UNIVERSITY of OTAGO

Te Whare Wananga o Otago

NEW ZEALAND

Российская Академия Наук

Cooperation Agreement and Memorandum of Understanding

Between

The Dodd-Walls Centre for Photonic and Quantum Technologies
And
Three Institutes of the Russian Academy of Sciences

Parties

UNIVERSITY OF OTAGO, a body corporate established under the University of Otago Ordinance 1869, the University of Otago Amendment Act 1961 and the Education Act 1989 of Dunedin, New Zealand, on behalf of the **Dodd-Walls Centre for Photonic and Quantum Technologies** ("Otago")

and the

following Institutes of Russian Academy of Sciences

- **Institute of Applied Physics** (IAP RAS), Nizhny Novgorod, Russia
- **Institute of Spectroscopy** (ISAN), Troitsk, Moscow, Russia
- **Institute of Laser Physics** (ILP SB RAS), Novosibirsk, Russia

Introduction

A. Otago is host to the Tertiary Education Commission ("TEC") funded Centre of Research Excellence ("CoRE") known as the Dodd-Walls Centre for Photonic and Quantum Technologies ("DWC").

B. The Institutes of the Russian Academy of Sciences ("RAS") are devoted to basic research in both, fundamental and applied aspects.

C. This cooperation agreement and memorandum of understanding (CAMOU) records the intention of the Parties to engage in collaboration between the DWC, IAP RAS, ISAN, and ILP SB RAS on projects of mutual interest ("Collaboration").

D. This Memorandum sets out the understanding between the Parties in relation to such Collaboration.

The Parties agree the following in relation to the Collaboration:

1. **The Collaboration:**
    1.1. The Parties will explore opportunities to collaborate on research projects of mutual interest and undertake to facilitate active research collaborations between staff of their respective organisations.
    1.2. The Parties will encourage visits between their respective institutions and provide local support to enable visits as appropriate, subject to resource availability and the discretion of the local host organization.
    1.3. Individual collaborative agreements between different institutions of the RAS and the DWC are listed in Appendix A.

2. **Arrangements and Funding**
    2.1. To implement the collaborative activities envisaged under this CAMOU, representatives of the Parties may meet periodically to negotiate and conclude specific project agreements and programmes of cooperation, including the scope and objectives of the projects/ programmes and the terms for their financing, with each other and with other parties provided that neither Party shall have the power to bind the other Party without the other Party's consent in writing and such arrangements shall not be legally binding until a valid and enforceable project agreement has been executed by the Parties and other parties (as the case may be) on terms agreed by the Parties and other parties (as the case may be).
    2.2. The financial arrangements relating to each collaborative activity will be in accordance with the specific project agreement and programme of cooperation covering each collaborative activity. The Parties agree that in the absence of any specific agreement to the contrary, all expenses, including but not limited to, salary, travel, living and allied costs relating to each collaborative activity shall be borne by the Party who incurs such expenses.

3. **Intellectual Property, Inventions, Innovations and Specimens**
    3.1. The terms with respect to ownership, title to, protection and exploitation of intellectual property, inventions and innovations (including but not limited to trademarks and service marks, copyright, patents, know-how, designs and confidential information on the subject of such intellectual property, inventions and innovations) will be negotiated on a project- by-project basis in the specific project agreements and programmes of cooperation referred to in Clause 5. Save as aforesaid, nothing in this CAMOU shall be construed as a license or transfer or an obligation to enter into any further agreement with respect to any intellectual property currently licensed to or belonging to either Party.
    3.2. All intellectual property held by a Party prior to entering into this CAMOU or disclosed or introduced in connection with this MOU and all materials in which such intellectual property is held, disclosed or introduced shall remain the property of the Party introducing or disclosing it.

4. Publication of Articles

4.1. Each Party may, with the written consent of the other Party, such consent not to be unreasonably withheld, publish the findings of the collaborative activities of the Parties in the form of an article in a journal, newspaper or other magazine.

5. Representation to the Public and Confidentiality

5.1. Neither Party shall use the name or logo of the other Party for any purpose whether in relation to any advertisement or other form of publicity without obtaining the prior written consent of the other Party.

5.2. Notwithstanding the generality of the above, the Parties may notify third parties of the fact that this CAMOU is in effect.

