



Cosmology

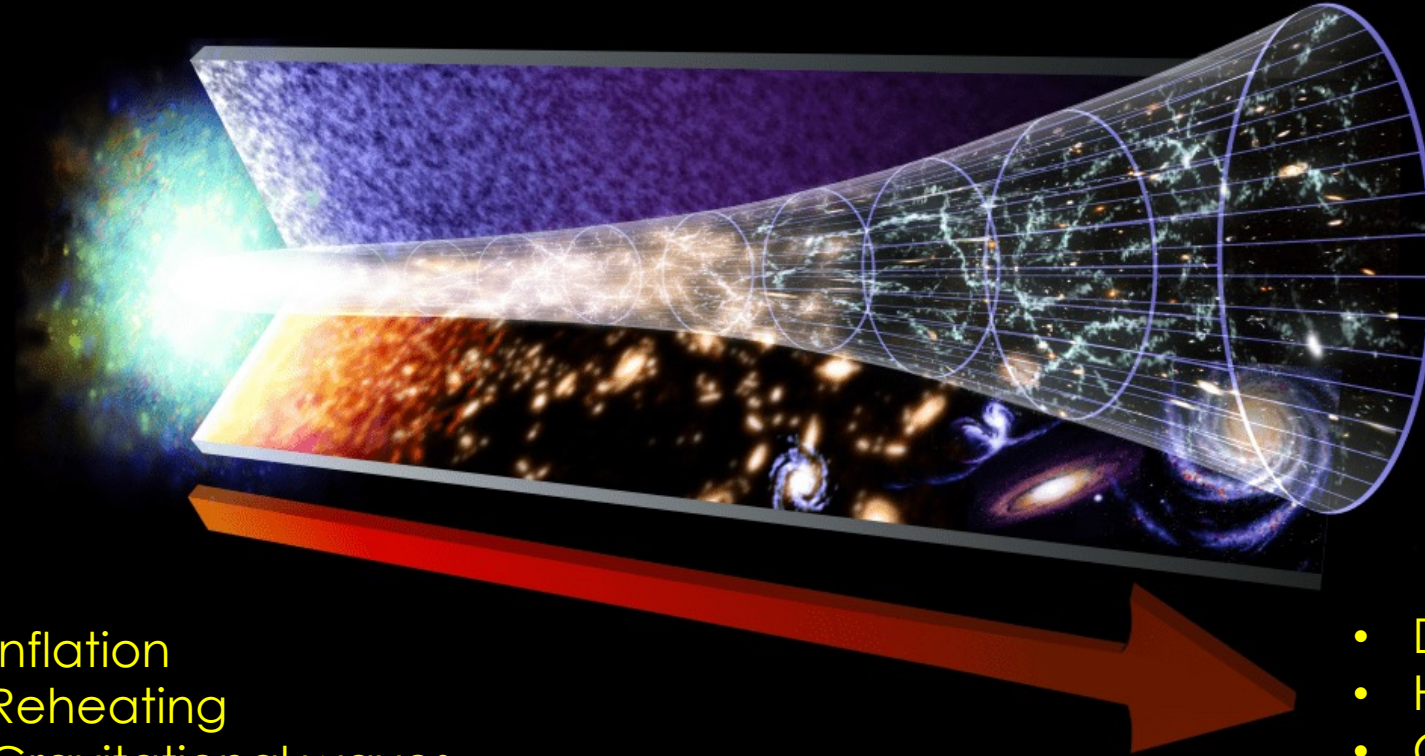
Nordita day of open doors, Nov. 20

Oksana Iarygina

Cosmology at Nordita

Early Universe cosmology

Late Universe cosmology

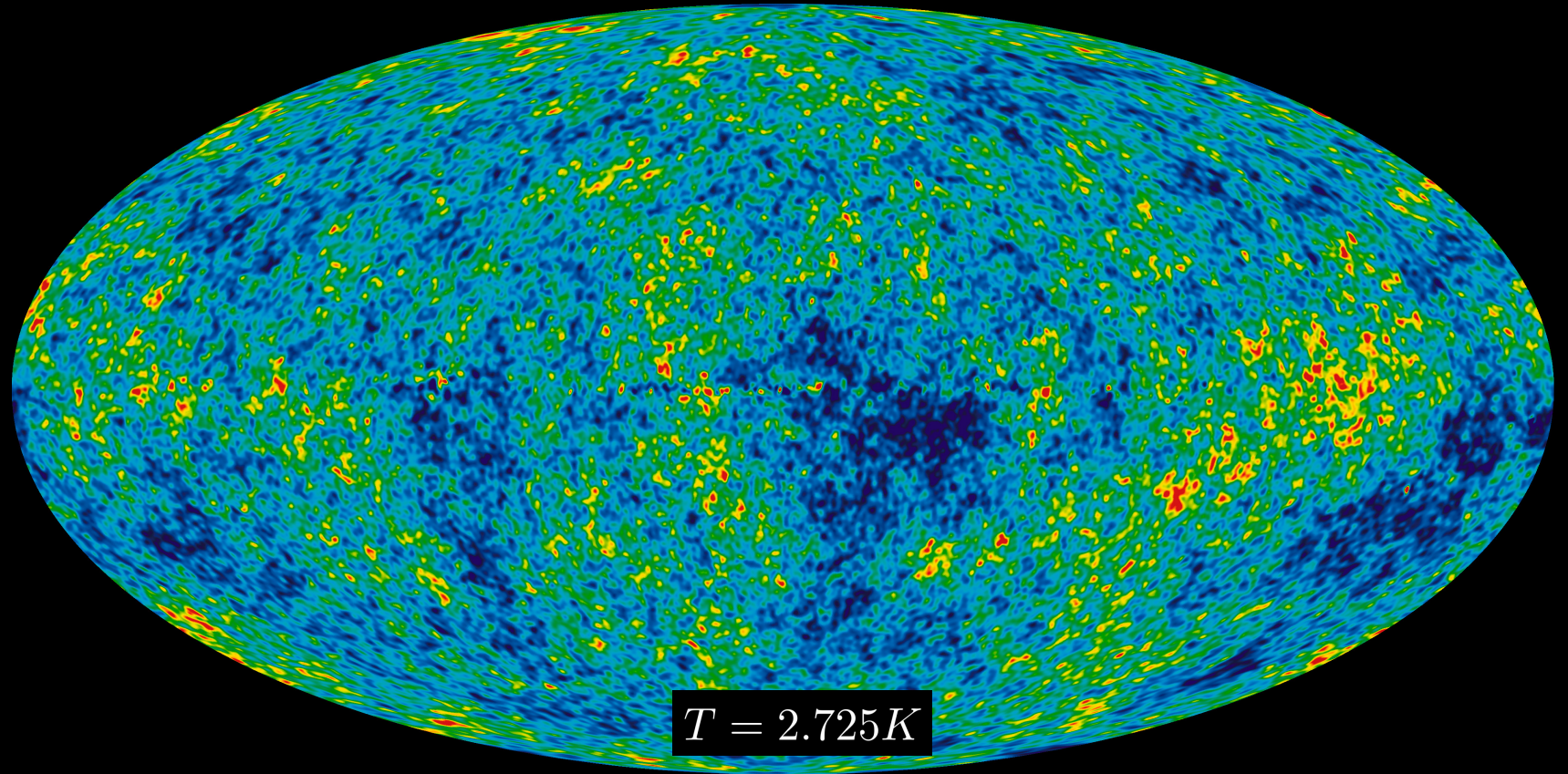


- Inflation
- Reheating
- Gravitational waves
- Magnetogenesis
- Phase Transitions
- Axion Physics
- UV completions

- Dark Matter, Dark Energy
- Hubble tension
- Cosmological constant problem
- Galaxy surveys

Early Universe. Horizon problem.

Causally connected patch of CMB today consists of $4 \cdot 10^4$ causally disconnected patches at the time when CMB photons were created.

