Title of Project： Dynamic Exciton: Emerging Science and Innovation

IMAHORI Hiroshi
(Kyoto University, Graduate School of Engineering, Professor)

Number of Research Area：20A201　Researcher Number：90243261

【Purpose of the Research Project】

Photochemistry is expected to play a versatile role in electronics, energy, medicine/heath care, and functional materials in modern society. In molecular donor-acceptor (D-A) systems, charge-transfer (CT) has been regarded as "static exciton" governed by Coulombic interaction (left bottom of Figure 1). However, in addition to Coulombic interaction, dynamic effects including movement of atomic nucleus and lattice as well as spin-orbit interaction influence behavior of electron and spin with the passage of time ranging from femtoseconds to seconds (defined as "dynamic exciton", right middle of Figure 1). For instance, recently power conversion efficiencies of organic photovoltaics (OPV) have been improved remarkably, but there is a limit to understanding the underlying mechanism solely from a framework of "static exciton", as things stand at the moment, becoming a bottleneck of high-performance OPV. Moreover, to get more deep insight into the dynamic effects occurring at primary stages of photophysical and photochemical events, it is needed to exploit precise spectroscopic measurements and theoretical treatments. In this project, we aim to solve the above issues by merging rational molecular design based on the dynamic effects with world-leading high-resolution spectroscopies and unique theoretical analyses. In particular, we focus on manipulating CT states for energy conversion such as organic light-emitting diodes (OLED) and OPV in term of electron-vibration and spin-orbit couplings (Figure 1).

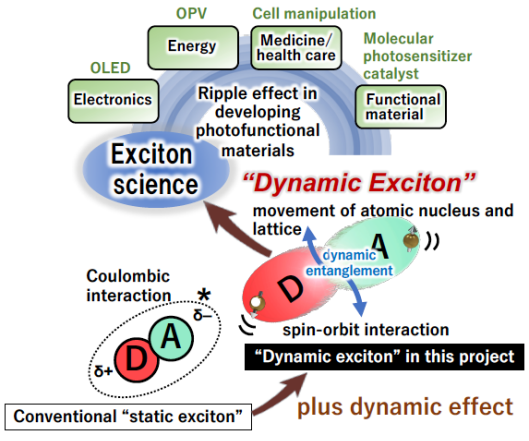


Figure 1. Purpose of the research project.

【Content of the Research Project】

In this project, we concentrate on four major topics: (1) creation of new D-A molecules and D-A model systems; science and technology of (2) OLED, and (3) OPV; (4) exploration of synthetic and biological features. Meanwhile, "Dynamic Exciton Creation (A01)", is a group of experts on well-tailored design and synthesis, "Dynamic Exciton Evaluation (A02)", that on the advanced measurements and precise analysis, and "Dynamic Exciton Function (A03)", that on the exploration of novel features. By integrating three complimentary groups synergically, we commit ourself to finding solutions to the above challenges.

【Expected Research Achievements and Scientific Significance】

In this project, we work towards not only interdisciplinary fusion of various academic fields including physics, chemistry, and biology by focusing on "dynamic exciton", creating a new comprehensive, photoinduced CT science, but also exploring versatile practical features such as OPV, OLED, molecular photosensitizer catalyst, and optical cell manipulation, which would be beneficial for modern society.

【Key Words】

Exciton: In physics exciton is defined as a state where electron and hole are bound tightly by Coulombic interaction. In chemistry exciton is considered as a locally excited (LE) state of donor (D*) or acceptor (A*) molecule. If a system composed of D and A segments is excited, partial charge-transfer (CT) may take place from D* to A or from D to A* to yield a CT state $(D^{\delta+}\text{-}A^{\delta-})^*$ possessing character of the LE states. In an extreme case complete ET occurs from D* to A or from D to A*, generating a charge-separated (CS) state $(D^{+\bullet}\text{-}A^{-\bullet})$ losing character of the LE states. Since all three cases highlight electron-hole pairs, we propose to extend the terminology exciton into an integrated class of LE, CT, and CS states.
Organic photovoltaics: OPV is a molecular D-A-based device for solar energy-electricity energy conversion. In this research project, we strive to manipulate CT states for achieving high photovoltaic performance.

