EMRP Call 2011 - Health, SI Broader Scope & New Technologies

Selected Research Topic number: **SRT-s09**
Version: 1.0

Title: Traceability for single-photon sources

Abstract

The development of highly efficient quantum light sources at the single photon level and the development of entanglement assisted measurement techniques would enable classical measurement limits to be overcome. These new traceable photon sources will underpin the growth of several emerging technologies, such as optical devices for quantum communication, computing, microscopy, nanosciences, nanofabrication and other new production technologies, as well as fundamental metrology.

Conformity with the Work Programme

This Call for JRPs conforms to the EMRP Outline 2008, section on “Grand Challenges” related to Health, New Technologies & Fundamental Metrology on pages 9, 11, 28 and 34.

Keywords

Photometry, Radiometry, SI base unit, Candela, Photon Metrology, Single-photon sources, Entanglement

Background to the Metrological Challenges

A new primary single-photon source for the femtowatt to nanowatt range can be based on the simple relation $P=nhf$, where the power P is given by Planck’s constant h, the frequency f of the photon, and the number n of emitted photons per second. This requires high calculable efficiency and careful characterisation of the entire photon collection system. A photon counting rate up to 5×10^7 photons/s from a quantum light source has been demonstrated in special conditions, but the wavelength ranges available are still limited.

Quantum information processing, such as quantum random number generation, quantum key distribution (QKD) and photon based quantum computation require near-perfect single-photon sources, in order to meet advanced encryption demands of modern security: it is essential that the QKD protocol is significantly shortened and reliability increased to ensure data security

The availability of reliable single photon sources and entanglement assisted measurement techniques would support fields such as sub-shot noise metrology, microscopy and spectroscopy. The detection of small amplitude or phase signals is limited by the shot noise present in classical illumination sources. By reducing noise below the shot limit, the sensitivity of these measurements will be increased.

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 traceable measurement and characterisation of source-based standards for photon metrology spanning the range 1 photon/s to 10^8 photons/s.

The specific objectives are:

1. To develop absolute and calculable single photon sources with high dynamic range at both telecom and visible wavelengths.
2. To develop efficient single photon sources, to support for SI traceable photon radiometry.

EURAMET, EMRP-MSU
National Physical Laboratory
Hampton Road, Teddington,
Middlesex, TW11 0LW, UK

Phone: +44 20 8943 6666
emrpA169@npl.co.uk
www.euramet.org

EMRP
European Metrology Research Programme
Programme of EURAMET

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

3. To develop quantum optical state sources for entanglement enhanced measurements.

4. To develop optimised photon-coupling strategies and methods between source and detector.

The sources developed in objectives 1-3, should be characterised for photon flux, and by appropriate metrics in terms of statistics, anti-bunching, indistinguishability, degree of entanglement and sub-shot-noise as required by the application.

These objectives will require large-scale approaches that are beyond the capabilities of single National Metrology Institutes and Designated Institutes. To enhance the impact of the research work, the involvement of the larger community of metrology R&D resources outside Europe is recommended.

Proposers should establish the current state of the art in industrial single photon sources, and explain how their proposed project goes beyond this, and the current development in the following EMRP JRPs:

- 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 2.7 M€ guideline for proposals in this call.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the "end user" community. This may be through the inclusion of unfunded JRP partners or collaborators, or by including links to industrial/policy advisory committees, standards committees or other bodies. Evidence of support from the "end user" community (e.g. letters of support) is encouraged.

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

You should detail how your JRP results are going to:

- feed into the development of urgent documentary standards through appropriate standards bodies
- transfer knowledge to the quantum communication, quantum information technology, biotechnology and optical metrology sectors.

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. 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.