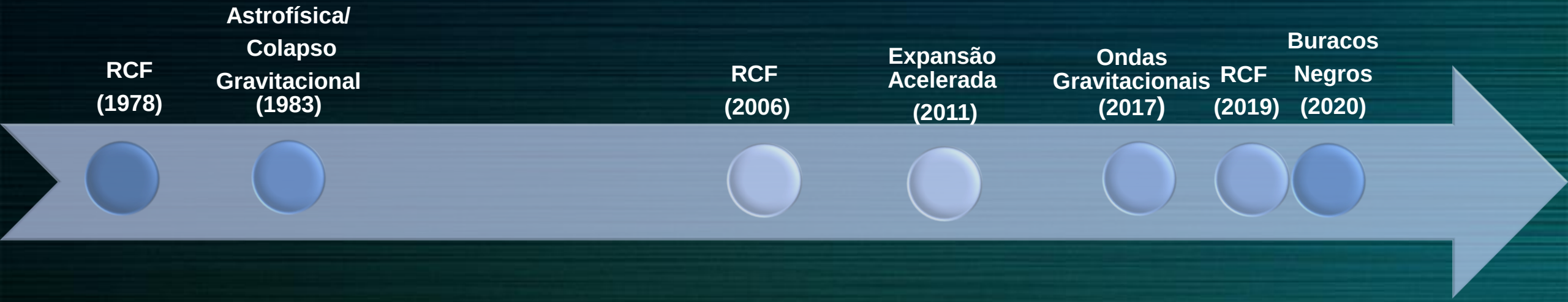
Um Panorama dos Prêmios Nobel de Cosmologia e Gravitação:

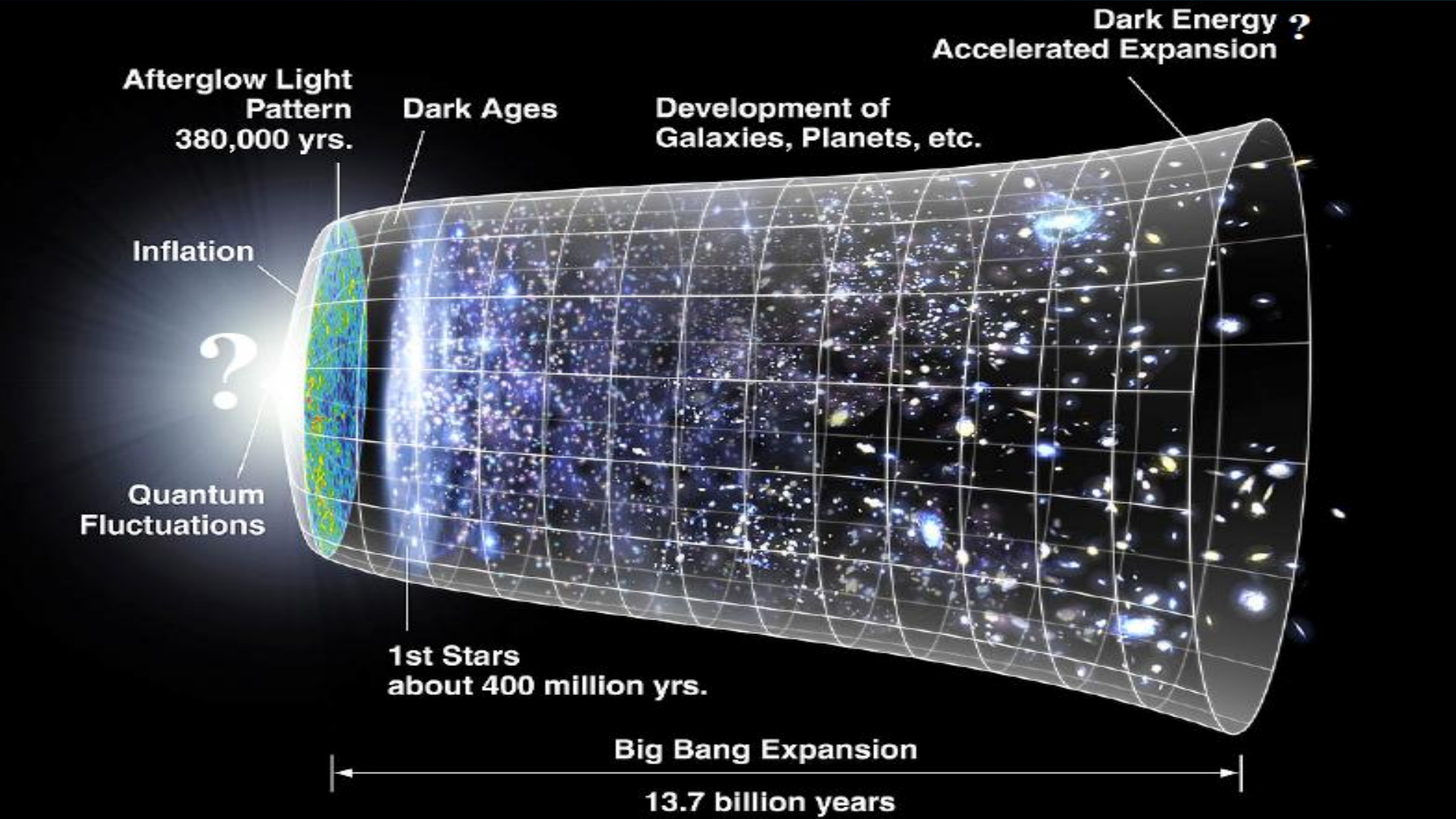
de 1978 ao Horizonte de Eventos.

Prof. Leila L. Graef

Universidade Federal Fluminense

17 de Dezembro de 2020


RCF
(1978)
Astrofísica/
Colapso
Gravitacional
(1983)
RCF
(2006)
Expansão
Acelerada
(2011)
Ondas
Gravitacionais
(2017)
RCF
(2019)
Buracos
Negros
(2020)


Dark Energy ?
Accelerated Expansion
Afterglow Light
Pattern
380,000 yrs.
Dark Ages
Development of
Galaxies, Planets, etc.
Inflation
?
Quantum
Fluctuations
1st Stars
about 400 million yrs.
Big Bang Expansion
13.7 billion years

RADIAÇÃO CÓSMICA DE FUNDO

1978

Arno Penzias and Robert Wilson

"for their discovery of the CMB”

2006

John C. Mather and George F. Smoot

"for their discovery of the blackbody form and anisotropy of the CMB”

