

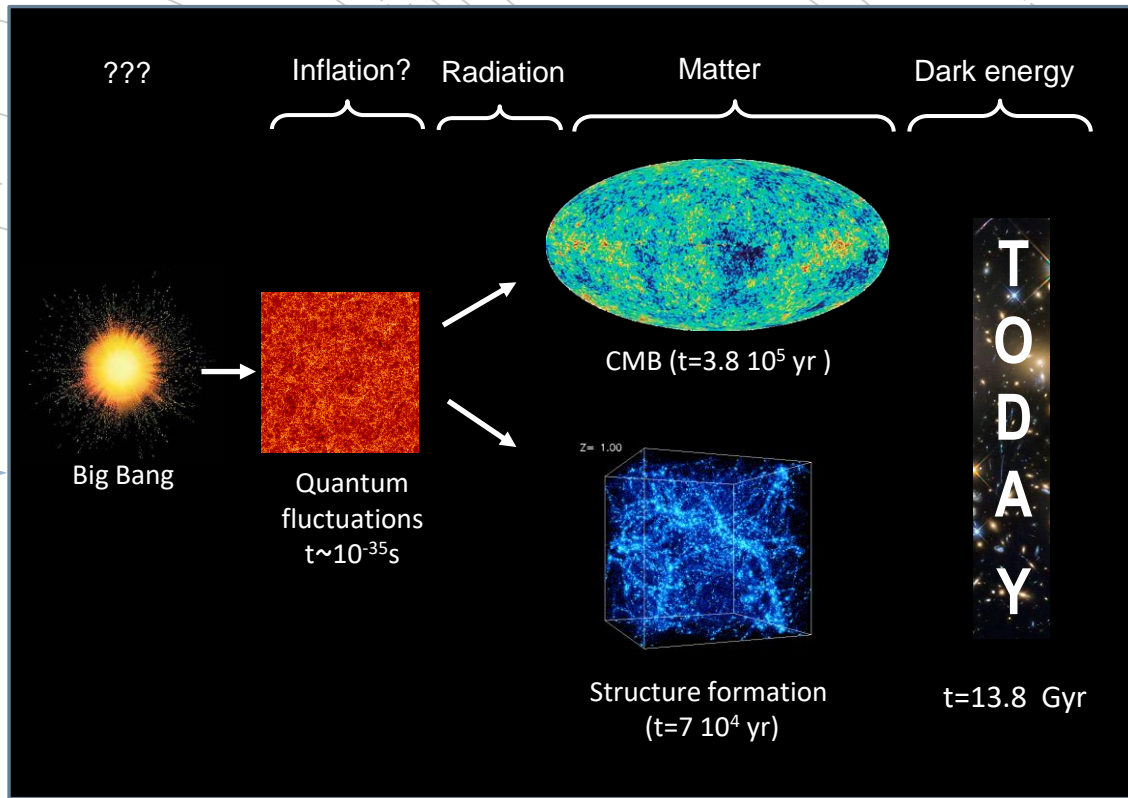


Theoretical gravity and cosmology at IPARCOS

J. A. R. Cembranos

Λ CDM cosmology

- ❑ Origin, evolution and structure of the universe on large scales
- ❑ Simple (six-parameter) model.
- ❑ Excellent fit to CMB, LSS, SNIa... data



