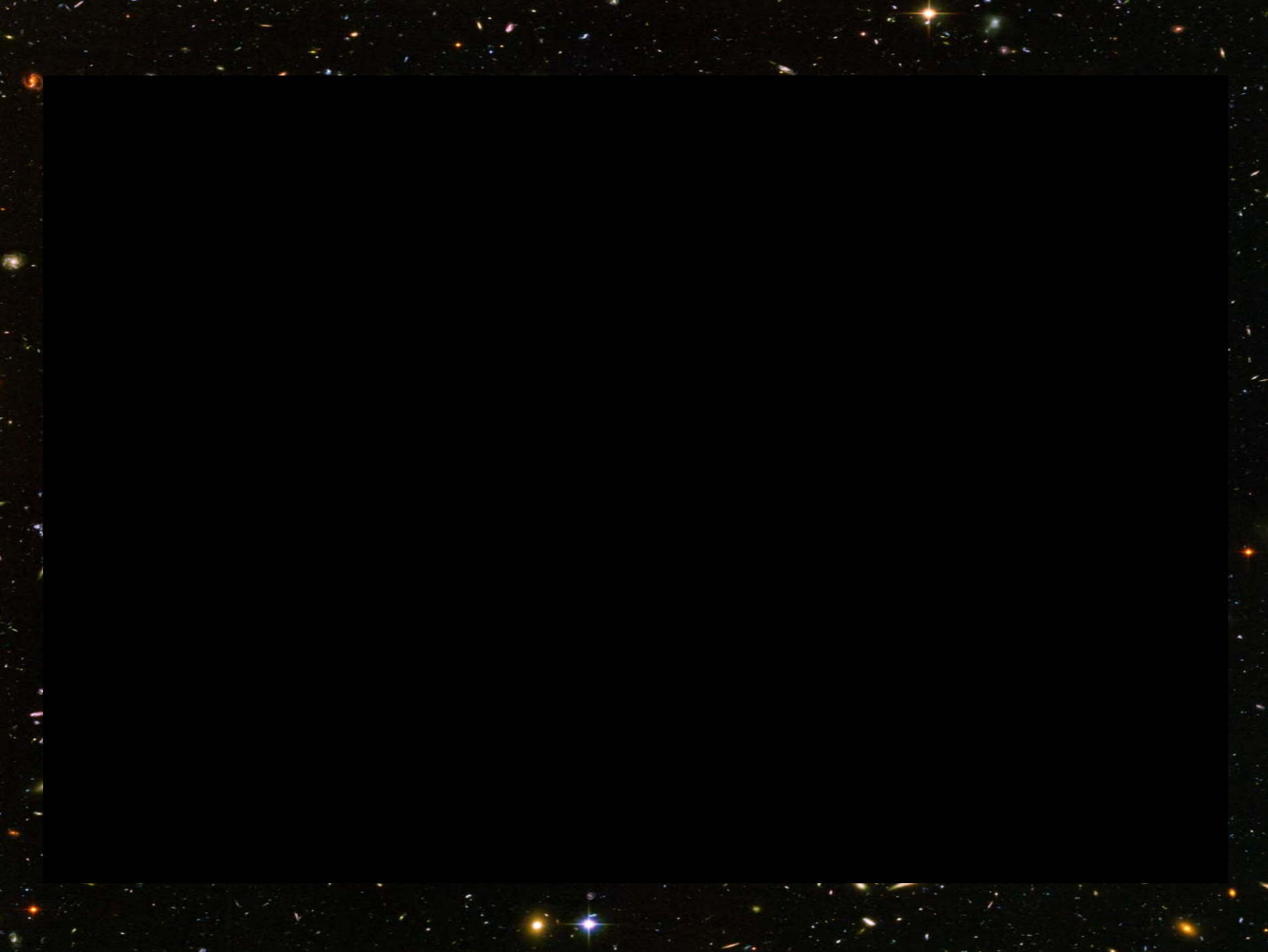
Dónde está el GRB?

