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The Ground-State Wave Function of a Polaron bound to a Coulomb Potential in a Strong Magnetic Field

The Fröhlich polaron is a model of an electron interacting with the quantized optical modes (phonons) of an ionic crystal. We shall consider a (three-dimensional) Fröhlich polaron in a homogeneous magnetic field of strength $B > 0$ and localized in a Coulomb potential. It can be shown using now-standard techniques in quantum field theory that there exists a unique ground-state wave function for all values of B.

It has been argued by E.A. Kochetov, H. Leschke and M.A. Smondyrev (Z. Phys. B. 89, 177-186 (1992)) that as $B \to \infty$ the (three-dimensional) magnetopolaron is "equivalent" to a one-dimensional polaron (without a magnetic field). Kochetov et. al's argument has been placed on a rigorous footing, at least for calculating the ground-state energy, only recently by R.L. Frank and L. Geisinger (Commun. Math. Phys. 338, 1-29 (2015)). Using their technique we see that as $B \to \infty$ the ground-state energy of our model is described by a one-dimensional minimization problem with a delta function potential.

Our contribution is to extend this description also to the wave function: We shall see that as $B \to \infty$ the ground-state wave function–after integrating out its phonon and transverse electron coordinates–converges in a weak sense to the (unique) minimizer of the corresponding one-dimensional problem. Moreover, the one-dimensional minimizer can be evaluated explicitly. Finally, we shall mention some open problems regarding the effective mass and the binding of polarons in strong magnetic fields.