Variational Monte-Carlo investigation of SU(N) Heisenberg chains

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Motivated by recent experimental progress in the context of ultra-cold multi-color fermionic atoms in optical lattices, we have investigated the properties of the SU(N) Heisenberg chain with totally antisymmetric irreducible representations, the effective models of Mott phases with \( m < N \) particles per site. These models have been studied in 1986 by Affleck [1][2] with non-abelian bosonization, an approach that allowed him to make predictions regarding the nature of the ground state (gapped or critical) in most but not all cases. Using exact diagonalization and variational Monte-Carlo based on Gutzwiller projected fermionic wave functions, we have been able to verify Affleck’s predictions for a representative number of cases with \( N \leq 10 \) and \( m \leq N/2 \), and we have shown that the opening of a gap is associated to a spontaneous dimerization or trimerization depending on the value of \( m \) and \( N \). We have also investigated the marginal cases where abelian bosonization did not lead to any prediction. In these cases, variational Monte-Carlo predicts that the ground state is critical, with exponents consistent with conformal field theory.