5.3. All information furnished in relation to this CAMOU by one Party to the other, which is clearly identified as "Proprietary" or "Confidential" at the time of disclosure **("Confidential Information"),** will be kept confidential by the receiving Party, and will not be disclosed to any third party otherwise than to carry out the provisions of this CAMOU, unless agreed in writing between the Parties. Information disclosed orally or visually and identified at the time of disclosure as "Confidential" shall be considered Confidential Information if it has been confirmed in writing as "Confidential" or "Proprietary", within thirty (30) days after its disclosure.

5.4. The provisions of Clause 5.3 above will not apply to information in the public domain; information in the possession of the receiving Party prior to the disclosure of the information; information which is developed by the receiving Party independently of Confidential Information; information required to be released by law; and information which is rightfully received by the receiving Party from third parties without any breach of confidentiality obligations.

5.5. Clauses 5.1, 5.2 and 5.3 will survive the expiry or termination of this CAMOU for three (3) years from the date of expiry or termination of this CAMOU.

6. Amendments

6.1. This CAMOU may be amended and supplemented in writing at any time by the mutual consent of the Parties in writing.

7. Term of CAMOU

7.1. This CAMOU shall commence on the Effective Date and shall remain in force for a period of three (3) years, unless earlier terminated. Either Party may terminate this CAMOU by not less than three (3) months' prior written notice to the other Party of its desire to terminate. This CAMOU may be extended by the mutual agreement of both Parties in writing.

7.2. The termination of this CAMOU shall not affect the implementation of the projects or programmes established under it prior to such termination, nor affect the rights and obligations of the Parties which have accrued prior to such termination.

8. Dispute Resolution

8.1. Any disputes arising under or in connection with this CAMOU which cannot be resolved by amicable discussions between the Parties shall be referred to the appropriate authority of the respective Parties or their nominees for amicable resolution. Failing settlement by the authorised representatives of both Parties after thirty (30) days of referral, the Parties may agree to appoint an independent mediator.

9. Non-binding Nature of this MOU

9.1. Despite the statements and obligations expressed herein and save for Clause 5, this CAMOU is a non-binding expression of the current intentions of the Parties, and neither Party will incur nor be bound to any legal obligations or expense hereunder to the other Party until and unless definitive agreements relating to specific research collaborations have been negotiated, approved by the necessary management levels of each Party and executed and delivered by authorised representatives of both Parties.

10. Good Faith

10.1. The Parties agree that all negotiations to be conducted and the transactions to be eventually entered into are on an arms' length basis and each Party shall act in good faith and take reasonable care and diligence in relation to the other Party during and throughout all negotiations and transactions.

11. Assignment

11.1. This CAMOU shall not be assigned by either Party without the prior written consent of the other Party hereto.

12. Contact Details:

Otago:

Notices:	Director, Research & Enterprise University of Otago PO Box 56 Dunedin 9054 New Zealand research@otago.ac.nz
technical liaison:	Assoc. Prof. David Hutchinson, Dodd-Walls Centre Department of Physics University of Otago, POBox 56 Dunedin 9054 New Zealand David.hutchinson@otago.ac.nz

IAP RAS:

Notices:	Prof. Grigory G. Denisov Acting Director Institute of Applied Physics, Russian Academy of Sciences 46 UL'yanov Street 603950, Nizhny Novgorod, Russia dir@appl.sci-nnov.ru
technical liaison:	Prof. Efim Khazanov Institute of Applied Physics 46 UL'yanov Street 603950, Nizhny Novgorod, Russia khazanov@appl.sci-nnov.ru

ISAN:

Notices:	Prof. Victor N. Zadkov Director Institute of Spectroscopy, Russian Academy of Sciences 5 Fizicheskaya Street 108840, Troitsk, Moscow, Russia Zadkov@isan.troitsk.ru
technical liaison:	Prof. Leonid A. Surin Institute of Spectroscopy 5 Fizicheskaya Street 108840, Troitsk, Moscow, Russia surin@isan.troitsk.ru

ILP SB RAS:

Notices:	Prof. Alexey V. Taichenachev Director Institute of Laser Physics, SB Russian Academy of Sciences 13, Ac. Lavrentieva Ave. 620090, Novosibirsk, Russia taichenachev@laser.nsc.ru
technical liaison:	Prof. Sergey N. Bagayev Institute of Laser Physics 13, Ac. Lavrentieva Ave. 620090, Novosibirsk, Russia bagayev@laser.nsc.ru

Signing:

This CAMOU is deemed to be executed on the later of the four dates appearing below

Authorized signature of Otago.

