11th IYPT '98
solution to the problem no. 9
presented by the team of Poland
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Woven textiles

Look at a point-like light source through different woven textiles. Describe what you see. What is the explanation of the phenomenon?

Abstract

This phenomenon is caused by difraction and wave interference. Set of elements (gaps) that deflact light is called diffraction grating. Woven textile is a diffraction grating. According to HUYGENS principal every gap is a source of new wave that can interfer with each other.
There are some facts that have influence on this phenomenon. First is type of woven textile: Syntetic or natural. Second is type of gape: Rectangular, triangular, round, ... This shape depends from configuration of threads in woven textile. Different angles between threads is important, too. Kind of light is important, too. When we use white light we observe dispersion which we would not see with monochromatic one. At last we can stretch textile vertical- then horizontal gaps would be thiner and inversely.

Thanks

I would like to thank all the organisators and all teams of XI. IYPT for the wonderful stay in Donaueschingen, pleasant atmosphere and exacting competition. I would like to thank our team leader – M. A. Urszula Woźnikowska-Bezak and Prof. Władysław Borgieł from Silesian University and every other people who helped me with this report. Without their help our second place would be impossible to achieve.

Overview

1 Introduction

First of all we have to say that when we use to see this phenomenon white light we can observe diffraction, wave interference and light dispersion. We can see shape that looks like glowing cross. When we use laser we only observe diffraction and wave interference without disperssion. This is caused by the fact that light from laser is monochromatic. With laser we can see set of points that compouse into glowing cross.
Second very important matter is my definition of woven textiles and point-like light source. Woven textile is grating compoused from horizontal and vertical threads. Point-like light source is a sourse that we can characterize with quotient of its diameter and distance between observator and this source. This quotient for ideal point-like light source would be zero.

2 Explanation with diffraction and wave interference

This phenomenon is caused by difraction and wave interference. Set of elements (gaps) that deflact light is called diffraction grating. Woven textile is a diffraction grating. According to HUYGENS principle every gap is a source of new wave that can interfer with each other. We have two kinds of diffraction gratings: one dimensional diffraction gratings and two dimensional diffraction gratings (woven textiles).

2.1 One dimensional diffraction grating

On figure 1 you can see that coherent, monochromatic light hits one dimesional diffraction grating. It deflects and we can see first rank of spectrum. Beneth formula is a condition of seeing white light. This condition must be maintained.

