High Energy Physics & Cosmology at Nordita

HEP/Cosmo group

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Konstantin Zarembo | Paolo di Vecchia | Watse Sybesma | Evita Verheijden | Ronnie Rodgers | Victor Mishnyakov

Florian Niedermann | Oksana Iarygina | Aleksandr Chatrchyan | Judit Prat Martí

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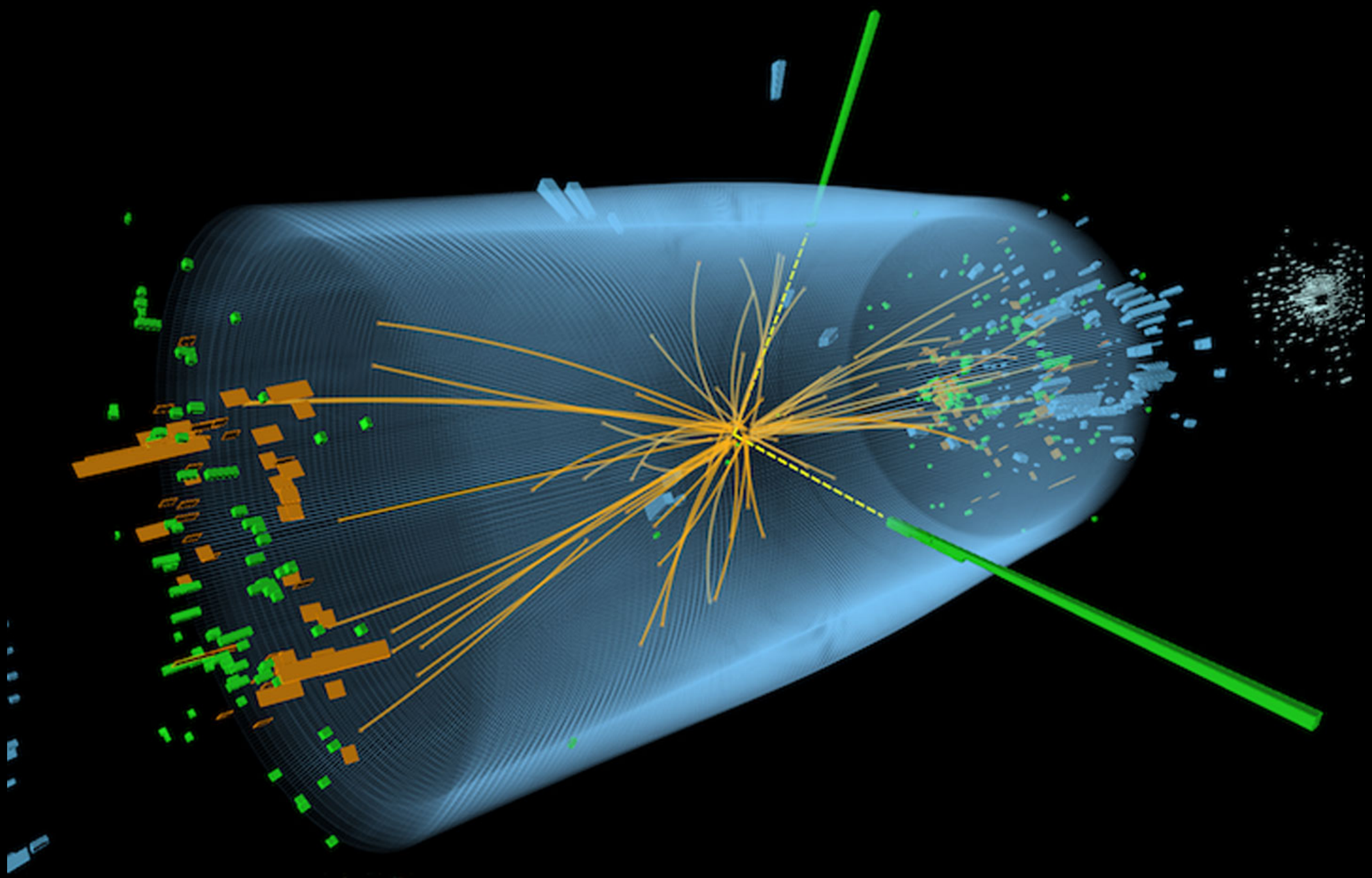
High Energy Physics



[Image: CMS/CERN]

