

# Satellietbeelden van Lemaître's Big Bang

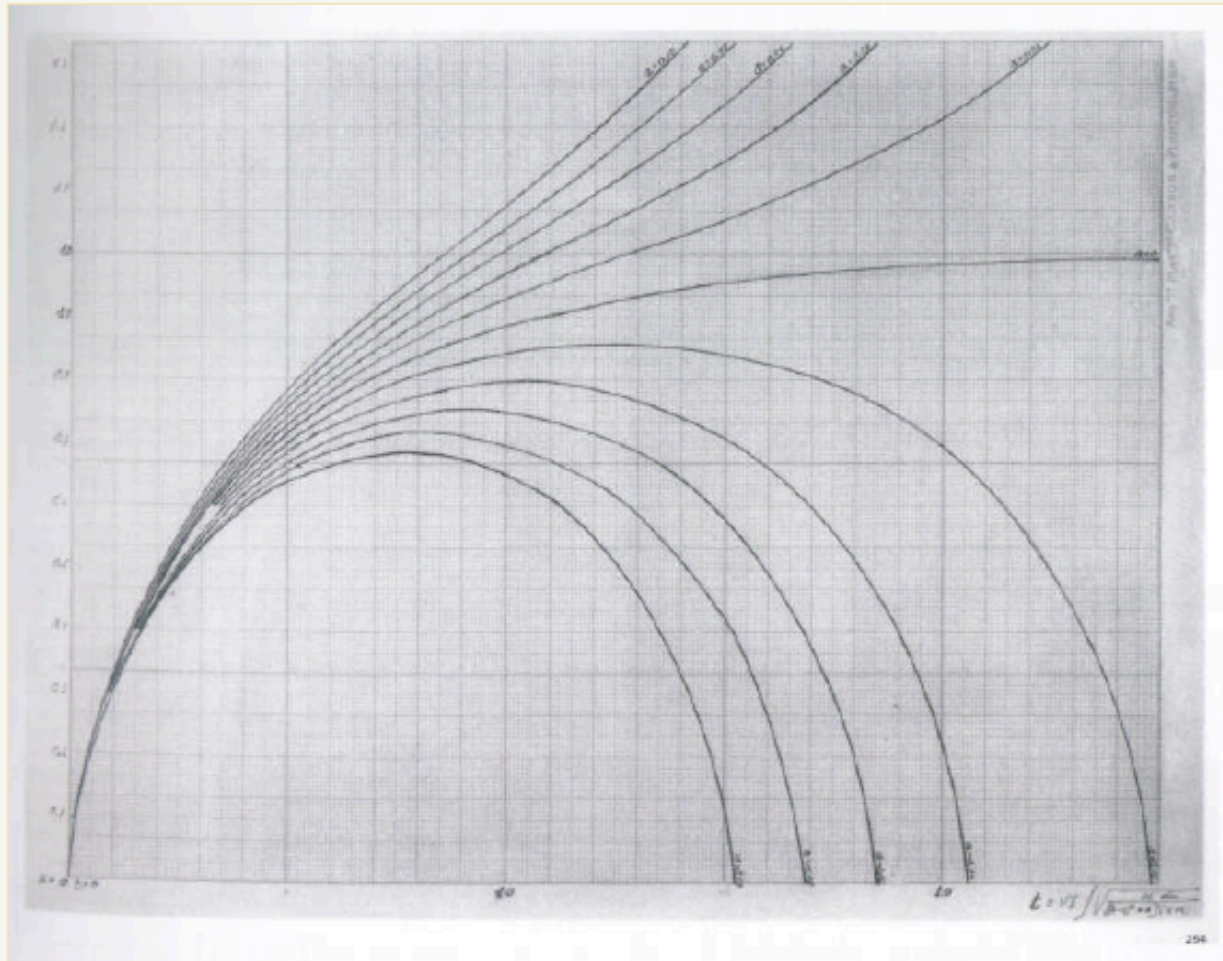
Thomas Hertog, KU Leuven  
Christophe Ringeval, UCL

