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Sensitometry of double exposures in application to film crossfading

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Abstract

Crossfading is in filmmaking a frequently used method to transit from one scene to another one very smoothly with a subtle change – that means: without jumps, dips and bumps of the total brightness of the overlapping images of the fading-out and the fading-in images. The transition is performed by double exposures, which can be made simultaneously or successively. In praxis the successive dissolve is preferred, because it needs only one technical equipment for the shots. Using for the dissolve process photographic material, then the SCHWARZSCHILD-effect must not be neglected, due to which the common copy of the overlapping scenes shows in the middle – dependent on the structure of the images – a more or less noticeable dip in brightness.

The referred article with the investigation of double exposures on photographic material is related to a method developed by LAU and KRUG using equidensites. It is shown how by means of exposures through gray wedges equidensitometric characteristic curves and density areas the influence of the SCHWARZSCHILD-effect can be demonstrated, determining moreover the SCHWARZSCHILD-exponent $p = 1/q$ of any photo-layers.

On the base of SCHWARZSCHILD's famous blackening law $E \cdot t^p$ =const (E intensity of light, t exposure time) the law of the double exposure is derived:

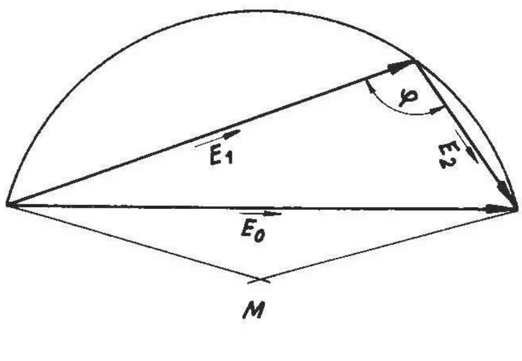
$$E_1{}^q t_1 + E_2{}^q t_2 = E_0{}^q t_0 = \text{const}$$

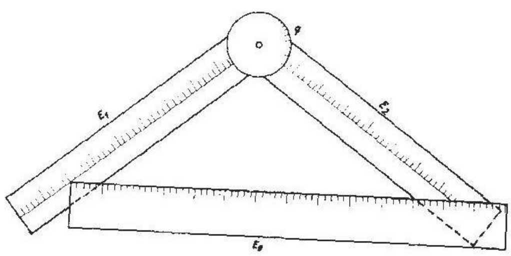
(The indices 1 and 2 mark the exposures; index 0 is the total exposure.)

In case of equal exposure times $t_1 = t_2 = t_0$ (as valid for the single images of the dissolved shots) we have a formula, which resembles that of PYTHAGORAS:

$$E_1{}^q + E_2{}^q = E_0{}^q = \text{const}$$

Since the SCHWARZSCHILD-exponent q has the limited range $1 < q < 2$ we can expect a similar geometrical construction like the rectangular triangle of PYTHAGORAS – only with an amplified angle φ, which is responsible for the SCHWARZSCHILD-effect:

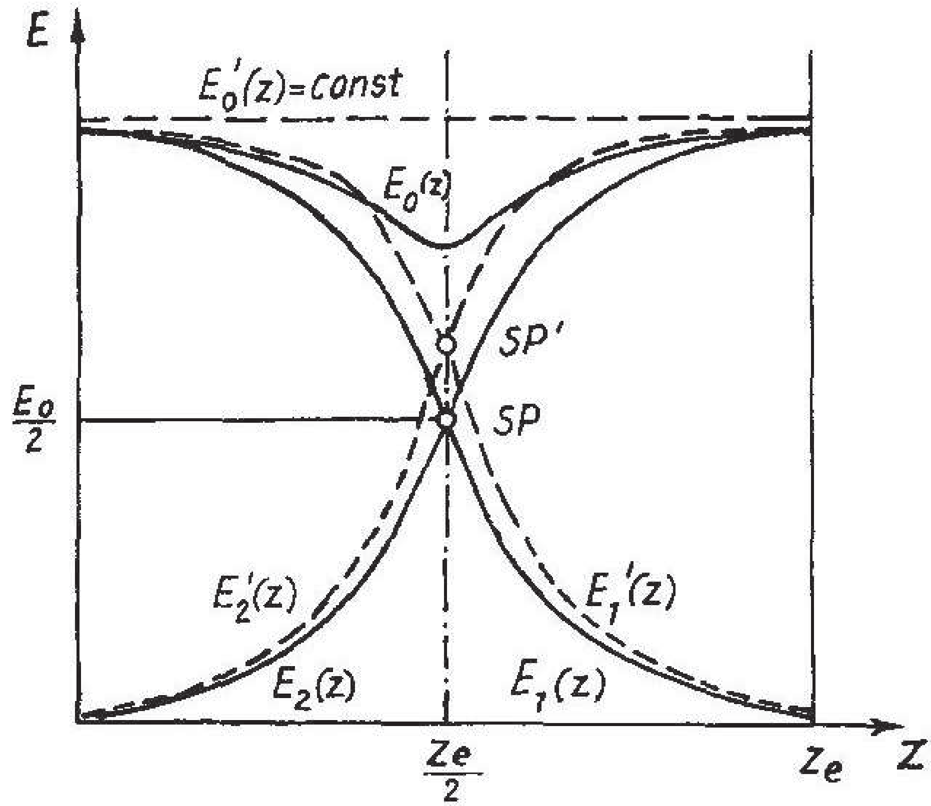




This geometrical relation gave the incentive for the construction of a "double-exposure slide-rule", which can be used for quick evaluation of the exposure data but also for the mechanic steering of an "exposure equipment":

For simultaneous (photographic) double exposures and for (electronic) video dissolves no correction accounting for the SCHWARZSCHILD-effect is necessary.

But in all cases of dissolves the transition run has to obey the sensory-physiological law of WEBER and FECHNER, according to which the decreasing intensity $E_1(z)$ of the fade-in scene progresses in time $t = z \cdot \triangle t$ ($\triangle t$ exposure time of a single picture, z running number of pictures) with $\frac{\triangle E}{E} = \triangle t{\cdot}\mathrm{const}$ by an exponential function down from the point SP, whereas the intensity $E_2(z)$ of the fade-out scene increases up to the point SP exponentially, respectively.



The rest of both intensity curves is the complement to the whole intensity – leading to mirror-symmetrical sigmoid curves (solid lines). The efficiency of the double exposure is reduced by the SCHWARZSCHILD-effect with a dip in the middle part of the resulting curve to $E_0(z)$. The SCHWARZSCHILD-correction is achieved by the banked intensities $E_1'(z)$ and $E_2'(z)$ (dashed lines).

The transition run holds also for scenes with unequal intensities and diminishing perceptibility of the deviations due to the SCHWARZSCHILD-effect from the middle to the beginning and to the end of the crossfading. Thus, the same cross-fading procedure can be applied for all dissolves – photographic and electronic ones – the last running only by the SCHWARZSCHILD-exponent $p = q = 1$.

Article available in German by the web-address: `www.ewald-gerth.de/10.pdf`