C.2.1 Quantum Nature of Light

SG6221

Related Experiment
A.1.1
D.1

Ordering Options

Equipment	
Code	**Description**
WK5600XEAAAA	SP5600E - Educational Photon Kit
or the all inclusive Premium Version	
WK5600XANAAA	SP5600AN - Educational Kit - Premium Version

Purpose of the experiment

Exploring the quantum nature of light thanks to bunches of photons emitted in a few nanoseconds by an ultra-fast LED and sensed by a state-of-the-art detector, a Silicon Photomultiplier (SiPM).

Fundamentals

In the XVII century the concept of wave-particle duality was developed, starting from the wave nature of light postulated by Huygens to the Einstein Photoelectric Effect, which postulates light quanta existence.

A basic principle of quantum mechanics is complementarity: each quantum-mechanical object has both wave-like and particle-like properties. With this approach the photon is at the same time wave and particle, but they can never be observed simultaneously in the same experiment, not even if the uncertainty principle is successfully bypassed.

Equipment

SP5600E - Educational Photon Kit

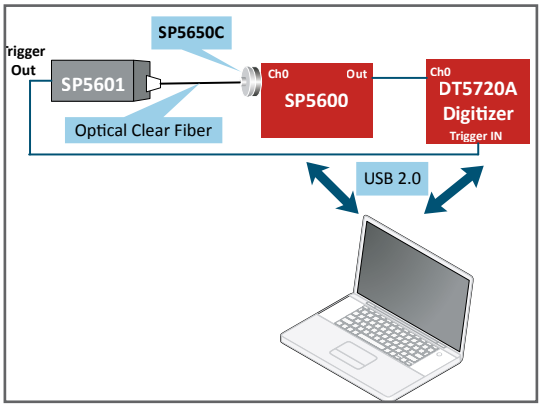
Model	SP5600	DT5720A	SP5601	SP5650C
Description	Power Supply and Amplification Unit	Desktop Digitizer 250 MS/s	LED Driver	Sensor Holder for SP5600 with SiPM
				
	p. 145	p. 145	p. 146	p. 146

Requirements

No other tools are needed.

Like the special theory of relativity, Einstein's quantum hypothesis arose from an experimental puzzle and an asymmetry or duality in physical theories. The duality consisted of the well-known distinction between material atoms and continuous ether, or, as Einstein wrote in the opening sentence of his light quantum paper, "between the theoretical conceptions that physicists have formed about gases and other ponderable bodies and the Maxwell theory of electromagnetic processes in so-called empty space." As noted earlier, Boltzmann and others conceived of gases as consisting of myriads of individual atoms, while Maxwell and Lorentz envisioned electromagnetic processes as consisting of continuous waves. Einstein sought a unification of these two viewpoints by removing the asymmetry in favor of a discontinuous, "atomic," or quantum, theory of light. Resolution of an experimental puzzle encouraged this approach. The Nobel Prize in Physics 1921 was awarded to Albert Einstein "for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect".

https://www.aip.org/history/exhibits/einstein/essay-photoelectric.htm



Experimental setup block diagram.

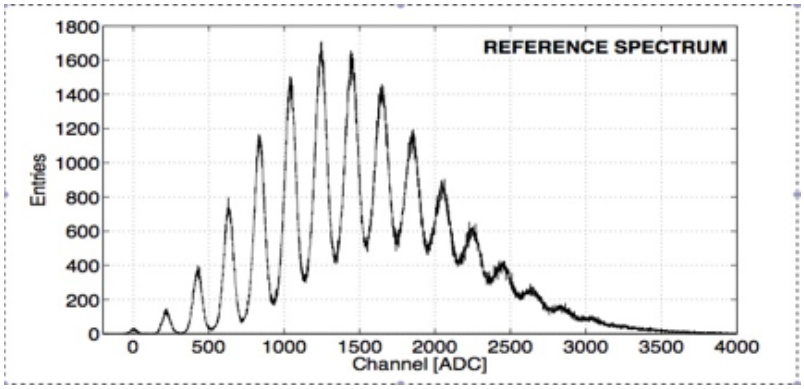
Carrying out the experiment

Plug in the SP5650A into one channel of SP5600 and connect the analog output to DT5720A channel 0. Remove the protection cover of the SP5601 and SP5650A, spread the optical grease on both ends of the optical fiber and connect them. Use internal trigger mode on SP5601 and connect its trigger output on the DT5720A trigger IN. Connect via USB the modules to PC and power ON the devices. Use the default software values or optimize the parameters to acquire the light spectrum.

In the spectrum of the SiPM response to a light pulse, every entry corresponds to the digitized released charge, measured integrating the electrical current spike during a predefined time interval. The peaks correspond to different number of cells fired at the same time by incoming photons.

Results

This detector can count the number of impacting photons, shot by shot, allowing to observe how the light is composed by photons. Moreover the SiPM measures the light intensity simply by the number of fired cells.



Spectrum of the photons emitted by a LED Driver and detected by a Silicon Photomultiplier.