Stable extended string-vortex solitons: new results

Igor Bogolubsky

Joint Institute for Nuclear Research, Dubna, Moscow Region

Investigation of field-theoretical models with extended string-like solutions opens new possibilities for theoretical consideration of nonperturbative phenomena in quantum field theory, condensed matter physics (e.g. high-temperature superconductivity) and cosmology (the "cosmic strings" hypothesis). Such studies should include two main steps: (i) analytical or numerical investigation of extended stable 2-dimensional solutions and (ii) their quantization using known methods based on notion of path integral.

In our presentation wa plan to discuss new features of solitonic strings which have been found recentlu within the so called $A3$ model. This model is the $U(1)$ gauge-invariant extension of the easy-axis Heisenberg antiferromagnet model. This contionuous gauge-invariant model posesses $Z(2)$ and local $U(1)$ symmetries which result in remarkable properties of its localized solutions.

The model under consideration belongs to the class of gauge-invariant sigma-models with $S2$-valued scalar field interacting with the Maxwell field. We shall show that there exist time-independent (stationary) topological solutions to the A3M model with topological indices ("mapping degree"), which have been found using so called "hedgehog" ansatz for the 3-component unit isovector field and "vortex" ansatz for the Maxwell field. Solitons exist for the values of dimensionless anisotropy parameter p such that $0 < p < p_{\approx}0.4$, and are dynamically stable for all admissible p. The energy of solitons is less than $8\pi Q_t$, that is the energy of Belavin-Polyakov topological solutions in isotropic model; for $p \to p$ soliton energy approaches $8\pi Q_t$ from below. For $p \to 0$ the soliton energy is about $1/3$ of the Belavin-Polyakov value for given Q_t. We shall consider properties of solitons with $Q_t = 1$ and $Q_t = 2$.

It is instructive to compare the $A3M$ topological solitons with Nielsen-Olesen vortices-strings found within the Abelian Higgs model. This comparison shows advantages of the $A3M$ solitons from the field theoretical viewpoint. The $A3M$ extended strings can be considered as an alternative to infinitesimally thin strings being considered in modern (super)string theory, in order to avoid possible ultraviolet divergencies of Feynman graphs caused by zero radius of strings.