【Term of Project】

FY2020-2024

【Budget Allocation】

1,140,800 Thousand Yen

【Homepage Address and Other Contact Information】

https://dynamic-exciton.jp
imahori@scl.kyoto-u.ac.jp

Title of Project： Next Generation Astrochemistry: Reconstruction of the Science Based on Fundamental Molecular Processes

SAKAI Nami
(RIKEN, Cluster for Pioneering Research, Chief Scientist)

Number of Research Area：20A202　Researcher Number：70533553

【Purpose of the Research Project】

Planet formation is a natural consequence of the star formation process, and there is an incredible variety of planetary systems, which are significantly different from the Solar System. Recent ALMA observations have revealed chemistry in planet-forming regions. Various complex organic molecules are found in protoplanetary-disk forming regions, and their abundances vary significantly among objects. This indicates that the Solar System may not have been common in terms of its initial chemistry, which invokes the discussion on the rarity of our existence. Progress of the Solar System exploration, including the recent successful return of the Hayabusa2 spacecraft, makes it possible to analyze pristine Solar System materials directly. The combination of such analysis with high-sensitivity observations of planet-forming regions will tell us the chemical origin of our Solar System and how common or rare it is in the universe. However, to tackle these questions, we have to revisit fundamental astrochemical processes. In the past decades, the astrochemical studies focused on chemistry under extremely low temperature and density conditions, where only barrierless exothermic reactions proceed efficiently. During the planetary system formation, on the other hand, the physical condition changes dynamically resulting in dynamic interactions of molecules between gas and dust(ice) surface. Investigation of such physical and chemical processes is crucial to understand the formation of complex organic molecules and the chemical variety of planet-forming regions. This transformative research area aims at the re-establishment of “astrochemistry” by investigation of the microscopic chemical processes with the close collaboration of astronomy, planetary science, and molecular science, and also aims at understanding the origin of the Solar System from the view of chemistry.

【Content of the Research Project】

Following studies are planned in our research area.

1) High resolution/sensitivity observations and laboratory spectroscopy to explore the entire view of chemical evolution and its diversity.

2) Analysis of extraterrestrial organics, including the returned Ryugu samples, along with laboratory experiments to reproduce the Solar System organics.

3) Experimental study on gas-phase reactions based on advanced beam technologies. Reaction pathways and rate coefficients are investigated as a function of temperature.

4) Experimental study on dust surface reactions, which aims at the molecular-scale elucidation of the reaction elementary processes by the single-molecule surface spectroscopy.

5) Theoretical astrochemistry based on microscopic processes in the gas and solid phases. Construct the model of chemical evolution model during the star and planet formation by the combination of hydrodynamic calculations, reaction parameters obtained by the laboratory experiments and quantum chemical calculations.

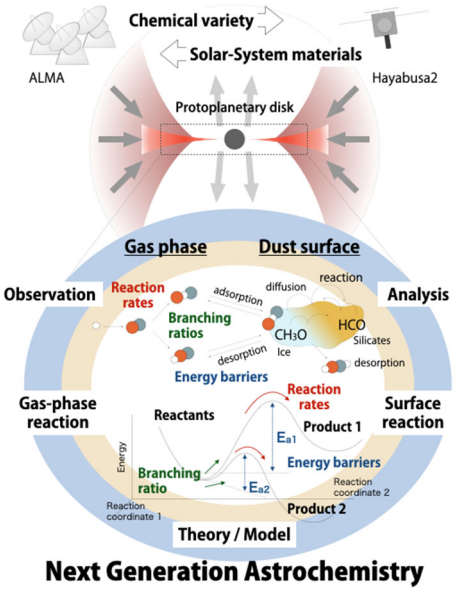


Fig 1. Next generation astrochemistry to reveal the chemical evolution along with the star/planet formation based on microscopic chemical processes.

【Expected Research Achievements and Scientific Significance】

The next generation astrochemistry will reveal the chemical evolution in the star/planet formation and the commonness/uniqueness of the origin of the Solar System. It is also applicable to various physical conditions in space, i.e., the material evolution in the Universe in general, and enable us to use chemistry as a diagnostic tool for the structure formation. Our research area is also beneficial to various fields such as astrobiology, exoplanet research, material science, molecular chemistry, and surface science.

【Key Words】 Astrochemistry : Chemistry taken place in space, which includes the Solar system and interstellar clouds.

