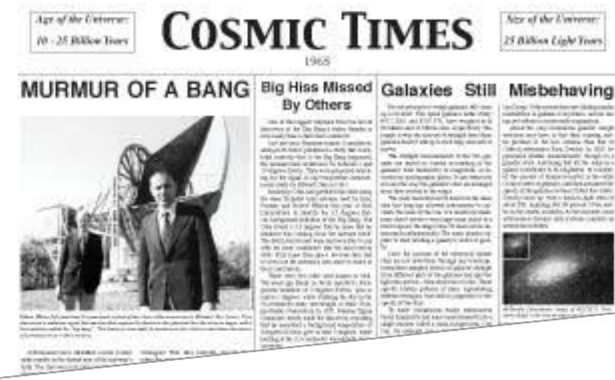
Fondo de radiación cósmico

Pezzutti Aldo
Mecánica estadística
27/6/2013

Descubrimiento del fondo de radiación

1965



A MEASUREMENT OF EXCESS ANTENNA TEMPERATURE AT 4080 Mc/s

Measurements of the effective zenith noise temperature of the 20-foot horn-reflector antenna (Crawford, Hogg, and Hunt 1961) at the Crawford Hill Laboratory, Holmdel, New Jersey, at 4080 Mc/s have yielded a value about 3.5° K higher than expected. This excess temperature is, within the limits of our observations, isotropic, unpolarized, and

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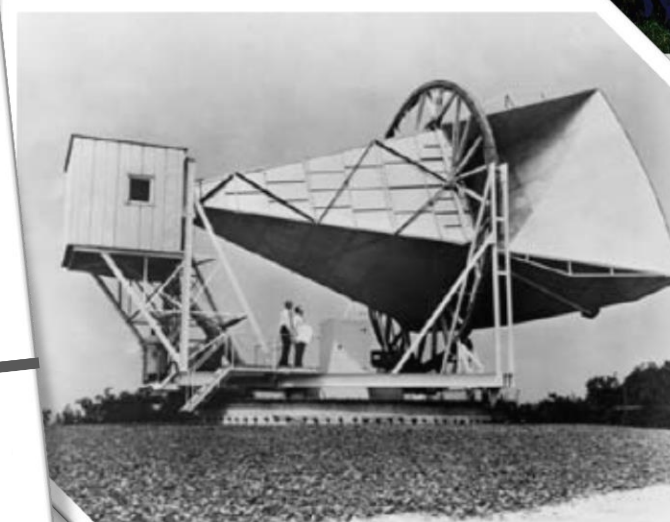
free from seasonal variations (July, 1964–April, 1965). A possible explanation for the observed excess noise temperature is the one given by Dicke, Peebles, Roll, and Wilkinson



Penzias A. A., Wilson R. W. *A mesurement of excess antenna temperature at 4080mc/s*. Astrophysical Journal 142-419(1965)

Descubrimiento del fondo de radiación

1965

COSMIC BLACK-BODY RADIATION*

One of the basic problems of cosmology is the singularity characteristic of the familiar cosmological solutions of Einstein's field equations. Also puzzling is the presence of matter in excess over antimatter in the universe, for baryons and leptons are thought to be conserved. Thus, in the framework of conventional theory we cannot understand the origin of matter or of the universe. We can distinguish three main attempts to deal with these problems.

1. The assumption of continuous creation (Bondi and Gold 1948; Hoyle 1948), which avoids the singularity by postulating a universe expanding for all time and a continuous but slow creation of new matter in the universe.

2. The assumption (Wheeler 1964) that the creation of new matter is intimately related to the existence of the singularity, and that the resolution of both paradoxes may be found in a proper quantum mechanical treatment of Einstein's field equations.

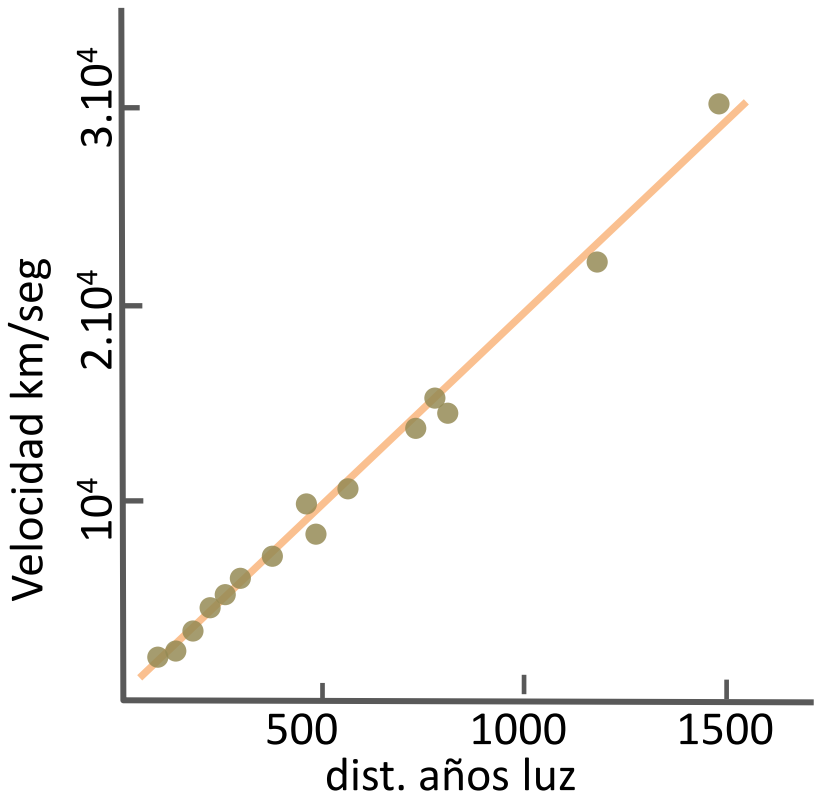
3. The assumption that the singularity results from a mathematical over-idealization,

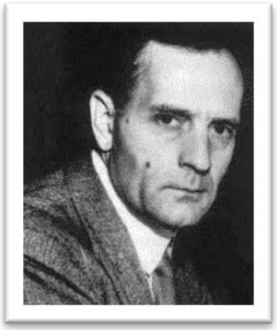
* This research was supported in part by the National Science Foundation and the Office of Naval Research of the U.S. Navy.

Dicke R. H., Peebles P. J. E., Roll P. G., Wilkinson D. T. *Cosmic Black-body radiation.* Astrophysical Journal 142-414(1965).

