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Fractional Miransky Scaling Law

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Abstract

We study dynamical mass generation in a strongly coupled abelian gauge theory when the differential structure of the gap equation is promoted to non-integer order. The starting point is the linearized rainbow Schwinger–Dyson equation, whose integer-order form is an Euler equation. We replace that equation by an equidimensional fractional Euler equation built with the Riemann–Liouville derivative and solve it with a power ansatz. The critical coupling appears as the point where two real characteristic exponents merge into a complex conjugate pair, while the infrared and ultraviolet boundary conditions quantize the ratio between the two scales of the problem. What comes out is a Miransky-type scaling law in which the fractional order reshapes the essential singularity through an order-dependent prefactor and shifts the additive constant, both of which return to their quantum electrodynamics values when the order goes back to unity. We map the critical line in the plane spanned by the coupling and the fractional order, and we ask what the memory carried by the fractional derivative does to the onset of chiral symmetry breaking.

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