

EVEN GOETHE WOULD LIKE IT: AN INTERACTIVE PRESENTATION OF COLORS

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Abstract

A 3m long water filled dispersion prism and a 1.8m tall egg-shaped body with a background surface illuminated by RGB LED-s were installed in the Central Market Hall in Budapest just during the International Year of Light in 2015. Based on Goethe's „Color Theory” this completed Color Space serves as an interactive presentation how colors are born by just simply watching through the prism or how different color hues appearing on the surface of the egg harmonize. Nature of additive color mixing caused by different methods can be observed as well.

In this article we hereby expound the structure of the installation as well as it's operation. We give a clear, visual and simple interpretation what happens along the black and white boundaries when watched it through the water prism; this explanation could be an easy-to-understand, however practical aid while teaching about primary or complementary colors or rules of additive color mixing. Based on a unique, novel revoluble 3-Layered (3LD) Color Wheel the installation is able to play pre-programmed time-varying sequences of remarkable color contrasts (60, 120, 180 degrees etc.) directed by control buttons.

Keywords: Goethe's color theory, additive color mixing, color contrasts, color harmonies

1 Introduction

It was just 200 years after Goethe's „Theory of Colors” when Szelényi, Károly published his book titled „Colors. Doings and pains of light. Geothe's theory in everyday life” in 2010. It took another 5 years when after the gorgeous initiative of the Central Market Hall in Budapest a so called Color Space was installed as part of the „Hungaricum street”, just during the International Year of Light. The installation was based on above book of 2010.

Within this Color Space or Color Square one can submerge into some basic experiments how colors are born: looking through probably the largest water dispersion prism ever (a 3m long and 0.6m high glass container filled with approx 300l of deionized water) one can experience what Goethe might felt during his observations recognising the birth of purple color by additive mixing of red and blue at the boundary of black and white transitions of an image. With the aid of this large water prism and the specially designed black and white test graphics every visitor can study how additive color mixing works in practice, with the use of very simple devices.

The other installation of the Color Space is a large, 1.8m tall egg-formed body suspended from a 5m high ceiling. The surface of the egg and the background wall is independently illuminated with time-varying sequences of lights emitted by high power RGB LED reflectors using pre-programmed driver. All the illumination was designed on a way that each reflector may emit almost any kind of additive mixed color light, and each egg reflector is responsible for a certain area of the egg's surface only. This installation serves as a special 3D projection screen for demonstrating color harmonies, color contrasts and additive color mixing samples as well.

2 Set-up

The Color Space is installed in the sector-formed 5m tall, SW-facing staircase of the 119 year old historical building of the Central Market Hall in Budapest. The 1.8m tall egg-formed body is illuminated by 5 independent RGB LED reflectors, with electrical power of 100W each. The position of the reflectors allows the beams to overlap gradually as the egg surface bends resulting in achieving additive color mixing effect on the surface. The egg-form was chosen since it's immensely natural and harmonic shape.

The acute-angled corner behind the egg serving as a background is illuminated simultaneously by 2 sets of 3m long RGB LED wall washers, with electrical power 120W

each. The mentioned 5 individual reflectors responsible for the egg have as little interference to the background as possible, Figure 1.

