

# Environmental noise reduction for holonomic quantum gates

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# What is Quantum Computation?

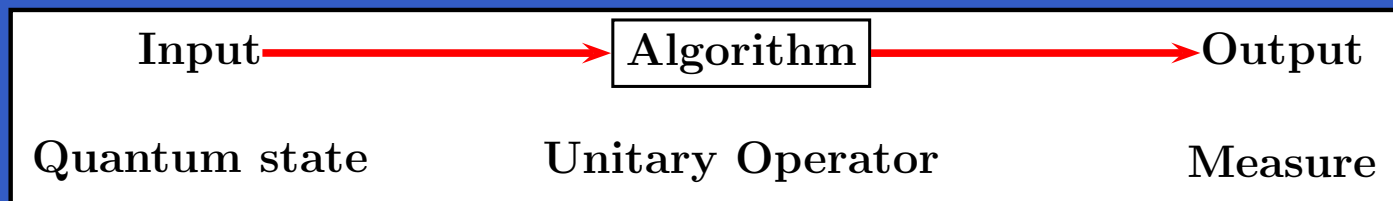
## Classical Computation



# What is Quantum Computation?

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Quantum Computation (QC)



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Power of QC: Ex. Quantum Parallelism

Logical Strings : 00001, 01010, 11010 etc.

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Superposition of "Logical Strings":

$$|\psi\rangle = |00001\rangle + |01010\rangle + |11010\rangle$$

# What is Quantum Computation?

Classical Computation

Quantum Computation (QC)

Power of QC: Ex. Quantum Parallelism

Stability against control and environmental noise?

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- 
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# Systems and Approaches to QC

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Almost any quantum system can be used to perform QC

- NMR, trapped ions, atom in cavity, Josephson Junction, Quantum Dots
- Quantum Dots with laser control



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Many way to perform QC

- Construction of "dynamical gates"
- Adiabatic Quantum Computation
- Geometric Quantum Computation

# Geometric Quantum Computation

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at the end of the evolution

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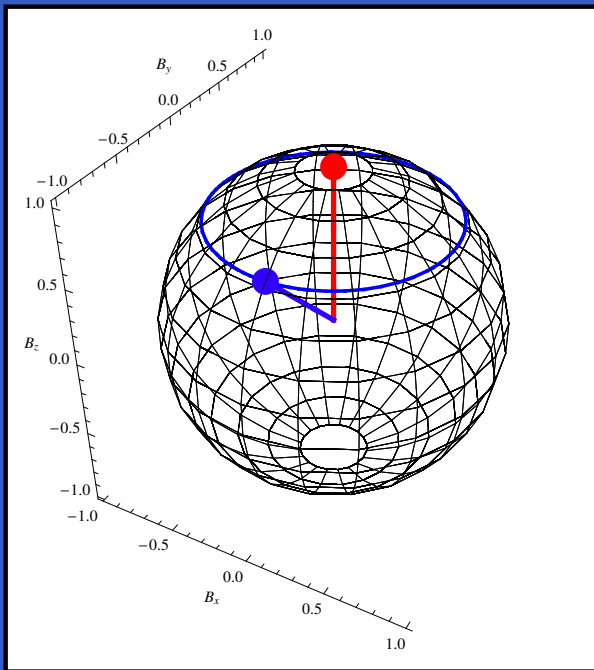
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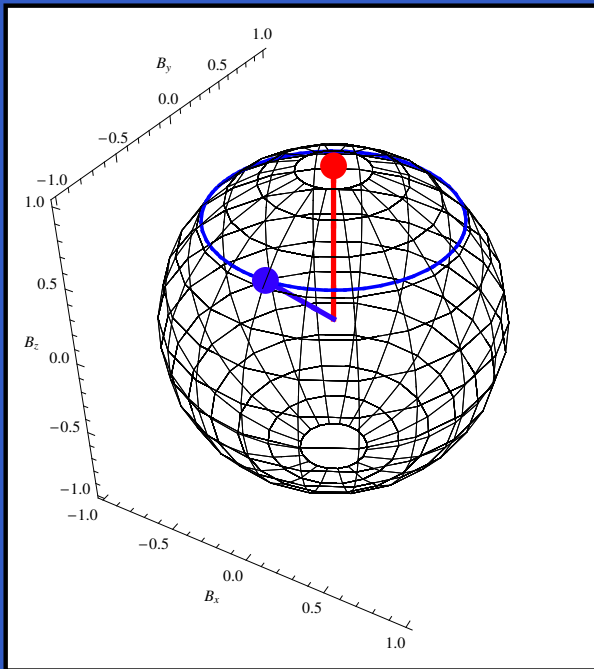
$\varphi$  is the **geometric (Berry) phase**

