

January 2022

**Proposal to Establish
The Ohio State University
Center for Quantum Information Science and Engineering**



**THE OHIO STATE
UNIVERSITY**

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Introduction

The emergence of quantum information science and engineering (QISE) rests on fundamental breakthroughs in our ability to understand and control the flow of quantum information, or more formally, quantum entanglement. This control provides exquisite sensitivity for next-generation sensors and secure communication. The potential for simultaneous sampling/processing of information is driving a revolution in computing, with additional opportunities appearing every few months (see recent reports from DOE and NAS). For example, quantum networks initially developed for communication can also serve to link remote sensors at the quantum level. This distributed entanglement suggests potential ranging from integrated sensor networks to creating telescopes with an effective lens one million miles in diameter. The level of disruption promised by these new technologies presents an opportunity with two edges: Acting quickly and decisively to establish leadership promises substantial rewards, whereas a policy of “stay the course” will have the net result of being left behind as new fields and new technologies dominate the landscape.

In early spring 2020 the Office of Research commissioned a Quantum Information Science and Technology (QIST)¹ Task Force (with representatives from 6 Departments across 2 Colleges) with the charge of reviewing the state of the field, comparing that to existing strengths and potential growth directions at Ohio State, and determining whether a path to national leadership in this field existed. The report of the Task Force was returned in early summer 2020 with the conclusion that such a path exists and articulation of recommendations on strategic steps to achieve that goal. As anticipated in the 2020 report (for example pg. 2, 8), the national landscape has shifted to near-term focus in **quantum networking**. The National Quantum Internet Initiative (NQII) in development in Congress promises a level of strategic investment on scale with the National Quantum Initiative (NQI) in 2018 (estimated at \$500 million). As another example, the recent passage through the Senate of the US Innovation and Competition Act (I&CA) calls out quantum information technologies as one of the top 10 technology areas identified for investment. Finally, the current budget framework includes substantial investments in education and workforce retraining which could strongly impact education efforts in QISE.

Further, the 2020 Task Force report outlined the need for action in four mutually reinforcing areas of activity/investment: Education, Partnerships, Faculty Development, and Infrastructure. Over the past year and half there has been rapid progress on all four fronts, with selected highlights listed below:

Education: Successful Phase I and Phase II NSF Convergence Accelerator awards for **QuSTEAM** initiative (total \$5.7 million over 3 years) establishing Ohio State as the **national leader in UG education in Quantum Information Science and Engineering (QISE)**. QuSTEAM brings together scientists and educators from over 20 universities, national laboratories, community colleges, and historically Black colleges and universities (HBCUs) to develop a research-based quantum education curriculum and prepare the next generation of quantum information scientists and engineers. The initiative also has over 14 industrial partners, including GE Research, Honda and JPMorgan Chase, and collaborates with leading national research centers to help provide a holistic portrait of future workforce needs. Through this grant, Ohio State will develop and implement a national educational model for the emerging field of quantum information science and technology that features reconfigurable in person, on-line, and hybrid delivery

¹ Note that as the field has evolved the application focus of “QIST” has given way to a broader acknowledgement of the contributions of both science and engineering to the enterprise, hence “QISE”. QISE will be used for the remainder of this proposal except where we explicitly refer to the 2020 QIST Task Force by name.

modules that address the needs of the current industrial workforce as well as the future workforce professionals engaged through community colleges and universities.

Partnerships: The QuSTEAM team includes **U Chicago, MSU, Michigan, UIUC, Argonne, IBM-HBCU Quantum Center** (20+ HBCU) plus 14 companies including **Applied Materials, HRL, IBM, GE Research, Honda, JP Morgan Chase, Quantum Design, QED-C, SRI, TOPTICA, Quantum Opus**. Building on this success, Ohio State was invited to join the **Chicago Quantum Exchange (CQE) as the first regional partner**, providing a framework for collaboration with CQE members (**U Chicago, Northwestern, Wisconsin, UIUC, Argonne, Fermilab**) and additional industrial partners (**Boeing, Ally, ColdQuanta, Corning, Discover, Hamamatsu, Microsoft, Quantum Machines, Qubittek, Rigetti, Toshiba, Verizon, Zurich Instruments**).

Faculty Development: Substantial increase in faculty-to-faculty interactions on QISE, supported by the **Frontiers in QISE** seminar series has brought field leaders to campus. During the past 18 months, 7 world leaders in QISE have given seminars (<https://opticalscience.osu.edu/qise-webinar>) with typical attendance of 100 live views with between 1/4 and 1/3 coming from outside Ohio State. For example, the seminar by Prof. Misha Lukin, Harvard, had 127 attendees with 59 from off campus including Denison, Miami (OH), Air Force Research Lab, AFIT, Case Western, U Dayton, Aerospace Corporation, NASA (nas.gov), Space Dynamics Lab at Utah State, and Atmospheric and Environmental Research (aer.com). On campus participation has spanned the Colleges of NMS and Engineering including Chemistry and Biochemistry, CSE, ECE, MSE, Math, MAE, and Physics. In addition, our membership in CQE has provided additional access to virtual seminars and networking opportunities. Stemming in part from these activities, a **Hiring Plan** (along with several subsequent updates) tied to the leadership and growth strategies contained in the Task Force report have been presented to Ohio State leadership.

Infrastructure: Thus far, focus has been placed on submitting federal equipment proposals, e.g. NSF MRI for pulsed-EPR (not successful); NSF MRI for chemical-mechanical polisher (**CMP**) for device fab/integration (successful); and pending NSF MRI for **dilution refrigerator**. In talks through CQE to partner with **OARnet, U Chicago, Argonne, JPMC, and Toshiba** to establish a local fiber loop in Columbus for a **quantum networking testbed** with planned expansion to include both local **Columbus-Dayton** and regional **Columbus-Chicago quantum links**. Success with these efforts will establish the Columbus-Chicago link as the longest in the country.

Taken together these developments, both internal and external, highlight the critical need for the creation of an Ohio State Center to coordinate these disparate activities in QISE. **Ohio State is positioned to become a state-wide and regional hub of activity in this emerging field**, pulling together universities, national labs, and private sector partners to facilitate both scientific discovery and economic and workforce development.

I. MISSION

To harness quantum information science and engineering (QISE) to drive a second quantum revolution based on exploiting quantum entanglement to transform communication, computation, and sensing.

A. Missions of the university (research, teaching, and service/outreach) relevant to QISE

As noted in the introduction, building on a groundswell in faculty activity in QISE over the past several years the Office of Research commissioned a QIST Task Force in spring 2020 to identify strategic opportunities for Ohio State in the field of quantum information. That report made a series of detailed recommendations but most importantly highlighted the need for an integrated strategy if Ohio State is to be competitive in this emerging field. In particular, the combination of inherent interdisciplinarity, a rapidly changing national and global research and technology landscape, and intense competition among academic institutions to establish a footprint in QISE necessitate a coherent and coordinated action. Here we summarize the key findings of that report within the framework of Ohio State's missions in *Research*, *Teaching*, and *Outreach* with specific examples identified from the list of recent activities outlined in the introduction:

Research:

1. Accelerate the pivot of Ohio State faculty into QISE by supporting both internal discussions and workshops as well as seminars delivered by outside experts to educate our research community on emerging challenges and opportunities. *Example: Frontiers in QISE seminar series in spring 2021.*
2. Amplify the scientific impact of faculty who are research active in QISE by facilitating teaming within the university through a combination of internal workshops, seed funding, and the development of critical research infrastructure. *Example: The development of a quantum network testbed in partnership with CQE and OARnet.*
3. Establish Ohio State as a regional hub for QISE by fostering external collaborations with partner universities, national labs, and relevant industry. *Example: Membership in CQE as a regional partner and the collaborations surrounding the quantum network testbed.*

Teaching:

4. Identify critical regional and national needs for workforce development in QISE and support the development of curricula and partnerships necessary to address those needs. *Example: Support for the QuSTEAM initiative.*
5. Facilitate the training of graduate students and postdocs in QISE through internal discussions and workshops aimed at building 'quantum literacy' and developing the necessary expertise to exploit relevant research infrastructure. *Example: Frontiers in QISE seminar series in spring 2021.*

Outreach:

6. Coordinate and facilitate academic/industry connections to support the development of a 'quantum economy' by helping relevant stakeholders to understand emerging challenges and opportunities in QISE. *Example: Extensive partnership network established through both CQE and QuSTEAM.*
7. Provide a reservoir of expertise and a forum for local and regional leaders, educators, and the community to consult in assessing emerging challenges and opportunities in QISE. *Example: Discussions with OARnet to identify near and medium-term implications for communications networks.*

B. Interdisciplinary nature of the center

Synergy with existing disciplinary research and educational programs

QISE is a broadly interdisciplinary field, with its potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by 6 core STEM departments: Chemistry and Biochemistry, Math, Physics, Computer Science and Engineering, Electrical and Computer Engineering, and Materials Science and Engineering, with potential applications rapidly expanding to include fields such as Medicine, Biology, and Mechanical Engineering. New opportunities in QISE are emerging organically from disciplinary research within these departments, and consequently have the potential for synergy with those host disciplines beyond their direct impact in QISE. As one example, an investment in developing molecule-based qubits for quantum sensing applications, driven by faculty within Chemistry and Biochemistry and Physics, can pay dividends in providing an atomic-scale sensor for monitoring coherent chemical processes. This novel measurement regime can in turn impact more established fields such as photoactivity/photosynthesis or catalysis. As another example, hires in QISE can serve to bridge gaps between departments such as Math and Computer Science and Engineering (where there is an established history of collaboration) as well as Physics and Economics (where new opportunities for collaboration are emerging). These bridges have potential impact well beyond the specific QISE-focused research programs as success in these collaborative activities contributes to the core disciplinary strength of both partner departments.

Similar synergies are available in educational programs, with potential benefits flowing both *from* and *to* core disciplinary pedagogy. In the direction toward QISE there is a clear reliance on existing discipline-specific courses and pedagogy in building the foundational skills necessary to become “quantum literate”. In the direction from QISE, there are opportunities to revitalize core disciplinary curricula in providing both technical content (i.e. modules describing emerging applications in science and technology) and in pedagogical approach (i.e. in piloting new approaches to STEAM education such as the QuSTEAM initiative discussed earlier in this report).

These synergies highlight how investments in QISE will have collateral impact on core disciplinary strengths and help to advance Ohio State’s efforts to establish excellence broadly across key STEAM disciplines.

Synergy with existing institutional research strengths

A survey of the current state of play on campus and in the field nationally identifies a critical opportunity, a critical gap, and a critical need for hiring in QISE at Ohio State.

Critical Opportunity: The rise of **quantum networking** as a near term priority at the federal level aligns with existing Ohio State **partnerships** and **infrastructure** plans. Further, the relative simplicity of the critical tasks for establishing an entanglement-based quantum network, **quantum transduction** and **quantum memory**, lend themselves to new-qubit development in a way that more established applications in quantum computing do not. Specifically, the opportunity for creating solid-state qubits based on embedding atomic qubits (such as rare earth ions) in a ‘solid-state vacuum’ (i.e. a wide-bandgap host crystal) directly aligns with Ohio State’s world leading strengths in wide-bandgap materials, quantum materials and defect characterization. We therefore identify quantum networking as the most ‘shovel

ready' integrated initiative to be targeted for CQISE development, including assistance in attracting new faculty to this area in collaboration with relevant departments and facilitating the pivot of current faculty into this field.