【Term of Project】 FY2020-2024

【Budget Allocation】 931,200 Thousand Yen

【Homepage Address and Other Contact Information】

https://next-astrochem.com
nextac_admi@ml.riken.jp

Title of Project： What is dark matter? - Comprehensive study of the huge discovery space in dark matter

MURAYAMA Hitoshi
(The University of Tokyo, Kavli Institute for the Physics and Mathematics of the Universe, Professor)

Number of Research Area：20A203　Researcher Number：20222341

【Purpose of the Research Project】

"Dark matter" certainly exists and plays a critical role in formation of all cosmic structures such as stars and galaxies. However, the nature of dark matter has yet to be known. As guided by particle physics, most efforts have focused on WIMP dark matter candidates in the mass range of two order magnitudes, but observations and experiments in 2010's did not find any clue of WIMP. There is now growing interest in non-WIMP dark matter candidates. In this program, to comprehensively cover the vast discovery space of dark matter search spanning 90 orders of magnitudes in the mass scale, we aim at opening up research areas using theoretical approaches, observations of the Universe, and terrestrial experiments.

【Content of the Research Project】

To perform a comprehensive study of dark matter that is a dominant component of matter in the Universe today, we focus on three categories of dark matter candidates, "light dark matter", "heavy dark matter", and "macroscopic dark matter".

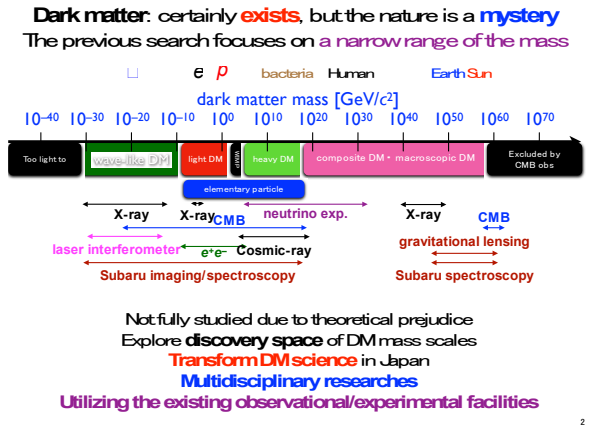


Fig 1. The mass range of dark matter candidates, and the purpose of this research program

Theory groups under this program (A01 – A03) will study generation mechanism of dark matter in the early universe and dark matter physics, and explore observation and experiment methods for dark matter search. Observation and experiment groups (B01 – B06) will explore the nature of dark matter using new methods based on the unique idea/consideration from this group and/or taking advantage of the cutting-edge observational data of the Universe. More exactly, we will use laser interferometer experiment (B01), spectroscopic data of Subaru telescope (B02), the innovative technical method/data in X-ray energy range (B03), high-cadence, wide-field-of-view imaging data in optical wavelengths (B04), electron-position accelerator experiment (B05), and cosmic microwave background (B06). Moreover, the research group (C01) will take a top-down approach such as quantum gravity to explore ultimate theory explaining the existence and physics of dark matter. The group (C02) will use numerical simulations to study how different dark matter models lead to characteristic features in cosmic structure formation. These C01 and C02 groups help and stimulate synergetic research between different research groups for dark matter physics. Thus we form a comprehensive research group covering both theory and observations/experiments and aim at unveiling the nature of dark matter during the period of this program.

【Expected Research Achievements and Scientific Significance】

We can obtain more stringent constraints on the nature of dark matter than previously obtained during the period of this research program. We will achieve realization of new table-top experiment, led by junior researchers in our group, and explore axion and gauge-boson dark matter candidates from the experiment data. We will explore X-ray emission originating from annihilation of dark matter from the cutting-edge data of the new-generation X-ray satellite XRISM that will be launched in 2022. We will use the cutting-edge imaging data from the already-running HSC camera at the 8.2m Subaru Telescope to obtain the unprecedented large three-dimensional map of dark matter in the Universe, and search for macroscopic dark matter candidates such as primordial black holes. Furthermore, using the data from wide-field, multi-object spectrograph, PFS, at the Subaru telescope, which is under construction and will be operated from 2023, we will obtain constraints on self-interaction strength and/or de Broglie wavelength of dark matter from the observations of dwarf galaxies in the Milky Way. In addition, we use the PFS data to obtain improved constraints on gamma-ray signals of dark matter annihilation from dwarf galaxies. We will also use the cosmic microwave background data to constrain axion dark matter or dark matter annihilation signal at the recombination epoch. Furthermore, we will install a new trigger into the Super-K Belle II accelerator that just started to be operated, and use the data to explore dark photon and SIMP dark matter. We aim to obtain these exciting new results during the period of this research program.

