Theory of flux penetration and flux motion in high temperature antiferromagnetic superconductors

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We demonstrate that the antiferromagnetic superconductor shows very interesting behavior in a magnetic field applied below the Neel temperature T_N. When a sample is in the virgin state, initially it magnetizes like ordinary type II superconductor, it undergoes transformation from the Meissner to the mixed state. When the field is further increased a new state appears, a kind of the Meissner state but, in the contrary to the original one, with a constant flux density inside the sample. We show that in this new Meissner−like state vortices undergo metamorphosis during which a domain of spin−flop phase is created around a vortex core. This metamorphosis leads to a spatial redistribution of the shielding supercurrent flowing around the core so as to keep constant the flux carried by the vortex and, also, leads to a redistribution of the magnetic induction inside the vortex. As the result, a new energy barrier is formed near a surface preventing vortices from entering into the sample. To overcome this barrier by the vortices with the newly created magnetic structure the external field must be increased beyond a second critical field for flux penetration. The above considerations apply to classical superconducting Chevrel phases [1] as well as to the high T_C superconductors, where antiferromagnetic order is produced by the regular lattice of the rare earth ions occupying the isolating layers [2,3]. We consider in this talk the resistive properties of the layered high T_C antiferromagnetic superconductor which are caused by a thermally assisted flux motion of the system of the above mentioned vortices. We will show that the behavior of several physical quantities such as: magnetization, activation energy, current−voltage characteristic and flux creep changes when the direction of the external field changes in the basal **ab** plane. It will also be shown that the decay of the trapped flux is logarithmic function of time. Next, using Caldeira−Leggett method we consider the tunneling of such vortices through the intrinsic pinning barriers. We will show that it is possible in the layered high T_C antiferromagnetic superconductor to crossover from the quantum creep regime to the thermal one, at constant temperature, if the intensity or the direction of the applied magnetic field is changed in the basal **ab** plane.

1. T. Krzyszton, and K. Rogacki, to be published in Phys. Rev.
2. T. Krzysztoń, Physica C 294, 47, (1998).
3. T. Krzysztoń, Physica C 340, 156, (2000).