Critical Gap: OSU has little activity in the broad area of **quantum computing**, with no faculty who have this challenge as the focus of their research program. While establishing leadership in this field may be a long-term endeavor, this critical gap will continue to hamper related efforts in QISE where quantum computing expertise is synergistic rather than central. We therefore identify the areas of **quantum algorithms** and **quantum simulations** as a critical gap, where we can exploit on-campus synergies with **AI/Cyberinfrastructure** and **quantum networking** to build critical mass of domain expertise. In addition, molecular qubits containing rare-earth f-elements, especially needed for quantum networking, and researchers who specialize on magnetic measurements also represent a current gap necessary for successful QISE activities at OSU. This expertise will substantially enhance the efforts of existing faculty to pivot into related areas and fill critical gaps in synergistic proposals in AI/Cyber and quantum networking, while laying the foundation for team and center level efforts in the future where quantum computing may play a more central role.

Critical Need: The success of the QuSTEAM initiative has already paid substantial reputational dividends for Ohio State, attracting new partners and making sure that Ohio State is part of the national conversation on QISE. It should be noted, however, that the NSF funding is for the *development* of curricula and that this reputational boost will wane if Ohio State does not execute on *delivering* new classes, degrees, and certificates in QISE. Further, there is a substantial opportunity for increased enrollment of both traditional and non-traditional students (i.e. workforce retraining) if Ohio State is to become **a leader in QISE curriculum delivery**. Existing university structures are investing resources to create the framework for these new classes and programs, but there is a **critical need for faculty to teach these classes**. QuSTEAM funded Ohio State faculty are currently stretched to cover the 4 required 'core' classes proposed for a new minor or certificate, and in the best-case scenario we will be able to recruit just enough additional instructors for the minimum of 3 additional elective classes called for in the QuSTEAM curriculum. We therefore identify a critical need to hire new faculty who are qualified to teach these classes and to help existing faculty develop the relevant expertise to teach these courses.

More broadly, the proposed center will have significant synergy with existing internal and federally supported centers and institutes. These centers focus on research that is either 'quantum adjacent' or where there is significant opportunity to expand into emerging quantum information related directions. Here we briefly highlight synergies that have been identified thus far, while noting that given the potential scope of the transformation promised by QISE, additional opportunities for leveraging existing strengths and resources will likely emerge as CQISE matures. Finally, we also comment that the broad scope of research represented by these partnerships highlights the need for a new interdisciplinary center focused on the needs of QISE to pull these disparate threads together to weave a coherent tapestry of support for QISE research.

Institute for Materials Research (IMR): The study of materials is a cross-cutting discipline that underlies most aspects of modern science and technology, including QISE. IMR (as well as CEM and ENCOMM, as discussed below) has recognized this synergy and opportunity for some time and has helped to germinate the QISE effort at Ohio State by supporting activities ranging from sponsoring sessions at IMR Materials Week for multiple years to the recent co-sponsoring, along with iOS and CEM, of the Frontiers

in QISE seminar series in Spring of 2021. This close relationship between materials and QISE has also led to preliminary discussion surrounding the leveraging of proposed CQISE seed funding with the existing Ohio State Materials Research Seed Grant Program (OSU-MRSGP; co-sponsored with CEM and ENCOMM) to nurture research into materials relevant for QISE. We also note the synergy with IMR-supported research infrastructure including nano/micro-fabrication facilities at NanoTech West and materials characterization at the Center Electron Microscopy and Analysis and the NanoSystems Laboratory.

Translational Data Analytics Institute (TDAI): The inherently interdisciplinary nature of TDAI provides multiple opportunities for synergy with CQISE. For example, the development of quantum algorithms and recent work on quantum machine learning are opening exciting new ground at the interface between these two fields. We note the potential for a bridge between CQISE and TDAI to address a current gap in expertise at Ohio State in the development of quantum computing. Supporting new hires and pivoting faculty in this area by linking to existing strengths in TDAI will enable Ohio State to rapidly shore up this *Critical Gap* discussed above. In addition educational programs, existing and in development, at TDAI will have significant overlap with curricular content in QISE being generated by QuSTEAM at the undergraduate level and potential graduate level classes in QISE that are currently being considered.

Institute for Optical Science (iOS): Ohio State has a national reputation in optical spectroscopy which has evolved from a focus on spectroscopy into the Institute for Optical Science (iOS). While this effort has spanned decades of research, a recent success has come from a focus on ultrafast studies of electron and spin leading to the establishment of NeXUS as a national NSF-supported user facility. The fundamental studies enabled by this unique research infrastructure will play a significant role in identifying and developing new quantum systems with potential applications in QISE. iOS is also responsible for hosting the first targeted Quantum Information Seminar on campus, with contributions from Physics and Math, and co-sponsored the extremely successful Frontiers in QISE seminar series.

Center for Emergent Materials (CEM): As noted in the discussion of synergy with IMR above, there is significant overlap between CQISE and CEM strategic goals. This has led to CEM co-sponsoring of the Frontiers in QISE seminar series and discussions about leveraging the OSU-MRSGP to further accelerate QISE-relevant materials research on campus. In addition, there is the potential to support future federal funding within the MRSEC program as NSF has indicated QISE as an area of interest for future MRSEC proposals. Finally, we note that CEM support for the NanoSystems Laboratory provides a critical foundation for QISE relevant research on campus, with a substantial and expanding library of user-accessible research tools ranging from cryogenic transport, optical, and magnetic characterization to microwave frequency magnetic resonance (including one successful and one pending NSF MRI proposal).

Center for the Exploration of Novel Complex Materials (ENCOMM): As the third leg of the tripod supporting materials research at Ohio State, ENCOMM synergies with CQISE promise to benefit both center's strategic goals. ENCOMM has a long history of supporting research infrastructure, including tools placed in the NanoSystems Laboratory, and has played a key role in developing the vibrant materials seed funding ecosystem represented by the OSU-MRSGP.

C. Goals of the center that cannot be met with existing academic units

The inherently interdisciplinary nature of QISE necessitates an institution-level response to the challenges and opportunities represented by this field. Goals and strategies developed within a single academic unit would therefore result in an incoherent scatter of activity and expertise at best and prevent any meaningful progress at worst. For example, developing distributed-entanglement quantum networks requires fundamental advances in our understanding of how to construct a quantum memory (Chemistry and Biochemistry, Physics), the ability to encode quantum information into telecom-wavelength photons (ECE, Physics), and the development of novel network topologies and protocols (CSE, ECE, Math). Similarly, advances in quantum computing require both the development of new classes of quantum algorithm (CSE, ECE, Math) and the identification of appropriate systems to model where ‘quantum advantage’ has the chance to play a transformative role (Chemistry and Biochemistry, Physics, MSE). This collaboration between existing academic units will be essential to meeting the strategic goals laid out in the Ohio State Strategic plan *Time and Change* (2020), in particular Section III: *Research and Creative Expression* with some collateral impact on Section I: *Teaching and Learning* and Section II: *Access, Affordability, and Excellence*.

We would like to highlight that CQISE will have significant impact on all three goals for Section III:

1. Attract, retain and support leading national scholars and rising stars in newly designed professorship program;
2. Be a national leader in prioritized research and creative expression areas that will drive positive societal impact and in which we have an opportunity to make a difference;
3. Provide world-class support and enhance accountability for our faculty researchers.

For two of the four goals for Section I:

4. Staff critical courses in line with demonstrated teaching excellence;
5. Gain a pre-eminent external reputation as a leader and innovator in teaching and learning practices, scholarship, and outcomes.

And for the following goal from Section II:

6. Achieve excellence by improving first-year retention and four-year graduation rates with a focus on bridging the gap in performance between underrepresented populations and the overall student body, across the Columbus and regional campuses.

These strategic goals can be deconstructed into the following domain-specific goals within the framework of the four key areas of activity identified within the 2020 QIST Task Force report, *Education, Faculty Development, Partnerships, and Infrastructure*:

Education

1. Create a working group to advise the university regarding curricular needs for training quantum-aware students at both the graduate and undergraduate level with an emphasis on both critical disciplinary knowledge and new approaches to pedagogy that foster a more open and inclusive learning environment (I.4, II.2).
2. Develop training programs and short courses to train researchers in the scope and use of critical quantum-relevant tools (III.3, I.4).

3. Support the creation of a postdoctoral fellowship program aimed at recruiting talented and diverse young scientists and engineers to work collaboratively at interfaces within the CQISE community to promote interdisciplinary coordination and cooperation and to promote national recognition of the CQISE (III.1, II.2).

Faculty Development

4. Support seminars and workshops that promote both internal discussion and alignment with national and international trends in the field to help faculty new to QISE pivot into the field and promote teaming among those who are already research-active (III.1-3, I.3).
5. Create a seed-funding program targeted supporting pre-federal research in QISE related areas, with an emphasis on supporting interdisciplinary and collaborative work. Explore opportunities to leverage this support with existing seed funding efforts in related areas of science and engineering (III.2,3).
6. Communicate to the CQISE community regarding internal (e.g., CQISE) and external (e.g., CQE) resources, events, and opportunities (III.3).

Partnerships

7. Serve as a hub for coordination with larger regional organizations (e.g., CQE) and local partners (e.g., colleges and universities, AFRL, NASA Glenn, industry partners) by including external members in CQISE activities and providing access to CQISE resources such as the planned quantum network testbed (III.1-3).
8. Coordinate campus-wide activities in QISE to identify areas of potential alignment with external partners (III.3).

Infrastructure

9. Support the development of a quantum network testbed that will allow Ohio State researchers to lead in the development of the next generation of quantum communication technologies (III.1-3).
10. Develop a synergistic set of quantum measurement tools that will allow leveraging of that network to accelerate and amplify the impact of related quantum information technologies (e.g., exploring distributed sensor networks, linking remote quantum computers, etc.) (III.1-3).
11. Coordinate access to public domain quantum resources, such as cloud-based quantum computing platforms, to facilitate faculty access and community engagement (III.1-3).

II. FACULTY:

A. Criteria for selection of faculty membership

The following criteria define the categories of membership in the Quantum Center:

Full member

- Full members must be Ohio State faculty or independent university researchers (e.g., principal investigator, research scholar, research associate) responsible for research and education.
- Full members should be actively involved in basic or applied research in QISE or a closely related field as measured by a pattern of publication, funding, or similar metric.

Trainee member

- Undergraduate students with an interest in QISE
- Graduate or professional students with an interest in QISE
- Post-graduate fellows or trainees with an interest in QISE

Staff member

- Staff performing research in a full member's laboratory and have interest in QISE

External member

- Individuals actively involved in basic or applied research in QISE that are not primarily affiliated with Ohio State. Appointment to this category requires approval by center leadership. While external members may participate in seminars and other center activities, they are not eligible to receive financial benefits, such seed funding.

Membership Review Procedures

In line with the need to significantly expand the sphere of faculty participating in QISE research, CQISE will not prohibit initial membership to anyone meeting the criteria described above. However, the director, with support from CQISE executive leadership, will review the participation of each member in center activities on a biennial basis. The two-year review procedure shall assess the following criteria, for which three of the seven conditions must be met and self-reported to retain membership:

- 1) Mentor or serve as a committee member of a QISE scientist,
- 2) Host for a seminar speaker in QISE,
- 3) Contribute to a QISE center grant proposal as PI, co-I, or contributing faculty,
- 4) Contribute to CQISE resource development efforts,
- 5) Contribute to CQISE curriculum, short-courses and/or workshops,

- 6) Serve as a CQISE consultant to study design and/or analysis, or
- 7) Serve on the CQISE Executive Advisory Committee.

