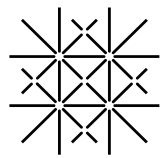
Probing SUSY at GW Observatories

Kevin Hinze



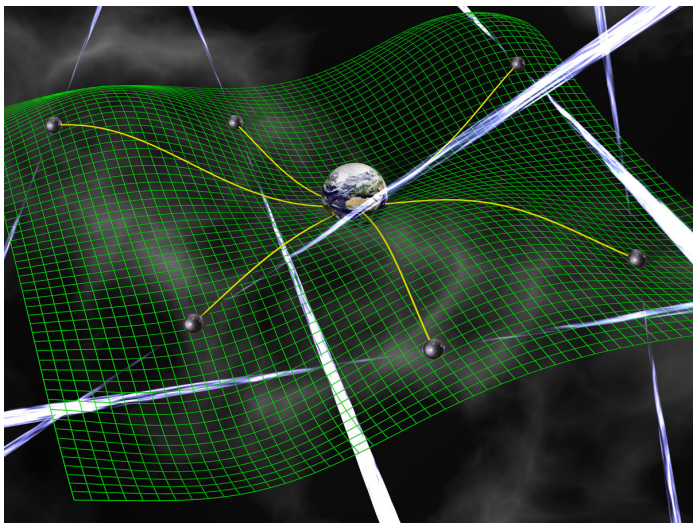
Universität
Basel

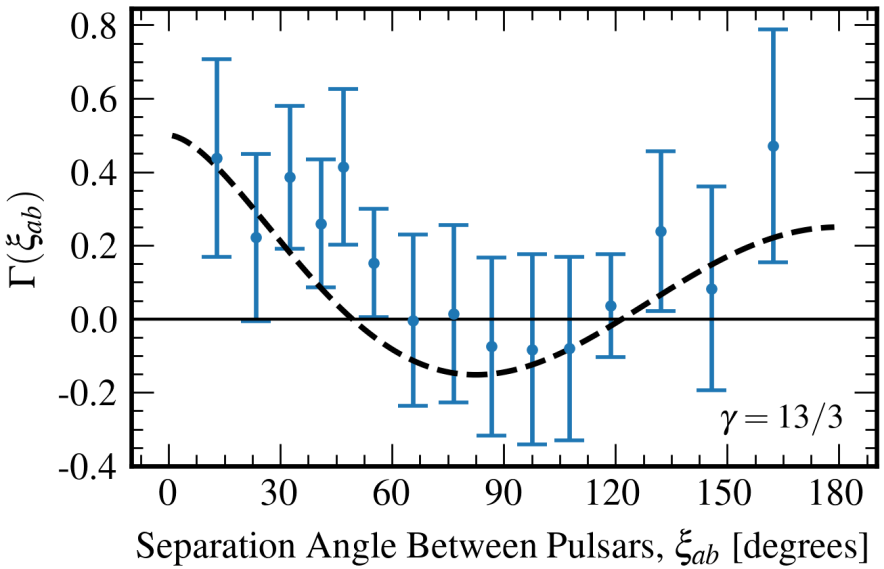
Swiss Cosmology Days 2025
June 6, 2025

Based on: - Phys.Rev.D 108 (2023) 9, 095053 (S. Antusch, KH, S. Saad, J. Steiner)
- Phys.Lett.B 856 (2024) 138924 (S. Antusch, KH, S. Saad, J. Steiner)
- JCAP 10 (2024) 007 (S. Antusch, KH, S. Saad)

Pulsar Timing Arrays: 2023

- PTA results point to a stochastic gravitational wave background (SGWB) at nHz frequencies