Expansión del universo-Ley de Hubble

1929





$$z = \frac{\lambda_1 - \lambda_2}{\lambda_1} = \frac{H_0}{c} D$$

$$v = HD$$

E. Hubble. *A relation between distance and radial velocity among extra-galactic nebulae.* PNAS. **15** 168-173.(1929).

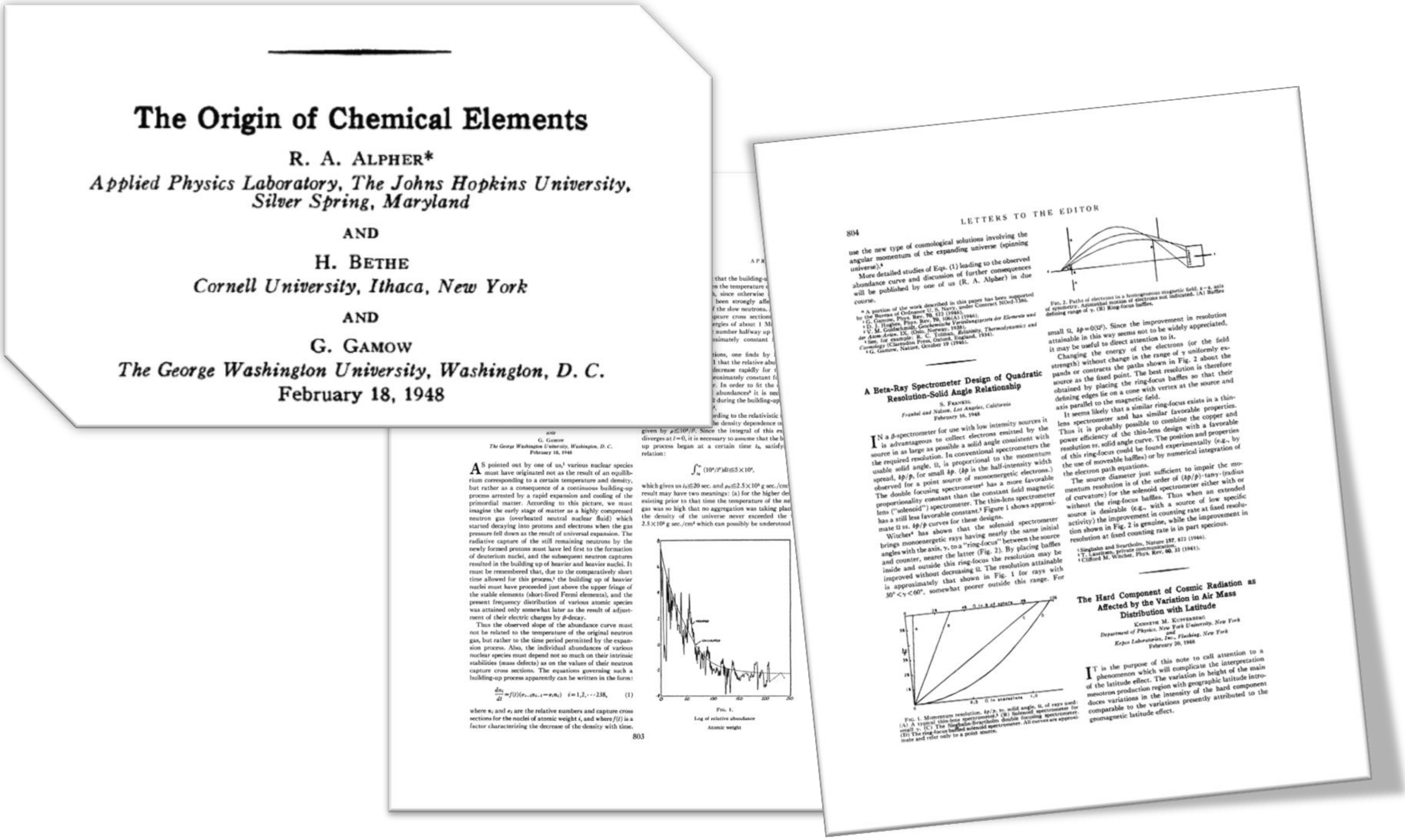
Descubrimiento del fondo de radiación

1935	Adams y Dunham	Análisis espectral de las ondas de radio emitidas por gas interestelar 2,3K
1950	T. Shmaonov P. Le Roux W.K.Rose	Radio astronomía 3K

Herman R. *The prediction of the cosmic microwave background radiation*. Gamov Symposium71-83(1997).

Descubrimiento del fondo de radiación

1948



The Origin of Chemical Elements

R. A. Alpher*
Applied Physics Laboratory, The Johns Hopkins University, Silver Spring, Maryland

AND

H. Bethe
Cornell University, Ithaca, New York

AND

G. Gamow
The George Washington University, Washington, D. C.
February 18, 1948

LETTERS TO THE EDITOR

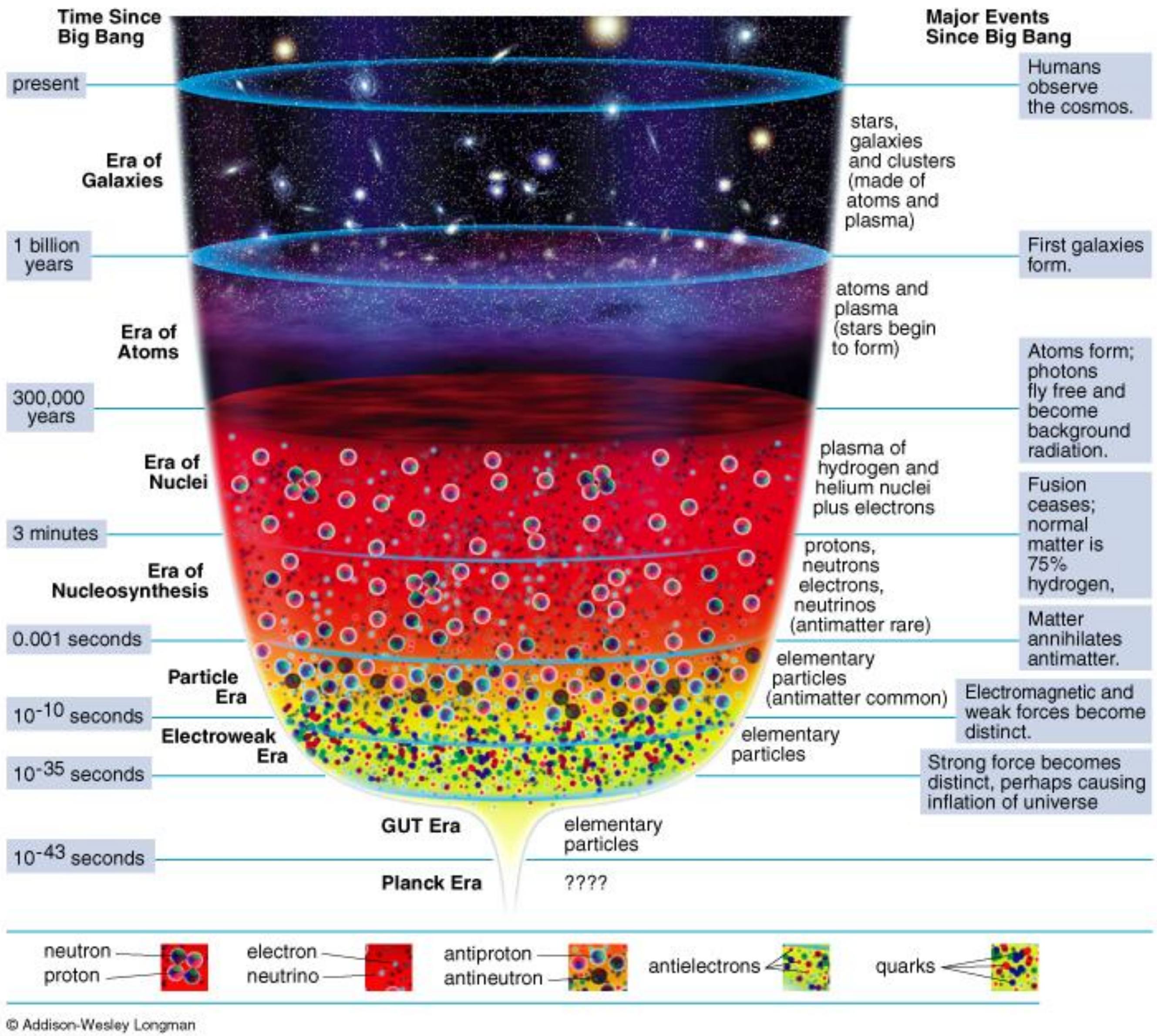
A Beta-Ray Spectrometer Design of Quadratic Resolution-Solid Angle Relationship

The Hard Component of Cosmic Radiation as Affected by the Variation in Air Mass Distribution with Latitude

Alpher R. A., Bethe H., Gamow G. *The origin of chemical elements*. Physical review 73-803 (1948).

