The last word

There's no such thing as a free lunch.

It's a standard demonstration now. Every school physics laboratory has a time machine.

If you haven't seen it, the apparatus is surprisingly uncomplicated. It's built around a grooved, inclined plane, with a steel ball weighing about a kilogram sitting on it. There's an electromagnet that holds the ball in place at the top, and a soft rubber bumper to stop it at the bottom.

The electromagnet is wired to a clock that counts down ten seconds and then turns off the electromagnet. The ball rolls down the inclined plane, hits the bumper and stops. That's the easy part.

What's more interesting is the sensitive photodetector connected to the clock. It takes only five photons hitting it to generate a signal that stops the countdown.

The photodetector is at one end of a black plastic pipe that is packed with retrorefractive crystals. At the other end is a xenon flash tube.

Retrorefractive crystals have a phenomenal refractive index, of the order of billions. Take out the detector from the end of the pipe, test-fire the flash tube and you'll see the flash several seconds later.

That's surprising, but not as surprising as what happens when you connect the power supply to the two big, brass terminals on the pipe. Turn up the juice until you have about two kilovolts applied to the crystals and something uncanny happens.

The crystals develop a second refractive index, which is exactly minus the normal one.

That's right, minus.

One flash goes in and two come out. Symmetrically. The first comes out several seconds before the original flash went in, the second the same number of seconds afterwards. The first is much weaker, and isn't always there, which is why you need the sensitive detector.

"Don't waste it," I hear you saying. "Feed in tomorrow's horse racing results so we can get the bets on now. Or in the interests of humanity tell us about tomorrow's earthquakes, bombs and plane crashes so we can avoid them."

It doesn't work.

Try to feed in that sort of information and you don't get the first flash.

Let's go on with the demonstration. Connect a storage scope to a current detector wired in series with the crystals, and wire a microswitch in the rubber bumper to the trigger of the flash tube.

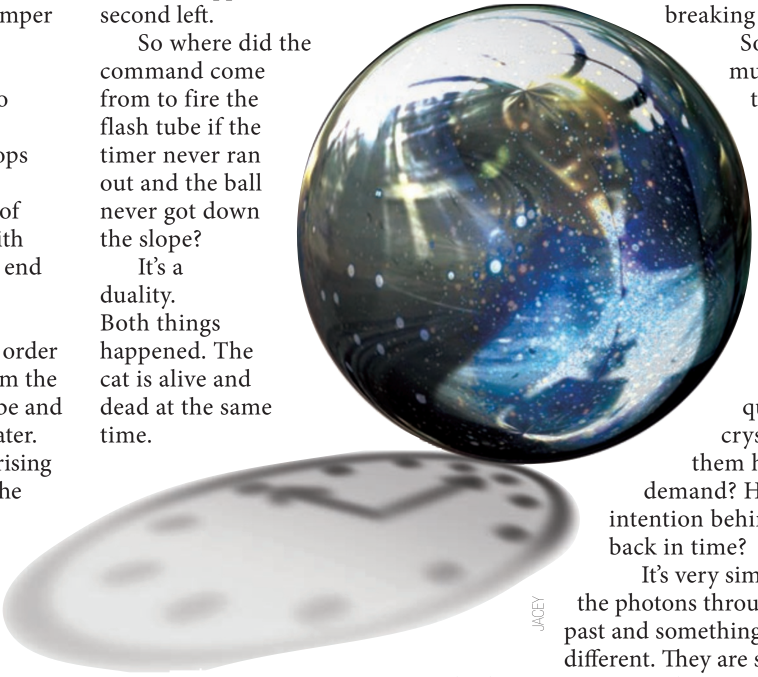
Now start the clock.

It counts down ten seconds, releases the ball and stops, showing all zeroes. The ball rolls down the slope and hits the bumper, the flash tube fires, the first packet of photons goes back in time to just before the timer ran out.

Then the miracle happens. The ball is back at the top of the ramp and the timer is stopped with about a second left.

So where did the command come from to fire the flash tube if the timer never ran out and the ball never got down the slope?

It's a duality. Both things happened. The cat is alive and dead at the same time.



Now look at the scope. There's a big peak just as the photons went back in time. Measure the area under the curve, multiply by two kilovolts, and you'll find that to send the command back in time needed exactly as much energy as it would have taken to lift the ball back up the incline.

Even time travel doesn't let you get something for nothing. You want the ball raised by ten centimetres and you've got to find a joule from somewhere. Going back to change the past requires exactly as much energy as making the same change in the present.

That's the first part of the demonstration.

Next we reset the apparatus, but in front of the rubber bumper we put a little glass tube.

This time the ball strikes the tube and shatters it, then goes on to hit the bumper. The flash tube fires and nothing else happens.

Now look at the scope. The trace is somewhere near the top of the screen and slowly coming down as the photons decay without going anywhere. It's not just the energy that would be needed to fuse the glass back together again that the crystals are requesting, it's getting on top of the change in entropy as well, of somehow reversing the disorder that breaking the glass has caused.

Some things require so much energy to change them — such as getting back dead friends or bumping off live grandfathers — that the combined horsepower of half-a-dozen novas wouldn't be enough. They are effectively impossible.

Which leaves one question: how do the crystals know? What tells them how much power to demand? How can they detect the intention behind sending a photon back in time?

It's very simple really. If they let the photons through, they change the past and something will always have been different. They are sensitive to the change in potential energy now, in fact they have to supply the energy to cause it. The Universe is very good at not letting you get free energy.

Time travel won't let you do away with free will, or murder your grandfather, or even know the winner of the 2:15 at Kempton Park in advance. Like everything else in the Universe that happens in the 'realm of middle dimensions' it's subject to the laws of thermodynamics.

And the one thing we know about thermodynamics is that it always has the last word.

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