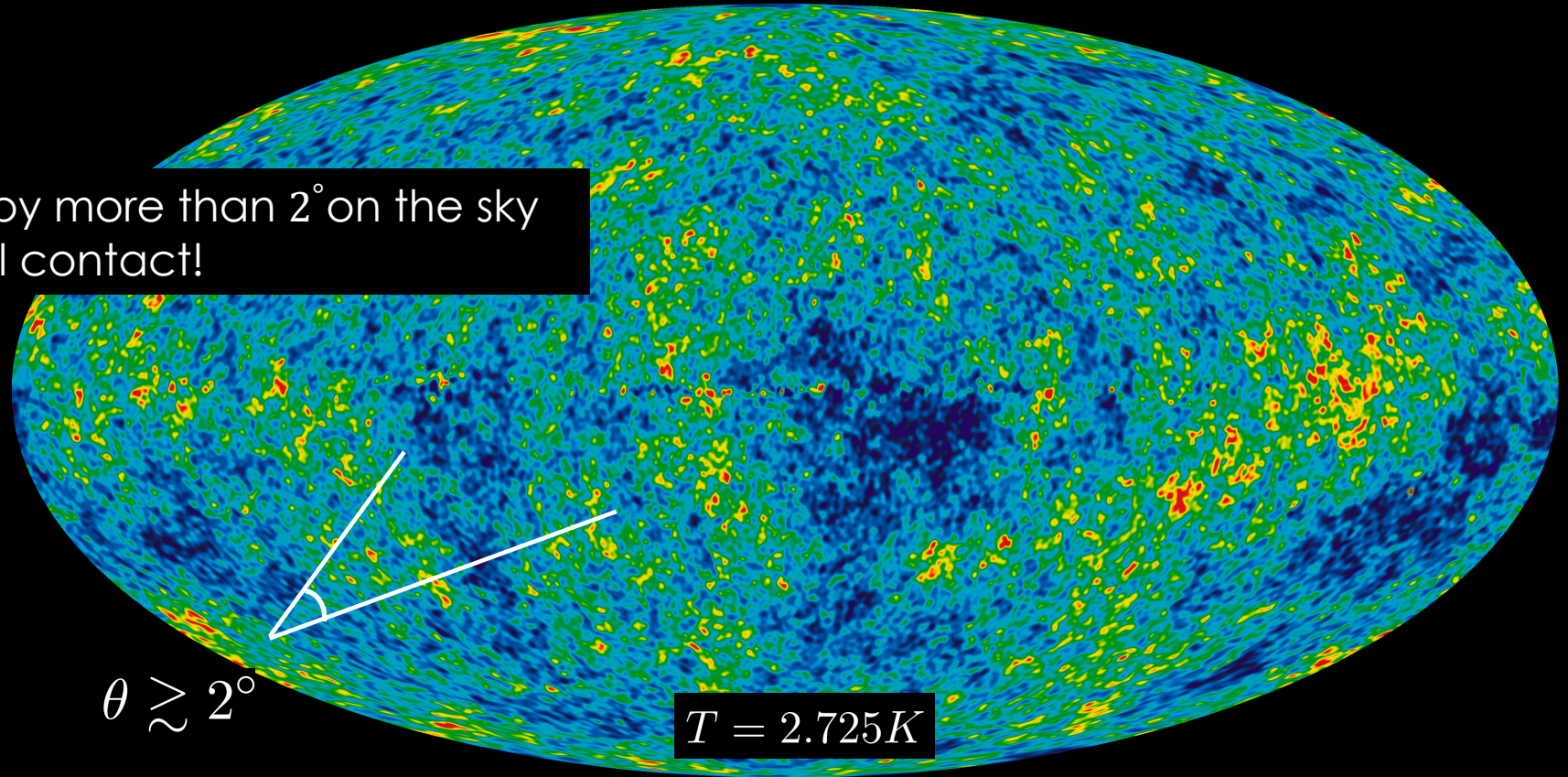


$$\frac{\Delta T}{T} \sim 10^{-5}$$

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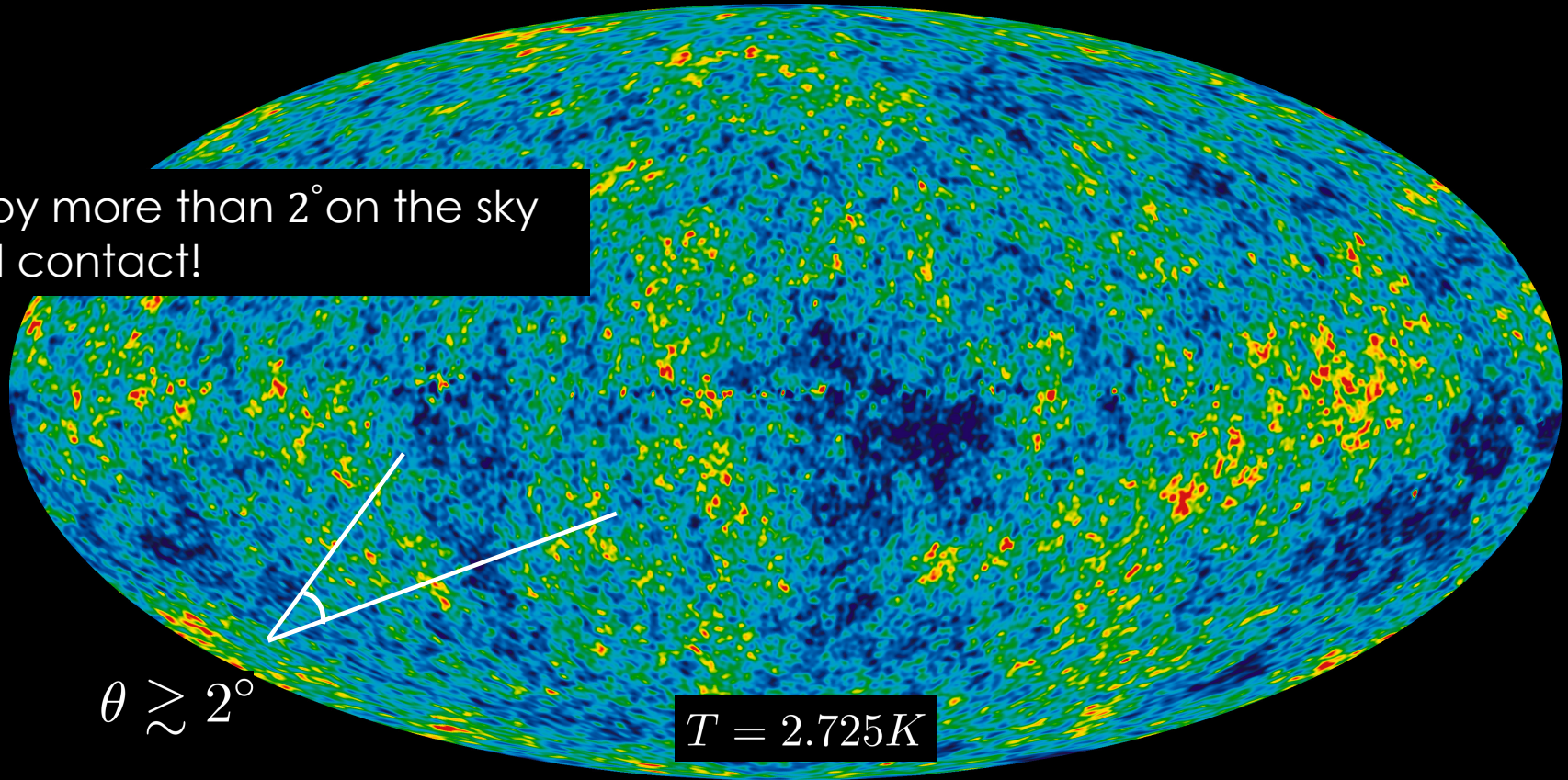
Points that are separated by more than 2° on the sky have never been in casual contact!