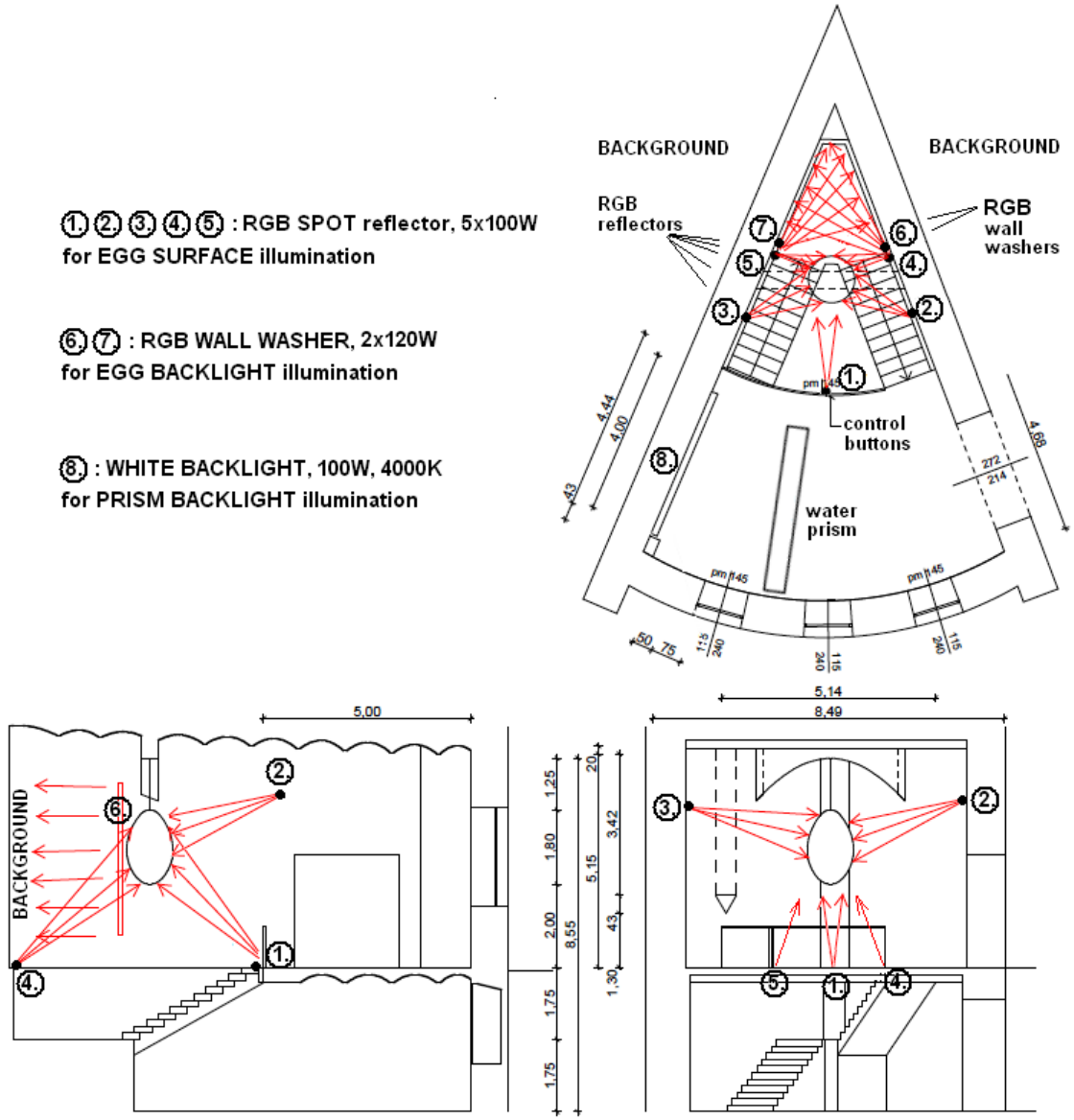


Figure 1. Setup layout of the Color Space in the sector-formed staircase

The 3m long, 0.6m tall, equilateral water prism is settled radially. Behind the prism a 3m long backlight (100W, 4000K LED) illuminates the illustration for the prism observation.



Figure 2. Panoramic view of the Color Space in the Central Market Hall, Budapest



LED drivers for the egg and the background illumination are installed in a switchboard behind the wall. Control buttons built into the balustrade are for selecting between pre-programmed color sequences.



Figure 3. Water prism backlight and control buttons for color sequences selection

3 Birth of colors by watching through the dispersion water prism

For citing Goethe's experiments adequate graphics from acknowledged artists (MAURER, Dóra; MEGYIK, János; GÁDOR, Tibor; REISINGER, Dan) are used, Figure 4. All have characteristic and sharp black and white transitions for best experiences. However for detailed analysis thematic figures were elaborated by Szelényi, Károly based on Goethe's test figures, Figure 6. Tapering black and white edges are perfect shapes for investigating how gap size influences the birth i.e. overlapping of colors. Let us ignore now evaluating some hard to explain interpretations in Goethe's color theory about birth of colors at the boundary of darkness and light; however let us focus in details how light originated from the boundaries disperses passing through the prism.

