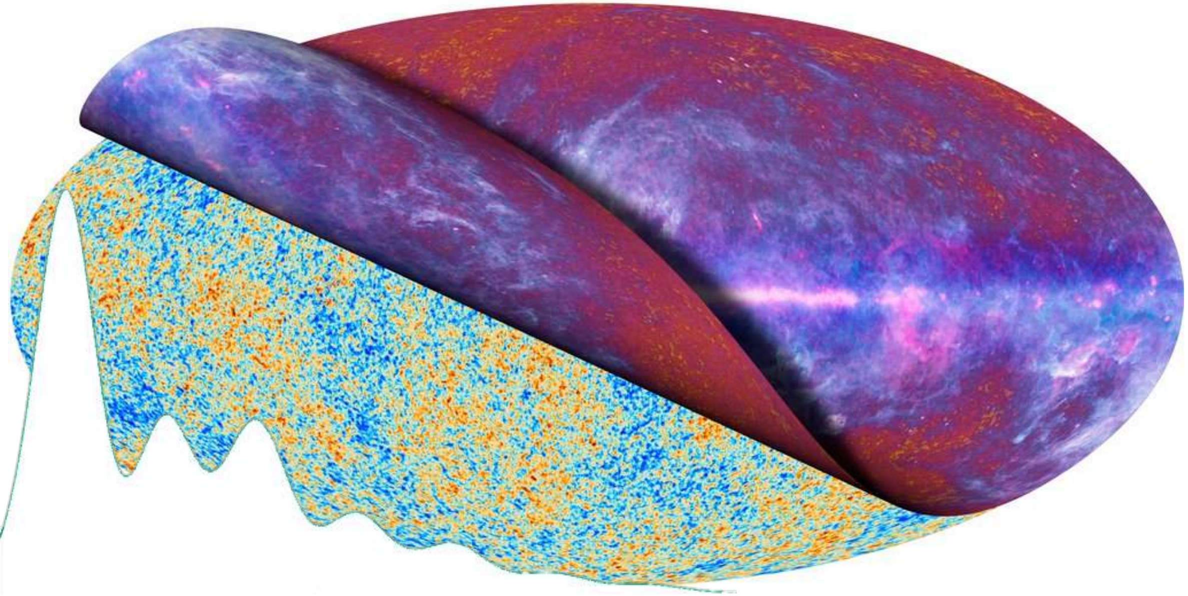


Le fond diffus cosmologique

Stéphane Ilić (stephane.ilic@gmail.com)

- CEICO, Prague
(• CPT, Marseillle)
(• IRAP, Toulouse)
(• IAS, Orsay)

I. Le quoi ?

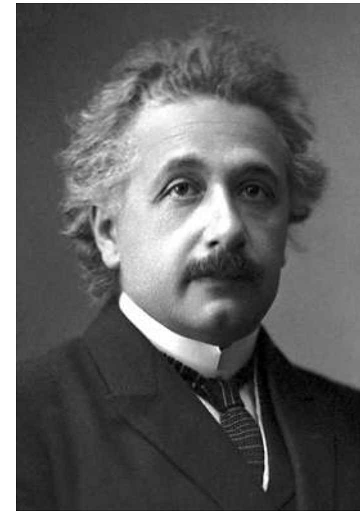
1915 : Relativité générale

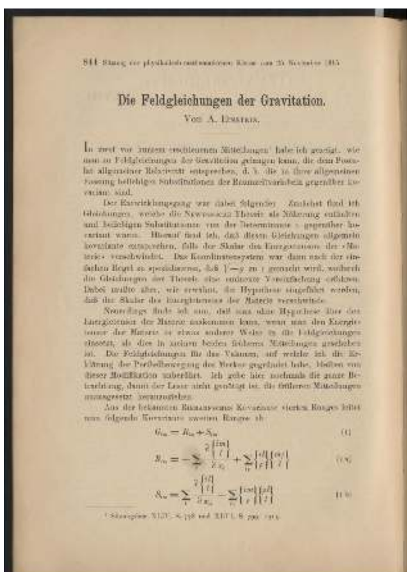

844 Sitzung der physikalisch-mathematischen Klasse vom 25. November 1915

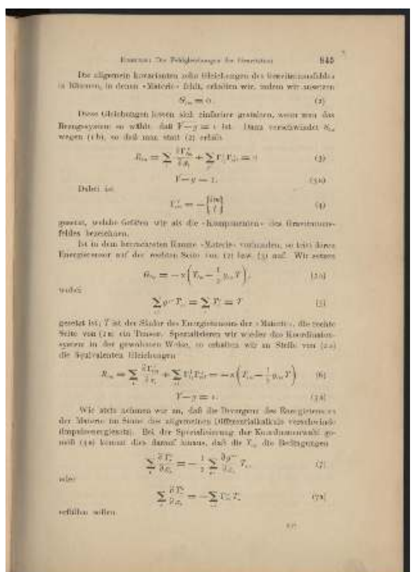
Die Feldgleichungen der Gravitation.

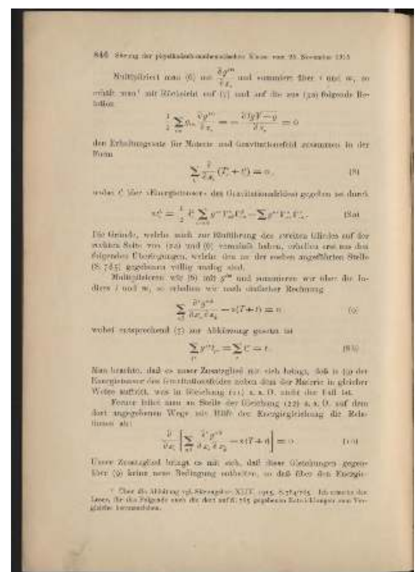
Von A. Einstein.

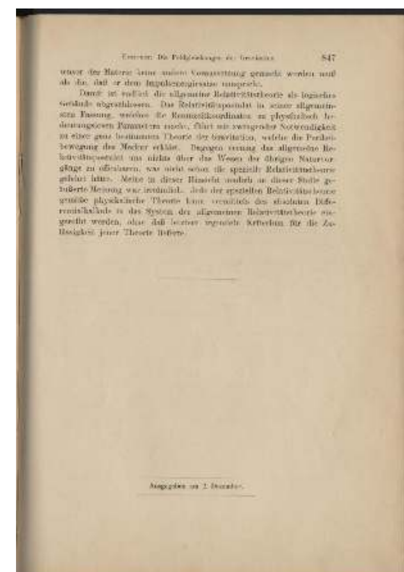
In zwei vor kurzem erschienenen Mitteilungen[1] habe ich gezeigt, wie man zu Feldgleichungen der Gravitation gelangen kann, die dem Postu-











1915 : Equations d'Einstein

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu}$$

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Géométrie de l'Univers

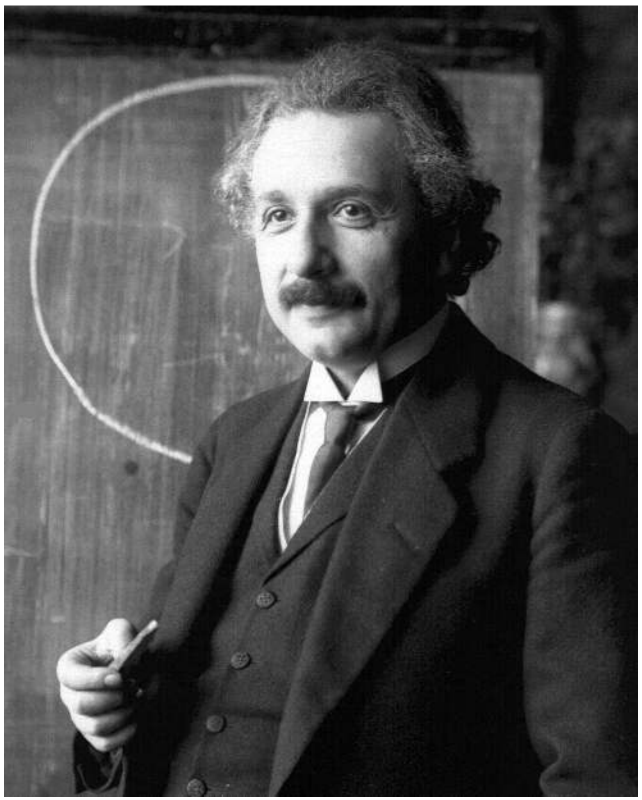
Contenu de l'Univers

Naissance de la Cosmologie moderne

1910s-20s :

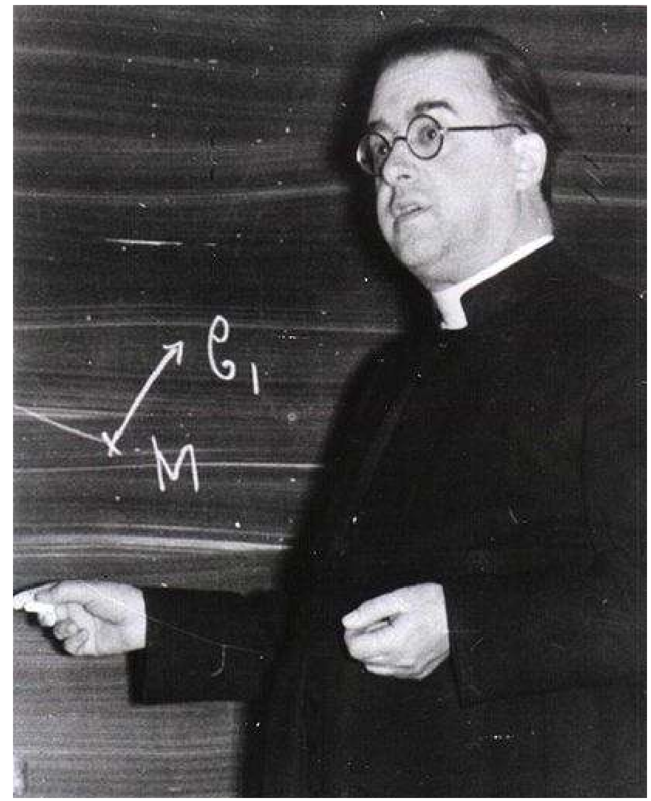
L'Univers est...

...Statique



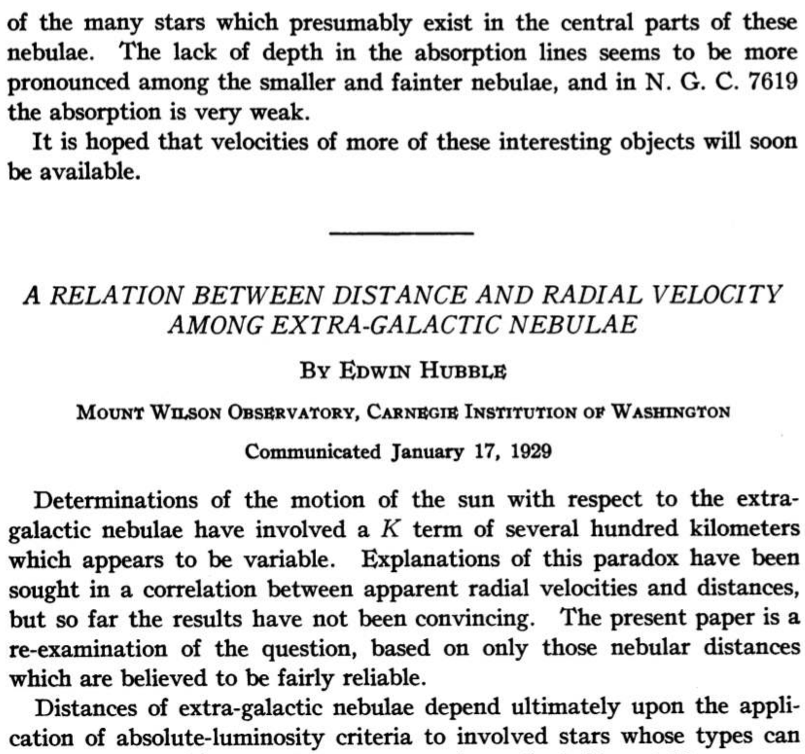
Einstein, Bondi, Gold, Hoyle...

...Dynamique



Lemaître, Gamov, ...

1929 : Fin du débat (?)



of the many stars which presumably exist in the central parts of these nebulae. The lack of depth in the absorption lines seems to be more pronounced among the smaller and fainter nebulae, and in N. G. C. 7619 the absorption is very weak.

It is hoped that velocities of more of these interesting objects will soon be available.

A RELATION BETWEEN DISTANCE AND RADIAL VELOCITY AMONG EXTRA-GALACTIC NEBULAE

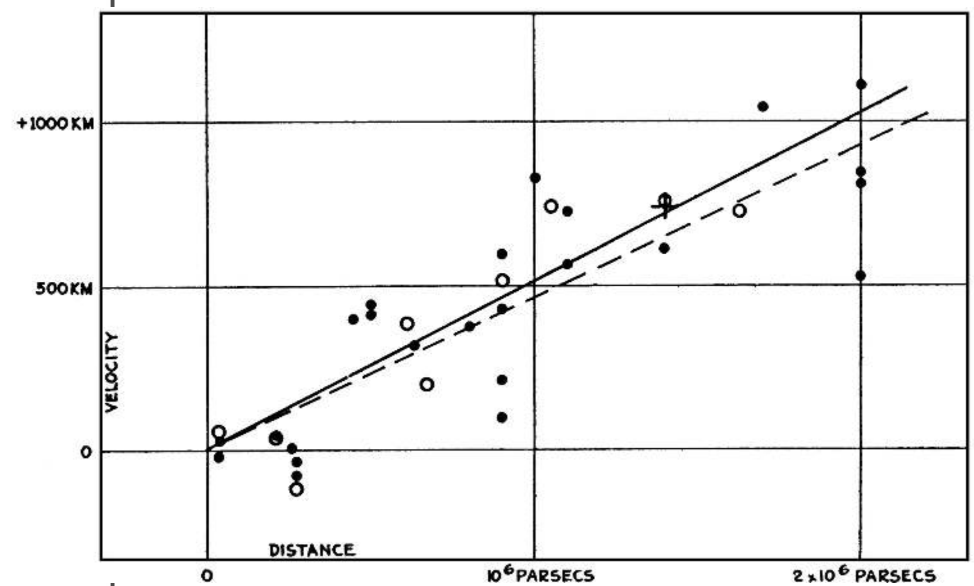
By Edwin Hubble

Mount Wilson Observatory, Carnegie Institution of Washington

Communicated January 17, 1929

Determinations of the motion of the sun with respect to the extra-galactic nebulae have involved a *K* term of several hundred kilometers which appears to be variable. Explanations of this paradox have been sought in a correlation between apparent radial velocities and distances, but so far the results have not been convincing. The present paper is a re-examination of the question, based on only those nebular distances which are believed to be fairly reliable.

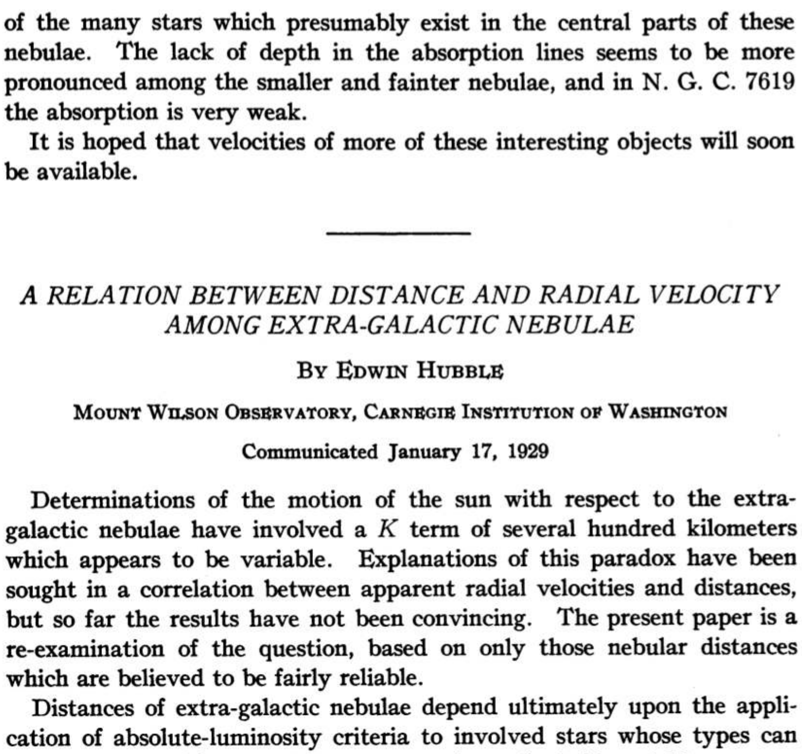
Distances of extra-galactic nebulae depend ultimately upon the application of absolute-luminosity criteria to involved stars whose types can



Vitesse = Distance x constante

=Univers en expansion

1929 : Fin du débat (?)



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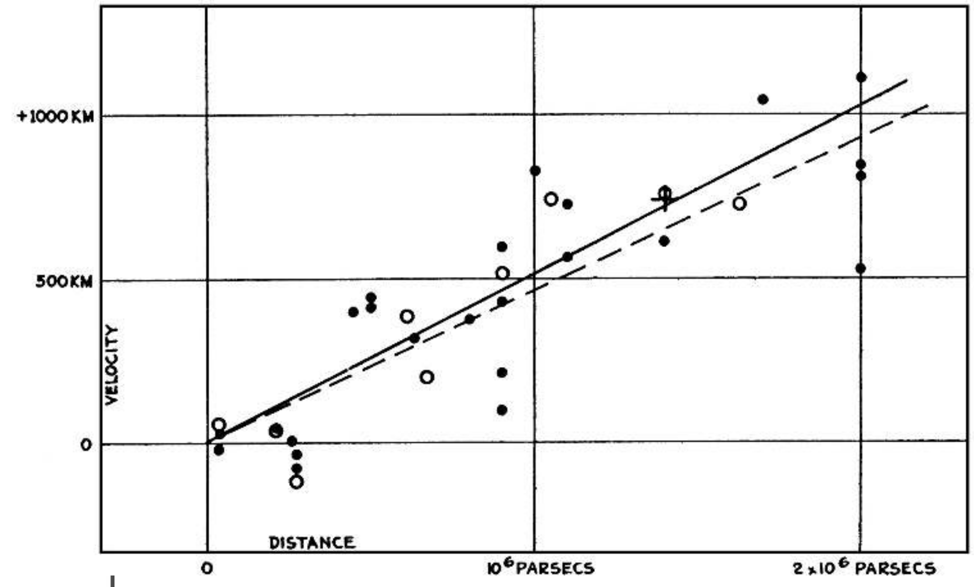
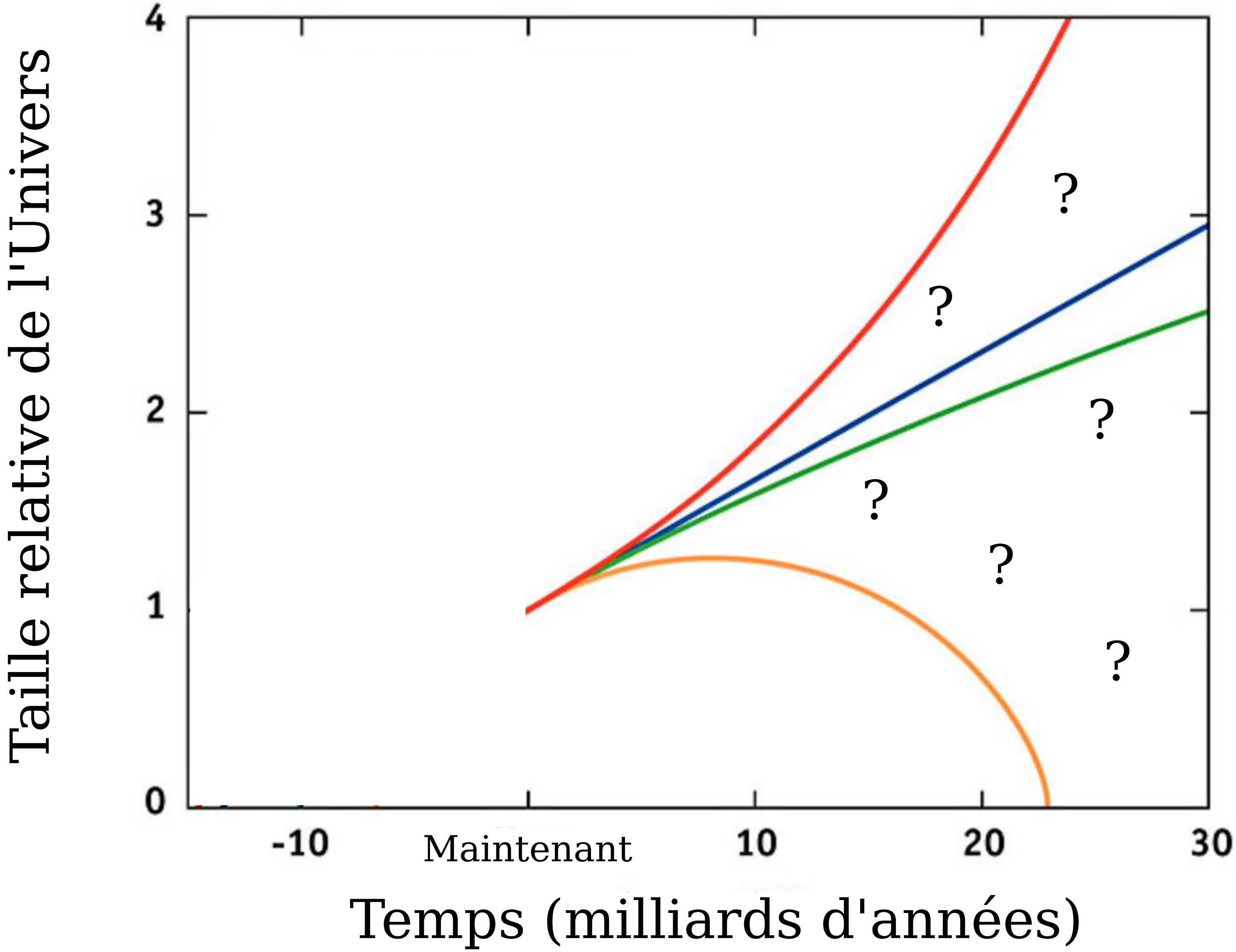


Vitesse = Distance x constante

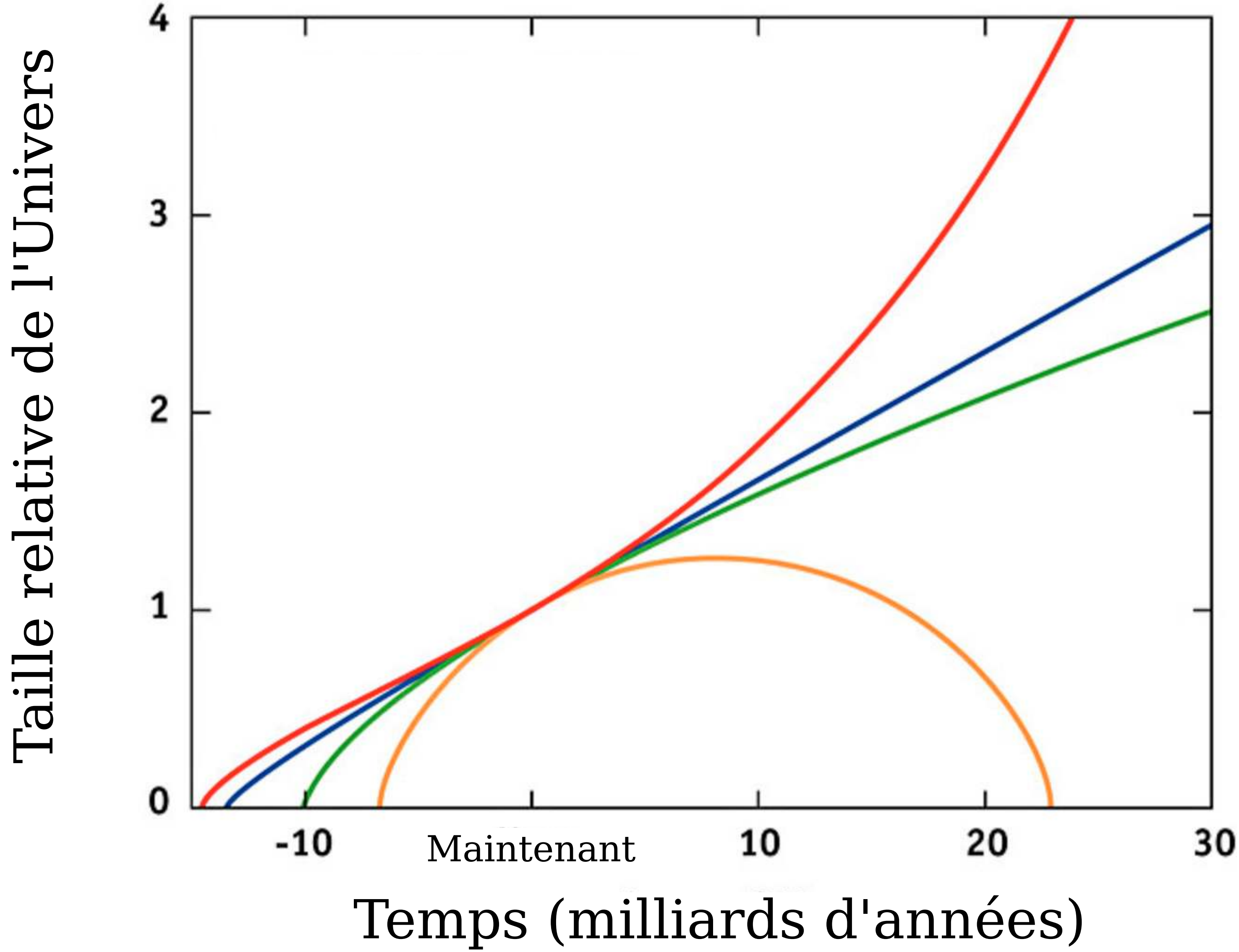
=Univers en expansion

1927...

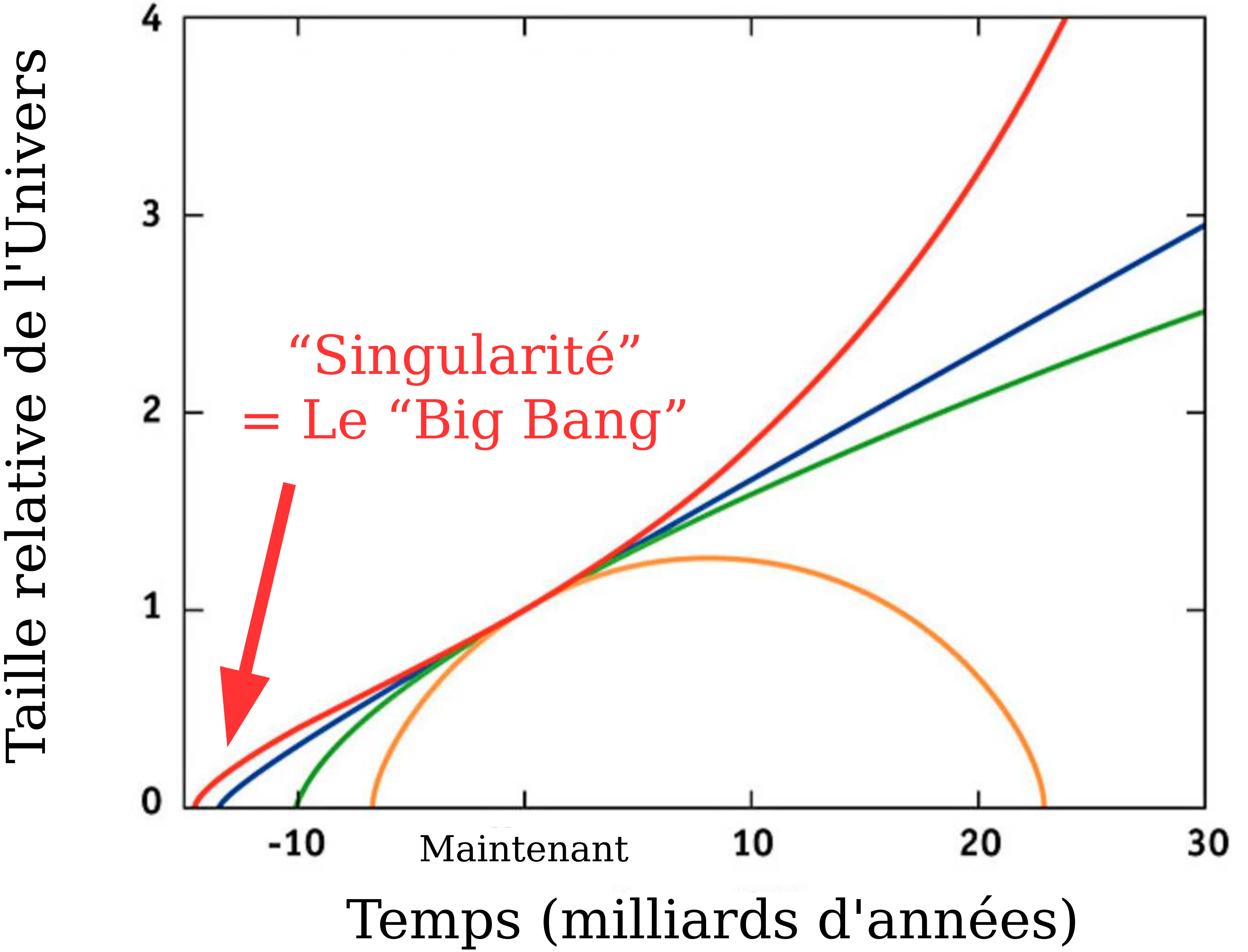
Expansion de l'Univers



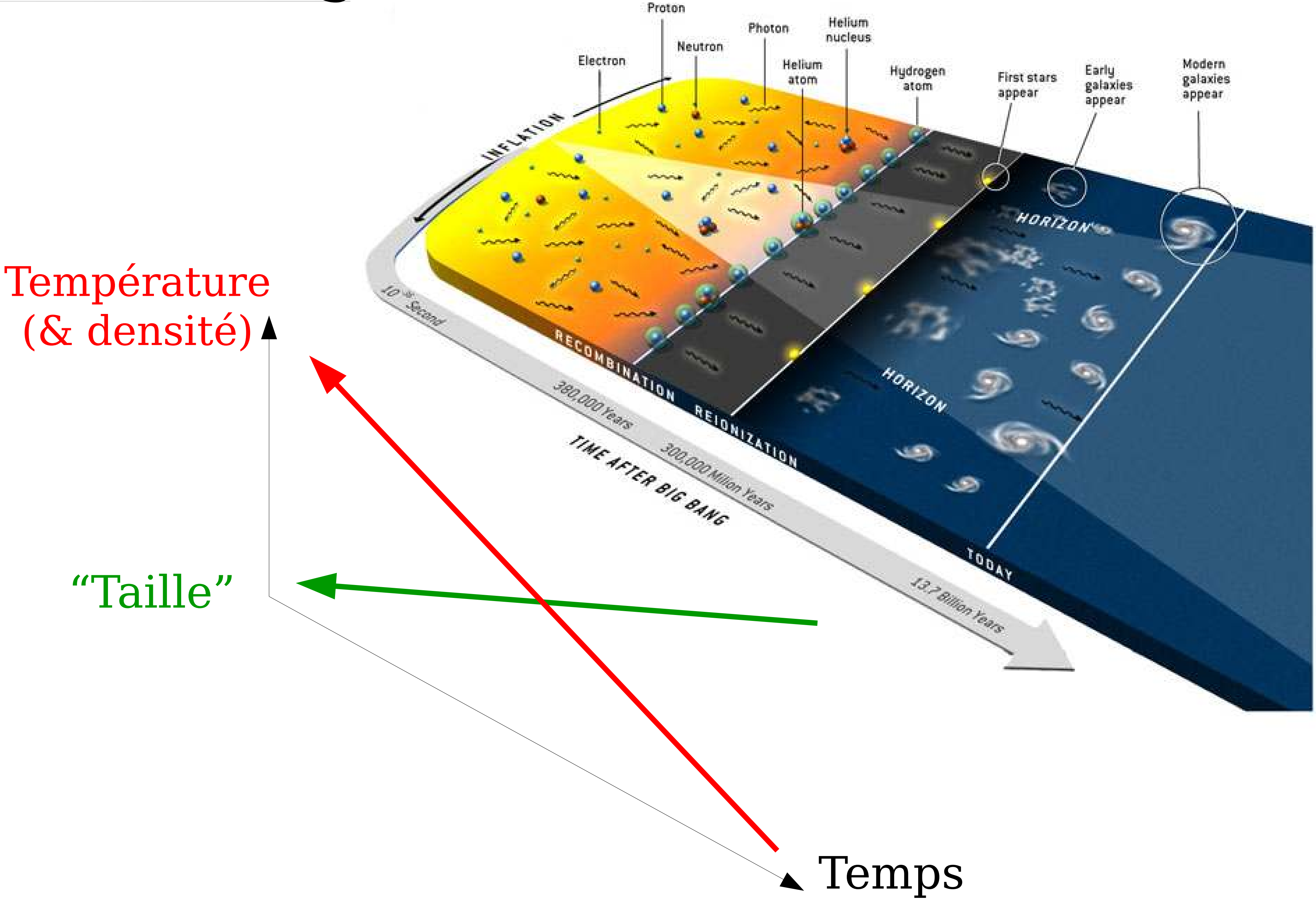
Expansion de l'Univers



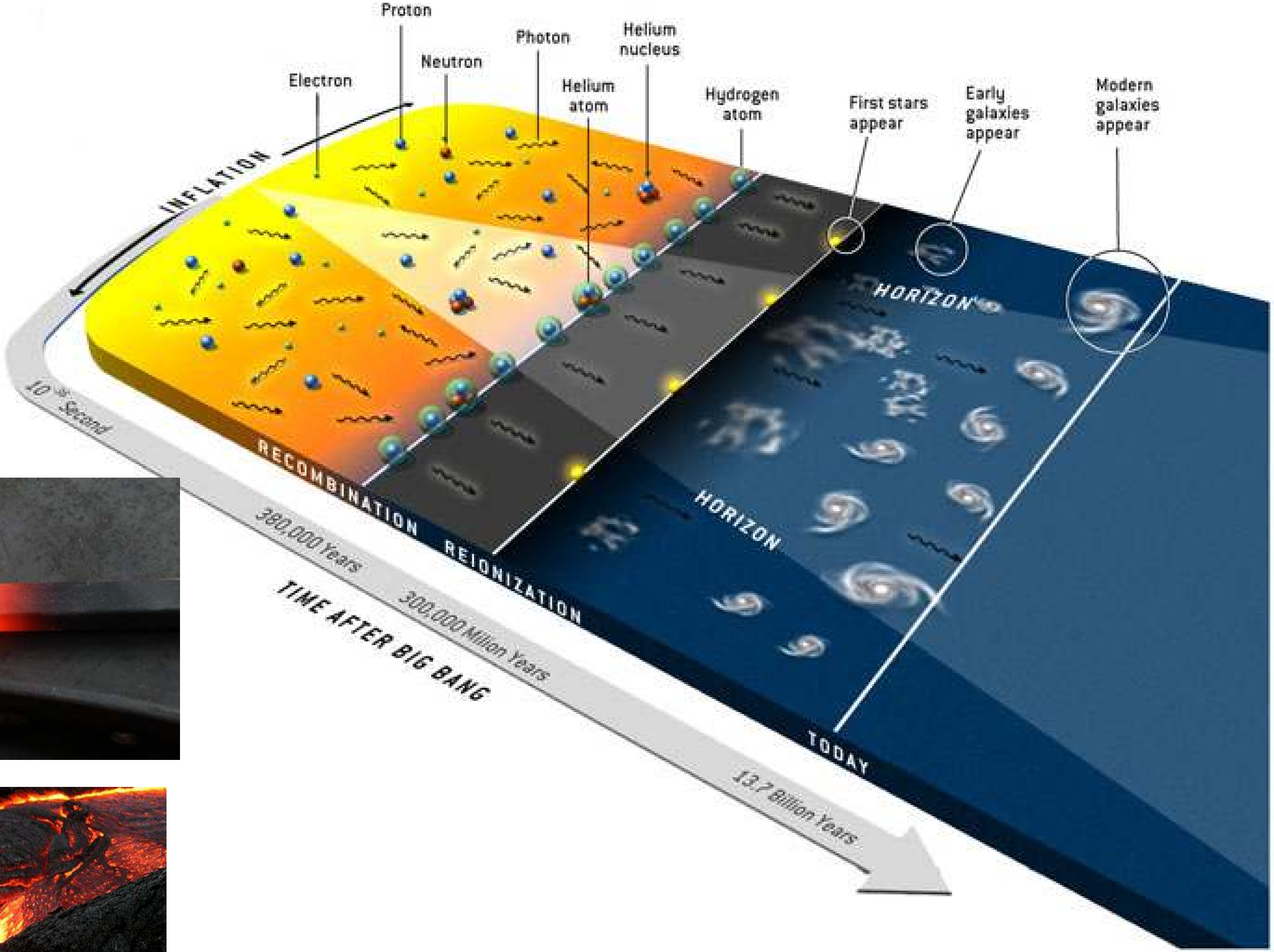
Expansion de l'Univers



Chronologie de l'Univers



Chronologie de l'Univers

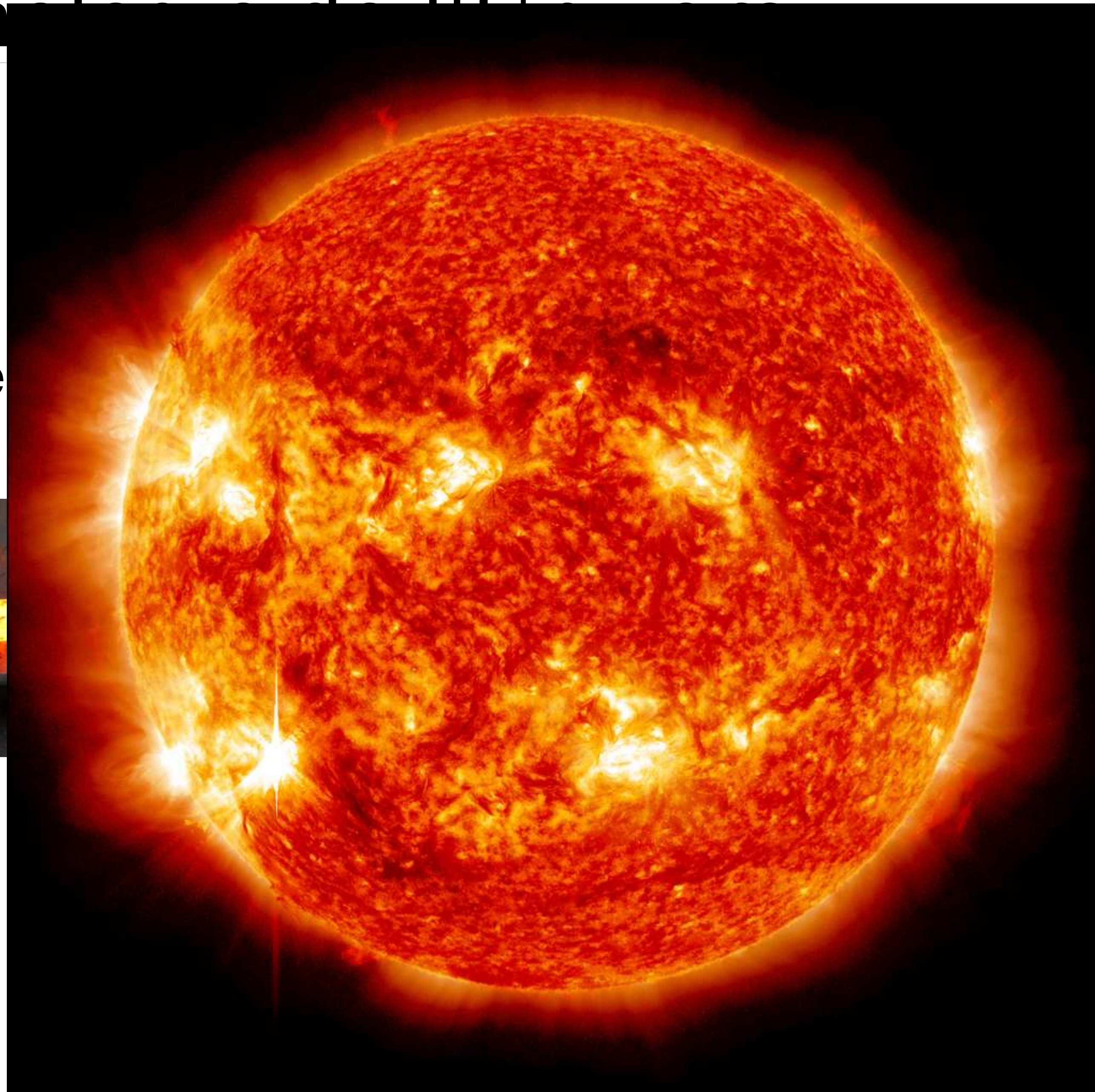


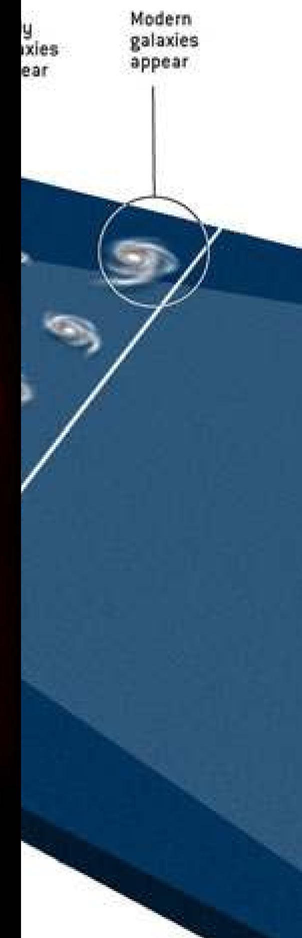
Rayonnement
de corps noir :

$$B_\nu(T) = \frac{2h\nu^3}{c^2}\frac{1}{e^{\frac{h\nu}{kT}}-1},$$ λ max prop. à 1/T

Chron

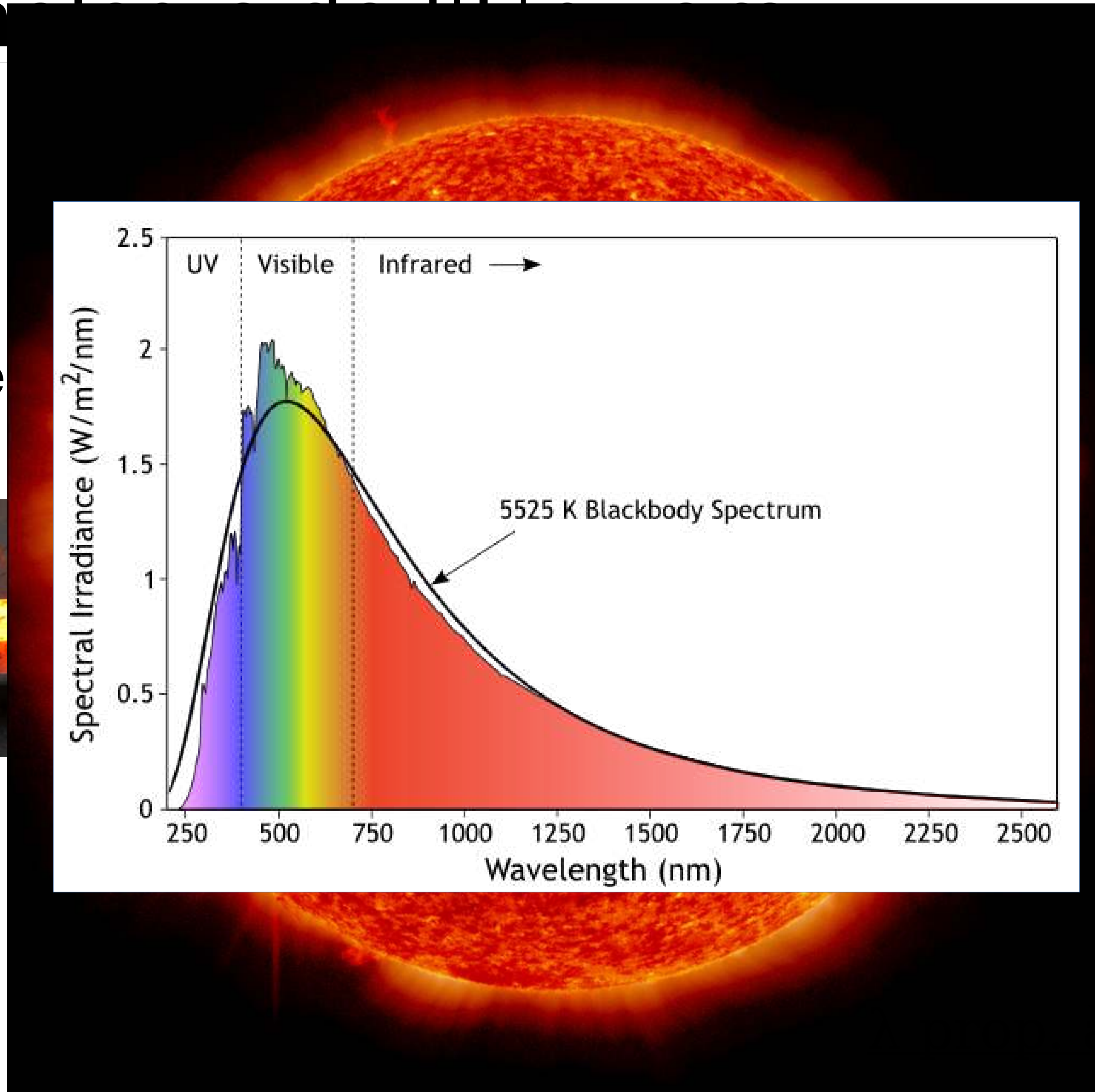
Rayonne
de corps





1/T

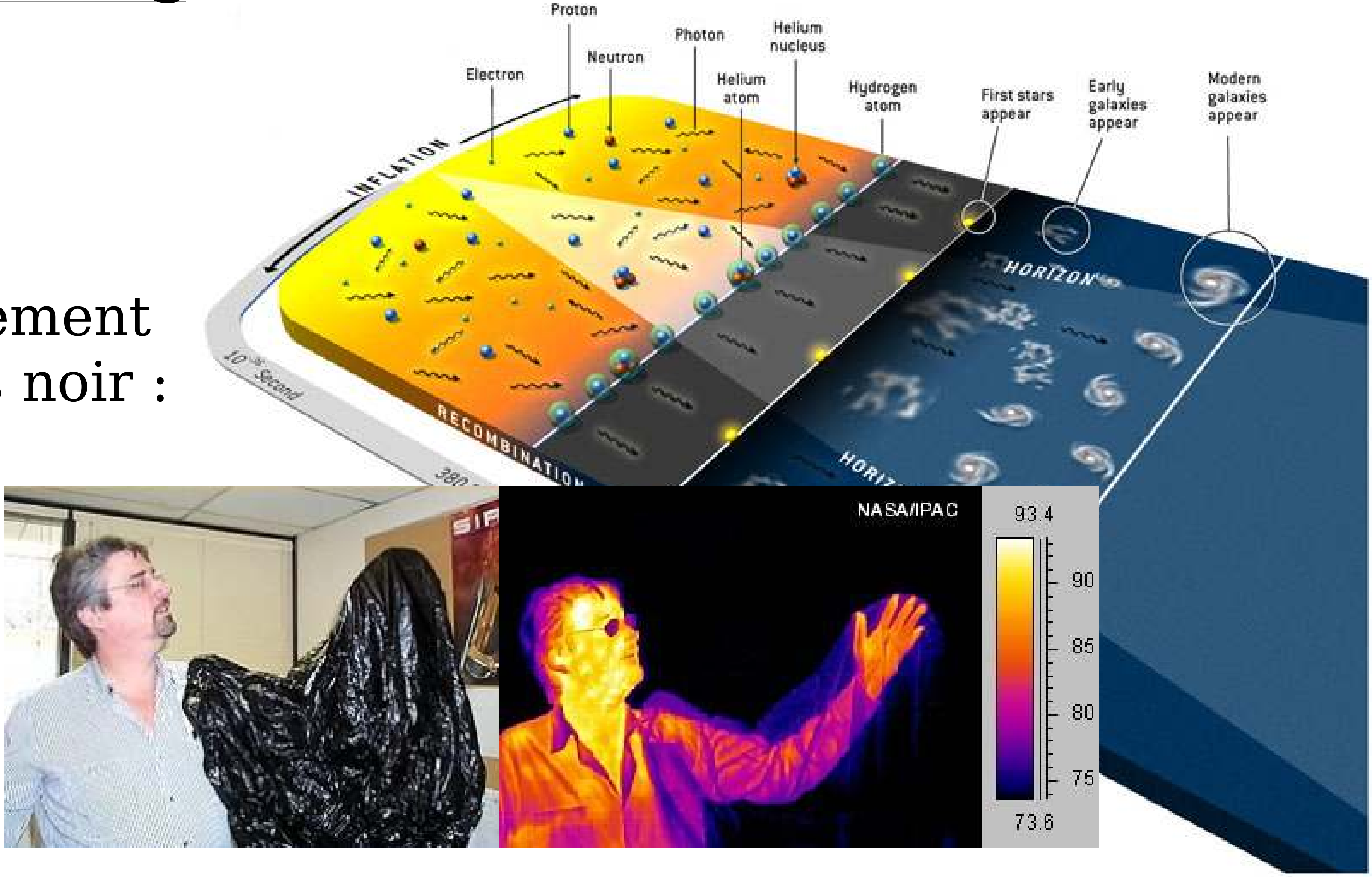
Chron



Rayonne
de corps

1/T

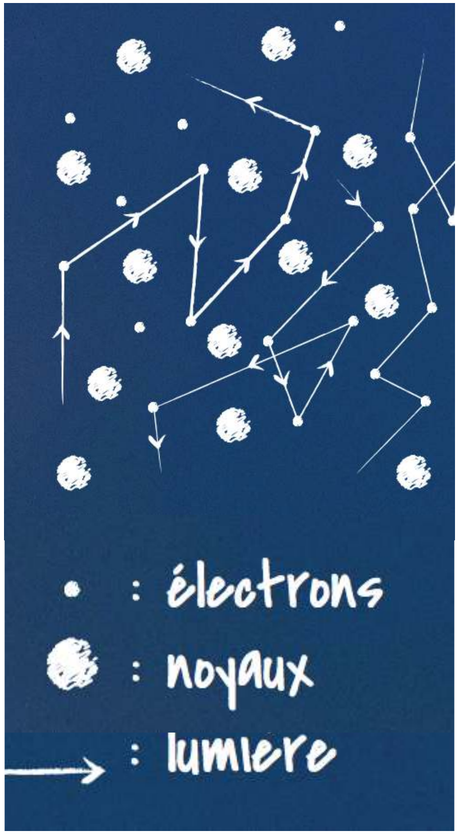
Chronologie de l'Univers

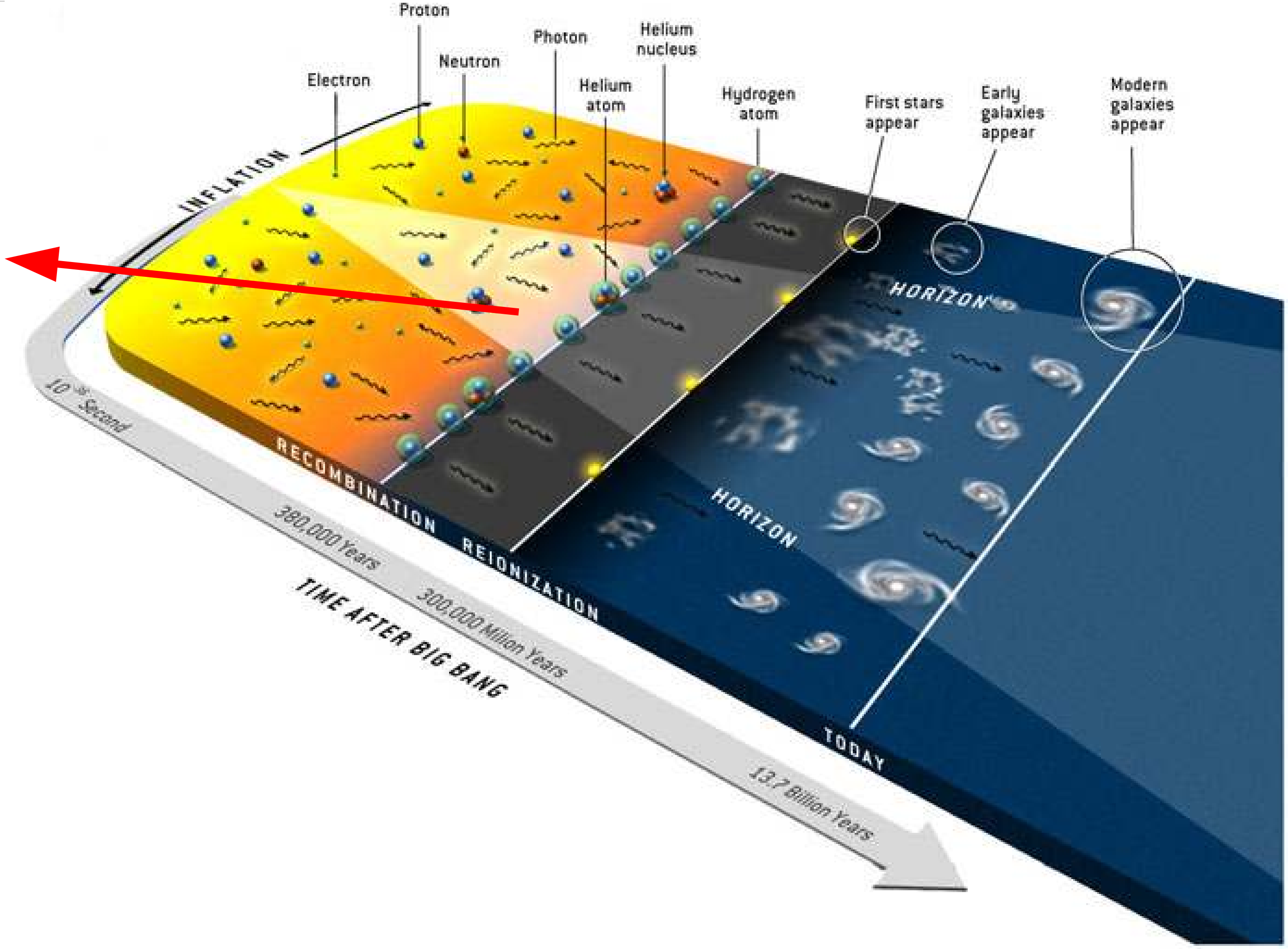


Rayonnement
de corps noir :

