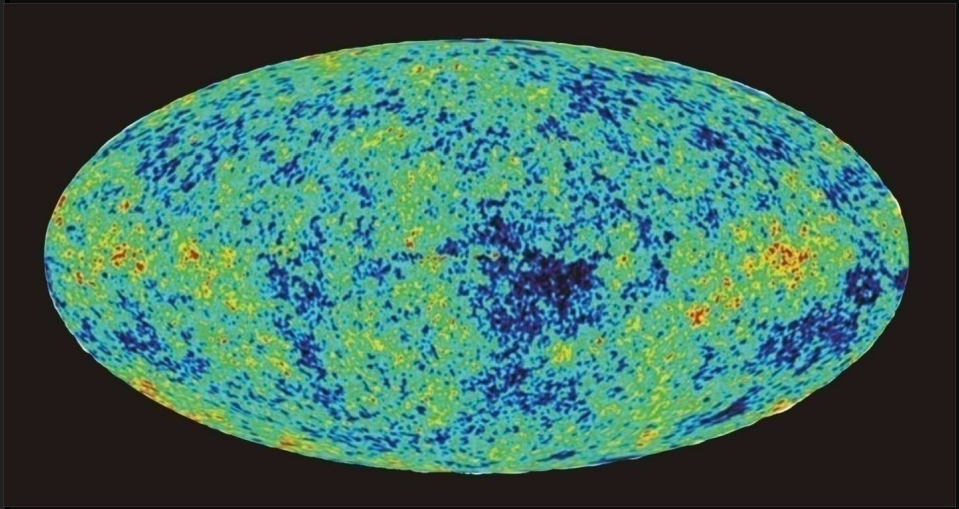
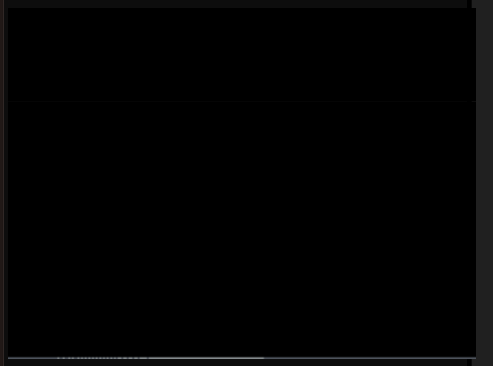
Taller de Astronomía



Mapa de las anisotropías en la RCF



Simulación de la evolución del Universo

5. Cosmología

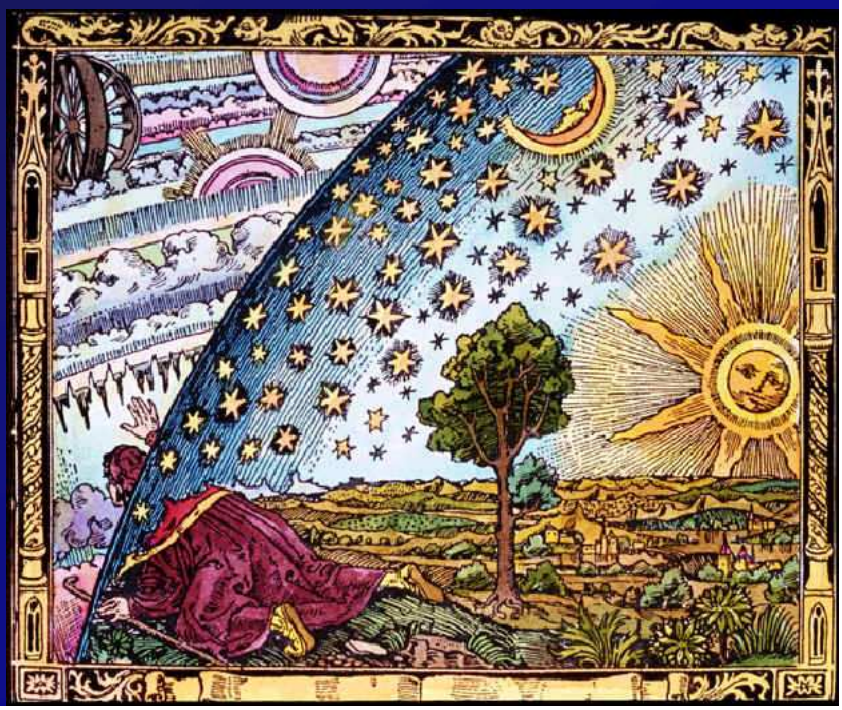
Prof. Dr. César A. Caretta – Departamento de Astronomía, UGto.

Cosmología

Κοσμολογία (del griego: "cosmos" = orden, todo; "logia" = discurso, estudio)
utilizada por primera vez en 1730 en el libro "Cosmologia Generalis" de Christian Wolff

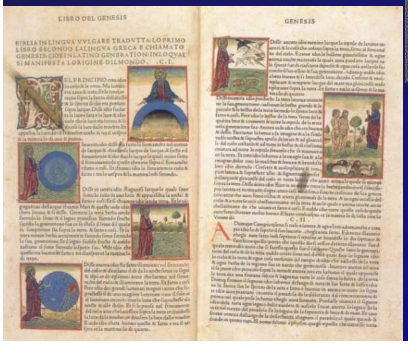
- Cosmología Clásica
- Cosmología Moderna
- Modelo de Concordancia

Cosmología Clásica



Mitos de Creación

- Explicación para el Universo como lo vemos y su creación (Tierra, Cielo, Océanos, etc)
- Dioses (quienes crean y controlan el Universo)
- Dualidades (lucha/separación entre oscuridad y luz, entre caos y orden, cielo y tierra, etc)
- Cotidiano (partes del cuerpo, animales, plantas, relaciones sociales/tabues, emociones)



P'an ku (China)

cráneo → bóveda celeste
piel/muslos → Tierra
huesos → piedras
sangre → ríos y océanos
ojos → Sol y Luna
pelos → vegetación
respiración → vientos
sudor/saliva → lluvias
voz → truenos
"gusanos" → ser humano y animales

Griegos

Caos

Erebo (noche) — Gaya (Tierra) — Eros (luz/día)

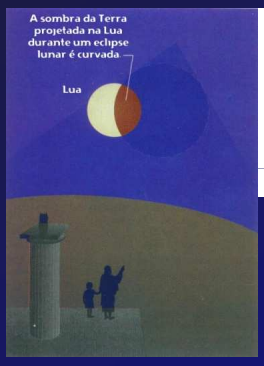
Urano (Cielo)

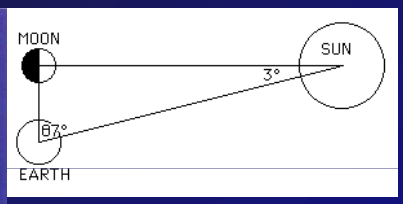
Afrodita, Cronos (tiempo), Océano (agua/firmamento) + 10 titanes
Zeus, Helio (Sol), Selene (Luna), Eos (aurora), etc

