The Open University

The Next Big Thing: Nanotechnology

Quantum Mechanics

COLIN
Jim can you tell us a bit more about this area of work.

JIM
Surely. Well the scanning tunnelling microscope is a technique that involves not looking, that is with conventional waves or with light for instance or electron beams which are also waves, but it's a technique of actually touching if you like, a feeling of tactile sensing atoms.

COLIN
We've got a bit of video of that Jim you can maybe tell us more about it there. Watch this.

JIM
Okay well obviously what you see there is an ant I believe, okay but beside the ant you see the…

COLIN
….that's not essential for the job is it.

JIM
No we, we don't need the ant at the moment yeah. But what you see is the sharp tip which is the functional part of the S.T.M.

COLIN
And what's it made of the tip?

JIM
The tip is typically made of tungsten or any conducting metal in the scanning tunnelling microscope, and you see this kind of aura around it that is quantum mechanical, quantum mechanically tunnelling electrons, and you can also exert a force.

So what you see this thing, looks like a potato, is actually an atom I guess in this schematic, and we're actually pulling the atom across the surface here in this cartoon, and repositioning it. So this is the ultimate in bottom up fabrication, repositioning atoms one by one in a perfect pattern. And of course if you think what could be a better perfect pattern since I work for IBM, you see what the result is.

COLIN
This is advertising on the BBC….

JIM
….and this, but this was actually achieved at close to zero temperatures using xenon atoms by Don Eigler a number of years ago, and there you can see the real result. These are real xenon atoms, repositioned by Don. And now what you see here is an extension of Don's work where he has a whole ring of iron atoms. You can see the walls of this, and he calls it the quantum coral okay, so it's a ring of atoms. And what you see here are not atoms, but you actually see the electron wave that the electron wave function associated with the electrons in the metal, and this is like a a tiny resonator, a quantum resonator.

JACKIE
This really sets you up for whole new structures. I mean you, I know you made the headlines with your nano calculator, the abacus, I mean could you explain a little bit about that?

JIM
Okay well, the nano abacus or in Japanese Soroban okay is slightly different. We used Harry's molecules, these C60 molecules, and the problem is at room temperature if Don tried to do that experiment at room temperature, the atoms would all run all over the place okay, because they're a very weakly bound. And we had to find a strategy, we wanted to demonstrate something at room temperature, repositioning at room temperature. And we found that when we tried to look at these C60 molecules, these fullerenes of copper, they were running all over the place with the thermal energy, but they stuck to steps, little mono atomic steps on the copper.

And we started to play around with this, but the real, the real idea this experiment occurred when I was in a Japanese railway station, and of course Japanese is a very high tech country, and I bought a ticket on the the underground, and one of the guys there, he was sitting with one of these abacuses that they call a soroban. And it stuck in my head, this is crazy in this country they're actually sitting using abacuses, and then I thought, why not make the soroban as a demonstration really of our capabilities with scanning tunnelling microscope to mechanically move molecules and demonstrate the positional control, molecule by molecule, at room temperature.

And we used these steps as guide rails, because the molecules were stabilised by the steps. And that's the history of that, and then it ended up in the New York Times and it's been all over the world and it's fun, because it's….

JACKIE
It's inspiring people…

JIM
…..it's inspired an artist in Berlin to make a artwork that actually hangs up there. So if it inspires art I'm happy.

JACKIE
What you're talking about is doing away with wires, doing away with connections, and do you think that's really going to take us into quantum computing. I mean is that where you see this whole revolution from an IBM perspective coming, not only storage of data but actually manipulating information.

JIM
Yeah..

HARRY
There is a point about quantum computing. If you, if the people that are doing the theory of this, and having read a little bit and understanding very little of it, indicate that there are problems that cannot be solved by modern type of computing approaches. Whereas the reason for moving into these new areas of quantum computing and quantum mechanical devices will open up calculations of the kind that are just beyond the, the possibility of even scaled up molecular computers.

JIM
Quantum mechanics can be used in many, many ways not just to make quantum computers. So I believe in short term, or when I say short term I mean, ten to twenty years before the current technology runs out, then there will be other approaches come along.

JACKIE
But that's the real problem, I think we would say in our world today, the thing that will be the crunch factor will be the amount of information that we're receiving, and how quickly we can process it. It really seems that that has to be one of the pressure points.