# C01 update

Hirosi Ooguri

PI: Hirosi Ooguri

members:

- Yasunori Nomura
- Jiro Soda
- Kazuhiro Yamamoto

# Yasunori Nomura

# Progress — Yasunori Nomura

- A step toward **holography** for **general spacetimes**

Holography:

Quantum gravity is expected to be formulated
as a "normal" (non-gravitational) quantum system in lower dimensions. cf. Black hole physics, etc.

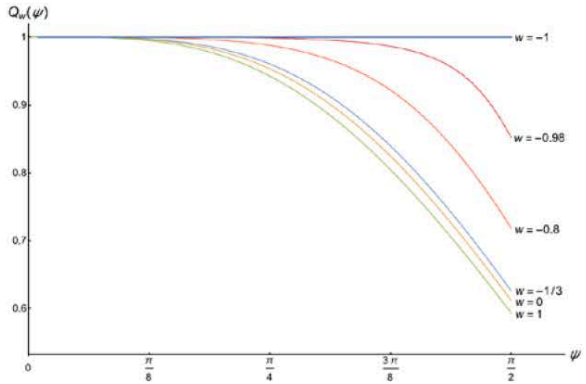
Explicit example — AdS/CFT (Anti-de Sitter/Conformal Field Theory) correspondence

… How to extend to general spacetimes, including cosmological spacetime?

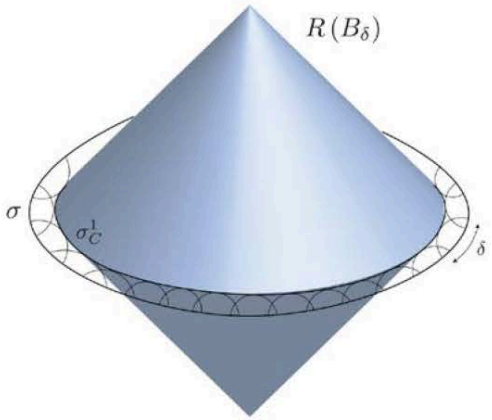
The origin of general (non-AdS) spacetimes and how they emerge holographically

… based on theories formulated on "holographic screens" Y.N., Salzetta, Sanches, Weinberg ('16)

Spacetime appears from deviations from maximal entanglement (through local correlations)




The boundary can be moved inward through coarse-graining



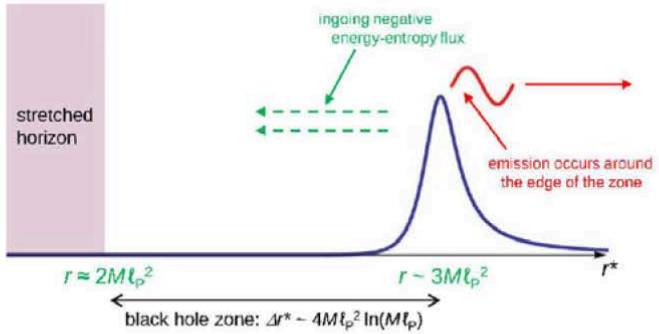

- "Spacetime from Unentanglement" Y.N., Rath, Salzetta, PRD **97** (2018) 106010
- "Pulling the Boundary into the Bulk" Y.N., Rath, Salzetta, PRD **98** (2018) 026010

— Solves mysteries of earlier treatments of holography … "entanglement shadows," etc.

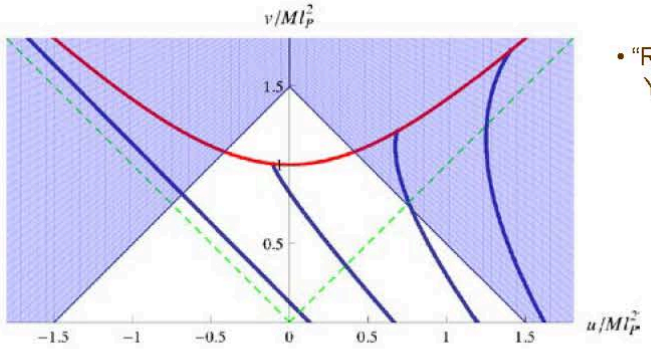
— Provides a new framework to address holography for general spacetimes

# • A complete picture of **quantum mechanics** of **evaporating black holes**

Importance of soft and hard modes in the black hole "zone"




