

IISc duo's claim of ambient superconductivity may have support in theory

Strong perturbations in the gold-silver matrix may liberate a latent superconductivity in the material

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In July, a two member team of chemists, Anshu Pandey and Devesh Kumar Thapa, posted a preprint on the arXiv server claiming to have observed superconductivity at ambient temperature and pressure in samples in their lab in the Solid State and Structural Chemistry Unit at Indian Institute of Science, Bengaluru. They had studied materials with silver nanoparticles embedded in a gold matrix and found that their samples showed the signs of becoming a superconductor on cooling below 236 K (-37 degrees Celsius). Further, when they altered the mole fraction of gold in the samples, they could bring up the critical temperature T_c (the temperature at which the transition to superconductivity happens) up to room temperature.

They found the two effects that are the considered the signatures

of superconductivity – resistance dropping close to zero below the critical temperature and the expulsion of magnetic flux from within the material – which often shows up as magnetic levitation at the superconducting temperature. The possible applications of such a discovery are unimaginably vast – a material that conducts electricity without resistance, or loss of power at room temperature. Magnetic levitation has also been discussed in the context of mag-lev trains etc.

Query raised

However, soon after the preprint was posted, there was a query raised by Brian Skinner, MIT physicist on two counts. One stemmed from his scepticism that a gold-silver combination could become a superconductor at all – because monovalent metals like gold and silver are by themselves never seen to become superconducting



Mag-lev: Expulsion of magnetic flux can lead to levitation. • AFP

even at low temperatures. It is broadly believed in the physics community that they cannot ever exhibit superconductivity. The other objection was stunning – Dr Skinner's analysis of the graphs plotted by Thapa and Pandey showed that the noise factor was too similar in two of the curves. Noise, being a random factor, cannot be similar for different trials, was his contention.

Amid this controversy, the IISc team chose to remain silent, only assuring Dr. Skinner in an email that they were studying the strange noise correlation.

But as to the unusual behaviour of gold-silver complex, G Baskaran, a Distinguished Fellow of The Institute of Mathematical Sciences, Chennai, is not surprised. He suggests that even though gold and silver are not themselves cap-

able of superconductivity, the combination can have different properties. "The material can house strong perturbations that can liberate a confined, or latent, superconductivity," he says.

According to him, even in isolation, there are many possible phases, including different types of superconducting phases, in which monovalent metals like gold, silver, copper etc can exist in principle. However, these phases do not manifest themselves in either calculation or direct experiments, and he believes this is because they are drowned out by competing quantum phases.

In fact, Prof. Baskaran includes in this list alkali metals such as sodium, potassium and others that have a similar electronic structure. (None of these, except for lithium, exhibits superconducting phases, even at very low temperatures.) Though in early days scientists tried to explain this, it is now

accepted by most that these can never be superconducting. "Good metals make bad superconductors," being the dictum.

Hubbard model

To overthrow this dictum, Baskaran invokes the Hubbard model, which is a theoretical model that describes the energetics of the system – monovalent metals. As he puts it, "different parts of the model exhibit superconductivity, but as a whole does not". Thus, there may be different possibilities open. Some such latent phases that have been discussed earlier include charge-density waves and spin-density waves. To this list, he includes several types of superconducting phases. Unlike in the pure metals, in composite material, the balance may tip in favour of superconductivity.

In the case of the Pandey-Thapa results, he says: "They have put silver nanoparticles into gold. Gi-

ven the chemistry of the two metals, silver being more electronegative, will donate the electrons into the gold matrix, making for strong perturbations to the individual energetics." This appears to be pushing the combination into a superconducting phase. He further adds that the lattice structure of the silver nanoparticles may be different from the regular face-centred cubic array that silver enjoys in the bulk, which may add to the effect.

According to Prof Baskaran, such effects can be seen in any combination of the eight monovalent metals he has named – sodium, potassium, lithium, rubidium, cesium, gold, silver and copper. "Perhaps not all combinations may be practically possible, owing to their solid state chemistry, but some at least, which have the right perturbations, should show interesting behaviour," he clarifies.