Descubrimiento del fondo de radiación

Descubrimiento del fondo de radiación



Época de recombinación

Scattering de Thomson

$$\gamma + e^- \rightarrow \gamma + e^-$$

Camino libre medio del fotón es

Temperatura $3x10^5 K$

$$l = \frac{1}{n_e \sigma_e}$$

Sección eficaz $\sigma_e = 6{,}65.\,10^{-29} m^2$ $\Gamma = c/l = n_e \sigma_e c$

Con el universo totalmente ionizado

$$n_e = n_{bar}$$

De la densidad actual de bariones

$$n_e = n_{bar} = \frac{n_{bar(hoy)}}{a^3}$$

$$n_{bar(hoy)} \approx 0{,}22 m^{-3}$$

Época de recombinación

para

$a = 10^{-5}$

$\Gamma = 4{,}4.\,10^{-6} seg^{-1}$

Cada fotón sufre 3 scatterings por semana

Constante de Hubble

$H(z) = 1{,}24.\,10^{-18} s^{-1} (1+z)^{3/2} \quad con\ z = 10^5$

$H = 2{,}1.\,10^{-10} seg^{-1}$

El universo se vuelve transparente

$\Gamma = H$

Época de recombinación

Época de la recombinación

$$H + \gamma \leftrightarrow p + e^-$$

$$n_x = g_x \left(\frac{m_x kT}{2\pi\hbar^2}\right)^{3/2} exp\left(-\frac{m_x c^2}{kT}\right)$$

$$g_s = 2\ electrón - \ protón \qquad g_s = 4\ átomo\ neutro$$

$$\frac{n_H}{n_p n_e} = \frac{g_H}{g_p g_e}\left(\frac{m_H}{m_p m_e}\right)^{3/2}\left(\frac{kT}{2\pi\hbar^2}\right)^{-3/2} exp\left(\frac{[m_p + m_e - m_H]c^2}{kT}\right)$$

$$\frac{n_H}{n_p n_e} = \left(\frac{m_e kT}{2\pi\hbar^2}\right)^{-3/2} exp\left(\frac{Q}{kT}\right)$$

Ecuación de Saha

Parámetro de ionización

$$X \equiv \frac{n_p}{n_p + n_H}$$

0 bariones totalmente neutros
1 bariones totalmente ionizados

Época de recombinación

$$n_H = \frac{1-X}{X} n_p$$

Neutralidad del universo $\quad n_e = n_p$

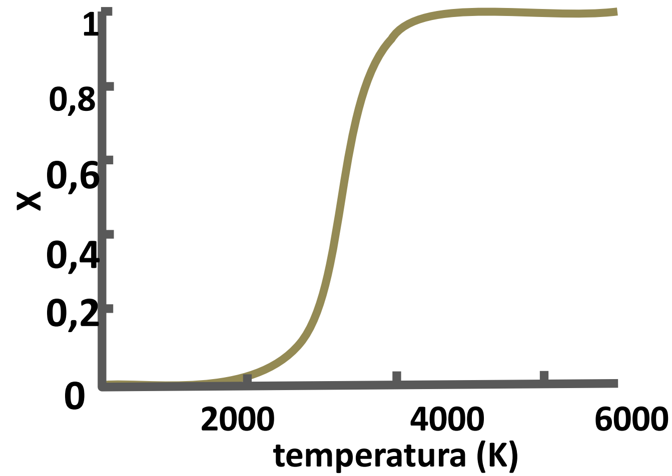
$$\frac{1-X}{X} = n_p \left(\frac{m_e kT}{2\pi\hbar^2}\right)^{-3/2} exp\left(\frac{Q}{kT}\right)$$

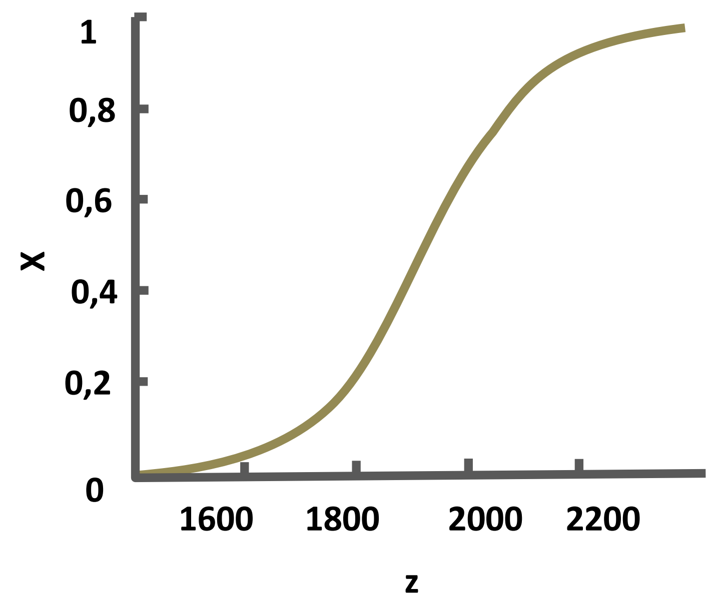
$$n_\gamma = 0{,}243 \left(\frac{kT}{\hbar c}\right)^3$$

$$\eta = \frac{n_p}{X n_\gamma} \cong 5{,}5.\,10^{-10}$$

La función de Saha, resulta

$$\frac{1-X}{X^2} = 3{,}84\eta \left(\frac{kT}{m_e c^2}\right)^{3/2} exp\left(\frac{Q}{kT}\right)$$





Época de desacoplamiento

$$\Gamma = n_e(z)\sigma_e c = X(z)(1+z)^3 n_{bar}\sigma_e c = 4{,}4.\,10^{-21} s^{-1} X(z)(1+z)^3$$

