Interaction-Free Detection

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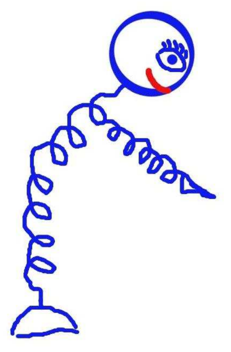


Can we detect an object without transferring any energy to it? Without touching, illuminating, or irradiating it?
That is, in such a way that *it* "cannot detect" that we are detecting *it*.

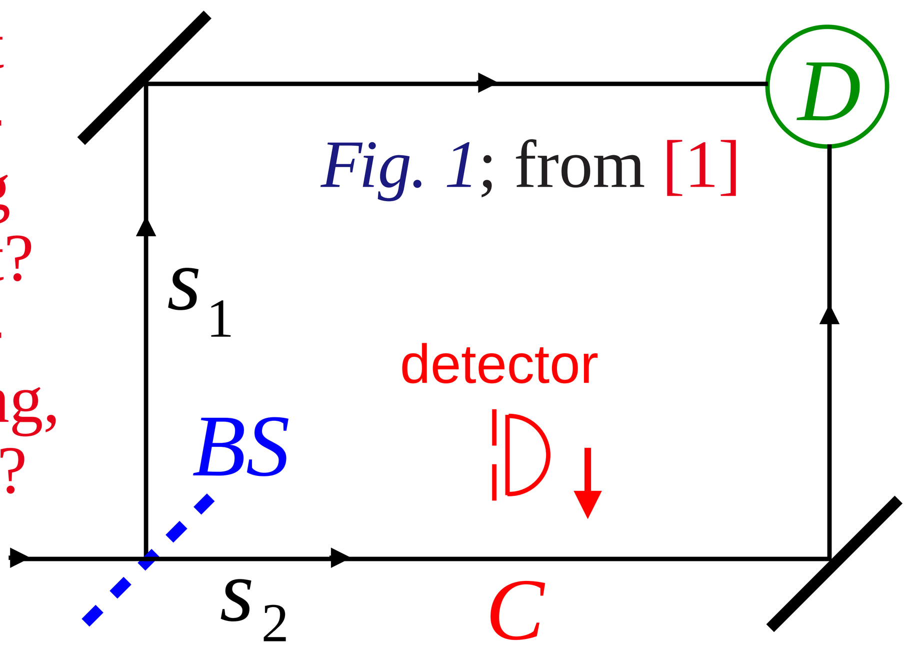
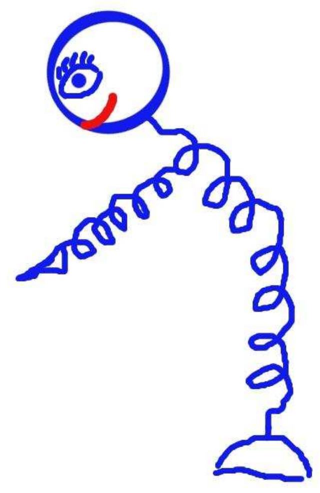


Fig. 1; from [1]

[1] Pavičić, PhD Thesis, 1986

Yes! In 1986 we "[c]onsider[ed] a photon experiment shown in Fig. 1 which results in an interference in the region D provided we do not know whether it arrived to the region by path s_1 or by path s_2... If we, after a photon passed the beam splitter, BS, and before it could reach point C, suddenly introduce a detector in the path s_2 at the point C and do *not* detect *anything*, then it follows that the photon must have taken the path s_1—and, indeed, one can detect it in the region D but it does *not* produce interference there." [1]



In 1993 A. C. Elitzur and L. Vaidman realised that measurements in region D can be used for finding out whether objects are or are not placed in C in Fig. [1]. The efficiency of such *interaction-free measurements* can ideally and with a highly asymmetrical beam splitter approximate 50%. The problem was that we need a controlled single photon source and realistically such sources, like downconverted photons, reduce the efficiency to under 5%.

Therefore in 1996 we devised a setup that dispensed with the need for having controlled single photon sources. This is achieved with the help of two photon exit channels from the resonator shown in Fig. 2 and enabled by the realistic efficiency of over 98%. When there is no object O in the path a destructive interference builds up at the first highly asymmetrical beam splitter after at least 200 round trips and photons exit into detector D_t. When there is an object in the path, photons exit into detector D_r. Only 2% of them hit the object.

