3D FOCAL CONIC DOMAIN VISUALIZATION

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ABSTRACT

Work using OpenGL and OpenInventor to render solid models of microscopic specimens of SmecticA liquid crystals focal conic domains imaged with a laser scanning confocal microscope is presented.

Categories and Subject Descriptors

D.3.3 [**Programming Languages**]: Language Contructs and Features – *abstract data types, polymorphism, control structures.* This is just an example,.

General Terms

Algorithms, Management, Measurement, Documentation, Performance, Design, Reliability, Experimentation, Standardization, Languages, Theory, Verification.

Keywords

Liquid crystals, Focal conic domains, confocal microscopy, 3D imaging, scientific and information visualization OpenGL, OpenInventor.

1. INTRODUCTION

The Center for Advanced Liquid Crystalline Optical Materials (ALCOM) is one of 25 NSF Science and Technology Centers and is comprised of university physicists, chemists, and mathematicians from Kent State University, Case Western Reserve University, The University of Akron. The Center represents the largest concentration of liquid crystal research in the United States and scientists investigate the optical and physical properties of liquid crystals to design and fabricate new advanced materials. Interactive multimedia creates opportunities to observe physical phenomena between the layers of liquid crystalline material. This paper presents work in progress using a confocal microscope, OpenGL, and OpenInventor, to capture images of focal conic domains of SmecticA liquid crystals rendered as 3-D animation where the user can rotate as well as focus particular portions of the images in the new media.

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2. Focal Conic Domains[1]

[1]

Because of the surface tension anisotropy the SmA droplet shows faceted structure in the image below. In SmA this faceting is provided by so-called focal conic domains in the form of cones of revolution. The focal conic domains fill the interior of the droplet: Their apexes meet in the center of the droplet and their circular bases are located on the droplet's surface.

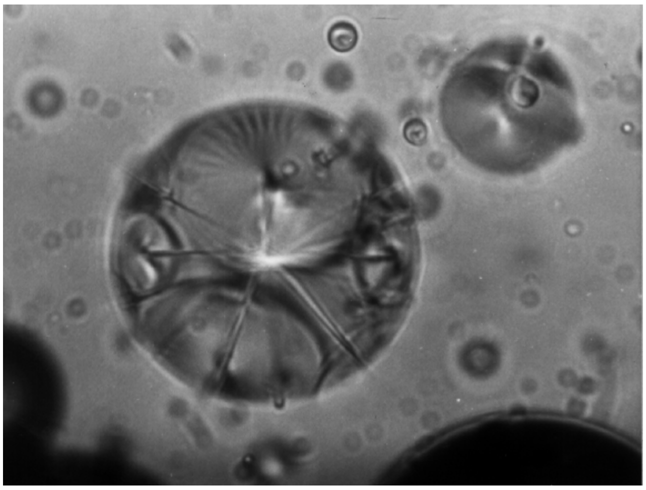

Figure 1. SmecticA Focal Conic Domain obtained by conventional light microscopy.

[1] image courtesy of Oleg Lavrentovich.

3. Scientific Visualization

3D visualization techniques are not commonly employed in analysis of focal conic domains. The goal of this work is to initiate discussion on a proposed new method of observation, on visualization issues, and on possible solutions. First, a novel method to produce solid models of microscopic specimens imaged with a laser scanning confocal microscope is presented. Second common visualization issues will be evaluated in an effort to determine the reliability of the proposed method. The visualization process can suppress information about the original data quality, add information not present in the original data, and lose information. All of this can result in incorrect assumptions about the structure or content of the original data or the meaning of the visualization. Finally, the work represents initial investigation of the proposed novel method with the intention of providing a framework for continued investigation. [2], [3], [4]

3.1 Confocal Microscopy[2]

Laser-scanning confocal microscopy enables microscopic examination of a wide variety of biological and inorganic specimens. This instrument utilizes a gas laser, conventional microscope, confocal optics, extremely sensitive light sensors, and a state-of-the-art computer and software to produce images of exceptional clarity and resolution. In addition, since information on focal conic domains is collected as volume data in digital format, OpenGL using Open Inventor is applied to further enhance the usefulness of the images. This ability to collect and manipulate high resolution, light microscopic data on structure and molecular composition may provide new opportunities for microscopic analysis of physical phenomena in the layers of liquid crystals. [5]

