



Title of Project : Hypermaterials: Innovation of materials science in hyper space

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Research Project Number : 19H05817 Researcher Number : 50307708

【Purpose of the Research Project】

The discovery of quasicrystals, with high symmetry impossible for three-dimensional periodic crystals, has brought about a paradigm shift in crystallography and has overturned the definition of crystals that have been accepted for hundreds of years. The quasicrystal has a cross-sectional structure of a high-dimensional periodic crystal, and another extra space called "complementary space" is required to describe the atomic structure. This project aims at establishing a new concept of substances, "hypermaterial", which is a high-level concept that includes the existing concept for substances, and also at creating a new theory that incorporates the concept of hypermaterial.

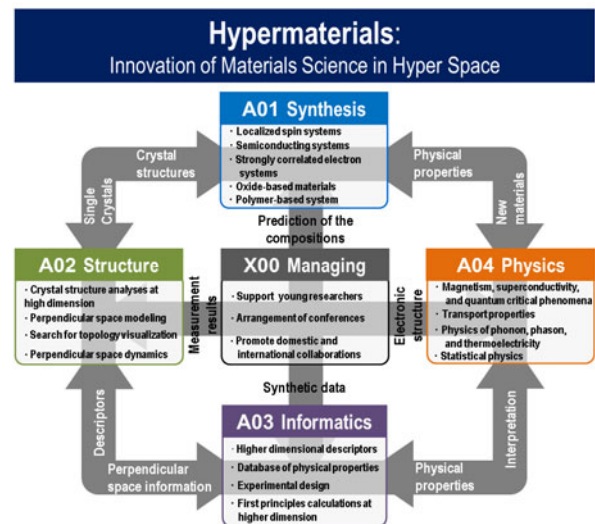
【Content of the Research Project】

In order to achieve the above purpose, this project will be conducted with four research groups (Figure).

- [A01] Synthesis of Hypermaterials
- [A02] Structure of Hypermaterials
- [A03] Hypermaterials Informatics and the Search for Hidden Orders
- [A04] Physics of Hypermaterials and the Search for Hidden Orders

The A01 group challenges to synthesize new metallic, semiconducting, ceramic, and polymer hypermaterials, partly based on the material compositions provided by the A03 group. In the A02 group, the static and dynamic structure of the newly synthesized hypermaterials are investigated by using X-ray, neutron beam, etc. In the A03 group, a database of hypermaterials is constructed, and the descriptors related to the stability of hypermaterials will be identified. Also, the descriptors related to the structure and physical properties of hypermaterials are searched in the real space as well as in the complementary space, and predictions of the compositions and physical properties of hypermaterials are performed. In the A04 group, the physical properties of the newly synthesized hypermaterials are measured, and the states of electrons, spins, phonons, etc. are investigated. Also, in cooperation with the A02 group, the physical quantities are mapped to the complementary space in order to elucidate the hidden orders, and their interpretation is performed.

Through active collaborative research among the four research groups, we will search for new physical properties and new phenomena, which cannot be obtained with conventional crystals, and will create new materials science based on the complementary space.



Organization of the Project

【Expected Research Achievements and Scientific Significance】

1. Hidden orders behind the complex behaviors of hypermaterials will be elucidated, and a new theory that incorporates the hidden orders will be developed.
2. The hypermaterial is a high-level concept of substances including existing periodic crystals, and this project will bring us a new material view, that is, leading us to view the structural information in the complementary space.
3. The world of hypermaterials will expand not only in metals, but also to semiconductors, ceramics, polymers.

【Key Words】

Hypermaterial: Abbreviation of "material" in "hyper space (high-dimensional space)". Quasicrystals and approximant crystals can be described as cross-sectional structures of high-dimensional periodic crystals. Hypermaterials refer to the substances described in a high-dimensional space in a unified way, and are characterized by having structural information not only in the real space but also in the "complementary space".

【Term of Project】 FY2019-2023

【Budget Allocation】 791,200 Thousand Yen

【Homepage Address and Other Contact Information】

<http://www.rs.tus.ac.jp/hypermaterials/html>