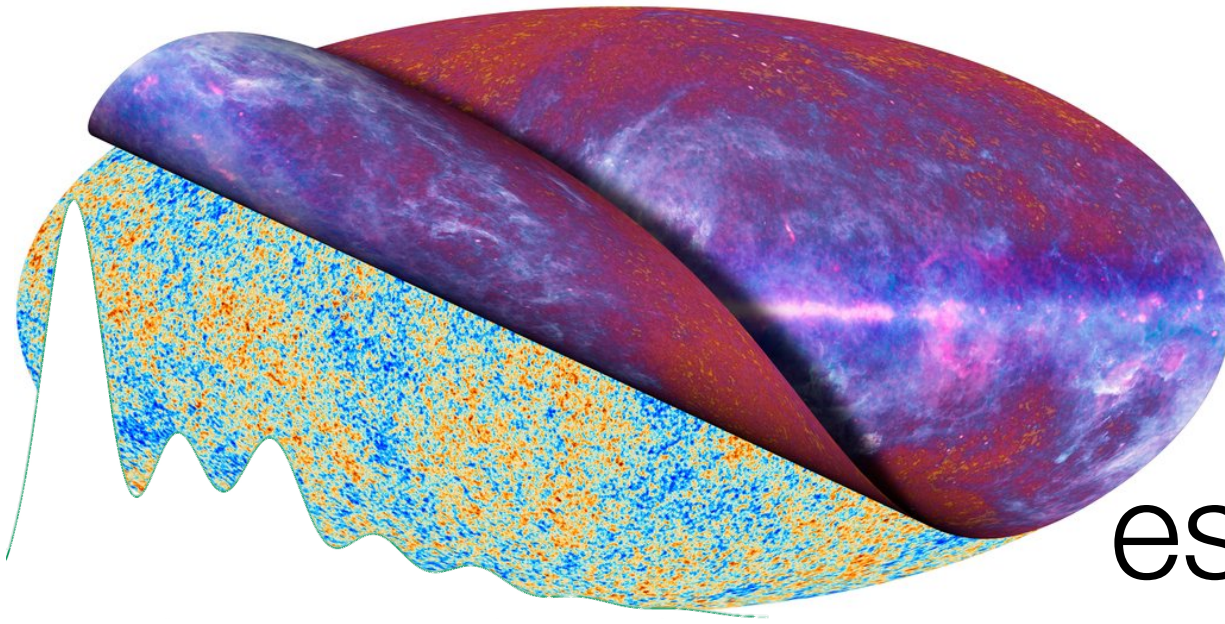




Pourquoi
la nuit
est-elle noire ?

Qu'en a vu Planck ?

Quelle est l'origine de l'Univers ?

Hervé Dole

Institut d'Astrophysique Spatiale, Orsay, France
Université Paris Sud, CNRS & université Paris-Saclay
<http://www.ias.u-psud.fr/dole/>



Comprendre le monde,
construire l'avenir®



DÉPARTEMENT
Sciences de la Planète
et de l'Univers





pourquoi la nuit
est-elle noire ?

1. Pourquoi la nuit est-elle noire ?
2. Petite histoire de l'univers
3. Les vibrations et le rythme dans l'univers jeune et l'apport de Planck
4. Des galaxies à l'unisson dans des proto-amas ?

pourquoi la nuit
est-elle noire ?



pourquoi la nuit
est-elle noire ?

pourquoi la nuit
est-elle noire ?

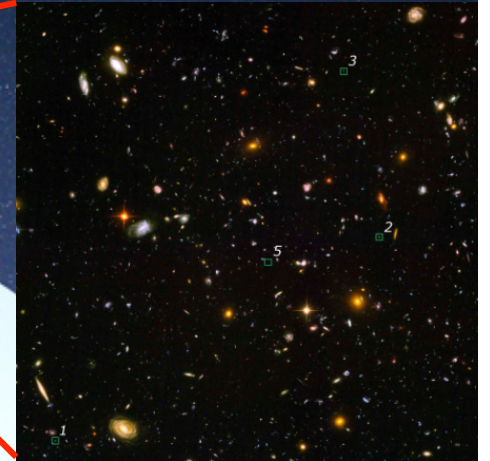
nuit

jour

pourquoi la nuit
est-elle noire ?

nuit

jour

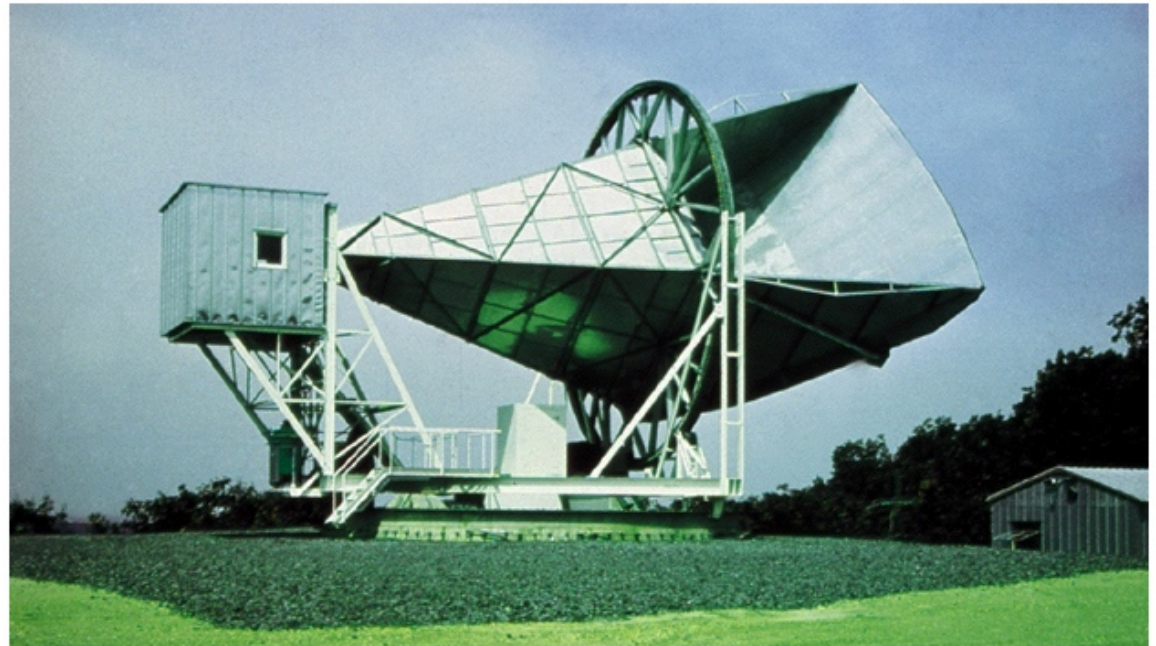
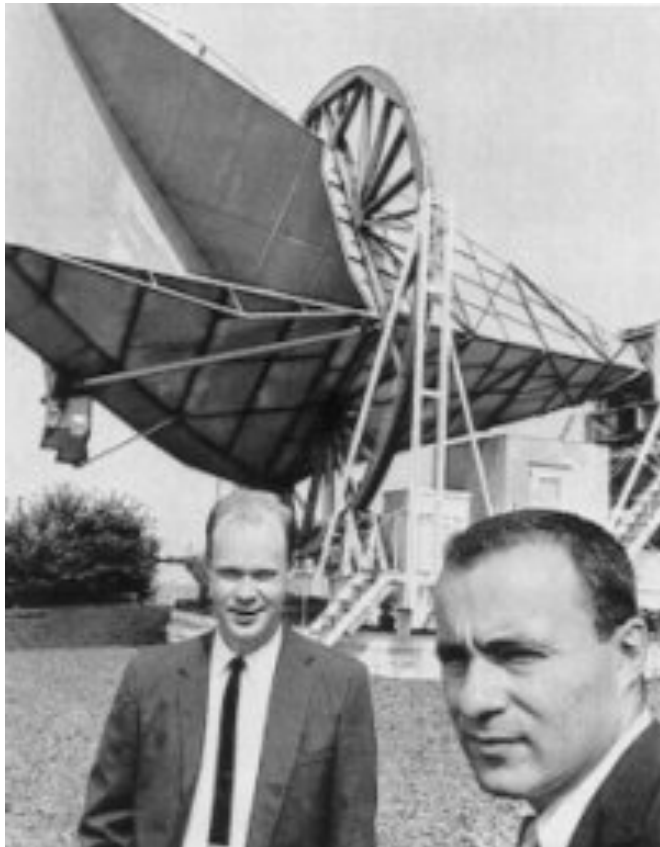


pourquoi la nuit
est-elle noire ?

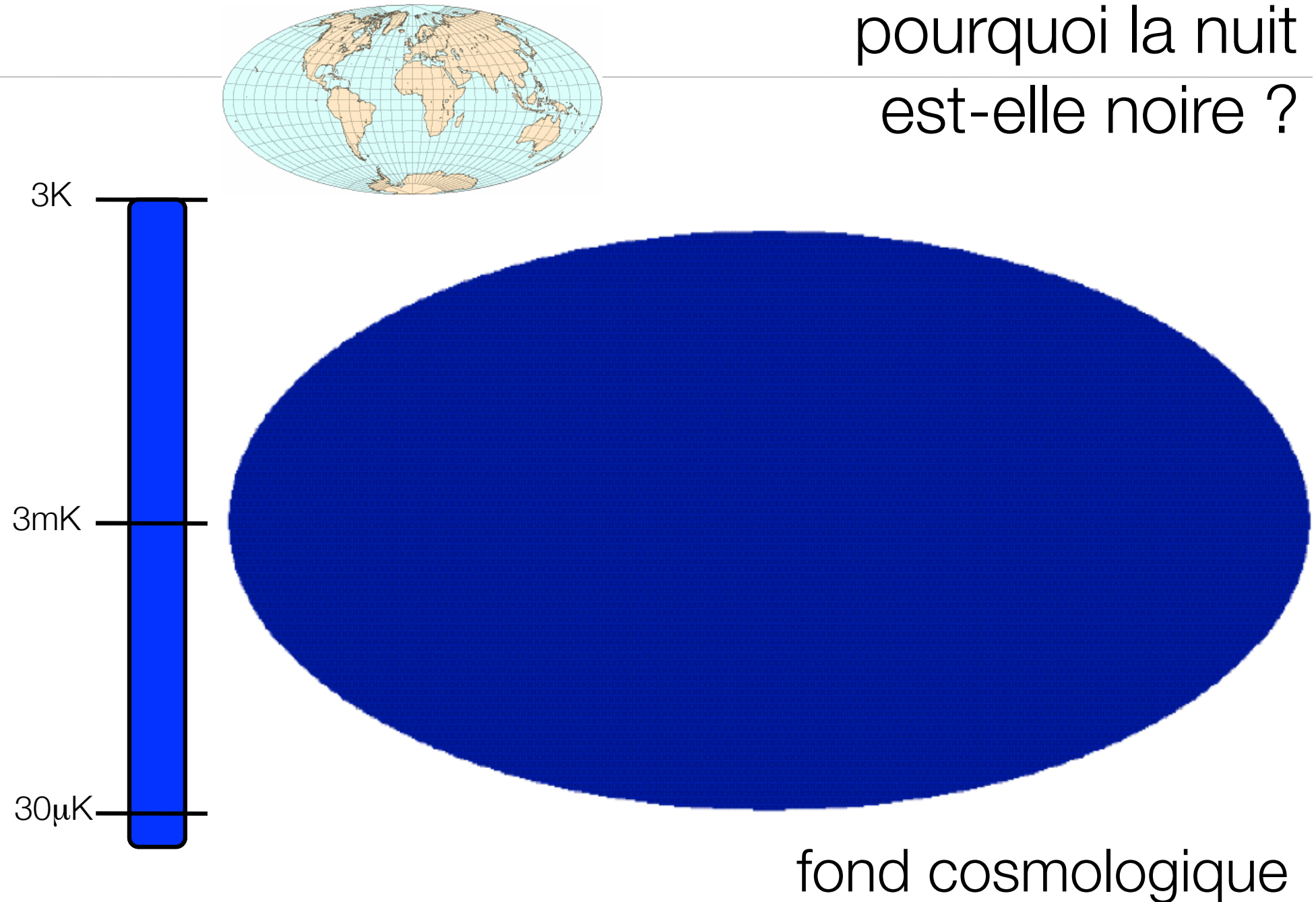
pourquoi la nuit est-elle noire ?

Digges (XVI^e), **Chéseaux** (XVII^e), Halley (XVIII^e), **Olbers** (XIX^e)
Herschel, Kant, Proctor, Fournier d'Albe, Charlier
Poe (XIX^e), **Kelvin** (XIX^e)
Hubble (1931)
Gamov (1949)
Penzias & Wilson (1965)
Wesson (1987, 1991)

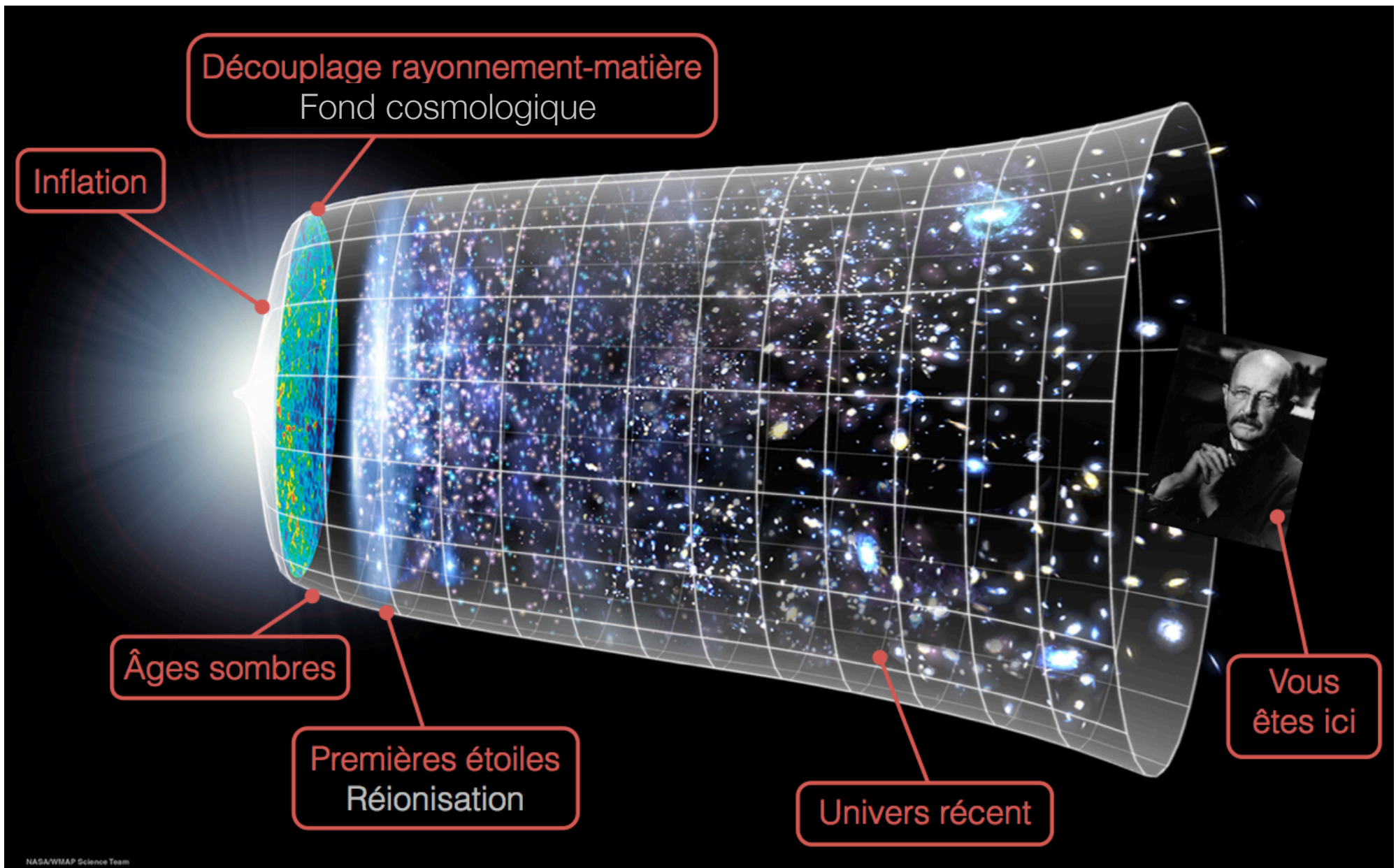
pourquoi la nuit est-elle noire ?

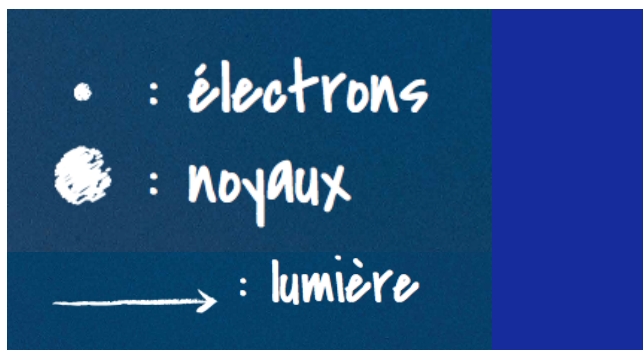
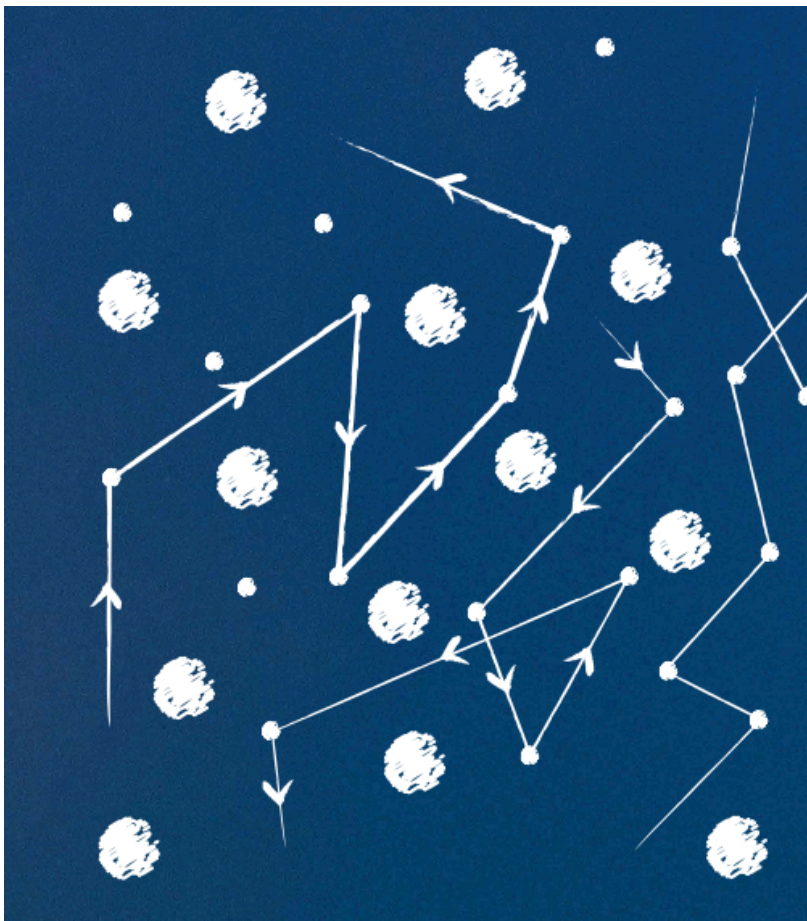


pourquoi la nuit
est-elle noire ?

