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## Appendix B: Color technicalities

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## APPENDIX B.

### COLOR TECHNICALITIES

An Introduction to Goethe's Theory of Color for Non-specialists as a Conversation with Hans-Georg Hetzel, (formerly) Technical Research Photographer, University of Freiburg-i-B, Germany.

#### **What are the so-called spectral colors in terms of Newton and in terms of Goethe?**

For Newton the spectral colors are those that he produced in his first experiment in a camera obscura in the following way: he admitted a light ray through a small hole in the shutters allowing it to pass through a prism held in front of the hole, whereby he refracted ("broke") the colors on the white wall opposite the hole. These colors constituted his famous color spectrum. On the basis of his observations and reflections about this, Newton came to the conclusion that these colors must have been contained in the light and refracted into various lengths by the prism. On this basis a scientific theory came to be built up.

Goethe, however, came to a different conclusion. He discovered that he could produce colors by focussing the prism (in an open space) on black and white edges. Colors appeared along the edges in accordance with the deflection caused by the material of the prism: dark before the light always results in yellow-red color boundaries (Figure 38) and light before the dark always results in the blue-violet color boundaries (Figure 40). These effects, according to Goethe, are the fundamental principles governing the genesis of all color (including what Newton saw). Additionally when Goethe caused, in the first instance just mentioned, the opposing borders to be narrowed over the white space between them (by manipulating the prism), the yellow and the blue poles combined to produce green (Figure 39). In the second instance, he narrowed the red and the violet poles over the black space and produced what he referred to as pure red (or *Purpur*—not our ordinary purple): Figure 41. This is sometimes referred to as magenta.

**Given the results of Goethe's experiments involving the producing of colors, how did he react to Newton's assumption that all colors are contained in light?**

In thinking over the phenomena, Goethe reached the conclusion that colors arise on the boundaries of light and dark (whenever and however these occur). The prism itself, through its distortion and deflection of the light ray, produces the necessary turbidity (*Trübe*). Goethe's view thereby differed fundamentally from Newton's assumption that the colors which are supposed to exist in light are refracted into differing lengths. For Goethe considered all surfaces that he viewed through the prism as displaced and distorted; to put it another way, the dark-light and light-dark parts of the surface are shoved over and into one another through the levering action of the glass on the light: in the first case yellow/red arises, in the second blue/violet. It must be emphasized that in the experiment the prism furnished the turbidity, through leverage and distortion, without which on the borders between dark-light and light-dark colors can never arise. Without turbidity there are no colors. This is made clear in Figure 42.

**Since Goethe could not accept Newton's view that colors are contained in light, and made their appearance dependent on particular conditions, where did he propose that colors are before they manifest?**

Goethe referred to this matter in only one passage, but there at any rate rather forthrightly. In the section concerning the psychological and mental/moral effects of color he wrote (*Farbenlehre*, B919; B920 continues the sense of this): When the distinction of yellow and blue is duly comprehended, and especially the augmentation into red, by means of which the opposite qualities tend towards each other and become united in a third; then, certainly, an especially mysterious interpretation will suggest itself, since a spiritual meaning may be connected with these facts; and when we find the two separate principles producing green on the one hand and red in their intenser state, we can hardly refrain from thinking in the first case on the earthly, in the last on the heavenly, generation of the Elohim. But we shall do better not to expose ourselves, in conclusion, to the suspicion of enthusiasm; since, if our doctrine of colours finds favour, applications and allusions, allegorical, symbolical, and mystical, will not fail to be made, in conformity with the spirit of the age. (Eastlake translation)

**What is the relation of Newton and Goethe respectively to the interpretation of color?**

Newton and his successors have investigated and researched light exclusively in order to make use of the energy contained in it. The so-called magenta spectrum (*Purpusspektrum*)—in terms of this study Light spectrum—as complementary pole to the well-known and much used green (Dark) spectrum remains outside the consciousness of current science and technology, since it is inexplicable by their concepts. Although Newton and many of his adherents had (have) some religious sensibilities, they do not

take these into account in their researches and are therefore unable to enter into the psychological and mental/moral aspects of the colors. Goethe investigated color from the standpoint not only of its physical and physiological but also of its psychological and mental/moral aspects, the latter—as we have just seen—in only an indicative way.

