

A Quick Guide to Geometric Phase: Theory and Experimental Observation

Huan Q. Bui

DEPARTMENT OF PHYSICS
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

April 27, 2022

Contents

1	Adiabatic theorem	2
2	Berry phase	2
3	Berry connection and curvature	2
4	Example: Two-level system	2
5	Aharonov-Bohm Effect	2
6	Aharonov-Casher Effect	2
7	Observation of a Gravitational Aharonov-Bohm effect	3
7.1	Theory	3
7.2	Experimental setup	3

1 Adiabatic theorem

State the full theorem here. Provide no prove. The point is to introduce the idea of a *parametric Hamiltonian* which will appear in the discussion of Berry phase.

2 Berry phase

aka Geometric phase. Berry phase arises whenever a system undergoes a cyclic adiabatic evolution.

3 Berry connection and curvature

These are concepts that are associated with the Berry phase. Berry connection is also known as the Berry potential. It is gauge dependent and therefore cannot be observed. It is physical only after integrating around a closed path.

Berry curvature... more complicated. Don't know how useful it is to bring up the full definition. Probably best to demonstrate what these things are in the two-level system picture.

4 Example: Two-level system

Consider a spinor in a magnetic field. The (parametric) Hamiltonian is given by

5 Aharonov-Bohm Effect

Consider a charged particle in a magnetic field... The (parametric) Hamiltonian is given by

what is the parameter of the Hamiltonian? What is the closed loop here? Answer these questions.

6 Aharonov-Casher Effect

A dual to the Aharonov-Bohm effect. This is more of a sideline. I will mention only in passing.

7 Observation of a Gravitational Aharonov-Bohm effect

7.1 Experimental Techniques

7.1.1 Atom interferometry: The Mach-Zehnder Interferometer for Atoms

7.1.2 Bragg transition