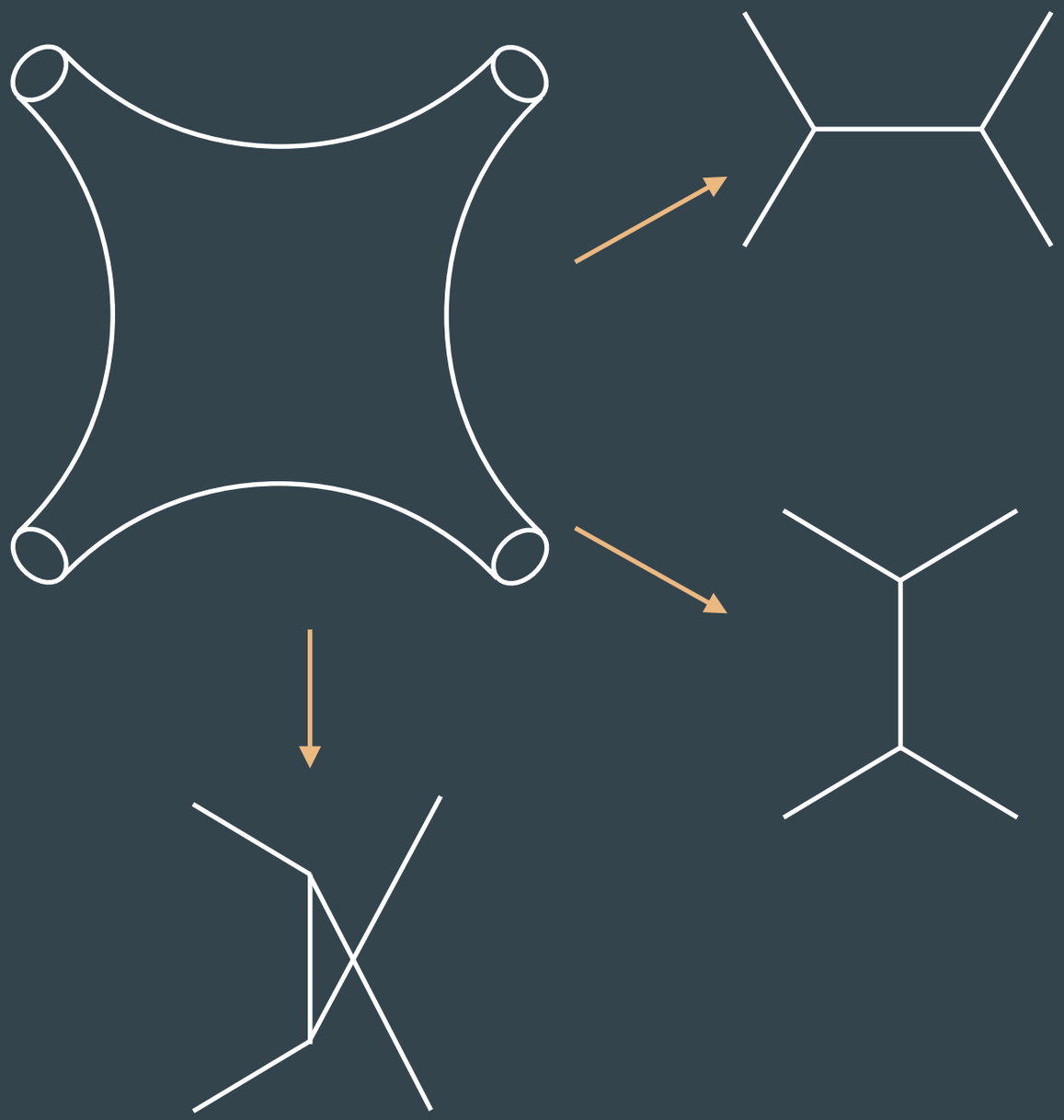
Scattering amplitudes

Paolo di Vecchia

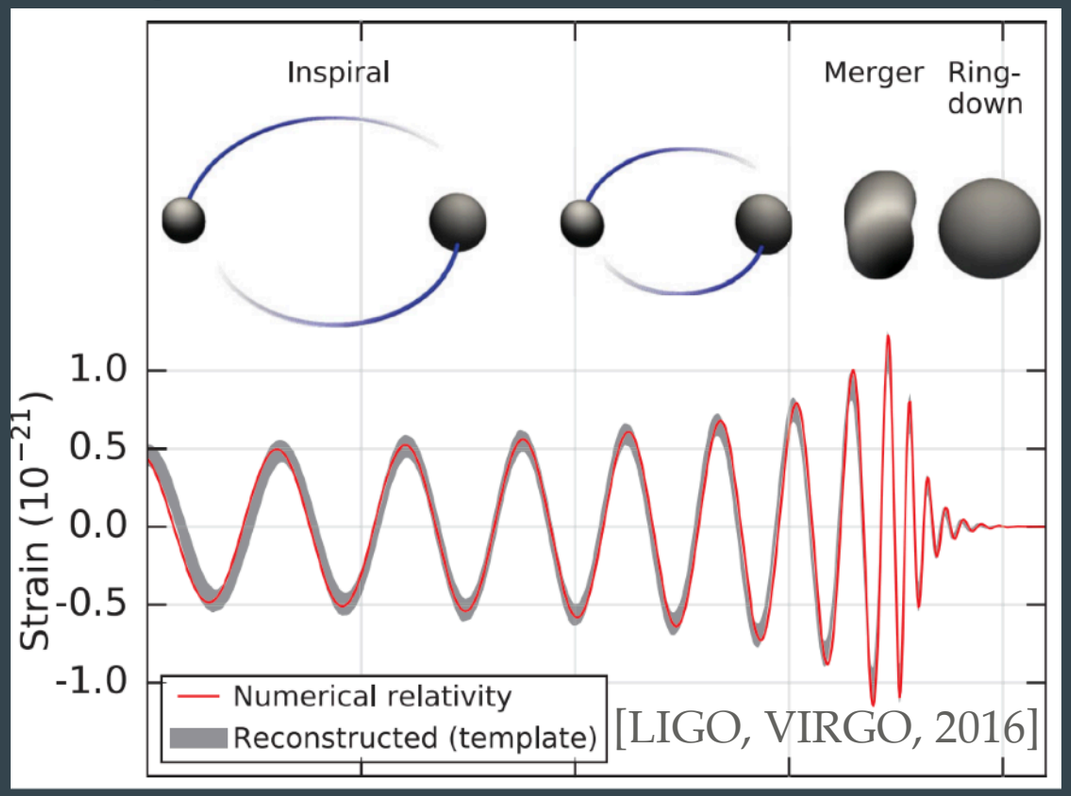
+ Uppsala

Henrik Johansson | Ingrid Vazquez-Holm | Michele Santagata

From string theory:



For gravitational waves:

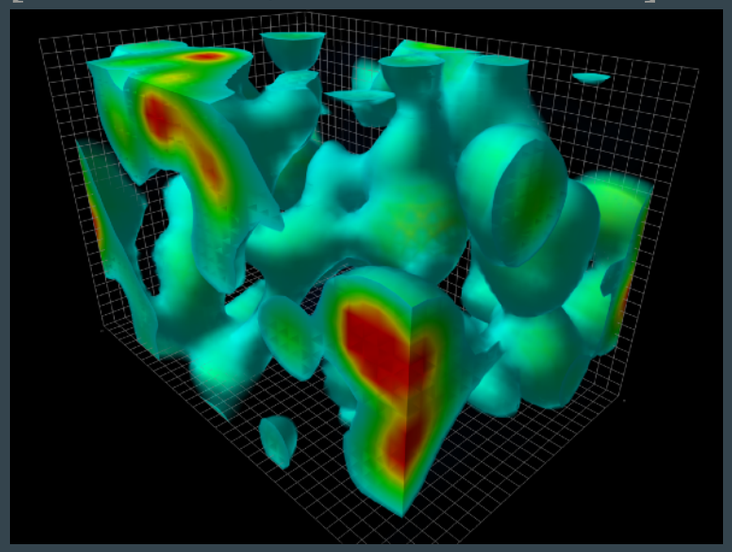


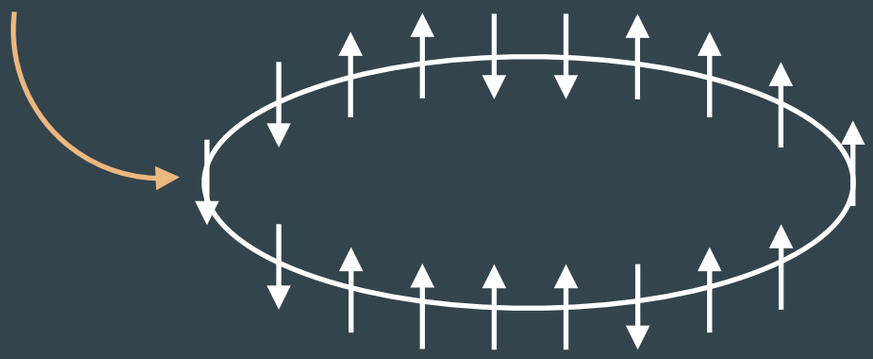
[LIGO, VIRGO, 2016]

