Prismatic colours explained with Goethe's fundamental phenomenon

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Zusammenfassung

Wenn Licht die Grenze zweier Medien mit unterschiedlicher optischer Dichte passiert, entstehen Farben, z.B. bei einem Prisma oder an einer Wasseroberfläche. Die gewöhnliche Newton'sche Erklärung dieses Phänomens ist allgemein bekannt. Neben Newton hat sich Goethe ausführlich mit der Farbenlehre beschäftigt. Er erklärte die Entstehung der Farben mit dem von ihm entwickelten «Urphänomen der Farbentstehung». Dennoch konnte er die prismatischen Farben nicht befriedigend erklären. Im vorliegenden Artikel werden auch die prismatischen Farben mit Goethes Urphänomen erklärt.

Summary

When light passes a transition between media of different optical density, colours arise, for example with a prism or a water surface. The usual Newtonian explanation of this phenomenon is well known. Besides Newton, Goethe also occupied himself intensively with the theory of colour. He explained the arising of colours with the 'fundamental phenomenon of colour' formulated by him. However, he could not satisfactorily explain the prismatic colours. In this article the prismatic colours are also explained on the basis of Goethe's fundamental phenomenon.

Introduction

When one is standing in the undisturbed water of a swimming pool and looks down and around, one sees the bottom curved and higher than it is in reality. It is as if one is standing in a large bowl. The shape of this bowl depends upon the height of ones eye above the water surface. If ones eye is high above the surface, the bowl will seem flat like a dish. But

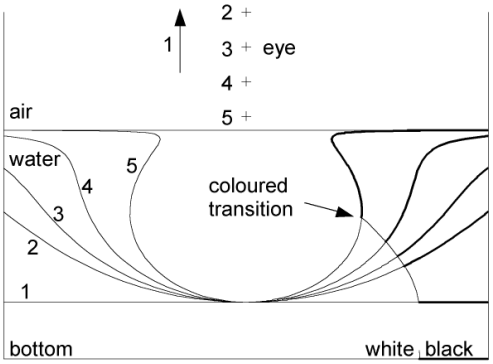

Fig. 1: Bottom raising with a bottom with a black and a white part: arising of a coloured transition

if one puts ones eye very close to the surface, the edge of the bowl will even curve towards one to give the impression one is standing in a vase. This phenomenon is called 'bottom raising'.

Figure 1 represents a cross section of a vessel with water in which this bottom raising is indicated for five different heights of the eye above the water surface. In position 1 the eye is located infinitely high above the water surface; in this case the image of the bottom is flat. It can be shown that in that case the image is situated at a height of $(1–1/n)$ times the water level in the vessel. Here n is the refractive index of water, $n = 1.33$, so that the image is situated at a quarter of the water level.

In the example of figure 1, the bottom consists of a black and a white part. Depending upon its distance above the water level, the eye sees the image of this black-white transition at different positions. The curve in the right half of the figure indicates the trajectory of the image of the black-white transition, when the eye moves down from infinity to the bottom-most position.

In practice it turns out that the image does not show a sharp black-white transition but a narrow coloured transition from black via violet, dark blue and light blue to white.

When the black and the white parts on the bottom change places, a transition arises from white via yellow, orange and red to black. The width of the transition depends on the distance of the eye from the water surface. The farther away the eye from the water surface, the smaller the transition. In position 1 no colours are perceptible.

According to *Goethe* (1810), colours arise from the interaction of light and darkness. In his view, light images in front of dark images cause blue to violet colours and dark images in front of light images yellow to red. This he called the fundamental phenomenon of colour. He conjectured that this phenomenon was also valid for the arising of prismatic colours but at that time found he could not show this convincingly. In this article it will be shown that Goethe's conjecture was right and that the arising of the prismatic colours can indeed be explained with the fundamental phenomenon of colour. Moreover, this proves the excellent powers of observation of this great phenomenologist.

In the past, other researchers have tried to explain prismatic colours with Goethe's fundamental phenomenon. Here only *Ott* (1965) is mentioned. There are several possible arguments to show that Ott's explanation is not correct, the shortest one being perhaps the notion that Ott bases his explanation on calculations with Snell's law of refraction with a *fixed* refractive index. This cannot be correct because prismatic colours are unarguably connected with a *variable* refractive index. If one assumes that Snell's law is correct, one should