DESY Summer Student Program 2009

PROJECT REPORT

Preparations to the experiments at FLASH.

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Abstract

This report describes work of a Polish student who participated in the DESY Summer Student Program, which took place in Hamburg, during the Summer 21.07 - 11.09. 2009. Author was assign to HASYLAB, which is orientated in synchrotron radiation research and CFEL which focus on developing and exploiting the scientific applications of the new radiation sources with outstanding properties.

I would like to thank my supervisor Henry Chapman for support, interest of my practice course and help in understanding the beauty of the FLASH experiments. Furthermore special thanks to Wladzimir Schymanovch, Helmut Mahn, Daniel DePonte and Zia Ahmad for introducing me to the interesting topics in which I was involved, kindness and help. Moreover I would like to thank all the CFEL group for kindness and organization of my work.

I will always remember my stay at CFEL group as the most exciting and fascinating experience in my life.

Content

1. Introduction

1.1 Synchrotron radiation

Synchrotron radiation is quite often to be found in the Universe, but for us, for many years it was an unknown phenomenon. First observation of synchrotron radiation was in 1947 by Schenectady at General Electric 70 MeV Synchrotron [1]. Synchrotron radiation is electromagnetic radiation with wavelengths ranging from infrared via visible and ultraviolet to x-rays. Synchrotron radiation has very strong intense and bright. Consists of ultra short bunches. Moreover it is highly collimated, precisely calculable and linearly and elliptically polarized. Because of such properties this radiation may be used for investigating a whole variety of material and observing dynamic processes in micro scale. That is why synchrotron radiation has become a major research tool.

1.2 Classical quantum lasers

Laser is an acronym of Light Amplification by Stimulated Emission of Radiation. Classical laser consists of three the most important elements: a laser medium which has at least three energy levels, energy for pumping and optical resonator (two mirrors which are responsible for amplification), fig.1 . The stimulated emission takes place between energy level E_2 and E_1. To achieve the laser action the population inversion is required. For this purpose electrons must be pumped (excited) from the lowest energy state E_1 to the highest state E_3 . From the E_3 to E_2 fast transition occurs and than the laser emission occurs between the E_2 and E_1 state.

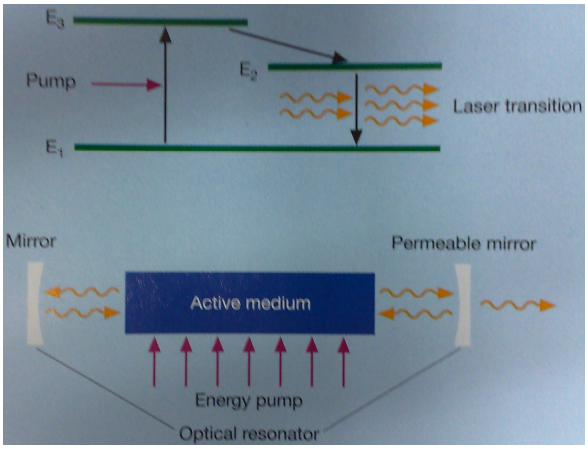

Fig. 1. Classical III energy level quantum laser [2].

1.3 Free Electron Laser

Above was describe in a nutshell the way classical laser works. Free Electron Laser produce radiation of an intensity several orders of magnitude greater than that from storage rings. The radiation has properties of laser light and has ultra short pulses. Instead of storage rings FEL use linear accelerators. Once the electrons has been accelerated they travel through a long undulator (a recurring sequence of magnets that causes them to follow a rapid slalom course), fig. 2. Accordance with SASE principle of Self Amplified Spontaneous Emission, the radiation pulses emitted by the electrons as they pass through the undulator increasingly reinforce one another, thus resulting ultimately in the production of extremely short (50 fs) and intense pulses of light [3].

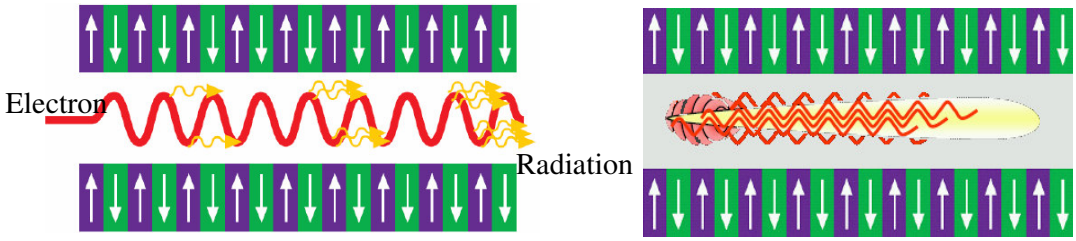

Fig. 2. Undulator in which coherent electromagnetic radiation is produced. [4]

2. My Practice at CFEL

2.1 Setting optics to the pomp – probe experiment at FLASH

At the beginning of my practice I set up optics for the IR light in the pump – probe experiment at FLASH hall. My task was to supply 800 nm beam into a chamber. The alignment was made with green laser because it is visible and harmless. The system is presented at fig. 3.