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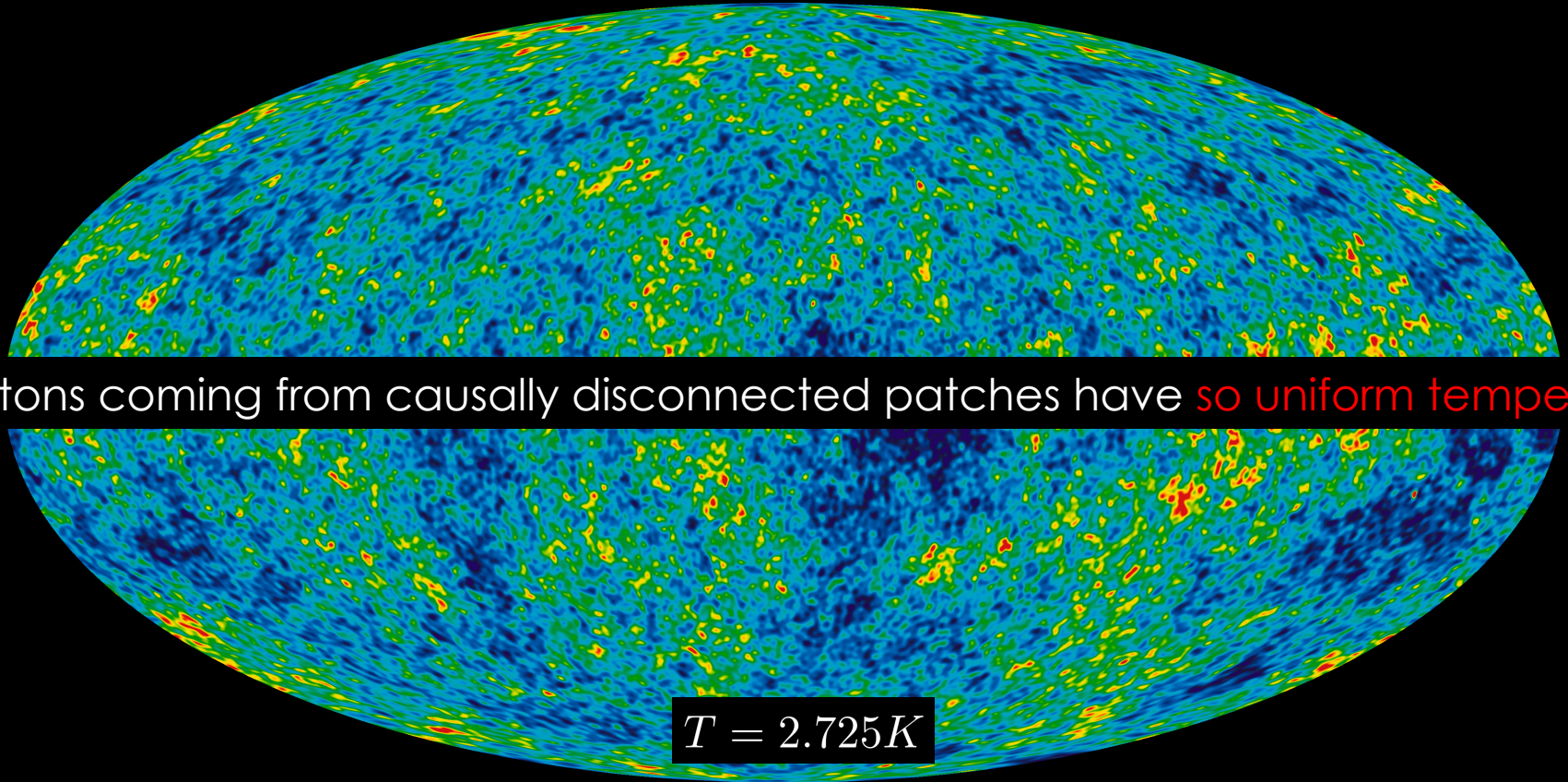
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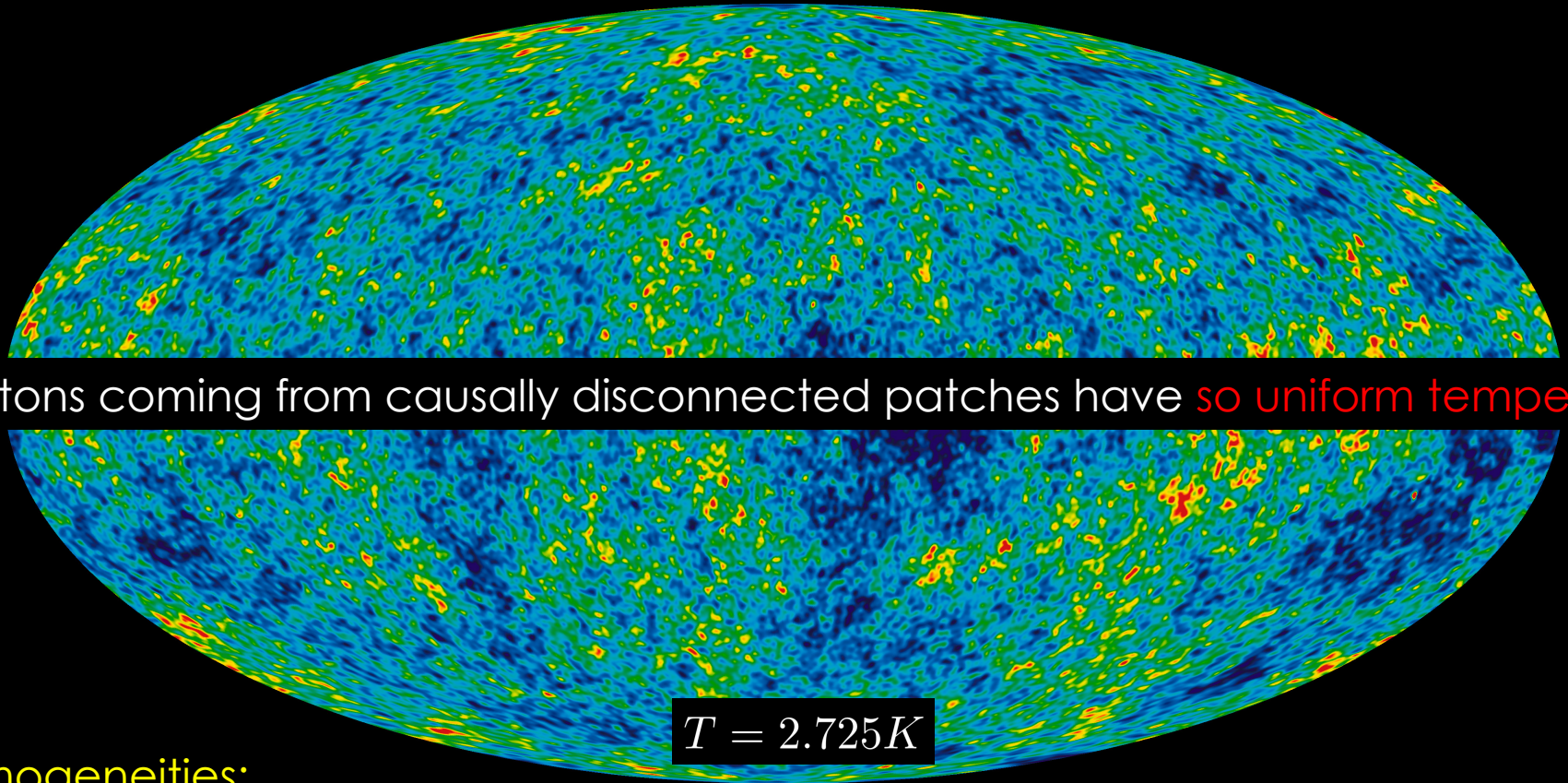
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How is it possible that photons coming from causally disconnected patches have so uniform temperature?



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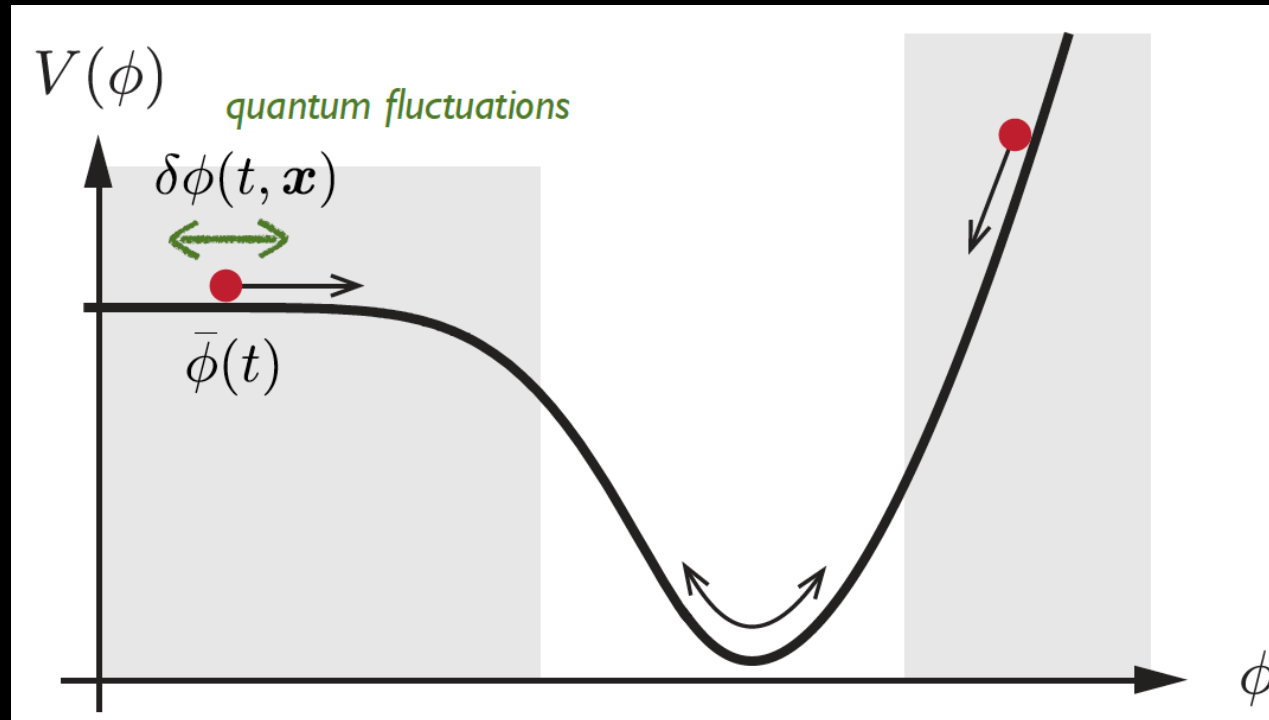
How is it possible that photons coming from causally disconnected patches have so uniform temperature?

