Can single photons be demonstrated on a screen?

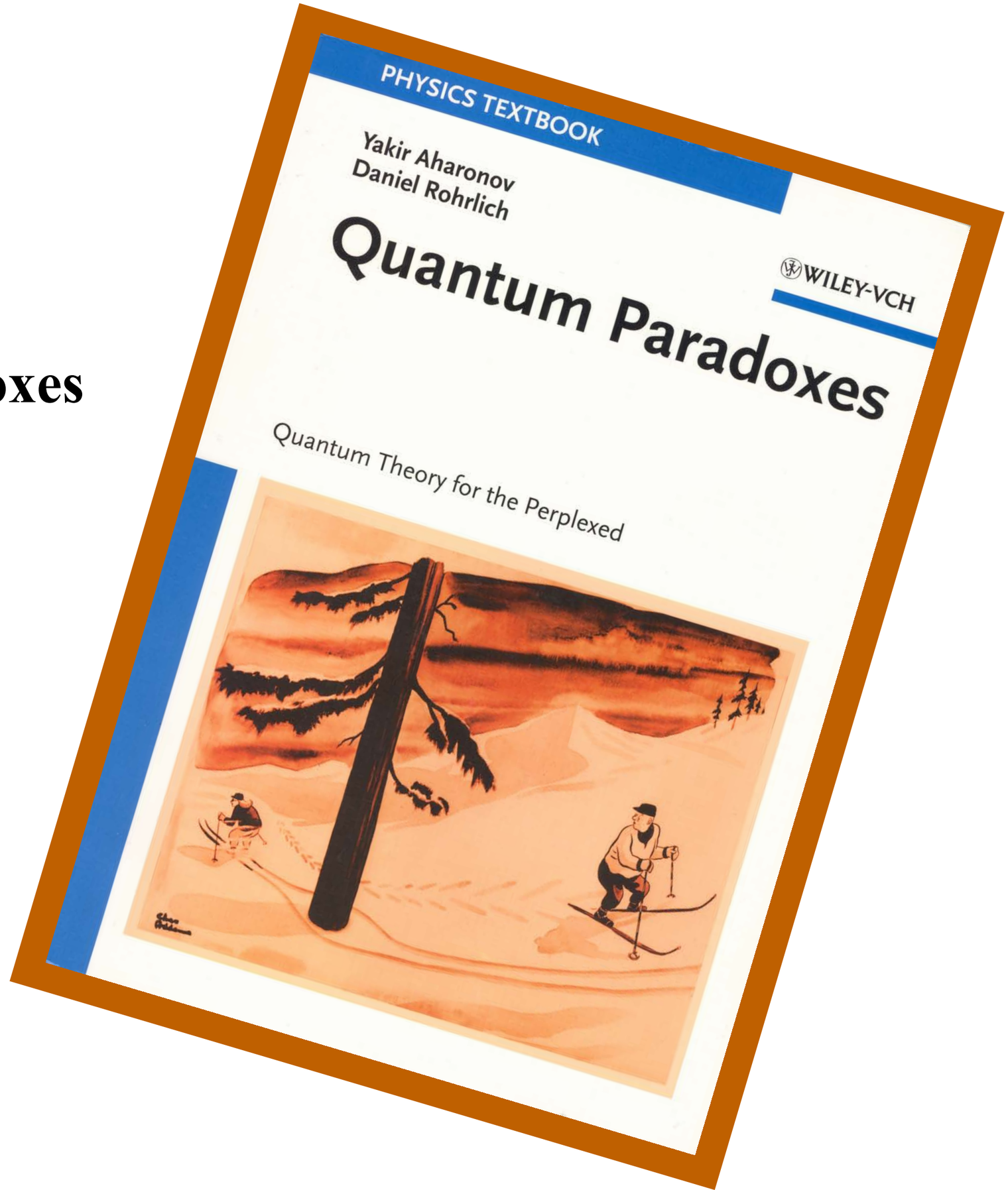
Arnt Inge Vistnes, Borys Jagielski
Department of Physics, University of Oslo, Norway

ABSTRACT

We are often interpreting experiments by a set of models. The conclusion we draw may not be the only possible one. If we are so confident with our models that we do not seriously explore other possible explanations, several important subtleties regarding the nature of light may remain out of the reach.

The purpose of this poster is to point out one detail when describing interference at very low intensity of light, where a common explanation might be wrong. The example in itself has limited value. However, if we are not critical enough to various explanations in general, we may slow down the development of new ideas in physics.

