

Report QFS2024

Organizing Committee:

- **Co-Chairs:** Prof. Wei Guo (Florida State University), Prof. Yoonseok Lee (University of Florida)
- **Committee Members:** Katherine Risher (**female**), Kevin Jackson (UF Conference Department)

Local Program Committee: (7 members, 1 female)

- Prof. Dafei Jin (University of Notre Dame)
- Prof. Tarek Saab (UF)
- Prof. Dominique Laroche (UF)
- Dr. Andrew Woods (National High Magnetic Field Laboratory)
- Prof. Jim Sauls (Louisiana State University)
- Prof. Rena Zieve (UC Davis, **female**)
- Prof. Nir Navon (Yale University)

Steering Committee:

- **Chair:** Prof. Andrei Golov (University of Manchester, UK)
- **Members:** Prof. Ambarish Ghosh (Indian Institute of Science, India), Prof. Robert Hallock (University of Massachusetts, USA), Prof. Naoto Nagaosa (IUPAP C5), Prof. Alexandr Levchenko (Russia), Prof. Keiya Shirahama (Keio University, Japan), and Prof. John Davis (University of Alberta, Canada).

International Advisory Committee:

This committee included 36 distinguished members from 14 countries with **5 females**, ensuring a broad international and topical perspective. Members included Prof. Warwick Bowen (Australia), Prof. Vladimir Eltsov (Finland), Prof. Philippe Roche (France), Prof. Ambarish Ghosh (India), Prof. Makoto Tsubota (Japan), Prof. John Saunders (UK), Prof. William Halperin (USA), and many others, representing the leading experts in the field of quantum fluids and solids.

Conference Overview:

The 2024 International Symposium on Quantum Fluids and Solids (QFS2024) was held from July 24-30 at the Hyatt Regency Jacksonville Riverfront, Jacksonville, Florida, USA. QFS2024 marked the continuation of a prestigious conference series that has become a cornerstone for researchers in quantum fluids and solids, covering both established topics and emerging interdisciplinary fields. The conference, organized by the University of Florida and Florida State University, was generously supported by major institutions like the National Science Foundation, the Gordon and Betty Moore Foundation, the International Union of Pure and Applied Physics (IUPAP), the National High Magnetic Field Laboratory, Florida State University, and the University of Florida, as well as industrial sponsors, including Oxford Instruments, Maybell Quantum, and Bluefors Inc. Their support was instrumental in hosting the conference at the Hyatt Regency Jacksonville Riverfront, a venue that provided participants with a beautiful riverside view and state-of-the-art facilities. The comfortable setting fostered a conducive environment for networking and collaboration among the attendees, which was consistently highlighted in the feedback.

Scientific Program:

The conference featured a comprehensive scientific program, which included traditional areas of quantum fluids and solids as well as new interdisciplinary topics which have not been included in

the previous events. Key sessions covered:

- Cold Atoms
- Quantum Liquids and Solids
- Topological Materials
- Superfluid ^3He
- Confined QFS Systems
- Vortices and Quantum Turbulence
- Quantum Fluids for Cosmology
- Superfluid Optomechanics
- Superconductivity and Low-Temperature Physics
- Quantum Information Science Using QFS Systems
- Impurities and Excitations in QFS
- Cryogenics Techniques

Quantum Computing Sessions:

A new and significant addition to QFS2024 was the inclusion of two specialized lectures on quantum computing, reflecting the growing intersection of quantum fluids, solids, and quantum information science.

- **Lecture 1: "Quantum Computing: Where Have We Come? Where Are We Going?" by Prof. Stephen A. Lyon (Princeton University)**
 - Prof. Lyon provided an in-depth historical perspective on quantum computing, highlighting the progression from theoretical constructs to practical implementations. He discussed the unique challenges in scaling quantum systems, particularly focusing on electron spin qubits in various environments, including superfluid helium. His lecture emphasized the importance of error correction and the technological hurdles that still need to be overcome.
- **Lecture 2: "Quantum Supremacy 5 Years Later" by Alan Ho (CEO of Qolab)**
 - Alan Ho offered a retrospective on Google's quantum supremacy experiment and discussed the advancements in superconducting qubit hardware necessary for achieving practical quantum supremacy, especially in condensed matter physics simulations. He outlined the ongoing challenges in qubit fabrication and the potential of four-qubit interactions to optimize quantum circuits.