### **In scientific contexts we hear of spectral colors and pigmentary colors. How do the two differ in the Newtonian view and the Goethean view?**

Spectral colors arise, according to Newton and Goethe, on the basis of refraction and displacement, respectively (see above). Pigment 5 are called chemical colors by Goethe. Basically the two categories of color are the same in both systems.

### **How do the atmospheric colors arise according to Goethe, who does not work with refraction of light rays?**

Goethe's color theory gives us to understand that at sunset the atmospheric mist, becoming denser near the earth's surface, is to be regarded as darkness before the setting sunlight. Accordingly, the colors red and yellow manifest—conforming to the general rule that dark before light produces red/yellow (Figure 43). Conversely, blue arises when the sun shines obliquely through the illuminated atmosphere before the darkness of the universe—again conforming to the rule that light before dark produces blue/violet (Figure 44).

### **Is there a concept of additive and subtractive color mixtures in Goethe's system?**

Goethe did not know these concepts nor can they be used in his system. He speaks only of a luminous and a toned-down mixture of colors. In the so-called additive color mixtures three (or two) colored lights are projected over one another. These combine to register a white color or neutralize one another partially or wholly. The massive luminosity on the point at which the two or three colors come together fades off to be seen as mere brightness (white) (Figure 45).

In the case of the subtractive color mixture only one light source is used. Each colored filter applied to it combines with the already existing color and is neutralized wholly or partially to gray by the next filter applied to it. Thus translucence is progressively reduced (Figure 46).

### **How do Newton and Goethe compare in regard to the conception of a color circle?**

Newtonian physics works with a linear scheme, that is, with ends which do not meet. Yet, it must not be overlooked that various modern technical processes, particularly photography and color-printing, must use Goethe's color circle. Goethe stated that he did not develop his color circle on the basis of the opposing, complementary spectra (hence, theoretically) but rather on the basis of the physiological colors, the after-image

phenomenon, i.e., successive contrasts (hence, entirely by direct human experience). The after-image is achieved by staring for 10–15 seconds at a particular color, for example magenta. When the gaze has then been turned to a neutral light spot, the after-image sets in as the impression of the complementary color, in this case green. Putting together successively the various colors and their complements obtained in this way (Figure 47), Goethe obtained the well-known complete color wheel (Figure 48). Goethe, however, *also* used light blue and light yellow as two basic polar colors which, mixed together, yield green. But if one exposes yellow successively to augmentation—that is, saturates it—orange and then red arise by degrees. Polarically to these colors, the corresponding colors of the other half of the spectrum arise, that is, to light yellow the violet, to orange the blue and to red the blue-green. When, in the final phase, the colors violet and red are mixed,\* the highest of all colors, magenta, results. This color contains, according to Goethe, partly *actu* and partly *potentia*, all the other colors (B793, *Farbenlehre*). The validity of Goethe’s color circle enjoys general acceptance. [\*I believe this point can only be understood in terms of the supersensory spectrum. J.L.B.]

### **What is a colored shadow and what is its meaning?**

The colored shadow results from a particular lighting arrangement of an object, whereby the shadow of a monocolored light remains without direct illumination but is brightened to the status of a half shadow indirectly through another neutral light source, or even from a clear neutral reflecting light-shield. Therewith the complementary color to the light source illuminating the object appears in the main shadow. This colored shadow is called in physiology a simultaneous contrast, that is, a color arising in the eye. When Goethe discovered the phenomenon (12.12.1777) he described it as an objective color (that is, arising outside the eye), but shortly thereafter changed his mind. However, three years before his death, in a conversation with Eckermann he admitted that the color of this phenomenon must after all be objective.

The colors of the colored shadow represent invariably and with exactitude the complementary color of the color illuminating the shadowed object. In terms of the doctrine of macrocosm and microcosm recognized by the Greeks and by Goethe, the microcosm is involved in the after-image and the macrocosm is involved in the colored shadow. (See an article by Hetzel: “Der farbige Schatten” in *Optometrie* 4 (1987) 177–179).