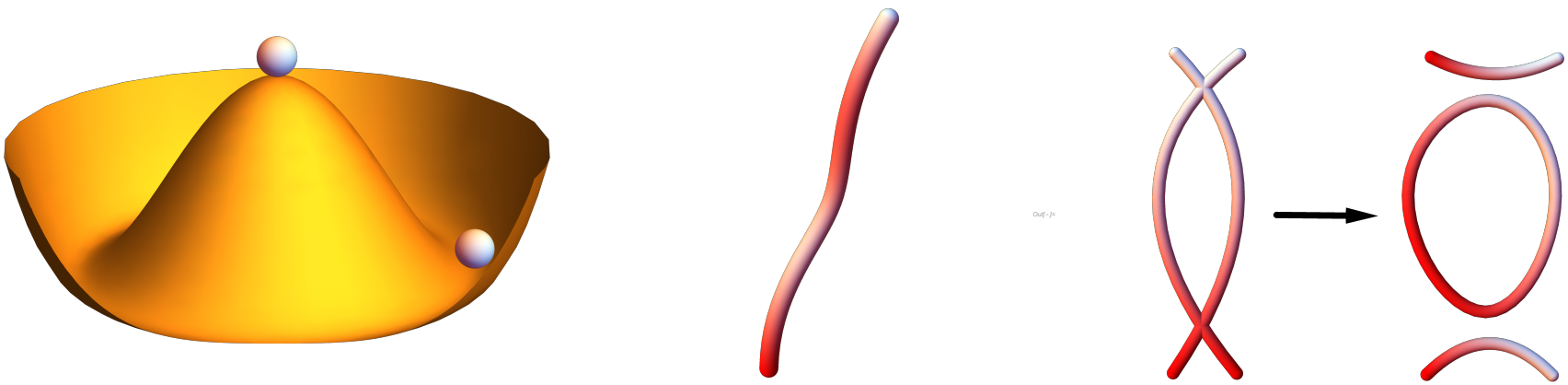


- NanoGrav, EPTA+InPTA, PPTA, CPTA

- What is the origin? Supermassive BH binaries? BSM physics?

Cosmic strings

- Spontaneous symmetry breaking $G \to H$ with non-trivial homotopy group $\pi_1(G/H)$, e.g. $U(1) \to 1$



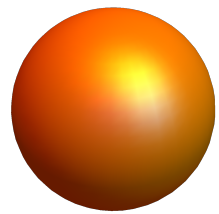
- Cosmic string tension: $\mu \sim 2\pi v_{\rm cs}^2$

Abrikosov (1957); Nielsen, Olesen (1973); Kibble (1976)

Monopoles

- Spontaneous symmetry breaking $G \to H$ with non-trivial homotopy group $\pi_2(G/H)$, e.g. $SU(2) \to U(1)$

- Monopole mass: $m \sim \frac{4\pi v_m}{g}$



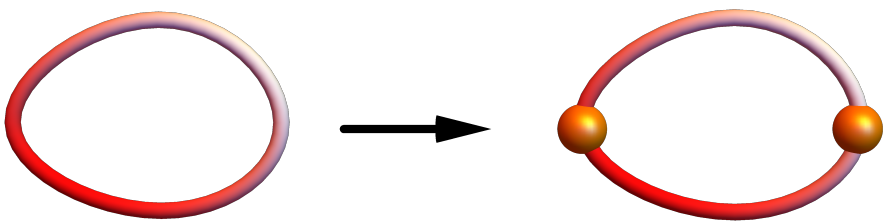
- Have to be diluted since they would overclose the universe

't Hooft (1974); Polyakov (1974); Kibble (1976); Preskill (1979)

Metastable cosmic strings

- Multistep spontaneous symmetry breaking, e.g.

$$SU(2) \xrightarrow[\text{production}]{\text{monopole}} U(1) \xrightarrow[\text{production}]{\text{cosmic string}} 1$$