Management of the Conference:

QFS2024 was an entirely in-person event, providing an immersive experience for all attendees. The University of Florida Conference Department played a crucial role in managing logistics, ensuring that the event ran smoothly. Katherine Risher and Kevin Jackson were instrumental in coordinating the event, from registration to the organization of sessions. The success of QFS2024 was also due in no small part to the efforts of the many student volunteers from Florida State University. These students assisted with various tasks, including setting up sessions, guiding participants, and ensuring that all logistical needs were met throughout the conference. Their dedication and hard work were greatly appreciated by both the organizers and participants.

Excursions and Social Activities:

Excursions: QFS2024 offered two exciting excursions that were highly popular among participants.

- **Kennedy Space Center Excursion:** This trip included a bus journey to the Kennedy Space Center, where participants had the opportunity to explore the Visitors Complex and learn about the history and future of space exploration.
- **Historic St. Augustine Trolley Tour:** Participants took a bus trip to the historic city of St.

Augustine, enjoying a scenic boat tour and time to explore the historic downtown area, with its charming shops, restaurants, and significant landmarks. Both excursions provided valuable networking opportunities in a relaxed setting, allowing participants to unwind while continuing their scientific discussions in a more informal environment.

Banquet: The buffe-style banquet was held in the evening of Monday. During the banquet, Robert Hallock gave a meaningful speech on the history of QFS from the 1st meeting in Sanibel Island, FL with a special emphasis on effort in keeping the community close and tight.

Poster Awards:

QFS2024 also featured a poster competition to encourage the participation of early-career researchers and students. Nine graduate students and postdocs were selected by the three groups of judges and the awards were presented during the conference, recognizing outstanding contributions in various topics. Each awardee received a certificate and a prize bag, which included conference swag and a special keepsake—a bitter disc from the National High Magnetic Field Laboratory. This unique prize was particularly well-received by the recipients, adding an extra element of recognition and celebration to their achievements.

Support for Students:

QFS2024 made a concerted effort to lower financial barriers for student participants. The registration fee for students was set at a substantially reduced rate of \$150, compared to the regular participant fee of \$550. In addition to the reduced registration fee, the organizers offered accommodation subsidies to students (\$300/person), further alleviating the financial burden and ensuring broader participation from early-career researchers.

Information on Participants and Presentations:

- Total Participants: **172**
- Countries Represented: **15**
- Invited Speakers: **49**
- Contributed Talks: **29**
- Poster Presentations: **70**

Sessions covered a wide array of topics, with each session led by experts in the field.

Issues and Prospects:

While QFS2024 was a resounding success, there were a few minor issues:

- **Travel Disruptions:** Due to a worldwide system breakdown of Windows operating systems that occurred a few days before the conference, many flights to Jacksonville, Florida, were either canceled or delayed. This affected the travel plans of several participants, leading to the need for some speakers to reschedule or shift their talks. The organizers handled these disruptions effectively, but it did cause some logistical challenges.
- **Visa Challenges:** Another issue was the difficulty faced by participants from certain countries in obtaining US visas to attend QFS2024. Some invited speakers had to cancel their talks or ask students to present on their behalf with short notice. This led to some last-minute adjustments in the scheduling of talks, posing challenges for both the students and the organizers.

Despite these challenges, QFS2024 was highly successful, with participants expressing strong satisfaction with the scientific content, networking opportunities, and overall organization.

Conference Report: The International Conference on Quantum Fluids and Solids (QFS2023)

Organizing Committee:

Co-chairs: Andrei Golov and Paul Walmsley (both University of Manchester, UK)

The International Conference on Quantum Fluids and Solids (QFS2023) was held in the Engineering building of the University of Manchester between 9-15th August 2023. This event was the 26th in the QFS series of conferences (<https://people.umass.edu/qfs98/history.htm>) and followed previous meetings in Edmonton, Canada (2019) and Bangalore, India (2021). QFS2021 was held entirely online due to the Covid pandemic, so QFS2023 was the first face to face QFS meeting in four years. Full details of the Conference can be found on the website: <https://qfs2023.org>.

There were 149 registered delegates (of which 12 were females) – these included 43 students. 8 delegates were accompanied by family members. There were also 6 exhibitors who represented Oxford Instruments and Cryogenic. Thus, the total number of participants was 163.

There were 19 countries represented with numbers of delegates:

- 73 from Europe (UK 51, Finland 5, France 4, Czech Rep. 4, Israel 2, then 1 each from: Austria, Germany, Ireland, Russia, Spain),
- 44 from Asia and Oceania (Japan 28, India 5, China 5, S. Korea 3, Australia 2, Taiwan 1),
- 32 from Americas (USA 26, Canada 4, Brazil 2).