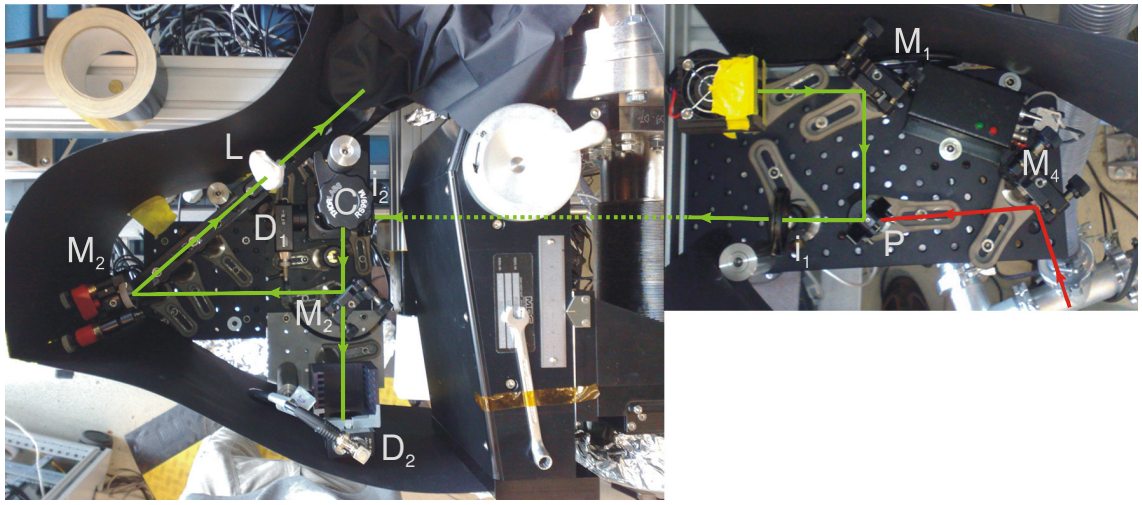

Fig. 3. Pumping system for pump - probe experiment made at FLASH, which was aligned with a green laser.

The green beam reflex from mirror M_1 and goes through the half transmitting plate which is orientated 45° degree corresponding to the normal. Than light pass through iris i_1 and another iris i_2. The optical window in chamber was much higher than the beam and the difference in altitude was 20 cm, that's why the beam had to be rised using two mirrors set under 45° corresponding to the normal. The lower mirror was half transmitting and diode D_1 was installed behind. Both mirrors was installed on one column C .After rising, the beam was reflected from half transmitting mirror M_2, to mirror M_3 which was installed in a motorized

holder. Behind mirror M_2 diode D_2 was installed. To ensure high intensity of light in the chamber, beam was focused by focusing lens L which focal length was 30 cm.

2.2 Mounting the microscope for FLASH experiment

From the other side of the chamber another window was installed for monitoring overlap of two beams : pumping and probing. Because of the fact that diameter of two beams is small, around few micrometers, the microscope was required.

For having good conditions to see the beams, 3 dimensional smoothly regulation of the microscope was required. My task was to construct a holder for this microscope and special board for joining blackboard with a holder. The stage had to be mounted 45 ° corresponding to the edge of the blackboard. The problem was that distance between mounting holes in the stage was 2,5 cm and distance between mounting holes in the blackboard in diagonally direction was 3,53 cm. That is why new board with suitable distance of holes was required.

In the fig.4. the board is presented.