A consistent lack of involvement will generate a communication from the director, and after two years of inactivity, membership will be abolished if extenuating circumstances are not communicated and/or accepted. Upon loss of membership, the individual will not qualify for certain incentives of the center, such as seed grants, support for proposal development, and consulting services. Membership may be reinstated after a minimum of one-year demonstrated activity to the criteria above and formal petition to the director.

B. Faculty expressing interest in associating with the center

A complete listing including departmental and college affiliations and contact information is provided in Appendix C. Accompanying letters of support from departmental chairs and directors are provided in Appendix B.

C. Student/Staff involvement

The center will create student working groups, provide workshops, seminars, symposia, discussions, and will communicate with members via monthly emails, and through the CQISE website.

Current opportunities available to center students and staff, and/or trainees include:

- **Working Groups:** Student working groups mobilized around topics such as entangled quantum networks, quantum sensing, or quantum algorithm development will meet monthly to create a space for learning, discussion, and idea generation.
- **Weekly and Monthly Seminars:** In addition to the Frontiers in QISE seminar series in spring 2021 (co-hosted by iOS and IMR), center faculty, staff, and trainees are active participants, organizers, and attendees of several relevant seminar series including speakers active in QISE including: iOS seminar, IMR Materials Week and special seminars, and departmental seminars in ECE, Chemistry and Biochemistry, CSE, MSE, Math, and Physics. In addition, through the CQE center participants have access to a variety of streaming seminars from other CQE partners such as the University of Chicago, the University of Illinois, Argonne National Lab, etc.
- **Participation in QuSTEAM Curriculum Development:** Center faculty are playing a leading role in the development of the QuSTEAM curriculum, both in holding leadership positions within the broader collaborative team and in developing new classes at Ohio State with initial offerings in spring 2022 and fall 2022.

III. ADMINISTRATION

During the startup phase (i.e., the first 1-2 years of operation) the Center for Quantum Information Science and Engineering (CQISE) will report to ERIK through the Office of Knowledge Enterprise with a direct reporting line to the Vice-President for Knowledge Enterprise. Once CQISE is fully ‘stood up’ and operational reporting will be transferred to the Office of Research, consistent with existing Ohio State research centers. The organizational structure is designed to empower individual members, foster more open communication, and improve coordination and speed of implementing ideas/plans. The center’s organizational structure includes two Faculty Co-Directors who report to the Office of Knowledge Enterprise, an Executive Advisory Committee (EAC), and program coordinator (0.5 FTE). As noted above, CQISE will have strong connections to the Institute for Materials Research (IMR), the Institute for Optical Science (iOS), the Translational Data Analytics Institute (TDAI), the Center for Emergent Materials (CEM), and the Center for Exploration of Novel Complex Materials (ENCOMM), as well as the Discovery Themes of Materials for Manufacturing and Sustainability and Translational Data Analytics. This broad community of Ohio State investigators and trainees will be linked to external academic organizations, and non-academic partners (e.g., industry and government).

A. Faculty Co-Directors

Responsibilities of the Faculty Directors

The Faculty Co-Directors will oversee all aspects of center operation in consultation with the EAC with the intentions of strengthening the position of Ohio State in the QISE space. Duties will be performed either jointly or by an equitable distribution of tasks between Co-Directors, as deemed appropriate by discussion between the Co-Directors and with the EAC. Functions include:

1. Implement strategy and tactics to achieve center goals,
2. Foster a culture of excellence based on integrity, sound fiscal policy, and accountability,
3. Represent the center within the university community and to the greater scientific community,
4. Implement policy decisions made in consultation with the executive and associate directors, and where possible after advisement from the executive advisory committee, and
5. Lead the development of a long-term financial sustainability plan and the executive advisory committee,
6. Identify and develop strategic internal and external partnerships with an emphasis on industry, government, and non-profit organizations,
7. Manage administrative aspects of external partnerships (e.g., teaming agreements, MOUs, educational partnerships, intellectual property),
8. Develop strategies to position CQISE as leader in quantum information science,
9. Manage center staff upon growth,
10. Lead communications efforts within the QISE community,
11. Build community within and between regional academic institutions to advance center goals and enhance connectivity of the quantum information science research community, and

12. Engage in and support research and education in quantum information science and aligned with center goals.

B. Composition and function of the Quantum Center Executive Advisory Committee

The composition of the executive advisory committee (EAC) will represent the interests of the Quantum Center. The initial composition of the EAC was determined by including one faculty member from each academic department with representation in the center. Recommendations for additional EAC members are made by the co-directors to the EAC, with the selection determined by the majority vote of the faculty co-directors and EAC. EAC terms are for two years, renewable up to six years upon majority vote of the co-directors, executive director, associate director, and EAC, with an effort to maintain diversity (gender, background, colleges represented, experience) on the EAC.

The EAC will work with the directors to:

- 1) Support the director in the development and implementation of the center's strategic plan,
- 2) Support educational and scientific programs,
- 3) Engage in outreach within the university community and with the greater scientific community,
- 4) Mentor junior faculty and facilitate the professional development of graduate students, postdoctoral fellows, and
- 5) Support annual reviews of the performance of the center.

C. Reporting line

The proposed center will initially report through the Office of Knowledge Enterprise. The co-directors will report to Dr. Dorota Grejner-Brzezinska, Vice-President for Knowledge Enterprise in the Enterprise for Research, Innovation, and Knowledge (ERIK) for the first 1-2 years. The center directors will work with the VP to formalize budgets and set strategies in alignment with ERIK strategic priorities. The VP will represent the center to the leadership of ERIK and the senior vice president for research administration.

D. Pattern of administration (to be formally established within one year)

The primary components of the center's administration are detailed in sections III.A-C. Working from the framework established by the 2020 QIST Task Force report and the community that has grown around the activities in QISE since that time, we anticipate a smooth transition to formal center status.

IV. BUDGET/FUNDING

Structured to implement the recommendations and ongoing work of the 2020 Quantum Task Force, initial investments are proposed to establish core operating infrastructure and supports for interdisciplinary research. The initial 3-year budget is based on a commitment from Executive Vice President of ERIK, Dr. Grace Wang, of \$250,00/year for three years. During this time the Directors and Executive Advisory Committee will work with Departmental and College leadership, potential external donors, and program sponsors to secure additional and sustainable funding streams.

A. Expected budget

Sources (~\$250,000)

As discussed above an initial three-year investment of \$750,000 from ERIK has been provided.

Uses

FY23, 24, 25 (~\$250,000 currently committed)

Personnel

Faculty Co-Director 1 (salary + fringe)	\$35,000
Faculty Co-Director 2 (salary + fringe)	\$35,000
Interdisciplinary Post-Doctoral Fellow (salary + Fringe)	\$75,000
50% FTE Program Coordinator (salary + fringe)	\$40,000

Operating Funds \$ 5,000

Seed Funding \$60,000

Personnel:

The **CQISE faculty co-directors** will receive a 5% administrative attachment and 1 summer month of compensation each. Dr. Zeke Johnston-Halperin and Dr. Ronald Reano have agreed to be the inaugural Faculty Co-Directors for the CQISE while the center is formed, with decisions on longer-term leadership to be determined by considerations such as potential senior-level hiring, the maturation of various sub-fields of QISE at Ohio State, the pursuit of center-level federal funding, etc. in consultation with the EAC and VP Grejner-Brzezinska. Dr. Johnston-Halperin has summer commitments that only permit 2-weeks of summer compensation for this effort; however, we have budgeted for a full month in order to preserve flexibility for future Co-Directors.

Funds for an interdisciplinary post-doctoral fellow are requested to implement a program similar to the successful Center for Cosmology and Astroparticle Physics (CCAPP) program. The selected candidate will support CQISE efforts to bridge faculty interests in QISE research across the university. Although salary for the post-doctoral fellow is budgeted as personnel, this individual will play an integral role in our seed funding program (see below).

To assist with planned activities, CQISE will utilize a 50% Program Coordinator. This individual will be responsible for scheduling planned activities, working with collaborating centers to orchestrate solicitation and review of seed funding, and assisting the directors with activities related to monitoring

member and overall center results.

Operating Funds:

A modest amount of operating funds (\$5,000) is requested to support Center meetings, workshops, and symposia; to help equip incoming personnel with required technology (computer); and to procure necessary office supplies.

Seed Funds:

Patterned after the highly successful joint IMR/CEM/ENCOMM Seed Fund, CQISE will offer one or two annual competitions to support interdisciplinary Quantum Information Sciences and Engineering research. Initial discussions have already taken place with all three centers to leverage CQISE support through collaborative seed funding. Although details will be determined with input from the Executive Advisory Committee during the first 3 months of operation, we anticipate offering two tracks of seed funding competition: one requesting funds to support interdisciplinary work (cash award) and one requesting 'in-kind' allocation of post-doctoral fellow to support interdisciplinary projects.

B. Facilities, equipment, and resources

No new physical space, equipment or resources are required to launch the proposed center, beyond office space for the 50% program coordinator and post-doctoral fellow. The Faculty Co-Directors will utilize existing allocated office space and will work through established scheduling systems to locate suitable space for Center meetings and events. Within the first six months of operation, the Faculty Co-Directors will work with the Executive Advisory Committee to identify future space needs and scout for suitable locations. For example, in preliminary discussions with OARnet, we understand that it may be possible to host the first generation of the quantum network testbed withing OARnet facilities, with subsequent iterations moving to permanent more specialized laboratory space appropriate for co-locating with other quantum infrastructure.

C. Sustainability of the center —possibilities for external funding, and details of related fundingproposal submissions.

For clarity, we separately discuss sources of internal and external support for CQISE moving forward.

Internal Support

We are pleased to note that there is a campus-wide push for faculty hiring in the area of QISE. Specifically, the College of Arts and Sciences, the College of Engineering, and the Enterprise for Research Innovation and Knowledge have jointly agreed to support hiring in this area for up to \$10 million over approximately five years to cover multiple faculty lines. These funds will be allocated towards an integrated cluster of hiring including near-term targeted searches for mid-career faculty complemented by a near/medium- term effort to recruit top-caliber junior faculty in this field.

While this program does not formally fall under the purview of CQISE, we note that these hires should have a substantial impact on the 'critical mass' of faculty working in these areas at Ohio State and should provide a significant boost to CQISE efforts in team building and collaborative network development. We anticipate that CQISE leadership (including the Faculty Co-Directors and the EAC) will play a role in advising departments and colleges regarding current trends in the field, helping to identify and recruit

promising candidates, etc. Overall, we anticipate that this investment will play a major role in sustaining the CQISE beyond the initial 3-year startup phase explicitly discussed in this proposal.

External Support

The development of next generation quantum technologies has been identified as an area of critical strategic interest on the national level, as evident with the passing of the National Quantum Initiative Act (H.R. 6227), signed into law on December 21, 2018. The National Quantum Initiative (NQI) Act creates a 10-year federal effort to boost quantum science, allocating \$1.275 billion from 2019-2023 to the Department of Energy, the National Institute of Standards and Technology, and the National Science Foundation.

The recent passage through the Senate of the US Innovation and Competition Act (I&CA) calls out quantum information technologies as one of the top 10 technology areas identified for investment. Industry investment in quantum computing has grown 444% over two years, up to \$1.02 billion in 2021 from \$187.5 million two years prior, according to the market data analyst Pitchbook. Companies like BMW and Goldman Sachs are already looking at quantum computing to improve safety configurations of sensors or optimize portfolio assets, respectively.