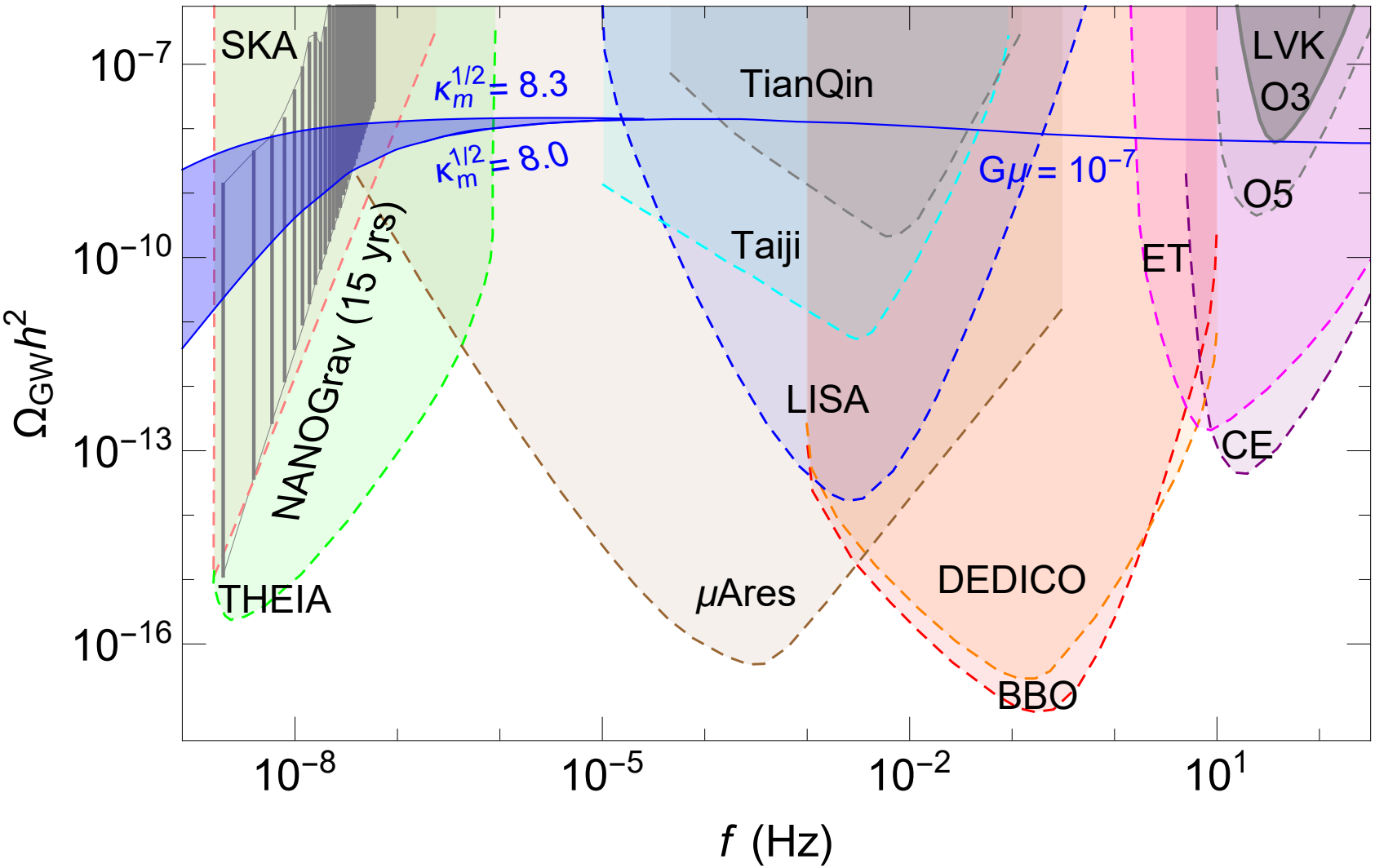


- Strings can decay by monopole-antimonopole nucleation

- Lifetime: $t_s = \sqrt{\frac{2\pi}{\mu}} e^{\pi\kappa}, \quad \kappa = \frac{m^2}{\mu} \sim \frac{8\pi}{g^2} \frac{v_m^2}{v_{cs}^2}$

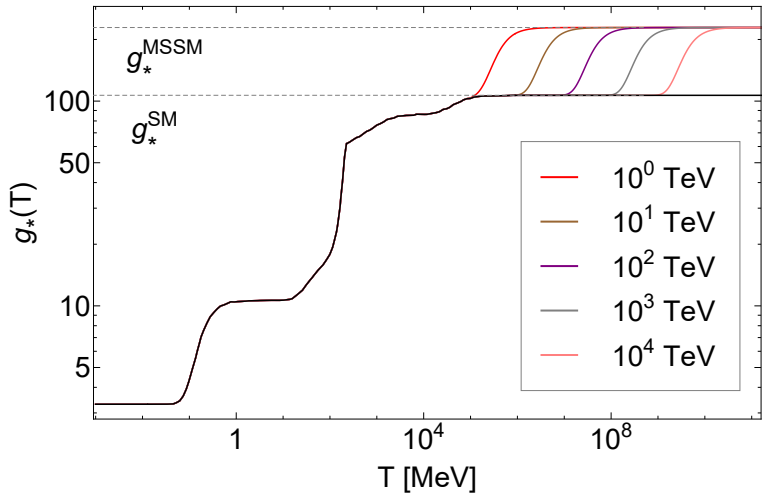
Lazarides, Shafi, Walsh (1982); Vilenkin (1982)

