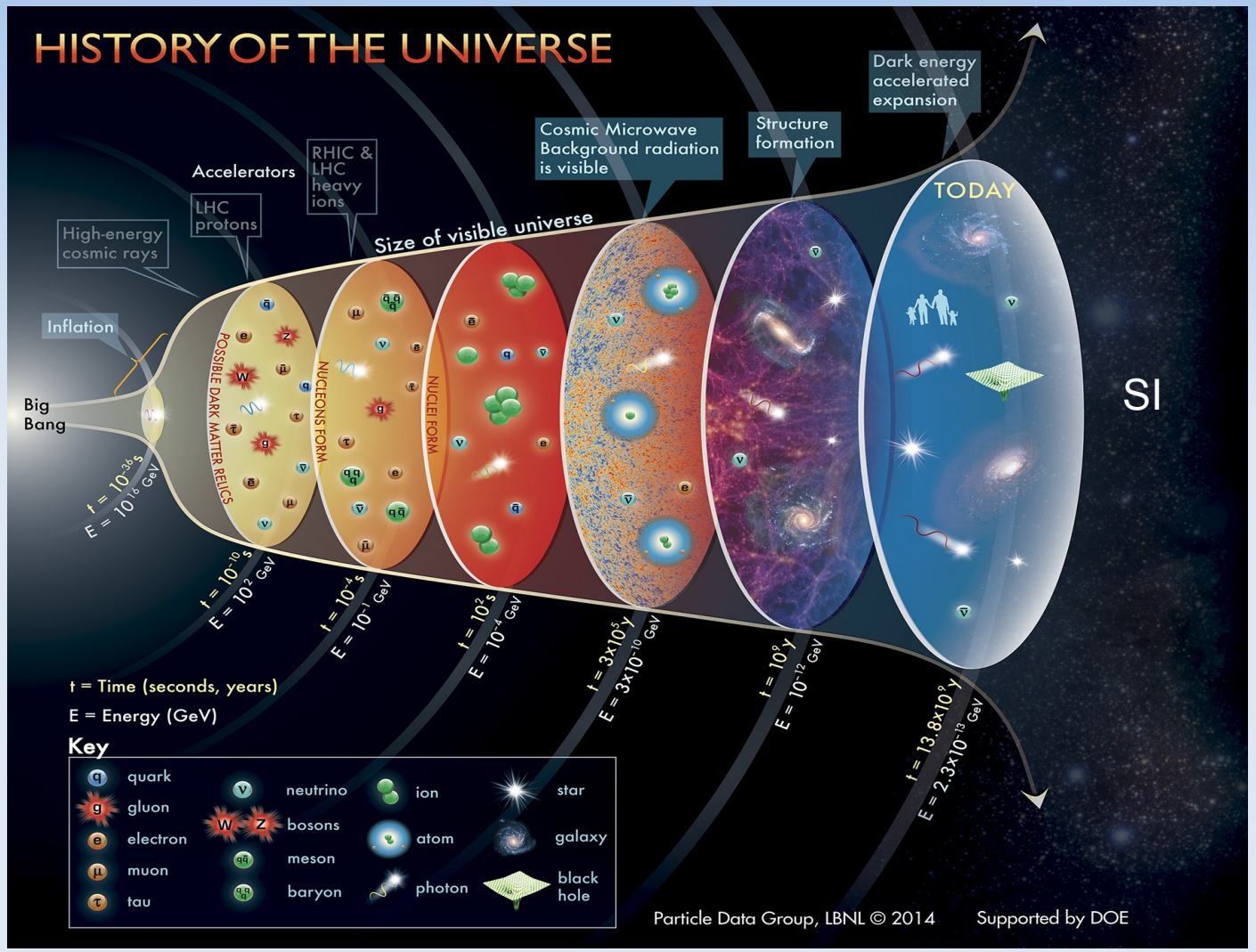
Linking Cosmology to Particle Physics

Thomas Konstandin

On behalf of various
theory activities at DESY and UHH

Attract.workshop
Nov 24, 20245

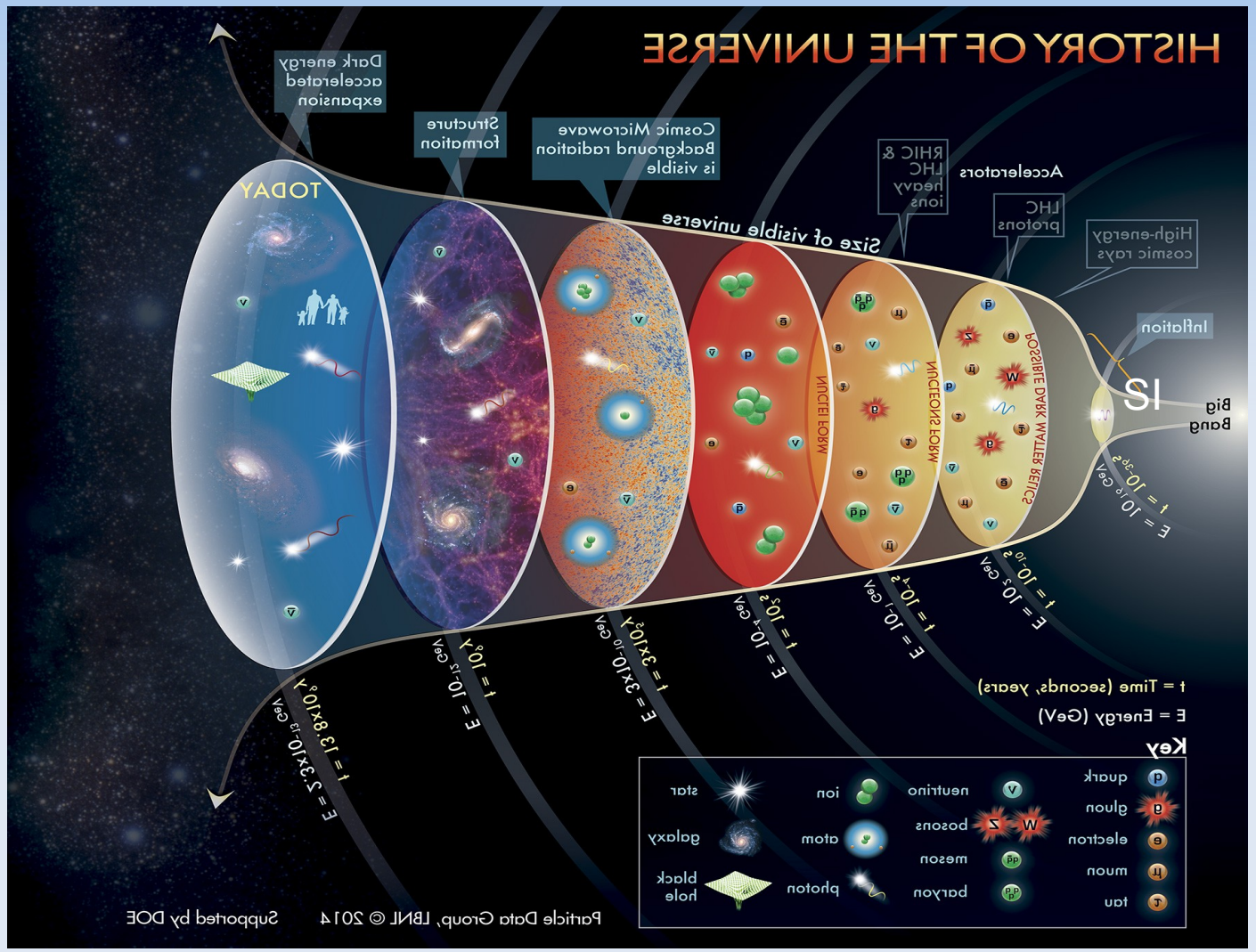
Standard Cosmology



time

temperature

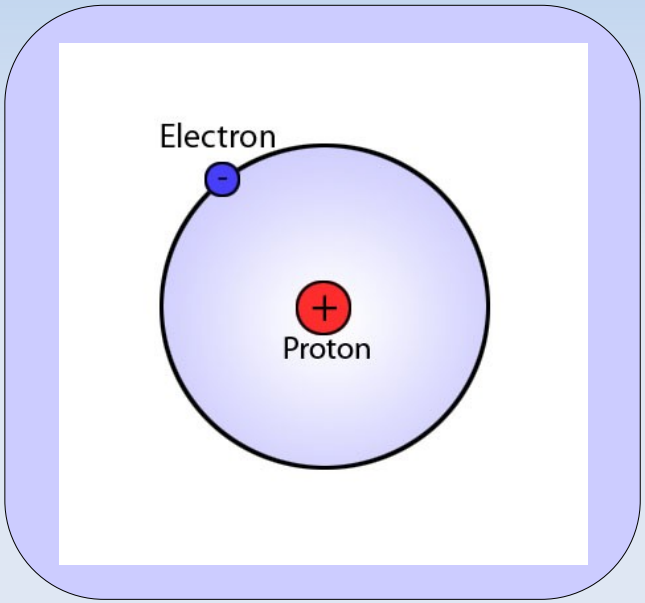