【Key Words】

Dark Matter: a form of matter thought to account for most of the matter in the Universe. Its presence is implied in a variety of astrophysical observations, and dark matter is believed to play a critical role in formation of cosmic structures. However, its nature is still a mystery.

【Term of Project】 FY2020-2024

【Budget Allocation】 1,130,500 Thousand Yen

【Homepage Address and Other Contact Information】
http://member.ipmu.jp/DarkMatter/

Title of Project： Condensed Conjugation Molecular Physics and Chemistry: Revisiting "Electronic Conjugation" Leading to Innovative Physical Properties of Molecular Materials

SEKI Shu
(Kyoto University, Graduate School of Engineering, Professor)

Number of Research Area: 20A204　Researcher Number: 30273709

【Purpose of the Research Project】

Herein, we will establish a novel concept of intermolecular electronic conjugation, referred to as "X"-conjugation, by revisiting thoroughly the longitude and latitude in the development of "conjugation" in chemistry. Starting from the precise design of organic molecules with well-confined intermolecular spaces, thermal fluctuations in the condensed phases of molecular systems will be controlled perfectly by the wide-range/spatial alignment of intermolecular interactions as well as the leading-edge energy dissipation theory. Such control will result in extraordinarily high density-of-states (DOS) in the molecular substances. A series of unique assessment techniques of opto- and magneto-electronic properties of molecular materials is presently the central complex of the current research project, pioneering the unprecedented properties of molecular systems with "X"-conjugation.

【Content of the Research Project】

We will approach the establishment of "X"-conjugation and its unprecedented physical properties through the following three strategies:

I) "X"-conjugation beyond σ- and/or π-conjugation

Since the beginning of π-electron conjugation in the 1890s, "π" electrons have been always the key player in electronic conjugation where the electronic states are stabilized by electron delocalization within a molecular skeleton. After the long interval of 50 years, electron delocalization over σ-bonding was established as σ-conjugation. These electronic conjugations have been defined in terms of the angular momentum of electrons in the atomic orbitals of elements. Now, our question is: Are there other electronic conjugations? Revisiting the first definition of conjugation as energy gain in electron delocalization, we must have room for establishing a new electronic conjugation in intermolecular spaces. By filling out the space with electrons/electronic states, the new "X"-conjugation must be found. The establishment of this conjugation is the consensus of our research project entitled "Condensed Conjugation of Molecular Physics and Chemistry" To achieve an extraordinarily high DOS in the condensed phases of organic molecules, including systems with "X"-conjugation, we will pave the following steps: (1) shrinking the intermolecular spaces to the limit (0.3 nm), (2) aligning precisely and programmatically the extremely wide-dynamic-ranging intermolecular interactions that control the thermal fluctuations of molecules, and (3) loading electrons/spins onto molecules and realizing new electronic states that contribute to the overall high DOS.

II) Toward unprecedented properties of "X"-conjugation

The electronic properties of organic molecular systems include extremely wide tunability; this property is the nature of organics, as represented by a single carbon-based material exhibiting both insulating and superconducting phases. The effective mass of electrons is controllable from a massless state to a considerably heavy state in strongly correlated systems; such characteristic inspires us to explore the huge potential of "electrons in space with tunable DOS." The nature of the electrons and their physical properties will be revealed with the unique complex of assessment techniques.

III) Interpretation of "X"-conjugation through simple and sophisticated theories/formulations.

The history of physics and chemistry illustrates that the new "X"-conjugation must be interpreted with simple and sophisticated theories/formulations. A concrete theoretical basis of intermolecular electronic conjugation, including "X"-conjugation, is provided and published as an international standard for future electronic conjugations.

【Expected Research Achievements and Scientific Significance】

In this research project, we aim to 1) explore the ubiquitous nature of massless electrons and 2) search for "heavy" electrons by designing "X"-conjugated molecular systems embedded with strongly correlated electron systems. The electron mobility in condensed-organic-molecular materials has reached 500 $cm^2V^{-1}s^{-1}$, which is competitive with Si-based materials. We will demonstrate the potentials of "X"-conjugated molecular materials as leading alternatives for future electronic materials. Moreover, the extremely wide tunability of DOS leads to the strong localization of electrons in specific sites with high effective mass, resulting in spin/charge frustrated systems, ferro/antiferro magnetism, and ferro/antiferro electricity of molecular materials. We will lead a paradigm shift in the research of organics from flexible/printable materials to prospective platforms to achieve ultimate opto- and magneto-electronic properties.

