Using Low-cost Magnetometers to Predict Atomic-scale Imaging Distortions

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Funding information:
IRC applicant encouraged, but full funding (EU fees + stipend) available for exceptional candidates.

Background
The scanning transmission electron microscope (STEM) is one of the most sensitive imaging instruments in use in materials research. It can yield magnifications of 40 million times or more and directly image individual atoms within a specimen. In the STEM, images are acquired pixel-by-pixel in a scanned manner with the frame building up over typically a few seconds. This means that, unless the microscope laboratory is perfectly shielded from magnetic interference, the recorded images can contain small distortions from stray fields. The sensitivity of the instrument to image distortion is estimated to be ≈0.5Å/mG [1]. The STEM is not affected by the static magnetic field of the Earth, ≈491mG in Ireland, but rather any time-varying fluctuations (such as from passing cars/trains).

Innovation
In this project we aim to build a low-cost DIY magnetic monitoring device using one or more low-cost PNI-RM3100 three-axis magnetic sensors [2,3]. We will 3D-print the remaining components in the group’s lab. The student will be trained to operate the transmission electron microscopes (TEM) in the Advanced Microscopy Laboratory (AML), and will then record atomic-resolution image series from along with synchronised readings of the magnetic field. Electron beam placement-errors will be evaluated from atomic-resolution image series [4]. Machine learning will be used to identify correlations between the image-distortions and the strength of varying magnetic fluctuations, before mitigation strategies are proposed.

Collaboration
Depending on the success of the project, there is the possibility to collaborate with one of our existing industrial partners. In this case travel to the collaborator within the EU would be likely.

Objectives and methodology
By the end of the project, the student will have:
• evaluated the feasibility of using low-cost sensors for indoor magnetic monitoring,
• learnt to independently operate the transmission electron microscopes (TEM),
• evaluated the correlation between detected fields and observed distortions in atomic resolution images, and
• developed a predictive model and proposals for environmental mitigation.

Essential/Desired abilities
A first class or upper-second degree at either Masters or Honours Bachelors is required in the areas of Physics, Electronics, Electronic Engineering or related subjects. The ideal student will have an interest in instrumentation design and manufacture. Experience with electronics, Raspberry Pi (or similar), or 3D printing would be a bonus but not essential.
Reference