- Horizon problem
- Flatness problem
- Problem of initial inhomogeneities:

What provides seeds for all structure we observe?

In the beginning, there was (probably) inflation

Scalar field induces exponential expansion of space.



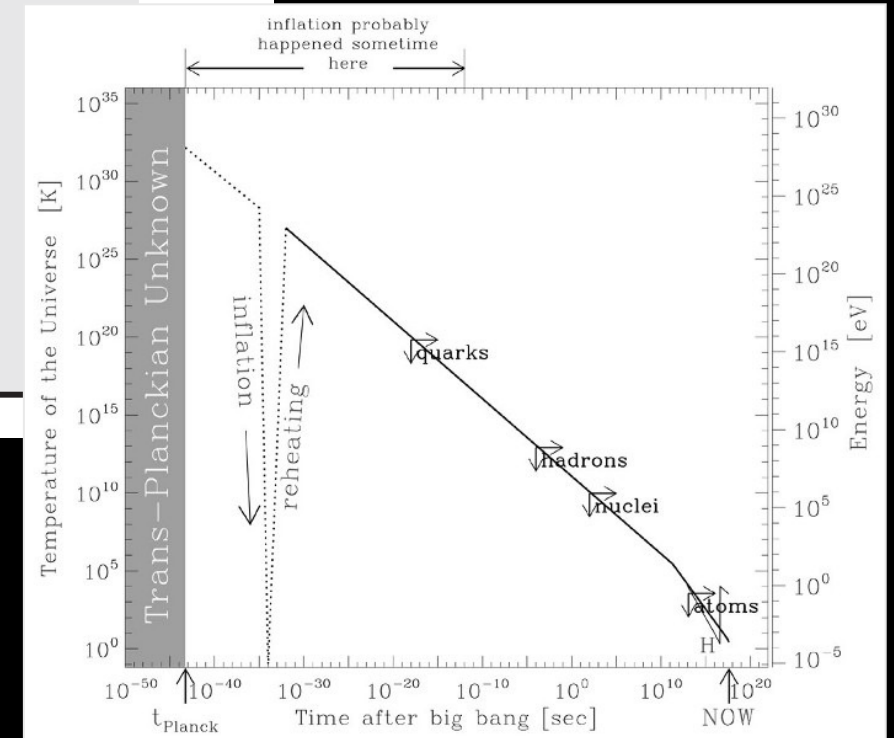
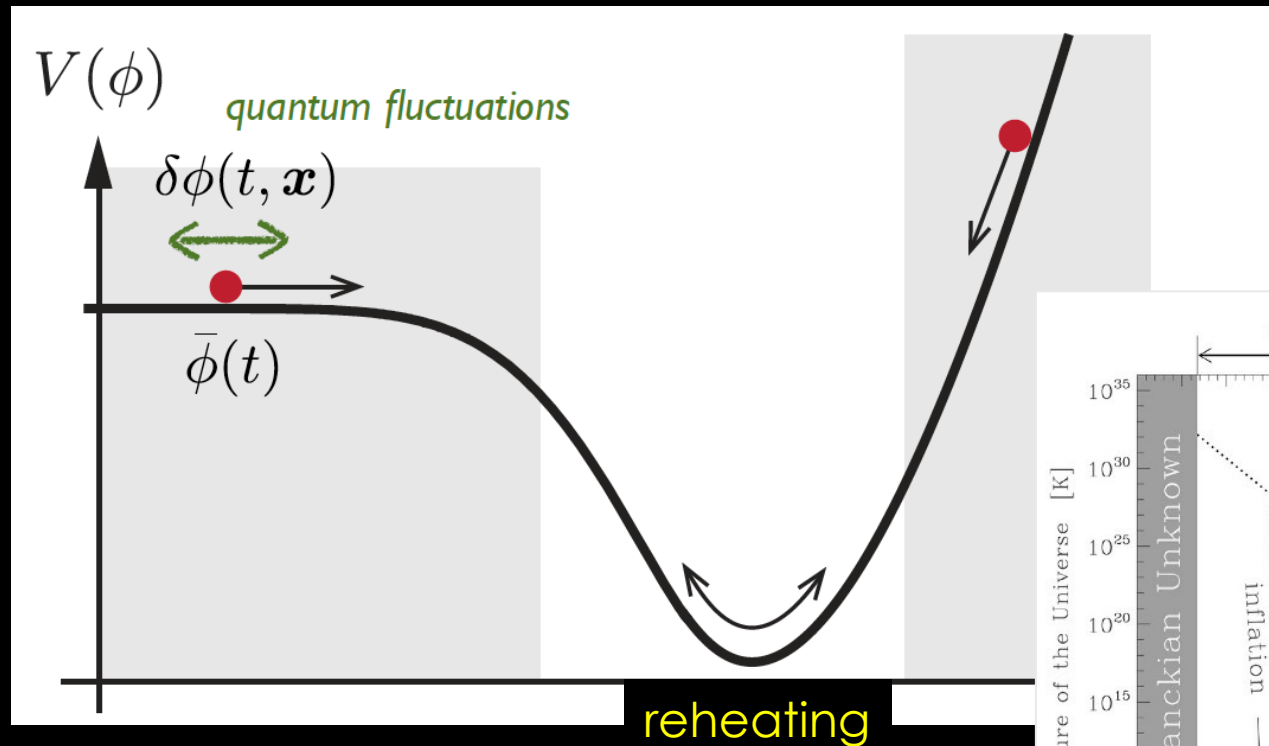
$$\delta\phi(x) \longrightarrow \delta\rho(x) \longrightarrow \delta T(x)$$

Quantum vacuum fluctuations around the inflaton vev

...translate into classical density fluctuations after inflation

...which become the CMB anisotropies.

Reheating: heats the Universe and enables particle production after inflation



Early Universe problems and research directions

inflation

before

Initial conditions

- How did inflation start?
- Inflation is past-geodesically incomplete.
- Is there a horizon problem in Quantum Gravity?

during

after

Early Universe problems and research directions

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Connection to [the HEP group](#), see the talk by [Johannes](#)!

during

after

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during What is the physics of inflation?

- What drives inflation?
- Falsifiability and observational probes
 - Gravitational waves
 - Magnetogenesis
 - Phase transitions
 - Non-Gaussianity
- UV completions
- Multi-field inflation
- Connection to dark energy/dark matter

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HEP group

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Astrphysics group

after



NORDITA

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HEP group

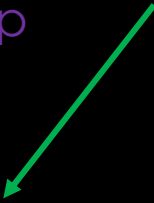
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HEP group

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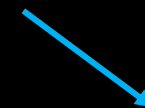


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OKC



after

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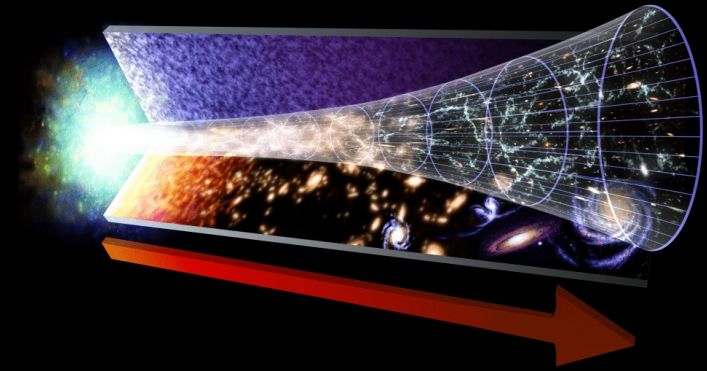
How did inflation end?

