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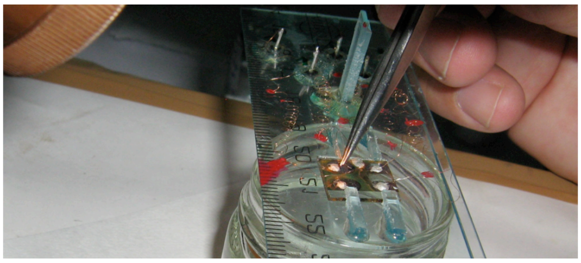
Magnetoresistance describes the effect of magnetic fields on electrical resistivity. Giant magnetoresistance is at the core of hard disks and on-chip sensors, and was the target of the 2007 Nobel prize in Physics awarded to Albert Fert and Peter Grünberg. Magnetoresistance and new related phenomena have been observed in organic semiconductors. Is this suggesting that we will, some day, have softer lower-cost magnetic storage?



Research team
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In collaboration with ITN and NHMFL.

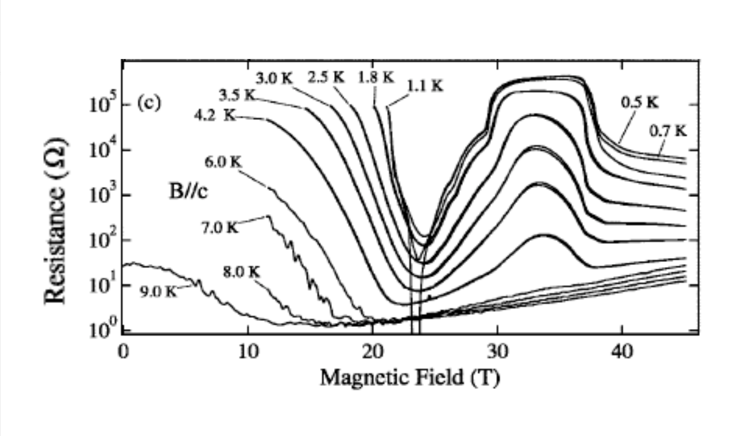
Organic Magnetoresistance

Organic materials are usually thought as insulators. However, in the late 1960's and early 1970's interest turned into the search for organic superconductivity, triggered by a paper appearing in the Physical Review, by W. A. Little, about the "Possibility of Synthesizing an Organic Superconductor" and based on the discovery of the first organic semiconductor, in Japan, in 1954. The dawn of organic superconductors came in 1980. The first with a very low critical temperature, 1.1 K. A decade later this critical temperature was raised by an order of magnitude in a new family of compounds.

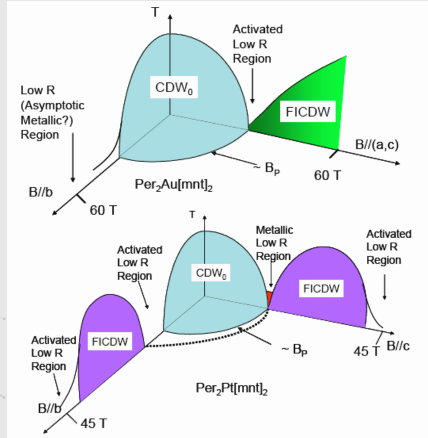
It was not surprising that this type of compounds were extensively studied under magnetic field, not only to get critical parameters of superconductivity, but also because they are extremely anisotropic, exhibiting low dimensional character in the energy band structure with subsequent instabilities, phase transitions and new interesting phenomena.

Magnetoresistance was observed even at room temperature and moderate fields in organic thin films sandwiched between two conductive electrodes — the structure of devices like OLEDs (organic light emitting diodes).

We are currently investigating the behaviour, under magnetic field, of organic electronic devices, prepared in our group in order to get insight into the mechanism responsible for the organic magnetoresistance.



The negative magnetoresistance of $Per_2M(mnt)_2$ up to 23 tesla (ref. 7)



Phase diagram of $Per_2M(mnt)_2$ (M=Pt,Au) (ref

As a product of the rush for high conductivity in organic systems, Alcácer and coworkers [1] obtained a compound based on perylene and a dithiolate complex of platinum, $(Perylene)_2Pt(mnt)_2$ where mnt=maleonitriledithiolate. The conductivity is metallic down to 8 K where a transition to an insulating state takes place. These compounds and others of the same family (M=Ni, Pd, Fe, Co) have been thoroughly investigated by collaborating groups in ITN, Sacavém, and our Institute. The influence of the magnetic field in the transition temperature was demonstrated by Matos et al [2] and more recently a collaboration with James Brooks of the National High Magnetic Field Laboratory, in Florida, USA, has extended the study of $Per_2M(mnt)_2$ (M = Au and Pt) to high magnetic fields. The main results, displayed in figures 1 and 2, show an impressive phase diagram. At very low temperatures and at zero magnetic field, these compounds behave as insulators (physicists call it a Charge Density Wave state, CDW). At these temperatures, by increasing the magnetic field they become much less resistive or even restore the metallic behaviour. This means that they have an enormous negative magnetoresistance, with applied field **B** up to 23 tesla. Further increase of the magnetic field gives rise to other insulating states, — the so-called Field-induced CDW. The effect depends on the relative orientation of **B** to the crystal axis [3,4,5]

References:

[1] L.Alcácer *et al Solid State Commun.* 1980, **35**, 945

[2] M. Matos *et al Phys. Rev. B,* 1996, **54**, 15307.

[3] “High magnetic field induced charge density wave state in a quasi-one dimensional organic conductor”, D. Graf, E.S. Choi, J. S. Brooks, M. Matos, R.T. Henriques, M. Almeida, *Phys. Rev. Lett.*, **93**, Art#076406 (2004).

[4] “Magnetic field dependence of CDW phases in (Per)(2)M(mnt)(2) (M = Pt, Au)”, J. S. Brooks, D. Graf, E.S. Choi, M. Almeida, J.C. Dias, R.T. Henriques, M. Matos, *Journal of Low Temperature Physics* **142** 787-803 (2006)
.

[5] Quantum interference in the quasi-one-dimensional organic conductor (Per)(2)Au(mnt)(2); Graf, D; Brooks, JS; Choi, E.S, M. Almeida, R. T. Henriques, J. C. Dias, and S. Ujil. PHYSICAL REVIEW B, **75**, 24, 245101 (2007)

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