Standard Cosmology

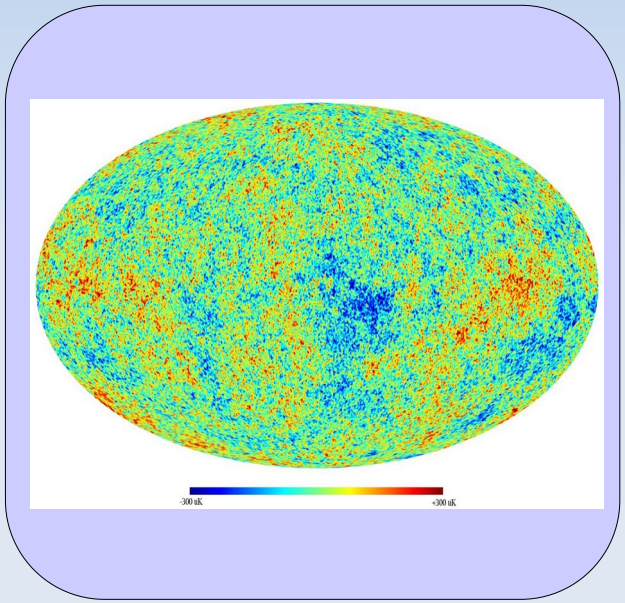


temperature →

← time

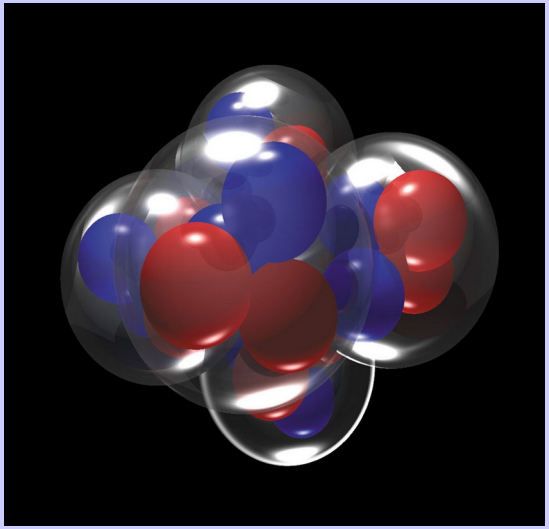
Atomic physics at T~eV

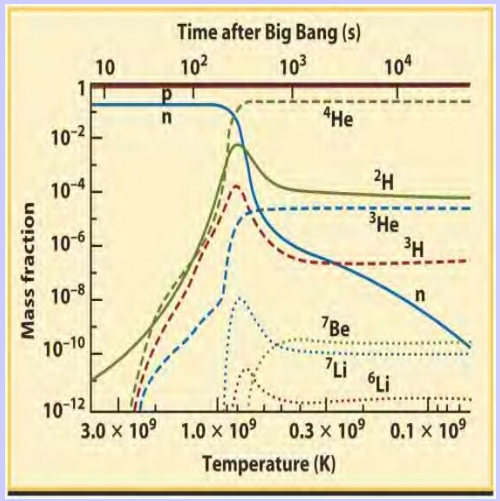




The Cosmic Microwave Background **links** atomic physics to cosmology at temperature T~eV