In addition to these federal funding opportunities, we note significant synergy between CQISE and state-level initiatives such as Jobs Ohio (through the training of a quantum-smart workforce) and OARnet (through the development of a quantum internet testbed and attendant infrastructure). Finally, leveraging the growing network of QISE-active industrial partners within the CQE (currently 32 partners including core partners Boeing and IBM, and corporate partners JP Morgan Chase, Toshiba, Verizon, and Applied Materials; <https://chicagoquantum.org/partners/corporate-partners>), we anticipate the potential for exploring industry/academic partnerships to support facilities and application-oriented research to be high.

As state- and industry-facing initiatives are still in the preliminary stages, we focus here on the broad scope of federal funding that has already been allocated to QISE (i.e., in advance of the new initiatives described above) to highlight the potential for increased federal funding in this area that would be enabled by CQISE.

Federal Funding Strategy:

The National Institute of Standards and Technology (NIST) promotes U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic prosperity. As authorized by the NQI Act, NIST is coordinating consortia focusing on quantum technologies, and maintaining fundamental QIS R&D programs. Quantum science is a top strategic priority for NIST. A recognized world leader in the field of quantum science and technology, NIST plays a central role in the National Quantum Initiative and is developing critical measurement capabilities necessary for the U.S. to win the race for quantum leadership. NIST's FY 2022 budget request outlines over \$233 million for foundational quantum research impacting quantum computing, communications, and cryptography. This research, combined with NIST's expertise in advanced materials, nanofabrication, and microelectronics; network of joint institutes (JILA and JQI); and the newly created Quantum Economic Development Consortium, make NIST a true hub of quantum innovation.

The National Science Foundation (NSF) promotes the progress of science by funding basic research at

approximately 2000 academic institutions throughout the United States. As authorized by the NQI Act, NSF is strengthening core programs and establishing new institutes focusing on fundamental QIS research and training. NSF has supported QIS research since the field's inception in the early 1980s. As part of its FY 2022 budget request, NSF has requested \$260 million for research to advance fundamental understanding of uniquely quantum phenomena that can be harnessed to promote information processing, transmission, and measurement in ways that classical approaches do less efficiently, or not at all. Building upon more than three decades of exploratory discovery, NSF investment in QIS will help propel the Nation forward as a leading developer of quantum technology. These investments are a key component of the National Quantum Initiative (NQI) and address the Administration's focus on helping build new industries. NSF's QIS investments build upon the agency's longstanding and continuing foundational investments in QIS as well as more recent, interdisciplinary investments in centers and small teams and targeted workforce development efforts. Investments will target all major areas of quantum computing, communications, sensing, networking, and simulation. NSF will continue the investment in Research Experiences for Undergraduates (REU) and NSF Research Traineeship (NRT) awards related to QIS begun in FY 2021 and will add intentional activities designed to grow the participation of investigators and students from institutions currently underrepresented in QIS.

The Department of Energy (DOE) ensures America's prosperity and security through several mechanisms including basic and applied scientific research, discovery and development of new technologies, and scientific innovation. The DOE Office of Science (SC) efforts in QIS, informed by community input, target DOE-mission-focused applications by leveraging SC's unique strengths. Major contributions to QIS focus on the following areas: (1) Supporting fundamental science that underpins quantum computing, simulation, communication, and sensing; (2) Creating tools, equipment, and instrumentation that go beyond what was previously imaginable; and (3) Establishing DOE community resources that enable the entire QIS ecosystem to innovate.

DOE's FY 2022 budget request to Congress includes \$292 million to target applications in quantum science areas as part of Advance Scientific Computing Research and Mathematical, Computational, and Computer Sciences Research and \$102 million for QIS in Basic Energy Sciences.

The Department of Defense (DOD) engages in basic research, defined as the 'systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind.' DOD has supported fundamental QIS research for three decades and continues to invest in basic QIS R&D activities via several DOD offices, agencies, and laboratories. The Science and Technology (S&T) enterprise of DOD has requested \$2.3 billion for Basic Research program funding, which includes quantum science, as part of their FY 2022 budget request.

V. EVALUATIVE CRITERIA AND BENCHMARKS

It is critical for CQISE to constantly assess its performance because the field of quantum information science is a technology space that is very new and growing at a rapid pace. Failure to be aware of the direction of the global community, the needs of our faculty and trainees, and the future trajectory of funding and other initiatives, could lead to low effectiveness. Evaluation criteria and benchmarks have been described as the means to assess center performance and, importantly identify and correct tactics for maximal benefits to Ohio State.

A. Evaluation criteria

Criteria for evaluation of the success of CQISE will include:

- 1) Increased funding of center members,
- 2) Increased number of collaborative grant applications,
- 3) Increased number of publications in quantum information sciences related journals with a priority placed on collaborative work (both total and high-impact publications),
- 4) New external collaborations between center members and investigators,
- 5) Honors and awards for center members,
- 6) Improvements in student and postdoc training, measured by increased numbers and impact of publications and research presentations, successful job placement after graduation, and computational skills acquisition,
- 7) Industry, non-profit, and government partnerships in education, workforce development, and research,
- 8) Number of patents and start-ups,
- 9) Diverse and inclusive environment,
- 10) Development of new QISE-relevant courses, workshops, and seminars, and
- 11) Provided or facilitated access to valuable QISE resources (e.g., computing tools, consulting services, fee-for-service, proposal support).

B. Benchmarks

Objective measurements for performance over the first three years of the center against the evaluation criteria as follows:

- 1) Extramural funding increase of greater than 10% each year for center member investigators,
- 2) Increased and sustained CQISE supported collaborative grant applications,
- 3) A 20% increase each year in the number of QISE-focused publications,
- 4) A 10% increase in membership each year, and demonstrated collaborations arising from center activities,
- 5) Recognition of QISE excellence for numbers and prestige of awards bestowed,

- 6) Academic excellence measured in publications (emphasis on high impact), student and post- doc career outcomes, and growth of trainee led communities,
- 7) New and sustained partnerships each year through formal agreements, contracts, or other engagements,
- 8) Internal and external comparisons to measure underrepresented group representation in membership and leadership,
- 9) Increased number of QISE related courses, workshops, and seminars, and
- 10) Establishment and sustainment of QISE resources measured by increased use of such resources and community feedback.

C. Evaluation of center performance

Per Ohio State University Academic Center Guidelines, Faculty Rule 3335-3-36 Centers and Institutes, Quantum Center leadership shall initiate a comprehensive self-study with guidance from at least two external reviews (identified by the director and executive advisory committee) aligned to the criteria for evaluation described above. The co-directors will be responsible for obtaining performance metrics for awards proposed and awarded per annum, student performance and placement, and demonstrations of internal and external collaborations. Upon yearly review, the director and EAC will establish strategies to bolster areas of performance that do not meet or exceed benchmark criteria. Furthermore, as defined in 3335-3-36, the center will be reviewed two years after initial establishment and four-year intervals thereafter, as articulated in 3335-3-36.

VI. SUPPORTING MATERIALS

A. Letters of support from Departmental Chairs, Deans and Center Directors within the University (Appendix B)

Each of the chairs, deans, and directors of units whose faculty will benefit from the creation of the Quantum Center were asked to provide letters of support.

B. Organizations supporting the Quantum Center (Appendix B)

The following organizations have provided letters of support expressing the value and importance of the Quantum Center and the potential for collaborations and partnerships.

C. Entities with similar emphasis

Requested, pending receipt.

Summary

Over the last few years, interest in quantum information has grown explosively as government agencies, industry, and academic researchers have absorbed the impact of a series of groundbreaking technical and scientific advances. From sensors, to communications, to computing and simulation, advances in quantum information (or quantum entanglement) are laying the foundation for a paradigm shift bridging much of modern science and technology. As a research institution, Ohio State needs to leverage the talent it has across multiple disciplines to grow its involvement in quantum information science and engineering (QISE), capitalizing on our leadership in educational initiatives like QuSTEAM and participation in regional networks such as the CQE, as well as their attendant academic and industry partners. Establishing the Center for Quantum Information Science and Engineering (CQISE) will position Ohio State as a regional Quantum hub for research and innovation, help the University to produce the next generation of the ‘quantum literate’ workforce, and support the ‘quantum economy’ by helping relevant stakeholders understand emerging challenges and opportunities in QISE. As one of the top 10 technology areas identified for investment, government agencies are geared to put over \$1.2 billion toward quantum initiatives over the next few years (building on prior investment at a similar scale), and industry investment was over \$1 billion in 2021 alone. Ohio State is well positioned to capitalize on these investment opportunities, and the Center for Quantum Information Science and Engineering can centralize the necessary components (research, faculty, students, administration, facilities, and partnerships) to move Ohio State to the forefront of quantum information research.

Appendix A - QISE Benchmarking and Competitive Intelligence Summary

The following chart was generated in early 2020 based on 2019 data and is based on publicly available information from each university’s website regarding active education programs in QISE. As a result, it may not represent a complete picture of each quantum program and likely undercounts the number of active programs in this rapidly changing landscape. Nonetheless, we believe it serves as a useful benchmark for the scope and scale of comparable efforts at peer and aspirational-peer institutions. We note that with the awarding of QuSTEAM in 2020 and the invitation to join the University of Chicago in the CQE in 2021, Ohio State’s current portfolio of academic and industrial partners compares quite favorably to the leading institutions identified below. However, we note that in the areas of seed funding, research infrastructure, and targeted hiring (not well captured by this survey) Ohio State still lags the early movers identified here.

Based on this public information, University of Chicago’s quantum program is strongest across all measures, and it is the only university with well-established undergraduate, graduate, and certificate programs in quantum information and technology. Wisconsin-Madison began a M.S. program in Quantum Computing in Fall 2019. Chicago and Harvard are the only schools offering quantum-specific seed funding for faculty while several universities on the list offer funding for postdocs and graduate students. Most universities with quantum institutes have a long list of partners including national labs, industry, and other universities. IBM specifically is partnered with four entities on the list - Chicago, Harvard, Berkeley, and UCSB. Most of the federal funding for quantum programs is concentrated in NSF, with nearly all top universities holding major center-level grants (PF, STC, Expeditions) and many of the universities on the list partner with one another as subs on these awards. Berkeley receives a large percentage of DOE funding available in quantum by virtue of the Lawrence Berkeley National Laboratory.

