EMRP Call 2012 – Open Excellence, Industry and SI Broader Scope

Selected Research Topic number: **SRT-x07**
Version: 1.0

Title: Single-photon sources for quantum technologies

Abstract

Currently no true single-photon source exists that can emit photons on demand – such a source would enhance quantum communications and enable developments towards quantum computers. The aim of this JRP should be to develop deterministic, compact and efficient single-photon sources for the purposes of quantum optical technologies. Furthermore, such a deterministic single photon source with calculable and predictable optical power could be a new primary standard source for the whole quantum technology field.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on “Grand Challenges” related to Industry & Fundamental Metrology on pages 33 and 34.

Keywords

Single-photon source, quantum optical technologies, photon metrology, non-classical light, quantum metrology, quantum interferometry, absolute radiometry

Background to the Metrological Challenges

In recent years there has been a tremendous effort and progress achieved towards the realisation of high photon emission rates of single-photon emitters based on colour centres in diamond and organic molecules in planar structures. An ideal single-photon source can be described as: one photon is emitted on demand at a time chosen by the user with the emitted photons being indistinguishable from one another and having an adjustable repetition rate. Quantum information processing (QIP) applications such as quantum random number generation, quantum key distribution (QKD) and photon based quantum computation rely on close to perfect single-photon sources.

Several applications in the emerging field of quantum information science require optical sources with strong quantum correlations between single photons. This is particularly true for quantum cryptography, which exploits the fundamental principles of quantum mechanics to provide unconditional security for communication. It has also been shown that the availability of a single-photon source enables implementation of quantum computation using only linear optical elements and photodetectors. The generation of light with sub-Poissonian fluctuations in the photon number provides the possibility of overcoming classical noise limits of measurements. Such crossing of the classical limits would introduce a step change in several measurement methods for research and development. In contrast to multi-photon pulses unavoidably produced by a laser, true single-photon sources need to be developed, in which the photon number can be carefully controlled and single photons generated at predetermined times. Single-photon sources would greatly support the emergence of applications of quantum technology such as entanglement assisted measurement techniques, i.e. sub-shot noise metrology, microscopy and spectroscopy.

In addition, a predictable, deterministic source is the ideal reference for calibrating single photon counter devices and in future could be used as in-line calibration/diagnostic tool of photonic systems.

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EMRP
European Metrology Research Programme
Programme of EURAMET

The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

Scientific and Technological Objectives

Proposers should address the objectives stated below, which are based on the PRT submissions. Proposers may identify amendments to the objectives or choose to address a subset of them in order to maximise the overall impact, or address budgetary or scientific / technical constraints, but the reasons for this should be clearly stated in the JRP-Protocol.

The JRP shall focus on the development of compact and efficient single-photon sources and the implementation of such sources in quantum optics applications to demonstrate enhanced performance.

The specific objectives are:

1. Development of bright, compact and near-unity collection efficiency single-photon sources with a photon flux of up to 10^7 photon/s based on quantum dots, vacancies in nano-diamonds and photonic waveguide technologies
2. Development of an excitation scheme with adjustable frequency allowing for traceable photon flux measurements at high photon rate to be utilised in the calibration of very low photon rates
3. Characterisation of these single-photon sources by appropriate metrics in terms of wavelength, bandwidth, photon statistics, anti-bunching, and indistinguishability
4. Demonstration of the suitability of these sources for different entanglement enhanced measurements based on those metrics

Proposers shall give priority to work that enables new metrological methods and techniques in the future through excellent science. The project need not address metrology directly.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this, reference to the following EMRP JRPs may be appropriate:

- T1 J2.3 qu-Candela “Candela: Towards quantum-based photon standards”
- IND06 MIQC “Metrology for Industrial Quantum Communication Technologies”

The total eligible cost of any proposal received for this SRT is expected to around the 1.8 M€ guideline for proposals in this call. The available budget for integral Research Excellence Grants is 84 months of effort.

Potential Impact

The project should be designed to bring together the best scientists in Europe and beyond whilst exploiting the unique capabilities of the National Metrology Institutes and Designated Institutes. Significant non-NMI/DI and international participation in the projects is expected and proposers should make full use of the larger budget for Research Excellence Grants available for this SRT.

You should detail other impacts of your proposed JRP as detailed in the document “Guide 4: Writing a Joint Research Project”

You should also detail how your approach to realising the objectives will further the aim of the EMRP to develop a coherent approach at the European level in the field of metrology and includes the best available contributions from across the metrology community. Specifically the opportunities for:

- improvement of the efficiency of use of available resources to better meet metrological needs and to assure the traceability of national standards
- the metrology capacity of Member States and countries associated with the Seventh Framework Programme whose metrology programmes are at an early stage of development to be increased
- outside researchers & research organisations other than NMIs and DIs to be involved in the work

Time-scale

The project should be of up to 3 years duration.