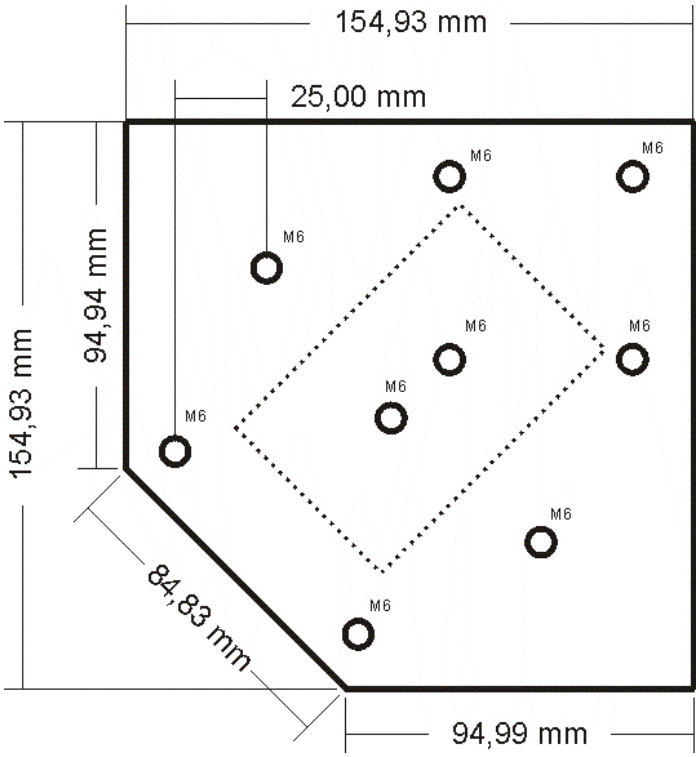

Fig. 4. Board joining the blackboard and smoothly regulated holder for microscope.

I used 7 M6 screws to make few millimeter thin aluminum board more rigid.

For smoothly 3D regulation I used 3 stages installed orthogonal to each other. Ready microscope holder installed on a chamber is presented in fig.5.

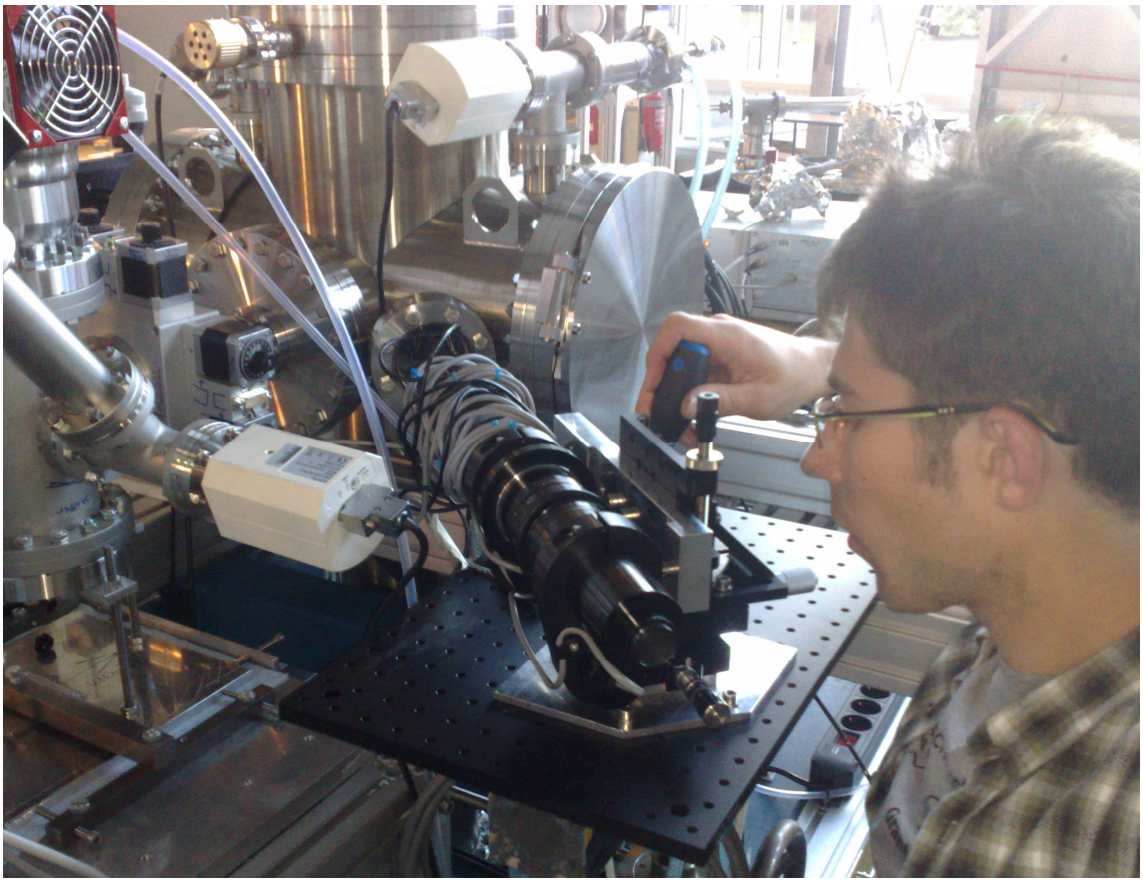

Fig. 5. Installation of the microscope.

