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Fractal dimension of Yang-Mills Fields

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The role played by non extensive thermodynamics in physical systems has been under intense debate for the last decades. With many applications in several areas, the Tsallis statistics [1] has been discussed in details in many works and triggered an interesting discussion on the most deep meaning of entropy and its role in complex systems. Some possible mechanisms that could give rise to non extensive statistics have been formulated along the last several years, in particular a fractal structure in thermodynamics functions [2] was recently proposed as a possible origin for non extensive statistics in physical systems [3]. In this work we analyse how scaling properties of Yang-Mills field theory allow the appearance of self-similar structures in gauge fields. The presence of such structures, which actually behaves as fractals, allow for recurrent calculation of vertexes even in high orders of perturbative calculation. Some general properties are indeed independent of the perturbative order, what simplifies the calculations. It is argued that for sufficiently high orders a statistical approach can be used, and it is shown that non extensive statistics is obtained, and the Tsallis index, q, is obtained in terms of the field theory parameters. The results are applied to QCD in the one-loop approximation, where q can be calculated, resulting in a good agreement with the value obtained in experiments. This work is based on Refs. [4,5].

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