There was a total of 136 presentations, which included 66 (of which 4 by females) invited oral and 70 (of which 6 by females) poster presentations. The conference programme was prepared by Carlo Barengi, Richard Haley and John Saunders together with Andrei Golov and Paul Walmsley. Speakers were selected based on input from the International Advisory Committee which included 42 members (including 5 women) from 15 countries.

The scientific programme covered the topics:

quantum liquids, solids and gases,
helium superfluids,
novel superfluids and superconductors,
quantum turbulence and vortices,
superfluid optomechanics,
quantum fluids for cosmology,
confined superfluids,
electrons in/on helium and neon,
impurities and excitations in quantum fluids,
cryogenic techniques and applications.

Special sessions were held in memory of Alexander Andreev, Henry Hall and Joe Vinen.

A special session on Equality and Diversity was organized by Priya Sharma.

An independent international committee selected the 10 best posters (of which 2 by females) presented by postgraduate students who were all awarded prize certificates.

Financial support totalling £7500 was provided to most overseas postgraduate students (24 cases) through the provision of a reduced registration fee.

A selection of free city bus and walking tours that explored the cultural and industrial heritage of Manchester were offered on Sunday 13th August. There were also opportunities to visit the nearby National Graphene Institute during conference lunch breaks and the two Manchester Rotating Cryostats housed in the Department of Physics and Astronomy in the evenings, which also included a display of some of the earliest dilution refrigerators built by Henry Hall and co-workers in 1965. The conference banquet was held in the Whitworth Hall of the University.

A collection of contributions associated with QFS2023 was published in a special issue of Journal of Low Temperature Physics (JLTP), with Paul Walmsley as guest editor, A total of 18 articles have been accepted and each of these has been scrutinised by two independent reviewers with the usual standards and criteria of JLTP applied.

Andrei Golov

Department of Physics and Astronomy, University of Manchester, Manchester UK

22/08/2024

The 29th International Conference on Low Temperature Physics Sapporo, Japan, August 18-24, 2022

The 29th International Conference on Low Temperature Physics (LT29) is a major meeting of the C5 Committee of the International Union of Pure and Applied Physics (IUPAP). Organized by the organization committee of LT29, Science Council of Japan, and the Physical Society of Japan, it was held at the Sapporo Convention Center for 7 days from August 17th (Thursday) to 24th (Wednesday), 2022. Due to the pandemic caused by the new coronavirus COVID-19, the originally planned August 2020 event was not possible, and two years later it was held in a hybrid format. It was managed to hold the event after taking unprecedented measures such as measures to prevent infectious diseases, support for face-to-face and remote participation, and visa acquisition assistance for local participants from overseas.

Sapporo is the capital of Hokkaido and has the comfortable climate especially in summer. Hokkaido university in Sapporo has the long history of low temperature physics, and one of the COE in Japan. The conference site Sapporo Convention Center is at the central area of Sapporo city with easy access, while the sizes of the rooms and halls are large enough, which was advantageous for the countermeasures of COVID-19.

The conference sessions focus on five sub-fields (1. Quantum Gases, Fluids and Solids, 2. Superconductivity, 3. Magnetism and Quantum Phases, 4. Nanophysics and Quantum Information, 5. Cryogenic Techniques and Device Applications). An international program committee consisting of 39 members, including the program chairperson, selected invited speakers based on the proposals of the International Advisory Committee (IAC) and decided on the overall program structure. 2022 marks the 50th anniversary of the discovery of superfluid helium-3, and two Nobel laureates gave lectures at the special symposium. Ingenuity unique to a hybrid event is also necessary, such as setting up a session that takes into consideration the local time of remote speakers as much as possible, and setting up a remote poster session after dinner on the same day in addition to the Sapporo local session in the afternoon as a poster presentation.

The followings are the brief summary of the scientific contents of the conference

SF1 Quantum Gases, Fluids and Solids

The year 2022 was marked the 50th anniversary of the discovery of superfluid ^3He in 1972. Superfluid ^3He was the first observed anisotropic superfluid and is still being actively studied. At LT29, a Special Symposium was held: Physics of Superfluid Helium 3 -Past, Present, and Future. First, Prof. Bill Halperin, the chair, talked about the significance of this symposium and the situation at Cornell University at the time of the discovery of superfluid ^3He . Two Nobel laureates, Profs. Lee and Leggett, then reported on the experimental and theoretical state of affairs before and after the discovery. Prof. Saunders reported on current and future research on ^3He .

The major keywords in the SF1 field in recent years are visualization, minute space, and qubit. Many interesting related research results were reported as described below.