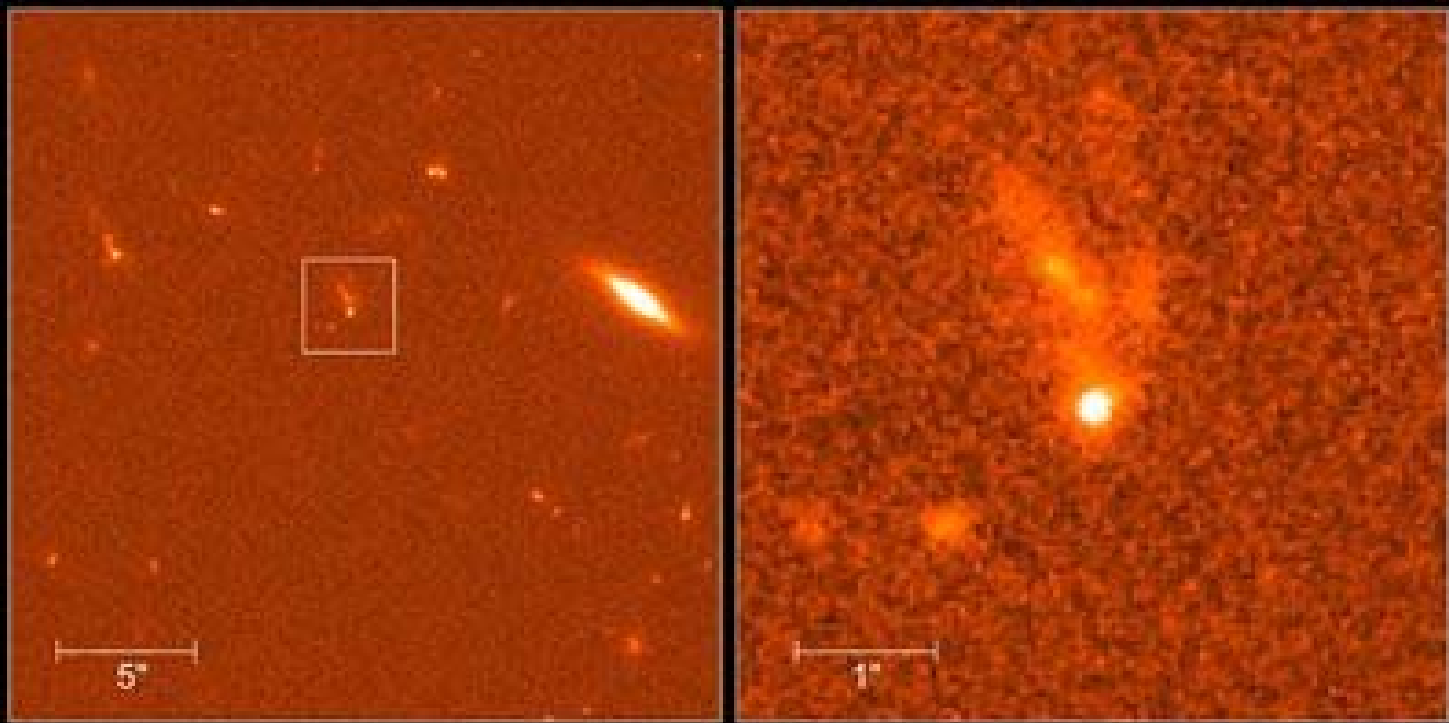


GRB: El descubrimiento

GRB970228, $z=0.69$





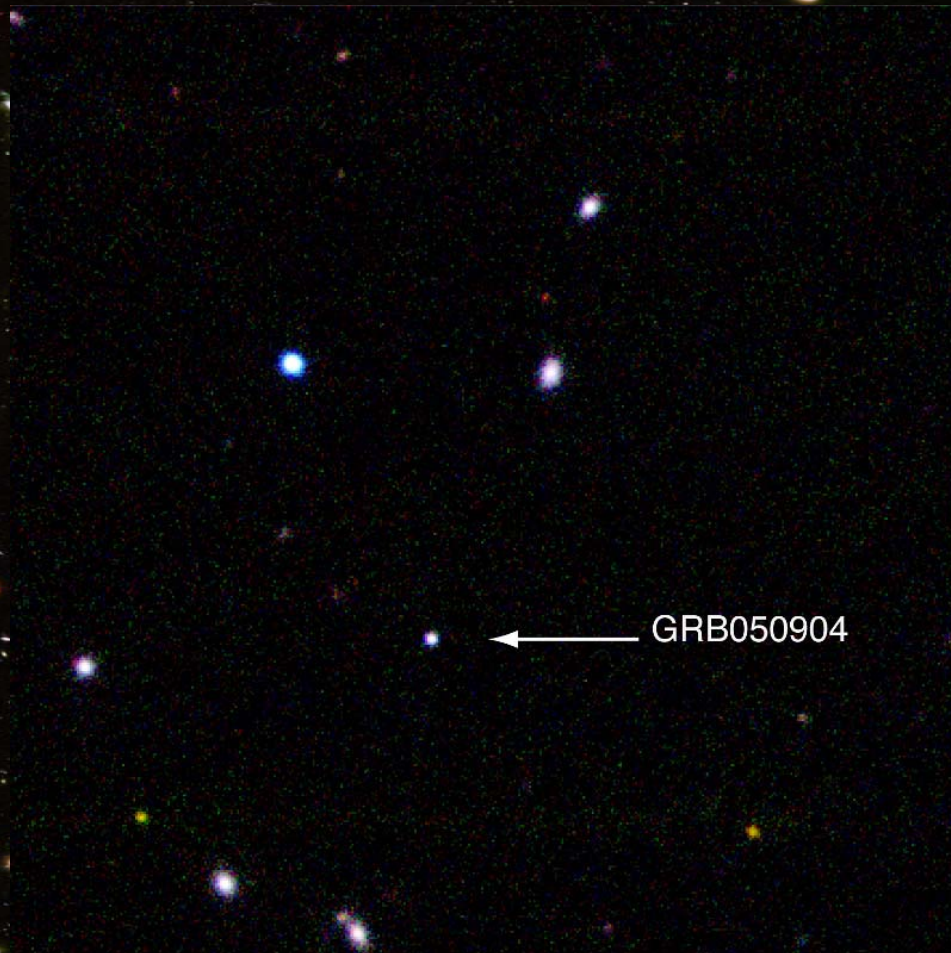


Gamma Ray Burst GRB990123