La Física Griega

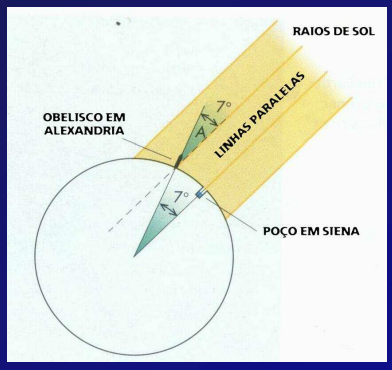
Los Griegos

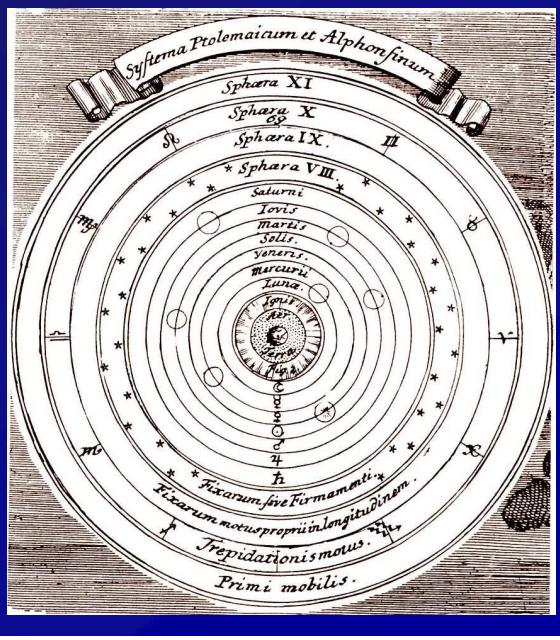
Aristarco

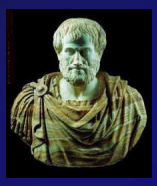




Tolomeo

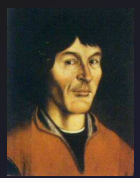






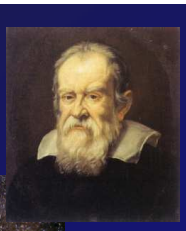
Aristóteles

Eratóstenes

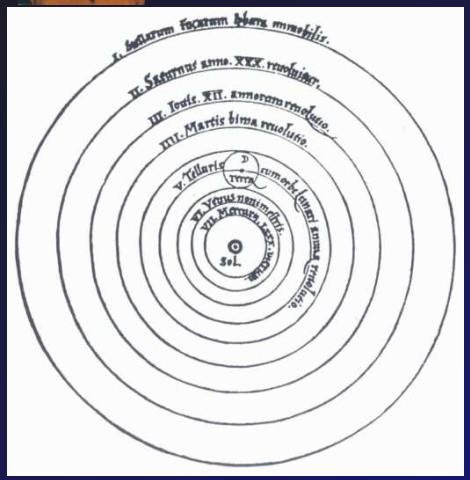


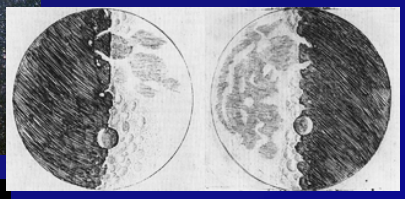
N. Copérnico

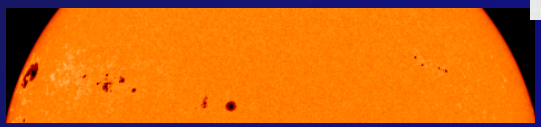
Renacimiento

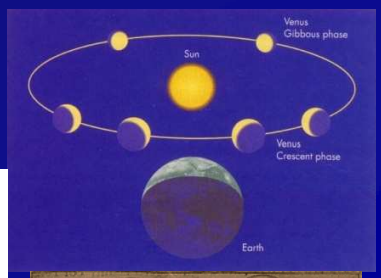


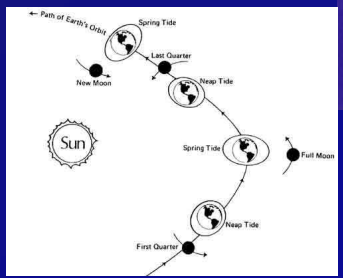
Galileo G.

