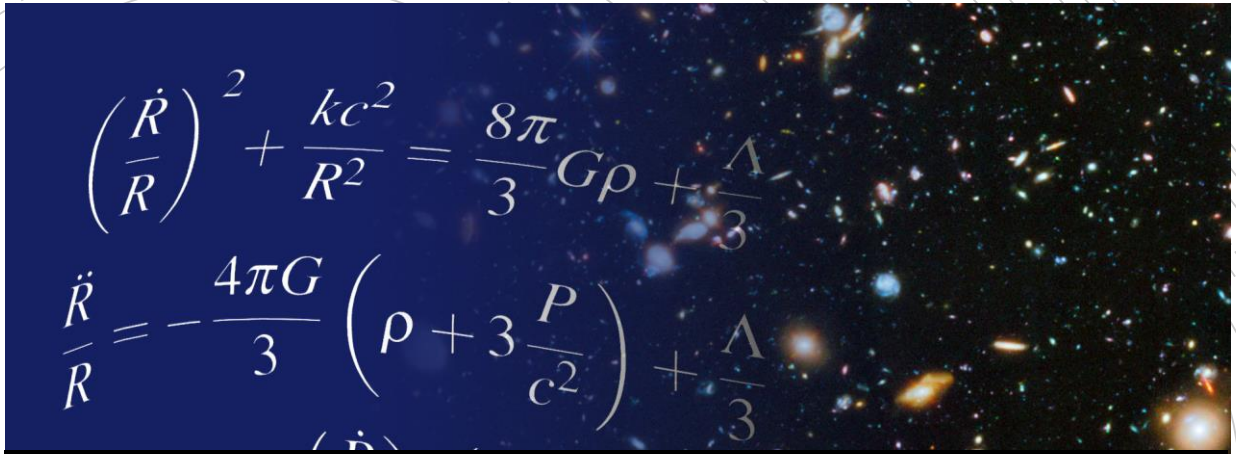
# Cosmology

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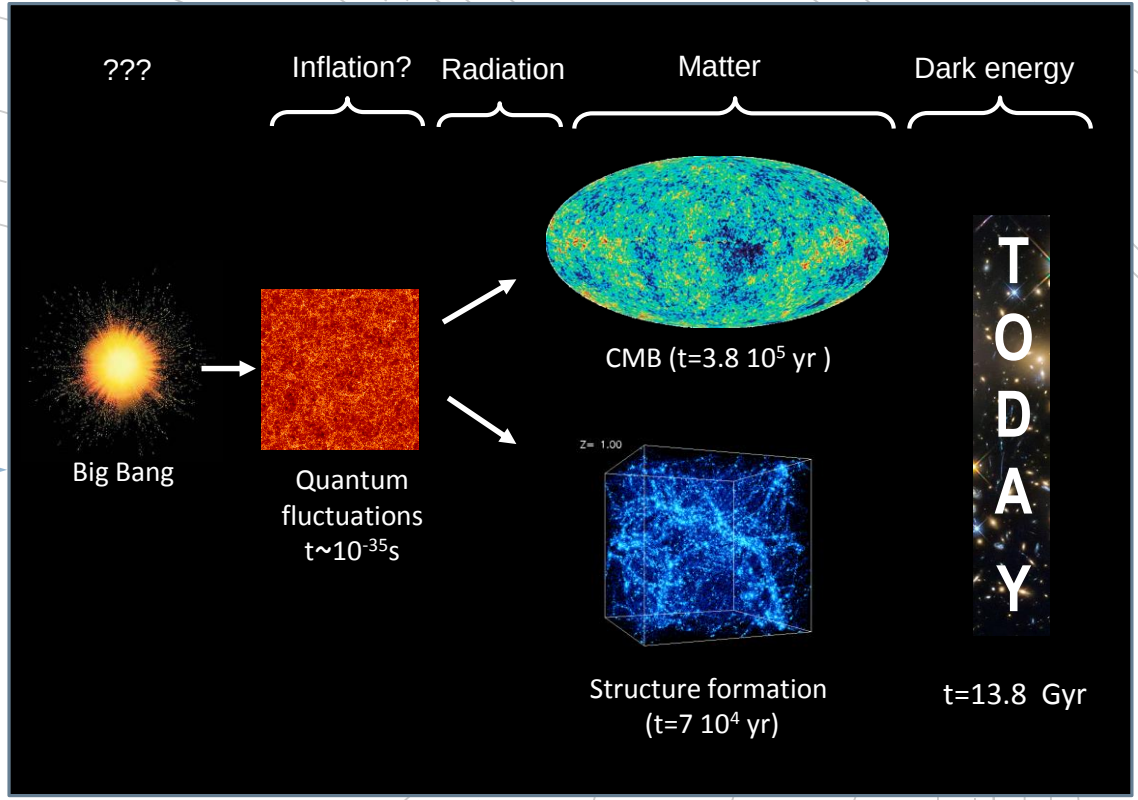
# ΛCDM cosmology