QFT beyond perturbation theory

Integrability

[Leinweber/CSSM Adelaide]





Holography (AdS/CFT)

[Escher]

Konstantin Zarembo

Ronnie Rodgers

Konstantin Zarembo

1. **Matrix models and Quantum Field Theory**

   Explore non-perturbative Quantum Field theory and holographic duality using matrix models that arise from localization of the path integral.

2. **Quantum Field Theory, AdS/CFT correspondence and integrable spin chains**

   Use integrability methods to study AdS/CFT duality and string theory.

3. **False vacuum decay**

   Study false vacuum decay in one-dimensional models, e.g. transverse-field Ising model.

Ronnie Rodgers

1. **Holographic entanglement entropy for defects**

   Developing and applying methods for computing entanglement entropy for quantum field theories with defects, using holography.

Nordita master's project list:

Quantum horizons

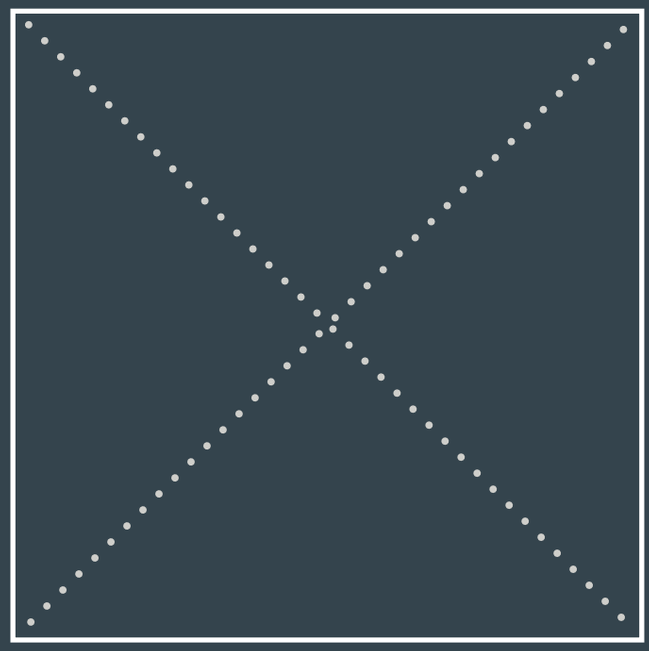
Evita Verheijden

Watse Sybesma

Of black holes:

[Event Horizon Telescope]

In de Sitter:



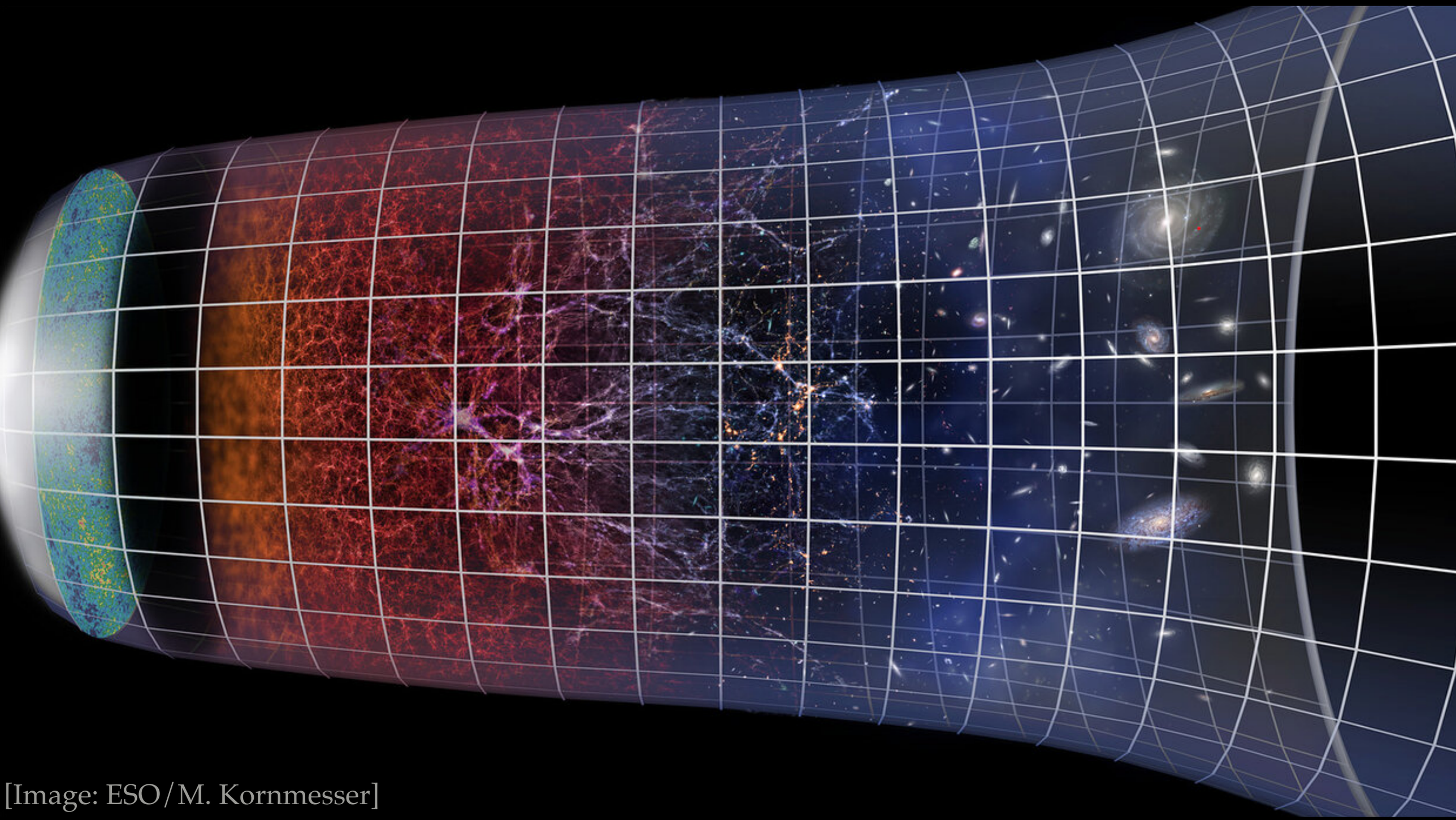
Quantum information

Hawking radiation

Two-dimensional gravity

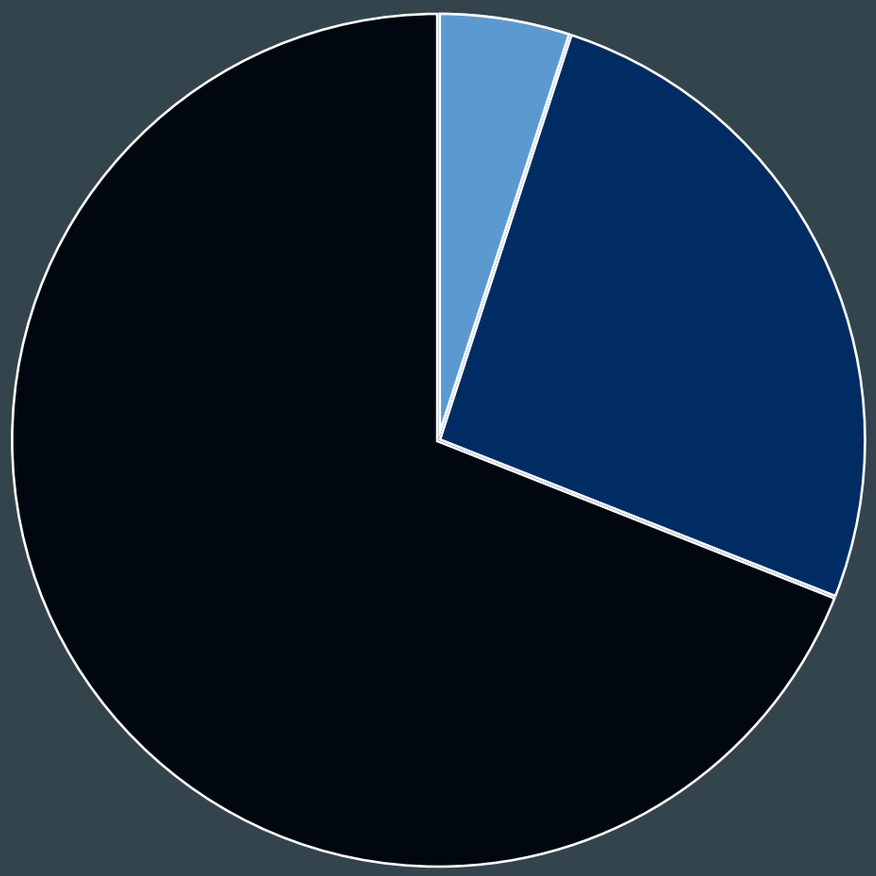
Holography

Cosmology



[Image: ESO/M. Kornmesser]

Dark energy



Cosmological constant?

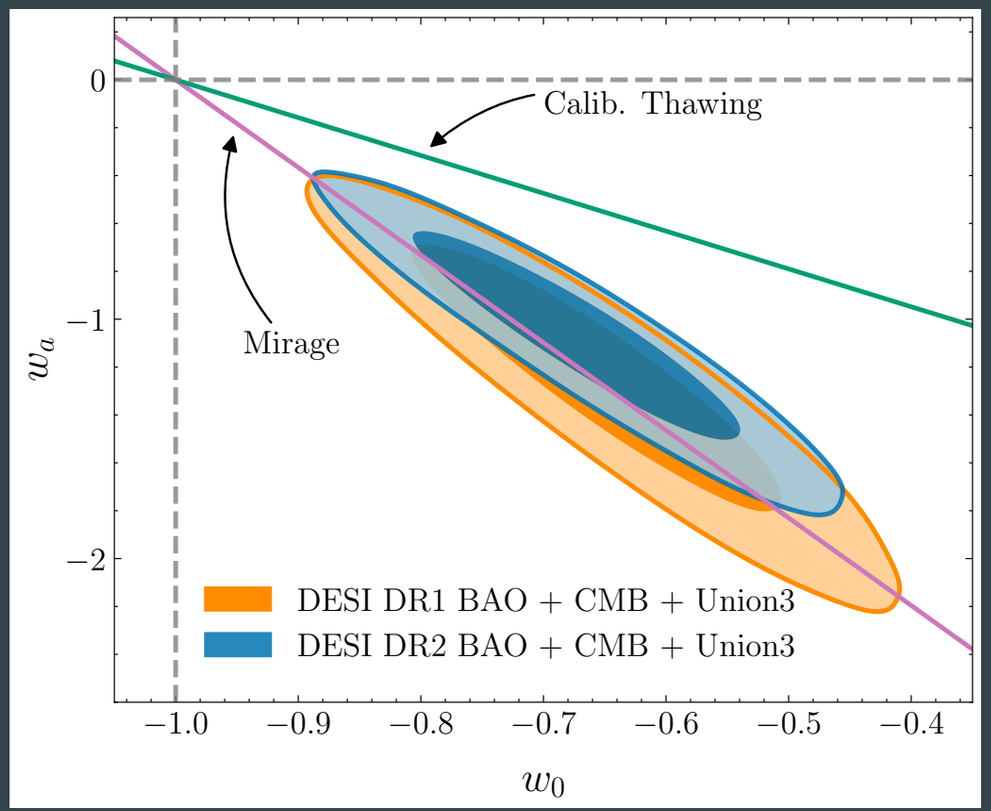
$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R + \Lambda g_{\mu\nu} = 8\pi G T_{\mu\nu}$$

