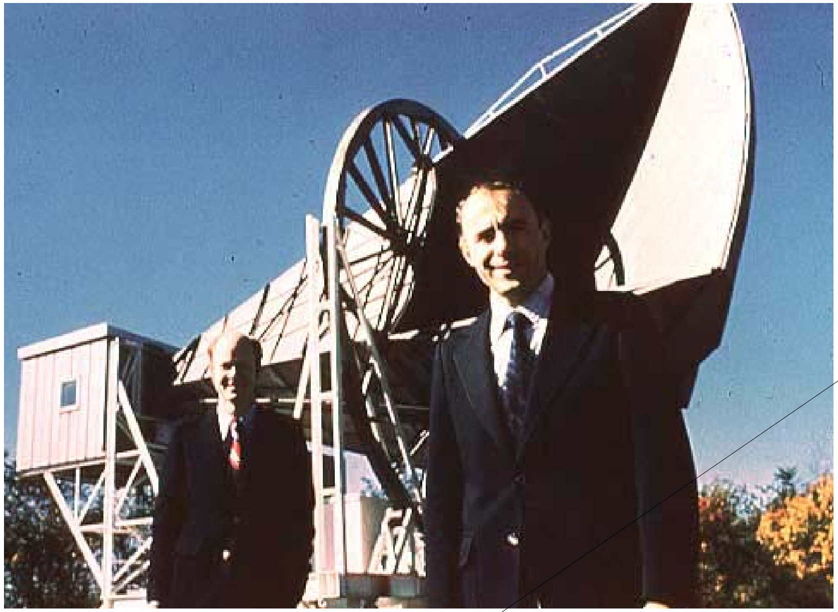
<u>Η μικροκυματική ακτινοβολία υποβάθρου</u>

Panzias A.A. & Wilson R.W., 1965, ApJ, 142, 419



<u>Abstract:</u> 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 of about 3.5 K higher than expected. This excess temperature is, within the limits of our observations, <u>isotropic, unpolarized, and free from seasonal variations (July, 1964 - April, 1965)</u>. A possible explanation for the observed excess noise temperature is the one given by Dicke, Peebles, Roll, and Wilkinson (1965) in a companion letter in this issue.

Μετρήσεις σε μία μόνο συχνότητα (~7.35 cm).
ΑΝ η εκπομπή μέλανος σώματος, τότε Τ~3.5 Κ.

high pressure, such as the zero-mass scalar, capable of speeding the universe through the period of helium formation. To have a closed space, an energy density of 2×10^{-29} gm/cm^3 is needed. Without a zero-mass scalar, or some other "hard" interaction, the energy could not be in the form of ordinary matter and may be presumed to be gravitational radiation (Wheeler 1958).

One other possibility for closing the universe, with matter providing the energy content of the universe, is the assumption that the universe contains a net electron-type neutrino abundance (in excess of antineutrinos) greatly larger than the nucleon abundance. In this case, if the neutrino abundance were so great that these neutrinos are degenerate, the degeneracy would have forced a negligible equilibrium neutron abundance in the early, highly contracted universe, thus removing the possibility of nuclear reactions leading to helium formation. However, the required ratio of lepton to baryon number must be $> 10^9$.

We deeply appreciate the helpfulness of Drs. Penzias and Wilson of the Bell Telephone Laboratories, Crawford Hill, Holmdel, New Jersey, in discussing with us the result of their measurements and in showing us their receiving system. We are also grateful for several helpful suggestions of Professor J. A. Wheeler.

