Potential European Partnership on Metrology
Call 2021 – Green Deal and Normative

Selected Research Topic number: **SRT-n02**
Version: 1.1

Important information about these documents

This call is being held ahead of any agreement from the Commission that the relevant funding will be available. At present the relevant legislation is still under discussion in both Council and Parliament, and there is no certainty on the detailed arrangements for funding selected projects. The funding of any selected project, and the terms and conditions of participation in the projects, are dependent on completion of the legislative process and the subsequent contractual processes between the European Commission and EURAMET. Proposers submit to this call at their own risk.

Background

Last year, EURAMET submitted a draft proposal to the EC for a further research programme to be established under article 185 of the Treaty on the Functioning of the European Union (TFEU) to follow on from EMRP and EMPIR. This was published by the EC at https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/european-partnerships-horizon-europe/candidates-digital-industry-and-space_en

The initiative would be called the European Partnership on Metrology and would aim to create, by 2030, a sustainable and effective system for metrology at European level that ensures Europe has a world-class metrology system that:

- Provides metrology solutions, fundamental metrological reference data and methods, offering fit-for-purpose solutions supporting and stimulating European innovation and responding to societal challenges.
- Supports and enables effective design and implementation of regulation and standards that underpin public policies that address societal challenges.

The Commission commissioned an impact assessment into this proposal and 11 others in similar priority areas, and, based on those findings, published their own proposal for the Partnership, their response to the impact assessment and a draft of the Decision on 23rd February 2021. See:

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:89:FIN

https://ec.europa.eu/commission/presscorner/detail/en/ip_21_702

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021SC0035&qid=1614677899327

That draft Decision is currently under discussion in the European Council and the European Parliament.

Under the assumption that the Council and Parliament pass the basic act which would form the legal basis for this research programme, and that the participating countries named in the Draft Decision submit the required commitment letters, EURAMET is publishing these potential Selected Research Topics and draft guidance notes. These documents are not approved by the Commission nor will they lead to a binding decision by EURAMET e.V. for any further negotiation or funding. All published guides and templates are subject to amendment by the EC and EURAMET e.V. as further information becomes known.

EURAMET MSU,
Phone: +44 20 8943 6666 Email: EMPIR.msu@euramet.org
msu.euramet.org

Title: Support for the standardisation of nanoscale magnetic field measurements

Abstract

Europe's high-technology industries require nanoscale traceable magnetic fields measurements. The rapid development of increasingly miniaturised magnetic devices and the application of nanostructured materials needs to be accompanied by basic and applied research, that critically depends on the further refinement of traceable characterisation methods. Subsequently, IEC TC 113 has developed a technical specification, TS 62607-9-1, which is the first international standard in the field of quantitative magnetic force microscopy (qMFM). However, it is based only on qMFM under ambient conditions with a spatial resolution down to 50 nm. This standard needs to be extended further to take into account advanced traceable high-resolution qMFM, in vacuum, with improved sensitivity. In addition, end users require clear guidance on the application of the technical specification to their specific measurement along with validated data sets and worked examples for qMFM measurements.

Keywords

Nanoscale magnetic field measurements, quantitative magnetic force microscopy, nanomagnetic materials, reference materials, validated data sets

Background to the Metrological Challenges

IEC's work programme for TC 113 includes the further development of TS 62607-9 series on spatially resolved magnetic field measurements, in liaison with European and International Standards Developing Organisations (SDOs). Reliable measurements of industrially relevant magnetic material parameters need to be traceable to the SI, via measurements of the stray fields of their magnetization distribution in units of A/m for magnetic field or in unit T for magnetic flux density. Subsequently, a letter written by the IEC TC 113 Secretary specifies the need for the advancement of the qMFM standard in accordance with industrial needs.

European high-tech industries (such as ICT and magnetic sensors manufacturers) and biomedical applications require reliable magnetic measurements on the nanometre scale. Given that the absolute stray field of magnetic nanostructures scales with their size, a higher field and spatial resolution is necessary to underpin reliable R&D and production control for present and future downscaled nanomagnetic materials and devices. The existing qMFM standard with a spatial resolution down to about 50 nm and 1 mT reaches its limits for advanced materials (such as magnetic nanoparticles, skyrmions, or domain wall devices with characteristic length scales in the nanometre range). Due to the fast decay of nanoscale magnetic stray fields, the dominant factor limiting spatial resolution is the field sensitivity. In vacuum, magnetic force microscopy (MFM) measurements, with its higher quality factor of the cantilever oscillation can enhance the sensitivity by orders of magnitude. However, a standardised procedure for reliable vacuum based qMFM addressing its specific parameters is not yet available.