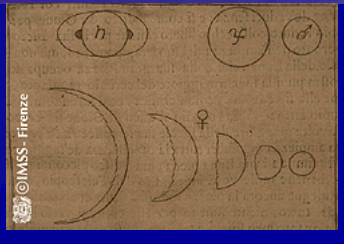




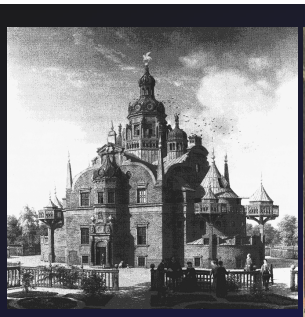


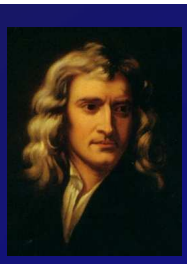






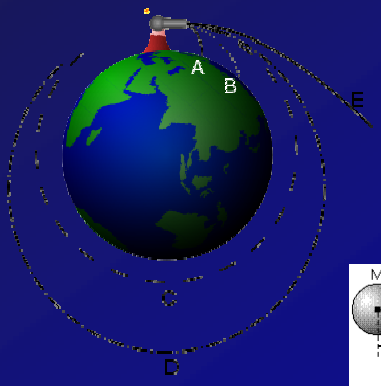
Renacimiento



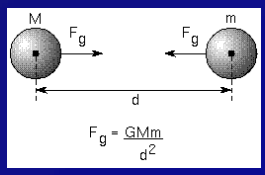


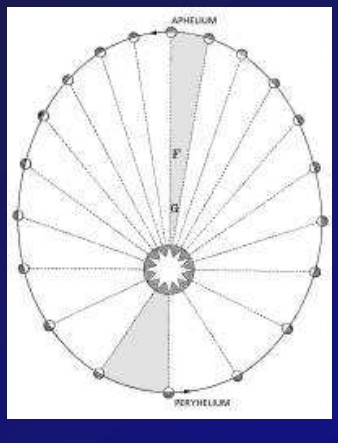
I. Newton

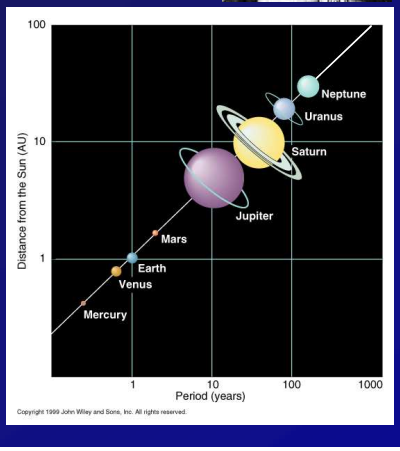
T. Brahe



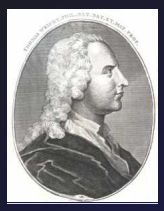
J. Kepler





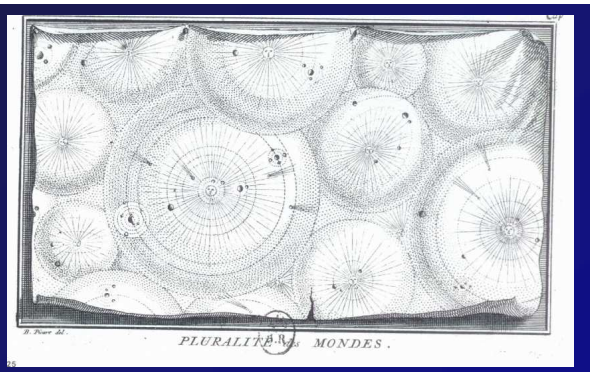


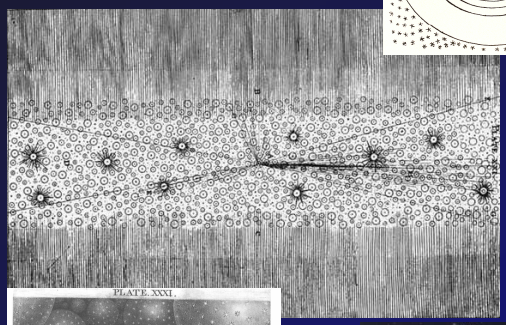
Discusiones Filosóficas



T. Wright

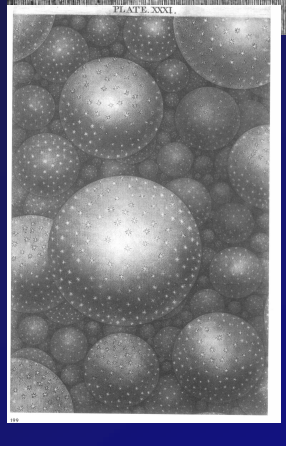
G. Bruno

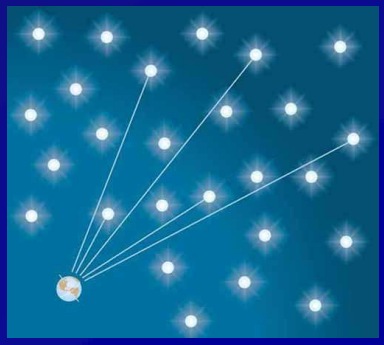




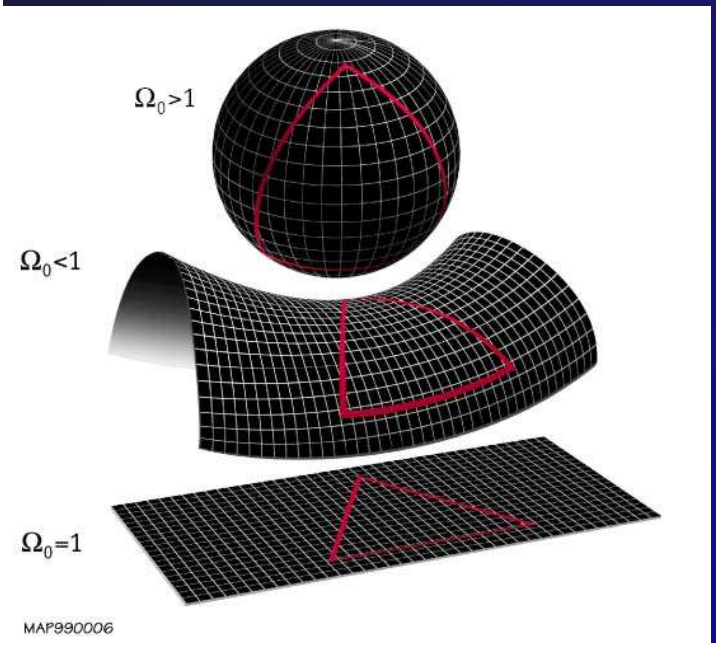
I. Kant

W. Olbers

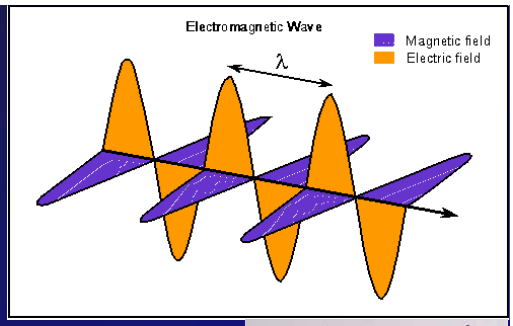




Cosmología Moderna



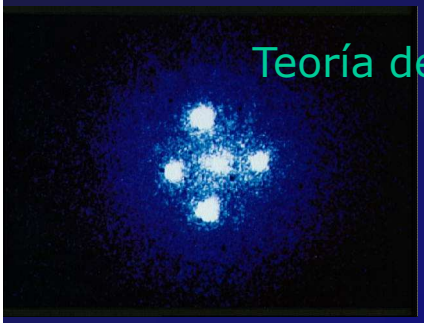
Revoluciones en Física y Biología



Biología
1858 - Evolución de las Especies (C. Darwin)
1866 - Genética (Gregor Mendel)

Eletromagnetismo
1831 - Inducción Electromagnética (M. Faraday)
1856 - Ecuaciones de Maxwell (J.C. Maxwell)

Mecánica Estadística (Termodinámica)
1860 - J.C. Maxwell
1871 - Ludwig Boltzmann



Teoría de la Relatividad
Albert Einstein
1905 - Restricta (o Especial)
1916 - General

$E = m.c^2$

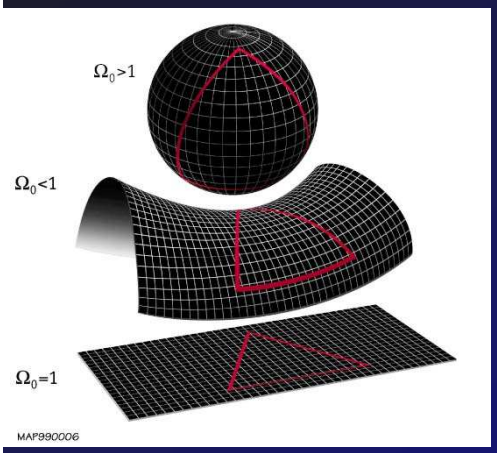
Mecánica Cuántica
1900 - Radiación de cuerpo negro (Max Planck)
1905 - Fotones (A. Einstein)
1926 - Ondas de materia (Louis de Broglie)
1926 - Funciones de onda (E. Schröedinger)
1927 - Principio del Incertidumbre (W. Heisenberg)
1928 - Electrodinámica Cuántica (Paul Dirac)

$E = h.\nu$

$\Delta x.\Delta p \approx \hbar$

Los primeros modelos matemáticos para el Universo

$\Omega = \rho/\rho_c$



Universo estático — Albert Einstein (1917)
→ constante cosmológica (Λ)

$$R_{\mu\nu} - \tfrac{1}{2} g_{\mu\nu} R = (8\pi G/c^2) T_{\mu\nu} - \Lambda g_{\mu\nu}$$

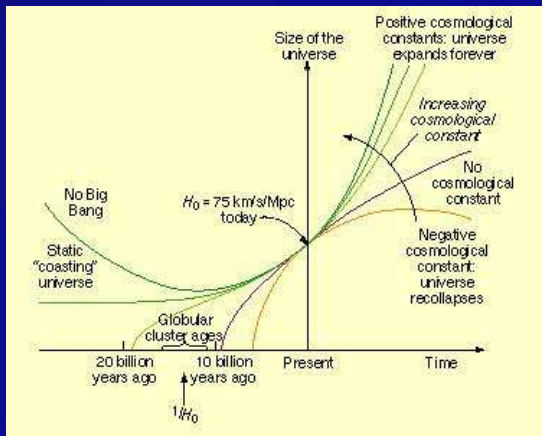
Universo vacío — W. de Sitter (1917)

A. Friedman (1922)

Universo dinámico → factor de escala [$a(t)$]
→ curvatura y cantidad de materia

$$H^2 = (8\pi G/3) \rho - k (c/a)^2 + {}^1/_3 \Lambda$$

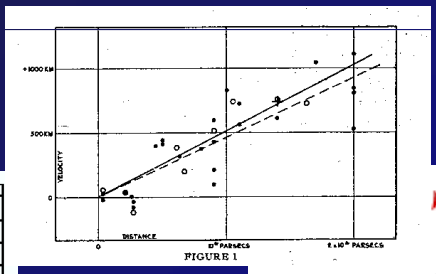
Colapso gravitacional — J. Jeans (1919)

