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The nature of the QCD thermal transition as a function of quark flavours and masses

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Attempts to extract the order of the chiral transition of QCD at zero chemical potential, with two dynamical flavours of massless quarks, from simulations with progressively decreasing pion mass have remained inconclusive because of their increasing numerical cost. In an alternative approach to this problem, we consider the path integral as a function of continuous number N_f of degenerate quarks. If the transition in the chiral limit is first-order for $N_f \geq 3$, a second-order transition for $N_f = 2$ then requires a tricritical point in between. This in turn implies tricritical scaling of the critical boundary line between the first-order and crossover regions as the chiral limit is approached. Non-integer numbers of fermion flavours are easily implemented within the staggered fermion discretisation. Exploratory simulations at $\mu = 0$ and $N_f = 2.8, 2.6, 2.4, 2.2, 2.1$, on coarse $N_\tau = 4$ lattices, indeed show a smooth variation of the critical mass mapping out a critical line in the (m, N_f) -plane. For the smallest masses the line appears consistent with tricritical scaling, allowing for an extrapolation to the chiral limit.

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