Prof. Skrbek. gave an excellent review lecture on quantum turbulence covering the early days to

the present, focusing on experimental research on superfluid ^4He and ^3He . Prof. Nomura reported an interesting physics on the melting and dynamics of non-equilibrium solid crystals in superfluid helium, showing many impressive animations. The followings are the topics presented in LT29.

1. *Cold atomic gas and BEC*: Prof. Kawaguchi presented a theory of non-Hermitian responses to periodic excitations of spinor BECs. Dr.

Fraser reported the response of an exciton-polariton BEC to mechanical rotation. Prof. Schuster reported the behavior of single electrons on helium and neon liquid surfaces.

2. *Quantum fluid dynamics*: Prof. Guo reported visualization of the motion of quantum vortex rings in superfluid ^4He and proposed a new formulation of mutual frictional force. Prof. Obara presented a study on sucking vortices in superfluid ^4He .

2. *Experimental research on superfluid ^3He* : Superfluid phases (suppression of B phase, etc.) in a restricted space have been reported.

Prof. Ikegai reported an excellent visualization experiment of phase A chiral domains.

3. *Superfluid ^4He* : Prof. Vilesov reported the production of rotating superfluid ^4He and normal ^3He particles and their angular momentum measurements. Prof. Fukuyama reported an experimental study of two-dimensional ^3He on graphite and discussed the possibility of quantum liquid crystals.

4. *Nano Confinement System*: Prof. Konstantinov described spin qubits. Rydberg transition using surface electrons in ^4He . The size effect of the superfluid transition of ^4He confined in nanospaces and the behavior of bubbles with electrons on the surface in superfluid ^4He were reported.

5. *Optomechanics/Nanomechanics*: Prof. Harris described droplets of superfluid ^4He levitated in vacuum. Prof. Tsepelin reported on the observation of a single quantum vortex using NEMS.

6. *Symposium Topological superfluid ^3He* : A major recent discovery is the observation of polar phases in superfluid ^3He confined in nematic airgels. Prof. Eltsov reported the observation of half-integer quantum vortices in this system. Prof. Dmitriev described the polar phase that he discovered. Prof. Mizushima reported a theoretical study of paired density waves in superfluid ^3He in parallel plates.

7. *Phase transition* : Prof. Shirahama discussed the quantum critical phenomenon of ^4He confined in nanoporous and argued that it exhibits a universal class of 4D XY models. The relationship between the AB phase transition and cosmology, the possibility of two-dimensional ^4He supersolids, etc. were reported.

SF2 Superconductivity

There were 24 invited talks (12 on-site) and 21 contributed talks (20 on-site), for a total of 45 oral presentations and 225 poster presentations. In addition, one Plenary talk (0 on-site) and five Half Plenary talks (3 on-site) talks were given on topics of particular relevance to SF2. The conference covered a wide range of current major issues and topics that are beginning to attract attention in basic research on superconductivity.

As the SF2-related Plenary talk, Jarillo-Herrero (MIT), the leader of the group that discovered superconductivity in moiré structures with magic angle twists in bilayer graphite, reviewed the current status of the topic. Half Plenary talks given by the following speakers reviewed recent

discoveries and current status of the outstanding topics in superconductivity: Nickolas Butch (Univ. of Maryland) on the discovery and properties of superconductivity in UTe_2 , Hong Ding (Shanghai Jiao Tong Univ.) on the Majorana quasiparticles in iron-based superconductors, Harold Hwang (Stanford Univ.) on the discovery and properties of superconductivity in nickel oxide with the crystal structure similar to copper oxide, Masatoshi Sato (Kyoto Univ.) on the progress of the theory of topological superconductivity, and Mackenzie (MPI-CPfS) on the recent progress of superconductivity in ruthenium oxide superconductivity under uniaxial strain.

The following is a brief summary of each session.

