High Temperature Superconductors: Complex materials with novel physics opportunities

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Superconductivity is a macroscopic quantum phenomenon with outstanding properties and impact in many applications. The quantum nature of superconductivity enables the formation of a condensate at the energy ground state by electron-pairing (Cooper pairs) providing zero resistance materials. Since high temperature superconducting (HTS) materials were discovered 30 years ago, new opportunities were envisaged because large electrical currents without losses could be expected at liquid nitrogen temperatures, however they faced unknown physics and new materials engineering complexities. HTS are strongly correlated systems showing unconventional superconductivity and novel vortex physics appear associated to high thermal fluctuations, larger crystalline anisotropy and nanometric nature of the HTS superconducting parameters. Beyond the still unsolved questions, nowadays, the international community is able to fabricate HTS materials for high current energy efficient applications (high power cables, wind generators, electrical aviation) and large scale infrastructures (fusion, circular colliders, high frequency NMR).

In this presentation, I will introduce the basic principles of superconductivity and discuss the unconventional physics of HTS. I will then present our contributions specially in the area of vortex physics of HTS materials. I will finalize with a brief summary of the present applications of HTS.

Control magnetic fields while controlling your professional career

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In this talk I will present a summary of our recent works on advanced control of magnetic fields. In particular, I will show how magnetically coupled systems can achieve asymmetric coupling by breaking magnetostatic reciprocity. I will also report our recent theoretical and experimental results on negative-permeability metamaterials which are shown to shape magnetic fields in unheard ways. On the other hand, I will also summarize my professional career and discuss the choices and uncertainties that I have faced and that still face now that I am aiming to make a professional transition.