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Physics of the spin gap in the $S = 1/2$ Heisenberg antiferromagnet on kagome[1]

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A combination of low spin and strong frustration makes the $S = 1/2$ Heisenberg antiferromagnet on kagome a likely candidate for an unusual ground state and elementary excitations. Exact-diagonalization studies [1] on finite clusters point to a lack of magnetic order in the ground state and to an energy gap of order $J/20$ for $S = 1$ excitations. The exact nature of the ground state and elementary excitations remains a subject of vigorous debate. Among the proposed ground states are chiral [2] and non-chiral [3] spin liquids and a valence-bond crystal (VBC) [4-5]; spin excitations range from deconfined spinons with a Bose [6] or Fermi statistics [2-3] to magnons [7]. We show that the system behaves as a collection of spinons, quasiparticles with $S = 1/2$ and Fermi statistics, whose motion disturbs valence-bond order. Attraction between spinons, mediated by exchange, binds them into small, massive pairs of $S = 0$ with a binding energy of $0.06J$ [8]. The pair formation strongly suppresses the motion of individual spinons and makes the survival of the Singh-Huse VBC plausible. A spin excitation amounts to breaking up a pair into two (nearly) free spinons with $S = 1$. The survival of the VBC is expected to lead to spinon confinement; however, small energy differences between various valence-bond configurations would make the confinement length large.

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