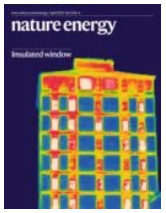
World Premier International Research Center Initiative (WPI)
FY2022 WPI Project Progress Report

Host Institution	Hiroshima University	Host Institution Head	Mitsuo Ochi
Research Center	International Institute for Sustainability with Knotted Chiral Meta Matter (SKCM^2)		
Center Director	Ivan I. Smalyukh	Administrative Director	Manabu Abe (Shinichi Tate from 4/1/23)

Summary of State of WPI Center Project Progress (write within 2 pages)

1. Advancing Research of the Highest Global Level

Since its formal establishment in November 2022, our WPI-SKCM^2 is quickly becoming the premier global center aiming to develop artificial analogs of atoms and even smaller building blocks of nature to gain a deeper understanding of the world around us & to introduce designable materials with highly desirable properties not encountered in nature. Through fundamental research, SKCM^2 also creates foundations for technological innovation to solve global problems & enable a sustainable future. Our WPI introduces the paradigm of "knotted chiral meta matter", striving to deepen fundamental understanding of natural phenomena through creating their pre-designed analogs, as well as help solve the "knotty" Global problems of growing energy demand & climate change by designing matter with highly desirable material properties. Through multiple on-site (including the Kickoff Symposium) & online meetings & exchanges, the WPI center successfully engaged 19 PIs & 8 co-PIs from all over the world, creating the SKCM^2 partnership of top researchers at Hiroshima Univ., RIKEN, Tokyo Tech, Keio Univ., MIT, CU-Boulder & Georgia Tech, Univ. Lisbon, Utrecht Univ., Cambridge Univ., Max Plank Institute, Univ. of Wroclaw, Tel Aviv Univ. & Academia Sinica. The researchers developed detailed plans for collaborations that they already pursue while jointly co-mentoring postdoctoral fellows & Ph.D. students, working on highly interdisciplinary projects within this WPI's scope. While the time period of the SKCM^2's existence is short, its name has already appeared in research articles (over 40) in many premier scientific journals like *Science, Nature Materials, Nature Physics, Nature Energy* (also on cover). The Director developed & implemented the new Meritocracy Principles that strongly encourage the WPI members to pursue the most challenging/ambitious scientific efforts and disseminate them via publications in the very top high-impact journals as well as via plenary, keynote & invited presentations at the top-level scientific meetings. Among examples of recent breakthroughs, SKCM^2 researchers discovered a new topological field configuration that is a hybrid structure of a soliton & an unknot of twist disclination with the topology of the Möbius strip [*NATURE PHYS.* **19**, 451-459 (2023)], uncovered the steering powers of nematic vortices in guiding solitonic laser light with potential technological utility in storing energy [*NATURE MATER.* **22**, 64-72], probed (within a large external collaboration) macromolecular organic matter of a carbonaceous asteroid samples brought to earth [*Science* **379**, 790 (2023)], as well as demonstrated how aerogels formed by entangled nanocellulose fibers exhibit extreme thermal insulation and high transparency at the same time [*Nature Energy* **8**, 381-396 (2023)] & [*Nature Energy* **8**, 327–328 (2023)]. Our work attracted a great deal of excitement. For example, [*Nature Energy* **8**, 381-396 (2023)] was featured over 100 times (including on the journal cover) & was downloaded over 12,000 times in about a month since publication. Overall, the WPI researchers strive to pursue highly ambitious goals that also have a potential for contributing to sustainability, where many new breakthroughs are happening while this report is being prepared and await to be reported in peer-review literature in the very near future.



2. Advancing fusion of research fields

Our center integrates the knot topology and chirality, which manifest themselves in phenomena on many length and time scales, across the natural hierarchy, from elementary particles to biological and cosmic systems, as well as in pure math, planetary sciences, and cosmology, & so on. Focusing on the significant new discovery, we are elucidating the emergent synergy of knot topology and chirality while dealing with a hierarchy of length and time scales as well as with the creation of entirely new concepts, laws, and generalizations, which are only possible within an interdisciplinary, international research network, like our WPI. This motivates us to cross-pollinate and fuse the topology- and chirality-focused research domains, bringing together researchers representing different fields but sharing common knots/chirality interests. We create a new interdisciplinary knotted chiral meta-matter research domain that is not a branch of physics, chemistry, biology, or material science, nor that is a subfield of engineering, but rather

is an intrinsically interdisciplinary mixture of these, a pursuit in which substantial progress is made simultaneously in the context of all these fields. Our WPI holistically explores the co-enabling role of chirality and knot topology at subatomic-to-cosmic scales, focusing on tabletop research and the translation of fundamental knowledge into applications that could enable technological breakthroughs. While the bulk of our research focuses on experimentally highly accessible systems, like liquid crystals, colloids, magnets, and biopolymers, our findings will immediately impact the studies of objects and phenomena on less accessible scales, like cosmology & elementary particles. Conversely, particle physics & cosmology theories inspire us to develop a deeper understanding and practical utility of related phenomena based on these accessible systems. The anticipated future technological applications enabled by our fundamental research range from sustainable energy-efficient building technologies to materials for extraterrestrial habitats to biomedical detection and treatment of diseases and to spintronics and data storage devices. Already within the 5-month performance period, WPI researchers produced many such discipline-fusing research works (e.g., see all articles referenced on 1st page above, some of which were co-authored by multiple PIs). To practically promote the fusion of research fields, our WPI requires that all WPI-supported students & postdocs have three co-mentors each (a primary mentor & 2 co-mentors), where these co-mentors have to represent different disciplines & at least one of the co-mentors has to be from a WPI node outside of Japan. Weekly seminar series that we organize on Thursdays feature both world-renowned speakers & local HU-based researchers and are designed to inspire & initiate cross-disciplinary international collaborations. Similarly, the Kickoff Symposium featured knot/chirality-focused talks given by representatives of different fields who are fusing interdisciplinary knowledge in their research, inspiring our students & postdocs, as well as the PIs & coPIs, to follow these examples.

3. Establishing an international research environment

We are establishing a robust, highly effective environment with optimal conditions for international collaborations and young researcher exchanges. For this, we hired bilingual support staff & established infrastructure to receive international scholars at HU. PIs from international institutions have their research group footprints at HU & direct collaborative research, mentoring & co-mentoring postdocs & students at HU. The WPI kickoff symposium was just held (over 120 participants) & an annual WPI school is being planned for later in 2023, where all members get together for a week (symposium) or two (school) to allow for extensive discussions & exchange ideas. Close communication among members is the top priority of this WPI's management. Current efforts include (1) international research exchanges, schools, conferences & forums, (2) organizing visits of international students & renowned scholars to HU, (3) efforts to hire at least 20% of staff from outside of Japan to benefit from the best administrative practices in other countries, (4) efforts to assure handling paperwork & all WPI activities in English, (5) setting an effective environment for international engagements of foreign researchers, including things like schooling of children, & (6) developing procedures for effective sample exchanges & visitor support.

4. Reforming the research organization

Our WPI intends to reform the HU research & education system while building on the best practices from around the world, with the help of our international PIs & co-PIs. For example, the Director implemented the meritocracy scheme first within the WPI, which will now be perfected & then adopted within the entire HU. Procedures related to meritocracy are discussed extensively with PIs/co-PIs, University administrators, & feedback on its further improvement is welcome so that valuable suggestions can be accounted for when this procedure will be applied again at the end of the next fiscal year. Our WPI is developing a new Graduate Program modeled based on the best practices of the US and UK graduate programs. For this, we invited the Director of the Interdisciplinary program "Topological design" (Mark Dennis) from U. Birmingham, as well as students from the US and UK to engage in our planning of details of the new program. The first graduate students will be admitted (currently applying) to start on October 1, 2023.

5. Efforts to secure the center's future development over the mid- to long-term

While currently temporarily using an existing building on campus, we secured space within the university to build the new building for SKCM^2, as well as applied to various sources of funding for the building construction, including from MEXT, HU & private sources. We have formally introduced SKCM^2 as a new institute at HU, with its regulations and bylaws suitable to serve its very important role. We have established the administrative office while building on the best practices of other WPIs. Three Deputy Directors & the Admin Director support the Director to assure smooth operation and swift decision-making. Further, meetings with President Ochi, PI/co-PI meetings & Steering Committee meetings are regularly held to discuss the WPI functioning & external funding opportunities, which are now being pursued. HU provided support to hire five skilled administrative staff. Overall, HU provides & is committed to providing

in the future full-fledged support, treating WPI as an important institute with a "special district" status.

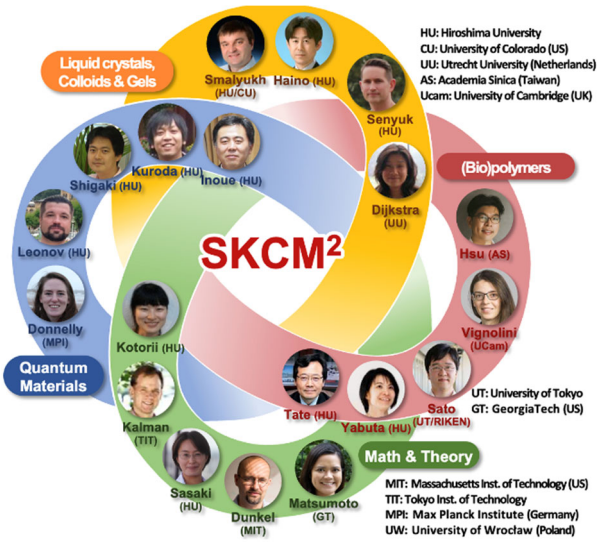
Common instructions:
* Unless otherwise specified, prepare this report based on the current (31 March 2023) situation of your WPI center.
* So as to execute this fiscal year's follow-up review on the "last" center project plan, prepare this report based on it.
* Use yen (¥) when writing monetary amounts in the report. If an exchange rate is used to calculate the yen amount, give the rate.
  - Prepare this report within 10-20 pages (excluding the appendices, and including Summary of State of WPI Center Project Progress (within 2 pages)).
* Describe clearly and concisely the progress being made by the WPI center project from the following viewpoints.

1. World-Leading Scientific Excellence and Recognition

1-1. Advancing Research of the Highest Global Level

* Among the research results achieved by the center, concretely describe those that are at the world's highest level. In Appendix 1, list the center's research papers published in 2022.

The first works published by our WPI members since its establishment already illustrate how our WPI introduces the new paradigm of knotted chiral meta matter, with its own analogs of fundamental particles and antiparticles, with profoundly deep insights ranging from the inner workings of the world to the origins of life and to fundamental breakthroughs capable of enabling green technologies needed for sustaining it. Among examples of very recent breakthroughs, SKCM^2 researchers discovered a new topological field configuration that is a hybrid structure of a soliton & an unknot of twist disclination with the topology of the Möbius strip [*NATURE PHYS.* **19**, 451-459 (2023)], uncovered the steering powers of nematic vortices in guiding solitonic laser light with potential technological utility in storing energy [*NATURE MATER.* **22**, 64-72], probed (within a large external collaboration) the macromolecular organic matter of carbonaceous asteroid samples brought to earth [*Science* **379**, 790 (2023)], as well as demonstrated how aerogels formed by entangled nanocellulose fibers exhibit extreme thermal insulation and high transparency at the same time [*Nature Energy* **8**, 381-396 (2023)] & [*Nature Energy* **8**, 327–328 (2023)], where all these papers appear with our WPI's affiliation. Our work has attracted a great deal of excitement already. For example, *Nature Energy* **8**, 381-396 (2023) was featured over 100 times (including on the journal cover) & was downloaded over 12,000 times in about a month since publication.



More generally, aiming to create entirely new embodiments of everything, from fundamental (anti)particles to quasi-atoms and quasi-molecules to both liquid & solid crystals of knots and to materials with highly unusual properties, our WPI's knotted chiral meta matter paradigm deepens fundamental understanding of natural phenomena through creating their pre-designed analogs, as well as aims to solve the knotty Global problems of growing energy demand & climate change by designing matter & unusual, highly desirable materials. This paradigm builds on particle-like quasi-atom properties of topological knot solitons, knotted vortices, and knots in colloidal or (bio)polymer molecular strands, with our PIs (knot diagram) being the international inter-disciplinary team of global research leaders in this emergent new field working as a team. Pursued by this our highly interdisciplinary international team of PIs, the fusion of topology & chirality research in this paradigm-changing context allows for new concepts and material/structural design strategies that may otherwise seem impossible. For example, our combined experimental and theoretical studies reveal what types of topological knot solitons can be stabilized by chirality in material systems, providing insights into topologically similar objects in other, experimentally less accessible systems, like particle physics and cosmology. While the bulk of our research focuses on experimentally highly accessible systems, like LCs, colloids, magnets, and biopolymers, our findings will have immediate impacts on the studies of objects and phenomena on less accessible scales, like the still elusive types of elementary particles and cosmic strings, for which even their very existence remains unknown. Conversely, particle physics and cosmology theories inspire us to develop a deeper understanding and practical utility of related phenomena based on these highly accessible condensed matter and biological systems. Potential technological applications that could be enabled by emergent knot chirality research range

from energy-efficient building technologies to thermally insulating materials, to bio-detection, treatment of diseases, spintronics, electro-optics & data storage.

Overview of ongoing research efforts. Our center is structured to optimize our ability to pursue ambitious research goals while most effectively using available resources. It comprises four research thrust areas shown in the above knot diagram. Considering the space limit of this document, we first give a brief general overview of the research of different thrusts and the cross-pollinating interactions between them, & then provide additional details in relation to examples of specific efforts. Within the research thrust area on liquid crystals (LCs), colloids & gels, the goal is to develop new forms of knotted soft matter. Haino synthesizes new chiral LCs & nano-colloidal systems; Smalyukh uses them as host media for novel solitons, vortices and crystals, whereas Senyuk exploits such solitonic active matter to gain insights into the behavior of knot quasi-atoms in an out-of-equilibrium setting. Additionally, LCs with designable high-dimensional order parameter spaces are modeled & co-implemented by Dijkstra, Smalyukh, Haino & co-PI Tasinkevych. Sato synthesizes new breeds of knotting-enabled high-porosity gels, like hydrogels & aerogels, & collaborates with Smalyukh to control & understand properties like infrared reflectivity, visible-range transparency and thermal conductivity, as needed for future building envelope applications. The research thrust of quantum matter knots explores multi-dimensional topology in both real and momentum spaces in spin systems and quantum chromodynamics (QCD). Inoue leads synthesis of new magnetic materials designed to host multi-dimensional topological solitons and their crystals. These efforts are guided by the modeling of stability diagrams by Leonov & Smalyukh & culminate in direct 3D experimental visualizations/mapping by Donnelly. Sasaki, Nonaka & Leonov collaborate to explore fundamental synergies between the phase diagrams in spin systems and QCD, and then Shigaki works with Inoue and Donnelly to experimentally probe these insights from the condensed matter and nuclear physics perspectives. Kuroda & Kimura study the momentum-space multi-dimensional topology, once again developing synergies with particle physics related to Weyl and Dirac semimetals in the solid state, working closely with Sasaki, Smalyukh, and Leonov. Within the (bio)polymer thrust, Yabuta studies the topology of nano-sized organic matter in extraterrestrial materials (e.g. from meteorites), as well as carries out an enantiomer analysis of not only amino acids but a larger suite of organic compounds in extraterrestrial objects to reveal how molecular chirality in Space played a role in chemical evolution toward the origins of life. Tate & Hsu study the role of knotting & solitonic configurations in biopolymers like RNA & DNA & in defining protein structures in contexts ranging from fundamental properties of biopolymer knotting & linking to Alzheimer's disease & Coronavirus mutations. Sato synthesizes molecules "programmed" for knotting & linking in controlled ways and for self-assembly into materials with unusual mesoscale structures enabled by chirality-controlled spontaneous knotting/linking. Vignolini & Smalyukh study how knot solitons can emerge in the natural photonic structures (like in cuticles of beetles) and hierarchically self-assembled cellulose nanocrystal based chiral LCs. We work to address many fundamental, inter-disciplinary questions on relations between chirality and the different knots (& their crystals) in vortices, colloids, LCs, proteins & so on. This study of various knots & solitons in diverse physical, chemical & biological systems will be integrated through the deep connections with mathematical knot theory modeling by Kotorii, Kalman, Sasaki, Dunkel & Matsumoto & the co-PIs from the entire Hiroshima knot theory group. We intend to expand the current cohort of PIs by bringing in 5-10 new hires at HU, further enhancing & integrating these research thrusts to further boost cross-pollination between the diverse research fields. Considering the size constraints of this proposal, below we provide detailed descriptions of specific current efforts for only a representative subset of activities that are pursued towards the overarching goals of creating our new paradigm described above.

High-energy nuclear physics: Shigaki (PI), Sasaki (PI), Nonaka (coPI), Nitta (coPI). Shigaki's group is currently devising a new detector named Muon Forward Tracker (MFT) that was installed in the ALICE at CERN in Switzerland, which enables to explore how heavy quarks (charm, beauty) behave and chiral symmetry restoration in the fireball of quarks and gluons. Shigaki operates MFT to study the extreme state of Quantum-Chromo-Dynamics (QCD) matter using proton-proton and nucleus-nucleus collisions. The research will reveal the evolution of the very early universe. Shigaki's group also engages in the next-generation international project of nuclear physics with Electron Ion Collider that will be constructed at Brookhaven National Laboratory in the US in 2030s. His group builds the time of flight (TOF) detector using advanced AC-LGAD sensor technology. This new research will gain more profound insights into the internal structures of hadrons like protons. Sasaki has been recently collaborating with Shigaki and Nonaka on a model for dilepton production in relativistic heavy-ion (HI) collision with chiral mixing, a crucial step in the QCD phase transition in

a medium. She revealed the direct consequence of dropping axial-vector meson mass on the production rates, which serves as the signatures of chiral symmetry restoration. They found a sizable difference from the case without chiral restoration, and she predicts there exists a high chance of measuring a trace of chiral crossover in HI experiments. Sasaki also works on parity-doublet, the nucleon, and its parity partner in focusing their influence on the susceptibility of baryon numbers. She found that individual component with both parities possesses the same critical exponent, while their strengths are different according to the parity quantum number, and the component with positive parity can become even negative. This theoretical study suggests that the proton number fluctuation demands carefully interpreting the HI experimental data. In a collaboration among SKCM^2 researchers, they explore the physics of chiral symmetry in QCD by combining their expertise: theory (Sasaki), phenomenology (Nonaka), and experiments (Shigaki), as well as working closely with condensed matter researchers (PIs Inoue, Leonov) & co-PI Nitta, who has both nuclear & condensed matter physics background, where Nitta particularly develops models of topological solitons that are key for explaining physics of both condensed matter & nuclear/particle physics systems.

Quantum material physics: Kuroda (PI), Donnelly (PI, Max Plank Inst.), Kimura (CoPI). Kuroda explores topological structures in the momentum space of solids. He devised a momentum-space imaging technique to experimentally observe new topological phases and non-trivial spin textures of quantum materials [PRL 129, 146401 (2022), PRB 105, 085421 (2022)]. He found a novel optical-spin coupling between the spin texture and the applied light field [PRB 105, L121102 (2022)]. Through the finding, he proposes that optical information can be projected to the three-dimensional spin vector of photo-excited electrons, demonstrating new topological states could play as a spin-polarized electron source that ensures its future application in opt-spintronics. Kimura works on the topological band structures of magnetic and superconducting materials using angle-resolved photoelectron spectroscopy (ARPES) combined with synchrotron radiation. He successfully observed the band structure of ordered Fe3Ga thin films with spin-resolved ARPES, giving the first observation of the spin-resolved band structure. The finding explains the large transverse thermoelectric effect of the ordered Fe3Ga thin films, giving ideas to maximize thermopower using this material. Kimura also found that the fastest velocity of Dirac fermions forms nodal loops in superconducting square-net materials, HfP2-xSex. He proposed that the proper arrangement of atomic charges and their distance in the square net elevates the Dirac velocity. This finding paves a way to generate elusive Majorana fermions that are supposed to facilitate fault-tolerant quantum computers. PI Donnelly collaborates with Kuroda (whose postdoc she will host) while studying material systems in the physical space using nanoscale imaging techniques like the ones based on x-rays. With such techniques, she also studies chiral magnet materials provided by Inoue to map field configurations of spin textures numerically and theoretically predicted by Smalyukh & Leonov.

Polymers & knotted metamaterials: PIs Haino, Yabuta, Sato (RIKEN), Matsumoto (Georgia Tech), co-PI Shokeff (Tel Aviv U). Haino is developing topologically unique supramolecular structures formed through non-covalent bonds: different topology of supramolecular copolymer leads to other chemical properties. He explores supramolecular synthesis to control the topology of copolymers artificially. He particularly focuses on manipulating the self-assembly pathway to change the resultant copolymer morphology; for example, by changing the cooling rate of the reaction solutions. Haino recently synthesized chiral-twisted nano-graphenes and nano-graphene with metal nanoparticle adsorbed, which exerted chiro-optical activity and catalysis, respectively. These are newly found chemical properties of nano-graphenes. Another supramolecular complex in a unique topology was made by Haino, which autonomously assembles to form capsules in racemic forms. In the presence of a chiral guest molecule, the supramolecular complex forms chirality-biased structures; the chirality of the guest molecule generates an enantiopure supramolecular capsule. The emissive guest molecule encapsulated in this supramolecule complex emits circularly polarized light. Sato develops the molecules with knotted structures that self-assemble to gain new functions. Sato made a molecule named "catenane" with a knot structure. The catenanes autonomously assembled to form porous crystals with isostructural frameworks. The crystals are found to tune the pore size at the sub-Angstrome level. Sato also generated another porous crystal having knotted structures, which are photochemically destroyed but become recovered autonomously. He also developed a 'photochemical surgery' to connect porous networks in the porous crystals. This method hybridizes different types of porous crystals in a desired arrangement, making them highly functional. The notable physical properties of the porous crystals Sato made rely on the self-assembly properties of molecules having functional groups with knot structures. The chemistry of the molecules having knotted structures will pave new ways to develop

materials exhibiting novel functions. The mechanical properties of knotted molecule-based crystals are being modeled by co-PI Shokef & experimentally probed by Sato; on the other hand, Smalyukh collaborates with Sato to measure thermal conductivity properties of the knotted porous crystals. PI Matsumoto studies the knotting & knitting in polymer systems at the level of 3D-printed configurations, which provides a model system for designing the synthetic knotted systems at the polymer strand level, as well as bridges this study with defining foundations for technological uses, e.g. in textiles. In a similar way, Yabuta extends the study of organic macromolecules to the field of planetary sciences, where she explores the structure of organic content derived from extraterrestrial entities like meteorites, including in cases when the studied systems have genus-one surface topology, with her recent article in Science in 2023 providing an example of such work.

