

Monday, December 11, 2017

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Science Technology

Posted at: Dec 9, 2017, 11:23 AM; last updated: Dec 9, 2017, 11:23 AM (IST)

## New form of matter 'excitonium' discovered



Photo for representation only.

### Los Angeles, December 9

Scientists have proven the existence of new form of matter called excitonium - which was first theorised almost 50 years ago.

Researchers from University of California Berkeley and University of Illinois at Urbana-Champaign in the US studied non-doped crystals of the transition metal dichalcogenide titanium diselenide (1T-TiSe<sub>2</sub>).

Excitonium is a condensate - it exhibits macroscopic quantum phenomena, like a superconductor. It is made up of excitons, particles that are formed in a very strange quantum mechanical pairing, namely that of an escaped electron and the hole it left behind.

It defies reason, but it turns out that when an electron, seated at the edge of a crowded-with-electrons valence band in a semiconductor, gets excited and jumps over the energy gap to the otherwise empty conduction band, it leaves behind a "hole" in the valence band.

That hole behaves as though it was a particle with positive charge, and it attracts the escaped electron.

When the escaped electron with its negative charge, pairs up with the hole, the two remarkably form a composite particle. a boson — an exciton.

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11 Dec 2017 | 2:18 AM

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#### SCI/TECH/GADGETS/ENV.



In point of fact, the holes particle-like attributes are due to the collective behaviour of the surrounding crowd of electrons. However, that understanding makes the pairing no less strange and wonderful, researchers said.

Until now, scientists have not had the experimental tools to positively distinguish whether what looked like excitonium was not in fact a Peierls phase.

Peierls phases and exciton condensation share the same symmetry and similar observables.

Abbamonte and his team were able to overcome that challenge by using a novel technique they developed called momentum-resolved electron energy-loss spectroscopy (M-EELS).

With their new technique, the group was able to measure collective excitations of the low-energy bosonic particles, the paired electrons and holes, regardless of their momentum.

"Ever since the term 'excitonium' was coined in the 1960s by Harvard theoretical physicist Bert Halperin, physicists have sought to demonstrate its existence," said Peter Abbamonte, professor at University of Illinois.

"Theorists have debated whether it would be an insulator, a perfect conductor, or a superfluid—with some convincing arguments on all sides," Abbamonte said.

"Since the 1970s, many experimentalists have published evidence of the existence of excitonium, but their findings were not definitive proof and could equally have been explained by a conventional structural phase transition," he said.

The findings, published in the journal Science, holds great promise for unlocking further quantum mechanical mysteries, researchers said.

It could also shed light on the metal-insulator transition in band solids, in which exciton condensation is believed to play a part. Beyond that, possible technological applications of excitonium are purely speculative. — PTI.



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