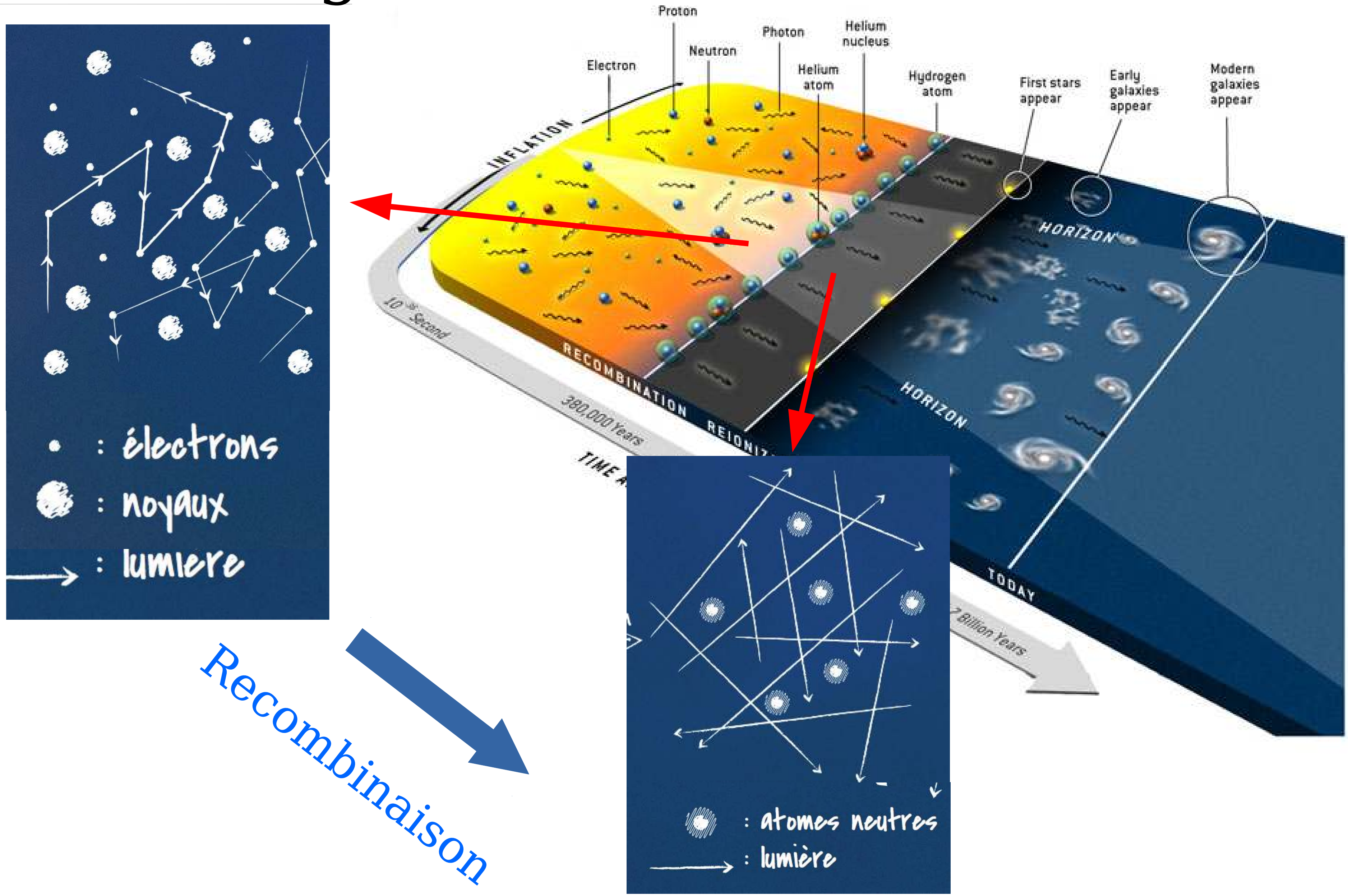
<u>λ prop. à 1/T</u>

Chronologie de l'Univers





Chronologie de l'Univers



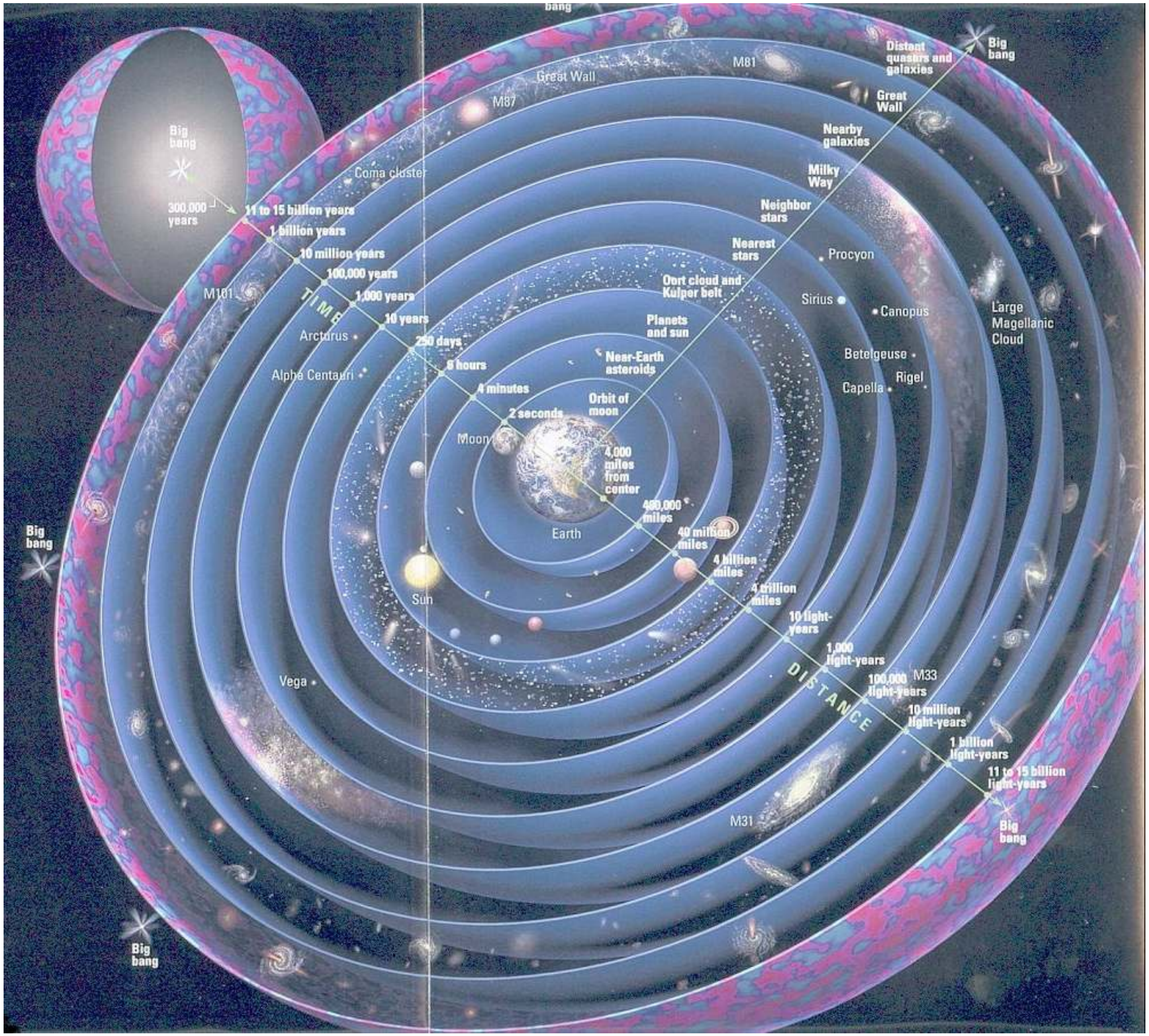
Chronologie de l'Univers

“Première” lumière libre de se propager dans l'Univers, émise il y a environ 13.7 milliards d'années
(~400000 ans après le Big Bang)

=

Fond diffus cosmologique

L'ultime lumière...

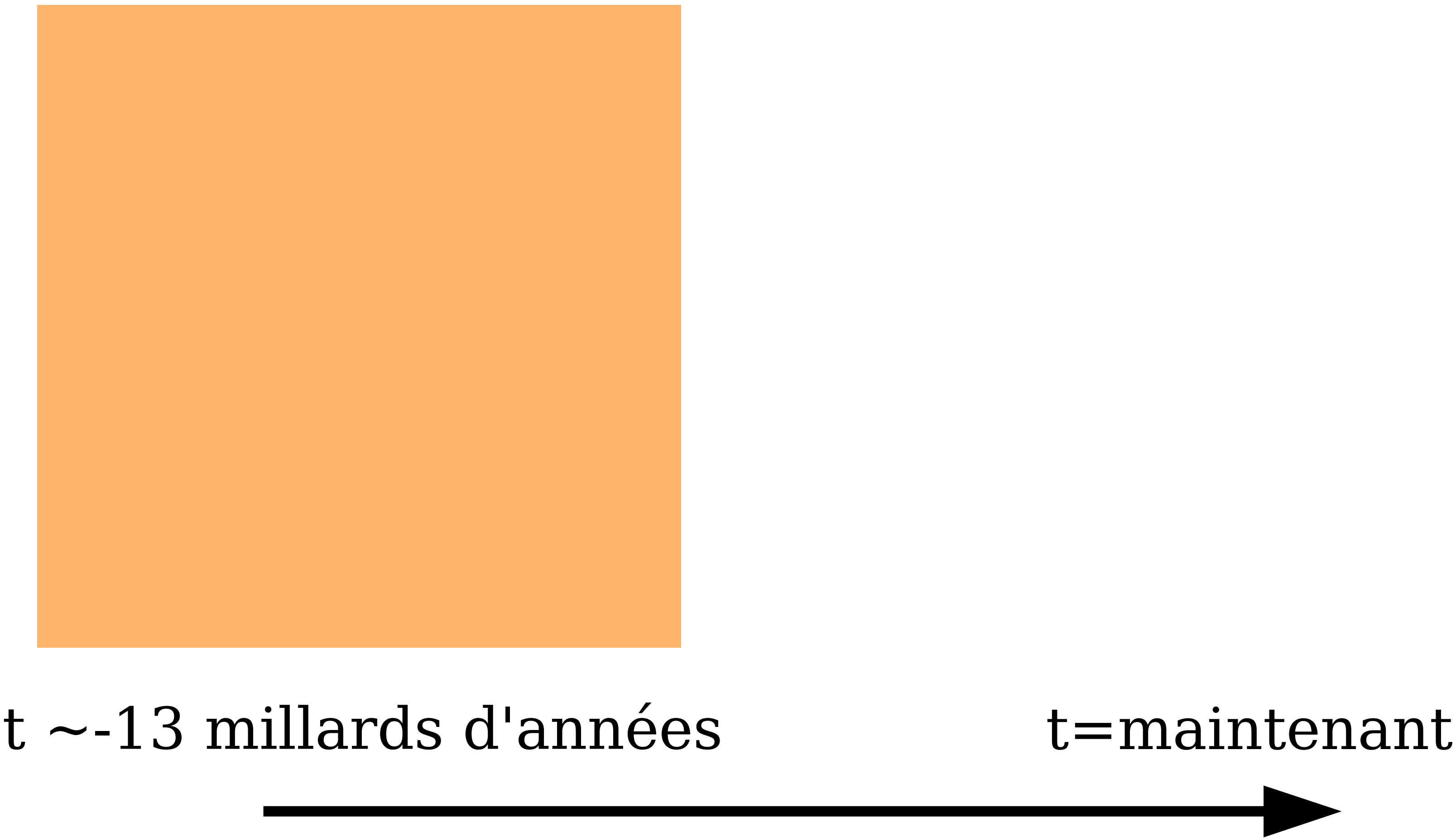


L'ultime lumière...

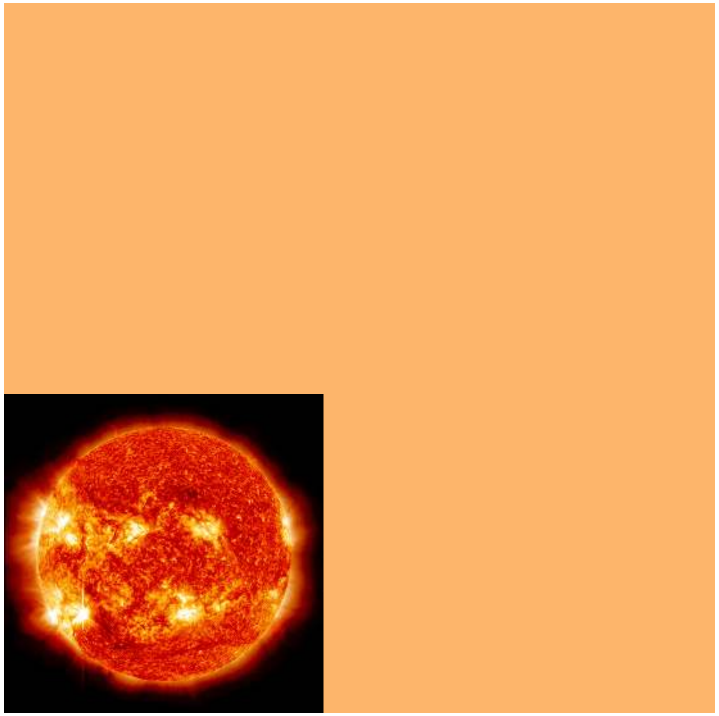
I. Un peu d'histoire…

II. Détecter le FDC

Le FDC à travers les âges...

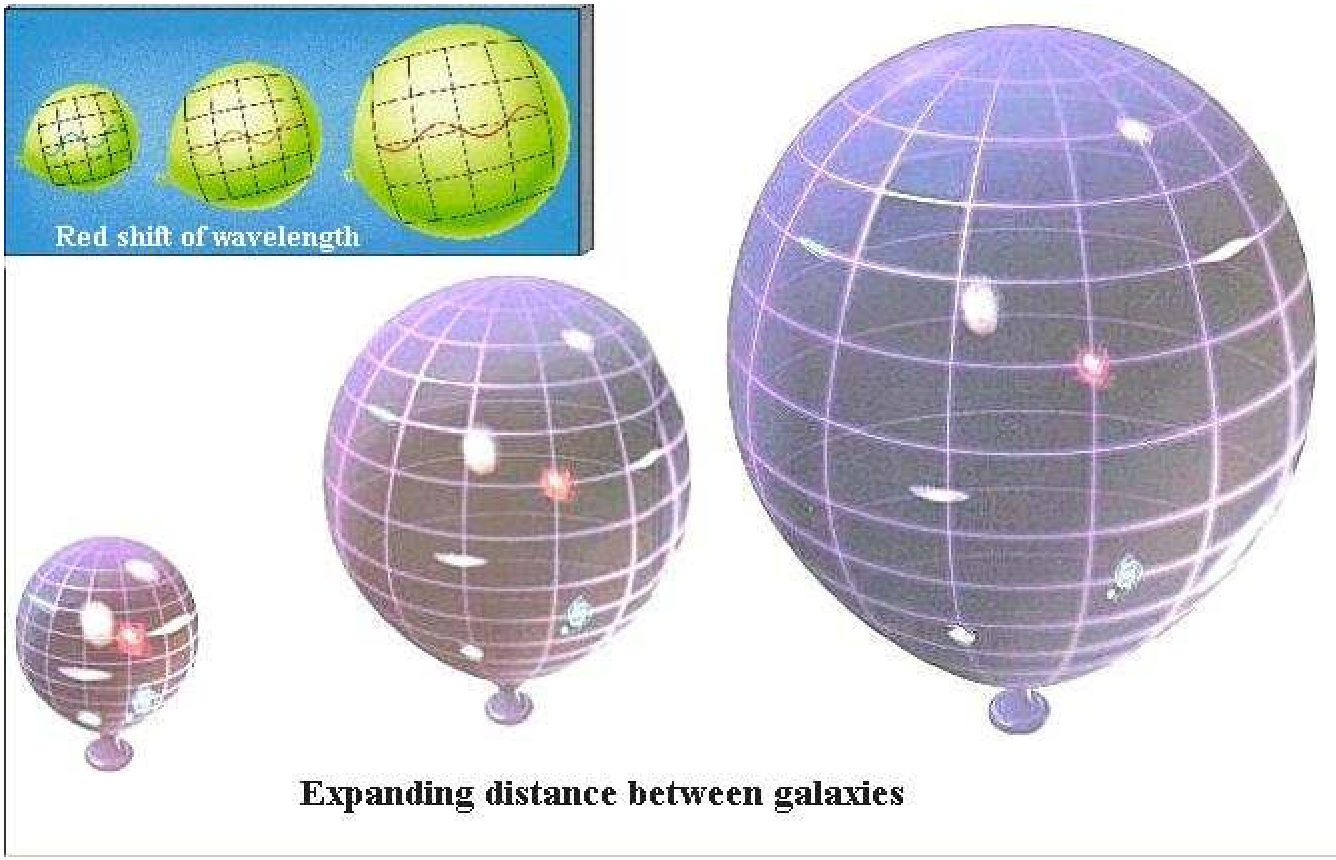


Le FDC à travers les âges...

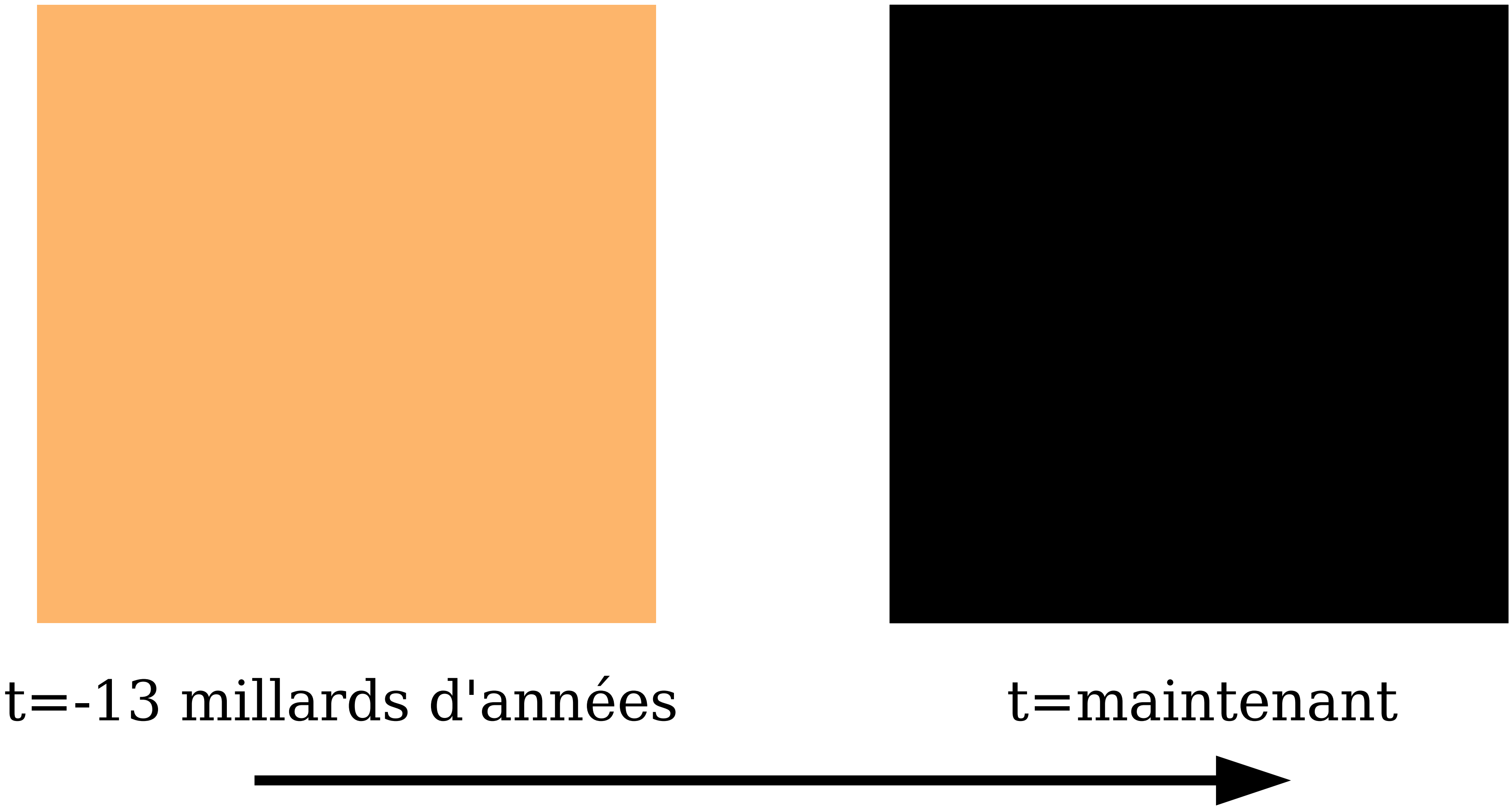


t ~-13 millards d'années

t=maintenant


Red shift of wavelength
Expanding distance between galaxies

Le FDC à travers les âges…



Taille Univers x ~1000

Longueur d'onde FDC x ~1000

Température FDC / ~1000

“fond diffus micro-ondes” ~ 3K

Détecter le FDC

Détecter le FDC

Des prédictions à la détection

1940s-60s : **Gamow**, Dicke, Alpher, Herman….

→ ~5 - 50K

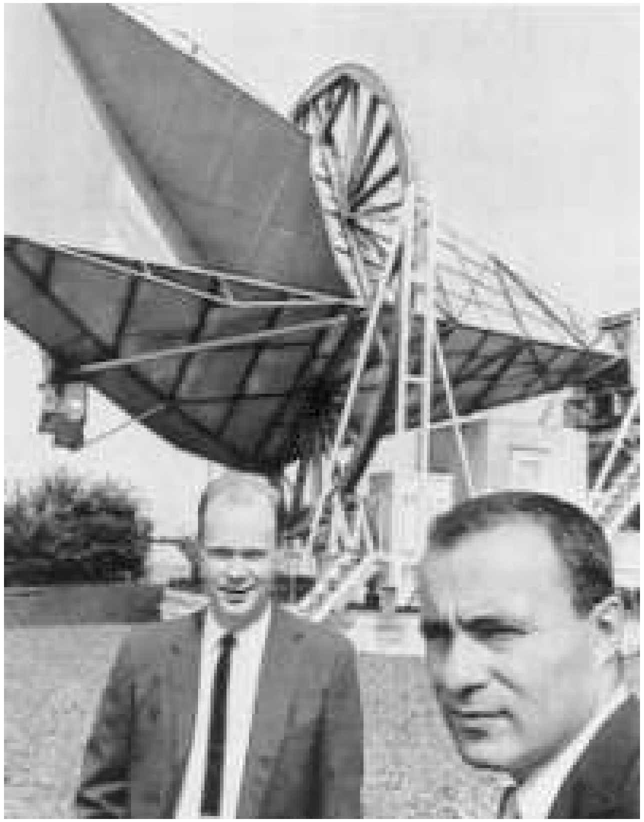
1964 :

- Doroshkevich & Novikov : radiation présentée comme détectable
- Princeton (USA) : Dicke, Peebles, & Wilkinson préparent une expérience pour essayer de mesurer cette “radiation micro-ondes”….

1964 : A Penzias & R. W. Wilson

Au même moment, à 60km de là (Holmdelm)….

…un bruit persistant…



1964 : A Penzias & R. W. Wilson

?

1964 : A Penzias & R. W. Wilson

?

Penzias : "To get rid of them, we finally found the most humane thing was to get a shot gun…and at very close range [we] just killed them instantly. It’s not something I’m happy about, but that seemed like the only way out of our dilemma"

1964 : A Penzias & R. W. Wilson

Penzias et Wilson entendent parler des prédictions de Dicke & cie à Princeton…

…Penzias contacte Dicke pour faire part de leur découverte…

…réaction de Dicke à ses collègues :
“Well boys, we've been scooped”

1978:

"for [the] discovery of cosmic microwave background radiation"

… seulement pour Penzias et Wilson

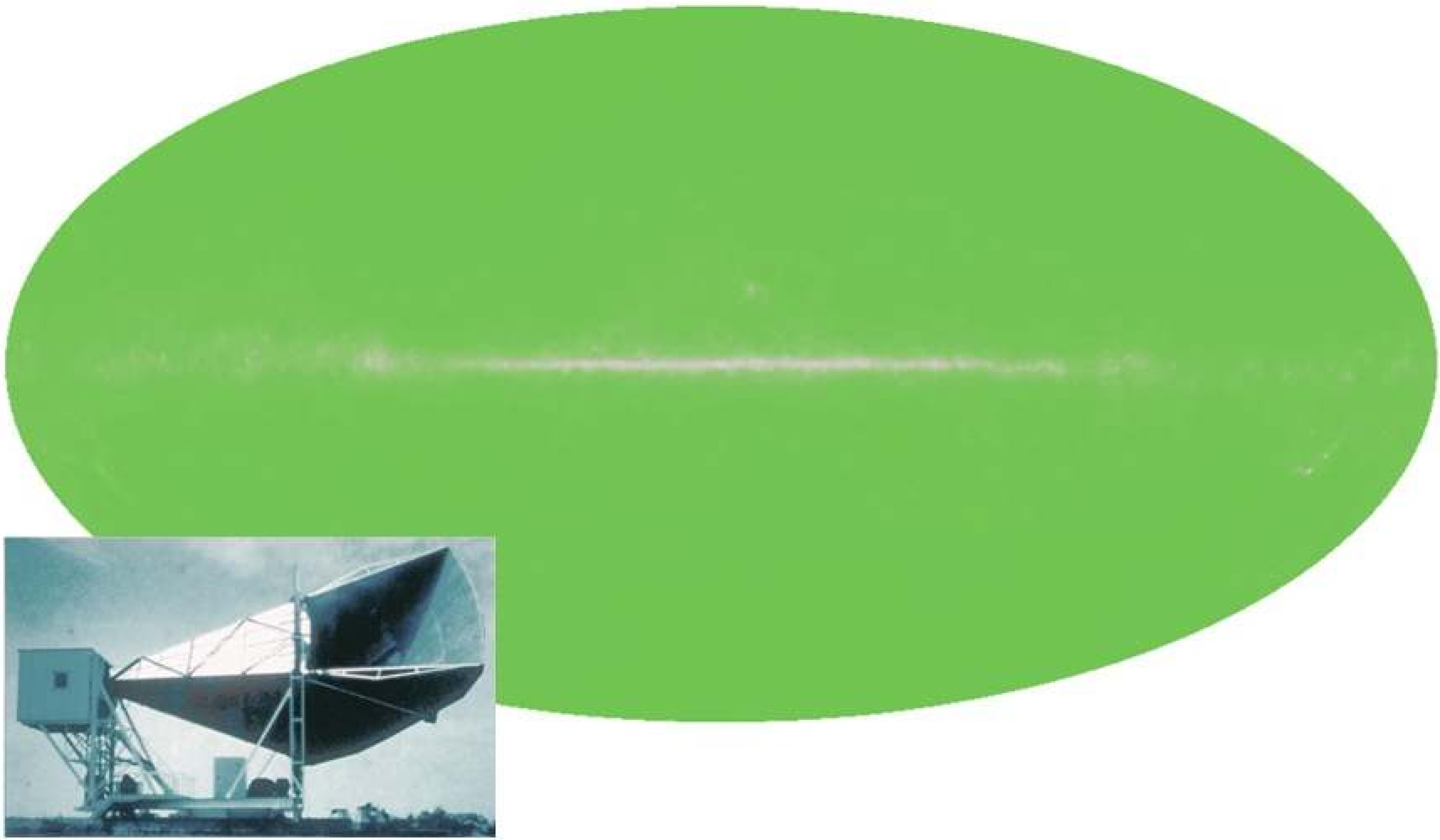
1978:

“for [the] discovery of cosmic microwave background radiation”

… seulement pour Penzias et Wilson

MORALE :
Fusil de chasse + pigeons = Prix Nobel

Le FDC vu par Penzias et Wilson



Le FDC vu par Penzias et Wilson

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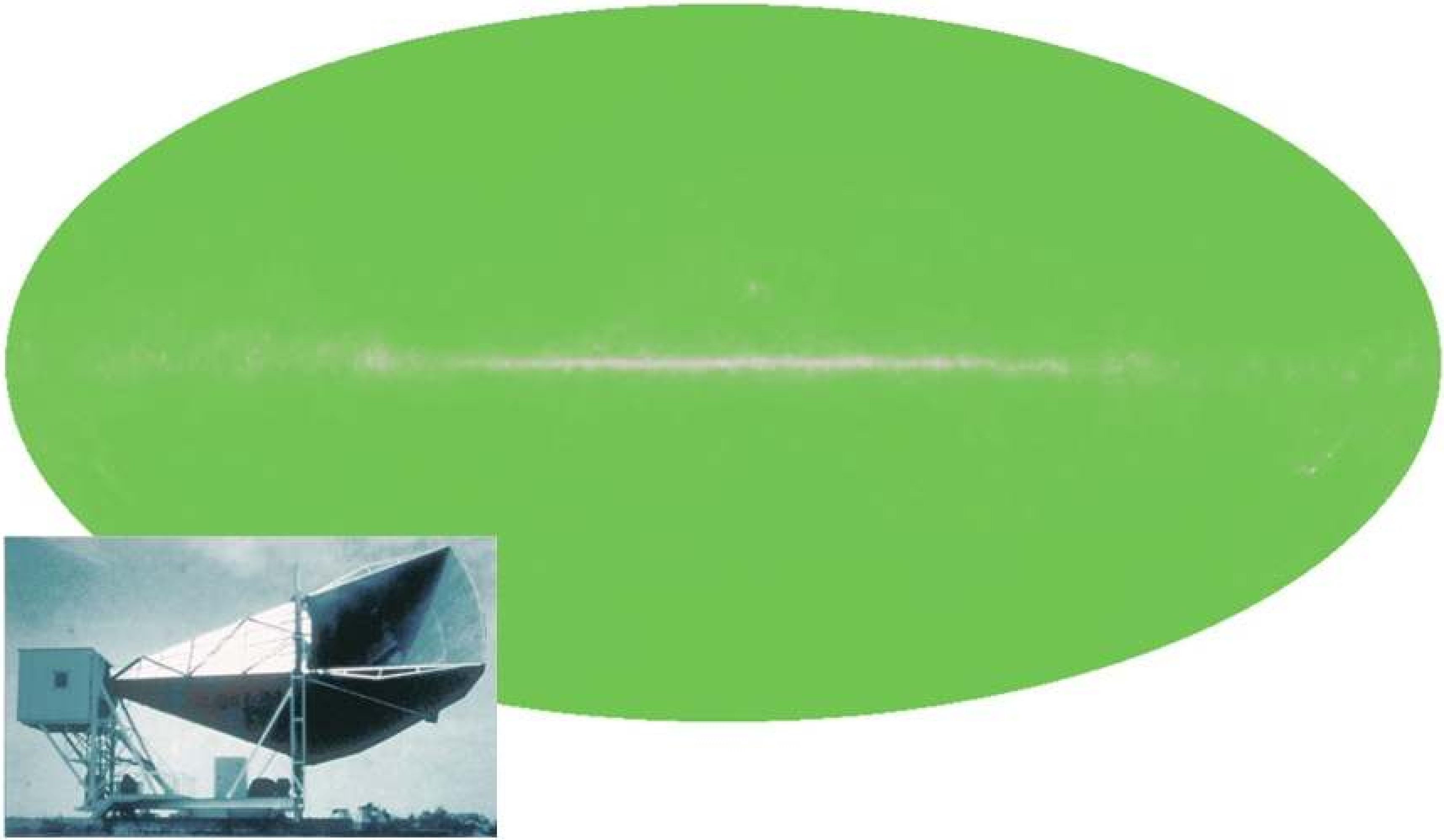


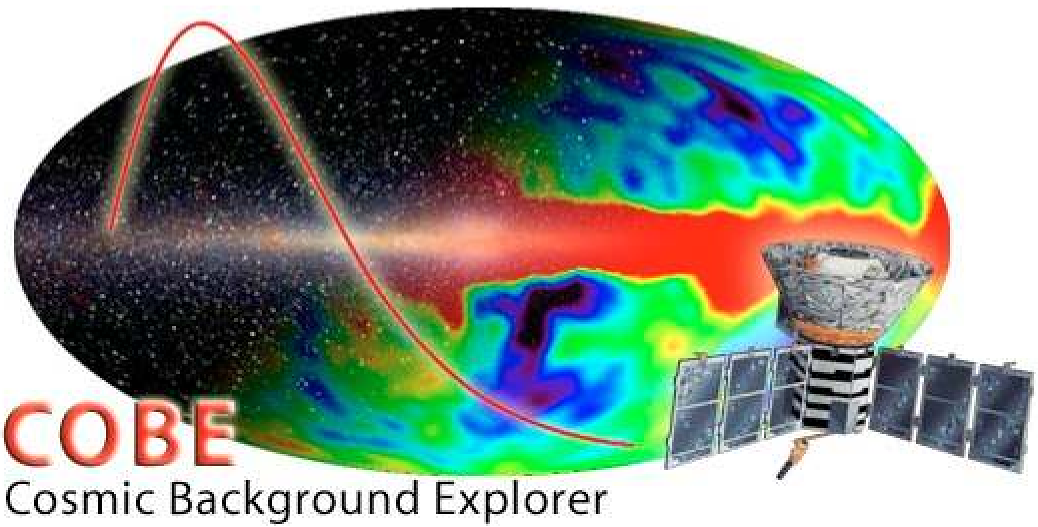
Le FDC vu par Penzias et Wilson

Est-ce bien le FDC ? Si oui :

- Spectre en fréquence caractéristique d'un corps noir

- (Petites) fluctuations attendues
1960s-90s : Sachs, Wolfe, Rees, Sciama...

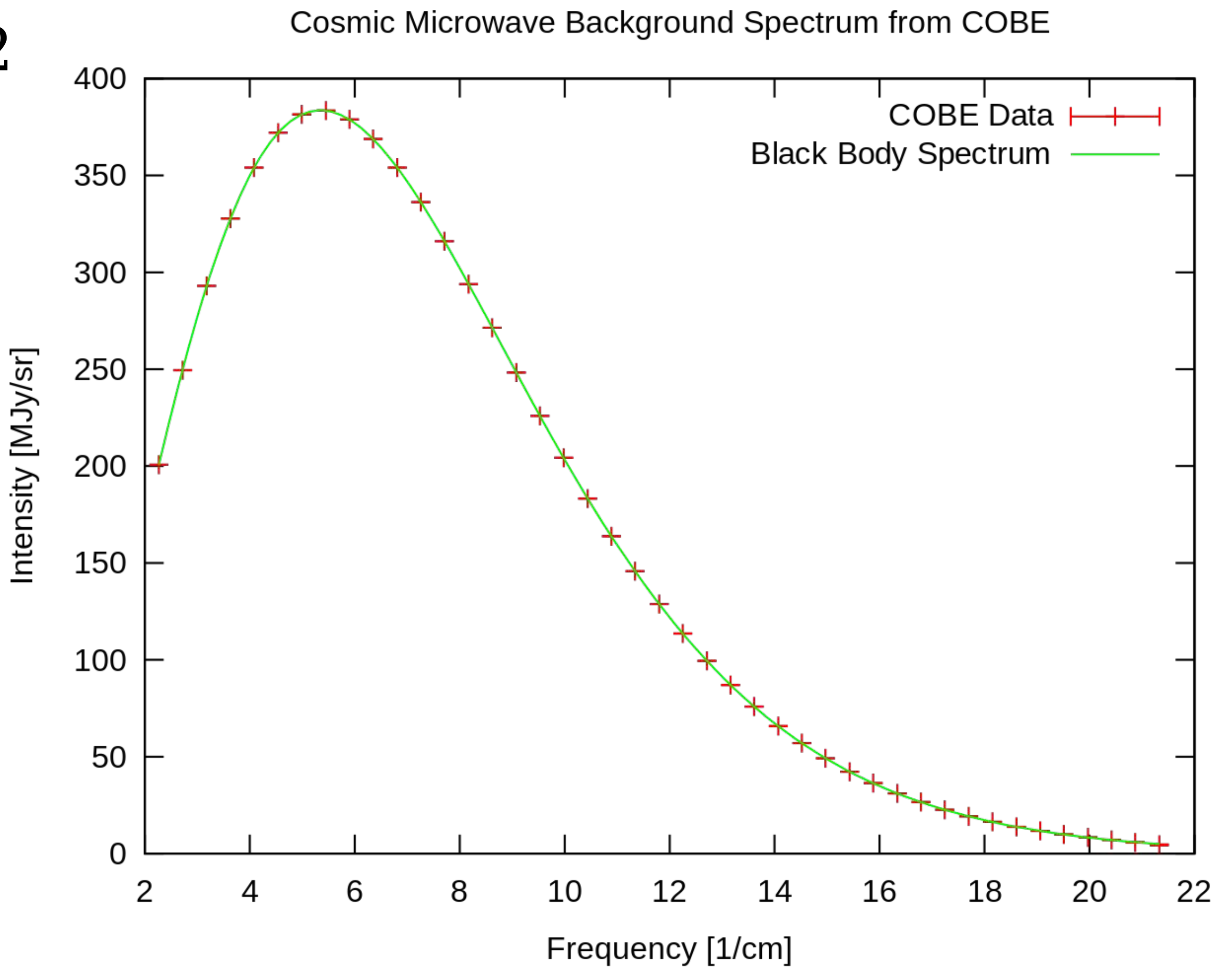
COBE: Cosmic Background Explorer



1974 : Appel à propositions de la NASA : 3 projets soumis
pour étudier le FDC → aucun sélectionné
1976 : Comité propose COBE à la NASA
1981 : Début construction (retardé)
1989 : Lancement du satellite (retardé) en orbite polaire

COBE: Cosmic Background Explorer

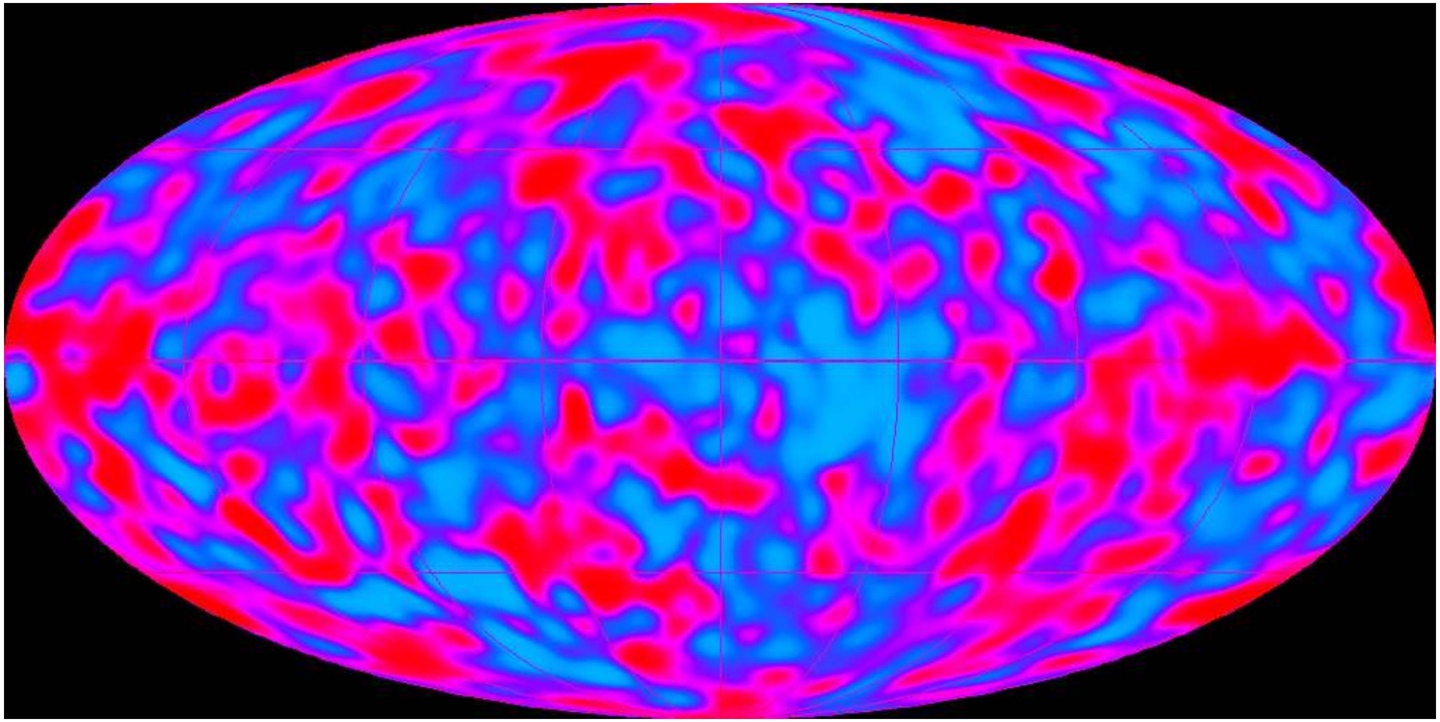
Avril '92



Corps noir → OK

COBE: Cosmic Background Explorer

Avril '92



$\delta \sim 10^{-5}$

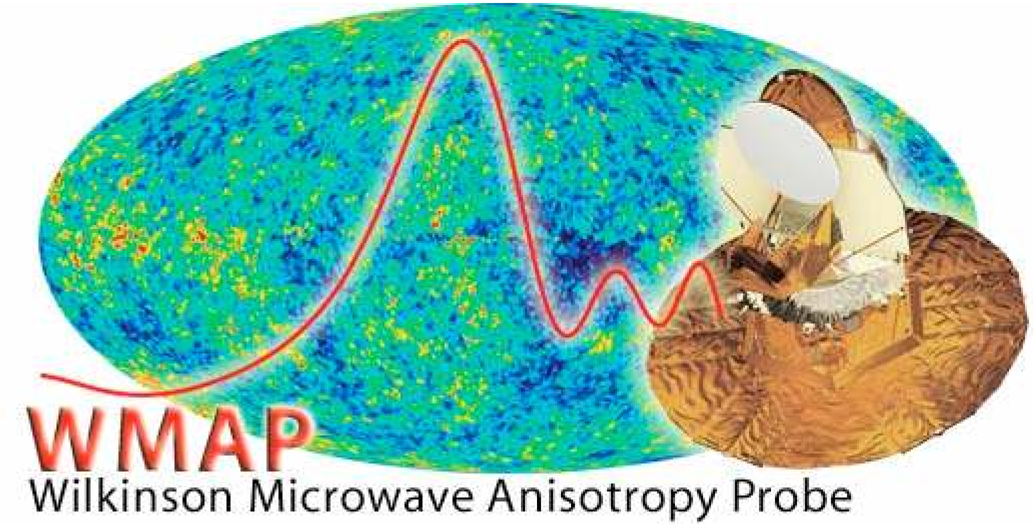
Fluctuations → OK

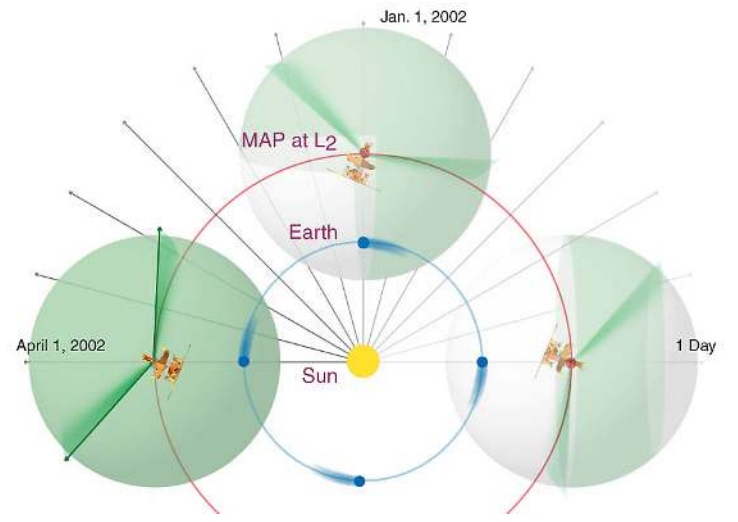
COBE: Cosmic Background Explorer

Attribué à J. C. Mather and G. F. Smoot : “for their discovery of the blackbody form and anisotropy of the cosmic microwave background radiation”

