ABSTRACT

Non-interacting lattice fermions in a two-dimensional lattice under strong uniform perpendicular magnetic field are found to behave strangely. For example, one comes across a *Hofstadter butterfly* spectrum, a fractal structure in quantum mechanics. The spectrum depends critically on the applied field $\alpha = p/q$; p and q are positive integers, (the ratio of the magnetic flux per plaquette to the flux quantum). What happens in the presence of Coulomb interaction (U) in a non-bipartite lattice? We present one such example. The magnetic field induces a charge-gap (largest at $\alpha = 0.5$) even in the absence of correlation, highlighting localization by the orbital magnetic field. Remarkably, this gap is initially suppressed by electron correlation and reappears at larger U in a simple correlated model, the Falicov-Kimball model (FKM). The condensation of preformed exciton in an extended FKM (EFKM) is addressed using self-consistent Hartree-Fock mean-field theory in the weak-coupling limit. The interaction U exponentially enhances the excitonic average (Δ), field α has a localization effect leading to a drop in Δ while V enhances Δ (exception at $\alpha = 1/3$, at low V and U). Exciton in a two-band system in an EFKM is studied using a semi-analytical approach, the slave rotor mean field theory in the large U-limit. The $\Delta - V$ behaviour is first order for single site and weakly first order for two-site approximation. We also investigate the orbital effects of a strong external magnetic field on the ground-state properties of a 2D Holstein polaron, employing variational approaches based on exact diagonalization (VAED). We calculate the electron-phonon correlation function, the average phonon number and the Drude weight. Although the external magnetic field affects the polaron throughout the parameter regime, it has a stronger effect on a loosely bound (spatially extended) polaron; it reduces the spatial extent of an extended polaron which results in a polaron of less spatial extent.