$$H(z) = 1{,}24.\,10^{-18} s^{-1}(1+z)^{3/2}$$

$$1 + z_{des} = \frac{43{,}0}{X^{2/3}(z_{des})}$$

De la ecuación de Saha

z_{des}=1100

T_{des}=3000K Edad del universo de 350000 años

Entropía de un gas de bosones

$$S = VT^d$$

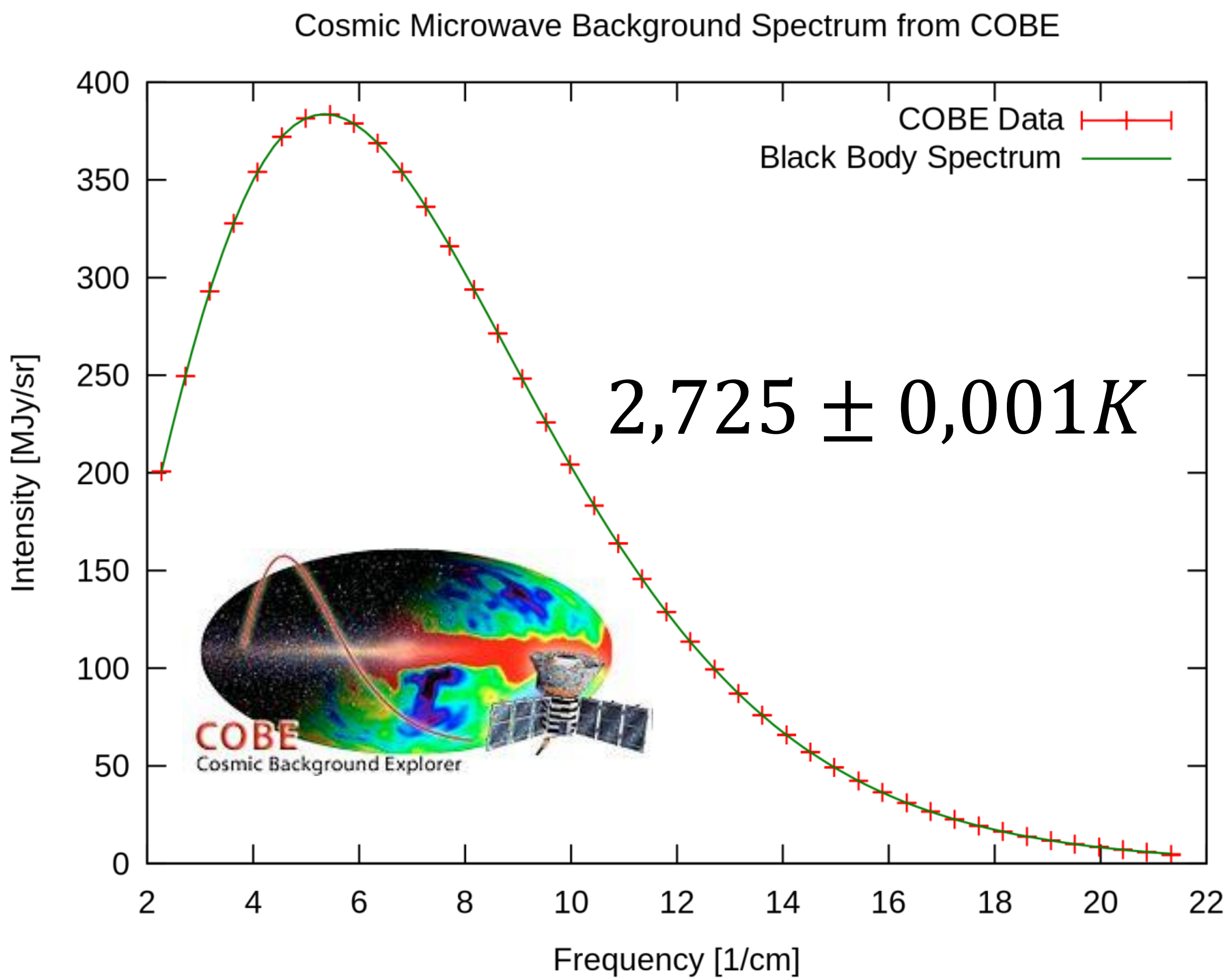
Expansión adiabática

$$VT^3 = cte \qquad con\ d = 3$$

$$\frac{V_{T(hoy)}}{V_{T(des)}} = \left(\frac{T_{des}}{T_{hoy}}\right)^3 \rightarrow T_{hoy} \approx 5K$$

COsmic Background Explorer

1989



Propiedades de la radiación de fondo

Temperatura $T = 2{,}725 \pm 0{,}001K$

Densidad de energía $\varepsilon_\gamma = 4{,}17.10^{-14} Jm^{-3}$

Densidad de fotones $n_\gamma = 4{,}11.10^{8} m^{-3} \approx 411\, \gamma_{\,CMB}\, cm^{3}$

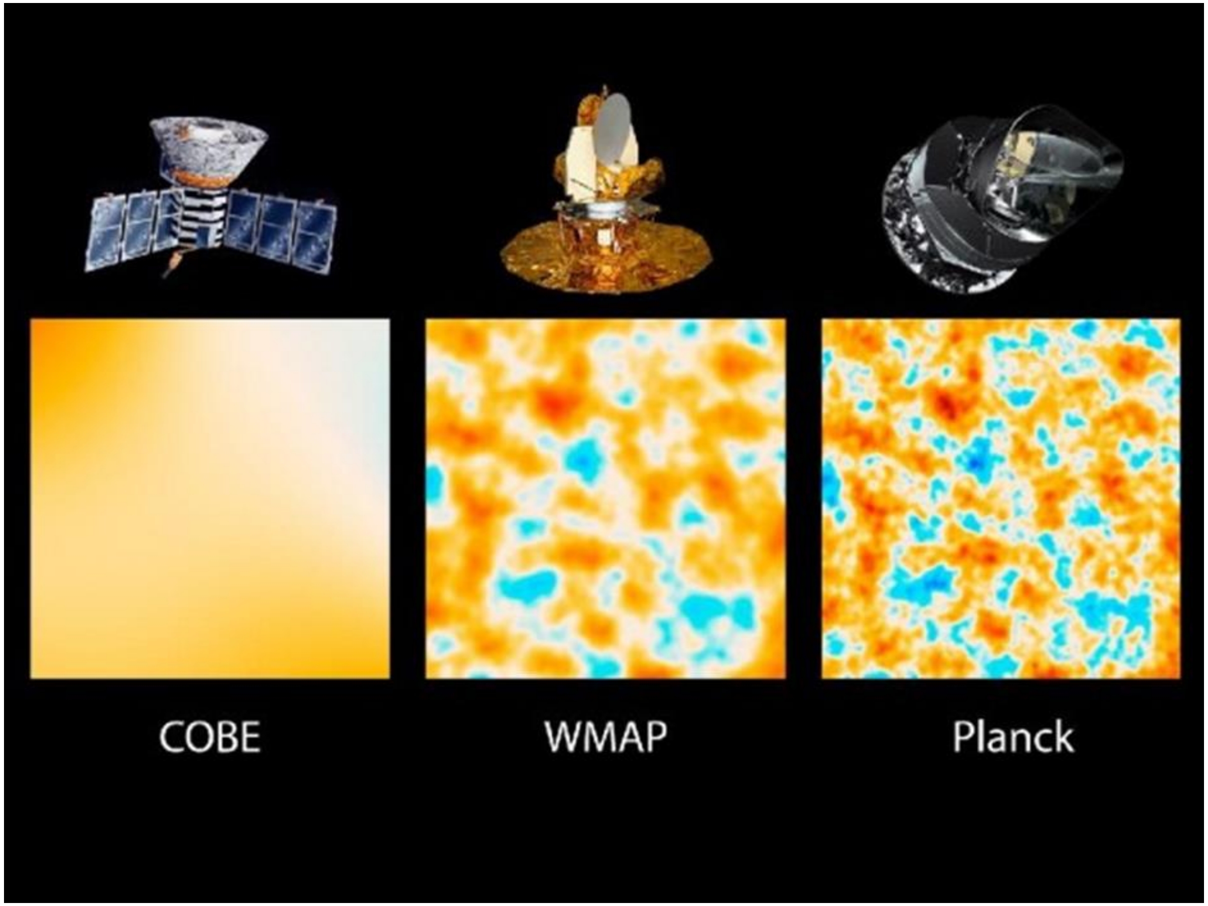
Energía media por fotón $< \gamma_\gamma > = 6{,}34.10^{-4} eV \ll 10eV$