Hubble Space Telescope • STIS

PRC99-09 • STScI OPO • A. Fruchter (STScI) and NASA

$m_v = 8.9$!!! $z = 1.6$

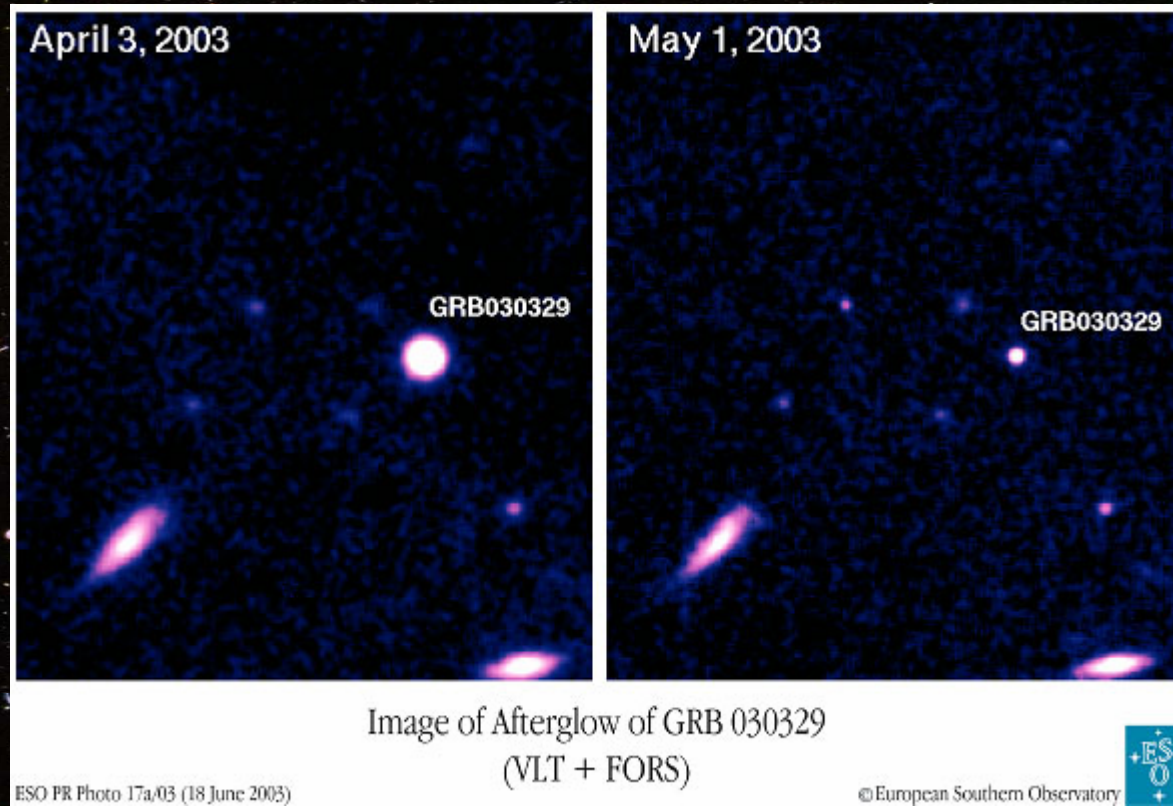
GRB050904: el más lejano