Chiral magnets: PIs Leonov, Donnely (Max Plank Inst), and Inoue & coPI Nitta (Keio U). Leonov studies complex mesophase formations in cubic non-centrosymmetric ferromagnets near the ordering temperatures. The complexity of the internal structure of these states is stipulated by the coupling between the magnitude and the angular part of the order parameter. Leonov purses this goal in collaboration with Ulrich Rossler (IFW Dresden) and Katia Pappas (TU, Delft). Four published refereed papers in 2022 form a solid basis for addressing more involved knotted structures (like hopfions) at high temperatures, which is directly related to the mission of SKCM^2. Inoue has developed a new spinel oxide chiral magnetic material, $MnCr_2O_4$, that behaves as spin incommensurate crystal at low temperatures [Phys. Rev. B (2023)] During the development of these molecular chiral magnets, we found that the ionic radius ratio A+/M2+ of the metal in the salt A+[M2+$(HCOO)_3$] can be controlled from the chiral monoclinic system to the chiral cubic system. In particular, the P213(B20) space group appears in the chiral cubic system, suggesting the possibility of three-dimensional chiral magnetic solitonic structures. These compounds are transparent chiral magnetic materials, and their magnetic structures are expected to be clarified by optical measurements. Inoue is engaged in theoretical collaborations as well. The same Lagrangian describes the QCD phase diagram and the spin chirality phase diagram. The CERN high-energy collision data shows the similarity between the inhomogeneous phase in the QCD phase diagram and the CSL (chiral spin soliton) phase. This theoretical research has been conducted in collaboration with researchers in WPI and external institutes, including RIKEN, KEK, and the University of Tokyo. On the topological soliton side of the spectrum (e.g., skyrmions & hopfions studied by Leonov & Smalyukh numerically & by Donnley & Innoue experimentally), co-PI Nitta helps to cross-pollinate this research area with the studies of solitons in nuclear and particle physics.

Biophysics group: PIs Tate (transitioning to become an Admin Director), Hsu (Academia Sinica), Vignolini (Cambridge U) & Dunkel (MIT). Tate's team works on the liquid droplets of proteins as functional condensed states forming membrane-less cell compartments. Tate has found that a protein VCP behaves as a molecular timer to determine the residence time of the stress granule, a type of protein droplet that occurs in the cells exposed to stress. He identified VCP as a major component of the stress granules through proteomics analysis using light-inducing proximity chemical cross-linking. He found that VCP consumes ATP inside the granules, which facilitates the initial stage of granule formation but eventually destabilizes the granules by lowering the ATP concentration in the granules, thus, the presence of VCP regulates the residence time of the stress granules [FEBS Lett. (2022)]. Tate's group found the other roles of protein droplets in different cell metabolism, including forming the regulatory sites of mRNA translation [iScience (2022)] and virus replications. In particular, the finding that CPSF6 forms granules that accumulate hepatitis B virus (HBV) coat proteins to facilitate capsid formations. This finding gives new insights into the replication mechanism of HBV replication in cells. Protein droplets are known to play as compartments where protein forms pathogenic fibrils that cause neurodegenerative diseases like Alzheimer's. Tate's recent studies showed that D-amino acids (less abundant enantiomeric amino acids in living systems) destabilize the droplets; the chirality of the co-solutes in cells alters the physical properties of protein condensates. Tate will extend the research exploring the roles of chirality of molecules inside protein condensates, which will lead to devising therapeutic approaches to prohibit the progression of neurodegenerative diseases. He now closely collaborates with Hsu in exploring the role of knotting in proteins. One collaborative project example is related to protein ubiquitination, a post-translational modification by which a ubiquitin (Ub) protein is tagged on to the target protein substrate through a cascade of enzymatic reactions to signal cellular functions. Another Ub can be attached to the first Ub that is anchored onto the substrate protein via one of the eight connecting points on the Ub, including seven lysine (K) residues and a methionine (N) residue at the beginning of the polypeptide chain. Different Ub linkage types encode different biological signals. The prototypical ubiquitination

function is used in the ubiquitin-proteasome system, which requires a linear chain of K48-linked Ubs to be recognized by the 26S proteasome for mechanical unfolding and processive protein degradation of the ubiquitinated substrate. In addition to the homotypic Ub chains that are formed by a single Ub linkage-type, heterotypic Ub chains have been reported, including linear but mixed Ub linkage types or a branched chain of which a Ub molecule can be modified at multiple sites to form a more complex topology. Given the large number of branching options of Ub chains, understanding the mechanism by which the Ub branching is made with appropriate spatial and temporal resolutions calls for new experiments & theory to be pursued by Hsu and Tate. A K11/K48-branched Ub chain is involved in cell cycle regulation and protein misfolding implicated in Huntington's disease. The proteasome for substrate degradation recognizes K11/K48 chains. Interestingly, K11/K48 chains are preferred substrates for a 5_2 knotted ubiquitin C-terminal hydrolase, UCH-L5, whose ubiquitin-removing activity is activated upon binding to the proteasome. PI Hsu recently found the unprecedented stability of UCH-L5 to withstand the mechanical unfolding of a bacterial proteasome, suggesting that the knotted topology confers the mechanostability required for UCH-L5 to function in a hostile environment in a tug-of-war against the mechanical unfolding and degradation of K11/K48 ubiquitinated substrates by the proteasome. Hsu will now biochemically reconstitute a K11/K48 chain in complex with the human proteasome and UCH-L5 for cryo-EM study to glean atomic insights into the structural basis of K11/K48 chain recognition by both the proteasome and UCH-L5. The goals of this thrust area of our WPI are: (i) develop new technologies to describe the topologies of different branched Ub chains quantitatively, (ii) explore the use of UCH-L5 as a sensor to detect branched Ub chains, and (iii) understand the dynamic interplay between the knotted UCH-L5 & the proteasome. Complimentary to these experimental methods, applied mathematicians led by PI Dunkel provide insights into such phenomena from statistical physics perspectives, where PI Dunkel further extends the studies of the role of knotting to biological media on larger scales, from proteins to active particles, tangled active filaments, worms, and snakes. On the other hand, Vignolini experimentally studies biopolymers like cellulose derived from wood or other biological sources to make materials with structural chilors while exploiting chiral photonic superstructures. She collaborates with Smalyukh to develop cellulose-based materials with golden- or silver-like reflections, which could be useful in thermal management.

Mathematics group: PIs Kotorii & Kalman, coPIs Teragaito, Koda and Nozaki. Kotorii and her collaborators constitute the pure math/topology division in SKCM^2. They started to explore topological defects by reviewing recent works. They have been working on knot theory as a pure mathematics subject and had limited experience in working on topological defects. They repeatedly discussed to understand Machon and Alexander's theorem showing that the number of nematic textures in the knot complement is given by the determinant of the knot in their familiar style of pure mathematics, as a first step to get into the interdisciplinary collaboration with experimental researchers in SKCM^2. They will keep working together to extend their contributions to promote collaboration by supporting the researchers with mathematical knowledge. Teragaito worked on the upsilon invariant of L-space knot, and found infinitely many pairs of hyperbolic L-space knots which have distinct Alexander polynomials but share the same upsilon invariant. Also, he showed that the secondary upsilon invariant of L-space knot is a concave conjugate of a certain function. Two papers containing these results were submitted to international journals. Kotorii worked on link-homotopy classes of links. She calculated the actions of the partial conjugations and the conjugations explicitly for 4- and 5-component string links, which gave classifications of the link-homotopy classes of 4- and 5-component links with her collaborator. Also, she gave Habegger and Lin's algorithm which determines whether two given links are link-homotopic or not for 4- and 5-component links with her collaborator. Koda worked on the correspondence between the isotopy classes of positive contact structures on a closed orientable 3-manifold and the equivalence classes of flow-spines of that manifold. He showed the existence and uniqueness (up to isotopy) of a contact structure for each positive flow-spine under that correspondence with his collaborators. Nozaki studied the mapping class group of a surface and the monoid of homology cylinders. It was an open problem whether the Torelli group has torsion elements. Using the LMO functor in quantum topology, he solved this problem affirmatively. Kalman studied mathematical descriptions of vortex line reconnections in various uniaxial and biaxial nematic liquid crystals, in addition to pursuing pure math knot theory problems. The pure math team held many engaging discussions with physics, chemistry, and biological science members of the WPI to explore collaborative opportunities.

Knotted meta matter & soft matter: PIs Senyuk, Smalyukh, Haino & Dijkstra & coPI

Tasinkevych (U Lisbon). Drawing inspiration from the QCD diagram/phases, Smalyukh, Dijkstra, Senyuk, Haino, and Sato collaborate to design & experimentally demonstrate highly ordered, low-symmetry (triclinic & other) fluids with emergent physical behavior not encountered in nature, which will be then used as host media for novel solitons and topological phases based on them. In this effort, Haino and Sato synthesize nanoparticles & knotted molecules, Dijkstra & Tasinkevych develop theory models predicting phase behavior & Senyuk & Smalyukh experimentally realize new phases of molecular-colloidal systems with low-symmetry order parameters. The combined soft matter science, pure math, applied math & physics perspective on knotted matter will put researchers in an ideal position to address a series of key fundamental questions with interdisciplinary importance:

→ What are the allowed transformations between knot configurations & their physical stability?
→ What restrictions do different material symmetries impose on the knot types?
→ What knot invariants have physical significance for each (chiral) knotted field realization?
→ How do soliton-type and singular knotted fields coexist with each other?
→ What new knot-soliton condensed matter phases are possible?
→ What is the relation between topological complexity and energy landscapes?
→ How do knotted structures interact? What dynamics of singular/solitonic knots can be realized?
→ How can dynamic phenomena lead to the entanglement of material properties?
→ Is knotting in order parameter spaces like (SO(3)=$\mathbb{S}^3/\mathbb{Z}_2$ & SO(3)/D_2=$\mathbb{S}^3/Q_8$) possible?

The above projects are just examples of many activities that are now pursued, so diverse that some may say they are unrelated. However, they are all inter-knotted & inter-linked by the topology, chirality & knot theory foundations on which the progress builds via cross-pollination.

1-2. Generating Fused Disciplines

* Describe the content of measures taken by the center to advance research by fusing disciplines. For example, measures that facilitate doing joint research by researchers in differing fields. If any, describe the interdisciplinary research/fused discipline that have resulted from your efforts to generate fused disciplines. You may refer to the research results described concretely in "1-1. Advancing Research of the Highest Global Level."

The WPI-SKCM^2 interknits mathematics, physics, chemistry, material science, biology, cosmology & planetary science to create an entirely new research field of knotted chiral meta matter (KCM^2) with the key mission to help enable a sustainable future via fundamental research. In particular, KCM^2 interlinks and cross-pollinates knot topology & chirality research across disciplines and scales. While KCM^2 intrinsically requires collaborations between researchers with different preparation backgrounds, we are now assuring that the WPI shared laboratories are set up to facilitate interdisciplinary collaborations of researchers recruited globally. Our way to promote collaborations is through co-mentoring of young researchers, doctoral students, and postdocs, where these researchers are guided to have primary, secondary, and international co-mentors with whom they will jointly publish while supported by the WPI grant. Having collaborative publications is an important aspect of performance evaluations, which we recently did for the 1st fiscal year period within our meritocracy procedure. Establishing the primary function of the WPI under one roof of a new building (being planned now) will promote discussions and scientific exchanges between researchers from different fields. Moreover, we organize various tutorials and short courses for teaching key concepts from fields different from one's primary training. Besides the formal seminars, the WPI facilitates an informal discussion forum of early outcomes of research, to which all WPI members are invited. While engaging our international PIs and their teams, we also take full advantage of online meetings, short- and long-term stays of overseas PIs and young researchers in Japan and vice versa (foreign researchers at all levels, from students to famous scientists, visited our WPI within 2023 already). From the science standpoint, the WPI researchers started exploring how topology and chirality manifest themselves in phenomena of many lengths and time scales, across the natural hierarchy, from elementary particles to biological and cosmic systems, as well as in pure math, like in the knot theory, in planetary sciences and cosmology, and so on. Topology and chirality are both examples of a "poster child" for emergence, the notion of the sum of the parts being less than the whole, so that a reductionist goal of reassembling understanding from well-understood components is not possible. Promising significant new discovery, the emergent synergy of knot topology and chirality require dealing with a hierarchy of length and time scales as well as with the creation of entirely new concepts, laws, and generalizations, which are only possible within an interdisciplinary, international research network, like the one we establish. This motivates and helps us to cross-pollinate and fuse the topology- and chirality-focused research domains, bringing together researchers that rarely meet. Thus, we create a new interdisciplinary knotted chiral meta matter research domain. Our center holistically explores the enabling role of chirality and knot

topology at subatomic-to-cosmic scales, with a focus on tabletop research and translation of fundamental knowledge into applications, leading to the new field of knotted chiral meta matter. Mathematical concepts, like the ones of knot and homotopy theories, aid us with understanding, classification, and generalization of findings. While the bulk of our research focuses on experimentally highly accessible systems, like liquid crystals, colloids, magnets, and biopolymers, our findings have immediate impacts on the studies of objects and phenomena on less accessible scales, like black holes and elementary particles. Conversely, theories of particle physics and cosmology inspire us to develop a deeper understanding and practical utility of related phenomena based on these accessible biological and condensed matter systems. The anticipated future technological applications enabled by the center's fundamental research range from sustainable energy-efficient building technologies to materials for extraterrestrial habitats to bio-detection, treatment of diseases & to spintronics and data storage. To achieve these goals, in a building temporarily used as our WPI's home, we have coffee/tea-time members meeting every day, where the intention is to seed collaborations and encourage collegiate discussions among students, postdocs, and faculty members in an informal friendly atmosphere. In a similar spirit, we organize weekend hikes around the campus of HU, where WPI members often learn from each other & exchange research ideas. On several occasions, such hikes were combined with outreach efforts on Miyajima island. The office space of postdocs, students & visiting faculty in the building is always shared, so that interactions can easily emerge; we are very happy to see how this sharing of space between young researchers of different preparation backgrounds promotes inter-disciplinary interactions & we are certain that this will eventually yield fruits of high-impact research discoveries.

2. Global Research Environment and System Reform

2-1. Realizing an International Research Environment

* Describe what's been accomplished in the efforts to raise the center's recognition as a genuine globally visible research institute, along with innovative efforts proactively being taken in accordance with the development stage of the center, including the following points, for example:
- Efforts being developed based on the analysis of number and state of world-leading, frontline researchers (in Appendix 2); exchanges with overseas entities (in Appendix 4); number and state of visiting researchers (in Appendix 5)
- Proactive efforts to raise the level of the center's international recognition and to obtain diversity within the center including gender balance.
- Efforts to make the center into one that attracts excellent young researchers from around the world (such as efforts fostering young researchers and contributing to advancing their career paths)

Every day we work very hard to establish our WPI as an institute without walls, a Center of research excellence with a prominent global presence and visibility. So far, this included specific efforts such as bringing world-renowned scientists as seminar and symposium speakers, attending major global meetings and visiting top institutions while promoting the WPI during plenary/keynote or similar high-visibility presentations, disseminating our findings through very top international journals, engaging very best scientists in our area as PIs/co-PIs or other collaborators, and so on. Specifically, we have successfully engaged international PIs with the highest research visibility and from top institutions globally, who already actively participate in our WPI's effort. While we have no international satellites, we strongly engage the international PIs and co-PIs, as well as the young researchers, as key contributors to all research and education missions of our WPI center. This is done by inter-knitting our activities through joint advising/mentoring of young researchers who mediate inter-PI interactions & partnerships. Young researchers are in the process of being hired through international searches while HU PIs are making the selections/recruitments jointly with PIs at the international nodes, so that candidates for these positions can meet everyone's high expectations, as needed for fruitful international collaborations. The Director oversees key decisions related to internationalization, including personnel, hiring, etc. His leadership team assists with the implementation of the vision and goals of the proposed project. HU supports foreign PIs strongly in an effort to increase the time they can spend at HU, e.g. through long-term sabbatical & other stays, cross-appointment, consulting & various other agreements. Foreign PIs are the primary advisors for their postdocs hired at HU, who are planning to spend 50% time abroad in the labs of these PIs. All Center-supported Ph.D. candidates have foreign PI co-mentors (currently, in most cases, still in the process of selection), spending six months or more time abroad within their Ph.D. career. We do everything to ensure that joining a research group within our WPI is like becoming a family member for our center's PIs, so that the foreign PIs will be all inter-knotted with family-like links & knots to their HU-employed group members. Welcoming new group members is what foreign PIs look forward to (see their commitment letters); for example, Claire Donnoley at Max Planck Institute will soon host a newly hired postdoc at HU, whose primary mentor is Kenta Kuroda. International PIs will be

great role models for HU young researchers to follow, giving them global research perspectives & collectively integrating knowledge of best practices in mentoring from ~100 top institutions globally. Young researchers connect the top global research centers with HU & erase disciplinary boundaries between the fields (by working with multiple co-mentors), ranging from math to physics & planetary science. Building on experiences (transferred via multiple discussions) of other WPI Directors who are based in the US home institutions, Smalyukh maximizes his time devoted to different missions of the WPI at the center. He also travels to different nodes of the WPI Center while leading administration, and collaborative research efforts at HU, CU & globally, building the research community. His enthusiasm & dedication are vital for inspiring & educating a new generation of researchers with a global perspective, as well as to building up the center's organization and operations, which receives his direct & full involvement. A regular in-person seminar series at HU have a zoom component, allowing international researchers join, with the timing of start at noon chosen to make this comfortable for WPI members in US & Asian time zones while recording all the presentations to provide access for European members of our WPI.

Among specific successes of our WPI so far, a WPI-supported postdoc working with Jon Dunkel since November 2022, Dr. Ziga Kos, just secured a faculty position at the University of Ljubljana, Slovenia; While Ziga will be leaving his current position within the WPI, Prof. Dunkel & collaborators already found a replacement, Petur Bryde currently of Harvard Univ., who is now defending Ph.D. and will be joining as a new WPI postdoc within several months. The WPI had very successful visits of Ph.D. students from U. Birmingham, Georgia Tech & Cambridge U; postdocs from Utrecht U, Cambridge U, U. Colorado Boulder & others. Examples of prominent researchers visiting the WPI include Dick Broer of U Eindhoven, Slobodan Zumer of Ljubljana U, Mark Bowick & Cristina Marchetti of UCSB, David Leigh of Manchester U, Mark Dennis of U Birmingham, and many others.

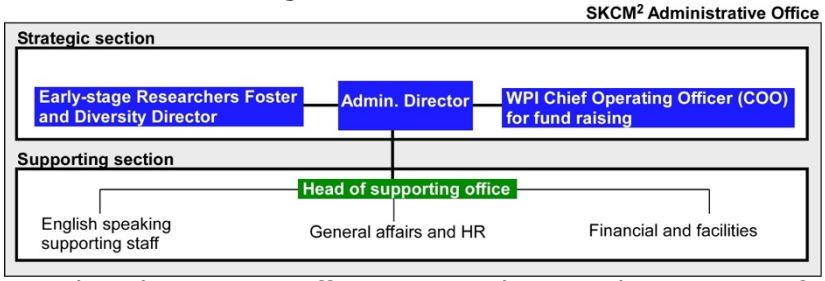
A robust and highly effective environment with optimal conditions for international collaborations and young researcher exchanges is being established. PIs from international institutions have their research group footprints at HU and direct collaborative research, mentoring & co-mentoring postdocs & students at HU. We have established regular research seminars & other meetings every week online to share progress with WPI members both at HU & abroad. The close communication among the members is the top priority in this WPI management. The frequent exchange of ideas on various organized occasions will ensure productive inter-disciplinary research in a cross-pollinating way. We also pursue efforts to foster young researchers in order to contribute to advancing their career paths while taking advantage of our global network. Gender balance is one of the top priorities, and we work hard to hire talented women researchers at all levels, from Ph.D. candidates to new PIs, where we benefit from the great experiences of our international colleagues. We have formed an External Advisory Board to advise the Director on the best practices related to realizing a diverse, welcoming International Research Environment, with the very helpful feedback provided at the most recent Board Meeting that was held in Hiroshima on March 24th.

