Instytut Fizyki Doświadczalnej
Wydział Matematyki, Fizyki i Informatyki
UNIWERSYTET GDAŃSKI

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DYDAKTYCZNE
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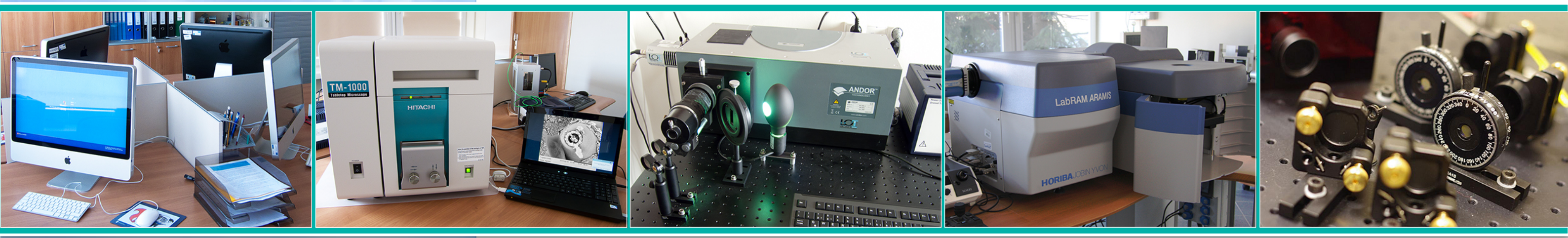
Experiment 10

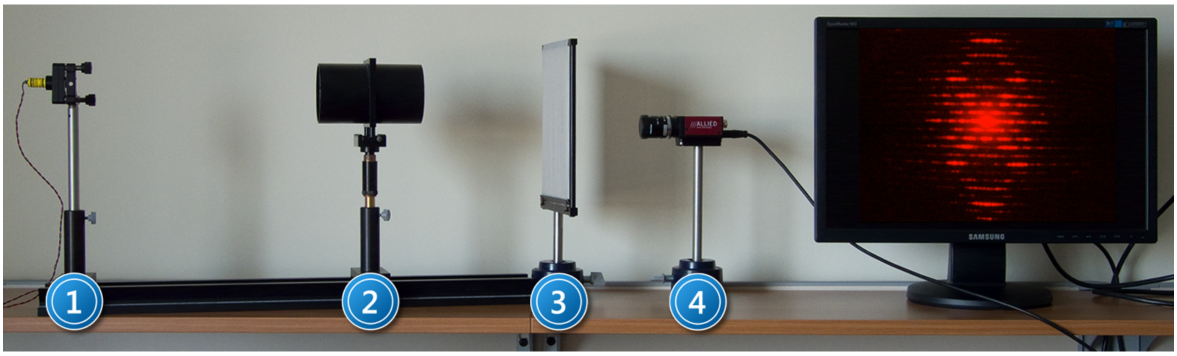
Optical simulation of β – DNA X-ray image

KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI
UNIWERSYTET GDAŃSKI
UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY



I. Background theory.

1. Wave nature of light.
2. Spatial and temporal coherence of light.
3. Interference of light. Young's double-slit experiment.
4. Diffraction of light.
5. Diffraction grating equation.
6. Analysis of real X-ray diffraction by β – DNA:
   a) X-ray radiation;
   b) experimental method of X-ray diffraction by a preparation of β – DNA;
   c) analysis of the characteristics of β – DNA X-ray diffraction.
7. Optical analogies of X-ray diffraction images.
8. The structure of deoxyribonucleic acid β – DNA.
9. Use of laser optical simulations for the interpretation of β – DNA X-ray diffraction:
   a) diffraction image analysis of the 9 gratings included in the experimental kit.
   b) linking the characteristic features of the diffraction images from the 9 gratings with the structural parameters of the model of a β – DNA molecule.
10. Principle of operation of semiconductor laser diodes.
11. Recording an image using the camera's CCD (Charge-Coupled Device).



Picture 1. Measuring system for the optical simulation of β – DNA X-ray diffraction:
1 – semiconductor laser; 2 – barrel with grating system; 3 – screen; 4 – CCD camera

II. Experimental tasks.

1. Refer to the measurement system shown in *Picture 1*.
2. Turn on the laser and CCD camera (1 and 4 in *Picture 1*).
3. Set up the slide with nine diffraction gratings (2 in *Picture 1*) such that the laser-light falls on the first grating (top-left corner).
4. Refer to page 3 of the appendix in the detailed instruction manual from National Instruments and record the resulting diffraction pattern.
   By moving the tube with the diffraction gratings, thereby choosing which of the gratings is in the path of the laser light, record images for each of the nine grids.
5. Measure the distance between the negative with gratings and the screen.
6. Compare the obtained diffraction images with the pattern of the grating used.
7. Analyse the relationship between the characteristic features of the obtained diffraction images and the elements of the double helix structure of β – DNA.
8. Based on the recorded diffraction images of the β – DNA model, calculate:
   a) the period of the double helix;
   b) the radius of the double helix;
   c) the distance between successive base-pairs;
   d) the coaxial displacement between individual spirals in β – DNA.

III. Apparatus.

1. Semiconductor laser diode (λ = 680 nm).
2. Set of 9 diffraction gratings.
3. Screen.
4. CCD camera.
5. Computer.

IV. Literature.

1. A.A. Lucas, PH. Lambin, R. Mairesse and M.Mathot – *"Revealing the Backbone Structure of* β– *DNA from Laser Optical Simulations of its X – Ray Diffraction Diagram",* 1997.
2. T.R. Welberry, J.M. Thomas – *"Optical Transform Methods"*, Chemistry in Britain ", 383, April 1989.
3. H. Lipson – "Optical Transforms", Academic Press, London – New York 1972.
4. R.T. Morrison, R.N. Boyd – *"Organic Chemistry"*, Prentice Hall, 2008.
5. Ch. Hammond – *"The Basic of Crystallography and Diffraction"*, Oxford Science Publications, Oxford 2009.

Appendix

National Instruments Instruction manual

1. Turn on the computer.
2. Run the application **NI MAX**.
3. When you see the configuration dialog **"National Instrument Measurement & Automation Explorer",** select the option **"Devices and Interfaces"** from the "**Configuration"** section (on the left-hand side of the screen). Expand this option and choose "**NI – IMAQdx Devices"**.
4. The following camera symbol appears: **AVT Stingray F 146 B**. Select this camera.
5. A dialogue-box will appear. Use "**Grab"** from the buttons at the top of the screen.
6. An image from the camera will be displayed on the computer screen. Right-click on the image. Select the option "**Viewer Tool"** and then "**Zoom to Fit"**.
   The camera image should now fill the screen.
7. Select "**Camera Attributes"** from the options which appear at the bottom of the dialogue-box.
8. You will see options to set the brightness and contrast of the image. Refer to "**Brightness"** and **"Shutter"**.
   Look at the image to select appropriate values for the camera shutter speed.
9. In order to record an image, use the button "**Save Image"** in the upper-right corner of the dialogue-box.
10. Save the image, choosing a name and extension (PNG, BMP, TIFF).