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May 7, 1965
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REFERENCES

Alpher, R. A , Bethe, H. A , and Gamow, G 1948, *Phys. Rev.*, **73**, 803
Alpher, R A., Follin, J W., and Herman, R. C. 1953, *Phys. Rev* , **92**, 1347.
Bondi, H , and Gold, T. 1948, *M N.*, **108**, 252.
Brans, C , and Dicke, R. H 1961, *Phys. Rev.*, **124**, 925.
Dicke, R. H. 1962, *Phys. Rev.*, **125**, 2163.
Dicke, R. H , Beringer, R., Kyhl, R L , and Vane, A B. 1946, *Phys. Rev.*, **70**, 340
Einstein, A , 1950, *The Meaning of Relativity* (3d ed.; Princeton, N.J.: Princeton University Press), p. 107.
Hoyle, F. 1948, *M N* , **108**, 372.
Hoyle, F , and Tayler, R J 1964, *Nature*, **203**, 1108
Liftshitz, E M., and Khalatnikov, I. M 1963, *Adv. in Phys* , **12**, 185.
Oort, J H 1958, *La Structure et l'évolution de l'universe* (11th Solvay Conf [Brussels: Éditions Stoops]), p. 163.
Peebles, P J. E. 1965, *Phys. Rev.* (in press).
Penzias, A. A., and Wilson, R. W. 1965, private communication.
Wheeler, J. A , 1958, *La Structure et l'évolution de l'universe* (11th Solvay Conf. [Brussels: Éditions Stoops]), p. 112.
——— 1964, in *Relativity, Groups and Topology*, ed C. DeWitt and B. DeWitt (New York: Gordon & Breach).
Zel'dovich, Ya. B. 1962, *Soviet Phys.—J.E.T.P.*, **14**, 1143.

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

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 (1965) in a companion letter in this issue.

The total antenna temperature measured at the zenith is 6.7° K of which 2.3° K is due to atmospheric absorption. The calculated contribution due to ohmic losses in the antenna and back-lobe response is 0.9° K.

The radiometer used in this investigation has been described elsewhere (Penzias and Wilson 1965). It employs a traveling-wave maser, a low-loss (0.027-db) comparison switch, and a liquid helium–cooled reference termination (Penzias 1965). Measurements were made by switching manually between the antenna input and the reference termination. The antenna, reference termination, and radiometer were well matched so that a round-trip return loss of more than 55 db existed throughout the measurement; thus errors in the measurement of the effective temperature due to impedance mismatch can be neglected. The estimated error in the measured value of the total antenna temperature is 0.3° K and comes largely from uncertainty in the absolute calibration of the reference termination.

The contribution to the antenna temperature due to atmospheric absorption was obtained by recording the variation in antenna temperature with elevation angle and employing the secant law. The result, $2.3° \pm 0.3°$ K, is in good agreement with published values (Hogg 1959; DeGrasse, Hogg, Ohm, and Scovil 1959; Ohm 1961).

The contribution to the antenna temperature from ohmic losses is computed to be $0.8° \pm 0.4°$ K. In this calculation we have divided the antenna into three parts: (1) two non-uniform tapers approximately 1 m in total length which transform between the $2\frac{1}{8}$-inch round output waveguide and the 6-inch-square antenna throat opening; (2) a double-choke rotary joint located between these two tapers; (3) the antenna itself. Care was taken to clean and align joints between these parts so that they would not significantly increase the loss in the structure. Appropriate tests were made for leakage and loss in the rotary joint with negative results.

The possibility of losses in the antenna horn due to imperfections in its seams was eliminated by means of a taping test. Taping all the seams in the section near the throat and most of the others with aluminum tape caused no observable change in antenna temperature.

