Off-shell mathematical science toward system's analysis and designing

Date： Feb. 22nd (Tue) 2022, 10:00 ～ 15:45
Feb. 24th (Thu) 2022, 10:00 ～ 16:15

Venue： Zoom meeting

Feb. 22nd (Tue) 2022

9:50 ～ 10:00

Opening remark: H. Sakuma (RODREP)

Session I：Dressed photon studies, keynote and selected speeches

10:00 ～ 10:45

Keynote speech: M. Ohtsu (RODREP)

Title: Recent progresses in experimental studies of dressed photons for off-shell science theories

Abstract: This presentation presents recent experimental results derived for promoting theoretical studies of off-shell science. It focuses on two essential phenomena. They are generation and energy transfer of dressed photons (DP). The former is found by evaluating the features of the light emitted from a silicon light-emitting diode; it exhibited anti-bunching in spite that it is composed of multiple photons. These photons imply the boson with spin 0, as have been theoretically identified by Sakuma. The latter is the experimental evaluations of DP generation efficiency of fiber probes. It agrees with the numerically simulated results based on the specific quantum walk (QW) model developed by Segawa. This agreement suggests that the QW model can be used as a powerful tool for analyzing the autonomous DP energy transfer that has been observed by a series of experiments.

10:45 ～ 11:30

Invited speech: S. Sangu, (Advanced Technology R&D Division, Ricoh Co., Ltd.)

Title: Considerations on dressed and free photon conversion and nanostructure formation

Abstract: It has been experimentally shown that chemical processing and dopant annealing under light irradiation induce autonomous nanostructure formation, and that the dressed photons play important role in the structure formation. On the other hand, the theory to explain these experimental situations are still inadequate, and a development of practical theory is expected for applications such as device design and optimization of device fabrication conditions. In this presentation, the conceptual model for the conversionbetween dressed and free photons is applied to the formation of a nanostructure mediated by the dressed photons, based on numerical simulations.

11:30 ～ 12:15

I. Banno, (Yamanashi Univ.)

Title: Theory of Quantum Dissipative Structure associated withDressed Photons

Abstract: The photon-breeding (PB) process [T. Kawazoe, M. A Mueed and M. Ohtsu, Appl. Phys. B**104**, p.747(2011)] makes light emitting diode from the indirect-type semiconductors. For along time, such the materials had been believed unsuitable for light emitting devices. The present theory describes the light emitting from the photon-breeding device, referringto the non-equilibrium thermodynamical theory of dissipative structure [G. Nicolis and I. Prigogine, "Self-Organization in Nonequilibrium Systems", Wiley (1977)]. The dissipative structure appears far from the equilibrium by balance between the entropy production in the system and the entropy dissipation out of the system. As suggested by the original theory, it is essential for the quantum version theory to treat the non-linear and open system. Our theory starts from the action integral in the non-relativistic quantum electrodynamics, and considers the nonlinearity employing the immanent vector potential,that is, dressed photon, and adjusts the causality and anti-causality together with the gauge function of the open system.

12:15 ～ 13:30

Lunch break

Session II: Dressed photon studies by quantum walk models, photosynthesis as a comparison study

13:30 ～ 14:15

E. Segawa, (Yokohama National Univ.)

Title: Comfortability of quantum walk

Abstract: A response from the surface of the internal graph is obtained by sequential input of quantum walks to the graph. This response tells some information on the graph structure. In this study, we will observe not only the information on the surface but also its interior induced by quantum walks. To this end, we introduce the notion of "comfortability" which gives how quantum walkers are stored in this graph for large time step; that is, how quantum walkers feel comfortable to this graph. We show that the comfortability can be expressed by some quantity of the graph geometry induced by quantum walk.

14:15 ～ 15:00

L. Matsuoka, (Hiroshima Institute of Technology)

Title: Maze-solving behavior in the quantum walk model on networks

Abstract: The study of the autonomous energy transfer of the Dressed Photons is in progress based on the specific quantum walk model. In this presentation, we show the recent progress of the study of the quantum walk model on the

network mazes where the shortest path is exhibited autonomously. We found the amount of the remained amplitude on the shortest path is expressed by rational numbers in most cases, which implies the existence of the mathematical rule corresponding to the network structure.

15:00 ～ 15:45

T. Yabuki, (Hokusei Gakuen University)

Title: Theoretical consideration on measures of quantum coherence and decoherence and its time evolution. =Towards to studies of photosynthesis=

Abstract: This presentation gives introductions of some kinds of measures for quantum coherence and decoherence which may begin with “Coherence and indistinguishability” proposed by L.Mandel, and has just now developed especially using “Purity of state”, and reports our theoretical comparative consideration and analysis on them, including an entropy measure. In the end, those recent studies of the time evolution of Purity and its recovery found in them are introduced, and our theoretical consideration and analysis on these results are reported.