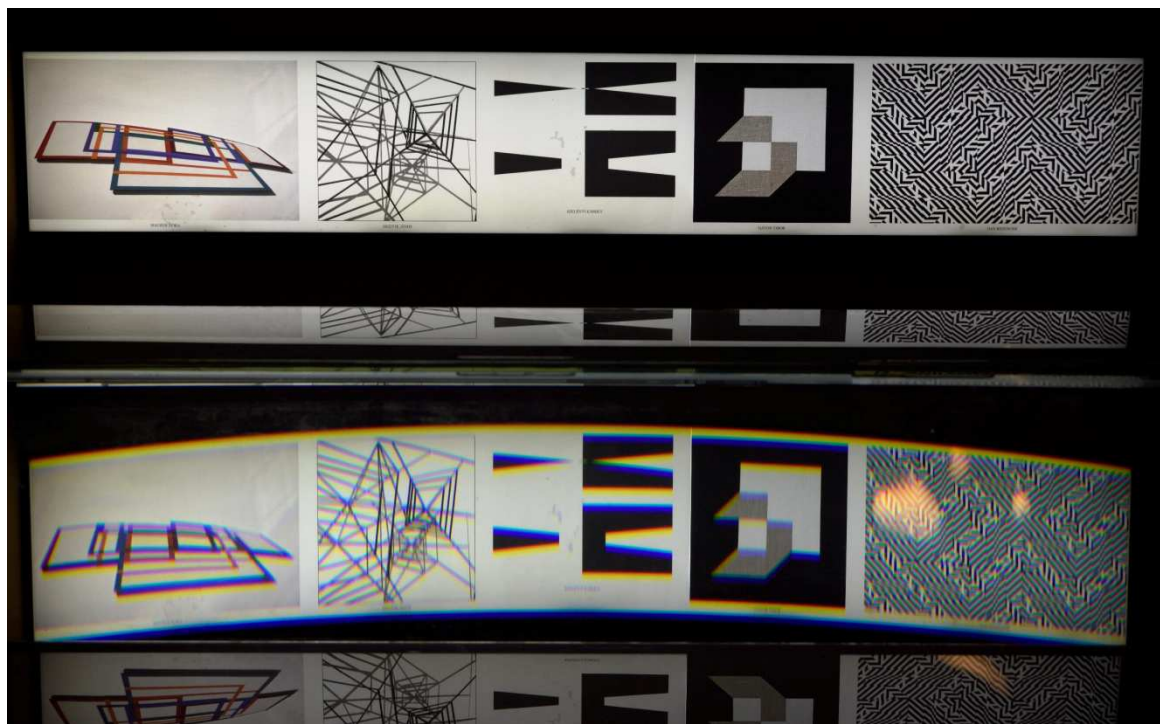


Figure 4. Water prism figures: bottom image is typically arched viewed through the prism

Positioning the prism must allow the viewer to watch the original image *above* the prism while being able to watch the dispersed and refracted image *through* the prism at the same time. Due to calculations and previous field tests the optimal distance of the graphics became 2.5m resulting in a satisfying dispersed image, Figure 5.

