A dark horse in the quantum computing race: the dark exciton

By Casey Johnston | Last updated a day ago

Yet another contender has entered the race to provide a quantum computing bit: the dark exciton. While this quasiparticle is marginally difficult to create, as researchers demonstrated in a paper published in *Nature*, it turned out to be very stable and easy to read and manipulate with external light. Because the dark exciton's structure essentially locks it into existence, the authors think it could make for a great qubit.

An exciton is a quasiparticle that consists of an electron and a "hole," or a empty spot in an atom's electron collection. When the spin of the electron and the hole align in opposite directions, the pair is called a bright exciton. Because the bright exciton's spins are opposite each other, it's very easy for the electron to drop back in the hole; a dark exciton, however, changes this relationship just enough to be able to live a long time.

A dark exciton would be the same as a bright exciton, except the spin of the hole and the electron are parallel. While a bright exciton only has to emit a photon to merge and eliminate its components, the dark exciton's electron and hole can't merge just by emitting a photon (hence the "dark") because their spins are the same. This makes a dark exciton much more resilient, but it also means they're harder to create than their bright brethren.

To make dark excitons, the scientists had to gather up three biexcitons, or pairs of excitons (six electrons and six electron slots in total). They found that when they pepared the biexcitons in a quantum triplet state, two of the biexcitons ended up with parallel spins: one up, one down. The biexciton with opposite spins would decay like a bright exciton, while the other two, which were oriented strictly up or down, became dark excitons.

Their existence alone wasn't enough to qualify them as qubits; researchers also needed to be able to read or write to them. Because dark excitons can't move between energy levels and can't emit or absorb photons of their own, the scientists realized they would need an additional process to access the dark excitons' information.

While normal dark excitons won't respond to light, there is another stimulus they will respond to: electric charge. When the researchers sent charge carriers at the dark excitons, they found that the newly negatively- or positively-charged excitons became optically active again.

Once the excitons were charged, the only way the excitons could decay back down to an electrically neutral state was to emit a photon. If they caught the photon on a detector and read its spin, this gave them information about whether the exciton was spin up or spin down—the equivalent of reading whether a computer bit is 1 or 0.

The authors found they were able to control the dark excitons in every way necessary for them to function as qubits: they could be created as stable particles, and read out when and if needed simply by charging them electrically.

Still, the conditions for producing dark excitons are not exactly simple, and some adjustments will need to be made before the dark exciton could be considered conventional storage. The authors could only predicably read them for the first five nanoseconds of excitation, so timing has to be pretty precise. The excitons also had to be read out while immersed in liquid helium at 4.2 Kelvin above absolute zero. So, at the moment, these are not the most convenient things to work with.

Nature Physics, 2010. DOI: 10.1038/NPHYS1812 (About DOIs).