Senaat, Brussel

# Georges Lemaître



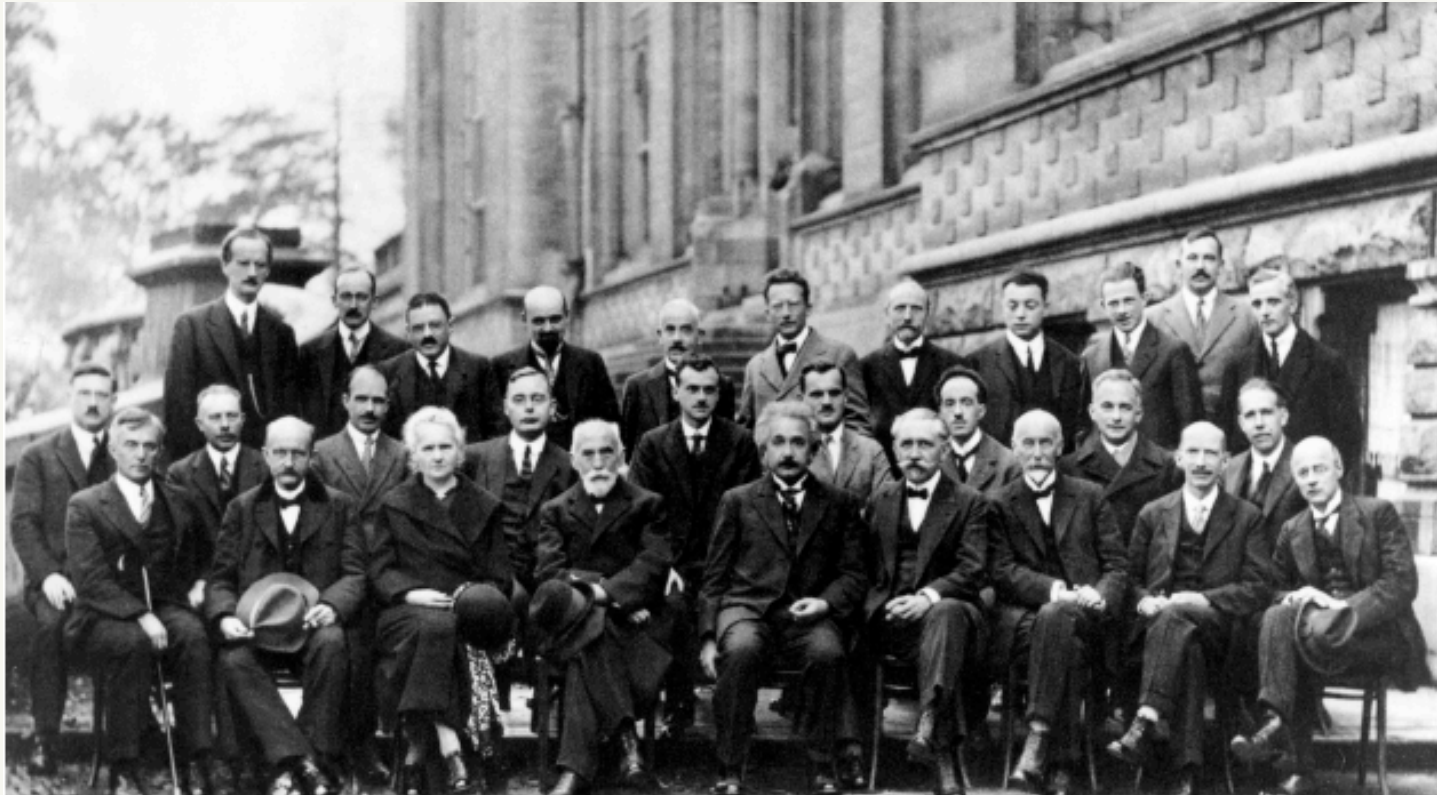
# Expanding universe



Space

Time

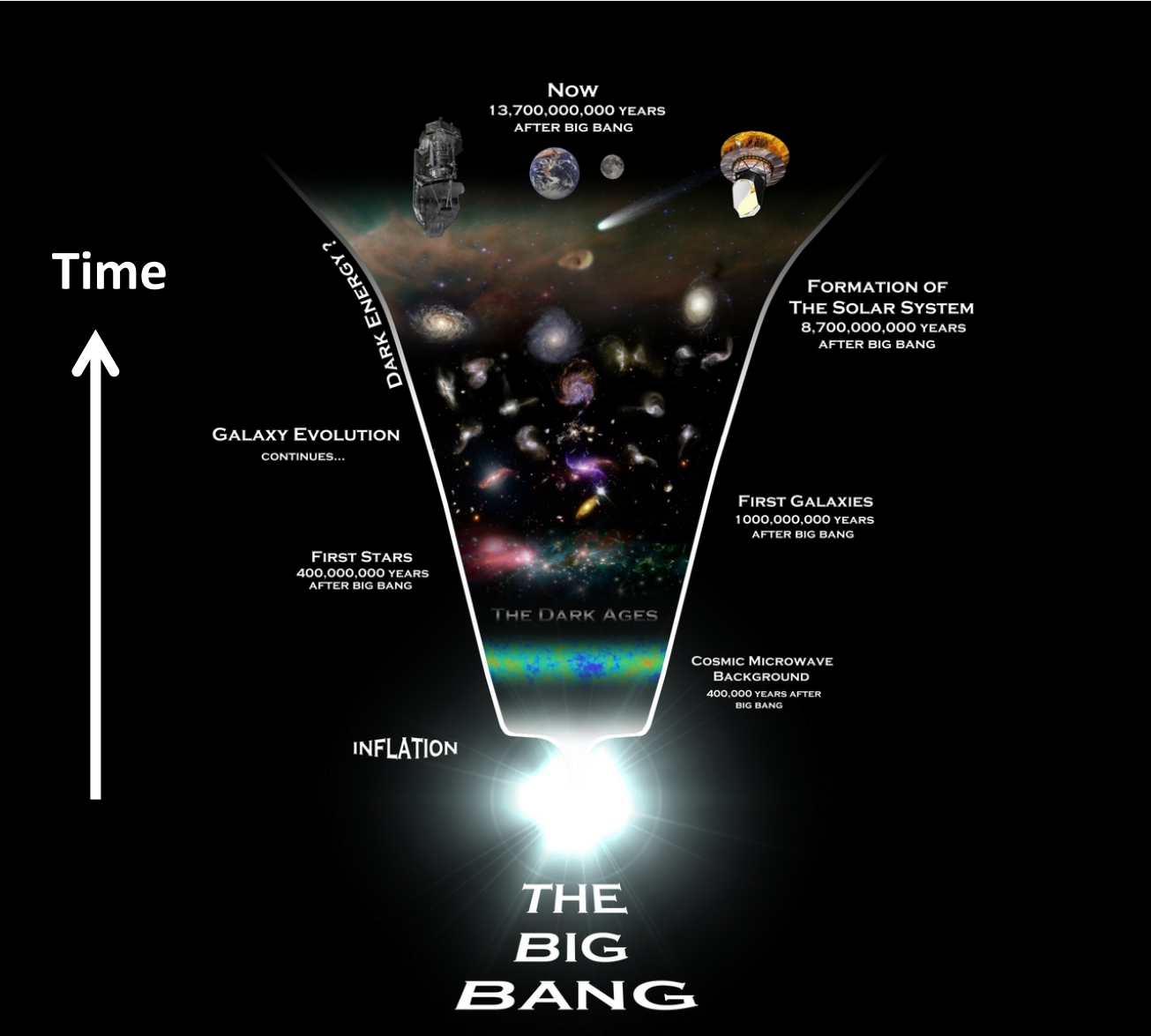
“Tout à fait abominable!”

