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量子ウォーク数理の新展開: 物質制御への応用

開催時期 2013-06-17 10:00~2013-06-21 12:10

場所 九州大学 伊都キャンパス 数理学研究教育棟/マス・フォア・インダストリ研究所B1 122号室

量子ウォーク数理の新展開: 物質制御への応用

Exploring of quantum walks: approach to a material science

※ この研究集会はマス・フォア・インダストリ研究所 共同利用研究の公開プログラムです。

開催期間 2013年6月17日(月)~6月21日(金)

開催場所 九州大学 伊都キャンパス 数理学研究教育棟/マス・フォア・インダストリ研究所B1 122号室
[伊都キャンパスへのアクセス](#), [伊都キャンパスマップ](#)

【プログラム】 6月17日(月)
(全11講演)

10:00 - 10:30

講演者: Akira ICHIHARA (Japan Atomic Energy Agency)

講演《An analytic expression to evaluate rotational transition processes of diatomic molecules in an optical frequency comb》

Abstract: We derived an analytic expression of the rotational population probability of diatomic molecules in the comb electric field which is given by a form of a periodic delta function. The diatomic molecule is approximated with a rigid rotor. The spectral frequencies of the comb are tuned to the molecular rotational transition frequencies. The formulation was performed using the spectral decomposition technique, and there we assumed the commutation of Hamiltonians between different time. The derived probability amplitude can be shown by the sum of the Bessel function of the first kind and other oscillating functions. The time dependence of obtained probability is given as a step function, which is consistent with computer simulations. Thus our formulation provides an analytic solution of the quantum delta-kicked rigid rotor model.

10:40 - 11:10

講演者: Leo Matsuoka (Japan Atomic Energy Agency)

講演《Developing an analytical model for evaluating imperfect rotational excitation cascade of molecules in a slightly detuned optical frequency comb》

Abstract: We introduce our attempts to develop an analytical model to evaluate the upper limit of rotational excitation by the slightly detuned optical frequency comb. An optical frequency comb induces the continuous-time quantum walk (CTQW) on a series of rotational states of diatomic molecules in an ideal situation. However, in real systems, the dispersed wave-packet is reflected at a certain upper limit due to the imperfection of frequency resonance which is caused by the centrifugal distortion. To find a unified parameter to evaluate the upper limit of rotational excitation, we inserted the effects of the frequency detuning into the CTQW model. We derived an analytical expression, which converges to the Bessel function in the limit of small detuning.

11:20 - 12:00

講演者: Etsuo Segawa (Tohoku University)

講演《Mapping theories of quantum walks》

Abstract: There exist two kinds of quantum walks, i.e., discrete- and continuous-time quantum walks. We show that spectrum of the quantum walks on graphs is constructed by the following two parts. First one is expressed by maps from corresponding random walk's spectrum to the unit circle. Second one, especially for the discrete-time quantum walk, characterizes circles of the graph.

References:

[1] E. Segawa (2013), Localization of quantum walks induced by recurrence properties of random walks, J. Comput. Theor. Nanosci., in press, arXiv:1112.4982.

[2] N. Obata, N. Konno, E. Segawa (2013), Localization of Grover walk on spidernet, Communications in Mathematical Physics, in press, arXiv:1206.4422.

6月18日(火)

10:30 - 12:00

講演者 : Keiichi Yokoyama (Japan Atomic Energy Agency)

講演 《**Studies for isotope separation based on the quantum control of molecules**》

Abstract: Through an appropriate control of quantum systems, one of the social problems regarding nuclear wastes may be solved. If we can "transmutate" the harmful wastes like Cs-135 into stable species, future potential public exposure of radioactivity will be suppressed by two orders of magnitude and, moreover, a sustainable nuclear energy system without emission of radioactive wastes will be realized. The feasibility of transmutation itself has already been proven. The remaining key technology which is not yet prospective is only the isotope separation with extremely high selectivity. In recent years, we are involved in this challenging research theme by approaching it with the technique of quantum control of molecules. In the present talk, review of conventional techniques, strategy to overcome the difficulties, some of our studies, existing technological gaps, and remaining scientific questions will be addressed.

13:20 - 14:50

講演者 : Norio Konno (Yokohama National University)

講演 《**An introduction to quantum walk and its applications**》

Abstract: The quantum walk (QW) can be considered as a counterpart of the classical random walk and has been extensively studied since around 2000, see [1,2], for example. First I sketch out the basic properties of QWs. After the introduction, I give some applications of QWs.

References:

[1] N. Konno (2008), Quantum walks, Lecture Notes in Mathematics, Vol.1954, Springer, pp.309-452.

[2] S. E. Venegas-Andraca (2012), Quantum walks: a comprehensive review, Quantum Information Processing, Vol.11, pp.1015-1106.

6月19日(水)

10:00 - 11:00

講演者 : Yusuke Ide (Kanagawa University)

講演 《**Continuous time quantum walks on some graphs**》

Abstract: Continuous time quantum walks (CTQWs) are viewed as quantum counterpart of continuous time random walks (CTRWs). However, the distributions of CTQWs are different from that of CTRWs. In this talk, I would like to show some results on the distribution of CTQWs on some graphs including threshold graphs and a graph consists of cycle plus an extra edge. The eigenspace of graph Laplacian plays an essential role in analysis of the distributions.

