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

Selected Research Topic number: **SRT-x02**
Version: 1.0

Title: Solid-state single quantum particle metrology

Abstract

For many novel quantum technology applications it is essential that the quantum particle source is truly a single particle source (i.e. no two particles should be generated simultaneously). Correlation measurement systems based on the Hanbury-Brown and Twiss (HBT) interferometer can be used to validate such single-microwave-photon and single-electron sources.

Single quantum particle devices are being actively developed for quantum tomography, sub-Rayleigh-limited spectral and spatial microscopy and lithography, and secure wireless networks. The reliability of these technologies crucially depends on the 'quantumness' of single-particle sources. This SRT calls for the establishment of metrological procedures to validate single-particle sources for solid-state circuits.

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 9, 11 and 32.

Keywords

Quantum standards, quantum particle sources, qubits, interferometers, nano-electronics, security, solid-state, scalability, single-particle quantum metrology.

Background to the Metrological Challenges

Many future quantum technologies depend on accurate and precise control of quantum states. For this, one requires a "simple" quantum system, in which the quantum states can be fully controlled. One type of such a system is single-quantum-particle source, where only one quantum particle is emitted at a time. Single-particle-quantum metrology is an emerging field in metrology that would underpin many areas of quantum technologies when fully developed. Some areas are well underway (e.g. telecom-wavelength single-photon source for quantum communications, or single-electron pumps for quantum current standards). Among the possibilities identified so far, the areas of electronic and RF photonic single-quantum-particle metrology have the greatest potential of supporting a new field of metrology, with the possibility to develop new metrological tools that would underpin the new field of quantum electronics, these areas being simultaneously almost unexplored and having the necessary recent technological developments to make possible dramatic further progress. Quantum electronics is specifically concerned with on-chip sources that inject quantum particles into solid-state circuits. The vision is that these types of sources can be developed into scalable technologies in fields such as Quantum Information Processing and Communications (QIPC) and precision metrology. However, there is a lack of metrological tools to evaluate their quantumness ie to evaluate the error rate of multiple-particle emission.

Recent advances in nano-electronics has led to the development of quantised charge pumps. These devices have been shown to on average pump a single electron per excitation cycle. Validation of the deterministic character of these devices is necessary for QIP applications and would in addition facilitate the development of a deterministic quantum current standard.

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

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 aim of this JRP is to establish metrological procedures to validate single-particle sources for solid-state circuits focused on single electron sources.

The specific objectives are to:

1. Develop hardware for the characterisation of on-chip single-quantum-particle sources.
2. Perform interference measurements and collect statistical data on single-quantum-particle beams in solid-state circuits.
3. Develop a methodology for quantifying and validating single-quantum-particle sources from statistical data.

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 may be made to previous projects including the EMRP JRP IND16 – Ultrafast.

The total eligible cost of any proposal received for this SRT is expected to be 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.