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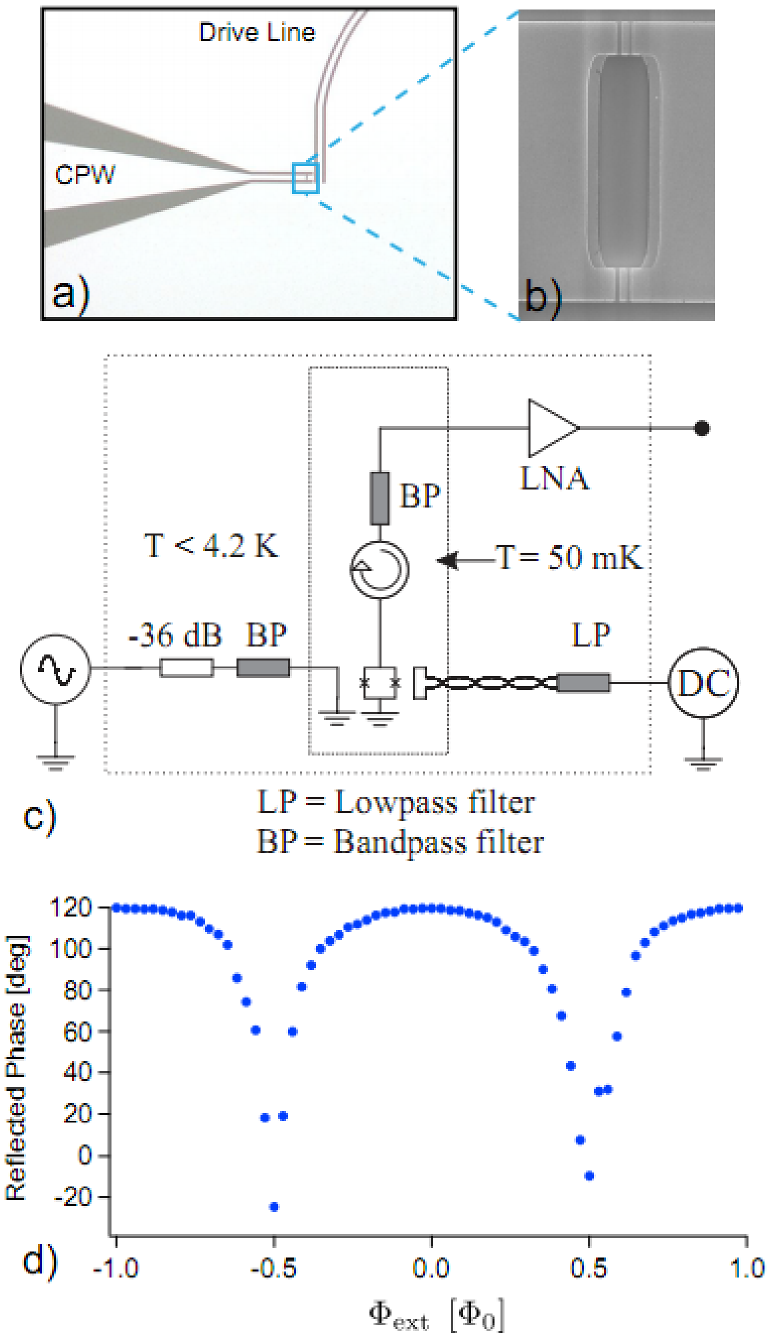
First Observation of the Dynamical Casimir Effect

A rapidly moving mirror that turns virtual photons into real ones is the first experimental evidence of the dynamical Casimir effect.

By kfc



"One of the most surprising predictions of modern quantum theory is that the vacuum of space is not empty. In fact, quantum theory predicts that it teems with virtual particles flitting in and out of existence."

So begin Christopher Wilson from Chalmers University in Sweden and friends in their marvellously readable paper about a rather extraordinary piece of science.

This maelstrom of quantum activity is far from benign. Physicists have known since 1948 that if two flat mirrors are held close together and parallel with each other, they will be pushed together by these virtual particles.

The reason is straightforward. When the gap between the mirrors is smaller than the wavelength of the virtual particles, they are excluded from this space. The vacuum pressure inside the gap is then less than outside it and this forces the mirrors.

This is the *static* Casimir effect and it was first measured in 1998 by two teams in the US.

But there is another phenomenon called the *dynamical* Casimir effect that has never been seen.

It occurs when a mirror moves through space at relativistic speeds. Here's what happens. At slow speeds, the sea of virtual particles can easily adapt to the mirror's movement and continue to come into existence in pairs and then disappear as they annihilate each other.

But when the speed of the mirror begins to match the the speed of the photons, in other words at relativistic speeds, some photons become separated from their partners and so do not get annihilated. These virtual photons then become real and the mirror begins to produce light.

That's the theory. The problem in practice is that it's hard to get an ordinary mirror moving at anything like relativistic speeds.

But Wilson and co have a trick up their sleeves. Instead of a conventional mirror, they've used a transmission line connected to a superconducting quantum interference device or SQUID. Fiddling with the SQUID changes the effective electrical length of the line and this change is equivalent to the movement of an electromagnetic mirror.

By modulating the SQUID at GHz rates, the mirror moves back and forth. To get an idea of scale, the transmission line is only 100 micrometres long and the mirror moves over a distance of about a nanometre. But the rate at which it does this means it achieves speeds approaching 5 per cent light speed.

So having perfected their mirror moving technique, all Wilson and co have to do is cool everything down, then sit back and look for photons. Sure enough, they've spotted microwave photons emerging from the moving mirror, just as predicted.

They finish with a short conclusion. "We believe these results represent the fifirst experimental observation of the dynamical Casimir effect."

Impressive result!

Ref: arxiv.org/abs/1105.4714: Observation of the Dynamical Casimir Effect in a Superconducting Circuit