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Master student traineeship proposal

Title: *Magnetic-Field Control of Keyhole Dynamics and Porosity Formation in Laser Processing of Nickel-based Superalloy*

Abstract:

Laser-based processing of nickel superalloys often suffers from keyhole-induced porosity, which limits component performance. Recent high-speed X-ray imaging experiments on ID19 have revealed that externally applied magnetic fields can modify melt-pool convection, stabilise the keyhole, and alter bubble trajectories, resulting in measurable reductions in defect size and porosity fraction in Inconel 718. This project will focus on quantitative analysis of the already acquired 50 kfps datasets: extracting keyhole geometry and oscillation behaviour, tracking bubble evolution using advanced image-processing and machine-learning tools, and correlating magnetic-field strength, frequency and orientation with changes in melt-pool dynamics. A comparison between LPBF and forged IN718 will help identify microstructure-dependent mechanisms. The traineeship provides strong training in synchrotron imaging data analysis, melt-pool physics and Python-based workflows. Although no additional beamtime is required, the student will gain valuable exposure to ID19's experimental environment, data-acquisition procedures and analysis pipeline.

References:

[1] L. Li, C. Huang, G. Han, and R. Chen, "Recent progress on external magnetic field assisted laser welding: mechanism, effect and technology," Int. J. Adv. Manuf. Technol., vol. 125, no. 1–2, pp. 1–23, 2023.

[2] Fan, Xianqiang, Tristan G. Fleming, Samuel J. Clark, Kamel Fezzaa, Anna CM Getley, Sebastian Marussi, Hongze Wang, Chu Lun Alex Leung, Andrew Kao, and Peter D. Lee. "Magnetic modulation of keyhole instability during laser welding and additive manufacturing." Science 387, no. 6736 (2025): 864-869.

Scientist in charge: Alexander Rack

Beamline(s)/Host Group: ID19 – Structure of Materials Group Traineeship

Supervisor(s): **Tinglian Zhang**

Access to Instruments/labs/computing/software: ***Python/Fiji/Tomwer***

Starting date and Duration: March/April 2026

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