UK Fusion: Inertial fusion in the UK
Dr Kate Lancaster

York Plasma Institute
School of Physics, Engineering and Technology
University of York
Temperature

Confinement time

Density
The main approaches

Inertial confinement

Magnetic confinement
Lasers or X-rays symmetrically irradiate pellet

Hot plasma expands into vacuum causing shell to implode with high velocity

Material is compressed to $\sim 1000 \, \text{gcm}^{-3}$

Hot ignition region formed at the centre of the fuel by piston-like action of imploding shell

Implosion results in compression, heating and finally thermonuclear ignition + burn

General principles of ICF
Lasers fire into a gold can called a hohlraum
- The heated hohlraum emits X-rays
- X-rays are absorbed causing outer layer of capsule to ablate
- The rest of the fuel implodes to high density

Lasers irradiate capsule surface directly
- Laser causes outer layer of capsule to ablate
- The rest of the fuel implodes to high density

Images courtesy of LLNL
The National Ignition Facility is a unique “ignition class” laser facility at LLNL, USA.

“Ignition” here is defined such that the energy obtained due to fusion reactions exceeds the laser energy delivered to the hohlraum.

After more than a decade of careful experimental and theoretical work, ignition was achieved for the first time on Dec 5th 2022 – 2.05 MJ of laser energy delivered to the hohlraum produced 3.15 MJ from fusion reactions.

Demonstration is robust - ignition has been reproduced on a number of occasions with increasing energy output.
Global picture

- NIF
- Z machine
- ORION
- VULCAN
- MAGPIE
- OMEGA/EP
- Laser Megajoule (LMJ)
- FIREX/GEKKO XII
- SG – II and III
- Z machine
Where does the UK sit?

• Despite the community being relatively modest in the UK, we have a huge amount of influence

• We have been world leaders in high intensity lasers (VULCAN, GEMINI, ORION), targetry, theory, and computational modelling in high energy density science for many decades

• Many UK scientists based at LLNL(and US) and in the UK were involved in the ignition experiments (and work leading up to it)

• We have a huge role to play in the future of IFE – particularly since the UK and US have committed to a more joined up approach for fusion energy moving forward.
The UK Inertial fusion landscape

The UK has formed the UK Inertial Fusion Consortium

It consists of ~90 members from: Central Laser Facility, Imperial College, University of Warwick, University of Oxford, AWE, University of York, University of Strathclyde, Queens University Belfast, University of Lancaster, First Light Fusion

It was established to foster collaboration, coordination and establish a collective voice within UK inertial fusion research

The consortium have created a UK inertial fusion roadmap covering the period 2021 – 2035

Inertial fusion energy is part of Fusion Futures envelope and there are funds to support some of this activity

Chair: Robbie Scott (Robbie.Scott@stfc.ac.uk)

https://www.inertial-fusion.co.uk
The UK Inertial fusion roadmap

The strategy recommends the UK focus on two main areas of research:

- High fusion-energy-gain laser fusion schemes
- The science of ignition

The roadmap focuses on the following areas:

- Research
- Funding
- Facilities and Technology
- UK Strategy

It also gives high importance to growth of community, EDI, and training.

More detail can be found here: https://www.inertial-fusion.co.uk/roadmap
Resources

NIF ignition
https://www.nature.com/articles/d41586-023-04045-8
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.132.065102
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.129.075001

High Gain ICF schemes
https://royalsocietypublishing.org/toc/rsta/2021/379/2189

UK Inertial Fusion Consortium
https://www.inertial-fusion.co.uk