$$\approx 4 \times 10^{-123} \ell_P^{-2}$$

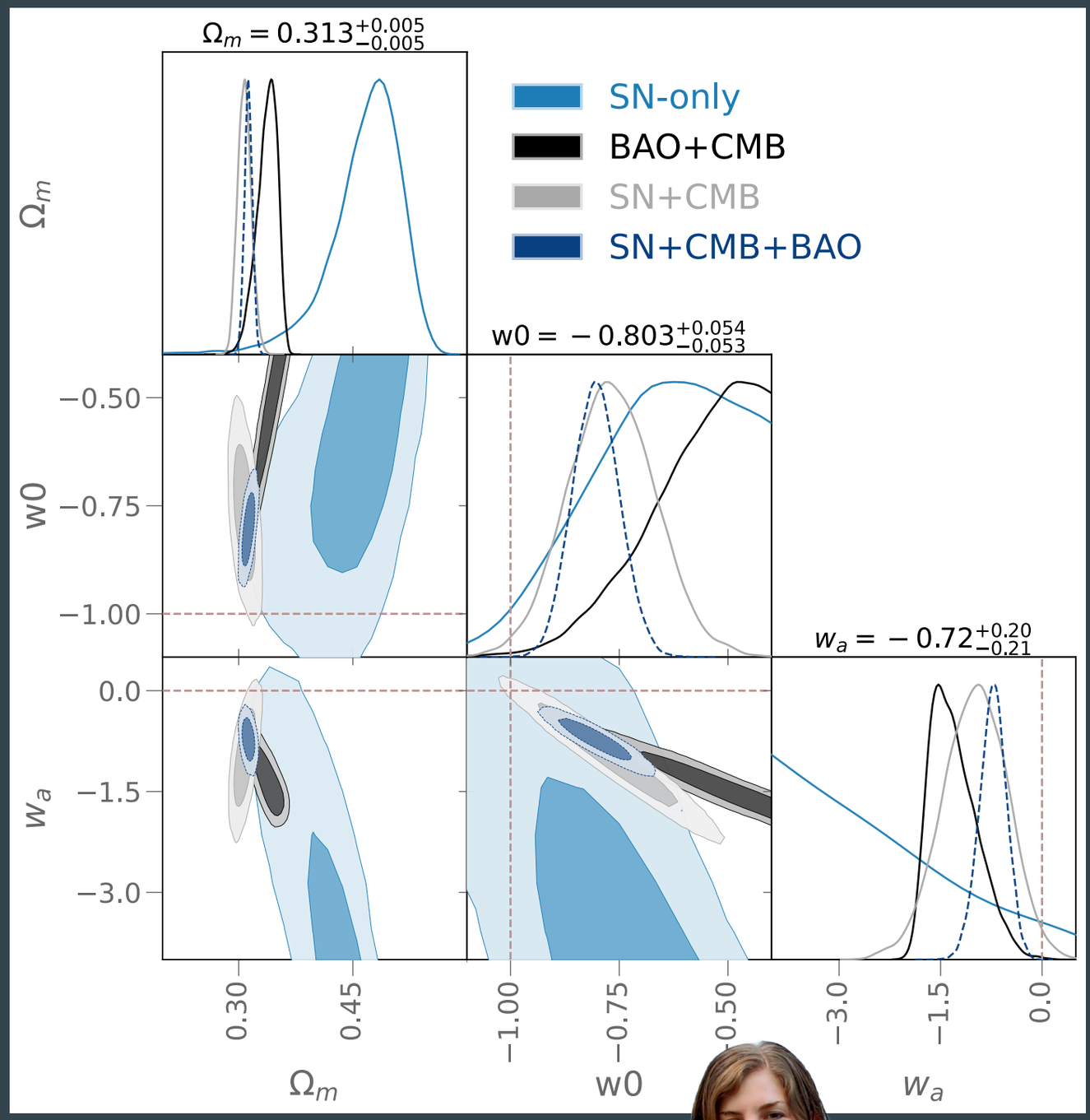
Dark energy

$$p = w\rho$$

$$w = w_0 + w_a(1 - a)$$



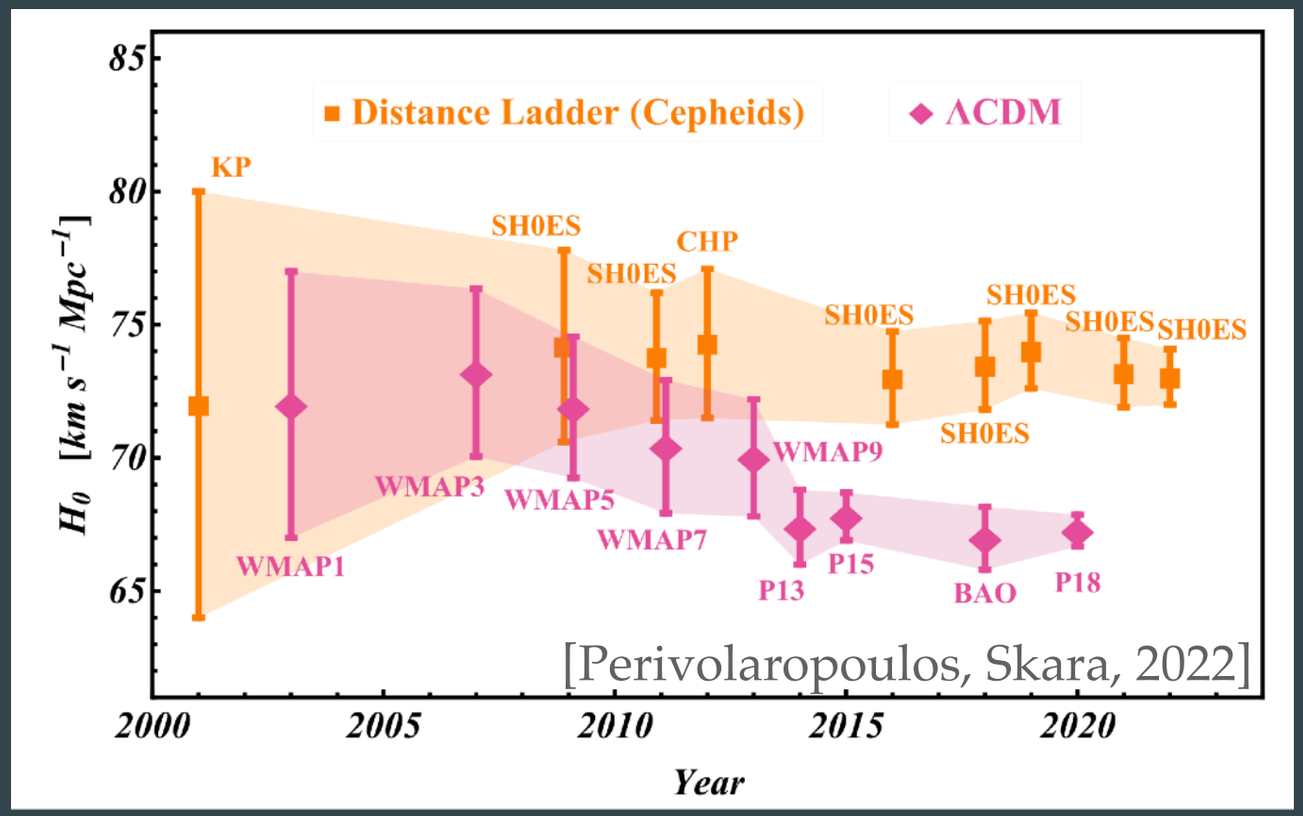
Dark Energy Spectroscopic Instrument
[Lodha et al, 2025]