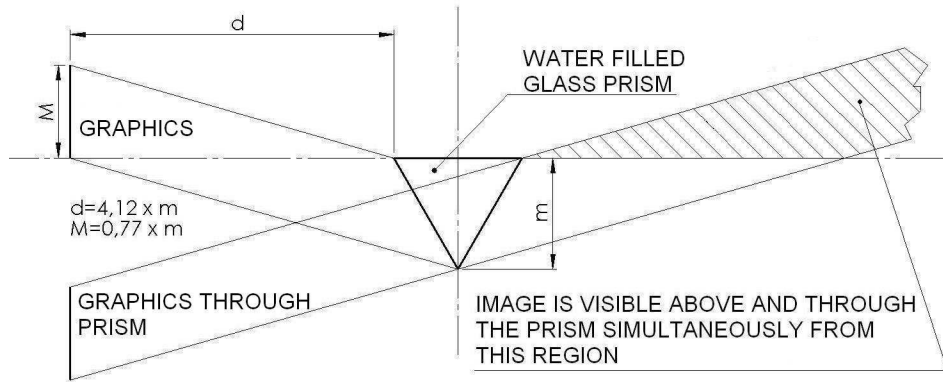


Figure 5. Water prism position for optimal watching region

Observing Figure 6 one can simply recognise the appearance of purple color at the tapering end of the black wedge. Similarly, green appears at the tapering end of the white wedge. And from top to bottom, along the white-black transition cyan and blue appears, while further along the black-white border red and yellow is generated.

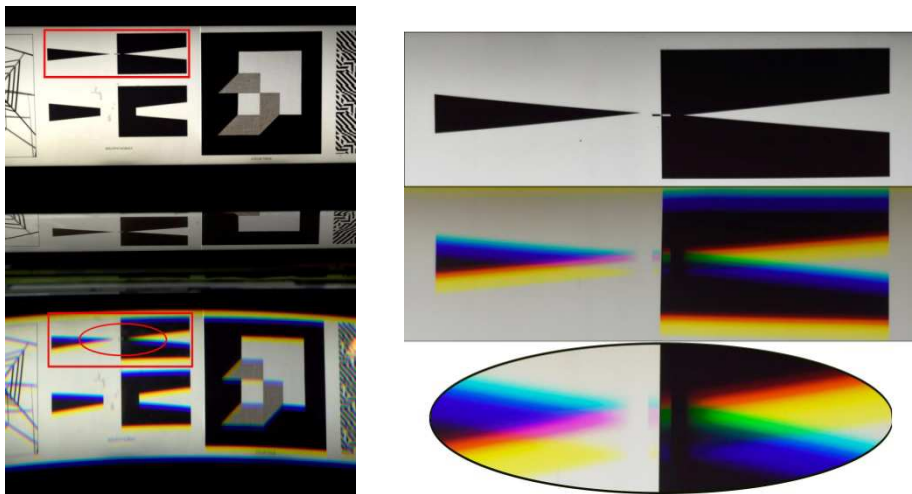


Figure 6. Tapering black and white edges for perfect overlapping of colors

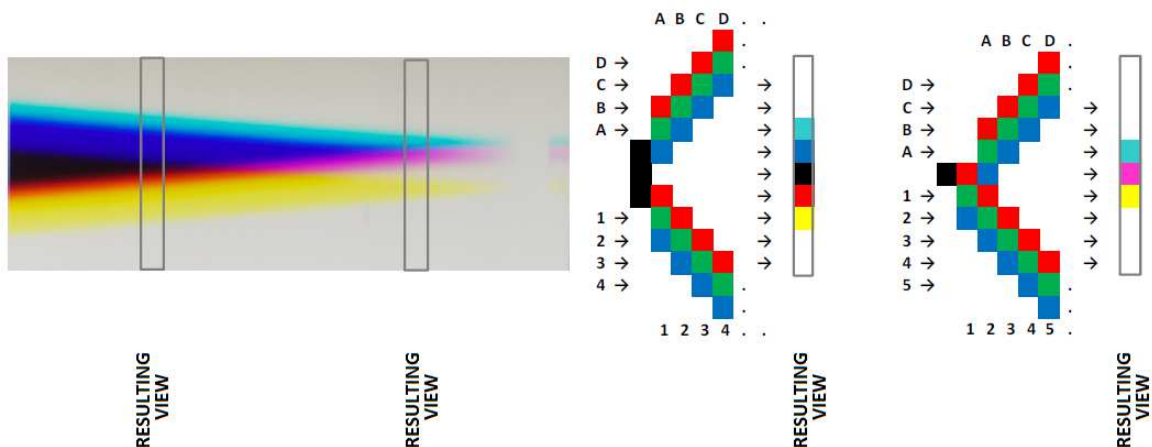


Figure 7. Colors overlapping on a tapering black edge: explained by additive color mixing