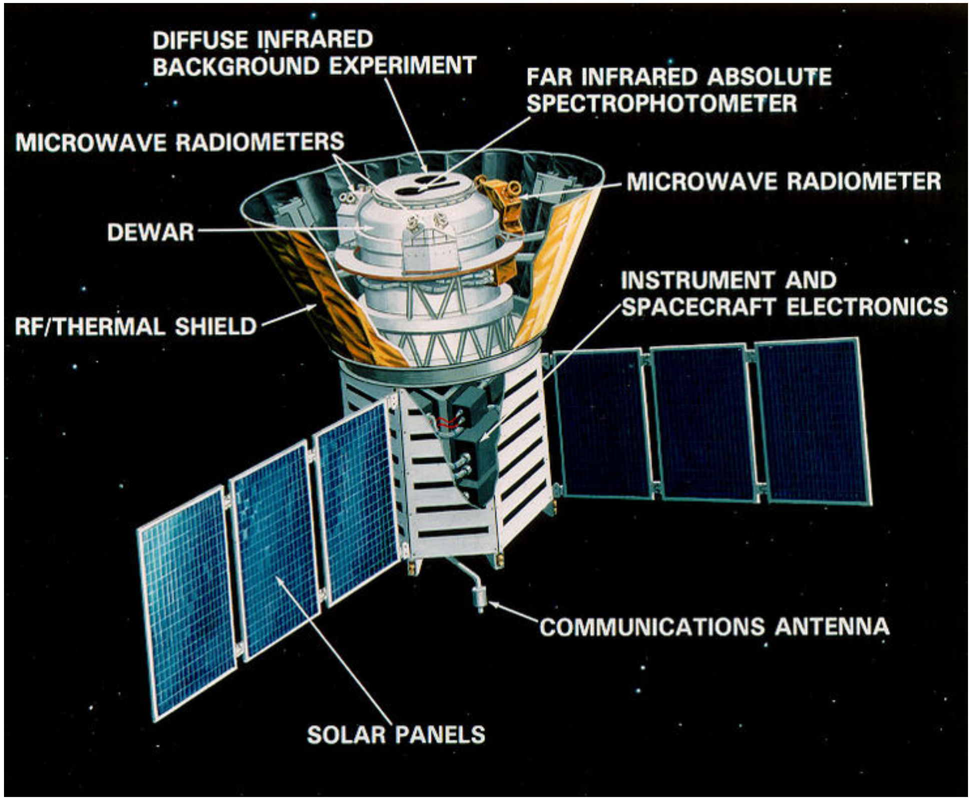
The backlobe response to ground radiation is taken to be less than 0.1° K for two reasons: (1) Measurements of the response of the antenna to a small transmitter located on the ground in its vicinity indicate that the average back-lobe level is more than 30 db below isotropic response. The horn-reflector antenna was pointed to the zenith for these measurements, and complete rotations in azimuth were made with the transmitter in each of ten locations using horizontal and vertical transmitted polarization from each position. (2) Measurements on smaller horn-reflector antennas at these laboratories, using pulsed measuring sets on flat antenna ranges, have consistently shown a back-lobe level of 30 db below isotropic response. Our larger antenna would be expected to have an even lower back-lobe level.

From a combination of the above, we compute the remaining unaccounted-for antenna temperature to be $3.5° \pm 1.0°$ K at 4080 Mc/s. In connection with this result it should be noted that DeGrasse *et al.* (1959) and Ohm (1961) give total system temperatures at 5650 Mc/s and 2390 Mc/s, respectively. From these it is possible to infer upper limits to the background temperatures at these frequencies. These limits are, in both cases, of the same general magnitude as our value.

We are grateful to R. H. Dicke and his associates for fruitful discussions of their results prior to publication. We also wish to acknowledge with thanks the useful comments and advice of A. B. Crawford, D. C. Hogg, and E. A. Ohm in connection with the problems associated with this measurement.

Nobel Prize, 1978

COsmic Background Explorer (COBE): Δορυφόρος της ΝΑΣΑ (1989-1993).



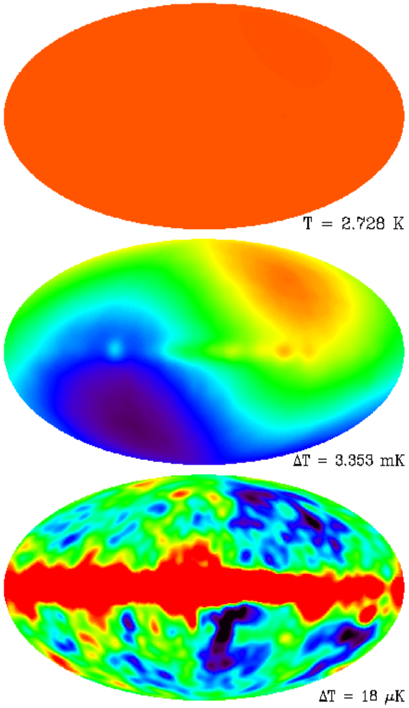
Instruments

Instrument	Acronym	Description	Principal Investigator
Differential Microwave Radiometer	DMR	a microwave instrument that would map variations (or anisotropies) in the CMB	George Smoot
Far-InfraRed Absolute Spectrophotometer	FIRAS	a spectrophotometer used to measure the spectrum of the CMB	John Mather
Diffuse InfraRed Background Experiment	DIRBE	a multiwavelength infrared detector used to map dust emission	Mike Hauser

} Βραβείο Nobel (2006)

Πληροφορίες από wikipedia.