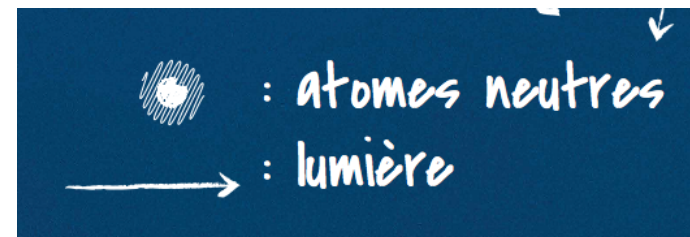
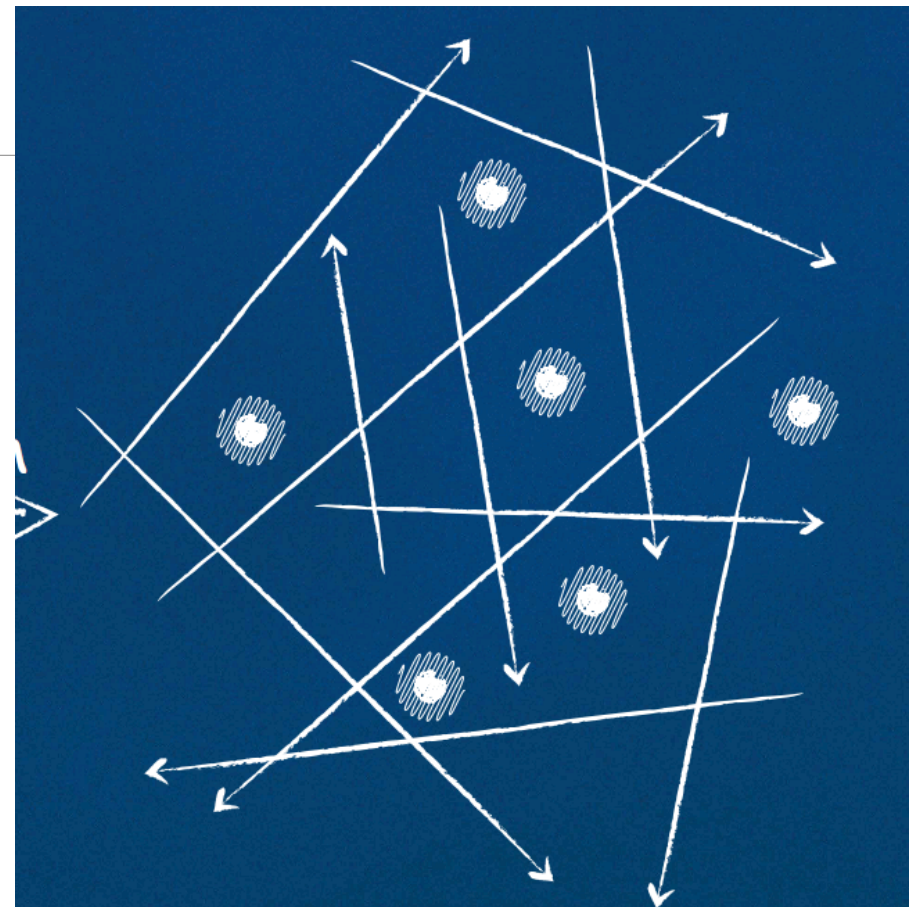


2. univers: 13.8 milliards d'années d'histoire

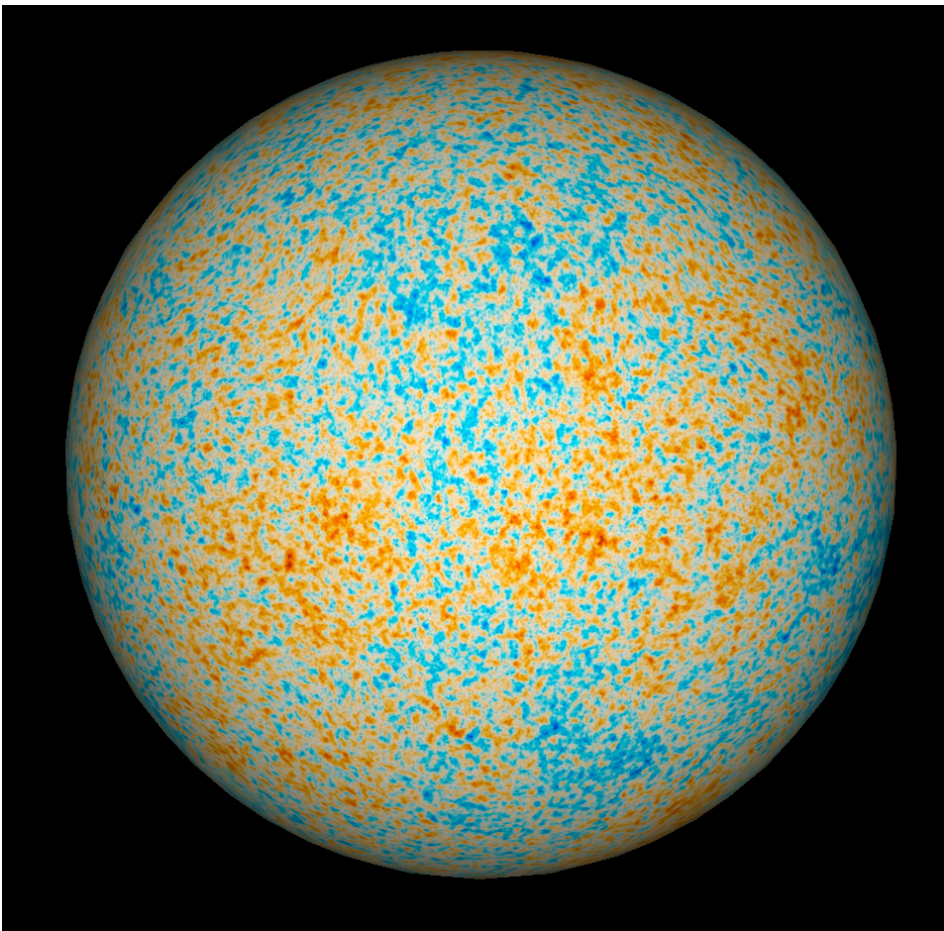




univers opaque

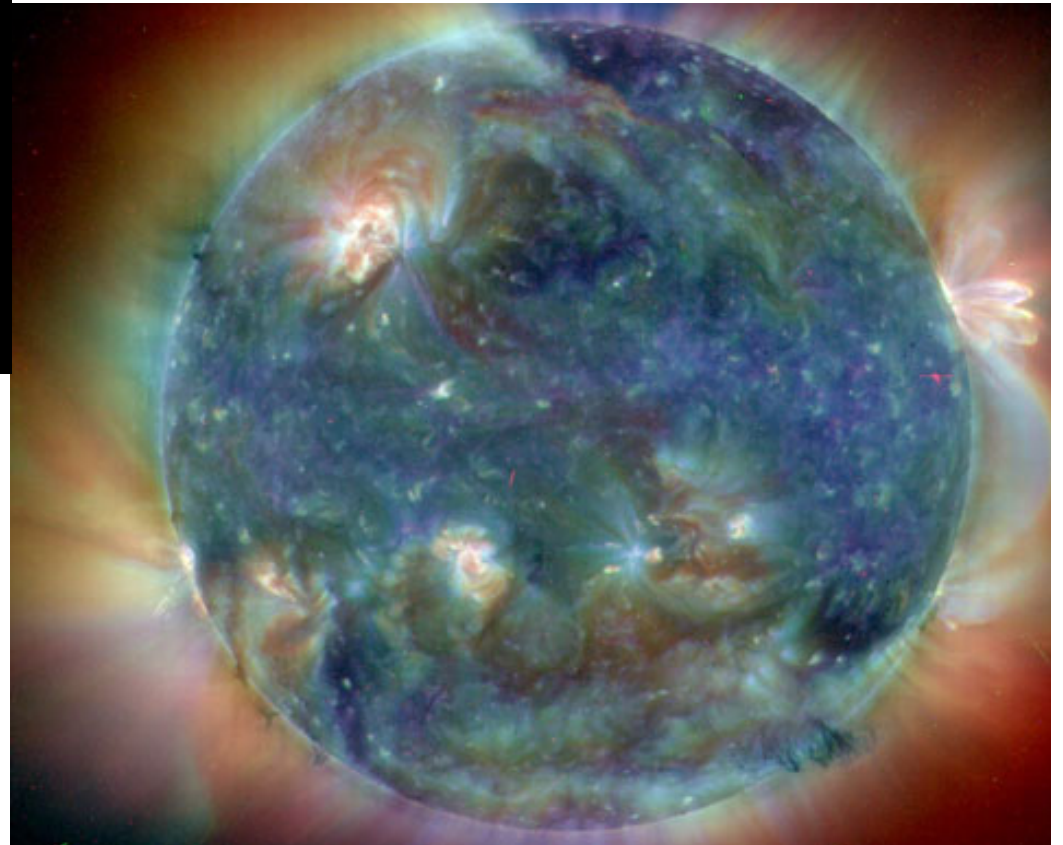


univers transparent

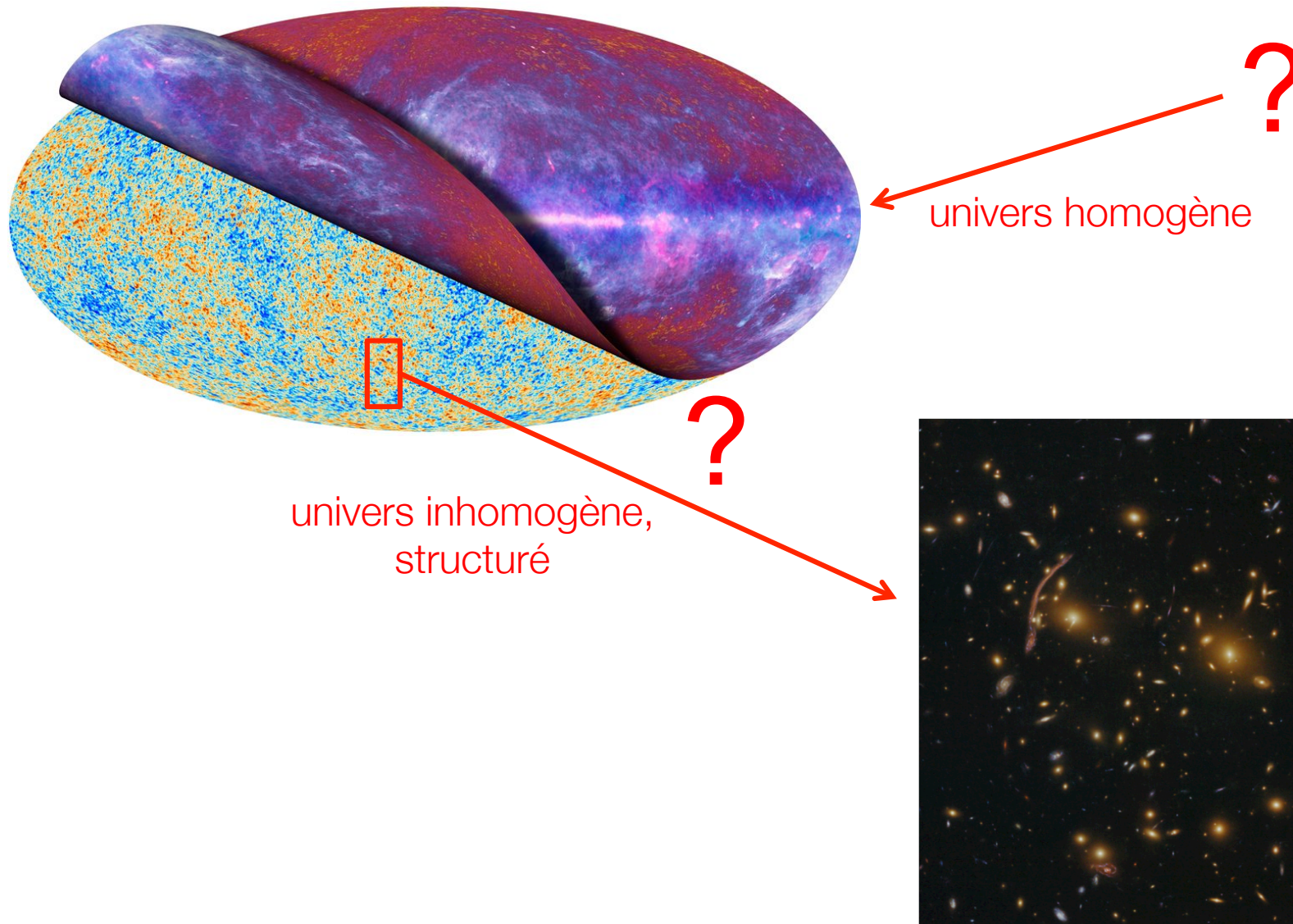


fond cosmologique

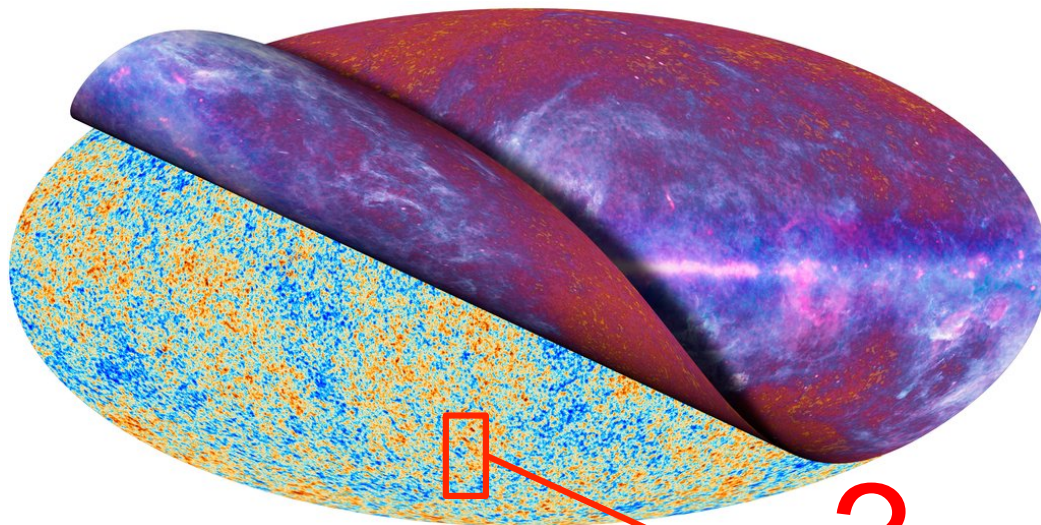
Soleil



les deux grandes questions



les deux grandes questions



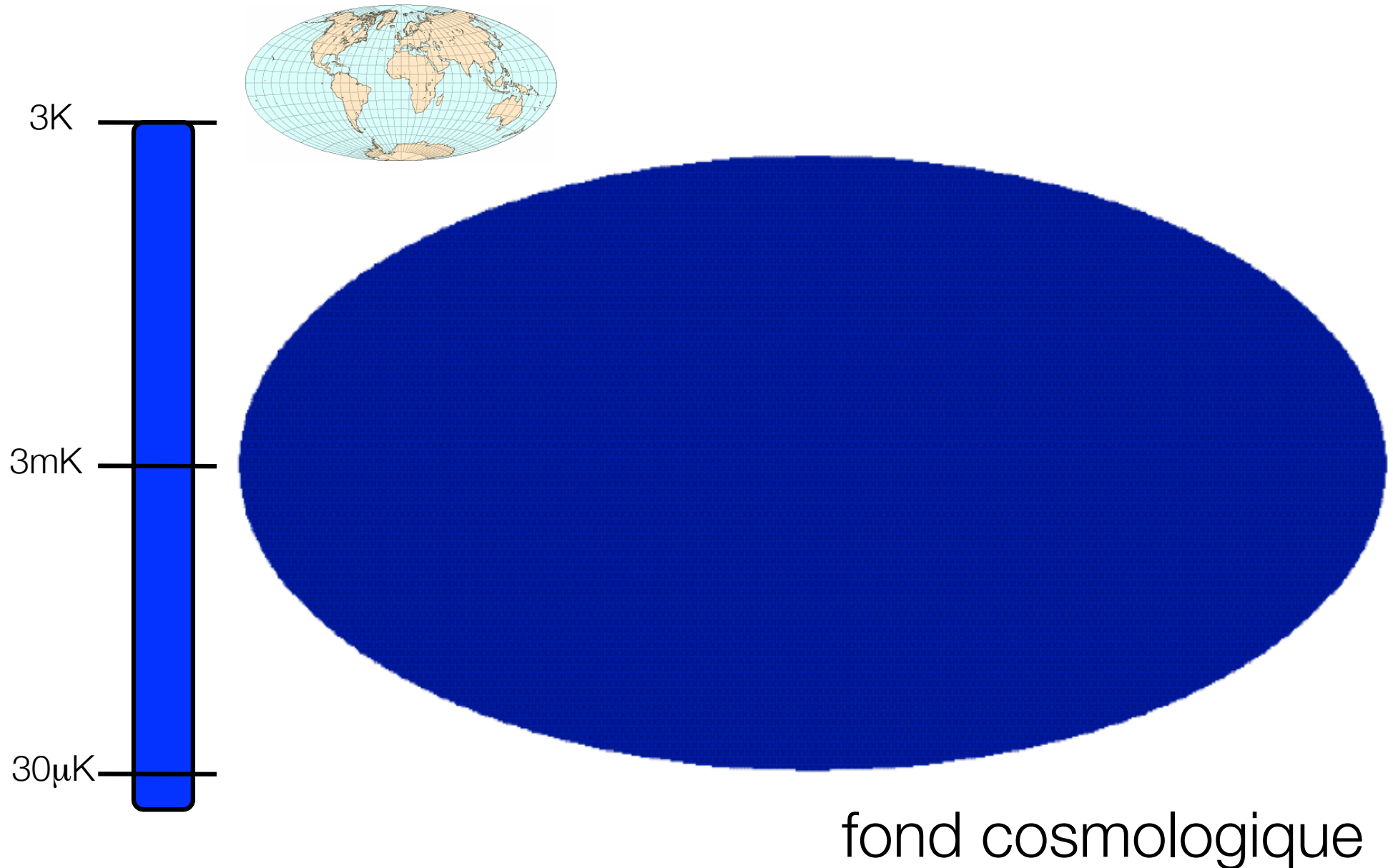
?
univers homogène
modèles d'inflation ?