$z=6.3!!!$
 $mi=14.1$

The Distant Gamma-Ray Burst GRB050904
(ISAAC/VLT)

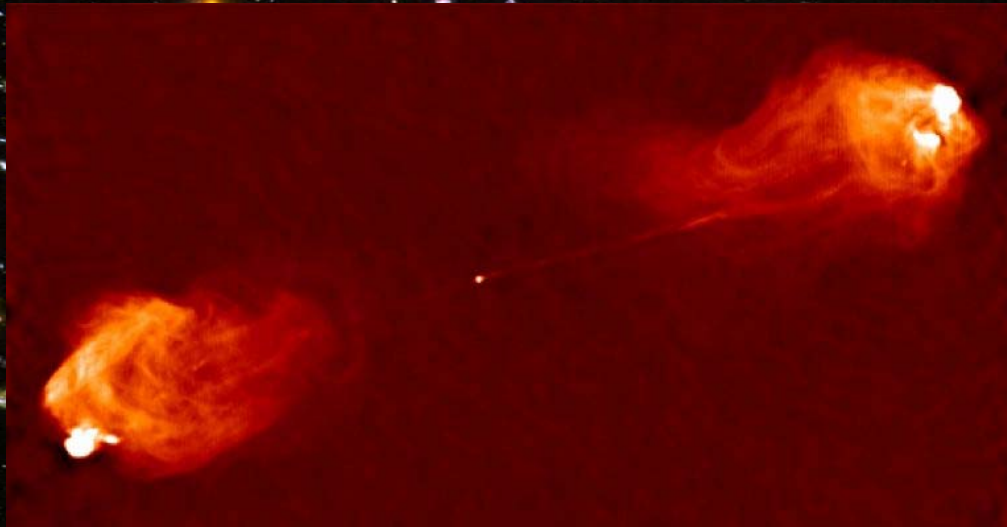
GRB050904: el más cercano



$z=0.18$ (~ 800 Mpc)

