

Detecting the love at a subatomic scale

What is love? Answering that question is not easy. We know it's some sort of connection between two people, we can witness it but we cannot really explain it. Similarly, "love" also exist at the subatomic world and is called *entanglement*. For lots of physicists, this is one of the weirdest phenomena in physics.

What is entanglement?

The idea of entanglement is that two particles can be linked to each other even if they are separated by billions of light years. Once two particles are entangled, the measurement of one particle instantaneously determines the state of a partner particle, no matter how far they are from each other: entanglement has no borders.

Love is not always between two people but love can also occur within a family or a group of friends. This is the same for entanglement which can occur between more than 2 particles. The origin of love is always the result of some type of interaction. Entanglement between particles can also happen as the result of almost any types of physics interaction as long as they are close enough to each other. One thing physicists are trying to do is to find ways to determine if two particles are entangled or not.

How to detect entanglement?

Your best friend knows everything about you and if you are in love with someone or not. But how can you tell if someone is in love without knowing everything about them? That's what physicists are trying to do with what we call *entanglement witnesses*. We can determine if two particles are entangled by acquiring all the information about that pair of particles by doing what we call *quantum full tomography*. While entanglement witnesses only require having some information about that pair to know whether the particles are entangled or not. The ultimate goal is to find a way to know if two particles are entangled or not by using the minimum information about the pair.

How fragile is entanglement?

Love is universal and can occur between lots of different type of things. In physics, entanglement can occur between any subatomic systems. For example, it can occur between photons which are the particles that make light and could also occur between electrons which are another type of particles.

But love isn't indestructible and can last as short as a one night stand and last some hours or it can last a whole life and never end. This is the same thing for entanglement, it can last extremely briefly or it could last indefinitely.

Eternal love is currently a fiction for electrons in the lab as their entanglement is usually very fragile because electron can interact very easily with other particles while photon interact much less with other particles and thus make the entanglement less fragile. We could compare electrons to an unfaithful couple that is more likely to have affairs with other people, the more affairs they have the more it destroys the couple: physicists call it *decoherence*. While entangled photons could be seen as a very loyal couple where love always stay strong.

The goal of this thesis is to detect the entanglement between two electrons which can be seen as investigating the love in a couple having affairs.