Figure 7 and 8 explain the physical background of what happens at the border. Let us divide the image along narrow vertical columns into equal squares. Let white squares (or pixels) than represent „slit” sources of white light (1, 2, 3 or A, B, C, respectively), each dispersed passing through the prism. Dispersion is done along the vertical column. On

the image plane of the camera (or one's eye) the final color of each „pixel” is the resultant additive mixed color of all color components reaching respective pixels („adding” in horizontal rows). By using simple rules of additive color mixing the resulting colors can be „calculated”, giving a clear and visual explanation where the colors come from. It is noted that these colors are generated on the observer's image plane that is a slight reflection to Goethe's theory saying that colors result from an effect of the eye.

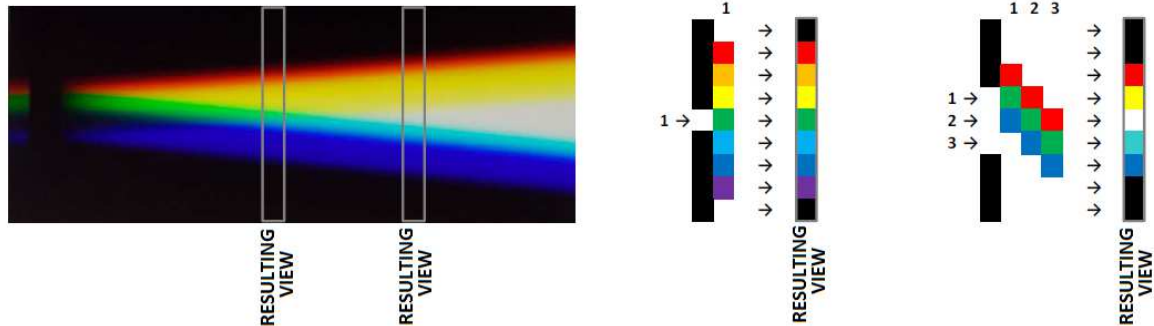


Figure 8. Colors overlapping on a tapering white edge: explained by additive color mixing

The spectra of the 4000K white LED-s used within the backlight is continuous enough to get a more or less full color spectra after dispersion.

4 Revolvable 3-Layered (3LD) Color Wheel

A novel Color Wheel was developed by Szelényi, Károly for easy alignment of different color harmonies, Figure 9. There are 3 manually revolvable layers having 12 color divisions based on RGB color model on each. Each color has it's complemer pair shifted by 180°. The top wheel has color framed openings allowing the appearance of the colors of the middle layer. However there are further egg-shaped openings on the middle sheet so the colors of the bottom layer are visible as well. By rotating the layers several color contrasts or even color triads can be adjusted resulting in a visual aid for easy study or presentation of color contrasts or color harmonies.