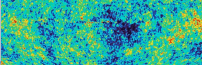


Conseil Solvay, Brussels, 1927



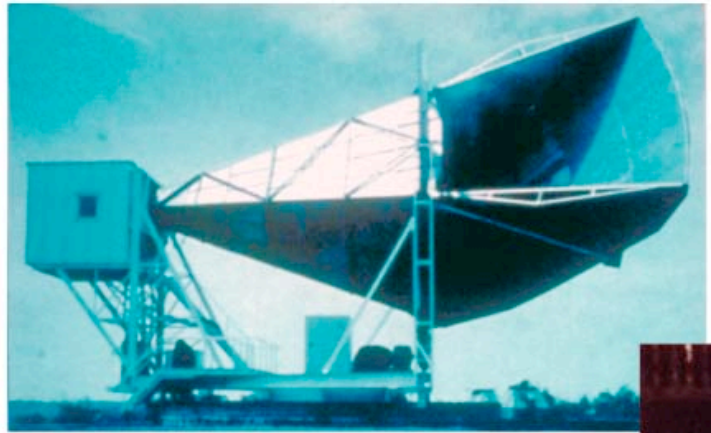
# Cosmic Evolution





# 1964, Crawford Hill NJ

## DISCOVERY OF COSMIC BACKGROUND

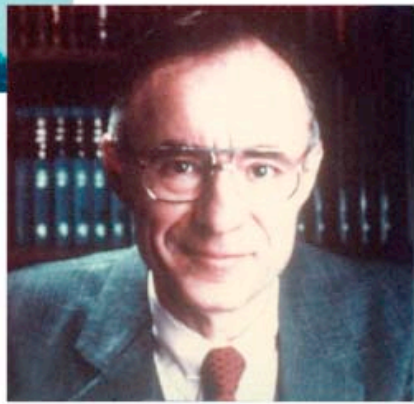


Microwave Receiver



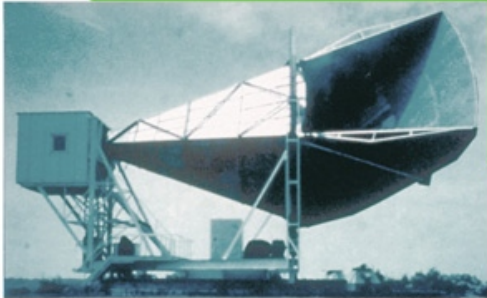
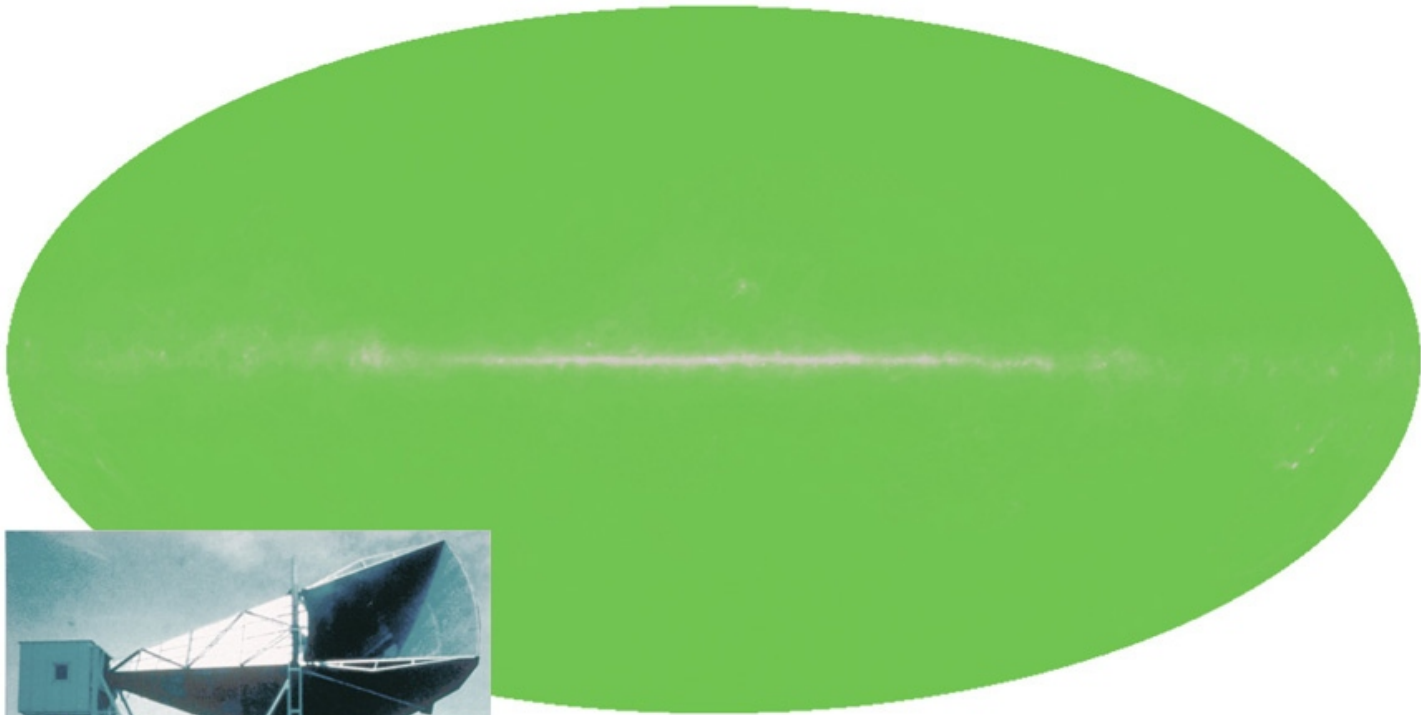
MAP990045

Robert Wilson



Arno Penzias

# Big bang afterglow

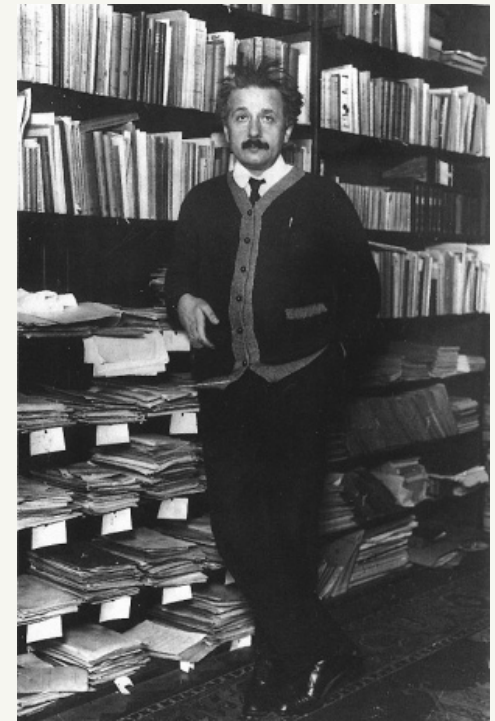
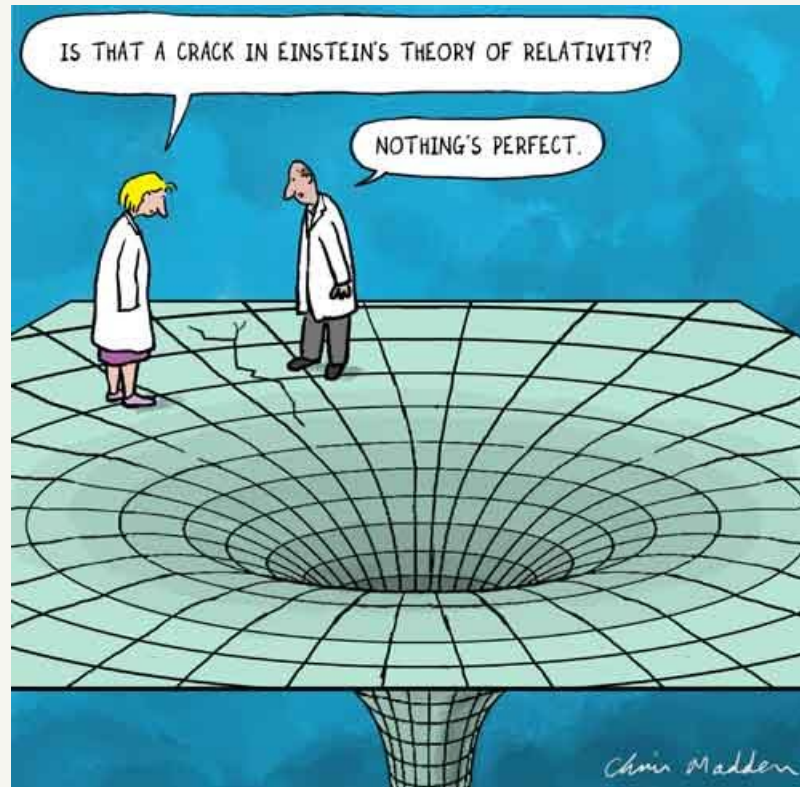


**Temp = 2.7 Kelvin**

# Origin?

“Notions of space and time have no meaning near the big bang. Einstein’s Theory of Relativity breaks down.”

