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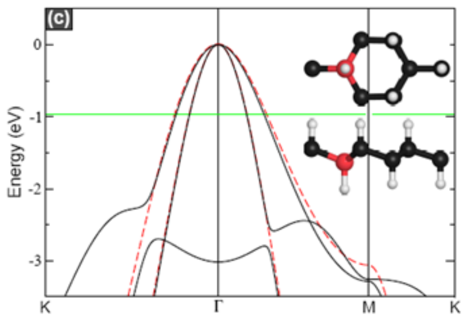
Friday, February 05, 2010

Doped Graphane Should Superconduct at 90K

New calculations reveal that p-doped graphane should superconduct at 90K, making possible an entirely new generation of devices cooled by liquid nitrogen.



There's a problem with high temperature superconductors. It's now more than two decades since the discovery that certain copper oxides can superconduct at temperatures above 30 K.

Those years have been filled with promise, hyperbole and feverish research. Physicists know that copper oxides superconduct in an entirely different way to conventional BCS superconductors (after Bardeen, Cooper and Schrieffer, who worked out the theory behind them). And yet, nobody agrees on precisely what the new mechanism is. Neither has anybody created a superconductor that works at a usable temperature, that is above the temperature of liquid nitrogen.

Even the resurgence of excitement last year over the discovery that magnesium diboride superconducts at high temperatures, probably in the old fashioned BCS way, soon gave way to malaise as physicists found they were unable to build on the breakthrough to make better superconductors. It's tempting to think that superconductors will never pass the liquid nitrogen barrier.

But today hope is restored thanks to a fascinating set of calculations carried out by Gianluca Savini at the University of Cambridge in the UK and a couple of buddies. They calculate the properties of p-doped graphane from first principles and say that it ought to superconduct at a balmy 90K or more, well within the range of liquid nitrogen cooling.

What's more p-doped graphane should superconduct in the same way as the old fashioned BCS superconductors. That's curious because everybody believes that BCS superconductivity cannot work at high temperatures.

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... : This is not about the originators of ideas, but about how the ideas spread. A well connected...

debu : Please read my ether-gravity or theory of gravitoethertons which explains many aspects of quantum...

ms : So is AMSC selling superconducting wire that doesn't exist?

shazl : I believe the results are not only because of somebody being post-paid or pre-paid. It's...

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sfrysfry : For ideas on entangling larger

The reason is the energy of the interaction between the superconducting electrons and the surrounding material. In ordinary BCS superconductors this is thought to be just a few tens of meVs. In the copper oxides, however, these interactions have an energy of a few hundred meVs. It's this difference, that makes physicists think that BCS superconductors will never work at the temperature of copper oxides.

And yet the discovery that magnesium diboride superconducts challenges that thinking--energy of these interactions in MgB_2 is much higher. Three factors seem to come together to make it possible, say Savini and co. First is the characteristic energy of the phonons in MgB_2 which is due to bond stretching and plays an important part in helping superconductors through the structure. Second is the electron density of states in the material and finally they point to the balance between the attractive electron-phonon coupling and the repulsive electron-electron interaction in MgB_2.

Might it be possible to find materials in which these quantities can be manipulated further? You betcha. Savini and co noticed that p-doped diamond has two of these characteristics but superconducts only at 4K.

However, they calculate that p-doped graphane fits the bill exactly and should superconduct in the old-fashioned BCS way at 90K. What's more they say there are hints that p-doped diamond nanowires might have similar properties.

Various groups are already playing around with doped diamond nanowires.

The implications of all this are astounding. First up is the possibility of useful superconducting devices cooled only by liquid nitrogen. At last!

But there's another, more exotic implication: by creating transistor-like gates out of graphane doped in different ways, it should be possible to create devices in which the superconductivity can be switched on and off. That'll make possible an entirely new class of switch.

Before all of that, however, somebody has to make p-doped graphane. That will be hard. Graphane itself was made for the first time only last year at the University of Manchester. It should be entertaining to follow the race to make and test a p-doped version.

Ref: arxiv.org/abs/1002.0653: Doped Graphane: a Prototype High-T_c Electron-Phonon Superconductor