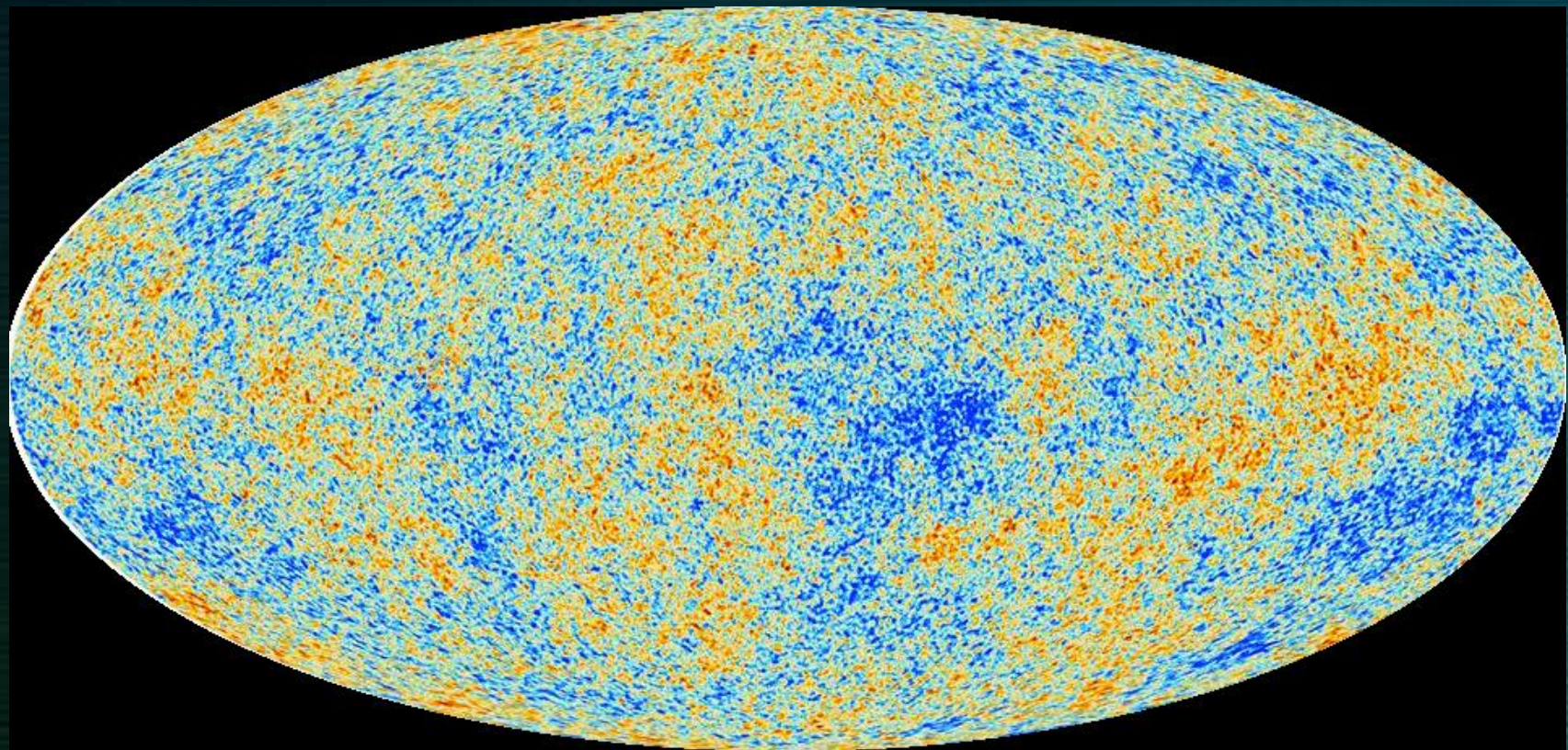
2019

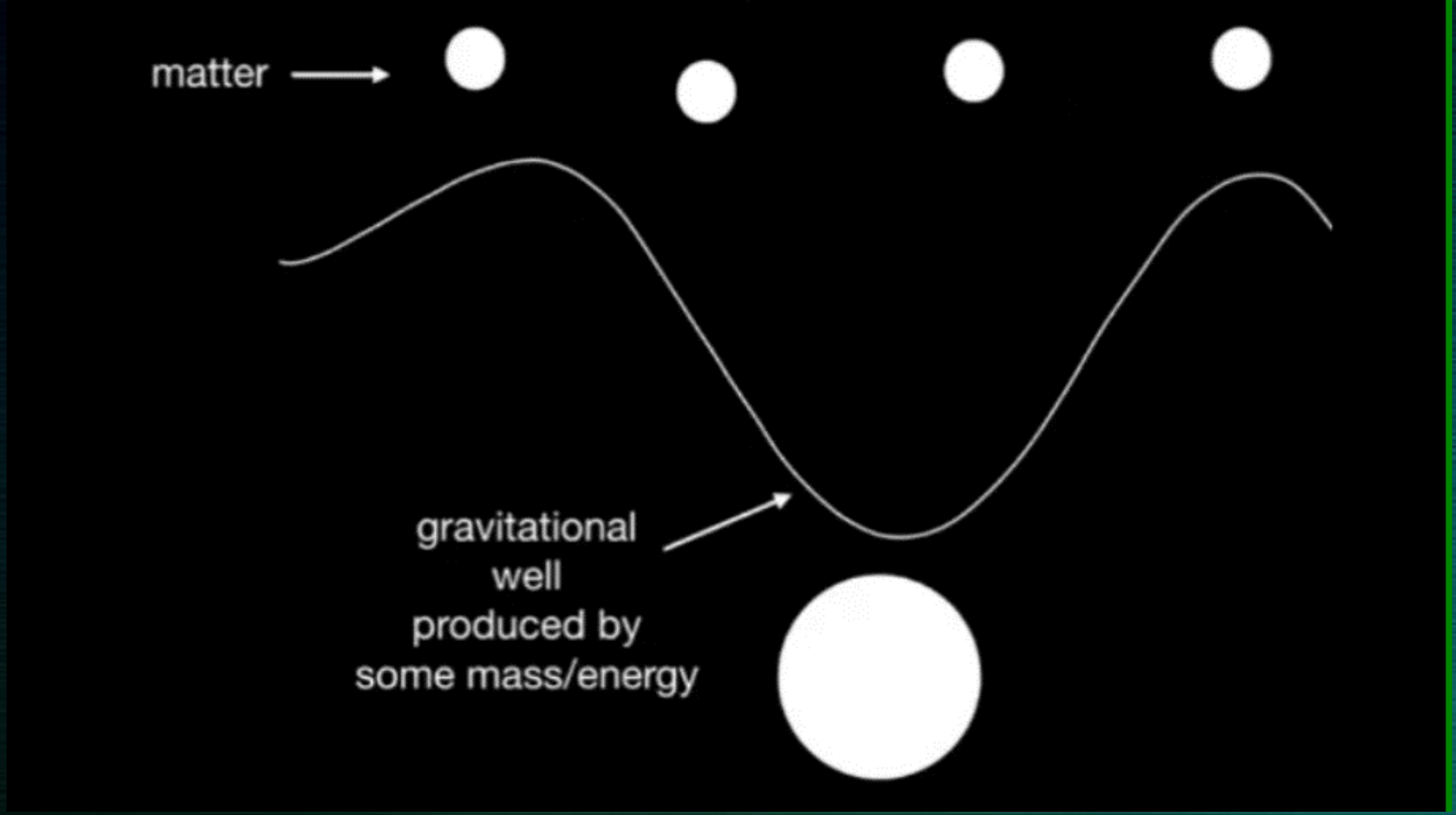
James Peebles

"for theoretical discoveries in physical cosmology”

