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EVALUATION REPORT OF THE RUSSIAN QUANTUM CENTER – RQC

Evaluation Committee members:

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General remarks

The Russian Quantum Center (RQC) is a non-governmental research organization that conducts fundamental and applied research in the field of modern quantum physics and technologies. The Center in its present capacity was launched in 2012. Thus, this report of the Evaluation Committee representing the RQC International Advisory Board, summarizes the first 5 years of operation of the RQC.

The evaluation committee is truly impressed with the achievements of RQC which has become the leading entity in the field of Quantum Technologies in Russia, on par with the most advanced centers in the field worldwide. The Center is engaged in fundamental research on quantum computing, simulation, communication and sensing, as well as in the development and commercialization of new technologies and devices based on quantum effects.

RQC today includes eleven research groups led by outstanding researchers hired through an open international competition. In total, 170 scientists and early career researchers (average age 34) are employed at RQC. The entire staff of the RQC is 198 people, including part-time employees.

Since 2012 more than 450 papers have been published by RQC researchers in leading peer reviewed international journals. Among those 88 articles have been already cited more than 10 times, 15 - more than 50 times, and 5 papers - more than 100 times. The total impact factor of the RQC publications for the 5 year period is close to 2000.

Twelve RQC laboratories with a total cost of equipment more than 500 million rubles (9 million USD based on the current exchange rate) built at the business center "Ural" in Skolkovo on 1250 square meters are fully operational. In addition the Center has been proactive in commercialization of its innovations with 6 high-tech start-ups launched.

The RQC research groups and their major research achievements

The “Quantum simulators and integrated photonics” group is led by Prof. Akimov who played a key role in establishing the RQC. His group achieved the first realization and application of a superconducting single photon detector operating in a visible domain, coupling of a Nitrogen Vacancy color center to metamaterials, and an effort on cooling of thulium atoms to quantum degeneracy, one of the most challenging experimental projects at RQC.

Prof. Belotelov heads the “Magneto-optics, plasmonics and nanophotonics” group which studies basic science and sensor applications of magneto-optical materials and magneto-optical plasmonic structures. The research highlights include the interaction of optical femtosecond pulses with magnetic dielectric films, plasmon-solitons in Kerr nonlinear heterostructures including control of the solitons with magnetic field, and a highly sensitive magnetometer for measurements on small animals and humans. Commercialization of the magnetic sensors has been recently launched.

Prof. Gorodetsky, the leader of the “Coherent micro-optics and radio-photonics” group, is the current Scientific Director of RQC. He has pioneered generation of dissipative Kerr solitons in microcavities. His research highlights include miniature frequency combs (microcombs), generation of soliton states with a deterministic soliton number, demonstration of a new microcomb pumping technique with an ordinary laser diode, and crystalline resonators with record-high quality factors.

The research of Prof. Kavokin’s “Quantum Polaritonics” group focuses on theoretical investigation of exciton-polaritons. The group has extensive collaborations with a number of leading experimental groups working in this field. Prof. Kavokin’s group played an important role in several major breakthroughs in the field including observations of excitation-polariton condensates and studies of their coherence properties.

The “Quantum measurements” group of Prof. Kolachevsky has been launched in 2014 and is one of the youngest group at the Center. The group has a status of “joint RQC-LPI group” and mainly resides at P.N. Lebedev Physical Institute (LPI). The major achievements of the group include the first demonstration of laser cooling of atomic Thulium which is a strong competitor to current the state-of-the-art Sr optical clock and new improved values for the Rydberg constant and the proton charge radius. Finally, the group is competitive in more applied projects on development of ultra-stable lasers with excellent commercial potential.

Dr. Kurochkin who leads the “Quantum Communication” group and who became an independent group leader in 2015 belongs to the younger generation of RQC researchers. His group has attracted very large external funding and has demonstrated the first Quantum Key Distribution outside the research laboratory in Russia. A startup company Qrate has been established to commercialize those results.

Prof. Alex Lvovsky leads the “Quantum Optics” group. The highlights of the research published in the highest-impact international journals include demonstration of quantum teleportation between discrete and continuous optical quantum variables, recovering entanglement of photonic variables degraded by transmission losses, and development, in collaboration with Yu.Kurochkin and A. Fedorov, of a quantum block-chain protocol.

