ABSTRACT

A MATHEMATICAL RECIPE FOR NUCLEAR PASTA

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The strong interactions are certainly the most difficult ones to deal with in the Standard Model, at least in the low energy limit. This is due to the divergent infrared nature of the running coupling constant computed by means of Quantum chromodynamics (QCD), which prevents from treating the theory perturbatively. Thus, at low energies the non-perturbative effects of QCD become relevant and must be taken into account. The mechanisms that govern some phenomena of strong interactions are not well understood yet (the confinement of quarks is an example). In order to deal with them, a solution is represented by the so-called Effective Field Theories (EFT). Their role is to describe the visible phenomena and to *hide* the underling physics. In this sense, the Skyrme model can be considered a good candidate in order to outline some properties of QCD. In particular, it represents an EFT for baryons, which are interpreted as solitonic solutions (called skyrmions) that arise in a mesonic field (or Skyrme field). It gives its importance in physics to the fact that, first af all, it has been shown to well reproduce many properties of single baryons (such as their mass and radius). Moreover, thanks to the works of t'Hooft and Witten, it can be considered as the leading order of the large N_c expansion (where N_c is the number of color).

In very recent years, new remarkable results showed how the Skyrme model is also suitable for representing the physics of complicated systems of baryons, such as the *nuclear pasta*. This type of system was previously described only by means of numerical simulations, due to the complicated equations of motions that characterize the Skyrme model. The introduction of new ansätze opens to the possibility of finding new solutions and describing nuclear pasta analytically.

In this talk, I am going to outline the main properties of these, let us call, *pasta ansätze* from a mathematical point of view. In particular, I will consider the case in which the skyrme field is represented by a map from the space-time to a compact, simple Lie group G, representing the underling symmetry group of quark flavors. I will discuss the conditions which lead to topologically non-trivial solutions, giving rise to solitons. As I will show, the main physical quantities (such as the energy and the baryonic charge) have a general formulation in terms of the properties of the Lie group G, depending on them only through some factors. In addition, I am going to discuss the possibility of introducing a coupling with a $U(1)$ gauge field, generalizing the concept of the *covariant baryonic charge*, already introduced by Witten, and defining the conditions which leads to analytical solutions to both the Skyrme equations and the gauge field equations.