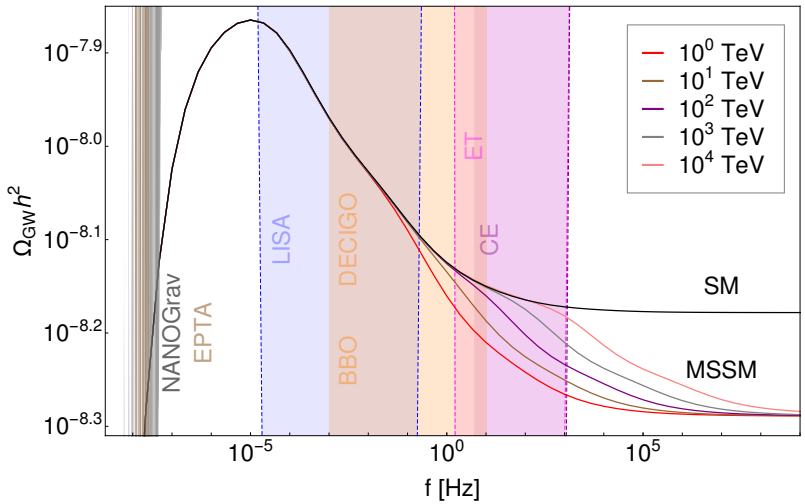
Gravitational wave spectrum

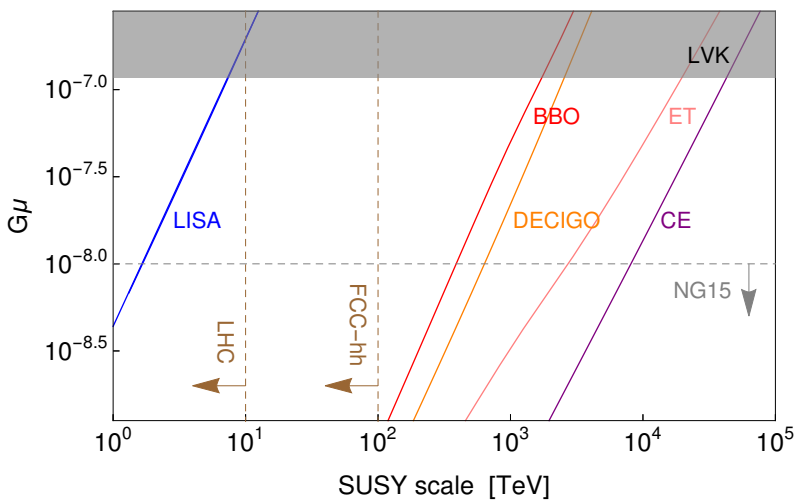


Antusch, KH, Saad, Steiner (2023)

Probing SUSY







Fisher analysis for $G\mu = 10^{-7}$

quantity	uncertainty
Δg_*	10%
$m_{\rm SUSY}$	5%

for $\begin{cases} m_{\rm SUSY} < 2 \text{ PeV} & \text{at ET} \\ m_{\rm SUSY} < 10 \text{ PeV} & \text{at CE} \end{cases}$

Antusch, KH, Saad, Steiner (2024)

Origin of MSCSs

Promising route is based on $\mathbf{10_H}$, $\mathbf{16_H}$ and $\mathbf{45_H}$.

Criteria

- Gauge coupling unification
- Proton decay bounds
- Hierarchy problem
- Doublet-triplet splitting
- Cosmic inflation
- Lower-dimensional representations