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



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Research lines

Singularities
Quantum gravity

Inflationary mechanisms

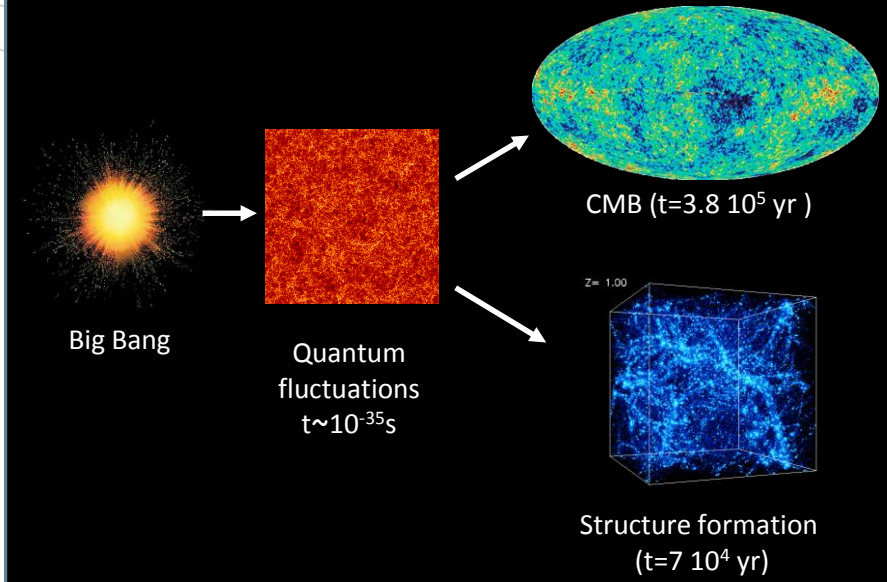
Dark matter models
LSS formation/N-body
Precision cosmology

Dark energy models
Modified gravity/GW
Galaxy surveys

# ΛCDM 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**?



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# Gravity and quantum theory

- Quantum field theory in curved space-time:
  - Dynamical particle production
    (Unruh, Hawking, Hartle-Hawking and Schwinger effects)
- Quantum gravity effects on black holes and cosmology
  - Loop quantum gravity
  - Black stars (without horizons)
- Regularization of classical singularities

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# Quantum space-time and Unimodular Gravity

- Non-commutative space-times
  - At very high energies point-like description of space-time is not adequate
  - Space-time must be replaced by mathematical objects of quantum nature known as non-commutative space-times
  - Particle interactions in such space-times are modified and lead at low energies to a constraint on GR
- Unimodular gravity
- Cosmological constant problem