Dark Energy Survey (DES)
[Popovic et al, 2025]

Judit Prat Martí

DE + Hubble tension



[Perivolaropoulos, Skara, 2022]

[Scientifika]

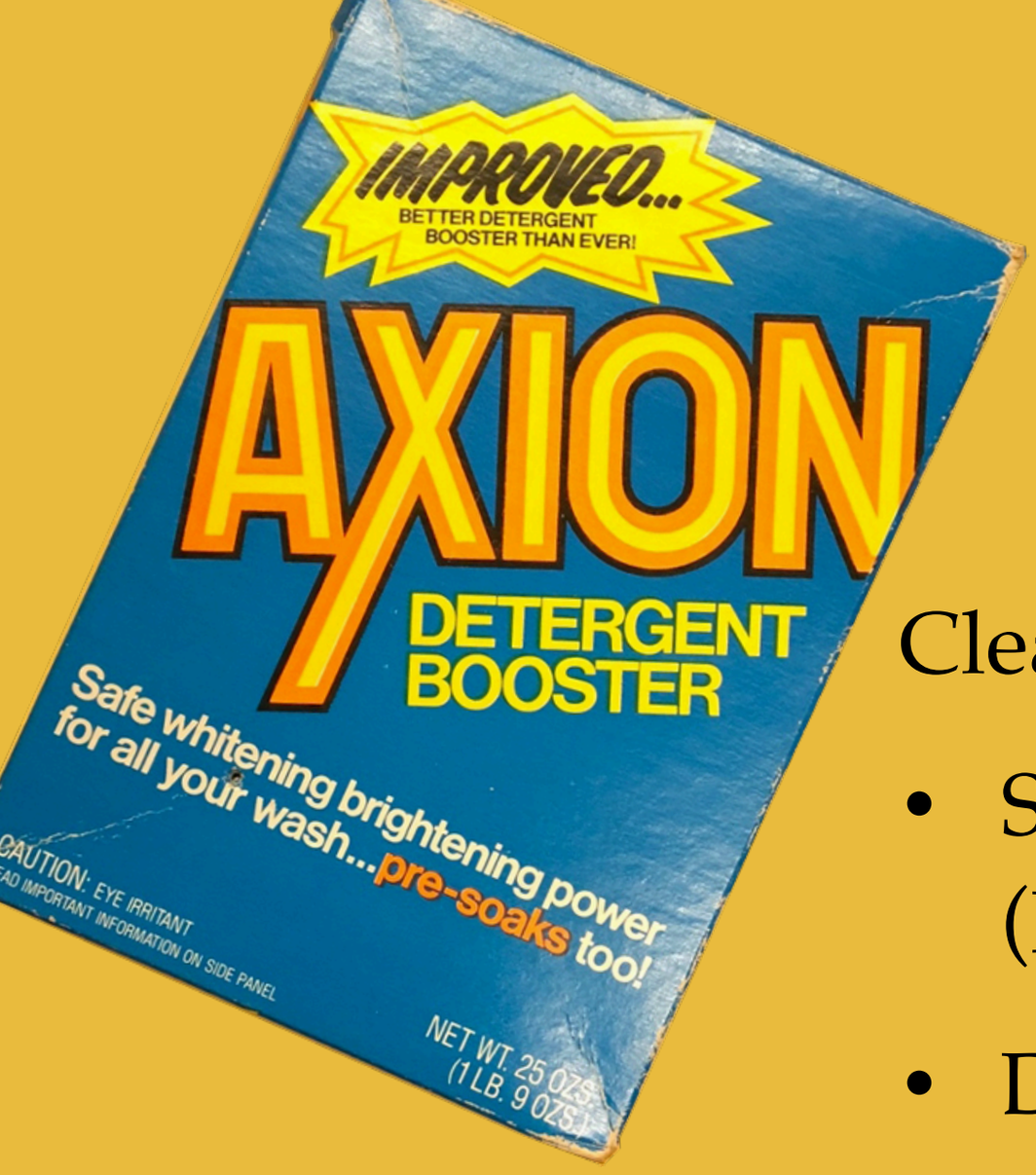
Florian Niedermann

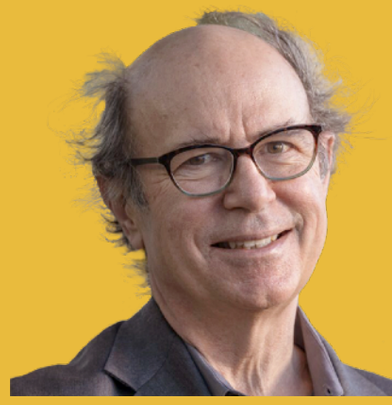
2. **Simulating Novel Cosmologies with an Early Dark Energy Component**

   This is a data analysis and coding project focused on testing a cosmological model describing the triggered decay of an early dark energy component. The first part of the project involves testing and improving a new implementation of the code TriggerCLASS. In the second part, the model will be tested against the latest CMB and LSS datasets. Depending on progress, the third part could explore devising and testing new scenarios.