[Hawking, 1966]





# Origin!

## The Beginning of the World from the Point of View of Quantum Theory.

SIR ARTHUR EDDINGTON<sup>1</sup> states that, philosophically, the notion of a beginning of the present order of Nature is repugnant to him. I would rather be inclined to think that the present state of quantum theory suggests a beginning of the world very different from the present order of Nature. Thermodynamical principles from the point of view of quantum theory may be stated as follows: (1) Energy of constant total amount is distributed in discrete quanta. (2) The number of distinct quanta is ever increasing. If we go back in the course of time we must find fewer and fewer quanta, until we find all the energy of the universe packed in a few or even in a unique quantum.

Now, in atomic processes, the notions of space and time are no more than statistical notions; they fade out when applied to individual phenomena involving but a small number of quanta. If the world has begun with a single quantum, the notions of space and time would altogether fail to have any meaning at the beginning; they would only begin to have a sensible meaning when the original quantum had been divided into a sufficient number of quanta. If this suggestion is correct, the beginning of the world happened a little before the beginning of space and time. I think that such a beginning of the world is far enough from the present order of Nature to be not at all repugnant.

It may be difficult to follow up the idea in detail as we are not yet able to count the quantum packets in every case. For example, it may be that an atomic nucleus must be counted as a unique quantum, the atomic number acting as a kind of quantum number. If the future development of quantum theory happens to turn in that direction, we could conceive the beginning of the universe in the form of a unique atom, the atomic weight of which is the total mass of the universe. This highly unstable atom would divide in smaller and smaller atoms by a kind of super-radioactive process. Some remnant of this process might, according to Sir James Jeans's idea, foster the heat of the stars until our low atomic number atoms allowed life to be possible.

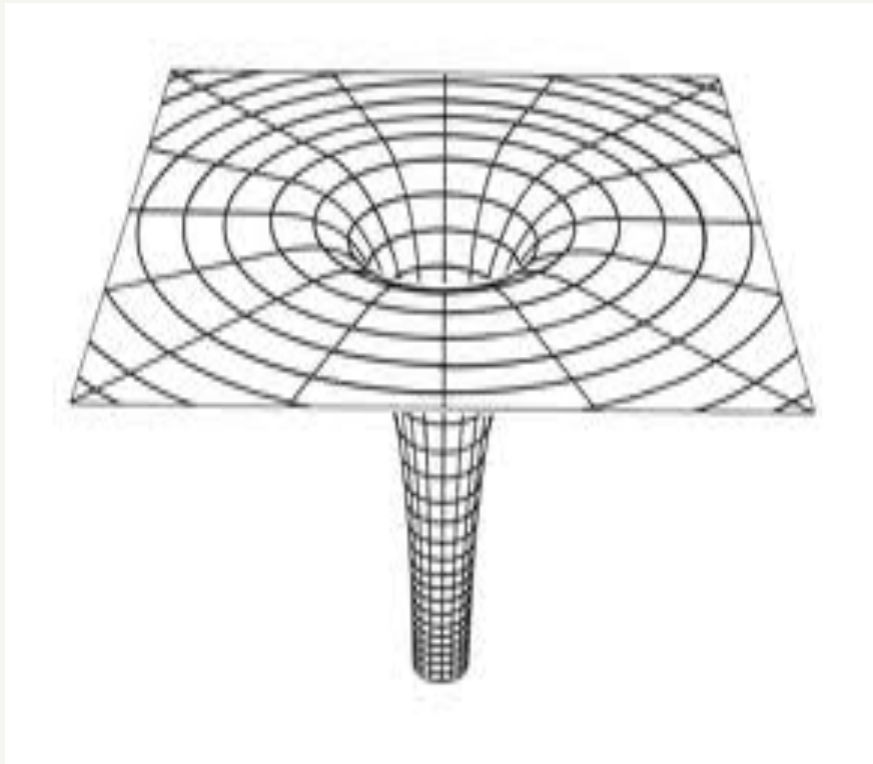
Clearly the initial quantum could not conceal in itself the whole course of evolution; but, according to the principle of indeterminacy, that is not necessary. Our world is now understood to be a world where something really happens; the whole story of the world need not have been written down in the first quantum like a song on the disc of a phonograph. The whole matter of the world must have been present at the beginning, but the story it has to tell may be written step by step.

G. LEMAÎTRE.

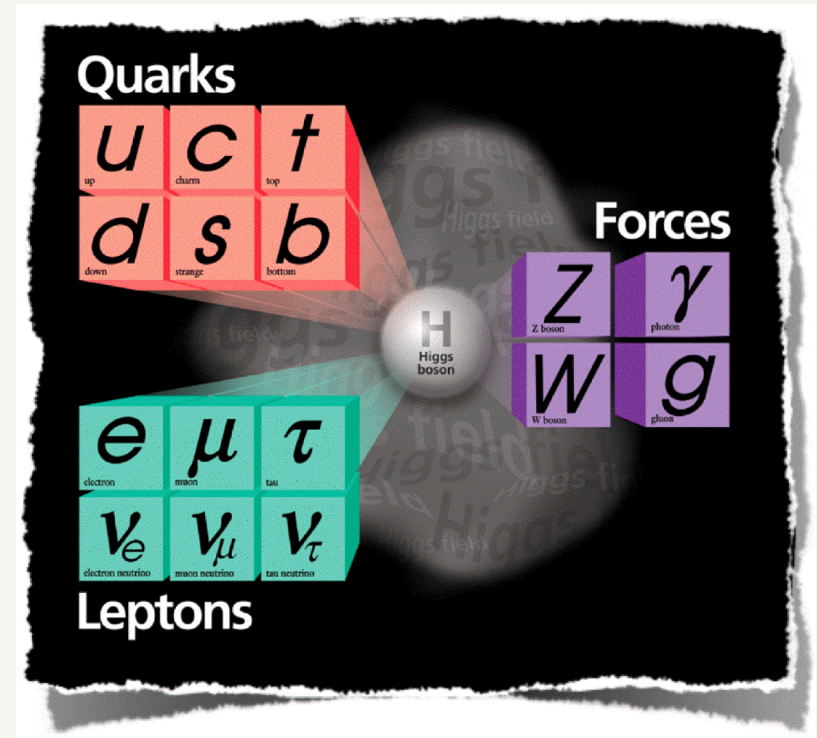
40 rue de Namur,  
Louvain.