Are some quantum paradoxes not paradoxes after all?



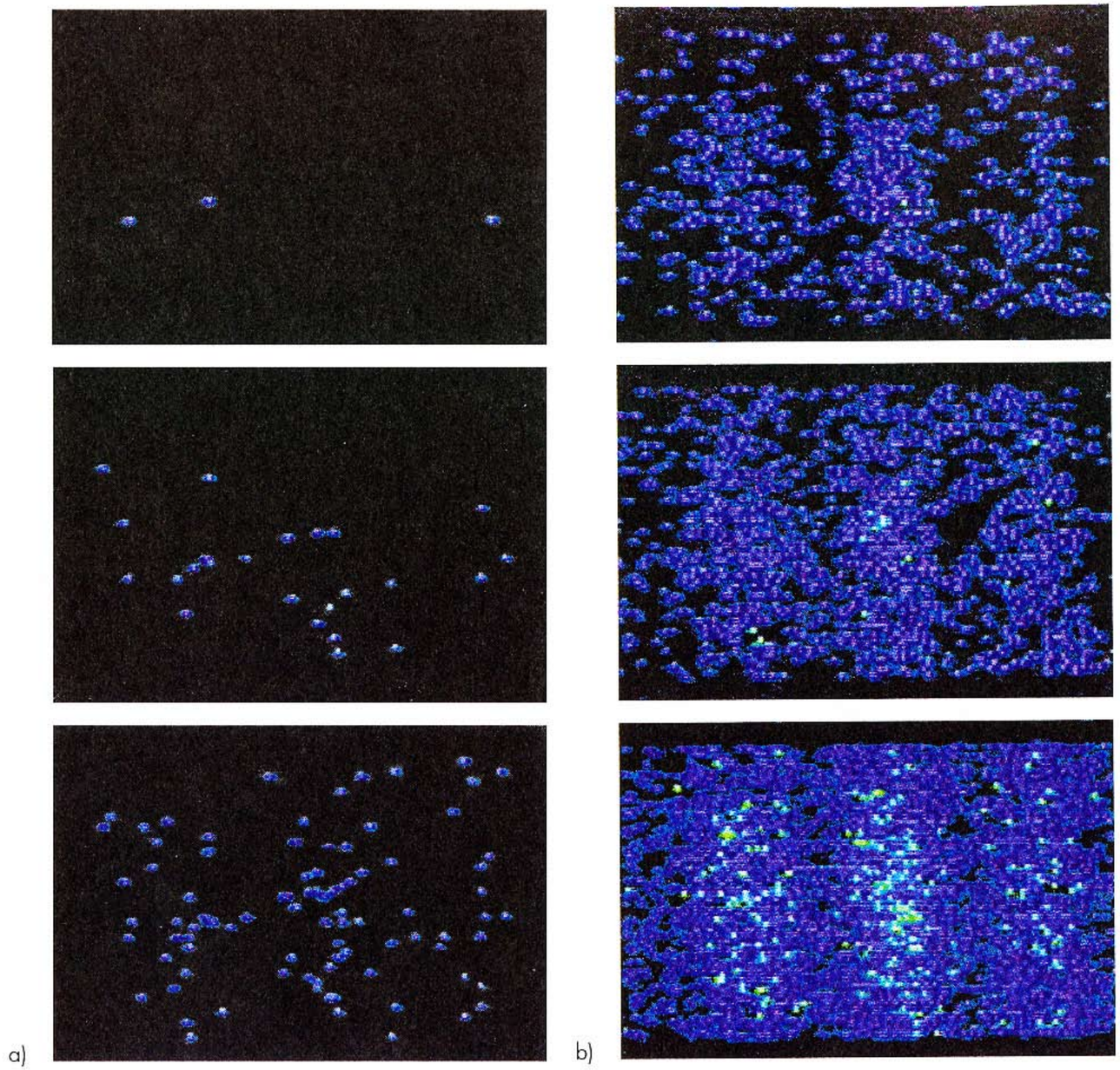


Figure 1. Interference detected on a screen. From: Thomas Walther and Herbert Walther: Was ist Licht?, C.H.Beck, Wissen, München, 1999, Tafel 9.

