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Articles

Optical Effect with Small Apertures as Result of Diffraction. Camera Obscura

Ignat Ignatov [a, *], Teodora P. Popova [b], Kevork Vanlyan [c]

[a] Scientific Research Center of Medical Biophysics (SRCMB), Sofia, Bulgaria
[b] University of Forestry, Faculty of Veterinary Medicine, Sofia, Bulgaria
[c] National Academy for Theatre and Film Arts, Sofia, Bulgaria

Abstract

In 1976, one of the co-authors, Ignatov, at 13 years old, described a phenomenon where small apertures produced optical effects. This was documented in a letter published in the Bulgarian scientific magazine "Cosmos." During the socialism in Bulgaria, access to information was limited to educational institutions and libraries. There was a lack of information about the described phenomenon at that time.

The phenomenon, where images are observed through small apertures, occurs entirely by chance. A camera obscura was constructed, projecting images through a narrow gap.

Also, a model for photographing images with a small aperture is suggested so operators can be trained to capture images under specific conditions.

Keywords: colors, shades, additive mixing, optical effects, image through a small aperture.

1. Introduction

A camera obscura is a specific device that mimics the anatomical structure of the human eye. It can change the lens's focal length, while a pinhole camera cannot. Thus, the human eye can be considered a compatible sensor (Kumar, Ashish, Gowtham, 2020). Cameras and photographic devices control the amount of light with an aperture (Ignatov, Vanlyan, 2020). The aperture changes the opening of the camera. Photography using a pinhole camera illustrates the Lorentz transformation's power. It can capture the contraction of length, which conventional photography cannot achieve. Using the Lorentz transformation, the emission of light rays from the source and their reception in the pinhole was investigated, and it was shown that depending on its orientation, the image could be a line or a curve. The image of a relativistic moving sphere in a pinhole camera forms an ellipse, elongated in the direction of motion. The image of such a sphere is a circle if it moves directly toward or away from the camera (Hassani, 2017).

2. Methods and materials

An experiment with Camera Obscura was conducted to project an image through a small aperture with a size of 1 mm. The object of the study was a needle (Figure 1).

* Corresponding author
E-mail addresses: mbioph@abv.bg (I. Ignatov)

Fig. 1. The object of the experiment is image projection through a small aperture.

3. Results

The results of the experiment on image projection through a small aperture are presented in Figure 2.

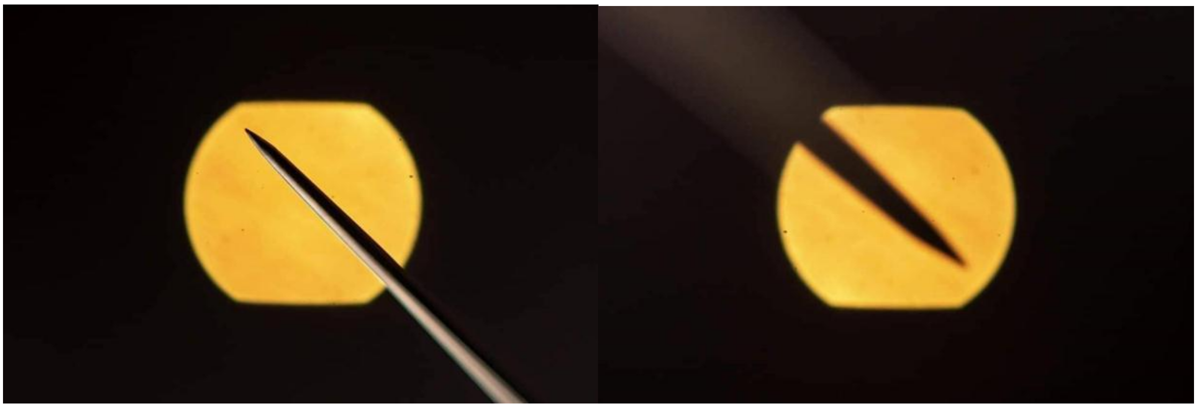

Fig. 2. Needle Projection through a Small Aperture (photo K. Vanlyan)

The image in Figure 2 is enlarged 1.5 times. The explanation given by 13-year-old Ignat Ignatov in 1976 is a diffraction effect. The aperture is 1 mm. The image is reduced when the distance from the object to the aperture increases. With this proposed exercise, operators can be trained in photographing an object and its image under specific conditions. The photography is done through a small aperture. The calculations of the object/image allow for the construction of a model for working in challenging conditions.

