

Editor's Foreword

*Above all, we must remember,
that we may move in the realm of images.*

Goethe, *Theory of Colour*, § 219

This volume gathers twenty-five texts of the Norwegian physicist Torger Holtmark. Most of them document his lifelong occupation with the problem of colour. They are contributions to colour theory and optics, where Holtmark picks up and develops research directions ranging from Plato and Aristotle through Kepler to Goethe and Wittgenstein. Underlying his interest in the historical context one always finds the question as to the genesis of image, the determination of colour and the fate of the ›seer‹. The answers that Holtmark finds lead him to demand a novel comprehension of the theory of light and in a practical way, to forge a didactic design for an extended theory of colour as a theory of images, an optics of visual experience.

The colour and the image

Holtmark considers two factors to be decisive for understanding the historical conditions under which optics now taught in schools and universities has developed. On the one hand he points to Kepler, the founder of modern imaging optics. Kepler distinguishes between the observed image as act of consciousness (*imago*) and the retinal image (*pictura*), which is a point of convergence of light beams geometrically tractable and technically manageable. In the further development spatial representation theory predominates while the appreciation of the reality of the image recedes in the background. For Holtmark geometrical optics arises from the spatialization of the image concept, and this is associated with a profound loss: the loss of the seer.

On the other hand Holtsmark refers to the fact that it was Newton's experiments for measuring colours, which established physical optics. The further development of this optics, however, shows that the relationship of colour to the measurable properties of light cannot be uniquely determined. Strictly speaking colour is thus no longer an object of physics, but rather, of the field of psychophysical phenomena. »Thanks to Kepler and Newton, optics has been split. The image was physicalized, but the real constitutive aspect of the image, namely colour, was animized.« (1963)

Holtsmark examined the profound effects of this development on the modern theory of colour, on the way we think and talk about light and colours in the widest sense. Against this background he outlined elements of an extended light and colour theory, which combines the spatial, qualitative and psychological manifestations of colours and emphasizes the act of seeing as a productive process. The height of his critical appraisals are doubtlessly his 1969/70 papers where he generalizes¹ Newton's dispersion experiments. Superficially this work is a contribution to the history of science. However, the consequences of Holtsmark's concept of optical inversion for a generalized representation of spectral phenomena as complementary phenomena have only become apparent and appreciated during the past few years. This also applies to his experimental and didactic work on optics as image theory. They show in an inspiring way in which Goethe's colour theory² can be regarded as a methodological design – as well as a practical implementation – of a future expanded image and colour theory. At the same time we come to feel that Holtsmark's central engagement is an educational one.

¹Goethe made the first step towards such a generalization when he asked whether spectral phenomena were symmetric. He showed that by inverting, i.e. by the interchange of light and dark in Newton's experimental setup a surprising variation of the experiment might be created: the »inverted spectrum«. An analysis of the history of this »inverted spectrum« and attempts to use it physically are beyond the scope of this foreword and is still waiting to be done. In this context one can ask whether the above inverting operation can also be applied to variations of Newton's *experimentum crucis* or whether the symmetry idea for spectral phenomena fails here (see for instance Wilhelm Ostwald in *Goethe, Schopenhauer und die Farbenlehre*, Leipzig: Unesma, 1918, p. 45).

²In 1994 Holtsmark published a partial translation of Goethe's colour theory into Norwegian. This was provided with a detailed optical commentary: *Goethes Farvelære*. Utvalg og kommentarer ved Torger Holtsmark, Oslo: Ad Notam Gyldendal.

On the History of the Book

The reader may wonder what prompted me to publish this book, since, with two exceptions, the texts in question were published some time ago. The short answer to this question is: During the study of the Holtsmark's texts my conviction grew, that his work represents original research contributions to the phenomenological theory of colour and image. At the same time I realized that the importance and topicality of these pioneering texts have hardly been recognized and appreciated outside Norway. In addition to this I feel that some important texts were published in obscure and inaccessible contexts. After consulting with several colleagues, I felt it worth tackling a comprehensive new edition of selected works of Holtsmark's central research field in order to make his occupation in the field of colour and image optics available to a broader public.