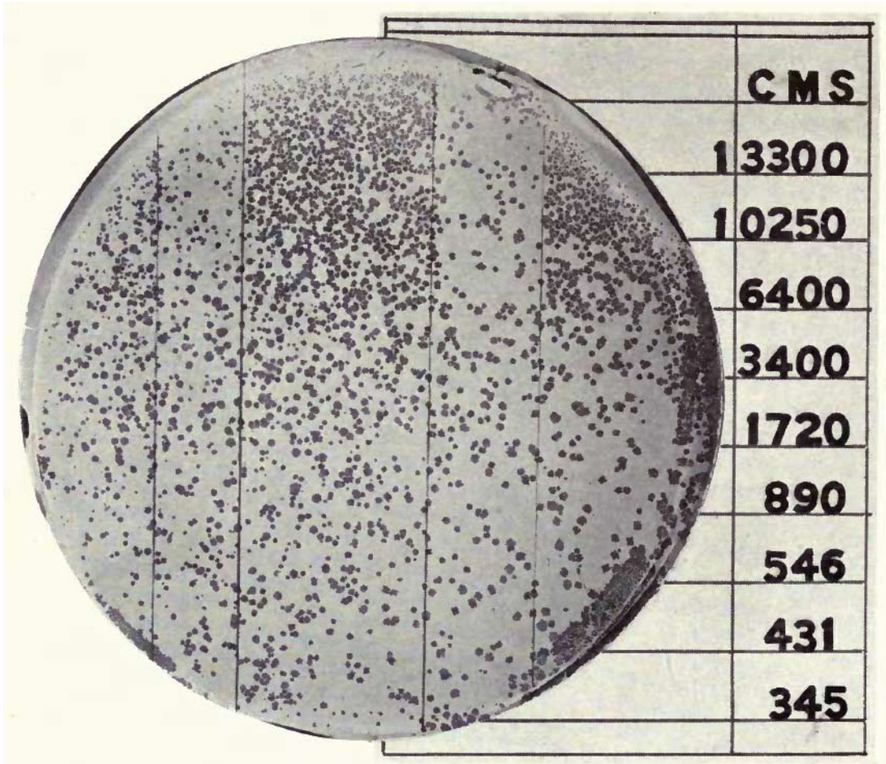
”SINGLE PHOTON REGIME”

We have all seen pictures like this. When light with very low intensity passes through a double slit and impinges on a photographic plate, the interference pattern is gradually established through occurence of more and more dots on the plate. Each dot shown is often thought to stem from one photon, giving all its energy locally to the detector system.

However, how are the dots formed?

If a photographic plate is the “detector system”, it contains small crystals of a silver salt (often silver chloride or silver bromide). If a crystal is light-exposed, it will be reduced by the developer to black metallic silver particles that form the image and the photographic “grain.” The important point is that ***the detection is almost entirely a digital process***: Either a metallic silver particle (a grain) is formed, or the silver salt in the crystal is dissolved through the developing process and no grain appear on the corresponding spot.

(A nice description from 1921 is to be found at http://www.archive.org/details/silverbromidegra00trivrich.)



Today's electronics detectors often work in a "digital mode" as well at very low light intensity. For example, the signal from a "Single Photon Avalanche Detector" is a pulse similar to the one shown in figure 2.

The shape of a pulse from a Single Photon Detector is entirely determined by the electronics circuits in the detector. A starting avalanche process in the semiconductor is quenched before it makes any damage, and the circuit stimulates the recovery so that the detector is able to be triggered again as soon as possible. Pulses from dark counts have exactly the same observed shape as pulses triggered by light.

The important point to notice is that most detectors respond digitally when they work in "a single photon mode". Only "0" or "1", defined in various ways depending on systems, are possible responses.

However, the input does not need to be digital ("a photon or not a photon") even if the output is.

Even a wavelike input signal that lasts for miliseconds will lead to digital responses, if it can trigger the detector at all.