Longitud de onda $1{,}06mm$

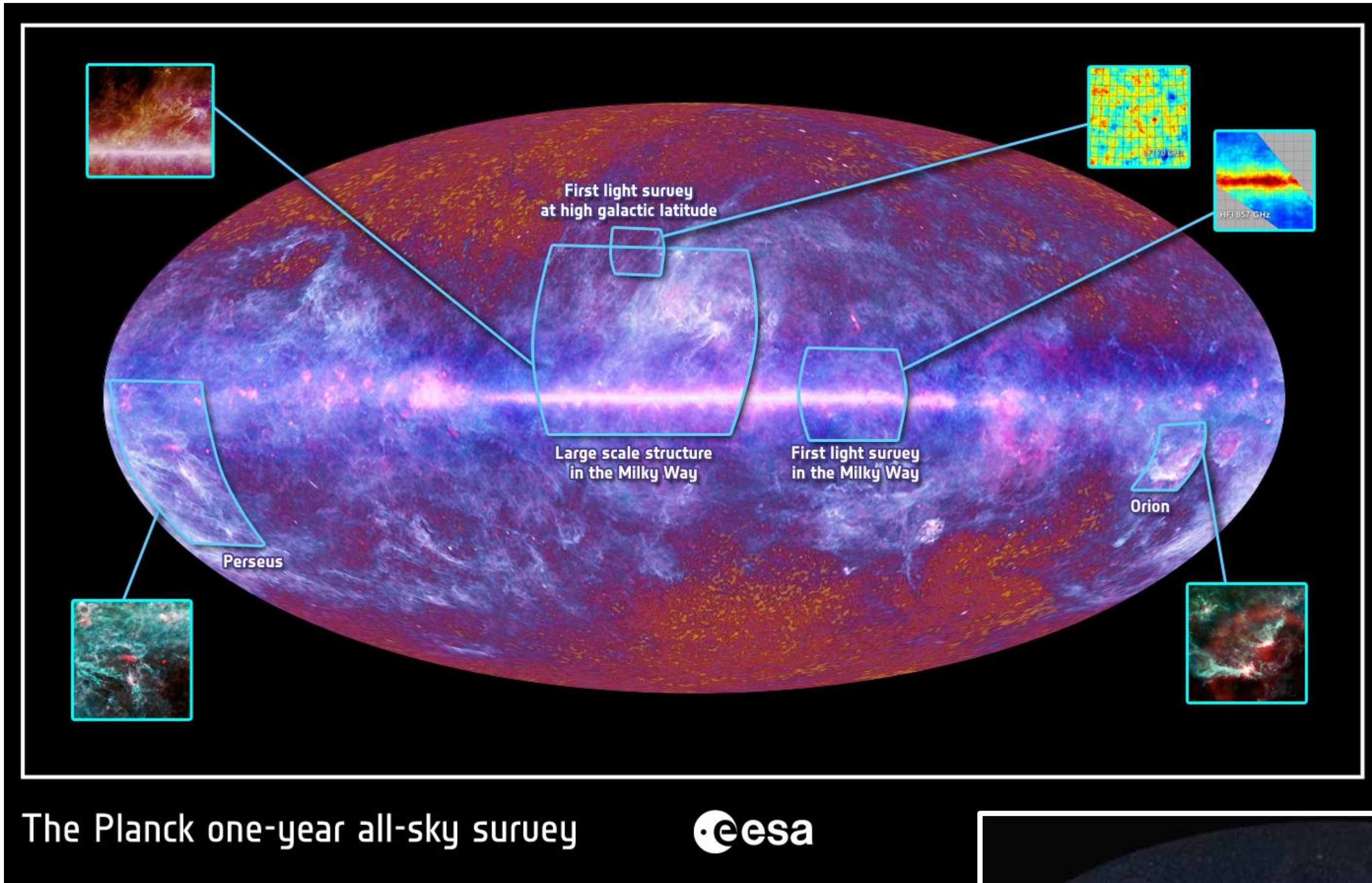
Frecuencia $283Ghz$

Misiones COBE, WMAP y Planck

2012



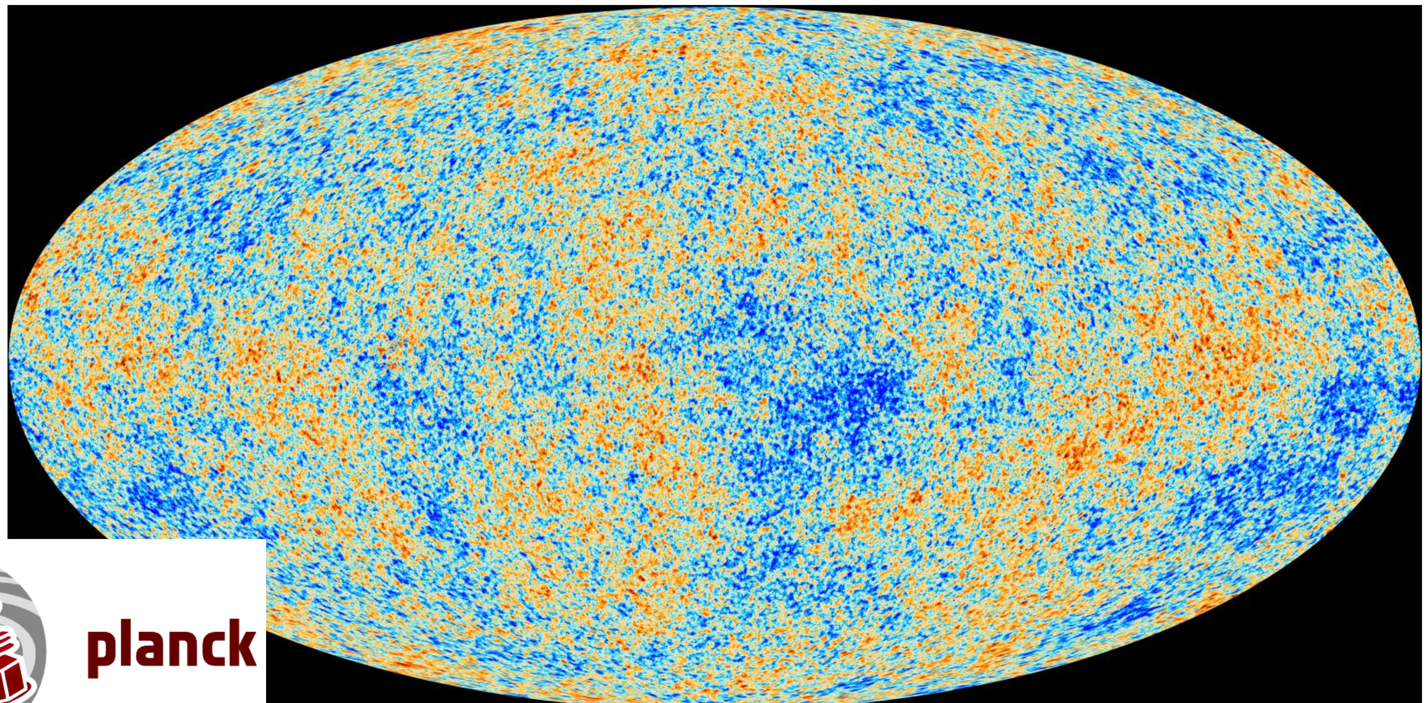
Fondo de radiación cósmico



Fondo de radiación cósmico

2012

$$2{,}7255 \pm 0{,}0001K$$



planck

Fondo de radiación cósmico

$$C(\theta) = \left\langle \frac{\delta T}{T}(n) \frac{\delta T}{T}(n') \right\rangle_{n.'n = cos\theta}$$