Maps Based on Four Years of DMR ("Differential Microwave Radiometers") Observation

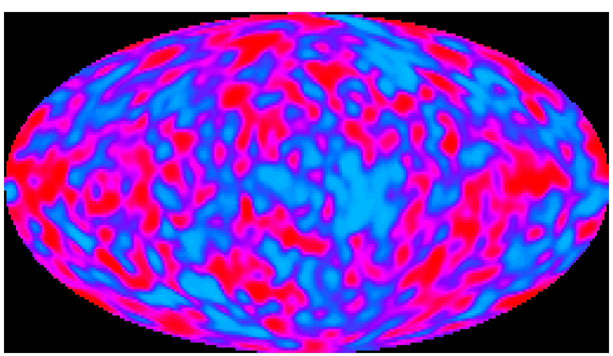


(Εικόνες αριστερά). Angular resolution of 10 degrees.

The images represent DMR data from the 53 GHz band – 5.7 mm (top) on a scale from 0 - 4 K, showing the near-uniformity of the CMB brightness.

The image in the middle is shown on a scale intended to enhance the contrast due to the "dipole emission": This is a smooth variation between relatively hot and relatively cold areas from the upper right to the lower left. It is due to the motion of the solar system relative to distant matter in the universe. The signals attributed to this variation are very small, only 1/100th the brightness of the sky.

In the bottom image the "dipole" component is subtracted. The plane of the Milky Way is horizontal across the middle of the picture. Sagittarius is in the center of the map, Orion is to the right and Cygnus is to the left.