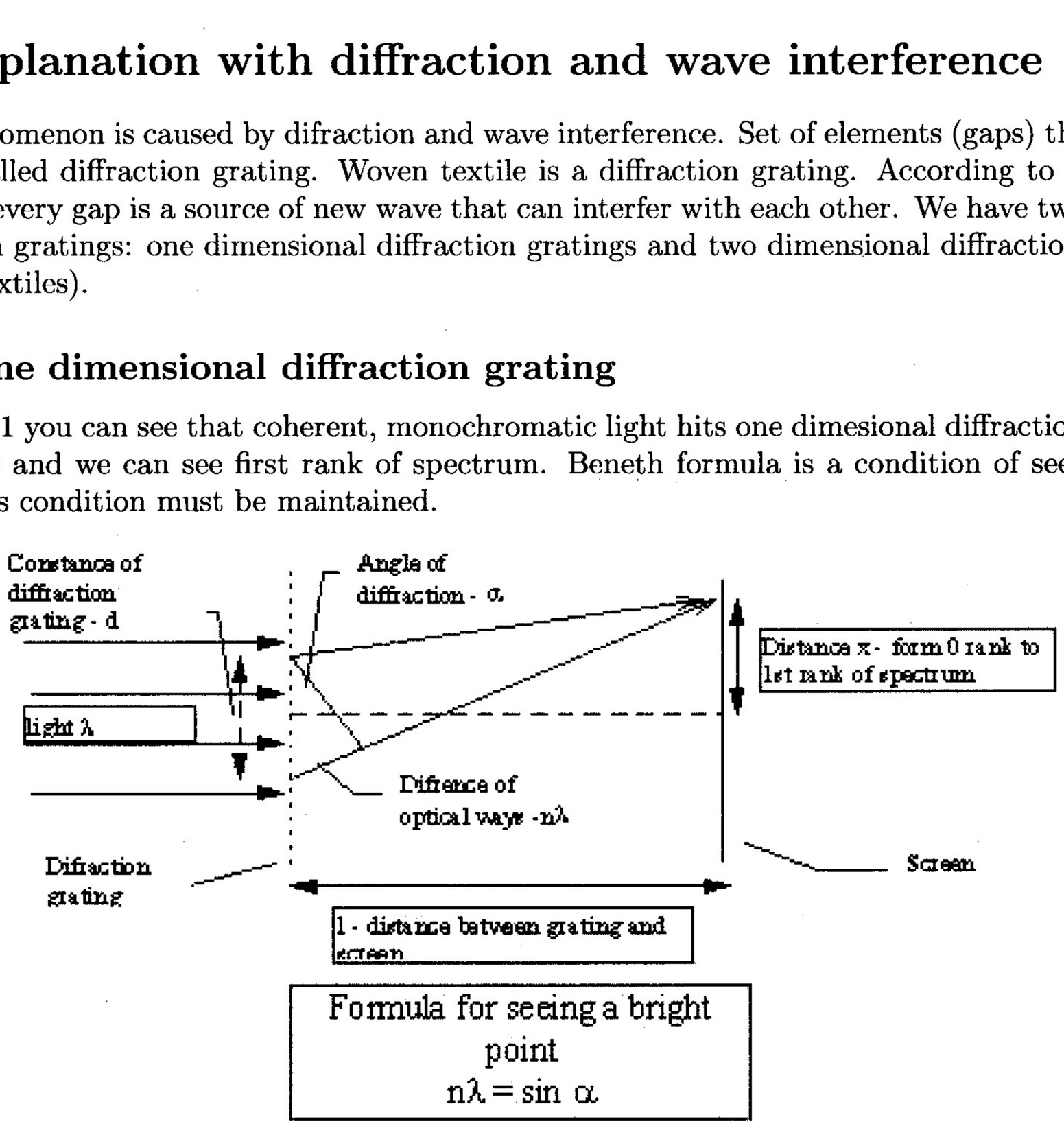

Figure 1: One-dimensional diffraction grating

2.2 Two dimensional diffraction grating

On figure 2 we can see theory for two dimensional diffraction grating (woven textile). Here we can see source of light (coherent, monochromatic), woven textile and observator. We can see that there are two angles of deflection and we have also two conditions. If only one of them will not be maintained we will not see bright point. Both conditions must be maintained.

2.3 "Grating" of a textile

We have to add that not every textile is regular. Structure of woven textile has great influence on phenomenon. If we look throught natural textile the image is less sharp than with sintetic one. This is caused by small threads ythat we can observe in natural woven textiles. Thoose small