$$C(\theta) = \frac{1}{4\pi} \sum_{l=0}^{\infty} (2l+1) C_l P_l(\cos(\theta))$$

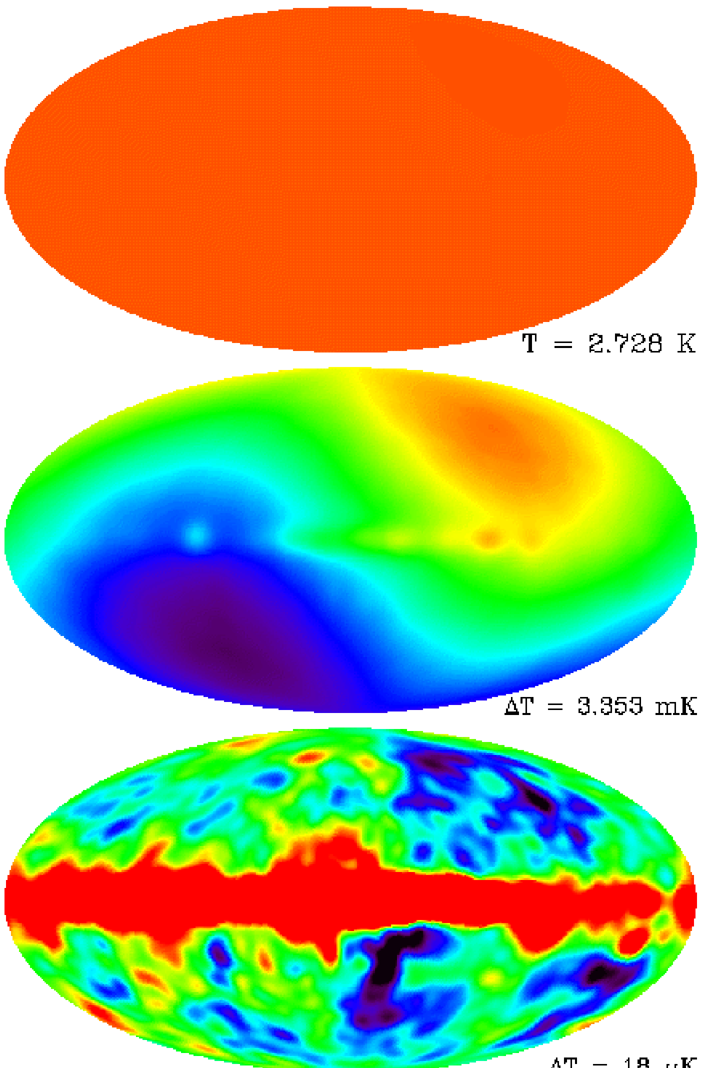
$$\theta = 180/l$$

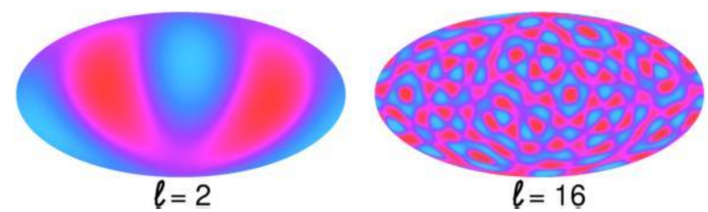
$$l = 0 \;\; monopolo\ independiente\ del\ angulo$$

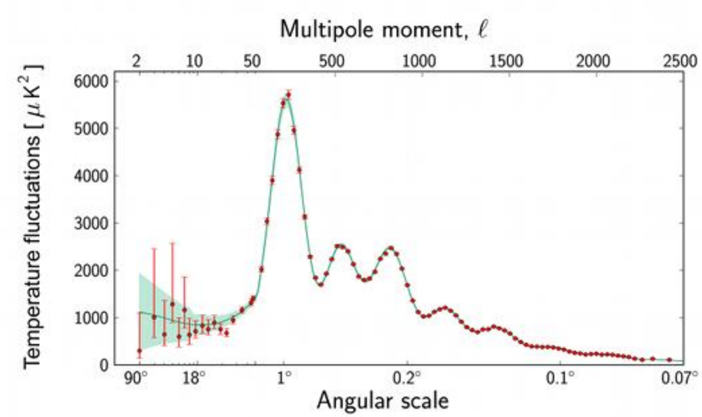
$$l = 1 \;\; dipolo\ variaciones\ 180$$

Para l>2 miden anisotropías menores a 180 grados, son muy pequeñas $10^{-5} K$

Fondo de radiación cósmico







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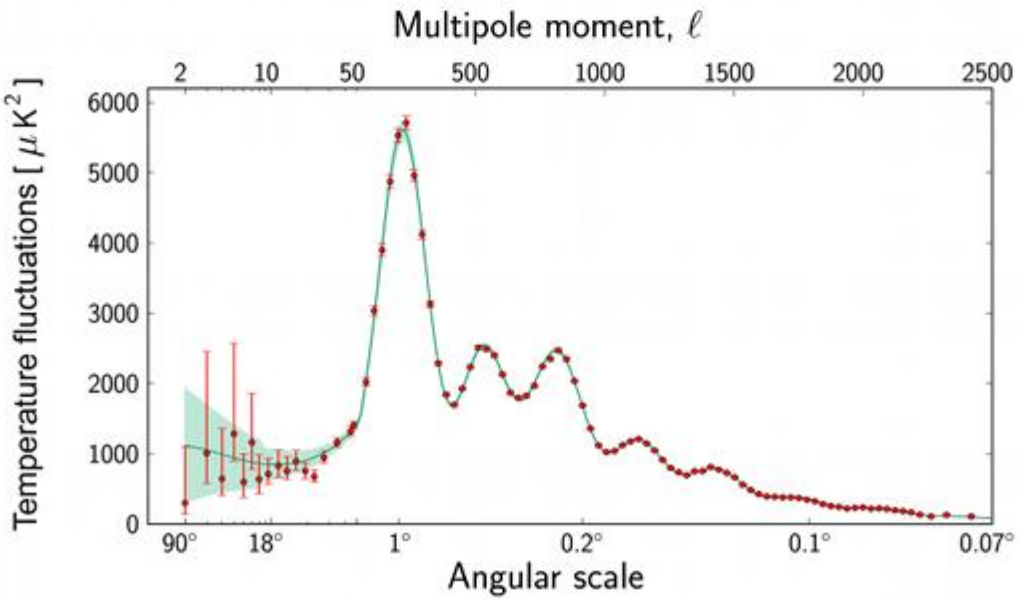
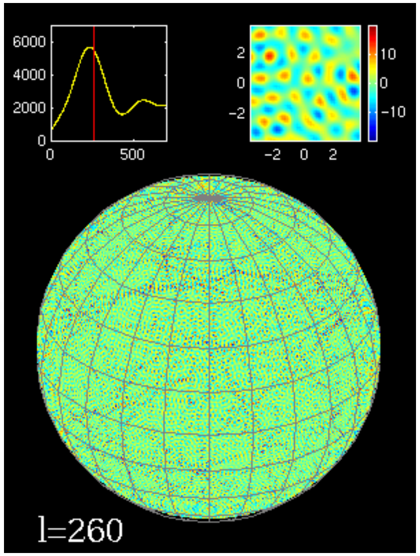
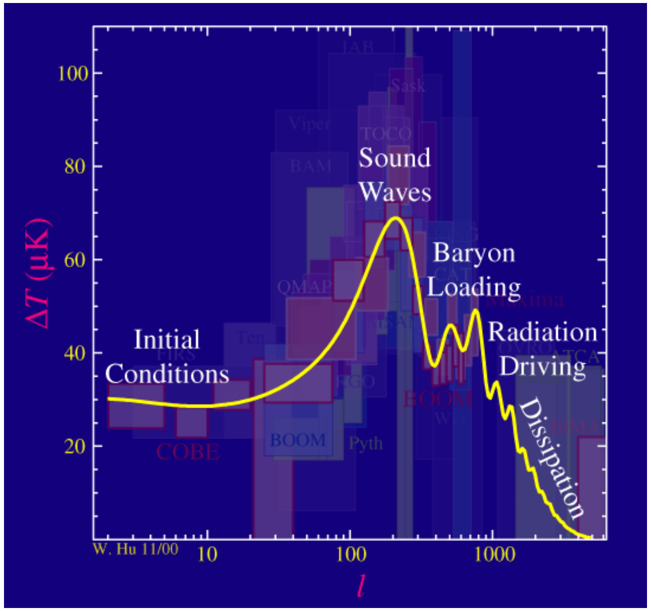
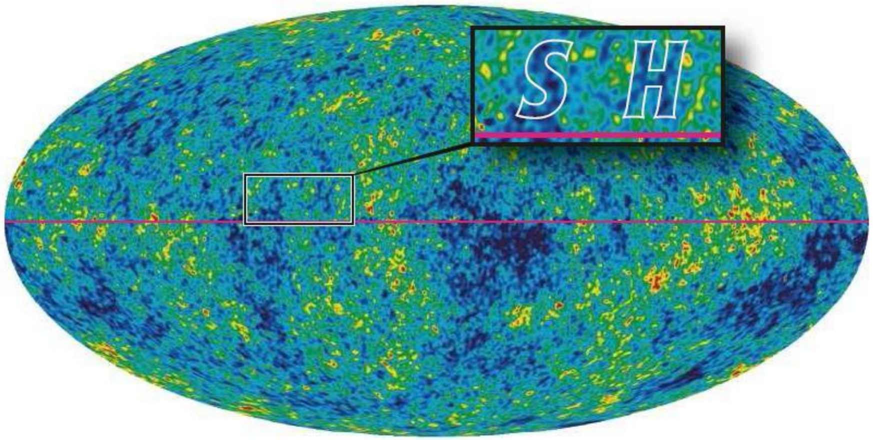




