Electrons with no mass acquire a mass in the presence of a high magnetic field

August 29 2016

Professor Stefano Sanvito, AMBER Centre and CRANN Institute, Trinity College Dublin. Credit: AMBER centre, Trinity College Dublin

An international team of researchers have for the first time, discovered that in a very high magnetic field an electron with no mass can acquire a mass. Understanding why elementary particles e.g. electrons, photons, neutrinos have a mass is a fundamental question in Physics and an area of intense debate. This discovery by Prof Stefano Sanvito, Trinity College Dublin and collaborators in Shanghai was published in the prestigious journal *Nature Communications* this month.

While the applications of this discovery remain to be seen, this represents a significant breakthrough in fundamental physics. It could inspire work in high-energy physics, such as the collision experiments carried out in particle accelerators like CERN. This is the third joint publication between the group in Trinity and Prof. Faxian Xiu at Fudan University in Shanghai, who approached Prof Sanvito to provide theory support for their experimental activity based on his previous publications and international reputation in the field of theoretical physics.

Prof Stefano Sanvito, Principal Investigator at the Science Foundation Ireland funded AMBER (Advanced Materials and BioEngineering Research) centre based at Trinity and the CRANN Institute and Professor in Trinity's School of Physics said, "This is a very exciting breakthrough because until now, nobody has ever discovered an object whose mass can be switched on or off by applying an external stimulus. Every physical object has a mass, which is a measure of the object's resistance to a change in its direction or speed, once a force is applied. While we can easily push a light-mass shopping trolley, we cannot move a heavy-mass 6-wheel lorry by simply pushing. However, there are some examples in Nature of objects not having a mass. These include photons, the elementary particles discovered by Einstein responsible for carrying light, and neutrinos, produced in the sun as a result of thermonuclear reactions. We have demonstrated for the first time one way in which mass can be generated in a material. In principle the external stimulus that enabled this, the magnetic field, could be replaced with some other stimulus and perhaps applied long-term in the development of more sophisticated sensors or actuators. It is impossible to say what this could mean, but like any fundamental discovery in physics, the importance is in its discovery."

He continued, "It has been very satisfying to continue to work with Prof Xiu in Shanghai. While his group are experts in growing and characterizing materials such as ZrTe5 which are very difficult to make, my group has the expertise in the theoretical interpretation. The measurements were carried out in Fudan and at the Wuhan National High Magnetic Field Center in China, while the Dublin team provided the theoretical explanation for the finding. This has been a very fruitful collaboration and we have a number of other publications in progress".

The team studied what happened to the current passing through the exotic material zirconium pentatelluride (ZrTe5) when exposed to a very high magnetic field. Measuring a current in a high magnetic field is a standard way of characterising the material's electronic structure. In the absence of a magnetic field the current flows easily through ZrTe5. This is because in ZrTe5 the electrons responsible for the current have no mass. However, when a magnetic field of 60 Tesla is applied (a million times more intense than the earth's magnetic field) the current is drastically reduced and the electrons acquire a mass. An intense magnetic field in ZrTe5 transforms slim and fast electrons into fat and slow ones.

More information: Yanwen Liu et al, Zeeman splitting and dynamical mass generation in Dirac semimetal ZrTe5, *Nature Communications* (2016). DOI: 10.1038/ncomms12516

Provided by Trinity College Dublin

August 29) retrieved 20 September 2024 from https://phys.org/news/2016-08-electrons-mass-presence-high-magnetic.html