- **Observational consequences**



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Late-Universe Cosmology



Florian Niedermann

Assistant Professor



Aleksandr Chatrchyan

PostDoc



Judit Prat

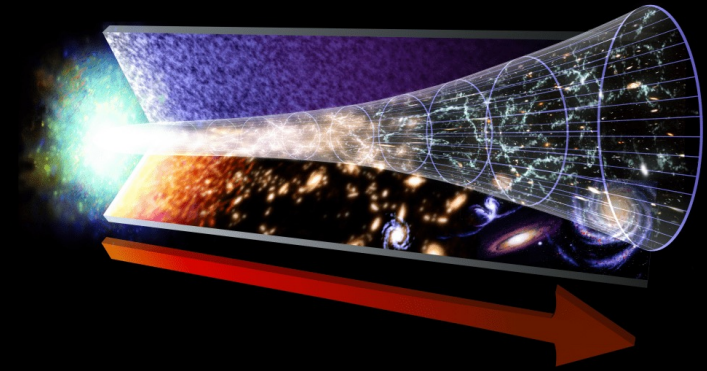
PostDoc, Arrives in January 2024



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Late-Universe Cosmology

- Dark Matter, Dark Energy
- Hubble tension
- Phase Transitions
- Cosmological constant problem
- Axion cosmology
- Galaxy surveys



Florian Niedermann

Assistant Professor



Aleksandr Chatrchyan

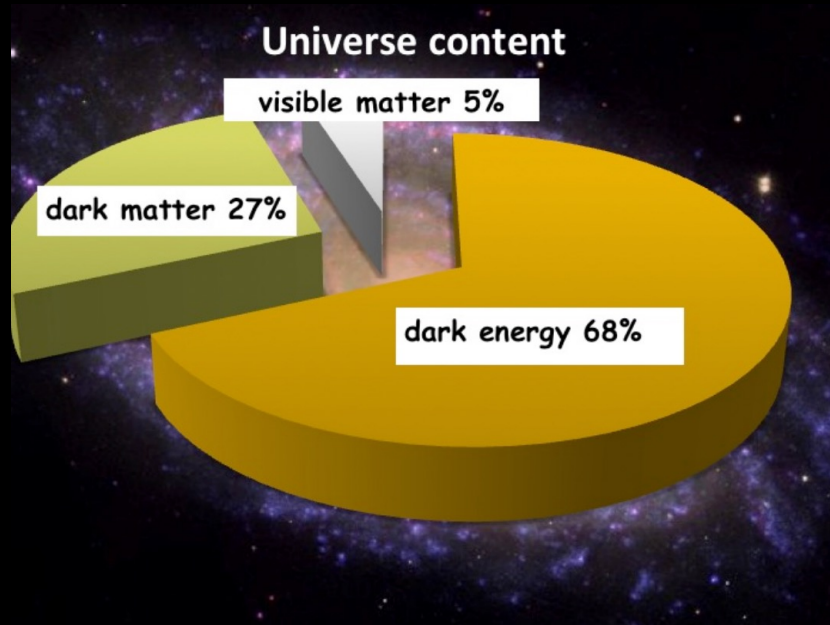
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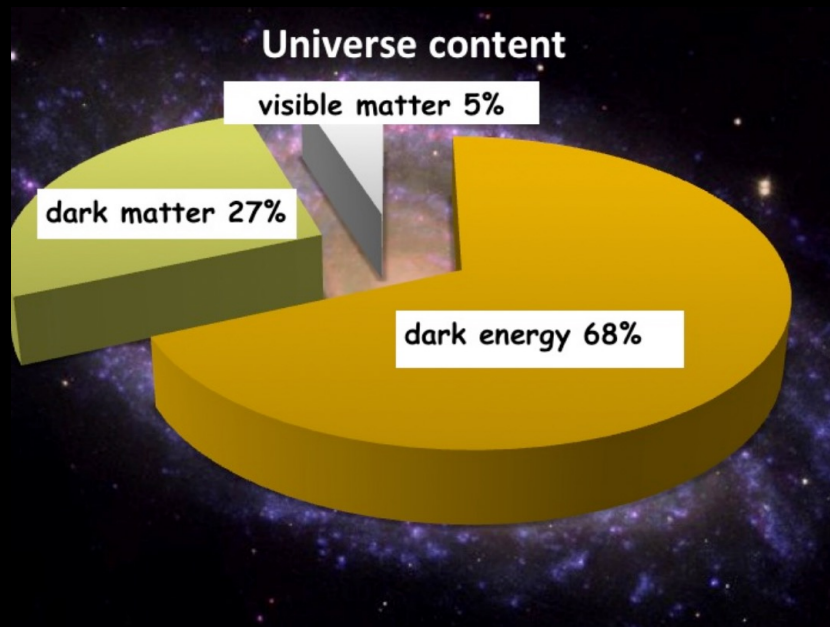
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Dark energy and dark matter