Closely implementing our initial vision, the administrative support of WPI researchers is currently carried out by three bilingual staff members in the administrative office (one more will start in May 2023). The staff members help foreign researchers and students from abroad to make arrangements for travel and stay at the university guest house, MIRAI CREA, to facilitate their visiting SKCM^2 (see Appendix 5). The researchers who will stay long at Hiroshima University are often concerned about their children's schooling during their stay. To solve this challenging problem, the administrative office has started negotiating with the principal of Hiroshima International School (James Stward) to invite its branch near the Higashi-Hiroshima HU campus. To further support the living of foreign visitors during short or medium-length stays at HU, the WPI support office purchased two electric cars for the convenience of the overseas WPI researchers staying at SKCM^2; they and our supporting staff use the vehicles to move to the airport/JR-station or visit the institutes near Hiroshima University to have lectures or collaborations, etc. These facilities mitigate the overseas researchers' challenges & obstacles during their stay in a rural area where the Higashi-Hiroshima campus is located, which will further facilitate the researchers/students exchange.

2-2. Making Organizational Reforms

* Describe the system reforms made to the center's research operation and administrative organization, along with their background and results.
* If innovated system reforms generated by the center have had a ripple effect on other departments of the host institutions or on other research institutions, clearly describe in what ways.
* Describe the center's operation and the host institution's commitment to the system reforms.

Operation & administrative organization. Our WPI Center is now established as an independent research organization, acting as an autonomous unit & a "special district" within HU, and is envisaged as a test bed to reform HU & other universities. We have developed regulations and laws of the WPI while establishing it as an institute within HU, which reflects its special reform-enabling role within the HU system. The center Director is given all the needed authority related to organization and management of the center, playing the following major roles in the institute's functioning: the Director defines strategic missions and goals, including both long- and short-term missions and goals, as well as determines the plans and timetables that effectively lead to their implementation; the Director develops ideas, designs and plans that maximize the interactions and effective collaboration of researchers, strengthening the center's organization as an entity within HU; the Director recruits & continuously updates the composition of a strong leadership/administrative team that can be effective in delivering on assigned tasks; the Director initiates and oversees the recruitment of promising young researchers & new PIs; with help of his leadership team, the Director oversees the dissemination of the center's research outcomes to the scientific community & society, as well as oversees the investment/spending of various resources. Deputy Directors Kotorii, Yabuta & Inoue bring tremendous experiences in conducting outreach/dissemination activities, overseeing science missions & organizing international exchanges/collaborations & reforming graduate education. To allow for the focused/dedicated administrative effort at the early stages of the WPI project implementation, we have changed the Admin Director (Dr. Abe, who was initially combining the roles of Executive Vice President of HU & Admin Director, and recently had health issues), where Prof. Shin-ichi Tate starts in this role from April 1, 2023 & will be fully dedicated to the Admin Director's role. To hit the road running, the Director & his team invited the world top researchers to join SKCM^2 under a flexible contract to start the worldwide collaboration soon after the SKCM^2 launched. Such swift decisions on personnel issues hardly happen in the existing university system, particularly when inviting leading-edge scholars from abroad. To enhance the living environments of overseas researchers who visit/work for a couple of months at the SKCM^2, the WPI purchased electric cars for foreign visitors. The Director's leadership in running the SKCM^2 is helped by the strong support of President Ochi & by the dedicated work of a Knot Steering committee & administrators.



The administrative office supports the everyday activities of the researchers and the students of the SKCM^2 with four English-speaking staff members, & it also has strategic roles. The Administrative Director oversees the smooth operation of the strategic section, along with input & help from the Director in charge of early-stage researchers (ESR) fostering and diversity and the chief operating officer (COO) for fundraising, as depicted in the above diagram. The Director in charge of ESR and diversity, Prof. Aida, has been working to help raise the ratio of women researchers at Hiroshima University as a vice president for years. She also has been directing the ESR fostering program, Hiraku-Global, to encourage the selected young faculties to work on interdisciplinary and international collaborations to raise their profiles. She has profound experiences and global connections to support ESRs. Her contribution to SKCM^2 is substantial & helps in fostering the postdocs and Ph.D. students in SKCM^2. Noriko Shiomitsu takes the role of chief operating officer (COO) for fundraising, who is a former officer in MEXT. She mainly engages in organizing various activities, which sometimes combine the efforts in running our SKCM^2 with the other activities in Hiroshima University, such us the encouragement to apply for the government budgets. Because she has experienced research management in various prestigious research institutes, including RIKEN and JAXA, her experience is essential to build up highly effective/productive researcher-friendly environments to boost research activities at SKCM^2. The new administrative Director Tate has been deeply involved in the details of the WPI functioning long before the formal transition of the Admin Director position from Manabu Abe to Shin-ichi Tate, and he is ready to effectively execute all functions anticipate from the Admin Director's role. Importantly, Tate has experience serving as

an Executive Vice President of the entire HU for two years, as well as in other administrative and leadership roles. As the Admin Director, he supports the center director by helping to oversee daily activities and will help the WPI researchers to effectively engage in the newly emerging interdisciplinary research of the SKCM^2.

Innovation via implementing meritocracy. An important reform that our WPI is implementing is related to meritocracy-based compensation, which is new for HU & Japan overall but very common practice at the top international centers. The salary compensation for international scholars recruited by the WPI and collaborating with the WPI members on a part-time special appointment basis is assured to be at a completive level, comparable to that of top US-based research institutions. Japan-based scholars traveling to other countries in which our WPI nodes are located will be compensated & supported at a level comparable to that of host institutions. The WPI handles each exchange visit of young/senior researchers with thoughtful & generous considerations of all related aspects to assure that the researchers are comfortable & well-supported while pursuing international collaborations. While the annual salary of the participating PIs (as well as other WPI members) is set by participating institutions, including in cases of joint/cross-appointments, our WPI strives to reward exceptional productivity and contributions to our WPI's development by bonuses allocated based on merit-focused evaluations. Thus, the concept of meritocracy is introduced. To implement this bonus-assigning procedure, the institute calculates the so-called "PI Performance Index of WPI" (PIPI$_{\mathrm{WPI}}$, denoted as Π^2_{WPI}) at the end of the first fiscal-year-based performance period & then on an annual basis, in the end of each fiscal year; this was done first time in March 2023. In partnership with HU-based PIs (in particular, together with the Internal Advising Committee), the Director derived the following expression for this Π^2_{WPI} index:

$$\Pi^2_{WPI} = \sum_{i=1}^{n} \delta_i \eta_i + \pi \sum_{j=1}^{m} \chi_j + \pi^2 \sum_{k=1}^{l} \Omega_k + \pi^3 \Delta - \pi^4 \mathrm{Z} + \pi^5 \left(\sum_{i=1}^{n} \delta_{math,i} \eta_i + \varepsilon_{math} \sum_{j=1}^{m} \chi_j / \pi \right) / 10$$

Here $\pi \approx 3.14$ and the first ($the\ \pi^0\ term$) term $\sum_{i=0}^{n} \delta \eta_i$ rewards for publications with the SKCM^2 International Institute listed as an affiliation, with δ_i being the number of PIs and co-PIs of the center involved as co-authors of a given publication; η_i is the impact factor of a journal in which the i-th article is published, summed for n articles published by a PI in a given year. This term encourages collaborative (within members of SKCM^2) inter-PI publications in high-impact journals. To be counted, the articles with the affiliation "International Institute for Sustainability with Knotted Chiral Meta Matter" must be published in print or online, with the official publication date within a fiscal year under evaluation and before the cutoff date in March of each fiscal year (determined each year as specified below). Articles published after the cutoff date shall be counted towards the next fiscal year's meritocracy evaluations and bonus assignments. The second term (the $\pi^1\ term$) rewards additional research grants that the PIs will secure to supplement the WPI grant from the JSPS, where χ_j is the amount of each grant divided by 10 M JPY (0.1 Million USD for awards outside Japan) in a grant secured, m is the net total number of research grants received within a given fiscal year. All grants received by PIs, co-PIs and postdocs in Japan will count. Grants from international funding agencies obtained outside Japan can be included in this term as long as they are being spent for related research effort and benefit the SKCM2 efforts (for example, support students or postdocs who come to HU for extended stays and research collaborations). The 3rd term (the $\pi^2\ term$) rewards major national and international awards received by PIs in a given year (the internal awards within individual institutions of PIs will not count). Here Ω_k=Ω_{Int}+Ω_{Dom}, where factors Ω_{Int}=2 are assigned for each international and Ω_{Dom}=1 for each domestic award; this term and factors help to reward the institute members for promoting the international visibility of SKCM^2 via receiving major awards, where awards must be for research and education accomplishments. This term $\pi^2 \sum_{k=1}^{l} \Omega_k$ summed over the net total number of such awards (l) in a given fiscal year period (to count, the Awards need to be announced within the given fiscal year's performance period and before the cutoff date). The net total of 4th and 5th terms is intended to reward for contributions related to service on committees for PIs or as part of regular administrative and supporting staff duties, and other creative contributions that benefit the WPI. The positive and negative signs in the terms roughly quantify positive (milestones accomplished ahead of the expected timelines, better than expected or meeting expectations) and negative (not meeting expectations, missing deadlines, etc.) contributions to the WPI development. The coefficient Δ quantifies positive contributions on a scale up to Δ=1, with Δ=0.5 corresponding to "meets expectations" (Δ=1 corresponds to

performance "always exceeding expectations"), Δ=0-0.5 range reflecting acceptable performance that leads to the accomplishment of goals but sometimes with delays and in a less perfect way. Negative impacts Z (expected to be highly uncommon) are quantified on a scale up to Z=1, where Z=1 would correspond to performance constantly causing the WPI to miss major opportunities or impacting its reputation in a negative way. These factors are qualitatively evaluated by the Director with the help of the Internal Advising Committee and with input from Administrators and PIs/co-PIs. The last term ($\pi^5\ term$) is the next-order correction term introduced in order to account for the specifics of the mathematics field that tends to have single-author articles and small impact factor journals; here $\delta_{math}\ is\ the$ number of mathematicians authoring the paper, taking value one for mathematicians and zero for members of other research fields; ε_{math} takes value one for mathematicians and zero for members of other research fields. This term also corrects the fact that successful mathematicians normally receive smaller research grants. In the future, as the meritocracy equation will account for the experience of implementing it the first time, additional correction terms may be introduced in order to further stimulate the performance of all WPI members. The meritocracy scheme intends rewarding excellence in research & outstanding service to the WPI missions. Each year, a threshold value of the Π^2_{WPI} index will be determined (no threshold for the first fiscal year due to the shortness of the performance period of only ~4 months and a "bonus bank" will be allocated to the PIs in proportion to their $\mathrm{PIPI}_{\mathrm{WPI}}$ indices. Normally only researchers in the SKCM^2 field will receive bonus contributions based on terms 1, 2, 3, and 6, whereas all SKCM^2 members can be rewarded for their efforts based on the 4th and 5th term (however, there can be exceptions when, for example, a URA can combine administration and research in the field of SKCM^2). This meritocracy scheme was first implemented in March 2023 & will be perfected and updated each year by the Director based on experience and recommendations from the Internal Advising Committee and External Advisory Board. The bonus amount of an individual WPI member (in Yen) is calculated using an expression $\beta = \Psi \bullet \Pi^2_{WPI} / \sum_{j=1}^{N} (\Pi^2_{WPI})_j$, where N is the net total number of WPI members at the time of being considered for the meritocracy-based bonus assignment, Ψ is the bonus bank amount of a given fiscal year, Π^2_{WPI} is the index of this member calculated as described above, and $\sum_{j=1}^{N} (\Pi^2_{WPI})_j$ giving a sum of such indices for all members under consideration. The minimum value of β will be set to zero (even in the case of 5th term giving a larger negative contribution, larger than other terms). To distribute the bonus bank, a spreadsheet is produced by the internal advising committee and Admin Director, with the terms 1,2,3 and 6 calculated for each member according to the above principles and using data supplied by SKCM^2 members by filling the spreadsheet forms. Then, the 4th and 5th terms are evaluated by the Director and Internal Advising Committee, with information from the Admin Director and other Administrators and PIs/co-PIs. Members of the SKCM^2 provide requested information when needed and will be informed about the procedures. The final spreadsheet of $\beta-$values will be provided to financial officers by COB on the cutoff day of each fiscal year, which will then be used to pay bonuses.

In addition to the bonus payment, the WPI developed a similar meritocracy-based procedure to provide travel subsidies. Each PI & co-PI will be supported to attend scientific meetings (symposia, schools, workshops) officially organized by the SKCM^2, in Japan or abroad. Additionally, the PI & co-PI can have access to travel subsidy budget to meetings where he/she presents the research outcomes related to the WPI. The pre-requisite to request this subsidy access is to have at least one article with affiliation "International Institute for Sustainability with Knotted Chiral Meta Matter" published (preprints not counted) within the current or previous fiscal year. The subsidy will be calculated by Admin Director and supporting personnel using an expression rewarding publications & taking into account the visibility of the conference and PI/co-PI's presentation.

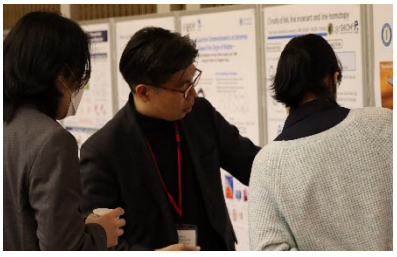
The meritocracy-based procedures/schemes described above will be soon evaluated for implementation at the level of the entire HU, and this has been discussed with President Ochi & other top HU administrators already. We feel that this meritocracy-based principle will make WPI & HU competitive in attracting young talent globally, seeding the anticipated fast development.

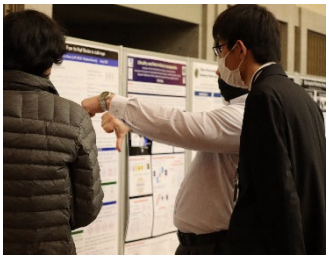
Weekly seminar series and the kickoff symposium. We have regular seminar series to exchange the members' research activities among the Japanese researchers at Hiroshima University and to take advantage of the world-top research lectures by overseas researchers, including members of our SKCM^2. Within January-March, we have hosted 13 lectures by leading, top-edge foreign researchers, such as David Leigh, Dick Broer & Lou Kauffman & others.

The SKCM^2 kickoff symposium was held for three days (Mar. 20-22, 2024), where 15 distinguished researchers delivered lectures on various aspects of topological knotted chiral meta-matters. We had

285 participants in total for three days (127 individuals from domestic institutions and 24 from abroad). The symposium gave a good opportunity to share the research focused on the SKCM^2 missions with the attending WPI researchers. During the three-day symposium, young researchers had many opportunities of talking with overseas PIs of SKCM^2. Some researchers took this advantage to initiate collaborations by sending postdocs to the foreign PIs' laboratories & vice versa. Images reveal the Symposium's spirit.

Meetings with the external advisory board members. Before & after the kickoff symposium, we had the first External Advisory Board meetings. The 1st meeting involved Director & Deputy and Admin Directors, whereas the 2nd meeting had entire Knot Steering Committee meeting with the External Advisory Board. The in-person participating external advisers, including Profs. Dennis (UK), Bowick (US), and Zumar (Slovenia), provided valuable suggestions related to running the WPI center. One more External Advisory Board member, Dr. Kiyoshi Kurokawa, was unable to attend due to other commitments but provided many valuable suggestions separately. All the Knot Steering committee representatives attended the meeting moderated by the center director. External advisors, each of whom has profound experience in managing interdisciplinary research promotion programs in the fields related to topological meta-matters, gave valuable suggestions in terms of recruiting Ph.D. students, introducing the new graduate program, gender balance, fostering early-stage researchers, and dissimilating the research outcomes to the public. This discussion with the external advisers helped us forge strategic initiatives for administration in the SKCM^2. We will plan to have annual meetings with advisory members in the following years of the WPI implementation.





3. Values for the Future

3-1. Creating and Disseminating the Societal Value of Basic Research

* Describe the content of measures taken by the center to widely disseminate the results of its basic research to the general public.
* Describe what was accomplished in the center's outreach and other activities last year and how they have contributed to creating the Societal Value of Basic Research. In Appendix 6, describe concretely the contents of these outreach activities. In Appendix 7, describe media reports or coverage, if any, of the activities.

SKCM^2 shares newly emerging science with pupils in high schools & the general public

To effectively conduct both school- and public-focused outreach, we have purchase VR helmets, developed software to show knot visualizations & illustrate chirality concepts, and purchased power generators, tents, and tables to be able to set an outreach even in a place of our choosing. We purchased materials for illustrations on how to make knots. These preparations paid off in a great

way. The WPI-SKCM^2 took two significant approaches to widely disseminating the results of its basic research to the general public: (a) interacting closely with young talents in secondary schools and (b) engaging the general public in the world of science. Both approaches not only increased public awareness of the state of the art in science related to chirality but also contributed to understanding issues regarding sustainability and the value of basic research for the development of society.

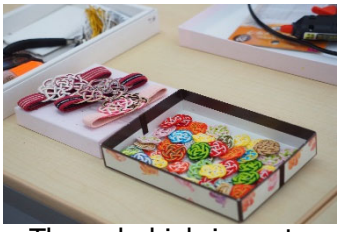



As a newly established WPI, SKCM^2 set forth its mission for fostering young talents who will one day flourish as great scholars contributing to scientific innovation. We started our endeavor by conducting an intensive workshop on students at a high school affiliated with Hiroshima University. Forty students in a mathematics class had been introduced to chirality/topology science and mathematics of knots; the students were immersed with quizzes of knots testing the students' mathematic ingenuity, virtual reality (VR) programs that walked them through the knotted structures, and various examples of particles with unique physical properties. Later, the students were introduced to material science that achieved, for instance, the artificial making of materials with extreme thermal insulation that realize very little energy consumption. Such introduction of science and its application facilitated them to envision the future in which fundamental knowledge cultivated in physics, chemics, and/or mathematics can accomplish a more environmentally sustainable world. The students were favorably impressed with the introduction of advanced science and innovation. The images (out of hundreds we have) reveal the genuine interest of high school students. Particularly female students took a strong interest as the outreach was conducted by PI Yuka Kotorii, & we hope many of them will now choose a science career.

The WPI-SKCM^2 has also been dedicated to attracting attention from many people in the general public since its establishment. We exhibited posters introducing the fundamental science of chirality and knotted matter and the institute's mission at the public exhibit room adjacent to Hiroshima Station—one of the most prominent hubs of the prefecture. In addition, we held a public outreach event in collaboration with a Mizuhiki-making class on Miyajima Island. Such a historically inherited Japanese tradition is connected to the science of knots regarding topology; Almost 200 people attended the event and were often surprised and inspired to learn by how fundamental knowledge in society and history can facilitate a better future with sustainability. Fundamental research on chirality in the field of physics, chemistry, mathematics, and/or planetary science introduced via VR, poster presentations, and model exhibits promoted the general public's understanding of how basic research in science can overcome limitations of traditional concepts and create new hypotheses, new theories, new materials, new reactions, and new methods. Many international PIs, postdocs & students took part in conducting the outreach activities. Pictures like the group photo below illustrate the success of the outreach events.

The SKCM^2 center hopes attracting the great interest of the broader community to which the outcomes of research are being disseminated. In addition to researchers themselves, these efforts will be supported & managed by dedicated science communicators & illustrators; the overall

outreach efforts of the SKCM^2 are led by Dr. Kotorii, communicating the ability of our WPI's basic research to solve challenging global problems, like ones related to the climate change.



Through high-impact publications & outreach, we convey to scientific communities & the general public how our fundamental research helps address many knotty problems that Japan & the entire World face, like the growing energy demand & its impact on climate change. For example, buildings consume 40% of all generated energy for cooling and heating; 20% out of it is lost through windows, the least efficient part of the building envelopes. Could one maintain the desired environment within a building interior without energy consumption, like in a thermos? Learning from nature, we will develop low-cost energy-efficient materials to address this challenge. From yet another perspective, further developments of electronics require miniaturization, which is limited by quantum effects at small scales. These limits can be overcome by our chiral magnetic spin systems and topological insulators. From the standpoint of biomedical applications, changes of knotting in proteins can cause protein metamorphosis diseases, such as Alzheimer's disease, so the ability to detect and control these processes may aid in developing biomedical treatments. Knots are also found in the viral RNA genome of coronavirus, showing how our research may help to address pressing problems that the world faces while achieving the missions of Japan's Society 5.0. To convey this to the broad audience, we pursue a vast variety of outreach activities designed to elevate public awareness of our sustainability-enabling research paradigm & to attract talented young people to science careers, under the oversight of Prof. Kotorii, Deputy director for outreach. Additionally, the planned WPI's summer schools will have public lectures & outreach activities designed to interest the public in Japan in science for sustainability. Mimicking the US NSF's guidance for the dissemination of research outcomes to the public, each PI was asked to develop his/her own unique outreach component of the WPI-related activity to broadly share the excitement about the research.

3-2. Human Resource Building: Higher Education and Career Development

* Describe the content of measures taken by the center to foster young researchers, including doctoral students, through their participation in a research system that creates new interdisciplinary domains within a rich international environment.

A new interdisciplinary graduate program modeled after US & UK graduate programs

We are currently introducing a new graduate program to foster young researchers who will work on the research subjects of the SKCM^2. We expect the students in this graduate program to have broader knowledge and skills than those that they are supposed to learn in the existing programs at HU. This new graduate program will formally start in Oct. 2023, with the applications being accepted now, with all materials developed & posted. In the short term, the WPI graduate program is placed as a sub-program to the existing graduate programs of Hiroshima University. Students who will join the WPI program are required to be enrolled in the existing graduate programs. They will take some credits in their original programs and take additional credits in the WPI sub-program, as specially designed by the WPI members to promote interdisciplinary scope. Students already in the existing graduate programs at Hiroshima University can join this WPI program by passing the examinations by WPI PIs.

