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NUS team finds quasiparticle with unique properties

When you delve into scales smaller than what any conventional microscope can see, the difference between a particle and a force begins to blur.

Imagine a ball that is being thrown. Normally, the force driving the ball forward and the ball itself are two different things.

But that is not the case in quantum physics, where forces can alter the fundamental properties of masses and create something new: quasiparticles.

A team led by Professor Thirumalai Venky Venkatesan, director of the National University of Singapore Nanoscience and Nanotechnology Initiative (NUSNNI), has discovered a new quasiparticle called a "polaronic trion".

There are two sides to this quasiparticle. On one side is the atomically thin layer of molybdenum disulphide (MoS2), and on the other is the single crystal of strontium titanate (SrTiO3) it is grown on. The SrTiO3 crystal has very special properties. When it is very cold (around minus 120 deg C), its atomic structure begins to vibrate at a very low energy.

Meanwhile, in the MoS2 layer, two electrons and a "hole" (a particle similar to an electron but with the opposite electric charge) couple to form a "trion". This trion interacts with the vibrations in the crystal and forms a "polaronic trion".

Dr Maxim Trushin, senior research fellow at the NUS Centre for Advanced 2D Materials, explained: "The polaronic trion can be visualised as a Russian doll. Inside the polaronic trion are a trion and vibrations, and inside the trion are electrons and holes."

When SrTiO3 is cooled, the atoms that are connected together in its structure begin to rotate together. The structure twists and this rotational nature allows it to combine with a trion, a particle which also rotates.

Said Dr Trushin: "It's like pushing a screw into a wall with a screwdriver, rather than a hammer. The two objects must be complementary."

The researchers hope that the new quasiparticle has impactful properties in optoelectronics (electronics that source, detect and control light).

Said Dr Soumya Sarkar, research fellow at NUSNNI: "The quasiparticle can absorb and emit light, and can be instantly destroyed with a small applied voltage, which could be useful for optical modulators."

Prof Venkatesan said the next step would be to see if polaronic trions can be found in other 2D materials.

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