The effective theory of the interior emerges through coarse-graining



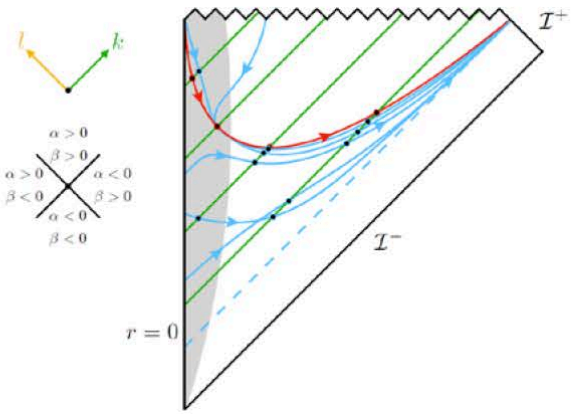

• "Reanalyzing an Evaporating Black Hole"
Y.N., arXiv:1810.09453 (to appear in PRD)

— Understanding of how the black hole interior emerges consistently with unitarity
… addresses the long-standing mystery in theoretical physics!

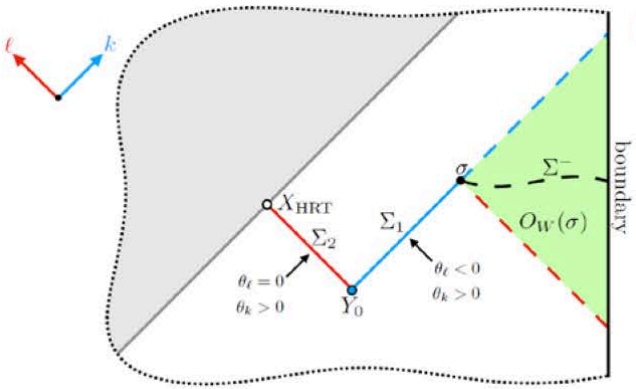
Hawking ('??)
....
Almheiri, Marolf, Polchinski, Sully ('??)
....

# • General formulation of **outer entropy** in gravity

"Generalized holographic screen"
with monotonic properties can be defined




… can be used to define "quasilocal energy"




• "Area Law Unification and the Holographic Event Horizon"
Y.N., Remmen, JHEP **08** (2018) 063

• "Outer Entropy and Quasilocal Energy"
Bousso, Y.N., Remmen, PRD **99** (2019) 046002

# • Pure natural **inflation**

• "Pure Natural Inflation," Y.N., Watari, Yamazaki, PLB **776** (2018) 227
• "Tensor Modes in Pure Natural Inflation," Y.N., Yamazaki, PLB **780** (2018) 106

Extremely simple models of inflation consistent with current data — see Y.N.'s talk