3. **Dynamical Relaxation of the Cosmological Constant**

   Recently, in **arXiv:2204.1312**, the idea was put forward that the value of the cosmological constant can be dynamically relaxed through numerous membrane nucleation events. This theory project aims to explore in detail how this proposal overcomes the challenges faced by previous mechanisms, such as Abbott?s construction in **InspireHEP:15763**.





Frank Wilczek

Cleans up problems:

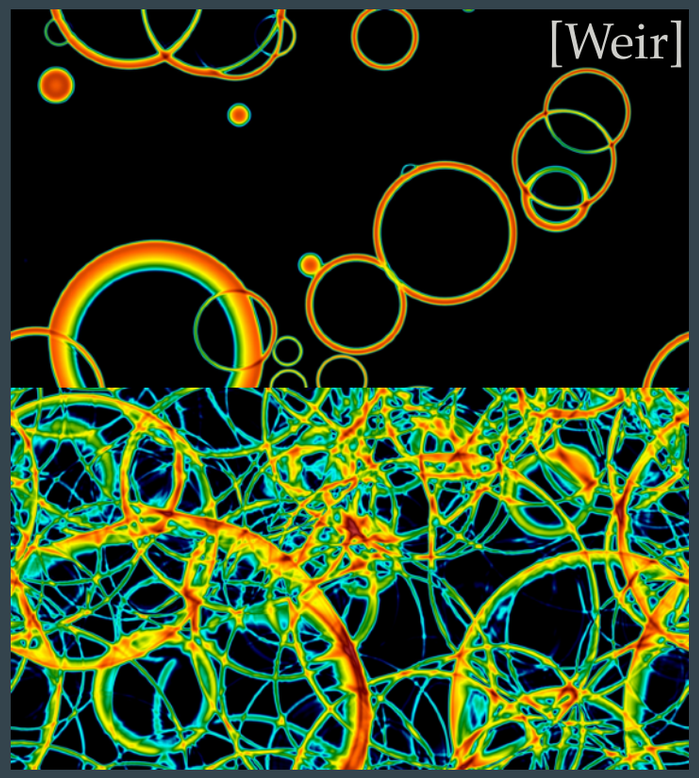
- Strong CP problem
  (Peccei-Quinn mechanism)
- Dark matter
- Inflation

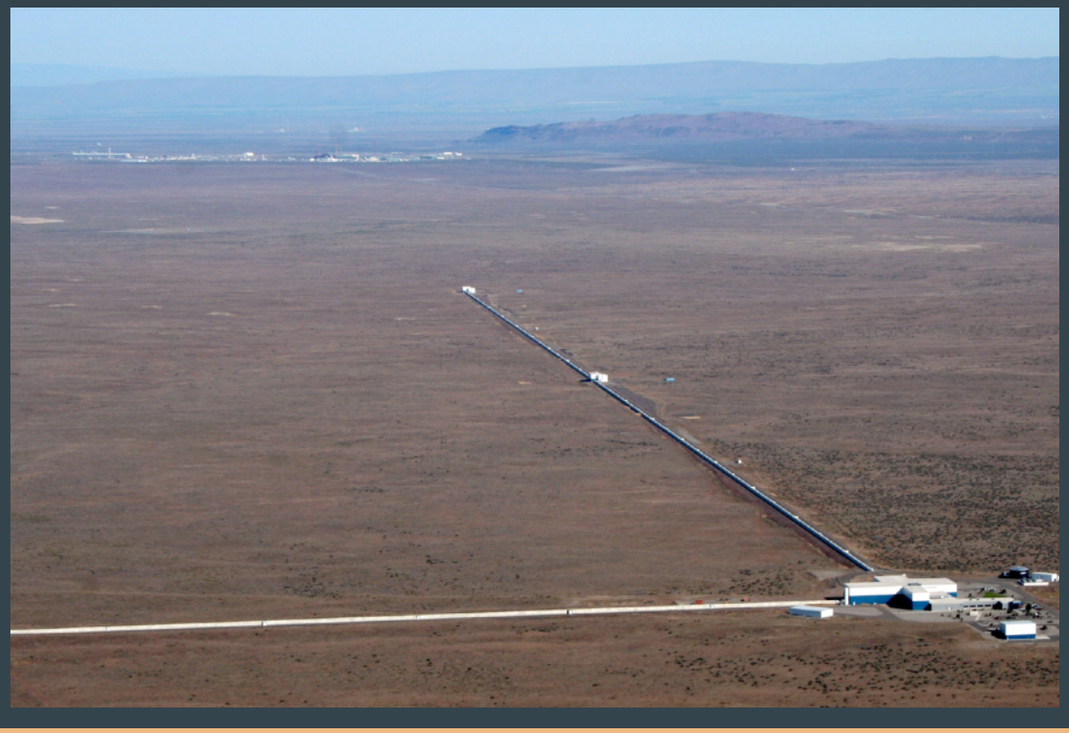
Oksana Iarygina

1. **Axion Inflation**

   This Master's project explores axion inflation, focusing on the amplification of gauge fields during inflation caused by interaction with an axion and the resulting production of gravitational waves.

