Signature of preformed pairs in angle-resolved photoemission spectroscopy

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We use density matrix renormalization group (DMRG) and variational exact diagonalization (VED) to calculate the single-electron removal spectral weight for the Hubbard-Holstein model at low electron densities. Tuning the strength of the electron-phonon coupling and of the Hubbard repulsion allows us to contrast the results for a liquid of polarons versus a liquid of bipolarons. The former shows spectral weight up to the Fermi energy, as expected for a metal. The latter has a gap in its spectral weight, set by the bipolaron binding energy, although this is also a (strongly correlated) metal. This difference suggests that angle-resolved photoemission spectroscopy could be used to identify liquids of pre-formed pairs. Furthermore, we show that the one-dimensional liquid of incoherent bipolarons is well approximated by a 'Bose sea' of bosons that are hard-core in momentum space, occupying the momenta inside the Fermi sea but otherwise non-interacting. This new proposal for a strongly-correlated many-body wavefunction opens the way for studying various other properties of incoherent (non-superconducting) liquids of pre-formed pairs in any dimension.