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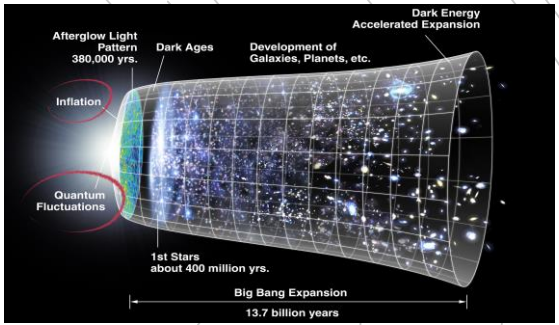
Juan J. Sanz Cillero
José A. Ruiz Cembranos

# 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.
- Coleman-Weinberg potential for inflation and dark sector



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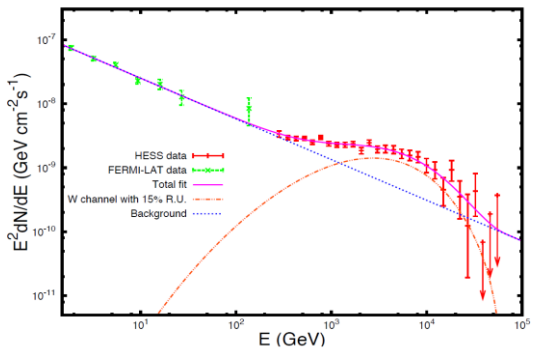
# Dark matter models

- Dark matter models
  - Extra dimensions (branons)
  - Heavy (TeV) dark matter
  - Ultra-light dark matter (arbitrary spin)
- Dark matter detection
  - Indirect detection: gamma, neutrino and antimatter



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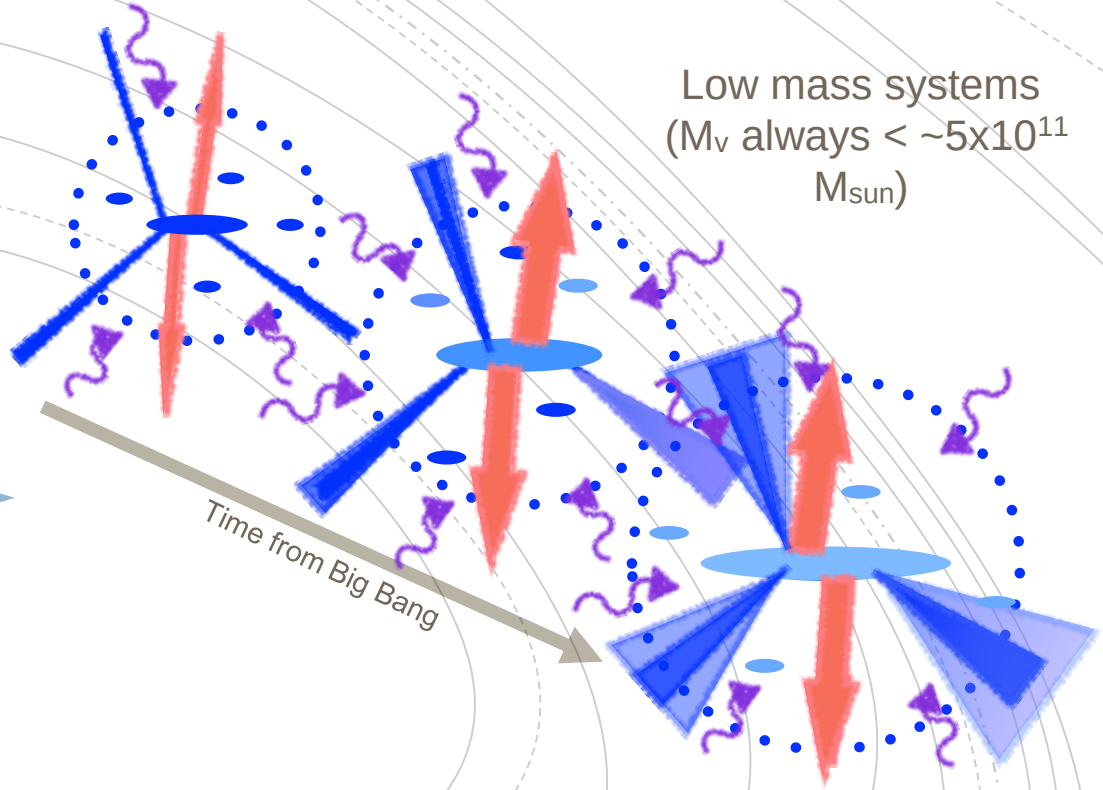
# Cosmological N-body simulations: CGM and IGM properties