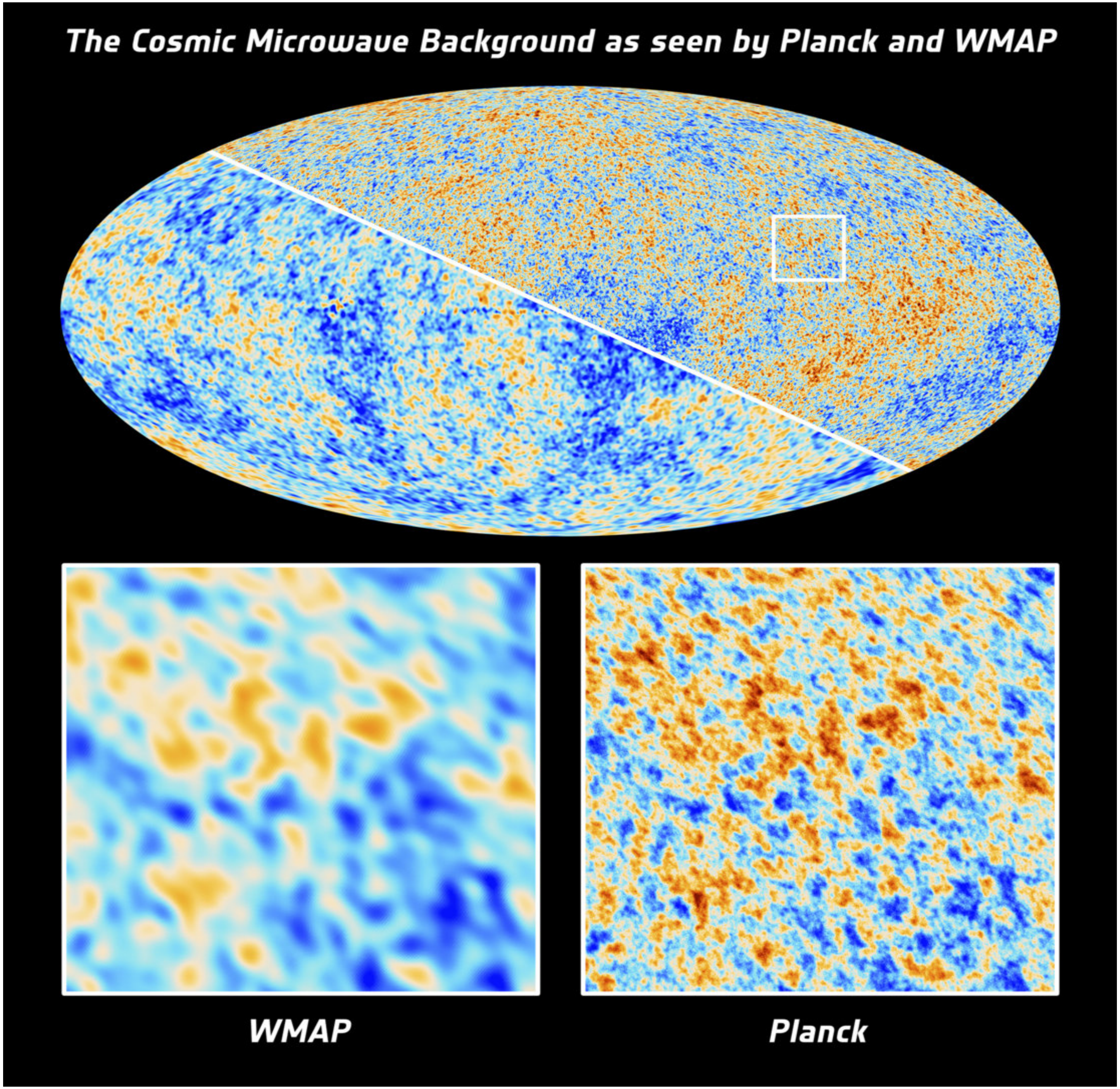


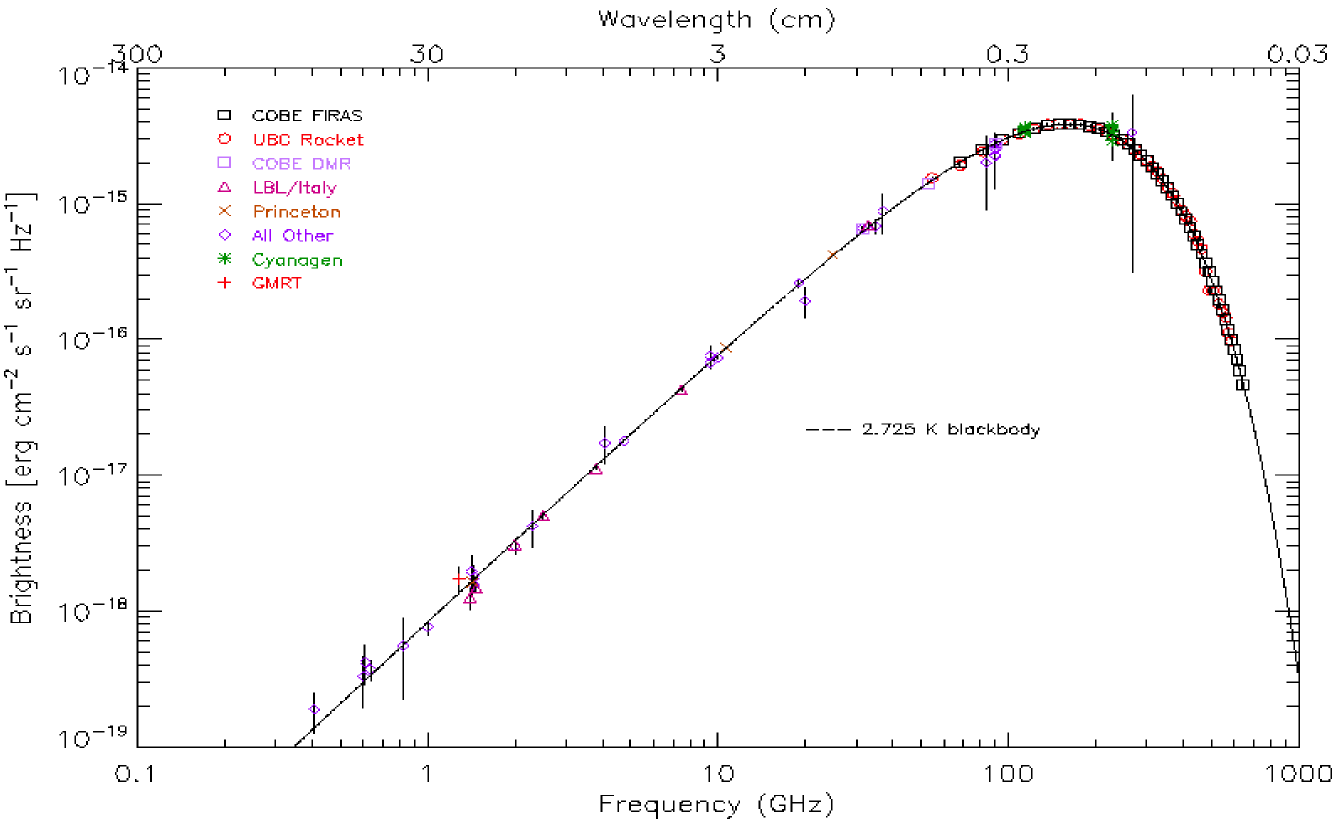
The image on the left shows the reduced map (i.e., both the dipole and Galactic emission subtracted). The cosmic microwave background fluctuations are extremely faint, only one part in 100,000 compared to the 2.73 degree Kelvin average temperature of the radiation field.

