# Closing address for KEK Theory Workshop 2024

Jun Nishimura (KEK, SOKENDAI)

# The focus this year was tensor network and quantum computation

1st day : Dec.11(Wed)

Shinji Takeda “Tensor renormalization group and application to elementary particle physics”

Tsuyoshi Okubo “Recent progress in tensor network approaches for condensed matter physics”

Related talks on tensor networks : Akiyama, Yosprakob, Kwok, Tanaka, Kim

Hiroki Ohata “Bosonization revisited: application to the sign problem and lattice chiral fermion”

Related talks on sign problem : Nishimura, Miura, Piensuk, Tripathi, Yamamori

# Two approaches in tensor networks

## Lagrangian approach

Shinji Takeda

applications to particle physics

partition function represented
by tensor network

CFT data accessible
(conformal chage,
scaling dimensions)

energy spectrum

reduced density matrix
entanglement entropy
(without replica trick)

## Hamiltonian approach

Tsuyoshi Okubo

applications to condensed matter physics

ground state represented
by tensor network
minimizing the energy expectation value
by variational method
machine learning technique

spin liquid
ground state of Kitaev model
correctly reproduced

Phase diagram of various models
mapped out.

# bosonization

## Hiroki Ohata

Schwinger model = (1+1)dim QED
with theta term → sign problem

bosonized theory = sine-Gordon model (no sign problem)

Monte Carlo simulation is possible !

## Harunobu Fujimura

calculation of Renyi entropy in 2d massless Thirring model

Bosonized theory is free compact boson.

$2^{nd}$ Renyi entropy using replica trick
→ partition function of free compact boson on a torus (exact result)

confomal mapping

Quantum entanglement has been investigated in interacting QFT.

# Quantum computing

2nd day : Dec.12(Thu)

Yutaro Akahoshi “Partially fault-tolerant quantum computing architecture”

Tatsuma Nishioka “Quantum error correction and holography”

Yoshifumi Nakata “Decoding quantum information from chaos: beyond the standard situation”

# Quantum error correction

## Yutaro Akahoshi

surface code
T gate is difficult.
Replace it by $R_Z(\Theta)$ gate.

## Tatsuma Nishioka

5 qubit code
holographic codes
relation to AdS/CFT
entanglement wedge

## Yoshifumi Nakata

quantum error correction
using quantum chaos
Decoding is nontrivial.

Hayden-Preskill protocol
toy model of BH info paradox
explicit construction of decoder

related talks

## Sinya Aoki

AdS structure emerging from CFT
through smearing procedure
GKP-Witten relation from CFT

BH info paradox

## Yoshinori Matsuo, Tin-Long Chau, Cheng-Tsung Wang

# Tensor network as renormalization group, relation to quantum algorithms

3rd day : Dec.13(Fri)

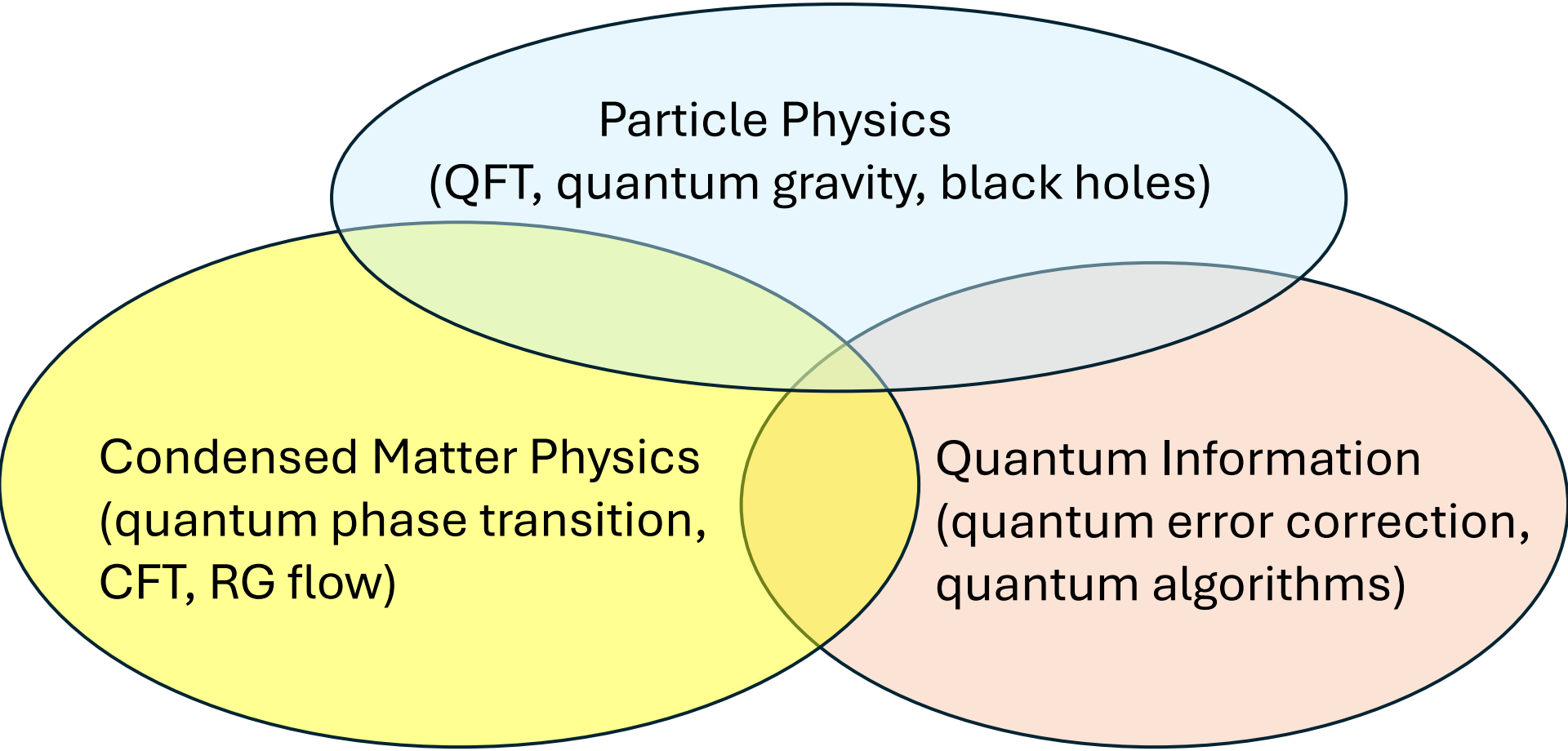
Masaki Oshikawa “Tensor networks as conceptual and computational tools for statistical physics”

Hiroshi Ueda “Advancements in numerical methods: synergy of tensor networks and quantum algorithms”

Slava Rychkov “Some rigorous and numerical results for renormalization groups of tensor”

Many other interesting talks on string theory, quantum field theory, etc..

# Fruitful discussions among reseachers from various fields



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Ph.D students (microphones, banquet etc.)

Shotaro Kawanago
Worapat Piensuk
Naoyuki Yamamori
Shotaro Yata
Cheng-Tsung Wang

See you again in
KEK Theory Workshop 2025 !