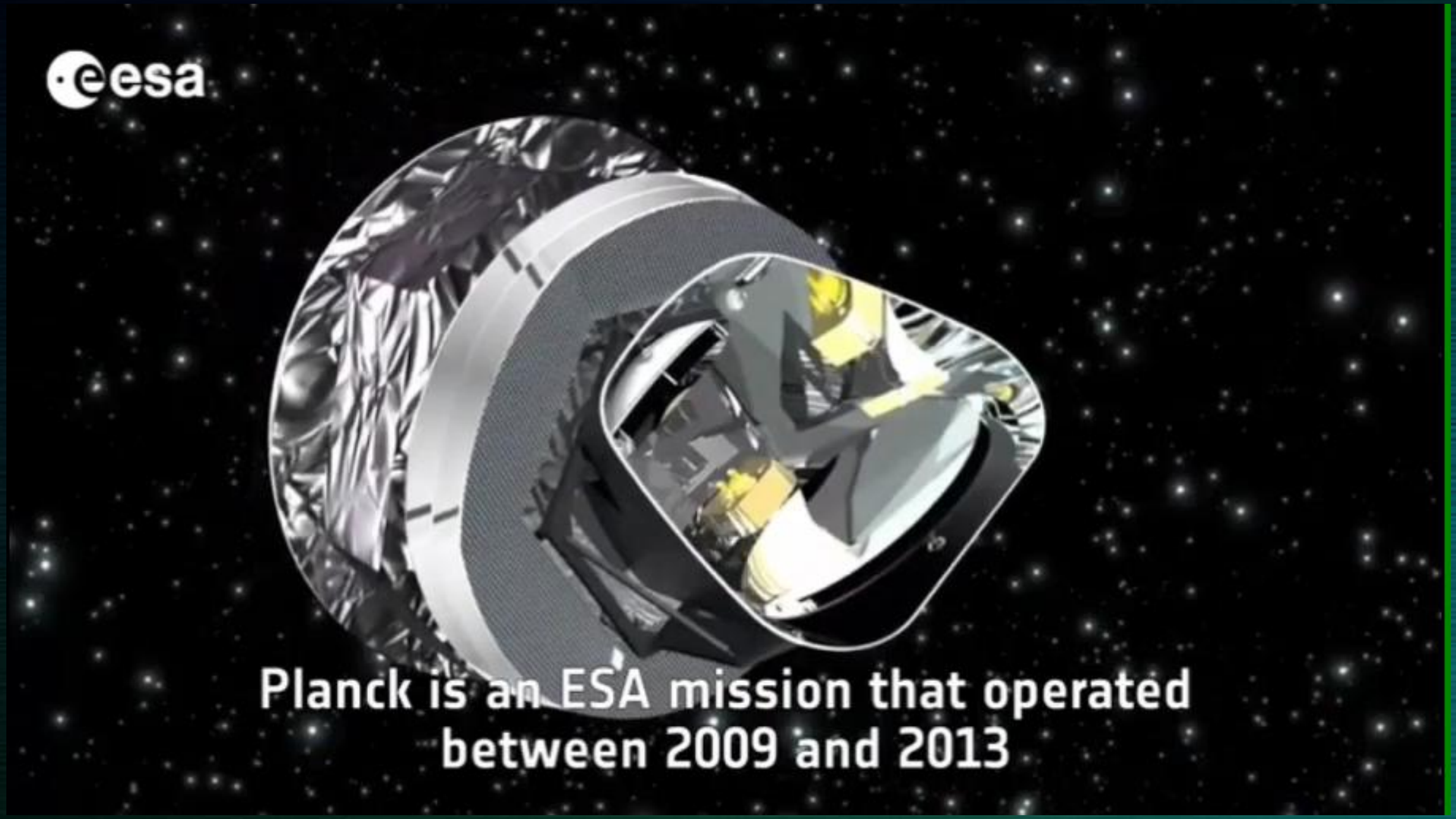
Radiação Cósmica de Fundo

- Princípio Cosmológico – Universo homogêneo e isotrópico em escalas > ~100 Mpc.
- São as flutuações Cosmológicas que nos dão informações sobre o universo antigo.



