Report of the Third Referee -- BG14421/Hirsch

In this paper, the author analyzes what happens in a cylindrical type-I superconductor in an external magnetic field when the temperature changes. Based on thermodynamic considerations he concludes that no entropy production should take place inside the sample during the process. On the other hand, from an analysis of the process within the two-fluid model he finds that the conventional theory does predict a finite amount of dissipation. Therefore he concludes that the conventional theory of superconductivity is incomplete.

I believe that this argument is not correct. In order to show this, let us consider a mechanical analogy of the process studied in this manuscript. Namely, let us consider a gas in a large container and let us take into account the effect of the gravitational field on the gas. We will be interested in the change of the entropy of the gas when its temperature changes from an initial value T_1 to the final value $T_2<T_1$. Following the discussion in the manuscript we will assume that, at the beginning, the gas and the reservoir are thermally insulated and both are in thermal equilibrium; at the end the gas and the reservoir are in full thermal contact and in equilibrium. If the process is infinitesimally slow, the change of the entropy of the combined system gas + reservoir (=universe) is ΔS. However, if the process runs at a finite speed, there will be a macroscopic flow of matter in the system (the center of gravity of the gas will move down). There definitely exist geometries for which the flow will be inhomogeneous. In a viscous gas, an inhomogeneous flow will generate heat Q_J due to internal friction (see e.g. Landau-Lifshitz, Hydrodynamics, paragraph 49) which generates an additional contribution S_J to the total entropy change of the universe, which is completely analogous to the contribution of the Joule heat in a superconductor. Having observed this, let us follow the argumentation of the present manuscript: “However, this does not make sense. Our system and the heat reservoir constitute our universe, their energy and entropy are functions of state, and the initial and final states in our process for both the system and the reservoir are uniquely defined. Therefore the heat transferred Q and the change in entropy of the universe ΔS are uniquely defined. There is no room for either Q_J nor S_J …. we have to conclude that the conventional theory is internally inconsistent, hence needs to be repaired or replaced.” Unfortunately, in our example the conventional theory is the usual hydrodynamics.

This leads me to conclude that the above argumentation must be wrong, most probably in some subtle sense which I am not able to identify clearly. In any case, if the author were right then not only the theory of superconductivity would have to be revised.

In conclusion, I believe that the presented argument is incorrect and the paper should not be published.