?
univers inhomogène,
structuré

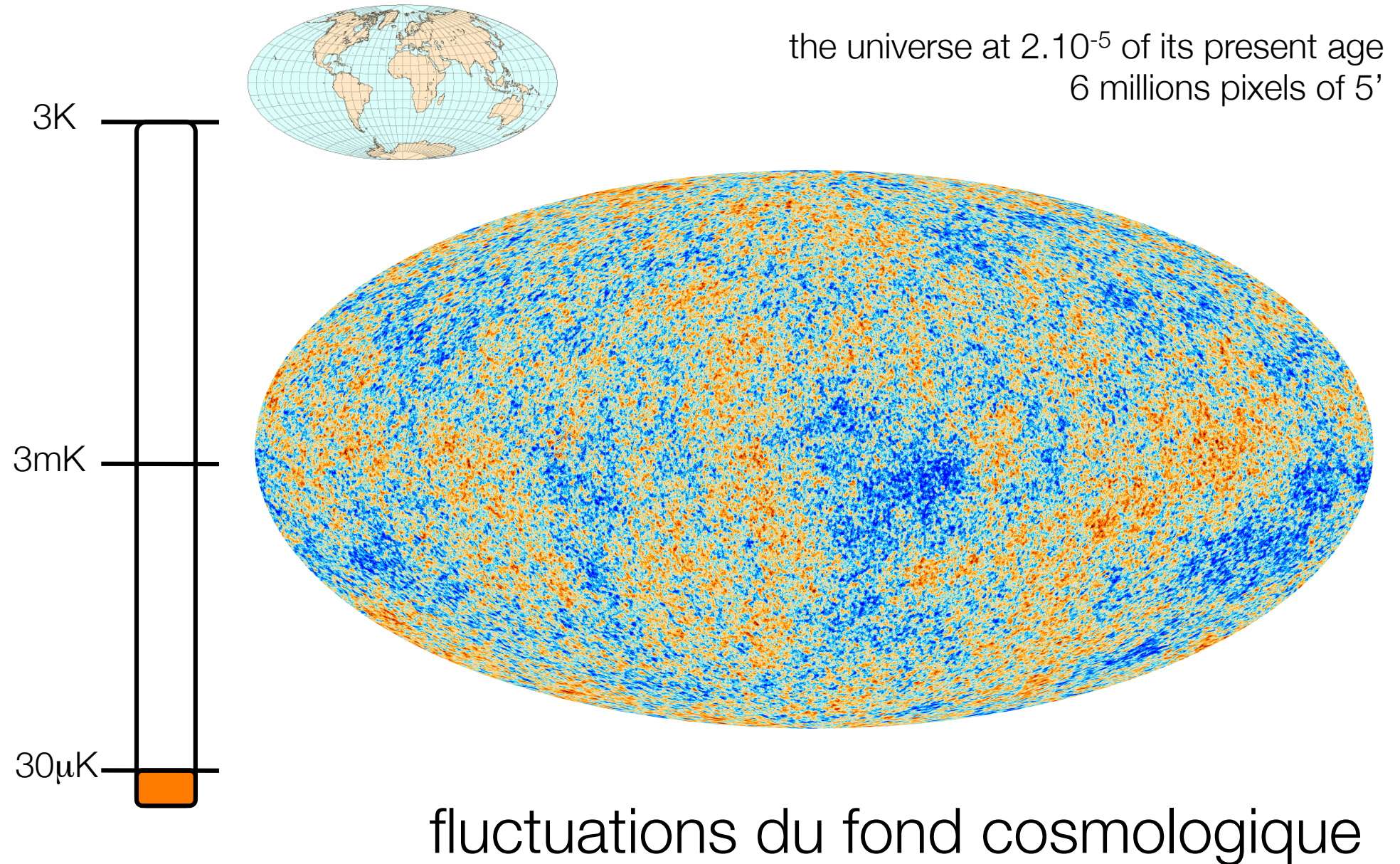
formation
des structures



3. les vibrations de l'univers jeune

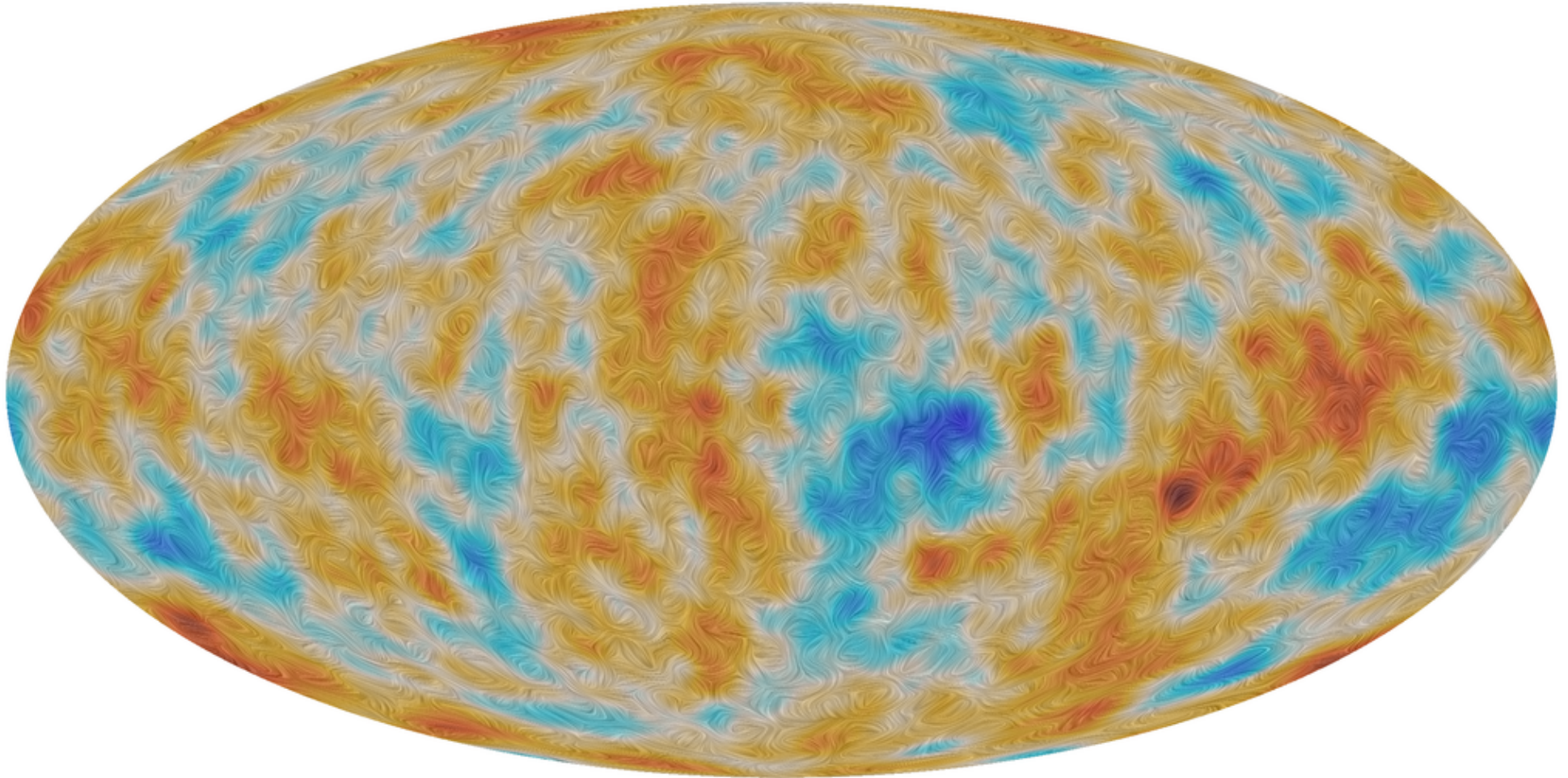


3. les vibrations de l'univers jeune

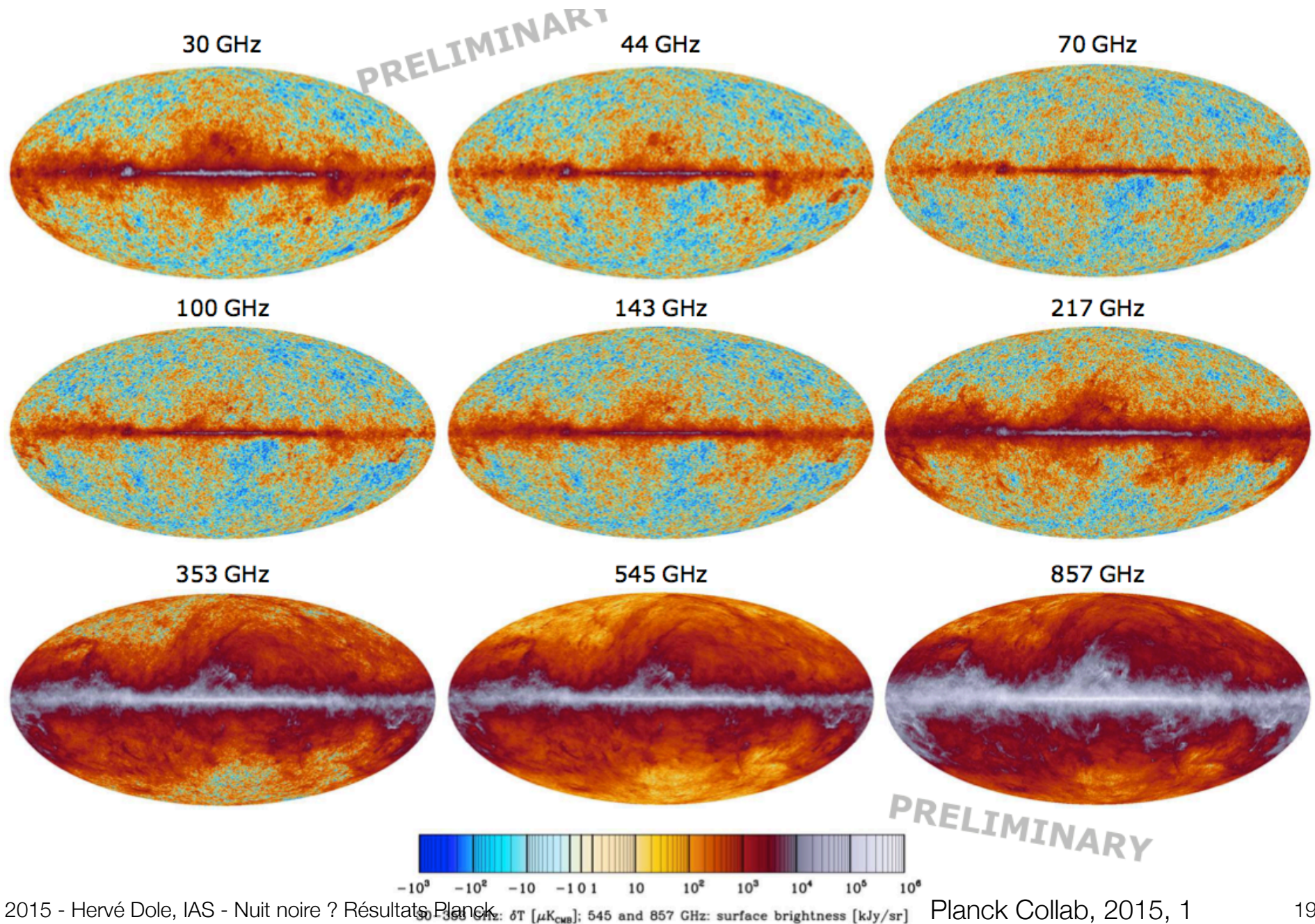


3. les vibrations de l'univers jeune

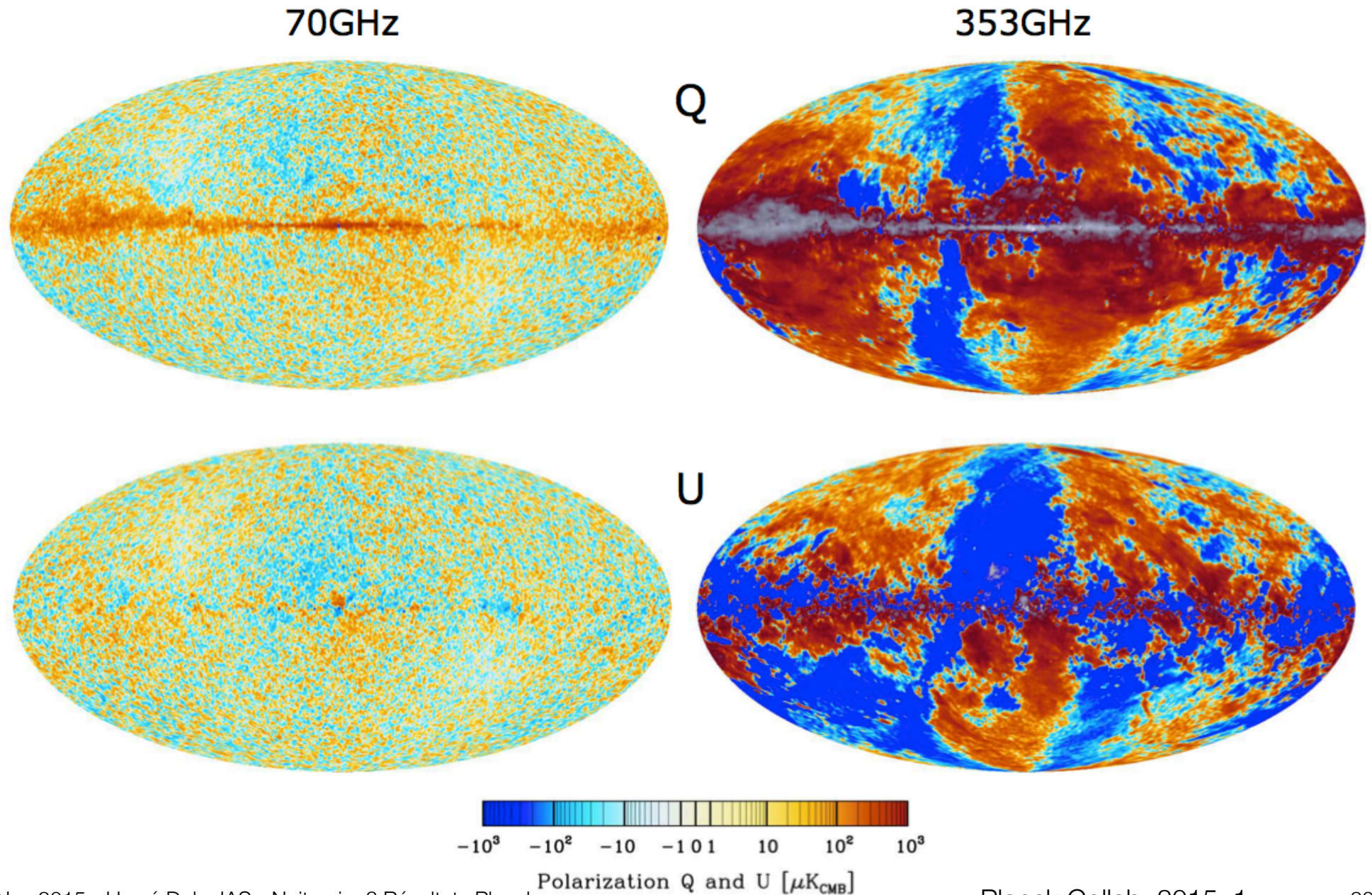
fluctuations de polarisation du rayonnement



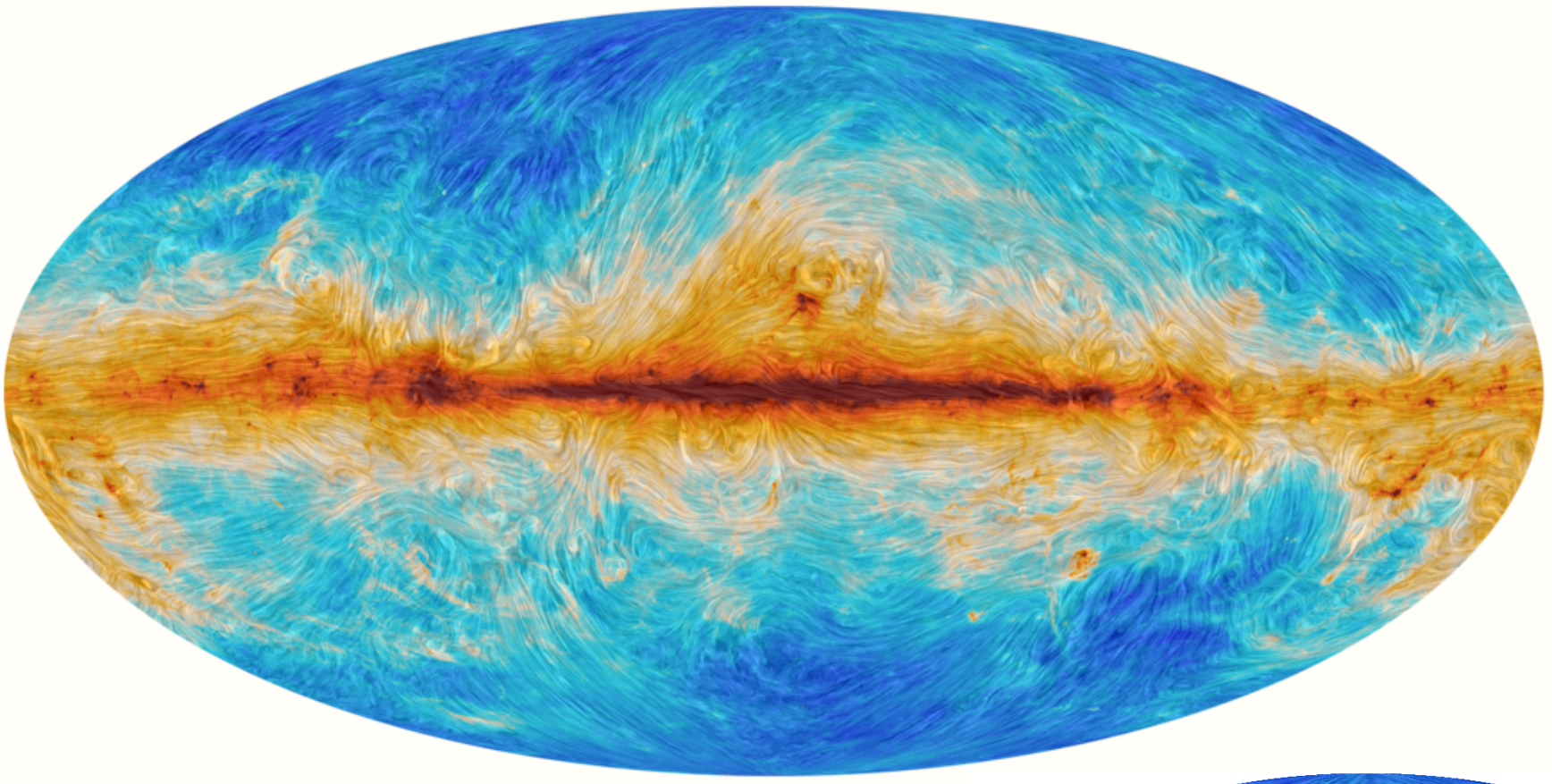
3.1 observations: Planck all-sky maps 2015



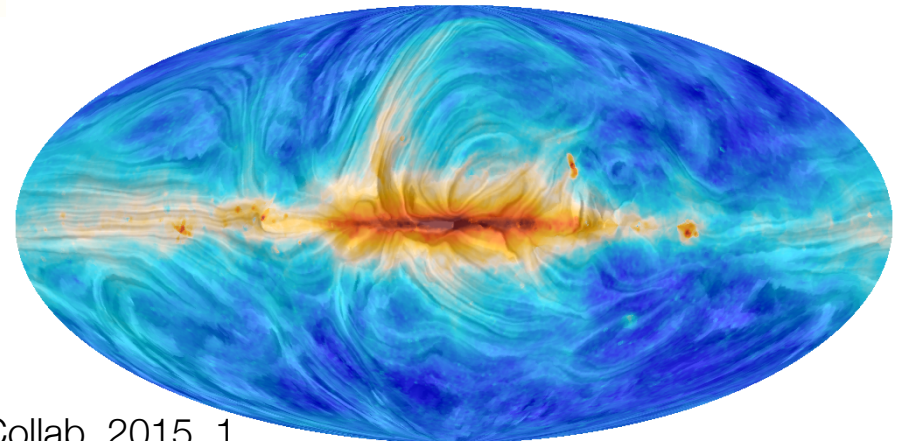
3.1 observations: polarisation 2015



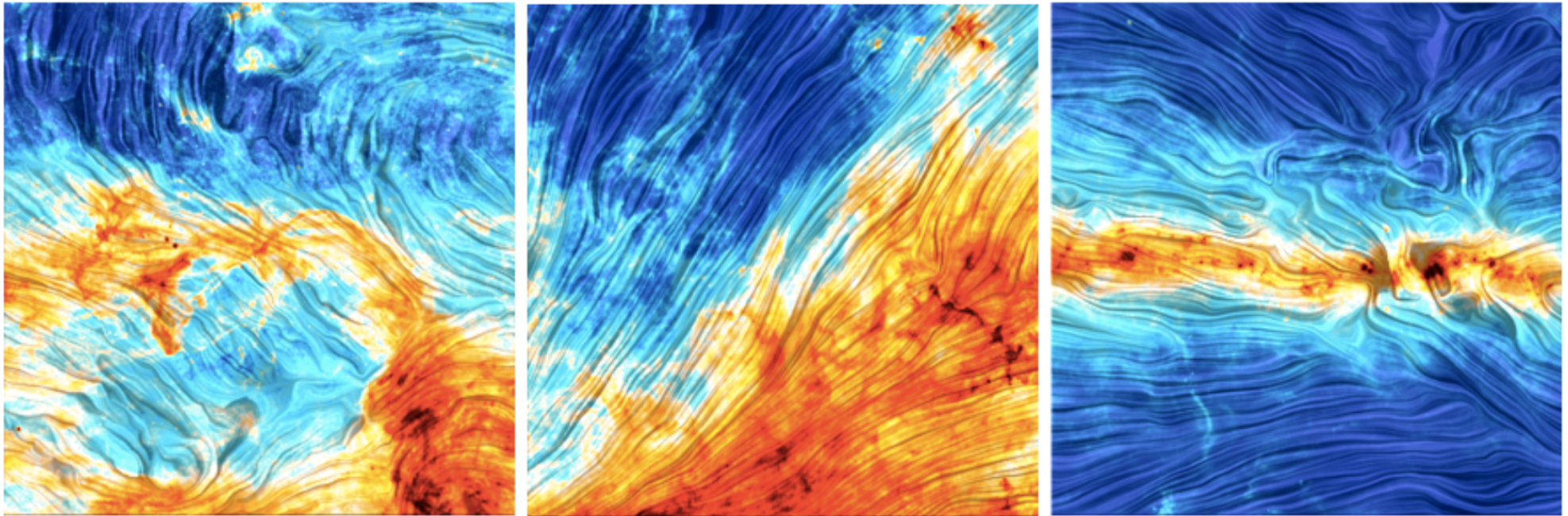
3.1 fantastiques vues du champ magnétique