<i>University</i>	<i># Of Centers</i>	<i>Curriculum</i>	<i>Internal Funding</i>	<i>Partners</i>
University of Chicago	1	<ul style="list-style-type: none"> • Bachelor’s • Undergrad Minor • PhD • Professional Certificate 	<ul style="list-style-type: none"> • Postdoc Fellowships (2) • \$250k Seed Fund • \$150k Seed Fund (seeds funded by UChicago, Argonne, Fermilab and the Toyota Technological Institute at Chicago) • QISE-NET Grad Training Program 	<ul style="list-style-type: none"> • Argonne National Laboratory • Fermi National Accelerator Laboratory • University of Illinois Urbana-Champaign • University of Wisconsin-Madison • Northwestern University • Boeing • Applied Materials • ColdQuanta • HRL Laboratories • Quantum Opus • IBM

Harvard University	5		<ul style="list-style-type: none"> • Postdoc Fellowship • \$100k Seed Fund • QISE-NET Grad Training Program 	<ul style="list-style-type: none"> • Element Six • Graphenea • Raytheon • MIT Lincoln Laboratory • STMicroelectronics • IBM
University of Maryland	5	<ul style="list-style-type: none"> • QI Undergraduate Specialization (in draft form) 	<ul style="list-style-type: none"> • \$67,600 Postdoc Fellowships (2) • \$36,000 Grad Fellowship 	<ul style="list-style-type: none"> • NIST • Laboratory for Physical Sciences • Laboratory for Telecommunication Sciences • National Information Assurance Research Laboratory
University of Wisconsin	1	<ul style="list-style-type: none"> • M.S. in Quantum Computing 	N/A	<ul style="list-style-type: none"> • Chicago Quantum Exchange • Coldquanta • Northrup Grumman • Q-next
University of Illinois	1	N/A	N/A	<ul style="list-style-type: none"> • Chicago Quantum Exchange
UC Berkeley	3	N/A	N/A	<ul style="list-style-type: none"> • Lawrence Berkeley National Laboratory • Google • Rigetti Computing • IBM Almaden Research Center • Bleximo
UC Santa Barbara	2	N/A	<ul style="list-style-type: none"> • \$4000 Undergrad Summer Internship • \$37,000 Grad Traineeship • Grad Associates Program 	<ul style="list-style-type: none"> • UC San Diego • Boston University • University of Pittsburgh • Bruker; General Electric • Google-Quantum AI Lab • Hewlett Packard Enterprise • Honeywell

				<ul style="list-style-type: none"> • HRL Laboratories, LLC • IBM; Intel • Microsoft Quantum • Newport • Northrup Grumman • NVision • Soma Logic • SRI International
University of Pittsburgh	1	N/A	<ul style="list-style-type: none"> • 4 available, none quantum specific 	<ul style="list-style-type: none"> • Carnegie Mellon University • Duquesne University
University of Michigan	0	N/A	N/A	N/A

Appendix B – Dean, Chair, and Director Letters of Support

Deans

David Horn, Executive Dean
College of Arts and Sciences
horn.5@osu.edu

Ayanna Howard, Dean
College of Engineering
howard.1727@osu.edu

Susan Olesik, Dean
College of Arts and Sciences
Natural and Mathematical Sciences
olesik@chemistry.ohio-state.edu

Department Chairs

Anish Arora, Chair
College of Engineering
Department of Computer Science and Engineering
anish@cse.ohio-state.edu

Jean-Francois LaFont, Chair
College of Arts and Sciences
Department of Mathematics
jlafont@math.ohio-state.edu

Michael Mills, Chair
College of Engineering
Department of Materials Science and Engineering
mills.108@osu.edu

Michael Poirier, Chair
College of Arts and Sciences
Department of Physics
poirier.18@osu.edu

Andrea Serrani, Chair
College of Engineering
Department of Electrical and Computer Engineering
serrani.1@osu.edu

Claudia Turro, Chair
College of Arts and Sciences
Department of Chemistry & Biochemistry
turro.1@osu.edu

Center Directors

Tanya Berger-Wolf, Director
Translational Data Analytics Institute
berger-wolf.1@osu.edu

Louis DiMauro, Director
Institute for Optical Science
dimauro.6@osu.edu

P. Chris Hammel, Director
Center for Emergent Materials
hammel.7@osu.edu

Dick Ridgway, Director
ElectroScience Lab
ridgway.57@osu.edu

Steven Ringel, Director
Institute for Materials Research
ringel.5@osu.edu

Fengyuan Yang, Director
Center for the Exploration of Novel Complex Materials
yang.1006@osu.edu



THE OHIO STATE UNIVERSITY

College of Arts and Sciences

186 University Hall
230 North Oval Mall
Columbus, OH 43210

614-292-1667 Phone
614-292-8666 Fax

artsandsciences.osu.edu

January 12, 2022

Dear Drs. Johnston-Halperin and Reano,

I am pleased to write in support of the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University, and to endorse the participation of Arts and Sciences faculty in the center.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

The mission of the Center of Quantum Information Science and Engineering focuses on fundamental breakthroughs in our ability to understand and control the flow of quantum information, or more formally, quantum entanglement. This control provides exquisite sensitivity for next-generation sensors and secure communication. The potential for simultaneous sampling/processing of information is driving a revolution in computing.

The Center of Quantum Information Science and Engineering will provide new interdisciplinary opportunities for faculty and students within my college to advance their research and training programs through the center's strategic initiatives. Moreover, it will position Ohio State as a world leader in quantum research and education, and I enthusiastically provide my support for the establishment of this university center.

Sincerely,

David Horn
Interim Executive Dean
College of Arts and Sciences
horn.5@osu.edu



January 12, 2022

Dear Drs. Johnston-Halperin and Reano,

I am the Dean of Natural and Mathematical Sciences in The College of Arts and Sciences, and I am pleased to write this letter in support of the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University, and participation of my faculty in the center.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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The Center of Quantum Information Science and Engineering will provide new interdisciplinary opportunities for faculty and students within my college to advance their research and training programs through the center's strategic initiatives. Moreover, it will position Ohio State as a world leader in quantum research and education, and I enthusiastically provide my support for the establishment of this university center.

Sincerely,

Susan V. Olesik
Distinguished University Professor
Dean of Natural and Mathematical Sciences
College of Arts and Sciences
Olesik.1@osu.edu



January 10, 2022

Dear Drs. Johnston-Halperin and Reano,

As the Dean of the College of Engineering, I am pleased to offer my full and enthusiastic support for the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University. I encourage and support the inclusion and participation of my faculty in this center.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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The Center of Quantum Information Science and Engineering will provide new interdisciplinary opportunities for faculty and students within my college to advance their research and training programs through the center's strategic initiatives. Moreover, it will position Ohio State as a world leader in quantum research and education. On behalf of the College of Engineering, I wholeheartedly support the establishment of this university center.

Sincerely,

Ayanna Howard, Ph.D.
Monte Ahuja Endowed Dean's Chair
Dean of the College of Engineering



College of Engineering

Department of Computer Science and Engineering

395 Drees Labs
2015 Neil Avenue
Columbus, OH 43210

614-292-5813 Phone
614-292-2911 Fax

cse.osu.edu

January 11, 2022

Dear Dr. Ezekiel Johnston-Halperin,

I am the chair of Computer Science and Engineering, and I am pleased to write this letter in support of the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University, and participation of my faculty in the center.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

The mission of the Center of Quantum Information Science and Engineering focuses on fundamental breakthroughs in our ability to understand and control the flow of quantum information, or more formally, quantum entanglement. This control provides exquisite sensitivity for next-generation sensors and secure communication. The potential for simultaneous sampling/processing of information is driving a revolution in computing.

The Center of Quantum Information Science and Engineering will provide new interdisciplinary opportunities for faculty and students within my department to advance their research and training programs through the center's strategic initiatives. Moreover, it will position Ohio State as a world leader in quantum research and education, and I enthusiastically provide my support for the establishment of this university center.

Sincerely,

DocuSigned by:

E7F92D72F2F8454

Anish Arora

Professor and Chair, Computer Science and Engineering
Program co-Director, Translational Data Analytics Institute
College of Engineering
Arora.9@osu.edu



College of Arts and Sciences
Department of Mathematics

100 Math Building
231 W. Eighteenth Avenue
Columbus, OH 43210

614-292-7173
614-292-1479 (fax)

January 12nd, 2022

Dear Colleagues,

I am the chair of the Department of Mathematics, and I am pleased to write this letter in support of the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University, and participation of my faculty in the center.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

The mission of the Center of Quantum Information Science and Engineering focuses on fundamental breakthroughs in our ability to understand and control the flow of quantum information, or more formally, quantum entanglement. This control provides exquisite sensitivity for next-generation sensors and secure communication. The potential for simultaneous sampling/processing of information is driving a revolution in computing.

The Center of Quantum Information Science and Engineering will provide new interdisciplinary opportunities for faculty and students within my department to advance their research and training programs through the center's strategic initiatives. Moreover, it will position Ohio State as a world leader in quantum research and education, and I enthusiastically provide my support for the establishment of this university center.

Sincerely,

A handwritten signature in black ink, appearing to read "JF Lafont".

Jean-François Lafont
Professor and Chair
Department of Mathematics
College of Arts and Sciences
Lafont.1@osu.edu

January 12, 2022

Re: Establishment of a Center of Quantum Information Science and Engineering

Dear Drs. Johnston-Halperin and Reano,

As chair of the Department of Materials Science and Engineering, and I am pleased to write this letter in support of the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University, and participation of my faculty in the center.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

The mission of the Center of Quantum Information Science and Engineering focuses on fundamental breakthroughs in our ability to understand and control the flow of quantum information, or more formally, quantum entanglement. This control provides opportunities for next-generation sensors and secure communication. The potential for simultaneous sampling/processing of information is driving a revolution in computing. The department of Materials Science and Engineering has several faculty that could play important roles in this initiative, and would also encourage growth in this area.

The Center of Quantum Information Science and Engineering will provide new interdisciplinary opportunities for faculty and students within my department to advance their research and training programs through the center's strategic initiatives. Moreover, it will position Ohio State as a world leader in quantum research and education, and I therefore enthusiastically provide my support for the establishment of this university center.

Sincerely,

Dr. Michael J. Mills
Chair and Taine G. McDougal Professor of Engineering
Department of Materials Science and Engineering
The Ohio State University
mills.108@osu.edu



THE OHIO STATE UNIVERSITY

Department of Physics
Office of the Chair

1040 Physics Research Building
191 West Woodruff Avenue
Columbus, Ohio 43210-1117

614-292-2653 Phone
614-292-7557 Fax

physics.osu.edu

Tuesday, January 11, 2022

Dear Profs. Johnston-Halperin and Reano,

I am the chair of The Department of Physics, and I am pleased to write this letter in support of the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University, and participation of my faculty in the center.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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The Center of Quantum Information Science and Engineering will provide new interdisciplinary opportunities for faculty and students within my department to advance their research and training programs through the center's strategic initiatives. Moreover, it will position Ohio State as a world leader in quantum research and education, and I enthusiastically provide my support for the establishment of this university center.

Sincerely,

Michael G. Poirier
Professor and Chair



205 Drees Laboratories
2015 Neil Avenue
Columbus, OH 43210

Phone (614)292-2571
Fax (614) 292-7596

serrani.1@osu.edu

January 7, 2022

To: Dr. Zeke Johnston-Halperin
Dr. Ronald Reano
Interim Co-directors, Center of Quantum Information Science and Engineering at OSU

Dear Zeke and Ron,

I am pleased to write this letter to express the strongest support of the Department of Electrical and Computer Engineering for the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University, and to affirm the participation of ECE faculty to the activities of the center.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

The mission of the Center of Quantum Information Science and Engineering focuses on fundamental breakthroughs in our ability to understand and control the flow of quantum information, or more formally, quantum entanglement. This control provides exquisite sensitivity for next-generation sensors and secure communication. The potential for simultaneous sampling/processing of information is driving a revolution in computing.

The Center of Quantum Information Science and Engineering will provide new interdisciplinary opportunities for faculty and students within my department to advance their research and training programs through the center's strategic initiatives. Moreover, it will position Ohio State as a world leader in quantum research and education.

I enthusiastically provide my support for the establishment of this university center.