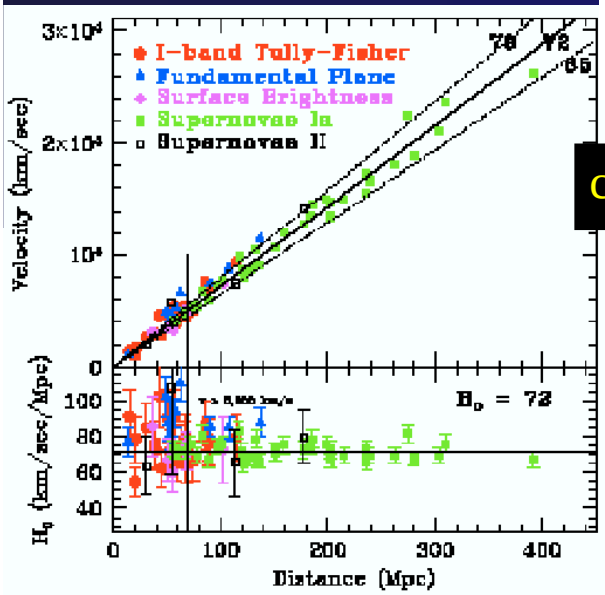


Universo en expansión

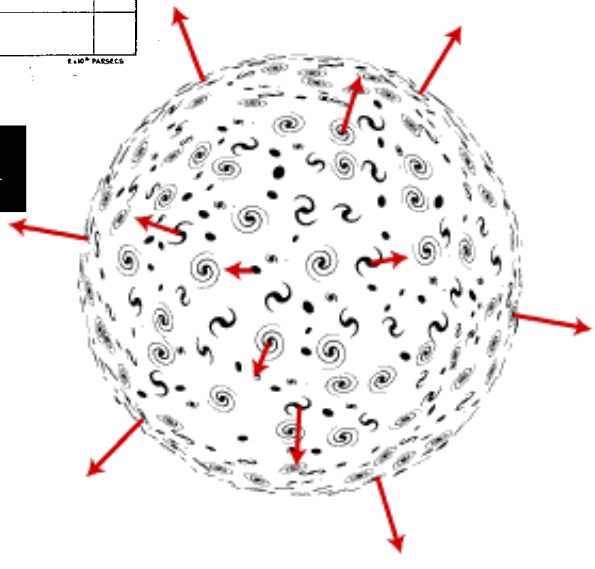
Galaxias → la mayoría alejándose de nosotros
→ velocidad proporcional a la distancia

Edwin Hubble (1929)
E. Hubble y M. Humason (1931)





$c.z = v_r = H_0.d$

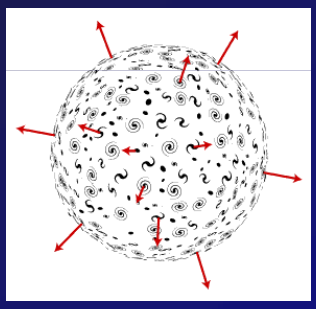


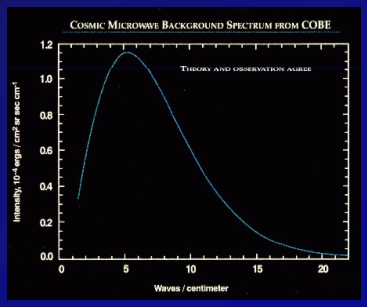
El modelo del *Big-Bang* Caliente (BBC)

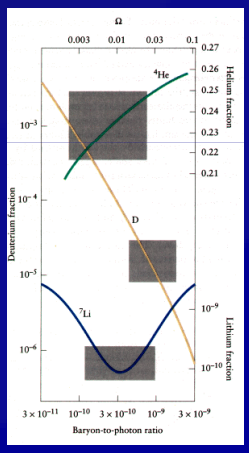
Átomo primordial — George Lemaître (1931)

Big-Bang → expansión = enfriamiento
→ radiación de fondo
→ nucleosynthesis primordial

George Gamow (1948)
Alpher e Herman (1948)



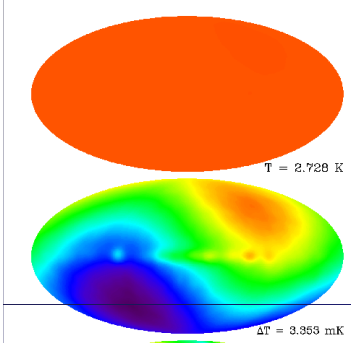


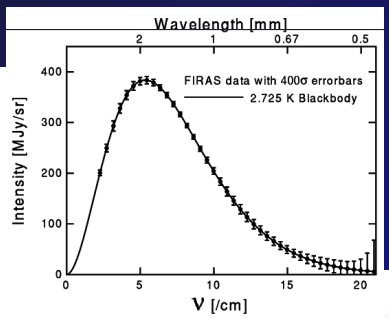


La Radiación Cósmica de Fondo

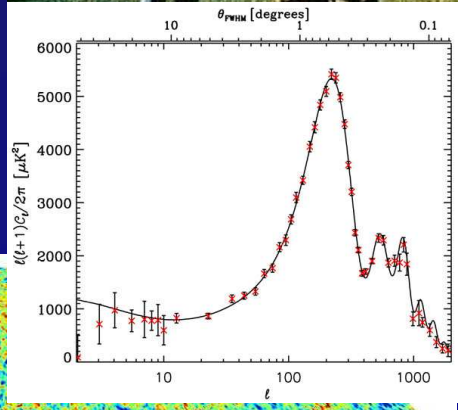
Descubrimiento accidental — Arno Penzias y Robert Wilson (1965)

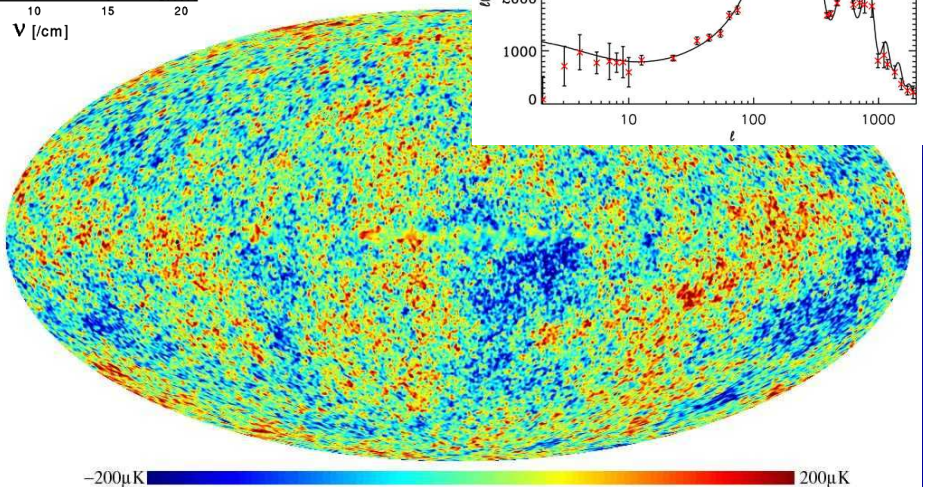
Satélite COBE





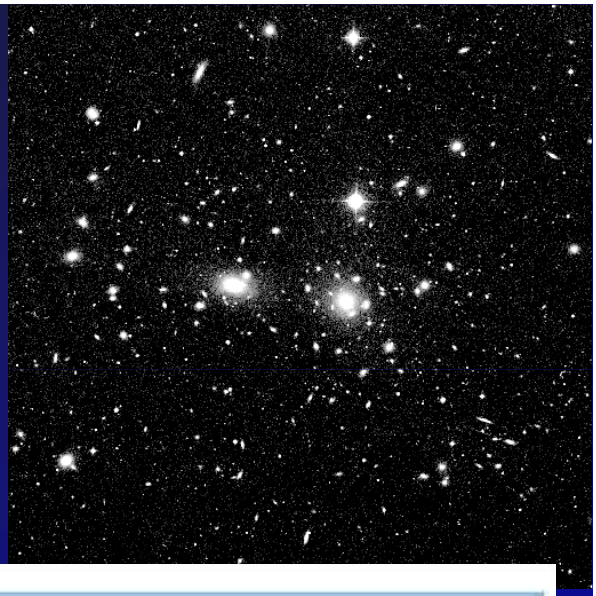
Boomerang, WMAP, Planck...