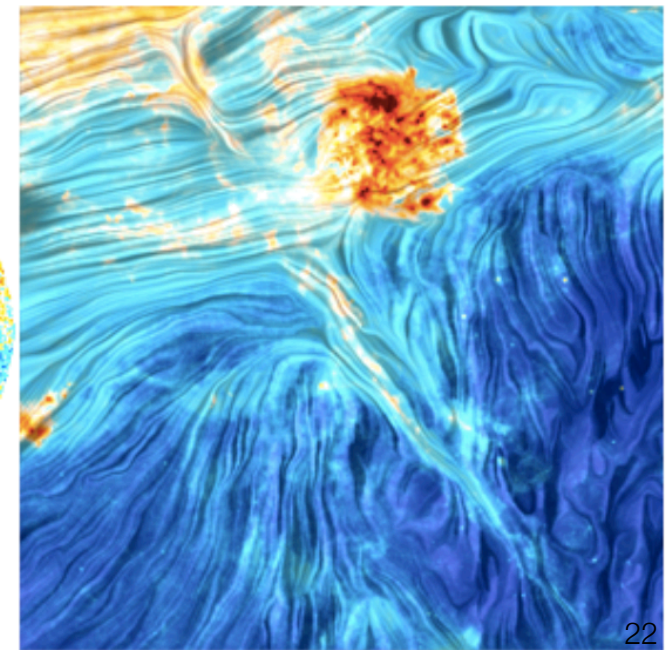
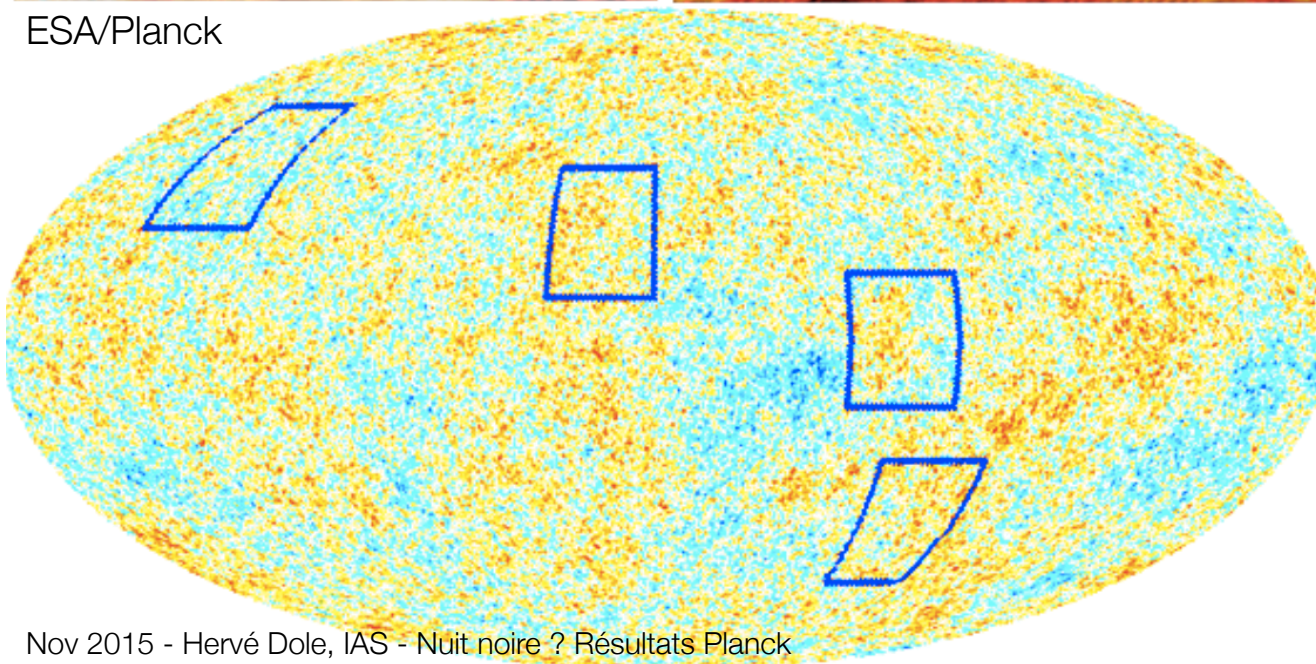
B field.
top: dust @ 353 GHz
right: synchrotron @ 30 GHz



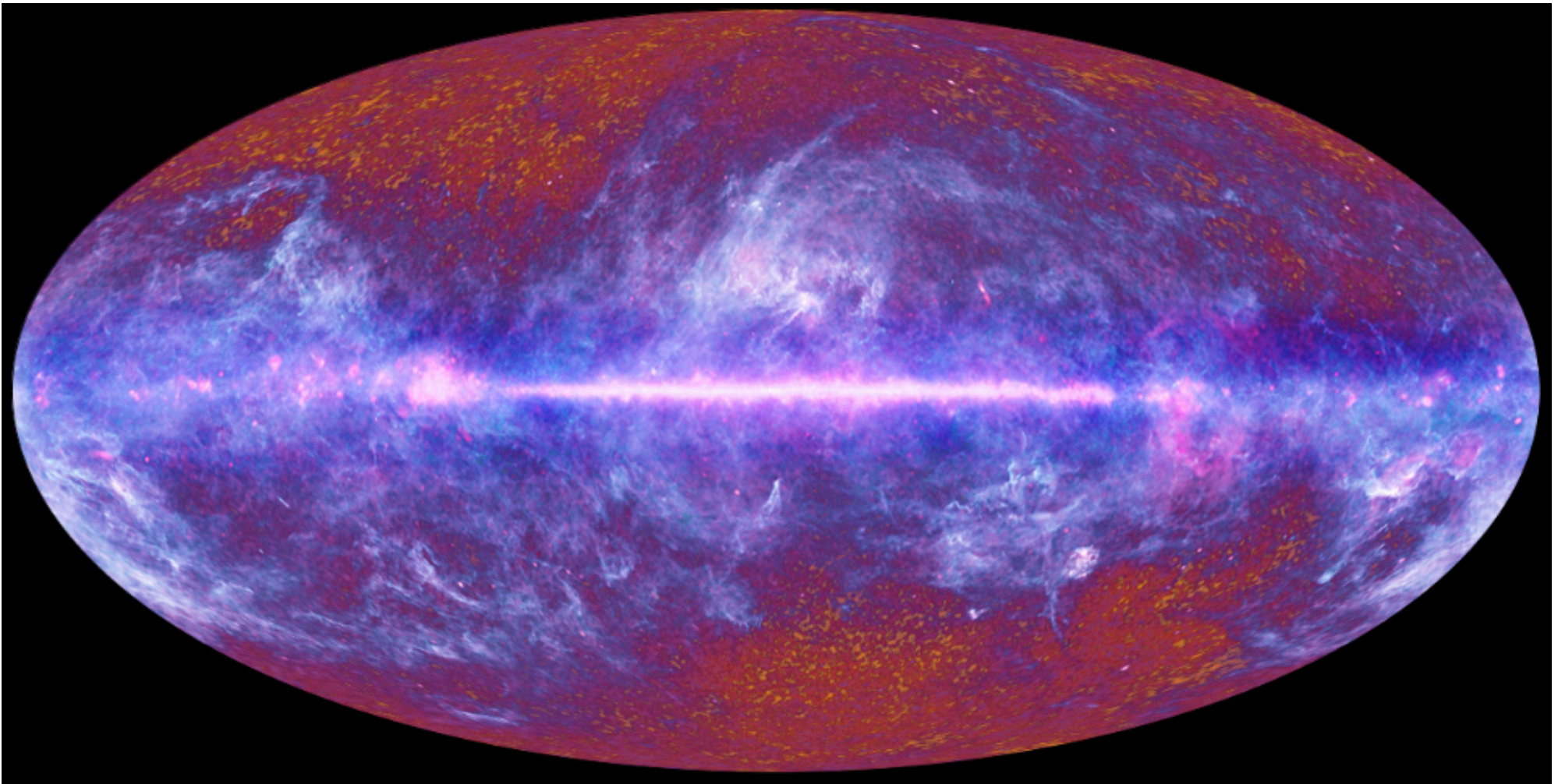
3.1 observations: polarisation 2015 et B



ESA/Planck



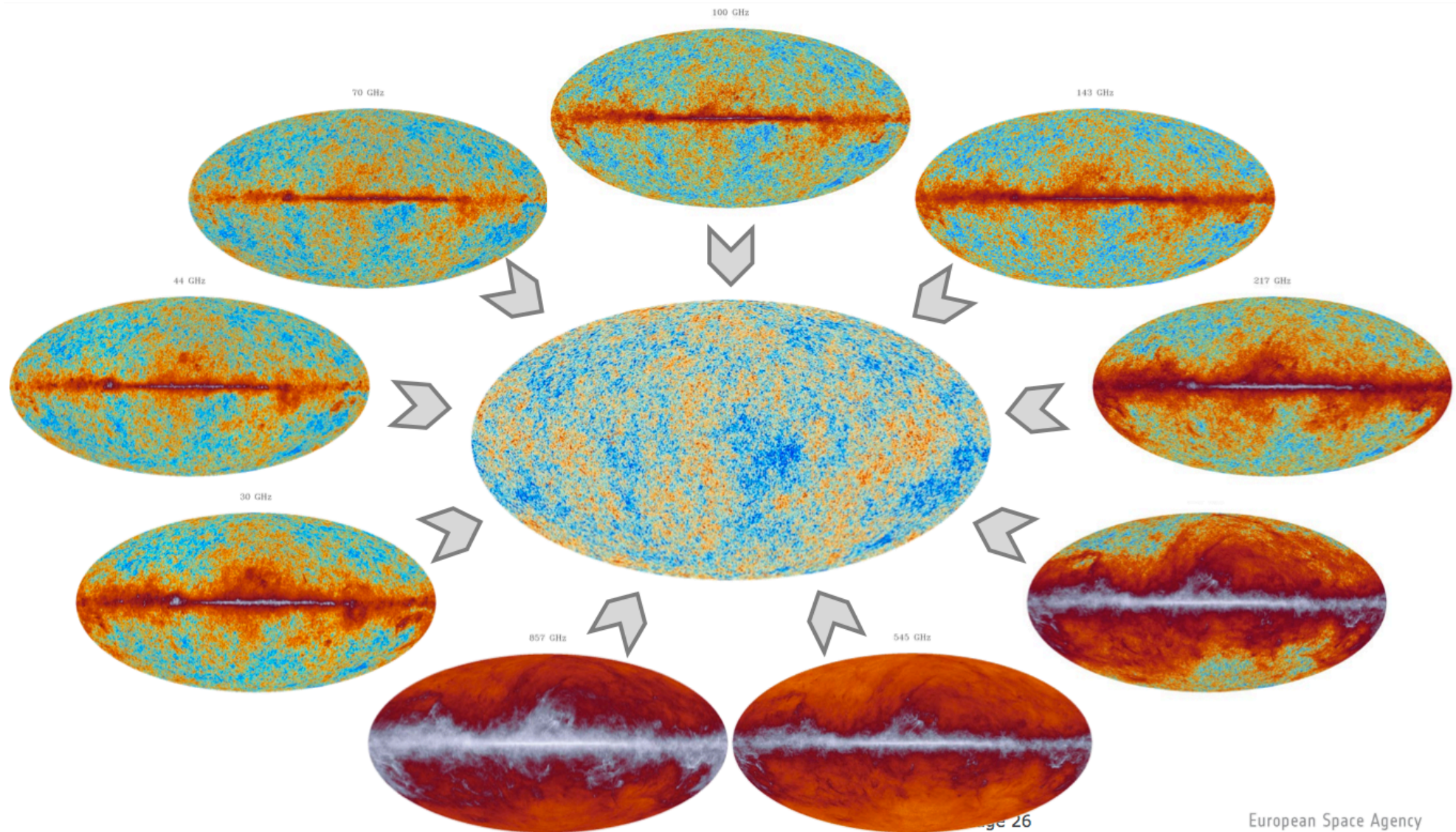
3.2 séparation de composantes



The PLANCK one-year all-sky survey



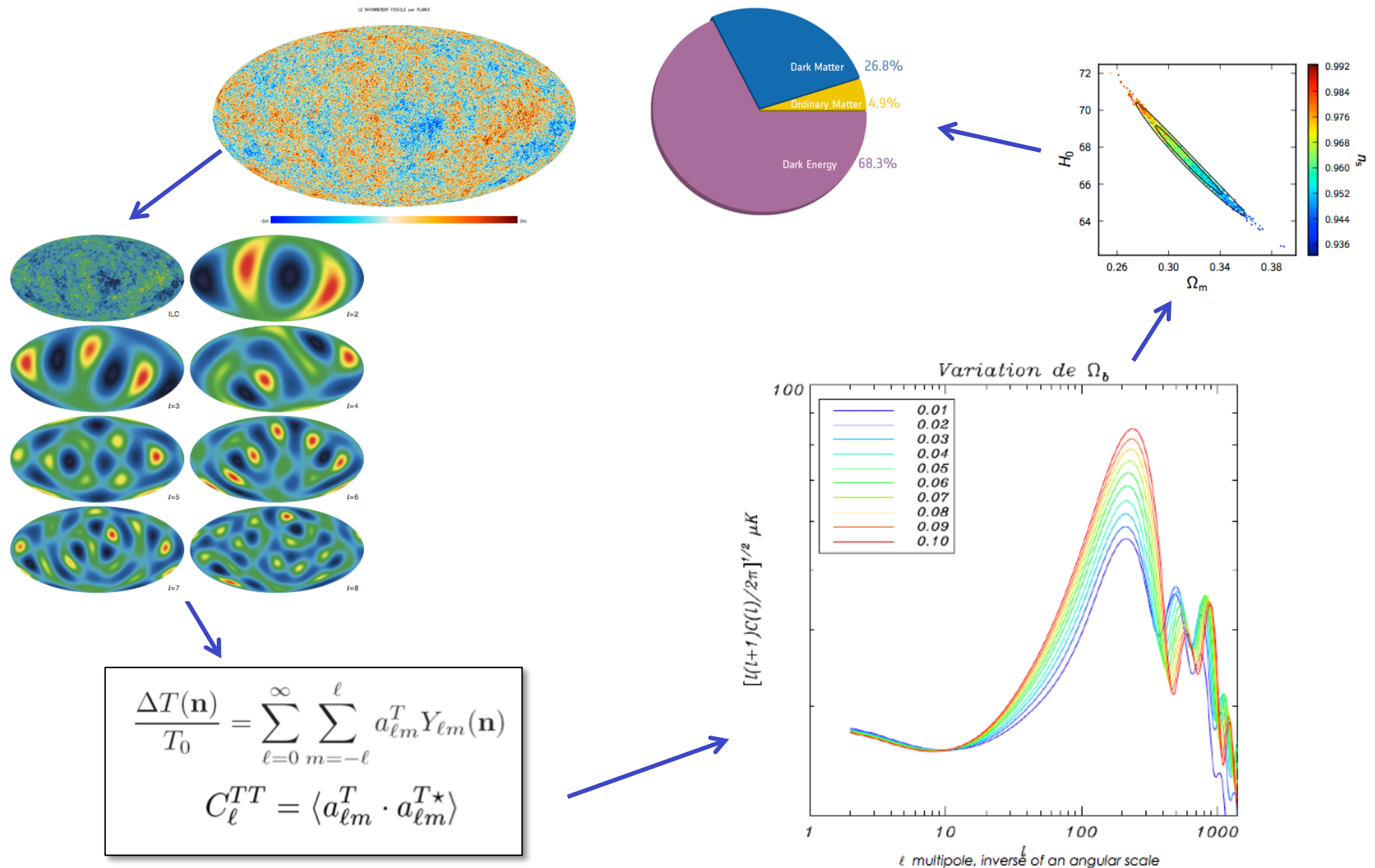
3.2 séparation de composantes



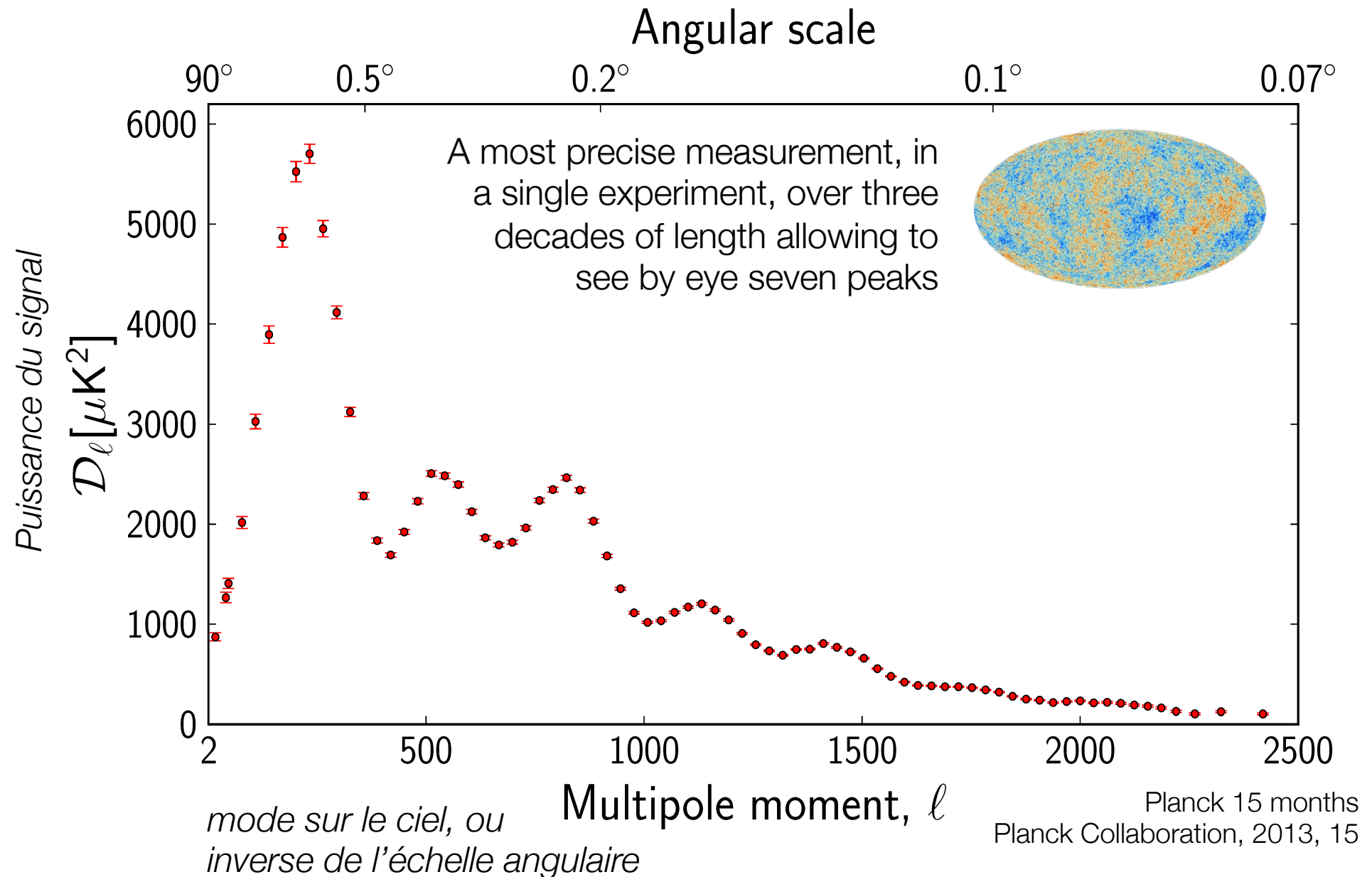
Page 26

European Space Agency

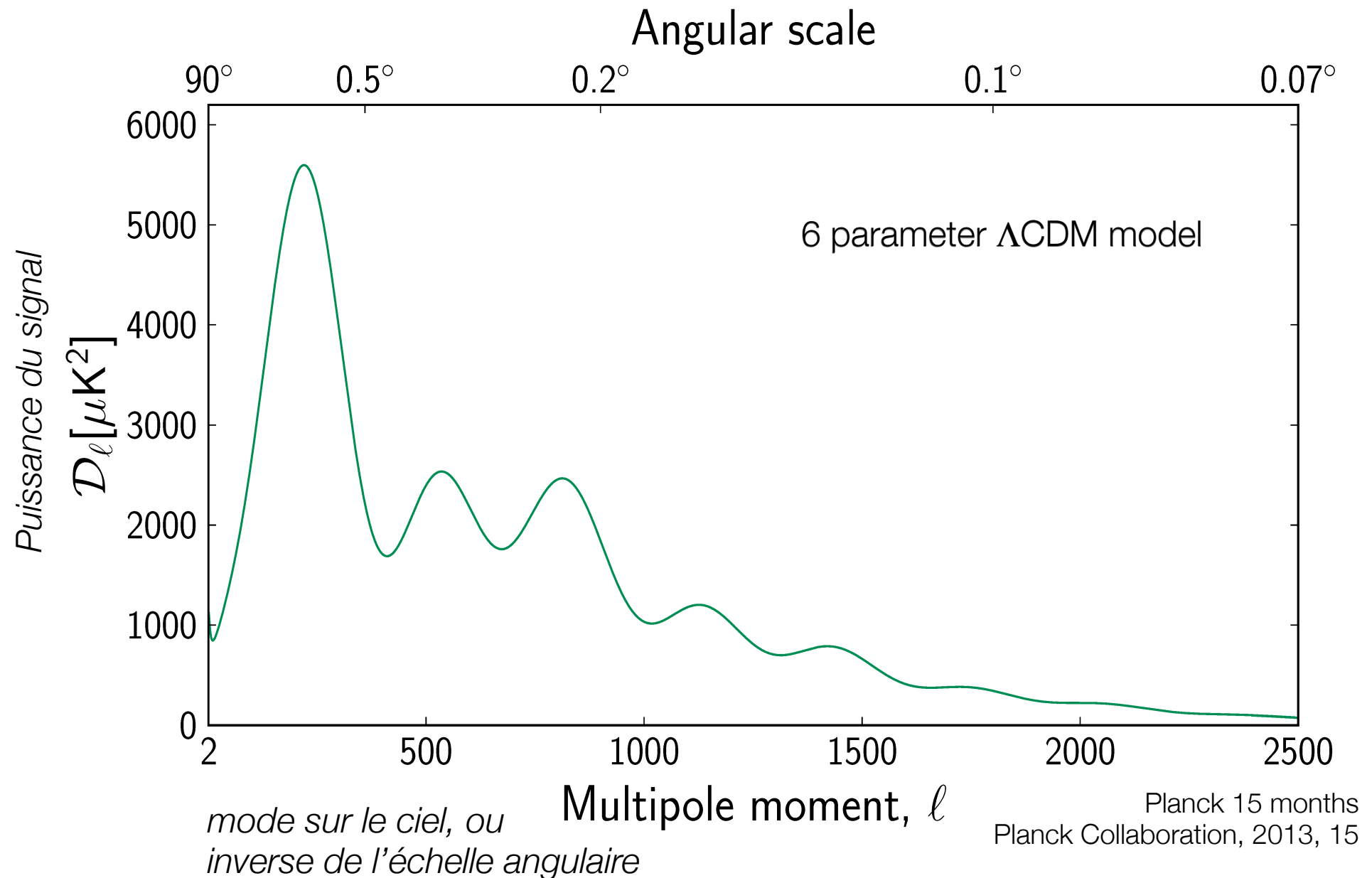
3.3 des cartes aux 6 param. cosmologiques