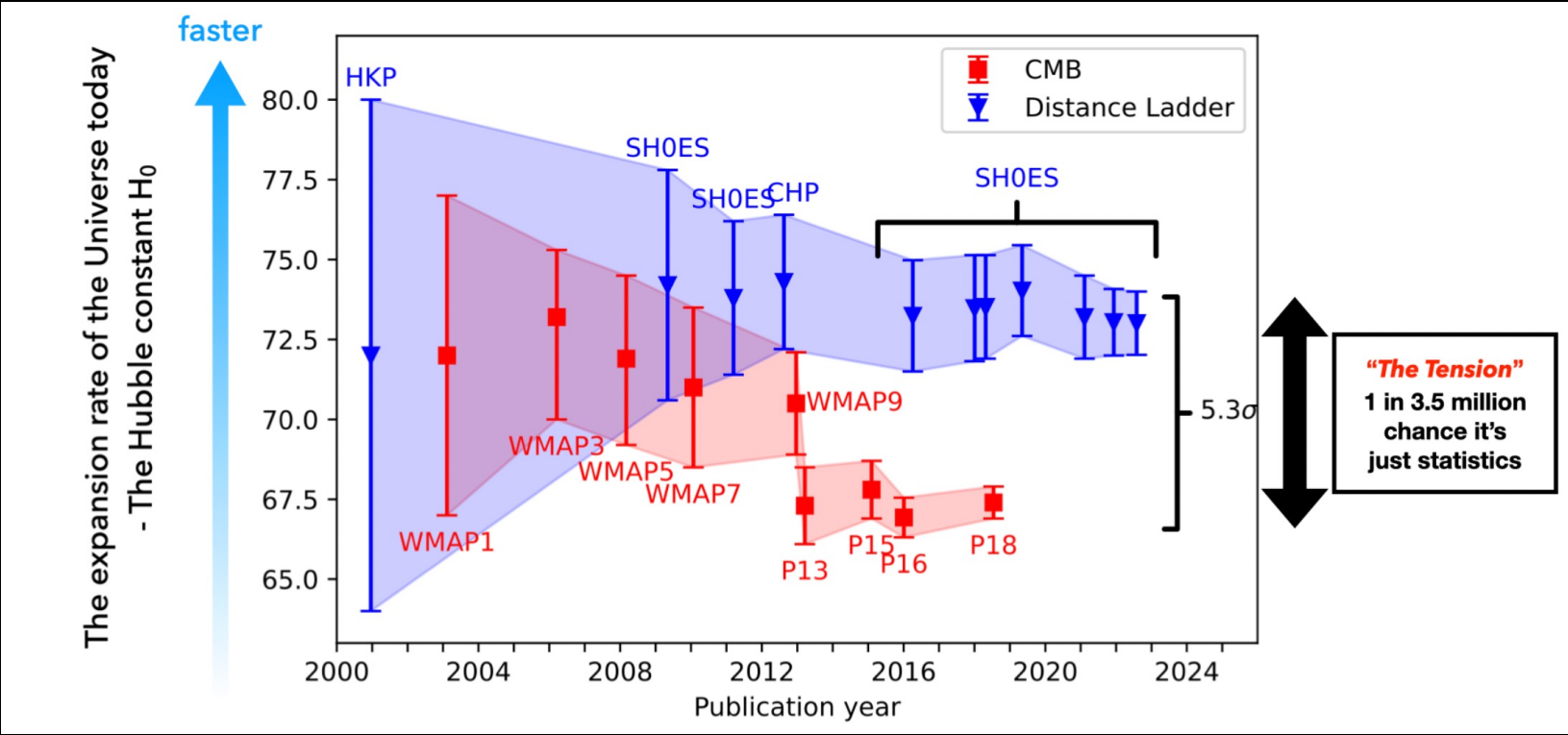
Dark energy and dark matter



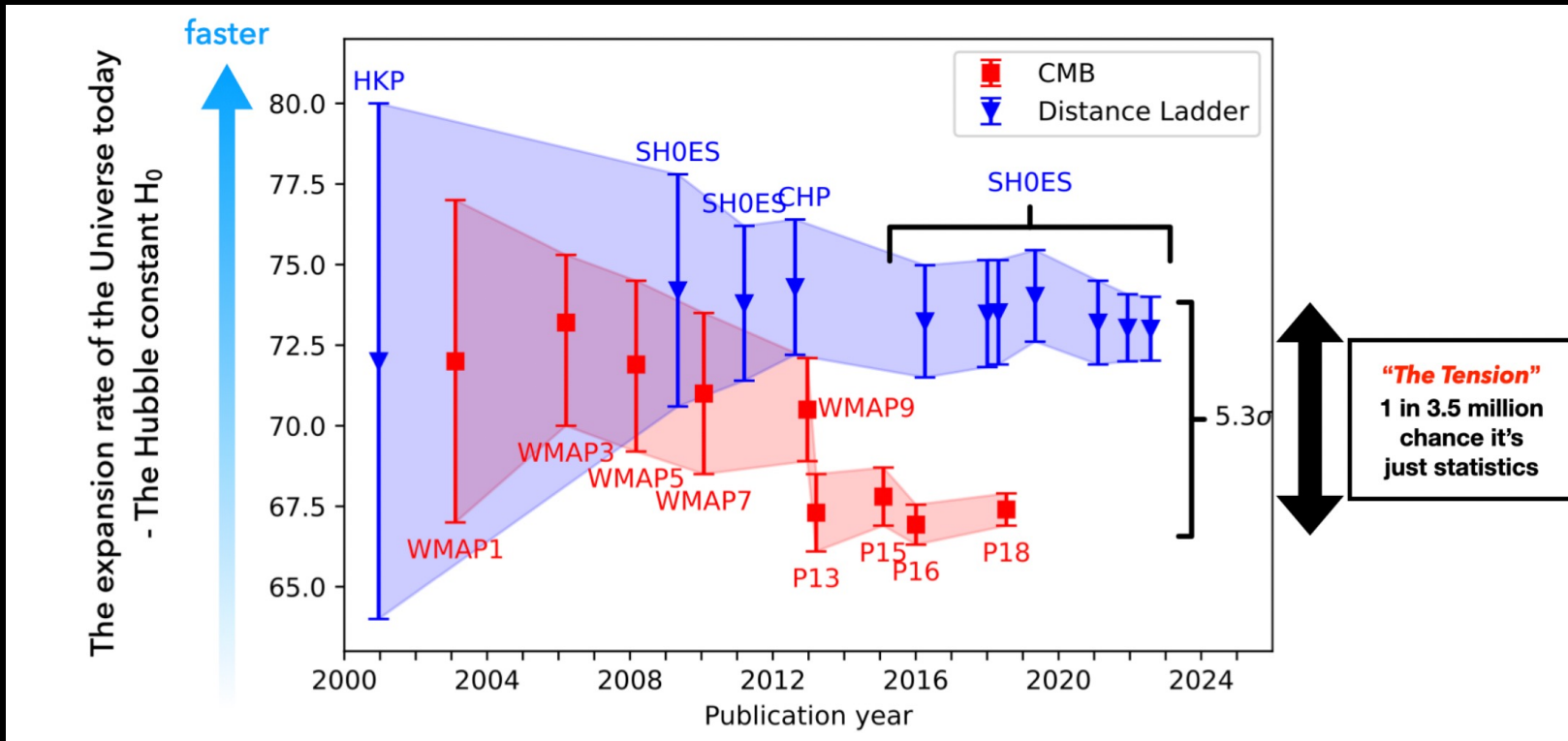
- What is Dark Matter?
- What is Dark Energy?

Cosmological constant problem: Why is dark energy so small compared to other scales in the standard model? Old self-tuning ideas are obstructed.

Hubble tension



Hubble tension

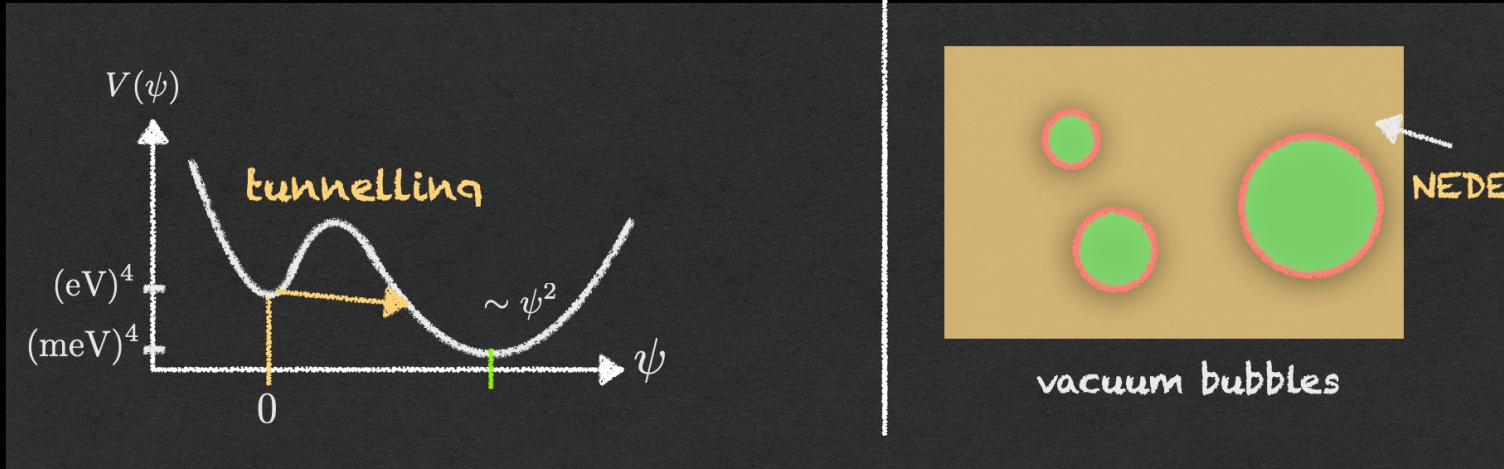


Hubble tension: There might have been a higher energetic phase of dark energy that decayed in a vacuum phase transition.

Dark energy from phase transitions in the Early Universe: Cold New Early Dark Energy



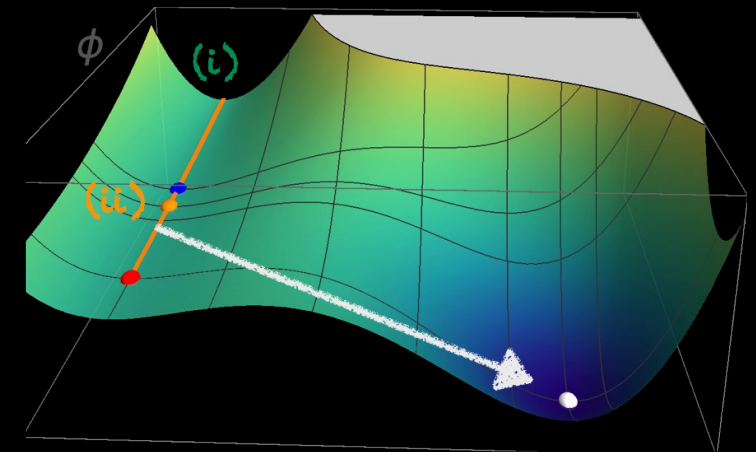
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Before transition: NEDE plays role of CC.
Phase transition lowers the CC
value in the early Universe down.

After transition: NEDE is described by decaying
dark fluid.

