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

Section Ⅱ

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

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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/