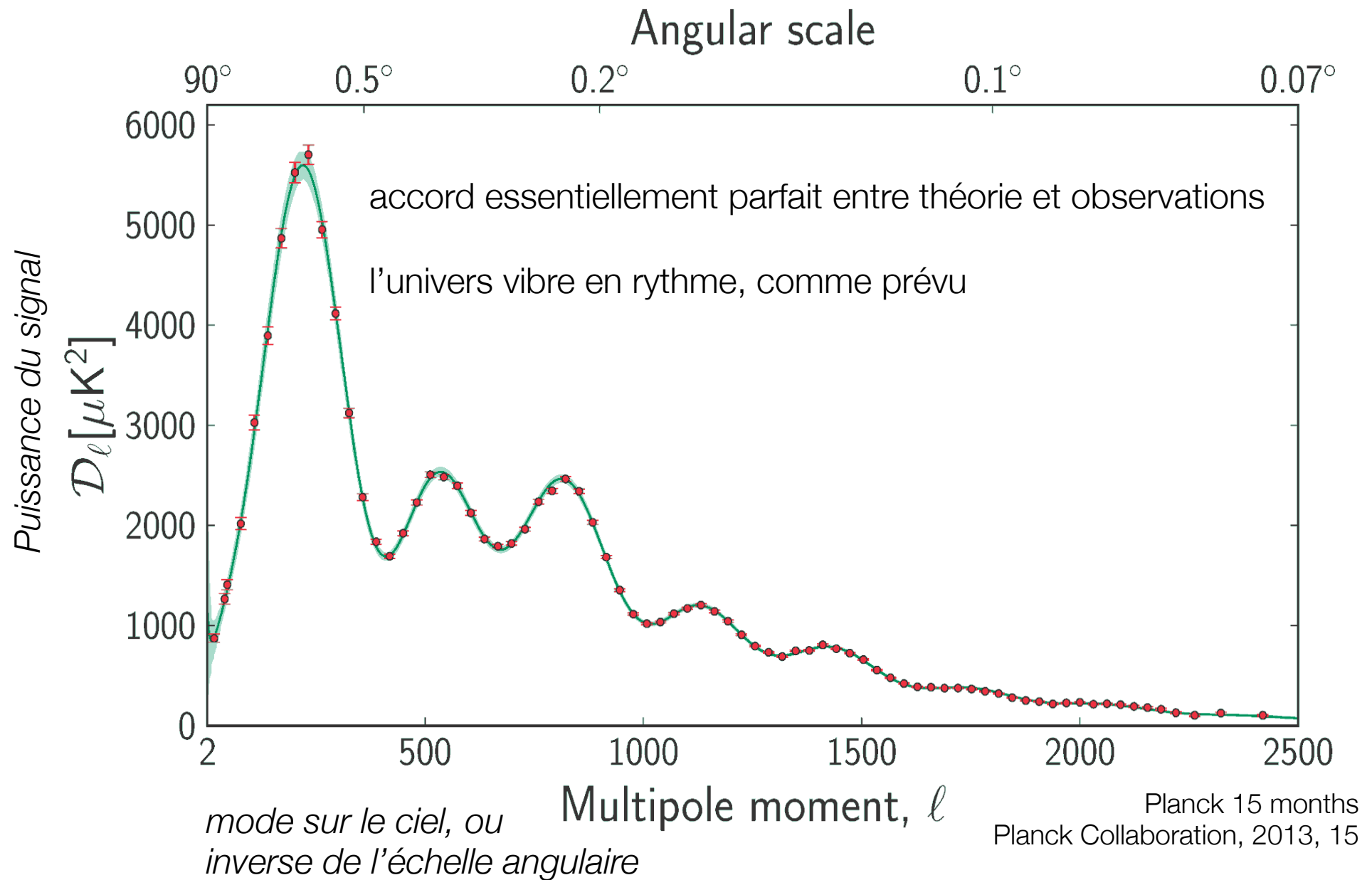
the Planck power spectrum of temp. anisotropies



Planck best fitting theoretical model



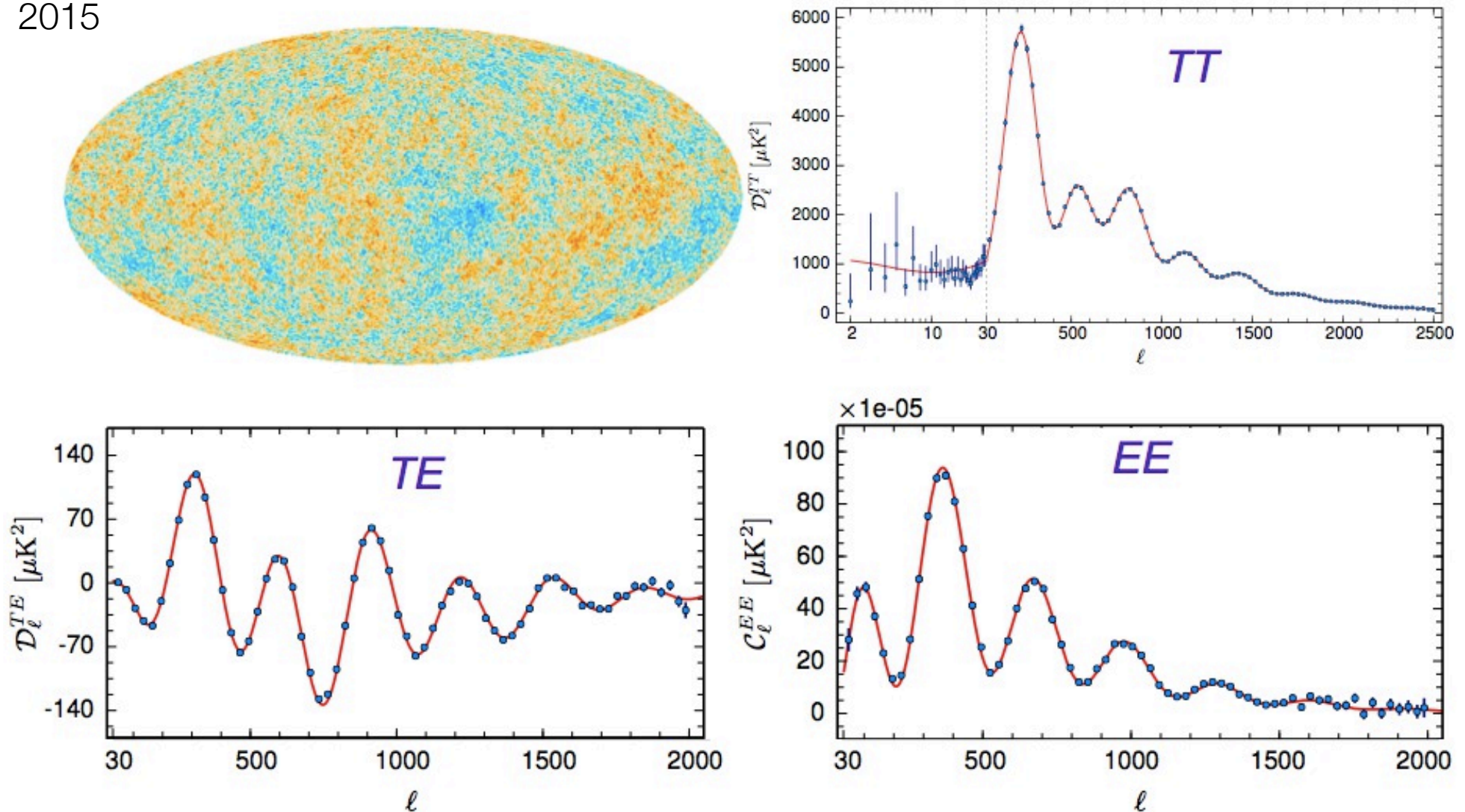
theory confronts data



theory confronts data – from 7 to 19 peaks

Le rayonnement fossile mesuré par Planck

2015



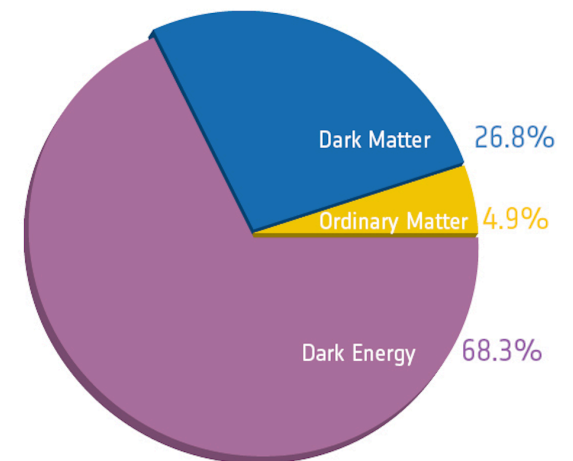
Planck 2015

paramètres cosmologiques les plus précis

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

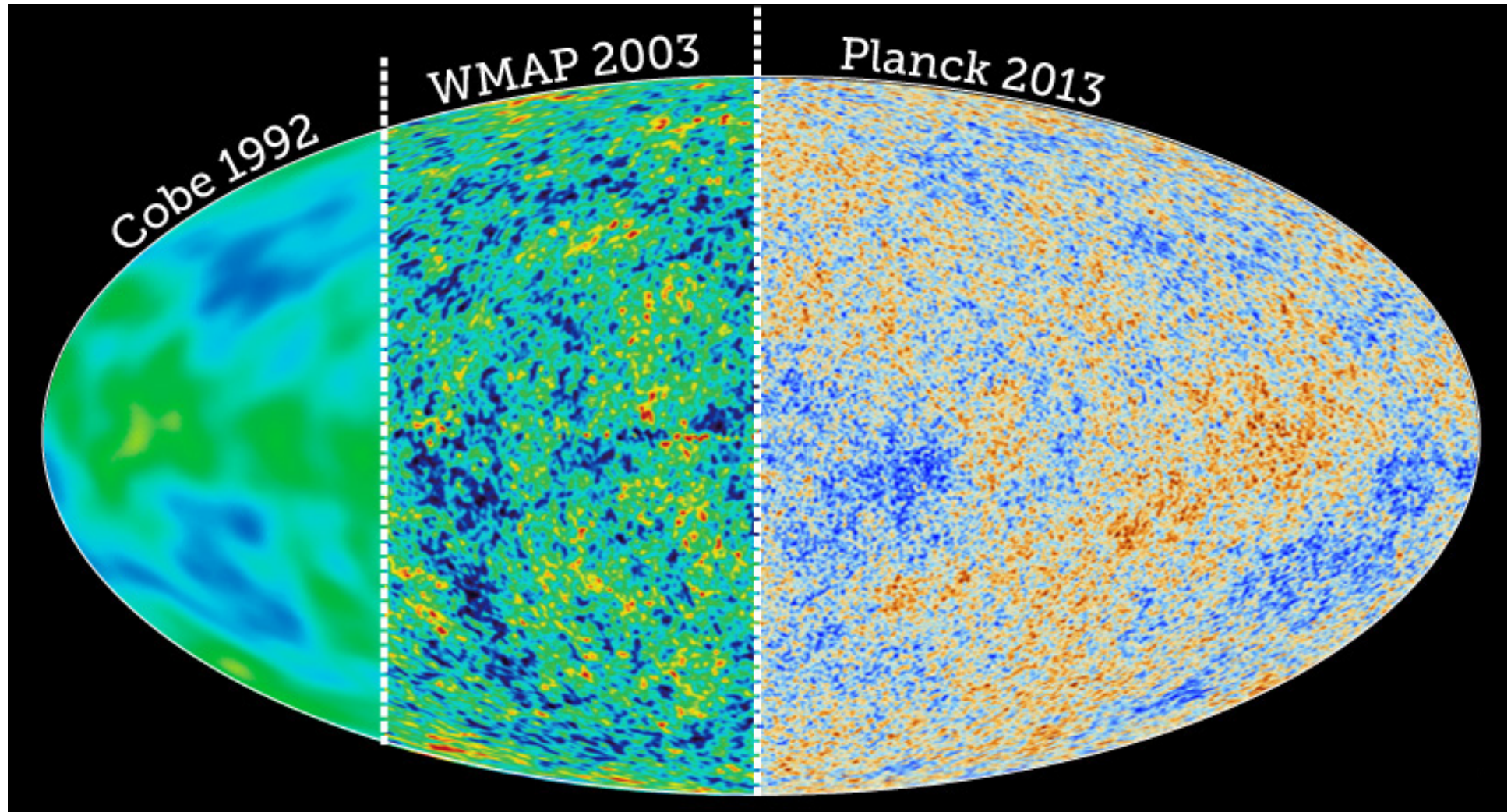
Parameter	<i>Planck</i> TT+lowP+lensing
$\Omega_b h^2$	0.02226 ± 0.00023
$\Omega_c h^2$	0.1186 ± 0.0020
$100\theta_{\text{MC}}$	1.04103 ± 0.00046
τ	0.066 ± 0.016
$\ln(10^{10} A_s)$	3.062 ± 0.029
n_s	0.9677 ± 0.0060
H_0	67.8 ± 0.9
Ω_m	0.308 ± 0.012
$\Omega_m h^2$	0.1415 ± 0.0019
$\Omega_m h^3$	0.09591 ± 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 cosmological parameters

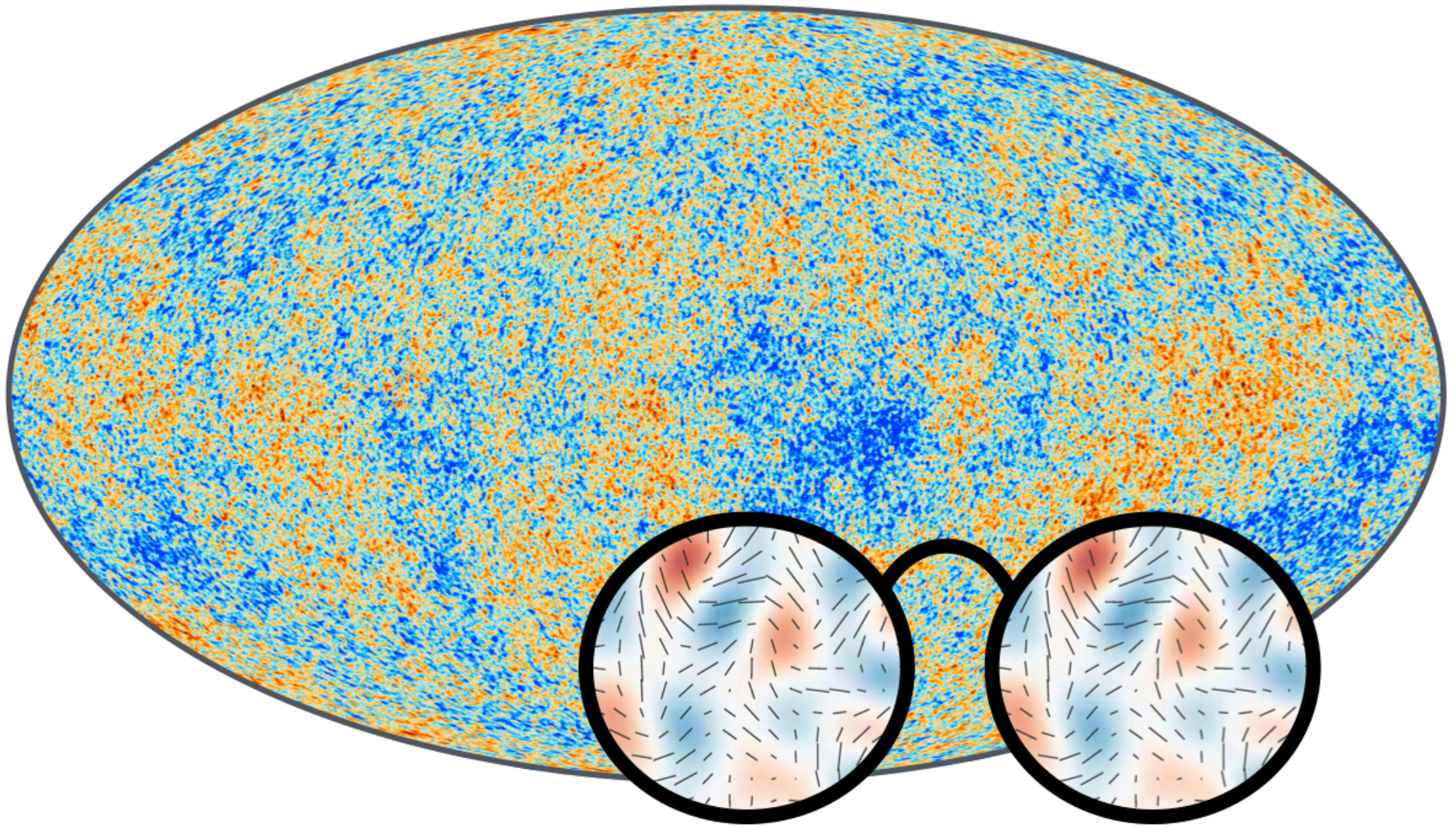


0.3% incertitude !