**Holonomic Quantum Computation:** geometric approach with generalized Berry phase

# Berry Phase



# Berry Phase



Evolution is driven by  $H(t)$ :  
a curve in the parameter space is associated to a  
dynamical evolution

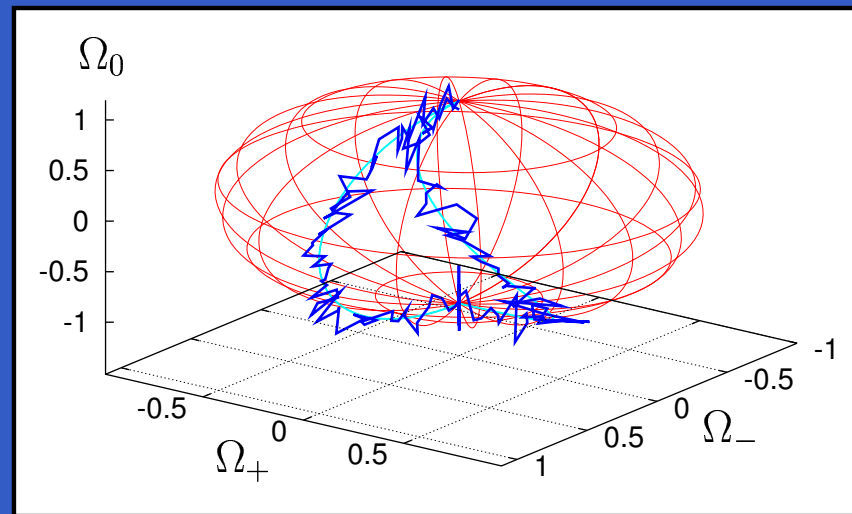
# Noise in QC

- Geometric Quantum Computation is robust against control errors



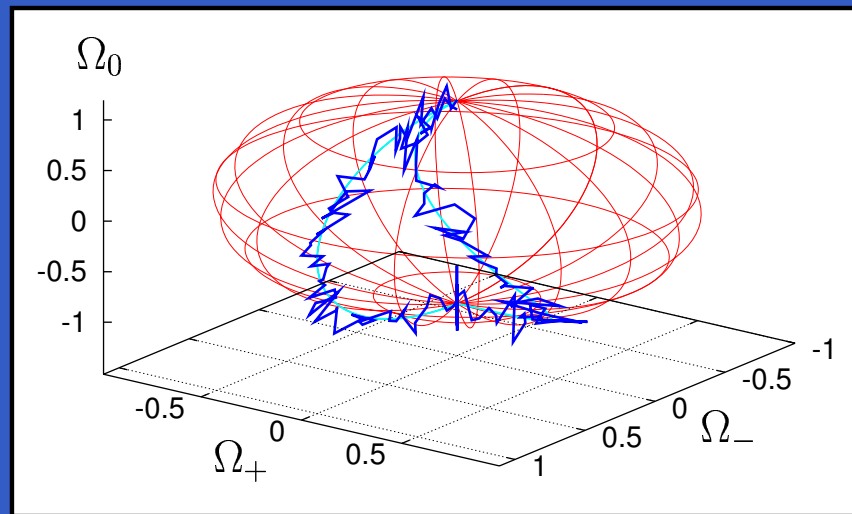
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- Control errors cancel out

# Environmental noise

- System interacting with a bath of bosons

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Analytical evaluation of the error induced by the environment

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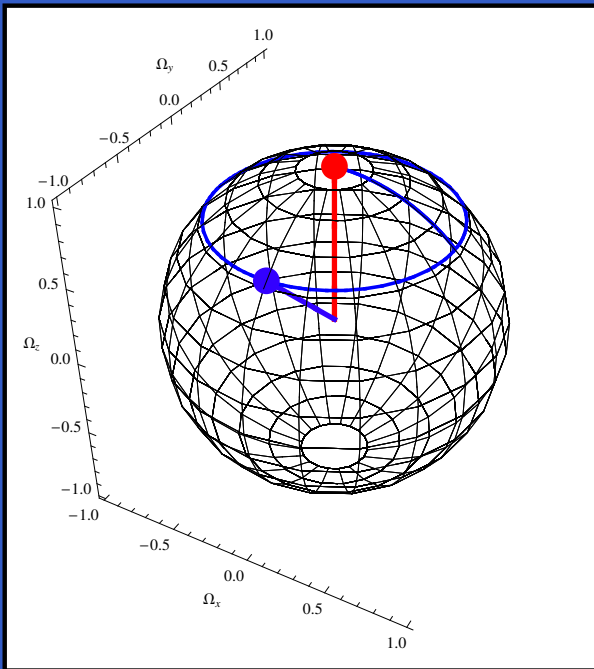
# Environmental noise