The camera obscura with a flat virtual screen is the standard model for obtaining images used in ray tracing. Figure 3 shows the demonstrative scheme of the museum in Teteven, Bulgaria.

A model with camera obscura can be extended with a cylindrical virtual screen to achieve a 360° or more extensive field of view. By using a suitable angular distribution of objects along the vertical axis, a 180° vertical field of view can also be obtained. This way, the entire celestial sphere can be mapped onto a planar image with acceptable distortion. The resulting panoramic images can be useful for interactive viewing of static images in a virtual reality system (Kenton, 1992). However, when the object is positioned behind glass, for example, a framed painting, and a pinhole camera and point light source are used, the path of light passes through the glass, and then the point at which it intersects the image is determined entirely by the refraction effect. Regardless of the light's direction, it reflects off the diffuse surface and refracts upon exiting the glass, resulting in significant dispersion (Pharr, Jakob, Humphreys, 2017). Similar effects form the basis of virtual reality and magic as a form of art illusion designed to appear contradictory to the laws of nature. Research into ways to enhance this sensation continues. For example, the Oculus Rift adaptation is designed to create a virtual reality with a stereoscopic 3D view. Unlike 3D in television or movies, this is achieved through unique parallel images for each eye (Lander, 2015). It demonstrates how flexible our sense of presence in reality is and that we still don't fully understand it. Virtual reality creates the illusion of actual presence in the virtual environment and the observer's sensation of physically being in another space. Illusions are also used in painting, often created through perspective (Lander, 2015; Pharr et al., 2017; Marelli et al., 2015; Jensen, Christensen, 2023). Capturing images with small apertures is challenging. It is practically helpful for photographers and operators.

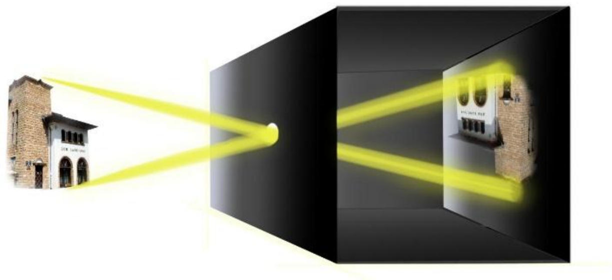

Fig. 3. A museum model in Teteven, Bulgaria, with camera obscura

A model for photographing images with a small aperture is suggested so operators can use camera obscura to simulate depth of field in the image. However, here, the fact that the surface of the lens provides a sequence of different views of the surroundings is not taken into account. This drawback is overcome by tracking the distribution of rays, but an embedded technique for the imaging process is required. The visibility of the surface is combined with the depth of the background in a limited way without integrating shading with background depth trained to capture images under specific conditions (Schofield et al., 2010).

4. Conclusion

This study corroborates the observation of diffraction effects by revisiting Ignatov’s 1976 achievement of optical effects via small apertures and experimentally validating these phenomena through a Camera Obscura. The projective qualities of a 1 mm aperture align with initial insights, forming the basis for a proposed model facilitating image capture under specific conditions. This model, leveraging Camera Obscura’s emulsion of depth of field akin to the human eye, offers a platform for operator training in image capture. Practical exercises conducted with photographers and operators using the described model system for capturing diffraction images enable the practical application of optical effects. On the other hand, fine-tuning the aperture and camera for specific captures in laboratory conditions is practice. Natural phenomena require professionalism and assessment of background and color characteristics.

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