3.4 la « révolution » Planck

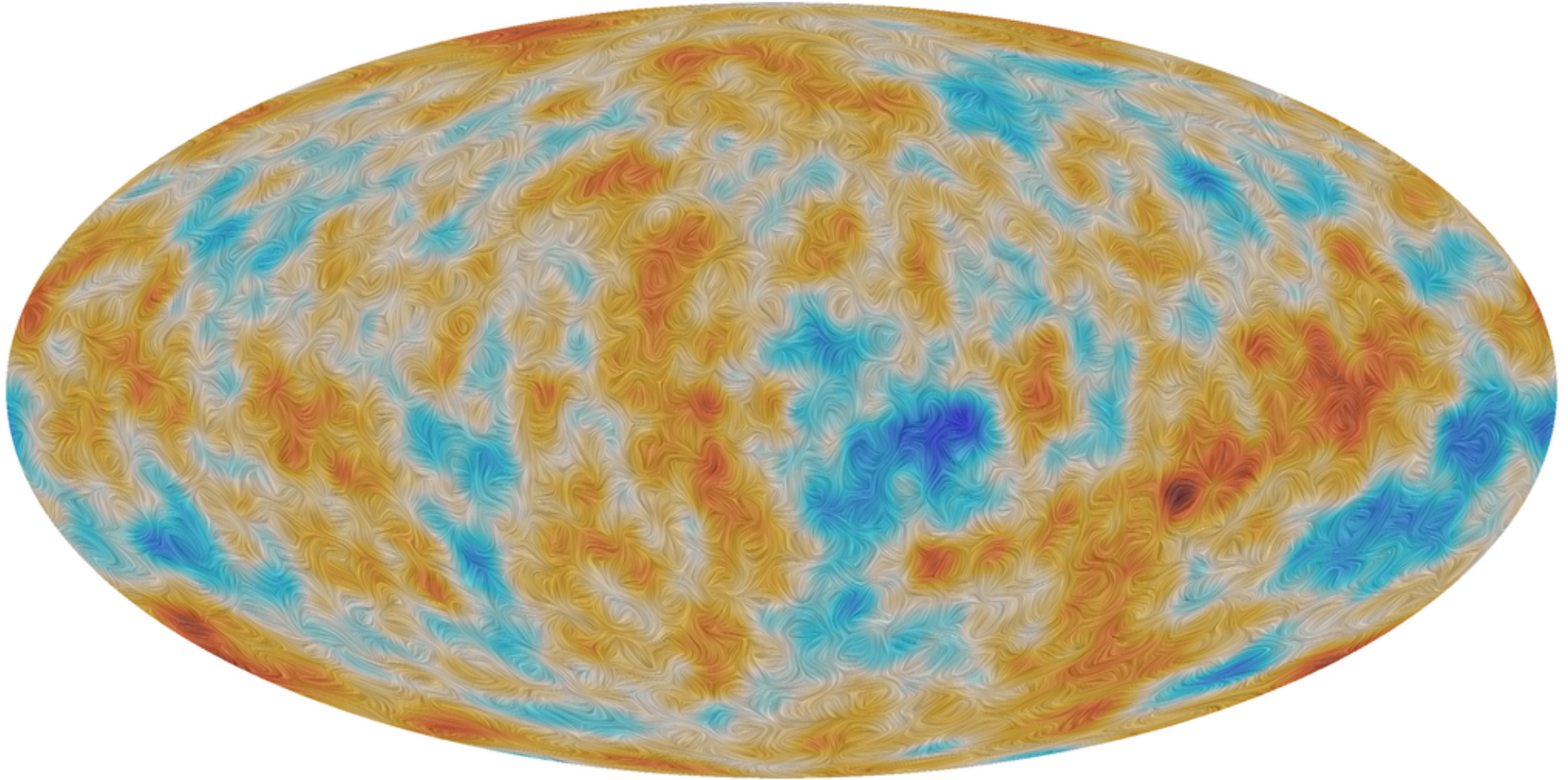


3.5 la polarisation du fond cosmologique



les vibrations de l'univers jeune: polarisation

fluctuations de polarisation du rayonnement



3.6 inflation 2015

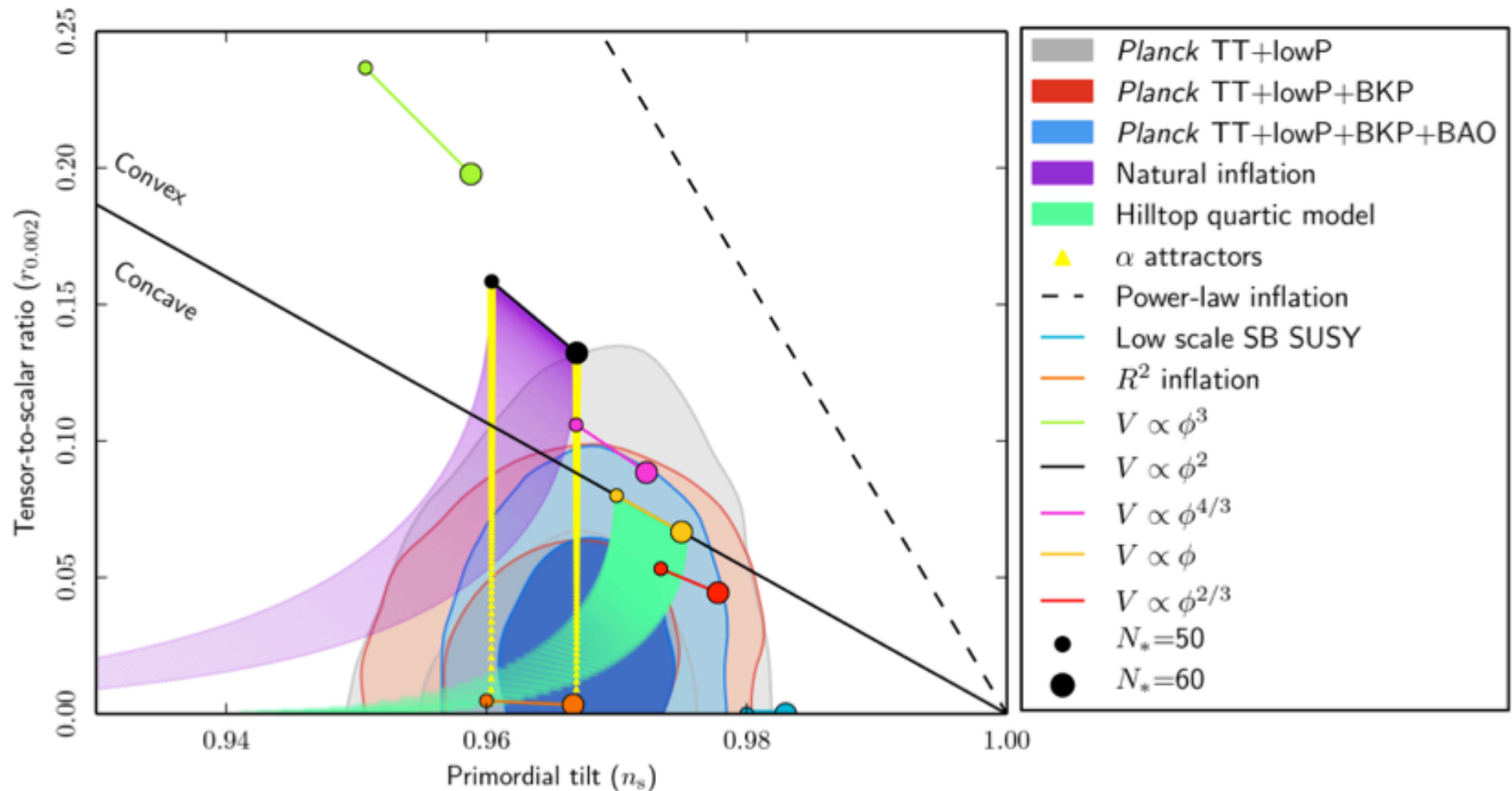
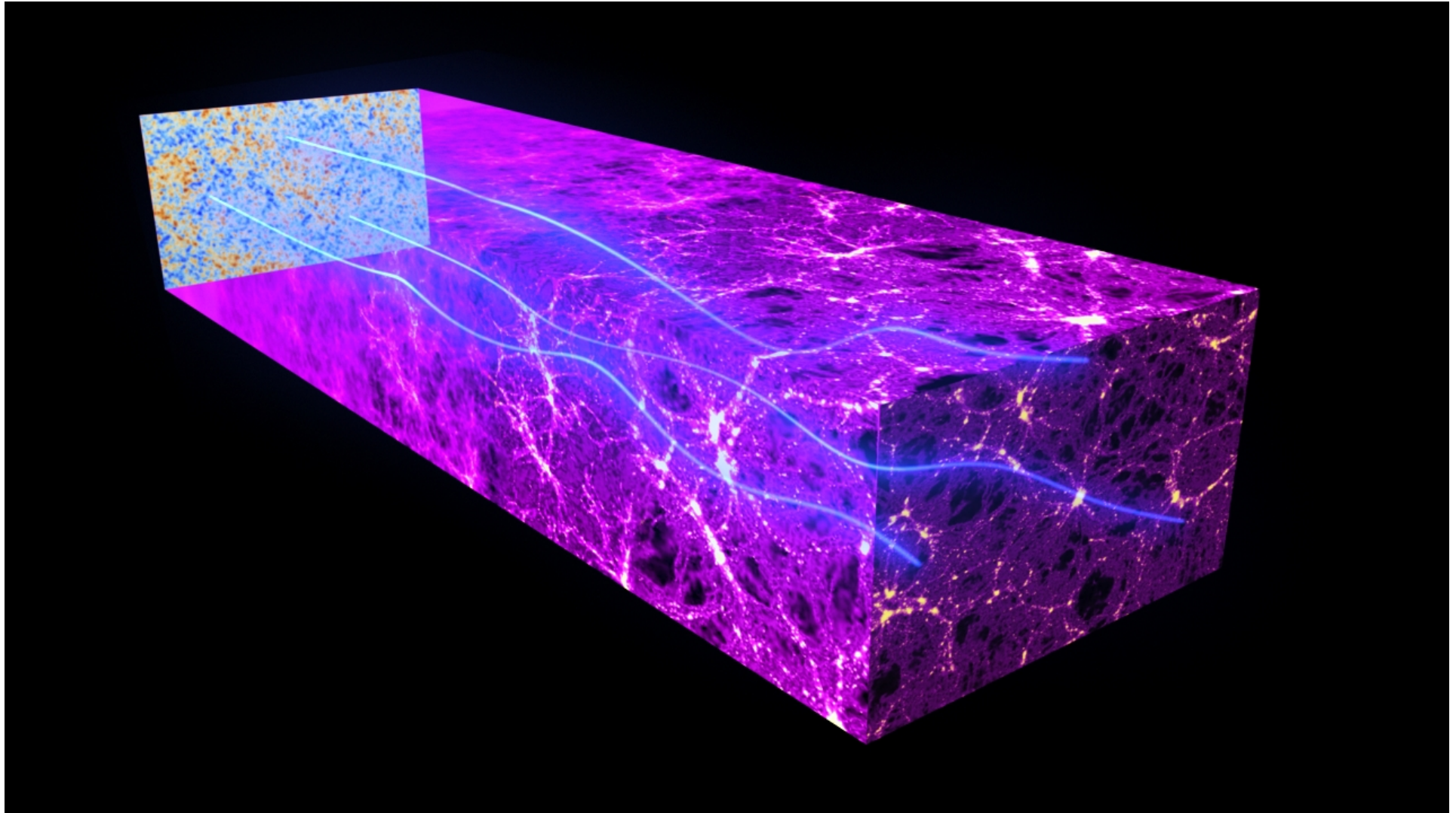


Fig.54. Marginalized joint 68 % and 95 % CL regions for n_s and $r_{0.002}$ from *Planck* alone and in combination with its cross-correlation with BICEP2/Keck Array and/or BAO data compared with the theoretical predictions of selected inflationary models.

cosmic inflation $< 10^{-35}$ second

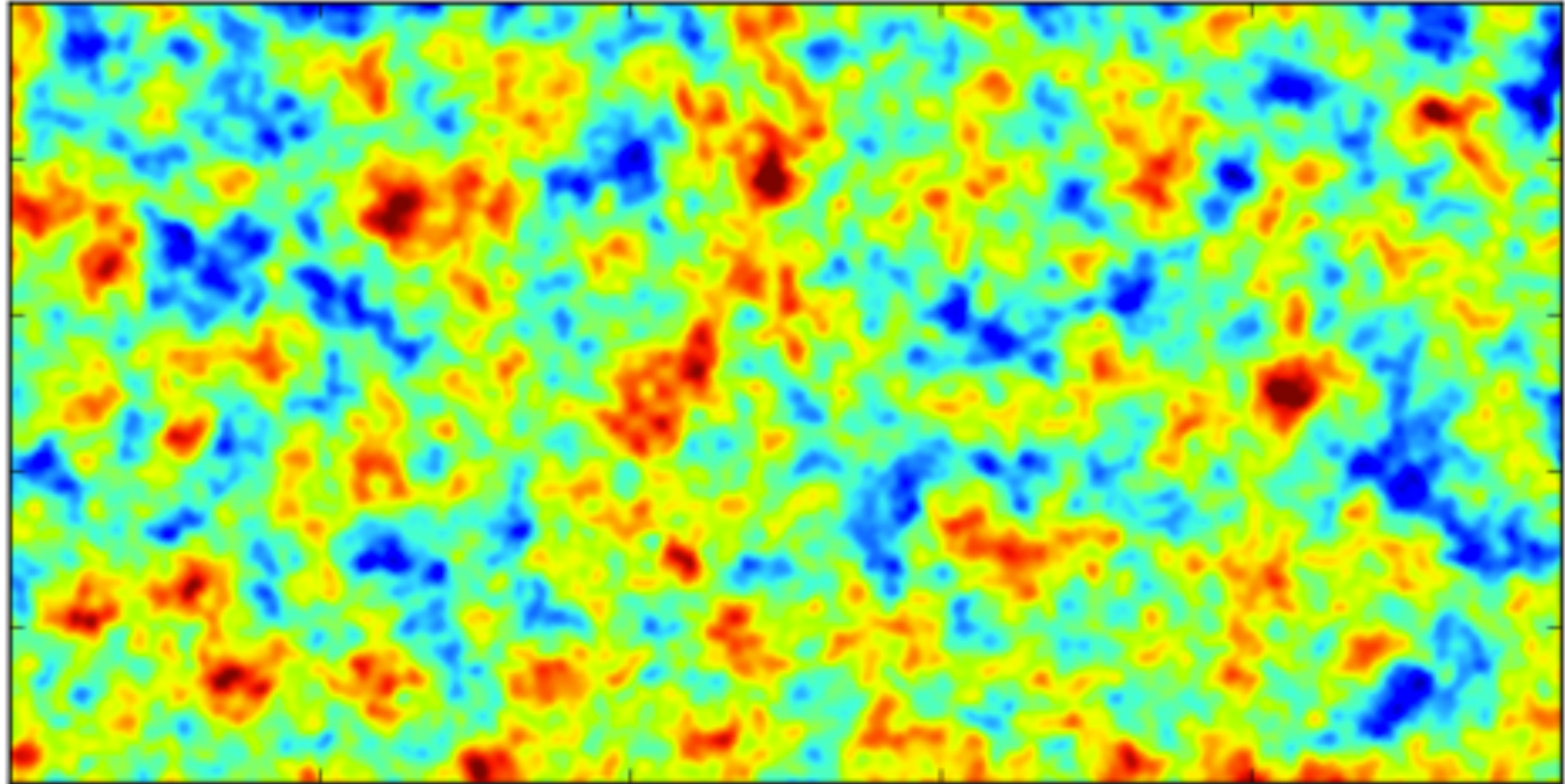
Planck 2015, 20

3.7 Planck révèle l'invisible: la matière noire



3.7 Planck révèle l'invisible: la matière noire

A simulated patch of CMB sky – before lensing



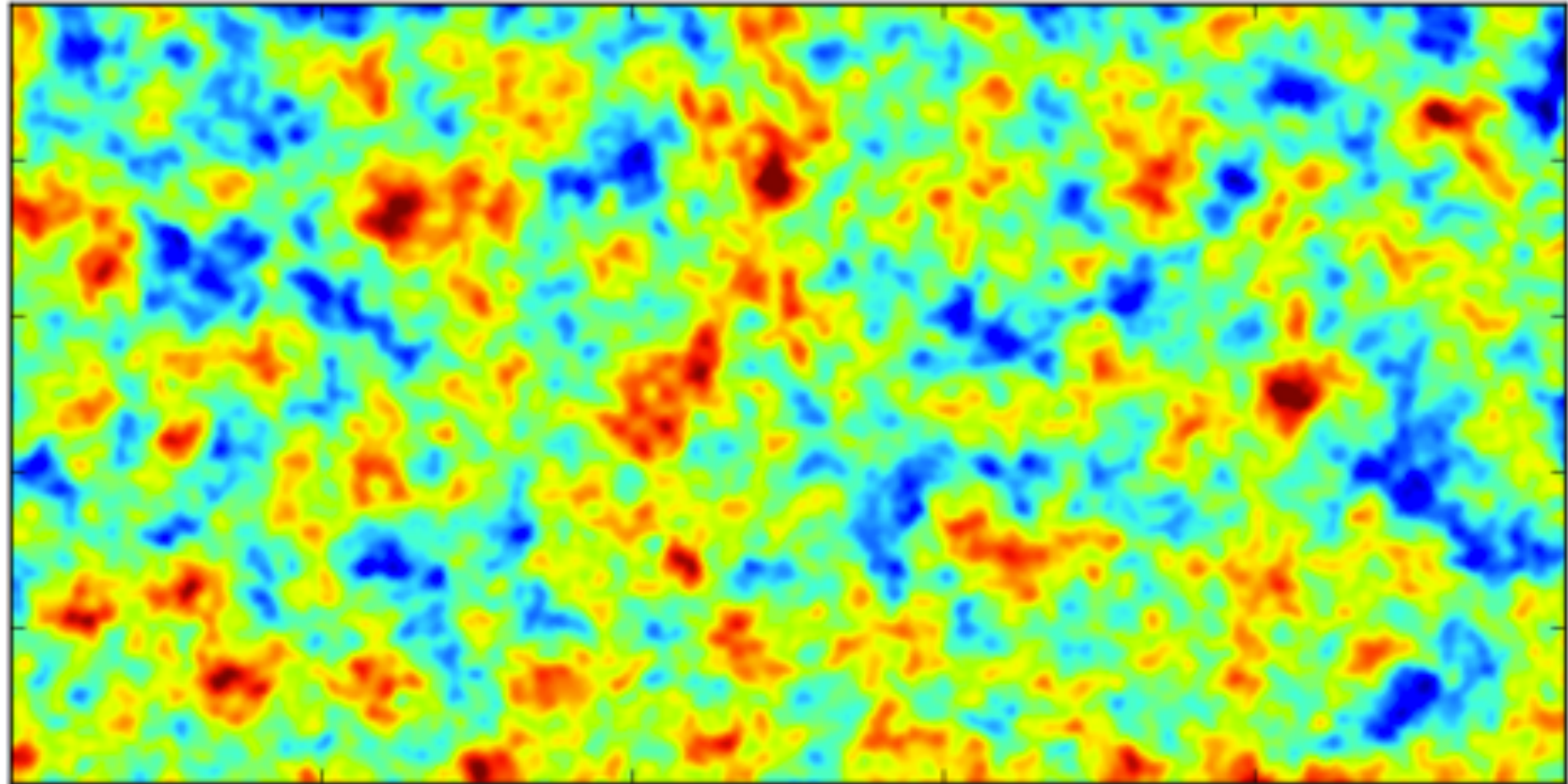
10°

typical deflection: 2.4 arcmin

Planck 15 months
Planck Collaboration, 2013, 17

3.7 Planck révèle l'invisible: la matière noire

A simulated patch of CMB sky – *after lensing*

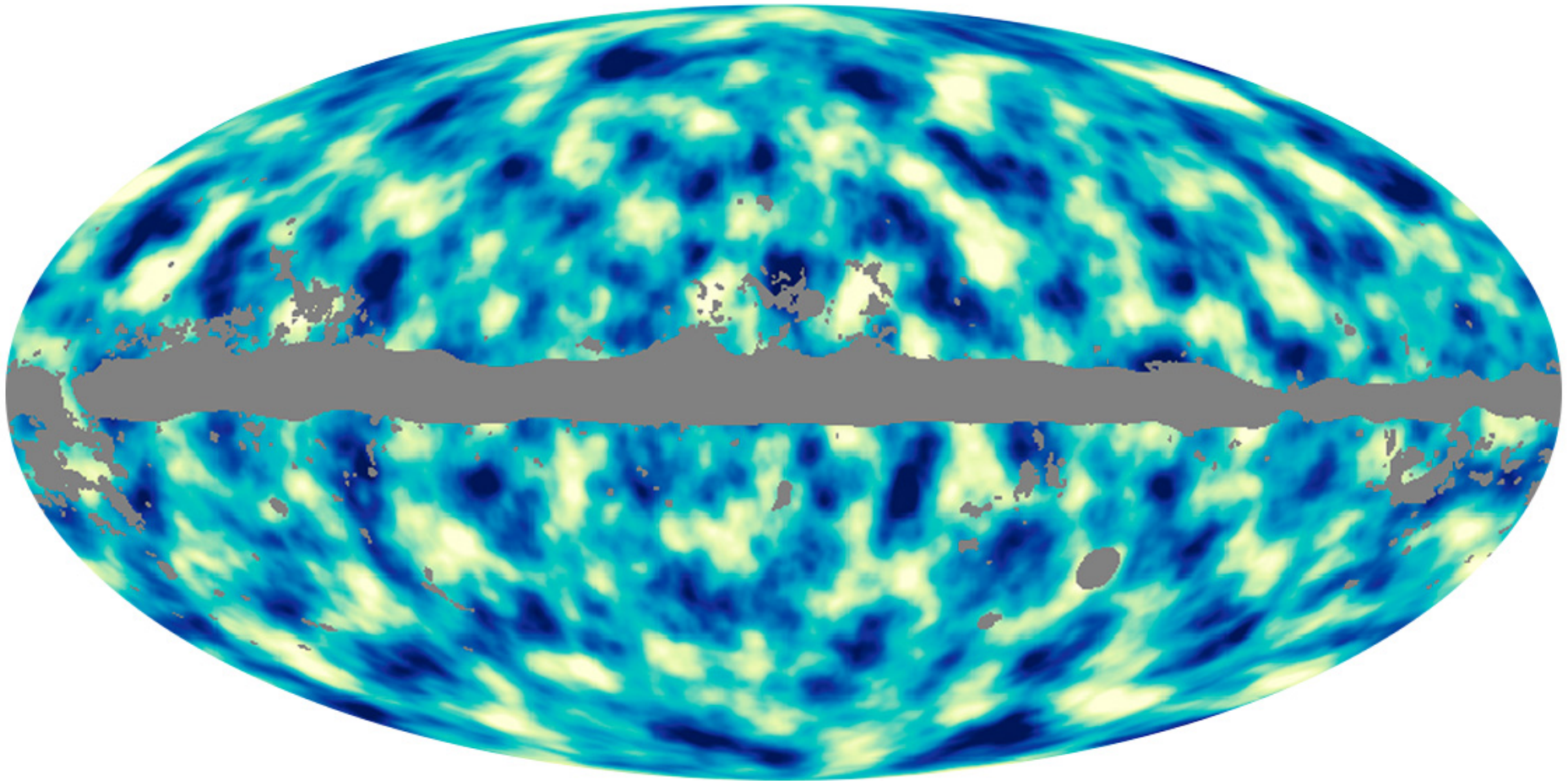


← 10° →

typical deflection: 2.4 arcmin

Planck 15 months
Planck Collaboration, 2013, 17

3.7 Planck révèle l'invisible: la matière noire



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

Planck 15 months
Planck Collaboration, 2013, 17

Kurd leader issues a call for cease-fire with Turkey

DIYARBAKIR, TURKEY
The jailed Kurdish rebel leader Abdi-Elah Ozal on Thursday called for a halt to the violence in Turkey and the release of all his fighters from Turkish jails. In a historic statement for a newly emerged effort to end a three-decade armed conflict with the Turkish government.

