Finite-size Effects on Cosmic String Breaking

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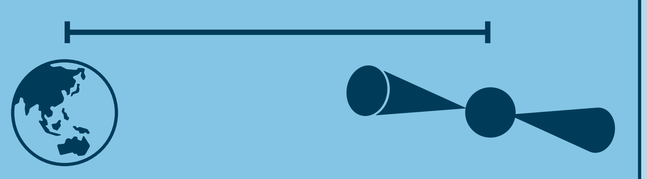
Backgrounds

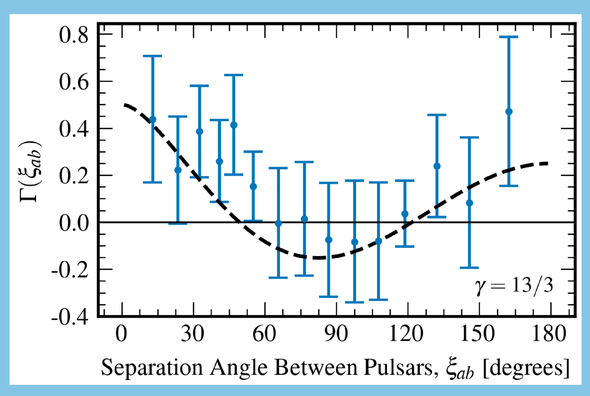
Stochastic Gravitational Wave Background (SGWB)

SGWB

- Superposition of gravitational waves from many sources
- Observed by pulsar timing array (PTA) experiments @ nHz band



Recent PTA Results



Taken from [2306.16213]

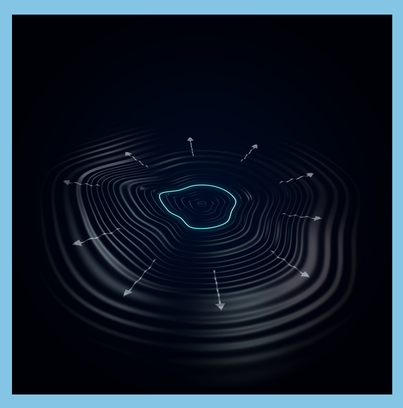
- Evidenced by many collaborations
  - NANOGrav [2306.16213]
  - EPTA+InPTA [2306.16214]
  - PPTA [2306.16215]
  - CPTA [2306.16216]

Possible Origin

- Supermassive black holes
- Cosmic strings
- Domain walls
- Phase transitions
- ….

Cosmic Strings as GW sources

Cosmic Strings

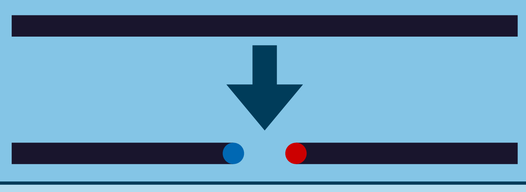


Credit: Daniel Dominguez from CERN's Education, Communications & Outreach (ECO) Department.

- String-shaped object in the Universe
- Predicted by many BSM models
  - e.g. Grand Unification
- Oscillation emits GW

Decay Rate

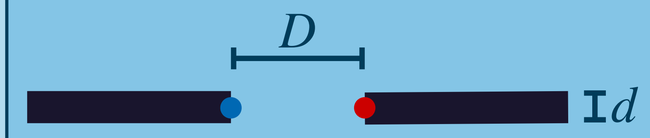
- NANOGrav: the strings must be metastable
  - Spontaneously cut by monopole-antimonopole pair production
- GW data: $\sqrt{\kappa} \sim 8$ for decay rate $\sim \exp[-\pi\kappa]$ [2306.16219]
  - Precise estimate is critical



Conventional Approximation

[Preskill & Vilenkin (1992)]