【Key Words】

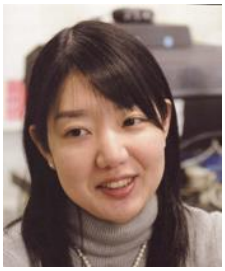
"X"-conjugation: New and unexplored concept of electron conjugation over molecular materials. The major target of the present research groups.

【Term of Project】 FY 2020–2024

【Budget Allocation】 1,168,000 Thousand Yen

【Homepage Address and Other Contact Information】

https://x-con.jp
X-conjugation-admin@t.kyoto-u.ac.jp



Title of Project： Biophysical Chemistry for Material Symbiosis

YAMAYOSHI Asako
(Nagasaki University, Graduate School of Biomedical Sciences, Professor)

Number of Research Area：20A205 Researcher Number：70380532

【Purpose of the Research Project】

In our body, we have some amazing symbiotic relationships with other organisms. The relationship between a mother and her unborn baby is a representative example of them. The mother does not reject her fetus, even though the fetus is completely another organism. This symbiosis is achieved *via* "symbiotic communications" between mother and fetus using an intricate and fascinating system, the placenta. Another intriguing example is the relationship between humans and our intestinal bacteria.

In contrast, although many different types of functional molecules, including biological drugs and biocompatible materials, have so far been developed, a symbiosis between humans and non-self molecules/materials has not fully been established. We have just started this unique research project to define what exactly is "material symbiosis." The primary goal of our material symbiosis project is to delineate previously-neglected, weak but specific interactions between living cells/biomolecules and materials, and eventually find ways to achieve material symbiosis in our body. In the end, we are hopefully able to compile knowledge obtained through this project, and establish a new field–what we call "biophysical chemistry for material symbiosis."

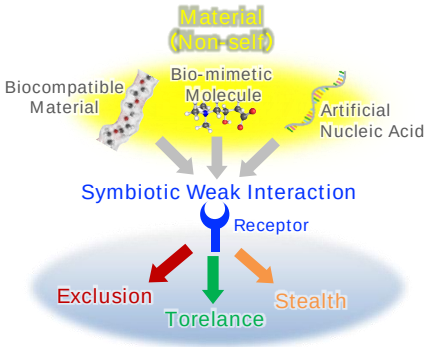


Figure 1. Schematic illustrations of "Symbiotic Weak Interaction" between materials and living cells /biomolecules.

【Content of the Research Project】

Three research groups pursue individual goals to elucidate underlying interactions between living cells/biomolecules and materials.

[A01] The A01 research unit is a center for measurement of "weak interactions" for material symbiosis. It is not easy to visualize and quantify the fast and unstable interactions that occur in living organisms; therefore, we try to develop novel imaging systems, structural analyses, physicochemical analyses, computational approaches, and other methods to identify symbiotic weak interaction.

[A02] In the A02 research unit, we are specifically focusing on interactions between biomolecules and materials. These interactions can be broken down into various elementary interactions, such as electrostatic, hydrogen bonding, hydrophobic, *van der Waals* forces. We translate the relationship between biomolecules and materials into more fundamental biophysics and chemistry terms such as thermodynamic, kinetic parameters, and other possible variables.

[A03] The goal of the A03 research unit is designing and creating novel materials that symbiotically interact with biomolecules. Such materials will be developed based on the unique knowledge of symbiotic interactions obtained in this program. We also analyze the biological responses induced by these functional molecules.

【Expected Research Achievements and Scientific Significance】

Our mission in this research project is to elucidate relationships between biomolecules and materials in terms of biophysical chemistry and to develop biomaterials that exhibit desired relationships with biomolecules or living cells. Conventional approaches for molecular design have been explored for efficient interactions between a ligand and its receptors with high specificity and high affinity. However, our immune system immediately responds to such materials and tries to exclude them from our body. One expected outcome of this project will be an effective design guideline for materials and drugs to avoid conventional side effects such as immunogenicity and induction of malignancy.

