Efficient Laser Wakefield Acceleration

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In Laser Wakefield Acceleration, a high intensity laser pulse is used to drive a plasma wave which contains an electric field on the order of 100 gigavolt per meter. The phase velocity of the plasma wave is close to the speed of light (***c***), and so this wave can be used to accelerate electrons to extremely high energies over distances of a few centimeters. This technique has the potential to revolutionise particle acceleration, by overcoming the electric field limits (~100 megavolts per meter) of conventional technology, and therefore making accelerator technology more widely available for applications in industry, medicine, and fundamental science.

One of the key research areas within this field is optimising the acceleration efficiency of the plasma wakefield. The group velocity of a laser pulse in plasma is slightly lower than ***c***, so that relativistic electrons gradually overtake the laser and leave the accelerating part of the plasma wakefield. This process, known as *dephasing*, limits the final energy of the electron beam.

The aim of this project is to design the ideal plasma accelerator to mitigate dephasing, and therefore maximise the final electron energy and acceleration efficiency. This will be explored via simulations using the particle-in-cell code FBPIC, which is well-suited for modelling laser wakefield acceleration. The student will modify existing code to tune the accelerator (for example, varying the plasma density profile) to maximise the accelerating field experienced by an electron bunch.

Required Background

The project will involve python programming and running and analysing simulations Experience with computer programming and particularly python will therefore be very beneficial. The core physics under study is electromagnetism, special relativity, and waves.

Further Reading

To gain more insight into laser wakefield acceleration, check out the interactive animation at https://kaldera.desy.de/.