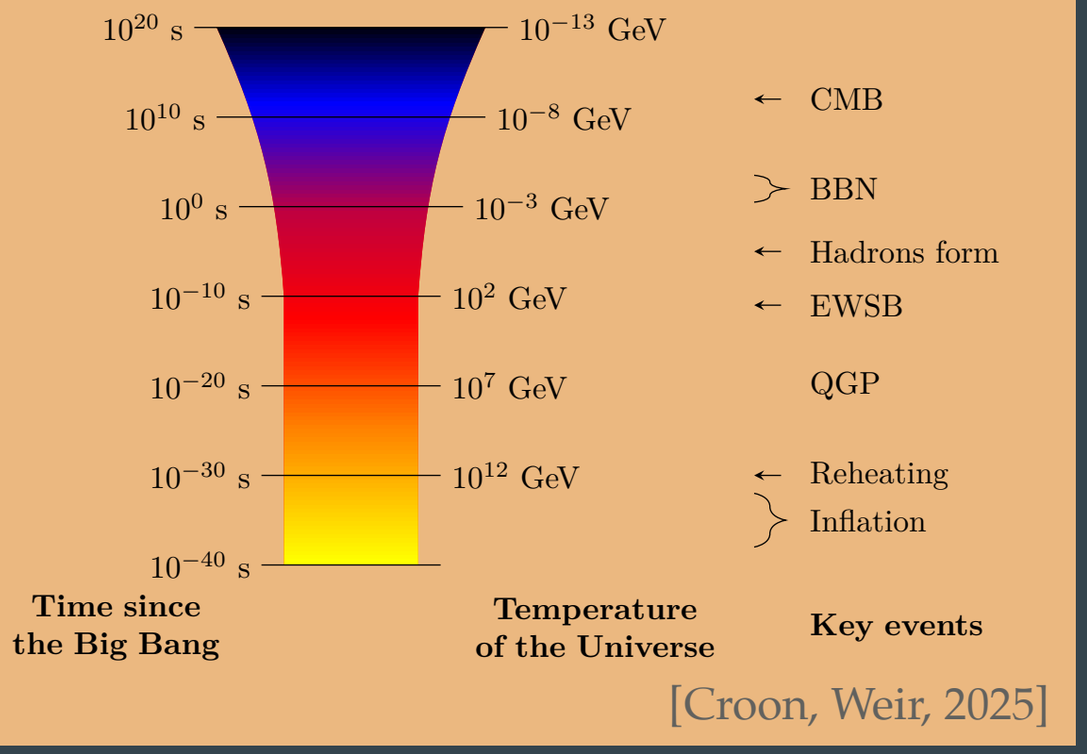
Phase transitions in the early universe





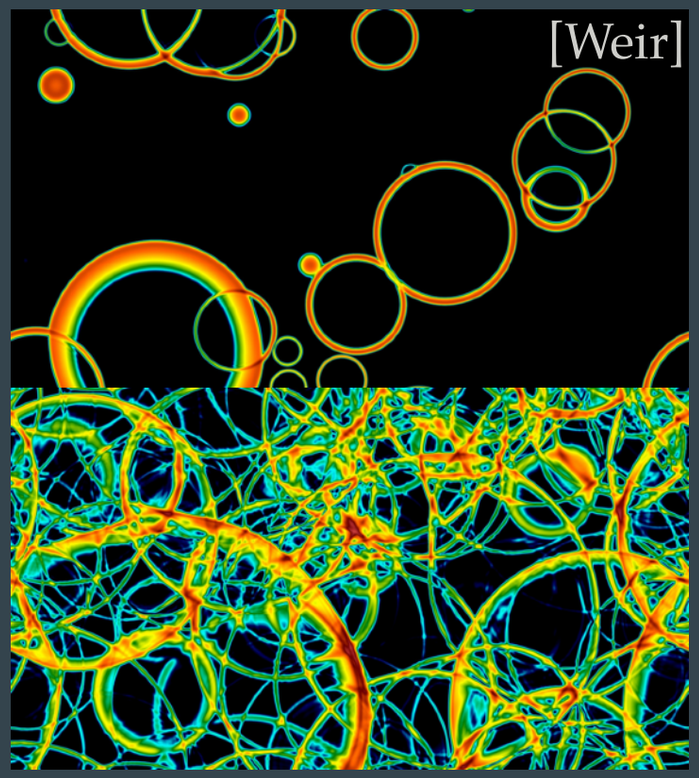
Florian Niedermann

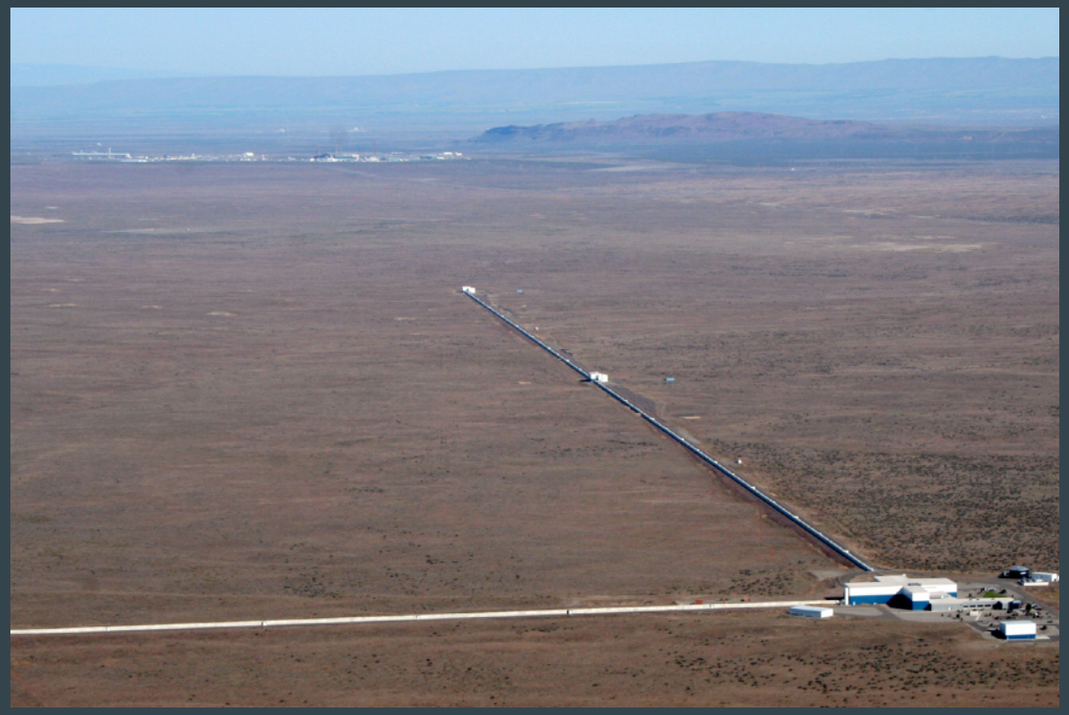
Aleksandr Chatrchyan



[Croon, Weir, 2025]

Phase transitions in the early universe





Florian Niedermann

1. **Probing scalar and tensor modes from a first-order phase transition with the cosmic microwave background**

   In this project, we will investigate the conditions under which scalar and tensor perturbations produced during a first-order phase transition in the dark sector can be probed through the cosmic microwave background and large-scale structure. Depending on the student's interests, the project can be extended in either a more theoretical or phenomenological direction.

How to find out more

- Contact details on Nordita people page
- Research papers: search “inspire <name>”
- Attend events:
  - Scientifika
  - Seminars / group meetings