The detailed history of the book began with the discovery of an omission. In 2005 together with colleagues at the Institute of Physics of the Humboldt University of Berlin I organized the conference *open eyes 2005*. Our goal was to create the opportunity for an exchange of views on approaches and perspectives of phenomenological optics within the physics educational research community. The term »phenomenological« indicates a range of methodological orientations, including those of Aristotle, Goethe, Steiner, Husserl and Merleau-Ponty. The common feature is the acceptance of the world as it appears to us, and thus the appreciation of its sensory nature. On the other hand, a relationship to phenomenological efforts within modern optics was also attempted, one that sought ways of describing observable-based optical states beyond the ontological debate on the nature of light.

Regarding the question of how the various branches of optics can be made accessible through concrete visual experience our main reference and source of inspiration was the former solid-state physicist Georg Maier, who developed a hypothesis-free approach. Together with Manfred von Mackensen he followed a suggestion of Steiner³ on Berkeley's concept of a visual object and

³Steiner, Rudolf (1995): Conference of 29th April 1924, in: Conferences with Rudolf Steiner, GA 300c: »Why is there no real epistemology there? Because no one has really brought seeing and cognition together since Berkeley wrote his book on vision.« cf. Berkeley, George (1709): *An Essay Towards a New Theory of Vision*, in: *The Works of George Berkeley*, ed.: Alexander Campbell Fraser, Oxford, Clarendon Press, 1901

developed this to an *Optics of Visual Experience*⁴ as a theory of the nature of visual objects, whose importance for optics education is becoming increasingly recognized and further developed. The Proceedings of the *open eyes 2005* conference initiated the present book series *Phenomenology in Natural Sciences* and provides an insight into the relationships described above insofar as they presented themselves at the said conference.

When I first met Holtsmark's work two years later I immediately realized that he should have been a keynote speaker beside Georg Maier at the *open eyes 2005* conference. The objective of the conference would have been decisively enriched by his involvement. Years ago he had developed his ideas following meetings of the Oslo colour group led by André Bjerke⁵ and he also had regularly presented results at the colour info-sessions of the German Centre for Colour. A proper consideration of his contributions would have added a vital expansion to our discourse.

This discovery disturbed me increasingly. I couldn't understand how Holtsmark's phenomenological optics and colour theory ideas could have escaped us and immediately began to study him thoroughly. I went in search of his other contributions, gradually gaining the impression that Holtsmark's conception of an extended colour and image theory had striking parallels to Maier's *Optics of Visual Experience*.⁶

⁴Maier, Georg (2011): *An Optics of Visual Experience*, New York: Adonis Press. This is a translation by Henry Saphir & John Barnes of (1986): *Optik der Bilder*, Dürna: Kooperative Dürna. See also: Maier, Georg (2004): *blicken – sehen – schauen (glancing, watching, seeing)*, ed.: J. Grebe-Ellis, Dürna: Kooperative Dürna; Mackensen, Manfred von & Ohlen-dorf, Heinz-Christian (1998): *Modellfreie Optik (Model-free Optics)*, Kassel: Pädagogische Forschungsstelle.

⁵Norwegian writer and poet (1918-1985). In the mid 20th Century following up on Rudolf Steiner, Fritz Lobeck, Max Barth and August Kirschmann, André Bjerke applied Goethe's inversion idea to all of Newton's essential experiments. He wanted to test how far Newton's concept of the decomposability of a light beam could be replaced by the formally equivalent concept of the »splitting of a dark beam«. This program was honed over the question of the invertibility of the *experimentum crucis*. To the best of my knowledge it was Bjerke who first inverted the *experimentum crucis* using crossed prisms (Newton, *Opticks*, Book I, Experiment 5). See Bjerke, André (1961): *Neue Beiträge zu Goethes Farbenlehre (New contributions to Goethe's colour theory)* Part 1, Stuttgart: Verlag Freies Geistesleben.