# Jiro Soda

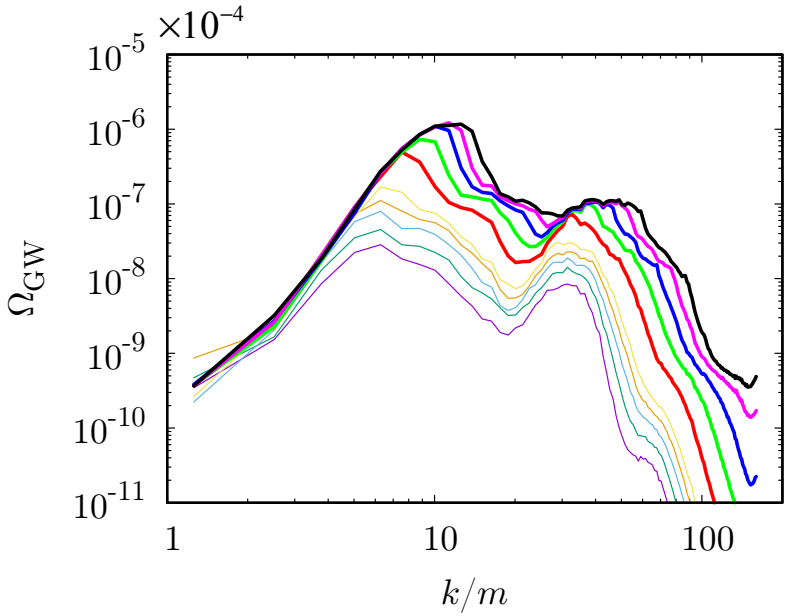
# GW production triggered by axion

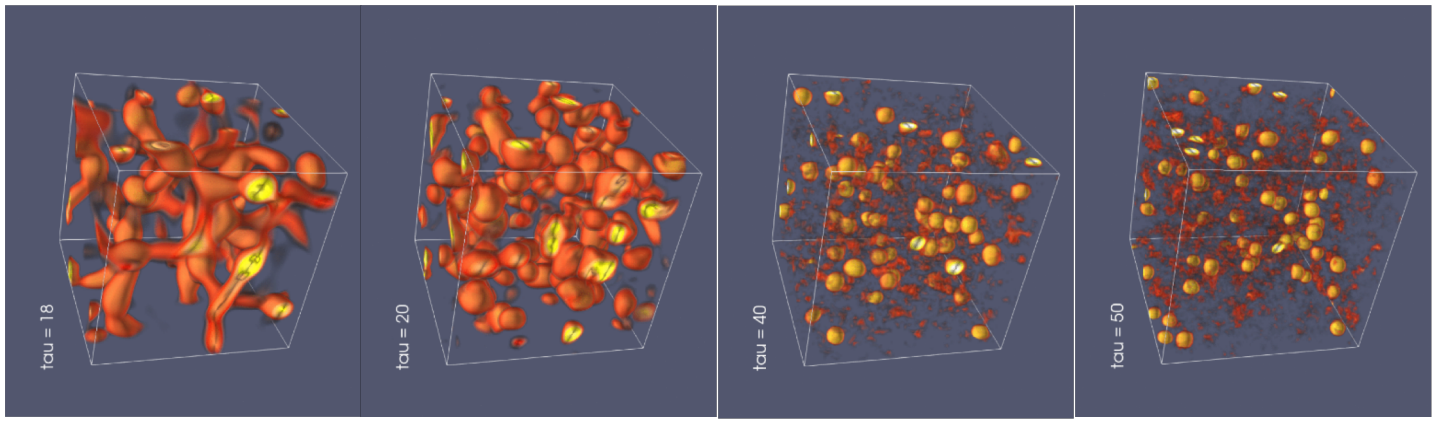
Kitajima, Soda & Urakawa 2018

Since axion is oscillating, there occurs a parametric resonance and the nonlinear inhomogeneity is developed during radiation domination. Subsequently, GWs are efficiently produced.

If we choose the decay constant $f \approx 10^{-2} M_p$

The peak frequency is determined by the axion mass.