Ω = 1,02 ± 0,02

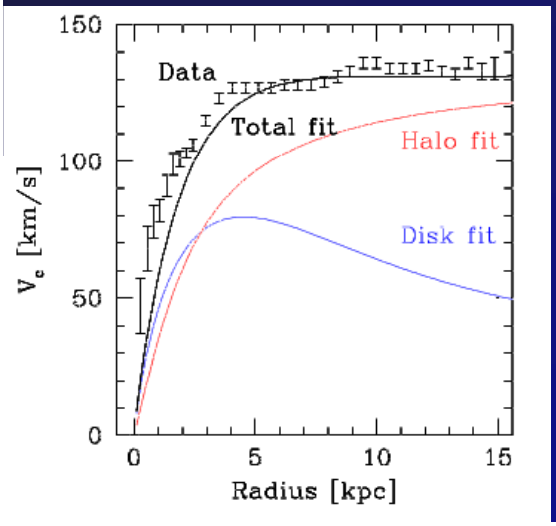
La materia Oscura

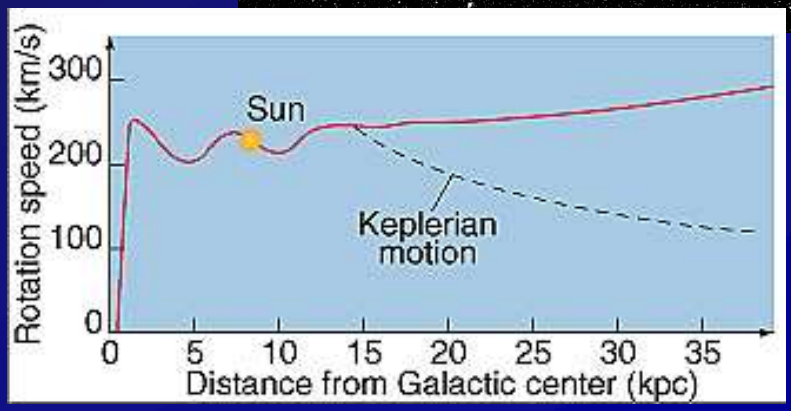


Masa de aglomerados de galaxias
(Coma Berenice) - Teorema del Virial

Fritz Zwicky (1933)

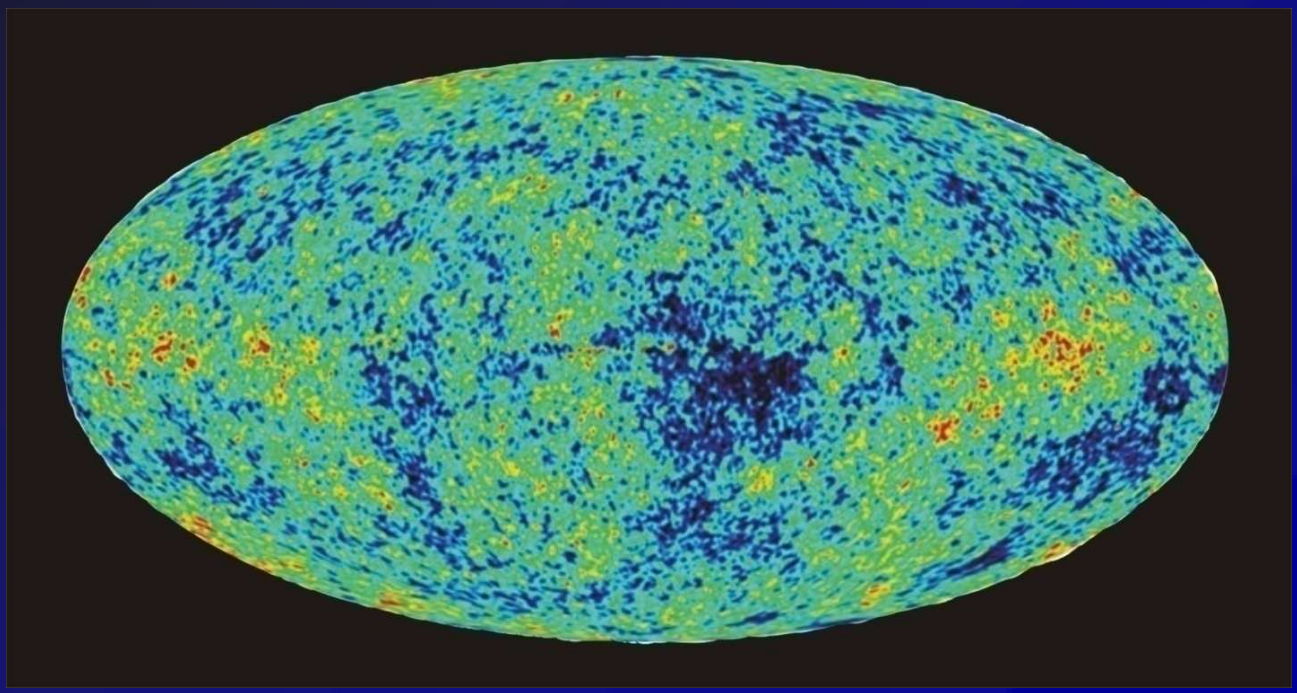
Rotación: Vía-Láctea y M31 J. Oort (1940)





Materia Oscura Fría (CDM) (1983)

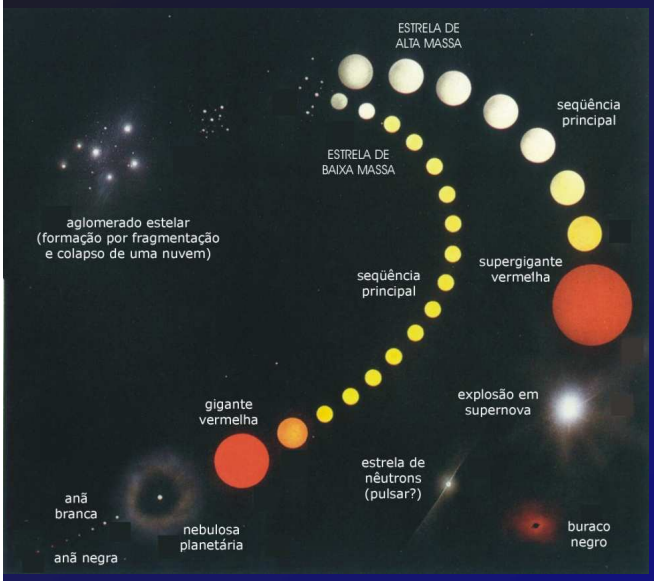
Modelo de Concordancia



Las Edades de la Tierra, el Sol y los Cúmulos Globulares

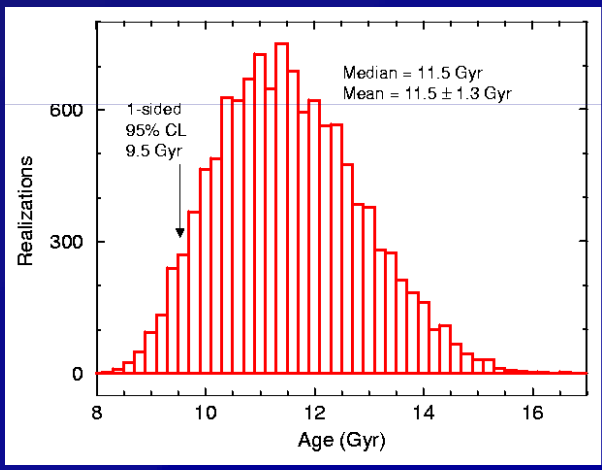
Tierra (4,6 Ga)

Evolución y Geología (C. Darwin e C. Lyell)
Radioactividad (E. Rutherford)
Rocas mas antiguas de la Tierra → 3,7 Ga
Meteoritos e rocas lunares



Sol (5 Ga)

Fusión Termonuclear



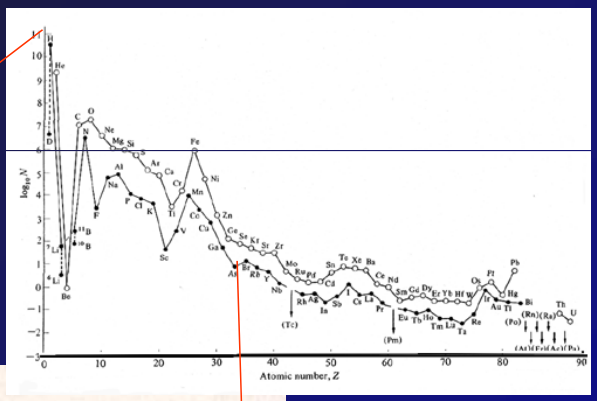
Cúmulos Globulares (11-12 Ga)