IPARCOS
Research lines

Λ CDM cosmology

Open questions

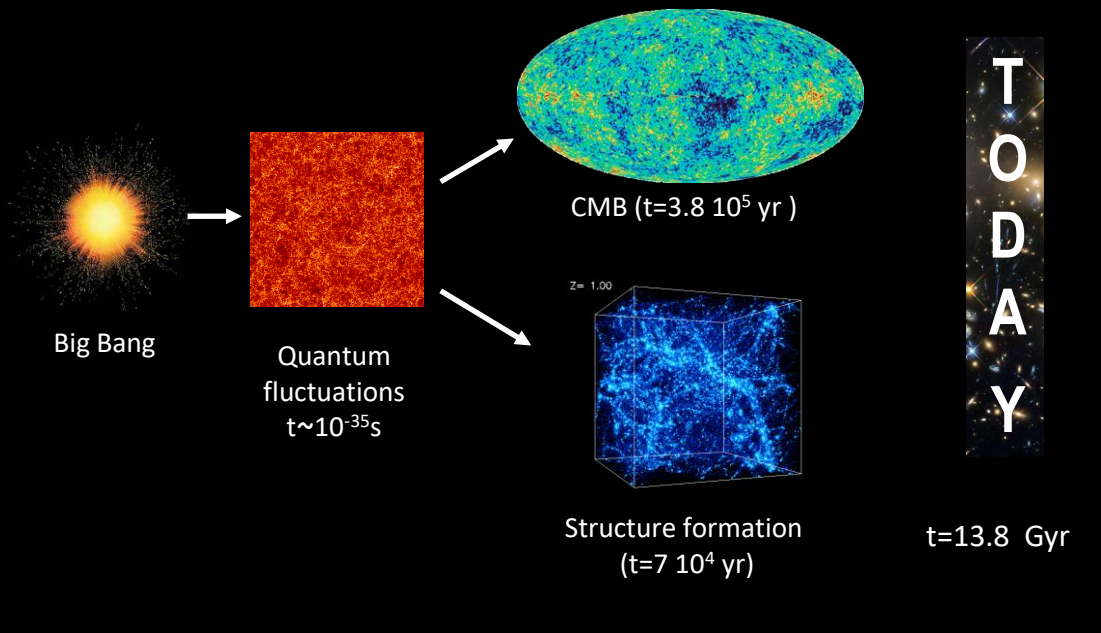
- Initial singularity.
- What is the mechanism of inflation?
- What is the nature of dark matter?
- What is the nature of dark energy?

Singularities
Quantum
gravity

Inflationary
mechanisms

Dark matter models
LSS formation/N-body
Precision cosmology

Dark energy models
Modified gravity/GW
Galaxy surveys

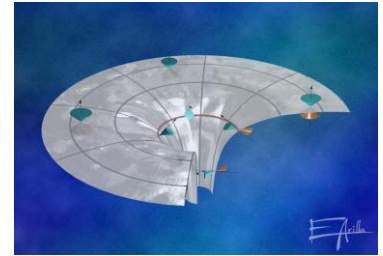


Luis J. Garay
Mercedes Martín Benito
Valentin Boyanov (PhD)
Rita Neves (PhD)
Álvaro Álvarez (PhD)

Quantum Fields & Gravity

■ QFT in curved spacetimes

- Black holes: Hawking radiation
- Semiclassical gravity effects: black stars
- Cosmology: quantization of primordial fluctuations
- Schwinger effect



■ Quantum gravity

- Non-perturbative quantization methods
- Loop Quantum Gravity/ Loop Quantum Cosmology
- Quantization of Weyl Transverse Gravity

Rafael Hernández Redondo
Carmelo Pérez Martín
Roberto Ruiz Gil

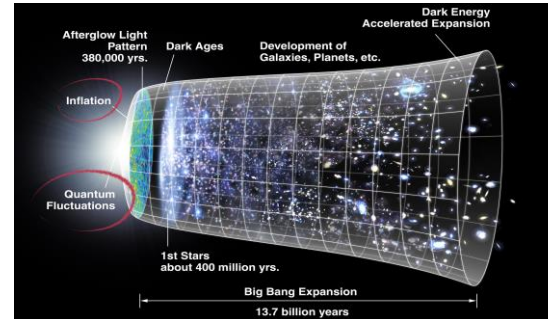
Quantum Unimodular Gravity and the AdS/CFT duality

- **Unimodular Gravity = Einstein's General Relativity at the classical level.**
- **Unimodular Gravity and General Relativity differ as Quantum Field theories:** Unimodular Gravity solves in a Wilsonian way part of the Cosmological Constant problem, General Relativity doesn't.
- **Pressing problems being analyzed:**
 - Quantization of Unimodular supergravity
 - How does Unimodular Gravity arise within the AdS/CFT duality?

Mindaugas Karciauskas
Jose Jaime Terente Díaz (PhD)

Inflation: the origin of cosmic structure

- ❑ What is the *fundamental theory* behind inflation? The role of gauge fields.
- ❑ Intersections between inflation and the *Standard Model* of Particle Physics. The stability of EW vacuum.





