Self−organization of the critical state in granular superconductors

S.L.Ginzburg and N.E.Savitskaya

Petersburg Nuclear Physics Institute, 188300, Gatchina, Russia

This report is devoted to the problem of self−organization of the critical state in granular superconductors. We study the two−dimensional multijunction SQUID with large SQUID−parameter , with being the critical current density, the size of granule, the magnetic flux quanta. Under this circumstances system has a large number of metastable states, which situation is typical for the self−organized critical state.

According to the concept of self−organized criticality (SOC) [1] the large dissipative systems never come to stable state but migrate from one metastable state to another by means of "avalanches" initiated by local perturbation. The criterion of self−organization in a system is the power−law behavior of probability density for avalanche sizes. Despite the wide range of dynamical systems behaves like self−organized ones the classical sand pile model and its modification still remain the main objects for theoretical investigations of self−organized criticality. The related experiments were performed only for a pile of sand [2].In this report we show that under certain conditions the critical state of the multijunction SQUID is self−organized. The physical properties of real granular superconductors lying in the basis of our model provides a number of new interesting properties that cannot be observed in classical models of self−organization [3]−[7]. For example, we demonstrate that when in SOC−state granular superconductors can exhibits the quasiperiodic behavior [6]. This fact can explain such important but poorly studied phenomenon as bulk−squid. The authors also demonstrated that SOC in granular superconductors can be realized in closed system that was impossible in previously considered models [5].

Our results appear to have a principal character in view of the possibility to manufacture SQUIDs on the base of the recent advances of technology. We hope that the studied system may suit for practical investigations of SOC.

This work was supported by the Russian Foundation for Basic Research (project no. 99−02−17545), the Scientific Council of the "Superconductivity" direction of the program "Topical Directions in Physics of Condensed Media" (project no. 96021 "Profile"), the subprogram "Statistical Physics" of the State Scientific and Technical program "Physics of Quantum and Wave Processes" (project no. VIII−3), the State program "Neutron Studies of Matter", and (in part) the Russian Foundation for Basic Research (project no. 00−15−96610).

1. P.Bak, C.Tang, K.Wisenfeld, Phys.Rev.Lett., **59**,381−384(1987).
2. G.A.Held, D.H.Solina, D.T.Keane, W.G.Hang, P.M.Horn, G.Grinstein, Phys. Rev. Lett.,**65**,1120−1123 (1990).
3. S.L.Ginzburg,"Self−organization of critical state in Josephson lattices and granular superconductors", JETP, **79**, 334−354 (1994).
4. S.L.Ginzburg, N.E.Savitskaya,"Self−organization of the critical state in a chain of SQUIDs", JETP Letters, **68**, 719−725 (1998);
5. S.L.Ginzburg, N.E.Savitskaya,"Self−organization of the critical state in 2D multijunction SQUID under closed boundary conditions", JETP Letters, **69**, 133−140 (1999);

6. S.L.Ginzburg, M.A.Pustovoit, N.E.Savitskaya, "Interavalanche correlations in self–organized critical state of multijunction SQUID", Phys.Rev.E, **57**,1319–1326(1998)
7. S.L.Ginzburg, N.E.Savitskaya, "Self–organization of the critical state in granular superconductors" JETP, **90**, 202–216 (2000).