

IFE relevant code development at Warwick

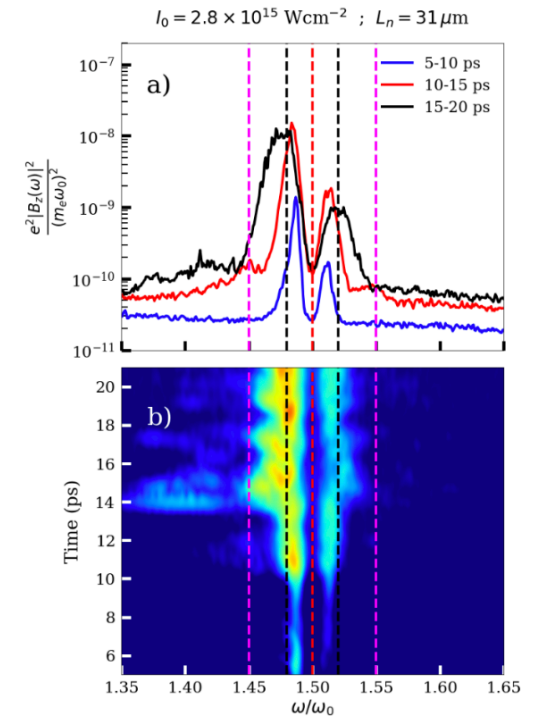
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Code inventory and roles in IFE

EPOCH - 3D particle-in-cell code

- Includes collisions, Bremsstrahlung, ionisation ...
- Useful for full LPI simulations - but expensive
- Reflectivity and hot-electron generation important for IFE
- Test for ML/AI approaches to LPI in fluid codes

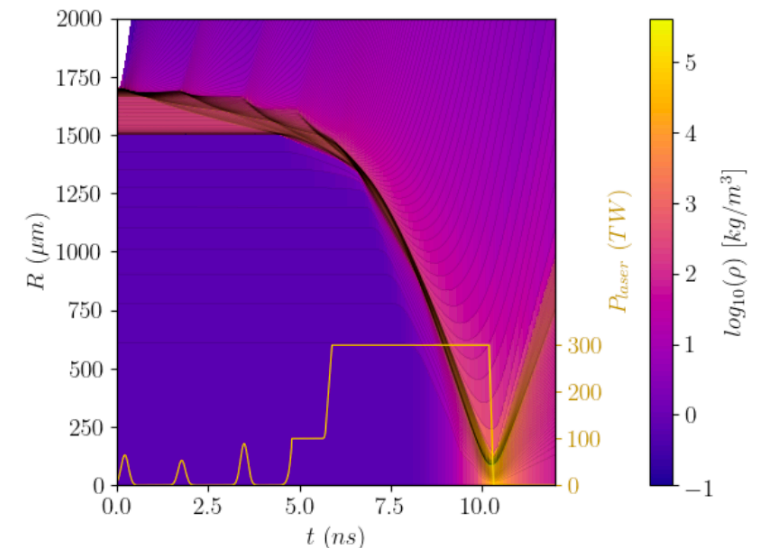
3/2 omega time/frequency resolved backscatter



Odin - 2D r-z radiation-transport ALE code

- ALE - Arbitrary-Lagrangian-Eulerian
- 2T - (ion/electron) temperature single fluid
- Arbitrary EoS
- SNB/limited conduction
- Multi-group radiation transport
- Aim is predictive IFE implosion simulations

Symmetric implosion. Odin grid collapses with implosion



EPOCH to EPOCH++

EPSRC funded project to rewrite EPOCH in modern C++

- Collaboration between Warwick physics and York computer science
- F90 version becoming difficult to maintain
- All HPC tools for CPU/GPU are in C++
- Enhance physics and diagnostics
- No visible change to users
- Full release in October 2025

On timescale of UPLiFT HPC will move to accelerated nodes with GPUs

- Code needs to be performant - fast
- Code needs to be portable - work on different HPC platforms
- Code needs to scale to many cores - **MPI + Kokkos/RAJA/SYCL ...**

Odin background and current status

Aim was to provide UK researchers with an ALE code for laser-driven fusion

Funded (Warwick, Imperial, York) by EPSRC from 2015-2018 but only a sub-set of the goals completed.

Current status:

- Two temperature (electron-ion) hydrodynamics, multi-material, arbitrary EoS
- Implicit flux limited thermal conduction for electrons and ions
- Temperature equilibration
- Laser deposition with IB choice of ray-tracing packages
- Hot-electron generation from LPI with 3D energy deposition/scattering
- Ideal MHD

Why have an ALE code?

Preparation for UPLiFT and beyond

- Improve grid relaxation and multi-material
- Implicit diffusive transport (thermal and radiation)
- Non-diffusive transport ($P_{1/3}$)
- Opacity and emissivity data
- Inverse ray-tracing
- Couple to realistic laser drivers (VisRad)
- CBET and other LPI on ray-tracing modules - deterministic and ML/AI
- Synthetic diagnostics
- Alpha heating
- Fast-VFP thermal transport from Oxford (Tony Bell)
- 3D

Access to Odin via collaboration with Odin team or scrambled binary on RAL HPC system for UK IFE research

Key physics for Odin in UPLiFT

From the original UPLiFT proposal document

- Experimental investigation of key Direct Drive physics: Experiments will be designed for existing facilities to cement our understanding of the key physics.
- Development of an Ignition Point Design: Initial point design work employing our best available models.
- Conceptual Design of Key Physics Diagnostics: Decision on key diagnostics and initial diagnostic design in-silico
- HPC scaling towards exa-scale and comparison with experimental data

Thank you