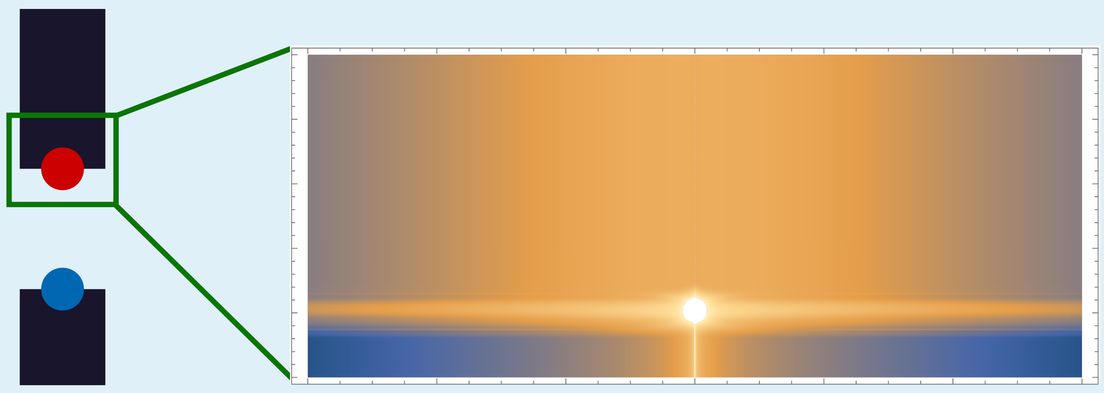
- Neglects string width & monopole size
- Valid only for $\sqrt{\kappa} \gg 1$
  - $\sqrt{\kappa} \propto D/d$
  - Cf. $\sqrt{\kappa} \sim 8$ for NANOGrav



Q: Is the conventional approximation OK for the PTA data?

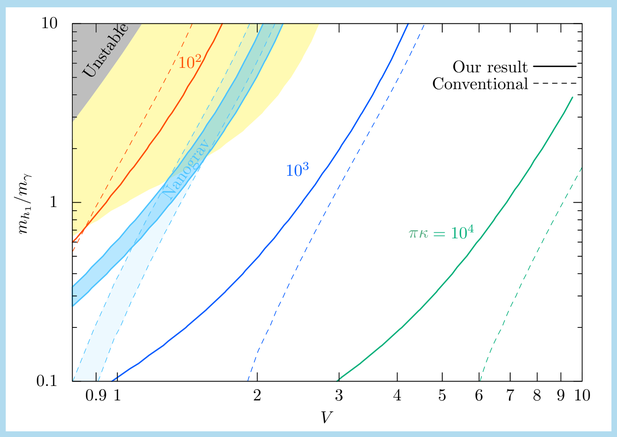
Alternative Evaluation

- Postulate an underlying model
  - Symmetry breaking pattern: SU(2) → U(1) → 1
- Construct the static string configuration
- Construct an “easy tunneling path”
  - Example →
- Calculate κ
  - Upper bound on true (optimal) κ



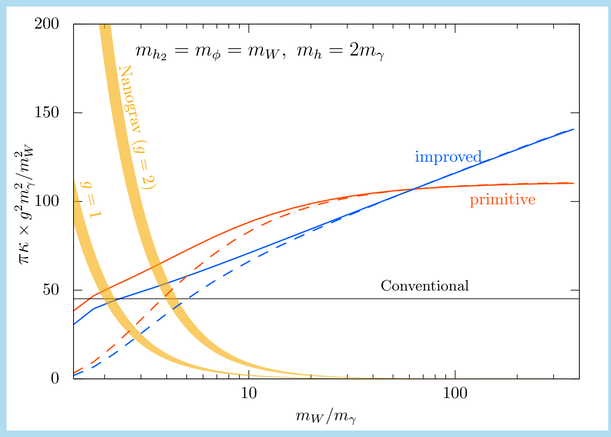
Results

Implications for the PTA regime



- Yellow: Our upper bound < κ by the conventional approximation
  - Overlap with NANOGrav region
    - Modification to the interpretation

VS. Conventional



- Solid: our upper bound on $\pi\kappa$
- Dashed: thin-wall
  - ~ our method & neglect string width
- For large κ, reproduced the conventional approximation up to an O(1) factor
- For small κ, thin-wall deviates from the full calculation
  - Signals breakdown of the assumption

Conclusions

- Upper bound on κ was calculated numerically (decay rate $\sim \exp[-\pi\kappa]$)
  - The string width and monopole size are taken into account
- The conventional approximation may be unsuited to interpret the PTA data