Classical and quantum behaviour of Skyrmions

This is a proposal for a University PhD Studentship

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Description of the research: Topological solitons are smooth, localized solutions of partial differential equation which can be thought of as extended particles. One important example is the Skyrme model, whose solitonic solutions are known as Skyrmions and model protons, neutrons and atomic nuclei. The study of the Skyrme model involves sophisticated numerical simulations. The development of efficient computer code for the simulation of topological solitons is one aim of the project.

Since protons and neutrons obey the laws of quantum mechanics, the Skyrme model with its Skyrmions also needs to be quantized. There are some technical issues (namely the calculation of what are called Finkelstein-Rubinstein constraints) which I have recently resolved. Using these techniques masses and excitation energies of atomic nuclei have been calculated and achieved remarkable qualitative agreement with nuclear physics. Improving and extending these calculations is an aim of this project.

A vast amount of nuclear physics experiments is concerned with the scattering of atomic nuclei - for example hitting a helium atom with a proton and measuring how the atomic nuclei break up. Such experiments can be compared to Skyrmion-Skyrmion scattering, an area of research which is currently in need of development. One of the aims of this project is to use both analytical approximations and numerical calculations to understand Skyrmion-Skyrmion scattering. There are early indications that the Skyrme model can help us to make experimental predictions in situations that are difficult to address with the standard techniques of nuclear physics.

References:

1) N Manton and P Sutcliffe, “Topological Solitons”, Cambridge University Press, 2004