Modelling Inertial Confinement Fusion Schemes Using ZEPHYROS
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Fusion energy is the future of high-yield, clean, and self-sufficient renewable energy. Technologies are being developed to recreate the inside of our own sun and harness the energy to power mankind while upholding environmental sustainability. Fusion energy will become necessary in the near future to avert the climate crisis caused by other polluting forms of high-yield energy.

Currently, inertial fusion energy, a method of fusion energy that attempts to ignite a compressed fuel core using laser or electron beams, has yet to be produced in a way that can be considered high-gain. In order to reach high gain, i.e. large energy output, new inertial confinement schemes must be investigated. One such scheme, fast ignition which uses huge currents of electrons to heat matter compressed by lasers, is a potential candidate. A potential problem with this scheme is in the divergence of electrons which heat the compressed core. Methods are currently being developed to collimate these electrons and ensure that as many as possible hit their intended target on the fuel core to reduce energy consumption in ignition. The main way of testing these methods is through the program ZEPHYROS, a simulation code that enables plasma fusion physicists to investigate if a collimating method will be successful in a fast ignition sequence before expending the resources to test it experimentally.

By using ZEPHYROS and the resources available at the York Plasma Institute, the project aims to further the development of electron columnating methods through two phases:

Phase 1: The objective of this phase is to become familiar with ZEPHYROS, analyse its outputs using python, and identify a particular parameter of fast ignition electron beams that can be improved. New simulations will then be run while adjusting the identified parameter to develop an improved method of columnating electrons for future experiments.

Phase 2: The objective of this phase is to continue the work of investigating the parameter in phase one using ZEPHYROS and python. Once a new method has been fully developed with the adjusted parameter, the process can begin once again by identifying another parameter to improve. The methods developed using these simulations will have potential to be used experimentally by other researchers in the future.

From my experience with computational physics at the Naval Research Laboratory in D.C., I have specific experience in modelling physics phenomena using Python, and this project allows me to use my skills towards my interest in energy sustainability. The proposed work fits well with the ‘Environmental Sustainability and Resilience’ theme, as well as the ‘Technologies for the Future’ theme. While also working towards achieving the objectives set out by the project, working alongside academics and PhD students will help me prepare for a career in research, and allow me to experience what my career could look like years in the future when I am in their places. I also have a solid background in writing scientific papers and presenting academic research, through conferences attended and publications that I co-authored while at the Naval Research Laboratory. I am devoted to studying physics and will approach this project with the same enthusiasm that I take towards my course.

Personal success in this project would be a deeper understanding of both computational physics and plasma fusion, as well as confidence working in a research environment with experts of the field. Success within physics would provide greater insight into how physics can be used to combat the climate crisis. Interdisciplinary success will be gained, experience in presenting research, collaboration with a research team, as well as a broadened idea of potential career pathways for the future.

Beyond the Scholarship, success would advance the process of making fast ignition inertial confinement fusion high-yield and possibly self-sustaining as an energy source. This project could potentially produce results that could be used by fusion researchers worldwide, eventually making fusion energy viable to power humanity at large and send pollutant energy sources into obsoletion.