Feb. 24th (Thu) 2022

Session III: Approaches from quantum field theories

10:00 ～ 10:45

H. Saigo, (Nagahama Institute of Bio-Science and Technology)

Title: Quantum Fields as Category Algebras

Abstract: In the present talk, we propose a new approach to quantum fields in terms of category algebras and states on categories. We define quantum fields and their states as category algebras and states on causal categories with partial involution structures. By utilizing category algebras and states on categories instead of simply considering categories, we can directly integrate relativity as a category theoretic structure and quantumness as a noncommutative probabilistic structure. Conceptual relationships with conventional approaches to quantum fields, including Algebraic Quantum Field Theory (AQFT) and Topological Quantum Field Theory (TQFT), are also discussed.

10:45 ～ 11:30

K. Okamura, (RODREP/Nagoya Univ.)

Title: On the Schrödinger picture in C*-algebraic quantum theory

Abstract: We discuss the Schrödinger picture in C*-algebraic quantum theory. In the Schrödinger picture, we treat the state change of the system caused by the dynamics (of the system and its environment). Dirac’s notion of transition probability plays a central role in this context. We formulate the Schrödinger picture using transition probability in a category theoretical way. Furthermore, we connect the theory of transition probability with quantum measurement theory. The axiomatic approach to quantum measurement in C*-algebraic quantum theory is consistent with sector

theory and gives good examples of transition probability in the category theoretical setting.

11:30 ～ 12:15

F. Hiroshima, (Math and Data, Kyushu Univ.)

Title: Semi-classical analysis between Newton-Maxwell equation and non-relativistic QED

Abstract: We are going to discuss the derivation of Newton-Maxwell equation, which describes interactions between classical electromagnetic field and electric charges, by applying semi-classical approximations to a certain dynamical model on quantum theory. Let (q(t), p(t), ¥alpha (k, t)) be a solution of Newton-Maxwell equation for a given initial data (q, p, ¥alpha(k)). A flow is defined to be a mapping connecting (q, p, ¥alpha(k)) and (q(t), p(t), ¥alpha (k, t)). We show that this flow can be derived through the notion of Wigner measure.

12:15 ～ 13:30

Lunch break

Session IV: Mathematical studies relating to the new theory of dressed photon

13:30 ～ 14:15

H. Sakuma, (RODREP)

Title: On the role of duality field for understanding “off-shell physics”

Abstract: In the comparison of “on-shell vs. of-shell fields”, we think that the former corresponds to physical objects or systems under consideration, while the latter to a background to which we won’t pay special attention. This simple view can be likened to the relation between a given physical system under consideration and spacetime as a “background” with which we describe the system. In the context of relativistic situations, we know that these two elements exist in a special interdependent way which may be called a kind of specific “duality”. In this talk, we discuss a possibility of opening up a novel view in pursuing off-shell science by reconsidering such a specific “duality”.

14:15 ～ 15:00

Y. Fukumoto, (IMI Kyushu Univ.) and R. Zou, (Department of Civil & Environmental Engineering, University of Hawaii at Mānoa, USA)

Title: Noether's first and second theorems and Nambu bracket for fluid and MHD equations

Abstract: For the ideal fluid dynamics and magnetohydrodynamics (MHD), Noether's theorem states that the topological invariant associated with the particle relabeling symmetry is the cross helicity, the volume integral of the scalar product of the velocity field and a frozen-in field. A proof to it is given in terms of variation of the Lagrangian label as a function of the Eulerian position. In the non-canonical Hamiltonian formalism, a topological invariant is no other than a Casimir (invariant). In addition to the cross-helicity, total mass, total entropy and the magnetic helicity

are Casimirs. We construct the Nambu bracket for the ideal fluid and for MHD, using all the four Casimir invariants, along with the total energy as the Hamiltonian. The Lie-Poisson bracket induced from the Nambu bracket gives an extension of the known one and automatically guarantees the cross-helicity to be a Casimir invariant. A remark is given to Noether's second theorem.

15:00 ～ 15:45

H. Ochiai, (IMI Kyushu Univ.)

Title: Symmetry of dressed photon and Grassmannian manifold

Abstract: Motivated by describing the symmetry of a theoretical model of dressed photons, we introduce several spaces with Lie group actions. We discuss the symmetry on these spaces using classical invariant theory, orbit decomposition of prehomogeneous vector spaces, and compact reductive homogeneous space s.

15:45 ～ 16:15

Wrap up discussion