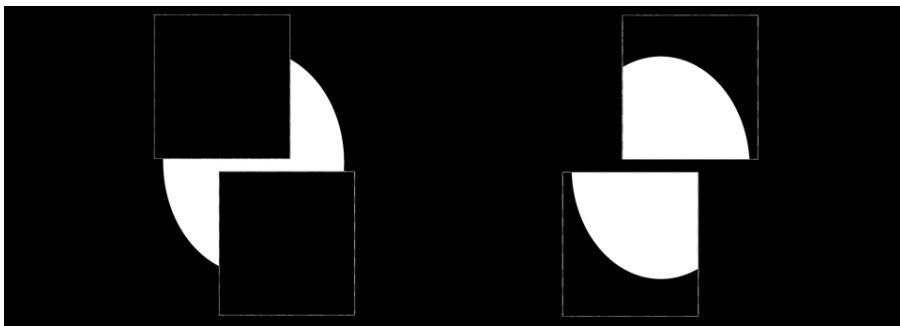
⁶Although Maier and Holtsmark knew of each other it does not seem as though they were conscious of each other's publications.

The path that Holtsmark developed as to the question of a novel grasp of optics as a theory of images was, however, different. In the previous section I indicated an aspect of his method. First he seeks historically significant steps in the thoughts of its protagonists about light- and colour theory. He then identifies the style of thought and refers it to that existential layer in humans in which the history of the theory of light and the history of consciousness go hand in hand. As far as I am concerned Holtsmark's studies contain something akin to an inner transition, which remains hidden when viewed from a merely historical or scientific-philosophical aspect. Holtsmark achieved this transition by not clinging to theoretical consideration, but rather by becoming an actor and really doing a phenomenology of image and colour that calls for practical comprehension and lets his deep educational intention become visible.

Was Holtsmark still alive and if so, would it be possible to make contact with him? In the meantime, the news of the »discovery« Holtsmark had circulated among colleagues and through the mediation of a friend, contact was established. In December 2008 a group of physicist friends went to a meeting in Oslo, in which, apart from a meeting with Norwegian colleagues, the almost eighty-four year old Torger Holtsmark was to be present.⁷ The meeting with him made a deep impression. He spoke German with us. We asked him about his academic career, about his work within Bjerkes Oslo colour group and about further volumes which Bjerke had announced in his 1961 book on colour theory, but which had never appeared.⁸ In particular we were interested in the question of whether he had realized his concept of inversion of New-

⁷Norwegian participants were Aksel Hugo (from the University of Oslo, whom I had met in September 2008 at a conference in Schwäbisch Gmünd and through whose agency our workshop *Talking on Phenomenology* at the Rudolf Steiner University College in Oslo came about), Torger Holtsmark, Morten Eide, Arne Nicolaisen, Jan Henrik Wold and Pehr Sällström from Järna. The German group consisted of Marc Müller, Matthias Rang, Wilfried Sommer and Johannes Grebe-Ellis (see illustration on page 322).

⁸It was by chance that during our stay in Oslo Bjerkes' colour theory research estate was in the hands of Jan Henrik Wold. Wold left me the materials for one night before handing it over to the Norwegian National Archives. There were two bags with notebooks and books, containing the minutes of meetings of the colour group and also very carefully executed handwritten drawings and illustrations on various problems on colour theory. I found no evidence that Holtsmark's solution to the problem of the inversion of Newton's *experimentum crucis* had been outlined – or at least guessed – by Bjerke.



Slit and stake: Transmission and reflection produce *simultaneously* complementary views of the same mirror-slit diaphragm.

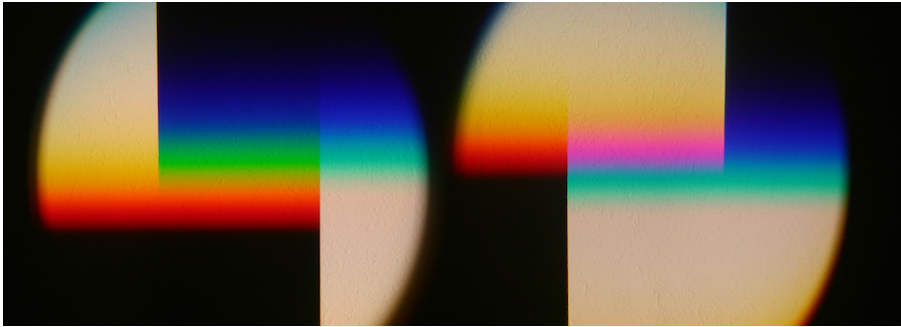
ton's *experimentum crucis* alone experimentally and how he had come to the crucial idea to use reflective aperture diaphragms for the solution of the Inversion problem. We all watched a half-finished film entitled *Monochromatic Shadow Rays*, which another friend of Holtsmark, the Swedish physicist Pehr Sällström, had produced from a first experimental realization of Inversion concept, which he succeeded in completing in 1976 at the Institute of Physics of the University of Stockholm.⁹ I reported on the research work of the Austrian painter and colour theory expert Ingo Nussbaumer, who on the basis of experiments with colour contrasts described the so-called »Extraordinary spectra«. ¹⁰ Finally, our colleague Matthias Rang presented an experiment for the simultaneous generation of complementary spectra, which he had been developing since 1999 without knowledge of Holtsmark's work, and whose central component consisted of a variable mirrored slit diaphragm.¹¹