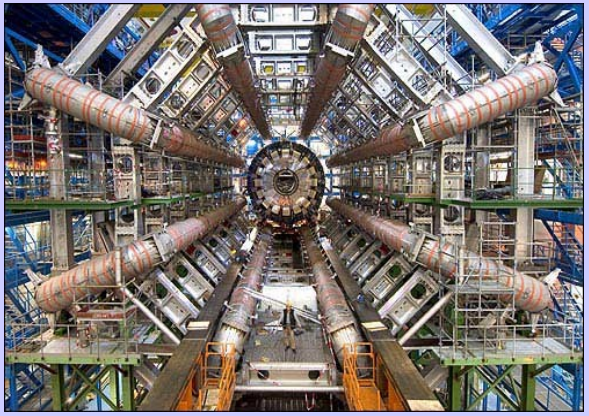
Nuclear physics at T~MeV

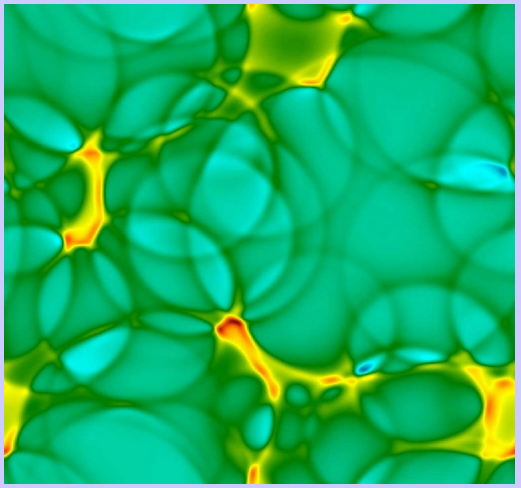




Big bang nucleosynthesis **links** nuclear physics to cosmology at temperature T~MeV

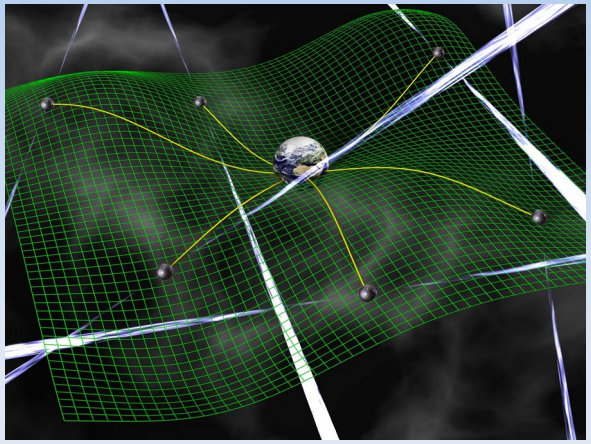
Phase transition at T~100 GeV?





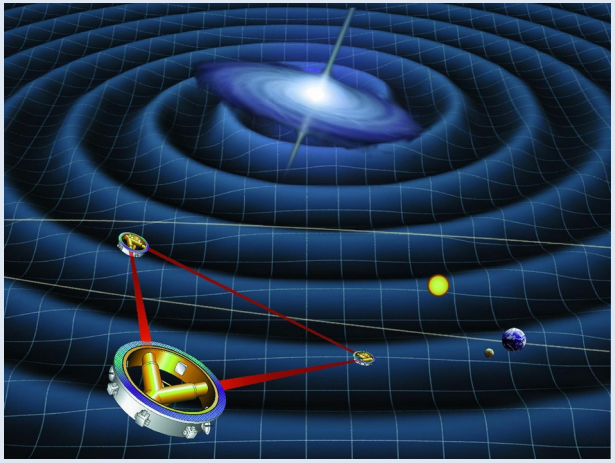
Possibly, the electroweak phase transition drove the Universe **out-of-equilibrium.** This would provide a link to current particle physics experiments.