Students permitted to join the WPI program will be paid as RAs: 1 M JPY/year for a student in a master program (an analog of pre-comps level in the USA) and 2 MJPY/year for one in Ph.D. program. All the students in the WPI program can be supported only if they commit to pursue Ph.D. degrees & meet requirements. Students in the WPI program are required to attend all the seminar series and symposiums the WPI organizes, as well as the coffee/tea discussion meetings. In the beginning, they are forced to be exposed to a wide variety of research running in SKCM^2, which will eventually motivate them to go beyond their familiar disciplines to get into exciting interdisciplinary research by knowing different ideas, techniques, and concepts in the other research field. In developing such a program, a key goal of our center is to develop the next generation of talented researchers and educators who have deep expertise in the interdisciplinary fields of knotted chiral meta matter. Our WPI will provide training and career development support at each stage, from graduate student to post-doctoral fellow to tenure-track or tenured faculty, where the support of young researchers will be our top priority. We allocate the WPI grant funds to supporting young scientists, including Ph.D. students & their international experiences, etc. To promote highly interdisciplinary research, we introduce a system of co-mentoring talented young researchers, doctoral students & postdocs, who will have 3 co-advisors with different backgrounds. For example, a doctoral student in Physics at HU might be co-advised by HU PIs in chemistry or math & by another PI from an international node. Specialized graduate coursework will be co-designed & taught by our WPI PIs. Our strategy will take advantage of the top international research centers in this area, allowing students and postdocs from HU, TokyoTech, and RIKEN to spend extended periods of time at the other WPI nodes, such as MIT, Cambridge & Boulder. Conversely, Japanese institutions host young researchers & PIs from the international nodes. Special arrangements will allow doctoral students to take specialized courses at the partner institutions. Furthermore, to help reform graduate education & cross-disciplinary training, we will introduce new coursework, along with the international research exchange, schools, conferences & forums to bring the broader interdisciplinary community together. Our WPI will not only pay Ph.D. students' salaries, like in the USA graduate programs but also will sponsor student/postdoc exchanges between Japanese & international nodes. **Recruiting new PIs & co-PIs, gender balance & internationalization.** We are eager to involve the top researchers globally in our WPI's efforts & plan to add new co-PIs to our team, both in Japan and abroad. We are currently developing plans on how new young PIs will be hired within the implementation period, striving to attract the most talented young researchers & achieve gender balance & diversity. Our WPI will seed reforms of education & research at HU & throughout Japan, will promote internationalization & gender balance in academia, will mobilize & reinforce global research efforts for a sustainable, peaceful future. The WPI strives to hire women PIs, students, postdocs & administrators. We also collaborate with institutions corresponding to its nodes outside Japan & with EPSRC Centre on Topological Design at Univ. Birmingham to manage our newly formed Ph.D. program while adopting the best practices from around the world. Young researchers will connect top global centers like MIT & Cambridge with HU & will erase disciplinary boundaries between the fields ranging from math to physics, chemistry, biology & planetary science.

3-3. Self-sufficient and Sustainable Center Development

* Describe the state of implementation of the host institution's mid-to-long term measures for supporting the center toward becoming self-sufficient and sustainable after the 10-year funding period ends, such as reforming the host institution's organization, providing personnel with priority allocation of tenured posts to the center, providing fundamental financial support, and material support including land and buildings.

We currently use an existing building (formerly known as venture business laboratory, VBL) on HU campus as the WPI's temporary home, until the new building is constructed. Some of the newly purchased instruments/facilities have been installed in VBL for the shared use of the researchers of SKCM^2, which will facilitate collaborative work while the new build is being constructed. The WPI-supported students, postdocs, and PIs, as well as the staff members, have shared offices in VBL.

One of the crucial functions of the VBL is to provide the chance to talk with people in different research fields, where otherwise they may never see each other. We have tea/coffee time every day starting at 15:00 on the first floor of VBL to invite people to get together to exchange their ideas. People staying in the VBL and some researchers in the Science Building located a bit far from the VBL join together during these 3 PM informal meeting sessions. While this VBL building is a temporary solution, we are eagerly awaiting a new building that will be dedicated to the WPI needs.

Constructing SKCM^2 center's building where all the members work under one roof

Our WPI & Hiroshima University are planning, designing, and constructing a new building dedicated to the research of SKCM^2 to be open in 2025, which will harbor 7,500 m^2 floors of the area in a five-story building. The new building will have dedicated laboratory space to facilitate the collaboration of the SKCM^2 with industries to produce new materials generated by the fundamental studies on the knotted meta-matters. In the research and development collaboration with companies, we will raise external funds besides the funds for the basic research in order to sustain the research activities of SKCM^2 after the funding period. The newly constructed building will be WPI's headquarters both within & beyond the 10-year implementation period.

The host institution supports to launch and boost SKCM^2. Hiroshima University swiftly renovated the Venture Business Laboratory (VBL) building (a four-story building, 1,500 m^2) to make it function as the central venue of the SKCM^2 activities. The VBL is a temporal venue for the SKCM^2 until the construction of the above building, but we will place a supporting office (having five Hiroshima University officers exclusively dedicated to the WPI management from April in 2023) and a secretary office having four English-speaking members. The VBL accommodates short-stay researchers and Ph.D. students for their research and discussion with the researchers/students at Hiroshima University, which helps SKCM^2 build international connections with the overseas PIs of SKCM^2 at the very early stage of the project. Streamlining the research- and education-related processes and boosting efficiency are among the key objectives of the proposed center, where HU's support is key. HU has created 24 unique incubation research centers & independent research centers, which represent the University's distinctive research efforts. When establishing our WPI, these existing centers will be reviewed, reorganized, integrated & restructured, forming five new interdisciplinary centers serving as permanent research institutions. This will help reduce the administrative burden, saving operational costs and overall boosting the output of our research/education enterprise. Our WPI will play the role of a key testbed for these centers. Therefore, as shown in the appropriation plan in this proposal, resources will be allocated to support the WPI center over the long term, including budget, human resources, facilities and equipment. This means that the entire university works together to promote the establishment of this WPI. Overseas members stay at HU Phoenix Intl. Center MIRAI CREA (fully furnished) on campus for mid- to long-term stays/visits. MIRAI CREA has rooms & facilities for science meetings & needs of family members, so that visiting scholars can productively generate new ideas & focus on research at ease. International Engagement staff coordinates the schedule of visits of foreign PIs with families for longer periods of time to assure that, in addition to productive research, their children can enroll in schools or daycare & the families receive all the needed support.

Securing long-term development. Our center management motivates (including through salary bonuses determined via meritocracy procedures) the PIs to seek additional funding from both government & private/philanthropic organizations. Young researchers, postdocs & students, are encouraged & aided (e.g. by Noriko Shiomitsu) to apply for various fellowships & scholarships. In addition to the MEXT WPI grant, PIs pursue multiple individual applications in Japan & elsewhere. Our ability to attract such funding is enhanced further by the network of collaborations & visibility of research outcomes. Besides these conventional funding sources, we pay attention to private foundations (like the Simons, Templeton & Moore foundations in the USA) & in the future will establish Endowed Chair positions & student-postdoc fellowships jointly with philanthropists & industry in Hiroshima/Japan/globally as well as local governments of Hiroshima prefecture/city. While several young PIs joined HU-WPI with the start of WPI grant & are initially supported by it, these WPI positions will be converted to tenured & tenure-track positions within the performance period & before the end of this project. While we a certain that HU's support will be sustained after ten years, we are working hard to assure that the supplemental funding will grow with each success, making the SKCM^2 a fully independent permanent center of excellence at HU, self-sustained after the implementation period. International PIs currently secure 5-10 times more funding than HU PIs. Part of the reason is that the researchers at HU & in Japan generally rarely pursue sources of funding outside of Japan, but this is now changing. Coaching sessions on how to apply to international

foundations are being introduced & HU PIs will soon gain access to funding from many private/philanthropic foundations around the world; the English-speaking personnel of our WPI is able to support such grant applications. Furthermore, extensive collaborations of HU PIs with PIs at top research institutions globally will make their applications more competitive. We, therefore, expect that the grant totals per PI for HU researchers will increase 3X within the next 5 years and 5X by the end of the project implementation period. The research funding of international PIs is anticipated to double in 10 years. The above estimates account only for the external funding not including the WPI grant from MEXT that will be based on this proposal.

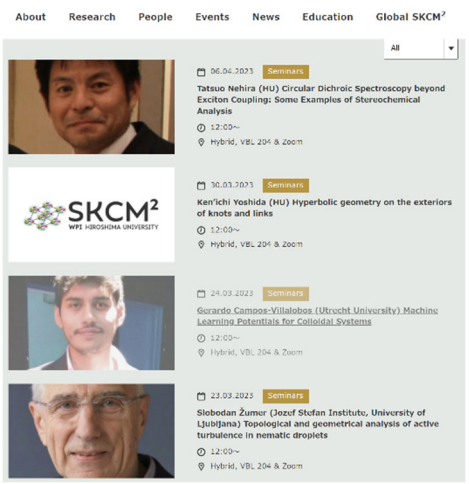
4. Others

* In addition to the above 1-3 points, if there is anything else that deserves mention regarding the center project's progress, please note it.

SKCM²'s Website

The WPI center's web page is intended to introduce our research paradigm & efforts to the entire world, including scientists & general public. It is also meant to be a resource to our WPI members & a means of recruiting young researchers. Therefore, a key goal of the SKCM² website is to be information-dense, attractive, and useful for our members and the international community. In designing the website, we also prioritized efficiency and usability from the perspective of both the user and the SKCM² website maintainers.

To achieve these goals, we have worked with a website development company Wave to develop four key systems, including:



1. Events: This system is designed to provide our members with detailed information about upcoming events at SKCM², including dates, times, and locations, and descriptions. There is also a Google Calendar embedded in the website that we link to each event on the website so that interested parties can easily subscribe to stay up to date.
2. News and Research Highlights: This system is designed to share key news and research highlights related to SKCM² activities. Photo galleries have been implemented to share photos, such as those related to research, team-building or outreach activities.
3. Members (partly in progress): This is designed so that users can easily search and learn about the researchers at SKCM². Users can filter according to different categories as well as search the member directory by keyword. This functionality should help prospective students, postdocs and collaborators learn more about the researchers at SKCM².
4. Publications (in progress): The Publications page allows users to learn about all the publications produced by SKCM² researchers. As a leading organization in our field, SKCM² researchers produce a significant number of publications each year, which is anticipated to grow. Therefore, this system was designed so that SKCM² staff members can easily update the webpage by uploading .csv files.

We have also created informational content about SKCM², graduate admissions, and preliminary useful information for employees and visitors. We plan to continue to refine our website systems and create more content to best serve our members and disseminate our research to the world.

SKCM² Seminar Series

SKCM² has held 22 weekly seminars presented by both SKCM² researchers and distinguished guests. The goals of the seminar series include helping to facilitate collaboration amongst our members from diverse backgrounds, international brain circulation, and exposing the greater HU community to the research related to SKCM². The seminars are both online and hybrid, depending on the presenter's location, which allows our colleagues from other parts of Japan and internationally to participate. The seminars are recorded as a resource for SKCM² members, and in the future, select lectures will be posted to YouTube, with the approval of the speakers, as a resource for the international PIs, coPIs, young researchers, and the broader scientific community.

Kick-off Symposium, March 20-22, 2023

SKCM^2 held the kickoff symposium on March 20-22, 2023, at Hiroshima International Conference Center. The kickoff Symposium brought together world-renowned scientists, young researchers, and distinguished local and national government officials to celebrate the formal opening of the International Institute for Sustainability with Knotted Chiral Meta Matter (SKCM^2). The Symposium consisted of scientific sessions related to knotted chiral meta matter and panel discussions related to internationalization and sustainability to help SKCM^2 meet its missions. Although it was conducted after being organized on a short time basis, it invited participants who are leaders in our field from various backgrounds, such as domestic/international scientists, government officials, university representatives, and local school representatives, which became a good opportunity to advertise the establishment of SKCM^2 to the scientific community both domestically and internationally.

5. Efforts to improve points indicated as requiring improvement in application review and results of such efforts

* Describe the status of responses to items in "Major points that need to be improved" in "The screening result for WPI centers launched in FY 2022."
* If you have already provided this information, please indicate where in the report.

We have updated our plans/strategy according to the guidance received in the notification letter, as detailed in the updated proposal materials submitted to MEXT. The following are three major points that are being improved and accounted for per MEXT's guidance, with the corresponding efforts:

1. *The prospective center director proposes to spend 50% of his time physically at Hiroshima University. It is desirable that he stays full time at the University at least for the initial couple of years. This will be vital for building up the center's organization and putting its operation in order, which will require his direct and full involvement.*

Response: This guidance is being fully accounted for. The Director took a partial leave of absence from his primary home University in order to be able to dedicate more time. His family is living in Japan, and his children attend elementary school in Hiroshima. This allows for the Director's very direct involvement in the development of the new institute and initiating international collaborations within the SKCM^2 global network. Further details are provided in the different sections of the report above, as well as in the proposal documents that were revised to account for this guidance.

2. *The foreign PIs are excellent, but their effort numbers are low. For the center to succeed in fusing diverse disciplines, their strong activity at Hiroshima University will be required. The measures proposed at the hearing regarding foreign PIs, including having research groups, spending significant physical time at Hiroshima University, and mentoring young researchers/students, should be implemented.*

Response: This guidance is being accounted for as described in sections of the report above & in the revised proposal documents that took this recommendation into account. In particular, the engagement of foreign PIs was boosted via having them supervise and co-supervise postdoctoral fellows and Ph.D. students hired at HU, host visiting scholars from HU & other nodes of the WPI, physically visit & stay at HU, give various seminars & other lectures and so on. While the new building with the planned laboratory space is still being designed/constructed, flexible arrangements have been made to allow postdocs/students & foreign PIs to conduct experiments in laboratories of collaborating WPI members & other institutions both at HU & abroad. Among different measures taken to facilitate long-term stays of PIs & other researchers in the rural area of the main campus, HU helped purchase electric cars for the WPI needs. All sections above, especially the section of this report, "2-1. Realizing an International Research Environment", provide details of various specific efforts of HU & our WPI in addressing this recommendation from MEXT within the first year so far.

3. *The organization of the center should be articulated in ways that clearly manifest its research operation and governance, support, societal dissemination, and administration as suitable for a WPI center.*

Response: This guidance was accounted for in the revised 25-page proposal document. Further, section "2-2.Making Organizational Reforms" and other sections describe these aspects of our WPI's organization in a great deal of detail. We appreciate MEXT's guidance that helped our new WPI to focus on things that are very important at the early stages of center development.

Appendix 1 FY 2022 List of Center's Research Results and Main Awards

1. Refereed Papers

- List only the Center's papers published in 2022. (Note: The list should be for the calendar year, not the fiscal year.)

(1) Divide the papers into two categories, A and B.
   A. WPI papers
      List papers whose author(s) can be identified as affiliated with the WPI program (e.g., that state "WPI" and the name of the WPI center (WPI-center name)). (Not including papers in which the names of persons affiliated with the WPI program are contained only in acknowledgements.)
   B. WPI-related papers
      List papers related to the WPI program but whose authors are not noted in the institutional affiliations as WPI affiliated. (Including papers whose acknowledgements contain the names of researchers affiliated with the WPI program.)

      Note: On 14 December 2011, the Basic Research Promotion Division (the Basic and Generic Research Division at present) in MEXT's Research Promotion Bureau circulated an instruction requiring paper authors to include the name or abbreviation of their WPI center among their institutional affiliations. From 2012, the authors' affiliations must be clearly noted.

(2) Method of listing paper
   - List only refereed papers. Divide them into categories (e.g., original articles, reviews, proceedings).
   - For each, write the author name(s); year of publication; journal name, volume, page(s) (or DOI number), and article title. Any listing order may be used as long as format is consistent. (The names of the center researchers do not need to be underlined.)
   - If a paper has many authors (say, more than 10), all of their names do not need to be listed.
   - Assign a serial number to each paper to be used to identify it throughout the report.
   - If the papers are written in languages other than English, underline their serial numbers.
   - Order of Listing
      A. WPI papers
         1. Original articles
         2. Review articles
         3. Proceedings
         4. Other English articles

      B. WPI-related papers
         1. Original articles
         2. Review articles
         3. Proceedings
         4. Other English articles

(3) Submission of electronic data
   - In addition to the above, provide a .csv file output from the Web of Science (e.g.) or other database giving the paper's raw data including Document ID. (Note: the Document ID is assigned by paper database.)
   - The papers should be divided into A or B categories on separate sheets, not divided by paper categories.

(4) Use in assessments
   - The lists of papers will be used in assessing the state of WPI project's progress.
   - They will be used as reference in analyzing the trends and whole states of research in the said WPI center, not to evaluate individual researcher performance.
   - The special characteristics of each research domain will be considered when conducting assessments.

(5) Additional documents
   - After all documents, including these paper listings, showing the state of research progress have been submitted, additional documents may be requested.

A. WPI papers

[Original articles]

1. Meng, CL; Wu, JS; Smalyukh, II. Topological steering of light by nematic vortices and analogy to cosmic strings. *Nat. Mater.* **2023**, 22(1), 64-72. doi: 10.1038/s41563-022-01414-y
2. Takahashi, S; Sekiya, R; Haino, T. Computational Studies on the Structures of Nanographenes with Various Edge Functionalities. *ChemPhysChem* **2023**, 24, e202200465. doi: 10.1002/cphc.202200465

B. WPI-related papers

[Original articles]

3. Kawasaki, N; Nagashima, K; Sakamoto, N; Matsumoto, T; Bajo, KI; Wada, S; Igami, Y; Miyake, A; Noguchi, T; Yabuta, H. et al. Oxygen isotopes of anhydrous primary minerals show kinship between asteroid Ryugu and comet 81P/Wild2. *Sci. Adv.* **2022**, 8(50), eade2067. doi: 10.1126/sciadv.ade2067

4. Paquet, M; Moynier, F; Yokoyama, T; Dai, W; Hu, Y; Abe, Y; Aleon, J; Alexander, COD; Amari, S; Yabuta, H. et al. Contribution of Ryugu-like material to Earth's volatile inventory by Cu and Zn isotopic analysis. *Nat. Astron.* **2023**, 7(2), 182-189. doi: 10.1038/s41550-022-01846-1
5. Sinnott-Armstrong, MA; Middleton, R; Ogawa, Y; Jacucci, G; Moyroud, E; Glover, BJ; Rudall, PJ; Vignolini, S; Donoghue, MJ. Multiple origins of lipid-based structural colors contribute to a gradient of fruit colors in Viburnum (Adoxaceae). *New Phytol.* **2023**, 237(2), 643-655. doi: 10.1111/nph.18538
6. Kitano, T; Nozaki, Y. An algebraic property of Reidemeister torsion. *Trans. London Math. Soc.* **2022**, 9(1), 136-157. doi: 10.1112/tlm3.12049
7. Hopp, T; Dauphas, N; Abe, Y; Aleon, J; Alexander, CMO; Amari, S; Amelin, Y; Bajo, K; Bizzarro, M; Yabuta, H. et al. Ryugu's nucleosynthetic heritage from the outskirts of the Solar System. *Sci. Adv.* **2022**, 8(46), eadd8141. doi: 10.1126/sciadv.add8141
8. Okazaki, R; Miura, YN; Takano, Y; Sawada, H; Sakamoto, K; Yada, T; Yamada, K; Kawagucci, S; Matsui, Y; Yabuta, H. et al. First asteroid gas sample delivered by the Hayabusa2 mission: A treasure box from Ryugu. *Sci. Adv.* **2022**, 8(46), eabo7239. doi: 10.1126/sciadv.abo7239
9. Teragaito, M. Hyperbolic L-space knots and their formal semigroups. *Int. J. Math.* **2022**, 33(12), 2250080. doi: 10.1142/S0129167X2250080X
10. Bazi, B; Tack, P; Lindner, M; Vekemans, B; De Pauw, E; Tkalcec, B; Brenker, FE; Garrevoet, J; Falkenberg, G; Yabuta, H. et al. Trace-element analysis of mineral grains in Ryugu rock fragment sections by synchrotron-based confocal X-ray fluorescence. *Earth Planets Space* **2022**, 74(1), 161. doi: 10.1186/s40623-022-01726-y
11. van Mastrigt, R; Dijkstra, M; van Hecke, M; Coulais, C. Machine Learning of Implicit Combinatorial Rules in Mechanical Metamaterials. *Phys. Rev. Lett.* **2022**, 129(19), 198003. doi: 10.1103/PhysRevLett.129. 198003
12. Sato, M; Kimura, Y; Tanaka, S; Hatakeyama, T; Sugita, S; Nakamuna, T; Tachibana, S; Yurimoto, H; Noguchi, T; Okazaki, R; Yabuta, H. et al. Rock Magnetic Characterization of Returned Samples From Asteroid (162173) Ryugu: Implications for Paleomagnetic Interpretation and Paleointensity Estimation. *J. Geophys. Res. Planets* **2022**, 127(11), e2022JE007405. doi: 10.1029/2022JE007405
13. Kalman, T; Lee, S; Tothmeresz, L. The Sandpile Group of a Trinity and a Canonical Definition for the Planar Bernardi Action. *Combinatorica* **2022**, 42, 1283-1316. doi: 10.1007/s00493-021-4798-9
14. Marin-Aguilar, S; Camerin, F; Dijkstra, M. Guiding the self-assembly of colloidal diamond. *J. Chem. Phys.* **2022**, 157(15), 154503. doi: 10.1063/5.0109377
15. Schroder, S; Sakatani, N; Honda, R; Tatsumi, E; Yokota, Y; Domingue, D; Cho, Y; Kameda, S; Kitazato, K; Yabuta, H. et al. Characterization of the MASCOT landing area by Hayabusa2. *Astron. Astrophys.* **2022**, 666, A164. doi: 10.1051/0004-6361/202244059
16. Noguchi, T; Matsumoto, R; Yabuta, H. et al. Antarctic micrometeorite composed of CP and CS IDP-like material: A micro-breccia originated from a partially ice-melted comet-like small body. *Meteorit. Planet. Sci.* **2022**, 57(11), 2042-2062. doi: 10.1111/maps.13919
17. Moynier, F; Dai, W; Yokoyama, T; Hu, Y; Paquet, M; Abe, Y; Aleon, J; Alexander, CMO; Amari, S; Yabuta, H. et al. The Solar System calcium isotopic composition inferred from Ryugu samples. *Geochem. Perspect. Lett.* **2022**, 24, 1-6. doi: 10.7185/geochemlet.2238