In this way we spent three intensive days filled with scientific discussion, experimentation and shared cordial exchange. Holtsmark, who, due to his poor health condition, only intended to spend an hour a day, finally spent two

⁹Sällström, Pehr (2010): *Monochromatic Shadow Rays. A film about experiments on the rehabilitation of darkness*. DVD, in three languages, with a foreword by J. Grebe-Ellis, Stuttgart.

¹⁰Nussbaumer, Ingo (2008): *Zur Farbenlehre. Entdeckung der unordentlichen Spektren (On colour theory. Discovery of the Extraordinary Spectra)*. Vienna: Splitter

¹¹Rang, Matthias & Grebe-Ellis, Johannes (2009): *Komplementärspektren – Experimente mit einer Spiegelspaltblende (Complementary spectra – experiments with a mirrored slit diaphragm)*. Mathematisch Naturwissenschaftlicher Unterricht (MNU), 62 (4): 227-231



Complementary spectra of slit and stake.
Photo M. Rang

full days with us. He was wide awake, told us parts of his biography, followed our experiments with comments, which showed that he clearly saw through the relationships and was touched by our interest and sympathy. He agreed to our final question, to publish a collection of his work. On returning to Germany the work began – a job that has taken four years, terminating with the publication of this volume.

The story of this book thus seems told, yet it would be incomplete in some way, if we were not to mention the fact that, five years after *open eyes 2005*, a meeting with Torger Holtsmark at the Humboldt University in Berlin did occur. The framework for this meeting was provided by the international Workshop *Experimentum Lucis* sponsored by the DFG, which I, together with Friedrich Steinle, Olaf Müller and Matthias Rang organized on the occasion of the bicentennial anniversary of Goethe's *Colour Theory* (1810) at the Humboldt University. The topic was: *On the generalization of Newton's experimentum crucis*. We managed to gather a small group of well-known physicists, historians and philosophers of science and developed a program¹² providing a balanced exchange between experimental presentations, lectures and in-depth discussions. In the meantime Matthias Rang had developed a variation on the *experimentum crucis*¹³ with which the rigorous

¹²cf. Program on page 323

¹³Rang, Matthias (2009): Der Hellraum als Bedingung zur Invertierung spektraler Phänomene (The bright space as a condition to inverting spectral phenomena), *Elemente der Naturwissenschaft* 90: 46-79, see also Rang, Matthias & Müller, Olaf L. (2009): Newton in Grönland

symmetrical properties of the spectral phenomena could be shown in the sense of both Goethe and Holtsmark. It was our goal to debut a demonstration of this experiment and to discuss it from a physical, philosophical and historical point of view. Holtsmark had come to Berlin with his daughter Liv as well as some Norwegian colleagues, and it was our pleasure to honour him with an experimental sequence, which began with the production and transformation of simple silhouettes and culminated in the simultaneous implementation of the *experimentum crucis* in Darkspace after Newton and then in Lightspace after Goethe.

On the structure of the book

The book consists of two parts, both of which are arranged chronologically. The first part: *Research Contributions* contains twelve articles, some of which were published in internationally renowned magazines. They represent the outer side of the scientific work and show with whom Holtsmark has cooperated as a physicist. The second part, *Essays*, unites a selection of texts written for various occasions: as free studies, as transcripts of conference presentations or as a summary of discussions that had been held in the circle of colleague-friends. They are thus freer in their form; Torger's style is more pronounced; the force and vivacity of his thoughts are more clearly palpable and the nuances and colours of his conceptions, more differentiated.

