Quantum Chess

If we rearranged chess rules according to quantum physics, what kind of game would we encounter?

The laws of physics shape our daily lives, form our habits and determine the relationship between nature and us, in short, they set our boundaries. These laws make up our perceptions. For example, a freely released object falls to the ground, if a glass of hot tea is left on the table it cools down, and so on. The rubber ball we throw on the wall never crosses the wall, it bounces back to us. We are so familiar with such everyday events that we wouldn't even think of it otherwise! All these were formulated with classical physics laws such as Newton's laws of motion, thermodynamics, or electromagnetic interactions. And they rule our predictions and expectations. Just like a game with strict rules.

Since the beginning of the 20th century, physicists have come up with a completely different understanding, which deeply shakes our common sense created by the laws of physics. This new world prevailing in atomic dimensions strongly refused to obey our 'classical' laws. While there was no place to ambiguity in classical physics, indeterminacy and possibilities prevailed in atomic dimensions. Everything observed on the micro scale was simply bizarre. For example the exact position and momentum of a particle cannot be simultaneously determined, electrons and protons could cross the energy barriers well above their potential: literally through the walls. While electrons could only exist in orbits around an atomic nucleus at the energy levels allowed for them, they could never, ever exist between these specific levels. What's even more interesting is that they could “jump” between these energy levels. So how would it be possible?

Such events could not be explained by any physical law that shaped our perception. All these observations led to completely new physics. The world ruled by these new unfamiliar laws has been called "quantum physics".

In this article, instead of describing quantum physics using mathematical language, which is extremely elegant but requires a solid background, we will play a game to see how quantum physics is against our common sense and we will apply these laws of quantum physics to chess. If we would play chess by using subatomic particles instead of chess pieces, what would it have looked like?

Uncertainty

In this new game, which we will call "quantum chess", there are no well-defined boundaries and strict results as in classical chess. Instead, there are probabilities and chess pieces without certain determined roles. Normally, each of the pieces has a specific role referred to it. In quantum chess, these roles are not that clear. For example in quantum chess, one piece can exist in more than one square at the same time. That is, you never know exactly where a piece is. Instead, you know the probability that that piece is found on several squares. Let us say there is a bishop in A8 with a 50% probability. When you look at A8, you may encounter another piece or more surprisingly may see nothing. Let's say you observed the bishop there. At that moment, naturally, the bishop's probability of being in another square is zeroed. To say, you made a move with the bishop. At that very moment, something very interesting happens and you cannot be sure that the piece you left as a bishop would remain as bishop. Because in this game, you can never know the exact position of a piece. When you look at your opponent's pieces, you cannot see in which squares your opponent's pieces are. Instead, you see the information about the probabilities of a piece being at a certain position. Therefore, when you make a move, you may not know for sure whether there is a piece in the square you are moving. The only way to know whether you can make a move, is to make the move. Let's call this feature the 'uncertainty' principle of chess pieces.

Quantum Tunneling

We are facing a game in which even making a simple move is so complicated. Not only that. The behaviour of each piece in classical chess is precisely determined. But in quantum chess this works a bit differently. In classical chess, the knight can move over the pieces, in quantum chess, the bishops, rooks and the queen can also jump. A piece standing in front of another piece is not an obstacle to making a move. Let's call this the "tunneling" feature of chess.

Superposition

In quantum chess, a piece can sometimes have the properties of several different pieces. The quantum rook, for example, can sometimes behave like a bishop. In fact, there exists a piece that shows this feature in classical chess. The classic queen has the ability of a rook and a bishop at the same time. In quantum chess, this feature is not limited only to the queen, but also 'super' features can be observed in any quantum chess piece. A quantum piece may behave like a classic bishop, rook, or knight at the same time. So this game has super queens. Let's call this the "superposition" property of quantum chess.

Entanglement

Another weirdness in this strange game is the feature that many pieces can be set on a single position simultaneously. Just as we can send as many light rays as we want into a dark box, many quantum pieces can be positioned on the same square. In classical chess, more than one piece are not allowed to stay in a square. But in quantum chess, the pieces do not have volume! Let's call these quantum chess pieces "photonic pieces".

Some of the quantum pieces form pairs and are very interestingly entangled with each other. The moment you make a move with one of these pairs tied together, the other moves simultaneously. Their movements are symmetrical to each other. Let's call these types of pieces "quantum entangled".

In classical physics, there is a possibility of a draw because both opponents may not be able to checkmate the other. Other than that, you either win or lose. In quantum chess, it is possible to win and lose at the same time. Because all those strange features that are listed above may trigger countless situations that cause both players to checkmate at once.

Beyond all these oddities, to make the game of quantum chess playable, we need a third conscience other than two players. The distribution of the probability of the pieces on the certain coordinates, superposition, photonic properties and the entanglement of some pieces must be determined independently of the two players before the game starts. Apart from this, complex operations such as the rearrangement of probabilities at the end of each move are needed. It is possible to implement quantum chess with software. Because we can generate random situations, random numbers with computers. However, it is unknown to us whether a decisive reason or a decider in nature that would regulate all this complexity and obscurity exists. The problem between quantum physics and determinism also arises here. In other words, probabilities and uncertainties are inherent in quantum physics. This situation was absurd to us as well as to physicists who discovered quantum physics since the 1900s. Einstein's well known quote "Gott würfelt nicht!" refers exactly to this unclarity. Einstein did not want to admit that there is indeterminacy in nature. On the other hand, despite all the years that passed, Heisenberg's uncertainty principle has become more and more undeniable.

For a better modeling of the universe physicists must never limit their imagination. Although their predictions, theories and experimental observations may contradict common expectations, they have to be very courageous in order to understand the natural laws in the frame of mathematics.

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