Πληροφορίες από: http://lambda.gsfc.nasa.gov/product/cobe/

WMAP (2001) produced the first fine-resolution (0.2 degree) full-sky microwave map of the CMB radiation.

PLANCK (2009) produced an even more detailed map of the CMB radiation.





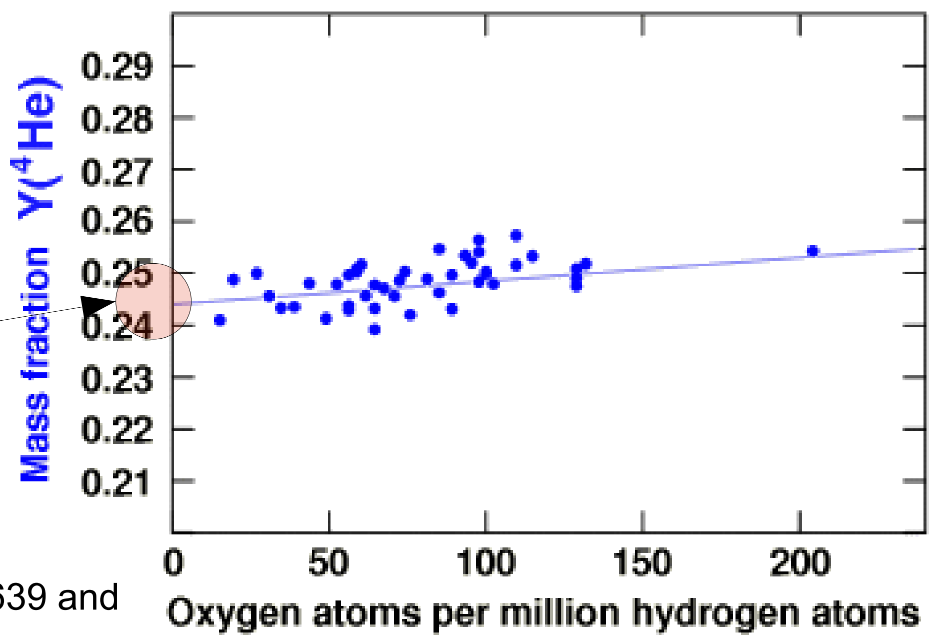
Φάσμα μικροκυματικής ακτινοβολίας υποβάθρου

Η "αφθονία" (abundance) των ελαφριών στοιχείων στο Σύμπαν (http://www.einstein-online.info/spotlights/BBN_obs)

1) Καθορισμός της "αρχέγονης/πρωτογενής" (primordial) αφθονίας του ^{4}He.