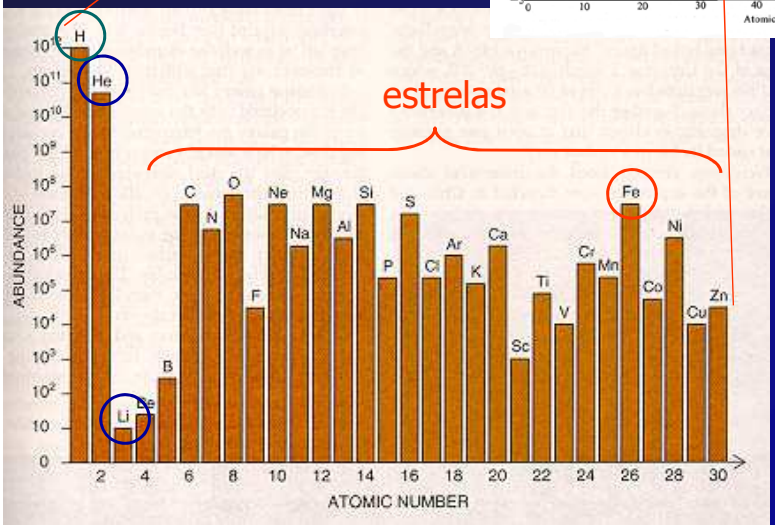
Contienen las estrellas mas viejas de la Galaxia
Estrellas Cefeadas e otros métodos - distancia

Abundancia de elementos químicos

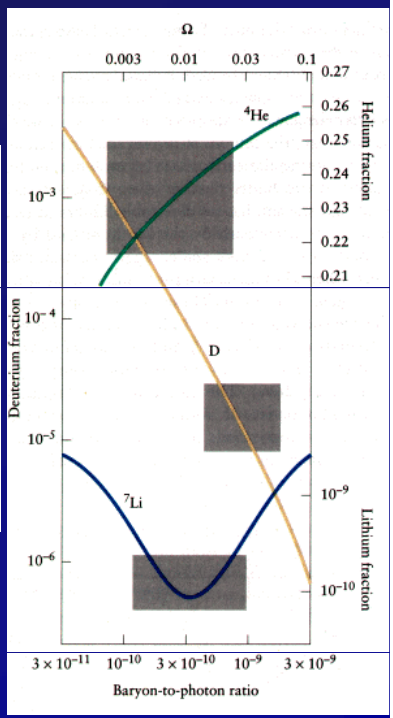
Abundancia promedia

Corteza terrestre
Sol
Meteoritos





$\Omega_B \approx 0,05$



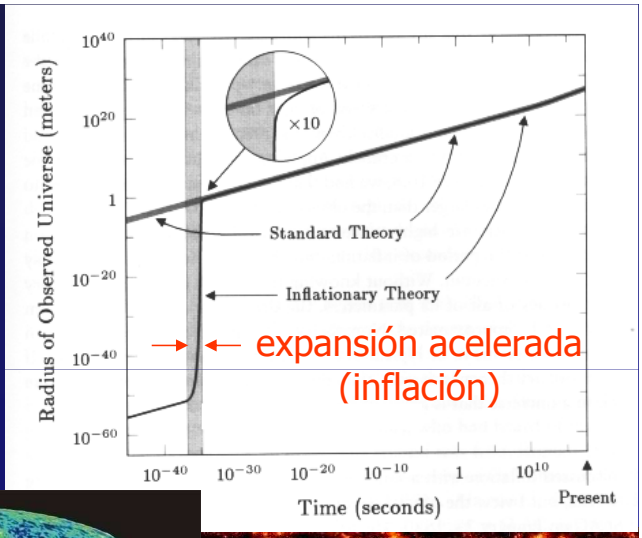
Abundancia primordial

D, ^{3}He, ^{4}He, Li
D (Burles & Tytler 1998)

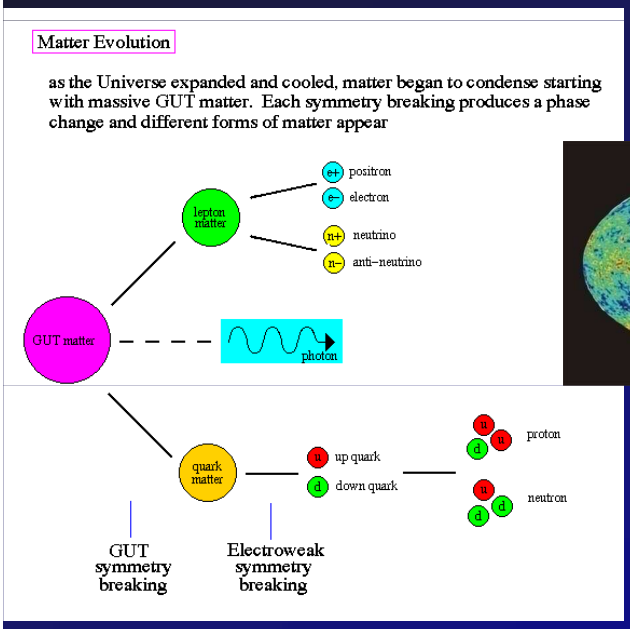
Inflación

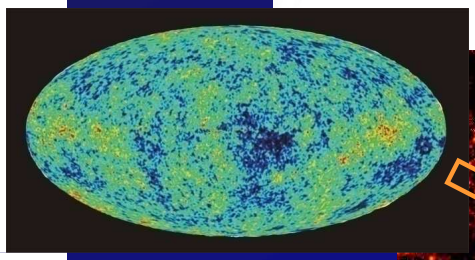
Problemas no explicados por el BBC

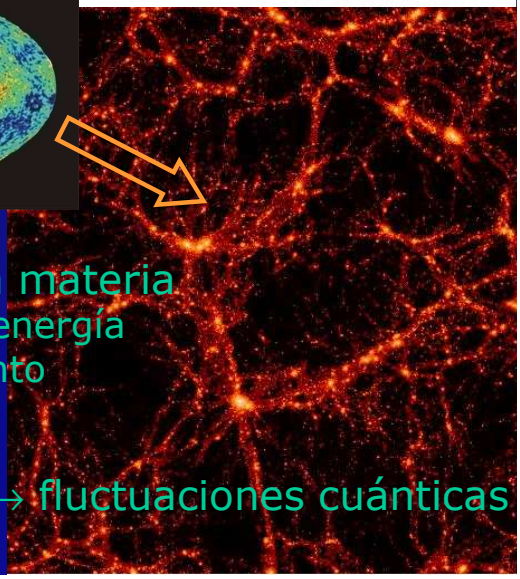
- horizonte (equilibrio térmico)
- planicidad (Ω huye de 1)
- homogeneidad (reliquias topológicas)



← expansión acelerada (inflación)





