Quantum mirage

Since it first appeared on the cover of *Nature* in February 2000, the "quantum mirage" has featured on posters, calendars, websites and the covers of various books and magazines. The image – which was obtained using a scanning tunnelling microscope – shows the electronic wavefunctions inside an elliptical "quantum corral" made of cobalt atoms on a copper surface. It was created by Hari Manoharan, Christopher Lutz and Don Eigler of the IBM Almaden Research Center in California.

Eigler has a track record of producing iconic images. In 1990, working with Erhard Schweizer, he spelt out the letters "IBM" using 35 xenon atoms. And three years later, working with Lutz and Michael Crommie, he released the first images of the "quantum corral", which have also been reproduced in numerous places. However, Eigler admits that he has been surprised by the widespread popularity of the quantum mirage. "I don't have much of a feel for what excites and interests other people," he told *Physics World*. "I did not think that the image of the quantum mirage would be of broad interest."

To create the image Manoharan, Lutz and Eigler first used a scanning tunnelling microscope (STM) to position 36 cobalt atoms in an elliptical ring (the orange peaks), and then placed another cobalt atom at one of the two focal points of the ring. Next they used the STM to measure the Kondo effect (the purple peak) caused by the magnetic properties of the lone cobalt atom (2000 *Nature* 403 **512**). They also detected a much weaker Kondo effect at the other focal point (the purple patch on the left), even though it did not contain a cobalt atom – hence the name "quantum mirage".

Hari Manoharan, who is now at Stanford University, chose the colours for the image, which is actually constructed from two data sets. The first set contains topographic data and the second the magnetic information. "Both data sets share the same *x*–*y* co-ordinates," he says, "so the challenge was to illustrate a 4D data set in a 3D surface." Manoharan represented the topographic data as height and the magnetic information (i.e. the Kondo effect) as colour, so the peaks in the image show where the atoms are located, while the colours represent the magnetic data, with purple corresponding to the strongest Kondo effect and green to the weakest.

Eigler, who is married to an artist, confesses that he does not like the colour scheme. "But", he adds, "there's no accounting for taste – my taste, Hari's taste or the public's – is there?" However, he says that he is "vitally interested" in the interaction between physics, aesthetics and art. This applies to his work and to his hobby – restoring and customizing cars. "Usually I pull art into my physics world, either in how I handle an image, or in the appreciation or design of some laboratory gizmo. I also apply my skills as a physicist – design, fabrication, electronics, welding – in my car restoration/customization pursuits."

So does Eigler think that physicists have anything to offer artists, or vice versa? "I am sure of it," he says, "but I am also sure that it is serendipitous." He also paints a vivid picture of the parallels between art and science: "long hours, commitment, passion, beauty, style, cliques, superstars and unknowns. But the most important one, I think, is the spark of creativity." Credit: IBM