Gravitational waves as a new window into the cosmos



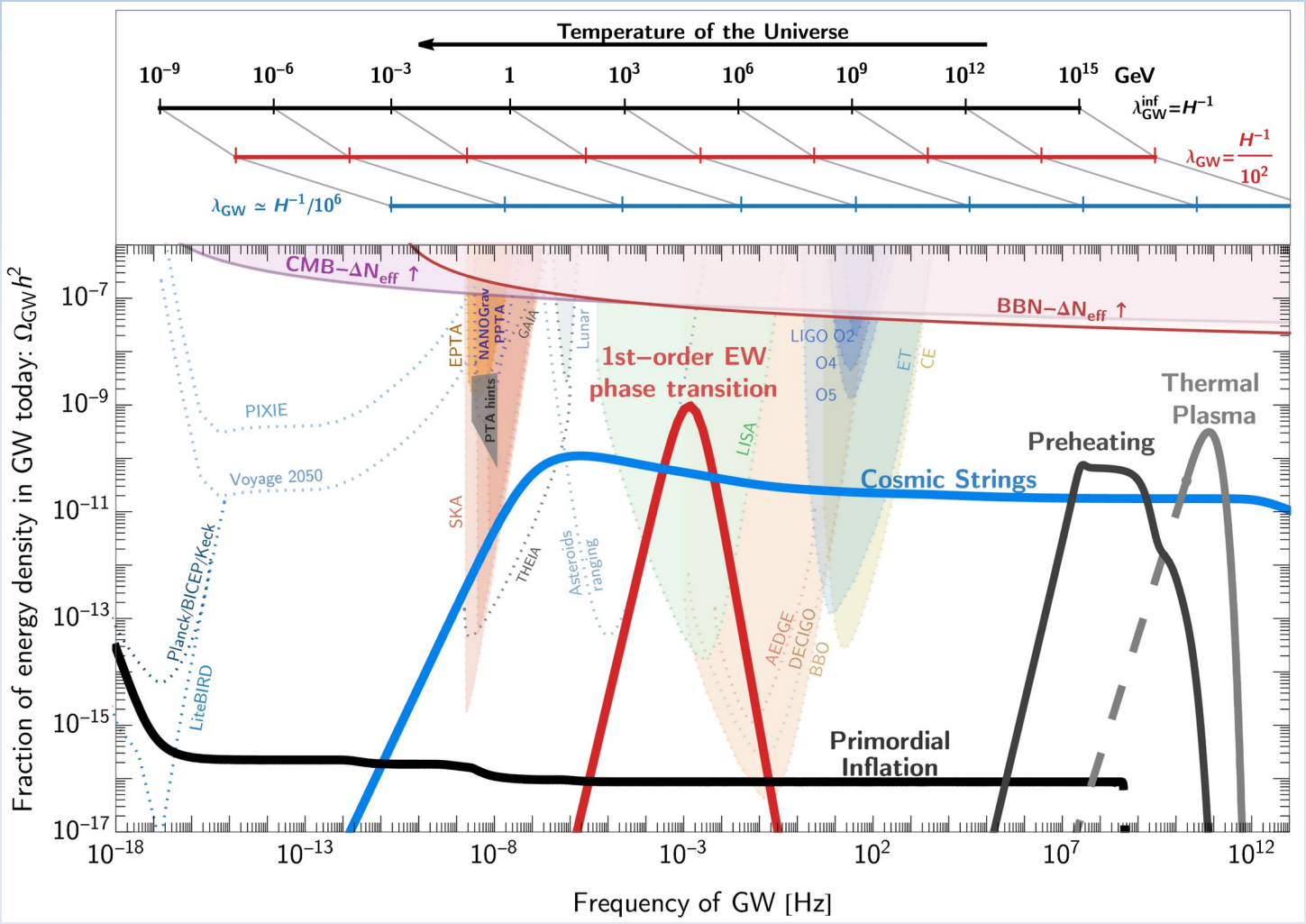
pulsar timing array

ground based
interferometers (LIGO)



space based
interferometers (LISA)