18. Wang, D; Hermes, M; Najmr, S; Tasios, N; Grau-Carbonell, A; Liu, Y; Bals, S; Dijkstra, M; Murray, CB; van Blaaderen, A. Structural diversity in three-dimensional self-assembly of nanoplatelets by spherical confinement. *Nat. Commun.* **2022**, 13(1), 6001. doi: 10.1038/s41467-022-33616-y
19. Boon, WQ; Veenstra, TE; Dijkstra, M; van Roij, R. Pressure-sensitive ion conduction in a conical channel: Optimal pressure and geometry. *Phys. Fluids* **2022**, 34(10), 101701. doi: 10.1063/5.0113035
20. Ghosh, S; Smalyukh, I. Electrical Switching of Nematic Plasmonic Nanocolloids for Infrared Solar Gain Control. *Adv. Opt. Mater.* **2022**, 10(20), 2201513. doi: 10.1002/adom.202201513
21. Kalman, T; Tothmeresz, L. Root polytopes and Jaeger-type dissections for directed graphs. *Mathematika* **2022**, 68(4), 1176-1220. doi: 10.1112/mtk.12163
22. Pip, P; Treves, S; Massey, JR; Finizio, S; Luo, ZC; Hrabec, A; Scagnoli, V; Raabe, J; Philippe, L; Heyderman, LJ; Donnelly, C. X-ray imaging of the magnetic configuration of a three-dimensional artificial spin ice building block. *APL Mater.* **2022**, 10(10), 101101. doi: 10.1063/5.0101797
23. Wang, DY; Jiang, Q; Kuroda, K; Kawaguchi, K; Harasawa, A; Yaji, K; Ernst, A; Qian, HJ; Liu, WJ; Zha, HM. et al. Coexistence of Strong and Weak Topological Orders in a Quasi-One-Dimensional Material. *Phys. Rev. Lett.* **2022**, 129(14), 146401. doi: 10.1103/PhysRevLett.129.146401
24. Sasaki, C. Anomaly-induced chiral mixing in cold and dense matter. *Phys. Rev. D* **2022**, 106(5), 54034. doi: 10.1103/PhysRevD.106.054034
25. Tack, P; De Pauw, E; Tkalcec, B; Lindner, M; Bazi, B; Vekemans, B; Brenker, F; Di Michiel, M; Uesugi, M; Yabuta, H. et al. Rare earth element identification and quantification in millimetre-sized Ryugu rock fragments from the Hayabusa2 space mission. *Earth Planets Space* **2022**, 74(1), 146. doi: 10.1186/s40623-022-01705-3
26. Kikuchi, S; Watanabe, SI; Wada, K; Saiki, T; Yabuta, H. et al. Site selection for the Hayabusa2 artificial cratering and subsurface material sampling on Ryugu. *Planet Space Sci.* **2022**, 219, 105519. doi: 10.1016/j.pss.2022.105519
27. Ryabov, A; Tasinkevych, M. Diffusion coefficient and power spectrum of active particles with a microscopically reversible mechanism of self-propelling. *J. Chem. Phys.* **2022**, 157(10), 104108. doi: 10.1063/5.0101520
28. Lo, PM; Szymanski, M; Redlich, K; Sasaki, C. Driving chiral phase transition with ring diagram. *Eur. Phys. J. A* **2022**, 58(9), 172. doi: 10.1140/epja/s10050-022-00822-7
29. Rebocho, TC; Tasinkevych, M; Dias, CS. Effect of anisotropy on the formation of active particle films. *Phys. Rev. E* **2022**, 106(2), 24609. doi: 10.1103/PhysRevE.106.024609
30. Takahashi, S; Sekiya, R; Haino, T. Metal Nanoparticles on Lipophilic Nanographenes. *Angew. Chem. Int. Ed.* **2022**, 61(42), e202205514. doi: 10.1002/anie.202205514
31. Sekiya, R; Haino, T. Integration of Nanographenes and Organic Chemistry - Toward Nanographene-based Two-Dimensional Materials. *ChemPhysChem* **2022**, 23(21), e202200311. doi: 10.1002/cphc.202200311
32. Huang, CY; Draczkowski, P; Wang, YS; Chang, CY; Chien, YC; Cheng, YH; Wu, YM; Wang, CH; Chang, YC; Hsu, ST. et al. In situ structure and dynamics of an alphacoronavirus spike protein by cryo-ET and cryo-EM. *Nat. Commun.* **2022**, 13(1), 4877. doi: 10.1038/s41467-022-32588-3
33. Kos, Z; Dunkel, J. Nematic bits and universal logic gates. *Sci. Adv.* **2022**, 8(33), eahp8371. doi:

10.1126/sciadv.abp8371

34. Harada, K; Sekiya, R; Haino, T. Chirality Induction on a Coordination Capsule for Circularly Polarized Luminescence. *Angew. Chem. Int. Ed.* **2022**, 61(39), e202209340. doi: 10.1002/anie.202209340
35. Kim, H; Skinner, DJ; Glass, DS; Hamby, AE; Stuart, BAR; Dunkel, J; Riedel-Kruse, IH. 4-bit adhesion logic enables universal multicellular interface patterning. *Nature* **2022**, 608(7922), 324-329. doi: 10.1038/s41586-022-04944-2
36. Fujiwara, H; Terashima, K; Otsuki, J; Takemori, N; Jeschke, HO; Wakita, T; Yano, Y; Hosoda, W; Kataoka, N; Kuroda, K. et al. Anomalously large spin-dependent electron correlation in the nearly half-metallic ferromagnet CoS2. *Phys. Rev. B* **2022**, 106(8), 85114. doi: 10.1103/PhysRevB.106.085114
37. Barosch, J; Nittler, LR; Wang, JH; Alexander, CMO; De Gregorio, BT; Engrand, C; Kebukawa, Y; Nagashima, K; Stroud, RM; Yabuta, H. et al. Presolar Stardust in Asteroid Ryugu. *Astrophys. J. Lett.* **2022**, 935(1), L3. doi: 10.3847/2041-8213/ac83bd
38. Zhu, WK; Droguet, B; Shen, QC; Zhang, Y; Parton, TG; Shan, XW; Parker, RM; De Volder, MFL; Deng, T; Vignolini, S; Li, T. Structurally Colored Radiative Cooling Cellulosic Films. *Adv. Sci.* **2022**, 9(26), 2202061. doi: 10.1002/advs.202202061
39. Campos-Villalobos, G; Giunta, G; Marin-Aguilar, S; Dijkstra, M. Machine-learning effective many-body potentials for anisotropic particles using orientation-dependent symmetry functions. *J. Chem. Phys.* **2022**, 157(2), 24902. doi: 10.1063/5.0091319
40. Tan, TH; Mietke, A; Li, JG; Chen, YC; Higinbotham, H; Foster, PJ; Gokhale, S; Dunkel, J; Fakhri, N. Odd dynamics of living chiral crystals. *Nature* **2022**, 607(7918), 287-293. doi: 10.1038/s41586-022-04889-6
41. Wang, Z; Chan, CLC; Haataja, JS; Schertel, L; Li, RT; Van de Kerkhof, GT; Scherman, OA; Parker, RM; Vignolini, S. Deconvoluting the Optical Response of Biocompatible Photonic Pigments. *Angew. Chem. Int. Ed.* **2022**, 61(34), e202206562. doi: 10.1002/anie.202206562
42. Guo, QL; Xue, RZ; Zhao, J; Zhang, YX; van de Kerkhof, GT; Zhang, KY; Li, YS; Vignolini, S; Song, DP. Precise Tailoring of Polyester Bottlebrush Amphiphiles toward Eco-Friendly Photonic Pigments via Interfacial Self-Assembly. *Angew. Chem. Int. Ed.* **2022**, 61(34), e202206723. doi: 10.1002/anie. 202206723
43. Lee, IJ; Sun, CP; Wu, PY; Lan, YH; Wang, IH; Liu, WC; Yuan, JPY; Chang, YW; Tseng, SC; Hsu, ST. et al. A booster dose of Delta x Omicron hybrid mRNA vaccine produced broadly neutralizing antibody against Omicron and other SARS-CoV-2 variants. *J. Biomed. Sci.* **2022**, 29(1), 49. doi: 10.1186/s12929-022-00830-1
44. Titirici, M; Baird, SG; Sparks, TD; Yang, SM; Brandt-Talbot, A; Hosseinaei, O; Harper, DP; Parker, RM; Vignolini, S. et al. The sustainable materials roadmap. *J. Phys-Mater.* **2022**, 5(3), 32001. doi: 10.1088/2515-7639/ac4ee5
45. Gudac, B; Kriener, M; Sharlai, YV; Bosnar, M; Orbanie, F; Mikitik, GP; Kimura, A; Kokanovic, I; Novak, M. Nodal-line driven anomalous susceptibility in ZrSiS. *Phys. Rev. B* **2022**, 105(24), L241115. doi: 10.1103/PhysRevB.105.L241115
46. Narkevicius, A; Parker, RM; Ferrer-Orri, J; Parton, TG; Lu, ZH; van de Kerkhof, GT; Frka-Petesic, B; Vignolini, S. Revealing the Structural Coloration of Self-Assembled Chitin Nanocrystal Films. *Adv. Mater.* **2022**, 34(31), 2203300. doi: 10.1002/adma.202203300

47. Yoshida, M; Hirao, T; Haino, T. Self-assembly of neutral platinum complexes controlled by thermal inputs. *Chem. Commun.* **2022**, 58(60), 8356-8359. doi: 10.1039/d2cc02571j
48. Park, G; Suh, A; Zhao, H; Lee, C; Choi, YS; Smalyukh, II; Yoon, DK. Fabrication of Arrays of Topological Solitons in Patterned Chiral Liquid Crystals for Real-Time Observation of Morphogenesis. *Adv. Mater.* **2022**, 34(29), 2201749. doi: 10.1002/adma.202201749
49. Chen, CC; Rodriguez, IB; Chen, YLL; Zehr, JP; Chen, YR; Hsu, STD; Yang, SC; Ho, TY. Nickel superoxide dismutase protects nitrogen fixation in Trichodesmium. *Limnol. Oceanogr. Lett.* **2022**, 7(4), 363-371. doi: 10.1002/lol2.10263
50. Repula, A; Abraham, E; Cherpak, V; Smalyukh, II. Biotropic liquid crystal phase transformations in cellulose-producing bacterial communities. *Proc. Natl. Acad. Sci. U. S. A.* **2022**, 119(24), e2200930119. doi: 10.1073/pnas.2200930119
51. Parker, RM; Zhao, TH; Frka-Petesic, B; Vignolini, S. Cellulose photonic pigments. *Nat. Commun.* **2022**, 13(1), 3378. doi: 10.1038/s41467-022-31079-9
52. Sinnott-Armstrong, MA; Ogawa, Y; van de Kerkhof, GT; Vignolini, S; Smith, SD. Convergent evolution of disordered lipidic structural colour in the fruits of Lantana strigocamara (syn. L. camara hybrid cultivar). *New Phytol.* **2022**, 235(3), 898-906. doi: 10.1111/nph.18262
53. Yeang, AL; Hernandez, TS; Strand, MT; Slotcavage, DJ; Abraham, E; Smalyukh, II; Barile, CJ; McGehee, MD. Transparent, High-Charge Capacity Metal Mesh Electrode for Reversible Metal Electrodeposition Dynamic Windows with Dark-State Transmission <0.1%. *Adv. Energy Mater.* **2022**, 12(32), 2200854. doi: 10.1002/aenm.202200854
54. Wangpraseurt, D; Sun, YZ; You, ST; Chua, ST; Noel, SK; Willard, HF; Berry, DB; Clifford, AM; Plummer, S; Xiang, Y; Vignolini, S. et al. Bioprinted Living Coral Microenvironments Mimicking Coral-Algal Symbiosis. *Adv. Funct. Mater.* **2022**, 32(35), 2202273. doi: 10.1002/adfm.202202273
55. Yang, TJ; Li, TN; Huang, RS; Pan, MYC; Lin, SY; Lin, S; Wu, KP; Wang, LHC; Hsu, ST. Tumor suppressor BAP1 nuclear import is governed by transportin-1. *J. Cell Biol.* **2022**, 221(6), e202201094. doi: 10.1083/jcb.202201094
56. Nozaki, Y; Sato, M; Suzuki, M. On the kernel of the surgery map restricted to the 1-loop part. *J. Topol.* **2022**, 15(2), 587-619. doi: 10.1112/topo.12233
57. Poy, G; Hess, AJ; Seracuse, AJ; Paul, M; Zumer, S; Smalyukh, II. Interaction and co-assembly of optical and topological solitons. *Nat. Photonics* **2022**, 16(6), 454-461. doi: 10.1038/s41566-022-01002-1
58. Coulon, R; Matsumoto, EA; Segerman, H; Trettel, SJ. Ray-Marching Thurston Geometries. *Exp. Math.* **2022**, 31(4), 1197-1277. doi: 10.1080/10586458.2022.2030262
59. Tai, JSB; Wu, JS; Smalyukh, II. Geometric transformation and three-dimensional hopping of Hopf solitons. *Nat. Commun.* **2022**, 13(1), 2986. doi: 10.1038/s41467-022-30494-2
60. van de Kerkhof, GT; Schertel, L; Caton, L; Parton, TG; Mueller, KH; Greer, HF; Ingham, CJ; Vignolini, S. Polysaccharide metabolism regulates structural colour in bacterial colonies. *J. R. Soc. Interface* **2022**, 19(190), 20220181. doi: 10.1098/rsif.2022.0181
61. Yang, H; Jacucci, G; Schertel, L; Vignolini, S. Cellulose-Based Scattering Enhancers for Light Management Applications. *ACS Nano* **2022**, 16(5), 7373-7379. doi: 10.1021/acsnano.1c09198
62. Skoric, L; Donnelly, C; Hierro-Rodriguez, A; Sandoval, MAC; Ruiz-Gomez, S; Foerster, M; Nino, MA;

Belkhou, R; Abert, C; Suess, D; Fernandez-Pacheco, A. Domain Wall Automotion in Three-Dimensional Magnetic Helical Interconnectors. *ACS Nano* **2022**, 16(6), 8860-8868. doi: 10.1021/acsnano.1c10345

63. Chang, T; Wang, BC; Yuan, D; Wang, YL; Smalyukh, I; Zhou, GF; Zhang, Z. Cellulose nanocrystal chiral photonic micro-flakes for multilevel anti-counterfeiting and identification. *Chem. Eng. J.* **2022**, 446, 136630. doi: 10.1016/j.cej.2022.136630
64. Morie, M; Sekiya, R; Haino, T. Chirality Induction in a Hydrophilic Metallohelicate. *Chem. Asian J.* **2022**, 17(12), e202200275. doi: 10.1002/asia.202200275
65. Parton, TG; Parker, RM; van de Kerkhof, GT; Narkevicius, A; Haataja, JS; Frka-Petesic, B; Vignolini, S. Chiral self-assembly of cellulose nanocrystals is driven by crystallite bundles. *Nat. Commun.* **2022**, 13(1), 2657. doi: 10.1038/s41467-022-30226-6
66. Marczenko, M; Redlich, K; Sasaki, C. Chiral symmetry restoration and Delta matter formation in neutron stars. *Phys. Rev. D* **2022**, 105(10), 103009. doi: 10.1103/PhysRevD.105.103009
67. Yasuda, K; Watanabe, TM; Kang, MG; Seo, JK; Rhee, HW; Tate, S. Valosin-containing protein regulates the stability of fused in sarcoma granules in cells by changing ATP concentrations. *FEBS Lett.* **2022**, 596(11), 1412-1423. doi: 10.1002/1873-3468.14353
68. Wang, Z; Chan, CLC; Parker, RM; Vignolini, S. The Limited Palette for Photonic Block-Copolymer Materials: A Historical Problem or a Practical Limitation? *Angew. Chem. Int. Ed.* **2022**, 61(22), e202117275. doi: 10.1002/anie.202117275
69. Puri, S; Chen, SN; Chiu, YH; Draczkowski, P; Ko, KT; Yang, TJ; Wang, YS; Uchiyama, S; Hsu, ST. Impacts of Cancer-associated Mutations on the Structure-Activity Relationship of BAP. *J. Mol. Biol.* **2022**, 434(9), 167553. doi: 10.1016/j.jmb.2022.167553
70. Bay, MM; Vignolini, S; Vynck, K. PyLlama: A stable and versatile Python toolkit for the electromagnetic modelling of multilayered anisotropic media. *Comput. Phys. Commun.* **2022**, 273, 108256. doi: 10.1016/j.cpc.2021.108256
71. Ito, N; Kotorii, Y; Takamura, M. Goussarov-Polyak-Viro conjecture for degree three case. *J. Knot Theory Ramifications* **2022**, 31(5), 2250019. doi: 10.1142/S0218216522500195
72. Sekiya, R; Harada, K; Nitta, N; Haino, T. Resorcinarene-Based Supramolecular Capsules: Supramolecular Functions and Applications. *Synlett* **2022**, 33(6), 518-530. doi: 10.1055/a-1679-8141
73. Gao, YL; Nishihara, S; Suzuki, T; Umeo, K; Inoue, K; Kurmoo, M. Ferroelastic-like transition and solvents affect the magnetism of a copper-organic radical one-dimensional coordination polymer. *Dalton Trans.* **2022**, 51(17), 6682-6686. doi: 10.1039/d2dt00135g
74. Bernardi, O; Kalman, T; Postnikov, A. Universal Tutte polynomial. *Adv. Math.* **2022**, 402, 108355. doi: 10.1016/j.aim.2022.108355
75. Gao, YL; Wang, YF; Gao, LG; Li, J; Wang, YL; Inoue, K. Three-Dimensional Supramolecular Architectures with Mn-II Ions Assembled from Hydrogen Bonding Interactions: Crystal Structures and Antiferromagnetic Properties. *ACS Omega* **2022**, 7(12), 10022-10028. doi: 10.1021/acsomega.1c05285
76. Lubner, CE; Artz, JH; Mulder, DW; Oza, A; Ward, RJ; Williams, SG; Jones, AK; Peters, JW; Smalyukh, II; Bharadwaj, VS; King, PW. A site-differentiated [4Fe-4S] cluster controls electron transfer reactivity of Clostridium acetobutylicum [FeFe]-hydrogenase I. *Chem. Sci.* **2022**, 13(16), 4581-4588. doi: 10.1039/d1sc07120c