Prix Nobel ? ...check

WMAP

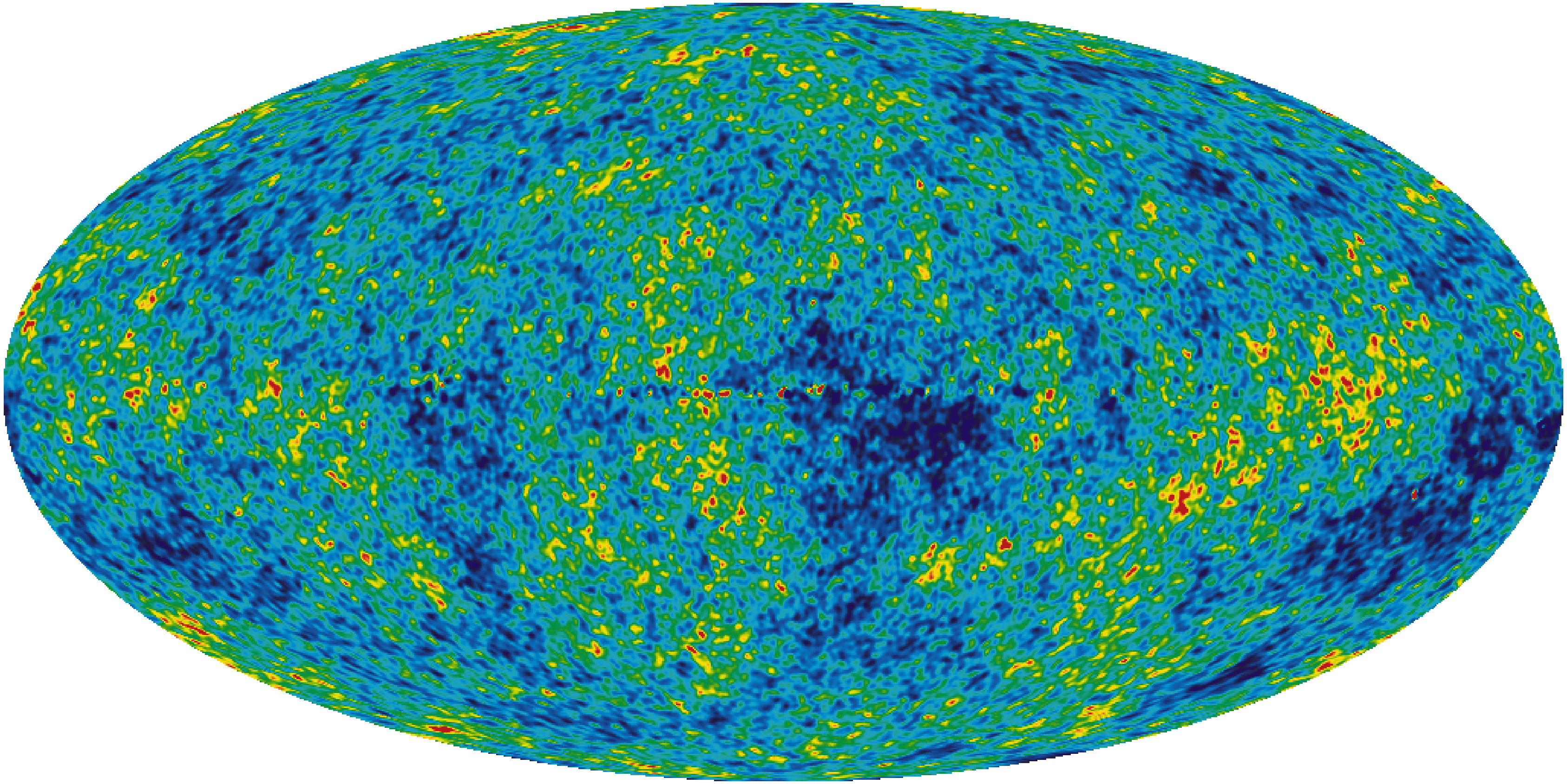




1995 : Proposé à la NASA
1997 : Approuvé pour développement
2001 : Lancement et trajet vers L2

WMAP

2001-2010 : 9 ans de fonctionnement et de données



(… mais pas de prix Nobel)

Planck

Objectif : Mesure utlime du FDC sur tout le ciel par satellite dédié

Mission sélectionnée par l'ESA en 1996 (lancée en 2009)

La collaboration Planck

Planck 2015 results. XIII. Cosmological parameters

Planck Collaboration: P. A. R. Ade[100], N. Aghanim[70], M. Arnaud[84], M. Ashdown[80,7], J. Aumont[70], C. Baccigalupi[99], A. J. Banday[111,11], R. B. Barreiro[76], J. G. Bartlett[1,78], N. Bartolo[36,77], E. Battaner[114,115], R. Battye[79], K. Benabed[71,110], A. Benoît[68], A. Benoit-Lévy[27,71,110], J.-P. Bernard[111,11], M. Bersanelli[39,58], P. Bielewicz[111,11,99], A. Bonaldi[79], L. Bonavera[76], J. R. Bond[10], J. Borrill[16,104], F. R. Bouchet[71,102], F. Boulanger[70], M. Bucher[1], C. Burigana[57,37,59], R. C. Butler[57], E. Calabrese[107], J.-F. Cardoso[85,1,71], A. Catalano[86,83], A. Challinor[73,80,14], A. Chamballu[84,18,70], R.-R. Chary[67], H. C. Chiang[31,8], J. Chluba[26,80], P. R. Christensen[94,43], S. Church[106], D. L. Clements[66], S. Colombi[71,110], L. P. L. Colombo[25,78], C. Combet[86], A. Coulais[83], B. P. Crill[78,95], A. Curto[7,76], F. Cuttaia[57], L. Danese[99], R. D. Davies[79], R. J. Davis[79], P. de Bernardis[38], A. de Rosa[57], G. de Zotti[54,99], J. Delabrouille[1], F.-X. Désert[63], E. Di Valentino[38], C. Dickinson[79], J. M. Diego[76], K. Dolag[113,91], H. Dole[70,69], S. Donzelli[58], O. Doré[78,13], M. Douspis[70], A. Ducout[71,66], J. Dunkley[107], X. Dupac[46], G. Efstathiou[80,73] *, F. Elsner[27,71,110], T. A. Enßlin[91], H. K. Eriksen[74], M. Farhang[10,97], J. Fergusson[14], F. Finelli[57,59], O. Forni[111,11], M. Frailis[56], A. A. Fraisse[31], E. Franceschi[57], A. Frejsel[94], S. Galeotta[56], S. Galli[71], K. Ganga[1], C. Gauthier[1,90], M. Gerbino[38], T. Ghosh[70], M. Giard[111,11], Y. Giraud-Héraud[1], E. Giusarma[38], E. Gjerløw[74], J. González-Nuevo[76,99], K. M. Górski[78,117], S. Gratton[80,73], A. Gregorio[40,56,62], A. Gruppuso[57], J. E. Gudmundsson[31], J. Hamann[109,108], F. K. Hansen[74], D. Hanson[92,78,10], D. L. Harrison[73,80], G. Helou[13], S. Henrot-Versillé[81], C. Hernández-Monteagudo[15,91], D. Herranz[76], S. R. Hildebrandt[78,13], E. Hivon[71,110], M. Hobson[7], W. A. Holmes[78], A. Hornstrup[19], W. Hovest[91], Z. Huang[10], K. M. Huffenberger[29], G. Hurier[70], A. H. Jaffe[66], T. R. Jaffe[111,11], W. C. Jones[31], M. Juvela[30], E. Keihänen[30], R. Keskitalo[16], T. S. Kisner[88], R. Kneissl[45,9], J. Knoche[91], L. Knox[33], M. Kunz[20,70,3], H. Kurki-Suonio[30,52], G. Lagache[5,70], A. Lähteenmäki[2,52], J.-M. Lamarre[83], A. Lasenby[7,80], M. Lattanzi[37], C. R. Lawrence[78], J. P. Leahy[79], R. Leonardi[46], J. Lesgourgues[109,98,82], F. Levrier[83], A. Lewis[28], M. Liguori[36,77], P. B. Lilje[74], M. Linden-Vørnle[19], M. López-Caniego[46,76], P. M. Lubin[34], J. F. Macías-Pérez[86], G. Maggio[56], N. Mandolesi[57,37], A. Mangilli[70,81], A. Marchini[60], P. G. Martin[10], M. Martinelli[116], E. Martínez-González[76], S. Masi[38], S. Matarrese[36,77,49], P. Mazzotta[41], P. McGehee[67], P. R. Meinhold[34], A. Melchiorri[38,60], J.-B. Melin[18], L. Mendes[46], A. Mennella[39,58], M. Migliaccio[73,80], M. Millea[33], S. Mitra[65,78], M.-A. Miville-Deschênes[70,10], A. Moneti[71], L. Montier[111,11], G. Morgante[57], D. Mortlock[66], A. Moss[101], D. Munshi[100], J. A. Murphy[93], P. Naselsky[94,43], F. Nati[31], P. Natoli[37,4,57], C. B. Netterfield[22], H. U. Nørgaard-Nielsen[19], F. Noviello[79], D. Novikov[89], I. Novikov[94,89], C. A. Oxborrow[19], F. Paci[99], L. Pagano[38,60], F. Pajot[70], R. Paladini[67], D. Paoletti[57,59], B. Partridge[51], F. Pasian[56], G. Patanchon[1], T. J. Pearson[13,67], O. Perdereau[81], L. Perotto[86], F. Perrotta[99], V. Pettorino[50], F. Piacentini[38], M. Piat[1], E. Pierpaoli[25], D. Pietrobon[78], S. Plaszczynski[81], E. Pointecouteau[111,11], G. Polenta[4,55], L. Popa[72], G. W. Pratt[84], G. Prézeau[13,78], S. Prunet[71,110], J.-L. Puget[70], J. P. Rachen[23,91], W. T. Reach[112], R. Rebolo[75,17,44], M. Reinecke[91], M. Remazeilles[79,70,1], C. Renault[86], A. Renzi[42,61], I. Ristorcelli[111,11], G. Rocha[78,13], C. Rosset[1], M. Rossetti[39,58], G. Roudier[1,83,78], B. Rouillé d'Orfeuil[81], M. Rowan-Robinson[66], J. A. Rubiño-Martín[75,44], B. Rusholme[67], N. Said[38], V. Salvatelli[38,6], L. Salvati[38], M. Sandri[57], D. Santos[86], M. Savelainen[30,52], G. Savini[96], D. Scott[24], M. D. Seiffert[78,13], P. Serra[70], E. P. S. Shellard[14], L. D. Spencer[100], M. Spinelli[81], V. Stolyarov[7,80,105], R. Stompor[1], R. Sudiwala[100], R. Sunyaev[91,103], D. Sutton[73,80], A.-S. Suur-Uski[30,52], J.-F. Sygnet[71], J. A. Tauber[47], L. Terenzi[48,57], L. Toffolatti[21,76,57], M. Tomasi[39,58], M. Tristram[81], T. Trombetti[57], M. Tucci[20], J. Tuovinen[12], M. Türler[64], G. Umana[53], L. Valenziano[57], J. Valiviita[30,52], B. Van Tent[87], P. Vielva[76], F. Villa[57], L. A. Wade[78], B. D. Wandelt[71,110,35], I. K. Wehus[78], M. White[32], S. D. M. White[91], A. Wilkinson[79], D. Yvon[18], A. Zacchei[56], and A. Zonca[34]

(Affiliations can be found after the references)

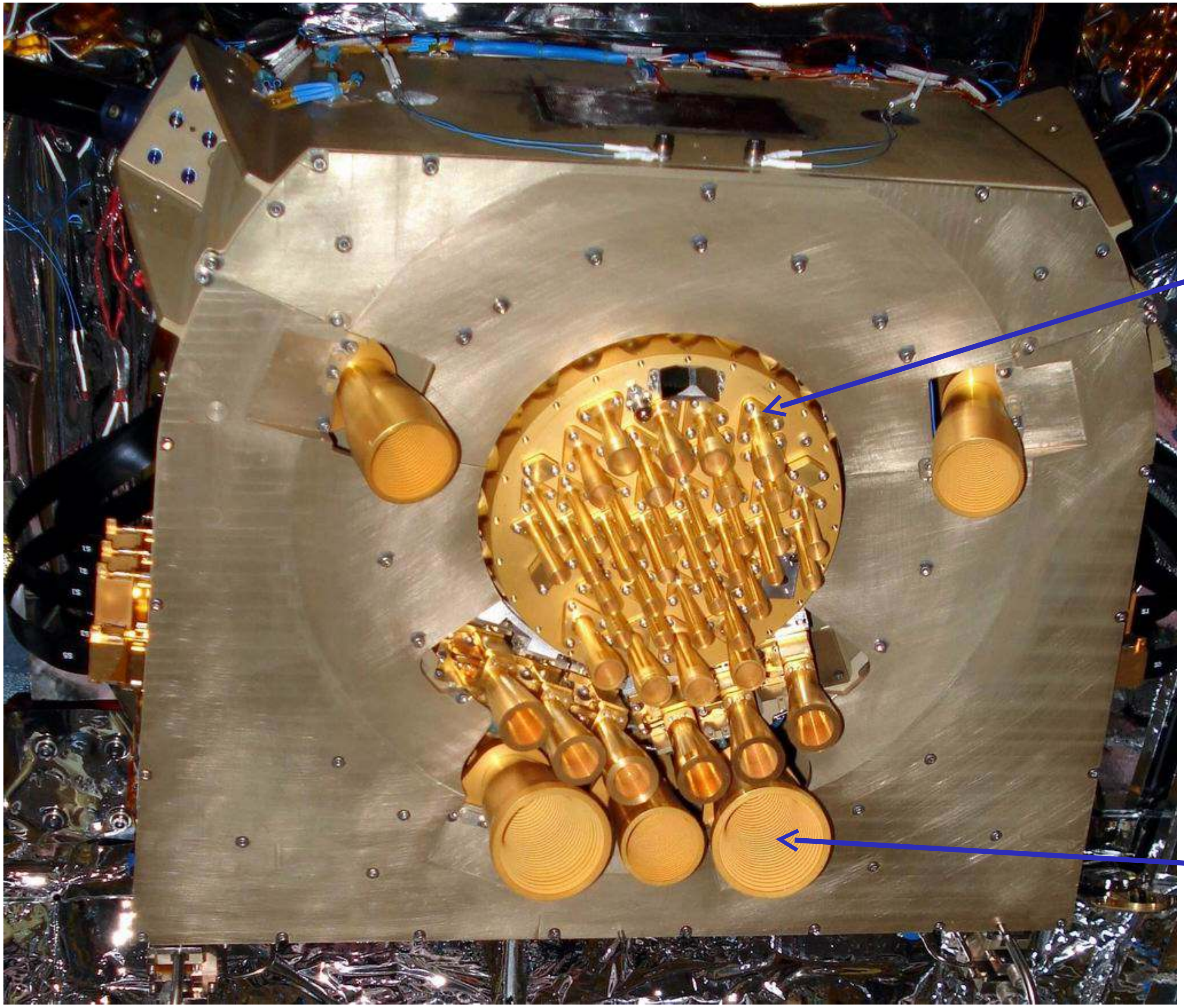
February 5 2015

ABSTRACT

This paper presents cosmological results based on full-mission *Planck* observations of temperature and polarization anisotropies of the cosmic microwave background (CMB) radiation. Our results are in very good agreement with the 2013 analysis of the *Planck* nominal-mission temperature data, but with increased precision. The temperature and polarization power spectra are consistent with the standard spatially-flat six-parameter ΛCDM cosmology with a power-law spectrum of adiabatic scalar perturbations (denoted "base ΛCDM" in this paper). From the *Planck* temperature data combined with *Planck* lensing, for this cosmology we find a Hubble constant, $H_0 = (67.8 \pm 0.9)$ km s^{-1}Mpc^{-1}, a matter density parameter

http://www.cosmos.esa.int/web/planck/publications

Le coeur de Planck : HFI & LFI



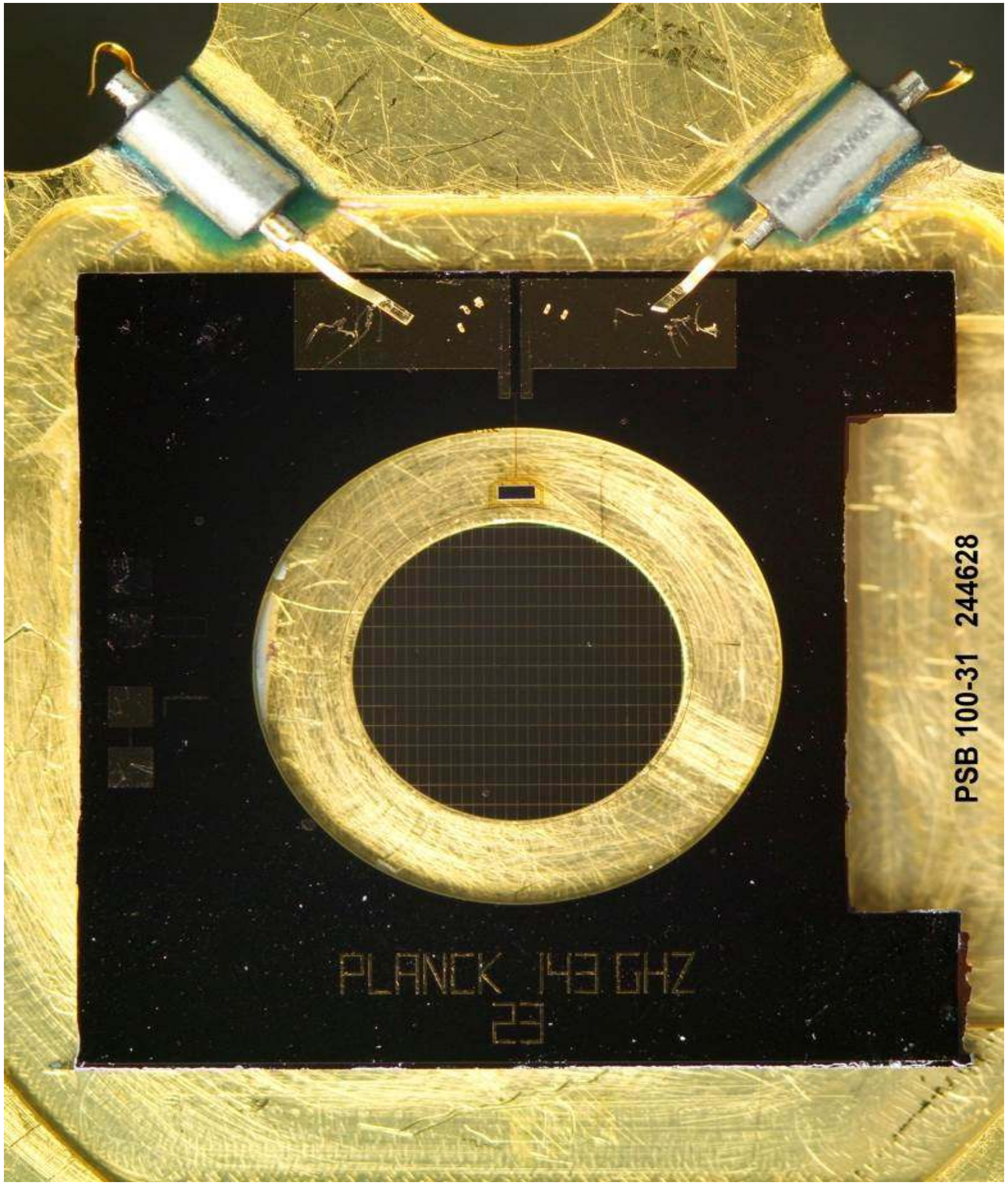
HFI fonctionne à 0.1K

Fabriqué sous responsabilité IAS, Orsay

LFI

Planck, ESA, HFI & LFI

Le coeur de Planck : HFI & LFI



"Planck first light"

planck

ESA | SCIENCE & TECHNOLOGY | PLANCK

Missions
- Show All Missions

Mission Home
- Summary
- Fact Sheet
- Objectives

Participants
- Mission Team
- Industrial Team

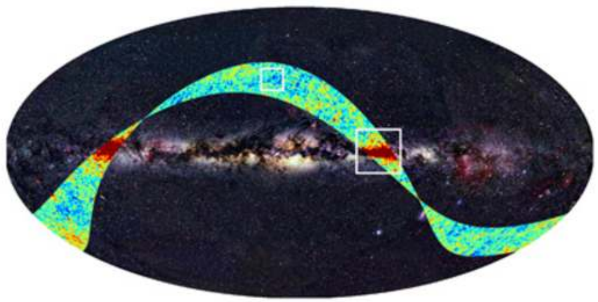
Science Results
- Planck's cosmology
- Cosmic structure
- Through the Milky Way

Spacecraft
- Spacecraft
- 3D Model
- Instruments
- Cooling system

PLANCK FIRST LIGHT YIELDS PROMISING RESULTS

17 September 2009

Preliminary results from the Planck First Light Survey, performed to demonstrate the stability of the instruments and the ability to calibrate them over long periods, indicate that the data quality is excellent. This bodes well for the full sky survey that has just begun.



The false-colour strip superimposed on an optical map of the Milky Way indicates the region of the Planck First Light Survey. The two squares indicate regions for which detailed images are available - see below. (Click on the image for further details.) *Credit: ESA, LFI & HFI Consortia (Planck), Background image: Axel Mellinger*

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Shortcut URL
http://sci.esa.int/jump.cfm?oid=45543

Images And Videos
- Planck First Light Survey
- Planck First Light Survey - detail of the Milky Way
- Planck First Light Survey - detail at high galactic latitude

Related Links
- HFI Consortium
- LFI Consortium
- Planck for the general public

See Also
- ESA Bulletin 139: The

“Planck first light”

Differences at low *l* in Planck's first light sky map of the cosmic microwave background from WMAP's and COBE's

Short title: Differences at low *l* in Planck's first light sky map from WMAP's and COBE's

Keith S Cover

New evidence for lack of CMB power on large scales

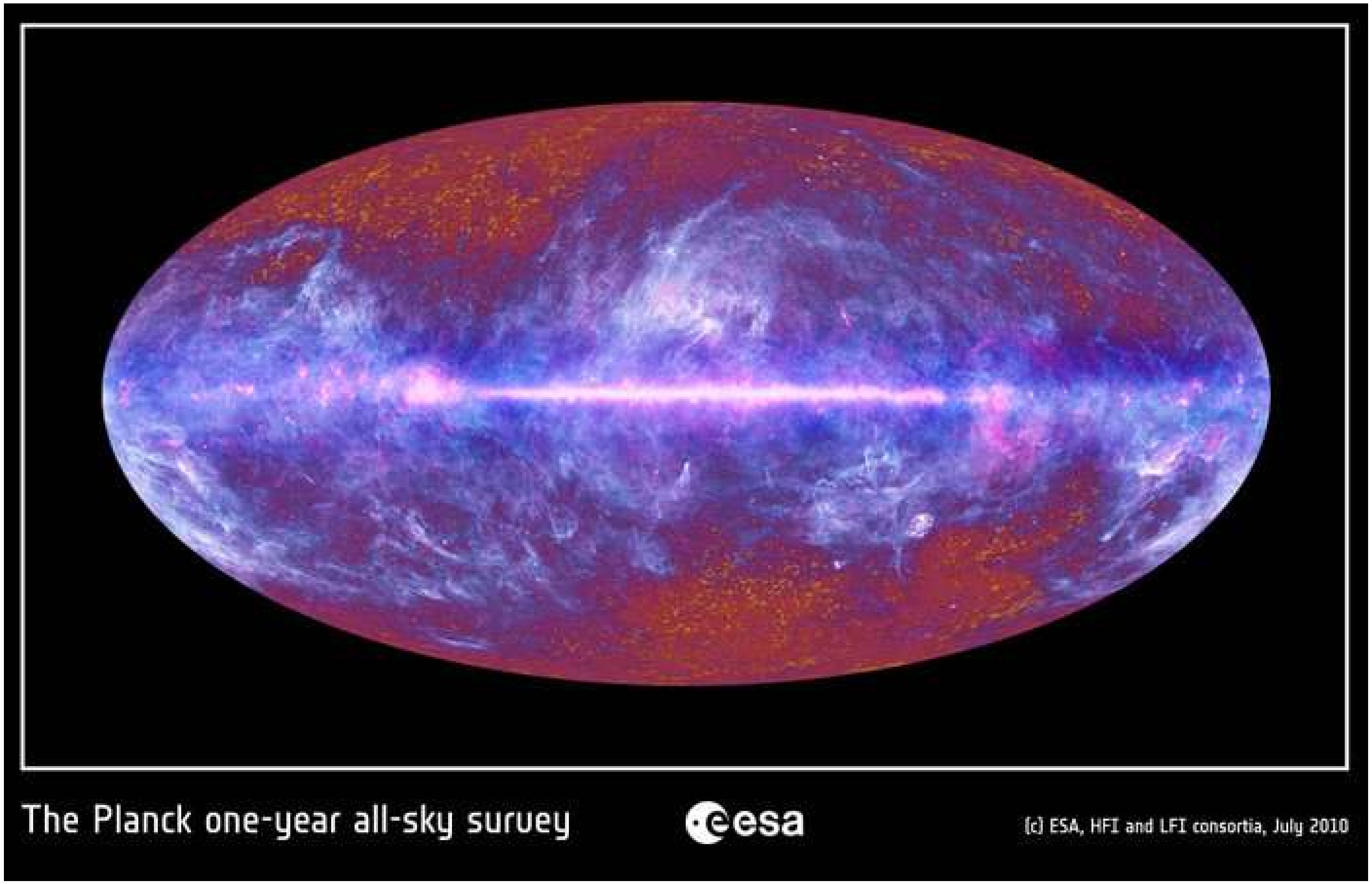
Hao Liu[1] and Ti-Pei Li[1,2,3]

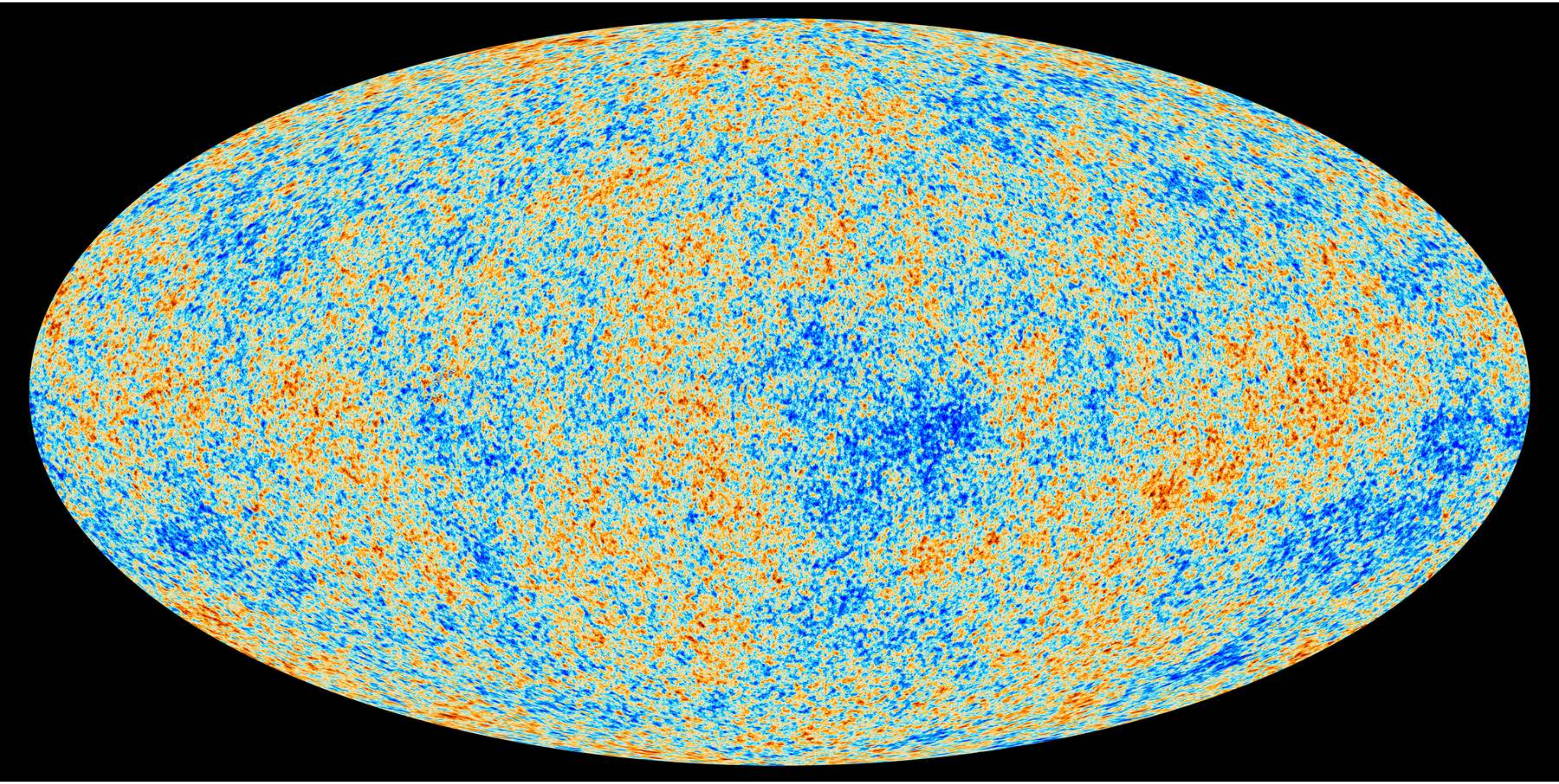
ABSTRACT

A digitalized temperature map is recovered from the first light sky survey image published by the Planck team, from which an angular power spectrum is derived. The amplitudes of the low multipoles measured from the preliminary Planck power spectrum are significantly lower than that reported by the WMAP team. Possible systematical effects are far from enough to explain the observed low-l differences.

Subject headings: cosmic microwave background — cosmology: observations

Planck après un an





HAVANA DECO SAVING A CITY'S ARCHITECTURE

PLAYERS UNITED BIGGER CHECKS ON THE WAY

FLOYD NORRIS THE FOLLY OF GIANT BANKS

International Herald Tribune

THE GLOBAL EDITION OF THE NEW YORK TIMES

Kurd leader issues a call for cease-fire with Turkey

From jail, Ocalan makes bold move to hasten end of a bitter conflict

Obama asks Israelis and Palestinians to talk again

By not insisting on freeze in settlement activity, he softens his earlier stance

The infant universe

Once rarity, women are U.S. Senate force

COLLECTION LE MONDE EST MATHÉMATIQUE

CRISE CHYPRIOTE : L'ULTIMATUM DE FRANCFORT

Le Monde

En Tunisie, le drame des disparus de la révolution

Vendredi 22 mars 2013

Moins d'impôts et plus d'austérité, Londres persiste

Le Royaume-Uni fait cavalier seul en matière fiscale et décide 13 milliards d'euros de coupes budgétaires

En panne de croissance comme le reste de l'Europe, Londres mise toujours plus sur la Banque d'Angleterre

L'efficacité des politiques d'austérité en question

LE MONDE DES LIVRES

Spécial Salon du livre de Paris

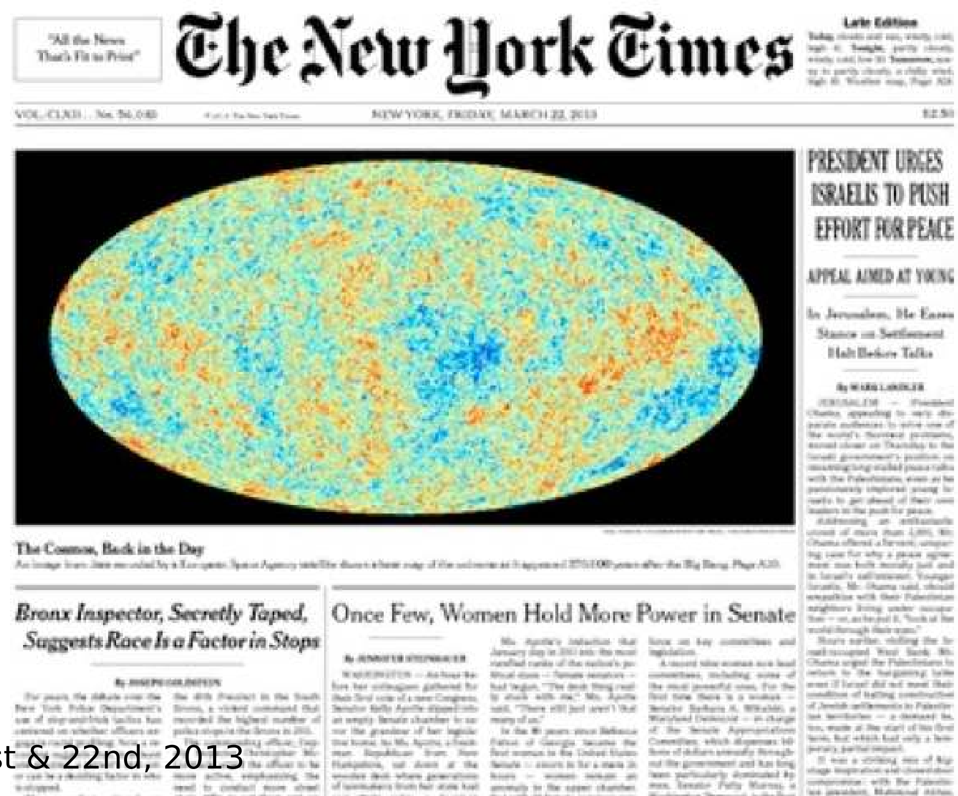
DES GTI POUR ROU… DES MÉCANIQUES

C'ÉTAIT L'UNIVERS IL Y A 13,8 MILLIARDS D'ANNÉES

Des images inédites du satellite européen Planck dévoilent l'enfance du monde. Ni étoile ni galaxie, mais des particules microscopiques, des électrons et des protons

Le pari de Cameron : politique de l'offre contre récession

AUJOURD'HUI



"All the News That's Fit to Print"

The New York Times

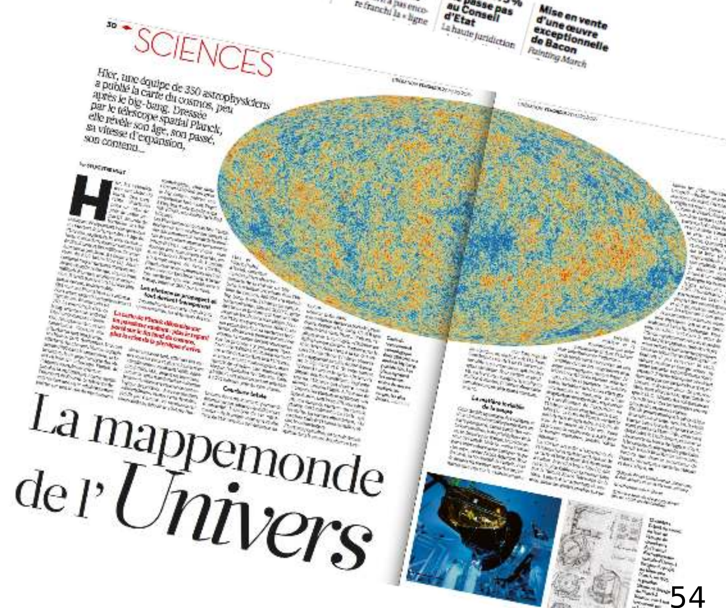
NEW YORK, FRIDAY, MARCH 22, 2013

PRESIDENT URGES ISRAELIS TO PUSH EFFORT FOR PEACE

The Cosmos, Back in the Day

Bronx Inspector, Secretly Taped, Suggests Race Is a Factor in Stops

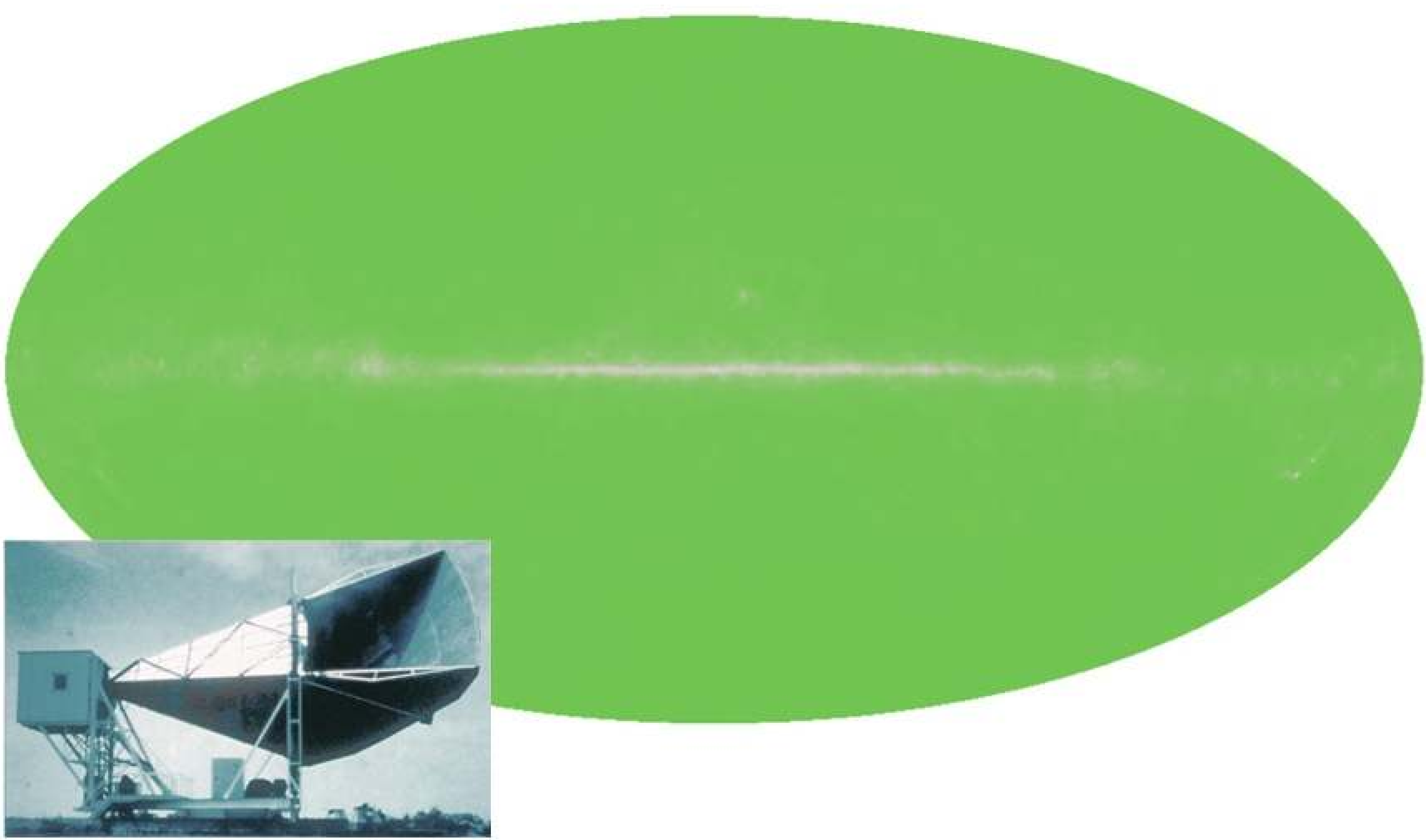
Once Few, Women Hold More Power in Senate

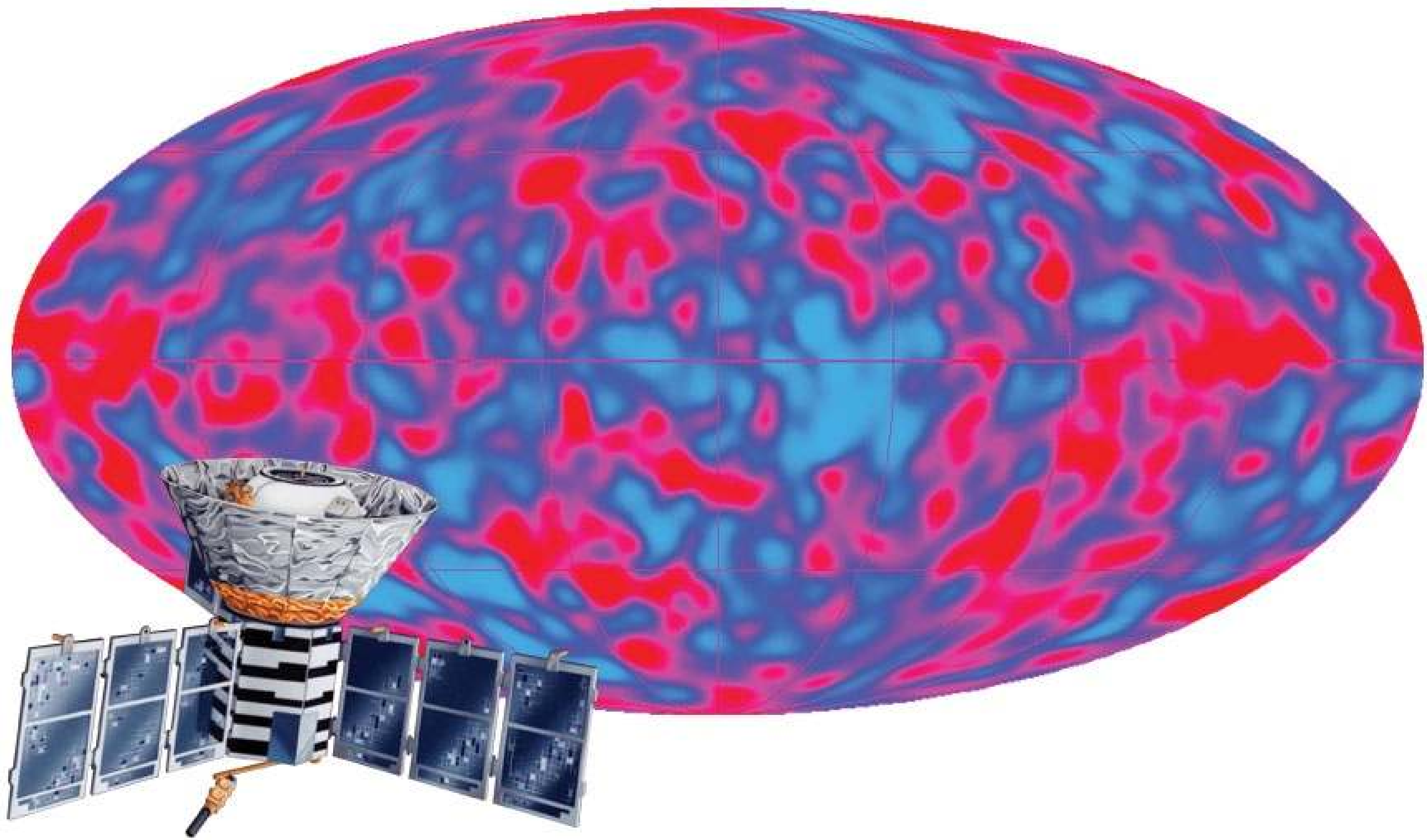


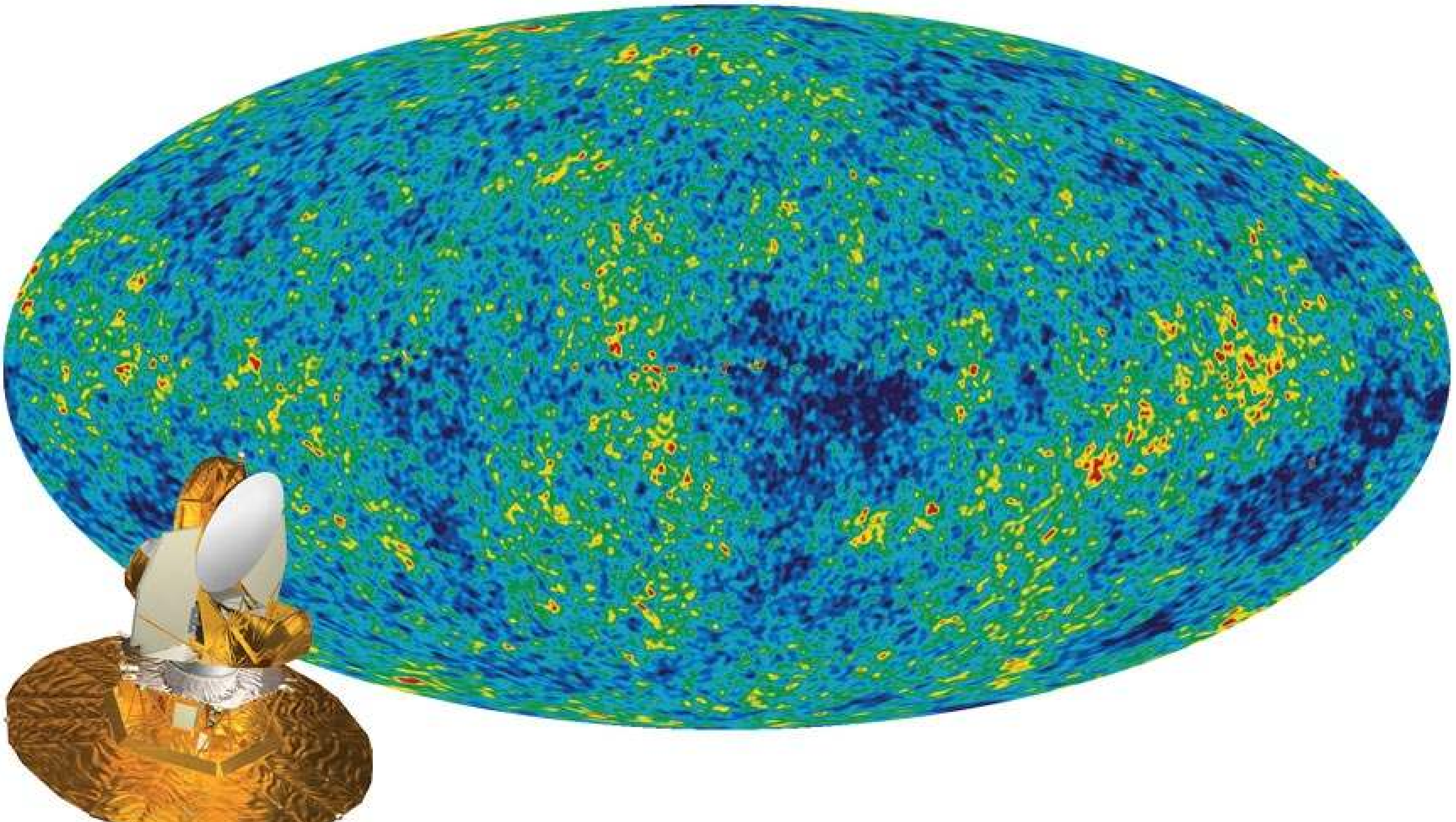
SCIENCES

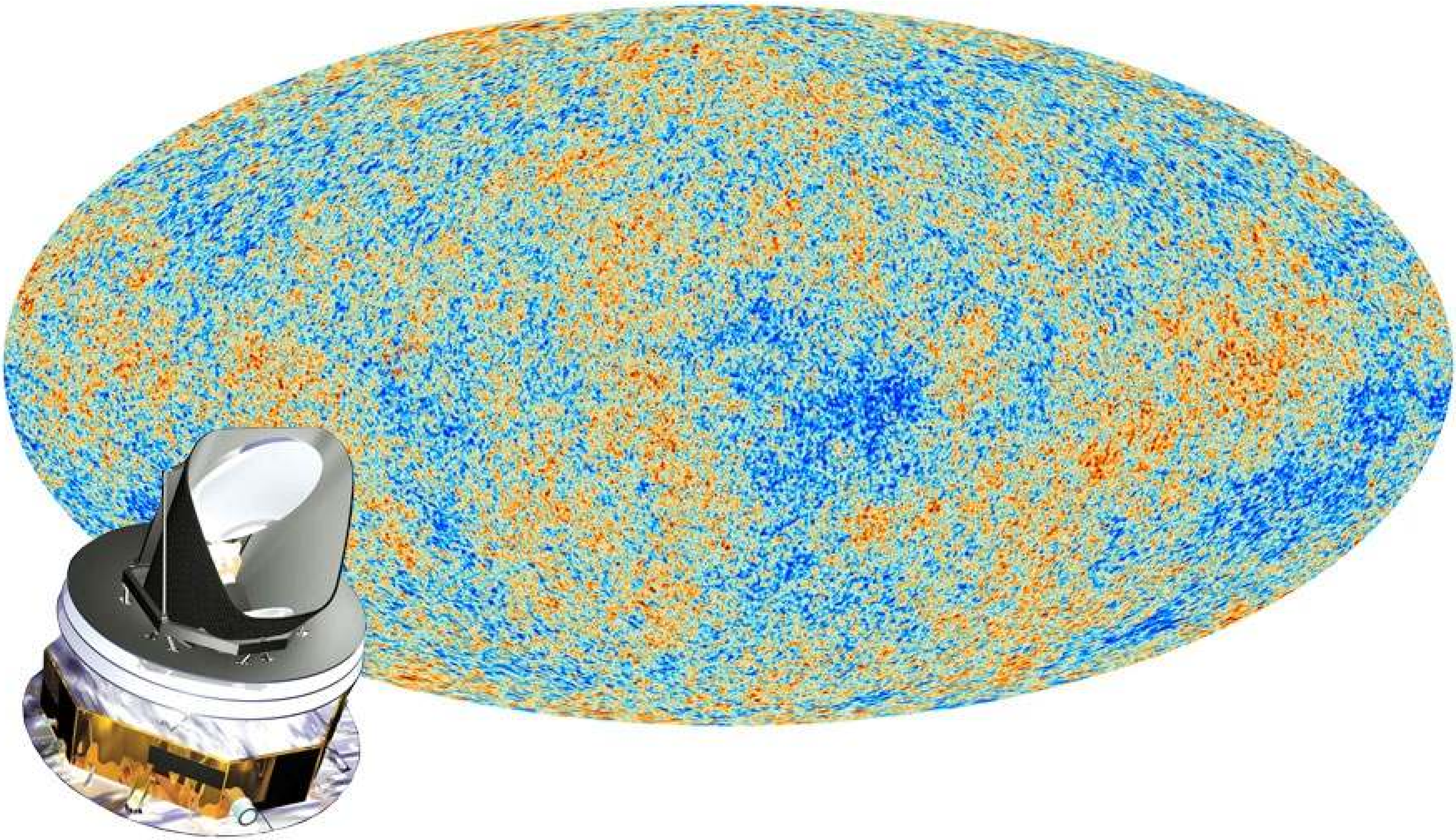
Hier, une équipe de 350 astrophysiciens a publié la carte du cosmos, peu après le big-bang. Dressée par le télescope spatial Planck, elle révèle son âge, son passé, sa vitesse d'expansion, son contenu...