The present IEC TS 62607-9-1 on qMFM measurements was developed within the EMPIR JRP 15SIB06 NanoMag which enabled reliable quantitative magnetic field measurements down to the 50 nm scale, based on qMFM under ambient conditions. In contrast, vacuum based non-contact qMFM allowing higher spatial resolution down to 10 nm and order of magnitude higher field resolution below 100 µT is not yet covered by the standard. Since industrial measurands are often secondary parameters, end-users need clear strategies and guidelines on the application of technical specifications (TS) to their specific measurements. Also, validated data sets and worked examples should be provided to enable a broad use of the standard and to relate the highly spatially resolved traceable magnetic field measurements that are relevant for material parameters (such as grain size, pole width of magnetic scales, domains size of magnetic sheets, or the magnetic moment distribution of magnetic nanoparticles for biomedical applications). This need should be addressed by providing worked examples and validated data sets of advanced reference samples, as required by industry to bridge the gap between the standard and its practical use in R&D and production

IEC TS 62607-9-1 covers the mathematical and physical backgrounds of qMFM measurements of nanoscale stray field distributions and defines a calibration and analysis procedure. Co/Pt multilayer films with stripe domain patterns have been established as refence materials for qMFM measurements however, other possible reference materials with specific applications and guidelines for their fabrications are not yet available. Moreover, the practical connection between the measured magnetic field distribution and industrially relevant measurands has not yet been established. As such, worked examples for typical measurement problems would reduce the complex and comprehensive approach described in the TS to make it more accessible for

industrial end users. A wider uptake of the novel TS 62607-9 series could be supported by developing relevant procedures and reference materials that can be introduced into the industrial quality management chain.

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 protocol.

The JRP shall focus on metrology research necessary to support standardisation in quantitative magnetic force microscopy (qMFM) to enable harmonised and reliable magnetic field measurements on the nanometre scale, with improved sensitivity and higher spatial resolution, suitable for high-tech industries and biomedical applications.

The specific objectives are

1. To develop and validate tools, methods, algorithms, reference materials, and measurement procedures for advanced qMFM measurement techniques, in vacuum conditions, with a target of sub 10 nm spatial and sub 100 µT field resolution. Detailed guidelines on the validated and traceable in-vacuum qMFM measurements should be produced.
2. To develop reference materials for advanced qMFM measurements and validate their properties (e.g. grain size, pole width of magnetic scales, domains size of magnetic sheets) by magnetic field measurements and micromagnetic simulations. In addition, to produce validated data sets for the reference materials, including written guidelines on the fabrication of the reference materials that can be introduced into the industrial quality management chain.
3. To provide documented worked examples of advanced qMFM measurements, both in ambient and vacuum conditions, using relevant materials and devices (e.g. magnetic nanoparticles, skyrmions, or domain wall devices with characteristic length scales in the nanometre range).
4. To contribute to a revision of IEC TS 62607-9-1 by providing the data, methods, guidelines and recommendations, which are necessary for the standardisation of nanoscale magnetic field measurements, to IEC TC 113. Outputs should be in a form that can be incorporated into suitable existing and future standards at the earliest opportunity and communicated through a variety of media to the standards community (e.g. IEC and ISO) and end users (e.g. manufacturers of ICT devices and magnetic sensors) to underpin the industrial use of TS 62607-9-1.

The proposed research shall be justified by clear reference to the measurement needs within strategic documents published by the relevant Regulatory body or Standards Developing Organisation or by a letter signed by the convenor of the respective TC/WG. EURAMET encourages proposals that include representatives from industry, regulators and standardisation bodies actively participating in the projects. The proposal must name a “Chief Stakeholder”, not a member of the consortium, but a representative of the user community that will benefit from the proposed work. The “Chief Stakeholder” should write a letter of support explaining how their organisation will make use of the outcomes from the research, be consulted regularly by the consortium during the project to ensure that the planned outcomes are still relevant, and be prepared to report to EURAMET on the benefits they have gained from the project.

Proposers should establish the current state of the art, and explain how their proposed research goes beyond this. In particular, proposers should outline the achievements of the EMPIR project 15SIB06 NanoMag and how their proposal will build on those.

EURAMET expects the average EU Contribution for the selected JRPs in this TP to be 0.8 M€, and has defined an upper limit of 1.0 M€ for this project.

EURAMET also expects the EU Contribution to the external funded partners to not exceed 30 % of the total EU Contribution across all selected projects in this TP.

Any industrial partners that will receive significant benefit from the results of the proposed project are expected to be unfunded partners.

Potential Impact

Proposals must demonstrate adequate and appropriate participation/links to the “end user” community, describing how the project partners will engage with relevant communities during the project to facilitate

knowledge transfer and accelerate the uptake of project outputs. Evidence of support from the “end user” community (e.g. letters of support) is also encouraged.

You should detail how your JRP results are going to:

- Address the SRT objectives and deliver solutions to the documented needs,
- Feed into the development of urgent documentary standards through appropriate standards bodies,
- Transfer knowledge to the high-technology and medical sectors.

You should detail other impacts of your proposed JRP as specified in the document “Guide 4: Writing Joint Research Projects (JRPs)”

You should also detail how your approach to realising the objectives will further the aim of the potential European Partnership on Metrology to develop a coherent approach at the European level in the field of metrology and include 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 EURAMET Member States whose metrology programmes are at an early stage of development to be increased
- organisations other than NMIs and DIs to be involved in the work.

Time-scale

The project should be of up to 3 years duration.