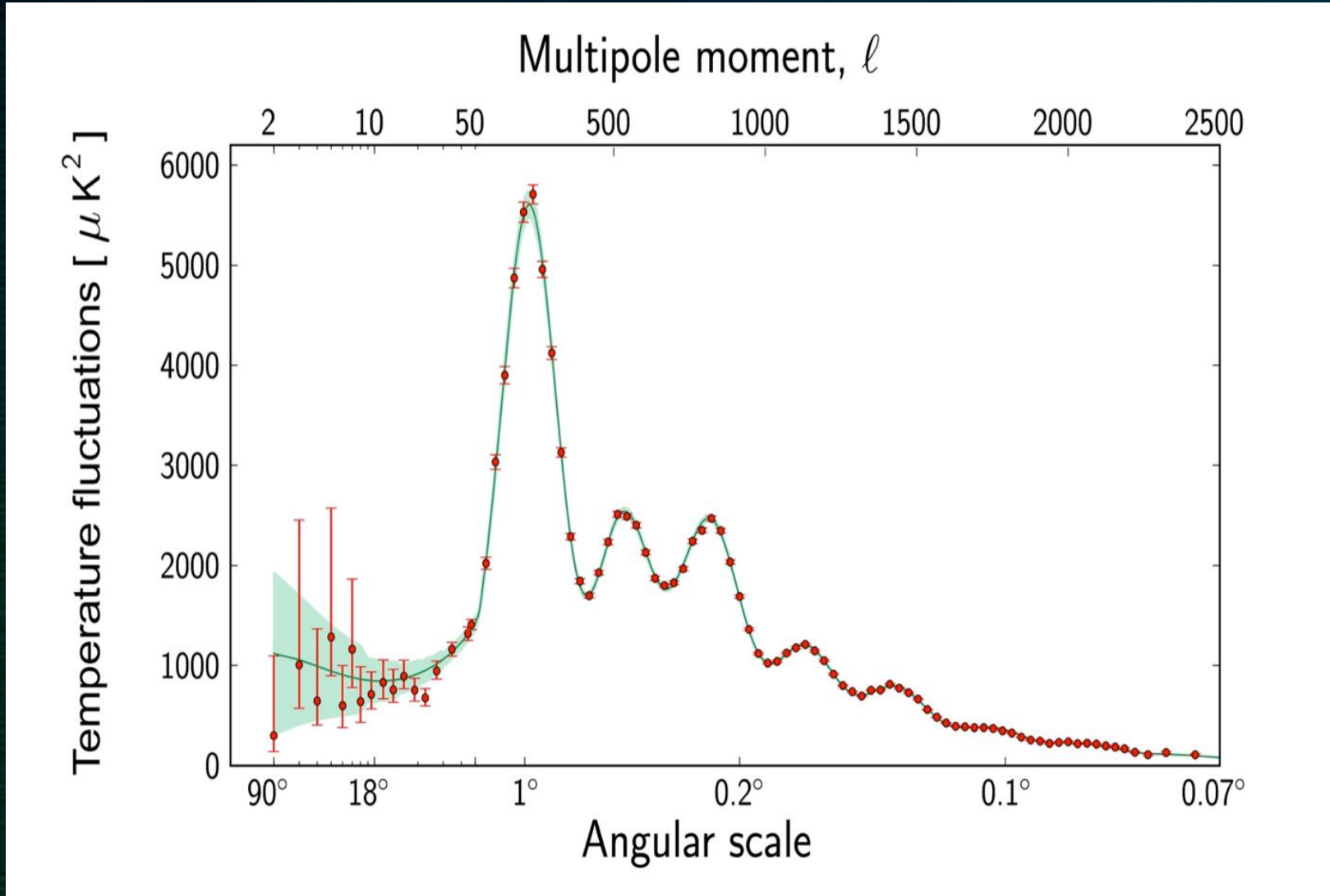


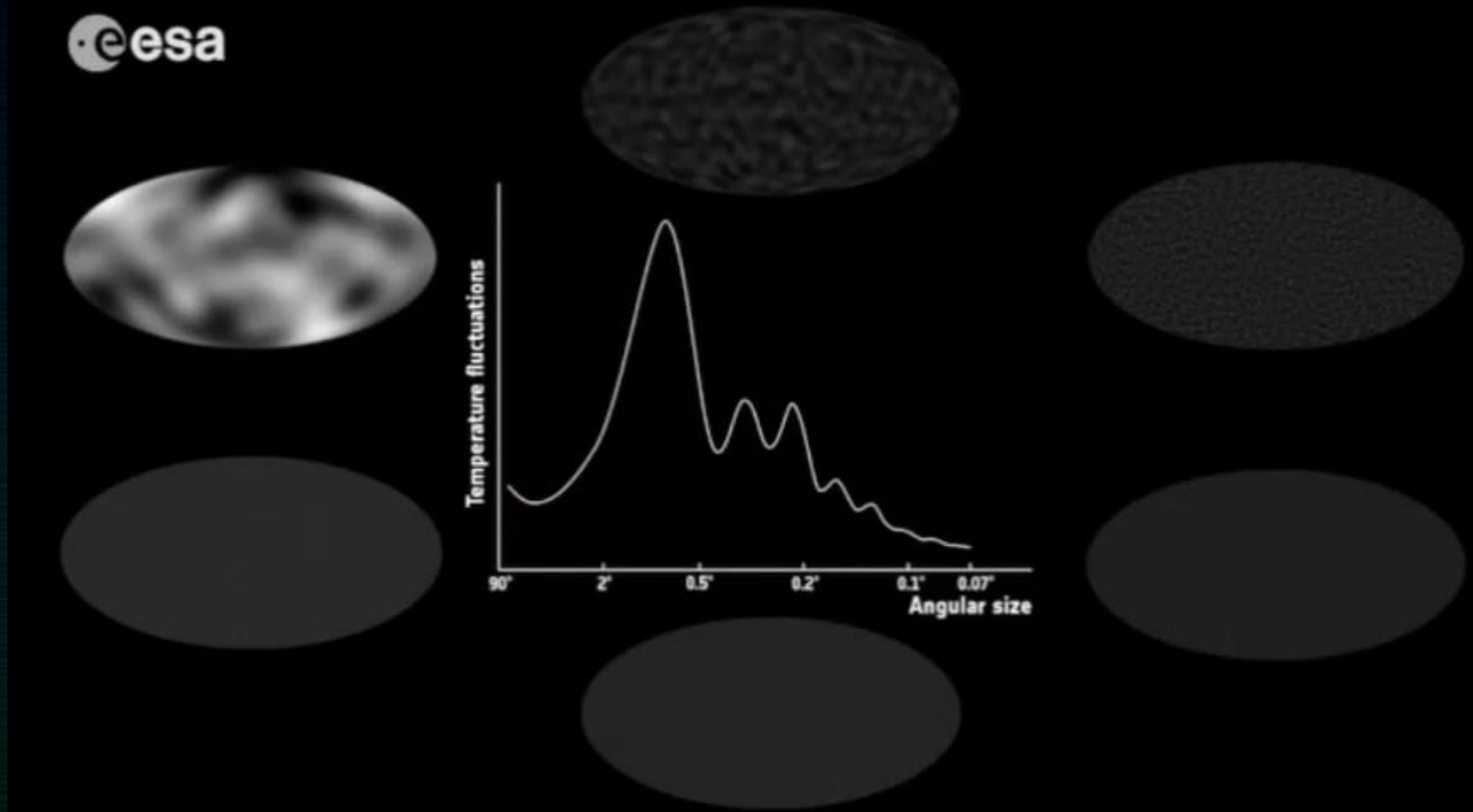
“Animação cordialmente cedida pelo Prof. Enrico Bertuzzo (IF-USP)”



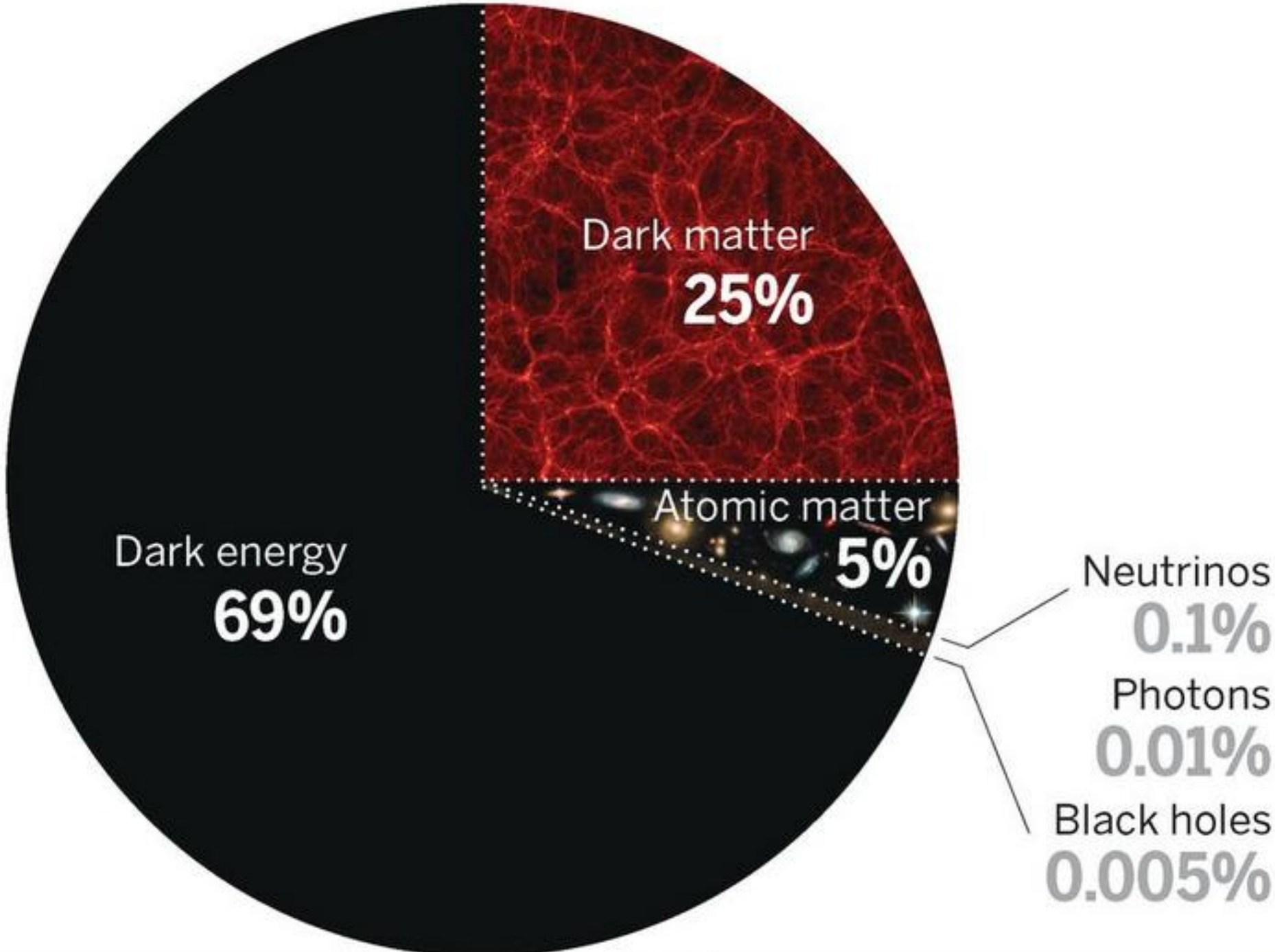
“Courtesy ESA/PLANCK ".