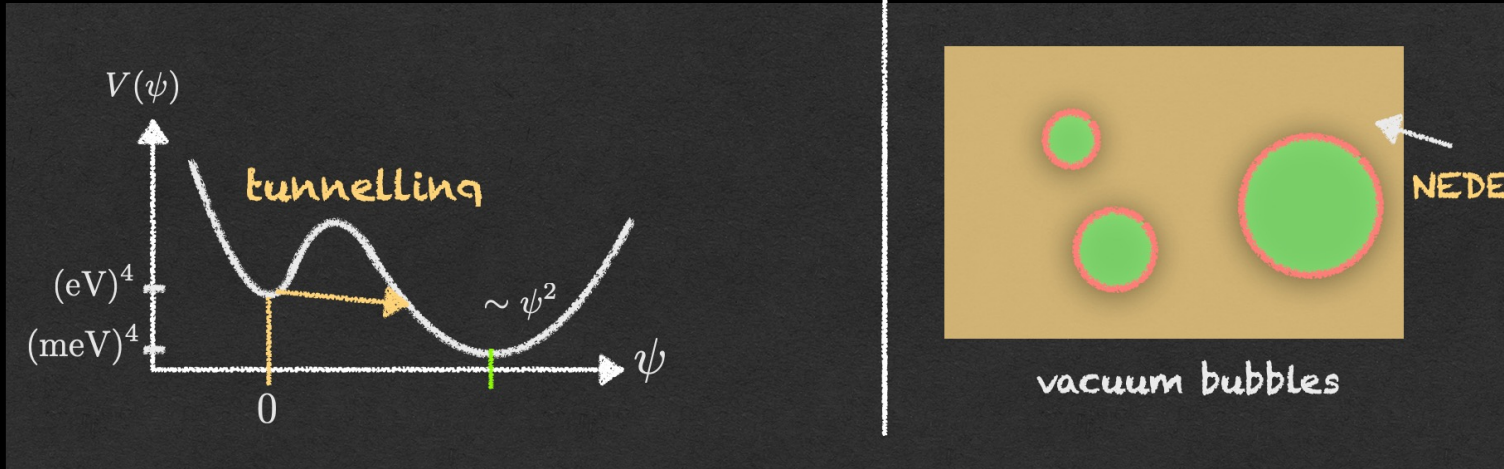
- Field tunnels from false to true vacuum.
- Vacuum energy is converted into kinetic energies of bubble walls.



Dark energy from phase transitions in the Early Universe: Cold New Early Dark Energy



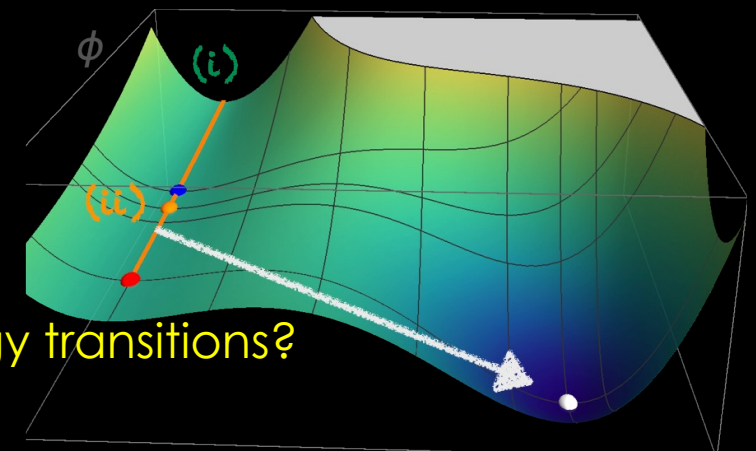
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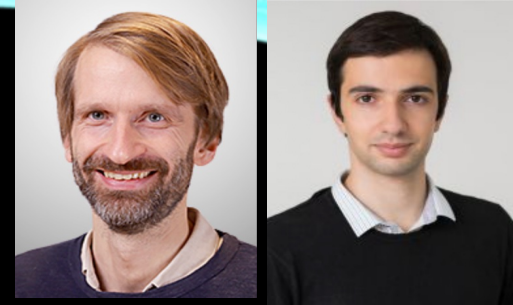
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After transition: NEDE is described by decaying
dark fluid.

- Is the Hubble tension the signature of a new phase of dark energy?
- Is dark energy small because Universe underwent many dark energy transitions?



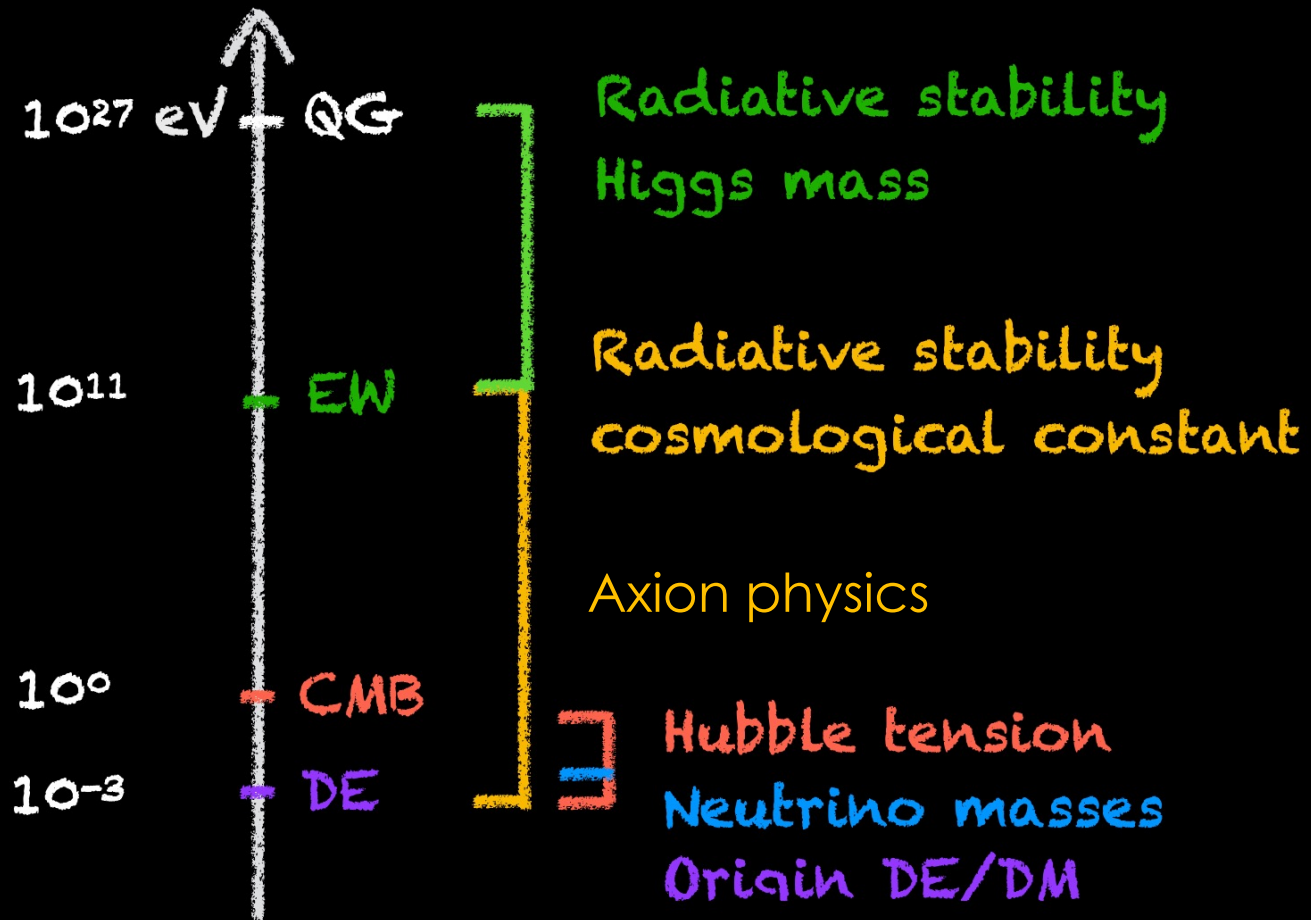
Research questions and directions



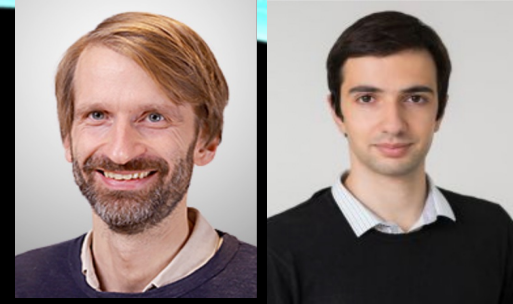
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scale

