Optics for Energy Generation by Laser Fusion

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At OpTIC-Glyndŵr and operated by Glyndŵr University

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Alternative energy sources

- Wind
- Wave
- Hydroelectric
- Tidal barrage
- Direct solar heating
- Photovoltaic
- Biomass

Ultimately, all derived from solar energy

- Geothermal

radioactivity and gravitational energy

Ultimately, derived from previous generations of stars

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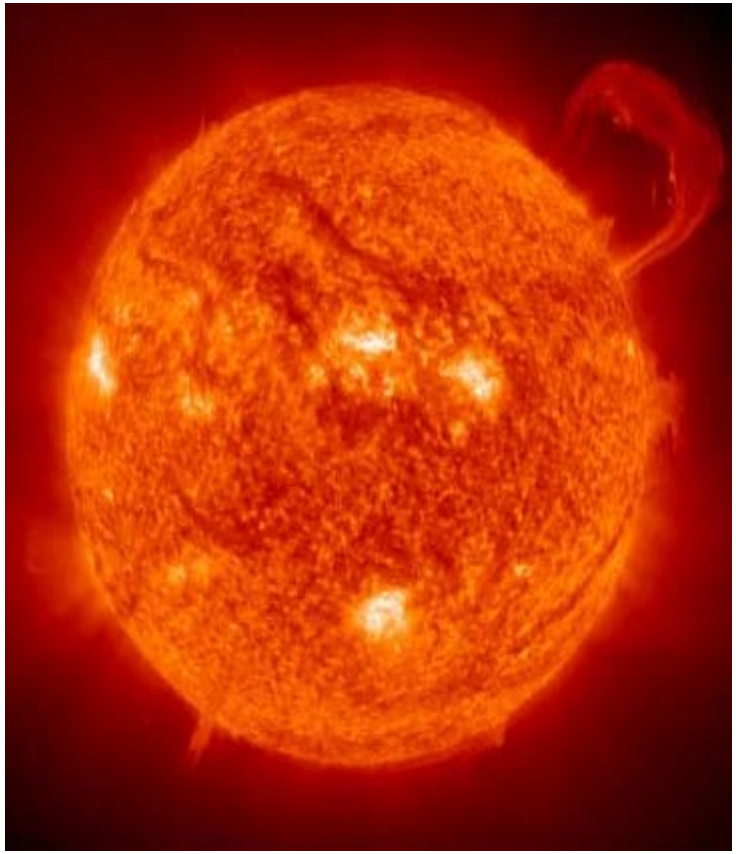
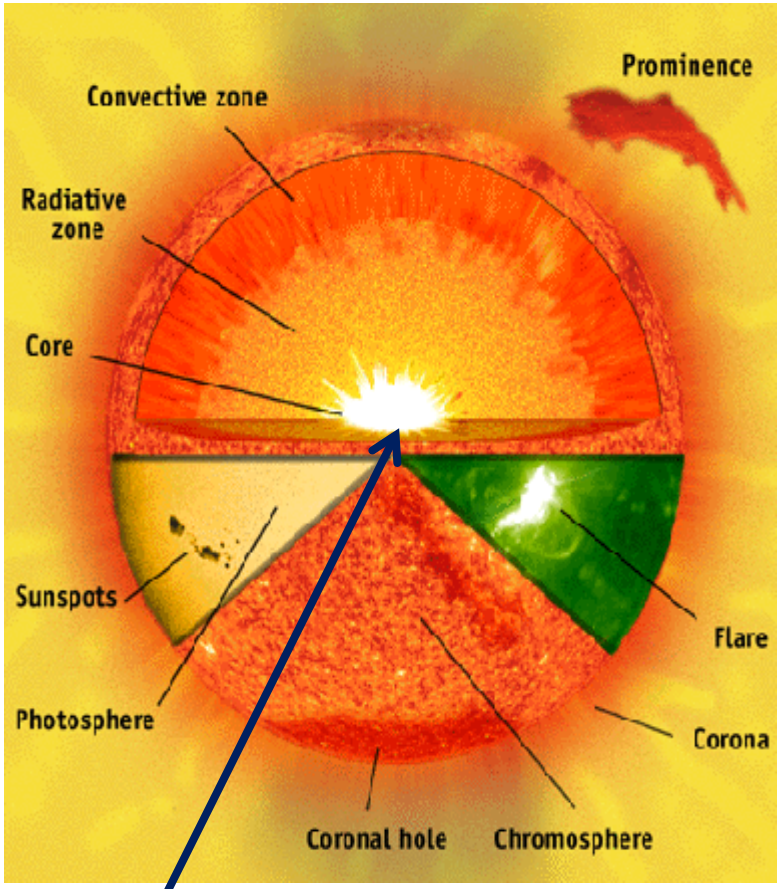
So, what is the source of the energy of the sun and stars?