<sup>1</sup> NATURE, Mar. 21, p. 447.

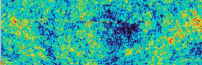
# 21<sup>st</sup> century: Unification of physics



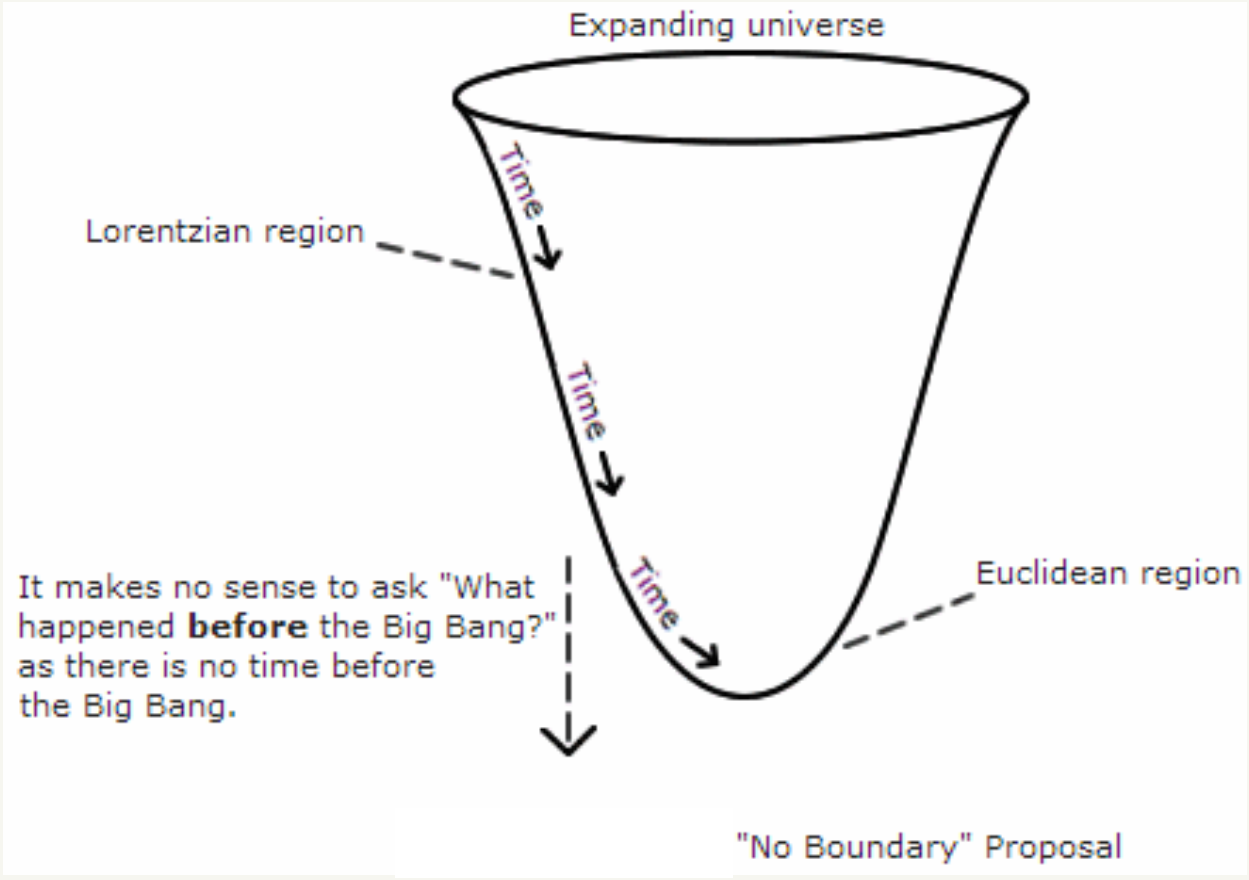
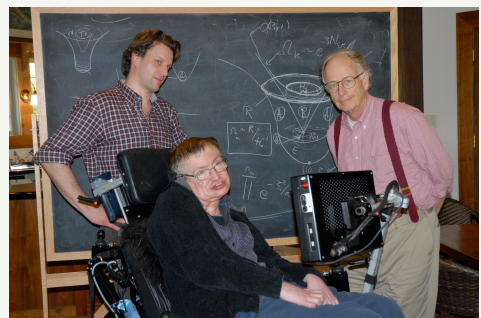
Gravity/cosmology



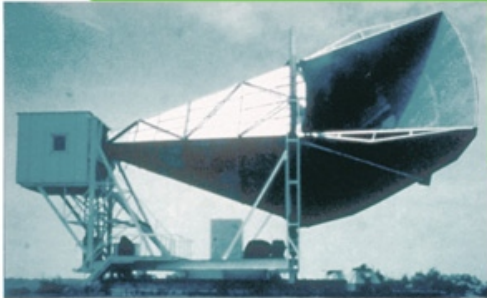
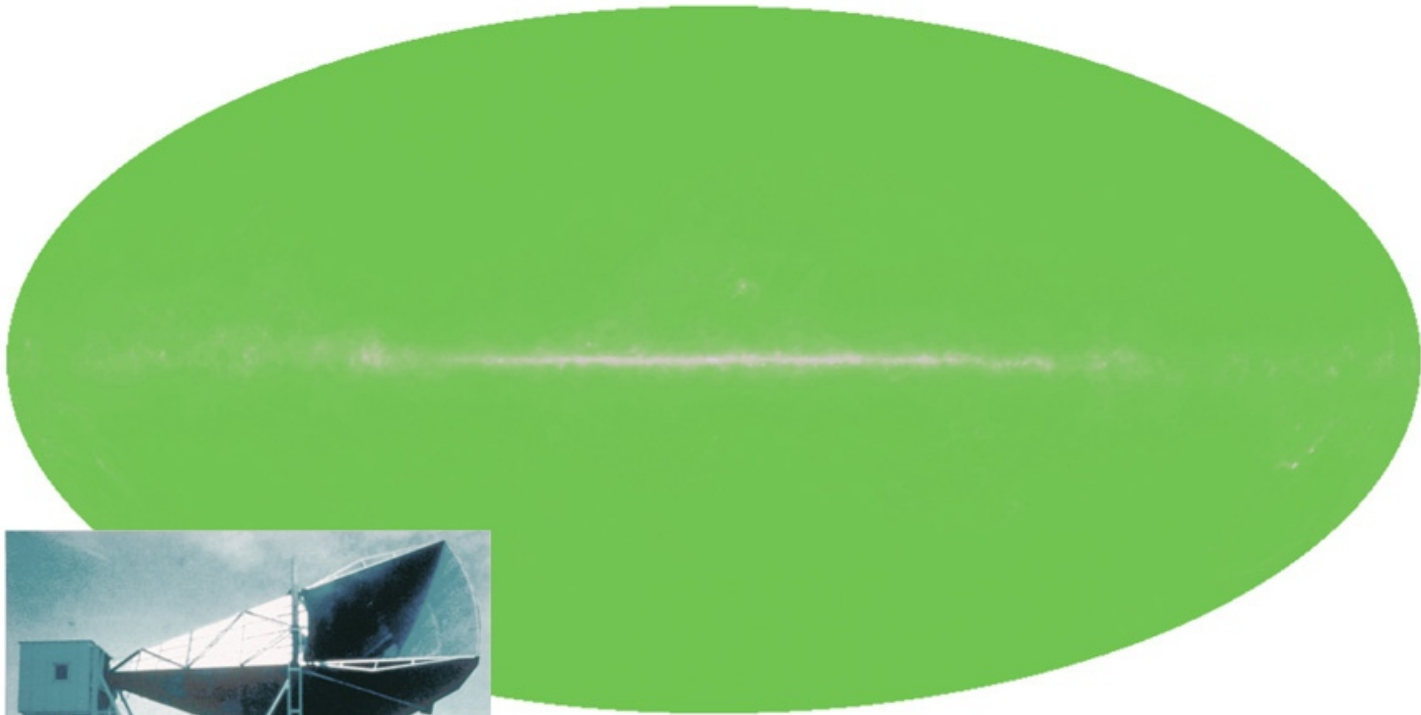
Particle Physics