Μελέτη γραμμών εκπομπής ιονισμένου ηλίου από νέφη ιονισμένου υδρογόνου (HII regions) σε γαλαξίες νάνους (dwarf galaxies), "φτωχούς" σε οξυγόνο και άζωτο (άρα, γαλαξίες στους οποίους η σύσταση του μεσογαλαξιακού αερίου δεν έχει επηρεαστεί από τη σύνθεση στοιχείων στο εσωτερικό άστρων). Ο συσχετισμός μεταξύ της έντασης των γραμμών εκπομπής ιονισμένου ηλίου, με εκείνες από ιονισμένο υδρογόνου μας δίνει το λόγο:

$$Y = \frac{\text{Μάζα ηλίου (ή οποιαδήποτε στοιχείου)}}{\text{Συνολική μάζα βαρυονίων}}$$

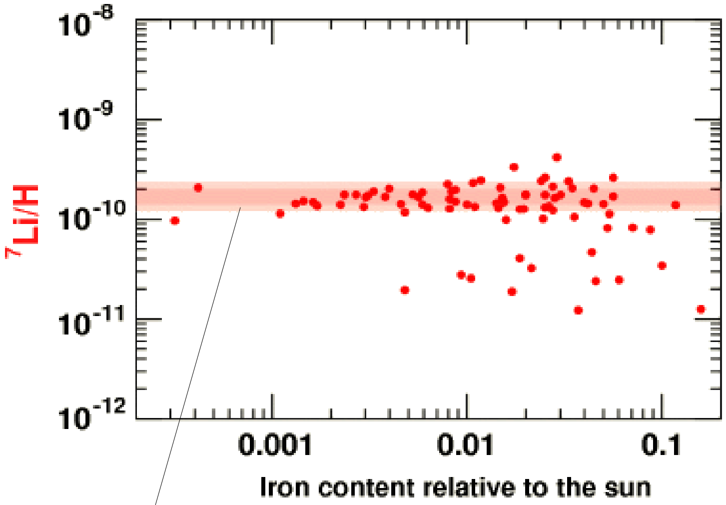


Y(^{4}He) ~ 23.2% – 25.8%

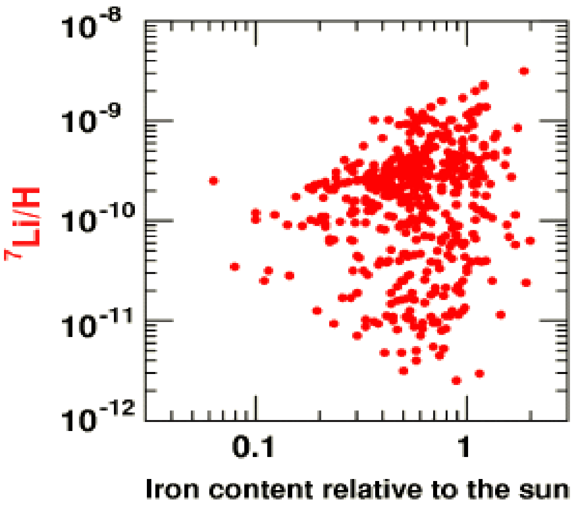
Image using data from Izotov & Thuan,1999, ApJ, 511, 639 and 1998, ApJ, 500 188

2) Καθορισμός της "αρχέγονης/πρωτογενής" (primordial) αφθονίας του ^{7}Li.

Λίθιο-7: παράγεται στο εσωτερικό των άστρων (αλλά και καταστρέφεται) κατά τη διάρκεια αντιδράσεων σύντηξης και από αντιδράσεις σωματιδίων "κοσμικών ακτίνων" με σωματίδια του μεσοαστρικού χώρου (στο Γαλαξία). Η "αφθονία" του στοιχείου μπορεί να καθορισθεί με μετρήσεις γραμμών απορρόφησης (και εκπομπής) του στοιχείου στις ατμόσφαιρες αστέρων.