Sincerely,

Prof. Andrea Serrani
Professor and Interim Chair
Department of Electrical and Computer Engineering



Claudia Turro
Professor and Department Chair

Department of Chemistry and Biochemistry
Newman and Wolfrom Laboratory
100 West 18th Ave., Columbus, OH 43210-1106

(614) 292-6723 turro.1@osu.edu
<http://chemistry.osu.edu>

January 11, 2022

Dear Drs. Johnston-Halperin and Reano,

I am the chair of the Department of Chemistry and Biochemistry, and I am pleased to write this letter in support of the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University, and participation of my faculty in the center.

Quantum Information is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry and Biochemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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The Center of Quantum Information Science and Engineering will provide new interdisciplinary opportunities for faculty and students within my department to advance their research and training programs through the center's strategic initiatives. Moreover, it will position Ohio State as a world leader in quantum research and education.

I enthusiastically provide my support for the establishment of this university center.

Sincerely,

Claudia Turro
Professor and Department Chair

January 10, 2022

Dear Drs. Johnston-Halperin and Reano,

I am the Director of the Translational Data Analytics Institute, and I am pleased to write this letter in support of the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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The Center of Quantum Information Science and Engineering will provide interdisciplinary opportunities for faculty and students to advance their research and training programs through the center's strategic initiatives that do not exist within the framework of existing university departments, centers, and institutes. Moreover, it will position Ohio State as a world leader in quantum research and education, and I enthusiastically provide my support for the establishment of this university center.

Sincerely,



Dr. Tanya Berger-Wolf
Director, Translational Data Analytics Institute
Professor, Computer Science and Engineering
Electrical and Computer Engineering
Evolution, Ecology, and Organismal Biology
The Ohio State University



January 11, 2022

Dear Drs. Johnston-Halperin and Reano,

I am the Director of the Institute for Optical Science, and I am pleased to write this letter in support of the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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Sincerely,

Louis DiMauro
Hagenlocker Chair and Professor
Department of Physics
The Ohio State University
dimauro.6@osu.edu



THE OHIO STATE UNIVERSITY

January 9, 2022

Dear Drs. Johnston-Halperin and Reano,

As Director of the Center for Emergent Materials, an NSF MRSEC, I am pleased to write this letter in support of the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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The Center of Quantum Information Science and Engineering will provide interdisciplinary opportunities for faculty and students to advance their research and training programs through the center's strategic initiatives that do not exist within the framework of existing university departments, centers, and institutes. Moreover, it will position Ohio State as a world leader in quantum research and education, and I enthusiastically support the establishment of this university center.

Sincerely,

P Chris Hammel
Professor and Director of the Center for Emergent Materials, an NSF MRSEC
Department of Physics
Arts and Sciences College
hammel.7@osu.edu

January 11, 2022

To: Dr. Zeke Johnston-Halperin
Dr. Ronald M. Reano

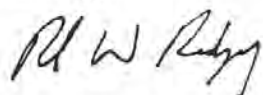
As the Director of the ElectroScience Laboratory within the College of Engineering, I am pleased to write this letter in support of the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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The Center of Quantum Information Science and Engineering will provide new interdisciplinary opportunities for faculty and students to advance their research and training programs through the center's strategic initiatives. Moreover, it will position Ohio State as a world leader in quantum research and education.

Sincerely,



Richard W. Ridgway, Ph.D.
Director
ElectroScience Laboratory
College of Engineering
ridgway.57@osu.edu



THE OHIO STATE UNIVERSITY
INSTITUTE FOR MATERIALS RESEARCH

E337 Scott Laboratory
201 West 19th Avenue
Columbus, OH 43210

614-581-9839 Phone
614-247-2581 Fax

imr.osu.edu

January 11, 2022

Dear Drs. Johnston-Halperin and Reano,

As the Executive Director of the OSU Institute for Materials Research and as Associate Vice President of Research within the Enterprise for Research, Innovation and Knowledge, I am pleased to provide this letter in support of the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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The Center of Quantum Information Science and Engineering will provide interdisciplinary opportunities for faculty and students to advance their research and training programs through the center's strategic initiatives that do not exist within the framework of existing university departments, centers, and institutes. Moreover, it will position Ohio State as a world leader in quantum research and education, and I enthusiastically provide my support for the establishment of this university center.

Sincerely,

Steven A. Ringel, Ph.D.
Distinguished University Professor
Professor and Neal A. Smith Endowed Chair, Electrical and Computer Engineering
Associate Vice President for Research, Office of Research
Executive Director, Institute for Materials Research (IMR)
The Ohio State University
ringel.5@osu.edu <https://ece.osu.edu/emdl> www.imr.edu



January 10, 2022

Dear Drs. Johnston-Halperin and Reano,

I am the Director of Center for the Exploration of Novel Complex Materials (ENCOMM) and I am pleased to write this letter in support of the establishment of the Center of Quantum Information Science and Engineering within the Enterprise for Research, Innovation and Knowledge at The Ohio State University.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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The Center of Quantum Information Science and Engineering will provide interdisciplinary opportunities for faculty and students to advance their research and training programs through the center's strategic initiatives that do not exist within the framework of existing university departments, centers, and institutes. Moreover, it will position Ohio State as a world leader in quantum research and education, and I enthusiastically provide my support for the establishment of this university center.

Sincerely,

Fengyuan Yang
Professor of Physics
Director, Center for the Exploration of Novel Complex Materials (ENCOMM)
The Ohio State University
Email: yang.1006@osu.edu

Appendix C - List of Faculty Members interested in associating with CQISE

Shamsul Arafin, Assistant Professor
College of Engineering
Electrical and Computer Engineering
arafin.1@osu.edu

L. Robert Baker, Associate Professor
College of Arts and Sciences
Chemistry & Biochemistry
baker.2364@osu.edu

Marc Bockrath, Professor
College of Arts and Sciences
Physics
bockrath.31@osu.edu

Leonard Brillson, Professor
College of Engineering
Electrical and Computer Engineering
brillson.1@osu.edu

Rafael Brüscheweiler, Professor
College of Arts and Sciences
Chemistry & Biochemistry
bruschweiler.1@osu.edu

Enam Chowdhury, Assistant Professor
College of Engineering
Materials Science and Engineering
chowdhury.24@osu.edu

Louis DiMauro, Professor
College of Arts and Sciences
Physics
dimauro.6@osu.edu

Sachin Gautam, Assistant Professor
College of Arts and Sciences
Mathematics
gautam.42@osu.edu

Maryam Ghazisaeidi, Associate Professor
College of Engineering
Materials Science and Engineering
ghazisaeidi.1@osu.edu

Joshua Goldberger, Professor
College of Arts and Sciences
Chemistry & Biochemistry
goldberger.4@osu.edu

Tyler Grassman, Associate Professor
College of Engineering
Materials Science and Engineering
grassman.5@osu.edu

Jay Gupta, Professor
College of Arts and Sciences
Physics
gupta.208@osu.edu

P. Chris Hammel, Professor
College of Arts and Sciences
Physics
hammel.7@osu.edu

Pooya Hatami, Assistant Professor
College of Engineering
Electrical and Computer Engineering
hatami.2@osu.edu

John Herbert, Professor
College of Arts and Sciences
Chemistry & Biochemistry
herbert.44@osu.edu

Joseph Heremans, Professor
College of Engineering
Mechanical and Aerospace Engineering
heremans.1@osu.edu

Christopher Hill, Professor
College of Arts and Sciences
Physics
hill.1369@osu.edu

Roy Joshua, Professor
College of Arts and Sciences
Mathematics
joshua.1@osu.edu

Roland Kawakami, Professor
College of Arts and Sciences
Physics
kawakami.15@osu.edu

Thomas Kerler, Professor
College of Arts and Sciences
Mathematics
kerler.2@osu.edu

Sanjay Krishna, Professor
College of Engineering
Electrical and Computer Engineering
krishna.53@osu.edu

Gregory Lafyatis, Associate Professor
College of Arts and Sciences
Physics
Lafyatis.2@osu.edu

Samir Mathur, Professor
College of Arts and Sciences
Department of Physics
mathur.16@osu.edu

David McComb, Professor
College of Engineering
Materials Science and Engineering
mccomb.29@osu.edu

Tawfiq Musah, Assistant Professor
College of Engineering
Electrical and Computer Engineering
musah.3@osu.edu

Roberto Myers, Professor
College of Engineering
Materials Science and Engineering
myers.1079@osu.edu

David Nippa, Research Scientist
College of Engineering
ElectroScience Lab
nippa.2@osu.edu

David Penneys, Associate Professor
College of Arts and Sciences
Mathematics
penneys.2@osu.edu

Mohit Randeria, Professor
College of Arts and Sciences
Physics
randeria.1@osu.edu

Brian Skinner, Assistant Professor
College of Arts and Sciences
Physics
skinner.352@osu.edu

Alexander Sokolov, Assistant Professor
College of Arts and Sciences
Chemistry & Biochemistry
sokolov.8@osu.edu

Fernando Teixeira, Professor
College of Engineering
ElectroScience Lab
teixeira.5@osu.edu

Christine Thomas, Professor
College of Arts and Sciences
Chemistry & Biochemistry
thomas.3877@osu.edu

Nandini Trivedi, Professor
College of Arts and Sciences
Physics
trivedi.15@osu.edu

Claudia Turro, Professor
College of Arts and Sciences
Chemistry & Biochemistry
turro.1@osu.edu

Casey Wade, Assistant Professor
College of Arts and Sciences
Chemistry & Biochemistry
wade.521@osu.edu

Fengyuan Yang, Professor
College of Arts and Sciences
Physics
yang.1006@osu.edu

Shiyu Zhang, Assistant Professor
College of Arts and Sciences
Chemistry & Biochemistry
zhang.8941@osu.edu

Appendix D - Faculty Membership Letters of Intent



THE OHIO STATE UNIVERSITY

January 11, 2022

Dear Drs. Johnston-Halperin and Reano,

Please accept this letter as recognition of my intent to be a member of the Center for Quantum Information Science and Engineering (CQISE) within the Enterprise for Research, Innovation and Knowledge. Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. CQISE will provide new interdisciplinary opportunities for the campus community to advance research and training programs through the center's strategic initiatives.

I understand full members must be OSU faculty or independent university researchers (e.g., principal investigator, research scholar, research associate) responsible for research and education, and actively involved in basic, applied, clinical, or translational research in QISE or a closely related field as measured by a pattern of publication, funding, or similar metric.

As a member, I will engage as (minimum of three of the following):

- 1) Contributor to a center grant proposal as PI, co-PI, or contributing faculty,
- 2) Contributor to resource development efforts,
- 3) Contributor to curriculum, short-courses, and/or workshops,
- 4) Consultant to study design and/or analysis,
- 5) Host for a seminar speaker,
- 6) Mentor or committee member of a Quantum scientist/engineer, or
- 7) Member of Executive Advisory Committee.

CQISE will position Ohio State as a world leader in quantum research and education. I enthusiastically provide my support for the establishment of this university center and look forward to my membership.

Sincerely,

Name: Shamsul Arafin
Title: Assistant Professor
Department : Electrical and Computer Engineering
College: College of Engineering
Email: arafin.1@osu.edu

January 7, 2022

Dear Drs. Johnston-Halperin and Reano,

Please accept this letter as recognition of my intent to be a member of the Center of Quantum Information Science and Engineering (CQISE) within the Enterprise for Research, Innovation and Knowledge at The Ohio State University.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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The Center of Quantum Information Science and Engineering will provide new interdisciplinary opportunities for faculty and students within my department to advance their research and training programs through the center's strategic initiatives. Moreover, it will position Ohio State as a world leader in quantum research and education, and I enthusiastically provide my support for the establishment of this university center.