Radio-galaxias: Galaxias masivas en el Universo primitivo

Las radio-galaxias están asociadas con objetos masivos y luminosos
Poseen un agujero negro central muy masivo.
La radiación en las radio-frecuencias puede atravesar el
medio intergaláctico sin ser afectada



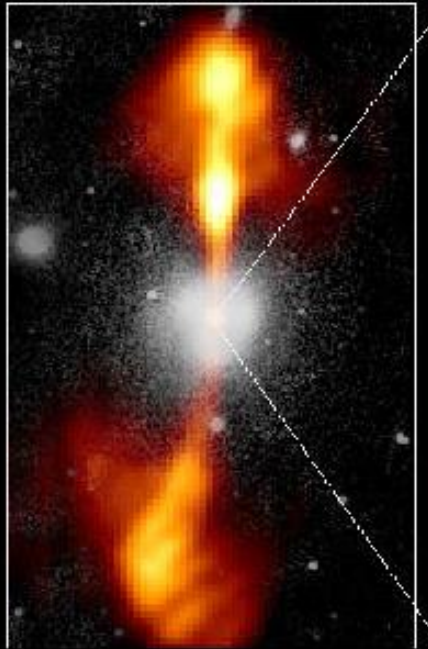


Evidencias de agujeros negros en radio-galaxias

Core of Galaxy NGC 4261

Hubble Space Telescope