Αστέρια μικρής μάζας, ψυχρά και μεγάλης ηλικίας

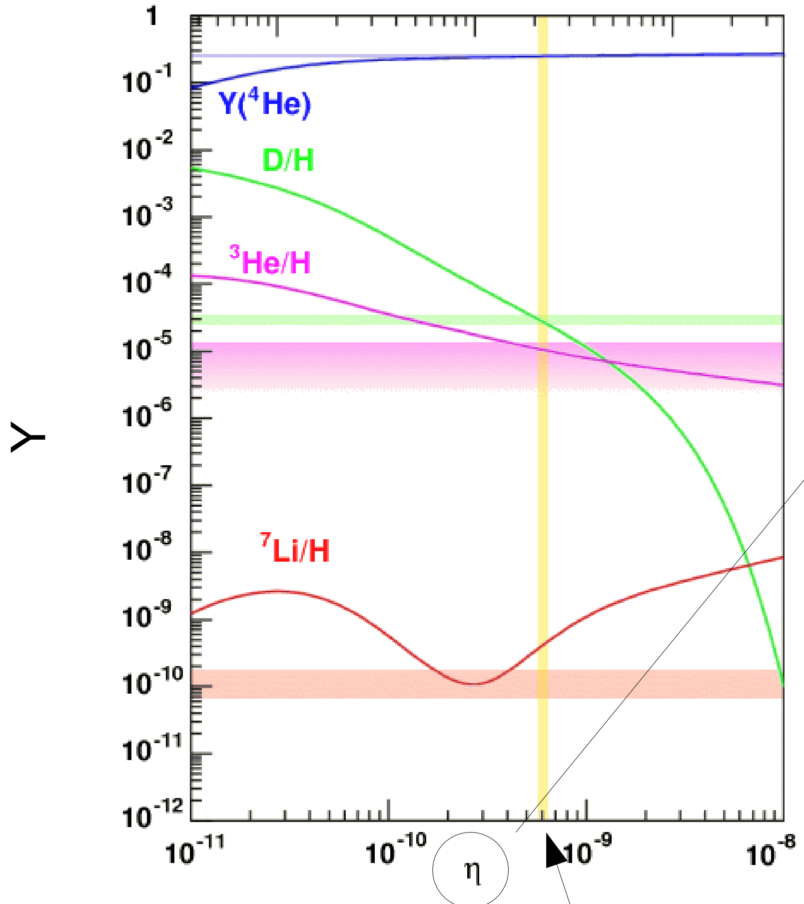


Αστέρια θερμά, μεγάλης μάζας και "μικρής" ηλικίας.

Ο λόγος πυρήνων λιθίου προς πυρήνες υδρογόνου είναι σταθερός και ίσος με ~ 1.3×10^{-10} – 2×10^{-10} για τα "μεγάλης ηλικίας" (10-12 Gyrs) αστέρια σε σφαιρωτά σμήνη αστέρων.

Image using data from Charbonnel & Primas, 2005, A&A, 442, 961

Σύγκριση θεωρίας και παρατηρήσεων:



η~6×10-6

$$\eta = \frac{\text{πυκνότητα βαρυονίων}}{\text{πυκνότητα φωτονίων}}$$

Η δημιουργία του He σύμφωνα με τη θεωρία της “Μεγάλης Έκρηξης”

Χρόνος	Θερμοκρασία	“Διεργασίες”	“Αποτέλεσμα”
10^{-4} s	$\sim 10^{12}$ K	$n + e^{+} \rightarrow p + \bar{\nu}_e$ $n + \nu_e \rightarrow p + e^{-}$ $n \rightarrow p + e^{-} + \bar{\nu}_e$	$(N_n/N_p) \sim 1$
~2 s	$\sim 10^{10}$ K	Σταματάνε οι αντιδράσεις: $\gamma \rightarrow e^{+} + e^{-}$, η ενέργεια νετρίνο ελαττώνεται, σταματάει η δημιουργία n	$(N_n/N_p) \sim 0.34$
~250 s	$\sim 10^{9}$ K	δημιουργία δευτερίου	$(N_n/N_p) \sim 0.19$
1000 s		Δημιουργία He	$Y_{He} \sim 0.3$