La mappemonde de l'Univers





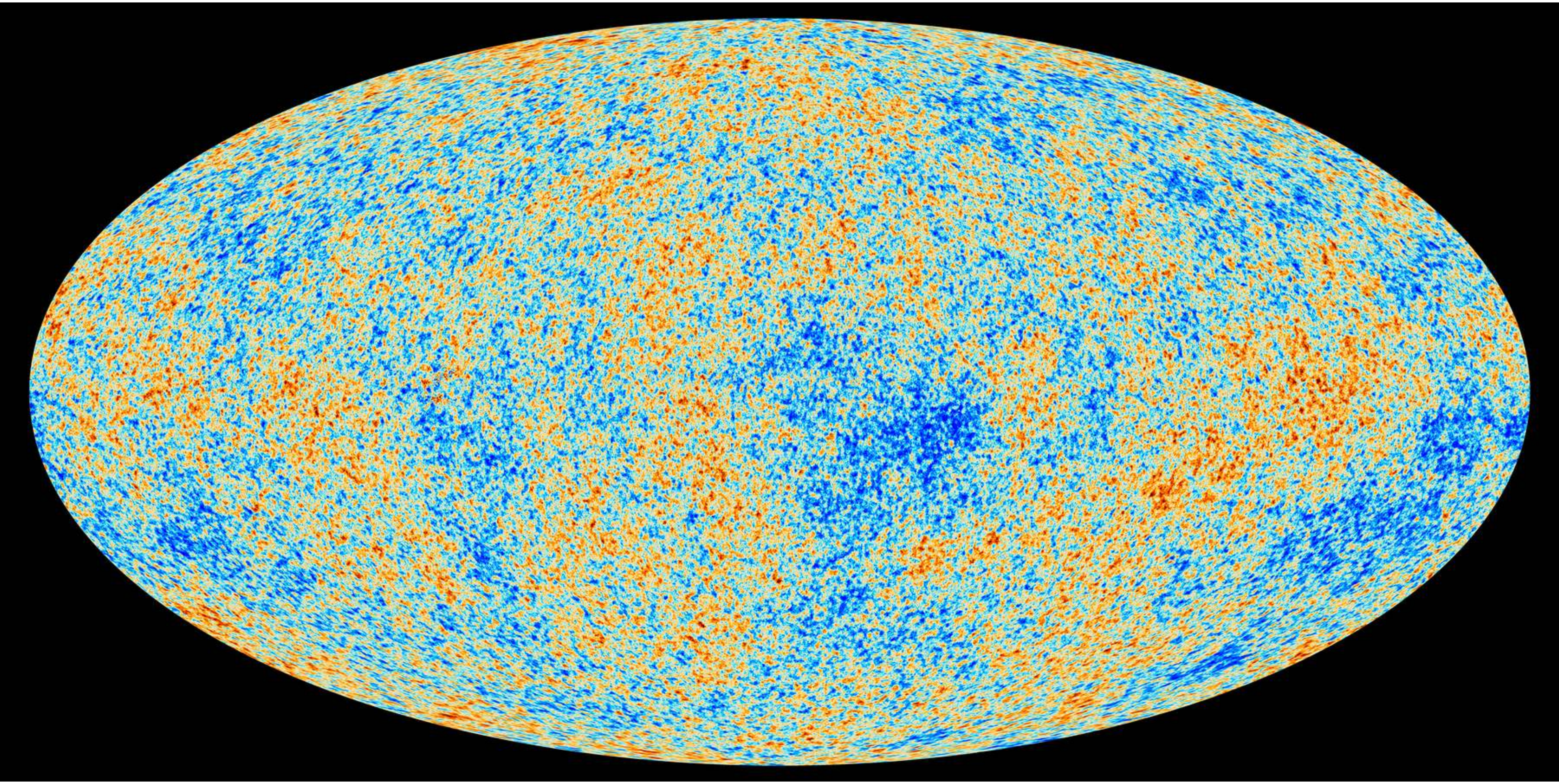


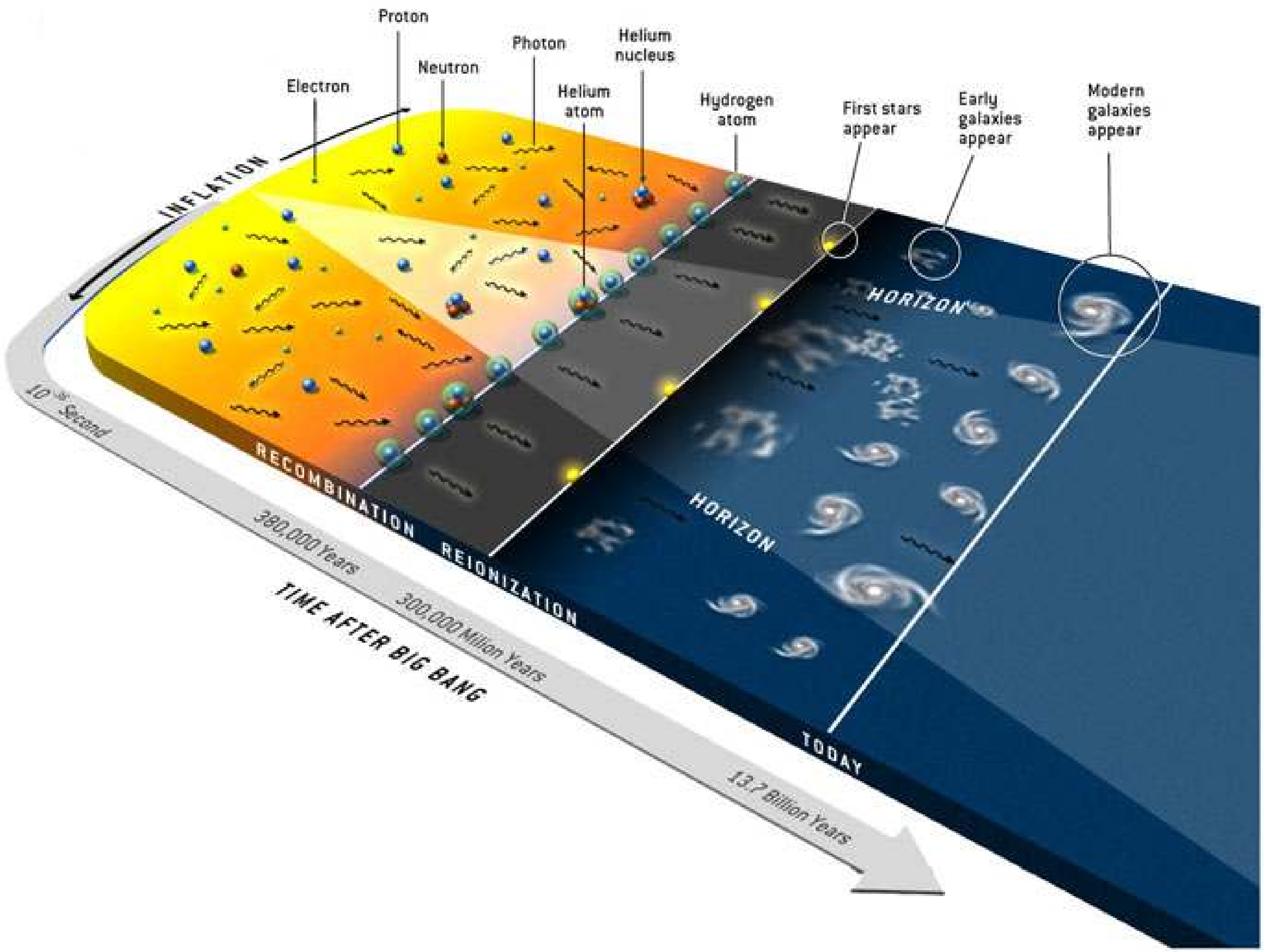


I. Un peu d'histoire…

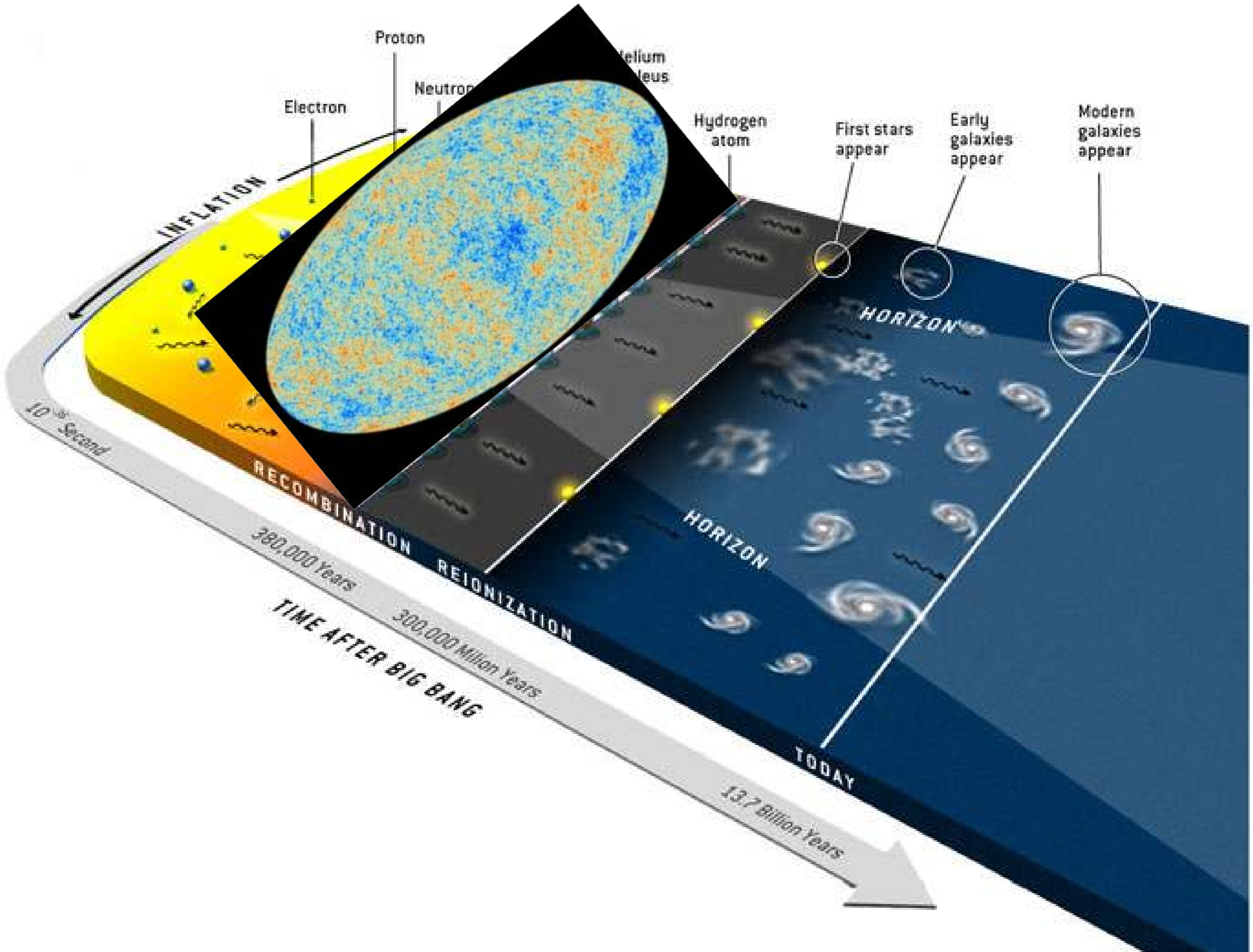
II. Détecter le FDC

III. La science du FDC





Proton
Photon
Helium nucleus
Neutron
Electron
Helium atom
Hydrogen atom
First stars appear
Early galaxies appear
Modern galaxies appear
INFLATION
HORIZON
HORIZON
RECOMBINATION
REIONIZATION
TODAY
10 Second
380,000 Years
300,000 Million Years
13.7 Billion Years
TIME AFTER BIG BANG



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13.7 Billion Years
TIME AFTER BIG BANG

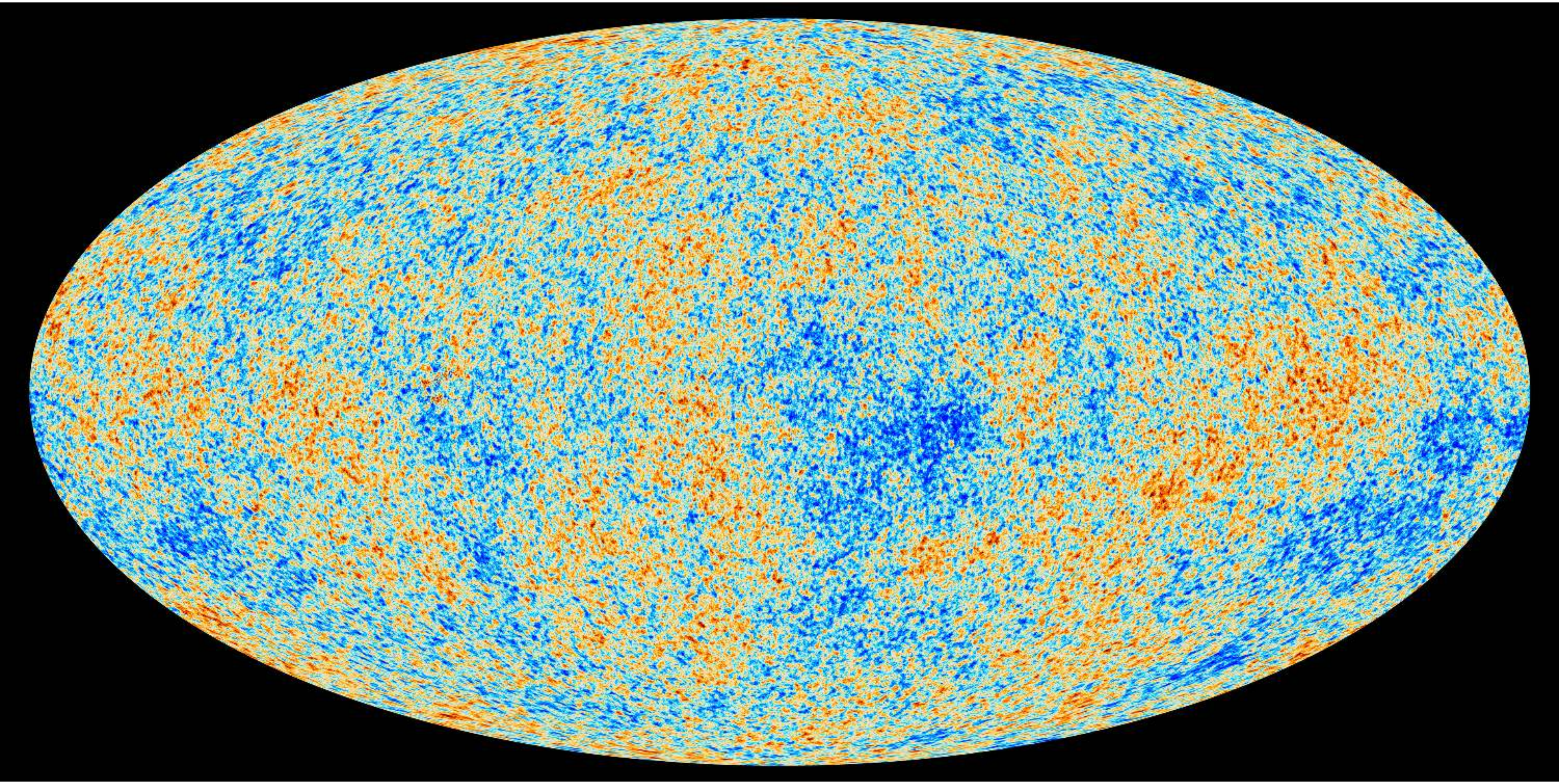
I. Un peu d'histoire...

II. Détecter le FDC

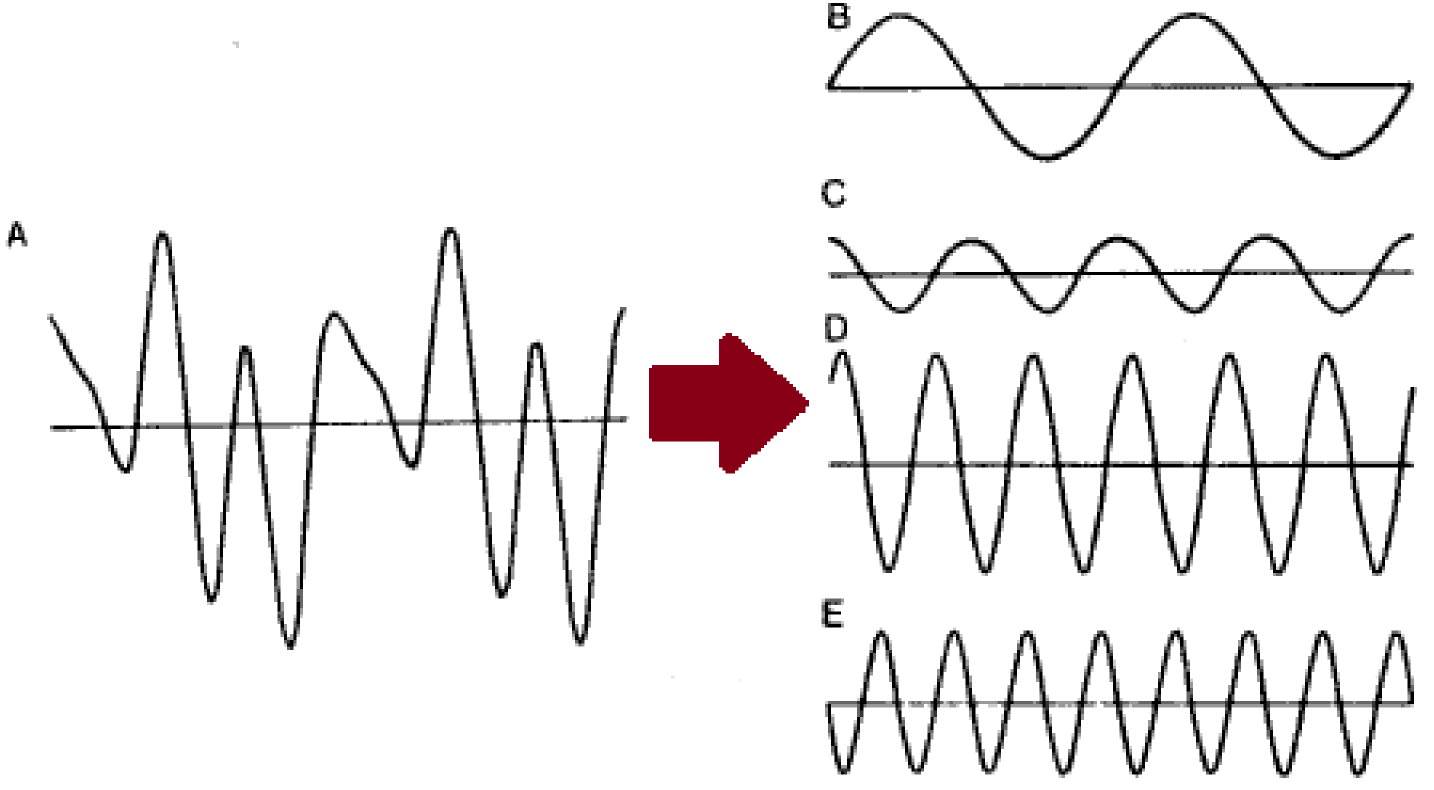
III. La science du FDC :

a) Préliminaires

Comment on analyse ça ???

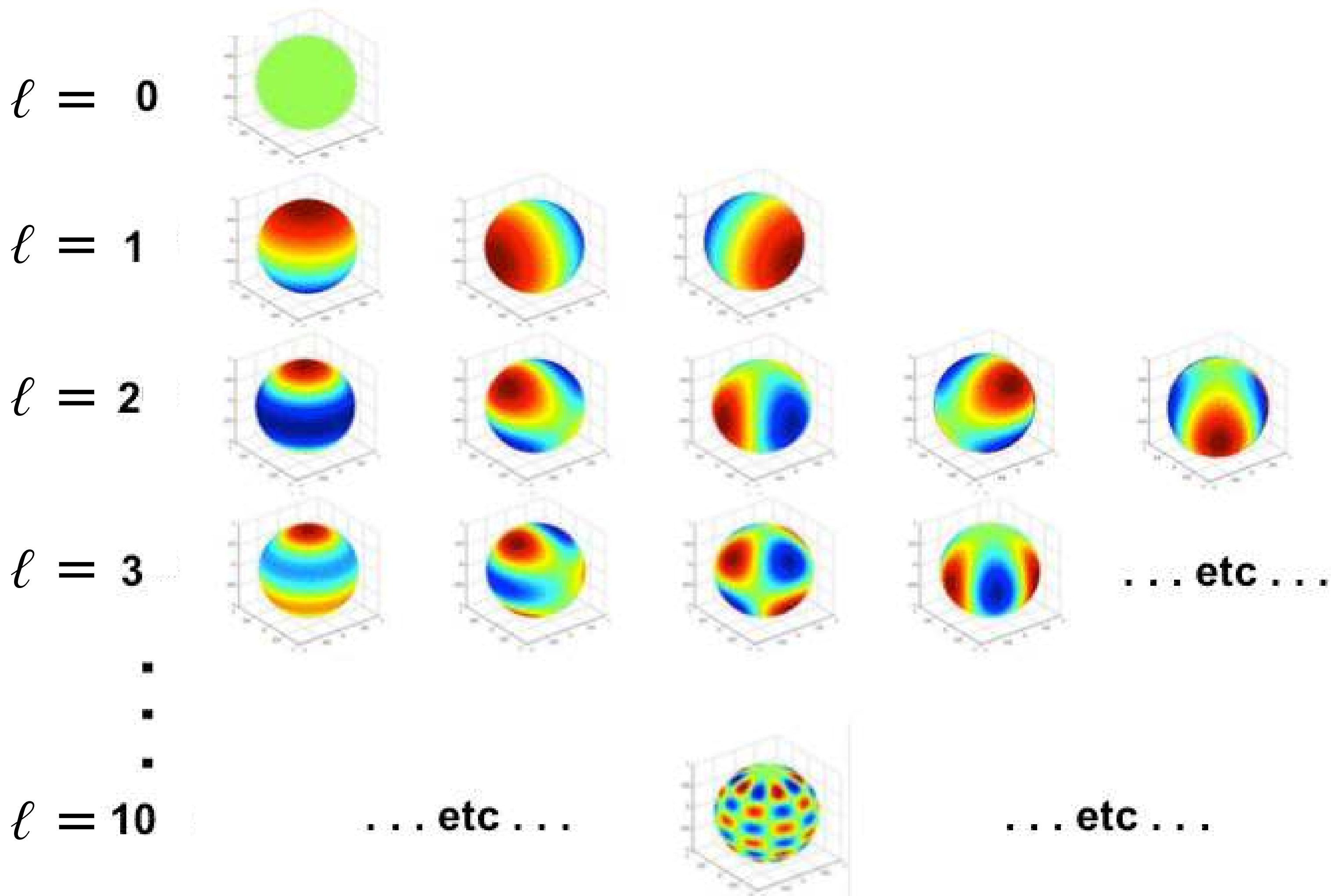


Décomposition de Fourier

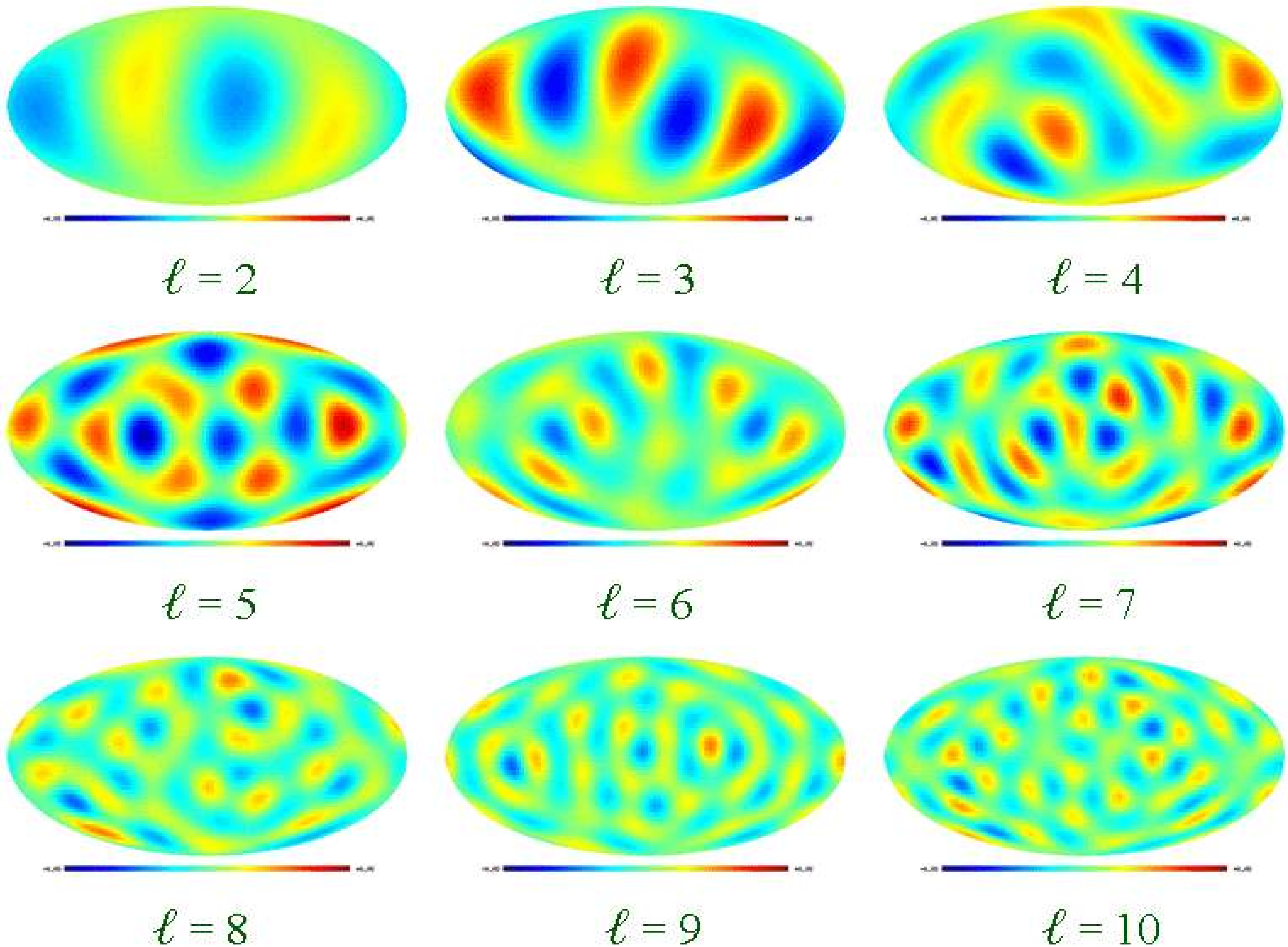


Harmoniques sphériques

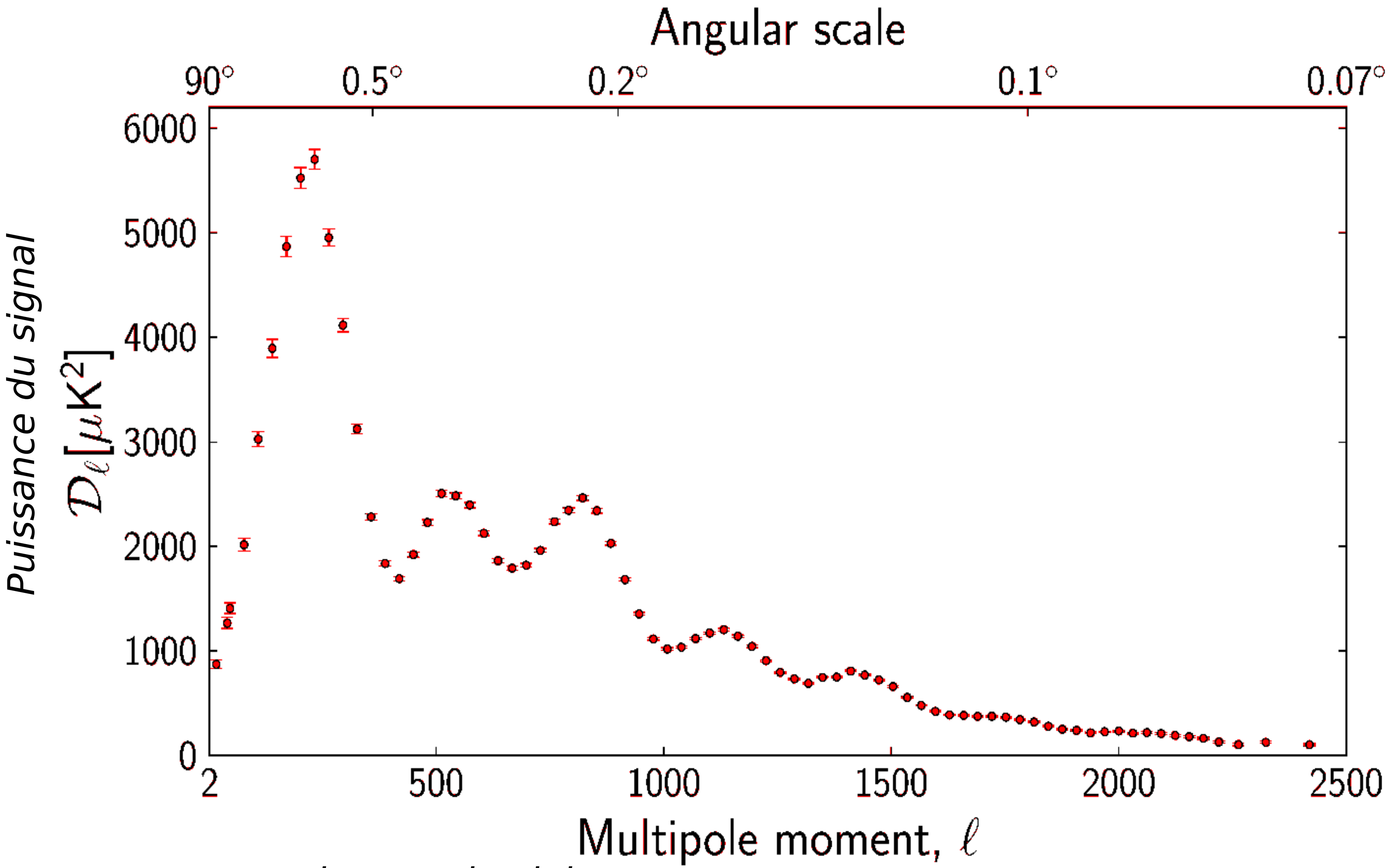
Ordre/multipole



Harmoniques sphériques



Le spectre de puissance par Planck



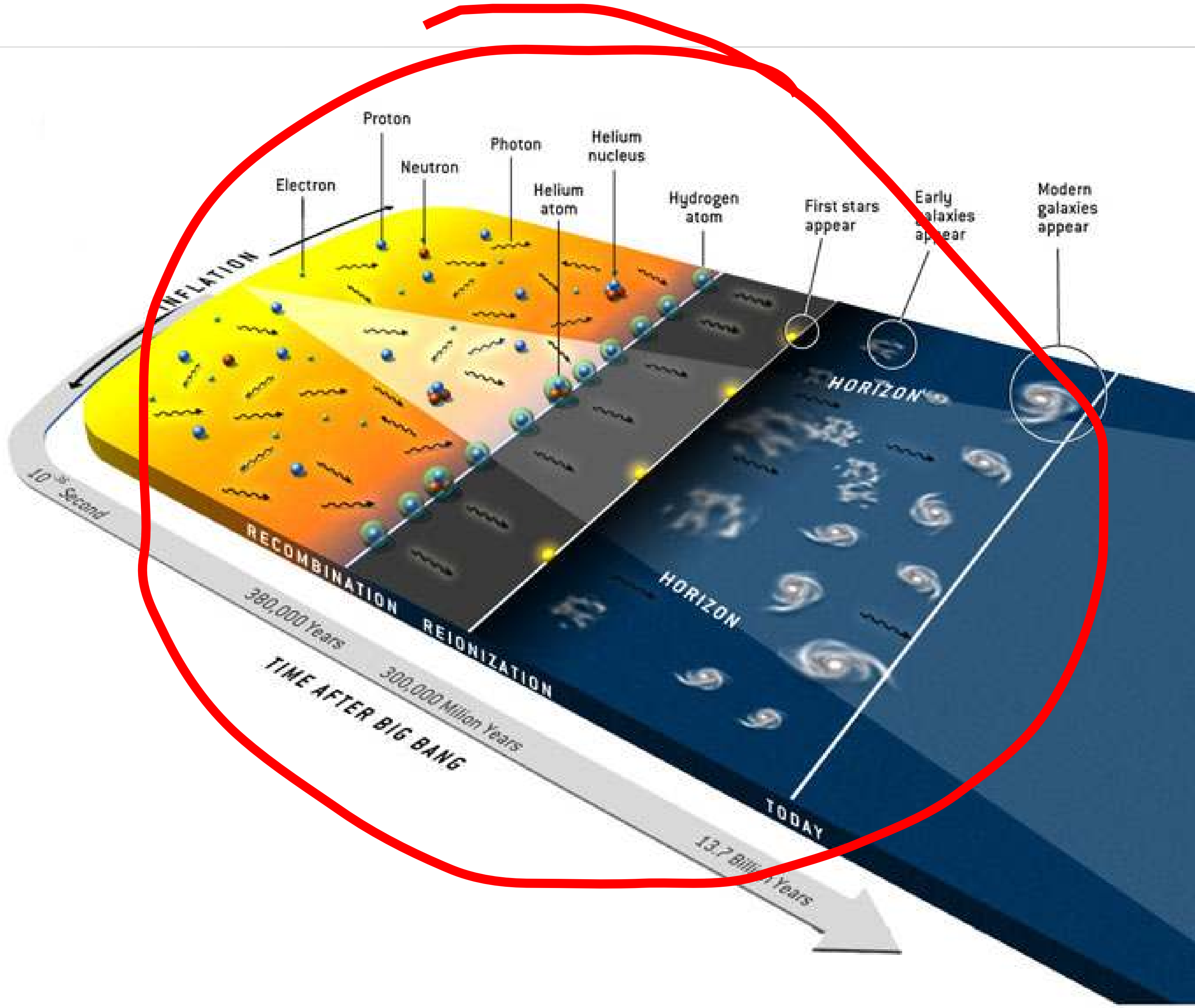
« mode » sur le ciel, ou
inverse de l'échelle angulaire

I. Un peu d'histoire...

II. Détecter le FDC

III. La science du FDC :

b) Origine des fluctuations (“blobs”)



Proton
Neutron
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First stars appear
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INFLATION
HORIZON
HORIZON
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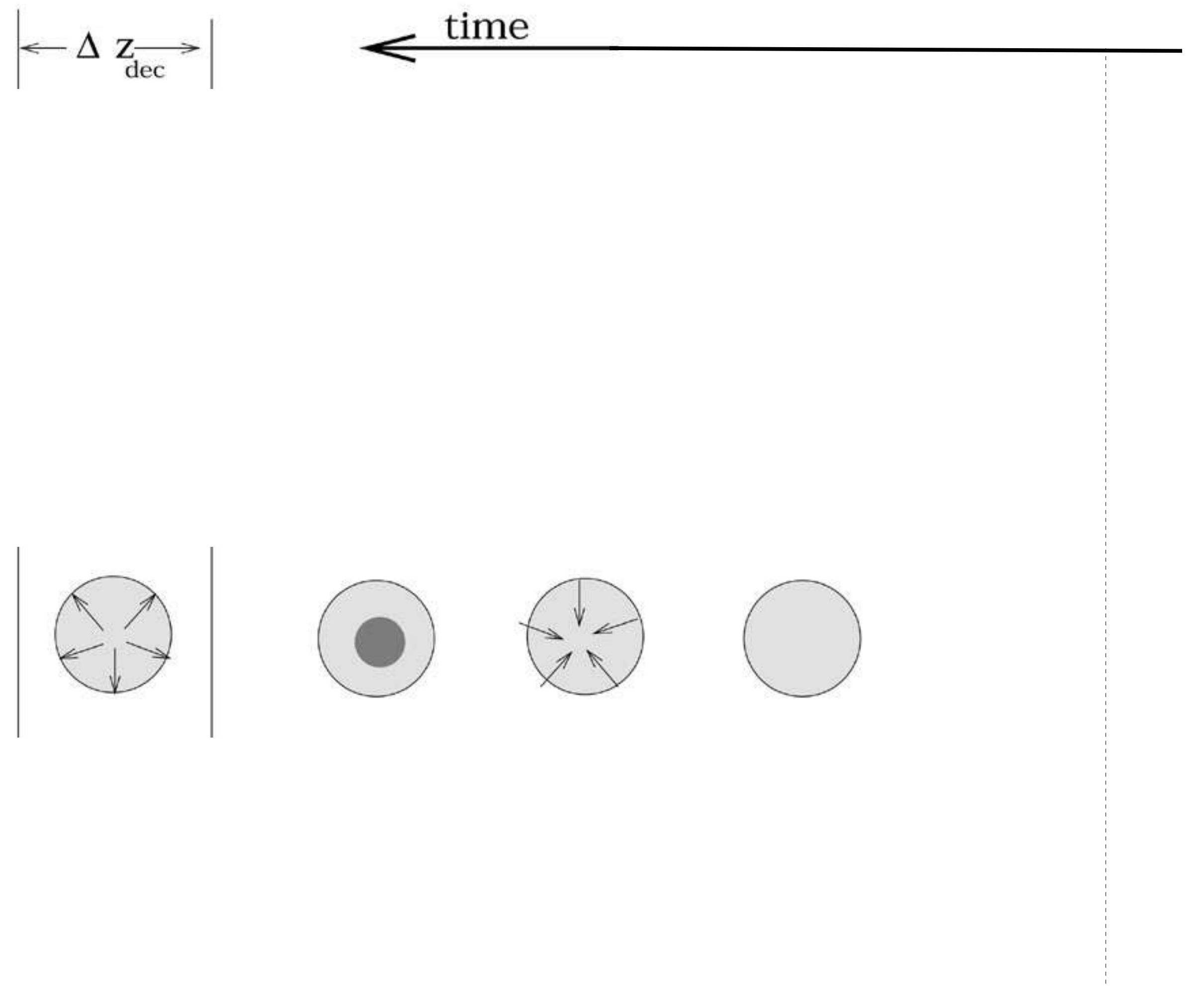
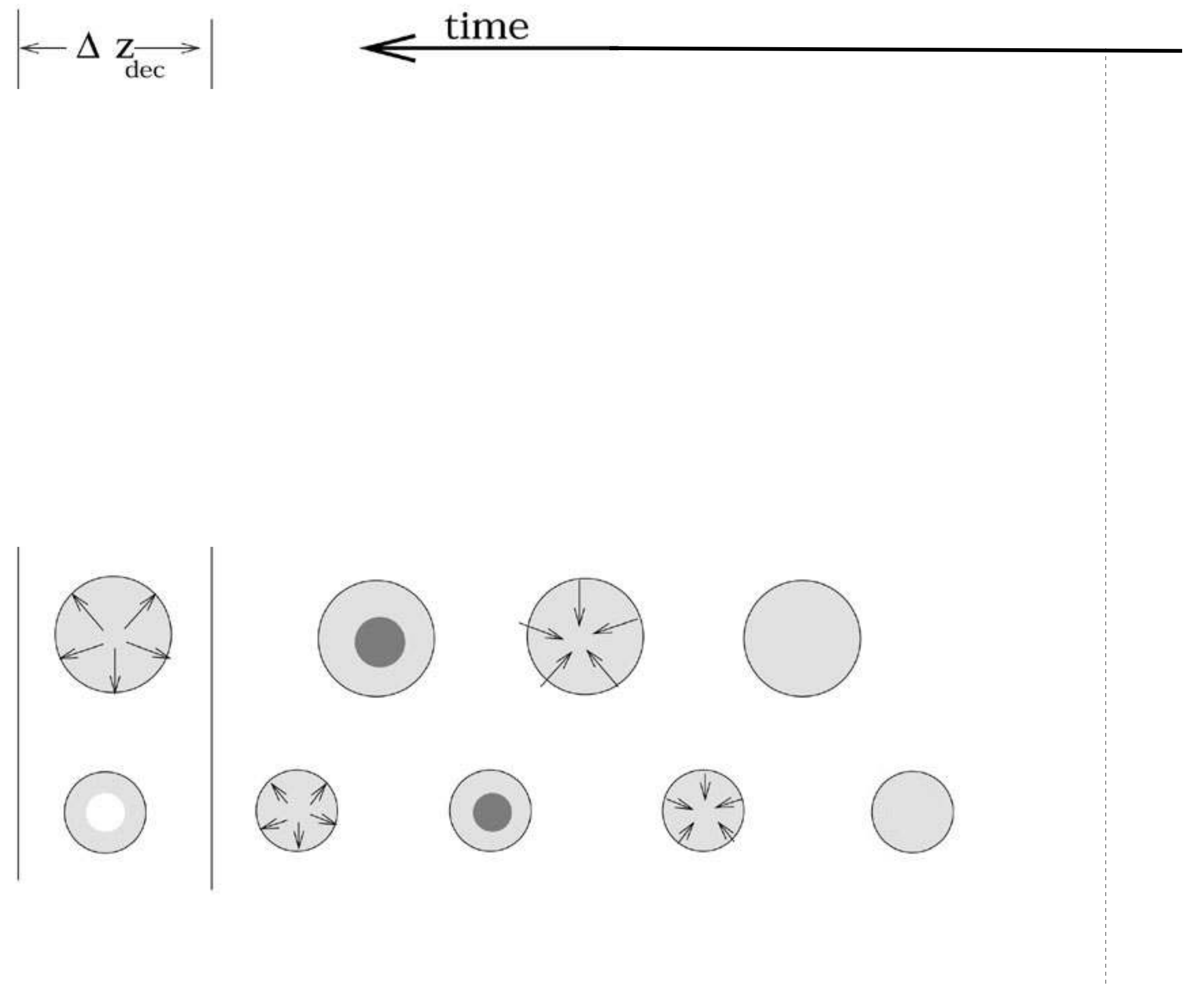
REIONIZATION
TODAY
10^{-35} Second
380,000 Years
300,000 Million Years
13.7 Billion Years
TIME AFTER BIG BANG

Evolution des fluctuations primordiales

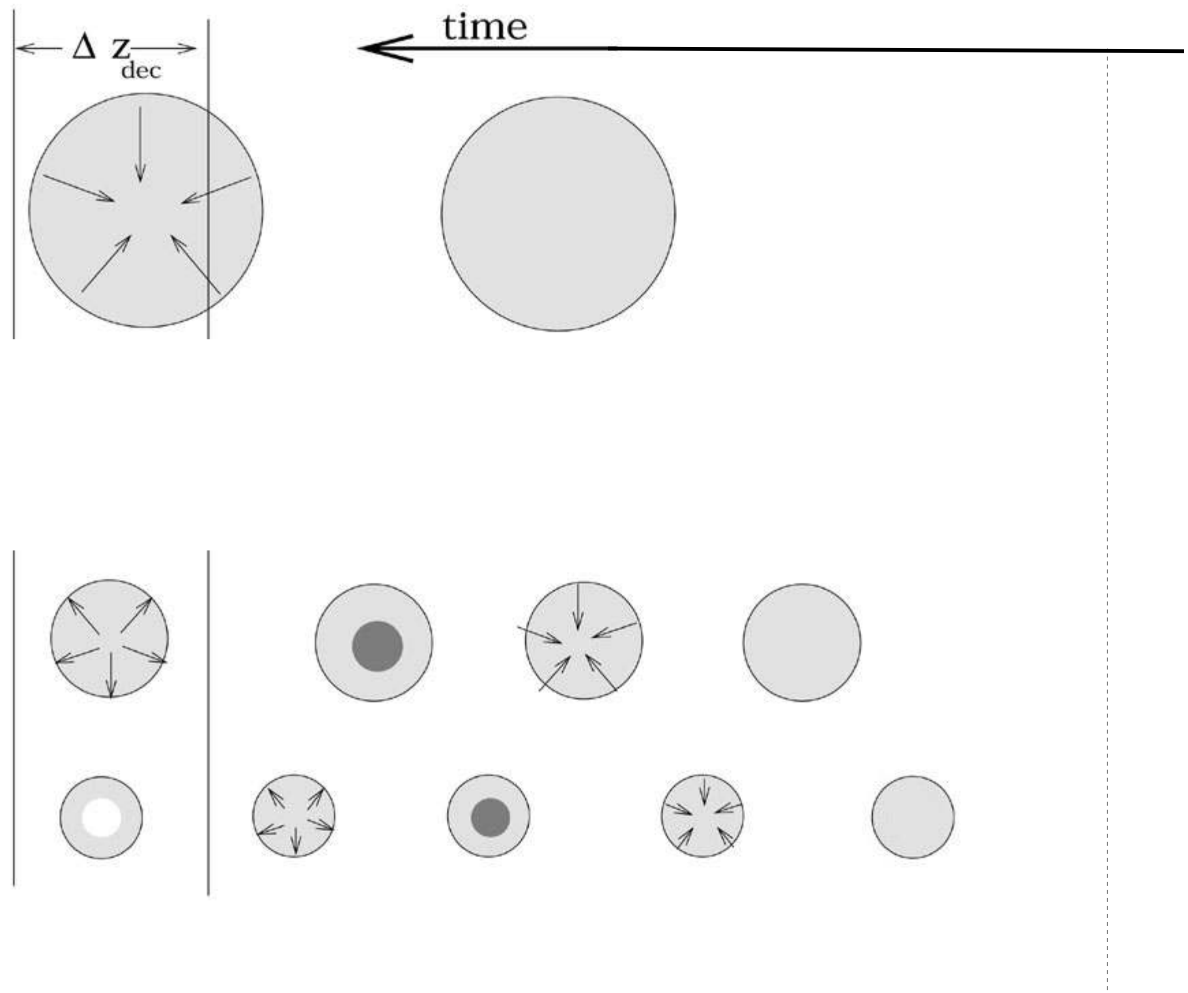
= aggrégat de matière baryonique + photon