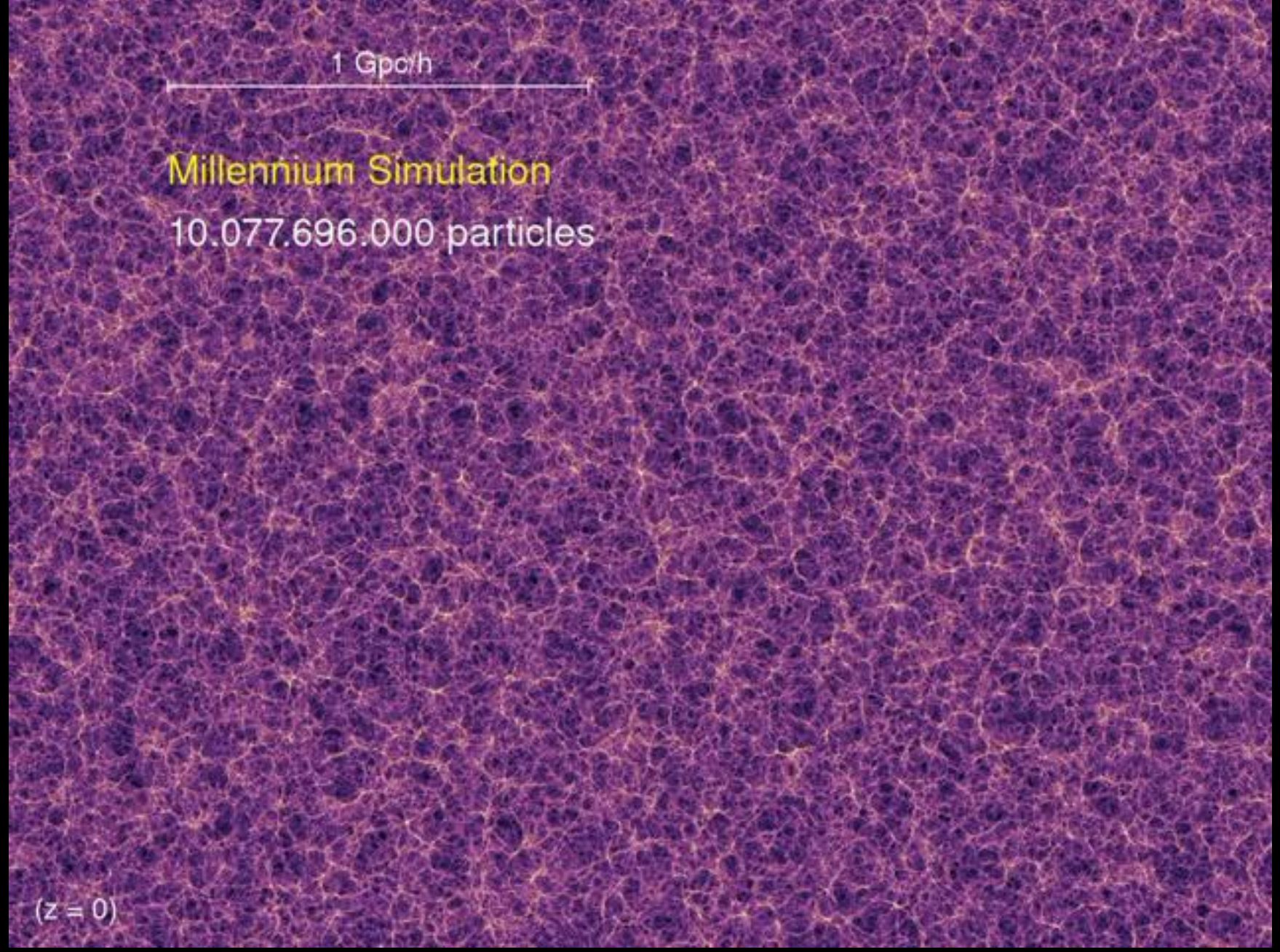
Diferentes modelos para o universo primordial podem ser testados com o espectro da Radiação Cósmica de Fundo.





“Courtesy ESA/PLANCK ".


Dark matter
25%
Atomic matter
5%
Dark energy
69%
Neutrinos
0.1%
Photons
0.01%
Black holes
0.005%

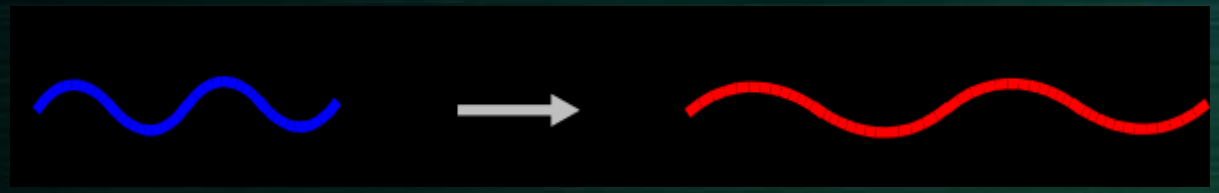

1 Gpc/h
Millennium Simulation
10.077.696.000 particles
(z = 0)

Nobel de Física-2011

S. Perlmutter, B. P. Schmidt, Adam G. Riess

"for the discovery of the accelerating expansion of the Universe - observations of distant supernovae."

- A radiação sofre redshift com a expansão do universo.
- Dois projetos independentes em 1998 mediram a aceleração da expansão.



