Hiroshima University

International Institute for Sustainability with Knotted Chiral Meta Matter (SKCM²)

Center Director
Ivan I. Smalyukh

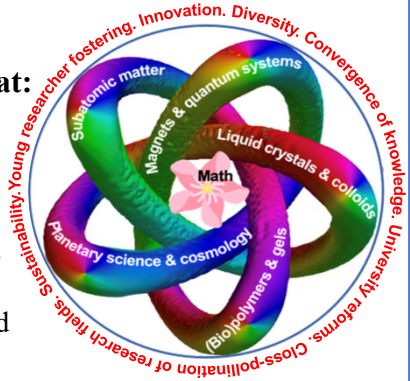
Professor Smalyukh is a World leader in material research and a recipient of many awards, including a presidential career award from the US White House. Within this project, he and the Center aspire to create new types of artificial materials by design, with physical properties not encountered in natural systems. This approach will enable highly desirable material properties needed to help address challenging global problems, like the growing energy demand and climate change.

Mission

We will develop artificial analogs of molecules, atoms and even smaller building blocks of nature to gain deeper understanding of the World around us. We will introduce designable materials with highly desirable properties not encountered in nature, as well as create foundations for technological innovation to solve global problems & enable sustainable future. While pursuing this research, we will create a testbed for research-based graduate education reforms in Japan & beyond, connecting young talent globally and inter-linking natural & social sciences for sustainability.

Identities

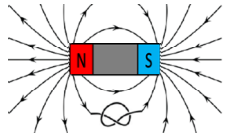
SKCM² is the only institute globally that:



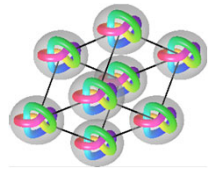
- develops knots in fields as designable building blocks of artificial matter, thus introducing a new paradigm of "knotted chiral meta matter"
- creates materials from such artificial designable particles to exhibit highly unusual & technologically useful properties, overcoming nature's limitations
- cross-pollinates mathematical knot theory & chirality knowledge across disciplines & scales

Research

Just like one can make a knot in a string, physical field lines (like the force field lines created by a magnet) can be knotted too. These knots then exhibit properties of particles, which are artificial analogs of atoms. We can create them at will in materials like magnets & liquid crystals with the help of chirality, a property of objects with mirror images not overlapping each other, like our right and left hands. We seek to establish a research paradigm of "knotted chiral meta matter," with such knots in physical fields as its building blocks. We will probe fundamental laws of nature at scales from its smallest building blocks to the entire Universe through recreating natural phenomena in experimentally accessible systems, like the liquid crystals used in displays. To accomplish this, we will integrate knowledge in pure & applied math with that in physics, planetary science, cosmology, biology, material science & engineering. By knotting & knitting physical fields and molecules, much like in the Mizuhiki artforms, we will help reveal mysteries of nature & enable new physical behavior & desirable properties that overcome its limitations. We will create crystals of knots in fields and other artificial analogs of natural matter, making new materials by design. For example, we will enable thermal superinsulation needed to save energy wasted for heating and cooling buildings, which consume 40% of all energy generated globally. Saving this energy by adopting our materials would help reduce the global energy demand and mitigate climate change.



force field lines



Knotted chiral meta matter

Superinsulation

Collaborations

SKCM² is a partnership of Hiroshima Univ. with RIKEN, Univ. of Tokyo & Tokyo Tech in Japan & MIT, CU-Boulder & Georgia Tech in the USA, Utrecht Univ. in the Netherlands, Cambridge Univ. in the UK, Max Plank Institute in Germany, Univ. of Wroclaw in Poland & Academia Sinica in Taiwan.