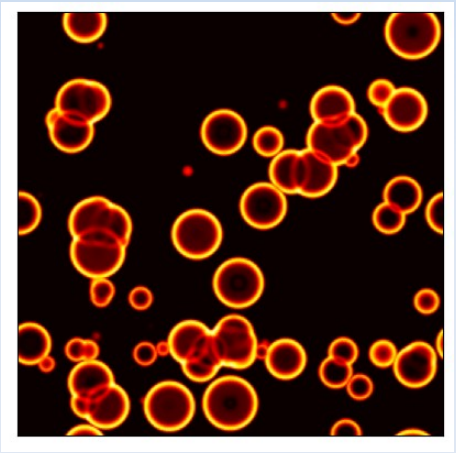
Stochastic GW landscape from cosmology

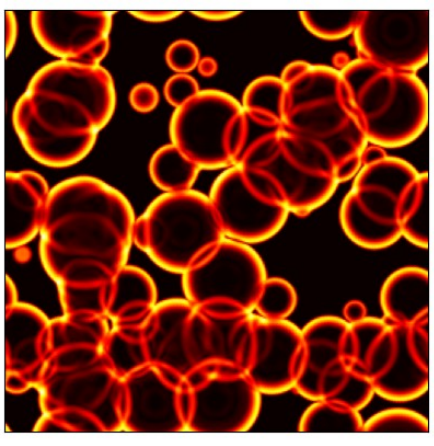


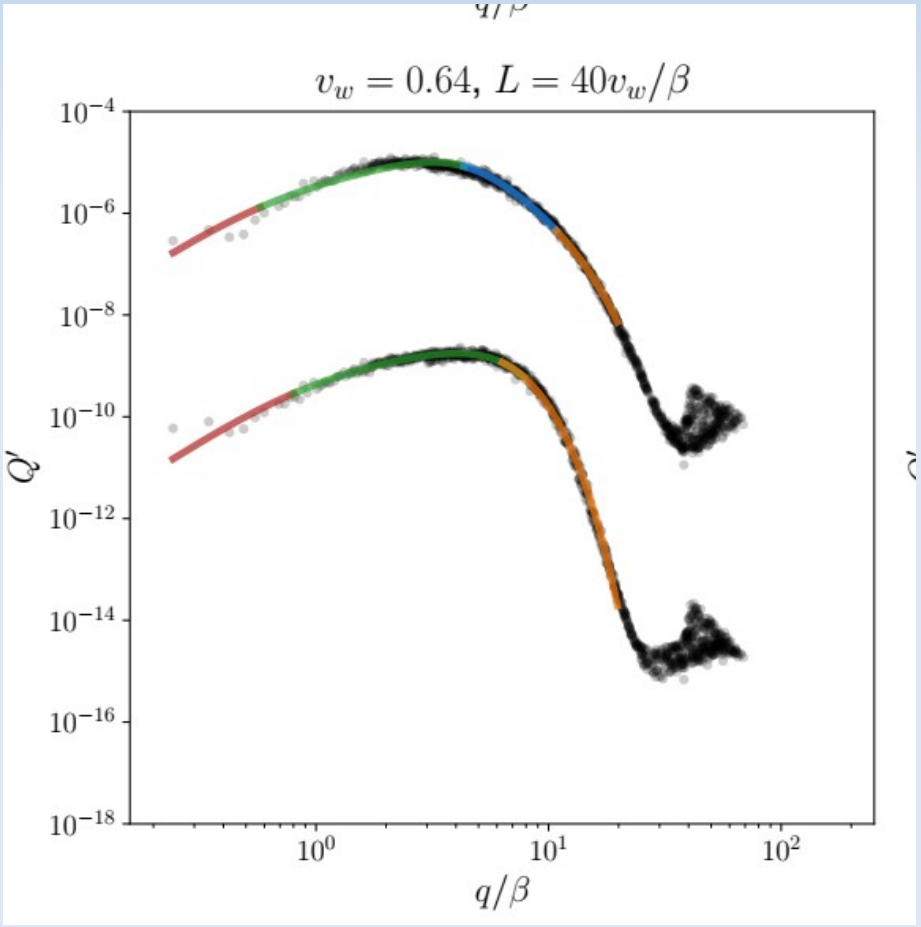
courtesy of Peera Simakachor

Power spectrum

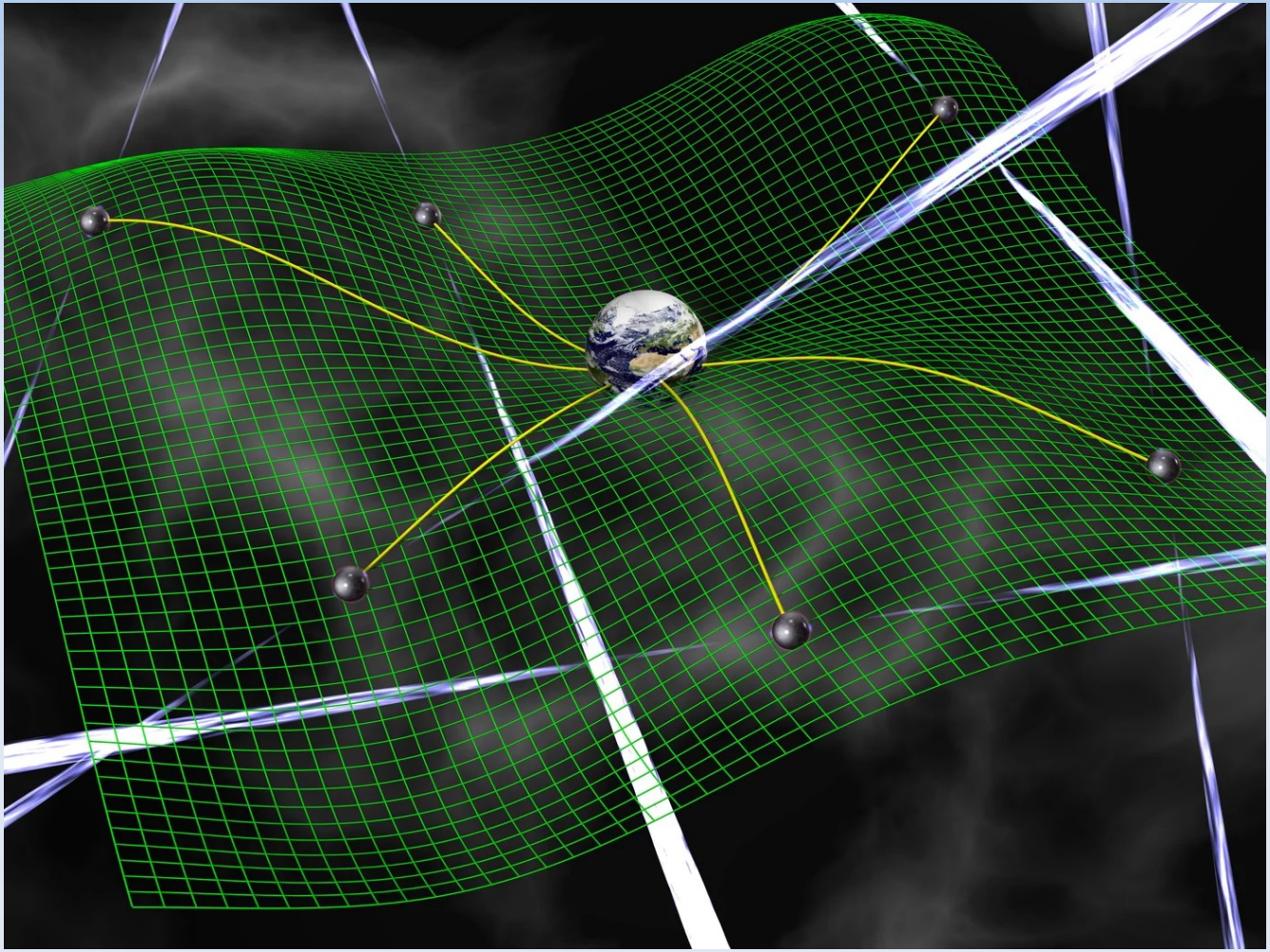
One activity in my group is to simulate the cosmic fluid during cosmological phase transition to predict the resulting GW spectrum