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José A. R. Cembranos
Antonio Dobado
Luis J. Garay
Antonio L. Maroto
Juan José Sanz-Cillero
Héctor Villarrubia-Rojo
Clara Álvarez-Luna (PhD)
Alfredo D. Miravet (PhD)
Álvaro Parra-López (PhD)

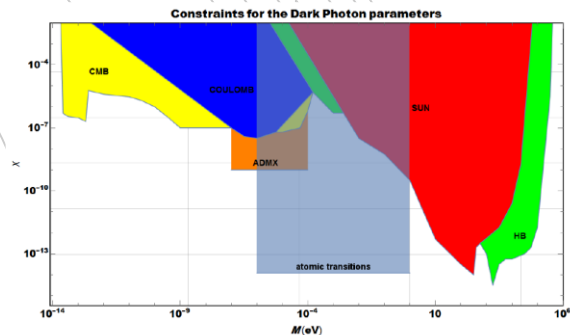
Dark matter models

■ Dark matter models

- Extra dimensions (branons)
- Heavy (TeV) dark matter
- Ultra-light dark matter (different spins)
- Gravitational production

■ Dark matter detection

- Indirect detection: gamma, neutrino, antimatter, gravitational waves,...
- Structure formation
- Direct detection



■ Models with extra fields

- Scalar: quintessence, Horndeski...
- Vector: vector-tensor, Proca, modified EM,...
- Higher-spin

■ The fate of the universe

- Big freeze and future singularities

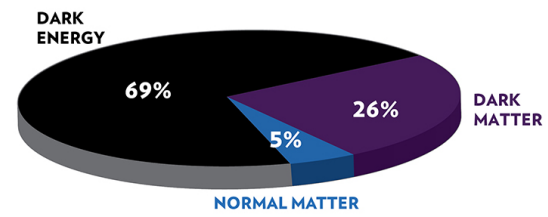
■ Vacuum energy

- Cosmological perturbations and the quantum vacuum

Prado Martín-Moruno
Antonio Dobado
José Alberto Ruiz Cembranos
Antonio L. Maroto
Héctor Villarrubia-Rojo
Teodor Borislavov Bassilev (PhD)

Dark energy models

ENERGY DISTRIBUTION OF THE UNIVERSE



Prado Martín-Moruno

Antonio Dobado

José Alberto Ruiz Cembranos

Antonio L. Maroto

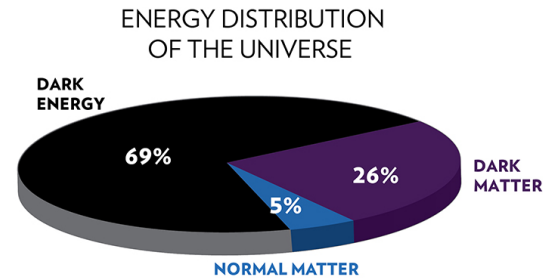
Héctor Villarrubia-Rojo

Teodor Borislavov Bassilev (PhD)

Dark energy models

■ Modified gravity

- $F(R)$, (cosmology, Black holes, neutron stars)
- Massive gravity (bigravity)
- Gravity waves in GR and MG (**LISA science group**)





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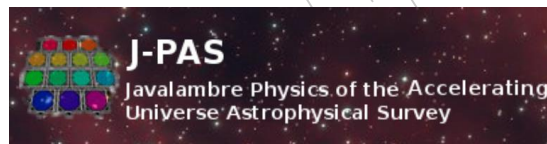
Antonio L. Maroto
Prado Martín-Moruno
Alfredo D. Miravet (PhD)

Testing gravity with galaxy surveys

■ Galaxy surveys

- Measuring the equation of state of dark energy
- Testing Λ CDM and GR
- Tomographic surveys (**J-PAS** and **Euclid**)
- Forecasts for modified gravity

■ Weak lensing surveys



Felipe J. Llanes Estrada
 Eva Lope Oter (PhD)
 Alexandre Salas (PhD)
 Adriana Bariego (Msc)
 Oliver Manzanilla (Msc)