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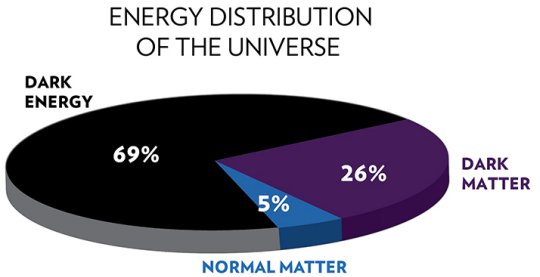
# Dark energy models

- 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



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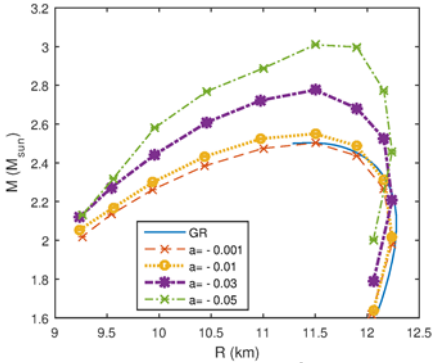
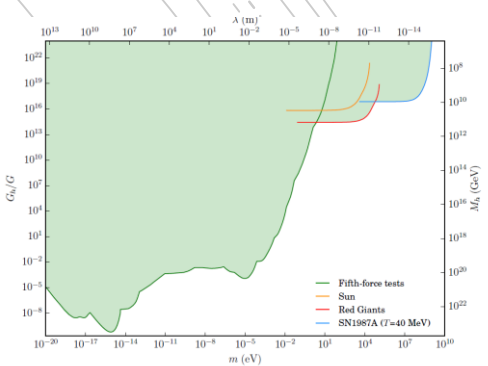
# Modified gravity

- Metric theories beyond GR
  - F(R), (cosmology, Black holes, neutron stars)
  - Massive gravity (bigravity)
- Model independent approach to MG
  - Scalar and vector modifications
  - Effects on astrophysical objects
- Gravity waves in GR and MG (LISA science group)



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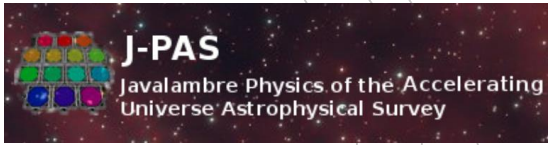
# Testing gravity with galaxy surveys

- Galaxy surveys
  - Measuring the equation of state of dark energy
  - Testing ΛCDM and GR
  - Tomographic surveys (J-PAS and Euclid)
  - Forecasts for modified gravity
- Weak lensing surveys

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# People

| 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<br>Mercedes Martín Benito<br>Prado Martín Moruno<br>Carmelo Pérez Martín | Mindaugas Karciauskas<br>Juan J. Sanz Cillero<br>José A. Ruiz Cembranos<br>Clara Álvarez Luna | S. Roca Fàbrega<br>J.A.R. Cembranos<br>A. Dobado<br>A. L. Maroto<br>M. Aparicio<br>J.M. Sánchez<br>H. Villarrubia | J.A.R. Cembranos<br>A.Dobado<br>F. Llanes<br>P. Martín Moruno<br>A. L. Maroto<br>M. Aparicio<br>E. Lope<br>J.M. Sánchez<br>H. Villarrubia |