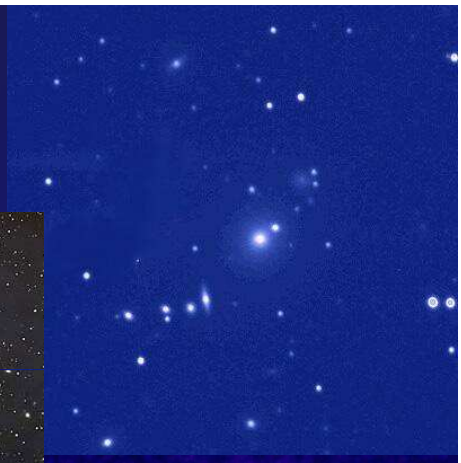


Creación de la materia

- equilibrio de energía
- recalentamiento

Semillas de la formación de estructuras → fluctuaciones cuánticas

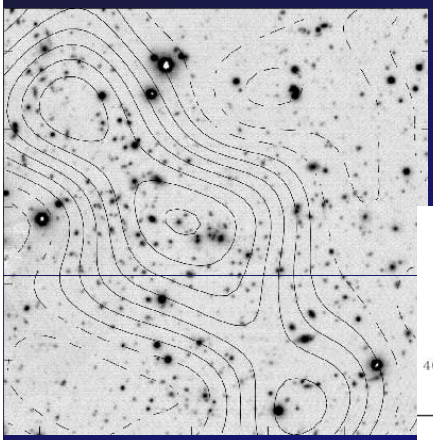
Masa de sistemas de galaxias



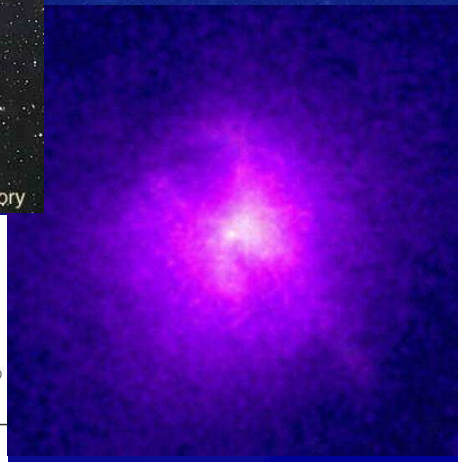
Dinámica → Teorema del Virial

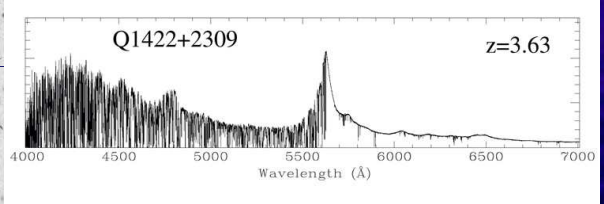
$$E_P = 2E_C$$

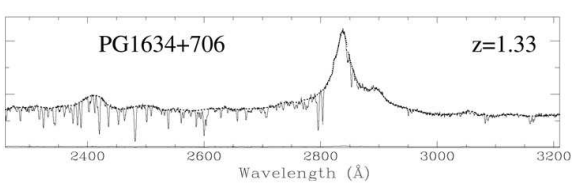
Rayos-X del medio intergaláctico



$\Omega_M \approx 0,3$



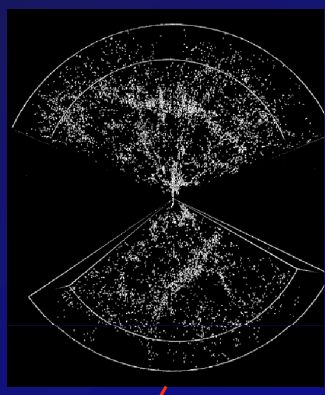




Lentes gravitacionales

Bosques Lyα

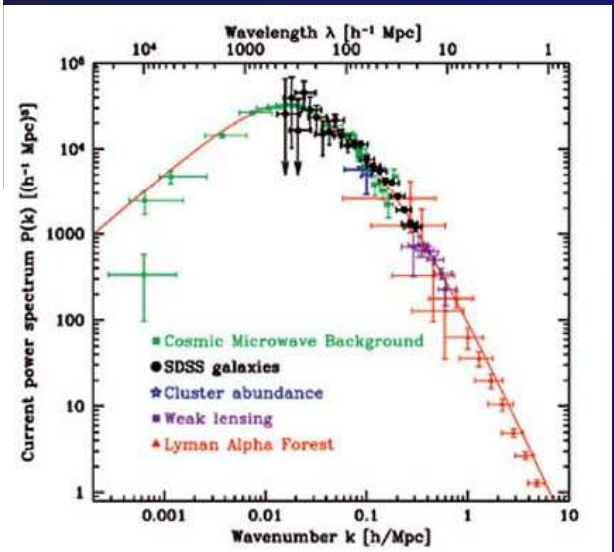
Estructura a Grand Escala

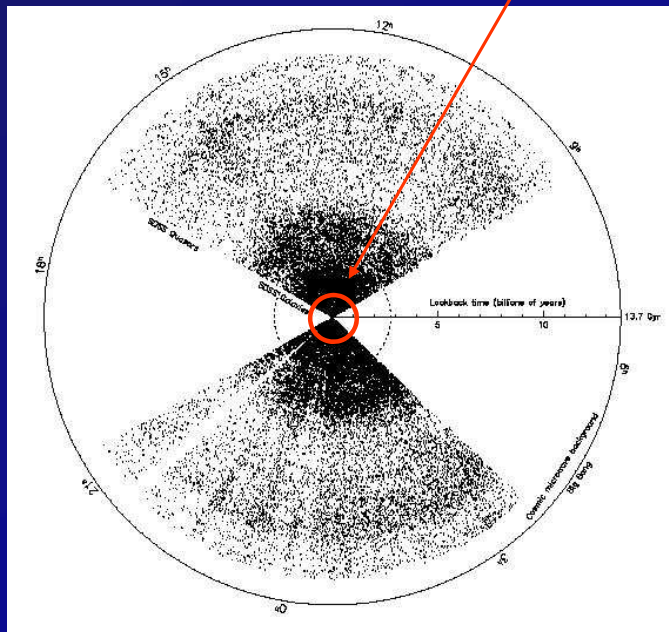


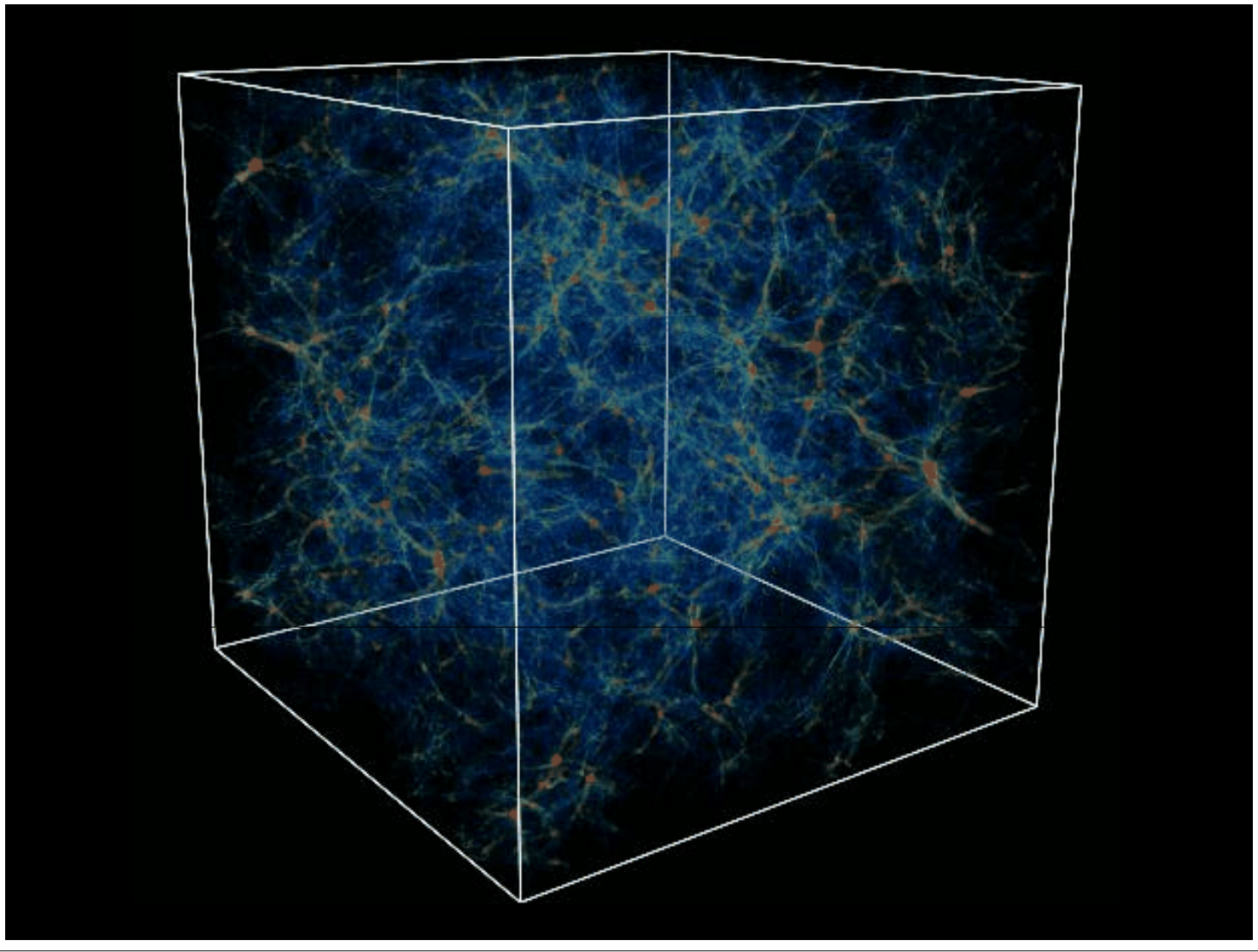
- ✓ CfARS
- ✓ SSRS
- ✓ LCRS
- ✓ 2dFGRS
- ✓ SDSS