1. (*SYMPOSIUM*) *Graphene*: Two days after the Plenary talk on the same topic, three invited speakers presented on superconductivity in magic-angle twisted bilayer graphene, superconductivity in untwisted ABC-type stacked trilayer graphene, and Li-doped (Zr, Hf)NCl, all discussing the control of electronic states by gate voltage.
2. (*SYMPOSIUM*) *Sr₂RuO₄*: On the day following the Half-Plenary lecture, three invited speakers reported on their recent results. First report was on the experimental results of nuclear magnetic resonance that overturned the interpretation of spin-triplet superconductivity. Next, there was a lecture that explained the ultrasonic experiment that confirmed the two-component superconducting state consistent with the time-reversal symmetry breaking. Finally, a theory including orbital-singlet, spin-triplet superconducting states was given as a proposal to explain the experimental results.
3. *Superconductivity theory*: Four invited speakers presented theories of superconductivity. First, two invited speakers reported new theories of superconductivity using different solvable models. The other speakers reported a comprehensive theory of anisotropic superconductivity due to higher-order spin electrons on a pyrochlore lattice and a theory of anomalous proximity effects in anisotropic superconductor junctions.
4. *AV₃Sb₅*: The Kagome-lattice materials AV_3Sb_5 ($A = K, Rb, Cs$), which exhibit superconductivity at low temperatures with an unusual charge density wave (CDW) transition at higher temperature, have attracted much attention recently. The group that discovered superconductivity reported details of the interlayer ordering of lattice deformations in the CDW state and reviewed experimental reports concerning the time-reversal symmetry breaking. The other presentations reported experimental results suggesting nematic and topological states, the nontrivial six-fold symmetry of the upper critical field of superconductivity, and a theory that treats the mechanisms of CDW and superconductivity in a unified manner from fluctuations in the bond order.
5. *Non-centrosymmetric superconductors*: Two invited speakers reported experimental and theoretical results on the two-step superconducting transition of $CeRh_2As_2$, a material with locally broken spatial inversion symmetry, under a magnetic field perpendicular to the plane. They discussed odd-parity superconductivity in the high field phase. There was also a report on $YbRh_2Si_2$.
6. *Interface-2D superconductivity*: There were two invited talks on superconducting proximity effects of the spin-triplet pairs from the *s*-wave superconductor to ferromagnetic materials or paramagnetic metal. The latter used a three-terminal T-type junction. In the second part, there

were two talks that revealed the spatially modulated structure of the superconducting order parameter (FFLO state): one reported torque measurements in a van der Waals material containing atomic layers of H-NbS₂, and the other reported nuclear magnetic resonance (NMR) evidence near the in-plane upper critical field of Sr₂RuO₄.

7. *Higgs, superconducting diode*: A theorist who proposed Higgs-mode collective excitation of superconductivity gave a lecture reviewing the comparison with recent experimental results. The other invited speaker reported on the superconducting diode phenomenon in Nb/V/Ta superlattice devices, namely the non-reciprocal nature of the critical current depending on the current direction. Concerning the superconducting diode effect, there were talks on the theory of helical superconducting states based on the Rashba effect and time-reversal symmetry breaking by the application of a magnetic field, and on the experiments in a two-dimensional electron system of Al/InGaAs/InAs.
8. *UTe₂*: Recent experimental and theoretical results on the superconducting state of UTe₂, a material in close proximity to the ferromagnetic phase, were reported. Experimental and theoretical results on spin triplet superconductivity, a study of the effect of non-conformal crystal symmetry on anisotropic superconductivity, a discussion on the presence of spontaneous time-reversal symmetry breaking in the superconducting state, and multiple superconducting phases were reported.
9. *Low-T_c superconductors*: An invited talk on gate-induced superconductivity at the EuO/KaTaO₃ interface reported that the transition temperature strongly depends on the crystal-axis direction at the KaTaO₃ interface and that such anisotropy is weak for LaAlO₃/SrTiO₃. Next, an invited talk reported on the discovery of superconductivity in quasicrystals and a comparison with superconductivity in neighbor-composition approximants. There were also talks that nematic superconductivity in Cu_xBi₂Se₃ is also topological superconductivity, and the discovery and the properties of superconductivity in the topological line-node metal CaSb₂.
10. *Fe-based superconductors*: The invited speaker gave a detailed report on the current status of the experimental verification of Majorana fermions emerging in vortexes of iron-based superconductors, emphasizing the need for high-resolution STM. Experimental and theoretical reports on iron-based superconductors were also presented.
11. *Cuprates and nickelates*: The latest experimental results on the pressure-induced quantum phase transitions in the cuprate superconductors as well as in UTe₂, and the strange-metal behavior of the cuprate superconductors were reported. In addition, an experiment on a nickel superconductor with a crystal structure similar to that of cuprate superconductors and a study to clarify its phase structure based on first-principles calculations were reported.
12. *Topological superconductors*: First, the invited speakers reported on their experiments on the effects of spin-orbit coupling and Coulomb forces on Andreev bound states, which are important for understanding the topological properties of superconductors. In addition, topics on superconducting single photon detectors using van der Waals materials, supersymmetry in topological superconductivity, and theories on topological superconductivity on quasicrystals were discussed.