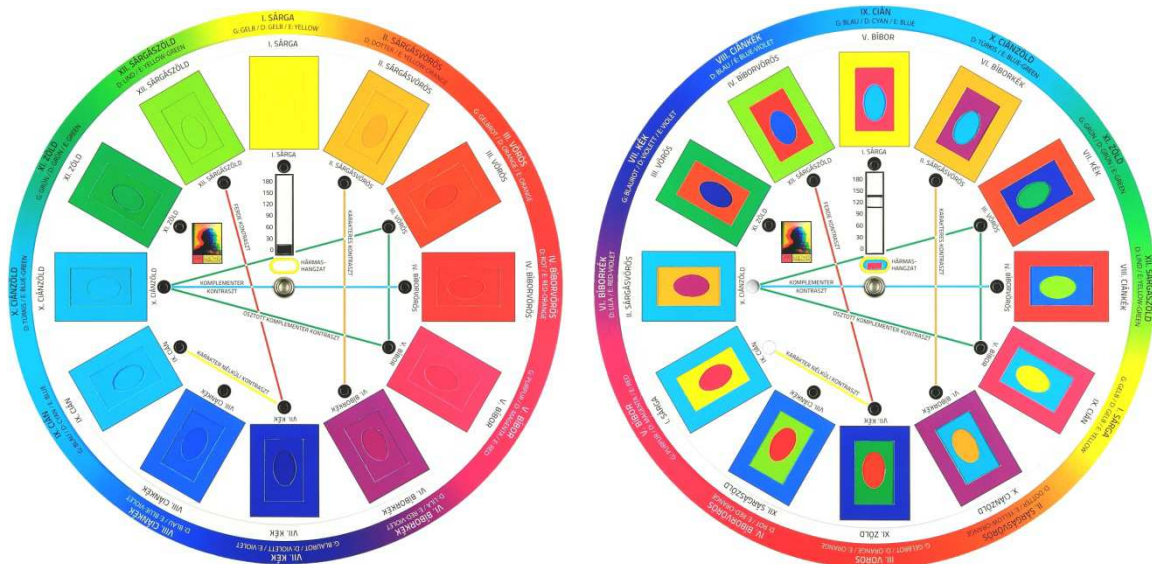


Figure 9. 3-Layered (3LD) Color Wheel: all layers in base position (0°, left), and triads

On this 3LD Color Wheel one can observe typically 12 different color contrasts at a time. With the use of the LED illuminated egg-formed body of the mentioned Color Space one can observe color contrast however one after the other in a time sequence, giving another interpretation of what color contrasts trigger in our mind. This method, together with another show of additive color mixing is explained below in Paragraph 5 and 6.

5 Sequences of color harmonies: color contrasts

Some remarkable color contrasts are pre-programmed as sequences of illuminations in the Color Space system. Contrasts are designated by the angle between colors along the wheel. Non-characteristic 60°, characteristic 120° and the noteworthy complementary 180° contrasts are presented on Figure 10., 11. and 12.



Figure 10. 60° contrasts on the 3LD Color Wheel (left) and phase images of 60° color contrast sequence on the egg-form



Figure 11. 120° contrasts on the 3LD Color Wheel (left) and phase images of 120° color contrast sequence on the egg-form



Figure 12. 180° contrasts on the 3LD Color Wheel (left) and phase images of 180° color contrast sequence on the egg-form

6 Illustrating additive color mixing

By illuminating the egg-form by different colors, resultants of additive color mixing appear as the beams overlap on the surface of the egg. Representative resultants like purple (mixing red and blue) or yellow (mixing red and green) are clean formed, Figure 13.

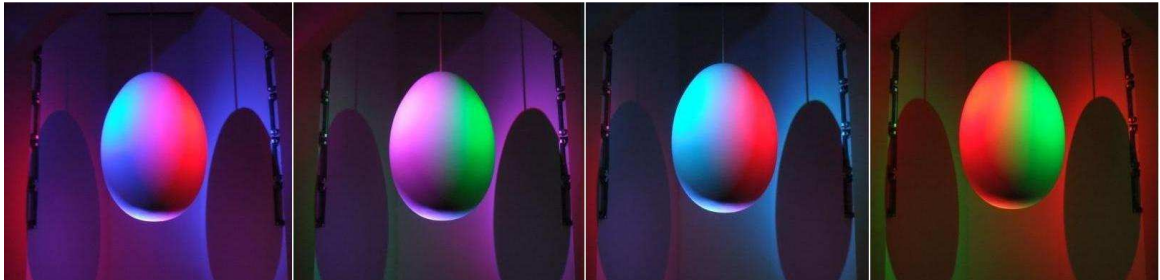


Figure 13. Phase images of additiv color mixing sequence on the egg-form

7 Illustrating triads

Illuminating the egg-form with 3 different colors at a time is also possible. This function allows the viewer to enjoy or study the impression of triad color harmonies together with additional mixed colors along the overlapped regions, Figure 14.



Figure 14. Phase images of triad color sequences on the egg-form

8 Illustrating CIE 1976 color space

It is rather didactic to use the egg-form for presenting the base triad color harmony by illuminating it with RGB base colors: red (bottom), green (top right) and blue (top left).

