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Co-existence of Superconductivity and Ferro-Magnetism

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Abstract:-

This article is about coexistence of superconductivity and ferro-magnetism. Theoretically it was believed that coexistence of superconductivity and ferro-magnetism is not possible due to Meissner effect, but recently many compounds are found where superconductivity and ferro-magnetism co exists.

Superconductivity has been a huge area for scientific research for its wonderful properties. Superconductors can allow current through itself with zero resistance, that means, basically no loss of energy. They are very very useful in today's technology. But if we want to use superconductors for higher level application, like devices operating on magnetic properties, magnetic memory and computing, it is obvious that we need to find a way, so that superconductivity and ferro-magnetism can co-exist.

Meissner effect:-

Critical temperature is the temperature below which a superconducting material shows superconducting properties. Above that temperature, general properties are shown, and ferro-magnetism within the material exists. When temperature falls to critical temperature, resistance to electrical current abruptly becomes zero and the material suddenly expel the maximum amount of applied magnetic field from itself. This happens because, below critical temperature, surface current of the material flowing without any resistance start to produce magnetization within the material under the influence of the external field. This magnetization happens to be equal and
Opposite of the given field, so, both cancel each other. This state is Meissner state, when there is little to no magnetic field.

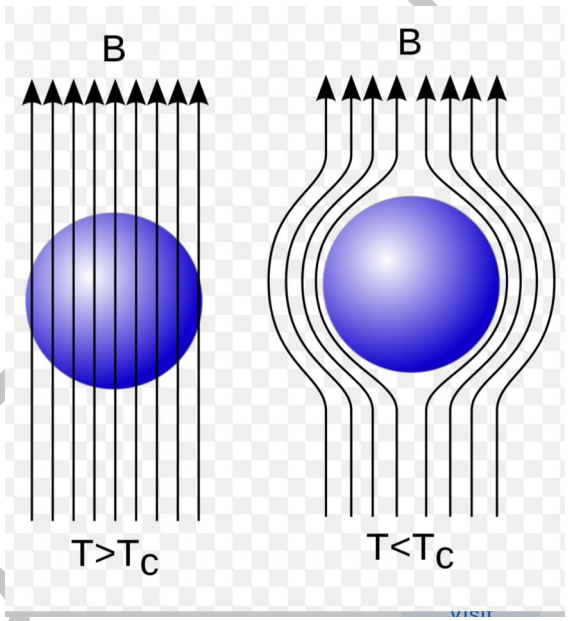

Image1:- magnetic field getting expelled out below critical temperature.

But this Meissner state completely breaks down if the applied magnetic field is greater than the critical value Hc. And in this state, superconductivity breaks down completely.

The new materials:-

University of Bath collaborating with the physicists from USA has investigated the rare property of RbEuFe4As4. They created magnetic field maps of the material in the superconducting state . They found out that the points in the material at the superconducting state where the magnetic field penetrates are broadened around the temperature of -258°C . This implies that the superconducting is strongly getting suppressed

T.E.M.S

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when the magnetic field is penetrating.

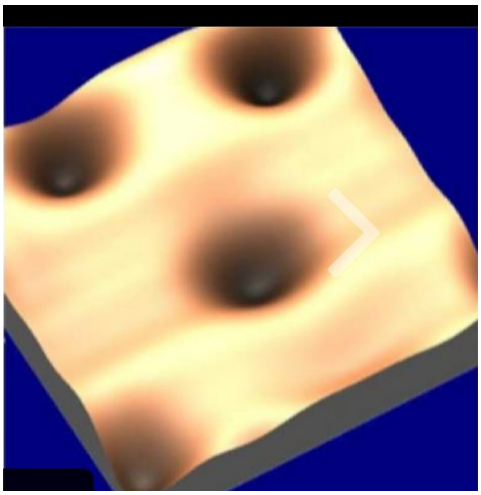

Image2:- the region where magnetic field penetrates.

The reason being proposed by Dr. Alexei Koshelev in a theoretical model. According to Dr. Alexei Koshelev, this is happening due to the presence of Europium(Eu) in the material. Magnetic direction in each of those atoms in the crystal fluctuate and align with each other which contributes to each other and the material becomes magnetic. This also shows that magnetism and superconductivity can stay apart within their own sub-lattices. In this process, superconductivity is weakens but not completely lost. There are some other materials too exhibiting such properties like, $Sr_{0.5}Ce_{0.5}FBiS_2$, $ReTm_2B_2C$.

Reference:-

SciTech daily
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Images1:- Wikipedia
Images2:- SciTech daily

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