Name: Prof Richard Blakie

Position: Deputy Vice Chancellor

Date: 25 October 2019

Signature:

Authorized signature of IAP RAS

Name: Prof Grigory G. Denisov

Position: Director

Date: 02 December 2019

Signature:

Authorized signature of ISAN (RAS)

Name: Prof Victor N. Zadkov

Position: Director

Date:

Signature:

9 December 2019

Authorized signature of ILP SB RAS

Name: Prof Alexey V. Taichenachev

Position: Director

Date: 10 December 2019

Signature:

Appendix A

This appendix describes the topical areas of scientific research in the optical sciences at the IAP-RAS, the ISAN, the ILP SB RAS, and the DWC, which are of joint interest to all partners and in which these partners would like to collaborate.

The Institute of Applied Physics of RAS at Nizhny Novgorod (IAP RAS)
Largely taken from: http://iapras.ru/english/scence_e.html

The IAP RAS was conceived and created as a multipurpose institution combining basic and applied research in the field of plasma physics, high-power electronics, physics of the atmosphere, hydro physics, and quantum electronics. Of particular relevance to this collaboration are IAP RAS scientific directions on 'Laser Physics and Nonlinear Optics' and 'Quantum Systems'.

IAP RAS possesses one of the largest Russia's parks of femtosecond laser facilities, including a petawatt laser complex based on parametric amplification in large-aperture nonlinear DKDP crystals, a terawatt Ti:sapphire system, subterawatt Ti-sapphire systems with high pulse repetition rate (1 kHz), and compact fiber-optic frequency-tuned femtosecond lasers.

In the last decade, femtosecond optics became one of the rapidly growing areas of laser physics. The minimum laser pulse duration has reached the limits of 1.5—2 optical cycles, and the power of commercially available femtosecond laser systems is now hundreds of terawatts. A number of unique laser systems at the petawatt power level have been constructed. Significant progress has been made in advancing the sources of high-intensity ultrashort laser pulses to the near and mid-infrared regions and in creating compact femtosecond lasers, including fiber-based lasers. IAP RAS is one of the leading academic institutes engaged in research in this area. A number of important theoretical and experimental results in femtosecond and attosecond optics have been obtained by the IAP RAS researchers.

The basic distinguishing feature of the IAP RAS approach to creating petawatt and multipetawatt femtosecond laser complexes is the use of optical parametric chirped pulse amplification (OPCPA) instead of conventional laser amplification. Parametric amplification is accomplished in nonlinear optical crystals. The laser system "PEARL", created at IAP RAS and based on this principle, is one of the most powerful laser systems in the world – the peak power of the generated pulses reaches 0.56 PW.

Many important laser applications concern not only high peak power but also high average power radiation. These lasers are used in many areas, such as medicine, precision material processing, ecological monitoring and production process control. The basic problems in the development of such lasers are related to destruction of their active elements due to high heat load and laser damage, as well as to deterioration of output beam qua lity caused by thermally induced phase distortions and depolarization. Special laser architecture with the use of methods of adaptive and nonlinear optics is developed for solution of these problems at IAP RAS. One of the most promising ways of creating high average and high peak power lasers is coherent combining of beams from multichannel laser systems.

Quantum physics, including the wave approach to matter description, has always been an inviting area of application for Nizhny Novgorod scientific school of nonlinear oscillations and waves. Quantum interference in atomic and/or photonic systems is essential e.g. in quantum computing, telecommunication, cryptography, ultra-precise measurements, development of the new-generation frequency standards. Currently, IAP implements an experimental program for the development of solid-state components of quantum data and telecommunication systems. It has been shown that the electro-magnetic induced transparency (EIT) effect can be amplified significantly by using a specially prepared ensemble of particles. A quantum memory based on the spectral array of ions of rare-earth metals, which are embedded in a non-organic crystal, has been developed.

Experiments with ultracold atomic Fermi gases influence various disciplines far beyond the limits of atomic physics, since in many cases, the same theoretical models are applicable to the Fermi gas and other Fermi systems: neutron stars and nuclei of heavy atoms; quark-gluon plasma, which existed during the Big Bang and is produced now in accelerators of elementary particles; helium-3 in liquid phases; future room-temperature superconductors, whose creation is one of the priorities in solid-state physics. At IAP ultracold gas is prepared in vacuum by the methods of laser trapping and cooling. The coldest temperature in Russia of about 10 nK has been achieved. For the first time in the world, the two-dimensional gas of fermion atoms has been prepared in the quantum degeneracy state at our institute.