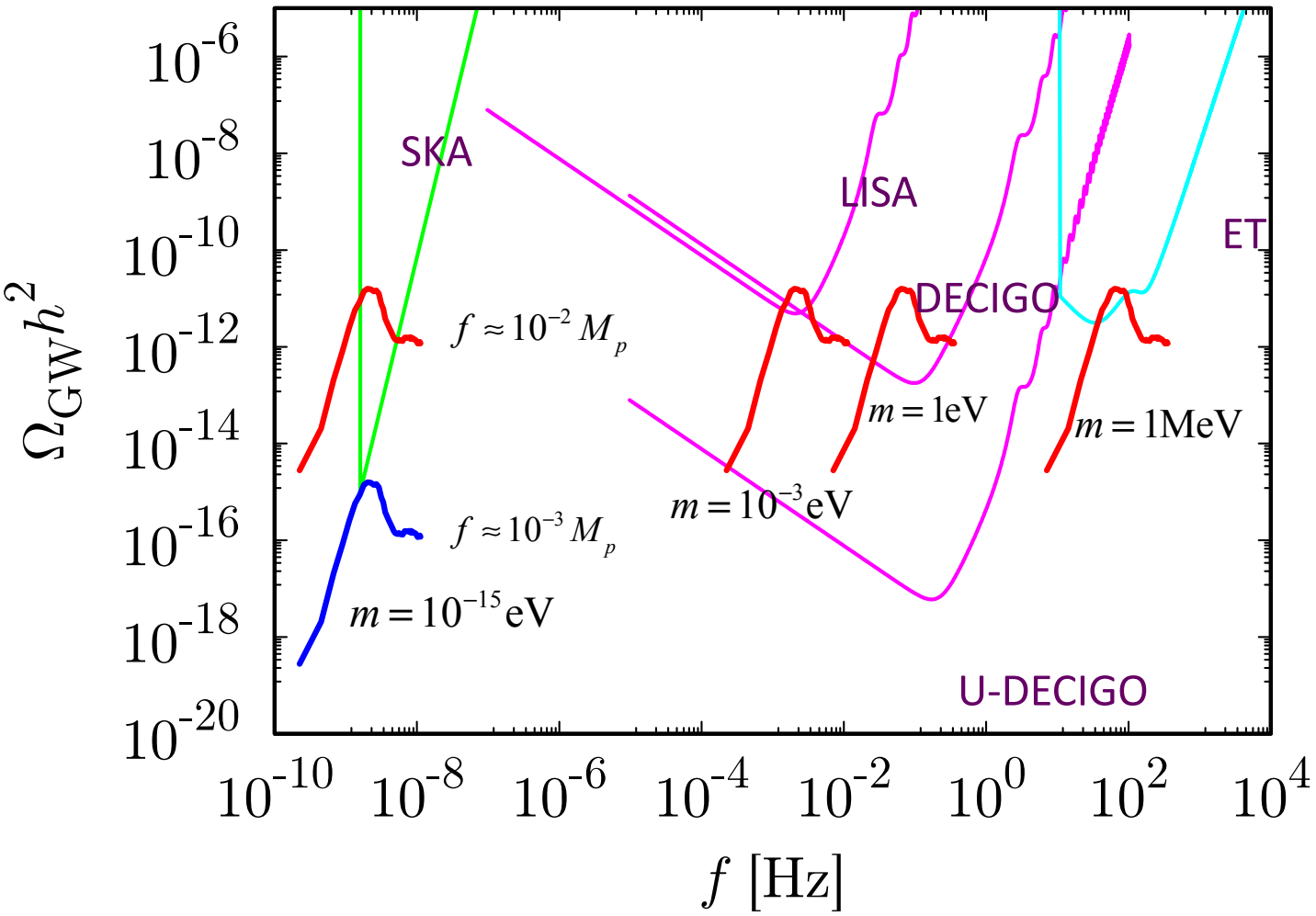


# GW Forest

Kitajima, Soda & Urakawa 2018

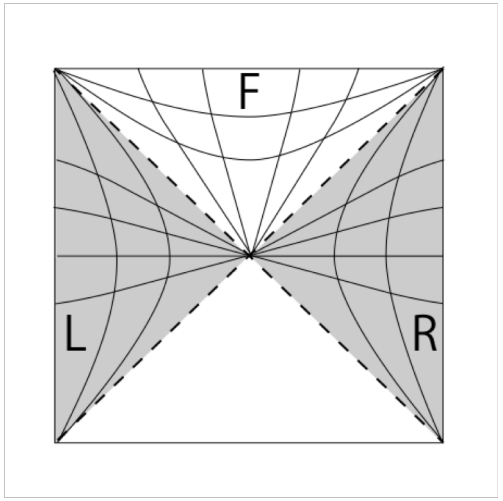
Since the string axions have a broad spectrum, there must be many peaks in the GW spectrum, which we named the GW forest.



# Kazuhiro Yamamoto

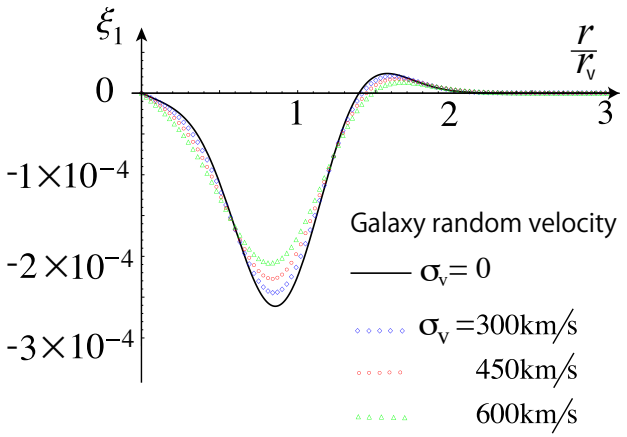
## Structure of vacuum and quantum fluctuations in de Sitter space

To clarify property of the quantum vacuum structure in de Sitter space, we have explicitly demonstrated the description for the vacuum states of a scalar field by the entangled states constructed with the static charts of the R and the L regions and with the coordinate of the F region.




## Predictions for galaxy clustering properties and dark energy model

- For a future test of general relativity, we investigated the **dipole component in the void-galaxy cross-correlation function** and found that it is useful to detect the gravitational redshift of voids.
- We developed a theoretical model of the higher multipoles of galaxy bispectrum in redshift space.
- We investigated the properties of a dark energy model with large-scale inhomogeneity and its observational signature.



# Hirosi Ooguri

# Swampland Question

Given an effective theory of gravity, how can one judge whether it is realized as a low energy approximation to a consistent quantum theory with **ultra-violet completion**, such as string theory?

Vafa: hep-th/0509212;
Vafa + HO: hep-th/0605264

# Landscape of Swampland Conditions