Equação de Einstein

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

Supondo Fluido Perfeito, Homogeneidade e Isotropia:

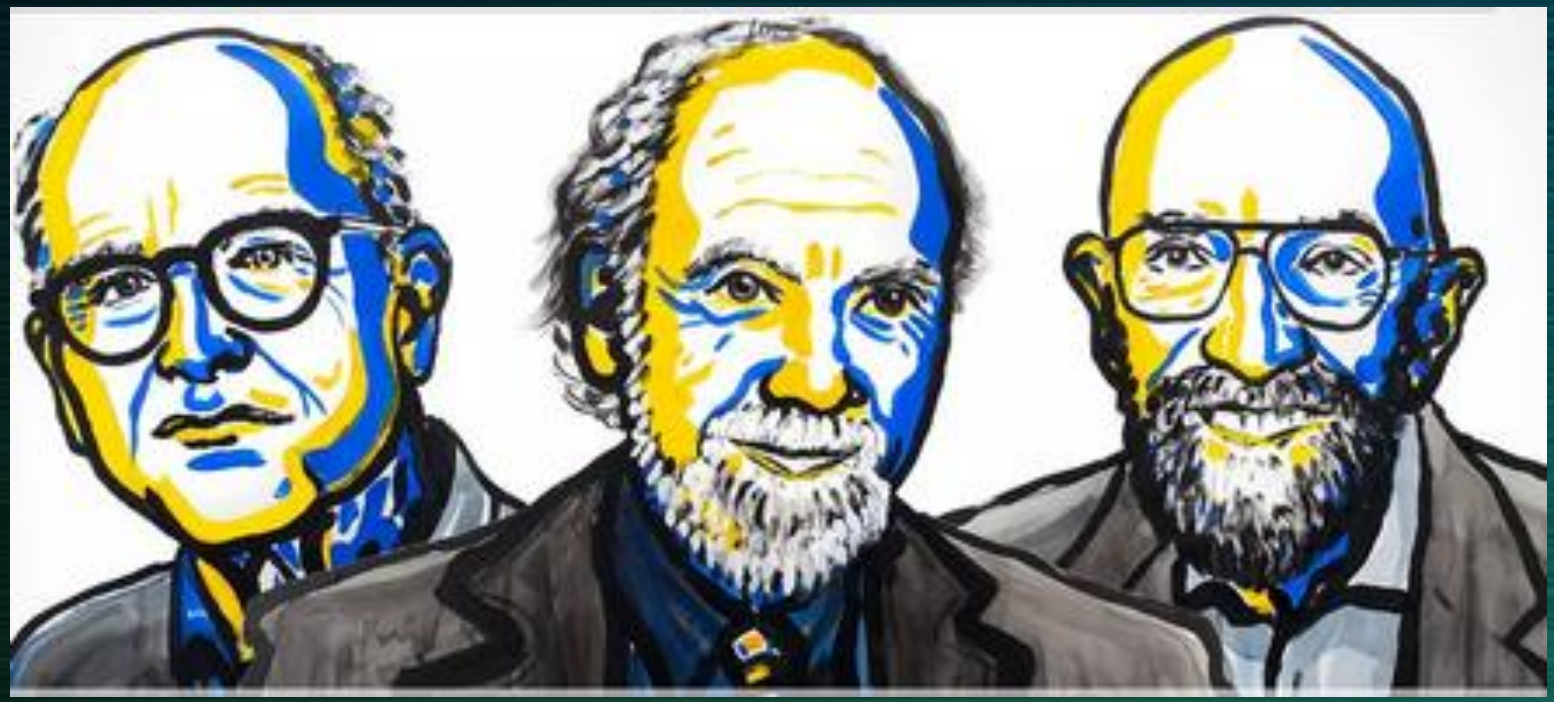
$$\frac{\dot{a}^2 + kc^2}{a^2} = \frac{8\pi G\rho + \Lambda c^2}{3}$$

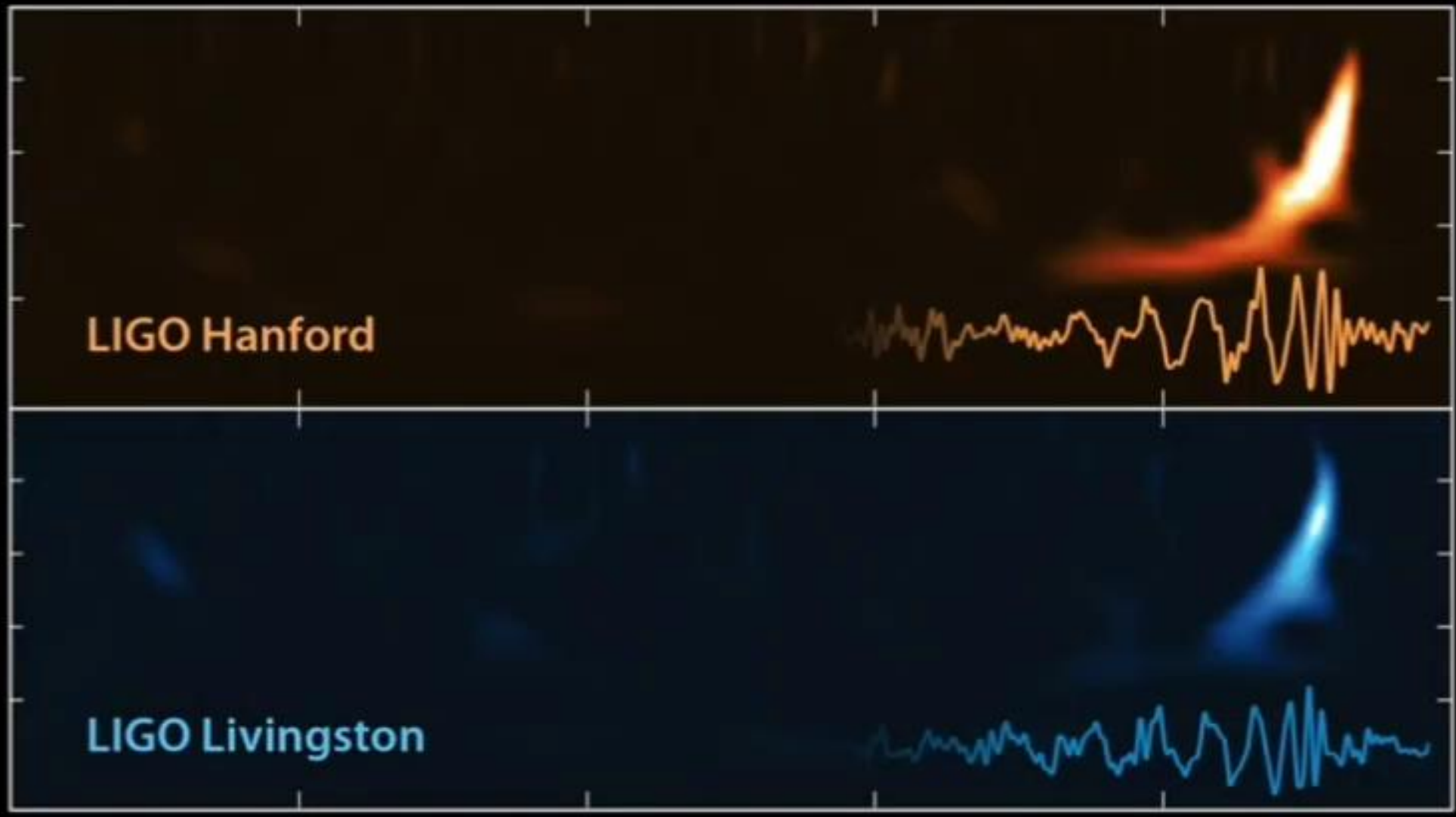
$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}\left(\rho + \frac{3p}{c^2}\right) + \frac{\Lambda c^2}{3}$$