The Institute of Spectroscopy of RAS at Troitsk, Moscow (ISAN)
Largely taken from: https://www.isan.troitsk.ru/en/

The Institute of Spectroscopy of the Russian Academy of Sciences is the successor of the Institute of Spectroscopy of USSR Academy of Sciences. The latter was the result of the reorganization of the Commission for Spectroscopy. This year ISAN celebrated its 50th anniversary at the occasion of which the European Physical Society (EPS) inaugurated ISAN as a "Historic Site of EPS" in June 2018. The plaque commemorating this inauguration reads: "This institute, thanks to the application of advanced optical and laser methods, including the spectroscopic ones, has become an internationally recognized landmark of Russian science for research across many fields of physics and astrophysics, chemistry, material sciences and life sciences. Glory and worldwide fame were brought to the institute by Sergey Mandelstam (theory of spectra of highly ionized atoms, analytical spectroscopy), Roman Personov (laser fluorescence line narrowing and hole burning in spectra of molecules), Vladimir Agranovich (theory of excitons, polaritons, and of resonant organic-inorganic nanostructures), and others. This is also the place where, in a creative environment, a team of talented young researchers inspired by Vladilen Letokhov made pioneering experiments on laser trapping and cooling of atoms, which paved the way to a whole bunch of new directions in physics, as well as on laser isotope separation using selected laser excitation of atoms and molecules, which finally led to the development of a new field of laser chemistry."

The principal scientific research directions of the Institute can be stated as follows:

1. Spectroscopy of atoms, ions, molecules, clusters, bulk and surface states of condensed media; development of new spectroscopy methods, nearfield optics, and nanooptics.
2. Laser spectroscopy with an emphasis on specific influence of light on substances and its applications: isotope separation, atom cooling, modification of molecule surrounding in matrices, and other applications in photochemistry, photobiology, analytical chemistry, etc.
3. Analytical spectroscopy and its applications to technology control, environmental monitoring, life-support systems, studies of natural and technological disasters, etc.
4. Development and design of unique spectral instrumentation, analytical devices, lasers, registration systems, measurement methods for principal directions of fundamental research work and its applications.
5. Top qualification training of researchers.

Spectroscopy is a dynamically developing science, in which new research areas are constantly emerging. Most of them are present at the Institute:

- optical near-field (evanescent field) spectroscopy;
- femtosecond spectroscopy;
- cavity quantum electrodynamics;
- new radiation sources with noise level below the quantum limit;
- single-atom and single-molecule spectroscopy;
- atom optics (laser control of atomic motion);
- near-field and far-field optical nanodiagnostics of advanced materials and nanostructures.

The Institute develops also new technologies:

- laser isotope separation;
- ultrasensitive methods of ultra-pure materials composition and environmental pollution control;
- super-dense plasma creation;
- deep cooling of atoms by laser radiation;
- new radiation sources;
- new communication systems;
- optical sensors and transmitters.

The Institute of Laser Physics of the Siberian Branch of RAS at Novosibirsk (ILP SB RAS)
Largely taken from: http://www.laser.nsc.ru

The Institute of Laser Physics, Siberian Branch of Russian Academy of Sciences (ILP SB RAS), has an excellent track record on ultra-stable lasers and high precision laser spectroscopy and became world known under the former director Venyamin P. Chebotayev.

ILP SB RAS has conducted, for many years now, investigations on femtosecond optical frequency synthesizers, which is unique in Russia. The Institute is one of leading organizations in the world on the development and creation of highly stable laser systems, in particular, femtosecond lasers. The femtosecond optical frequency synthesizer based on a Ti:Sa laser created at the Institute has an excellent reputation world-wide.

Optical fibre communication lines (OFCL) are widely used. One way for increasing the OFCL transmission capacity is the spectral separation of channels. However, as the number of channels increases and the distance between them decreases, the problem of tuning to a specific spectral channel becomes more complicated. For this task, a stable chain of optical frequencies is required. It is convenient to use the radiation from a stabilized femtosecond laser as such a frequency chain. It is based on the equidistant spectral components of radiation, a peculiar property of the femtosecond laser modes. It is sufficient to stabilize the inter mode interval and the absolute frequency of one component in order to stabilize the entire frequency chain. The prospects for using such femtosecond synthesizers for OFCL are confirmed by the fact that there are many publications on this theme. Papers on the creation of such synthesizers for OFCL on the basis of phase locked diode lasers, Cr:Forsterite, Cr^{4+}:YAG, and erbium fibre lasers have been published. A multichannel optical frequency generator for optical fiber communication on the basis of Yb lasers will be created and will cover the optical range from 0.8 – 2.0 µm.

