



DECEMBER 10, 2017 SPARKONIT PHYSICS

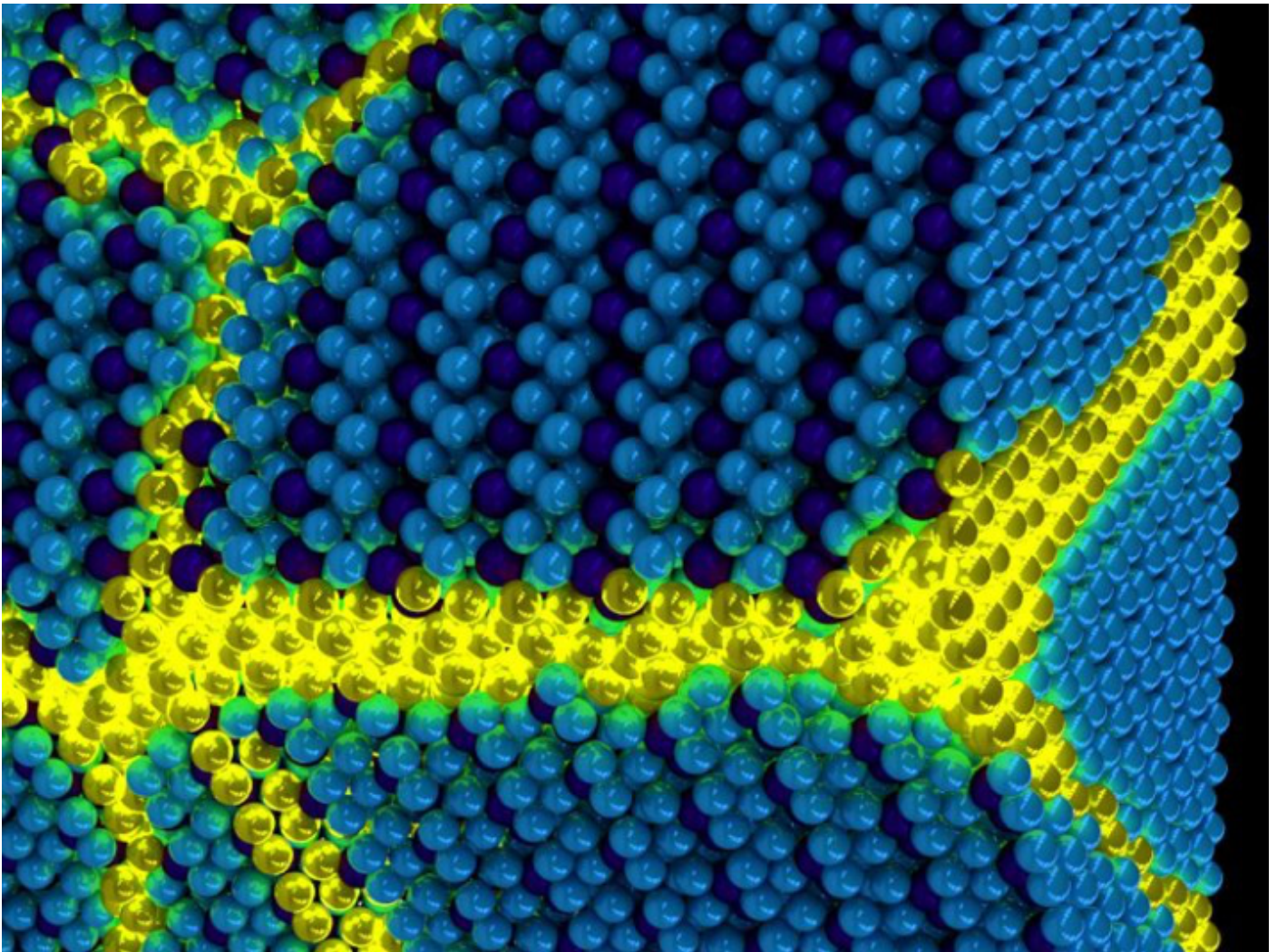
Physicists Have Discovered A New Form Of Matter Called Excitonium

An international team of physicists from the University of Illinois at Urbana-Champaign, University of California, Berkeley, and University of Amsterdam, claim they have finally proven the existence of a new form of matter called excitonium, almost 50 years after it was first theorized. Upon studying non-doped crystals of the transition metal dichalcogenide titanium diselenide (1T-TiSe₂), the researchers were able to observe the material and its precursor soft plasmon phase called the “smoking gun” that proves the existence of this rare, exotic material. And surprisingly, they were able to reproduce the results 5 times on different cleaved crystals during the experiments.

