

Transparent aluminium is 'new state of matter'

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Experimental set-up at the FLASH laser used to discover the new state of matter.

(PhysOrg.com) -- Oxford scientists have created a transparent form of aluminium by bombarding the metal with the world's most powerful soft X-ray laser. 'Transparent aluminium' previously only existed in science fiction, featuring in the movie *Star Trek IV*, but the real material is an exotic new state of matter with implications for planetary science and nuclear fusion.

In this week's *Nature Physics* an international team, led by Oxford University scientists, report that a short pulse from the FLASH laser 'knocked out' a core electron from every [aluminium](#) atom in a sample

without disrupting the metal's crystalline structure. This turned the aluminium nearly invisible to extreme ultraviolet radiation.

"What we have created is a completely new state of matter nobody has seen before,' said Professor Justin Wark of Oxford University's Department of Physics, one of the authors of the paper. 'Transparent aluminium is just the start. The physical properties of the matter we are creating are relevant to the conditions inside large planets, and we also hope that by studying it we can gain a greater understanding of what is going on during the creation of 'miniature stars' created by high-power laser implosions, which may one day allow the power of [nuclear fusion](#) to be harnessed here on Earth.'

The discovery was made possible with the development of a new source of radiation that is ten billion times brighter than any synchrotron in the world (such as the UK's Diamond Light Source). The FLASH laser, based in Hamburg, Germany, produces extremely brief pulses of soft X-ray light, each of which is more powerful than the output of a power plant that provides electricity to a whole city.

The Oxford team, along with their international colleagues, focused all this power down into a spot with a diameter less than a twentieth of the width of a human hair. At such high intensities the aluminium turned transparent.

Whilst the invisible effect lasted for only an extremely brief period - an estimated 40 femtoseconds - it demonstrates that such an exotic state of matter can be created using very high power X-ray sources.

Professor Wark added: 'What is particularly remarkable about our experiment is that we have turned ordinary aluminium into this exotic new material in a single step by using this very powerful laser. For a brief period the sample looks and behaves in every way like a new form

of matter. In certain respects, the way it reacts is as though we had changed every aluminium atom into silicon: it's almost as surprising as finding that you can turn lead into gold with light!

The researchers believe that the new approach is an ideal way to create and study such exotic states of matter and will lead to further work relevant to areas as diverse as planetary science, astrophysics and nuclear fusion power.

A report of the research, 'Turning solid aluminium transparent by intense soft X-ray photoionization', is published in [Nature Physics](#). The research was carried out by an international team led by Oxford University scientists Professor Justin Wark, Dr Bob Nagler, Dr Gianluca Gregori, William Murphy, Sam Vinko and Thomas Whitcher.

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