"Superconductors, the Big Bang, and how to cool electrons at a rate of $10^8$ K/sec"

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Some Cosmological models propose that elementary particles were created during the cooldown of the universe after the “Big Bang”, through a series of symmetry breaking phase transitions[1]. According to these models, these elementary particles are “topological defects” of the cold, ordered phase in which the universe is found today. The equations describing these phase transition of the universe are similar to those describing the transition from a normal conducting metal into a Superconductor.

Obviously, the “Big Bang” cannot be recreated. However, It was suggested that these cosmological models can be tested in the laboratory using Superconductors[2]. We decided to test these prediction. In a superconductor, the topological defects which should appear during the transition are single quanta of magnetic flux, each carrying a flux $\Phi_0 \equiv h/2e = 2 \times 10^{-7}$ Gauss cm$^2$. To get a feel for small it is, it takes more than $10^6$ flux quanta/cm$^2$ to produce the earth’s field. The rate of creation of these defects is predicted to depend on the cooling rate as $(dT/dt)^{1/8}$, namely very weakly. In order to have any chance of observing the effect, one must use a very high cooling rate.

We describe an experiment in which we cooled a thin Superconducting film was at rates approaching $10^8$ K/sec. Simultaneously, we constructed a highly sensitive Magneto-optical detection system which is capable of resolving single flux quanta.

The experiment, its outcome and relation to the Cosmological models will be discussed.