Fundamental theoretical research is conducted also in the fields of laser cooling and trapping of atoms, nonlinear atomic laser spectroscopy. Most of the investigations are devoted to the polarization aspect of atom-field interactions. The results can be applied to quantum metrology (miniature atomic clocks and magnetometers, new-generation optical clocks and standards), and optical communications (slow and "fast" light).

The Dodd Walls Centre for Photonic and Quantum Technologies at New Zealand (DWC)
Largely taken from: https://www.otago.ac.nz/dodd-walls/

The Dodd-Walls Centre is a national Centre of Research Excellence (CoRE) involving six NZ universities, hosted by the University of Otago. It is named after two pioneers of quantum optics and atomic physics world-wide who are mainly responsible for the prominent standing of quantum optics, photonics and ultra-cold atom physics. John Newton (Jack) Dodd developed the concept of quantum beats in atomic fluorescence together with George Series. Daniel F. Walls, became prominent in quantum optics in his prediction, with Howard Carmichael, of the existence of photon antibunching in the spectrum of resonance fluorescence, and thus initiated the study of non-classical light as an experimentally realizable subject. Dan Walls, together with his friend and colleague Crispin W. Gardiner, brought quantum optics to the southern hemisphere. The Dodd-Walls-Centre research spans and integrates sensing and imaging techniques, spectroscopy, new and improved laser sources, ultracold atoms and atomtronics, quantum information and quantum theory.

Lasers are the power tools in the world of science. In this theme DWC uses their extraordinary light to see, hear, smell and feel far beyond the reach of our senses. When you fire a laser at an object there is a tremendous amount of information in the light that bounces back. The different colours, pulses and powers of laser light are used to learn about the structure and function of biological tissue and many other surfaces. Interpreting the way light interacts with matter has led to many unexpected and fruitful collaborations across New Zealand and overseas. We are developing sensors to sort sperm for the dairy industry, detect bacteria on carcasses, grade the quality of meat and locate blossoms on kiwifruit plants. We are working with engineers and medical researchers to develop a technique for detecting eye disease, a new method for measuring the intensity of skin burns and a force sensor for keyhole surgery. We are also working with geophysicists to measure vibrations deep beneath New Zealand's alpine fault. The sensing and imaging projects at DWC are underpinned by a strong focus on theory and numerical modelling.

DWC is developing new and improved lasers, fibre optic cables and other optical devices as tools to open up new frontiers for research and applications. These tools enhance the research and probe further into the quantum world. DWC is world-renowned for our expertise in fibre lasers, which are versatile, lightweight and cheap to produce. These fibre lasers are developed for use as cutters, sorters and sensors for a wide variety of industrial and science applications. Another route is research in nonlinear optics which is all about understanding what happens when light stops behaving by the normal rules. Researchers at DWC have devised a new way to transform a single colour of laser light into hundreds of different colours using tiny disks of crystal. The resulting new type of 'micro resonator optical frequency comb' could improve the energy efficiency of the internet, which currently sucks up vast amounts of energy to encode and transport data. They could also enable ultra-precise new methods of imaging and spectroscopy and could one day be used in portable devices to detect diseases, chemicals or explosives. The fundamental theories and numerical models developed at DWC are used by top research groups across the world and have led to advances in the development of optical frequency combs, cavity solitons and other nonlinear devices that could revolutionize the internet and many other fields.

The quantum realm is the wild west of modern science. Although we know some of the basic rules, the vast majority of quantum interactions remain uncharted. In this theme DWC explores cold atom physics, which is like a playground for quantum phenomena. By cooling atoms to just above absolute zero and precisely controlling their state, one has the ability to create and observe almost any quantum effect one can think of. DWC runs experiments and develops theory to investigate quantum phenomena such as quantum vortices, quantum turbulence, conditions before the Big Bang, and biological processes involved in photosynthesis. Furthermore, this new understanding is used to develop quantum technologies such as extremely precise gravitometers and clocks.