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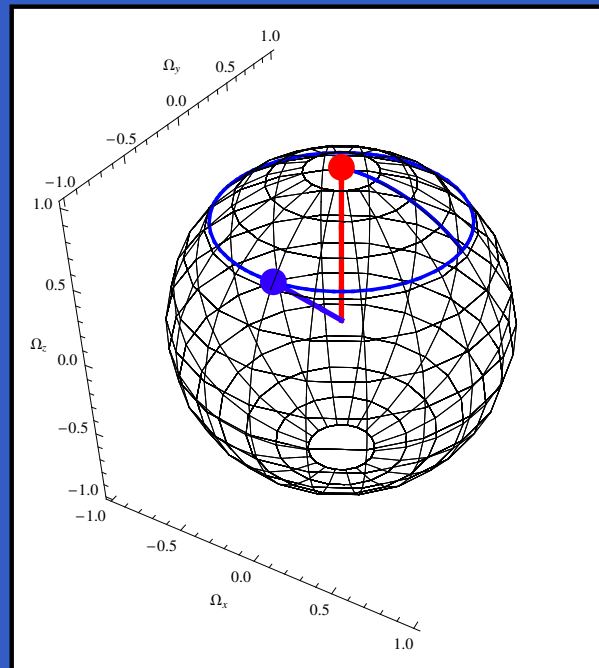
⇒ we can separate the operator applied from the dynamical evolution

find a weakly affected evolution producing the same geometric operator

# Environmental noise

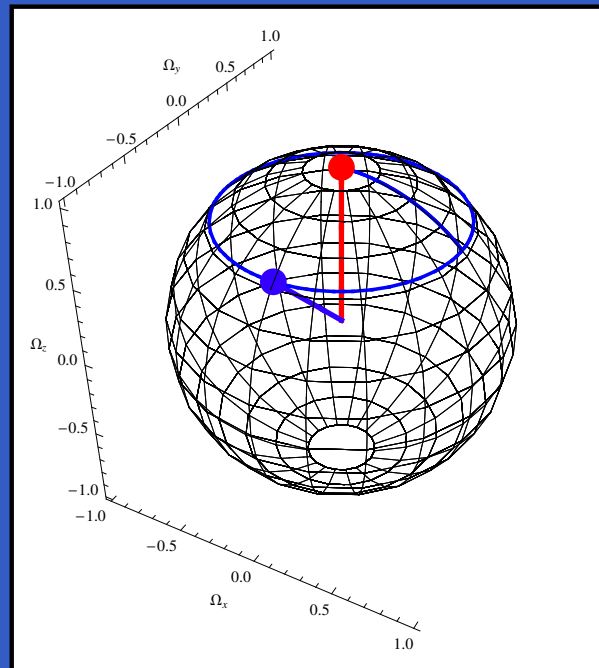


# Environmental noise



- the North Pole is a noise free point  $\Rightarrow$  Best loops are those near the North Pole
- Spherical Cap covered several time

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Once fixed

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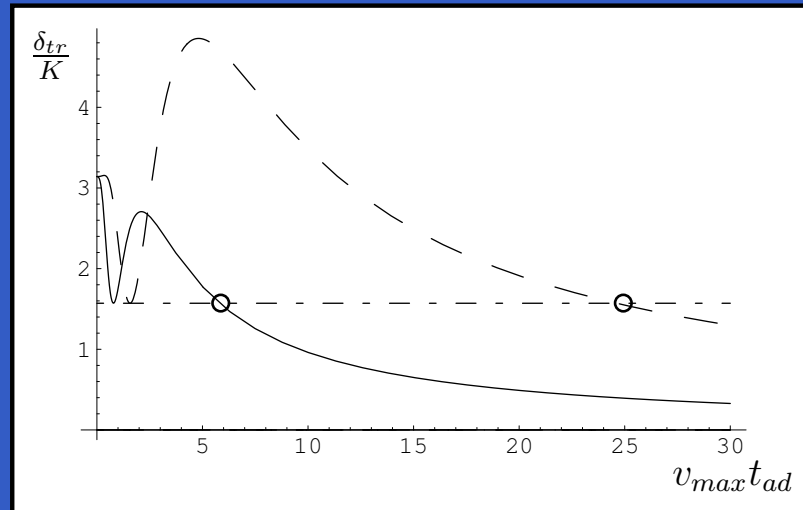
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⇒

the noise effect decrease decrease with time evolution  $\delta \propto \frac{1}{T}$

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## Geometrical Quantum Computation

- Robust against control error
- Possibility to reduce the environmental noise
- Separation of Geometric Operator from Dynamical (Noise) Effect
- Choice of the best loop to produce robust gates