Nuclear fusion reactor

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So…

- Please don’t think that…

Nuclear energy is bad

Solar energy is good

Effectively, *all* our energy sources are ultimately derived from nuclear processes in stars!

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Alternative energy

- Most alternative energy sources do not produce a regular flow of energy

- Increasing base-load demand: bulk, reliable, safe, constant energy-supply, independent of cycles of weather, daylight, tides etc.

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Nuclear fission

- The typical “nuclear reactor”
  - Heavy elements (isotopes of uranium etc) are split into lighter elements
  - Total mass of the products is very slightly less than the mass of the “fuel”
  - Mass-loss converted to energy by $E=Mc^2$
  - Products are long-lived radioactive isotopes
  - Environmental impact:- disposal / safety issues

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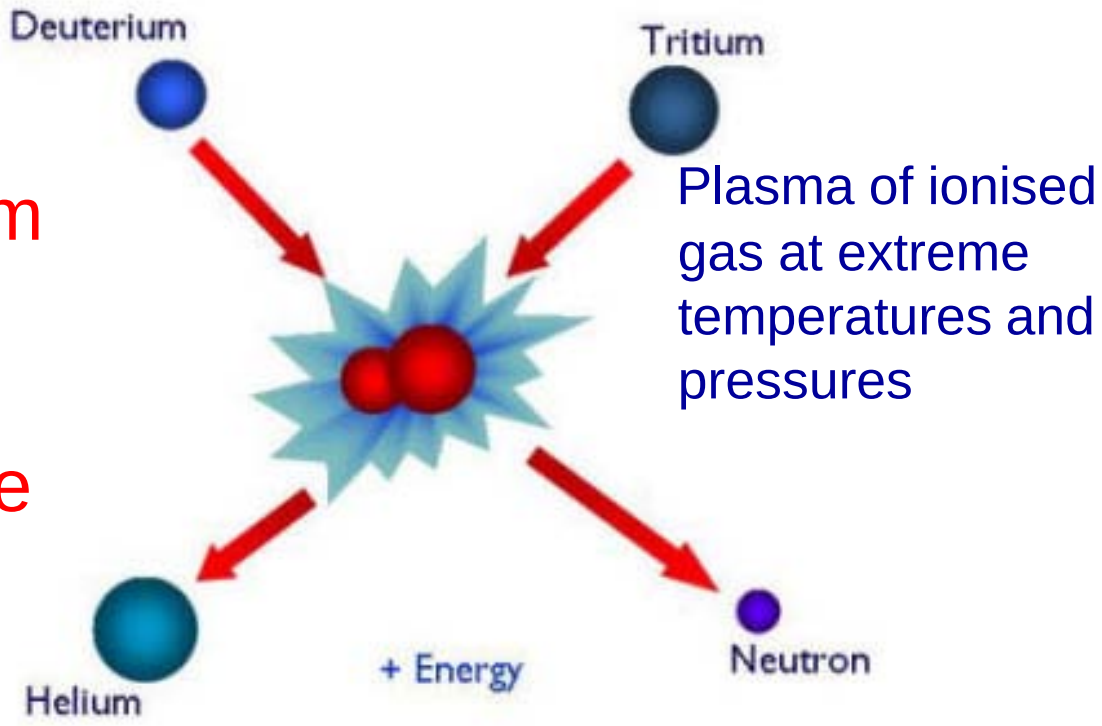
Nuclear fusion

- Fuse two nuclei of hydrogen isotopes together to produce helium, plus a neutron.
- Mass of helium+neutron < deuterium+tritium
- Produces energy

Fusion energy from deuterium in1Km cube of seawater equivalent to entire known oil-reserve



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Fusion:- nuclear waste

- Carbon-neutral:- the primary by-product is helium.
- Also produces neutrons
  - will make the reaction chamber and immediate environment radio-active.
- Calculated time to return a fusion power plant to brown field-status (doing nothing) is only ~100 years.