Wide Field / Planetary Camera

Ground Based Optical/Radio Image



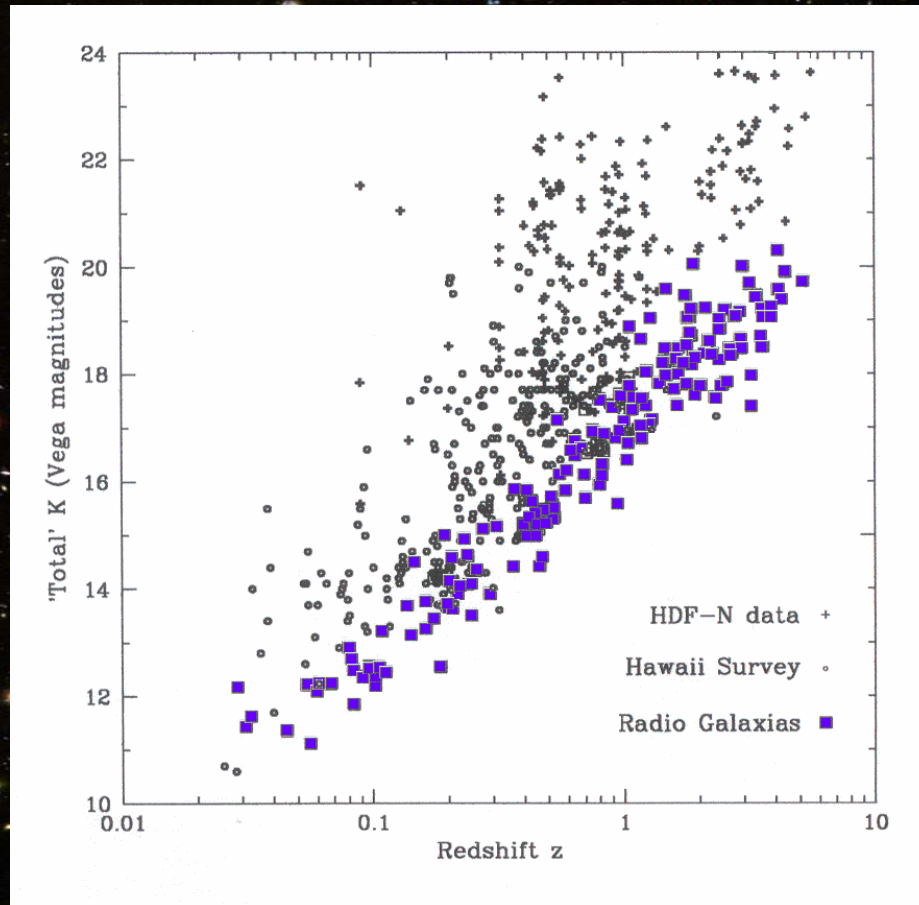
380 Arc Seconds
88,000 LIGHTYEARS

HST Image of a Gas and Dust Disk



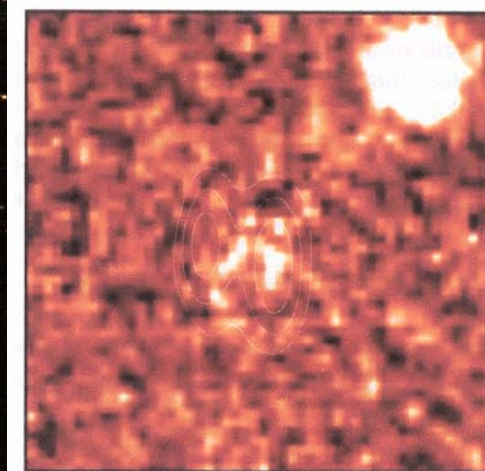
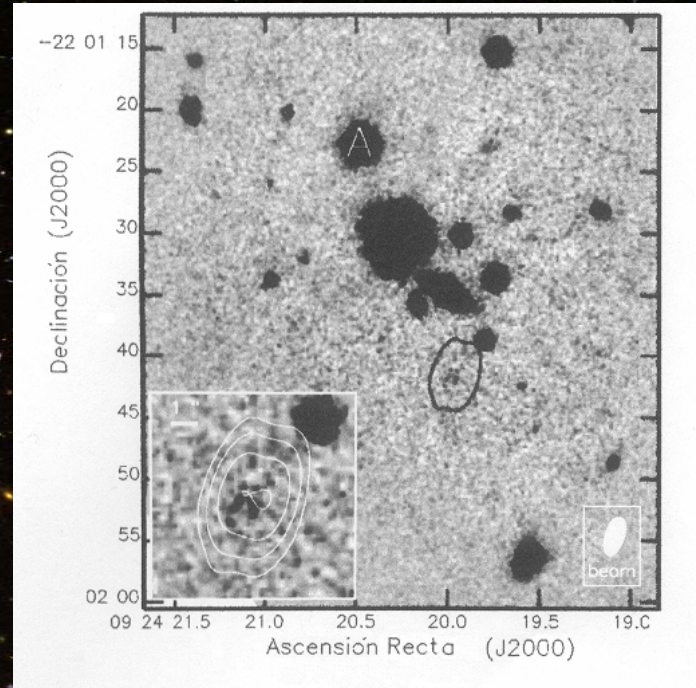
17 Arc Seconds
400 LIGHTYEARS

Diagrama de Hubble para radio-galaxias:



La Radio-galaxia más lejana: TN J0924-2201 $z=5.19$.

