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Instantons within the Functional renormalization group

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As spatial dimensionality gets lower it becomes more difficult for a system to order. At some dimensionality, the so called lower critical dimension, the fluctuations prevent ordering all together and the only way to order is to put temperature to 0. We discuss the scenario of the approach to lower critical dimension within the Functional renormalization group (FRG) for the scalar φ^4 theory. There we expect localized, instanton-like (kink-like) excitations to proliferate and the fixed point to disappear. Despite FRG seemingly being a correct tool for the job, capturing this scenario has proven to be a difficult problem and one typically obtains the possibility of ordering where it should not be possible [1,2]. We uncover the analytical structure of the FRG that allows us to understand the source of the problem [3]. Remarkably we indeed find that FRG captures the localized instantonic excitations, albeit in a rather indirect way. We shall discuss the applications of our work to some open problems that we believe we can elucidate, for example: a) quantum mechanical tunneling problem in the low temperature limit which appears in description of the Sine-Gordon problem [4]; b) the question of lower critical dimension in hysteresis [5]. References [1] Ken-Ichi Aoki, Atsushi Horikoshi, Masaki Taniguchi and Haruhiko Terao: “Non-Perturbative Renormalization Group Analysis in Quantum Mechanics” , Progress of Theoretical Physics 108 571 (2002) [2] Alfio Bonanno, Alessandro Codello and Dario Zappalà: “Structural aspects of FRG in quantum tunneling computations”, Annals of Physics 445 169090 (2022), [3] Lucija Nora Farkaš, Gilles Tarjus, Ivan Balog: “Approach to the lower critical dimension of the φ^4 theory in the derivative expansion of the functional renormalization group”, Physical Review E 108 054107 (2023) [4] Romain Daviet and Nicolas Dupuis: “Nature of the Schmid transition in a resistively shunted Josephson junction”, Phys. Rev. B 108, 184514 (2023) [5] D. Spasojević, S. Janičević, and M. Knežević: “Numerical Evidence for Critical Behavior of the Two-Dimensional Nonequilibrium Zero-Temperature Random Field Ising Model” Physical Review Letters 106, 175701 (2011)

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