I understand full members must be:

- Ohio State faculty or independent university researchers (e.g., principal investigator, research scholar, research associate) responsible for research and education.
- Actively involved in basic, applied, clinical or translational research, and be a principal investigator on an extramurally funded grant or a principal investigator of an individual project within a larger extramurally funded program project grant.

To support the mission of the Center of Quantum Information Science and Engineering, fundamental breakthroughs in understanding and controlling the flow of quantum information, or more formally, quantum entanglement, as a member I will commit to a minimum of three of these seven activities:

- 1) Mentor or serve as a committee member of a Quantum scientist,
- 2) Host for a seminar speaker in Quantum Information,
- 3) Contribute to a center grant proposal as PI, co-I, or contributing faculty,
- 4) Contribute to CQISE resource development efforts,



THE OHIO STATE UNIVERSITY

- 5) Contribute to CQISE curriculum, short-courses and/or workshops,
- 6) Serve as a CQISE consultant to study design and/or analysis, or
- 7) Serve on the Executive Advisory Committee.

I understand a consistent lack of involvement will generate a communication from the director, and after two years of inactivity, membership will be abolished if extenuating circumstances are not communicated and/or accepted. Upon loss of membership, I will not qualify for certain incentives of the center, such as seed grants, support for proposal development, and consulting services. My membership may be reinstated after a minimum of one-year demonstrated activity to the criteria above and formal petition to the director.

Sincerely,

L. Robert Baker

L. Robert Baker
Associate Professor
Department of Chemistry & Biochemistry
College of Arts and Sciences
Email: baker.2364@osu.edu



January 11, 2022

Dear Drs. Johnston-Halperin and Reano,

Please accept this letter as recognition of my intent to be a member of the Center of Quantum Information Science and Engineering (CQISE) within the Enterprise for Research, Innovation and Knowledge at The Ohio State University.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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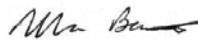
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- 4) Contribute to CQISE resource development efforts,
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Sincerely,



Marc Bockrath
Professor
Department of Physics
College of Arts and Sciences
Bockrath.31@osu.edu



January 7, 2022

Dear Drs. Johnston-Halperin and Reano,

Please accept this letter as recognition of my intent to be a member of the Center of Quantum Information Science and Engineering (CQISE) within the Enterprise for Research, Innovation and Knowledge at The Ohio State University.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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- Ohio State faculty or independent university researchers (e.g., principal investigator, research scholar, research associate) responsible for research and education.
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- 3) Contribute to a center grant proposal as PI, co-I, or contributing faculty,
- 4) Contribute to CQISE resource development efforts,
- 5) Contribute to CQISE curriculum, short-courses and/or workshops,
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I understand a consistent lack of involvement will generate a communication from the director, and after two years of inactivity, membership will be abolished if extenuating circumstances are not communicated and/or accepted. Upon loss of membership, I will not qualify for certain incentives of the center, such as seed grants, support for proposal development, and consulting services. My membership may be reinstated after a minimum of one-year demonstrated activity to the criteria above and formal petition to the director.

Sincerely,

A handwritten signature in black ink, appearing to read "Leonard J. Brillson", written over a horizontal line.

Leonard J. Brillson
Professor
Departments of Physics and Electrical & Computer Engineering
College of Arts & Science, College of Engineering
Brillson.l@osu.edu

January 8, 2022

Dear Drs. Johnston-Halperin and Réano:

Please accept this letter as recognition of my intent to be a member of the Center of Quantum Information Science and Engineering (CQISE) within the Enterprise for Research, Innovation and Knowledge at The Ohio State University.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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- Ohio State faculty or independent university researchers (e.g., principal investigator, research scholar, research associate) responsible for research and education.
- Actively involved in basic, applied, clinical or translational research, and be a principal investigator on an extramurally funded grant or a principal investigator of an individual project within a larger extramurally funded program project grant.

To support the mission of the Center of Quantum Information Science and Engineering, fundamental breakthroughs in understanding and controlling the flow of quantum information, or more formally, quantum entanglement, as a member I will commit to a minimum of three of these seven activities:

- 1) Mentor or serve as a committee member of a Quantum scientist.
- 2) Host for a seminar speaker in Quantum Information.
- 3) Contribute to a center grant proposal as PI, co-I, or contributing faculty.
- 4) Contribute to CQISE resource development efforts.
- 5) Contribute to CQISE curriculum, short-courses and/or workshops.
- 6) Serve as a CQISE consultant to study design and/or analysis, or
- 7) Serve on the Executive Advisory Committee.

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and/or accepted. Upon loss of membership, I will not qualify for certain incentives of the center, such as seed grants, support for proposal development, and consulting services. My membership may be reinstated after a minimum of one-year demonstrated activity to the criteria above and formal petition to the director.

Sincerely,

A handwritten signature in cursive script that reads "R. Bruschweiler".

Rafael Bruschweiler, Ph.D.
Professor and Ohio Research Scholar
Executive Director, CCIC NMR and National Gateway Ultrahigh Field NMR Center
Department of Chemistry and Biochemistry, College of Arts and Sciences
Department of Biological Chemistry and Pharmacology, College of Medicine
The Ohio State University, Columbus, OH

E-mail: Bruschweiler.1@osu.edu



Enam A. Chowdhury
Assistant Professor
Department of Materials Science and Engineering
Department of Electrical and Computer Engineering
Department of Physics

The Ohio State University, 2041 College Rd., Columbus, OH 43210
myers.1079@osu.edu | myersgroup.engineering.osu.edu | 614-547-9771

January 12, 2022

Subject: CQISE intention to join new center

To: Profs. Ezekiel Johnston-Halperin and Ronald Reano

I intend to be a member of the Center of Quantum Information Science and Engineering (CQISE) at OSU. I am an assistant professor of Materials Science and Engineering, and my expertise is in strong field non-perturbative ultrafast laser materials interaction. I am also the PI on an Air Force Office of Scientific Research (AFOSR), titled “Femtosecond laser induced damage in extremes: from single cycle to atomic resolution”, where with my colleague and co-PI from condensed matter physics, Prof. Jay Gupta, where we are studying and characterizing strong field laser induced single atom defect states in a wide variety of materials, which have potential applications in forming quantum entangled states in solid state materials. I also have well-established collaboration with the Air Force Institute of Technology (AFIT, WPAFB Ohio) and the Air Force Research Laboratory (AFRL, WPAFB Ohio), and the Army Research Laboratory (Aberdeen Proving Ground, MD) in studying strongly correlated systems under extreme optical fields, and serve as senior consultant to the Department of Defense. I already have established cross-college (between CoE and CAS) collaborative research where I have PhD students in my group from both colleges, have a strong interest in expanding collaborations and funding opportunities across departments and colleges at OSU, and also with AFIT and AFRL. I wish to be an active member of the CQISE and help in fostering the growth of various QIST research activities and proposal development on campus, and provide new types of laser based tools for developing and probing novel quantum correlated materials and states.

Sincerely,

A handwritten signature in black ink that reads 'Enam A. Chowdhury'.

Enam A. Chowdhury
Assistant Professor of Materials Science, Electrical Engineering, and Physics
The Ohio State University, Columbus, Ohio, 43210
chowdhury.24@osu.edu | 614-247-8392 | <https://u.osu.edu/chowdhury.24/>



January 11, 2022

Dear Dr. Johnston-Halperin,

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Sincerely,

A handwritten signature in black ink, appearing to read "Louis DiMauro", with a long horizontal flourish extending to the right.

Louis DiMauro
Hagenlocker Chair and Professor
Department of Physics
The Ohio State University
dimauro.6@osu.edu



January 07, 2022

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Sincerely,

A handwritten signature in blue ink, appearing to read "Sachin", with a long horizontal flourish extending to the right.

Professor Name: Sachin Gautam
Title: Assistant Professor
Department: Mathematics
College: Arts and Sciences
Email: gautam.42@osu.edu



THE OHIO STATE UNIVERSITY

Maryam Ghazisaeidi
Associate Professor

Department of Materials Science and Engineering

The Ohio State University, 2041 College Rd., Columbus, OH 43210
ghazisaeidi.1@osu.edu | 614-292-8474

January 12, 2022

Subject: CQISE intention to join new center

To: Profs. Ezekiel Johnston-Halperin and Ronald Reano

I intend to be a member of the Center of Quantum Information Science and Engineering (CQISE) at OSU. I am a professor of Materials Science and Engineering, currently a co-PI on the National Science Foundation (NSF) funded MRSEC center at OSU, where my group is contributing to efforts to create and control Metal/Magnetic-Insulator Interfaces. I am also the PI on an Air Force Office of Scientific Research (AFOSR), titled “dislocation as nature’s quantum wires”, where with my colleague Prof. Roberto Myers, we are developing 1D defects as quantum wires in wide band gap materials. My research is therefore increasingly moving in the area of first principles calculations in quantum material and I have a particular interest in being an active member of the CQISE and fostering the growth of these research activities and proposal development on campus. I am eager to connect with researchers at OSU to develop research programs that could benefit from our computational capabilities.

Sincerely,

Maryam Ghazisaeidi
Associate Professor of Materials Science and Physics (by courtesy).
The Ohio State University



January 07, 2022

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THE OHIO STATE UNIVERSITY

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Sincerely,

Joshua Goldberger
Professor
Department of Chemistry and Biochemistry
College of Arts and Sciences
Goldberger.4@osu.edu



THE OHIO STATE UNIVERSITY

Tyler J. Grassman

Associate Professor

Dept. of Materials Science & Engineering

Dept. of Electrical & Computer Engineering

The Ohio State University

4017 Fontana Lab, 140 W 19th Ave.

Columbus, OH 43210

614-688-1704

grassman.5@osu.edu

<https://engineering.osu.edu/people/grassman.5>

January 12, 2022

Re: Intent of membership in Center of Quantum Information Science and Engineering (CQISE)

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Tyler J. Grassman
Associate Professor
Department of Materials Science & Engineering
Department of Electrical & Computer Engineering
College of Engineering
grassman.5@osu.edu



January 7, 2022

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Sincerely,

A handwritten signature in black ink, appearing to read 'Jay Gupta', with a long horizontal stroke extending to the right.

Jay Gupta, PhD
Professor
Department of Physics
College of Arts & Sciences
Gupta.208@osu.edu



January 9, 2022

Dear Drs. Johnston-Halperin and Reano,

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Sincerely,



P Chris Hammel
Professor and Director of the Center for Emergent Materials, an NSF MRSEC
Department of Physics
Arts and Sciences College
hammel.7@osu.edu



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Pooya Hatami
Assistant Professor
Computer Science and Engineering
College of Engineering
hatami.2@osu.edu



THE OHIO STATE UNIVERSITY

Prof. John M. Herbert
Dept. of Chemistry & Biochemistry
100 W. 18th Ave.
Columbus, OH 43210
(614) 292-6851
herbert@chemistry.ohio-state.edu
www.chemistry.osu.edu/~herbert

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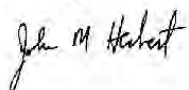
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Professor of Chemistry & Biochemistry
College of Arts & Sciences
herbert@chemistry.ohio-state.edu



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Sincerely

Joseph P. Heremans
Ohio Eminent Scholar and Professor



January 10, 2022

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Sincerely,

Christopher S. Hill
Professor
Physics
Arts & Sciences
chill@physics.osu.edu



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The Center of Quantum Information Science and Engineering will provide new interdisciplinary opportunities for faculty and students within my department to advance their research and training programs through the center's strategic initiatives. Moreover, it will position Ohio State as a world leader in quantum research and education, and I enthusiastically provide my support for the establishment of this university center.