77. Ryabov, A; Tasinkevych, M. Enhanced diffusivity in microscopically reversible active matter. *Soft Matter* **2022**, 18(16), 3234-3240. doi: 10.1039/d2sm00054g
78. Hisano, N; Haino, T. Host-Guest Complexation of Bisporphyrin Cleft and Electron-Deficient Aromatic Guests. *J. Org. Chem.* **2022**, 87(6), 4001-4009. doi: 10.1021/acs.joc.1c02742
79. Mito, M; Tajiri, T; Kousaka, Y; Togawa, Y; Akimitsu, J; Kishine, J; Inoue, K. Paramagnetic magnetostriction in the chiral magnet CrNb3S6 at room temperature. *Phys. Rev. B* **2022**, 105(10), 104412. doi: 10.1103/PhysRevB.105.104412
80. Kuroda, K; Yaji, K; Noguchi, R; Harasawa, A; Shin, S; Kondo, T; Komori, F. Visualization of optical polarization transfer to photoelectron spin vector emitted from a spin-orbit coupled surface state. *Phys. Rev. B* **2022**, 105(12), L121106. doi: 10.1103/PhysRevB.105.L121106
81. Finizio, S; Donnelly, C; Mayr, S; Hrabec, A; Raabe, J. Three-Dimensional Vortex Gyration Dynamics Unraveled by Time-Resolved Soft X-ray Laminography with Freely Selectable Excitation Frequencies. *Nano Lett.* **2022**, 22(5), 1971-1977. doi: 10.1021/acs.nanolett.1c04662
82. Chen, XL; Lawrence, JM; Wey, LT; Schertel, L; Jing, QS; Vignolini, S; Howe, CJ; Kar-Narayan, S; Zhang, JZ. 3D-printed hierarchical pillar array electrodes for high-performance semi-artificial photosynthesis. *Nat. Mater.* **2022**, 21(7), 811-818. doi: 10.1038/s41563-022-01205-5
83. Tachibana, S; Sawada, H; Okazaki, R; Takano, Y; Sakamoto, K; Miura, YN; Okamoto, C; Yano, H; Yamanouchi, S; Yabuta, H. et al. Pebbles and sand on asteroid (162173) Ryugu: In situ observation and particles returned to Earth. *Science* **2022**, 375(6584), 1011-1016. doi: 10.1126/science.abj8624
84. Tanaka, H; Okazaki, S; Kuroda, K; Noguchi, R; Arai, Y; Minami, S; Ideta, S; Tanaka, K; Lu, DH. et al. Large anomalous Hall effect induced by weak ferromagnetism in the noncentrosymmetric antiferromagnet CoNb3S6. *Phys. Rev. B* **2022**, 105(12), L121102. doi: 10.1103/PhysRevB.105.L121102
85. Leonov, AO. Skyrmion clusters and chains in bulk and thin-layered cubic helimagnets. *Phys. Rev. B* **2022**, 105(9), 94404. doi: 10.1103/PhysRevB.105.094404
86. Kuo, CW; Yang, TJ; Chien, YC; Yu, PY; Hsu, STD; Khoo, KH. Distinct shifts in site-specific glycosylation pattern of SARS-CoV-2 spike proteins associated with arising mutations in the D614G and Alpha variants. *Glycobiology* **2022**, 32(1), 60-72. doi: 10.1093/glycob/cwab102
87. Matsumoto, I; Sekiya, R; Fukui, H; Sun, RD; Haino, T. Electrochromism of Nanographenes in the Near-Infrared Region. *Angew. Chem. Int. Ed.* **2022**, 61(17), e202200291. doi: 10.1002/anie.202200291
88. Wan, YX; Wang, LH; Kuroda, K. et al. Selective observation of surface and bulk bands in polar WTe2 by laser-based spin- and angle-resolved photoemission spectroscopy. *Phys. Rev. B* **2022**, 105(8), 85421. doi: 10.1103/PhysRevB.105.085421
89. Chen, T; Yeh, HW; Chen, PP; Huang, WT; Wu, CY; Liao, TC; Lin, SL; Chen, YY; Lin, KT; Hsu, ST; Cheng, HC. BARD1 is an ATPase activating protein for OLA1. *Biochim. Biophys. Acta-Gen. Subj.* **2022**, 1866(5), 130099. doi: 10.1016/j.bbagen.2022.130099
90. Anzivino, C; van Roij, R; Dijkstra, M. Coupling between splay deformations and density modulations in splay-bend phases of bent colloidal rods. *Phys. Rev. E* **2022**, 105(2), L022701. doi: 10.1103/PhysRevE.105.L022701
91. Puri, S; Hsu, ST. Oxidation of catalytic cysteine of human deubiquitinase BAP1 triggers misfolding and aggregation in addition to functional loss. *Biochem. Biophys. Res. Commun.* **2022**, 599, 57-62. doi:

10.1016/j.bbrc.2022.02.029

92. Arai, Y; Kuroda, K; Nomoto, T; Tin, ZH; Sakuragi, S; Bareille, C; Akebi, S; Kurokawa, K; Kinoshita, Y. et al. Multipole polaron in the devil's staircase of CeSb. *Nat. Mater.* **2022**, 21(4), 410-415. doi: 10.1038/s41563-021-01188-9
93. Atifi, S; Mirvakili, MN; Williams, CA; Bay, MM; Vignolini, S; Hamad, WY. Fast Self-Assembly of Scalable Photonic Cellulose Nanocrystals and Hybrid Films via Electrophoresis. *Adv. Mater.* **2022**, 34(12), 2109170. doi: 10.1002/adma.202109170
94. Mietke, A; Dunkel, J. Anyonic Defect Braiding and Spontaneous Chiral Symmetry Breaking in Dihedral Liquid Crystals. *Phys. Rev. X* **2022**, 12(1), 11027. doi: 10.1103/PhysRevX.12.011027
95. Marczenko, M; Redlich, K; Sasaki, C. Reconciling Multi-messenger Constraints with Chiral Symmetry Restoration. *Astrophys. J. Lett.* **2022**, 925(2), L23. doi: 10.3847/2041-8213/ac4b61
96. Coelho, RCV; Tasinkevych, M; da Gama, MMT. Dynamics of flowing 2D skyrmions. *J. Phys. Condes. Matter* **2022**, 34(3), 34001. doi: 10.1088/1361-648X/ac2ca9
97. Jaramillo-Fernandez, J; Yang, H; Schertel, L; Whitworth, GL; Garcia, PD; Vignolini, S; Sotomayor-Torres, CM. Highly-Scattering Cellulose-Based Films for Radiative Cooling. *Adv. Sci.* **2022**, 9(8), 2104758. doi: 10.1002/advs.202104758
98. Chan, CLC; Lei, IM; van de Kerkhof, GT; Parker, RM; Richards, KD; Evans, RC; Huang, YYS; Vignolini, S. 3D Printing of Liquid Crystalline Hydroxypropyl Cellulose-toward Tunable and Sustainable Volumetric Photonic Structures. *Adv. Funct. Mater.* **2022**, 32(15), 2108566. doi: 10.1002/adfm.202108566
99. Shimono, S; Ishibashi, H; Nagayoshi, Y; Ikeno, H; Kawaguchi, S; Hagihala, M; Nishihara, S; Inoue, K. et al. Structural phase transition in cobalt oxyfluoride Co3Sb4O60F6 observed by high-resolution synchrotron and neutron diffraction. *J. Phys. Chem. Solids* **2022**, 163, 110568. doi: 10.1016/j.jpcs.2021.110568
100. Chiappini, M; Dussi, S; Frka-Petesic, B; Vignolini, S; Dijkstra, M. Modeling the cholesteric pitch of apolar cellulose nanocrystal suspensions using a chiral hard-bundle model. *J. Chem. Phys.* **2022**, 156(1), 14904. doi: 10.1063/5.0076123
101. Senyuk, B; Adufu, RE; Smalyukh, II. Electrically Powered Locomotion of Dual-Nature Colloid-Hedgehog and Colloid-Umbilic Topological and Elastic Dipoles in Liquid Crystals. *Langmuir* **2022**, 38(2), 689-697. doi: 10.1021/acs.langmuir.1c02546
102. An, BH; Bae, Y; Kalman, T. Ruling invariants for Legendrian graphs. *J. Symplectic Geom.* **2022**, 20(1), 49-98. doi: 10.4310/JSG.2022.v20.n1.a2
103. Coli, GM; Boattini, E; Filion, L; Dijkstra, M. Inverse design of soft materials via a deep learning-based evolutionary strategy. *Sci. Adv.* **2022**, 8(3), eabj6731. doi: 10.1126/sciadv.abj6731
104. Nozaki, Y; Sato, M; Suzuki, M. Abelian quotients of the Y-filtration on the homology cylinders via the LMO functor. *Geom. Topol.* **2022**, 26(1), 221-282. doi: 10.2140/gt.2022.26.221
105. Sekiya, R; Haino, T. Nanographene - A Scaffold of Two-Dimensional Materials. *Chem. Rec.* **2022**, 22(3), e202100257. doi: 10.1002/tcr.202100257
106. Donnelly, C; Hierro-Rodriguez, A; Abert, C; Witte, K; Skoric, L; Sanz-Hernandez, D; Finizio, S; Meng, FF; McVitie, S; Raabe, J; Suess, D; Cowburn, R; Fernandez-Pacheco, A. Complex free-space magnetic field textures induced by three-dimensional magnetic nanostructures. *Nat. Nanotechnol.* **2022**, 17(2), 136-

142. doi: 10.1038/s41565-021-01027-7

107. Yada, T; Abe, M; Okada, T; Nakato, A; Yogata, K; Miyazaki, A; Hatakeda, K; Kumagai, K; Nishimura, M; Yabuta, H. et al. Preliminary analysis of the Hayabusa2 samples returned from C-type asteroid Ryugu. *Nat. Astron.* **2022**, 6(2), 214-220. doi: 10.1038/s41550-021-01550-6
108. Droguet, BE; Liang, HL; Frka-Petesic, B; Parker, RM; De Volder, MFL; Baumberg, JJ; Vignolini, S. Large-scale fabrication of structurally coloured cellulose nanocrystal films and effect pigments. *Nat. Mater.* **2022**, 21(3), 352-358. doi: 10.1038/s41563-021-01135-8
109. Nguyen, L; McCord, KA; Bui, DT; Bouwman, KM; Kitova, EN; Elaish, M; Kumawat, D; Daskhan, GC; Tomris, I; Hsu, ST. et al. Sialic acid-containing glycolipids mediate binding and viral entry of SARS-CoV-2. *Nat. Chem. Biol.* **2022**, 18(1), 81-90. doi: 10.1038/s41589-021-00924-1
110. Prinz-Zwick, M; Szigeti, BG; Gimpel, T; Ehlers, D; Tsurkan, V; Leonov, AO. et al. Nuclear and Electron Spin Resonance Studies on Skyrmion-Hosting Lacunar Spinels. *Phys. Status Solidi B-Basic Solid State Phys.* **2022**, 259(5), 2100170. doi: 10.1002/pssb.202100170
111. Ohshita, J; Ohta, A; Saadom, SZB; Adachi, Y; Murakami, H; Haino, T. Synthesis and optical properties of disiloxane-linked decathiophene and dodecathiophene polymers. *Polym. J.* **2022**, 54(1), 91-96. doi: 10.1038/s41428-021-00541-8
112. Lamers, BAG; van Son, MHC; de Graaf, FV; van den Bersselaar, BWL; de Waal, BFM; Komatsu, K; Sato, H; Aida, T. et al. Tuning the donor-acceptor interactions in phase-segregated block molecules. *Mater. Horizons* **2022**, 9(1), 294-302. doi: 10.1039/d1mh01141c
113. Hirose, S; Iguchi, D; Kin, E; Koda, Y. Goeritz Groups of Bridge Decompositions. *Int. Math. Res. Notices* **2022**, 2022(12), 9308-9356. doi: 10.1093/imrn/rnab001
114. Ito, T; Motegi, K; Teragaito, M. Generalized torsion for hyperbolic 3-manifold groups with arbitrary large rank. *Bull. London Math. Soc.* **2022**, 1-7. doi: 10.1112/blms.12784
115. Noguchi, T; Matsumoto, T; Miyake, A; Igami, Y; Haruta, M; Saito, H; Hata, S; Seto, Y; Miyahara, M; Yabuta, H. et al. A dehydrated space-weathered skin cloaking the hydrated interior of Ryugu. *Nat. Astron.* **2023**, 7, 170-181. doi: 10.1038/s41550-022-01841-6
116. Aarts, M; Boon, WQ; Cuenod, B; Dijkstra, M; van Roij, R; Alarcon-Llado, E. Ion Current Rectification and Long-Range Interference in Conical Silicon Micropores. *ACS Appl. Mater. Interfaces* **2022**, 14(50), 56226-56236. doi: 10.1021/acsami.2c11467
117. Takahashi, S; Sekiya, R; Haino, T. Computational Studies on the Structures of Nanographenes with Various Edge Functionalities. *ChemPhysChem* **2023**, 24, e202200465. doi: 10.1002/cphc.202200465
118. Senyuk, B; Meng, CL; Smalyukh, II. Design and Preparation of Nematic Colloidal Particles. *Langmuir* **2022**, 38(30), 9099-9118. doi: 10.1021/acs.langmuir.2c00611
119. Wu, JS; Smalyukh, II. Hopfions, heliknotons, skyrmions, torons and both abelian and nonabelian vortices in chiral liquid crystals. *Liq. Cryst. Rev.* **2022** Mar.3 doi: 10.1080/21680396.2022.2040058
120. Lo, PM; Szymanski, M; Redlich, K; Sasaki, C. Driving chiral phase transition with ring diagram (vol 58, 172, 2022). *Eur. Phys. J. A* **2022**, 58(10), 191. doi: 10.1140/epja/s10050-022-00836-1
121. Wilts, BD; Rudall, PJ; Moyroud, E; Ogawa, Y; Vignolini, S; Steiner, U; Glover, BJ. Ultrastructure and optics of the prism-like petal epidermal cells of Eschscholzia californica (California poppy) (vol 219, pg 1124, 2018). *New Phytol.* **2022**, 236(2), 792-792. doi: 10.1111/nph.18406

122. Eto, M; Hamada, Y; Jinno, R; Nitta, M; Yamada, M. Abrikosov-Nielsen-Olesen strings from the Coleman-Weinberg potential. *Phys. Rev. D* **2022**, 106(11), 116002. doi: 10.1103/PhysRevD.106.116002
123. Amari, Y; Akagi, Y; Gudnason, SB; Nitta, M; Shnir, Y. CP2 skyrmion crystals in an SU(3) magnet with a generalized Dzyaloshinskii-Moriya interaction. *Phys. Rev. B* **2022**, 106(10), L100406. doi: 10.1103/PhysRevB.106.L100406
124. Fujii, H; Itakura, K; Miyachi, K; Nonaka, C. Radiative hadronization: Photon emission at hadronization from quark-gluon plasma. *Phys. Rev. C* **2022**, 106(3), 34906. doi: 10.1103/PhysRevC.106.034906
125. Eto, M; Nitta, M. Quantum nucleation of topological solitons. *J. High Energy Phys.* **2022**, (9), 77. doi: 10.1007/JHEP09(2022)077
126. Eto, M; Nishimura, K; Nitta, M. Phases of rotating baryonic matter: non-Abelian chiral soliton lattices, antiferro-isospin chains, and ferri/ferromagnetic magnetization. *J. High Energy Phys.* **2022**, (8), 305. doi: 10.1007/JHEP08(2022)305
127. Marra, P; Inotani, D; Nitta, M. Dispersive one-dimensional Majorana modes with emergent supersymmetry in one-dimensional proximitized superconductors via spatially modulated potentials and magnetic fields. *Phys. Rev. B* **2022**, 105(21), 214525. doi: 10.1103/PhysRevB.105.214525
128. Nishimura, H; Fujimori, T; Misumi, T; Nitta, M; Sakai, N. Resurgence and semiclassical expansion in two-dimensional large-N sigma models. *J. High Energy Phys.* **2022**, (6), 151. doi: 10.1007/JHEP06(2022)151
129. Marra, P; Inotani, D; Nitta, M. 1D Majorana Goldstinos and partial supersymmetry breaking in quantum wires. *Commun. Phys.* **2022**, 5(1), 149. doi: 10.1038/s42005-022-00920-4
130. Masaki, Y; Mizushima, T; Nitta, M. Non-Abelian half-quantum vortices in P-3(2) topological superfluids. *Phys. Rev. B* **2022**, 105(22), L220503. doi: 10.1103/PhysRevB.105.L220503
131. Nitta, M. Relations among topological solitons. *Phys. Rev. D* **2022**, 105(10), 105006. doi: 10.1103/PhysRevD.105.105006
132. Kobayashi, M; Nitta, M. Core structures of vortices in Ginzburg-Landau theory for neutron P-3(2) superfluids. *Phys. Rev. C* **2022**, 105(3), 35807. doi: 10.1103/PhysRevC.105.035807
133. Gudnason, SB; Nitta, M. Reducing the O(3) model as an effective field theory. *J. High Energy Phys.* **2022**, (3), 30. doi: 10.1007/JHEP03(2022)030
134. Eto, M; Hamada, Y; Nitta, M. Stable Z-strings with topological polarization in two Higgs doublet model. *J. High Energy Phys.* **2022**, (2), 99. doi: 10.1007/JHEP02(2022)099
135. Hidaka, Y; Nitta, M; Yokokura, R. Global 4-group symmetry and 't Hooft anomalies in topological axion electrodynamics. *Prog. Theor. Exp. Phys.* **2022**, 2022(4). doi: 10.1093/ptep/ptab150

[Review Articles]

136. Nepal, D; Kang, S; Adstedt, KM; Kanhaiya, K; Bockstaller, MR; Brinson, LC; Buehler, MJ; Coveney, PV; Dayal, K; Vignolini, S. et al. Hierarchically structured bioinspired nanocomposites. *Nat. Mater.* **2023**, 22(1), 18-35. doi: 10.1038/s41563-022-01384-1
137. Kimel, A; Zvezdin, A; Sharma, S; Shallcross, S; de Sousa, N; Garcia-Martin, A; Salvan, G; Hamrle, J; Stejskal, O; Donnelly, C. et al. The 2022 magneto-optics roadmap. *J. Phys. D-Appl. Phys.* **2022**, 55(46), 463003. doi: 10.1088/1361-6463/ac8da0
138. Hirao, T; Haino, T. Supramolecular Ensembles Formed via Calix[5]arene-Fullerene Host-Guest Interactions. *Chem. Asian J.* **2022**, 17(16), e202200344. doi: 10.1002/asia.202200344

139. Eichhorn, SJ; Etale, A; Wang, J; Berglund, LA; Li, Y; Cai, Y; Chen, C; Cranston, ED; Johns, MA; Vignolini, S. et al. Current international research into cellulose as a functional nanomaterial for advanced applications. *J. Mater. Sci.* **2022**, 57(10), 5697-5767. doi: 10.1007/s10853-022-06903-8
140. Tang, YM; Yang, H; Vignolini, S. Recent Progress in Production Methods for Cellulose Nanocrystals: Leading to More Sustainable Processes. *Adv. Sustain. Syst.* **2022**, 6(3), 2100100. doi: 10.1002/adsu.202100100

[Other English articles]

141. Sekiya, R; Haino, T. Integration of Nanographenes and Organic Chemistry - Toward Nanographene-based Two-dimensional Materials. *ChemPhysChem* **2022**, 23(21), e202200738. doi: 10.1002/cphc.202200738
142. Fernandez-Pacheco, A; Donnelly, C. The racetrack breaks free from the substrate. *Nat. Nanotechnol.* **2022**, 17(10), 1038-1039. doi: 10.1038/s41565-022-01206-0

2. Invited Lectures, Plenary Addresses (etc.) at International Conferences and International Research Meetings

- List up to 10 main presentations during FY 2022 in order from most recent.
- For each, write the date(s), lecturer/presenter's name, presentation title, and conference name.

Date(s)	Lecturer/Presenter's name	Presentation title	Conference name
Mar. 26, 2023	Shang-Te Danny Hsu	Visualization and Functional Annotation of Coronavirus Spike Protein Glycoshields	DiscoverBMB 2023, Seattle, USA
Mar. 21, 2023	Masakazu Teragaito	Hyperbolic L–space knots and their Upsilon invariants, Masakazu Teragaito,	Breath in low-dimensional topology, Japan
Mar, 5, 2023	Jorn Dunkel	Data-driven Dynamical Systems in Biology and Soft Matter	Symmetry-informed model inference for living matter Symposium: APS March Meeting, USA
Feb. 7, 2023	Yuta Nozaki	A non-commutative Reidemeister-Turaev torsion of homology cylinders	The 18th East Asian Conference on Geometric Topology (online)
Jan. 7-12 2023	Ivan I. Smalyukh	Knotted Solitonic Matter	Mathematics of complex materials workshop/program, Hausdorff Research Institute for Mathematics, Germany
Nov. 25, 2022	Ivan I. Smalyukh	Topological steering of light by nematic vortices (keynote lecture)	Annual Meeting of Taiwan Liquid Crystal Society (2022 TLCS), Taiwan
Nov. 10, 2022	Marjolein Dijkstra	From a computer game for understanding liquids towards autonomous design of soft materials	Lorentz medal, the Netherland
Oct. 31, 2022	Kenta Shigaki	From Bridging Quark and Hadron Hierarchies to Even Broader View of QCD World	International Symposium on Clustering as a Window on the Hierarchical Structure of Quantum Systems (CLUSHIQ2022), Japan
Oct. 17, 2022	Kenta Kuroda	Electronic correlations of CeSb under the devil's staircase transition	2nd Global Summit on Condensed Matter Physics (CONMAT2022), UAE
Oct. 10, 2022	Yair Shokef	Geometry, Combinatorics and Topology of Personalized Mechanical Metamaterials	EUROMECH Colloquium Unification of Microsystems and Metamaterials for New Generation Engineering Solutions, Italy

3. Major Awards

- List up to 10 main awards received during FY 2022 in order from the most recent.
- For each, write the date issued, the recipient's name, and the name of award.
- In case of multiple recipients, underline those affiliated with the center.

Date	Recipient's name	Name of award
July 26, 2022	Takeharu Haino	An Asian Core Program Lectureship from Singapore
July 26, 2022	Takeharu Haino	An Asian Core Program Lectureship from Korea
June, 9, 2022	Ivan I. Smalyukh	2022 ICMS Distinguished Scholar, Institute for Complex Molecular Systems, Eindhoven University of Technology, The Netherlands
Feb. 23, 2022	Ivan I. Smalyukh	IAS 2021/2022 Distinguished Scholar in The Mortimer and Raymond Sackler Institute of Advanced Studies at Tel-Aviv University

Appendix 2　FY 2022 List of Principal Investigators

NOTE:

*Underline names of principal investigators who belong to an overseas research institution.

*In the case of researcher(s) not listed in the proposal for newly selected centers in FY2022, attach a "Biographical Sketch of a New Principal Investigator"(Appendix 2a).

*Enter the host institution name and the center name in the footer.

<Results at the end of FY2022> **Principal Investigators Total: 19**

Name	Age	Affiliation (Position title, department, organization)	Academic degree, specialty	Effort (%)*	Starting date of project participation	Status of project participation (Describe in concrete terms)	Contributions by PIs from overseas research institutions
Center director: Ivan I. Smalyukh	50	(1) Professor/Department of Physics, MSE and Renewable Sustainable Energy Institute/University of Colorado at Boulder (2) Director & Specially Appointed Visiting Professor/Hiroshima University	Ph.D., Topological solitons, knotted matter, self-assembly, predesigned building blocks of matter, soft matter	80	Nov. 11, 2022	He stays at the center (80%) while also directing WPI-related activities at HU and at Univ Colorado and Globally	He organizes the center and directs its overall activities
Deputy director for Education: Katsuya Inoue	58	Professor/Academy of Hiroshima University, Graduate School of Advanced Science and Engineering, Chemistry/Hiroshima University	Ph.D., Experimental material sciences, chemistry	70	Nov. 11, 2022	He usually stays at the center.	
Deputy director for Outreach & Dissemination: Yuka Kotorii	38	(1) Associate Professor/Academy of Hiroshima University, Graduate School of Advanced Science and Engineering, Mathematics/Hiroshima University (2) Visiting Scientist/Interdisciplinary Theoretical and Mathematical Sciences Program (iTHEMS)/RIKEN	Ph.D., Mathematics (topology, knot theory)	70	Nov. 11, 2022	She usually stays at the center.	

