Coloured Shadows

More Details

The RGB model

Colours and shadows are not possible without light. The light that is visible to us and is white in its entirety is only a very narrow range of electromagnetic radiation. In practice, two colour models have proven to be effective for approximating this infinite variety of colours: The additive and the subtractive colour model.

The subtractive colour model describes the work with colour substances (Fig. 1(b)). More details on this and on light can be found in the experiment "Colour and Light".

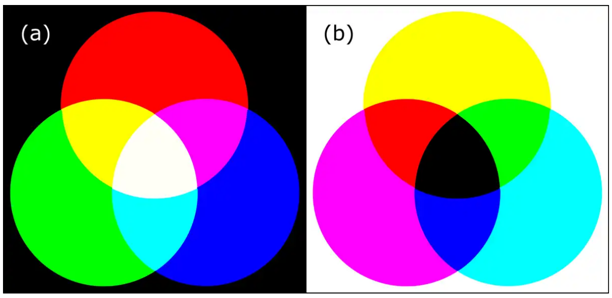

Abb. 1: Additive (a) and subtractive (b) colour model.

In this experiment, however, the additive colour model is important. It is present when we work with coloured light (Fig. 1(a)). Corresponding to the three types of visual cells of the human retina, the additive colour model is based on the three primary colours red, green and blue. Therefore, it is also called RGB model. By mixing (i.e. "adding") the lighter colours shown in Fig. 1(a) are created. If all three colours are mixed in full intensity and equal proportions, they complement each other to form white. If you look at white areas on the screen (TV, PC) with a magnifying glass, you can see this phenomenon. In this technical application, the RGB model with several million colours is only an approximation of the entire colour spectrum. The LCD televisions of a well-known company expand the colour palette quite considerably by adding yellow.

Shadow theatre

We know different shadows in shades of grey from "everyday life". An almost black, sharply defined cast shadow is created by a point light source (e.g. sun). It reproduces the object.

Several light sources create a penumbra (lighter part of a shadow) and an umbra (the darkest part of a shadow). But it is only our eye that makes these grey tones out of the more or less pronounced absence of light in the shadow area.

In our experiment we are dealing with coloured artificial light, which creates coloured shadows on a white wall. If you illuminate an object with a red and a green lamp, you get a green and a red penumbra. To our surprise the green lamp creates the red shadow and vice versa (Fig. 2). In its shadow area, the object removes the red light on the white wall. The resulting penumbra is now only illuminated by the green light. The area around the umbra and the penumbra of the object is illuminated by both green and red light – both colours mix resulting in yellow.

Fig. 2: Red and green penumbras
created by green and red lamps.

The right mixing

This tension between habitual perception and physical interpretation becomes even clearer when the complexity is increased by a third lamp in the colour of blue. Now one has to look at the shadow areas from the point of view of what light must be missing for the observed colour to appear. For example, the wall appears yellow where red and green light falls but blue is missing (Fig. 4). In the red shadow areas, the light from the green and blue lamps is missing, etc. This is a simple way of obtaining the mixing rules for the basic light colours of the RGB colour mixing shown above.

Fig. 3: Additive colour mixing in penumbras.