Particle-Wave Duality and Single Photon Interference in a Suitcase in the Secondary School

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Abstract: One of the most spectacular results in quantum physics is that when photons go through a double slit one-by-one, they still produce an interference pattern. We created a handy and portable experimental set-up in a dark suitcase together with data analysis and presentation software. This should have impressed grade 12 students, but it did not. Students are already used to counter-intuitive physics results. And most of them could recount and interpret the results properly. However, we did make some big changes in the lesson set-up to improve the surprise effect and articulate wave-particle differences and will present the results.

In a dark suitcase we built a double slit experiment (figure 1) with a single photon counting module. This consists of a photon detector which can move perpendicular to the light beam. A linear actuator moves the single photon counting module through 300 positions. At each position it stops to count for 100 ms. Results are displayed simultaneously on a screen.

The laser light is emitted by a laser diode (λ = 635 nm) and attenuated by an Neutral Density filter ("sun glasses") which lets through only 1 out of 100.000 photons. The photons then pass a double slit. Sound signals like those of a Geiger counter announce the arrival of photons to articulate the particle nature of the photon.

The cover of the suitcase contains a safety switch to switch off the detector when the cover opens. At present several suitcases are managed by universities and circulate among Dutch schools for classroom demonstrations. A detailed manual is available for teachers on how to handle the hardware and software and with teaching suggestions.

Although physicists have been quite surprised and intrigued with the outcomes of single photon interference, secondary school students show little surprise. They seem used to physics demonstrations that are counterintuitive such as predict-explain-observe-explain experiments. In interviews right after the demonstration, most students can reiterate the most important points and they can properly interpret what they see in the PhET simulation during the interview. However, they do not seem to realize the difference between waves and particles. When asked for differences they answer that particles have mass and that a wave is an oscillation that is passed on. They do not mention that particles are clearly localized in space while waves are spread out. Therefore, we redesigned the demonstration lesson to better articulate wave-particle differences before conducting the single photons experiment.

In the poster session we will show the experiment and visitors can ask about hardware and software, the teaching approach, and the results of our students.

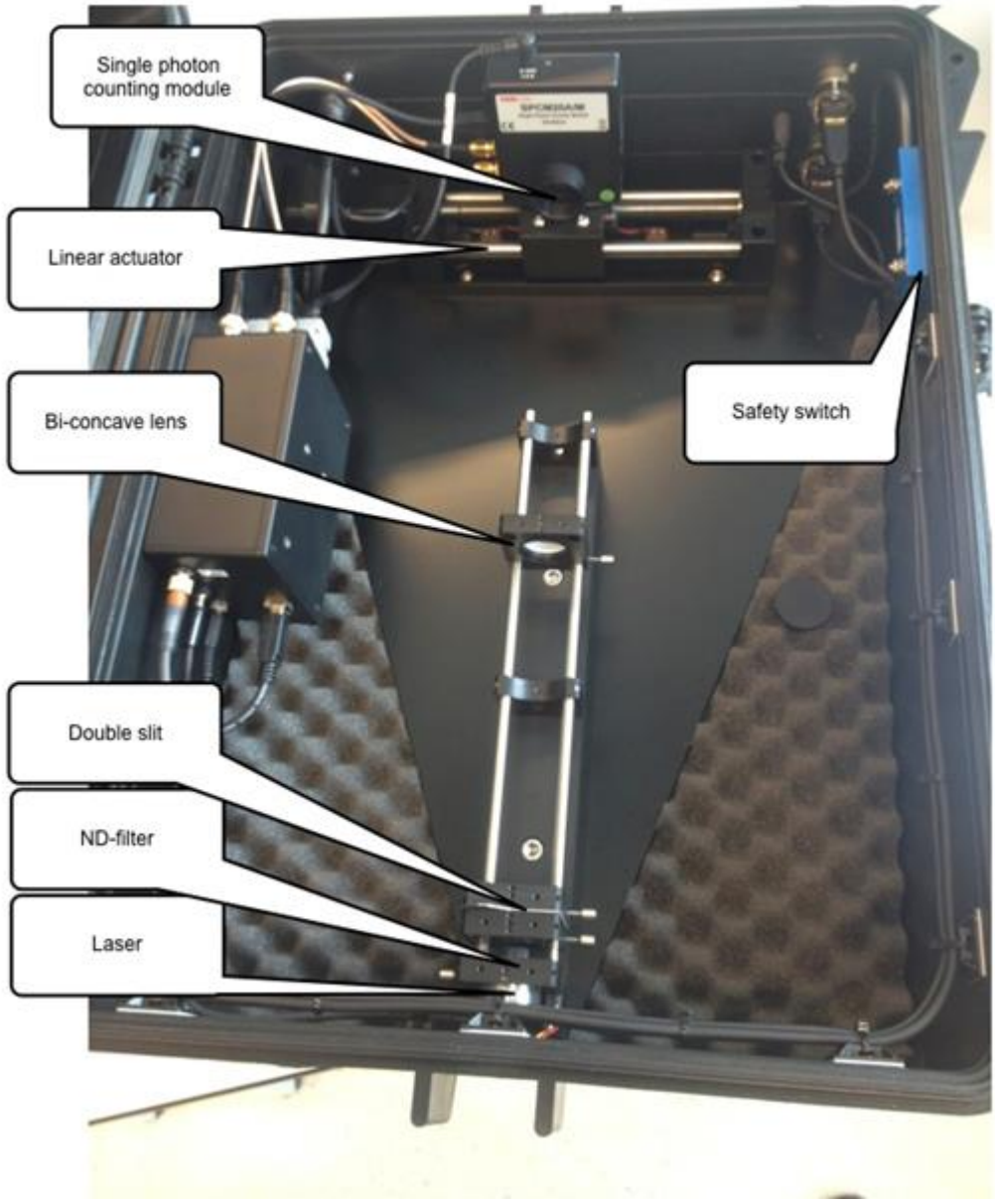

Figure 1 Single Photon interference set-up in suitcase