challenge



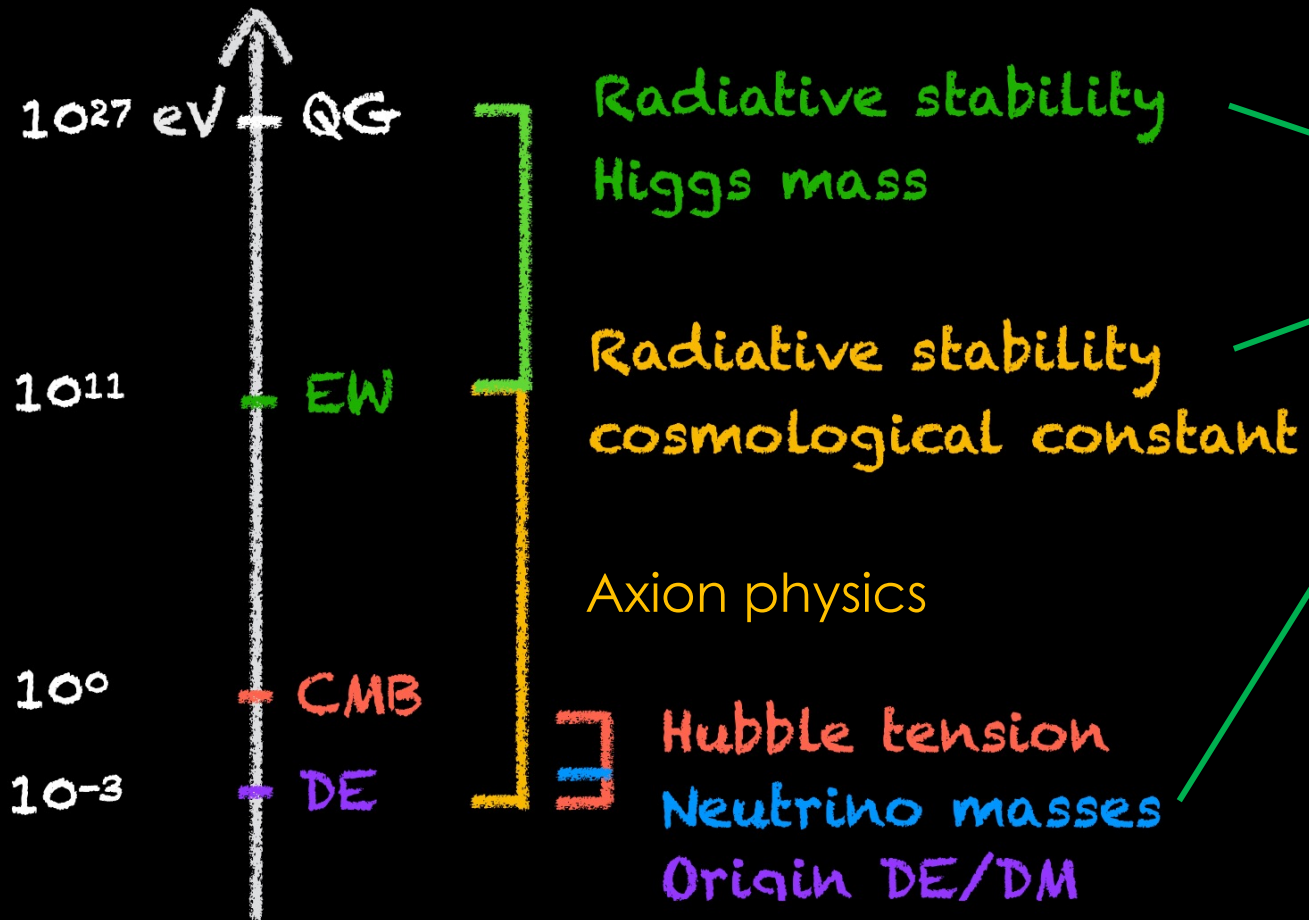
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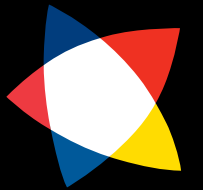
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Connection to the HEP group



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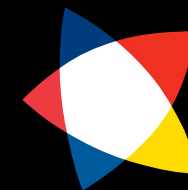
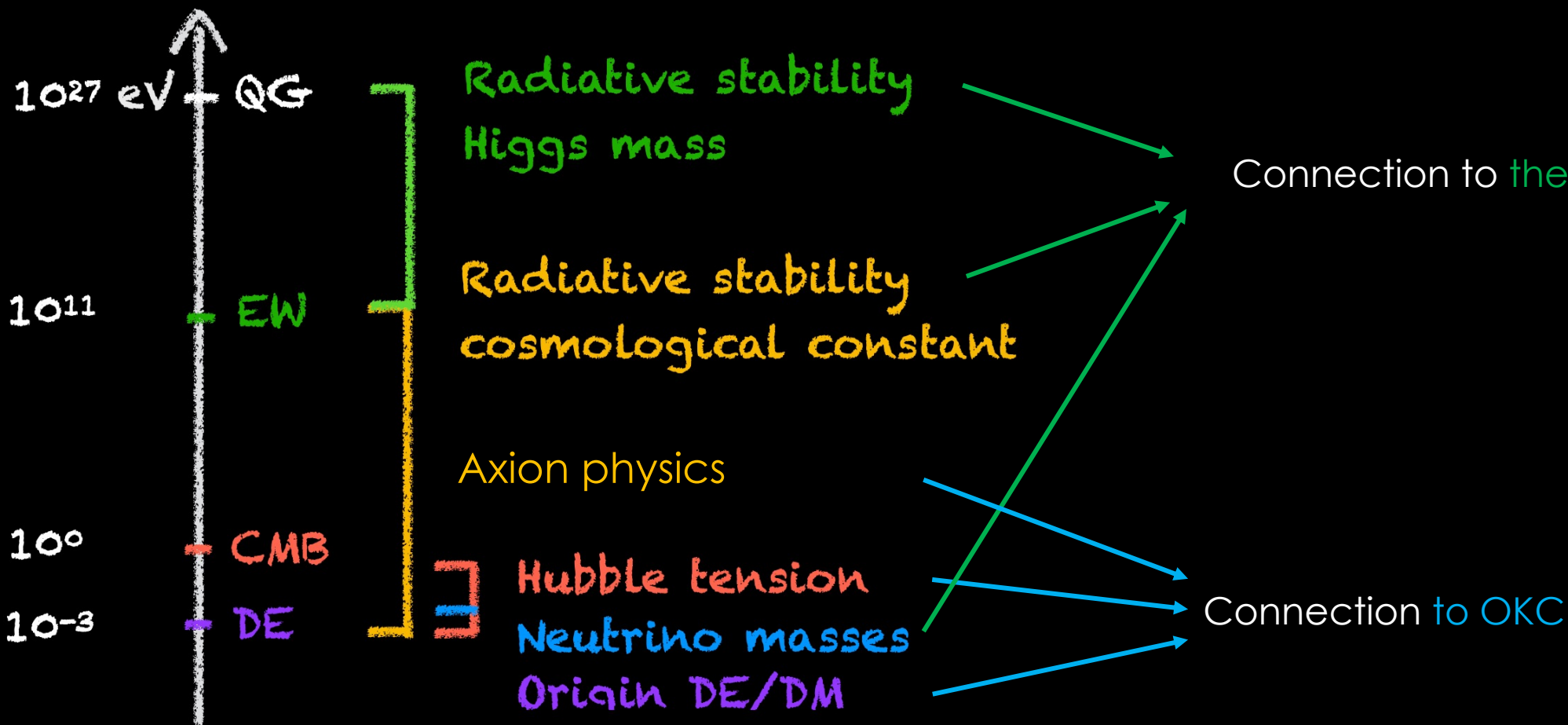
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Connection to the HEP group

NORDITA



Connection to OKC

Connections with Nordic Universities!



<https://nordita.org/cosmo2023>

First Nordic Cosmology meeting, Nordita 2023

Bi-weekly Theoretical Cosmology journal club: Joint OKC & Nordita

Theoretical Cosmology Journal Club

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Joint OKC & Nordita Theoretical Cosmology journal club

Thursdays at 11am every other week in AlbaNova A5:1041/CoPS room and on [Zoom](#).

We collect papers [here](#).

Join our mailing list using [this link](#).

There are 10 events in the future. [Show](#)

November 2023

- Nov 30 [Scott Melville](#)
- Nov 16 [Yu-Cheng Qiu](#)
- Nov 16 [Silvia Gasparotto](#)
- Nov 02 [Journal Club](#)

October 2023

- Oct 31 [Massimiliano Lattanzi](#)
- Oct 05 [Florian Niedermann \(Nordita\), Addressing Cosmic Tensions with a New Phase Transition in the Early Universe](#)

There are 14 events in the past. [Show](#)

Oksana Tarygina + 3 • 3d
Cosmology JC

November 2

December 14

arxiv.org

Aspects of Particle Production from Bubble Dynamics at a First Order Phase Transition

Suggested by David

0 likes 0 comments

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Reconstructing the early-universe expansion and thermal history

arxiv.org

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Thank you & get in touch!



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