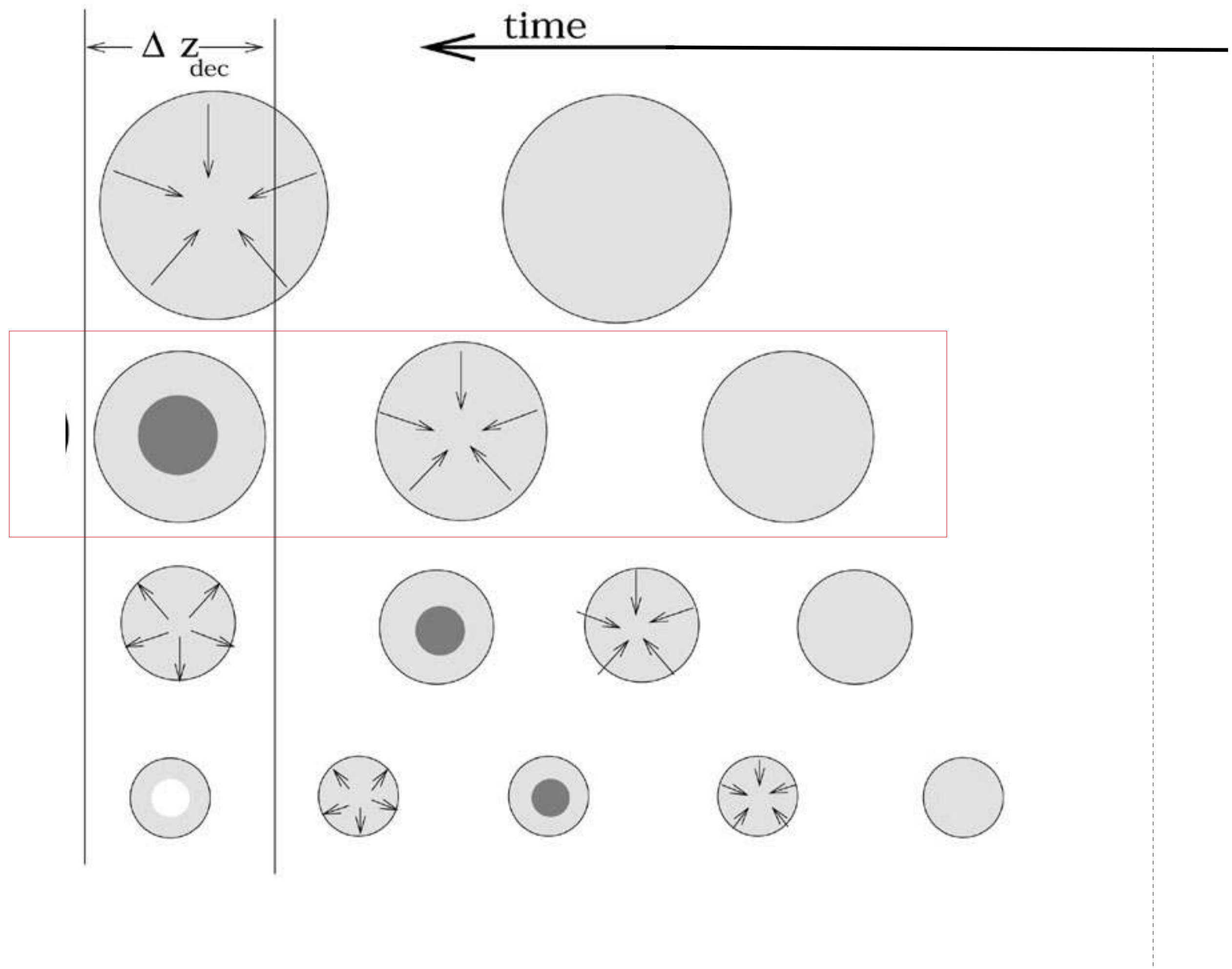
Evolution des fluctuations primordiales



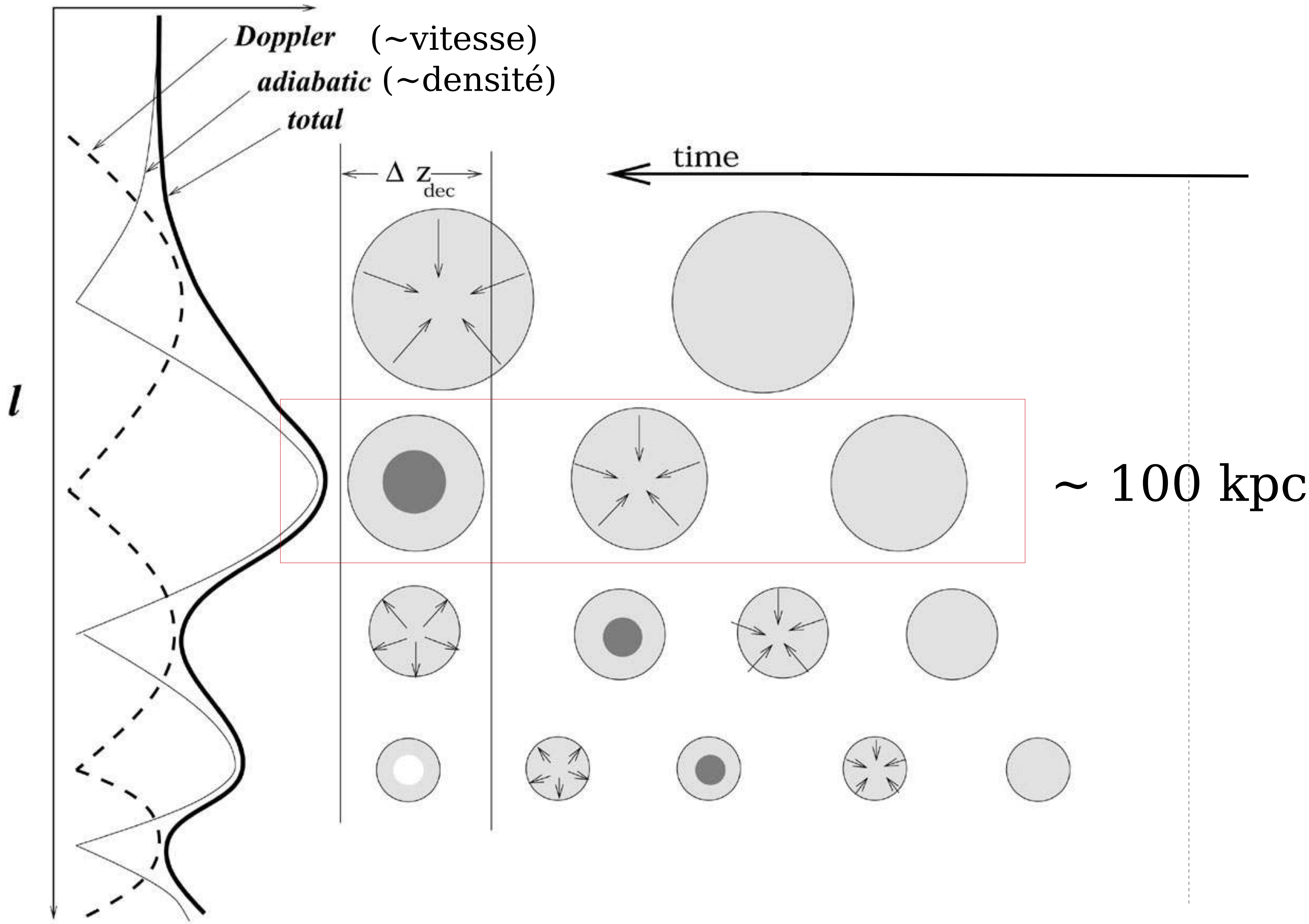
Evolution des fluctuations primordiales



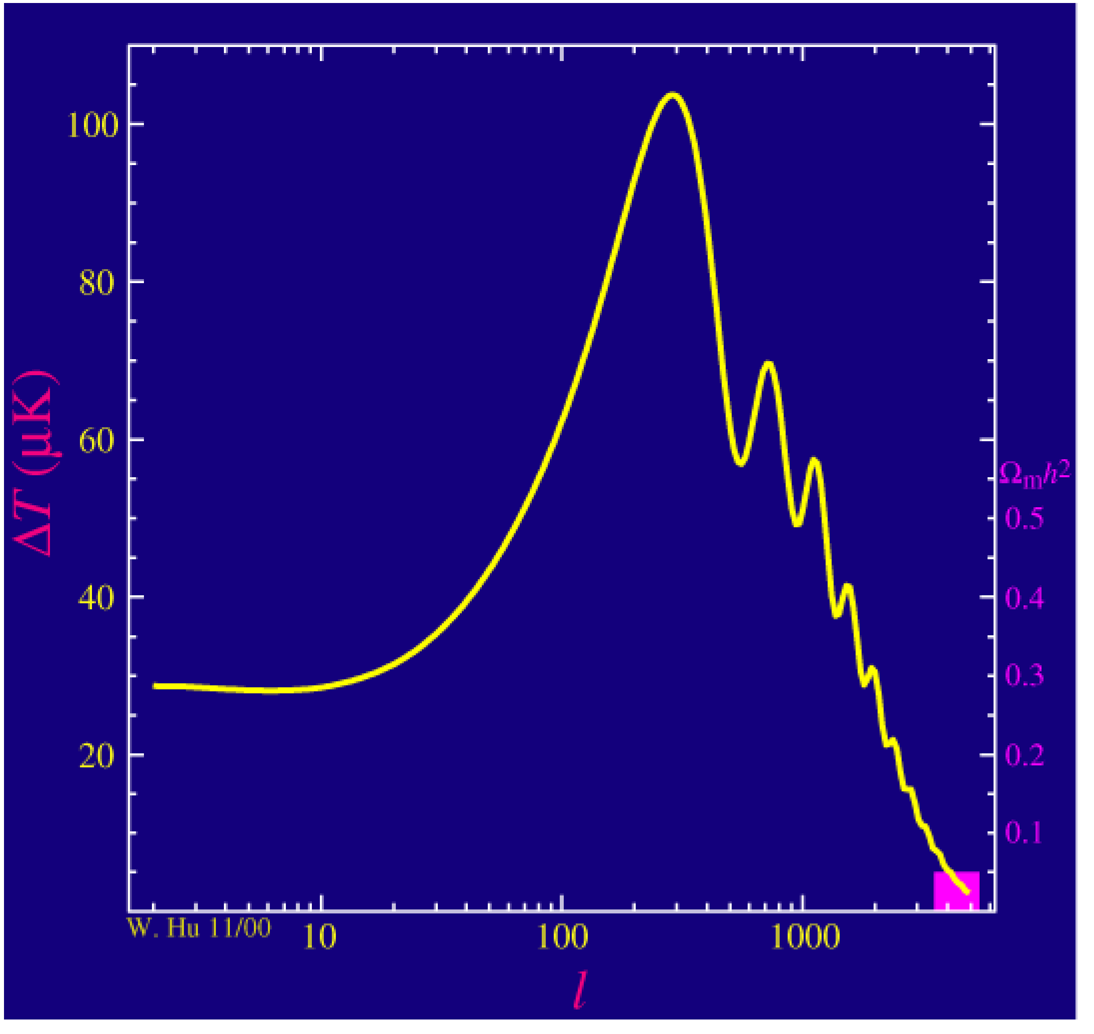
Evolution des fluctuations primordiales



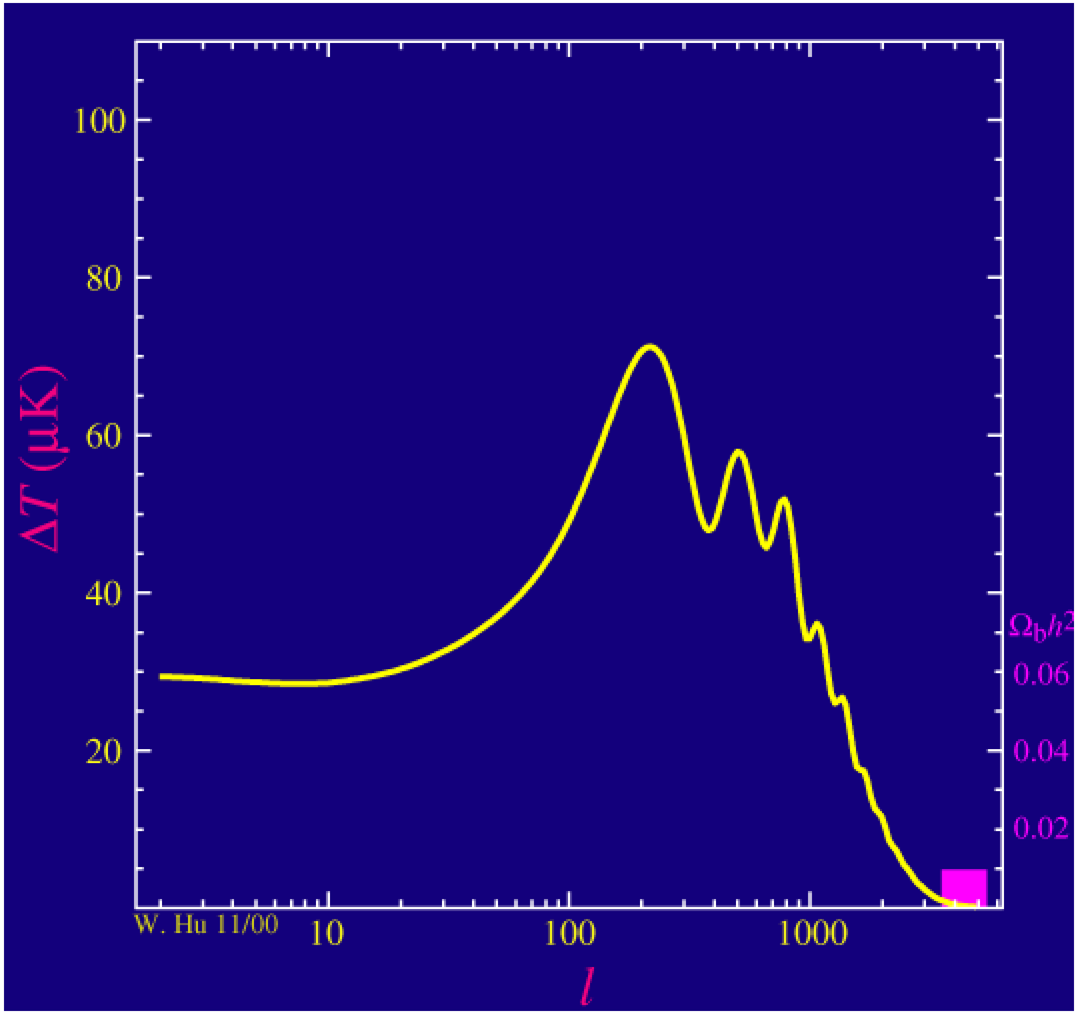
Evolution des fluctuations primordiales



Effet de la quantité de matère (totale)



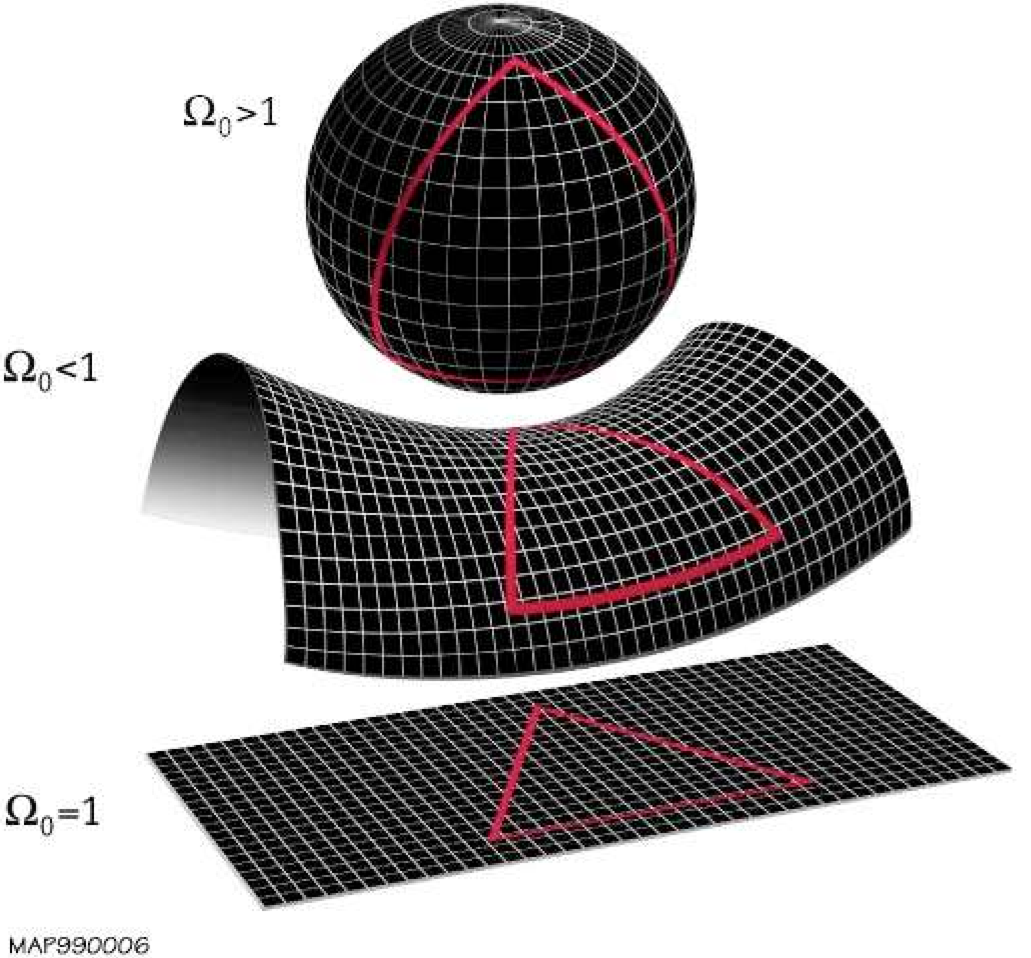
Effet de la quantité de baryons

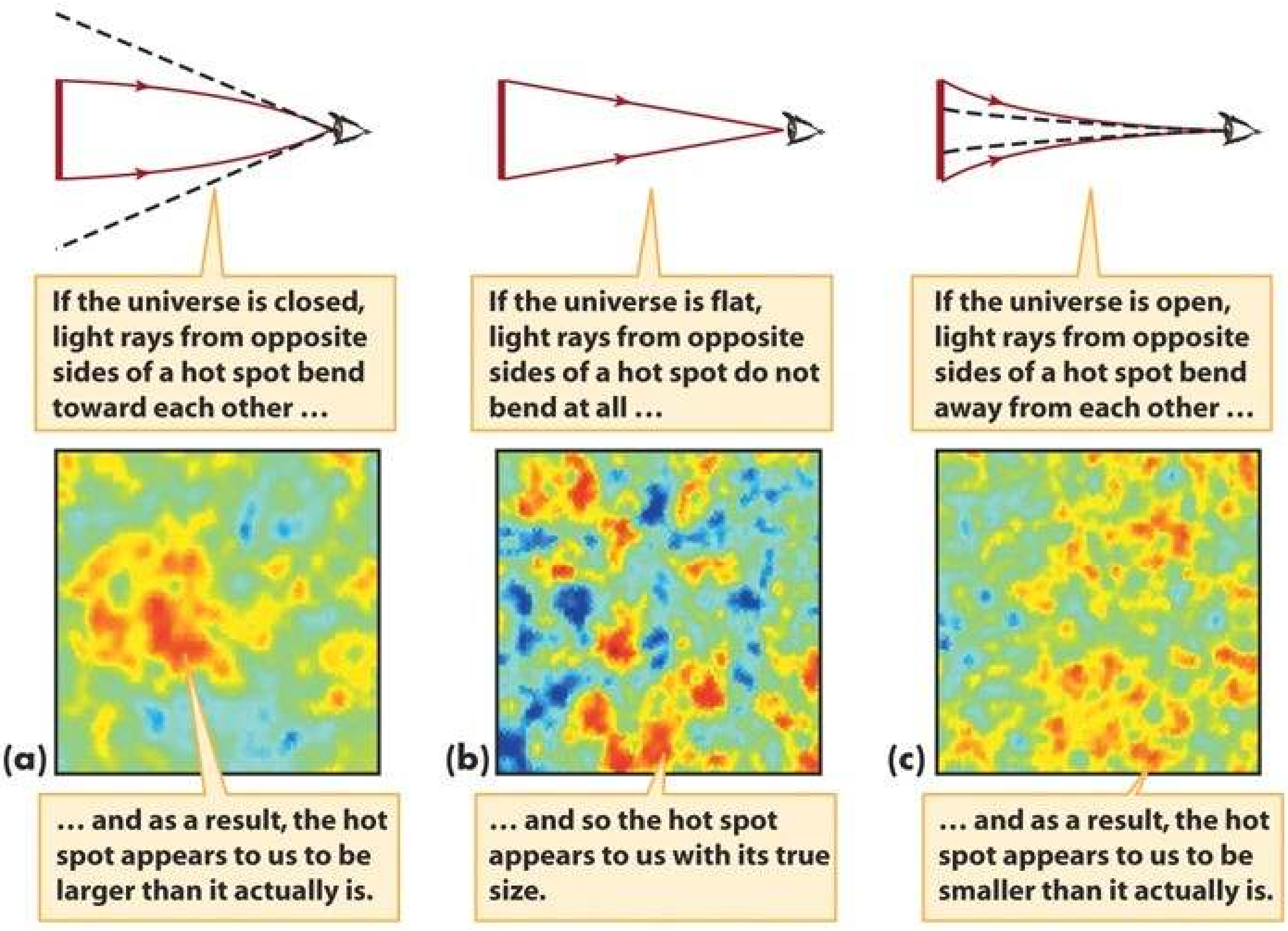


Taille physique des “blobs” → OK

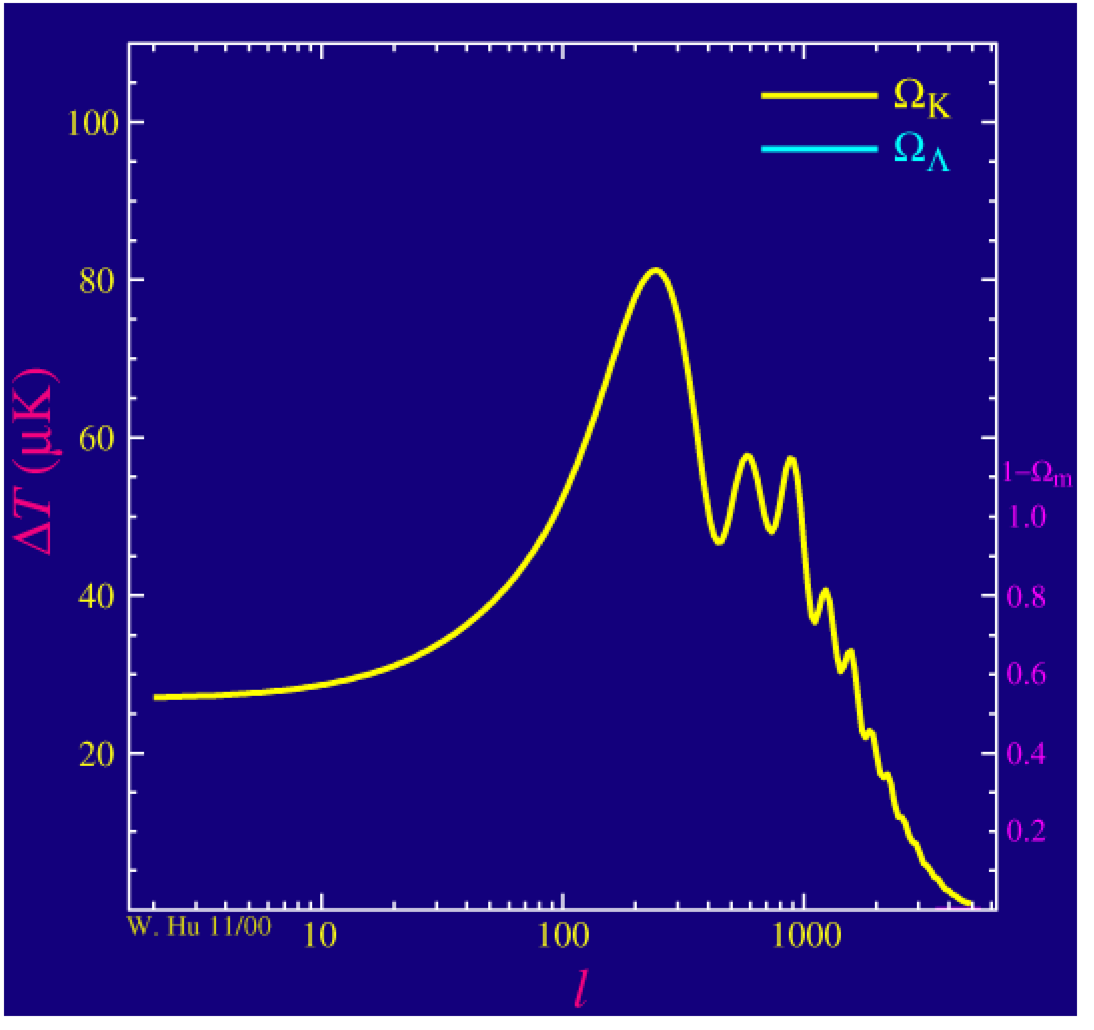
Taille apparente dans le ciel ?

Taille apparentre des fluctuations

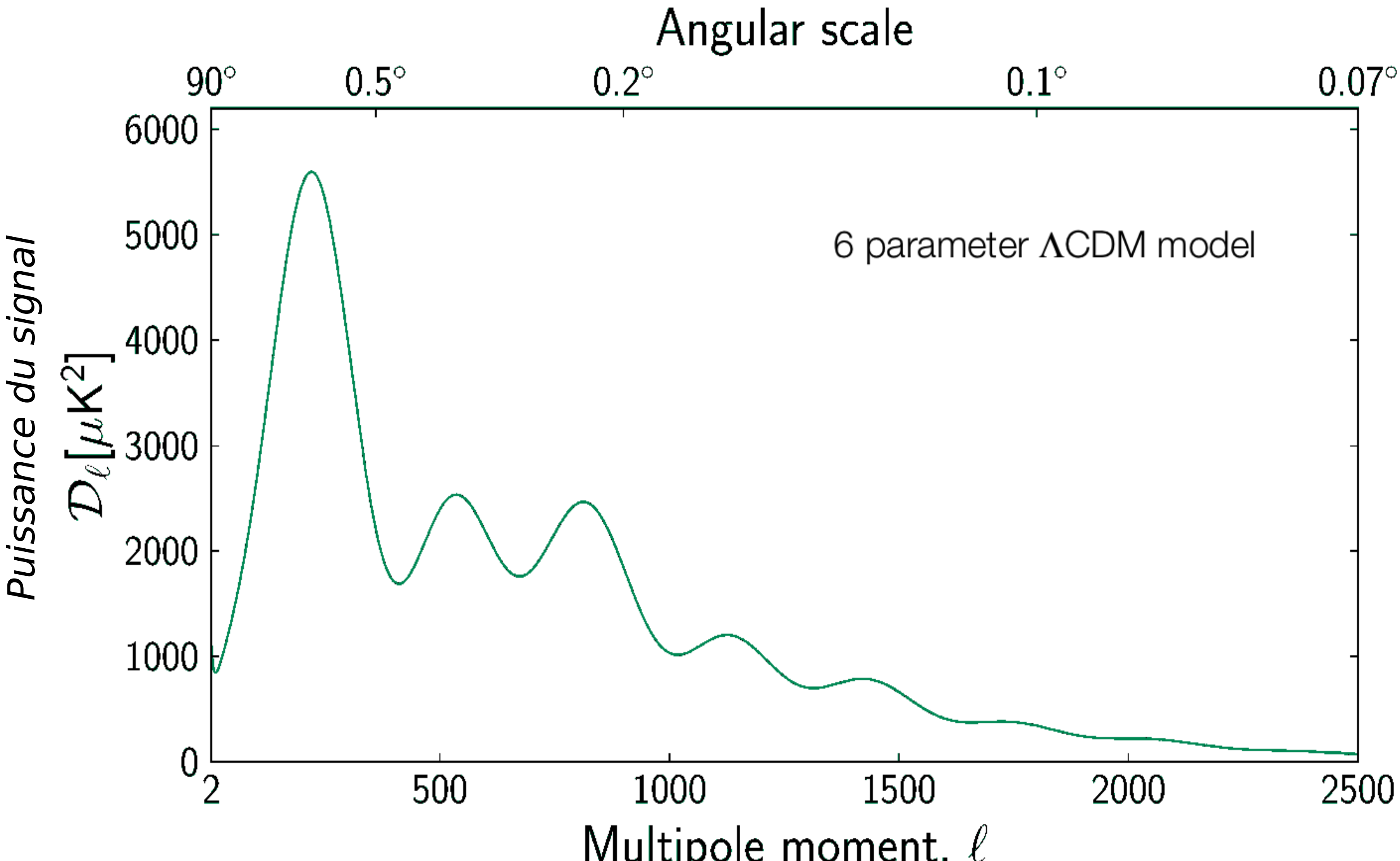



If the universe is closed, light rays from opposite sides of a hot spot bend toward each other …
If the universe is flat, light rays from opposite sides of a hot spot do not bend at all …
If the universe is open, light rays from opposite sides of a hot spot bend away from each other …
(a)
(b)
(c)
… and as a result, the hot spot appears to us to be larger than it actually is.
… and so the hot spot appears to us with its true size.
… and as a result, the hot spot appears to us to be smaller than it actually is.

Effet de la densité totale

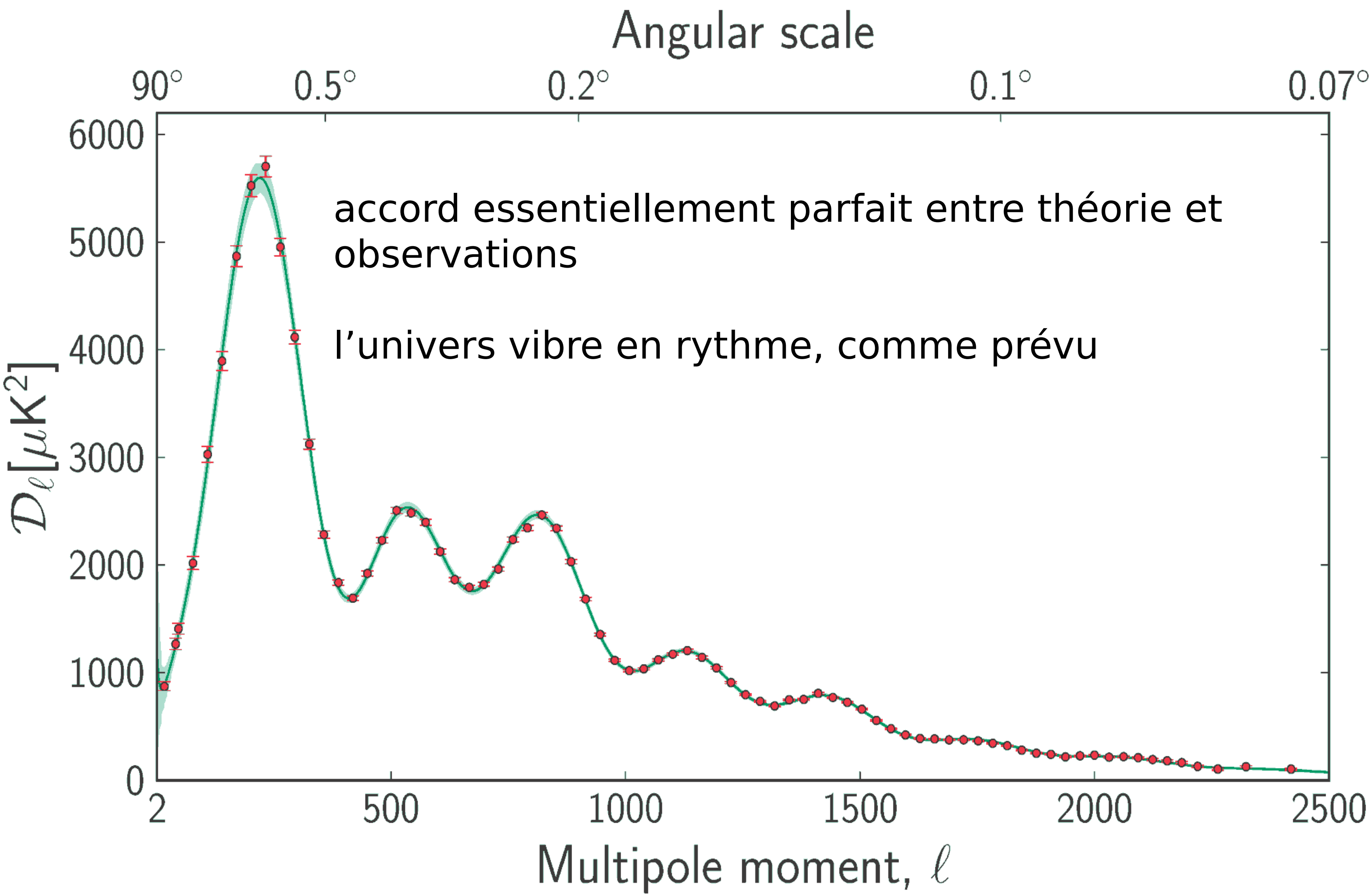


Le spectre de puissance théorique



« mode » sur le ciel, ou
inverse de l'échelle angulaire

La comparaison…



accord essentiellement parfait entre théorie et observations

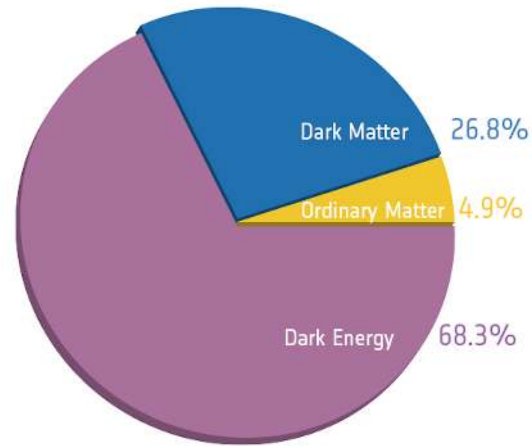
l’univers vibre en rythme, comme prévu

Puissance du signal

« mode » sur le ciel, ou
inverse de l’échelle angulaire

Les paramètres du modèle standard

Table 9. Parameter 68 % confidence levels for the base ΛCDM cosmology computed from the *Planck* CMB power spectra, in combination with the CMB lensing likelihood ("lensing").

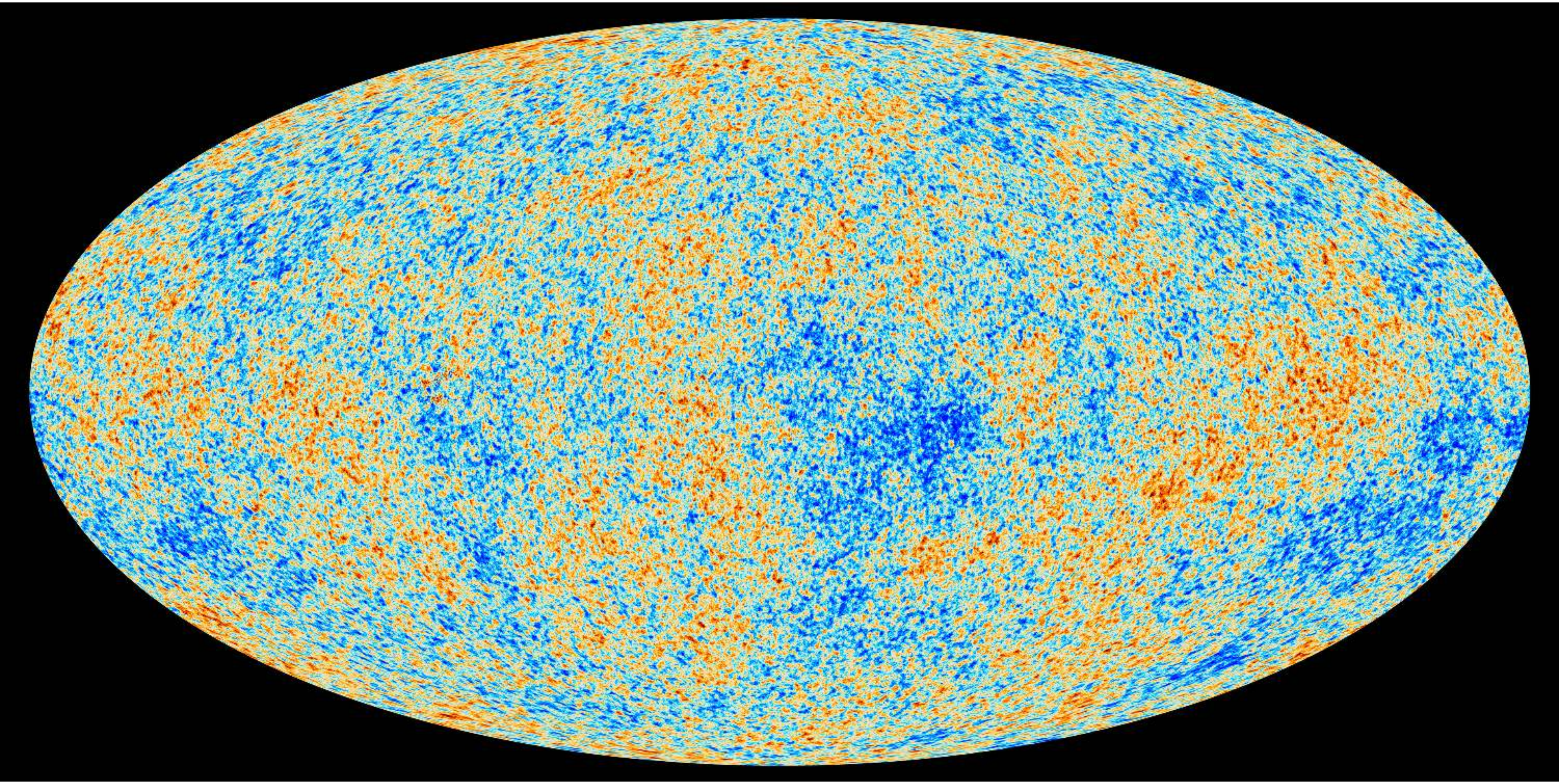


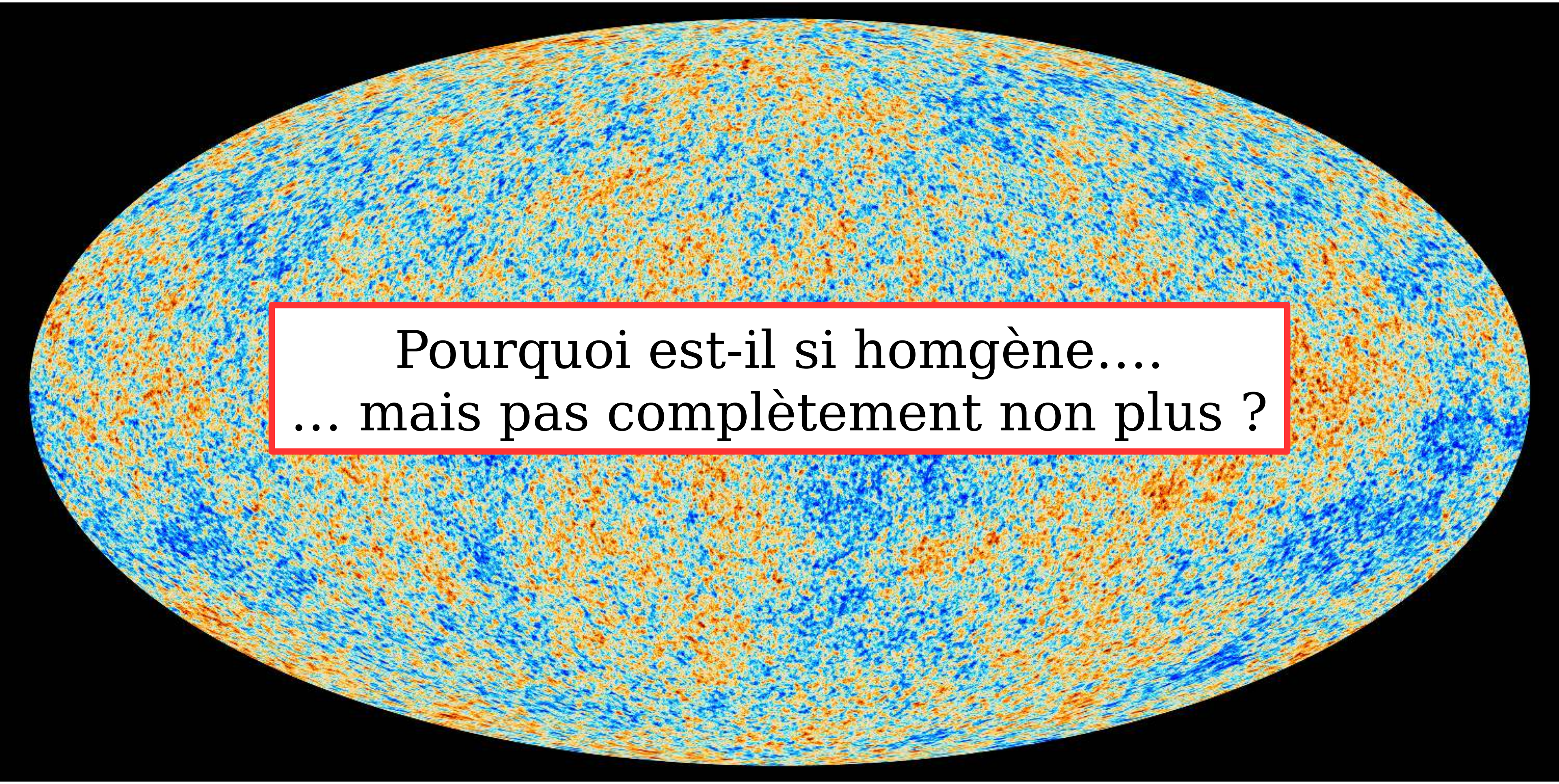
Parameter	*Planck* TT+lowP+lensing
$\Omega_b h^2$	0.02226 ± 0.00023
$\Omega_c h^2$	0.1186 ± 0.0020
$100\theta_{MC}$	1.04103 ± 0.00046
τ	0.066 ± 0.016
$\ln(10^{10} A_s)$	3.062 ± 0.029
n_s	0.9677 ± 0.0060
H_0	67.8 ± 0.9
Ω_m	0.308 ± 0.012
$\Omega_m h^2$	0.1415 ± 0.0019
$\Omega_m h^3$	0.09591 ± 0.00045
σ_8	0.815 ± 0.009
$\sigma_8 \Omega_m^{0.5}$	0.4521 ± 0.0088
Age/Gyr	13.799 ± 0.038
r_{drag}	147.60 ± 0.43
k_{eq}	0.01027 ± 0.00014

6 paramètres cosmologiques

0.3% d'incertitude !

Planck Collab, 2015, 1

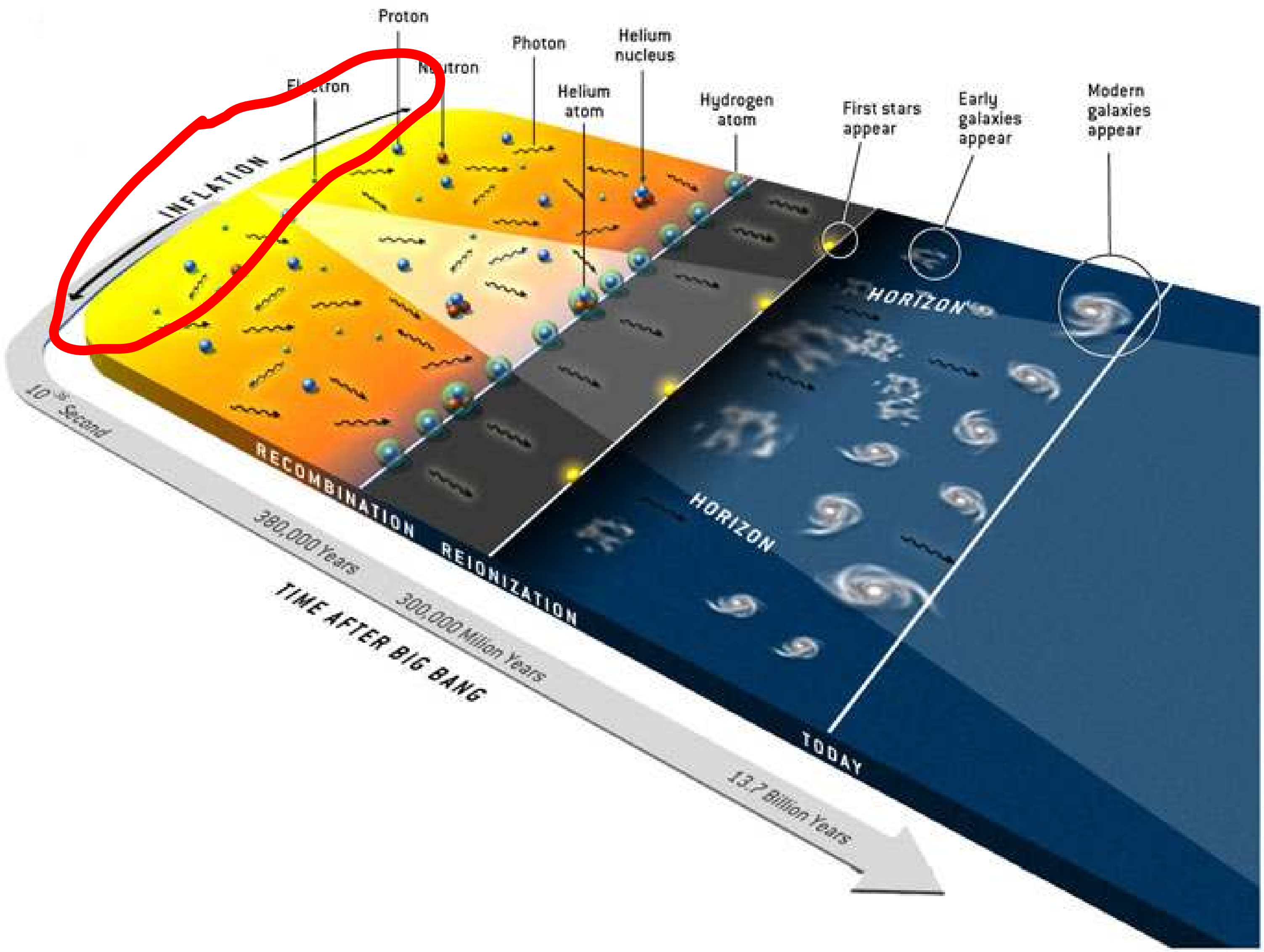



Pourquoi est-il si homgène….
… mais pas complètement non plus ?

I. Un peu d'histoire...

II. Détecter le FDC

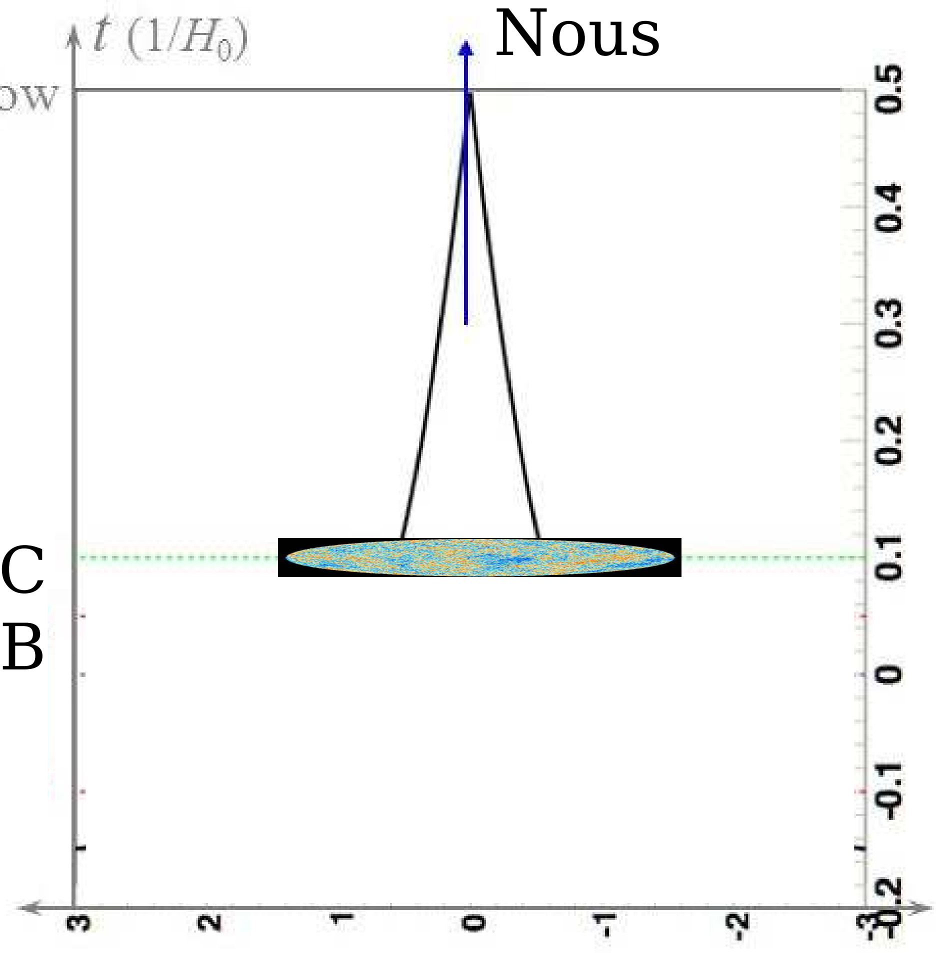
III. La science du FDC :
c) Univers primordial et FDC



Proton
Photon
Helium nucleus
Helium atom
Hydrogen atom
First stars appear
Early galaxies appear
Modern galaxies appear
INFLATION
HORIZON
HORIZON
RECOMBINATION
REIONIZATION
TODAY
380,000 Years
300,000 Million Years
13.7 Billion Years
TIME AFTER BIG BANG

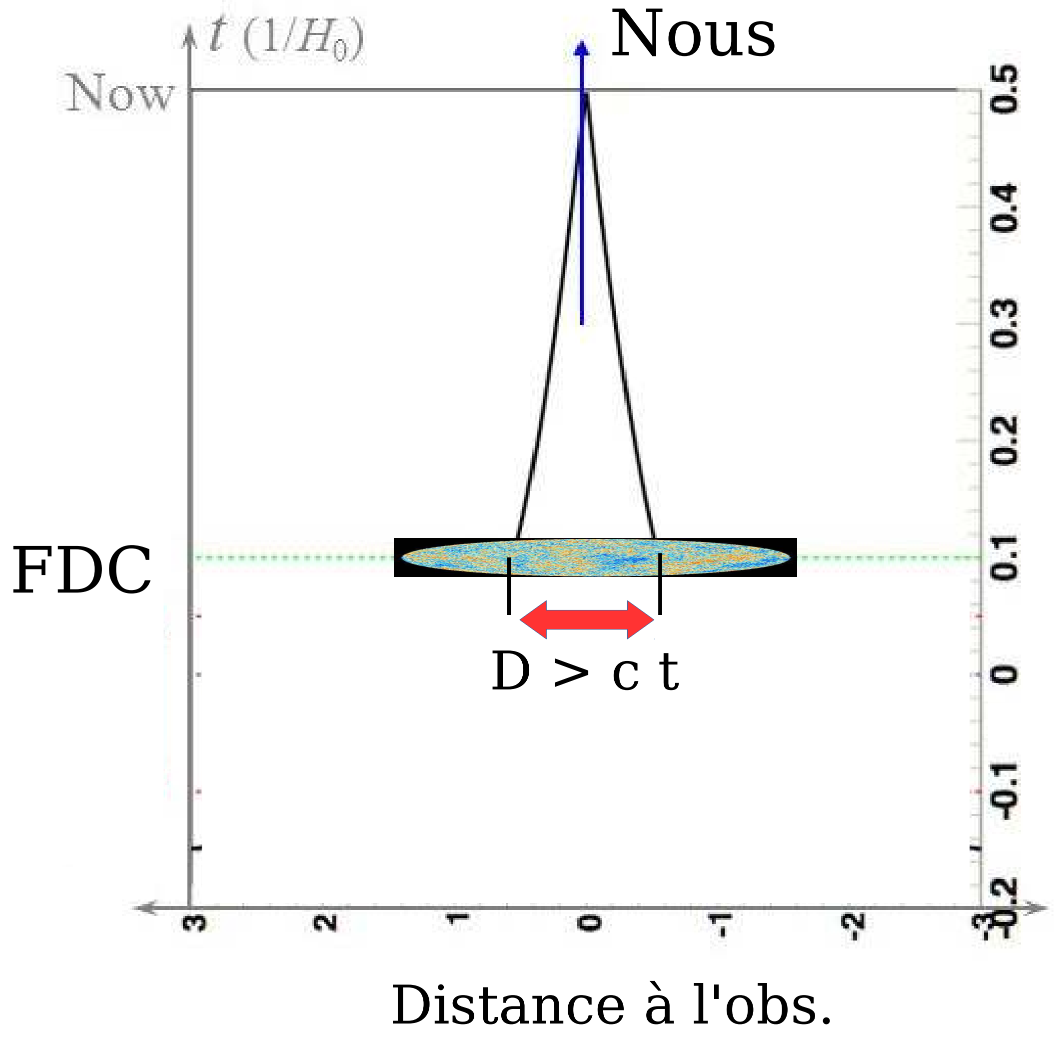
L'inflation cosmique

FDC
380,000 ans après BB

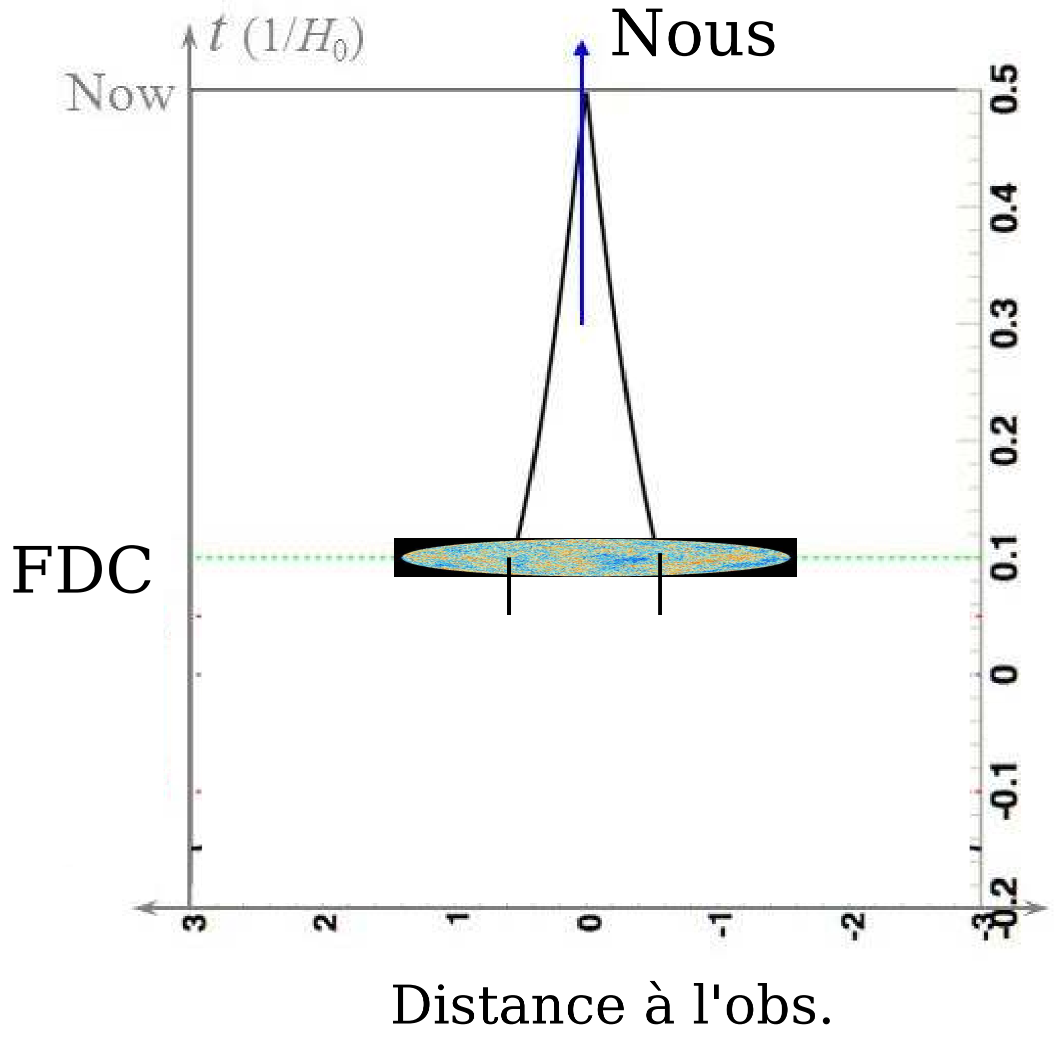


Distance à l'obs.