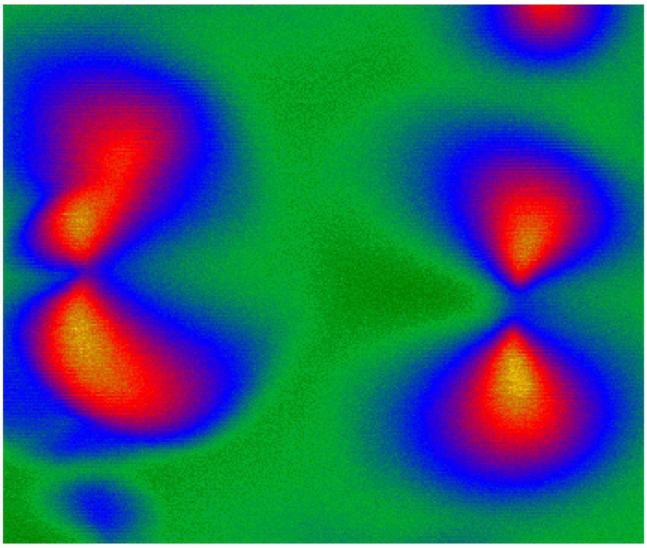

Figure 2. SmecticA Focal Conic Domain obtained by Laser Scanning Confocal Microscopy.

[2] image courtesy of Oleg Lavrentovich.

3.2 Novel Method for presenting Focal Conic Domains

An understanding of the morphology and the developmental changes in the shapes and dimensions of focal conic domains requires three-dimensional (3-D) analysis in order to observe physical phenomena between the layers of liquid crystalline material. We devised a simple protocol using confocal laser scanning microscopy (CLSM), to render the 3-D. We will evaluate the reliability of our method by comparing results with those of a parallel study of the same material by conventional light microscopy to determine if the images of optical sections obtained by CLSM were of high quality and accuracy. We will also evaluate whether optical sections and high contrast images provide clear information about the shapes and nuclear status of focal conic domains which have previously been difficult to determine using conventional microscopy. Finally we will evaluate the use of the confocal microscope with OpenGL and OpenInventor as a quick and easy method for visualization of the structure of focal conic domains.

[It will be nice to add a little detail about the type of boundary value equation we will be solving to extrapolate the slice data into volume data-- a good IT problem. Some time it is done physics domain by using the property equations (CT scan etc.). However, in other cases it is more appropriate to extract the visual information by slice based processing and geometric interpolation (shape reconstruction)]

[Perhaps then it makes sense to identify some sort of procedures and steps how we will do it.]

3.3 OpenGL

OpenGL is used to produce high quality 3D images and animation in many areas, such as scientific data visualization. It is a hardware-independent standard 3D graphics programming interface and has been an important factor for graphics-intensive applications by providing an underlying portable software platform that optimizes the use of available graphics hardware. [6]

3.4 OpenInventor™

The implementation of the new method is based on the Open Inventor™, an object-oriented 3D rendering toolkit.

4. ACKNOWLEDGMENTS

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5. REFERENCES

[1] Kleman M, Lavrentovich O.D., Grain Boundaries and the Law of Corresponding Cones in Smectics European Physical Journal E 2: (May 2000) 47-57.

[2] Robinson, D. M. A structure map as a visualization aid in three-dimensional treatment planning. Medical Dosimetry, 25, (Winter, 2000), pp. 249-253.

[3] Viergever, M.A; Maintz, J.B.A.; Niessen, W.J.; Noordmans, H.J.; Pluim, J.P.W.; Stokking, R.; Vincken, K.L. Registration, segmentation, and visualization of multimodal

brain images. Computerized Medical Imaging and Graphics, 25 (March, 2001), 147-151.

[4] Taylor R.M., Practical scientific visualization examples, Computer Graphics-US 34: (Feb 2000)74 -79.

[5] Robinson J.P., Principles of confocal microscopy, Methods in Cell Biology, 63 (2001), 89-92.

[6] Portmann S., Luthi H.P .MOLEKEL: An interactive molecular graphics tool, CHIMIA, 54, (Dec 2000) 766-770.