Adiabatic Approximation and Berry's Phase in Quantum Mechanics

Mariam Vatsadze

e-mail: mariam.vatsadze907@ens.tsu.edu.ge
Department of Physics, Faculty of Exact and Natural Sciences,
Ivane Javakhishvili Tbilisi State University,
3, I. Tchavtchavadze Avenue, Tbilisi, 0179, Georgia

Analytical solution of time-dependent problems in quantum mechanics is often associated with difficulties; however, when the Hamiltonian of the system changes extremely slowly in time, the adiabatic approximation method — and its geometric generalization, the Berry phase, can be used. The thesis considers the time-dependent Schrodinger equation for cases where the Hamiltonian of the system changes slowly enough under the influence of external parameters under the conditions of a non-degenerate spectrum. Based on the expansion of the wave function into instantaneous eigenstates and the analysis of the corresponding system of differential equations for the coefficients, the adiabatic approximation is applied. It is shown that, in addition to the standard dynamical phase, the total ket-vector of the system acquires a geometric phase factor — the Berry phase. With the help of the gauge transformation and Stokes's theorem, it is substantiated that the Berry phase on a closed contour is a gauge-invariant and physically observable quantity.