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How can the plasma at ~ 100 million ^{o}C be contained?

- Natural solution – by gravity, in the centre of a star
- Magnetic solution – in a “magnetic bottle” (international *ITER* project)
- Photonic solution – using the pressure exerted by high-power laser-beams (international *HiPER* project)

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The pathfinder:- US National Ignition Facility “NIF”)

- 8000 metre-scale optical components
- 30,000 small optical components

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HiPER: principle of operation

- Hydrogen isotopes in a spherical plastic pellet
- High-power laser system explosively compresses gas
- “Spark-plug” laser system ignites fusion
- Energy generated … ultimately used to boil water and power a steam turbine!

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HiPER project

A factory-sized laser-fusion facility to put energy back into the Grid!

"Spark-plug" Ignition System:-

Requires large segmented focussing mirror

- very similar to segmented telescope mirror!

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ZEEKO Ltd

CNC polishing of telescope mirror segments

- Consortium led by OpTIC-Glyndŵr
  - €5m contract to produce seven 1.4m prototype mirror segments for the 42m European Extremely Large Telescope
- Telescope project requires 1,148 mirror segments, at value of ~ €150M
- Goal is to deliver prototypes and form industrial consortium to win this work for Wales

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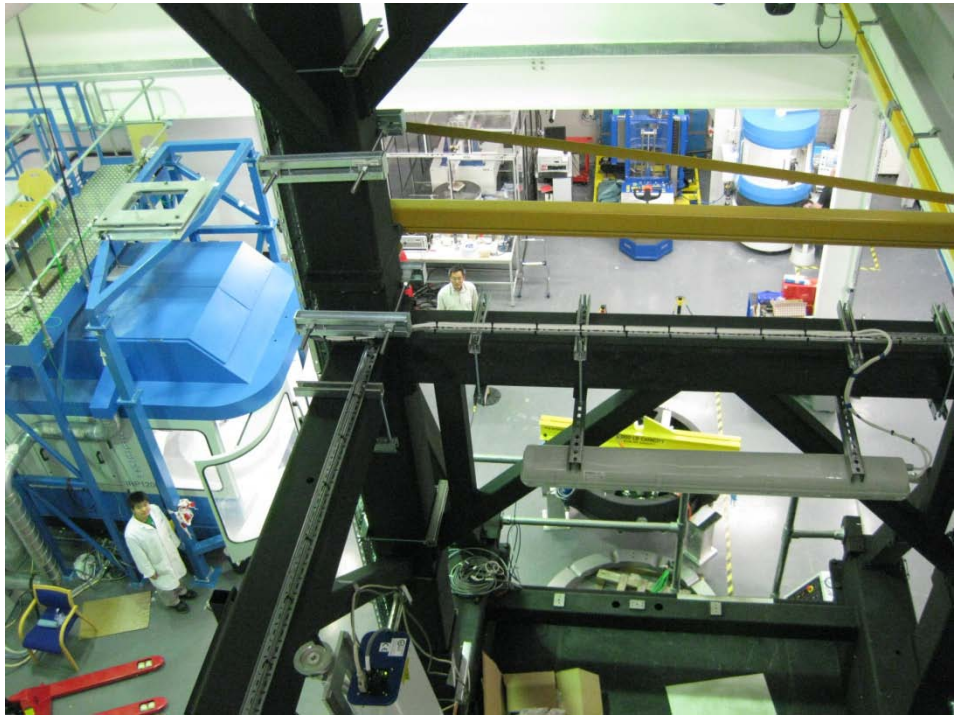
OpTIC-Glyndŵr in engaging with HiPER project:- opportunity to provide mirrors and other optics



OpTIC facility,
St Asaph, N. Wales

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Master Segment in polishing at OpTIC

Key issues for HiPER

- Metre-scale surfaces
- High energy-densities on optics from laser flux
- High-efficiency coatings
- Cost, time and surface-quality in mass-production

Thank
you!

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