PhD position to carry out fundamental research in particle physics within the research group SOM (Flavour and origin of matter, Sabor y Origen de la Materia)

Research Project / Research Group Description:
The research activities of the SOM group address open questions in particle physics and cosmology that point towards physics beyond the Standard Model (SM).

The SM explains accurately most of the experimental results involving elementary particles and their interactions, however it faces still several challenges, particularly in those processes involving the strong interactions. The regularization of the theory on a space-time lattice is a first-principles method that has been successfully applied to understand non-perturbative phenomena such the rich mesonic and baryonic spectra, the breaking of chiral symmetry or the confinement of color charges. Lattice QCD has become an indispensable tool to identify possible effects of new physics in flavor physics.

On the other hand, the results of the first phase of LHC with the discovery of a resonance with the properties of the Brout-Englert-Higgs particle, together with no other deviation from the predictions of the SM, have put forward the intriguing possibility that the SM could be all there is up to very high energy scales (even as far as the Planck scale). The hierarchy problem and the flavour puzzle remain daunting open questions. The SM is a very predictive theory in perturbation theory, however the limits of the SM as an effective theory remain also beyond the scope of perturbation theory (e.g. there is a Landau pole in the self-coupling of the Higgs at a sufficiently high energy). This problem also needs a non-perturbative approach such as that provided by the lattice formulation.

Our research group involves six senior researchers with an internationally recognized experience in particle physics and cosmology. We are involved in two European networks: the Training Network Elusives (H2020-MSCA-ITN-2015//674896-ELUSIVES) and the RISE project InvisiblesPlus (690575 — InvisiblesPlus — H2020-MSCA-RISE-2015). Both of these projects focus on neutrino and dark matter phenomenology and their connection, with emphasis on the role of the symmetry relating matter and antimatter. They involve research groups from six other European countries and seven associated nodes from non-european ones. The PhD candidate will have the opportunity to participate in all the training, research and networking activities of these networks.

Job position description:
The candidate is expected to contribute to two of our research lines in lattice field theory. The first concerns a long-standing problem in lattice QCD, which is the so-called Delta I=1/2 rule, which refers to the large hierarchy observed in the rates of hadronic kaon decays to two pions in the two isospin channels. A new approach pioneered by our group towards the understanding of this problem is the first-principles study of its dependence on the number of colours, Nc, via the lattice formulation. It is well-known that QCD simplifies significantly in the limit of large number of colours, while maintaining essential properties such as confinement and chiral symmetry breaking. Although the strict large Nc limit cannot account for the Delta

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I=1/2 rule, the leading 1/Nc dependence might give some important clues towards a full understanding of the underlying dynamics.

The second line of research concerns the interesting possibility that the electroweak sector may be a confined and a strongly interacting theory, and nevertheless resemble a weakly coupled theory at low-energies, an idea put forward in the late 70's that has not been disproved. Such possibility would most probably imply deviations from the SM at energies not much higher than the electroweak scale and could predict a rich phenomenology in the second phase of LHC. The simplest of such scenario is the SU(2)-gauged non-linear chiral model that is known to give rise to a Higgs-like resonance. The very significant progress in lattice QCD of the last decade has resulted in new methods and algorithms that can be readily applied to the lattice formulation of these models improving significantly the old results of the 80's and 90's. In particular, the precise determination of the spectrum provides very valuable information and might have very interesting implications for the SM. Initial promising results have been published by our team.

Skills required: the candidate is expected to have taken courses at the master level in Quantum Field Theory and the Standard Model of particle physics.

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