【Key Words】

Material Symbiosis: We refer to the symbiosis between human living cells and materials as "material symbiosis". The main feature of this research project is to understand and elucidate "material symbiosis" from the mechanism of material recognition through "symbiotic intermolecular communications" by living cells or biomolecules.

【Term of Project】 FY2020-2024

【Budget Allocation】 1,144,300 Thousand Yen

【Homepage Address and Other Contact Information】

https://material-symbiosis.jp

【Grant-in-Aid for Transformative Research Areas（A）】

Section Ⅱ

Title of Project： Progressive condensed matter physics inspired by hyper-ordered structures

HAYASHI Koichi
(Nagoya Institute of Technology, Faculty of Engineering, Professor)

Number of Research Area：20A206　Researcher Number：20283632

【Purpose of the Research Project】

The functional properties of various materials is attributable to the cooperative effects between the matrix and dopants. Thus, the science of defects has significantly progressed. However, as long as the dopant is used as a point defect, there is a limit to the functional properties that can be achieved.

In this project, we will proactively use “hyper-ordered structures” to break through that limit. “Hyper-ordered structures” are nanostructures composed of different elements and vacancies. For example, the In-Nb-Ti^{3+} structure in FIG. 1(a) contributes to enhancing the dielectric constant of titanium oxide by 1000 times. Unlike ordinary single-element doping, we can pursue infinite possibilities of functionality originating from these “hyper-ordered structures” by controlling the combination of elements and their 3D arrangement.

Figure 1(b) shows the atomic arrangement of zeolite before crystallization, which forms a geometrically highly ordered vacant structure. It is known that the relationship between this vacant structure and the Al dopant correlates to the high temperature durability of zeolite catalysts. Such a relationship between the vacant structure and the dopant is also regarded as a "hyper-ordered structure", which can be described by the concept of topology.

“Hyper-ordered structures” can be regarded as a treasure trove of material functionality. The purpose of this project is to bring a new breakthrough in material science based on accurate determination, profound understanding, and effective control of “hyper-ordered structure”, which can be achieved by advanced experimental, theoretical, and synthetic techniques.

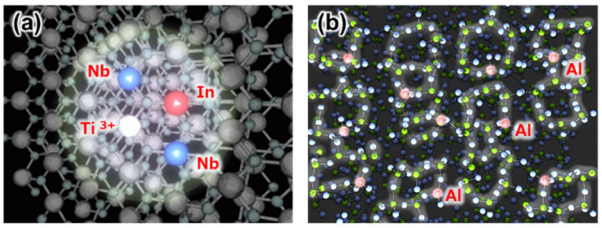


Fig. 1 Example of "hyper-ordered structure". (a) In-Nb-Ti^{3+} nanostructure in TiO_2. (b) Crystal-like topology in amorphous zeolite.

【Content of the Research Project】

This project sets three research targets: (A) “dopant-induced hyper-ordered structures”, (B) “hyper-ordered structures with vacancies and voids”, and (C) “hyper-ordered structures at crystal/amorphous boundary”. The organization consists of A01 sample team, A02 measurement team, and A03 theory team.

The "hyper-ordered structures" embedded in various materials will be accurately determined by site-selective quantum beam in combination with computational techniques. We will elucidate their functionality, and design a new “hyper-ordered structure” using large-scale first-principles calculations. In addition, by utilizing mathematical methods such as topology analysis, we will propose descriptors for “hyper-ordered structures”. Based on these insights, we will promote efficient exploration of “hyper-ordered structure” materials utilizing data science. We will go beyond the idea of single-site doping and pave a way to create a highly functional materials based on a topology control.

【Expected Research Achievements and Scientific Significance】

This project possesses the world's highest level of analysis techniques for determining “hyper-ordered structure”. In this project, further development of these analysis techniques can be achieved, and the international leadership of Japan can be solidified.

This project will also develop an emerging research field that connects crystalline and amorphous materials. It is expected that new academic fields will be created, which induces collaboration in fields that have few common ground. Through such collaborations, many young researchers will be cultivated.

In terms of applications, some breakthroughs are expected. For example, “Innovative dielectric with 1000 times the relative permittivity and high temperature stability”, “Super heat resistant zeolite deNOx catalyst”, “Low cost thin film transistor with 100$cm^2/V{\cdot}s$ mobility”, “Unbreakable cover glass for smartphones”, etc., which can contribute to the development of Japanese industry.

