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Mathematical Physics and Nonlinear PDEs

My research work centers around two broad topics: the analysis of nonlinear elliptic Partial Differential Equations arising from gauge theoryand the variational method on the Newtonian N-body problem.

(A) In the last decade, various **Chern-Simons theories** have been studied in various physical model, such as relativistic Chern-Simon theory of high temperature superconductivity, Lozano-Marques-Moreno-Schaposnik model of bosonic sector of N=2 supersymmetric Chern-Simons-Higgs theory, and Gudnason model of N=2 supersymmetric Yang-Mills-Chern-Simons-Higgs theory. Those Chern-Simons models, after suitable ansate, can be reduced to nonlinear elliptic PDEs. I am interested in the following research topics.

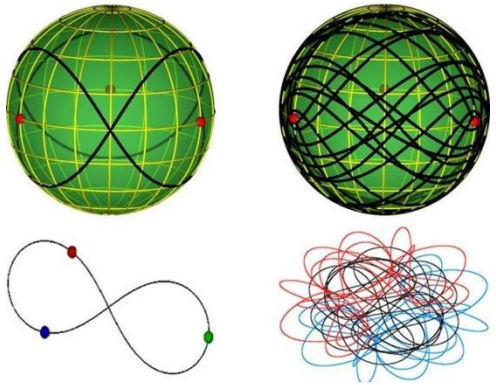
[1] limiting phenomenon of solutions.
[2] Shape estimates on the bubbling solutions.
[3] Sufficient and necessary conditions for the existence of bubbling solutions.

Chern-Simons-Higgs Equation $$\Delta u + \frac{1}{\varepsilon^2} e^u (1 - e^u) = 4\pi \sum_{j=1}^{N} \delta_{p_j}$$

(B) In the Newtonian **N-body problem**, the motion of N particles is determined by a system of second order differential equations. The least action principle suggests that the orbits extremize the Lagrangian action functional. However, the variational method had not been successfully applied to the Newtonian N-body problem until Chenciner and Montgomery's remarkable work in 2000. The main difficulty is to avoid unnecessary collisions occurred in the minimizers of the Lagrangian action functional. Collisions make the potential functional become infinite and the action may still be finite. I am interested in the following research topics.

[1] Existence of periodic solutions by variational method.
[2] Behaviors on the collision orbits and parabolic orbits by variational method.

Newtonian N-body Problem $$m_i \frac{d^2 q_i}{dt^2} = - \sum_{j=1, j \neq i}^{N} \frac{m_i m_j (q_i - q_j)}{||q_i - q_j||^3}, \quad i = 1 \cdots N$$



"Figure eight orbit" and "yarn orbit" to the three-body problem can be viewed on an abstract shape-sphere (*top*) or in real space (*bottom*).
Milovan Šuvakov and Veljko Dmitrašinović, *Phys. Rev. Lett.*, (2013); Milovan Šuvakov and Veljko Dmitrašinović /University of Belgrade