Entanglement on demand

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One of the problems in quantum information processing is inefficiency. Photon entanglement is generally considered a leading candidate for quantum computing (it is used for teleportation and cryptography), but right now it is sort of a hit and miss proposition. “The only methods we have for generating entangled photons are random,” Yosi Avron tells *PhysOrg.com*. “You don’t always get an entangled pair, and when you do, after you test the photons, they are useless.”

Avron, a physicist at the Technion-Israel Institute of Technology, believes that he and his colleagues may have found a technique that could solve this problem of photon entanglement. Avron worked with Gershoni, Bisker, Lindner and Meirom at Technion-Israel, as well as Warburton at Heriot-Watt University in Edinburgh. The team’s scheme revolves around time reordering, and is explained in *Physical Review Letters*: “Entanglement on Demand through Time Reordering.”

“The key is something called switch path ambiguity,” explains Avron. He points out that in quantum mechanics, a particle can be in two places at once. “If you have two slits on a paper, and you send a photon toward them, the photon can go through both at once. It doesn’t have to choose. If you have a screen behind these two slits, the interference pattern that shows is the same behind each slit. The photon went through both.”

Avron goes on to explain that the key is in setting up different paths for the photons to follow, and in creating a situation in which two states give the same result. In that way, it would be possible to produced entangled photons on demand, rather than using hit and miss:

“If you have a system with an atom, you start it in an excited state. Then it relaxes and releases a photon at an intermediate state. Then it relaxes more and releases a photon at the ground state. The ambiguity comes in when we create a second intermediate state, identical to the first, so that you have a state where two photons are generated in alternative ways.”

It sounds nice, but Avron acknowledges that this where more problems arise. “It is difficult to get two states that are precisely identical like that,” he says. “The states have slightly different energies and this adversely affects entanglement.”

The solution the team came up with was to re-arrange the timing of the system. “This is not a new idea,” he qualifies, “but we were the first to create a believable theory of how it could be done.”

“All we have to do is reorder one of the paths,” Avron explains. “And if you do, then you could get a situation where you get entanglement because the states become identical…Instead of matching in each generation of photons, it is possible to match across generations and reorder them. Quantum mechanics allows for this without penalty.”

Avron is careful to point out that at this stage the results are theoretical. “But,” he continues, “we think that it is possible to design an experiment to test it. David Gershoni is working on such an experiment.”

The experiment may take one or two years to get done, but Avron is confident of the results. “It has been difficult to get high quality entanglement on demand,” he explains, “and what we have discovered is that it is possible and something that we can do in a few years’ time.”