【Key Words】

Hyper-ordered structure: a characteristic nanostructure formed by dopants and vacancy. Specifically, complex defects due to different elements and vacancies, and nanoscale atomic arrangements that show a topological order even if they are amorphous.

【Term of Project】

FY2020-2024

【Budget Allocation】

1,155,300 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.hyperordered.org
khayashi@nitech.ac.jp

Title of Project： Comprehensive understanding of scattering and fluctuated fields and science of clairvoyance

MATOBA Osamu
(Kobe University, Organization for Advanced and Integrated Research, Professor)

Number of Research Area：20A207　Researcher Number：20282593

【Purpose of the Research Project】

Optics and related imaging techniques have played essential roles in the development of natural sciences. However, one of the fundamental problems that cannot be overcome even with state-of-the-art optics is scattering and fluctuation that disturbs the straightness of propagating light. While the scattering theory determined by wavelength and particle size has already been established, there is no theory to deal comprehensively with the four-dimensional (three-dimensional space and time) scattering and fluctuations that exist ubiquitously in the real world such as air, water, and living organisms.

The purpose of this research area is to comprehensively understand and overcome the scattering and fluctuation phenomena that exist ubiquitously in multi-scales of nanometer to kilometer size in three-dimensional space. For that purpose, we establish new optical measurement techniques to obtain the physical quantities of light propagation in scattering and fluctuation media in the real world from the living body to the atmosphere, and develop new scattering theories and deep learning to elucidate the scattering and fluctuation phenomenon that exists on a multi-scale. Furthermore, by seeing through scattering and fluctuation media themselves and beyond, we will bring the innovation to natural sciences such as life science and astronomy, and information and communication technology. By promoting above researches, we will create “Science of clairvoyance” as a unified integrated academic area dealing with scattering and fluctuation phenomena, and this is the goal of this research area.

【Content of the Research Project】

For the establishment of new integrated academic area as “Science of clairvoyance”, we will create digital twin modeling that mutually interacts optical measurement technology and mathematical modeling methods. We will measure the scattered light in detail and visualize the light propagation through living tissues, surface air, and atmosphere, which are multi-scale scattering and fluctuation media in the real world. By developing mathematical modeling to analyze and model multi-scale scattering and fluctuation media, we will establish a new scattering theory to comprehensively understand scattering and fluctuation and correct them for clairvoyance. To accomplish those purposes, we set up following three research sub-fields. A01: Physical basis of science of clairvoyance, A02: Mathematical basis of science of clairvoyance, and A03: Science of clairvoyance in actual problems. A01 includes physical basic researches on imaging methods and optical systems to comprehensively elucidate the properties of complex and diverse scattering and fluctuation fields, and to compensate them to achieve clairvoyance. A02 includes mathematical basic researches on mathematical modeling and mathematical approaches for the essential understanding of scattering and fluctuation fields. A03 includes the measurement of scattering and fluctuation fields in the real world, elucidation of scattering and fluctuation phenomena in multi-scale, and verification of the effectiveness of our clairvoyance theory and techniques. We will create innovative academic fields through collaboration within and between research sub-fields.

【Expected Research Achievements and Scientific Significance】

Based on the research results in this area, we will establish “Science of clairvoyance”, which aims at comprehensively understanding the scattering and fluctuation phenomena that exist ubiquitously in multi-scales of nanometer to kilometer size in three-dimensional space. This makes it possible to see through scattering and fluctuations by physical and mathematical approaches and clarify the information inside and beyond. It is also possible to utilize the scattering and fluctuations themselves as information. The academic fields that are transformed by “Science of clairvoyance” are not limited to life science, information and communication technology, and astronomy that are being tackled in this research area. Since it can be applied to multi-scales, it covers a wide range of fields involving light, such as applied physics including nanomaterials, medical science including abnormal cell detection and non-contact health management, and maintenance engineering including infrastructure defect inspection.

【Key Words】

Scattering and fluctuations: Light travels straight in a medium with a uniform refractive-index field, but in spatially and temporally non-uniform fields, the straightness of light is lost and the path of propagating light cannot be specified.

【Term of Project】 FY2020-2024

【Budget Allocation】 1,159,100 Thousand Yen

【Homepage Address and Other Contact Information】
http://www.org.kobe-u.ac.jp/scattering_clairvoyance/