Levantamientos de *redshifts*

Espectro de Potencia



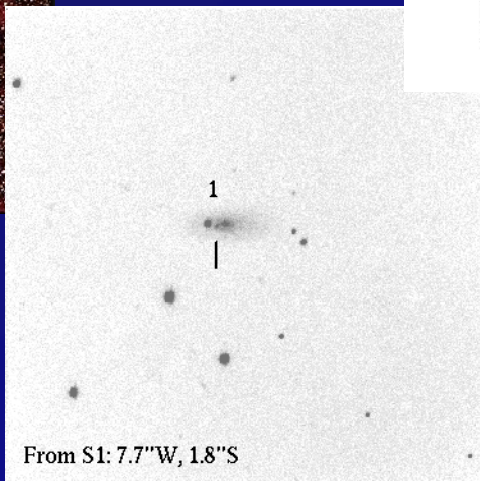


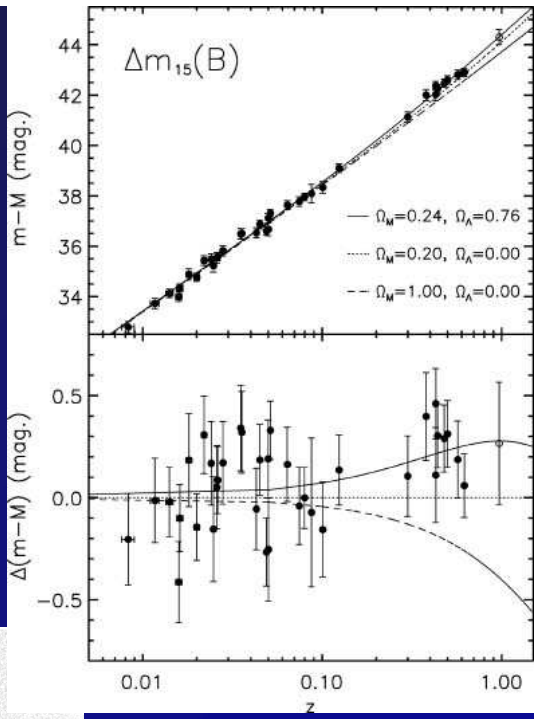


1998 - Los proyectos de SN Ia

Desviaciones en la relación de Hubble
(desaceleración o aceleración)

Supernovas del tipo Ia





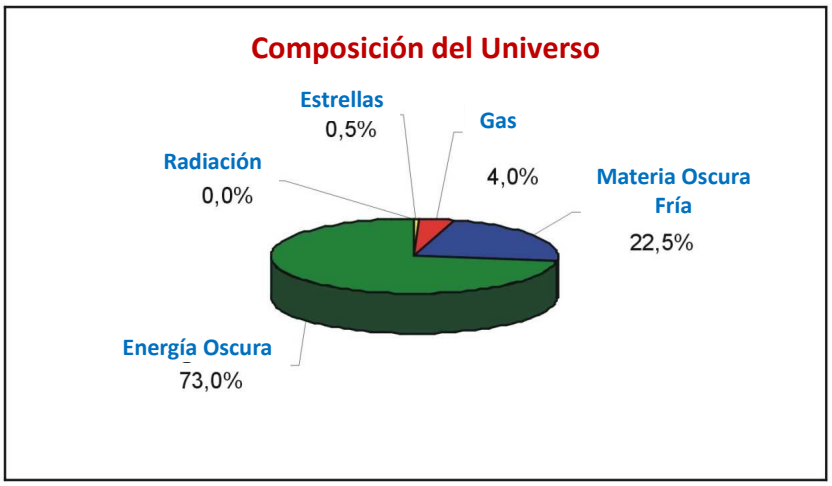
Expansión Acelerada

Perlmutter et al.
Riess et al.

$\Omega_X \approx 0,7$

Resumen

Cantidad de materia-energía



Radiación Cósmica de Fondo

$\Omega = 1,02 \pm 0,02$

Abundancia primordial

$\Omega_B \approx 0,05$

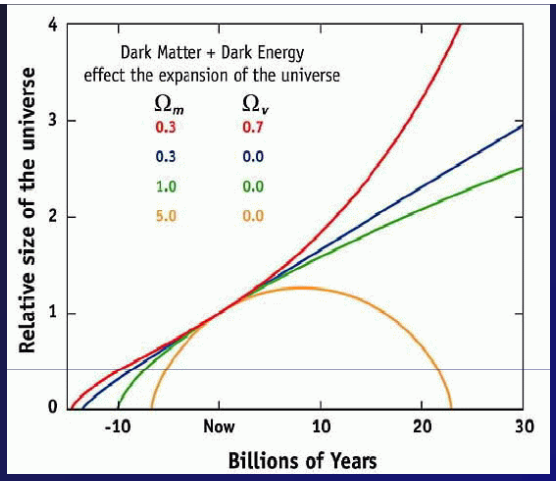
Masa de sistemas de galaxias

$\Omega_M \approx 1/3$

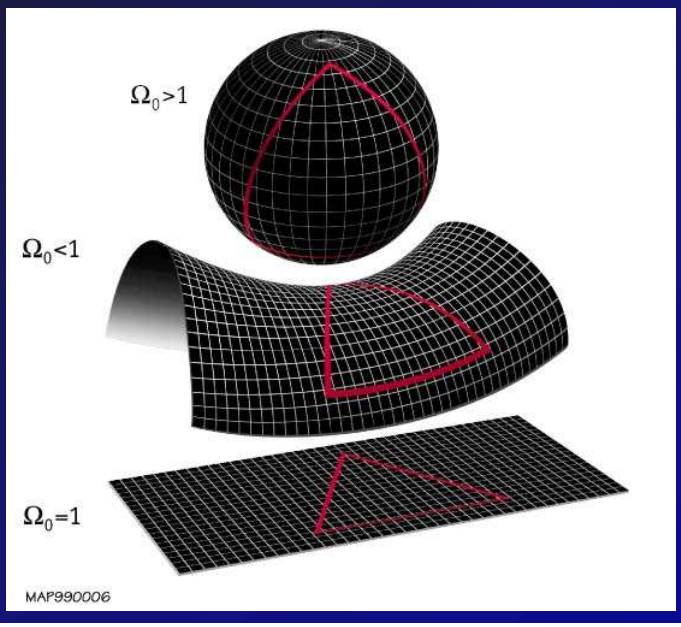
Supernovas - Expansión Acelerada

$\Omega_X \approx 2/3$

Destino



Curvatura



Topología	Destino
Finito	Abierto (Λ grande) o cerrado
Finito o infinito	Abierto
Finito (toro) o infinito (plano)	Abierto