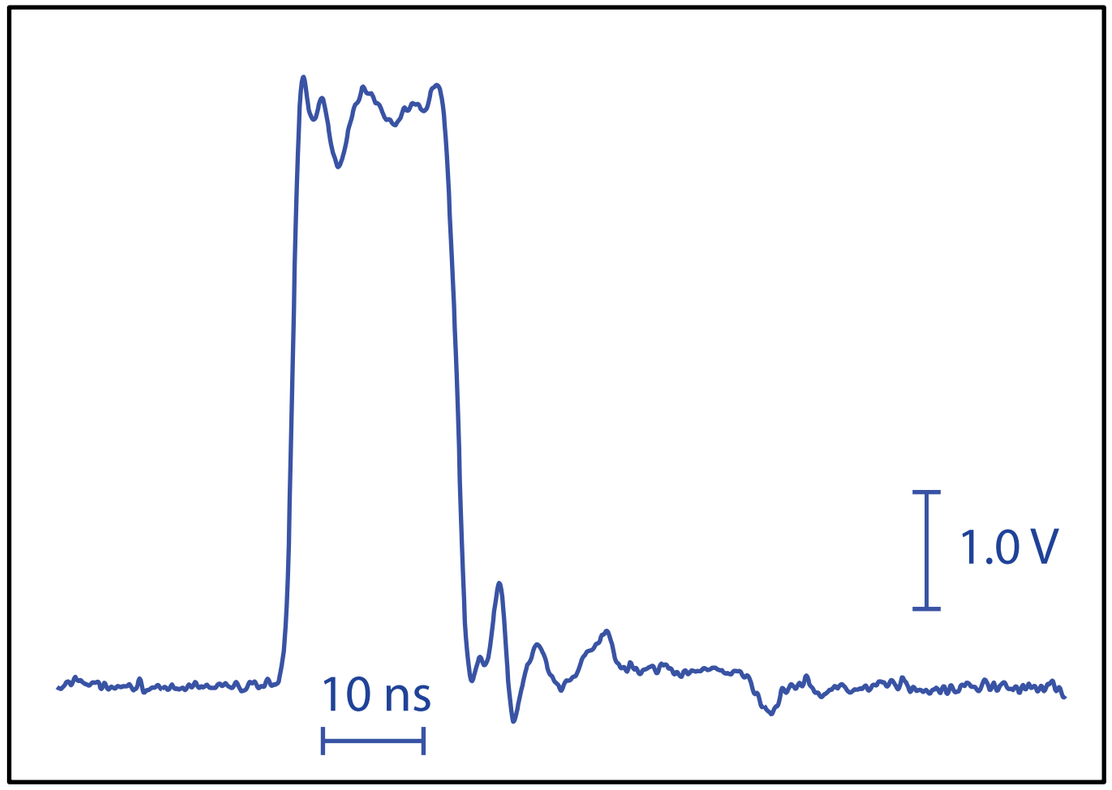
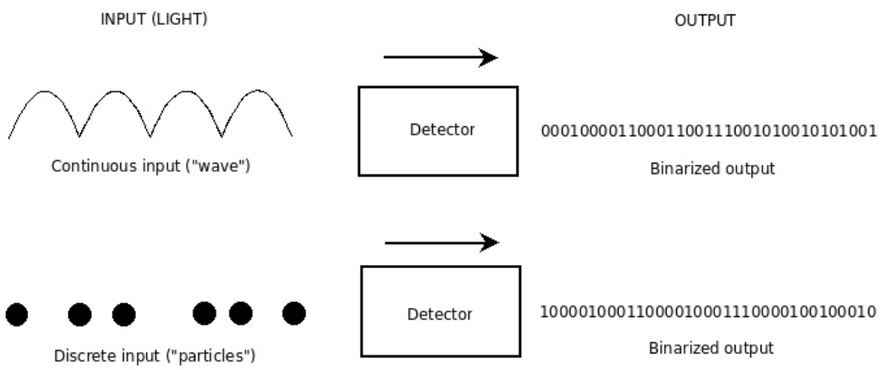


Figure 2. One pulse from a "Single Photon Avalanche Detector". Except for noise, the shape of a pulse is always the same, either the pulse is triggered by light or not.



SO WHAT?

You may think like this: Even if we cannot conclude that it is a single photon that create a pulse on a detector, there are so many other experiments that confirm such an idea.

It might be right. However, we have started a systematic work on analyzing experiments that are crucial for the present wave-particle dualism doctrine in physics. We have not been impressed by the arguments used in many papers. In our opinion it is strange to notice that many people use the concepts “wave” and “particle” in a rather primitive way, without defining finer details that should characterize the concepts.

As a symptom of the situation, the question “How big is a photon?” seems to have as many answers as physicists! How can we handle a question like this in a more professional way than today in order to gain more understanding?

We have the working hypothesis that clarifying these concepts, and looking very carefully through the arguments used on explaining various experiments, might reveal details that would bring our understanding forward. Maybe it is possible to explain the double slit experiment, and many other strange phenomena as well, without any need for talking about paradoxes?

If you are devoted to the same kind of challenges as mentioned above, please contact us by e-mail to a.i.vistnes@fys.uio.no