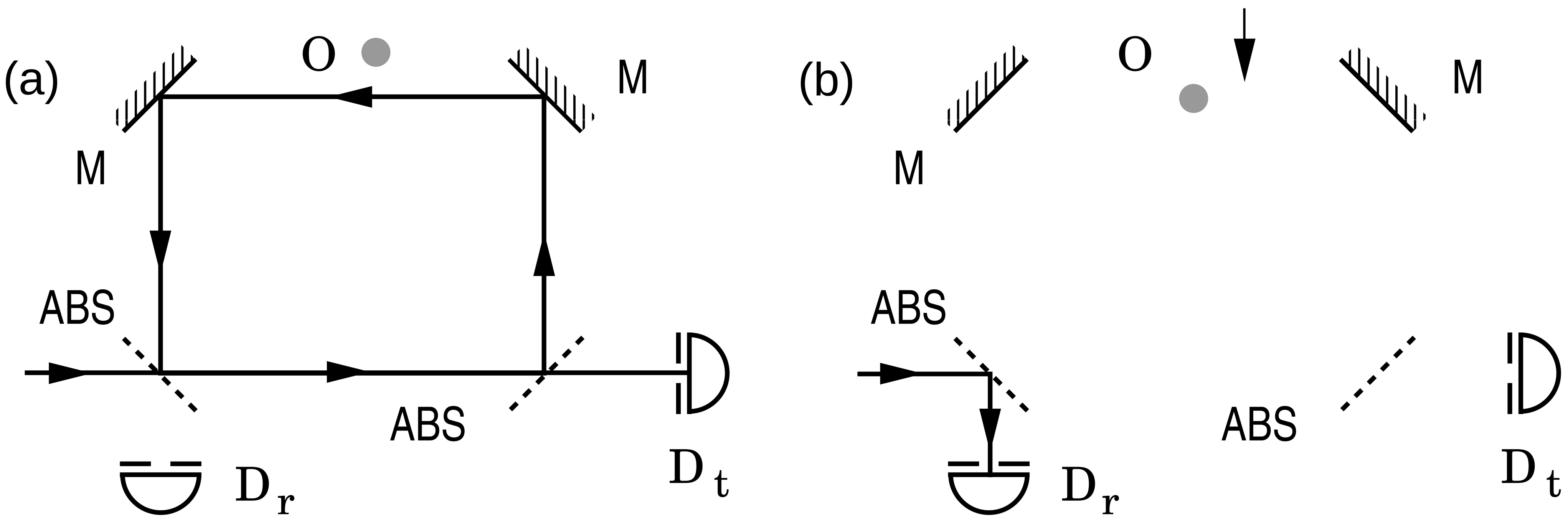
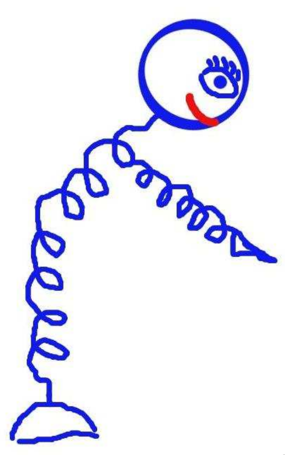


Fig. 2; according to [2] and [3].

Interaction-free resonators can be used in quantum computation and communication, however in [4] we have already obtained the following fundamental result.

Sheer transfer of information can change the state of a quantum system without any transfer of energy.

The way we obtain this result is shown in Fig. 3. Free falling atoms pass a double slit and form interference fringes at MCP when the resonators are not on. Atoms can absorb photons of particular color and we also tune the resonators to the same frequency. When we switch on the resonators, the photons will "see" the atoms without hitting them. That reveals the slits the atoms passed through and the interference fringes will not be formed.