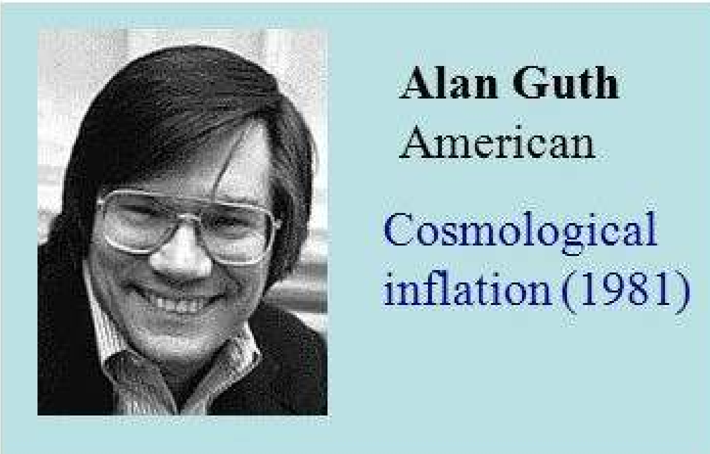
L'inflation cosmique

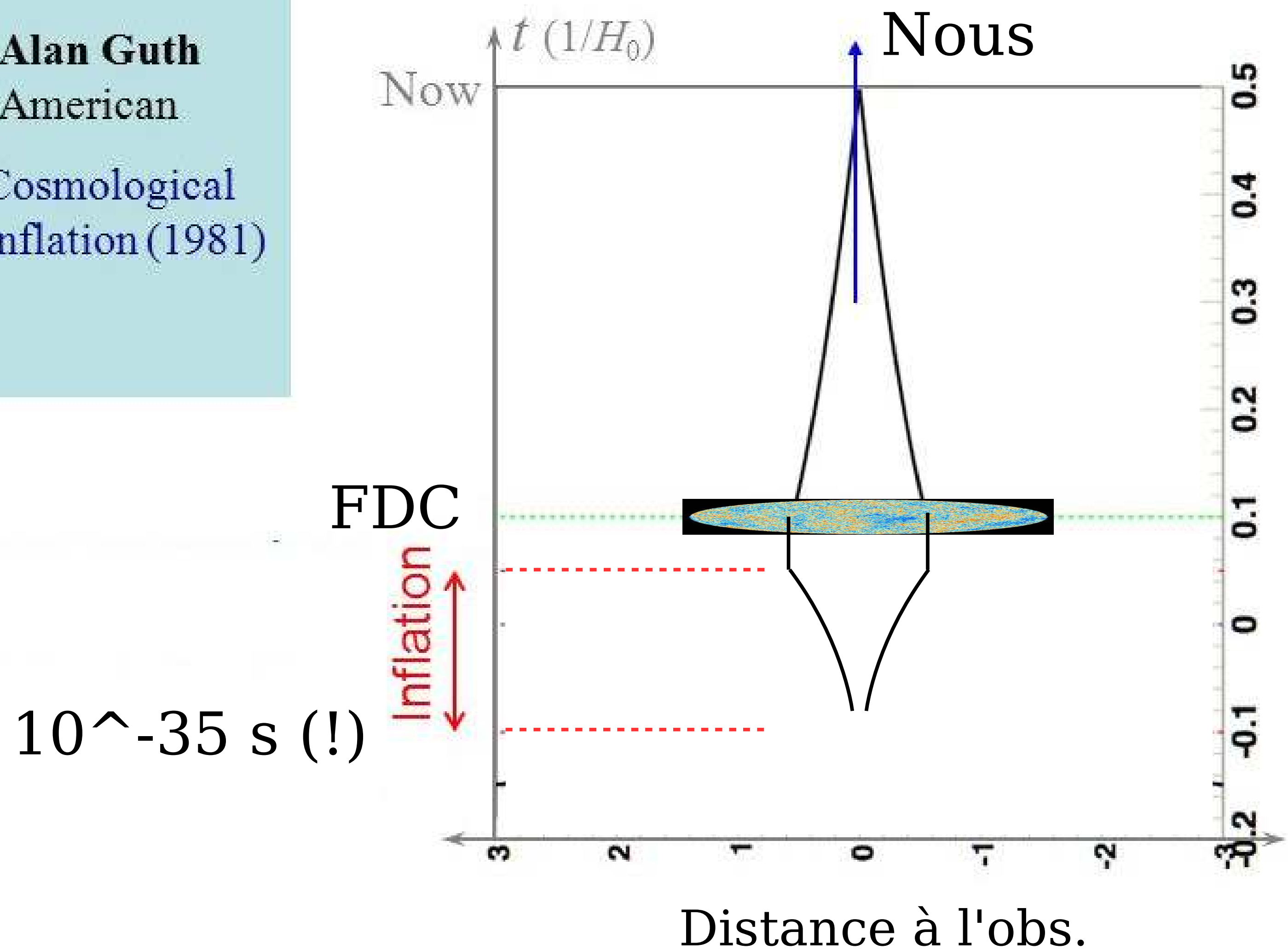


L'inflation cosmique

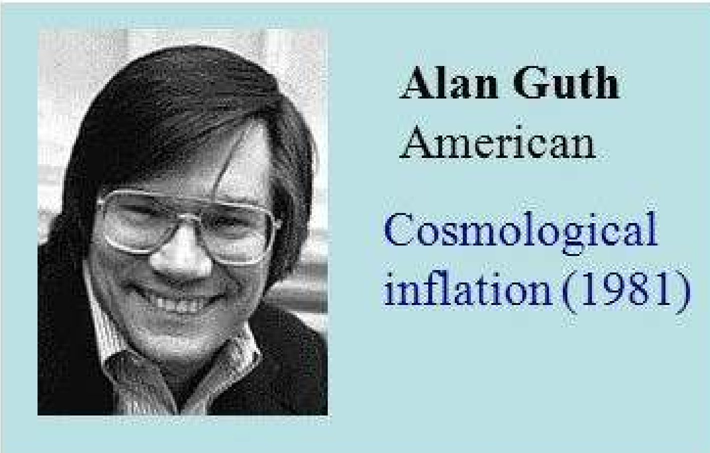


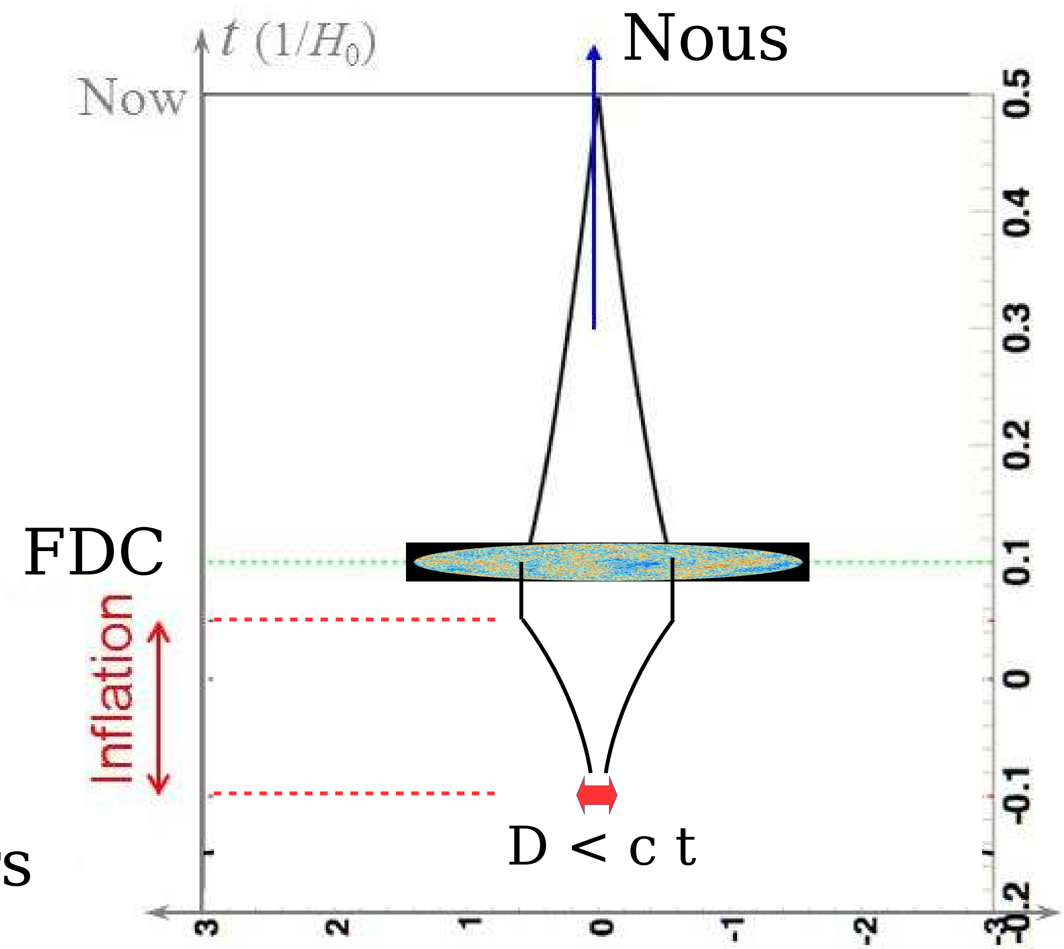
L'inflation cosmique





L'inflation cosmique

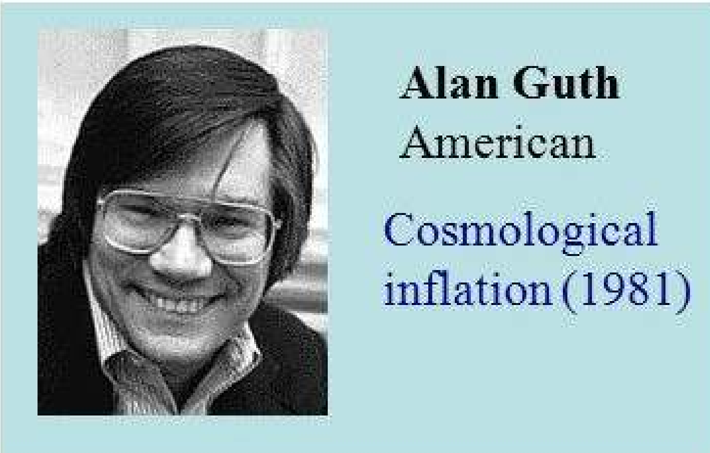


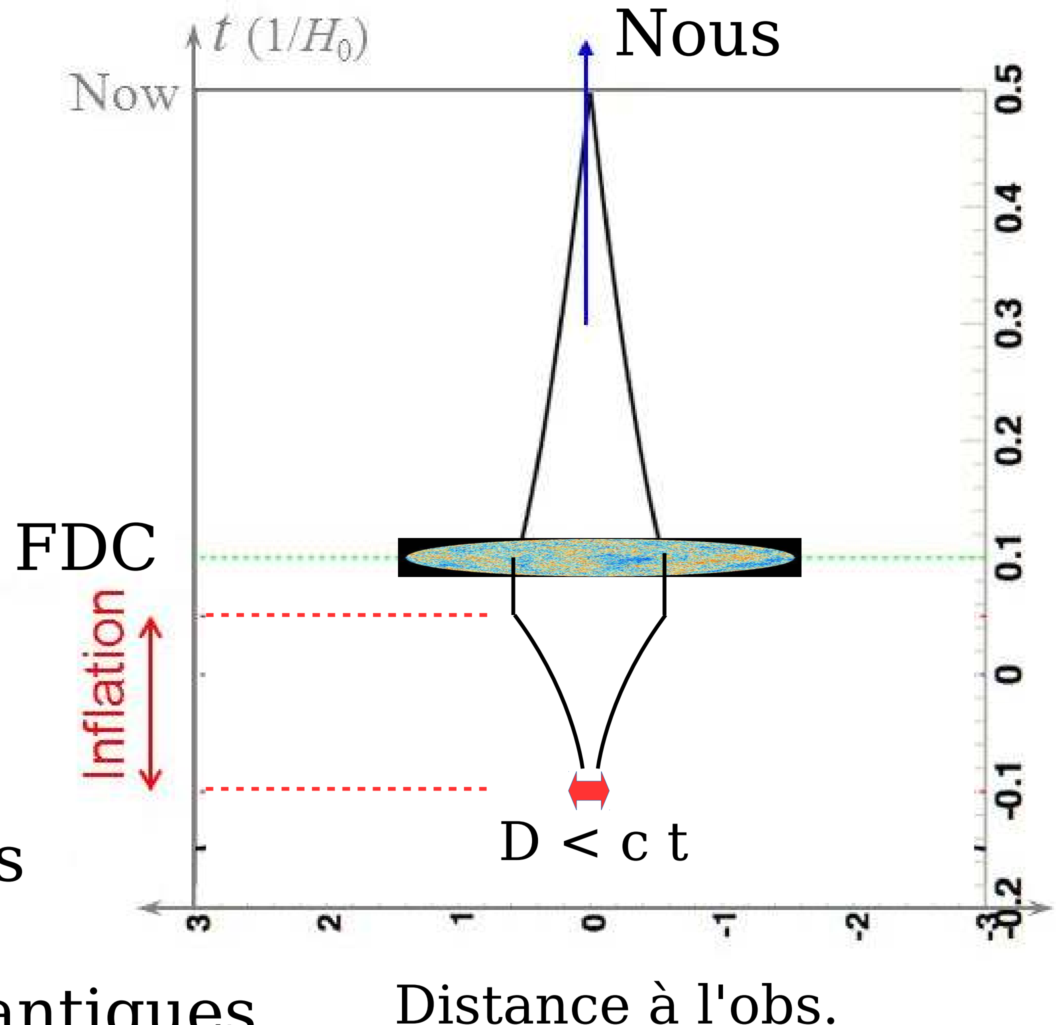


Distance à l'obs.

- Homogénéise l'Univers

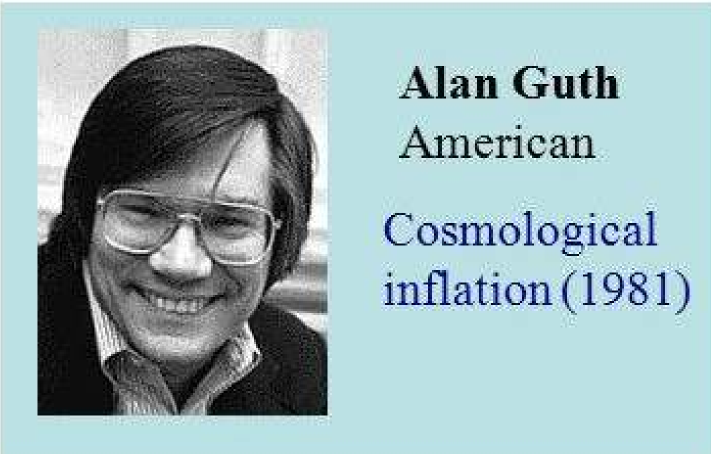
L'inflation cosmique

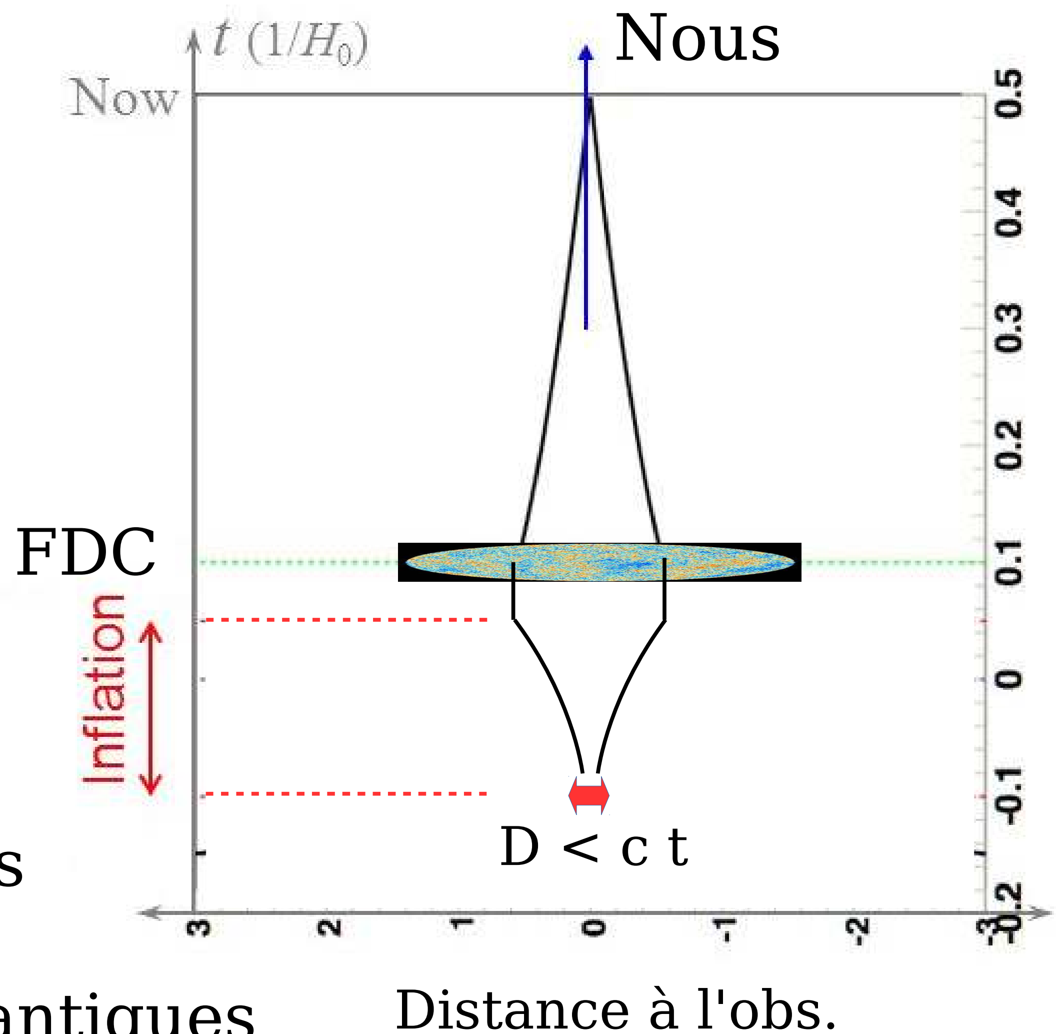




- Homogénéise l'Univers
- Génère fluctu. macro.
  à partir des fluctu. quantiques

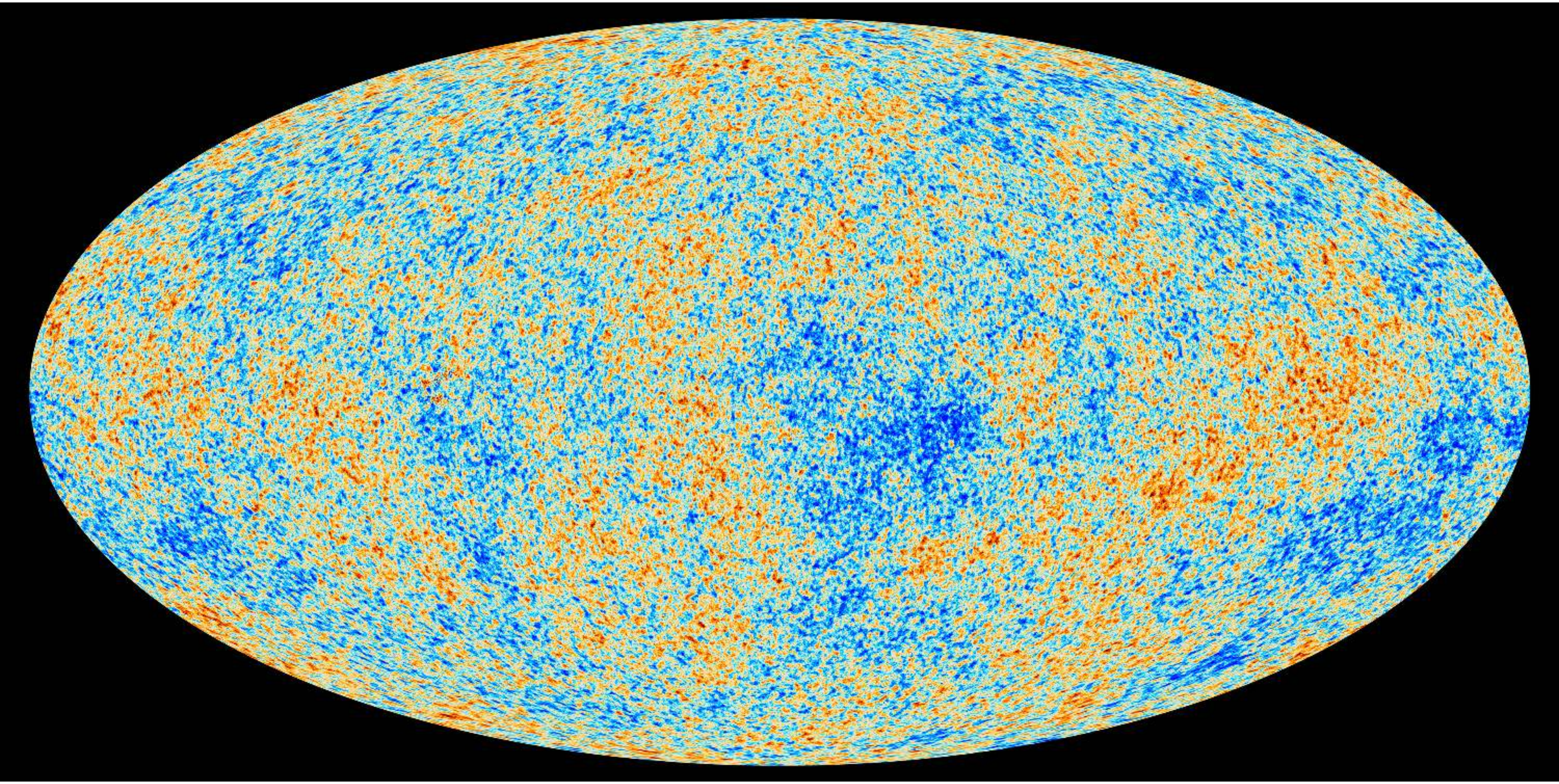
L'inflation cosmique



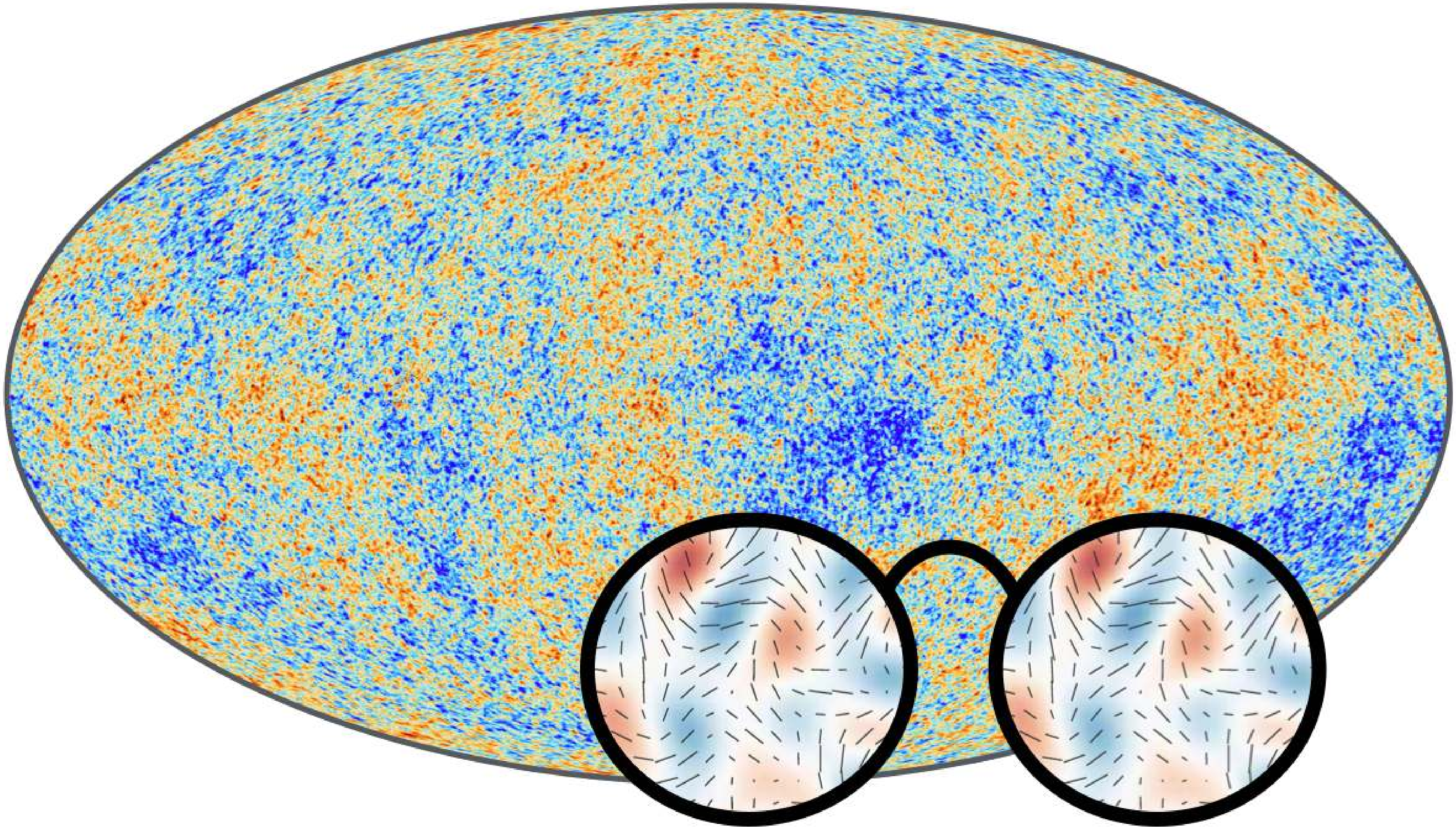


- Homogénéise l'Univers
- Génère fluctu. macro.
  à partir des fluctu. quantiques

Comment vérfier l'inflation ?



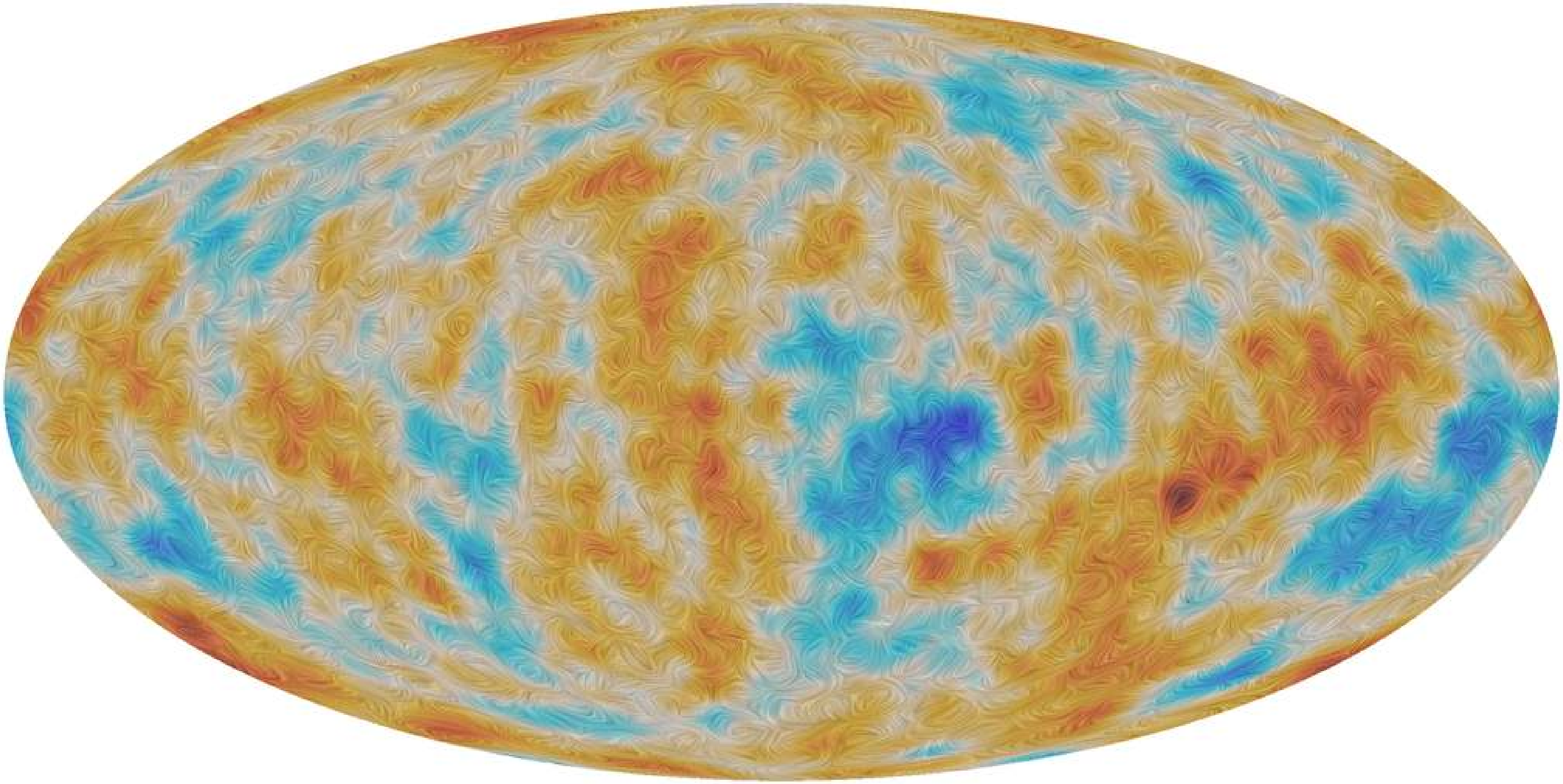
Polarisation du FDC



courtesy J. Aumont

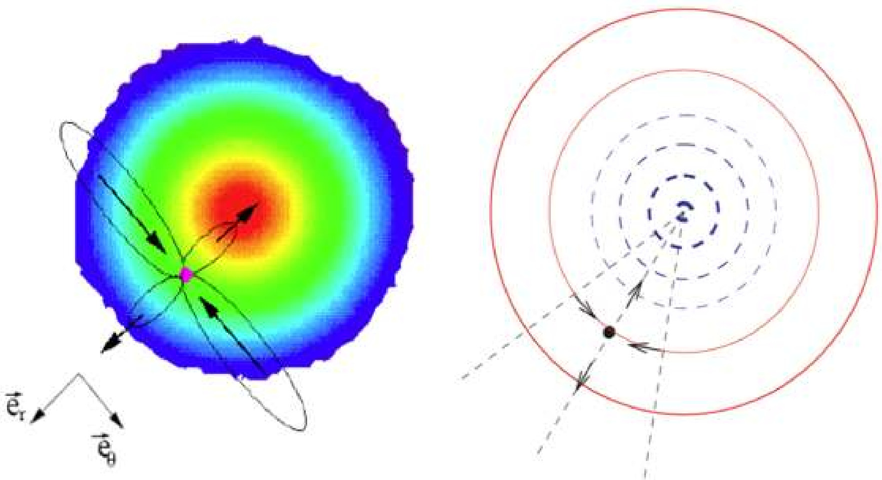
Polarisation vue par Planck

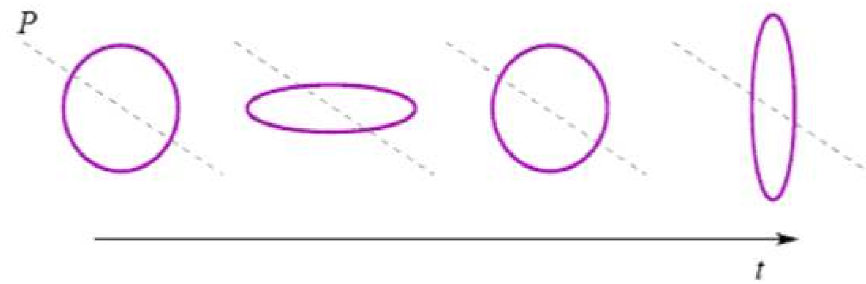
fluctuations de polarisation du FDC



Planck Collab, 2015, 1

Théorie de la polarisation

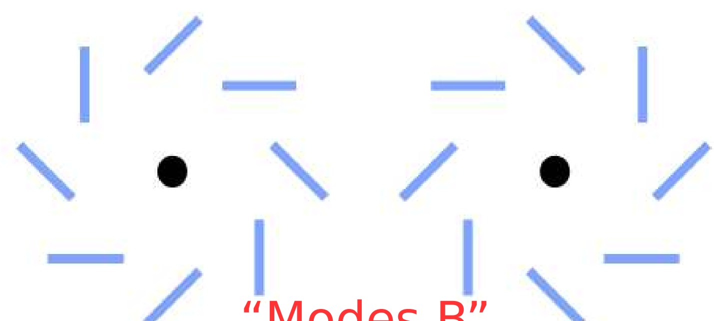




Perturbations scalaires
Perturbations de densité
Génèrent de la polarisation Q_r

Perturbations tensorielles
Ondes gravitationnelles primordiales
Génèrent de la polarisation Q_r et U_r

"Modes E"

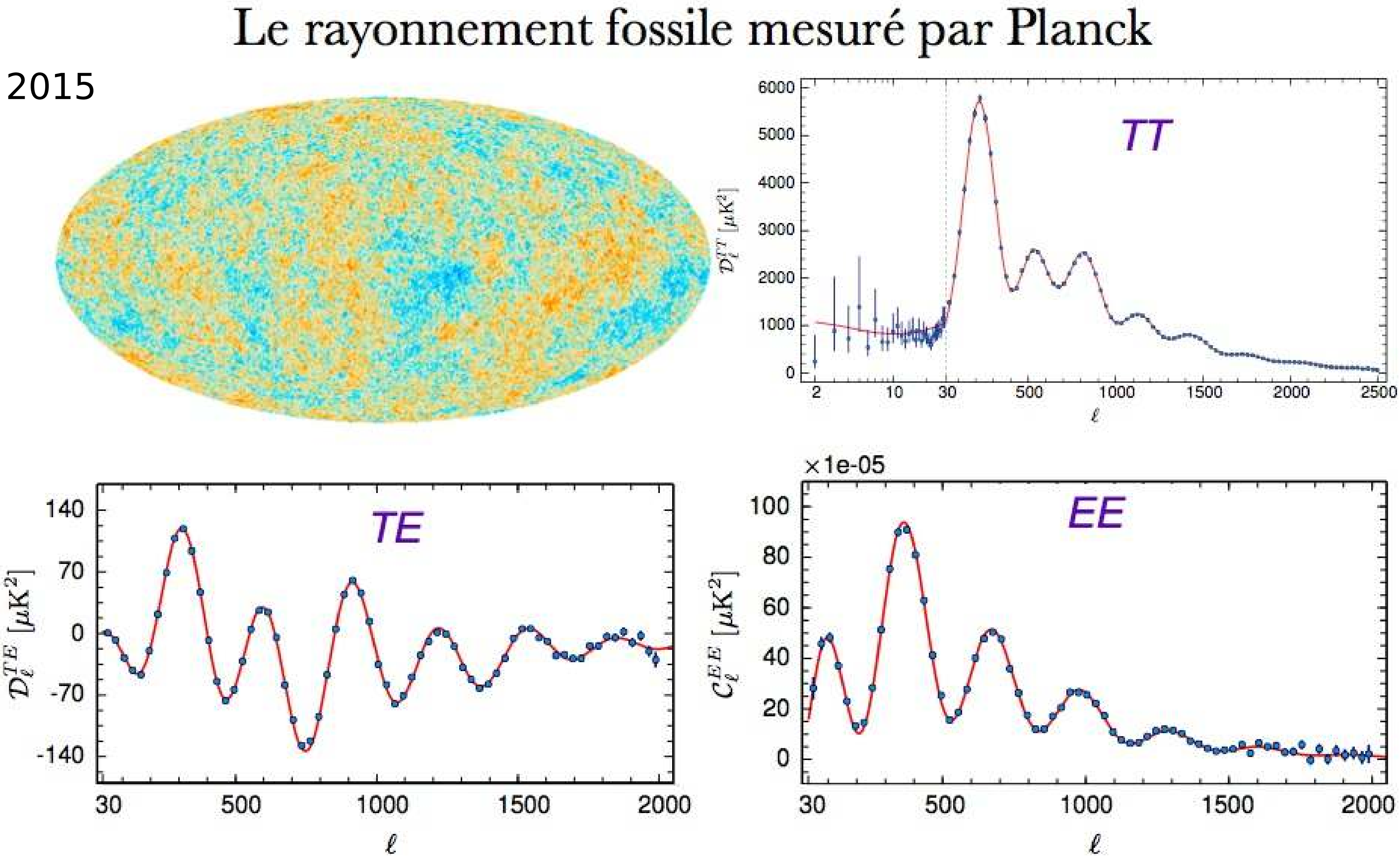


"Modes B"
→ signature directe de l'inflation

courtesy J. Aumont

Modes E ? ok !

2015

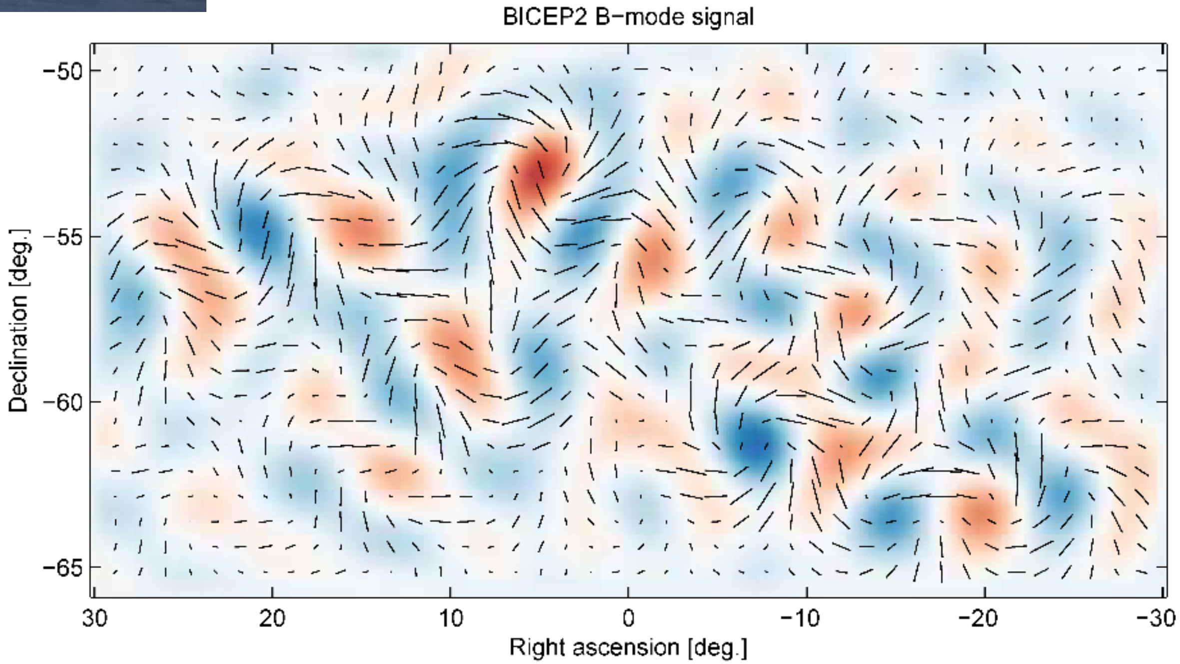


Planck 2015

Modes B ? ... pas encore publié

Modes B de polarisation

Mars 2014 :
détection des modes B primordiaux ?
un débat vif !



Modes B de…

The Washington Post

Achenblog

Cosmic smash-up: BICEP2's big bang discovery getting dusted by new satellite data

nature

Home | News & Comment

News & Comment > News

NATURE | NEWS

Full-Galaxy dust map muddles search for gravitational waves

Planck probe's survey of polarized light casts further doubt on BICEP2's gravitational-wave discovery claims.

Ron Cowen

Fig. 2. P… described … of P is sho…

Pla…

M Sciences

SCIENCES | Vidéos | Archéologie | Biologie | Cosmos | Géologie | Grandes idées de la science

Des poussières brouillent l'écho du Big Bang

Le Monde.fr | 22.09.2014 à 10h34 • Mis à jour le 22.09.2014 à 13h32 |

Par David Larousserie

Criticism of Study Detecting Ripples From Big Bang Continues to Expand

Libération

{SCIENCES²}

Par Sylvestre Huet
Journaliste à Libération

echercher

ONDES GRAVITATIONNELLES: L'ÉNIGME PERSISTE

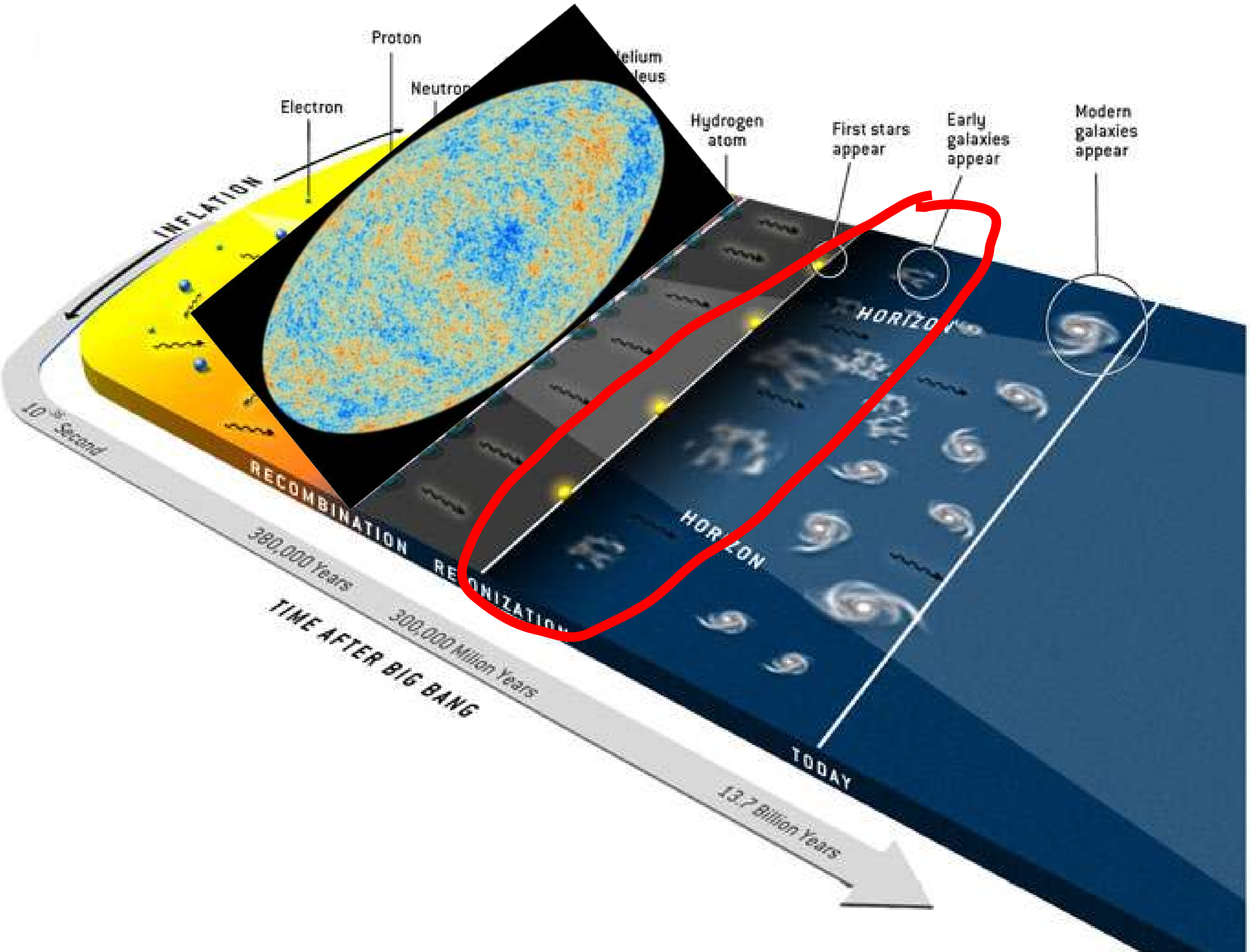
Planck

I. Un peu d'histoire...

II. Détecter le FDC

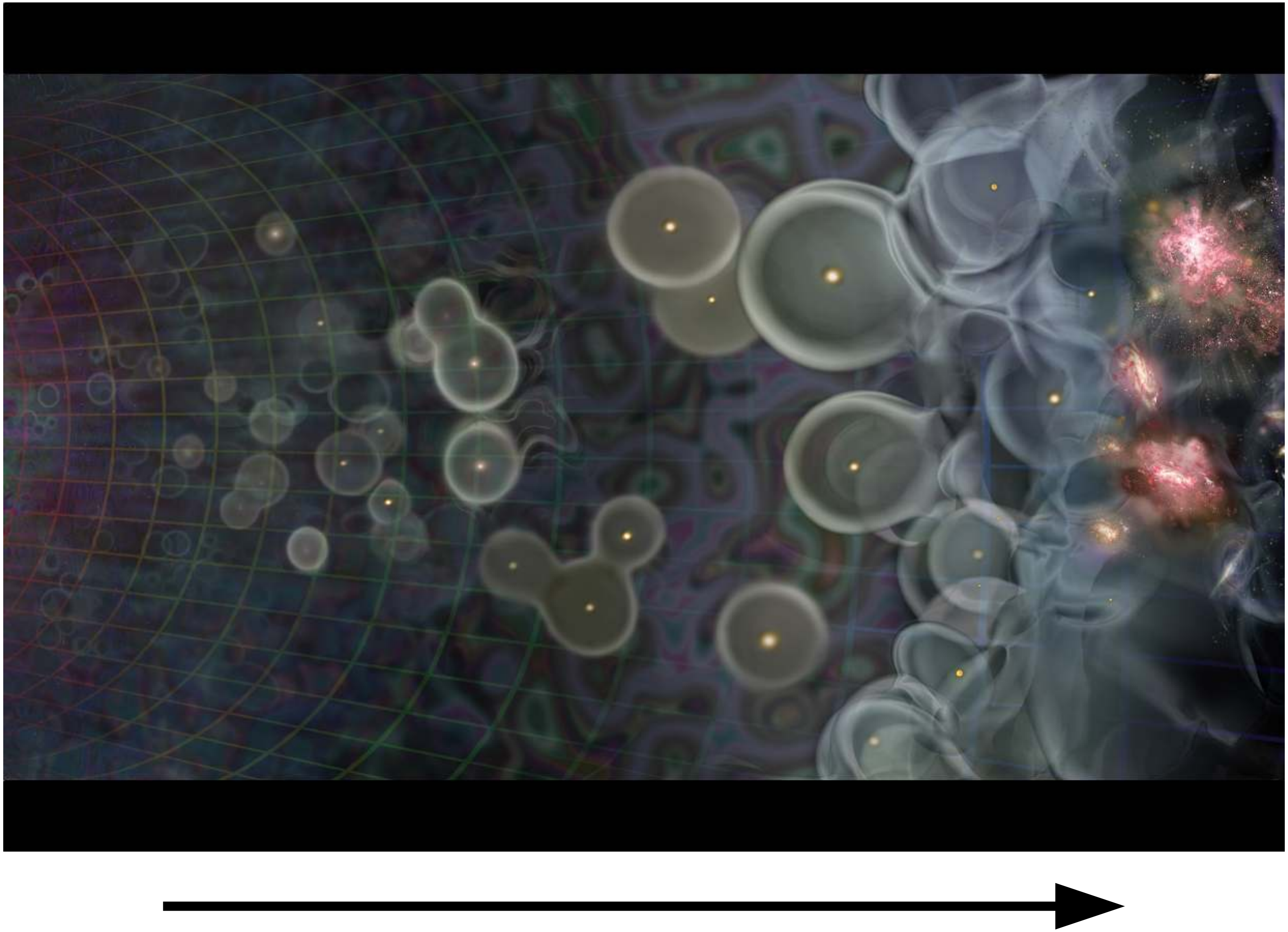
III. La science du FDC :

d) Les premières structures



Proton
Electron
Neutron
elium
leus
Hydrogen atom
First stars appear
Early galaxies appear
Modern galaxies appear
INFLATION
HORIZON
HORIZON
RECOMBINATION
REIONIZATION
TODAY
10 Second
380,000 Years
300,000 Million Years
13.7 Billion Years
TIME AFTER BIG BANG