SF3 Magnetism and Quantum Phases

In the Sub-Field 3: Magnetism and Quantum Phases, there were 14 invited talks, 17 contributed talks, and about 350 posters. The eight oral sessions below were held. In the sessions of SF3, the topics related mainly to quantum critical points, graphene, frustrated magnetism, exotic magnetism, and heavy fermions were discussed over a wide range of materials, including high- T_c cuprates, transition metal oxides, rare earth compounds, and organic materials. In particular, there were many presentations on the problems of topology and electron correlation. We got an impression that research on topological properties such as skyrmions, magnetic Weyl semimetals, Dirac metals, and Majorana fermions has become an active new field. There were many poster presentations and the face-to-face discussions in the poster hall were very active.

Some of the specific topics are as follows:

1. *Quantum critical points*: There were two invited talks and high- T_c superconductivity, ferromagnetic quantum critical point, spin density waves in YbRh_2Si_2 , and one-dimensional ferromagnetism in CeRh_6Ge_4 were discussed.
2. *Graphene*: The electronic states of moiré superlattices with controlled magnitude of electronic correlations were the central topics. In addition, de Haas-van Alphen effect and Floquet states were discussed.
3. *Frustrated Magnetism*: There were two invited talks. Here, exotic excitations and topological order in quantum spin liquid states realized in kagome lattices such as Kitaev compounds and Herbertsmithite were discussed. Quantum phase transitions under pressure in Shastry-Sutherland systems were also discussed.
4. *Exotic magnetism*: Here, new topics such as recent progress in skyrmions excitations, Co compounds, hidden orders, Berry curvature in heavier electron Weyl semimetals, quantum oscillations in Kondo semiconductors, and nonreciprocal transport in polar Dirac metals were discussed.
5. *Heavy Fermions*: Quadrupolar density wave, field-induced phase transitions, and magnetic order in honeycomb lattice were discussed.
6. *Correlation and Topology*: Topological phases from first principles calculation, ferromagnetic Weyl semimetal, and pyrochlore lattices were discussed.
7. *A mini-symposium on experiments of Kitaev quantum spin liquid*: There were active discussions between three invited speakers.

SF4. Nanophysics and Quantum Information

Sub-Field 4 (SF4) covers “Nanophysics and Quantum Information,” such as superconducting/semiconducting quantum bits, 2D materials, nanomechanics, integer/fractional quantum Hall effect, quantum information technology, and various kinds of quantum transport. SF4 had ten oral sessions and four poster sessions; The oral sessions had 12 invited talks and 20 contributed talks, and the poster sessions had 94 posters. While we cannot address all of them due to the limit of space, we briefly introduce some notable reports in the oral sessions.

1. Prof. Sacépé (France) reported the spin configuration in the quantum Hall ferromagnetic state in graphene using AFM/STS measurement. Prof. Ensslin (Switzerland) presented many

experimental results of graphene nanostructures. Both talks remind us that graphene is still an attractive topic since the first report in 2004.

Prof. Takada (Japan) and Prof. Wang (France) addressed the single electron manipulation using surface acoustic waves. Prof. Kobayashi (Japan) reported the quantitative behavior of quantum liquid. These works are related to the basics of nonequilibrium physics. Prof. Wallraff (Switzerland) and Prof. Zhu (China) explained the recent development of quantum computation with superconducting quantum bits. Their demonstrations of the quantum error correction and 62 qubits operation attract worldwide interest.

2. We had a session focusing on the anyon, a peculiar elementary excitation in the fractional quantum Hall state. Prof. Manfra (USA), Lee (Korea), Maillet (France), and Spånslätt (Sweden) reported valuable experimental and theoretical evidence of anyon and its braiding. Anyon has the potential of the fundamental basis of future quantum technology.

3. We had a session on nanomechanics, where the quantum mechanical coupling between a nanomechanical oscillator and electrical circuits are topical. Profs. Collin (France), Sillanpää (Sweden), and Hüttel (Germany) explained their various elaborated experiments. They conveyed the real thrill of experiments to challenge the ultimate sensitivity with ultra-high-precision measurements.

4. Prof. Takeda reported the first demonstration of quantum error correction in semiconducting quantum bits. Prof. Hsiao (Netherlands) presented the quantum simulation using semiconducting quantum bits. These works evidenced the future potential of those bits. In addition, various research works on quantum transport were reported: “Real-time detection of two-electron tunneling processes in a Cooper pair splitter” by Prof. Ranni (Finland), “Excitonic nature of magnons in a quantum Hall ferromagnet” by Prof. Roulleau (France), “Transmission of quantum state of electrons across a metallic island with Coulomb interaction” by Prof. Anthore (France), “A hallmark of disordered reconstructed-edge transport at a fractional-integer quantum Hall junction” by Prof. Hashisaka (Japan), and “Universal Hydrodynamic Flow in a Two-Dimensional Electron Fluid” by Prof. Hamilton. The reported results were of high-quality, cutting-edge and reminded us that researchers worldwide are promoting research with diverse ideas.