# Modeling the big bang



# Afterglow



**Temp = 2.72548 Kelvin**

# Dedicated satellite missions



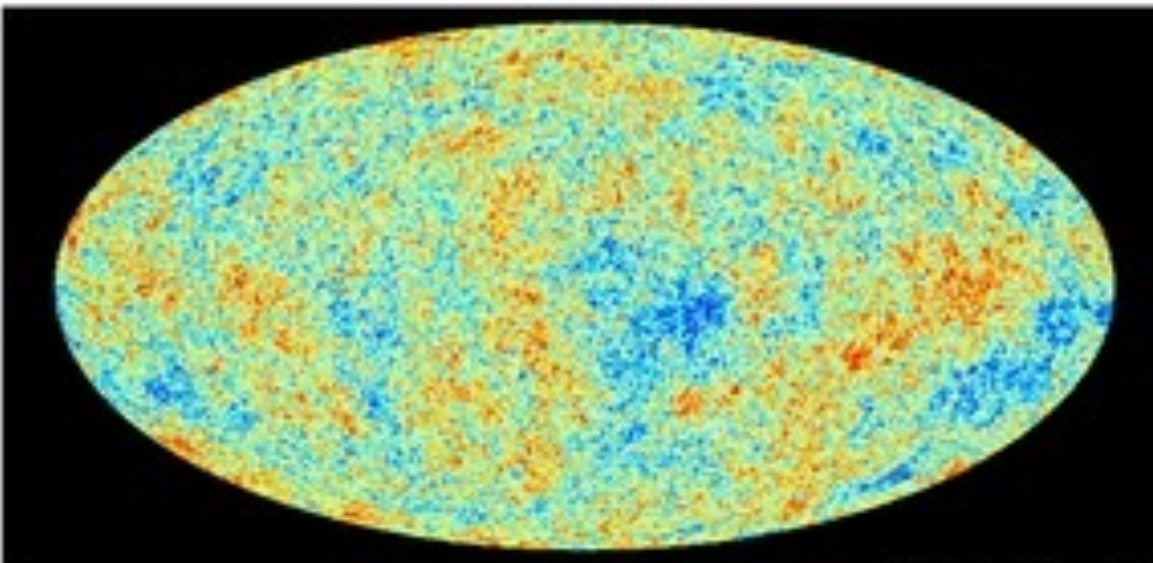
# Big Bang imprinted on the Sky !

"All the News That's Fit to Print"

# The New York Times

Late Edition  
Today: clouds and sun, windy, cold, high 41. Tonight: partly cloudy, windy, cold, low 30. Tomorrow: sun, to partly cloudy, a chilly wind, high 41. Weather map, Page A28

VOL. CLXXI . . . No. 54,048      © 2011 The New York Times      NEW YORK, FRIDAY, MARCH 22, 2013      \$2.50



**PRESIDENT URGES ISRAELIS TO PUSH EFFORT FOR PEACE**  
**APPEAL AIMED AT YOUNG**  
**In Jerusalem, He Eases Stance on Settlement Halt Before Talks**  
**By MARK LINDLER**  
JERUSALEM — President Obama, appealing to very disparate audiences to solve one of the world's thorniest problems, moved closer on Thursday to the Israeli government's position on reversing long-stalled peace talks with the Palestinians, even as he passionately implored young Israelis to get ahead of their own leaders in the push for peace.  
Addressing an enthusiastic crowd of more than 1,000, Mr. Obama offered a fervent, unapologetic case for why a peace agreement was both morally just and in Israel's self-interest. Young Israelis, Mr. Obama said, should empathize with their Palestinian neighbors living under occupation — or, as he put it, “look at the world through their eyes.”  
Hours earlier, visiting the Israeli-occupied West Bank, Mr. Obama urged the Palestinians to return to the negotiating table