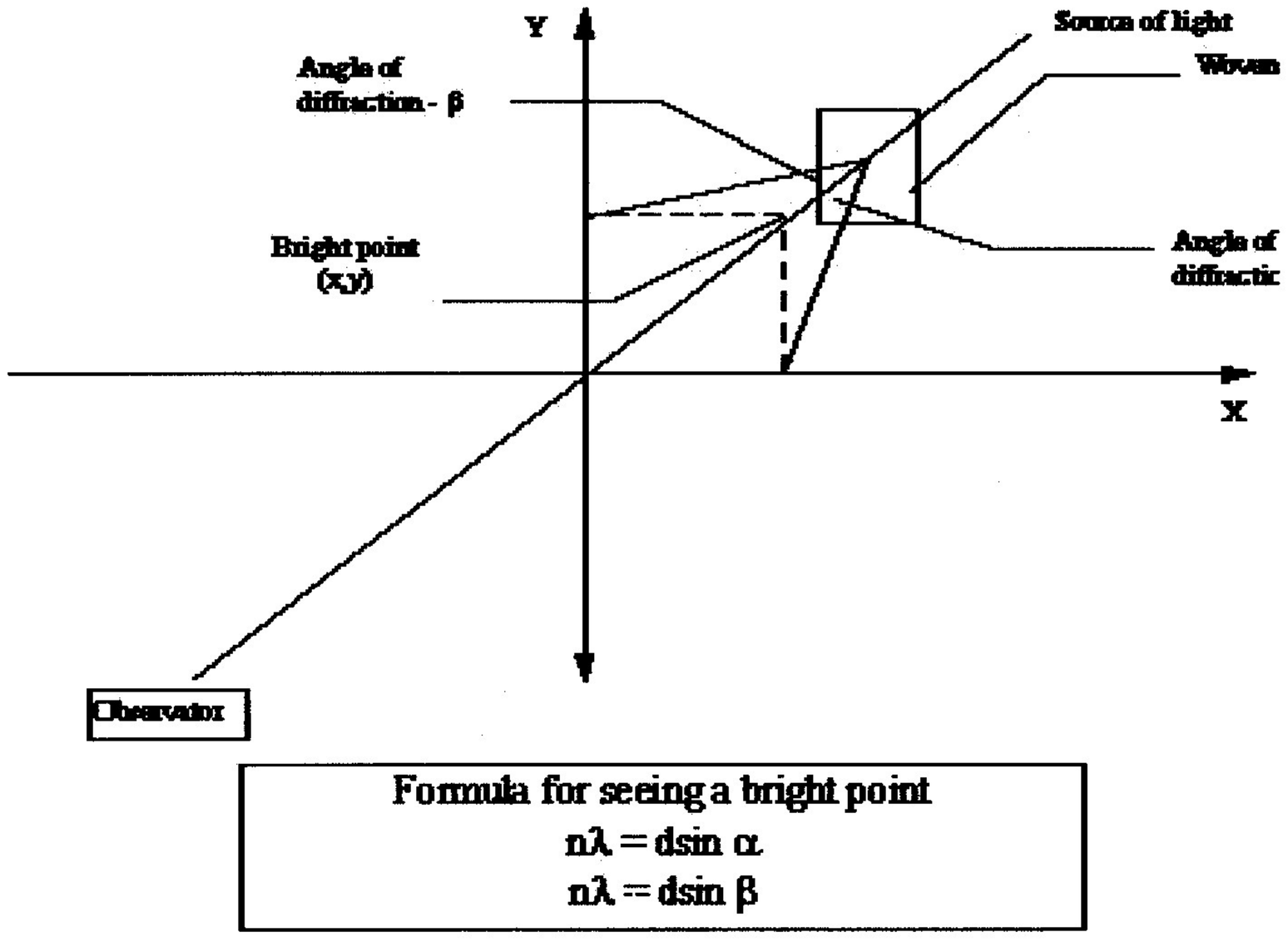

Figure 2: Two-dimensional diffraction grating

threads will create small diffraction gratings which will dim diffraction image-cross. Syntetic woven textile do not have them so the image is sharper. Great effect has also angle between threads. The measure of angle in woven textile is the same that the measure of angle in diffraction image.

3 Conclusion

To sum up we have to say that this phenomenon was caused by diffraction, wave interference and dispersion of light. There are some facts that have influence on this phenomenon. First is type of woven textile: Syntetic or natural. Second is type of gape: Rectangular, tangular, round, ... This shape depends from configuration of threads in woven textile. Different angle between threads is important, too. We can add here state of woven textile, too. If woven textile would be wet every drop of water would act like small prism and we would have additional dispersion of light. Kind of light is important, too. When we use white light we observe dispersion which we would not see with monochromatic one. At last we can stretch textile vertical – then horizontal gaps would be thiner and inversely.