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The possible non-perturbative physics of the (Beyond the) Standard Model is as much debated at least as the break-down of its very useful perturbative expansions: this is only one reason to search for and talk about nonperturbative phenomena from condensed matter to complex systems going through quantum computing. Substantially relaunched by Fermi himself, the idea of 'soliton' or 'instanton', for instance, travelled to us through the work of great physicist like Bethe, Yang, Coleman, 't Hooft, Polyakov, Polchinski, Zamolodchikov, Witten, Parisi and Maldacena, just to mention some, to take a privileged place in gravitational and gauge phenomena, -nowadays related by non-perturbative dualities -, but also in statistical mechanics and disordered systems. In this very exciting milieu, the world-wide expert V. Kazakov (prominent professor at Ecole Normale Supérieure in Paris) will be talking with us (students, professors, researchers) about the very modern achievements in solving exactly and definitely some (quantities of) peculiar quantum field theories living in our four-dimensional world and still keeping hidden many mysteries of their solvability or, better, integrability.

SOLVABLE QUANTUM FIELD THEORIES IN 3+1 DIMENSIONS

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ABSTRACT

Strongly interacting 4-dimensional quantum field theories (QFT), are of paramount importance for the description of Nature, but are very hard to study. We still have very poor set of analytic tools to analyze their non-perturbative dynamics, to go beyond Feynman perturbation theory and renormalization group. On the other hand, we have a big variety of exactly solvable, or integrable, 2-dimensional QFTs, where we can compute analytically, or with great precision numerically, genuinely non-perturbative quantities. Can we apply this knowledge for the study of 4-dimensional theories? In the past 20 years, there have been developed new analytic methods of studying the strong coupling regime of at least a handful of these theories, using the AdS/CFT correspondence. The most remarkable of the QFTs is the maximally supersymmetric Yang-Mills theory, called $\mathcal{N}$=4 SYM. Its string dual allows to penetrate into the mystery of its strong coupling behavior. Moreover the dual string sigma model, at least in the absence of string interactions, represents a particular integrable QFT and hence we have a unique possibility to study $\mathcal{N}$=4 SYM at any coupling, at least in a special large N_c ('t Hooft) limit. After quick overview of integrable (1+1)-dimensional systems, I will demonstrate how this 2D integrability led to the solution of the problem of spectrum of anomalous dimensions of $\mathcal{N}$=4 SYM. I will illustrate it by particular non-perturbative results and mention some interesting limits of $\mathcal{N}$=4 SYM, such as fishnet conformal field theory.