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I understand a consistent lack of involvement will generate a communication from the director, and after two years of inactivity, membership will be abolished if extenuating circumstances are not communicated and/or accepted. Upon loss of membership, I will not qualify for certain incentives of the center, such as seed grants, support for proposal development, and consulting services. My membership may be reinstated after a minimum of one-year demonstrated activity to the criteria above and formal petition to the director.

Sincerely,

Roy Joshua
Title: Professor
Department: Mathematics
College: Arts and Sciences
Email: joshua.1@osu.edu



January 11, 2022

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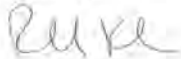
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Sincerely,



Roland Kawakami
Professor
Department of Physics
College of Arts and Sciences, The Ohio State University
kawakami.15@osu.edu



January 11, 2022

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Sincerely,

Thomas Kerler
Professor & Vice-chair
Department of Mathematics
College of Arts and Science
Kerler.2@osu.edu



January 10, 2022

Sanjay Krishna,
Professor and George R Smith Chair in Engineering,
Department of Electrical and Computer Engineering
377 Caldwell Lab 2015 Neil Avenue Columbus, OH 43210
Phone: 614 292 3715 Fax: 614 292 7596 Email: krishna.53@osu.edu
<https://kind.engineering.osu.edu/>

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Sincerely,

A handwritten signature in black ink, appearing to read "Gregory P. Lafyatis". The signature is written in a cursive style with some loops and flourishes.

Gregory Lafyatis
Associate Professor of Physics

Lafyatis.2@osu.edu



January 07, 2022

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Sincerely,

Samir Mathur

Professor Name: Samir D. Mathur

Title: Professor

Department: Physics

College: Arts and Sciences

Email: mathur.16@osu.edu



Center for Electron Microscopy and Analysis
Department of Materials Science and Engineering
1305 Kinnear Rd
Columbus, OH 43212
614-643-3110 Phone
cemas.osu.edu

12 January 2022

Subject: CQISE intention to join new center

To: Profs. Ezekiel Johnston-Halperin and Ronald Reano

I intend to be a member of the Center of Quantum Information Science and Engineering (CQISE) at OSU. I am a professor of Materials Science and Engineering, currently a co-PI on the National Science Foundation (NSF) funded MRSEC center at OSU, where my group is contributing to efforts to develop “quantum spin liquids” in new magnetic materials, as well as to develop experimental methods to probe the magnons in quantum materials. I am also a co-PI on a DARPA funded project on Topological materials, in particular skyrmion materials. My research group is increasingly focused on developments in variable temperature electron microscopy methods for the study of materials at or below room temperature. Such developments have been the recent focus of national reports from both NSF and DoE and will be key to the characterization of quantum materials and devices with high spatial resolution. I am highly excited by the prospect of interacting with other research programs that could benefit from these novel characterization methods in the future.

Yours sincerely

David McComb
Professor of Materials Science and Engineering
Ohio Research Scholar
Director, Center for Electron Microscopy and Analysis



THE OHIO STATE UNIVERSITY

January 12, 2022

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As a member, I will engage as:

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- 2) Contributor to curriculum, short-courses, and/or workshops,
- 3) Consultant to study design and/or analysis,
- 4) Host for a seminar speaker,

CQISE will position Ohio State as a world leader in quantum research and education. I enthusiastically provide my support for the establishment of this university center and look forward to my membership.

Sincerely,

Tawfiq Musah
Assistant Professor
Electrical and Computer Engineering
College of Engineering
Email: musah.3@osu.edu



THE OHIO STATE UNIVERSITY

Roberto C. Myers
Professor

Department of Materials Science and Engineering
Department of Electrical and Computer Engineering
Department of Physics

The Ohio State University, 2041 College Rd., Columbus, OH 43210
myers.1079@osu.edu | myersgroup.engineering.osu.edu | 614-547-9771

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Sincerely,

Roberto C. Myers
Chair, Graduate Studies Committee, MSE Dept.
Professor of Materials Science, Electrical Engineering, and Physics
The Ohio State University, Columbus, Ohio, 43210
myers.1079@osu.edu | 614-547-9771 | myersgroup.osu.edu/



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David W. Nippa, Ph.D.
Research Scientist
ElectroScience Laboratory
College of Engineering
The Ohio State University
nippa.2@osu.edu



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Professor Name: David Penneys
Title: Associate Professor
Department: Mathematics
College: Arts and Sciences
Email: penneys.2@osu.edu

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A handwritten signature in black ink that reads "Mohit Randeria". The signature is written in a cursive style with a large, stylized 'M' and 'R'.

Mohit Randeria
Professor
Department of Physics
College of Arts and Science
Email: randeria.1@osu.edu



January 07, 2022

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A handwritten signature in cursive script, appearing to read "Brian Skinner".

Brian Skinner
Assistant Professor
Department of Physics
College of Arts and Sciences
skinner.352@osu.edu



January 7, 2022

Dear Drs. Johnston-Halperin and Reano,

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- 3) Contribute to a center grant proposal as PI, co-I, or contributing faculty,
- 4) Contribute to CQISE resource development efforts,
- 5) Contribute to CQISE curriculum, short-courses and/or workshops,
- 6) Serve as a CQISE consultant to study design and/or analysis, or
- 7) Serve on the Executive Advisory Committee.

I understand a consistent lack of involvement will generate a communication from the director, and after two years of inactivity, membership will be abolished if extenuating circumstances are not communicated and/or accepted. Upon loss of membership, I will not qualify for certain incentives of the center, such as seed grants, support for proposal development, and consulting services. My membership may be reinstated after a minimum of one-year demonstrated activity to the criteria above and formal petition to the director.

Sincerely,

Prof. Alexander Sokolov
Assistant Professor
Department of Chemistry & Biochemistry
College of Arts and Sciences
The Ohio State University

E-mail: sokolov.8@osu.edu
Phone: +1 (614) 688-3636



January 12, 2022

Dear Drs. Johnston-Halperin and Reano,

Please accept this letter as recognition of my intent to be a member of the Center for Quantum Information Science and Engineering (CQISE) within the Enterprise for Research, Innovation and Knowledge. Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. CQISE will provide new interdisciplinary opportunities for the campus community to advance research and training programs through the center's strategic initiatives.

I understand full members must be OSU faculty or independent university researchers (e.g., principal investigator, research scholar, research associate) responsible for research and education, and actively involved in basic, applied, clinical, or translational research in QISE or a closely related field as measured by a pattern of publication, funding, or similar metric.

As a member, I plan to engage as:

- 1) Contributor to a center grant proposal as PI, co-PI, or contributing faculty,
- 2) Contributor to resource development efforts,
- 3) Contributor to curriculum, short-courses, and/or workshops,
- 4) Host for a seminar speaker,
- 5) Mentor or committee member of a Quantum scientist/engineer.

CQISE will position Ohio State as a world leader in quantum research and education. I enthusiastically provide my support for the establishment of this university center and look forward to my membership.

Sincerely,

Fernando Lisboa Teixeira
Professor
ElectroScience Laboratory
Department of Electrical and Computer Engineering
teixeira.5@osu.edu

January 10, 2022

Dear Drs. Johnston-Halperin and Reano,

Please accept this letter as recognition of my intent to be a member of the Center of Quantum Information Science and Engineering (CQISE) within the Enterprise for Research, Innovation and Knowledge at The Ohio State University.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

The mission of the Center of Quantum Information Science and Engineering focuses on fundamental breakthroughs in our ability to understand and control the flow of quantum information, or more formally, quantum entanglement. This control provides exquisite sensitivity for next-generation sensors and secure communication. The potential for simultaneous sampling/processing of information is driving a revolution in computing.

The Center of Quantum Information Science and Engineering will provide new interdisciplinary opportunities for faculty and students within my department to advance their research and training programs through the center's strategic initiatives. Moreover, it will position Ohio State as a world leader in quantum research and education, and I enthusiastically provide my support for the establishment of this university center.

I understand full members must be:

- Ohio State faculty or independent university researchers (e.g., principal investigator, research scholar, research associate) responsible for research and education.
- Actively involved in basic, applied, clinical or translational research, and be a principal investigator on an extramurally funded grant or a principal investigator of an individual project within a larger extramurally funded program project grant.

To support the mission of the Center of Quantum Information Science and Engineering, fundamental breakthroughs in understanding and controlling the flow of quantum information, or more formally, quantum entanglement, as a member I will commit to a minimum of three of these seven activities:

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- 3) Contribute to a center grant proposal as PI, co-I, or contributing faculty,
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Sincerely,

Christine M. Thomas
Fox Professor and Vice Chair for Graduate Studies
Department of Chemistry and Biochemistry
College of Arts and Sciences
thomas.3877@osu.edu



January 11, 2022

Dear Drs. Johnston-Halperin and Reano,

Please accept this letter as recognition of my intent to be a member of the Center of Quantum Information Science and Engineering (CQISE) within the Enterprise for Research, Innovation and Knowledge at The Ohio State University.

Quantum is a broadly interdisciplinary field, with potential scope impacting the entire STEAM enterprise through the development of new quantum technologies, the exploitation of those technologies to enhance existing activities, and considerations of the societal and cultural impacts of these transformative changes. To date, the field has been driven nationally by six core STEM departments: Chemistry, Math, Physics, Computer Science, Electrical and Computer Engineering, and Materials Science and Engineering.

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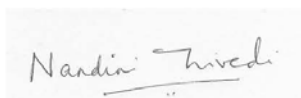
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Sincerely,

A handwritten signature in cursive script that reads "Nandini Trivedi". The signature is written in black ink on a light-colored background.

Professor Name: Nandini Trivedi
Title: Professor
Department: Physics
College: Arts and Sciences
Email: trivedi.15@osu.edu



January 11, 2022

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Sincerely,

Claudia Turro
Professor and Department Chair



THE OHIO STATE UNIVERSITY

Casey R. Wade
Assistant Professor

wade.521@osu.edu
(614) 688-4722

College of Arts and Sciences
Department of Chemistry and Biochemistry

4105 Newman & Wolfrom Lab
100 West 18th Ave.
Columbus, OH 43210

January 10, 2022

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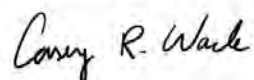
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Sincerely,

Handwritten signature of Casey R. Wade in cursive script.

Casey R. Wade
Assistant Professor
Department of Chemistry & Biochemistry
College of Arts and Sciences
wade.521@osu.edu



January 7, 2022

Dear Drs. Johnston-Halperin and Reano,

Please accept this letter as recognition of my intent to be a member of the Center of Quantum Information Science and Engineering (CQISE) within the Enterprise for Research, Innovation and Knowledge at The Ohio State University.

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Sincerely,

A handwritten signature in black ink, appearing to read 'Fengyuan Yang', written in a cursive style.

Fengyuan Yang
Professor
Department of Physics
College of Arts and Sciences
Email: yang.1006@osu.edu

January 07, 2022

Dear Drs. Johnston-Halperin and Reano,

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- 5) Contribute to CQISE curriculum, short-courses and/or workshops,
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Sincerely,

Shiyu Zhang

Assistant Professor

Department of Chemistry and Biochemistry

College of Arts and Sciences

zhang.8941@osu.edu