2.3 Data selection

When the experiments finished I was asked to select images taken during the experiment. There is a huge amount of files containing data information from the measured samples. During the measurement every second a data from the CCD camera was collected and saved to a different file.

Not every file includes important information, because sometimes the x ray beam didn't hit the CCD. My task was to select few files including well hit detector. The typical image taken from the well hit CCD cameras is presented below in fig. 6.
In the experiment 3 cameras was used to cover bigger area, fig. 6.

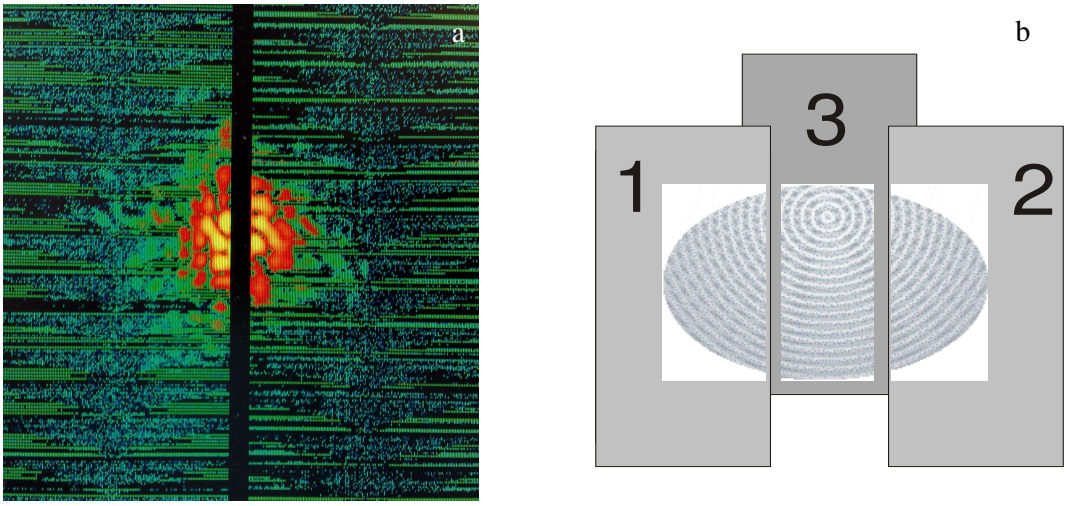

Fig. 6. a) Diffraction image of nanorice on camera 1 and 2. b) system of 3 CCD cameras used in a chamber .

2.4 Introducing to modeling a 3D diffraction imagine

I was also introduced to laser diffraction imagining. This experiment is being prepared for test the 3D diffraction imagining setup and program for processing 2D into 3D diffraction patterns which will be used at FLASH in the following years.
The setup is presented in fig. 7.

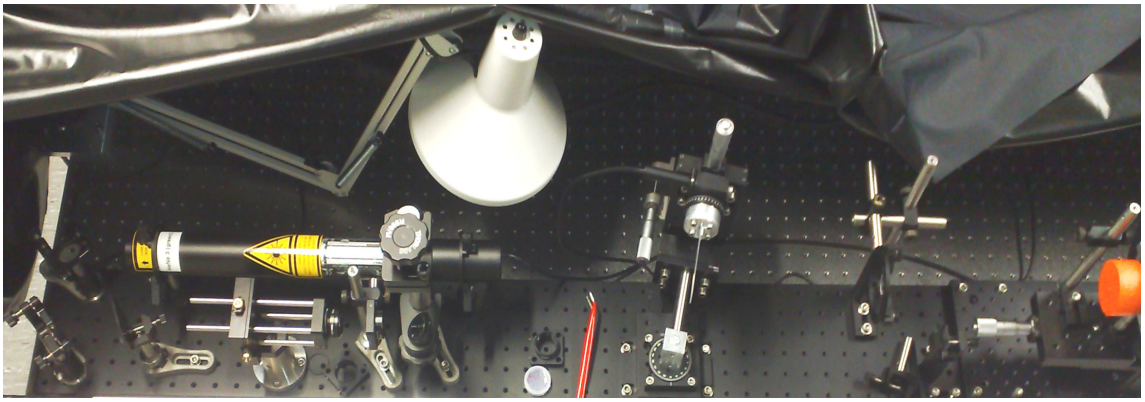

Fig. 7. Setup for 3D diffraction imagining.