Deputy director for Science: Hikaru Yabuta	48	Professor/Academy of Hiroshima University, Graduate School of Advanced Science and Engineering, Earth and Planetary System Science/Hiroshima University	Ph.D., Cosmochemistry, geochmistry	70	Nov. 11, 2022	She usually stays at the center.	
Claire Donnelly	31	Lise Meitner Group Leader/Max Planck Institute for Physical Chemistry of Solids	Ph.D., 3D topology in magnets, nanoscale imaging	30	Nov. 11, 2022	She usually stays at Max Planck Institute as a partner institute and visits the center	She co-mentors & hosts young scientists like postdocs from Hiroshima University.
Kenta Kuroda	36	Associate Professor/Academy of Hiroshima University, Graduate School of Advanced Science and Engineering, Physical Science/Hiroshima University	Ph.D., Solid state physics, momentum-space topology in quantum matter	70	Nov. 11, 2022	He usually stays at the center.	
Elisabetta Matsumoto	37	Assistant Professor/School of Physics/Georgia Institute of Technology	Ph.D., Geometry and topology of soft matter	30	Nov. 11, 2022	She usually stays at Georgia Institute of Technology as a partner institute and visits the center	She sent her students to HU & will co-mentor young postdoctoral scientists and students from HU
Hiroshi Sato	42	Unit Leader/Emergent Molecular Assembly Research Unit, Cross-Divisional Materials Research Program/RIKEN Center for Emergent Matter Science	Ph.D., Chemistry, material science	50	Nov. 11, 2022	He usually stays at RIKEN as a partner institute and visits the center every three months.	He will move to SKCM2 in two years, once the new building is constructed; currently coming for frequent visits to HU
Silvia Vignolini	42	Professor/Department of Chemistry/University of Cambridge	Ph.D., Chiral bio-materials, self-assembly	30	Nov. 11, 2022	She usually stays at University of Cambridge as a partner institute and visits the center	She plans to send a young scientist in SKCM2.

Andrey Leonov	43	Associate Professor/Academy of Hiroshima University, Graduate School of Advanced Science and Engineering, Chemistry/Hiroshima University	Ph.D., Condensed matter physics theory	70	Nov. 11, 2022	He usually stays at the center.	
Chihiro Sasaki	46	Professor/ Hiroshima University & Institute of Theoretical Physics/University of Wroclaw	Ph.D., High energy particle physics (theory)	70	Nov. 11, 2022	She usually stays at University of Wroclaw as a partner institute (50%) and visits the center within about 50% time	She hired a young researcher as a postdoc at SKCM2 & co-mentors students/postdocs at HU
Jörn Dunkel	46	Associate Professor/Department of Mathematics/ Massachusetts Institute of Technology	Ph.D., Applied mathematics, and topoloty	30	Nov. 11, 2022	He usually stays at Massachusetts Inst. Tech. as a partner institution and visits the center	He mentors young reserachers, students & postdocs
Shang-Te Danny Hsu	47	Research Fellow/Institute of Biological Chemistry/Academia Sinica	Ph.D., Biophysical chemistry, structural biology, knotted proteins, COVID-19	30	Nov. 11, 2022	He usually stays at Academia Sinica as a partner institute and visits the center	He mentors young reserachers, students & postdocs
Tamás Kálmán	48	Associate Professor/Department of Mathematics/Tokyo Institute of Technology	Ph.D., Low-dimensional topology, combinatorics	40	Nov. 11, 2022	He usually stays at Tokyo Inst. Tech. as a partner institute and visits the center	He mentors young reserachers, students & postdocs
Bohdan Senyuk	51	Associate Professor, Hiroshima University	Ph.D., Chemical physics, soft matter, liquid crystals physics	70	Nov. 11, 2022	He usually stays at the center	He just moved to SKCM2 and mentors or co-mentors young scientists and students to work with him

Kenta Shigaki	55	Professor/Academy of Hiroshima University, Graduate School of Advanced Science and Engineering, Physics/Hiroshima University	Ph.D., High energy particle physics (experiment)	70	Nov. 11, 2022	He usually stays at the center.	
Marjolein Dijkstra	55	Professor/Faculty of Science, Debye Institute for Nanomaterials Science/Utrecht University	Ph.D., Condensed matter theory, toplogy	30	Nov. 11, 2022	She usually stays at Utrecht University as a partner institute and visits the center once a year.	She plans to mentor and co-supervise young postdoctoral scientists and students in SKCM2.
Takeharu Haino	58	Professor/Academy of Hiroshima University, Graduate School of Advanced Science and Engineering, Chemistry/Hiroshima University	Ph.D., Chiral supramolecular chemistry	70	Nov. 11, 2022	He usually stays at the center.	
Shin-ichi Tate	61	Professor/Academy of Hiroshima University, Graduate School of Integrated Sciences for Life, Mathematical and Life Sciences/Hiroshima University	Ph.D., Biophysics, protein condensates	70	Nov. 11, 2022	He usually stays at the center	

*Percentage of time that the principal investigator devotes to working for the center vis-à-vis his/her total working hours.

Principal investigators unable to participate in project in FY 2022

Name	Affiliation (Position title, department, organization)	Starting date of project participation	Reasons	Measures taken

Appendix 3-1 FY 2022 Records of Center Activities

1. Researchers and center staff, satellites, partner institutions

1-1. Number of researchers in the "core" established within the host institution

- Regarding the number of researchers at the Center, fill in the table in Appendix 3-1a.

Special mention

- Enter matters warranting special mention, such as concrete plans for achieving the Center's goals, established schedules for employing main researchers, particularly principal investigators.
- As background to how the Center is working on the global circulation of world's best brains, give good examples, if any, of how career paths are being established for the Center's researchers; that is, from which top-world research institutions do researchers come to the Center and to which research institutions do the Center's researchers go, and how long are their stays at those institutions.

We established a collaborative network with leading-edge researchers in knotted meta matter right at the time of launching SKCM^2, including top-ranked institutions like MIT, Max Planck Inst., the University of Cambridge, and so on. The researchers from these partner institutions have interacted with the researchers in SKCM^2 at Hiroshima University to exchange their research ideas/topics (see the visitors record in Appendix 5); they visited on multiple occasions, including PIs and students or postdocs working with them.

The research field/paradigm that the SKCM^2 is establishing is very new, although, with our WPI's leadership, it is now getting the central focus as an interdisciplinary research of material science and mathematics (topology) worldwide. We work hard to hire talented postdocs and Ph.D. students eager to get into these emerging research fields and send them to these partner institutes for visits and collaborations for several months to expand young scientists' global research perspectives. We expect that these young researchers will find greater chances to become leaders in these growing research fields than in the well-explored existing areas. For example, one woman postdoc currently hired in SKCM^2 at HU is scheduled to go to Max Planck Institute (Dr. Donnelly lab.) to start her collaboration on material physics in summer 2023. We continuously encourage young researchers to go beyond their expertise to get into interdisciplinary areas by working with the PIs in the prestigious partner institutes of SKCM^2. On the other hand, many postdocs and students visit and stay at the HU's headquarters of the SKCM^2. For example, among visiting students were Ph.D. students from U. Birmingham (UK), Harvard U and Georgia Tech (USA) and Cambridge U (UK) and among visiting postdocs were ones from Utrecht U (the Netherlands), U Colorado Boulder and MIT (USA), and many other. Within the implementation period, some foreign PIs visited multiple times (e.g. Jorn Dunkel from MIT, USA & Danny Hsu from Academia Sinica, Taiwan).

In our External Advisory Board, we have three foreign advisers who are experienced in managing top interdisciplinary research programs. Prof. Mark Dennis is the director of the EPSRC Centre for Doctoral Training in Topological Design. In this center, they foster young researchers who will explore how topology is linked to the behavior of physical, biological, and other systems with the vision of its future application to engineering. His experience will help us to foster Ph.D. students in SKCM^2. Prof. Mark Bowick is the deputy director of the Kavli Institute for Theoretical Physics (KITP) at the University of California, Santa Barbara. The KITP has been working on a unique activity to encourage theorists in physics to work together on different interdisciplinary science topics while collaborating globally and hosting many international programs. One of their focusing topics is topological pattern formation in dynamic fluids. The KITP experiences in bringing theoretical researchers into other fields, including experimental, will give us good models to organize interdisciplinary research in SKCM^2. Prof. Slobodan Zumer is one of the leaders in organizing European TOPology Interdisciplinary Action (EUTOPIA). EUTOPIA aims to build a collaborative platform to explore how the physical properties of many systems, including biopolymers, liquid crystals, and some other artificial materials, are ascribed to topology. Understanding the interplay between a system's topological state (or three-dimensional structure) and its overall characteristics enables new approaches for controlling biomaterials and artificial materials, which will profoundly impact fundamental sciences and high-tech applications. His leadership role in international societies provides valuable perspectives on internationalization. His experience in coordinating multidisciplinary collaborations among researchers of a broad spectrum of expertise will promote collaborations among the international connections in SKCM^2. Prof. Kiyoshi Kurokawa's many years of experience in academia and leadership in different countries and Japan's government organization provide a beneficial perspective on expectations from our WPI. Helpful input from these experienced advisors guides our center activity of SKCM^2, which will prompt collaboration and researcher/student exchange among the high-ranked research nodes in the world.

1-2. Satellites and partner institutions

- List the satellite and partner institutions in the table below.
- Indicate newly added and deleted institutions in the "Notes" column.
- If satellite institutions have been established overseas, describe by satellite the Center's achievements in coauthored papers and researcher exchanges in Appendix 4.

<Satellite institutions>

Institution name	Principal Investigator(s), if any	Notes

< Partner institutions>

Institution name	Principal Investigator(s), if any	Notes
Department of Physics, University of Colorado	Ivan I. Smalyukh	Director of SKCM2
Department of Mathematics, Massachusetts Institute of Technology	Jörn Dunkel	
Max Planck Institute for Physical Chemistry of Solids	Claire Donnelly	
Department of Chemistry, University of Cambridge	Silvia Vignolini	
School of Physics, Georgia Institute of Technology	Elisabetta Matsumoto	
Debye Institute for Nanomaterials Science, Utrecht University	Marjolein Dijkstra	
Emergent Molecular Assembly Research Unit/RIKEN Center for Emergent Matter Science	Hiroshi Sato	
Institute of Theoretical Physics, University of Wroclaw	Chihiro Sasaki	
Department of Mathematics, Tokyo Institute of Technology	Tamás Kálmán	
Institute of Biological Chemistry, Academia Sinica	Shang-Te Danny Hsu	
University of Lisbon, Portugal	Mykola Tasinkevych, coPI	
Tel Aviv University, Israel	Yair Shokef, co-PI	

2. Holding international research meetings

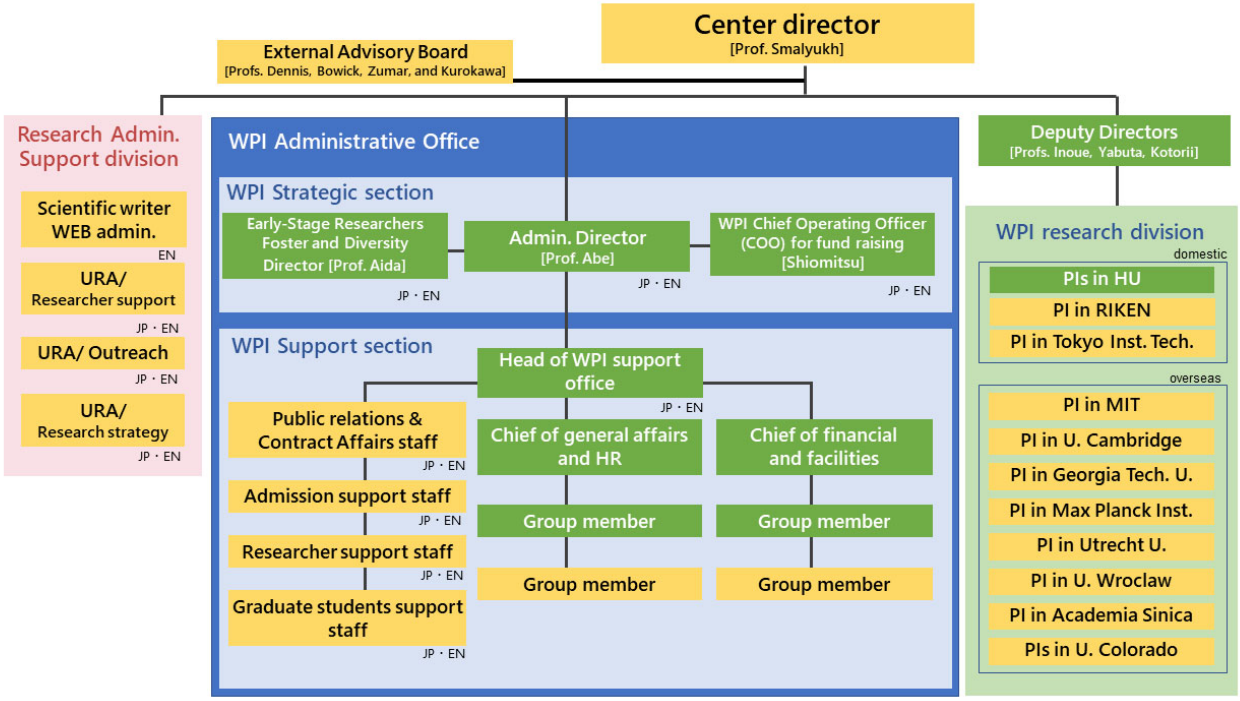
- Indicate the number of international research conferences or symposiums held in FY2022 and give up to three examples of the most representative ones using the table below.

FY 2022: 1 meeting

Major examples (meeting titles and places held)	Number of participants
Mar. 20-22, 2023 SKCM2 Kickoff Symposium, Hiroshima International Conference Center	From domestic institutions: 127 From overseas institutions: 24

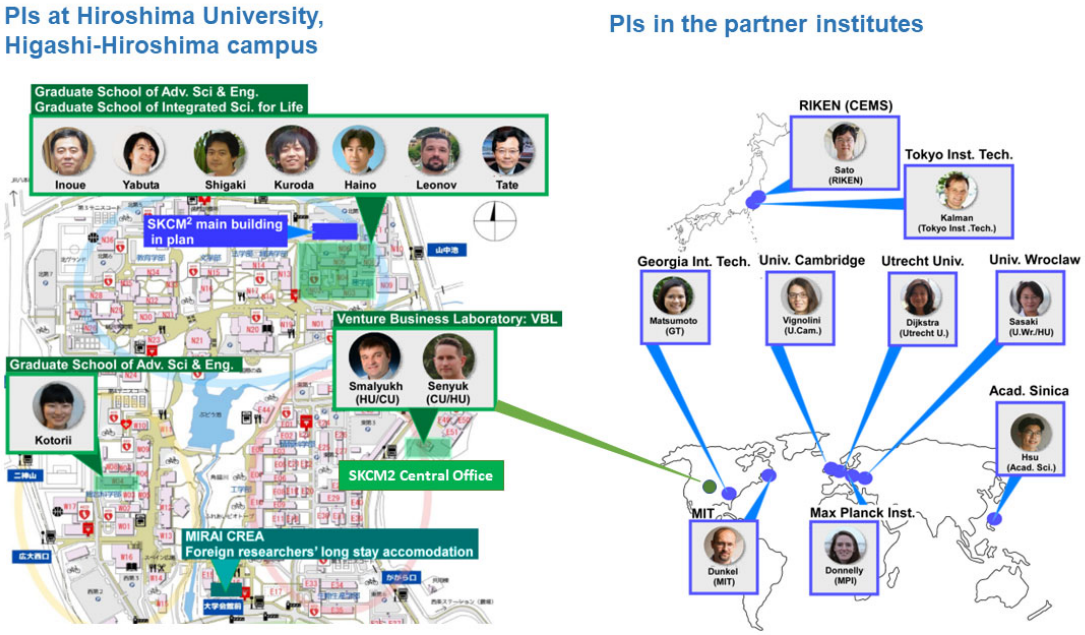
3. Diagram of management system

- Diagram the center's management system and its position within the host institution in an easily understood manner.
- If any new changes have been made in the management system from that in the latest "center project" last year, describe them. Especially describe any important changes made in such as the center director, administrative director, head of host institution, and officer(s) in charge at the host institution (e.g., executive vice president for research).



4. Campus Map

- Draw a simple map of the campus showing where the main office and principal investigator(s) are located.



5. Securing external research funding*

External research funding secured in FY2022

Total: 187,662,800 yen

- Describe external funding warranting special mention. Include the name and total amount of each grant.
* External research funding includes "KAKENHI," funding for "commissioned research projects," "joint research projects," and for others (donations, etc.) as listed under "Research projects" in Appendix 3-2, Project Expenditures.

Type of Funding	Funding Amount
Grants-in-Aid for Scientific Research (KAKENHI)	104,780,000 yen
Commissioned Research Projects	52,822,800 yen
Joint Research Projects	16,060,000 yen
Total* (total for above mentioned)	**173,662,800 yen**
Others (donation funds, etc.)	140,00,000 yen
Grand Total including donations etc.	187,662,800 yen

Appendix 3-1a FY 2022 Records of Center Activities

Researchers and other center staff

Number of researchers and other center staff

* Fill in the number of researchers and other center staff in the table blow.
* Describe the final goals for achieving these numbers and dates when they will be achieved described in the last "center project."

a) Principal Investigators

(full professors, associate professors or other researchers of comparable standing)

(number of persons)

	At the beginning of project	At the end of FY 2022	Final goal (Date: April, 2027)
Researchers from within the host institution	9	9	10
Researchers invited from overseas	8	8	10
Researchers invited from other Japanese institutions	2	2	4
Total principal investigators	19	19	24

b) Total members

	At the beginning of project		At the end of FY 2022		Final goal (Date: April, 2027)	
	Number of persons	%	Number of persons	%	Number of persons	%
Researchers	30		34		156	
Overseas researchers	13	43	13	38	79	51
Female researchers	7	23	9	26	79	51
Principal investigators	19		19		24	
Overseas PIs	8	42	8	42	12	50
Female PIs	7	37	7	37	12	50
Other researchers	8		9		66	
Overseas researchers	2	25	2	22	34	52
Female researchers	0	0	1	11	34	52
Postdocs	3		6		66	
Overseas postdocs	3	100	3	50	33	50
Female postdocs	0	0	1	17	33	50
Research support staffs	2		5		6	
Administrative staffs	3		8		14	
Total number of people who form the "core" of the research center	35		47		176	

	At the beginning of project		At the end of FY 2022		Final goal (Date: April, 2027)	
	Number of persons	%	Number of persons	%	Number of persons	%
Doctoral students	0		5		72	
Employed	0	-	5	100.0	72	100.0

※b) The number of doctoral students in the lower table can be duplicated in the upper table of overall composition.

Appendix 3-2 Project Expenditures

1) Overall project funding

* In the "Total costs" column, enter the total amount of funding required to implement the project, without dividing it into funding sources.
* In the "Amount covered by WPI funding" column, enter the amount covered by WPI within the total amount.
* In the "Personnel," "Project activities," "Travel," and "Equipment" blocks, the items of the "Details" column may be changed to coincide with the project's actual content.