The research of the “Strongly correlated quantum systems” group lead by Prof. Alexey Rubtsov is broad and spans different areas of theoretical condensed matter physics. The group is very active with the highlights which include achievements in some of the most interesting areas in the field, such as plasmons in Mott materials, impurities in Bose-Einstein condensates, and studies of criticality of open quantum systems,

Prof. Shlyapnikov, one of the international leaders in quantum physics of cold atoms, is the head of the “Many body theory” group. The group is very visible and active, with a very large number of invited talks at international conferences and schools. Selected highlights during the reporting period include the theory for superfluids of microwave-dressed polar molecules in two-dimensional optical lattices, the feasibility of a quantum computer logical gate of two atoms in a trap, proposal for creation of stable supersolids, and the discovery of surprising novel phases in one-dimensional quantum gases.

Prof. Ustinov is the leader of the “Superconducting quantum circuits” group which studies superconducting circuits for quantum information. His research is well known including both circuit fabrication and implementation of dilution refrigeration experiments. His RQC group has realized the first quantum computer circuits in Russia. Among the major group achievements are frequency-division multiplexing readout which has been adopted worldwide in the field and demonstration of a qubit metamaterial.

Prof. Zheltikov’s and his “Advanced photonics” group focus on ultra-fast physics. Within RQC laboratories they have realized a unique Mid-Infrared laser, which has been used by this team and collaborators for a number of ground-breaking experiments. Other major contributions include ultrafast remote sensing of atmosphere, and quantum sensing with diamond nanocrystals within a new field of neurophotonics. Prof. Zheltikov also made major contributions to the RQC community by serving as the Scientific Director during its formative stages.

Fund raising, international visibility and collaborations

The extremely successful build-up stage and operation of RQC has been made possible by the ability of its administration and researchers to attract large amounts of external funding. In total 2 billion rubles (35 million USD) have been obtained on competitive basis from the government and from one of the country's largest bank - Gazprombank.

The Center has become very visible at the international stage not only through its high level research but also through organization of top level international meetings. Four international conferences with the participation of Nobel Prize laureates have been held since 2012. Lectures and seminars by the world leading scientists in the field of quantum physics have been held on a regular basis. Four summer and spring schools for young scientists, 5 special lecture courses, and a student laboratory course have been organized. RQC is also active in popularization of science and technology with more than 150 public lectures held and 6 popular science books published.

RQC is involved in active cooperation with leading scientific institutes and researchers from ~40 countries around the world, such as MIT (USA), Max Planck Institute for Quantum Optics (Germany), University of Calgary (Canada), Harvard (USA), EPFL (Switzerland), Mediterranean Institute of Fundamental Physics (Italy), University of Amsterdam (Netherlands), Texas A&M University (USA), University of Bath (UK), etc.

The center has been very active in public relations and outreach: more than 2500 materials in the largest Russian and foreign outlets, including articles in Wired, Business Insider, Popular Science, Forbes, etc., TV broadcasts (Channel 1, Russia, RBC TV, Russia Today, Rain, NTV ...) and radio broadcasts (Vesti FM, Ekho Moskv, Silver Rain, Business FM, Kommersant FM ...). The efforts of Anna Shangina, the RQC head of public relations deserve special recognition.



Highlights of present and near future high-level projects at RQC:

- A project towards development of a Russian quantum computer has been initiated
- A strategic partnership agreement with Pricewaterhouse Coopers in the field of quantum communications was signed
- A large-scale project to create an industrial device for quantum cryptography (successful testing with Gazprombank and Sberbank)
- In 2016, the center became the first in Russia to launch a quantum-secure connection using commercial fiber networks. In May 2017, RQC developed the country's first multi-node quantum network and the world's first quantum block-chain.
- By September 2018, it is planned to move to the Skoltech building with a total RQC's area there of 3400 square meters.

In conclusion, within five years since the start of its full-scale operation, RQC has become the leading Center in Quantum Technologies in Russia, with high international visibility. The Center has been very successful in attracting external funding on competitive basis, such as key funding from one of the largest banks in Russia - Gasprombank. A crucial role in all those achievements has been played by the RQC CEO Dr. Ruslan Yunusov. The present Scientific Director Prof. Michael Gorodetsky has provided excellent research guidance.

All research teams at RQC are operating at a high international level, with some being among world leaders in their respective fields. A healthy combination of fundamental research and commercial efforts deserves special recognition. The Center leadership has been extremely proactive in positioning RQC at the Russian “quantum landscape” which definitely helped attracting external funding.

RQC is certainly the strongest single player in Russia in its field. It faces strong competition in quantum computing, communication and sensing from many Centers in the USA, the European Quantum Technologies Flagship and Chinese Quantum Technology programs. The International Evaluation Panel recommends that the support of the Center by the government and private foundations is further strengthened, in order to secure a suitable position of the Russian Federation within the highly internationally competitive field of Quantum Technologies.

Prof. Ignacio Cirac | Prof. Michael Lukin | Prof. Eugene Polzik | Prof. Kerry Vahala