Sonder la réionisation



Temps

Sonder la réionisation

Libération d'e- :

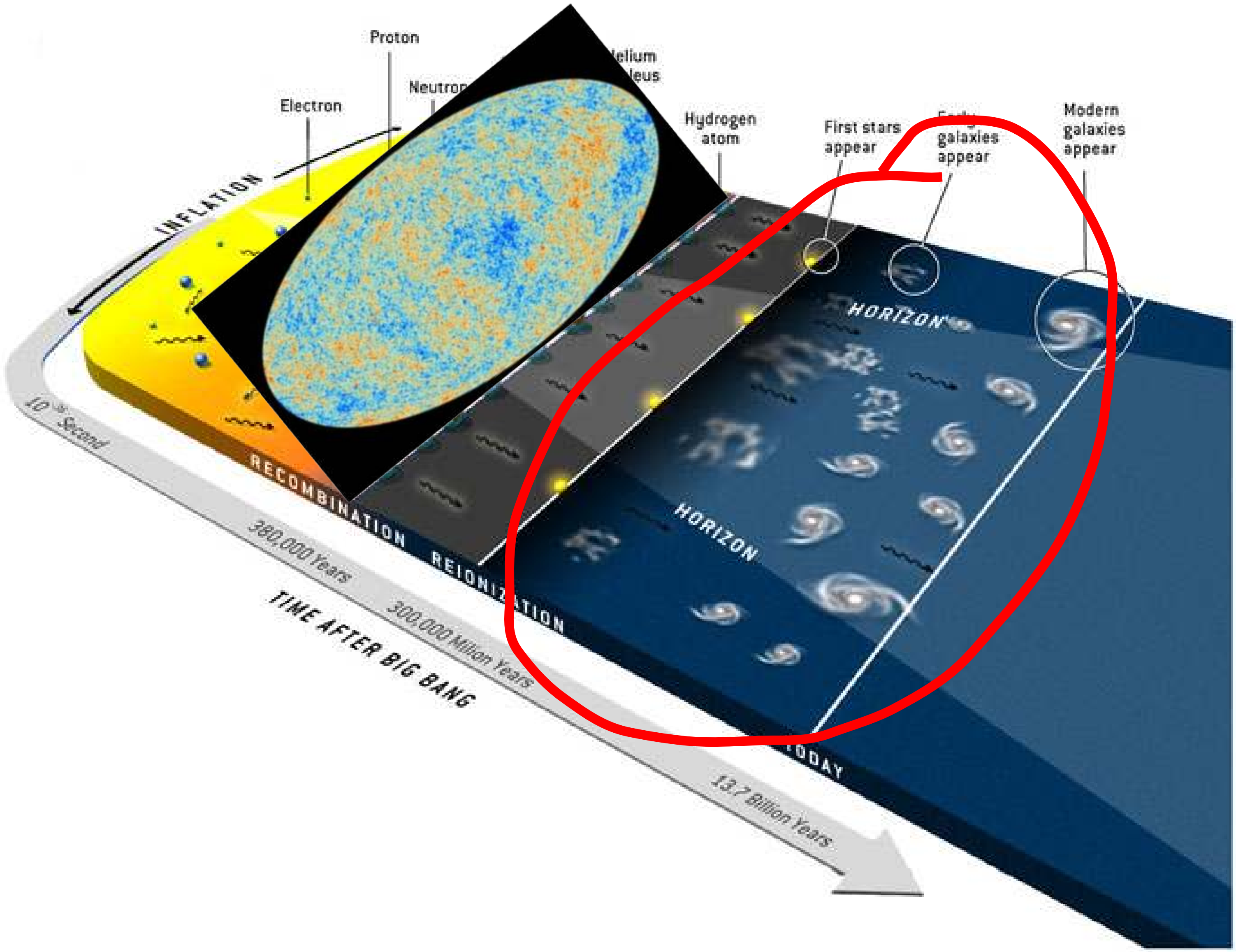
- Collision avec photons FDC
- “brouille” le signal : pics moins haut en Temp.
- Ajoute de la polarisation

→ Temps

I. Un peu d'histoire...

II. Détecter le FDC

III. La science du FDC :
e) L'univers proche/récent


Proton
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HORIZON
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380,000 Years
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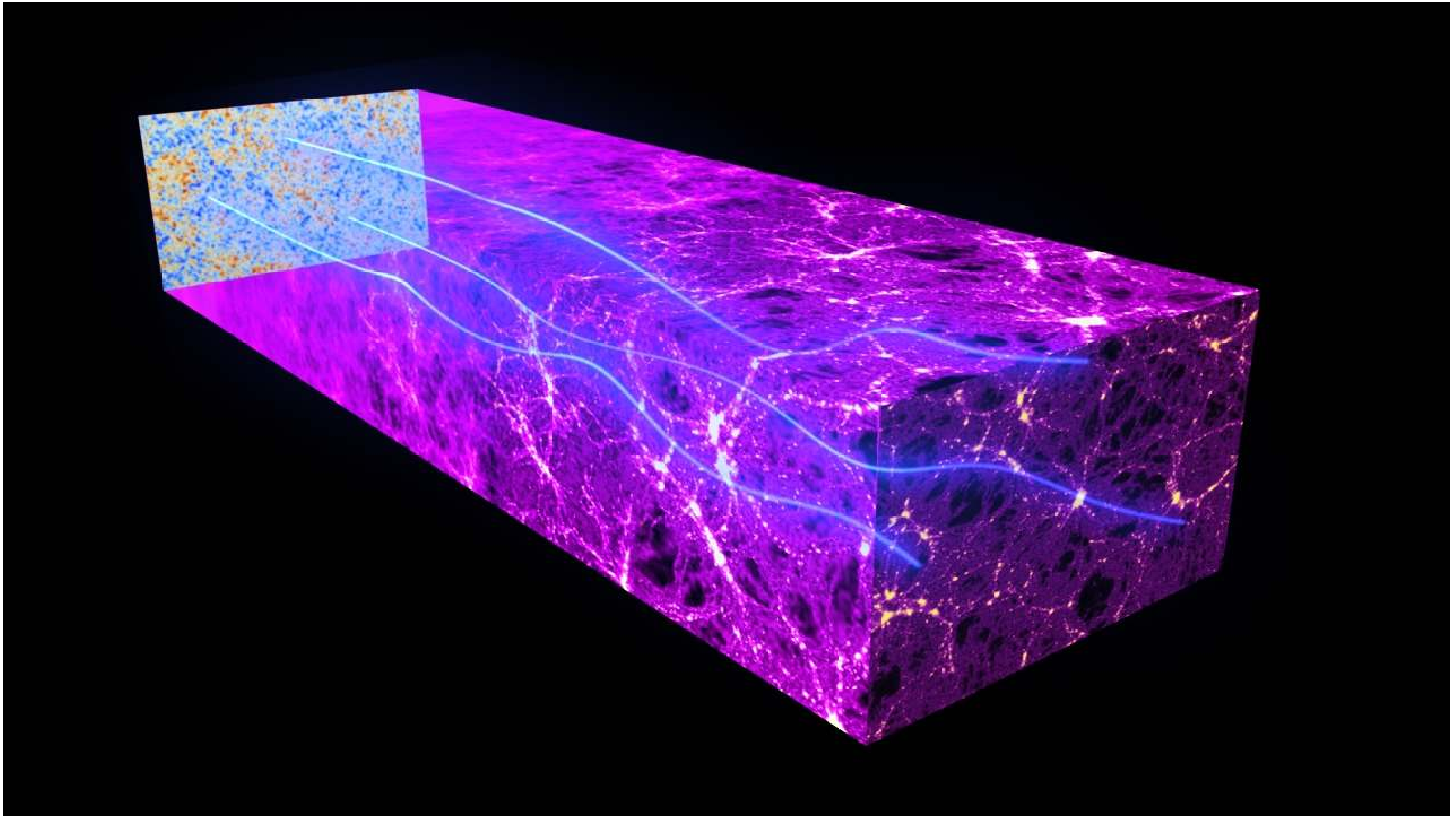
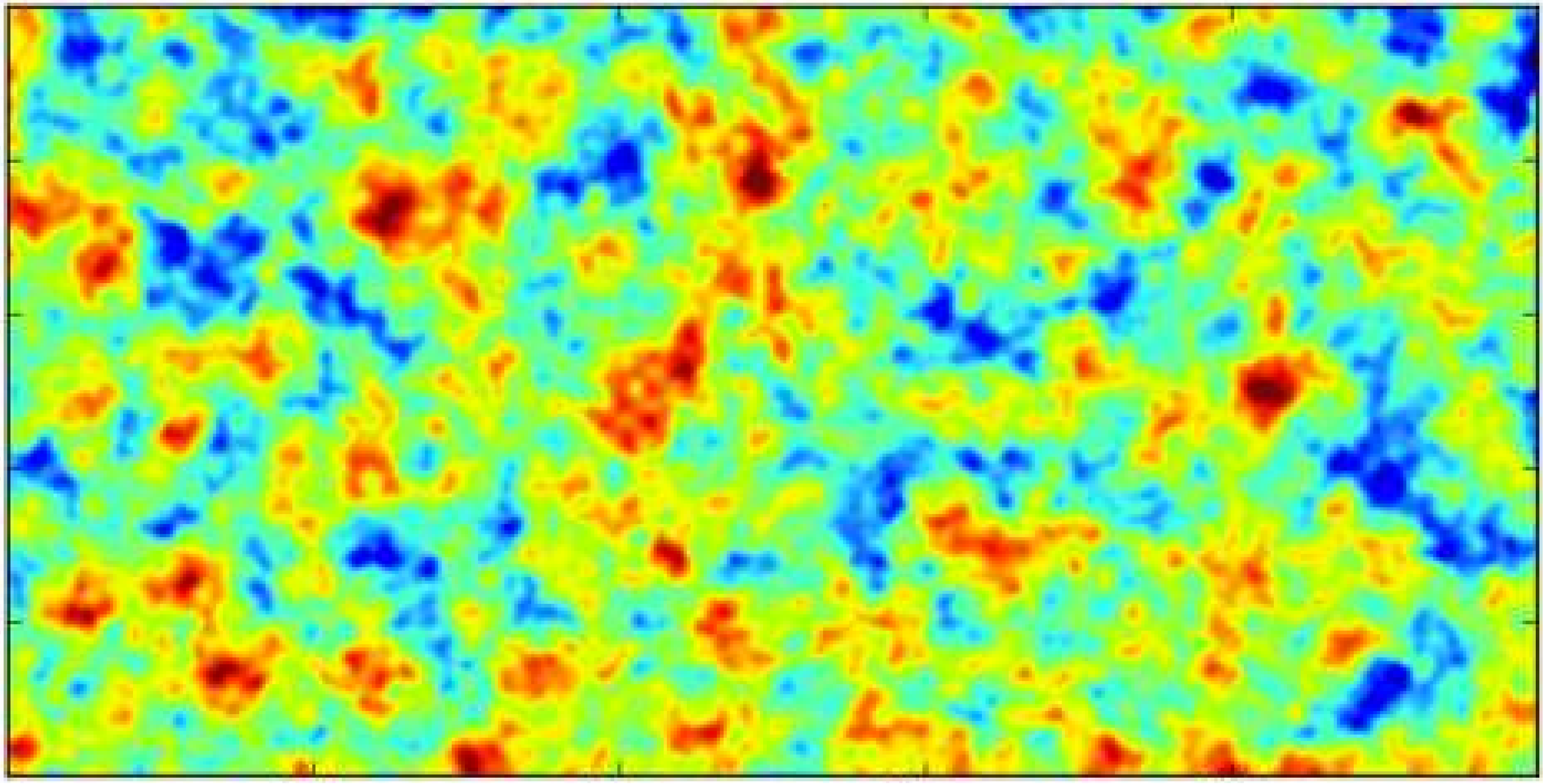
Lentillage gravitationnel



Lentillage gravitationnel

patch du FDC simulé – avant lentillage



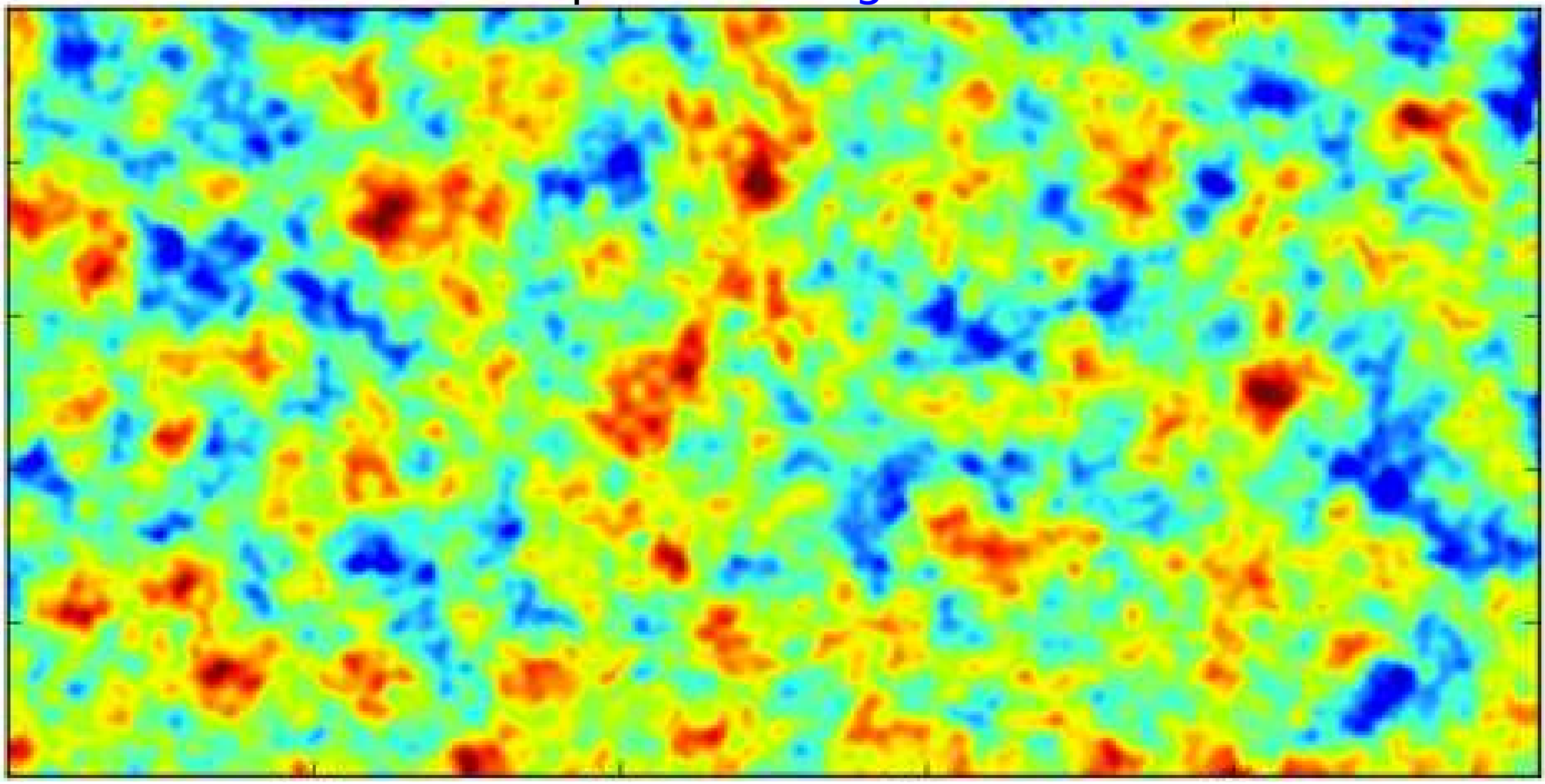
10º

Déviation moyenne : 2.4 arcminutes

Planck 15 months
Planck Collaboration, 2013, 17

Lentillage gravitationnel

patch du FDC simulé – après lentillage

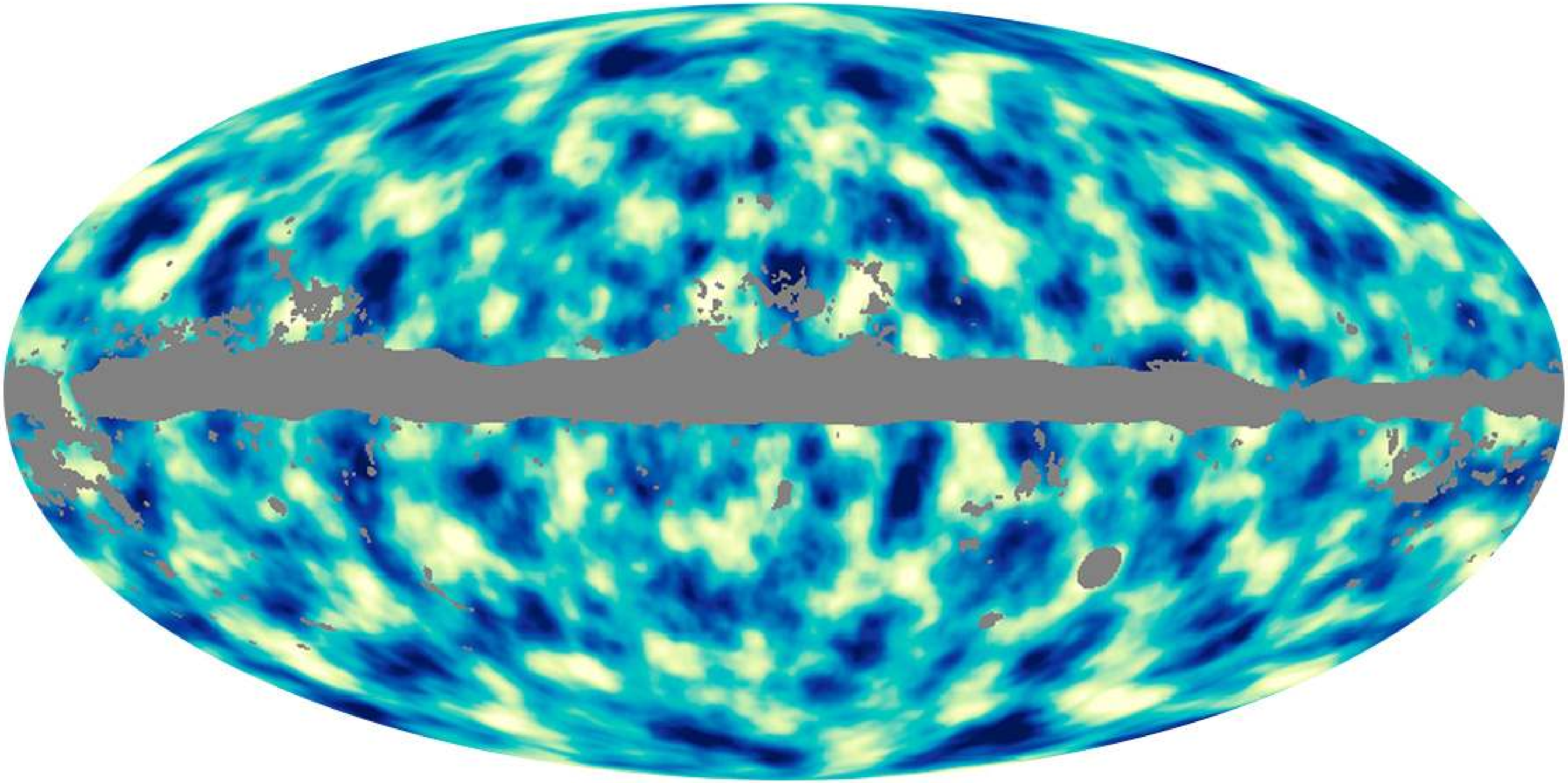


10º

Déviation moyenne : 2.4 arcminutes

Planck 15 months
Planck Collaboration, 2013, 17

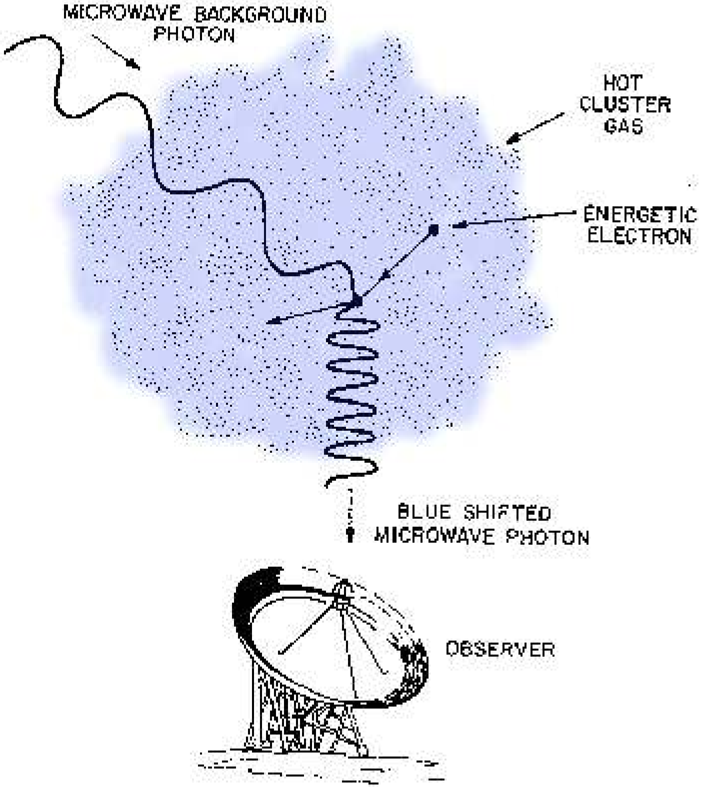
La matière sombre révélée



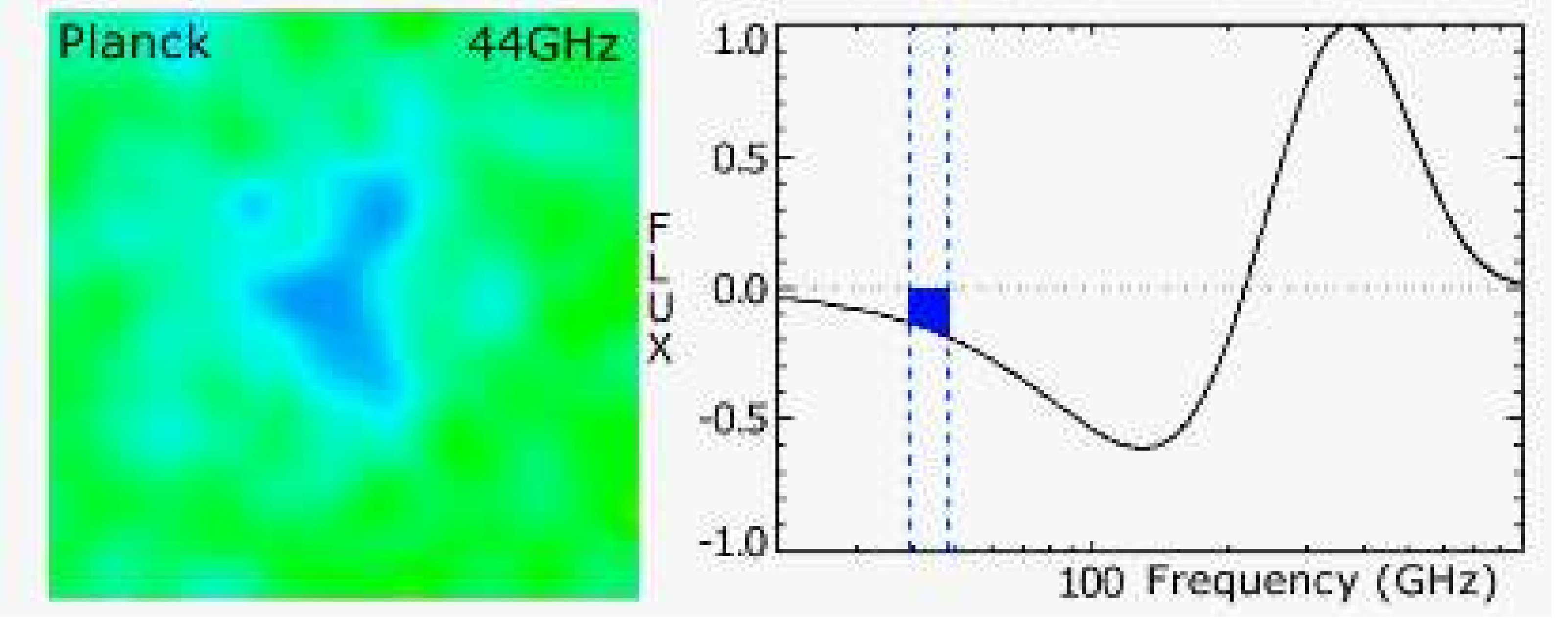
= carte de la masse de matière projetée sur la ligne de visée

Planck 15 months
Planck Collaboration, 2013, 17

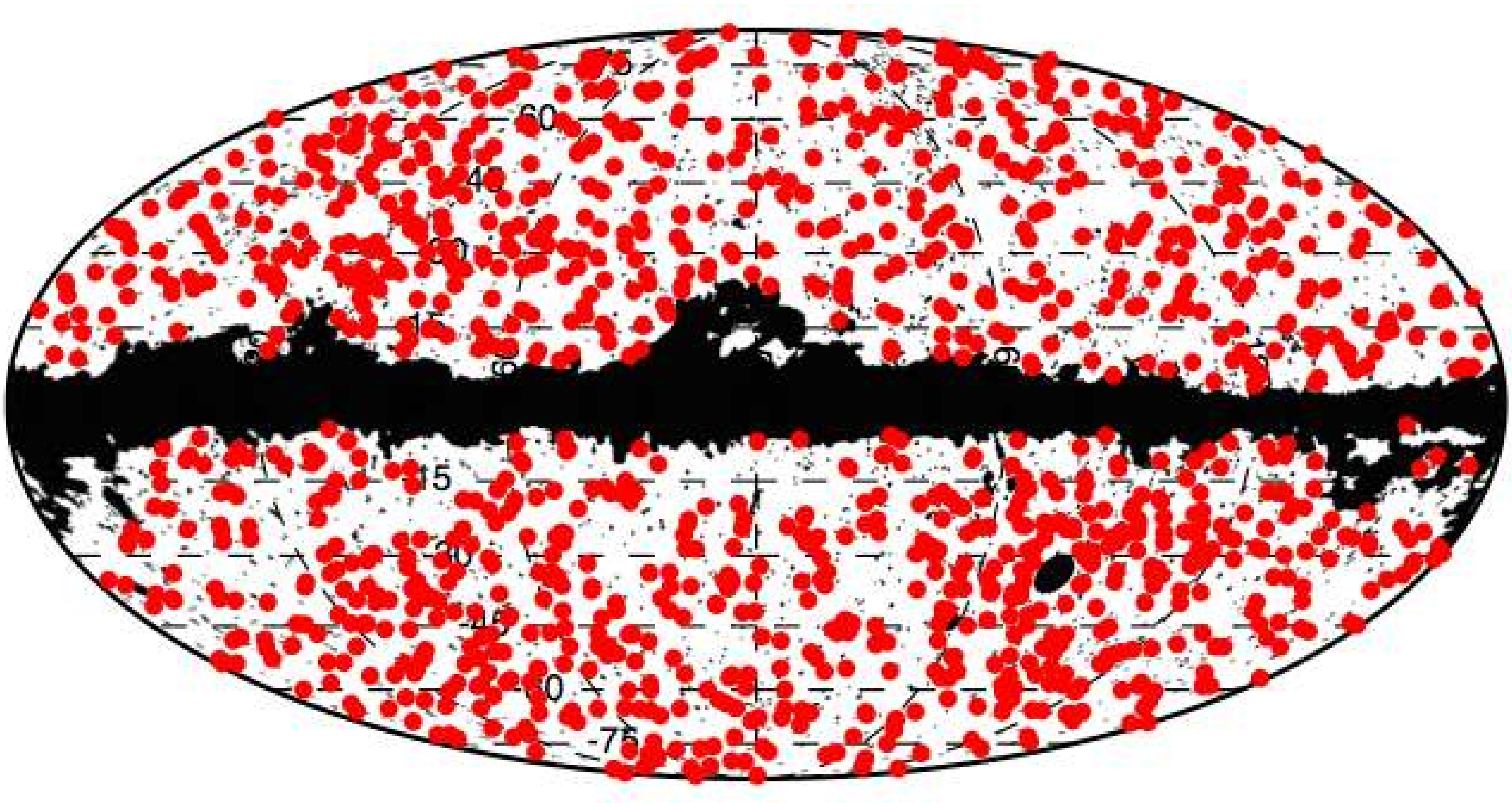
Effet Sunyaev Zel'dovich



Effet Sunyaev Zel'dovich



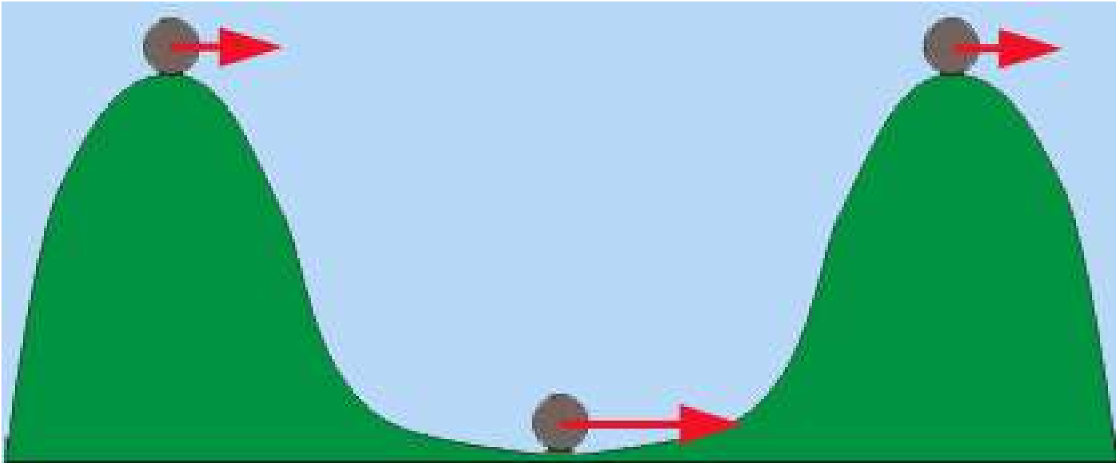
Amas par effet Sunyaev Zel'dovich



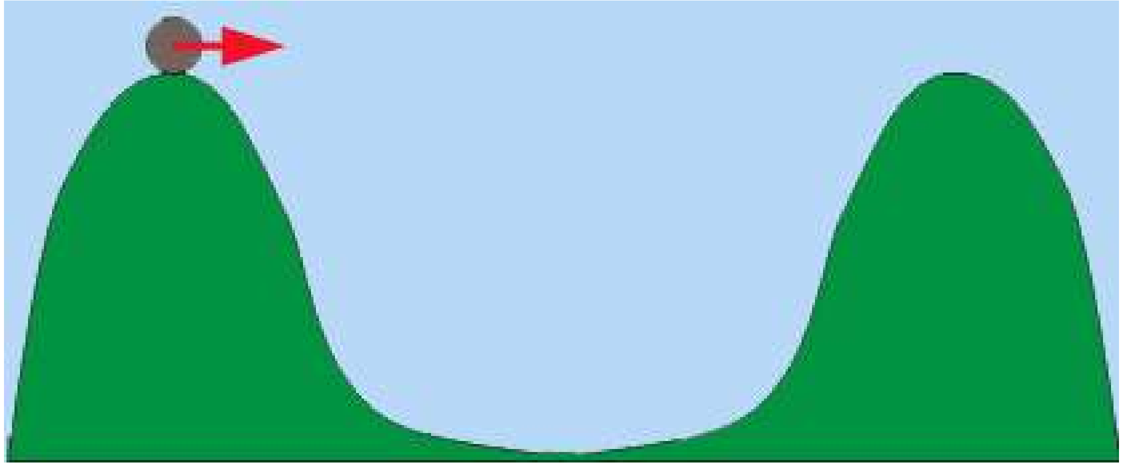
1227 amas détectés -> dont 366 inédits

Planck Collab, 2013, 29

Effet Sachs-Wolfe intégré

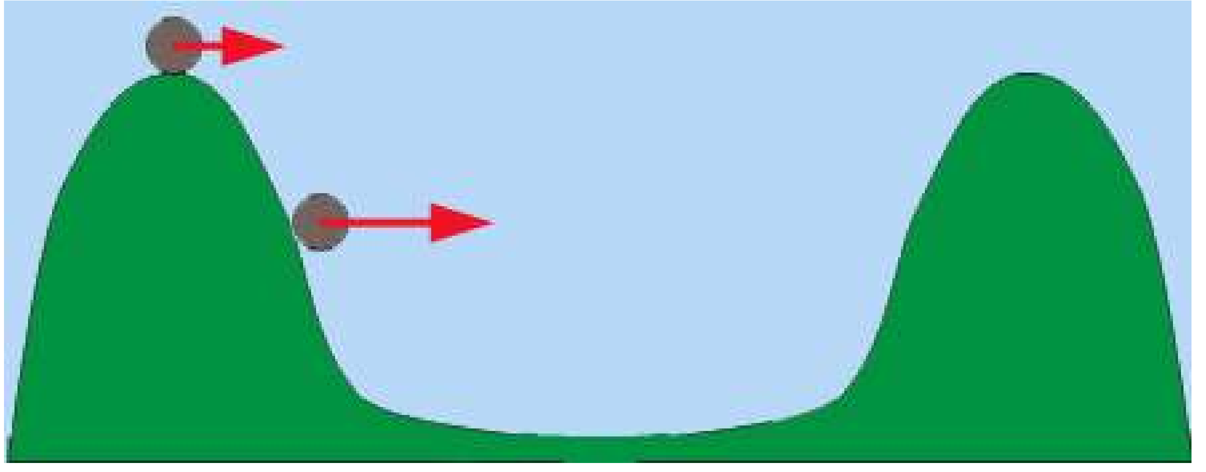


Effet Sachs-Wolfe intégré



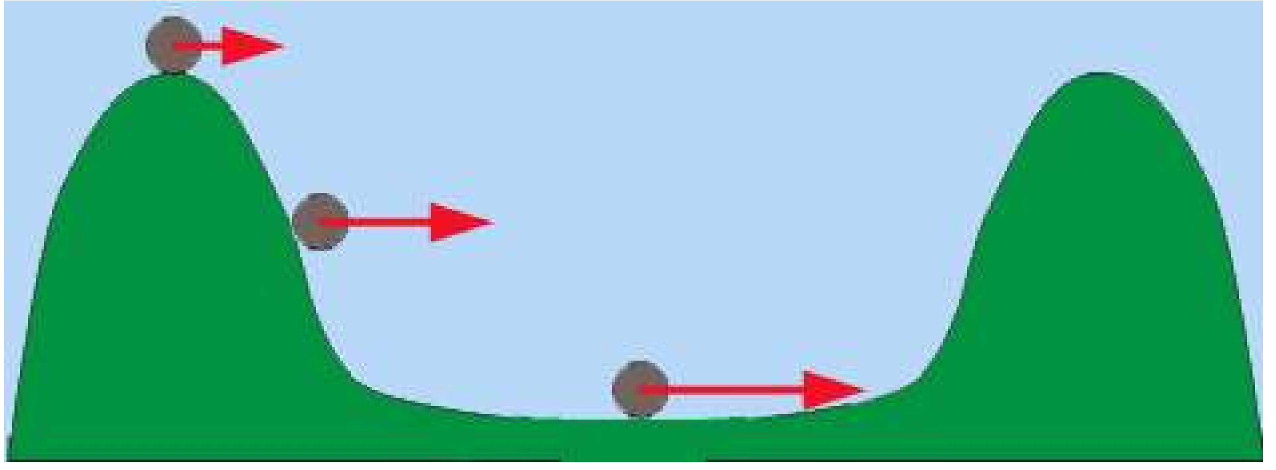
L'énergie sombre “applatit” les potentiels gravitationnels

Effet Sachs-Wolfe intégré



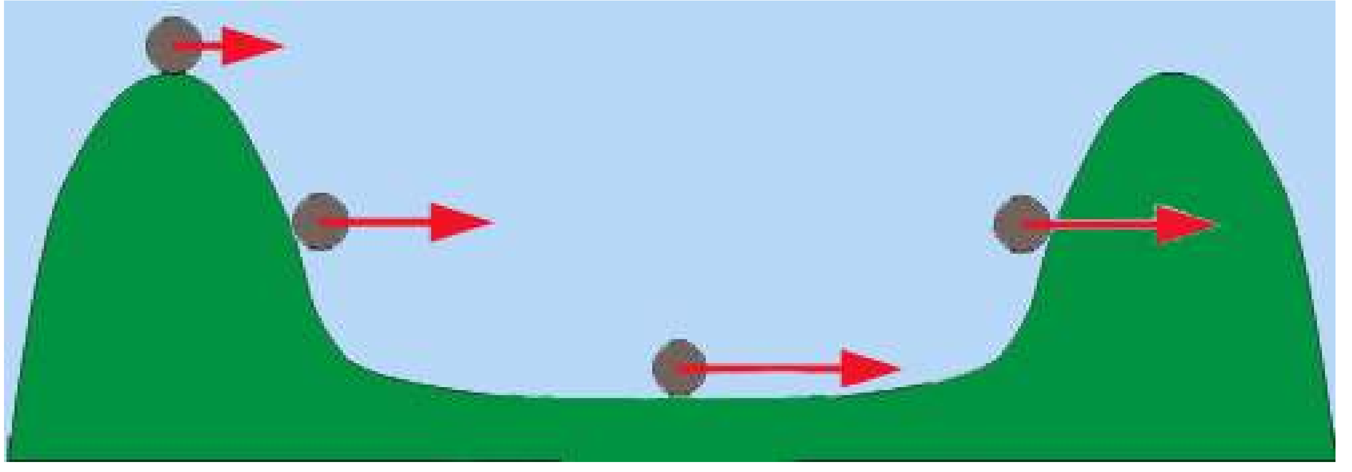
L'énergie sombre “applatit” les potentiels gravitationnels

Effet Sachs-Wolfe intégré



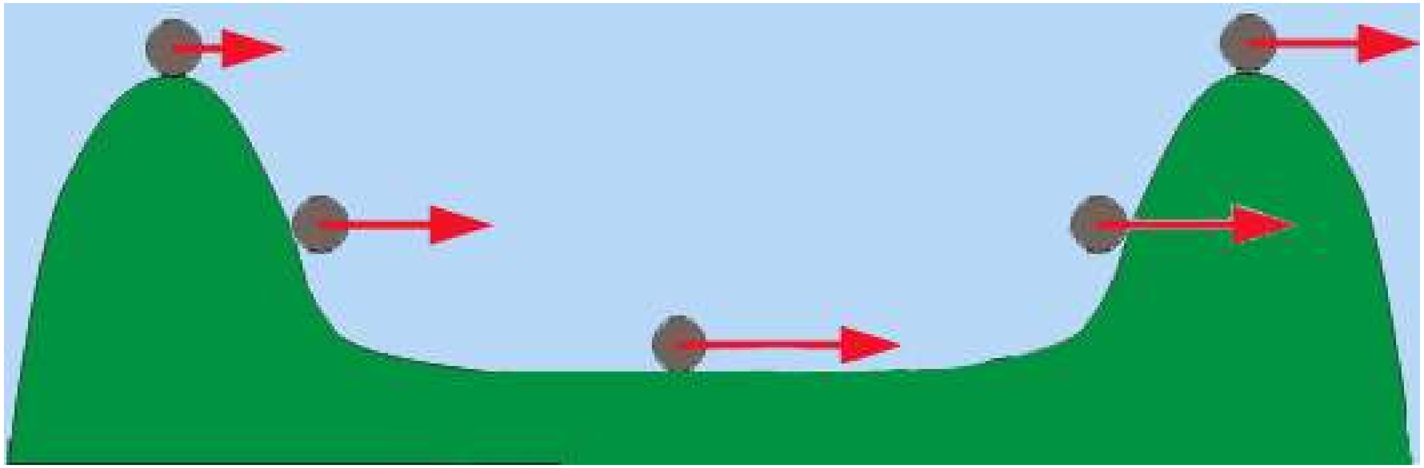
L'énergie sombre “applatit” les potentiels gravitationnels

Effet Sachs-Wolfe intégré



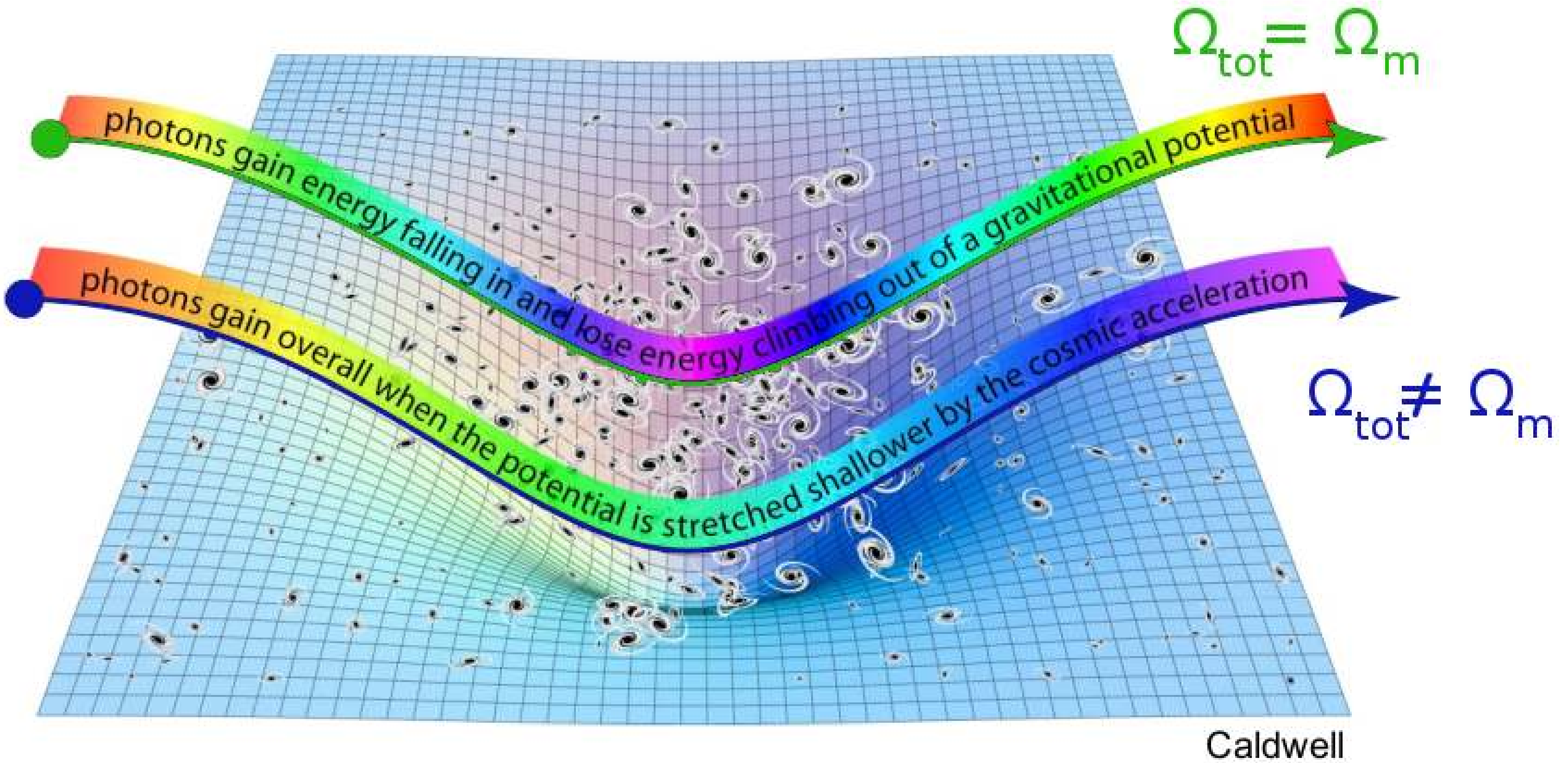
L'énergie sombre “applatit” les potentiels gravitationnels

Effet Sachs-Wolfe intégré



L'énergie sombre “applatit” les potentiels gravitationnels

Effet Sachs-Wolfe intégré



L'énergie sombre “applatit” les potentiels gravitationnels

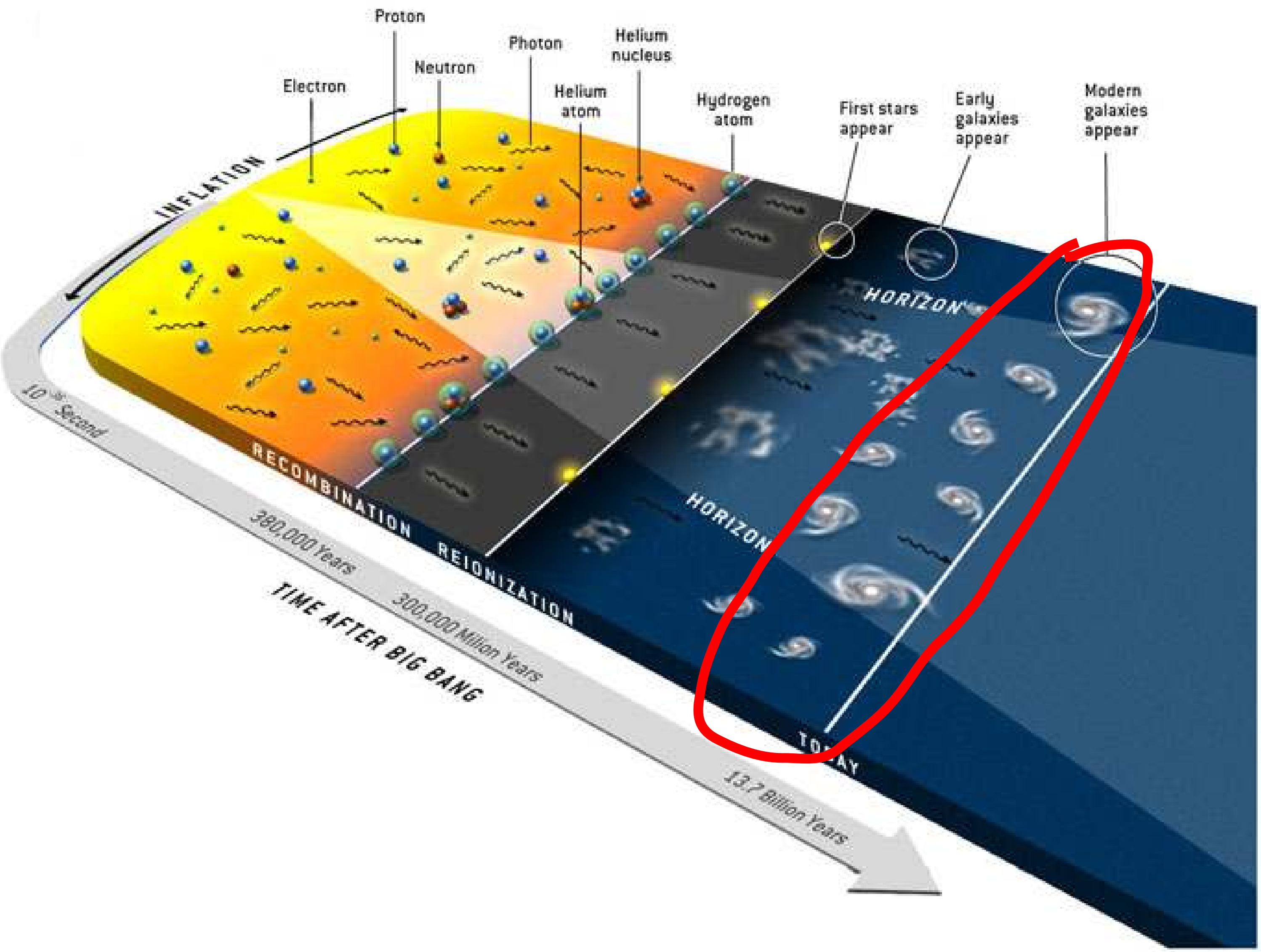
→ Les photons du FDC sont affectés

I. Un peu d'histoire…

II. Détecter le FDC

III. La science du FDC :

f) Bonus !