Van Breugel et al. 2001

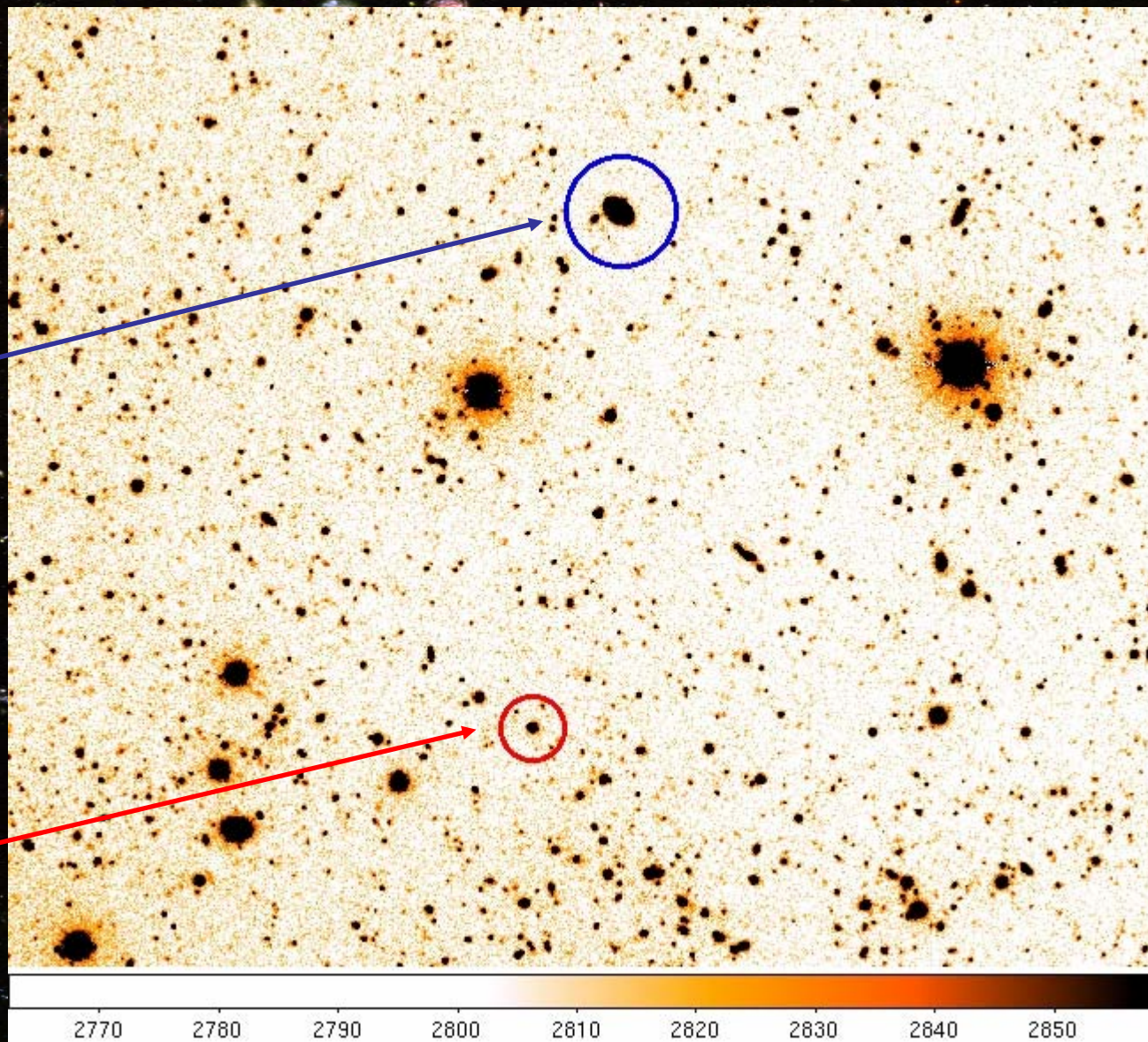


Quásars: Galaxias luminosas en el Universo primitivo



Galaxia
 $z=0.01$

QSO
 $z=4$



Implicancias Cosmológicas

- El descubrimiento de galaxias distantes nos dice cómo es el Universo primitivo
Nos da información sobre el espacio y la materia entre la fuente y nosotros
- La detección de galaxias distantes puede poner restricciones muy fuertes a los modelos cosmológicos
- La formación de galaxias masivas, *i.e* radio-galaxias ó QSOs distantes es un fenómeno poco conocido. La observación de estos objetos a altos corrimientos al rojo es importante para conocer estos procesos.



MUCHAS GRACIAS!!!