SF5. Cryogenic Techniques and Device Applications

In Sub-Field 5: Cryogenic techniques and device applications, there were 5 invited talks (2 on-site), 11 contributed talks (9 on-site), and 46 posters. The four oral sessions below were held at Hall 4 (Small Hall) and attended by on-site audiences of 50 to 80 people. It was interesting and stimulating to listen to the presentations covering various applications of cryogenic techniques and the physics behind them.

1. *Electronic devices at low temperatures*: There were two invited talks. The first one reported temporally and spatially resolved observation of error bursts on a superconducting qubit array. Quasiparticle generation by phonon bursts in the substrate triggered by the absorption of a high-energy particle from a cosmic ray was suggested as the mechanism, and possible approaches for mitigation were discussed. The other invited talk demonstrated cooling of the electron temperature down to 0.5 mK by using nuclear adiabatic demagnetization in on-chip indium

electrodes. The temperature was measured with an integrated Coulomb-blockade thermometer.

2.*Cryogenic techniques*: Various applications of large-scale cryogenic systems were discussed. The topics included the axion search using a 100-L-scale microwave resonator under a large magnetic field and at low temperature, the operation of the world-largest dilution refrigerator with a ton-scale heavy detector array mounted for the observation of neutrino-less double beta decay, and the neutron-beam imaging of the phase separation of the $^3\text{He}/^4\text{He}$ mixture in a dilution.

3.*Low-temperature detectors*: The rapid progress in the development of large-scale MKID (microwave kinetic-inductance detector) arrays was reviewed in an invited talk. The working principles, material engineering, and peripheral electronics were introduced, and applications in astronomy and biology as well as challenges for future improvement were discussed. There was a contributed talk on the demonstration of a single microwave photon counter based on a bolometer using the zero-bias conductance anomaly in a SNIS-type tunnel junction for the readout.

4.*Thermometry*: There was an invited talk on a novel thermometry technique based on the switching current measurement of a superconducting nanoconstriction to study dynamical thermal phenomena at the nanoscale with high temporal and spatial resolutions. A contributed talk presented a capacitance thermometer using a material with a magnetic-field-independent and temperature-dependent dielectric constant and its application to pulse-magnet experiments up to 60 T.

There were also a few plenary and half-plenary talks related to SF5 during the conference.

In his on-site plenary talk, Dr. Sae Woo Nam (NIST) introduced the frontier of the SNSPD (superconducting nanowire single-photon detectors) research and development and discussed their ambitious plan of implementing neuromorphic computing using SNSPD, SFQ (single-flux quanta logic circuits), and silicon photonics technologies.

In the half-plenary talks, Dr. Eli Zeldov (Weizmann) beautifully visualized the nanoscale spatial distributions of the local current and dissipation in quantum Hall systems using a scanning SQUID probe. Dr. Takayuki Tomaru (NAOJ) introduced gravitational wave astronomy and presented the cryogenic mirror system critical for achieving ultrahigh sensitivity in their gravitational wave detector, KAGRA. His talk resonated with the following on-site presentation by Dr. John Teufel (NIST) on superconducting membrane nanomechanical resonators and gave a strong impression of the advancement of the physics and applications of quantum optomechanical systems.

LT29 conference summary respectfully submitted by Naoto Nagaosa, Chair, C5

Conference Report: International Conference on Ultra-low Temperature Physics 2022 (ULT2022)

Organizing Committee:

Chair: Keiya Shirahama (Keio University)
Vice-Chair: Makoto Tsubota (Osaka Prefectural University)
Eunseong Kim (KAIST, Korea)
Ryuji Nomura (Hokkaido University)

International Conference on Ultra Low Temperature Physics 2022" (ULT2022) was held at the Grand Park Otaru, Otaru, Hokkaido, Japan, from August 25 (Thu) to 28 (Sun), 2022.

The ULT conference series of ULT conferences began in Hakone, Japan (1977) as a symposium discussing state-of-the-art ultralow temperature physics. ULT2022 was the 15th ULT conference.

Preparation of the Conference:

ULT2022 was originally scheduled in 2020 as a satellite conference of LT29, but it was postponed for two years with LT due to the COVID-19 pandemic. The ULT conferences focus on discussing specific topics with 100-200 participants in a relaxed atmosphere. To this end, non-Japanese researchers are required to participate in person. However, it was impossible for non-Japanese tourists to enter Japan by February 2022.