2017

Rainer Weiss, Barry C. Barish, Kip S. Thorne
LIGO/VIRGO Collaboration

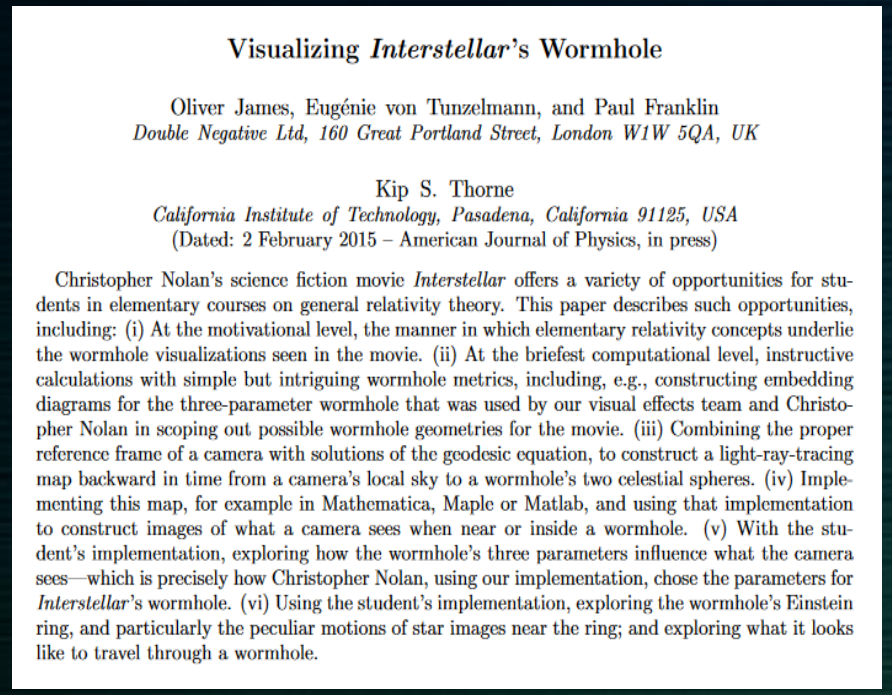
“for decisive contributions to the LIGO detector and the observation of gravitational waves”





“Courtesy Caltech/MIT/LIGO Laboratory".

Kip Thorne

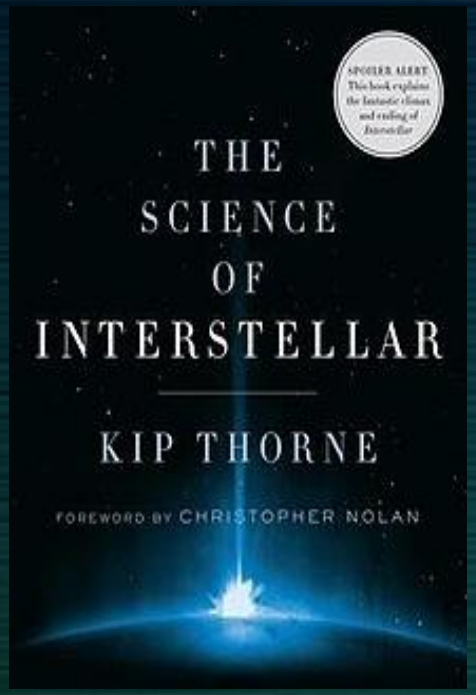


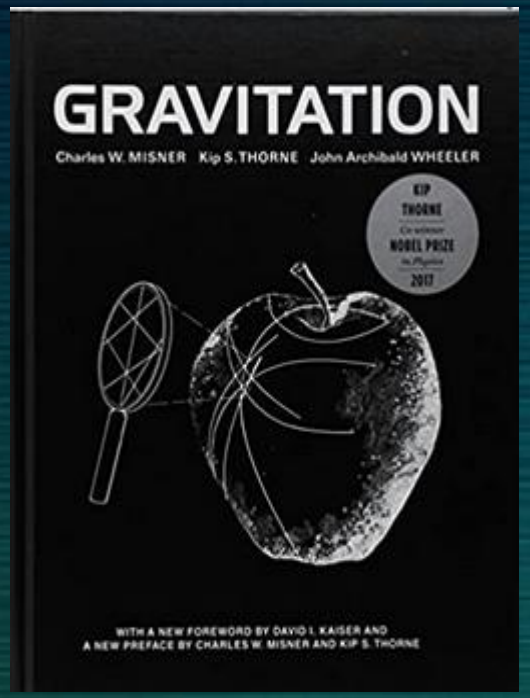
Visualizing *Interstellar*'s Wormhole

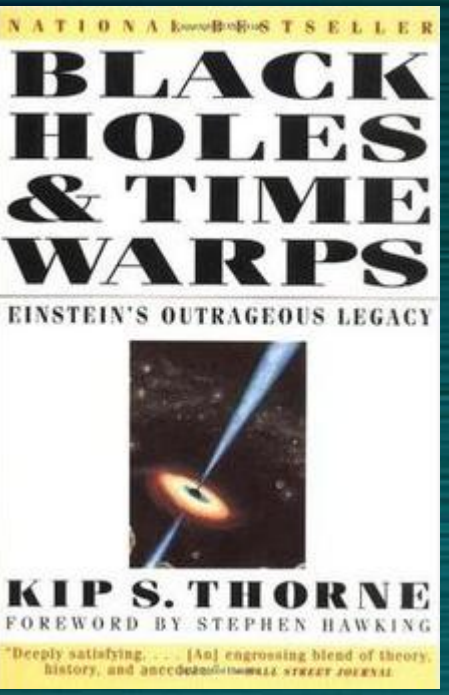
Oliver James, Eugénie von Tunzelmann, and Paul Franklin
Double Negative Ltd, 160 Great Portland Street, London W1W 5QA, UK

Kip S. Thorne
California Institute of Technology, Pasadena, California 91125, USA
(Dated: 2 February 2015 – American Journal of Physics, in press)

Christopher Nolan's science fiction movie *Interstellar* offers a variety of opportunities for students in elementary courses on general relativity theory. This paper describes such opportunities, including: (i) At the motivational level, the manner in which elementary relativity concepts underlie the wormhole visualizations seen in the movie. (ii) At the briefest computational level, instructive calculations with simple but intriguing wormhole metrics, including, e.g., constructing embedding diagrams for the three-parameter wormhole that was used by our visual effects team and Christopher Nolan in scoping out possible wormhole geometries for the movie. (iii) Combining the proper reference frame of a camera with solutions of the geodesic equation, to construct a light-ray-tracing map backward in time from a camera's local sky to a wormhole's two celestial spheres. (iv) Implementing this map, for example in Mathematica, Maple or Matlab, and using that implementation to construct images of what a camera sees when near or inside a wormhole. (v) With the student's implementation, exploring how the wormhole's three parameters influence what the camera sees—which is precisely how Christopher Nolan, using our implementation, chose the parameters for *Interstellar*'s wormhole. (vi) Using the student's implementation, exploring the wormhole's Einstein ring, and particularly the peculiar motions of star images near the ring; and exploring what it looks like to travel through a wormhole.





