

# QSquare - Description

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## Objective

The objective of this project is to explore how the effects of entanglement can allow remote players to coordinate their actions instantaneously and to explore such coordination power using the language of so-called non-local games. This application specifically focuses on the famous Mermin-Peres Magic Square Game, which challenges two players to decide on a pre-match quantum strategy which will enable them to win the game.

## Summary

QSquare is a gaming application built on Simulaqron which allows users to play the Mermin-Peres Magic Square game with the advantage of quantum entanglement. QSquare can be used to come up with winning strategies for the Mermin-Peres Magic Square game. This application showcases the power of quantum entanglement to win such non-local games with greater probability than classical methods.

## Design Overview

Sequence of the game

1. This game involves a  $3 \times 3$  matrix.
2. Alice and Bob decide a pre-game strategy which they will be using during the game. They are not allowed to communicate at any point after the game begins.
3. The Judge assigns a row number to Alice and a column number to Bob.
4. Alice has to fill the assigned row with zeroes and ones, in such a way that there are even number of ones in that row.
5. Bob has to fill the assigned column with zeroes and ones, in such a way that there are odd number of ones in that column.
6. Both Alice and Bob submit their solution to the Judge
7. Alice and Bob win if they agree on the value of the cell belonging to the intersection of Alice's row and Bob's column. They lose otherwise.

The game consists of four main components:

- 1) **Strategy:** This is the pre-match quantum strategy that needs to be decided by Alice and Bob before the game begins. This strategy involves selecting the quantum measurement operations 'X', 'Y', 'Z' or 'I', which will be performed on the entangled qubits of Alice and Bob during the game. This strategy should be decided before the game begins, as Alice and Bob are not allowed

to communicate at any point after the Judge assigns the row and column number to Alice and Bob respectively.

- 2) **Judge:** The first role of the judge is to assign a row number to Alice and a column number to Bob to start the game. The second role is to check if the answers submitted by Alice and Bob are consistent. Alice and Bob win if they agree on the value of the cell belonging to the intersection of Alice's row and Bob's column. They lose otherwise.
- 3) **Alice:** Alice is one of the two players of the game. Alice creates two EPR-pairs (entangled pairs) with Bob. Depending on the challenge from the judge and taking into consideration of the Strategy decided before the game began, Alice will perform certain measurement on her entangled qubits. Alice can then fill in the values in her assigned row based on the outcome of the measurements. Alice then submits her answer to the judge for review.
- 4) **Bob:** Bob is the second player of the game. Bob receives the two EPR-pairs (entangled pairs) sent by Alice. Depending on the challenge from the judge and taking into consideration of the Strategy decided before the game began, Bob will perform certain measurement on his entangled qubits. Bob can then fill in the values in his assigned column based on the outcome of the measurements. Bob then submits his answer to the judge for review.