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On the Proof of Chiral Symmetry Breaking from Anomaly Matching in QCD-like Theories

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Confining QCD-like sectors are often present in BSM phenomenology. We critically reconsider the argument based on 't Hooft anomaly matching that aims at proving chiral symmetry breaking in 4d confining QCD-like theories with $N_c > 2$ colors and N_f flavors. We provide a detailed proof and clarify under which (dynamical) conditions the historical approach of N_f-independence holds, as a property of the solutions of the anomaly matching and persistent mass equations. The validity of N_f-independence was assumed in previous works based on qualitative arguments, but it was never proven rigorously. Then, we furnish a novel strategy, called 'downlifting', that allows to prove chiral symmetry breaking for any $N_f \geq p_{min}$, where p_{min} is the smallest prime factor of N_c. Contrary to earlier attempts, our results do not rely on ad-hoc assumptions on the spectrum of massless bound states. The proof can be extended to $N_f < p_{min}$ under the additional assumption on the absence of phase transitions when quark masses are sent to infinity.

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