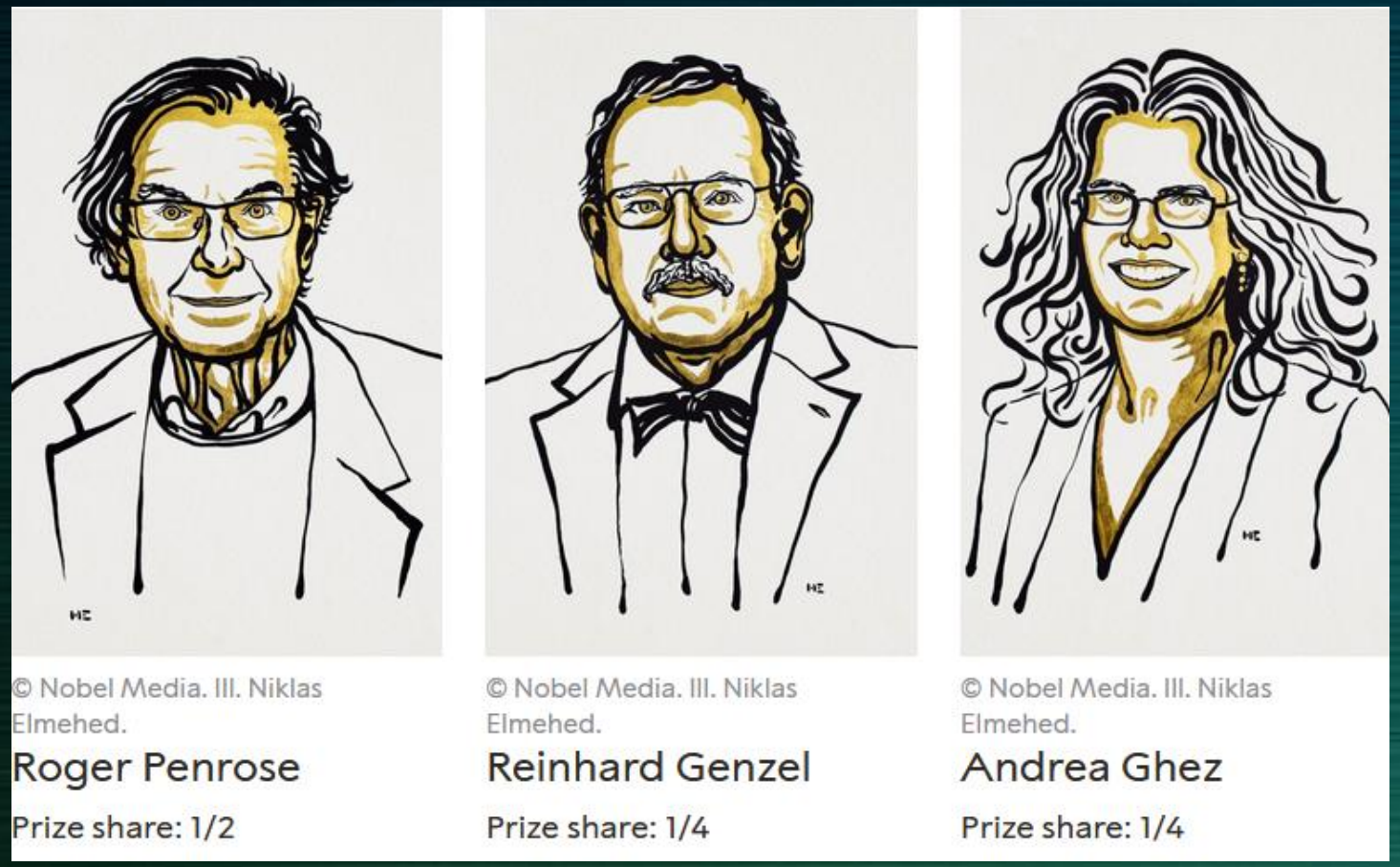


arXiv: 1502.03809 [gr-qc]

"Interstellar has real science built into its fabric, thanks to a strong science commitment by the director, screenwriters, producers, and visual effects team, and thanks to Thorne's role as an executive producer."

2020
Roger Penrose

"for the discovery that black hole formation is a robust prediction of the general theory of relativity"



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Roger Penrose
Prize share: 1/2

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Reinhard Genzel
Prize share: 1/4

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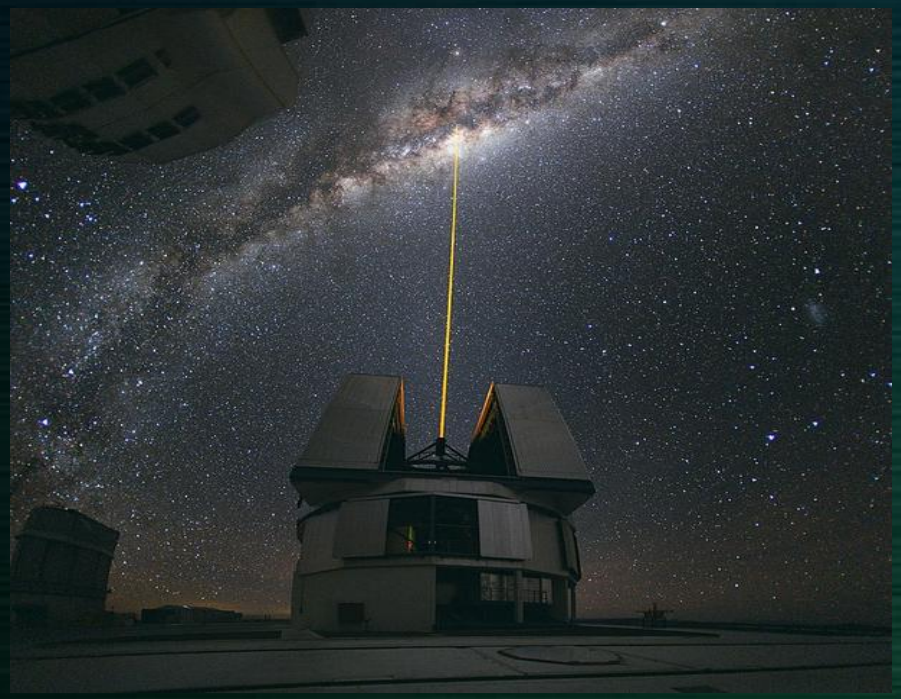
Andrea Ghez
Prize share: 1/4

2020

Reinhard Genzel, Andrea Ghez

"for the discovery of a supermassive compact object at the center of our galaxy."

Reinhard Genzel
VLT/ESO



Andrea Ghez
Keck Observatory

O Horizonte de Eventos

Nova era de precisão:

CMB-S4, Euclid, Rubin Obs., Roman Space Telescope, SKA, LISA...
No Brasil: JPAS, BINGO...

Questões:

Setor escuro, Inflação, Relatividade Geral / Gravitação Modificada,
idade do universo, gravitação quântica...

Muitas novidades estão por vir!!!

AGRADECIMENTOS

Ao comitê organizador do *COLMEA*

Ao Prof. Enrico Bertuzzo (IF USP)

Ao Felipe Carrelli

Aos amigos:

Luís Oxman

Satheeshkumar Veerahanumakkanapalya Honnappa

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