(Million yens)

Cost items	Details (For Personnel - Equipment please fill in the breakdown of fiscal expenditure, and the income breakdown for Research projects.)	Total costs	Amount covered by WPI funding
Personnel	Administrative director	6.2	0.2
	HU Principal investigators (no. of persons):8	24.4	16.4
	HU Co-PIs (no. of persons):5	5.6	0
	Posdoc (no. of persons):3	1.5	1.5
	RAs (no. of persons):6	2.2	2.2
	Research support staff (no. of persons):4	4.5	0.5
	Administrative staff (no. of persons):8	11	2.2
	Bonus bank	47.7	47.7
	Subtotal	103.1	70.7
Project activities	Rental fees for research space	7	0
	Accommodation fee(Usage fee for MIRAI CREA)	0.7	0
	Office furniture and equipment	7.6	7.6
	Facility maintenance costs (utility expenses, etc.)	3.5	0
	Startup funds(no. of persons):14	83	83
	Article publishing charge	4.2	4.2
	Kick off International Symposium	4.7	3.5
	Consulting Fee(Overseas PI, etc.)	65	36.9
	External advisory fee	3	3
	Public relations expenses	6.5	6.3
	Other costs	24.9	10.7
	Subtotal	210.1	155.2
Travel	Domestic travel costs	2	1.8
	Overseas travel costs	5.4	4.5
	Travel and accommodations cost for invited scientists	27.3	27.3
	(no. of domestic scientists):10		
	(no. of overseas scientists):34		
	Travel cost for scientists on transfer	0	0
	Subtotal	34.7	33.6
Equipment	Depreciation of buildings	16.2	11.6
	Depreciation of equipment	151.9	151.9
	Subtotal	168.1	163.5
Research projects (Detail items must be fixed)	Project supported by other government subsidies, etc. *1	0	0
	KAKENHI	104.8	0
	Commissioned research projects, etc.	52.8	0
	Joint research projects	16.1	0
	Ohers (donations, etc.)	14	0
	Subtotal	187.7	0
Total		703.7	423

Costs (Million yens)

WPI grant in FY 2022	650
Costs of establishing and maintaining facilities	11.6
Establishing new facilities	0
(Number of facilities: , 0m²)	
Repairing facilities	11.6
(Number of facilities: , 1.514 m²)	
Others	0
Costs of equipment procured	152
Atomic Force Microscope	50
(Number of units:1)	
Confocal Laser Microscope	35
(Number of units:1)	
Infrared Spectroscopic Microscope	15
(Number of units:1)	
Steady-state thermal conductivity measurement	11
(Number of units:1)	
Others	41

*1. Management Expenses Grants (including Management Enhancements Promotion Expenses (機能強化経費)), subsidies including National university reform reinforcement promotion subsidy (国立大学改革強化推進補助金) etc., indirect funding, and allocations from the university's own resources.
*2 When personnel, travel, equipment (etc.) expenses are covered by KAKENHI or under commissioned research projects or joint research projects, the amounts

*1 運営費交付金（機能強化経費を含む）、国立大学改革強化推進補助金等の補助金、間接経費、その他大学独自の取組による学内リソースの配分等による財源
*2 科研費、受託研究費、共同研究費等によって人件費、旅費、設備備品等費を支出している場合も、その額は「研究プロジェクト費」として計上すること

Appendix 4 FY 2022 Status of Collaboration with Overseas Satellites

1. Coauthored Papers

- List the refereed papers published in FY 2022 that were coauthored between the center's researcher(s) in domestic institution(s) (include satellite institutions) and overseas satellite institution(s). List them by overseas satellite institution in the below blocks.
- Transcribe data in same format as in Appendix 1. Italicize the names of authors affiliated with overseas satellite institutions.
- For reference write the Appendix 1 item number in parentheses after the item number in the blocks below. Let it free, if the paper is published in between Jan.-Mar. 2023 and not described in Appendix 1.

SKCM^2 does not have any overseas satellites but many partner institutes. We will list the coauthored papers among the researchers in the institutions of PIs from our global partnership.

Utrecht University (Total: 1 papers)

1) Chiappini, M; Dussi, S; Frka-Petesic, B; *Vignolini, S*; *Dijkstra, M*. Modeling the cholesteric pitch of apolar cellulose nanocrystal suspensions using a chiral hard-bundle model. J. Chem. Phys. 2022, 156(1), 14904. doi:10.1063/5.0076123

University of Cambridge (Total: 1 papers)

2) Chiappini, M; Dussi, S; Frka-Petesic, B; *Vignolini, S*; *Dijkstra, M*. Modeling the cholesteric pitch of apolar cellulose nanocrystal suspensions using a chiral hard-bundle model. J. Chem. Phys. 2022, 156(1), 14904. doi:10.1063/5.0076123

University of Colorado Boulder (Total: 2 papers)

3) *Senyuk, B*; Adufu, RE; *Smalyukh, II*. Electrically Powered Locomotion of Dual-Nature Colloid-Hedgehog and Colloid-Umbilic Topological and Elastic Dipoles in Liquid Crystals. Langmuir 2022, 38(2), 689-697. doi: 10.1021/acs.langmuir.1c02546
4) *Senyuk, B*; Meng, CL; *Smalyukh, II*. Design and Preparation of Nematic Colloidal Particles. Langmuir 2022, 38(30), 9099-9118. doi: 10.1021/acs.langmuir.2c00611

2. Status of Researcher Exchanges

- Using the below tables, indicate the number and length of researcher exchanges in FY 2022. Enter by institution and length of exchange.
- Write the number of principal investigator visits in the top of each space and the number of other researchers in the bottom.

SKCM^2 does not have any overseas satellites but many partner institutions. We will report the researcher exchanges among the partnering/collaborating institutions for reference.

Utrecht University

<To satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022					

<From satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022					
	1				

University of Colorado Boulder

<To satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022					

<From satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022		1			
		1			

University of Cambridge

<To satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022					

<From satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022					
	1				

University of Wroclaw

<To satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022					

<From satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022		1			

Academia Sinica

<To satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022					

<From satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022		1			

Max Planck Institute for Physical Chemistry of Solids

<To satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022					

<From satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022					
	1				

Georgia Institute of Technology

<To satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022					

<From satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022	1				
		1			

Massachusetts Institute of Technology

<To satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022					

<From satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022		1			

Tokyo Institute of Technology

<To satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022					

<From satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022		1			

RIKEN Center for Emergent Matter Science

<To satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022					

<From satellite>

	Under 1 week	From 1 week to 1 month	From 1 month to 3 months	3 months or longer	Total
FY2022		1			

Appendix 5 FY 2022 Visit Records of Researchers from Abroad

* If researchers have visited/ stayed at the Center, provide information on them in the below table.
* Enter the host institution name and the center name in the footer.

Total: 32

	Name	Age	Affiliation		Academic degree, specialty	Record of research activities (Awards record, etc.)	Time, duration	Summary of activities during stay at center (e.g., participation as principal investigator; short-term stay for joint research; participation in symposium)
			Position title, department, organization	Country				
1	Mykola Tasinkevych	49	Senior Lecturer, School of Science & Technology, Nottingham Trent University	UK	Ph.D., Soft condensed matter theory	Senior Lecturer, School of Science & Technology, Nottingham Trent University	Jan.11-Jan.19, 2023	Short-term stay for discussion and research
2	Brian M Day	28	Undergraduate Research Assistant, Georgia Institute of Technology	USA	Undergraduate Research associate, Geometry and topology	Undergraduate Research Assistant, Georgia Institute of Technology	Jan.23-Jan.31, 2023	Short-term stay for discussion and research
3	Shang-Te Danny Hsu	47	Associate Research Fellow, Institute of Biological Chemistry, Academia Sinica	Taiwan	Ph.D., Biophysical Chemistry, knotted proteins	Associate Research Fellow, Institute of Biological Chemistry, Academia Sinica	Jan.25-Jan.31, 2023	Short-term stay for discussion and research
4	Jay Morris	27	PhD Student, Computational Soft Matter, University of Birmingham	UK	Ph.D. Student, Computational softmatter chemistry	PhD Student, Computational Soft Matter, University of Birmingham	Jan.26-Mar.31, 2023	Participation in Kick-off symposium, outreach, discussion and seminar
5	Chihiro Sasaki	46	Professor, Institute of Theoretical Physics, University of Wroclaw	Poland	Ph.D., High energy particle physics (theory)	Professor, Institute of Theoretical Physics, University of Wroclaw	Jan.28-Feb.4, 2023	Short-term stay for discussion and research
6	Jörn Dunkel	46	Professor, Department of Mathematics, Massachusetts Institute of Technology	USA	Ph.D., Applied mathematics, and topology	Professor, Department of Mathematics, Massachusetts Institute of Technology 2020 Robert E. Collins Distinguished Scholar, MIT 2017 Gallery of Fluid Motion Award, APS/DFD 2011 Gustav Hertz Prize (DPG)	Jan.29-Feb.2, 2023	Short-term stay for discussion and research

7	Yair Shokef	48	Professor, School of Mechanical Engineering, Tel Aviv University	Israel	Ph.D., Non-equilibrium statistical physics	Professor, School of Mechanical Engineering, Tel Aviv University	Jan.29-Feb.2, 2023	Short-term stay for discussion and research
8	Dwaipayan Chakrabarti	46	Associate Professor in Soft Matter, School of Chemistry Univ. of Birmingham	UK	Ph.D., Computational chemistry, physical chemistry	Associate Professor in Soft Matter, School of Chemistry Univ. of Birmingham	Feb.13-Feb.17, 2023	Short-term stay for discussion and seminar
9	Dirk Jan Broer	73	Emeritus Professor, Chemical Engineering and Chemistry Eindhoven Univ. of Technology	Netherlands	Ph.D., Liquid crystals, nanotechnology	Emeritus Professor, Chemical Engineering and Chemistry Eindhoven Univ. of Technology A member of the Royal Netherlands Academiy of Arts and Science (KNAW)	Feb.15-Feb.27, 2023	Short-term stay for discussion and seminar
10	David A Leigh	60	Royal Society Research Professor & Sir Samuel Hall Chair of Chemistry, Univ. of Manchester	UK	Ph.D., Organic chemistry	Royal Society Research Professor & Sir Samuel Hall Professor of Chemistry Department of Chemistry The University of Manchester Distinguished Professor School of Chemistry and Molecular Engineering East China Normal University 2019 Honorary Membership of the Israel Chemical Society 2020 Academic Influence 'Top Influential Chemists 2010-2020'	Mar. 9-Mar.10, 2023	Short-term stay for discussion and seminar
11	Cristina Marchetti	68	Professor of Physics, UC Santa Barbara	USA	Ph.D., Theoretical physics, condensed matter physics	Professor of Physics, UC Santa Barbara 2019 Leo P. Kadanoff Prize	Mar.17-Mar.23, 2023	Participation in Kick-off symposium as invited speaker
12	Mark Bowick	66	Distinguished Professor, UC Santa Barbara, Deputy Director, Kavli Institute	USA	Ph.D., Condensed matter theory and High energy theoretical physics	Distinguished Professor, UC Santa Barbara, Deputy Director, Kavli Institute 1986 Gravity Research Foundation Essay Competition 2004 APS Fellow 2022 AAAS Fellow	Mar.17-Mar.23, 2023	Participation in Kick-off symposium as invited speaker (External advisory board member)
13	Paul Sutcliff	54	2H Course Director, Professor, Mathematical & Theoretical Particle Physics, Durham University	UK	Ph.D., Mathematical physics, topological soliton	2H Course Director, Professor, Mathematical & Theoretical Particle Physics, Durham University 2006: London Mathematical Society Whitehead Prize 1995 : Nuffield Foundation Newly Appointed Lecturer Award	Mar.19-Mar.24, 2023	Participation in Kick-off symposium as invited speaker

14	Mark Dennis	47	Professor of Theoretical Physics, University of Birmingham	UK	Ph.D., Theoretical physics, optics	Professor of Theoretical Physics, University of Birmingham Director of EPSRC Centre for Doctoral Training in Topological Design	Mar.17-Apr.3, 2023	Participation in Kick-off symposium as invited speaker (External advisory board member)
15	Slobodan Zumer	78	Professor of Physics, University of Ljubljana	Slovenia	Ph.D., Condensed matter physics	Physics Department, Faculty of Mathematics and Physics Condensed Matter Physics Department University of Ljubljana 2019 Freederiksz medal 2017 National Zois Award for lifetime research achievements 2017 APS Fellow of APS 2016 Member of European Academy of Sciences and Arts 1990 Boris Kidric Prize for the research of Polymer Dispersed Liquid Crystasls 1980 Boris Kidric Foundation Prize for the research of Magnetic Relaxation in Condensed Matter	Mar.19-Mar.24, 2023	Participation in Kick-off symposium and weekly seminar as invited speaker (External advisory board member)
16	Alexander Gareth	41	Associate Professor in Physics, University of Warwick	UK	Ph.D., Theoretical soft matter physics	Associate Professor in Physics, University of Warwick	Mar.18-Mar.26, 2023	Participation in Kick-off symposium as invited speaker
17	Qiwen Zhan	49	School of Optical-Electrical and Computer Engineering, University of Shanghai for Science and Technology	China	Ph.D., Optics, Metrology	Distinguished Chair Professor in Nanophotonics at Univ of Shanghai for Science and Technology	Mar.18-Mar.27, 2023	Participation in Kick-off symposium as invited speaker
18	Renzo Ricca	63	Professor of Mathematical Physics, University of Milano-Bicocca	Italy	Ph.D., Topological fluid dynamics, magnetothermodynamics	Professor of Mathematical Physics, University of Milano-Bicocca 1991 J.T. Knight's Prize	Mar.19-Mar.23, 2023	Participation in Kick-off symposium as invited speaker
19	Miha Ravnic	42	Head of Softmatter Group Vice-dean, Faculty of Mathematics and Physics, University of Ljubljana	Slovenia	Ph.D., Condensed matter physics	Head of Softmatter Group Vice-dean, Faculty of Mathematics and Physics, University of Ljubljana	Mar.18-Mar.23, 2023	Participation in Kick-off symposium as invited speaker
20	Kos Ziga	32	PhD, Faculty of Mathematics and Physics, University of Ljubljana,	Slovenia	Ph.D., Condensed matter physics	PhD, Faculty of Mathematics and Physics, University of Ljubljana, 2022 Top research achievement award (Univ. Ljubljana) 2022 Jozef Stefan Golden Emblem Prize 2017 Best poster prize at 14the European Conference on Liquid Crystals	Mar.18-Mar.23, 2023	Participation in Kick-off symposium

21	Gerald Campos Villalobos	30	Postdoctoral Researcher, Utrecht University	Netherlands	Ph.D. liquid crystasl, Nano-technology	Postdoctoral Researcher, Utrecht University	Mar.19-Mar.24, 2023	Participation in Kick-off symposium and weekly seminar as invited speaker
22	Petur Bryde	29	PhD student in Applied Mathematics, Harvard University	USA	Applied mathematics	PhD student in Applied Mathematics, Harvard University	Mar.18-Mar.25, 2023	Participation in Kick-off symposium
23	Bruno Frka-Petesic	39	Senior Research Associate, Department of Chemistry, University of Cambridge,	UK	Ph.D. Soft matter physics	Senior Research Associate, Department of Chemistry, University of Cambridge	Mar.18-Mar.22, 2023	Participation in Kick-off symposium
24	Benjamin Teall	27	Research student, University of Cambridge	UK	Research student Softmatter physics	Research student, University of Cambridge	Mar.18-Mar.23, 2023	Participation in Kick-off symposium
25	Katarzyna Matczyszyn	48	Associate Professor, Faculty of Chemistry, Wroclaw University of Science and Technology	Poland	Ph.D., Physical Chemistry	Associate Professor, Faculty of Chemistry, Wroclaw University of Science and Technology	Mar.18-Mar.23, 2023	Participation in Kick-off symposium as panelist
26	Chihiro Sasaki	46	Professor, Institute of Theoretical Physics, University of Wroclaw	Poland	Ph.D., High energy particle physics (theory)	Professor, Institute of Theoretical Physics, University of Wroclaw	Mar.8-Mar.23, 2023	Participation in Kick-off symposium and weekly seminar as invited speaker
27	Bohdan Senyuk	51	Senior Research Associate, Department of Physics, University of Colorado Boulder	USA	Ph.D., Chemical physics of soft matters	Senior Research Associate, Department of Physics, University of Colorado Boulde	Mar.14-Apr.29, 2023	Participation in Kick-off symposium, discussion and seminar
28	Elisabetta Matsumoto	37	Associate Professor, School of Physics, Georgia Institute of Technology	USA	Ph.D., Geometry and toplogy of softmatters	Associate Professor, School of Physics, Georgia Institute of Technology 2020 Cottrell Scholar Award	Mar.18-Mar.23, 2023	Participation in Kick-off symposium as discussion leader
29	Jörn Dunkel	46	Professor, Department of Mathematics, Massachusetts Institute of Technology	USA	Ph.D., Applied mathematics, and topology	Professor, Department of Mathematics, Massachusetts Institute of Technology 2020 Robert E. Collins Distinguished Scholar, MIT 2017 Gallery of Fluid Motion Award, APS/DFD 2011 Gustav Hertz Prize (DPG)	Mar.19-Mar.23, 2023	Participation in Kick-off symposium as invited speaker
30	Shang-Te Danny Hsu	47	Associate Research Fellow, Institute of Biological Chemistry, Academia Sinica	Taiwan	Ph.D., Biophysical Chemistry, knotted proteins	Associate Research Fellow, Institute of Biological Chemistry, Academia Sinica	Mar.19-Mar.22, 2023	Participation in Kick-off symposium

31	Claire Donneley	31	Lise Meitner Group Leader, Max Planck Institute for Physical Chemistry of Solids	Germany	Ph.D., Material physics	Lise Meitner Group Leader, Max Planck Institute for Physical Chemistry of Solids 2023 IEEE Magnetics Society Early Career Award	Mar.19-Mar.23, 2023	Participation in Kick-off symposium as invited speaker
32	Vladyslav Cherpak	46	Senior Research Associate, Soft Matter Physics Smalyukh Research Group, University of Colorado Boulder	USA	Ph.D., Soft-matter physics	Senior Research Associate, Soft Matter Physics Smalyukh Research Group, University of Colorado Boulder	Mar.19-Mar.28, 2023	Participation in Kick-off symposium, discussion and seminar

Appendix 6 FY2022 State of Outreach Activities

* Fill in the numbers of activities and times held during FY2022 by each activity.
* Describe the outreach activities in the "3-1. Societal Value of Basic Research" of Progress Report, including those stated below that warrant special mention.

Activities	FY2022 (number of activities, times held)
PR brochure, pamphlet	2
Lectures, seminars for general public	1
Teaching, experiments, training for elementary, secondary and high school students	1
Science café	0
Open houses	0
Participating, exhibiting in events	1
Press releases	13
Publications of the popular science books	0
Others（Miyajima Outreach）	1
Others（Website）	1
Others（Hiroshima University Alumni Networking Event）	1

*If there are any rows on activities the center didn't implement, delete that (those) row(s). If you have any activities other than the items stated above, fill in the space between parentheses after "Others" on the bottom with the name of those activities and state the numbers of activities and times held in the space on the right. A row of "Others" can be added, if needed.

Outreach Activities and Their Results

List up to three of the Center's outreach activities carried out in FY 2022 that have contributed to enhancing the brand or recognition of your Center and/or the brand of the overall WPI program, and describe its concrete contents and effect in narrative style. (Where possible, indicate the results in concrete numbers.)

Examples:
- As a result of using a new OO press-release method, a OO% increase in media coverage was obtained over the previous year.
- By holding seminars for the public that include people from industry, requests for joint research were received from companies.
- We changed our public relations media. As a resulting of using OO to disseminate information, a OO% increase in inquiries from researchers was obtained over the previous year.
- As a result of vigorously carrying out OO outreach activity, ¥OO in external funding was acquired.

【Workshop and Seminar for the General Public】

- As a result of the outreach event held for the general public on Miyajima Island, we were able to collect questionnaires from 46 participants, of which 96% were satisfied with the event. Approximately 150 participants from the public informally expressed interest in science conducted at SKCM^2 after engaging with VR and poster presentations. The participants came from a variety of age backgrounds, ranging from under 10 to over 60, and many people from outside of the Chugoku region (including foreign tourists) also attended the event. 500 leaflets were distributed to the general public.

- By conducting outreach in a form of science workshop at a high school affiliated with Hiroshima

University, a group of students interacted with the director, PIs, and graduate students from the institute and learned science related to knotted chiral meta matter. As a result, 40 leaflets introducing the center were distributed. (https://www.hiroshima-u.ac.jp/news/75678)

- Public online seminar by Dr. Hikaru Yabuta, 2022/09/07: Dr. Yabuta introduced the latest results of analysis on solid organic matter collected by Hayabusa 2. She also talked about the connection between asteroids and us living on Earth, and the nature of the asteroid Ryugu revealed through astronomical observations. As a result, more than 200 participants participated in the seminar and attracted awareness of research related to earth and planetary science.

- Hiroshima University Alumni Exchange Social（Fundraising event）2023/3/10, Three graduates of Hiroshima University, who are currently working for companies in the scientific and technological fields, were invited to the Hiroshima University Tokyo Satellite. The goal of the event was to establish a network that would serve as a foothold for future fund raising, and they were introduced to the scientific and technological outlook that SKCM^2 is developing.

【Media Coverage and Press Release】

- SKCM^2's activities are advertised in a variety of media. A total of 8 studies by Deputy Director Inoue and Deputy Director Yabuta have been covered on the website of Hiroshima University and the JAXA.

- Outreach and other public events were also featured on TV and the web. For example, regarding the adoption of the WPI, the center's director was televised at the press conference. The high school visits and Miyajima outreach were also introduced in the university's public relations media. Posters for the general public (Japanese only) has been displayed at the "Kiteminsai Lab" adjacent to Hiroshima Station (The annual report on the number of visits is yet to be released).

Appendix 7 FY 2022 List of Project's Media Coverage

* List and describe media coverage (e.g., articles published, programs aired) in FY 2022.

* Enter the host institution name and the center name in the footer.

	Date	Types of Media (e.g., newspaper, magazine, television)	Description
1	Jan. 9, 2022	television 1	[BS Fuji] Analysis of samples brought back by Hayabusa2 from the asteroid Ryuguu (Prof. Yabuta)
2	Feb. 17, 2022	newspaper 1	[Nikkan Kogyo Shimbun Feb. 17] Discovery of quasiparticle multipole polaron (Assoc. Prof. Kuroda)
3	Oct. 24, 2022	television 2	[Hiroshima Television, TSS Television] Selection of the WPI Program (President's Regular Press Conference)
4	Nov. 5, 2022	newspaper 1	[Asahi Shimbun Nov. 5] Selection of the WPI Program
5	Nov. 17, 2022	web	[hotozero.com] Focused researcher by URA: Knot theory expands our visions of the world (Prof. Kotorii)
6	Jan. 23, 2023	web	[GAKU POTA] Introducing young researcher on toplogy (Prof. Kotorii)
7	Jan. 28, 2023	newspaper 1	[Chugoku Shimbun Jan. 28] Establishment of the International Institute for Sustainability with Knotted Chiral Meta Matter (President's Regular Press Conference)
8	Feb. 26, 2023	television 1	[NHK E television] Research report on Hayabusa2 (Prof. Yabuta)
9			
10			
11			
12			