
Report of the Third Referee -- WJ10056/Hirsch

I recommend that this paper be rejected.

The author believes that the modern theory of superconductivity fails to explain the dynamics of the superconducting transition; specifically, the process of expelling the magnetic field from the during cooling the system from the normal to the superconducting state.

The logic of the authors is as follows.

1. At a temperature slightly above the critical point, a superconductor is an almost perfect conductor.

2. Being an almost perfect conductor, the system has to respect—with a reasonable accuracy—the Alfven's theorem.

3. The Alfven's theorem implies the flow of the charge from the bulk towards cold walls.

There is a profound flaw in this logic. What the author misses is the two-fluid behavior of superfluid/superconducting systems at finite temperature. The close-to-perfect conductivity on the approach to the critical comes from the (almost)superfluid component of the system, while the normal component stays absolutely normal, with a finite viscosity. Yet another crucial element of the picture is the tangle of vortices, each vortex carrying quantized magnetic flux. In the absence of the normal component, the vortices would move with the local velocity of the superfluid component, in perfect agreement with the Alfven's theorem. In the presence of the normal component, the dynamic picture changes dramatically. The normal component interacts with the vortices, severely breaking the regime of Alfven's theorem.

In fact, the phenomenon explaining the cooling dynamics is the COUNTERFLOW: The normal component flows from the bulk towards the cold walls, dragging the vortices and thus purging the system from the magnetic field. The superfluid component flows from the walls into the bulk.