The Dirac equation with the singular potential

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Abstract

We study the Dirac equation with a singular potential consisting of a superposition of the Aharonov-Bohm (AB) field (the field of an infinitely long and infinitesimally thin solenoid) and a collinear uniform magnetic field. Using von Neumann's theory of the selfadjoint extensions of symmetric operators we construct selfadjoint Dirac Hamiltonians in 2+1 and 3+1 dimensions. Each extension of the families is specified by certain asymptotic boundary conditions at the AB solenoid. The spectrum and eigenfunctions for each value of the extension parameter are found. We consider the regularized case of a finite-radius solenoid and study the dependence of the eigenfunctions on the behavior of the magnetic field inside the solenoid. We obtain particular selfadjoint Hamiltonians corresponding to the zero-radius limit of a finite solenoid (the natural extensions).

We construct and study various Green functions of the Dirac equation with the said singular potential. We consider the problem in 2+1 and 3+1 dimensions for the natural extensions of the Dirac operator and derive the Green functions as proper time integrals. We discuss a specificity of the problem related to the peculiarities caused by nontrivial behavior of the solutions in the neighbourhood of the background singularity.