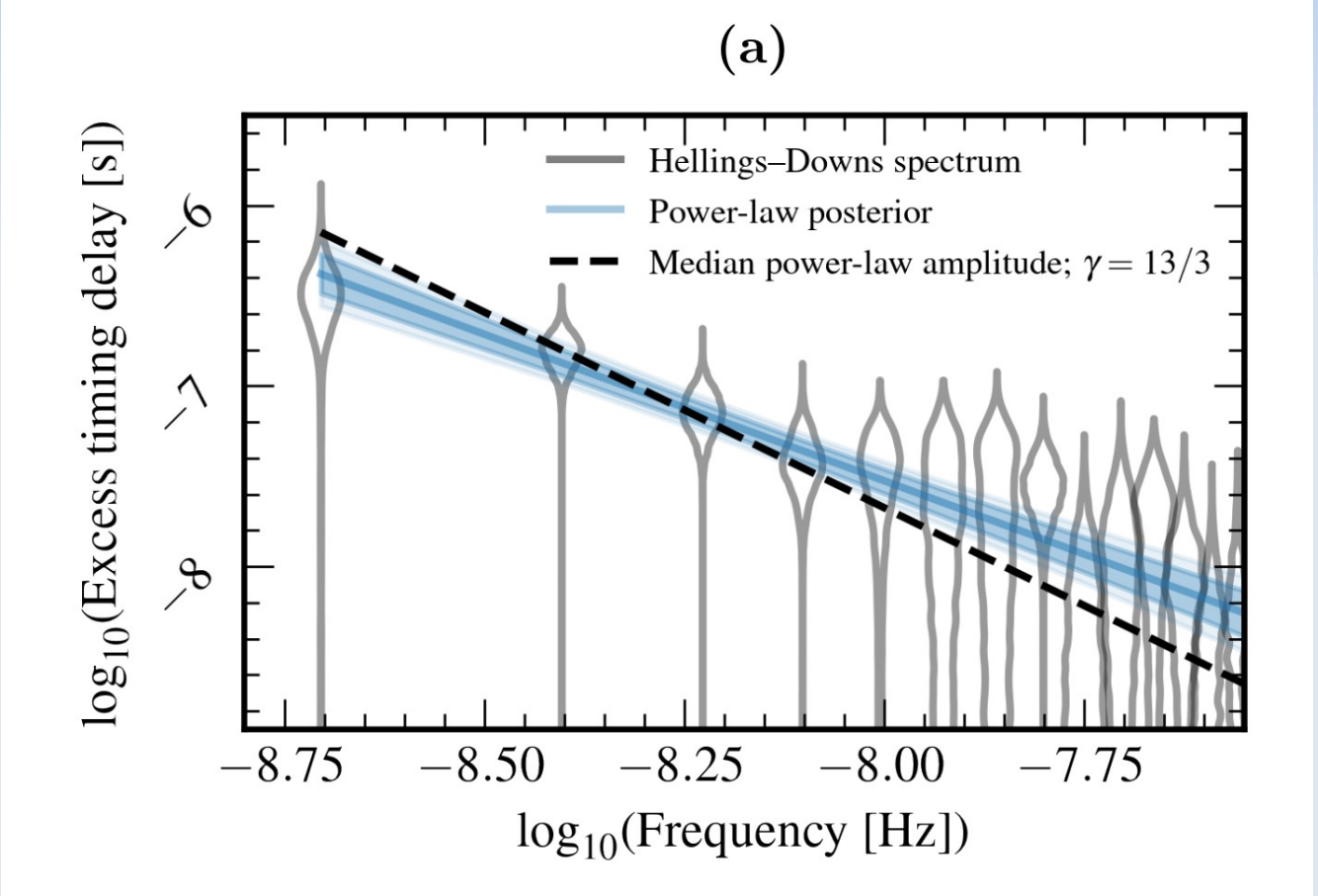
Pulsar timing array



Credit: David Champion/Max Planck Institute for Radio Astronomy

New data release

NANOGrav measured a common red noise spectrum in the nHz regime (1/10 year)

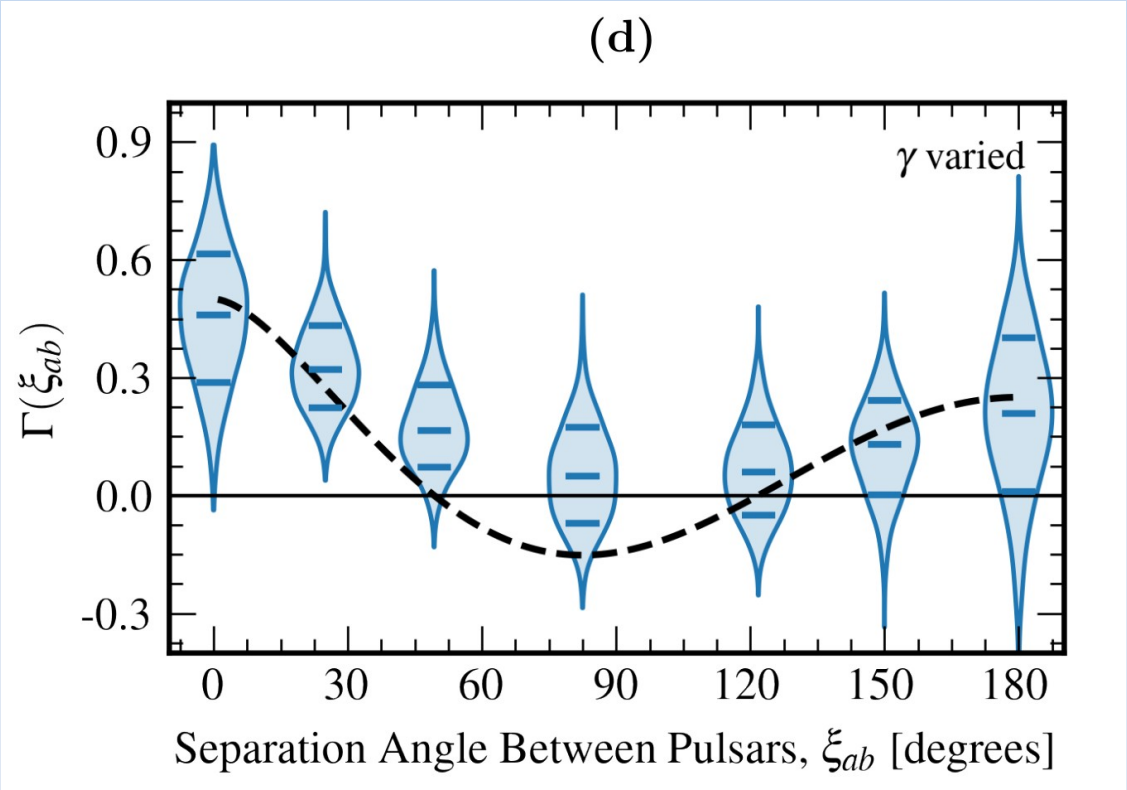


Other PTA experiments had similar results with somewhat less statistics (EPTA, PPTA, CPTA)

[NANOGrav 2023]

Are these really GWs?