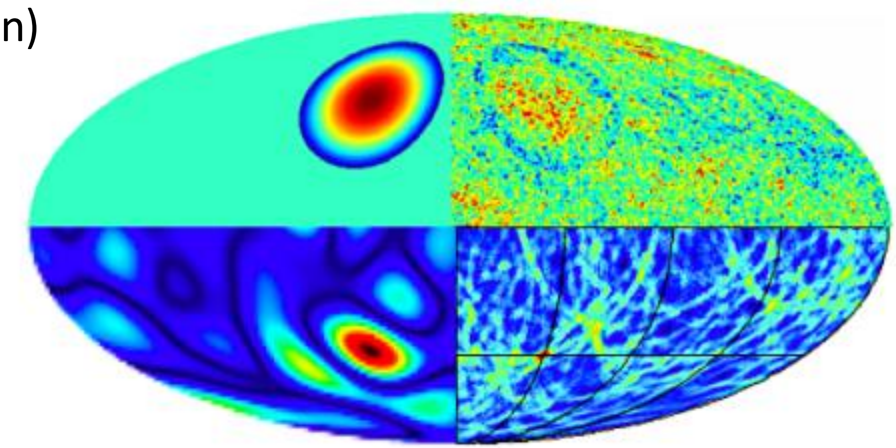


http://www.astro.virginia.edu/~dmw8f/sounds/cdromfiles/index.php

Fondo de radiación cósmico



Las iniciales de Stephen Hawking
(mapa ILC o Internal Linear Combination)



Roger Penrose. Colisiones con otros universos

V.G.Gurzadyan, R.Penrose. *Concentric circles in WMAP data may provide evidence of violent pre-Big-Bang activity* arXiv:1011.3706.(2010).

A. Moss, D. Scott, J. P. Zibin. *No evidence for anomalously low variance circles on the sky*.arXiv:1012.1305 (2010).

Fondo de radiación cósmico

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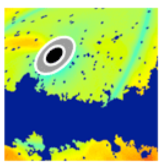
Synopsis: Collisions on the sky



S. M. Feeney *et al.*, Phys. Rev. D (2011)

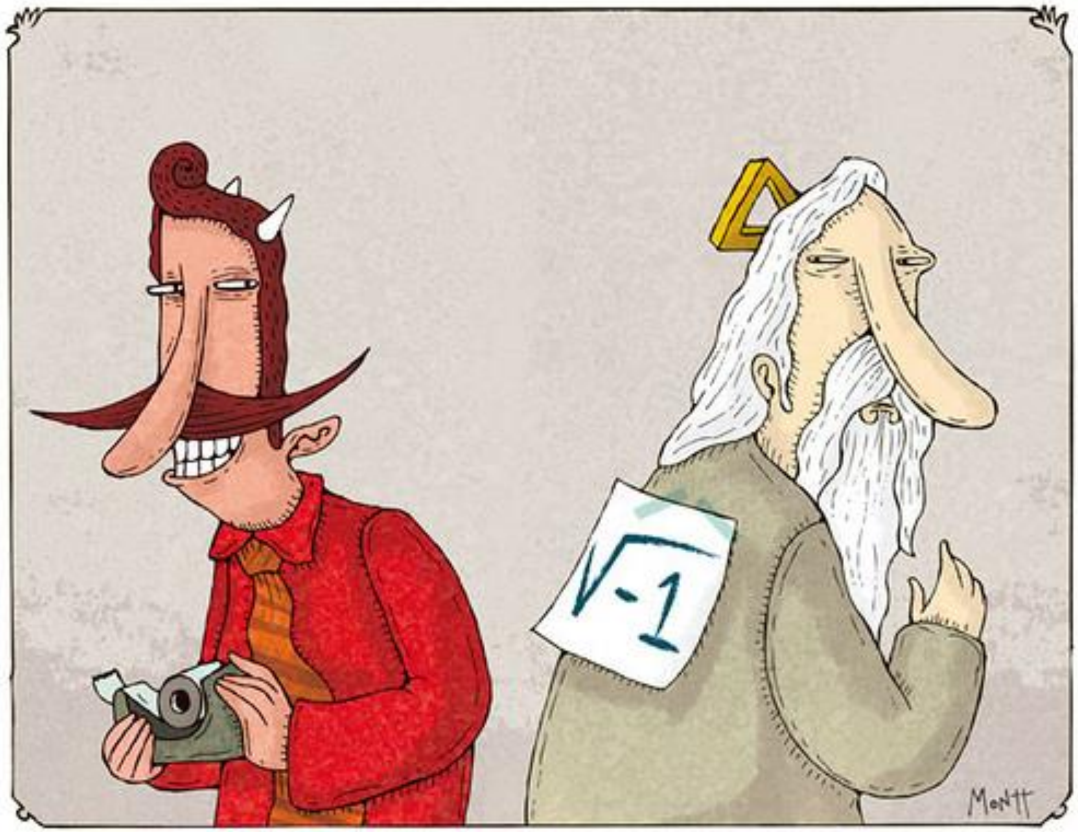
First observational tests of eternal inflation: Analysis methods and WMAP 7-year results
Stephen M. Feeney, Matthew C. Johnson, Daniel J. Mortlock, and Hiranya V. Peiris
Phys. Rev. D **84**, 043507 (2011)
Published August 8, 2011

First Observational Tests of Eternal Inflation
Stephen M. Feeney, Matthew C. Johnson, Daniel J. Mortlock, and Hiranya V. Peiris
Phys. Rev. Lett. **107**, 071301 (2011)
Published August 8, 2011

A rapid expansion of the early universe—cosmological inflation—offers the best explanation so far of what astronomers observe. One flavor of this concept, called eternal inflation, involves nucleation of bubble universes (one of which we are in) in a continually inflating background. The collection of bubbles is known as the multiverse. Many aspects of this model would be difficult, if not impossible, to test, but one approach is to look for imprints of bubble behavior in the cosmic microwave background radiation. In a paper in *Physical Review Letters*, and a longer technical exposition in *Physical Review D*, Stephen Feeney at University College London and his colleagues analyze seven years of cosmic microwave background data from the Wilkinson Microwave Anisotropy Probe (WMAP) to hunt for signatures of eternal inflation.

