Imperial College London

MAGPIE Pulsed Power Generator

Developing a longitudinal Zeeman splitting diagnostic to measure magnetic fields in high-energy-density plasmas @ MAGPIE Pulsed Power Laboratory, Imperial College London

Project type: **Experimental (lab based)**	Open to: **Undergraduates (years 2 & 3 preferred*)**
Location: **Blackett Laboratory, Imperial College London, SW7 2BW**	
Duration: **8-10 weeks** **(June-Sept period, dates flexible)**	Bursary: **£400/week**
Application deadline: **Mon 24th Feb, 5pm**	Contact: **Dr Lee Suttle** (ls910@ic.ac.uk)

*Students must be enrolled in a degree program at the time of the placement (i.e. graduating 2026 or later). 4th year students accepted for 5-year degree programs.

Project description

Advances in the capabilities of high powered laser sources and pulsed power generators allow the exploration of matter and radiation under extreme conditions. This has led to a new and exciting field of research: High Energy Density Physics (HEDP), where physicists are able to produce highly-ionized plasmas at energy densities in excess of 100 KJ/cm^3 and study their interactions, often in the presence of strong electromagnetic fields and intense Xray-radiation.

At the MAGPIE generator at Imperial College London, we employ high-voltage electrical discharges to produce supersonic flows of ablated plasma to study fundamental processes in the HEDP regime. Our house sized generator, located in the basement of the Blackett Laboratory, delivers a pulsed electrical current of 1.4 MA in a timescale of 250 ns. Plasma flows launched from this driver form centimeter scale structures, with velocities of ~100 km/s and often in the presence of strong magnetic fields (~1-10 T). Control of the material and geometry of these plasma flows allows us to study processes such as magnetohydrodynamic shocks, instabilities and magnetic reconnection, as well as creating intense X-ray sources (X-pinches and Z-pinches), and supporting research in applications such as inertial confinement fusion and laboratory astrophysics.

For summer 2025, we are looking for undergraduate students to contribute to the development of a new tool for making spatially resolved measurements of the magnetic fields present in HEDP plasma experiments. This diagnostic will make use of the longitudinal Zeeman effect, where plasma line emission undergoes a binary spectral-splitting in the direction of observation parallel to the magnetic field. For the field strengths we typically encounter, this splitting is difficult to resolve on a standard spectrometer. However, we can make use of the left- and right-handed circular polarization introduced by longitudinal splitting to separate the light onto individual channels, which can be directly compared to infer the field strength. Additionally, due to the significant plasma flow velocities present, the measurements must account for and distinguish between the often competing effects of Zeeman splitting and Doppler shifts on the spectra.

The project will entail the design, fielding and testing of the apparatus on numerous plasma experiments. In doing so you will be working as member of the MAGPIE laboratory team, gaining experience in many ongoing research projects as well as the day-to-day running of this large scale university facility. The studentship may therefore also include the maintenance and development of technical infrastructure and methods related to the operation of the pulsed-power machinery. Prior experience in plasma physics is not necessary, but applicants should demonstrate experimental & technical qualities, excel in a team environment, and show proficiency in undergraduate level laboratory and data analysis techniques. To apply please send your CV and an accompanying cover letter.

Further reading

https://www.imperial.ac.uk/plasma-physics/magpie/
[1] http://sun.stanford.edu/~sasha/PHYS780/SOLAR_PHYSICS/L5/Lecture_05_PHYS780.pdf
[2] L.G. Suttle *et al.*, Plasma Physics and Controlled Fusion (2020)
[3] S.V. Lebedev, A. Frank and D.D. Ryutov, Reviews of Modern Physics (2019)
[4] L.G. Suttle *et al.*, Review of Scientific Instruments (2021)