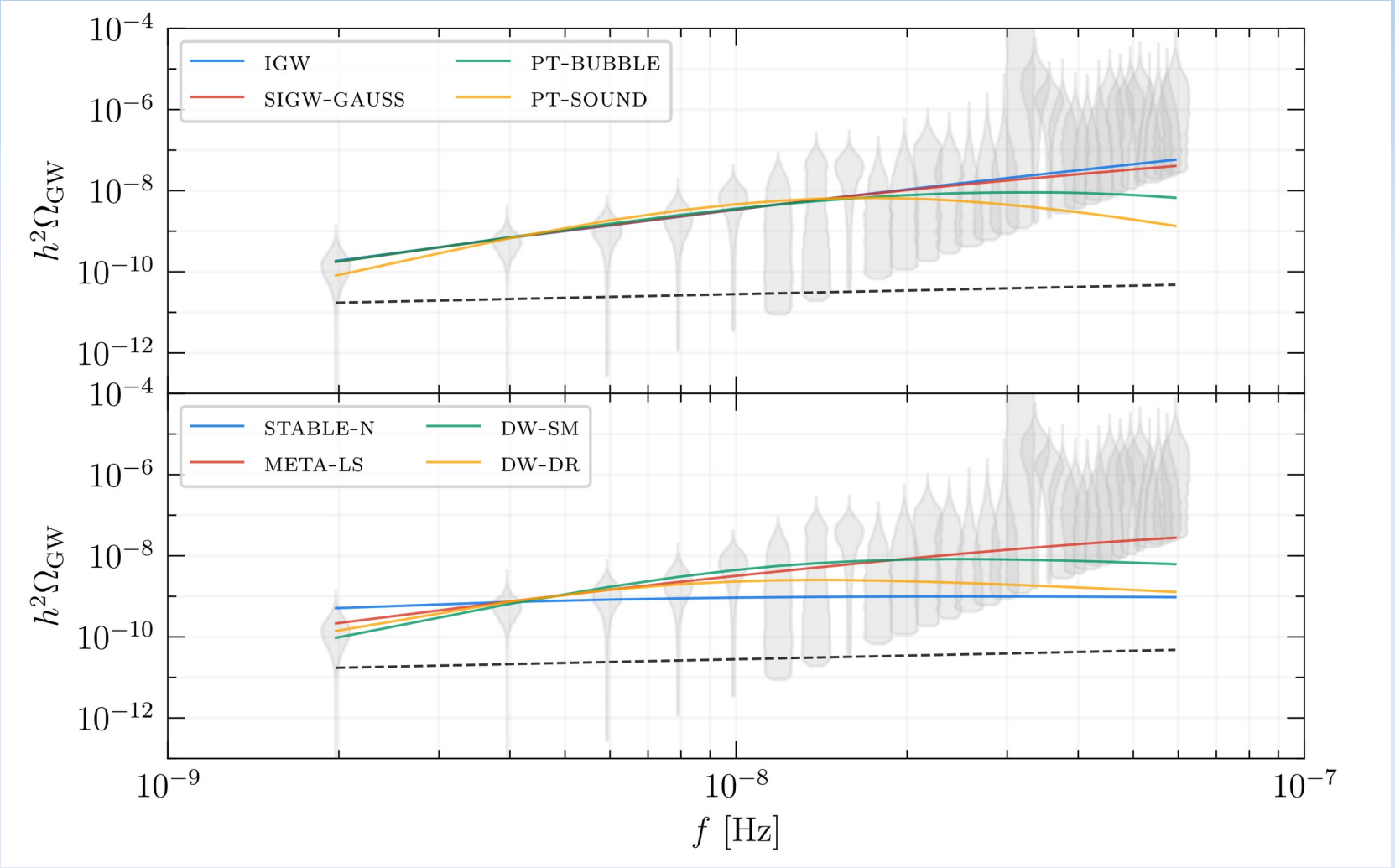
The smoking gun for a stochastic GW source is a correlation that follows the Hellings-Downs curve



The data seems to support a Hellings-Downs curve, even though there is also a quite large monopole.

[NANOGrav 2023]