Excitonium is a **condensate**, which exhibits **macroscopic quantum phenomena**, like a superconductor, or superfluid, or insulating electronic crystal. It consists of particles called **excitons** which are formed as a result of pairing of an escaped electron and the hole it leaves behind.

When an electron goes beyond its maximum energy level, it's no longer bound to the nucleus of its atom and it's considered to be ionized. When an electron

temporarily occupies that energy state greater than its ground state, it's considered to be in an **excited state**. So as it gets excited, it jumps over the energy gap to the otherwise empty conduction band and leaves a “hole” behind. The hole behaves as though it were a positively-charged particle itself and attracts the escaped electron. They then pair up to form the composite particle, a boson known as an exciton.



In the study, the team used a novel technique they developed called momentum-resolved electron energy-loss spectroscopy (M-EELS), which they say is more sensitive to excitations than any other techniques such as **inelastic X-ray scattering** (IXS) or **neutron scattering** techniques. They retrofit an EEL spectrometer with a goniometer which allows them to precisely measure the electron's momentum in real space. And doing this, the researchers were able to

measure collective excitations of the low-energy bosonic particles, the paired electrons and holes, regardless of their momentum.

What's even more exciting is that – for the first time ever, the researchers were even to observe a soft plasmon phase that emerged as the material approached its critical temperature of 190 Kelvin. And, this soft plasmon phase is “smoking gun” proof that excitonium exists, researchers say.

“This result is of cosmic significance,” explained Peter Abbamonte, Professor of Physics who was involved in the study. “Ever since the term ‘excitonium’ was coined in the 1960s by Harvard theoretical physicist Bert Halperin, physicists have sought to demonstrate its existence. Theorists have debated whether it would be an insulator, a perfect conductor, or a superfluid—with some convincing arguments on all sides. Since the 1970s, many experimentalists have published evidence of the existence of excitonium, but their findings weren’t definitive proof and could equally have been explained by a conventional structural phase transition.”

Anshul Kogar, who was one of the graduate students who took part in the study, explained that discovering excitonium was not the original motivation for the research, but he later emphasized that “excitonium was a major interest.”

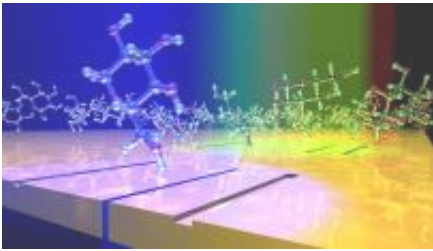
“This discovery was serendipitous. But Peter and I had had a conversation about 5 or 6 years ago addressing exactly this topic of the soft electronic mode, though in a different context, the Wigner crystal instability. So although we didn’t immediately get at why it was occurring in TiSe_2 , we did know that it was an important result—and one that had been brewing in our minds for a few years.”

Researchers say their discovery holds “great promise for unlocking further

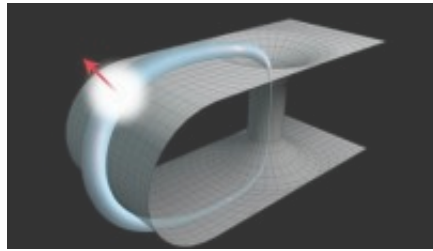
quantum mechanical mysteries.” The study, entitled “**Signatures of exciton condensation in a transition metal dichalcogenide**” has been published in the journal *Science*.

Source: **University of Illinois at Urbana-Champaign**

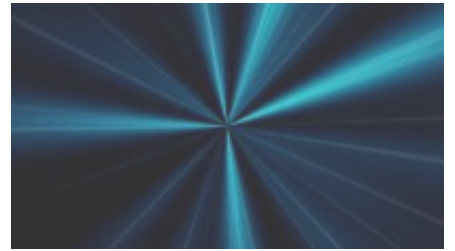
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2 thoughts on “Physicists Have Discovered A New Form Of Matter Called Excitonium”



prior..

DECEMBER 11, 2017 AT 2:20 AM

sparkonit really does feature some amazing up-to-date info – so glad to have connected paths again this year – :)

REPLY



John Love

DECEMBER 10, 2017 AT 6:34 PM