"We have reached the point where we should go silent and stop should speak," Mr. Ozal wrote in a letter sent out to jihadist groups gathered in the Kurdish mountainous region of Turkey. "A new era starts when politics, instead of guns, comes to the forefront."

The conflict, between Mr. Ozal's Kurdistan Workers' Party, or P.K.K., and the Turkish government, has claimed nearly 60,000 lives and has kept nearly 40,000 people in camps in Turkey since 1984. While there have been previous periods of cease-fire, the group, never led

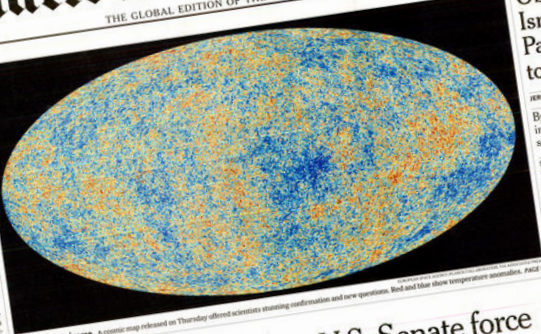
Obama asks Israelis and Palestinians to talk again

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

JERUSALEM
President Barack Obama, speaking on Thursday first to Palestinians in the occupied West Bank and then to young Israeli leaders in Jerusalem, called on both sides to reach a new understanding of the other's fears and concerns, and a new willingness to reach across the border divide separating them.

"If we're going to be successful, part of what we're going to have to do is get out of the historical and habits that have blocked progress," Mr. Obama said in a news conference in the West Bank city of Ramallah. "Both sides are going to have to talk more."

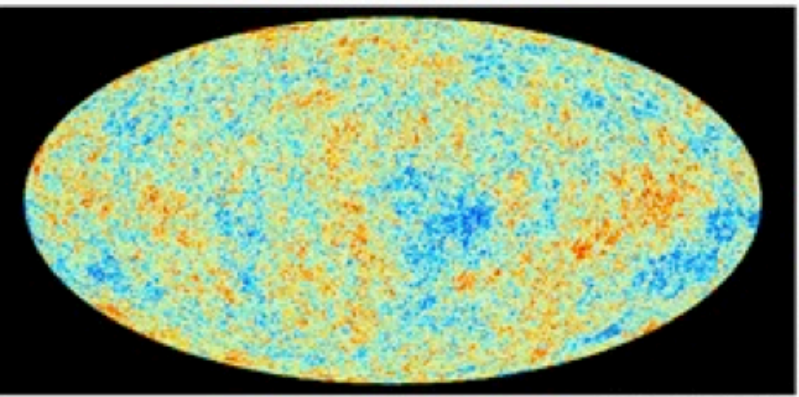
Speaking on the second day of a four-day visit to the region, Mr. Obama appeared to move closer to the Israeli position on increasing long-stalled peace talks with the Palestinians, dropping short of remarks his administration long



Once rarity, women are U.S. Senate force

day in 2011 into a critical rank of American political class — female senator

WASHINGTON
The female factor: In 2011, women made up 17 percent of the U.S. Senate, a critical rank of American political class. Today, that number has risen to 20 percent, and the number of women in the Senate is expected to rise further.



The Common, Back in the Day

An image from 1966 recorded by a European Space Agency satellite shows a clear view of the universe as it appeared 370,000 years after the Big Bang. PAGE A20.

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

The police, the debate over the New York Police Department's use of stop-and-frisk tactics has continued on whether officers are given racial profiling. Now a recording of a stop-and-frisk of a young man, a 19-year-old, has been released. The recording, which was secretly taped by a police officer, shows the officer asking the young man if he was a drug dealer. The young man replied that he was not. The officer then searched the young man's pockets and found a small amount of marijuana. The officer then arrested the young man and charged him with possession of a controlled substance.

Once Few, Women Hold More Power in Senate

WASHINGTON — The female factor: In 2011, women made up 17 percent of the U.S. Senate, a critical rank of American political class. Today, that number has risen to 20 percent, and the number of women in the Senate is expected to rise further.

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

LIRE P. 13 ET LA CHRONIQUE D'ALAIN FRACHON P. 20

LE MONDE DES LIVRES

Spécial Salon du livre de Paris

- Barcelone ville invitée, Roumanie à l'honneur et au lycée ? Regard d'auteurs et d'enseignants
- Le livre numérique peine à décoller

SUPPLÉMENT, DÉBATS P. 38-39 ET P. 14

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

« C'est prendre du temps », a dit le chancelier à ceux qui pensent qu'il va dans le mur. Car les résultats ne sont pas au rendez-vous. Le déficit budgétaire reste l'un des plus élevés du monde.



SCIENCE

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

La carte du Planck, la plus précise jamais réalisée, révèle l'âge et la composition de l'univers. Elle montre que l'univers est composé à 68% de matière noire, à 27% de matière ordinaire, et à 5% d'énergie noire.

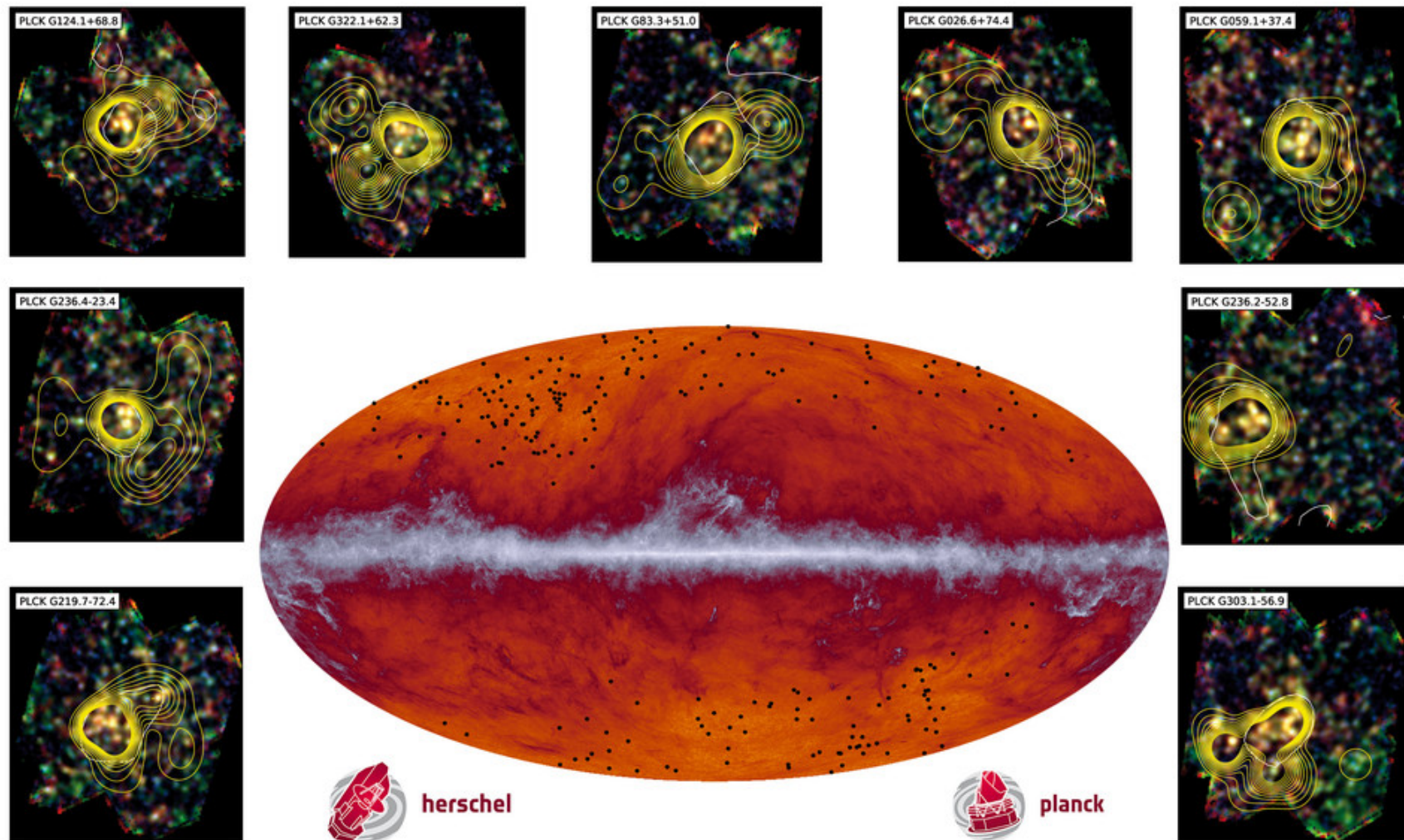


March 21st & 22nd, 2013

Nov 2015 - Hervé Dole, IAS - Nuit noire ? Résultats Planck

4. des galaxies en rythme et à l'unisson ?

→ **Herschel and Planck proto-cluster candidates** 



Communiqué de presse ESA, NASA, A&A, INSU 31 mars 2015
Planck Collab. Int., 2015, XXVII

the case of one field: Spitzer

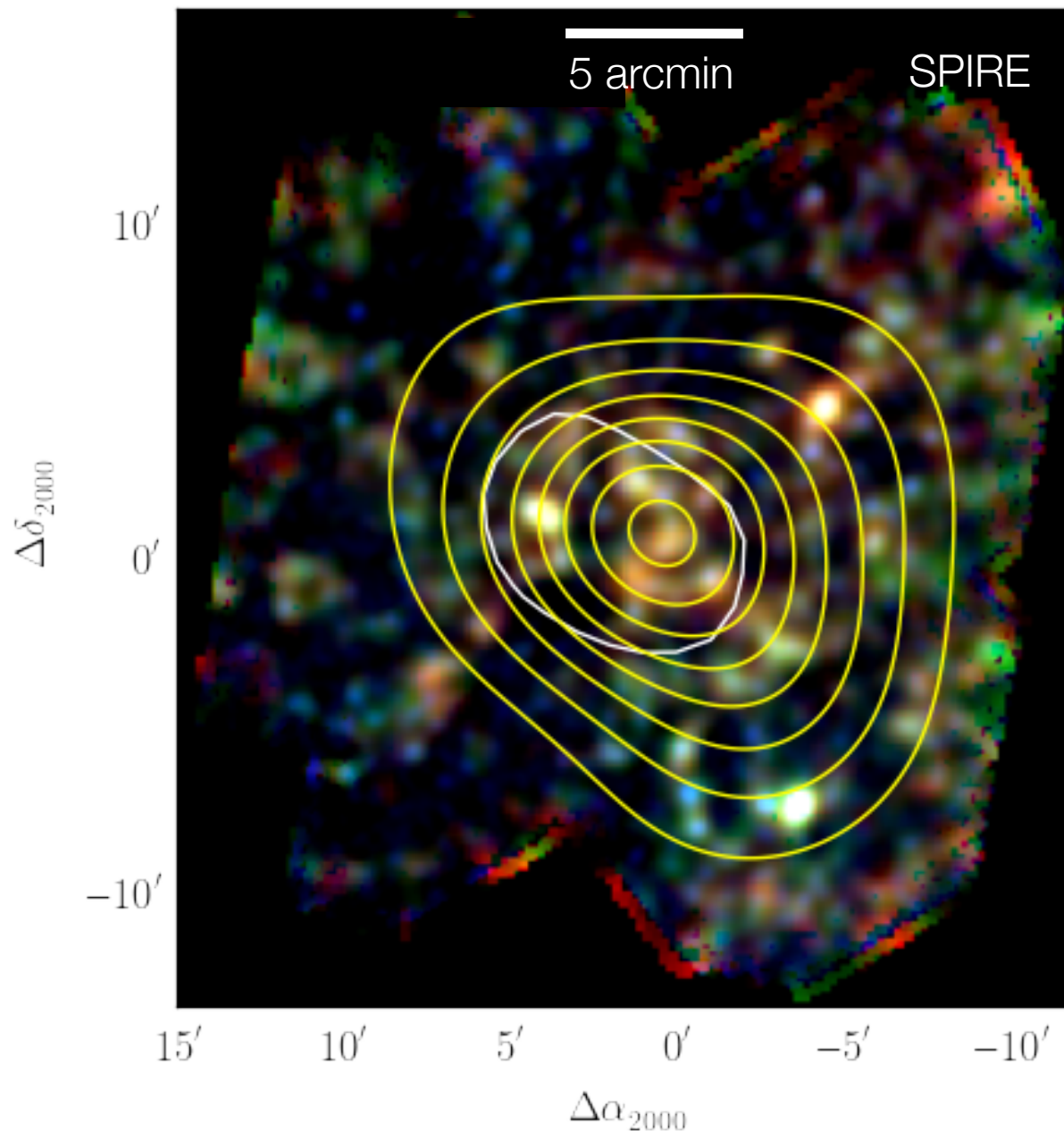
Herschel-SPIRE

3-color image:

blue = 250 μ m

green = 350 μ m

red = 500 μ m



the case of one field: Spitzer

Herschel-SPIRE

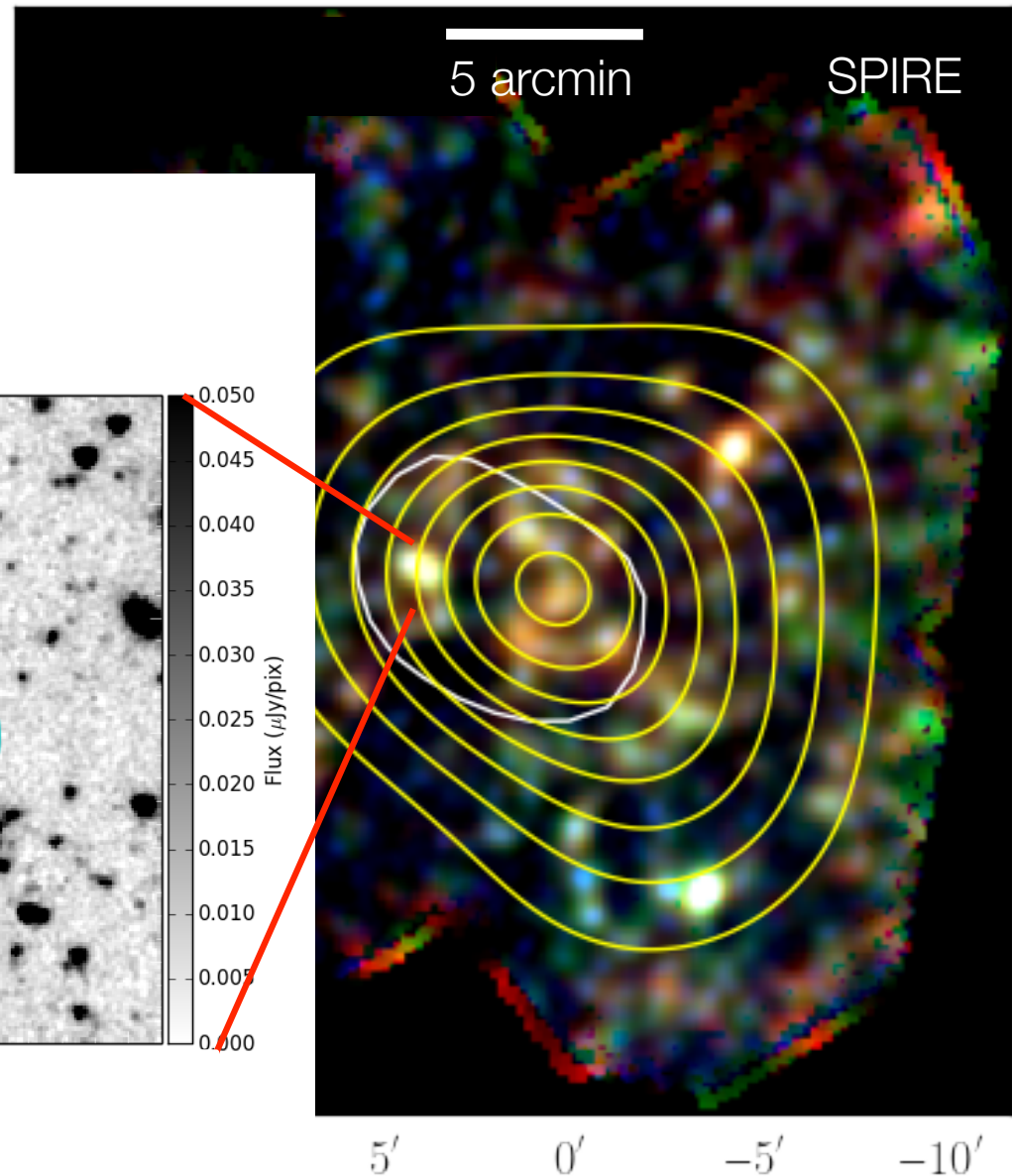
3-color image:

blue = 250 μ m

green = 350 μ m

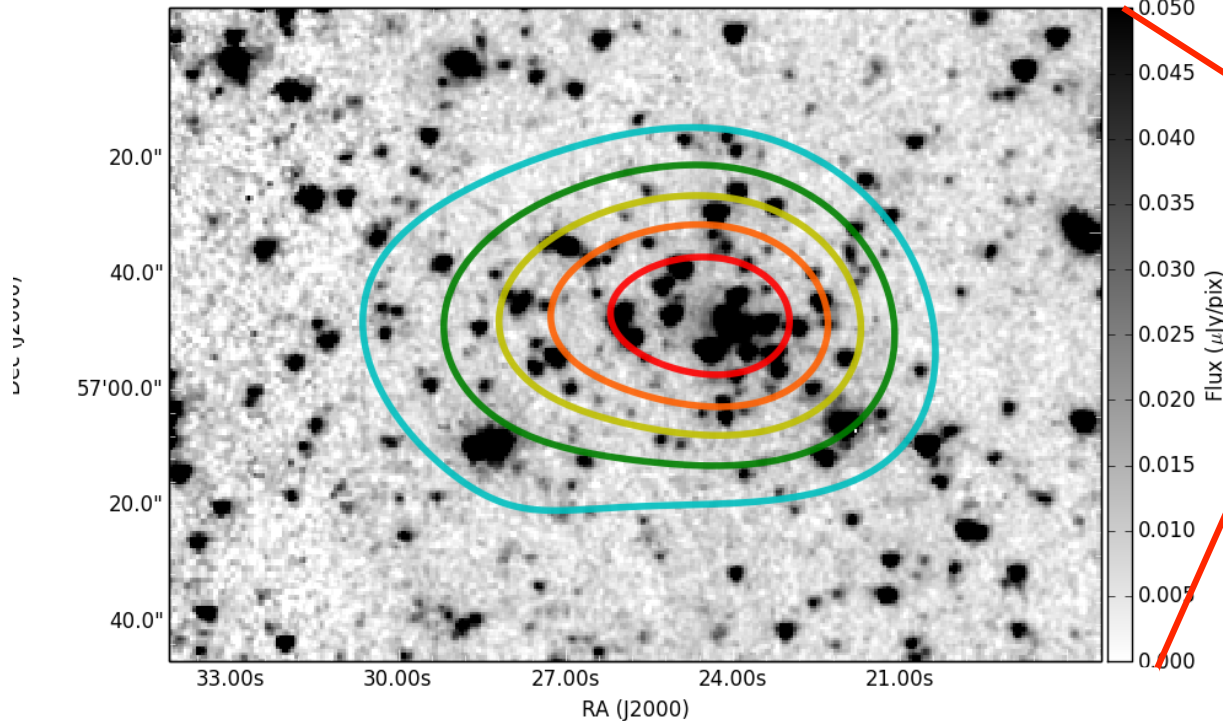
red = 500 μ m

Euclid will provide this kind of
sensitivity over the whole sky !
JWST and WFIRST much
better, on smaller sky areas !