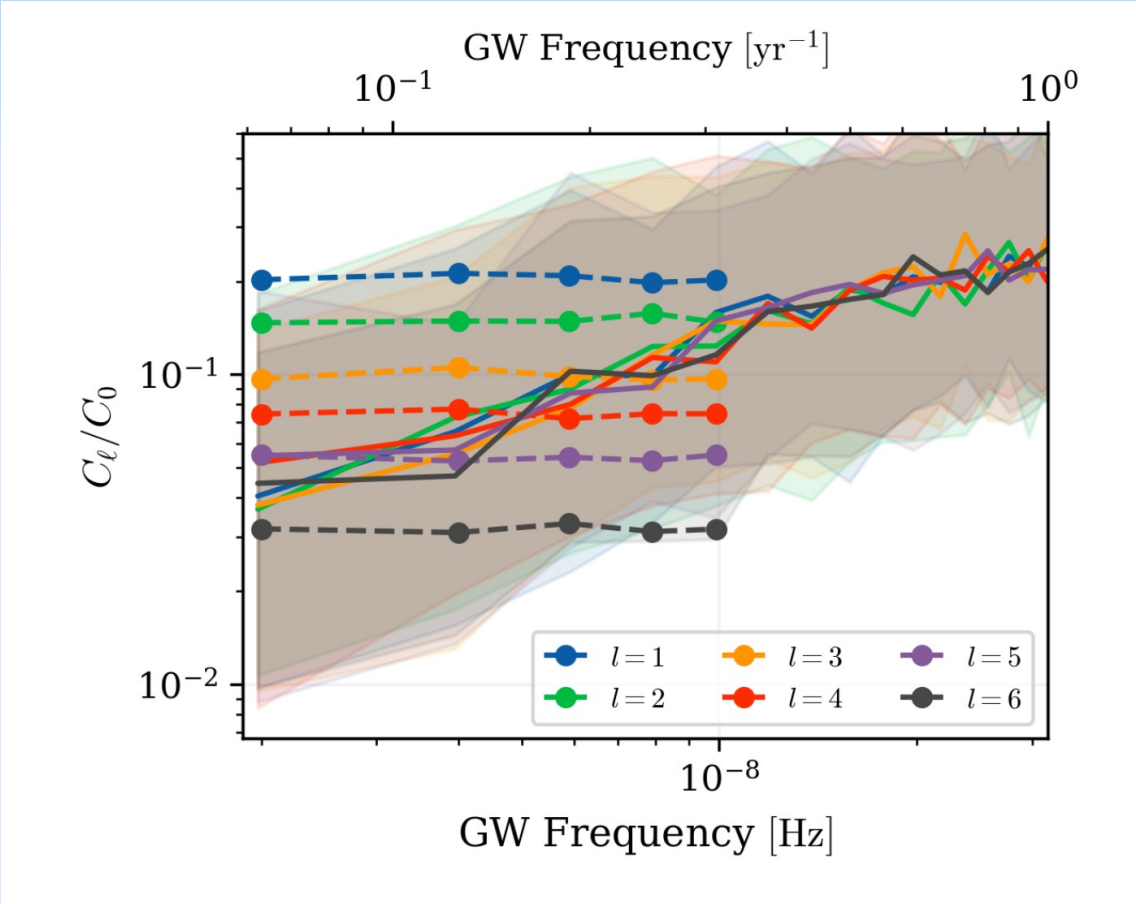
Signals from new physics



[NANOGrav 2023]

Anisotropies

No anisotropies have been found so far.

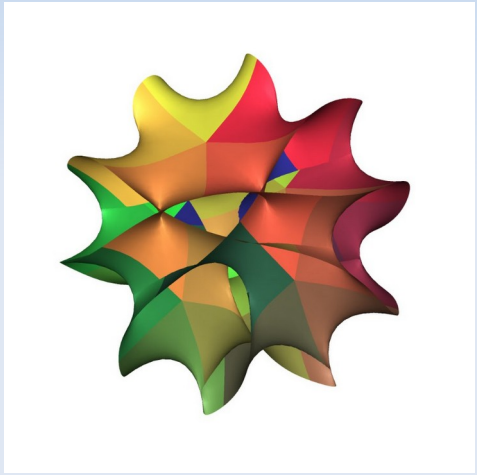


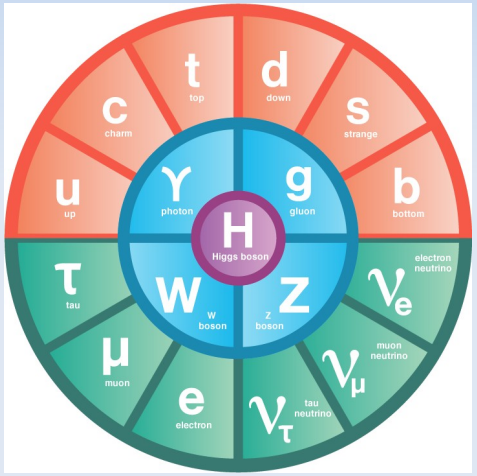
The bands denote expectations from SMBH.
The measurements are upper limits.

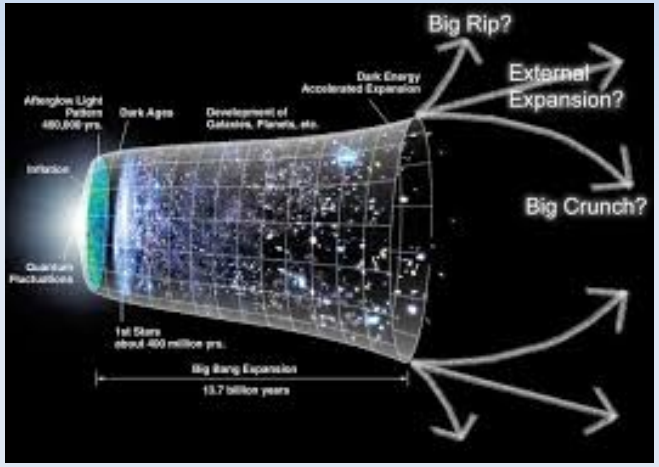
[NANOGrav 2023]

Quantum Universe Cluster

Many of these activities are under the umbrella of the Quantum Universe Cluster of Excellence







Alexander Westphal

Christophe Grojean

Gudrid Moortgat-Pick

Georg Weiglein

Thomas Konstandin

Gunther Sigl

Geraldine Servant

And many more …….

PhD in particle cosmology

What you need:

curiosity for fundamental science and particle physics

enthusiams for theory

participation in group events (journal club, seminars)

What you get:

International team of researchers

large community instead of a working group

expertise in particle physics+cosmolgy but also coding / data science / ML

Thanks!

II. Institut für Theoretische Physik

Universität Hamburg

DER FORSCHUNG | DER LEHRE | DER BILDUNG

T

DESY Theory Group

DESY.