

Sem 8 Project Doc

Sachin Verlekar

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1 Aim

To study Quantum correlations in a 2-qubit system interacting with a layered environment under the effect of scrambling.

2 System

2-qubit system + 2 qubit first layer of environment + 3 qubit second layer of environment

This is realised in an NMR system using the molecule : [Bis\(2,2,2-trifluoroethyl\) phosphite](#)

3 Outline

This experiment is an attempt at combining and exploring the following two proposals in the setting of our system :

- OTOC is a measure of scrambling of information.
- Discord is a "good" measure of quantum correlations.

Through our experiment it will be possible to explore some connection between the two. In the experiment, we use OTOCs as a measure of the scrambling that takes place and we monitor Quantum discord (our choice of quantum correlation) during the same.

4 Experimental Procedure

Our scheme for calculating OTOC is based on a [previously implemented method](#) using NMR systems. Also, to compute discord, we use a [Matlab code developed previously](#) to compute quantum discord for 2-Qubit systems.

The system's two qubit Hamiltonian (H_{12}) is always "on" during the course of the experiment.

Initially, the system evolves only under the Hamiltonian that couples the two-qubit system to the first layer of the environment :

$$H_{23} = J_{23}(\sigma_{2i}(\sigma_{3i} + \sigma_{4i}))$$

for a time " t ".

Then, we introduce scrambling into the system by turning on the interaction between the two layers of environment. Thus, evolution now takes place according to the Hamiltonian :

$$H = H_{23} + H_{34}$$

$$H_{34} = J_{34}(\sigma_{3j} + \sigma_{4j})(\sigma_{5j} + \sigma_{6j} + \sigma_{7j})$$

for a time $\tau/2$, where τ represents the total scrambling time. Note : H_{12} is always on and $i, j \in \{x, y, z\}$

Then, We apply a π pulse on the system qubits after which we evolve it again under the previous two Hamiltonians, but now in the opposite sequence.

Finally, we calculate Discord and OTOC using the initial and final density matrices.

All codes and results can be found at [this repository](#).