The authors zeroed in on what might be the best target of opportunity, namely the effects of bubble collisions. Although direct observation of other bubble universes is not possible, the bubbles might have collided with one another and this bashing together might have left imprints on the cosmic microwave background, essentially itself a palimpsest of cosmic history. Feeney *et al.* carry out a statistical analysis of the full sky WMAP data, searching for specific distortions that may have been the wreckage of bubble crashes. They find no signatures of collisions, but are able to use this null result to put an upper limit on the number of bubble collisions the theory could predict and still be consistent with the data. The hope now is to continue the search for eternal inflation by applying the same tests to better data expected from the Planck satellite, which was launched in 2009. – *David Voss*

Previous synopsis | Next synopsis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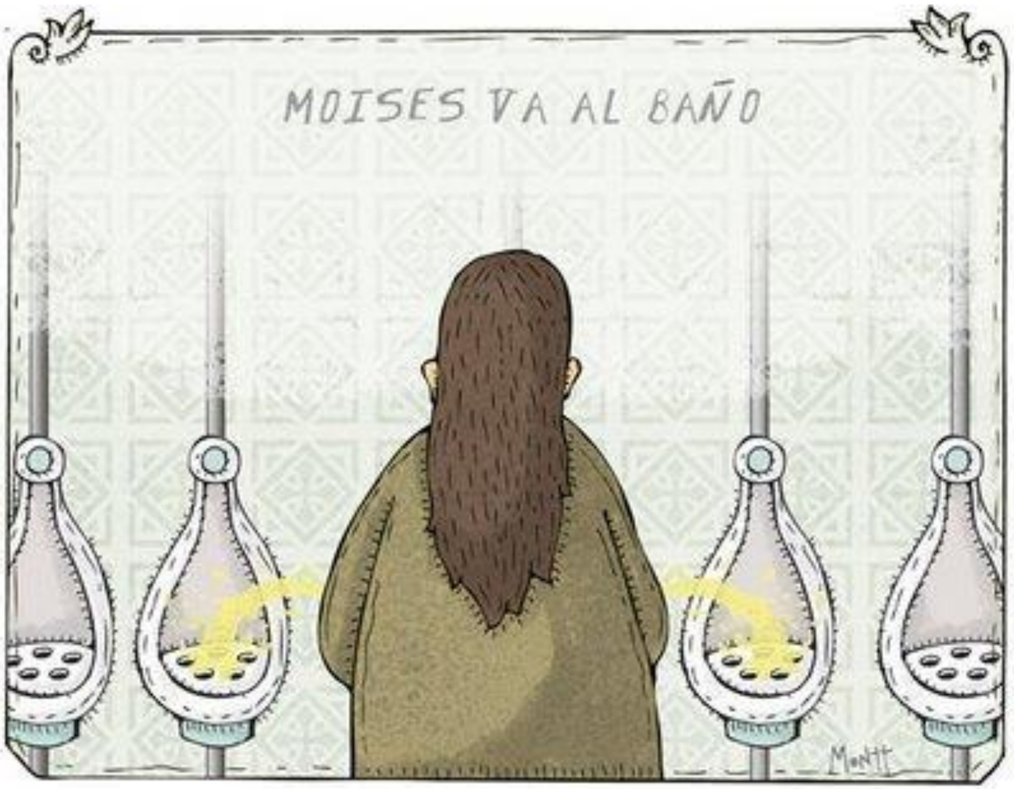
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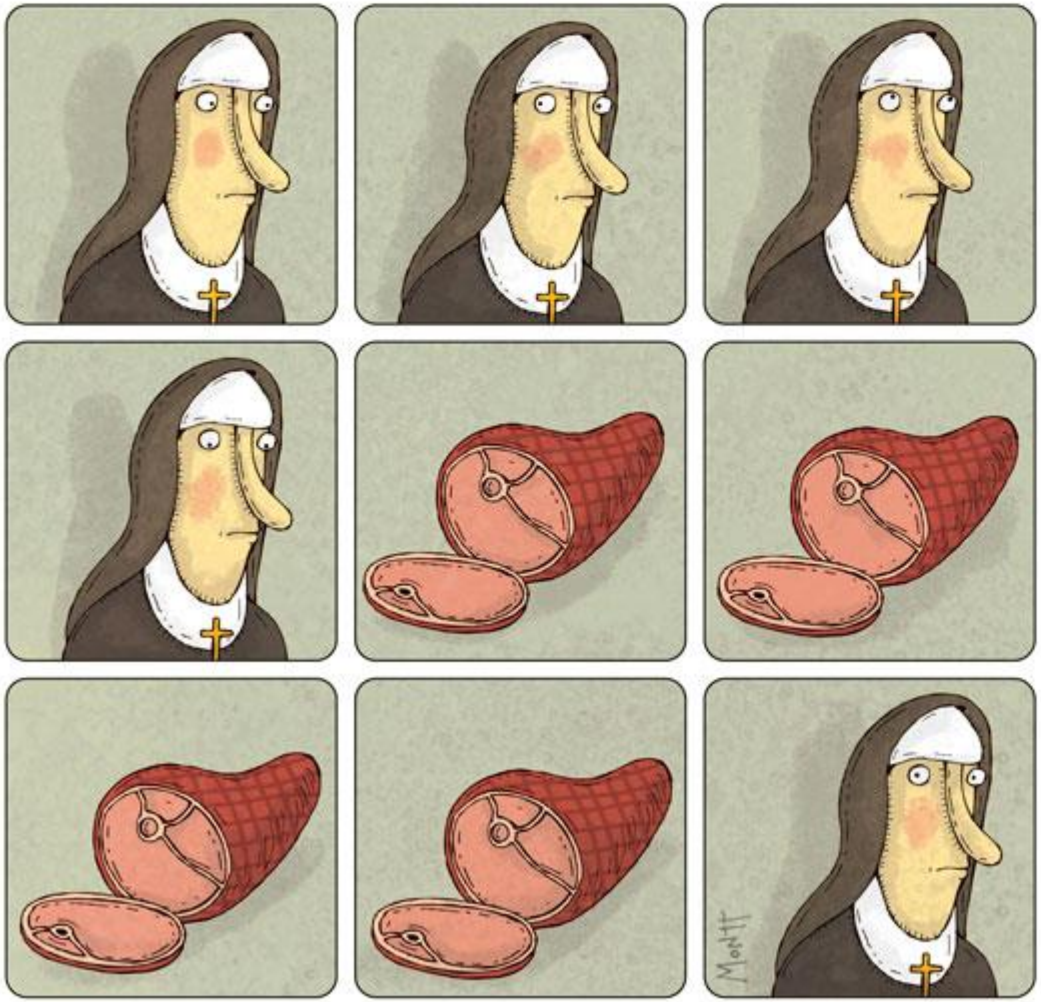
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