11:10 - 12:10

講演者 : Hyun Jae Yoo (Hankyong National University, Korea)

講演 《**Large deviation principle for Markov chains and some applications**》

Abstract: First, we discuss a large deviation principle for Markov chains. As a simple application, we show the invertibility of diagonally dominant matrices, which is a Taussky's theorem. Next, we try to apply it to open quantum random walks. Attal et al. introduced the concept of quantum trajectories for open quantum random walks, which is a Markov chain on the quantum state spaces.

6月20日(木)

10:30 - 12:00

講演者 : Salvador E. Venegas-Andraca (Tecnologico de Monterrey Campus Estado de México and Disruptive Computer Technologies, SA de CV)

講演 《**Quantum walks: a concise review with emphasis on quantum walk-based algorithms, computational universality and potential applications**》

Abstract: Quantum walks, the quantum mechanical counterpart of classical random walks, is an advanced tool for building quantum algorithms that has been recently shown to constitute a universal model of quantum computation. Quantum walks is now a solid field of research of quantum computation full of exciting open problems for physicists, computer scientists and engineers. In order to provide a concise introduction to quantum walks, to contribute to further development of our discipline as well as to think of new scientific and engineering applications of quantum walks, will talk about three topics:

1. will review the foundations of both discrete- and continuous-time quantum walks, together with the role that randomness plays in quantum walks, the connections between the mathematical models of coined discrete quantum walks and continuous quantum walks, as well as a succinct review of experimental proposals and realizations of discrete-time quantum walks.

2. will review several algorithms based on both discrete- and continuous time quantum walks as well as a most important result: the computational universality of both continuous- and discrete-time quantum walks.

3. The tremendous success of computer science in modern society is mostly due to its pervasiveness. If quantum computing is to have not only spectacular results but also long-term success, it is compulsory to find how exactly Mankind will benefit from the realization and commercialization of quantum computers. The role of classical random walks to develop stochastic algorithms for NP-complete problems (K-SAT) is a traditional justification for doing research on quantum walks. With the purpose of stimulating new discussions about plausible applications of quantum walks in challenging problems of contemporary society, in the last part of my talk I will present some applications of classical random walks in several branches of science and engineering.

13:20 - 14:20

講演者 : Salvador E. Venegas-Andraca (Tecnologico de Monterrey Campus Estado de México and Disruptive Computer Technologies, SA de CV)

講演《**Quantum Image Processing and Quantum walk-based Morphological Operators**》

Abstract: Computer science and computer engineering are disciplines that have definitely permeated and transformed every aspect of modern society. In particular, the field of image processing is a pervasive and cross-disciplinary branch of computer science that focuses on storing, manipulating and retrieving visual information in computer systems. Image processing is a most important discipline in many branches of science and engineering (e.g. astrophysics, pattern recognition, medical diagnosis and oil extraction) due to our constant and increasing need to extract information out of images and videos. Because of the restricted architecture of classical computers and the often overwhelming computational complexity of state-of-the-art classical algorithms in image processing, finding efficient algorithms to manipulate visual information is an important research area in this field. Mathematical morphology is a scientific field, based on set and lattice theories, devoted to analyzing and processing structures contained in images. Quantum Image Processing is a discipline devoted to the development of novel quantum algorithms for storing, processing and retrieving visual information. If quantum image processing, as quantum computing in general, is meant to have a long-term success, it is compulsory to find how exactly Mankind will benefit from it, i.e. we need to find some 'killer applications' of quantum image processing. With the purpose of stimulating new discussions about plausible applications of quantum image processing in challenging problems of contemporary society, in this talk I will address three topics:

1. I will concisely introduce the field of classical image processing, with a particular focus on how classical random walks are used for building algorithms in this field and related areas. Moreover, I will present several open problems in this field and related areas
2. I will provide a state-of-the-art review of quantum image processing.
3. I will present a quantum walk-based version of fundamental mathematical morphology operators.

6月21日(金)

10:00 - 11:00

講演者 : Tatsuaki Wada (Ibaraki University)

講演《**Anomalous slow diffusion in nonlinear quantum walk**》

Abstract: We propose a simple nonlinear generalization of a discrete-time quantum walk on a line by incorporating a nearest-neighbor interaction into the coin operator. In this model the coin operator depends on the coin states of the nearest-neighbor sites in the previous step. We show that our proposed model has an anomalous slow diffusion, and its long-time behavior is characterized by the porous medium equation.

Reference: arXiv:1303.3432

11:10 - 12:10

講演者 : Yutaka Shikano (Institute for Molecular Science)

講演《**How to implement the discrete time quantum walk in the hybrid quantum system?**》

Abstract: In this talk, we propose a quantum-electrodynamics scheme for implementing the discrete-time, coined quantum walk with the walker corresponding to the phase degree of freedom for a quasi-magnon field realized in an ensemble of nitrogen-vacancy centres in diamond. The coin is realized as a superconducting flux qubit. Our scheme improves on an existing proposal for implementing quantum walks in cavity quantum electrodynamics by removing the cumbersome requirement of varying drive-pulse durations according to mean quasiparticle number. Our improvement is relevant to all indirect-coin-flip cavity quantum-electrodynamics realizations of quantum walks. Our numerical analysis shows that this scheme can realize a discrete quantum walk under realistic conditions.

Reference: arXiv:1301.1050