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NONADIABATIC GEOMETRIC ANGLE IN NUCLEAR MAGNETIC RESONANCE CONNECTION

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Abstract. By using the Grassmannian invariant-angle coherents states approach, the classical analogue of the Aharonov-Anandan nonadiabatic geometrical phase is found for a spin one-half in Nuclear Magnetic Resonance (NMR). In the adiabatic limit, the semi-classical relation between the adiabatic Berry's phase and Hannay's angle gives exactly the experimental result observed by Suter *et al* [12].

1. Introduction

The adiabatic **Berry's phase** and its classical counterpart (adiabatic **Hannay's angle**) are one of the most finding in the quantum and classical dynamics these recent years. Their extension to the nonadiabatic case has attracted great interest. Indeed, removing the nonadiabatic hypothesis, Aharonov and Anandan [1] have generalized Berry's result. They have considered a cyclic evolution of states which return to itself after some time up to a phase. A way to get such a basis of cyclic states is to consider the eigenvectors of a Hermetian periodic invariant $I(t)$ defined by

$$\frac{\partial \hat{I}}{\partial t} = \mathrm{i}\left[\hat{I}, \hat{H}\right]. \tag{1}$$

Indeed, any eigenstate $|n, 0\rangle$ (relative to the time-independent eigenvalue λ_n) of the invariant operator $I(0)$ at time zero evolves into the corresponding eigenstate $|n, t\rangle$ of the invariant operators $I(t)$ at time t exactly as an eigenstate of the Hamiltonian does when the evolution is adiabatic [8].

Since the **invariant action** due to Lewis and Riesenfield exists, a geometrical angle can be defined on constant-action surface for a cyclic evolution [2, 4] and the angle thus obtained is the classical counterpart of the **geometrical phase** due to Aharonov and Anandan.