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Development of CARS and SRS microscopy with speed wavelength scanning laser

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1. Introduction

Coherent anti-Stokes Raman scattering (CARS) and stimulated Raman scattering (SRS) are attractive tools in biological application, since they offer a non-invasive label-free imaging with molecular sensitivity [1-3]. In these techniques, two wavelength are used, and as, they are a nonlinear optical process, picosecond lasers has to be used. The need of two picosecond lasers, lead to the necessity of using a synchronization system with picosecond level of jitter. In this work I reduced the jitter of the synchronization and the changes in the repetition rate of the Acoustic-Optic Tunable Filter (AOTF) laser. In the development of the laser we had faced two main problems. The first is to keep the synchronization of the lasers with low level of jitter. We previously used a digital PID controller, but using a discrete control system, it was hard to improve the level of noise. We replaced the digital PID controller by an analog PID controller. The second problem was to keep the repetition rate constant. As the piezo-motors response is too slow to make fast scanning, we added an offset in the analog PID controller and controlled the repetition rate.

2. Development of AOTF laser

To tune the wavelength, the AOTF was used. The AOTF is made of a birefringent crystal in which by using a transducer, RF mechanical frequencies are used to, periodically, change refractive index of the medium, what makes the crystal to behave as a diffracting grating. Therefore, AOTF filters a specific wavelength with narrow bandwidth. In order to keep the repetition rate of the two lasers equal, we also need to change the repetition rate of the AOTF laser. As the repetition rate of the pulses is function of the cavity length and the oscillating wavelength, we needed to keep the cavity length during the scanning of wavelength. This is done by using piezo-motors and a pair of galvano-motors driven parallel plates. Finally, we also need to change the phase of the lasers to make the synchronization. We changed the phase in two different ways. The rough adjustment is done by rotating the parallel plates and the fine adjustment is done by using a piezo-actuator. All components of our laser are controlled by a computer and the synchronization is kept using PID controllers in a phase-locked loop.

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