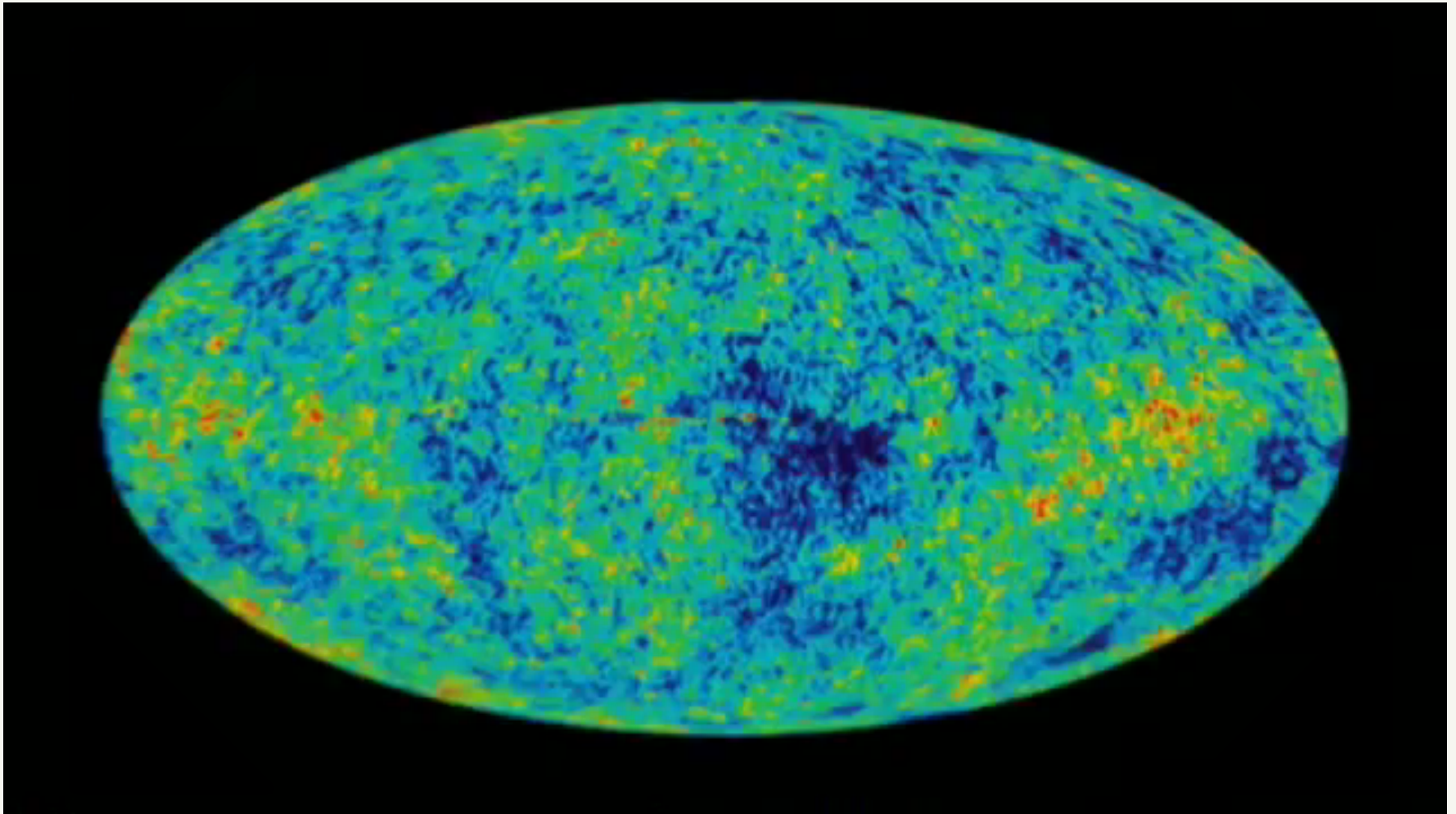
**The Cosmos, Back in the Day**  
An image from data recorded by a European Space Agency satellite shows a heat map of the universe as it appeared 370,000 years after the Big Bang. Page A20.

**Bronx Inspector, Secretly Taped, Suggests Race Is a Factor in Stops**  
**By JENNIFER STEPMER**  
WASHINGTON — An hour after

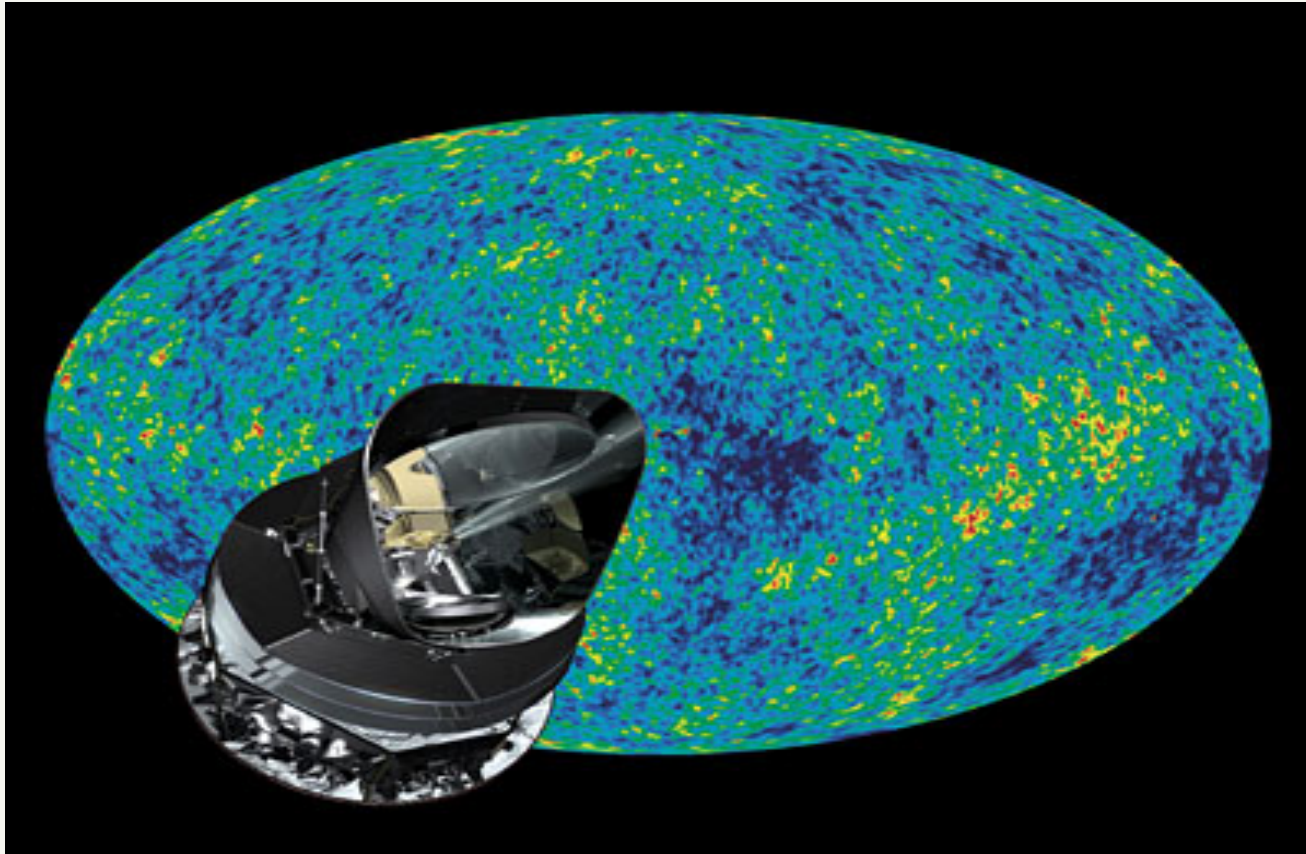
**Once Few, Women Hold More Power in Senate**  
Ms. America's induction that January day in 2011 into the most powerful ranks of the nation's political class — female senators —

... have on key committees and legislation.  
A record nine women now lead committees, including some of