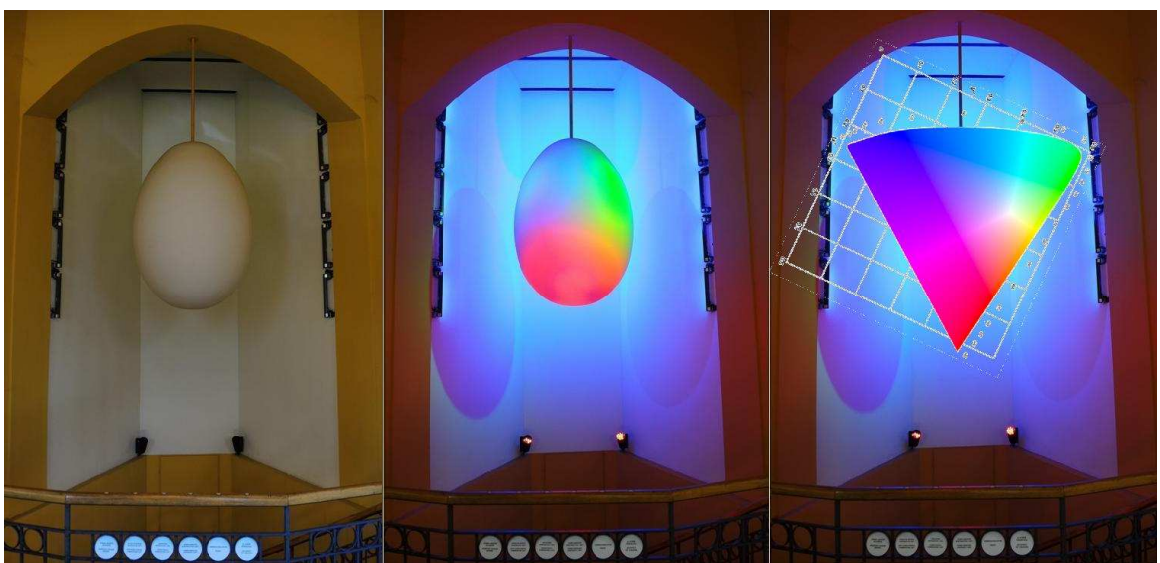


Figure 15. The egg-form unlighted (left); appearance of RGB primary and secondary colors (center); CIE 1976 color space montage

This way beside additive primary colors all secondary colors appear on the surface (cyan, purple, yellow) at the same time, and in the middle even a grey zone turns up representing „white”, as a resultant mixture of RGB colors. The surface of the egg-form at this status present almost all colors that could be mixed or generated by the use of a certain RGB LED set at a time.

By switching off all lights and getting a characteristic antagonism of the previous full colored status we can pay tribute to Goethe’s spirituality by showing the contrast between light and dark.

And finally let us „photoshopping” a CIE 1976 color space graph onto our egg-form. By comparing the real photo with this montage gives us the link between the beauty of the full colored, RGB illuminated egg-form and color science by giving a smart illustration what Color Space means. The overhanging regions of the CIE graph yet also represent that achievable color hues with a certain set of RGB base colors are limited.

9 Conclusion

An interactive set-up to experience Goethe’s color experiments was presented. Genesis of colors watching through a water filled dispersion prism and an egg-form for displaying color contrasts and additive color mixing were demonstrated. The set-up may be useful while teaching about colors and color mixing, as well as studying the total impact of color harmonies.

Acknowledgments

Special thanks to NAGY, Gergely, Pannonterv Ltd; DÉNES, Ákos and OROSZI, Zoltán, CSAPI; SZELÉNYI, Aranka, Hungarian Pictures Ltd; SZABÓ, Andreas, Germany; BUJÁKI Krisztián, RADVÁNSZKY, Roland and BAKI, Mihály, OMI OPTIKA Ltd; and to all colleagues of mentioned organizations for the outstanding collaboration during the realization of the Color Space in the Central Market Hall, Budapest.

Thanks to NOWACKI, Krisztián, BME for his repro work.

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