Single Pulse Quantum Imaging

Michael Förtsch, Christoffer Wittmann, Christoph Marquardt, Gerd Leuchs,
Max Planck Institute for the Science of Light, Erlangen, Germany (May 2011)

Application Note

Introduction

Entanglement is a key requirement for many quantum protocols and usually formed between two distinct beams. This evokes a fast increasing complexity in growing quantum networks. By superimposing different optical modes within one optical beam one can overcome this problem. To have almost unlimited access to these different modes we plan to investigate the quantum mechanical properties of any arbitrary spatial mode by using a CCD camera (Andor iKon-M DU934N-BR-DD). To resolve the quantum mechanical properties of the light pulses the essential requirements for the CCD camera are high quantum efficiency in combination with low dark current and read-out noise.

Experimental Setup

In order to adapt the repetition rate of the light pulses from the Ti:Sapphire Laser to the readout rate of the camera, pulse picking is an indispensable operation. In our setup (Figure 1) this is done in two stages. First the 82 MHz repetition rate is reduced via an acoustic-optical modulator (AOM). Since the extinction ratio of such devices is limited, in a second stage the reduced pulses are sent onto a piezo tilt mirror and swept over a pinhole. This increases the extinction ratio sufficiently to ensure a single pulse resolution on the CCD camera. The second stage acts like an additional pulse picker and by using a synchronization circuit matches exactly one pulse to the readout frequency of the CCD camera. During the whole measurement process the camera is controlled via a self-programmed user interface based on LabView VI and the Andor Software Development Kit (SDK). This gives us the opportunity of real time monitoring different parameters, i.e. the mean or the variance value calculated for any arbitrary region of interest.

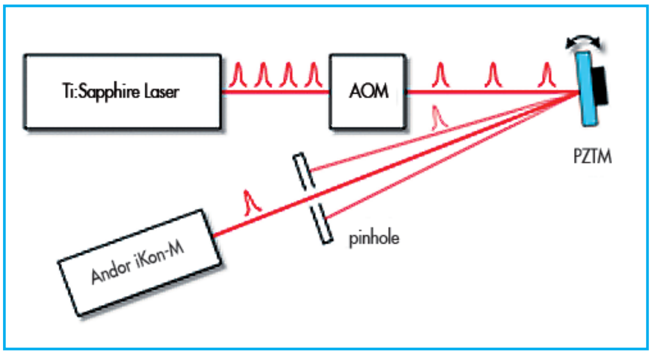

Figure 1 Scheme of the setup. The pulse repetition rate is reduced in two stages. First with an acoustic-optical modulator (AOM) and second with a piezo tilt mirror (PZTM) sweeping over a pinhole. Finally the pulse is captured by the Andor iKon-M.

Results and Outlook

We succeeded in having single femtosecond pulses on demand synchronized with the readout frequency of the camera.

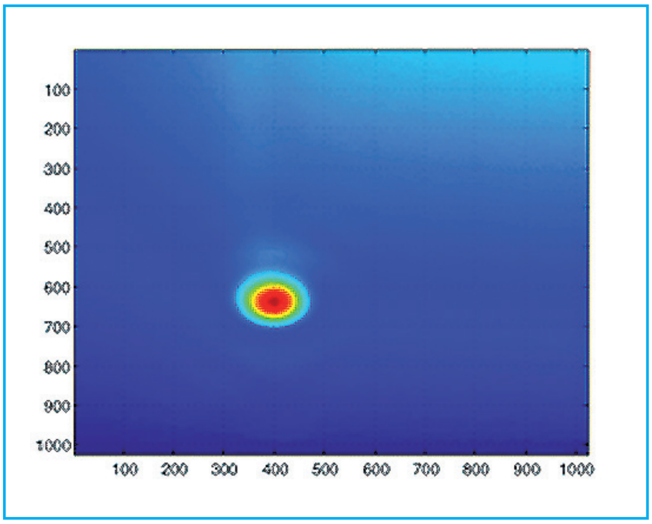

Figure 2 Single fs pulse captured with the Andor iKon-M CCD camera

Figure 2 shows an image of one single fs pulse captured with the camera at a readout frequency of 1Hz. The pulse energy was around 24 pJ corresponding to an average photon number of 2.9 10^8 per pulse at the chosen wavelength of 810 nm. These results enable us to investigate the noise properties of single fs laser pulses. In a first step we will characterize the noise properties of the Ti:Sapphire Laser alone. Subsequent experiments will investigate sub shot noise properties of nonclassical states of light. In addition to the investigation of quantum properties of optical pulses the presented technique also can be applied in the context of single ultra-short pulse spectroscopy.

Contact:
Michael Förtsch
MPI for the Science of Light
Guenther-Scharowsky-Str. 1, Building 24
D-91058 Erlangen, Germany

Phone: +49 9131/6877-121
E-mail: Michael.Foertsch@mpl.mpg.de
http://www.mpl.mpg.de/mpf/php/abteilung1/index.php?lang=en&show=workgroups&in=qiv