IRAC

30 arcsec



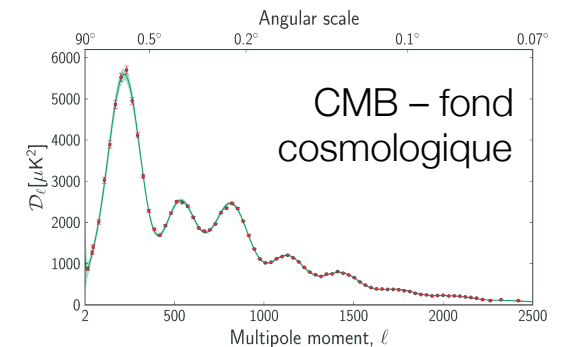
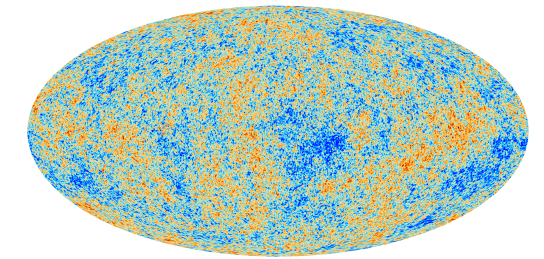
IRAC image at 3.6 μ m

$\Delta\alpha_{2000}$

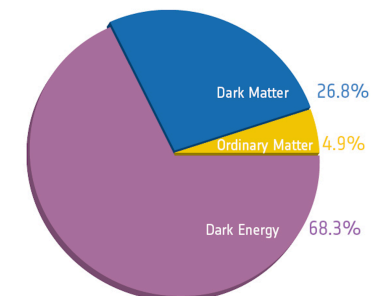
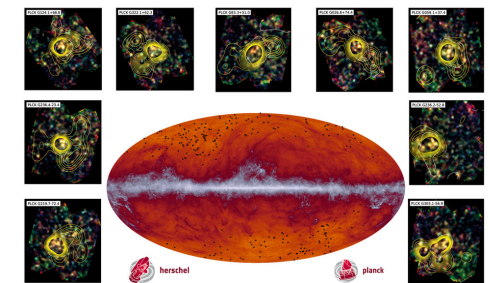
Martinache et al., in prep 42

en conclusion: le rythme de l'univers

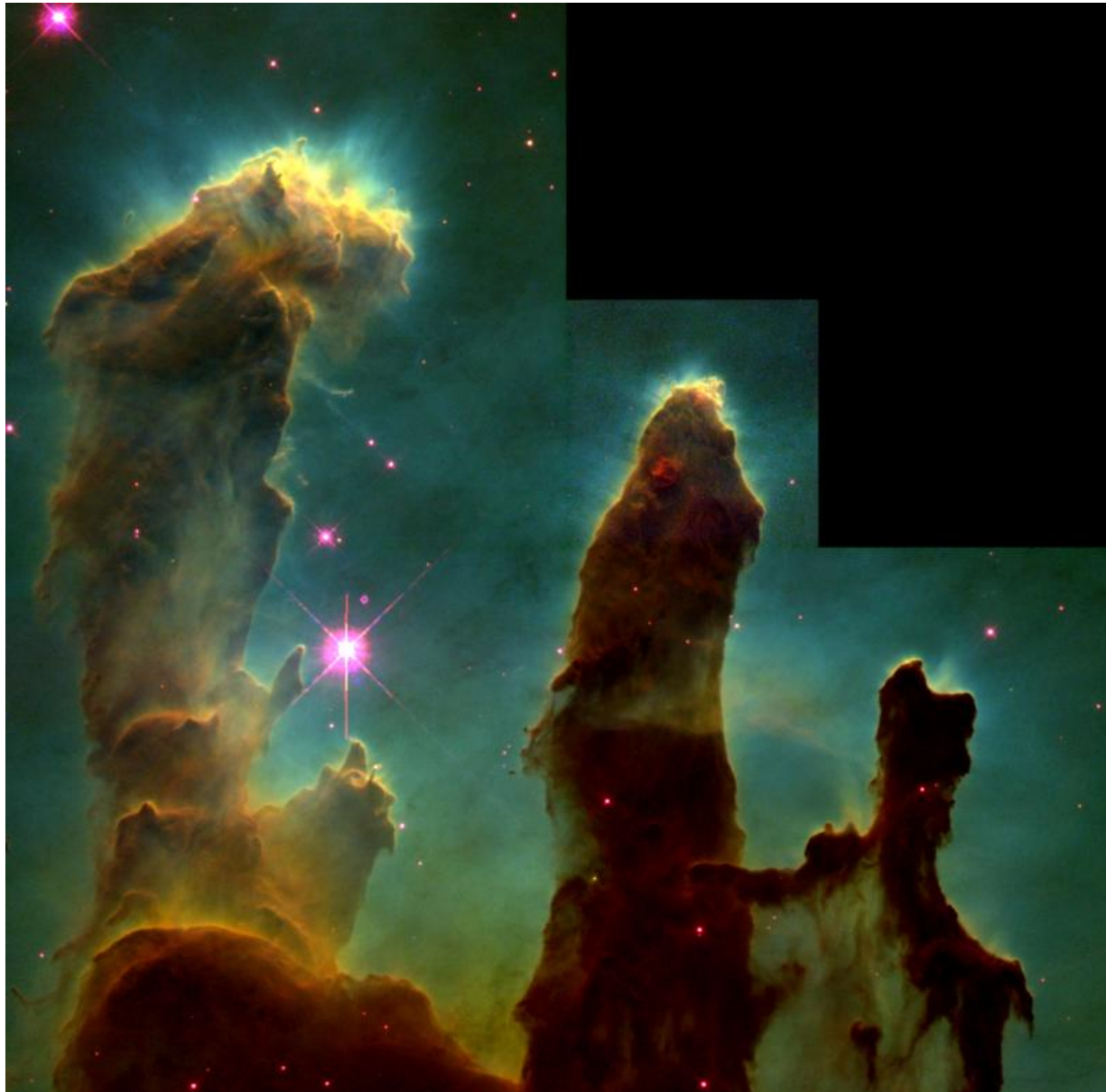
- L'univers jeune vibre à toutes les échelles, surtout aux grandes
- Les traces de ces vibrations se retrouvent aujourd'hui dans les galaxies
- Prédiction et mesures en accord avec grande précision
- Découverte de galaxies concentrées: la piste des proto-amas de galaxies ?
- De grandes questions demeurent
 - Existence et nature de la matière noire ?
 - Nature de l'énergie sombre ?
 - Scénario de l'inflation cosmique ?
 - Formation des galaxies ?
 - Perspectives: Euclid (ESA) en 2021



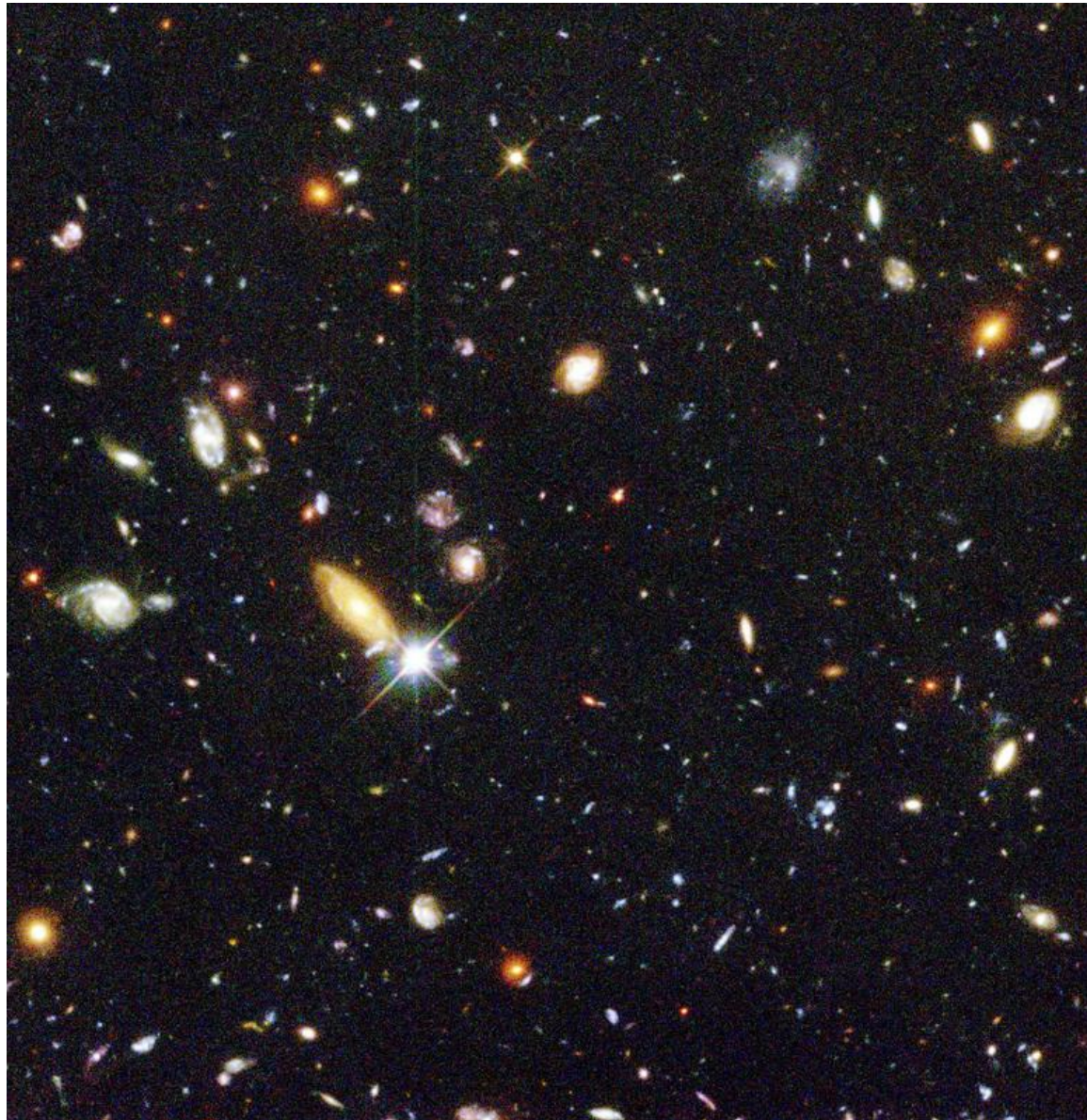
→ Herschel and Planck proto-cluster candidates 



remarques finales



remarques finales



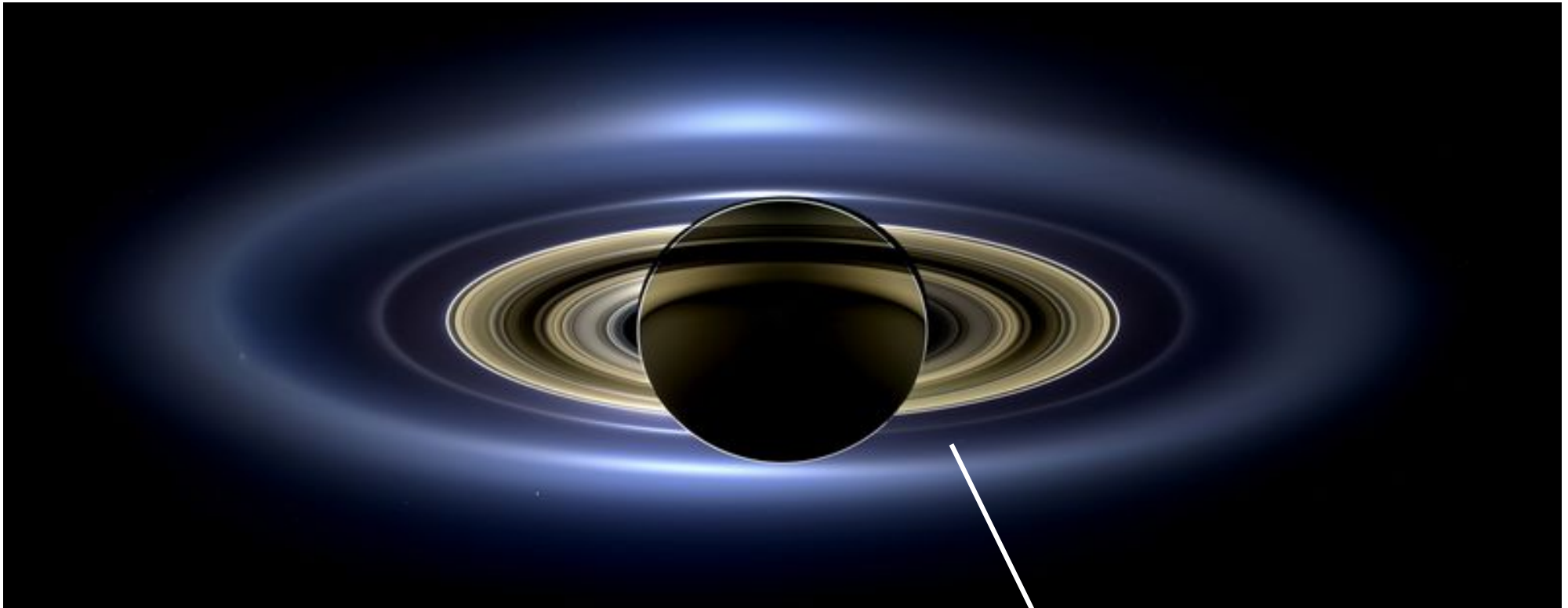
remarques finales



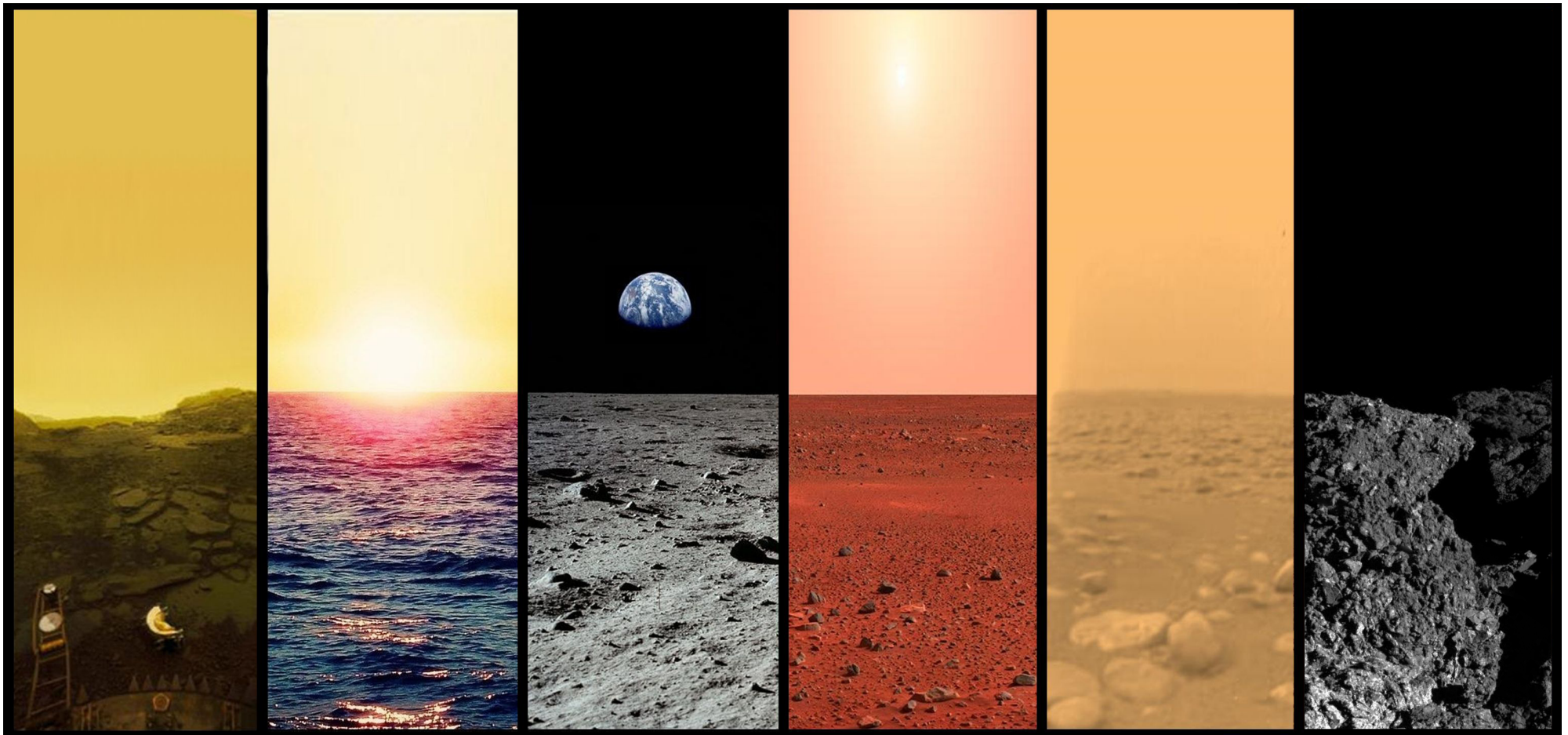
remarques finales



remarques finales



remarques finales



remarques finales

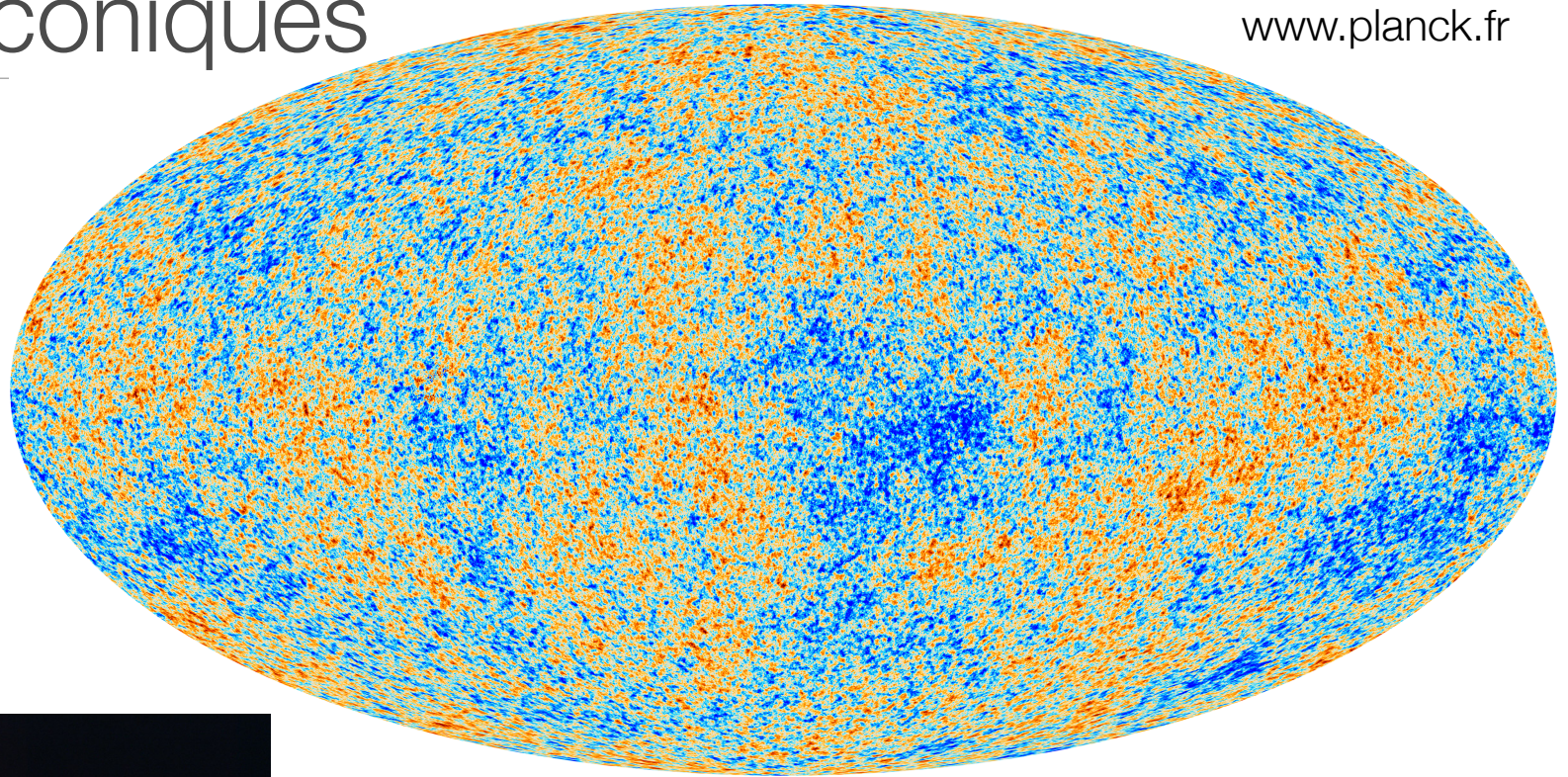
Apollo VIII, Noël
1968- Lovell, Anders,
Borman

Nov 2015 - Hervé Dole, IAS - Nuit noire ? R



images iconiques

www.planck.fr



... nous ramènent environ 13,8 milliards d'années en arrière

... nous permettent de commencer à sonder l'inflation cosmique, une fraction de seconde après le Big Bang

... et nous permettent de penser le monde et d'avoir une vision du monde