Proton
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REIONIZATION
TODAY
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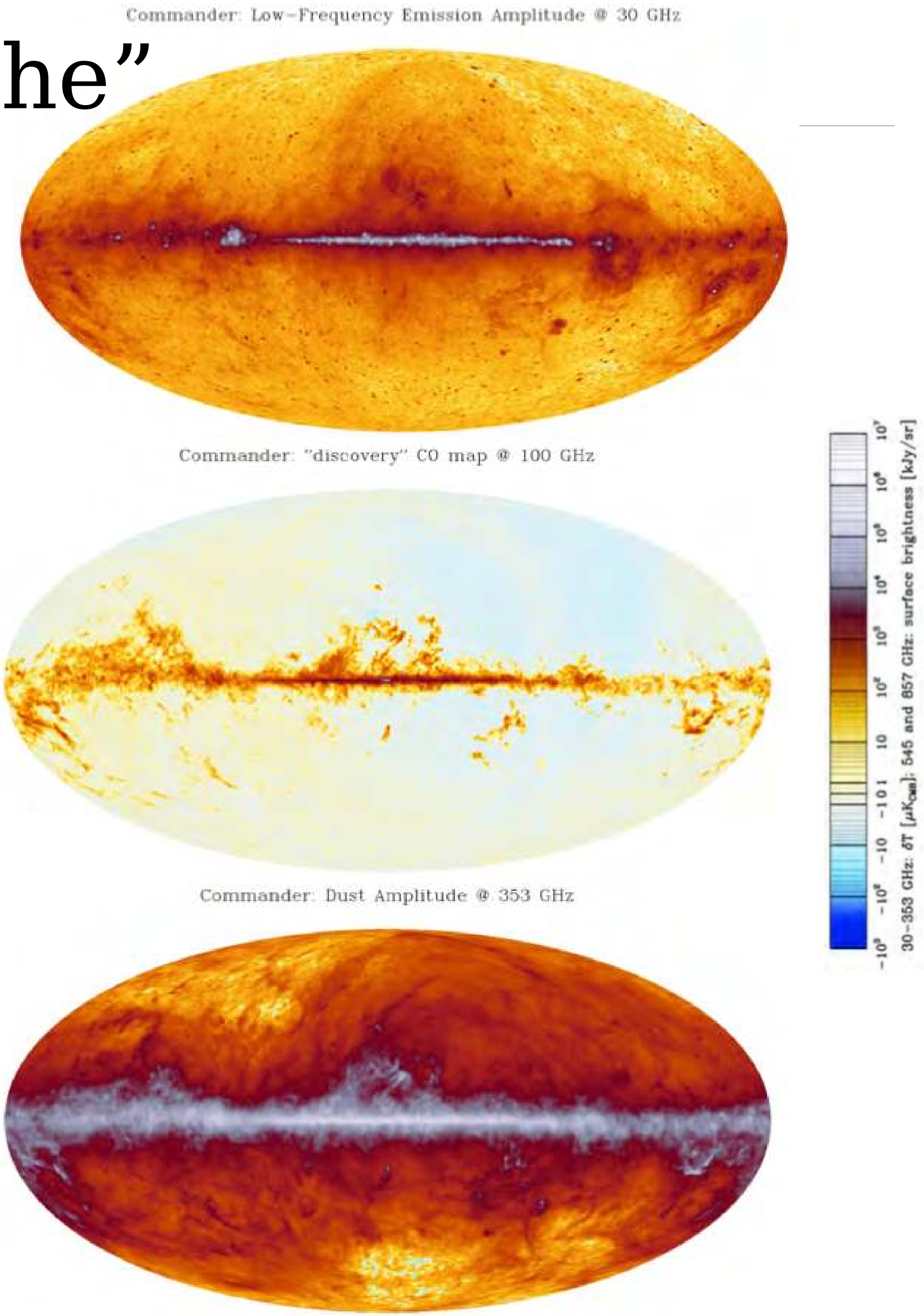
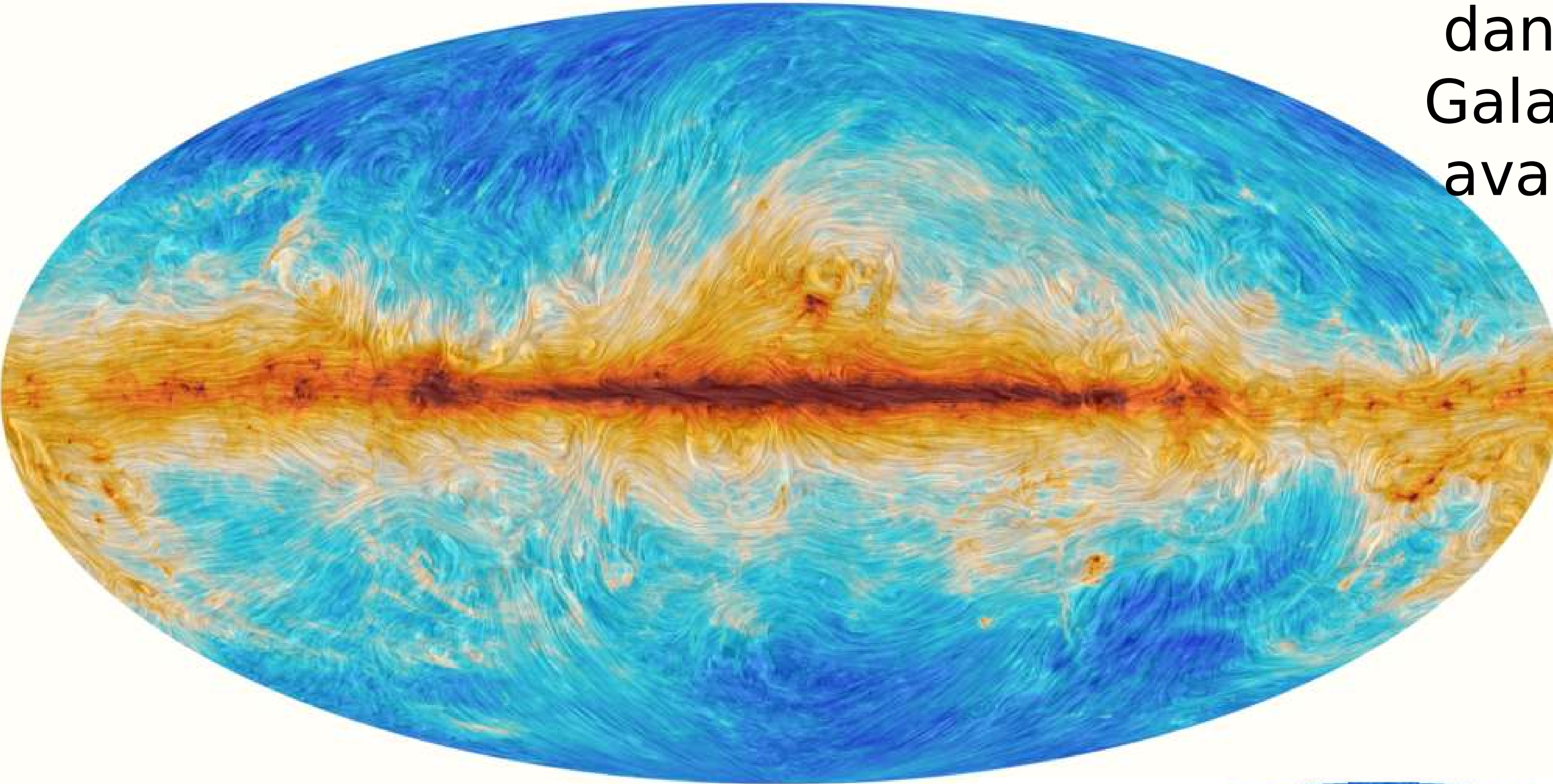
380,000 Years
300,000 Million Years
13.7 Billion Years
TIME AFTER BIG BANG

Univers “très proche”

Carte de la “poussière”
dans notre galaxie

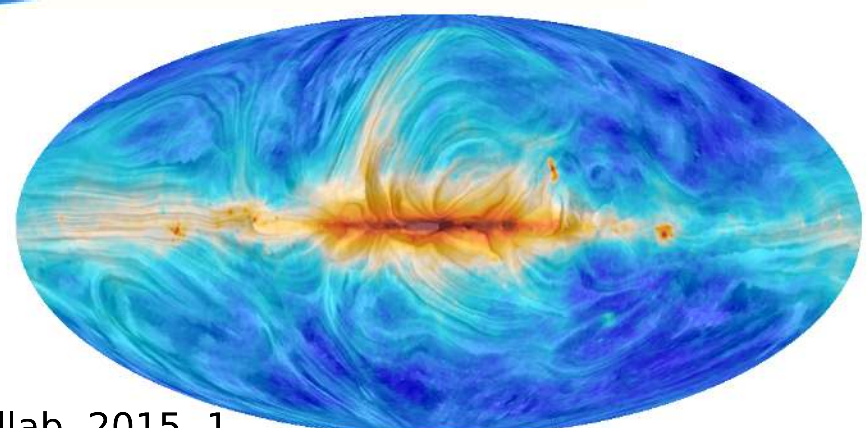


En polarisation



dans notre
Galaxie, un
avant-plan

B field.
top: dust @ 353 GHz
right: synchrotron @ 30 GHz



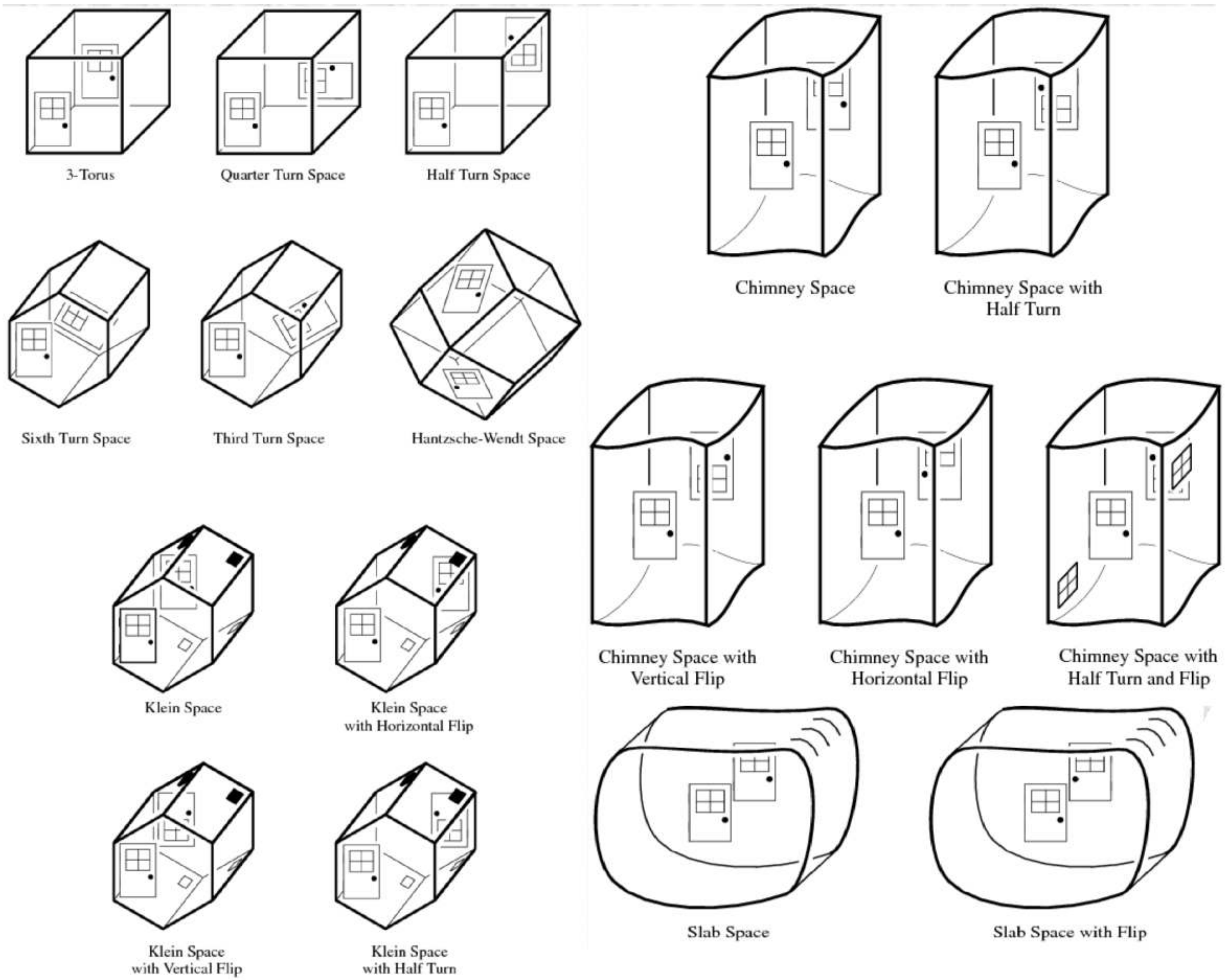
Planck Collab, 2015, 1

Contraindre la taille de l'Univers

L'univers est-il de taille finie ?

Si oui, quelle est sa taille ?

Contraindre la taille de l'Univers



I. Un peu d'histoire...

II. Détecter le FDC

III. La science du FDC :
g) Tant d'autres choses....

PLANCK TECHNICAL RESULTS

The technical papers presented here reflect some of the work carried out by the Instrument Teams, Data Processing Centers, and Working Groups. Note that this list is not intended to be complete.

Title	Authors	Publication
Polarization measurements analysis I. Impact of the full covariance matrix on polarization fraction and angle measurements	Montier et al.	2014 arXiv:1406.6536
Polarization measurements analysis II. Best estimators of polarization fraction and angle	Montier et al.	2014 arXiv:1407.0178
Study of Cosmic Ray Impact on Planck/HFI Low Temperature Detectors	Miniussi et al.	2014 J. Low Temp. Phys., 0022-2291
Impact of particles on the Planck HFI detectors: Ground-based measurements and physical interpretation	Catalano et al.	2014 A&A 569, A88
Characterization and Physical Explanation of Energetic Particles on Planck HFI Instrument	Catalano et al.	2014 arXiv:1403.5639
Analytical approach to optimizing alternating current biasing of bolometers	Catalano et al.	2014 arXiv:1403.5631
In-flight calibration and verification of the Planck-LFI instrument	Gregorio et al.	2013 J. Inst. 8 T07001
The pre-launch Planck Sky Model: a model of sky emission at submillimetre to centimetre wavelengths	Delabrouille et al.	2013 A&A, 553, A96
PowellSnakes II: a fast Bayesian approach to discrete object detection in multi-frequency astronomical data sets	Carvalho et al.	2012 MNRAS 427, 1384
Application of XFASTER power spectrum and likelihood estimator to Planck	Rocha et al.	2011 MNRAS 414, 823
Fast Pixel Space Convolution for Cosmic Microwave Background Surveys with Asymmetric Beams and Complex Scan Strategies: FEBeCoP	Mitra et al.	2011 ApJS 193, 5
Performance of XFaster likelihood in real CMB experiments	Rocha et al.	2010 Submitted to MNRAS
Multi-mode horn design and beam characteristics for the Planck satellite	Murphy et al.	2010 J. Inst. 5 T04001
Markov chain beam randomization: a study of the impact of Planck beam measurement errors on cosmological parameter estimation	Rocha et al.	2010 A&A 513, A23
Measuring Planck Beams with Planets	Huffenberger et al.	2010 A&A 510, A58
Dynamic validation of the Planck-LFI thermal model	Tomasi et al.	2010 J. Inst. 5 T01002
A fast Bayesian approach to discrete object detection in astronomical data sets - PowellSnakes I	Carvalho et al.	2009 MNRAS 393, 681
Making maps from Planck LFI 30 GHz data with asymmetric beams and cooler noise	Ashdown et al.	2009 A&A 493, 753
A systematic approach to the Planck LFI end-to-end test and its application to the DPC Level 1 pipeline	Frailis et al.	2009 J. Inst. 4 T12021
Off-line radiometric analysis of Planck-LFI data	Tomasi et al.	2009 J. Inst. 4 T12020
Level 1 on-ground telemetry handling in Planck-LFI	Zacchei et al.	2009 J. Inst. 4 T12019
Optimization of Planck-LFI on-board data handling	Maris et al.	2009 J. Inst. 4 T12018
LFI Radiometric Chain Assembly (RCA) data handling ``Rachel"	Malaspina et al.	2009 J. Inst. 4 T12017
Cryogenic characterization of the Planck sorption cooler system flight model	Morgante et al.	2009 J. Inst. 4 T12016
Cryogenic environment and performance for testing the Planck radiometers	Terenzi et al.	2009 J. Inst. 4 T12015
Advanced modelling of the Planck-LFI radiometers	Battaglia et al.	2009 J. Inst. 4 T12014
Planck-LFI radiometers tuning	Cuttaia et al.	2009 J. Inst. 4 T12013
Thermal susceptibility of the Planck-LFI receivers	Terenzi et al.	2009 J. Inst. 4 T12012
The linearity response of the Planck-LFI flight model receivers	Mennella et al.	2009 J. Inst. 4 T12011
Planck-LFI radiometers' spectral response	Zonca et al.	2009 J. Inst. 4 T12010
Noise properties of the Planck-LFI receivers	Meinhold et al.	2009 J. Inst. 4 T12009
The Planck-LFI Radiometer Electronics Box Assembly	Herreros et al.	2009 J. Inst. 4 T12008
The Planck-LFI flight model composite waveguides	D'Arcangelo et al.	2009 J. Inst. 4 T12007
Planck-LFI: design and performance of the 4 Kelvin Reference Load Unit	Valenziano et al.	2009 J. Inst. 4 T12006
The Planck-LFI flight model ortho-mode transducers	D'Arcangelo et al.	2009 J. Inst. 4 T12005
Planck-LFI flight model feed horns	Villa et al.	2009 J. Inst. 4 T12004
LFI 30 and 44 GHz receivers Back-End Modules	Artal et al.	2009 J. Inst. 4 T12003
Design, development and verification of the 30 and 44 GHz front-end modules for the Planck Low Frequency Instrument	Davis et al.	2009 J. Inst. 4 T12002
Design, development, and verification of the Planck Low Frequency Instrument 70 GHz Front-End and Back-End Modules	Varis et al.	2009 J. Inst. 4 T12001
Initial test results on bolometers for the Planck high frequency instrument	Holmes et al.	2008 Appl. Opt. 47, 32
Component separation methods for the Planck mission	Leach et al.	2008 A&A 491, 597
Making sky maps from Planck data	Ashdown et al.	2007 A&A 467, 761
Making maps from Planck LFI 30 GHz data	Ashdown et al.	2007 A&A 471, 361
A simulation pipeline for the Planck mission	Reinecke et al.	2006 A&A 445, 373
Scanning strategy for mapping the Cosmic Microwave Background anisotropies with Planck	Dupac & Tauber	2005 A&A 430, 363
The Planck High Frequency Instrument, a third generation CMB experiment, and a full sky submillimeter survey	Lamarre et al.	2003 New Astron Rev 47, 1017

PLANCK TECHNICAL RESULTS

The technical papers presented here reflect some of the work carried out by the Instrument Teams, Data Processing Centers, and Working Groups. Note that this list is not intended to be complete.

Title	Authors	Publication
Polarization measurements analysis I. Impact of the full covariance matrix on polarization fraction and angle measurements	Montier et al.	2014 arXiv:1406.6536
Polarization measurements analysis II. Best estimators of polarization fraction and angle	Montier et al.	2014 arXiv:1407.0178
Study of Cosmic Ray Impact on Planck/HFI Low Temperature Detectors	Miniussi et al.	2014 J. Low Temp. Phys., 0022-2291
Impact of particles on the Planck HFI detectors: Ground-based measurements and physical interpretation	Catalano et al.	2014 A&A 569, A88
Characterization and Physical Explanation of Energetic Particles on Planck HFI Instrument	Catalano et al.	2014 arXiv:1403.5639
Analytical approach to optimizing alternating current biasing of bolometers	Catalano et al.	2014 arXiv:1403.5631
In-flight calibration and verification of the Planck-LFI instrument	Gregorio et al.	2013 J. Inst. 8 T07001
The pre-launch Planck Sky Model: a model of sky emission at submillimetre to centimetre wavelengths	Delabrouille et al.	2013 A&A, 553, A96
PowellSnakes II: a fast Bayesian approach to discrete object detection in multi-frequency astronomical data sets	Carvalho et al.	2012 MNRAS 427, 1384
Application of XFASTER power spectrum and likelihood estimator to Planck	Rocha et al.	2011 MNRAS 414, 823
Fast Pixel Space Convolution for Cosmic Microwave Background Surveys with Asymmetric Beams and Complex Scan Strategies: FEBeCoP	Mitra et al.	2011 ApJS 193, 5
Performance of XFaster likelihood in real CMB experiments	Rocha et al.	2010 Submitted to MNRAS

PLANCK PRE-LAUNCH RESULTS

These papers contain detailed technical descriptions of the status of Planck immediately prior to launch, including the satellite, the optical system, its two scientific instruments, and the main results of its multiple ground characterization and calibration campaigns.

Title	Authors	Publication
Planck pre-launch status: High Frequency Instrument polarization calibration	Rosset et al.	2010 A&A 520, A13
Planck pre-launch status: HFI ground calibration	Pajot et al.	2010 A&A 520, A10
Planck pre-launch status: the optical system	Tauber et al.	2010 A&A 520, A2
Planck pre-launch status: the HFI instrument from specification to actual performance	Lamarre et al.	2010 A&A 520, A9
Planck pre-launch status: HFI beam expectations from the optical optimisation of the focal plane	Maffei et al.	2010 A&A 520, A12
Planck pre-launch status: Low Frequency Instrument calibration and expected scientific performance	Mennella et al.	2010 A&A 520, A5
Planck pre-launch status: the optical architecture of the HFI	Ade et al.	2010 A&A 520, A11
Planck pre-launch status: design and description of the Low Frequency Instrument	Bersanelli et al.	2010 A&A 520, A4
Planck pre-launch status: The Planck mission	Tauber et al.	2010 A&A 520, A1
Planck pre-launch status: the Planck-LFI programme	Mandolesi et al.	2010 A&A 520, A3
Planck pre-launch status: Low frequency instrument optics	Sandri et al.	2010 A&A 520, A7
Planck pre-launch status: calibration of the Low Frequency Instrument flight model radiometers	Villa et al.	2010 A&A 520, A6
Planck pre-launch status: expected LFI polarisation capability	Leahy et al.	2010 A&A 520, A8

The Planck-LFI Radiometer Electronics Box Assembly	Herreros et al.	2009 J. Inst. 4 T12008
The Planck-LFI flight model composite waveguides	D'Arcangelo et al.	2009 J. Inst. 4 T12007
Planck-LFI: design and performance of the 4 Kelvin Reference Load Unit	Valenziano et al.	2009 J. Inst. 4 T12006
The Planck-LFI flight model ortho-mode transducers	D'Arcangelo et al.	2009 J. Inst. 4 T12005
Planck-LFI flight model feed horns	Villa et al.	2009 J. Inst. 4 T12004
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Component separation methods for the Planck mission	Leach et al.	2008 A&A 491, 597
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Making maps from Planck LFI 30 GHz data	Ashdown et al.	2007 A&A 471, 361
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Scanning strategy for mapping the Cosmic Microwave Background anisotropies with Planck	Dupac & Tauber	2005 A&A 430, 363
The Planck High Frequency Instrument, a third generation CMB experiment, and a full sky submillimeter survey	Lamarre et al.	2003 New Astron Rev 47, 1017

PLANCK EARLY RESULTS

These papers are produced by the Planck Collaboration, and are based on data acquired by Planck between 13 August 2009 and 6 June 2010. This set of papers describes the scientific performance of the Planck payload, and presents results on a variety of astrophysical topics related to the sources included in the ERCSC, as well as selected topics on difuse emission. The papers are available online, and links to each are provided below. If you use any of these results for presentations, please acknowledge the corresponding paper, ESA/Planck, and the Planck Collaboration.

Title	Authors	Publication
Planck early results. I. The Planck mission	Planck Collaboration	2011 A&A 536, A1
Planck early results. II. The thermal performance of Planck	Planck Collaboration	2011 A&A 536, A2
Planck early results. III. First assessment of the Low Frequency Instrument in-flight performance	Mennella et al.	2011 A&A 536, A3
Planck early results. IV. First assessment of the High Frequency Instrument in-flight performance	Planck HFI Core Team	2011 A&A 536, A4
Planck early results. V. The Low Frequency Instrument data processing	Zacchei et al.	2011 A&A 536, A5
Planck early results. VI. The High Frequency Instrument data processing	Planck HFI Core Team	2011 A&A 536, A6
Planck early results. VII. The Early Release Compact Source Catalogue	Planck Collaboration	2011 A&A 536, A7
The Explanatory Supplement to the Planck Early Release Compact Source Catalogue	Planck Collaboration	2011 ESA
Planck early results. VIII. The all-sky early Sunyaev-Zeldovich cluster sample	Planck Collaboration	2011 A&A 536, A8
Planck early results. IX. XMM-Newton follow-up for validation of Planck cluster candidates	Planck Collaboration	2011 A&A 536, A9
Planck early results. X. Statistical analysis of Sunyaev-Zeldovich scaling relations for X-ray galaxy clusters	Planck Collaboration	2011 A&A 536, A10
Planck early results. XI. Calibration of the local galaxy cluster Sunyaev-Zeldovich scaling relations	Planck Collaboration	2011 A&A 536, A11
Planck early results. XII. Cluster Sunyaev-Zeldovich optical scaling relations	Planck Collaboration	2011 A&A 536, A12
Planck early results. XIII. Statistical properties of extragalactic radio sources in the Planck Early Release Compact Source Catalogue	Planck Collaboration	2011 A&A 536, A13
Planck early results. XIV. ERCSC validation and extreme radio sources	Planck Collaboration	2011 A&A 536, A14
Planck early results. XV. Spectral energy distributions and radio continuum spectra of northern extragalactic radio sources	Planck Collaboration	2011 A&A 536, A15
Planck early results. XVI. The Planck view of nearby galaxies	Planck Collaboration	2011 A&A 536, A16
Planck early results. XVII. Origin of the submillimetre excess dust emission in the Magellanic Clouds	Planck Collaboration	2011 A&A 536, A17
Planck early results. XVIII. The power spectrum of cosmic infrared background anisotropies	Planck Collaboration	2011 A&A 536, A18
Planck early results. XIX. All-sky temperature and dust optical depth from Planck and IRAS – constraints on the "dark gas" in our Galaxy	Planck Collaboration	2011 A&A 536, A19
Planck early results. XX. New light on anomalous microwave emission from spinning dust grains	Planck Collaboration	2011 A&A 536, A20
Planck early results. XXI. Properties of the interstellar medium in the Galactic plane	Planck Collaboration	2011 A&A 536, A21
Planck early results. XXII. The submillimetre properties of a sample of Galactic cold clumps	Planck Collaboration	2011 A&A 536, A22
Planck early results. XXIII. The first all-sky survey of Galactic cold clumps	Planck Collaboration	2011 A&A 536, A23
Planck early results. XXIV. Dust in the diffuse interstellar medium and the Galactic halo	Planck Collaboration	2011 A&A 536, A24
Planck early results. XXV. Thermal dust in nearby molecular clouds	Planck Collaboration	2011 A&A 536, A25
Planck early results. XXVI. Detection with Planck and confirmation by XMM-Newton of PLCK G266.6-27.3, an exceptionally X-ray luminous and massive galaxy cluster at z~1	Planck Collaboration	2011 A&A 536, A26
Simultaneous Planck, Swift, and Fermi observations of X-ray and gamma-ray selected blazars	Giommi et al.	2012 A&A 541, A160

PLANCK INTERMEDIATE RESULTS

Intermediate results are presented in a series of papers based on Planck data. These results are produced by the Planck Collaboration. The papers are available online, and links to each are provided below. If you use any of these results for presentations, please acknowledge the corresponding paper, ESA/Planck, and the Planck Collaboration.

Title	Authors	Publication
Planck intermediate results. I. Further validation of new Planck clusters with XMM-Newton	Planck Collaboration	2012 A&A 543, A102
Planck intermediate results. II. Comparison of Sunyaev-Zeldovich measurements from Planck and from the Arcminute Microkelvin Imager for 11 galaxy clusters	Planck and AMI Collaborations	2013 A&A 550, A128
Planck intermediate results. III. The relation between galaxy cluster mass and Sunyaev-Zeldovich signal	Planck Collaboration	2013 A&A 550, A129
Planck intermediate results. IV. The XMM-Newton validation programme for new Planck clusters	Planck Collaboration	2013 A&A 550, A130
Planck intermediate results. V. Pressure profiles of galaxy clusters from the Sunyaev-Zeldovich effect	Planck Collaboration	2013 A&A 550, A131
(Corrigendum) Planck intermediate results. V. Pressure profiles of galaxy clusters from the Sunyaev-Zeldovich effect	Planck Collaboration	2013 A&A 558, C2
Planck intermediate results. VI: The dynamical structure of PLCKG214.6+37.0, a Planck discovered triple system of galaxy clusters	Planck Collaboration	2013 A&A 550, A132
Planck intermediate results. VII. Statistical properties of infrared and radio extragalactic sources from the Planck Early Release Compact Source Catalogue at frequencies between 100 and 857 GHz	Planck Collaboration	2013 A&A 550, A133
Planck intermediate results. VIII. Filaments between interacting clusters	Planck Collaboration	2013 A&A 550, A134
Planck intermediate results. IX. Detection of the Galactic haze with Planck	Planck Collaboration	2013 A&A 554, A139
Planck intermediate results. X. Physics of the hot gas in the Coma cluster	Planck Collaboration	2013 A&A 554, A140
Planck intermediate results. XI. The gas content of dark matter halos: the Sunyaev-Zeldovich-stellar mass relation for locally brightest galaxies	Planck Collaboration	2013 A&A 557, A52
Planck intermediate results. XII. Diffuse Galactic components in the Gould Belt System	Planck Collaboration	2013 A&A 557, A53
Planck intermediate results. XIII. Constraints on peculiar velocities	Planck Collaboration	2014 A&A 561, A97
Planck intermediate results. XIV. Dust emission at millimetre wavelengths in the Galactic plane	Planck Collaboration	2014 A&A 564, A45
Planck intermediate results. XV. A study of anomalous microwave emission in Galactic clouds	Planck Collaboration	2014 A&A 565, A103
Planck intermediate results. XVI. Profile likelihoods for cosmological parameters	Planck Collaboration	2014 A&A 566, A54
Planck intermediate results. XVII. Emission of dust in the diffuse interstellar medium from the far-infrared to microwave frequencies	Planck Collaboration	2014 A&A 566, A55
Planck intermediate results. XVIII. The millimetre and sub-millimetre emission from planetary nebulae	Planck Collaboration	2015 A&A 573, A6
Planck intermediate results. XIX. An overview of the polarized thermal emission from Galactic dust	Planck Collaboration	2015 A&A 576, A104
Planck intermediate results. XX. Comparison of polarized thermal emission from Galactic dust with simulations of MHD turbulence	Planck Collaboration	2015 A&A 576, A105
Planck intermediate results. XXI. Comparison of polarized thermal emission from Galactic dust at 353 GHz with optical interstellar polarization	Planck Collaboration	2015 A&A 576, A106
Planck intermediate results. XXII. Frequency dependence of thermal emission from Galactic dust in intensity and polarization	Planck Collaboration	2015 A&A 576, A107
Planck intermediate results. XXIII. Galactic plane emission components derived from Planck with ancillary data	Planck Collaboration	2015 A&A 580, A13
Planck intermediate results. XXIV. Constraints on variation of fundamental constants	Planck Collaboration	2015 A&A 580, A22
Planck intermediate results. XXV. The Andromeda Galaxy as seen by Planck	Planck Collaboration	2015 A&A 582, A28
Planck intermediate results. XXVI. Optical identification and redshifts of Planck clusters with the RTT150 telescope	Planck Collaboration	2015 A&A 582, A29
Planck intermediate results. XXVII. High-redshift infrared galaxy overdensity candidates and lensed sources discovered by Planck and confirmed by Herschel-SPIRE	Planck Collaboration	2015 A&A 582, A30
Planck intermediate results. XXVIII. Interstellar gas and dust in the Chamaeleon clouds as seen by Fermi LAT and Planck	Planck and Fermi Collaborations	2015 A&A 582, A31
Planck intermediate results. XXIX. All-sky dust modelling with Planck, IRAS, and WISE observations	Planck Collaboration	2016 A&A 586, A132
Planck intermediate results. XXX. The angular power spectrum of polarized dust emission at intermediate and high Galactic latitudes	Planck Collaboration	2016 A&A 586, A133
Planck intermediate results. XXXI. Microwave survey of Galactic supernova remnants	Planck Collaboration	2016 A&A 586, A134
Planck intermediate results. XXXII. The relative orientation between the magnetic field and structures traced by interstellar dust	Planck Collaboration	2016 A&A 586, A135
Planck intermediate results. XXXIII. Signature of the magnetic field geometry of interstellar filaments in dust polarization maps	Planck Collaboration	2016 A&A 586, A136
Planck intermediate results. XXXIV. The magnetic field structure in the Rosette Nebula	Planck Collaboration	2016 A&A 586, A137
Planck intermediate results. XXXV. Probing the role of the magnetic field in the formation of structure in molecular clouds	Planck Collaboration	2016 A&A 586, A138
Planck intermediate results. XXXVI. Optical identification and redshifts of Planck SZ sources with telescopes in the Canary Islands Observatories	Planck Collaboration	2016 A&A 586, A139
Planck intermediate results. XXXVII. Evidence of unbound gas from the kinetic Sunyaev-Zeldovich effect.	Planck Collaboration	2016 A&A 586, A140
Planck intermediate results. XXXVIII. E- and B-modes of dust polarization from the magnetized filamentary structure of the interstellar medium	Planck Collaboration	2016 A&A 586, A141
Planck intermediate results. XXXIX. The Planck list of high-redshift source candidates	Planck Collaboration	2016 A&A 596, A100
Planck intermediate results. XL. The Sunyaev-Zeldovich signal from the Virgo cluster	Planck Collaboration	2016 A&A 596, A101
Planck intermediate results. XLI. A map of lensing-induced B-modes	Planck Collaboration	2016 A&A 596, A102
Planck intermediate results. XLII. Large-scale Galactic magnetic fields	Planck Collaboration	2016 A&A 596, A103
Planck intermediate results. XLIII. The spectral energy distribution of dust in clusters of galaxies	Planck Collaboration	2016 A&A 596, A104
Planck intermediate results. XLIV. The structure of the Galactic magnetic field from dust polarization maps of the southern Galactic cap	Planck Collaboration	2016 A&A 596, A105
Planck intermediate results. XLV. Radio spectra of northern extragalactic radio sources	Planck Collaboration	2016 A&A 596, A106
Planck intermediate results. XLVI. Reduction of large-scale systematic effects in HFI polarization maps and estimation of the reionization optical depth	Planck Collaboration	2016 A&A 596, A107
Planck intermediate results. XLVII. Planck constraints on reionization history	Planck Collaboration	2016 A&A 596, A108
Planck intermediate results. XLVIII. Disentangling Galactic dust emission and cosmic infrared background anisotropies	Planck Collaboration	2016 A&A 596, A109
Planck intermediate results. XLIX. Parity-violation constraints from polarization data	Planck Collaboration	2016 A&A 596, A110
Planck intermediate results. L. Evidence for spatial variation of the polarized thermal dust spectral energy distribution and implications for CMB B-mode analysis	Planck Collaboration	2017 A&A 599, A51
Planck intermediate results. LI. Features in the cosmic microwave background temperature power spectrum and shifts in cosmological parameters	Planck Collaboration	2016 Submitted to A&A
Planck intermediate results. LII. Planet flux densities	Planck Collaboration	2017 Accepted by A&A

These papers are produced by … 009 and 6 June 2010. This set of papers describes the scientific … s related to the sources included in the ERCSC, as well as selecte… d below. If you use any of these results for presentations, pleas…

Title	Authors	Publication
Planck early results. I. The Pla…	Planck Collaboration	2011 A&A 536, A1
Planck early results. II. The the…	Planck Collaboration	2011 A&A 536, A2
Planck early results. III. First as…	Mennella et al.	2011 A&A 536, A3
Planck early results. IV. First as…	Planck HFI Core Team	2011 A&A 536, A4
Planck early results. V. The Lo…	Zacchei et al.	2011 A&A 536, A5
Planck early results. VI. The Hi…	Planck HFI Core Team	2011 A&A 536, A6
Planck early results. VII. The E…	Planck Collaboration	2011 A&A 536, A7
The Explanatory Supplement t…	Planck Collaboration	2011 ESA
Planck early results. VIII. The a…	Planck Collaboration	2011 A&A 536, A8
Planck early results. IX. XMM-…	Planck Collaboration	2011 A&A 536, A9
Planck early results. X. Statisti…	Planck Collaboration	2011 A&A 536, A10
Planck early results. XI. Calibr…	Planck Collaboration	2011 A&A 536, A11
Planck early results. XII. Cluste…	Planck Collaboration	2011 A&A 536, A12
Planck early results. XIII. Statis… Catalogue	Planck Collaboration	2011 A&A 536, A13
Planck early results. XIV. ERC…	Planck Collaboration	2011 A&A 536, A14
Planck early results. XV. Spect…	Planck Collaboration	2011 A&A 536, A15
Planck early results. XVI. The …	Planck Collaboration	2011 A&A 536, A16
Planck early results. XVII. Orig…	Planck Collaboration	2011 A&A 536, A17
Planck early results. XVIII. The…	Planck Collaboration	2011 A&A 536, A18
Planck early results. XIX. All-sk… our Galaxy	Planck Collaboration	2011 A&A 536, A19
Planck early results. XX. New l…	Planck Collaboration	2011 A&A 536, A20
Planck early results. XXI. Prop…	Planck Collaboration	2011 A&A 536, A21
Planck early results. XXII. The …	Planck Collaboration	2011 A&A 536, A22
Planck early results. XXIII. The …	Planck Collaboration	2011 A&A 536, A23
Planck early results. XXIV. Dus…	Planck Collaboration	2011 A&A 536, A24
Planck early results. XXV. Ther…	Planck Collaboration	2011 A&A 536, A25
Planck early results. XXVI. Det… X-ray luminous and massive ga…	Planck Collaboration	2011 A&A 536, A26
Simultaneous Planck, Swift, an…	Giommi et al.	2012 A&A 541, A160

PLANCK INTERMEDIATE RESULTS

Intermediate results are presented in a series of papers based on Planck data. These results are produced by the Planck Collaboration. The papers are available online, and links to each are provided below. If you use any of these results for presentations, please acknowledge the corresponding paper, ESA/Planck, and the Planck Collaboration.

Title	Authors	Publication
Planck intermediate results. I. Further validation of new Planck clusters with XMM-Newton	Planck Collaboration	2012 A&A 543, A102
Planck intermediate results. II. Comparison of Sunyaev-Zeldovich measurements from Planck and from the Arcminute Microkelvin Imager for 11 galaxy clusters	Planck and AMI Collaborations	2013 A&A 550, A128
Planck intermediate results. III. The relation between galaxy cluster mass and Sunyaev-Zeldovich signal	Planck Collaboration	2013 A&A 550, A129
Planck intermediate results. IV. The XMM-Newton validation programme for new Planck clusters	Planck Collaboration	2013 A&A 550, A130

PLANCK 2013 RESULTS

The scientific findings of the mission are presented in a series of papers based on data from the first 15.5 months of Planck operations. These recent results are produced by the Planck Collaboration. The papers are available online, and links to each are provided below. If you use any of these results for presentations, please acknowledge the corresponding paper, ESA/Planck, and the Planck Collaboration. **The Planck Legacy Archive (PLA) contains all public products originating from the Planck mission.**

An international conference was held at ESA/ESTEC, Noordwijk, The Netherlands, between 2-5 April 2013, to highlight the Planck 2013 results: ESLAB 2013: The Universe as seen by Planck. The ESLAB presentations are available online here.

Title	Authors	Publication
Planck 2013 results. I. Overview of products and results	Planck Collaboration	2014 A&A 571, A1
Planck 2013 results. II. Low Frequency Instrument data processing	Planck Collaboration	2014 A&A 571, A2
Planck 2013 results. III. LFI systematic uncertainties	Planck Collaboration	2014 A&A 571, A3
Planck 2013 results. IV. Low Frequency Instrument beams and window functions	Planck Collaboration	2014 A&A 571, A4
Planck 2013 results. V. LFI calibration	Planck Collaboration	2014 A&A 571, A5
Planck 2013 results. VI. High Frequency Instrument data processing	Planck Collaboration	2014 A&A 571, A6
Planck 2013 results. VII. HFI time response and beams	Planck Collaboration	2014 A&A 571, A7
Planck 2013 results. VIII. HFI photometric calibration and mapmaking	Planck Collaboration	2014 A&A 571, A8
Planck 2013 results. IX. HFI spectral response	Planck Collaboration	2014 A&A 571, A9
Planck 2013 results. X. HFI energetic particle effects: characterization, removal, and simulation	Planck Collaboration	2014 A&A 571, A10
Planck 2013 results. XI. All-sky model of thermal dust emission	Planck Collaboration	2014 A&A 571, A11
Planck 2013 results. XII. Diffuse component separation	Planck Collaboration	2014 A&A 571, A12
Planck 2013 results. XIII. Galactic CO emission	Planck Collaboration	2014 A&A 571, A13
Planck 2013 results. XIV. Zodiacal emission	Planck Collaboration	2014 A&A 571, A14
Planck 2013 results. XV. CMB power spectra and likelihood	Planck Collaboration	2014 A&A 571, A15
Planck 2013 results. XVI. Cosmological parameters	Planck Collaboration	2014 A&A 571, A16
Planck 2013 results. XVII. Gravitational lensing by large-scale structure	Planck Collaboration	2014 A&A 571, A17
Planck 2013 results. XVIII. The gravitational lensing-infrared background correlation	Planck Collaboration	2014 A&A 571, A18
Planck 2013 results. XIX. The integrated Sachs-Wolfe effect	Planck Collaboration	2014 A&A 571, A19
Planck 2013 results. XX. Cosmology from Sunyaev-Zeldovich cluster counts	Planck Collaboration	2014 A&A 571, A20
Planck 2013 results. XXI. Power spectrum and high-order statistics of the Planck all-sky Compton parameter map	Planck Collaboration	2014 A&A 571, A21
Planck 2013 results. XXII. Constraints on inflation	Planck Collaboration	2014 A&A 571, A22
Planck 2013 results. XXIII. Isotropy and statistics of the CMB	Planck Collaboration	2014 A&A 571, A23
Planck 2013 results. XXIV. Constraints on primordial non-Gaussianity	Planck Collaboration	2014 A&A 571, A24
Planck 2013 results. XXV. Searches for cosmic strings and other topological defects	Planck Collaboration	2014 A&A 571, A25
Planck 2013 results. XXVI. Background geometry and topology of the Universe	Planck Collaboration	2014 A&A 571, A26
Planck 2013 results. XXVII. Doppler boosting of the CMB: Eppur si muove	Planck Collaboration	2014 A&A 571, A27
Planck 2013 results. XXVIII. The Planck Catalogue of Compact Sources	Planck Collaboration	2014 A&A 571, A28
Planck 2013 results. XXIX. The Planck catalogue of Sunyaev-Zeldovich sources	Planck Collaboration	2014 A&A 571, A29
Planck 2013 results. XXX. Cosmic infrared background measurements and implications for star formation	Planck Collaboration	2014 A&A 571, A30
Planck 2013 results. XXXI. Consistency of the Planck data	Planck Collaboration	2014 A&A 571, A31
Planck 2013 results. XXXII. The updated Planck catalogue of Sunyaev-Zeldovich sources	Planck Collaboration	2015 A&A 581, A14
Planck 2013 results. Explanatory supplement	Planck Collaboration	2013 ESA
Planck 2013 results. Web-based explanatory supplement	Planck Collaboration	2013 ESA

Title	Authors	Publication
... the reionization optical depth	Collaboration	596, A107
Planck intermediate results. XLVII. Planck constraints on reionization history	Planck Collaboration	2016 A&A 596, A108
Planck intermediate results. XLVIII. Disentangling Galactic dust emission and cosmic infrared background anisotropies	Planck Collaboration	2016 A&A 596, A109
Planck intermediate results. XLIX. Parity-violation constraints from polarization data	Planck Collaboration	2016 A&A 596, A110
Planck intermediate results. L. Evidence for spatial variation of the polarized thermal dust spectral energy distribution and implications for CMB B-mode analysis	Planck Collaboration	2017 A&A 599, A51
Planck intermediate results. LI. Features in the cosmic microwave background temperature power spectrum and shifts in cosmological parameters	Planck Collaboration	2016 Submitted to A&A
Planck intermediate results. LII. Planet flux densities	Planck Collaboration	2017 Accepted by A&A

PLANCK INTERMEDIATE RESULTS

Intermediate results are presented in a series of papers based on Planck data. These results are produced by the Planck Collaboration. The papers are available online, and links to each are provided below. If you use any of these results for presentations, please acknowledge the corresponding paper, ESA/Planck, and the Planck Collaboration.

Title	Authors	Publication
Planck intermediate results. I. Further validation of new Planck clusters with XMM-Newton	Planck Collaboration	2012 A&A 543, A102
Planck intermediate results. II. Comparison of Sunyaev-Zeldovich measurements from Planck and from the Arcminute Microkelvin Imager for 11 galaxy clusters	Planck and AMI Collaborations	2013 A&A 550, A128
Planck intermediate results. III. The relation between galaxy cluster mass and Sunyaev-Zeldovich signal	Planck Collaboration	2013 A&A 550, A129
Planck intermediate results. IV. The XMM-Newton validation programme for new Planck clusters	Planck Collaboration	2013 A&A 550, A130

PLANCK 2013 RESULTS

PLANCK 2015 RESULTS

The first release of the 2015 PLANCK results using the full mission data are presented here. These recent results are produced by the Planck Collaboration. The papers are available online, and links to each are provided below. If you use any of these results for presentations, please acknowledge the corresponding paper, ESA/Planck, and the Planck Collaboration. **The Planck Legacy Archive (PLA) contains all public products originating from the Planck mission.**

Title	Authors	Publication
Planck 2015 results. I. Overview of products and results	Planck Collaboration	2016, A&A, 594, A1
Planck 2015 results. II. Low Frequency Instrument data processing	Planck Collaboration	2016, A&A, 594, A2
Planck 2015 results. III. LFI systematic uncertainties	Planck Collaboration	2016, A&A, 594, A3
Planck 2015 results. IV. LFI beams and window functions	Planck Collaboration	2016, A&A, 594, A4
Planck 2015 results. V. LFI calibration	Planck Collaboration	2016, A&A, 594, A5
Planck 2015 results. VI. LFI mapmaking	Planck Collaboration	2016, A&A, 594, A6
Planck 2015 results. VII. High Frequency Instrument data processing: Time-ordered information and beam processing	Planck Collaboration	2016, A&A, 594, A7
Planck 2015 results. VIII. High Frequency Instrument data processing: Calibration and maps	Planck Collaboration	2016, A&A, 594, A8
Planck 2015 results. IX. Diffuse component separation: CMB maps	Planck Collaboration	2016, A&A, 594, A9
Planck 2015 results. X. Diffuse component separation: Foreground maps	Planck Collaboration	2016, A&A, 594, A10
Planck 2015 results. XI. CMB power spectra, likelihoods, and robustness of cosmological parameters	Planck Collaboration	2016, A&A, 594, A11
Planck 2015 results. XII. Full Focal Plane Simulations	Planck Collaboration	2016, A&A, 594, A12
Planck 2015 results. XIII. Cosmological parameters	Planck Collaboration	2016, A&A, 594, A13
Planck 2015 results. XIV. Dark energy and modified gravity	Planck Collaboration	2016, A&A, 594, A14
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Planck 2015 results. XXV. Diffuse, low-frequency Galactic foregrounds	Planck Collaboration	2016, A&A, 594, A25
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Planck 2015 results. XXVII. The Second Planck Catalogue of Sunyaev-Zeldovich Sources	Planck Collaboration	2016, A&A, 594, A27
Planck 2015 results. XXVIII. The Planck Catalogue of Galactic Cold Clumps	Planck Collaboration	2016, A&A, 594, A28
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Comparison of absolute gain photometric calibration between Planck/HFI and Herschel/SPIRE at 545 and 857 GHz	Bertincourt et al.	2016 A&A, 588, 107B
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Aussi avec Planck :

- Nature de la matière noire
- Abondance des éléments primordiaux
- Nombre/masse des neutrinos
- Test des modèles de gravité modifiée
- Topologie de l'Univers
- ...

Remarques finales

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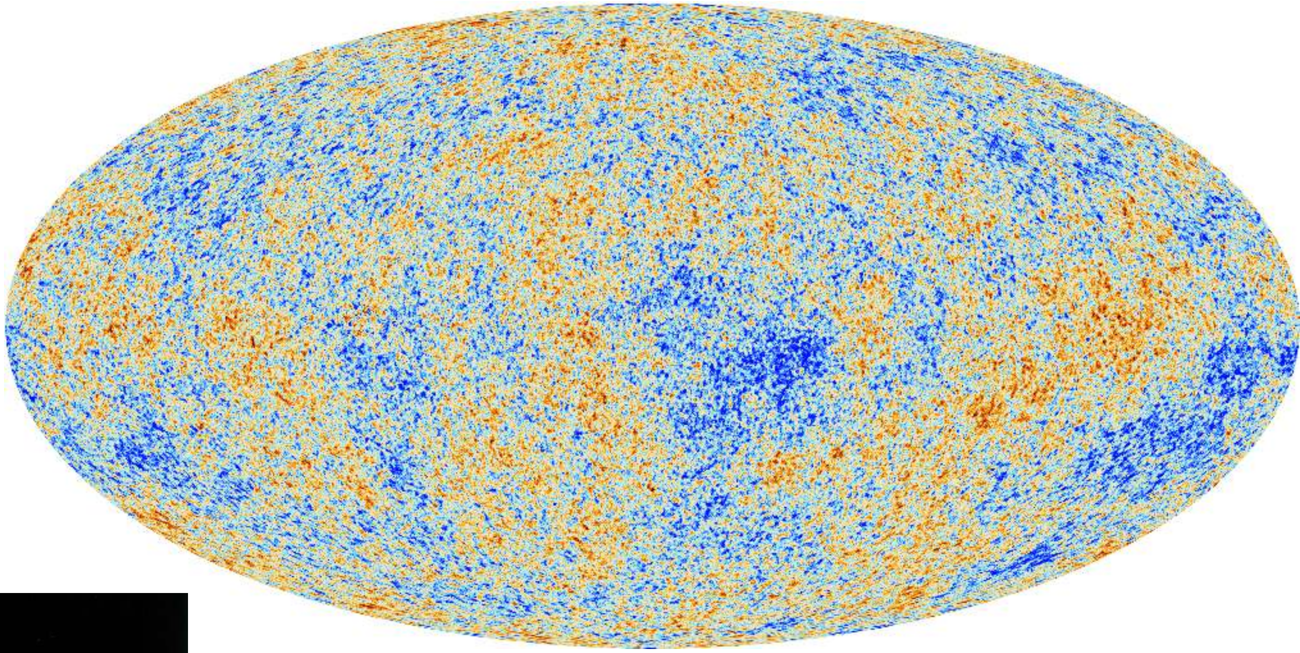
Apollo VIII, Noël 1968- Lovell, Anders, Borman

Remarques finales



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