Breaking chains

(a) $SO(10) \to 3221$ — monopole
$\to 3211$ — cosmic string
$\to 321$

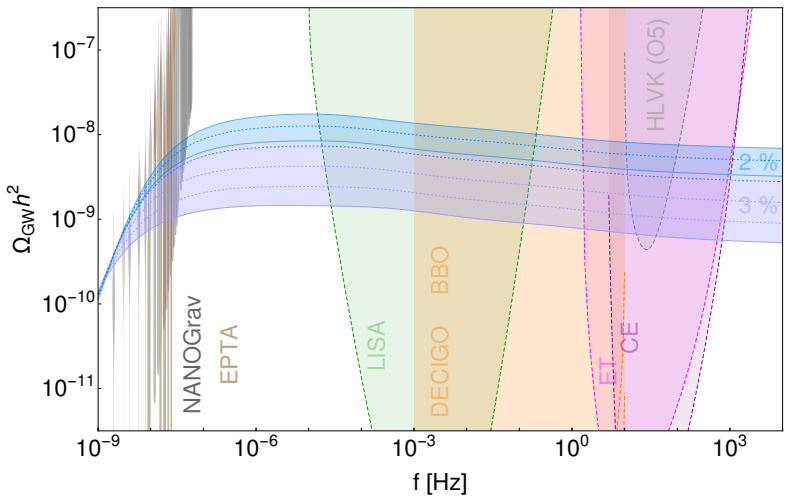
(b) $SO(10) \to 421$ — monopole
$\to 3211$ — cosmic string
$\to 321$

(c) $SO(10) \to 3211$ — monopole
$\to 321$ — cosmic string

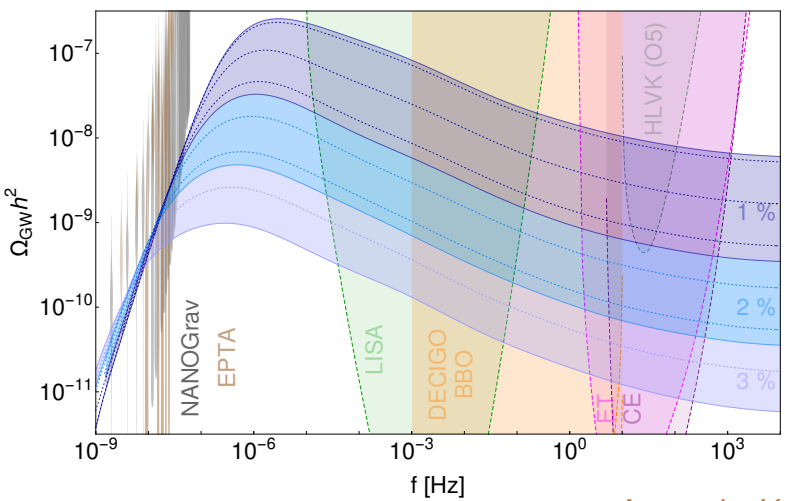
Antusch, KH, Saad, Steiner (2023); Antusch, KH, Saad (2024)

Gravitational wave spectrum

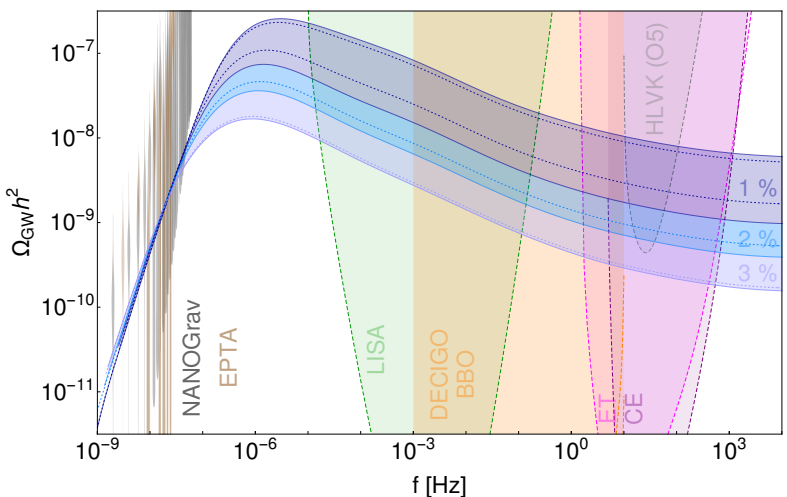
GW spectrum with standard cosmology, case (*a*)



GW spectrum with an intermediate matter era, case (*a*)



GW spectrum with an intermediate matter era, case (*b*)



Antusch, KH, Saad (2024)

Summary

If MSCSs are the correct explanation of the PTA result ...

- Fantastic reach for NP with extra DOF (such as SUSY)
  - ET and CE can look for NP scales as high as 10^7 GeV with measurement uncertainty of 5% for the NP scale and 10% for the number of DOF
- PTA signal can be explained by "promising" SO(10) GUTs
  - PTA signal also helps to "single out" SO(10) breaking chains