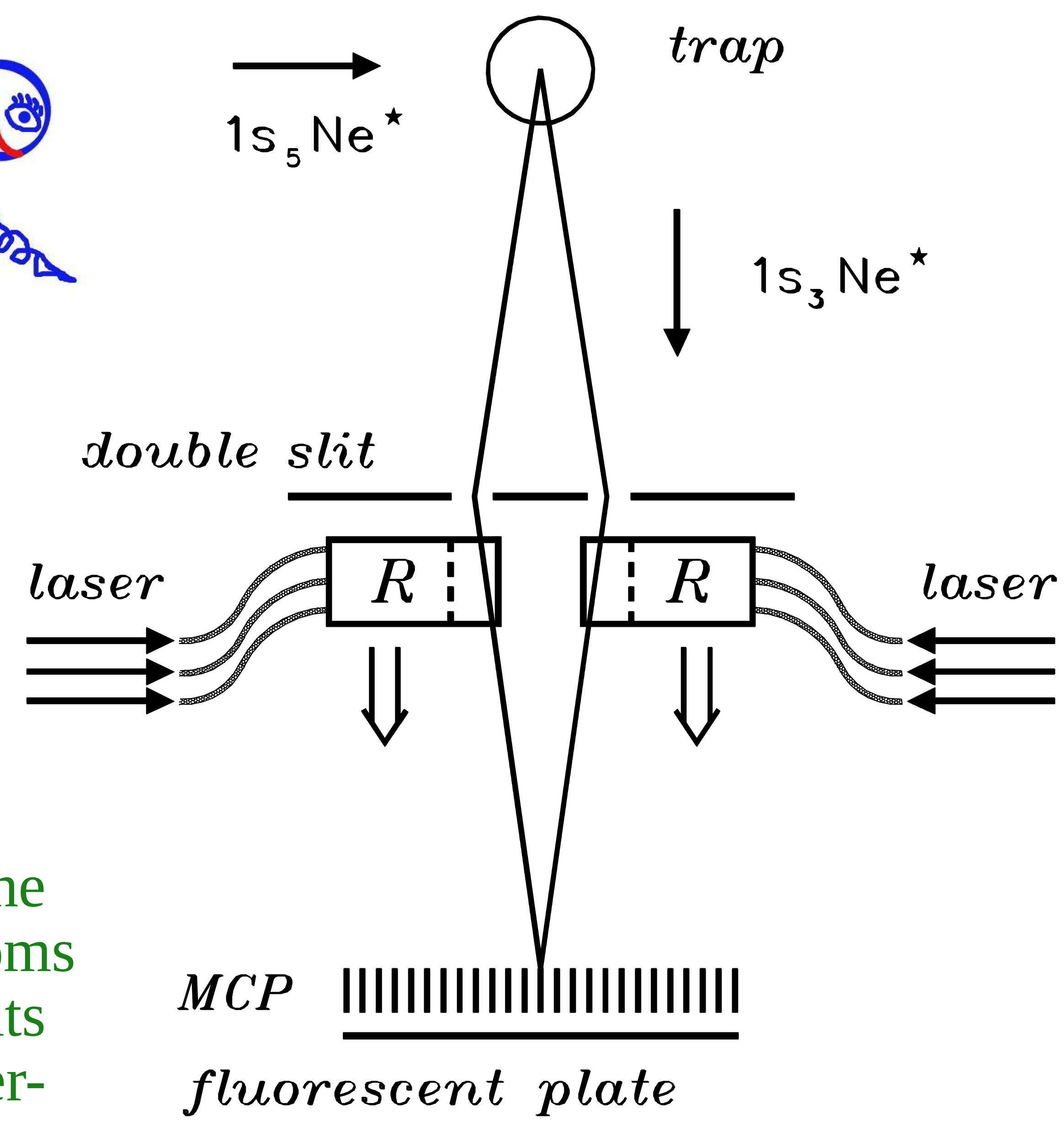


Fig. 3; from [4]

[2] Paul, H. and Pavičić, M., Resonance Interaction-Free Measurement, *International Journal of Theoretical Physics*, **35**, 2085–2091 (1996).

[3] Paul, H. and Pavičić, M., Nonclassical Interaction-Free Detection of Objects in a Monolithic Total-Internal-Reflection Resonator, *Journal of the Optical Society of America*, **B 14,** 1273–1277 (1997).

[4] Pavičić,M., Resonance Energy-Exchange-Free Detection and 'Welcher Weg' Experiment, *Physics Letters*, **A 223**,241-5(1996).