DM & Modified gravity at subcosmological scales

■ **Neutron stars**

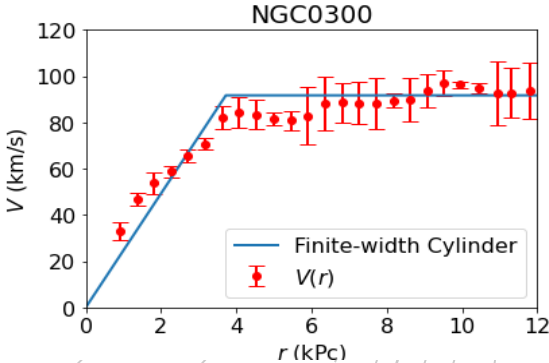
- QCD equation of state
- New gravitational interactions Phenomenology

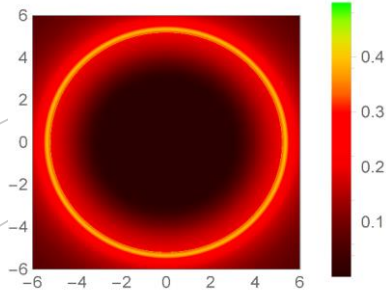
■ **Dark matter halos**

- Morfology study
- Analasys of SPARC data base

■ **Einstein Telescope**

- QCD studies for neutron stars
- Effects of the strong interactions detectable from n-star mergers





Diego Rubiera-Garcia
Mercè Guerrero (PhD)

Black holes and other compact objects

■ Theory

- Regular black holes out of various matter sources
- Shortcut methods for solving field equations of modified gravity
- Rotating black holes of modified gravity
- Alternative compact objects: wormholes, bounces, boson/Proca stars...

■ Phenomenology

- Shadows from accretion disks: background geometries, multiple critical curves, additional light rings, modellings for the geometrical, optical and emission properties of the disk...
- Gravitational waves: generation and propagation. Echoes of horizonless compact objects
- Limiting masses of stellar and sub-stellar objects
- Imprints from additional geometrical structures in energy levels

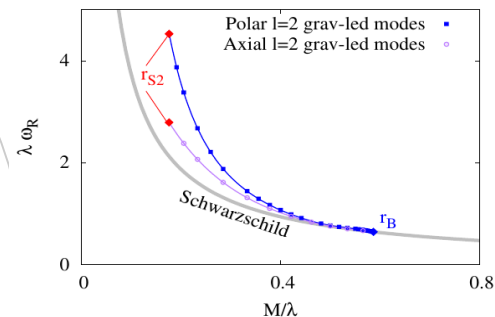
José Luis Blázquez Salcedo
Francisco Navarro-Lérida

Luis Manuel González Romero (ext.)
Fech Scen Khoo (ext.)
Jutta Kunz (ext.)
Eugen Radu (ext.)
Carlos Herdeiro (ext.)

**Compact
objects in
alternative
theories:
gravitational
waves,...**

■ Quasinormal modes of compact objects

- Black holes, neutron stars, wormholes, etc...
- Alternative theories of gravity:
 - Einstein-Gauss-Bonnet, scalar-tensor-theory, ...
- Imprint on the spectrum of quasinormal modes
- Analysis of the stability, hyperbolicity, isospectrality
- Universal relations of neutron stars
- **Einstein Telescope**



IPARCOS
Theoretical Gravity
and Cosmology

People

■ Members (with PhD): 16

Luis J. Garay

Mercedes Martín Benito

Rafael Hernández Redondo

Carmelo Pérez Martín

Roberto Ruiz Gil

José Alberto Ruiz Cembranos

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Francisco Navarro-Lérida

IPARCOS
Theoretical Gravity
and Cosmology

People

- PhD students: 11

- Valentin Boyanov
- Rita Neves
- Álvaro Álvarez
- Eva Lope Oter
- Alexandre Salas
- Clara Álvarez-Luna
- Alfredo D. Miravet
- Álvaro Parra-López
- Mercè Guerrero
- Jose Jaime Terente Díaz
- Teodor Borislavov Bassilev

- Total: 27