In the first part of the volume, the research *results* appear in the foreground, in the second part the *process* of this research becomes noticeable. Here reciprocal relationships between both parts become plain. This is particularly the case for the central topic of the generalization of Newton's dispersion experiments. For us it was interesting that Holtsmark's seminal article, and one of his internationally renowned works, in which he published his solution to the Inversion problem, was indeed translated from an already existing German version invited by Holtsmark's physicist friend Georg Unger.¹⁴

With the exception of five texts that Dagmar Mißfeldt had translated from Norwegian into German for this publication, all are printed in the language

(Newton in Greenland), *Philosophia naturalis* 46: 61-114.

¹⁴Über eine mögliche Verallgemeinerung der Dispersionsexperimente Newtons, *Mathematisch-Physikalische Korrespondenz* Nr. 71: 3-9 (1969); Newton's *Experimentum crucis* Reconsidered, *American Journal of Physics* 38, Nr. 10: 1229-1235 (1970).

in which they were written. The complete bibliographic information is given at the beginning below each title. The two most recent texts (1990 and 2002) appear here for the first time.

Acknowledgements

Many people have been involved in the development of this book, and I would like to thank them here for their support. Morten Eide, a mathematician and relative of Holtsmark, played a decisive part in obtaining an overview of Holtsmark's journalistic work, in the recovery of numerous manuscripts that would otherwise not have been available to me as well as in gaining information on various details. He was my main correspondent over a period of nearly four years concerning the content and technical details of the book, especially when Torger's health situation interrupted our contact, he ensured that we remained in touch. If Morten got stuck I knew I could ask the physicist and colour theory expert Jan Henrik Wold, who was Holtsmark's pupil and friend over a long time. He helped me to get the translation and reprint licenses and further supported me in writing a proposal for the translation Program at NORLA. I was particularly pleased to gain the support of Arne Valberg, physicist, colleague and Holtsmark's co-author, for writing a preface to the book. Arne Nicolaisen wrote the detailed biographical sketch at the end of the book. He is a physicist and physics teacher at the Oslo By Steinerskole, is a long-time friend of Holtsmark and corresponded with Morten Eide.

I also want to thank the translator Dagmar Mißfeldt, who immersed herself in Holtsmark's texts. Through her work using five major Holtsmark studies core topics of his scientific interest have become available beyond Norwegian speakers for the first time. Through the generous support of NORLA, the Norwegian government Translation program, it has been possible to refinance half of the translation costs. I am grateful to David Auerbach, who translated the foreword into English. Inga Wied supported me with my research on Holtsmark's activities at the colour info-sessions of the German Colour Centre, and recovered treasures from the archive of the Colour Centre. Furthermore I thank the editors, who gave their consent to reprint Holtsmark's articles. I have mentioned the first place of publication in all cases, especially when the editors could no longer be located.

My final thanks go to my colleague Thomas Quick. I guess he is the one who knows Holtsmark's texts best of us all. During our cooperation he spent years involved with countless researches, with updating bibliographic data and examining quotations. Based on the previous work of Stephanie Tatge and Cornelia Iden he did the proofreading of all English texts, revised illustrations – or newly created them, where the originals were unusable due to poor quality, and finally, on the basis of a jointly developed layout for the book – created the TEX-File for typesetting the print.

Right at the end we discovered that a page of the paper *Halbschatten und Bild (Penumbra and image)* (1976) – together with illustrations, had been lost during digitization. When we found the page it became clear that the pictures, photos of silhouettes were unusable for printing. We were thus forced to do the experiment described in the text and realize the shadows described in the text (see page 212). What we did not expect and where the photos showed but a mere glimpse was the overwhelming beauty of his experiments! A fundamental principle of optical imaging was made clear to us in simple terms: the functional complementarity of imaging and imaged. Without realizing it we were suddenly caught up in optics lessons with Holtsmark and felt again the excitement and joy that accompanied us in the work on this book in recent years. I wish the readers of this book that they too get to know this joy and excitement.

Wuppertal 24th September 2012

Johannes Grebe-Ellis