In March, the Japanese government relaxed the border measures, and foreigners became able to participate in ULT by obtaining a visa. We decided to take on the responsibility of issuing visas to foreign participants. Through this service, about 40 foreign researchers attended ULT in person.

Management of the Conference:

To avoid infection by COVID-19 and keep social distance, we employed the largest ballroom at the conference venue, which was twice the original conference room we planned.

As was LT29, the sessions in ULT were operated in a hybrid style, switching between on-site and online talks. Except for a problem caused by an automatic update of the Windows operating system, all sessions went smoothly and were a great success. As in LT, we held two poster sessions, one in person and another online.

Throughout the conference, thorough measures were taken to prevent the infection. The measures were basically the same as those taken at LT29: antigen test kits, masks, disinfection sheets, etc. were distributed to all on-site participants. They were required to measure body temperature at the entrance, disinfect, and wear a mask in the venue. Excursions and conference banquets were canceled. On-site poster sessions were held in the same ballroom as that used for oral sessions. Lunch boxes were prepared and taken at the venue, and tea and snacks were provided in small portions during breaks to prevent contact infection. In addition, we discussed with local travel agencies and made arrangements for PCR testing and hospitalization when infection happened.

The above measures were successful, and there were no cases of infection throughout the conference.

Information on Participants and Presentations:

The total number of participants was 129 (including 14 women) from 14 countries.

Local participants: 93

(Japan 46, UK 18, USA 12, Czech Republic 4, Finland 3, Netherlands 3, Slovakia 3, Germany 1, Korea 1, Spain 1, France 1 (11 countries))

Online participants: 36

(Japan 13, UK 9, USA 3, China 2, Taiwan 2, Finland 2, France 1, Germany 1, Russia 1, Switzerland 1 (10 countries))

Invited speakers: 17 (including 1 female speaker)
Female participants: 14

Number of members of the International Organizing Committee (including conference organizers):
25 (including 3 women)

Number of invited talks: 17 (11 on-site, 6 online)
Number of other oral presentations: 35 (28 on-site, 7 online)
Number of poster Presentations: 50 (41 on-site, 9 online)

Topics:

Session topics are;
Superfluid Helium-3
Novel Electron Systems
Quantum Computing
Low-dimensional quantum fluids
Quantum turbulence
Ultracold atomic gases
Superconductivity
Quantum fluid in restricted space
Dark matter physics
Electron systems on the helium surface
Novel ULT Technologies.

The session on quantum computing should be noted as a new topic, which was not covered in previous ULT conferences. Malcolm Carroll (IBM-Q) and Eisuke Abe (RIKEN), both working at the forefront of superconducting quantum computers, told us the current status of the developments. In particular, Dr. Carroll discussed tunneling two-level systems, which has been studied as an important subject in ULT physics, as the most fatal source of decoherence in quantum computers. This attracted the interest of the audience.

The hybrid operation of the conference produced interactive discussions between online and on-site participants.

Issues and Prospects:

The most significant aspect of the traditional ULT conferences was that participants discuss topics in ultra-low temperature physics in a relaxed atmosphere after the LT meeting. Therefore, the on-site participation of foreign participants was a prerequisite for the success of the conference. Fortunately, the border measures were relaxed in March, and we were able to welcome over 40 overseas participants than we expected, thanks to visa issuance support.

However, the number of overseas participants was unforeseeable. This caused a serious delay in our decision on the size of the conference room and the conference style (hybrid or online-only). The selection of invited speakers also took until June, and we gave priority to local participants for oral presentations. We were not able to meet the requirements of the prospective participants who decided to participate based on the list of invited speakers. This is our regret.

We have successfully operated the hybrid conference, a possible new style of conference in the post-Covid era. However, the issue of the time difference and the difficulty in communicating to and between online participants remained a major problem. In fact, the number of online participants was

less than expected. Although the hybrid style is less significant after the end of the pandemic, it is useful for researchers who cannot participate in person for some reason. It is desirable to establish a convenient hybrid conference procedure, for example, by developing metaverses.

Otaru City, where the conference was held, has few hospitals and PCR facilities that can handle COVID. Many infected persons, if any, would have seriously interfered with the conference. The selection of the venue will also be essential for an unpredictable pandemic.

Reported by Prof. Keiya Shirahama, the chairman of ULT2022
forwarded by Naoto Nagaosa, Chair of C5 commission.