# Secrets from within planets pave way for cleaner energy

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Research that has provided a deeper understanding into the centre of planets could also provide the way forward in the world's quest for cleaner energy.

An international team of scientists, led by the University of Oxford, working alongside researchers at the Science and Technology Facilities Council's (STFC) Central Laser Facility, has gained a deeper insight into the hot, dense matter found at the centre of planets and as a result, has provided further understanding into controlled thermonuclear fusion. The full paper on this research has been published, 19 October, in the scientific journal, *Nature Physics*.

This deeper insight into planets could extend our comprehension of fusion energy – the same energy that powers the sun, and laser driven fusion as a future energy source. Fusion energy is widely considered an attractive, environmentally clean power source using sea water as its principal source of fuel, where no greenhouse gasses or long lived radioactive waste materials are produced.

Using STFC's Vulcan laser, the team has used an intense beam of X-rays to successfully identify and reproduce conditions found inside the core of planets, where solid matter has a temperature in excess of 50,000 degrees. The understanding of the complex state of matter in these extreme conditions represents one of the grand challenges of contemporary physics. The results from the Vulcan experiments are intended to improve our models of Jupiter and Saturn and to obtain

better constraints on their composition and the age of the Solar System.

Using inelastic X-ray scattering measurements on a compressed lithium sample, it was shown how hot, dense matter states can be diagnosed and structural properties can be obtained. The thermodynamic properties – temperature, density and ionisation state, were all measured using a combination of non-invasive, high accuracy, X-ray diagnostics and advanced numerical simulations. The experiment has revealed that the matter at the centre of planets is in a state that is intermediate between a solid and a gas over lengths larger than 0.3 nanometres. To put this into context, 1 nanometre equates to less than 1/10000th of a human hair! Results showed that extreme matter behaves as a charged liquid, but at smaller distances it acts more like a gas.

Dr Gianluca Gregori, of the University of Oxford and STFC's Central Laser Facility said: "The study of warm dense matter states, in this experiment on lithium, shows practical applications for controlled thermonuclear fusion, and it also represents significant understanding relating to astrophysical environments found in the core of planets and the crusts of old stars. This research therefore makes it not only possible to formulate more accurate models of planetary dynamics, but also to extend our comprehension of controlled thermonuclear fusion where such states of matter, that is liquid and gas, must be crossed to initiate fusion reactions. This work expands our knowledge of complex systems of particles where the laws that regulate their motion are both classical and quantum mechanical. "

Professor Mike Dunne, Director of the Central Laser Facility at STFC said: "Using high power lasers to find solutions to astrophysical issues is an area that has been highly active at STFC for some time. We are very excited that the Vulcan laser has contributed to such a significant piece of research. The use of extremely powerful lasers is proving to be a particularly effective approach to delivering long-term solutions for

carbon-free energy."

Source: Science and Technology Facilities Council