# *Brief history of time*

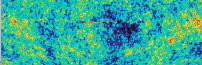


# Cosmic 'Rosetta stone'

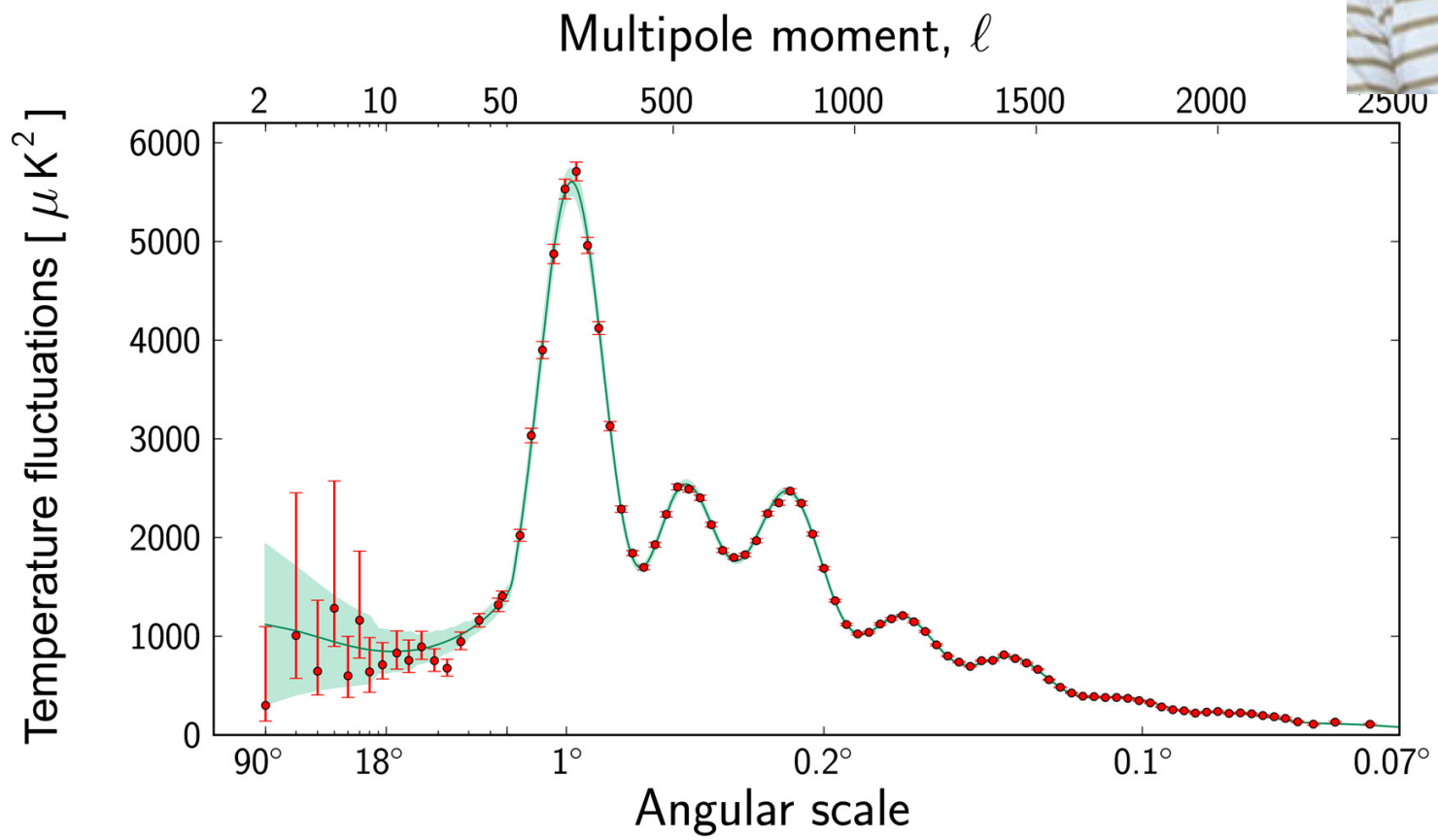
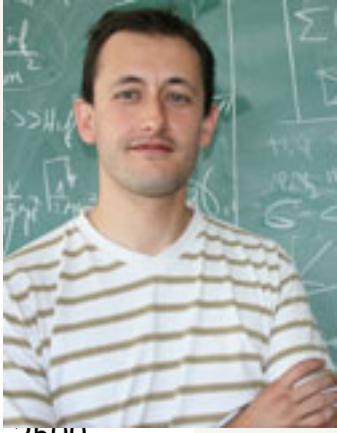


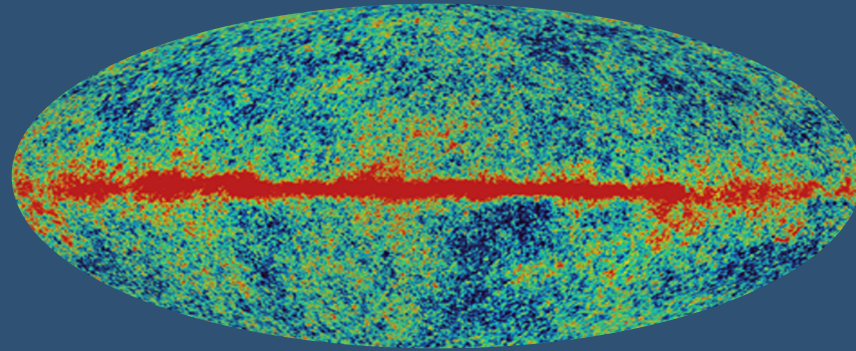
$\Delta T = 0.00057$  Kelvin





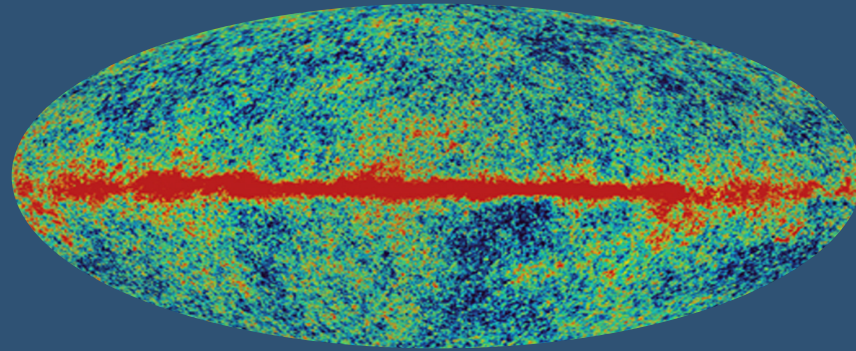
# Universe as high-energy lab





## Conclusion

- Lemaître's big bang is alive and well !
- Models of big bang predict seeds of galaxies
- Sattelite images reveal details of universe's origin



## Challenges and Opportunities

- Strengthen observational cosmology
- Bring experts of particle physics and cosmology together in a joint world-class research Centre
- Connect public to fundamental science



Hawking lecture Oct 2011, central park, Leuven