Laser beam is reflected from mirror 1 and 2 and directed on a pin hole, where diffraction occurs. To get good diffraction image, laser beam should be represented by a plane wave. It is done choosing the k = 0 diffraction line using the iris. After iris the system of two mirrors is installed for rising the beam. Next the beam is directed on a sample which is placed on a glass plane. This plane is mounted to an arm which can rotate along z axis. Using this rotating arm is possible to light up a sample under different angles. Than the beam is focused on a CCD camera.

2.5 Microscope for needle injector

My last task was to construct a microscope which will be used for checking the properly work of needle injector. This injector is used for injecting the water or other substances solved in a liquid solvents into a chamber. Special microscope was needed because the small vacuum pipe chamber was too big to install it on a Zeis optical microscope.

I used small vacuum pipe chamber with two windows for installing the needle. Than I construct a special holder for the microscope. Holder has possibility to adjust it smoothly in 3 dimensions. Microscope was connected to a webcam and plugged with a USB cable to a computer. Very important thing was to prepare good illumination from bottom. I used fiber light, one mirror oriented 45° respect to the table plane and lens oriented perpendicular to the table and mounted on a stage which give me a possibility to change a high.

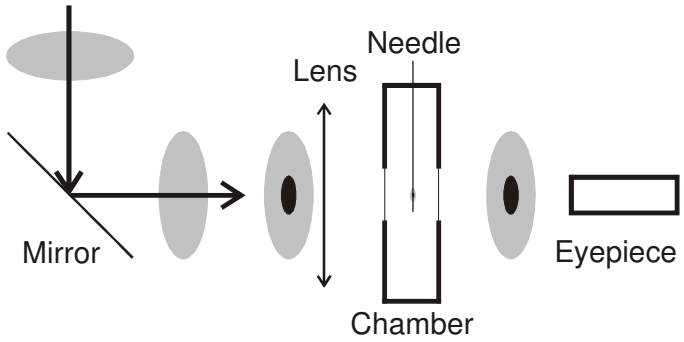

Fig. 8. Idea of illumination with a dark field.

Using such a system which is describe above the needle was very strongly lighted and the camera was saturated. That is why it was impossible to see the needle. The idea was to put between the mirror and lens a beam stop. When the lighten ring is focused, the dark field is very small and the needle is well illuminated, fig. 8. The most important is that thanks to the beam stop the camera is not saturated, because it is situated in this dark field and the object is still well seen. The system is presented in fig. 9.

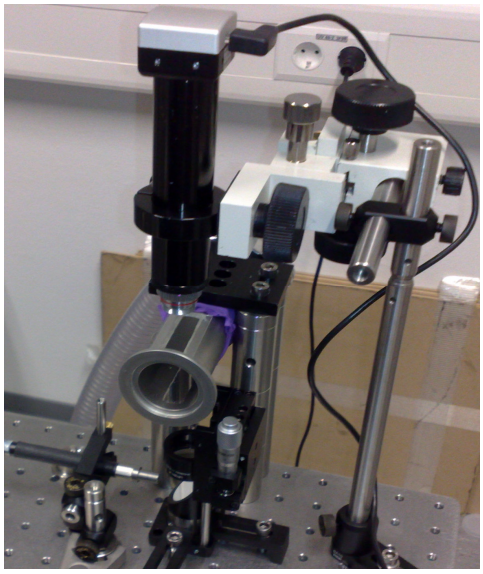

Fig. 9. Microscope for needle injector.

3. References

[1] J. Viefhaus, Research with Synchrotron Radiation 1, DESY Summer Student Lecture 2009

[2] J. N. Schneider, R. Nielsen, J. Feldhaus, B. Kietel, W. Laasch, P. Schmuser, B. Sonntag, K. Tiedtke, Flash, DESY

[3] I. Flegel, Textlabor, Jena, High Lights, DESY

[4] M. Dohlus, Free Electron Laser, DESY Summer Student Lecture 2009