

## **Title: Optical standards for the traceable characterisation of dynamic pressure fields**

### **Abstract**

Primary standards for acoustic device calibration derive their traceability through a complicated web of electrical measurements, dimensional measurements and models of the thermodynamic properties of air (or water) based on measurements of temperature, humidity and static pressure. The methods can only be applied to specific standardised devices and have insufficient uncertainty for current and future measurement requirements. At dynamic pressures of higher amplitude there are traceability requirements that cannot be provided by existing standards. This JRP should aim to establish primary standards for sound based on optical methods, removing the reliance on commercially available artefacts.

### **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 37 and 38.

### **Keywords**

Optical interferometry, photon spectroscopy, acousto-optic tomography, Rayleigh scattering, fluorescence spectroscopy, acoustical metrology, dynamic, microphone, MEMS, hydrophone, acoustic pascal

### **Background to the Metrological Challenges**

Current primary standards for the calibration of microphones and hydrophones apply to a limited range of measurement devices of specific dimensions. These devices are expensive and designed to be calibrated rather than used. There are significant further uncertainties introduced in the transfer of the calibration from the laboratory standard devices to the working standards. This is a significant barrier preventing the development of new technologies in acoustical measurements which could meet industrial and societal needs at reduced cost. From a metrological perspective, there is a need to realise and apply the pascal such that the responses of the devices are expressed directly as functions of applied pressure.

In airborne acoustics, microphones are used extensively for measurement as well as for realising the primary standard via reciprocity calibration. This process relies on the continued availability of so-called laboratory standard microphones that are produced commercially by just two manufacturers worldwide. Working standard microphones are then used in everyday measurement applications, but again to facilitate calibration, their pattern is regulated through standards, creating difficulties in calibrating and using microphones of non-standard patterns. Such constraints can be seen as a barrier to the take up of new technology such as MEMS microphones, and restricts the range of applications utilising acoustic measurement.

In the area of underwater acoustics, the current primary standard is also based on reciprocity; however, the difficulties and uncertainties associated with the technique at high frequencies limit the accuracy and usefulness, and provide insufficient headroom in uncertainty between primary standards and the dissemination chain.

In ultrasonics, primary standards are already realised through optical methods; however, the method is limited by the sources of error and uncertainty at high frequencies that need to be addressed. Within the ultrasound area, increasingly, there is a demand from the user community for calibrations at elevated frequencies, well above the 15 MHz which is the upper limit of the relevant CCAUV key comparison.

New primary standards that realise the acoustic pascal directly and in an absolute manner are required – these standards should be applicable to all acoustic devices regardless of their dimensions and should not rely on the existence, long-term availability and performance of reference artefacts. In addition, these standards should also provide fit-for-purpose uncertainties and be applicable in all areas of acoustical metrology. Optical standards based on homodyne and heterodyne interferometry, as well as photon correlation spectroscopy, have demonstrated the potential of such realisation with traceability through the wavelength of the light source used.

## 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 of acoustic pressure by optical methods.

The specific objectives are

1. To review optical methods of measuring the pascal suitable for the acoustic range, and beyond, and propose practical implementations of these methods for use in both air and water.
2. To implement an optical method of measuring the acoustic pascal in air, in a free-field environment, that would allow a non-standard microphone to be calibrated with the same uncertainty that can be achieved with the traditional method (e.g. as described in IEC 61094-8) applied to a Working Standard Microphone.
3. To implement an optical method of measuring the acoustic pascal in water, in a free-field environment, that would allow a non-standard hydrophone to be calibrated with the same uncertainty that can be achieved with the equivalent traditional method.

The methods developed should cover at least the full frequency range covered by the existing equivalent methods.

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. A strong industry involvement is expected in order to align the project with their needs and guarantee an efficient knowledge transfer into industry.

Proposers should establish the current state of the art, and explain how their proposed project goes beyond this. Any synergy with the existing project IND09 “Traceable Dynamic Measurement of Mechanical Quantities” should be documented.

The total eligible cost of any proposal received for this SRT is expected to be around the 2.7 M€ guideline for proposals in this call. The available budget for integral Research Excellence Grants is 42 months of effort.

## 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 (eg letters of support) is encouraged.

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 electroacoustics sector.

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.