Research Plans

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One of long-term aims for my study is to get further progress in studies of domain walls and vortices and their application to particle physics, cosmology and condensed matter physics. For those application, we need to extend the moduli-matrix method so that we can treat solitons in various matter-Yang-Mills systems.

In the paper[33], we extended the moduli-matrix method for $U(N)$ gauge group coupled to $N_f(> N)$ fundamental matters, to that for an arbitrary gauge group $G\times U(1)$ coupled to matters of arbitrary representations, by considering conditions on the holomorphic G' invariants. Using this extended moduli-matrix method we actually obtained vortex solutions and their moduli spaces in $G = SO(N), G = USp(N)$ cases[38,45]. This extention tells us that generic solitons in generic systems contain new type of vortex solution, 'fractional vortex' we called and vortices we had treated so far are of the special types in some sense[39]. In such a sense it is important to consider further extention of the moduli-matrix method so that we can treat more various types of vortices.

So far we assumed that a gauge group G must act on matters freely in vacuum, that is, there is no Coulomb phase with respects to any subgroup of G since existence of vortices and domain walls is supported by topological defects in Higgs phases. But this assumption might be too strong and I am trying to get a systematic method to construct solutions and extract moduli parameters of solutions under the assumption relaxed. An extention of the method induced by this relaxation is unavoidable, for instance, to investigate vortices in models like the standard model. Recently, as a preliminary we considered vortex solutions in a model where a vacua is in a Coulomb phase respects to an $U(1)_{em}$ subgroup of $G = SU(2) \times U(1)$. We found characteristic phenomena with non-trivial $U(1)_{em}$ magnetic flux on those vortices, which causes the Aharonov-Bohm effect for $U(1)_{em}$ charged particles in an effective low energy theory. It is interesting and important to investigate a systematic method to determine moduli of solitons in generalized models under the assumption relaxed and understand which phenomena emerges.