Relativistic dynamics of domain wall in one-dimensional SQUID array

M. Nishida[a], Y. Aoki[a], and T. Fujii[b]

[a]Graduate School of Advanced Science of Matter, Hiroshima University, Higashi-Hiroshima, Japan
[b]Department of Physics, Asahikawa Medical University, Asahikawa, Japan

A superconducting quantum interference device (SQUID) composed of three Josephson junctions has two lowest energy states, $|0\rangle$ and $|1\rangle$, which correspond to a persistent current circulating in opposite directions, when the total phase across the three junctions becomes π by applying half a flux quantum or by inserting a π junction. In a one-dimensional array of such SQUIDs, domain walls are formed between $|0\rangle$ and $|1\rangle$ domains. Since the SQUIDs in this array can be approximately described by a double sine-Gordon (DSG) model which obeys Einstein's special theory of relativity[1], it is expected that relativistic motion of the domain wall will be observed.
We investigate the classical dynamics of a domain wall in a one-dimensional SQUID array. We conduct numerical simulations of a discrete DSG equation, and show that the domain wall propagates solitonically through the SQUID array and exhibits quasi-relativistic behavior which agrees reasonably well with the predictions from a relativistic equation of motion of a particle, whose rest mass is extremely small compared to that of a single electron.
We also study the relativistic quantum mechanics of the domain wall, and discuss the possibility of the observation of relativistic quantum effects, such as Klein tunneling.

[1]M. Nishida, T. Kanayama, T. Nakajo, T. Fujii and N. Hatakenaka, Physica C **470**, 832 (2010).