Journal for General Philosophy of Science (2026) 57:185–194
https://doi.org/10.1007/s10838-025-09732-w

DISCUSSION

An Argument Against Müller's Criticism of Newton

Timm Lampert[1]

Accepted: 24 March 2025 / Published online: 27 October 2025
© The Author(s) 2025

Abstract
Newton claimed to have proven the heterogeneity of sunlight by experiment. Olaf Müller argues that one could likewise prove the heterogeneity of darkness from inverting Newton's experiments. Müller concludes that both, Newton's proofs and his underlying methodology, are inconclusive and that Newton's theory is underdetermined. This paper argues that Müller's criticism is not justified because the conducted inverted experiments to which Müller refers do not replace Newton's source of light with a source of darkness. Therefore, Müller does not refute Newton's methodology, nor does he provide an example of underdetermined theories.

Keywords Underdetermination · Newton · Goethe · Experimental proof

1 Introduction

Newton claims to have proven the heterogeneity of light by experiment, notably by his *experimentum crucis* (Newton 1671; 1730, 3078–3079 Theorem 2 / Experiment 6; cf. Lampert 2021 for an explanation of Newton's proof and his inductive method). Taking up an argument of Goethe (1810a, 86), Müller argues that Newton's claim can be reduced to absurdity by applying his methodology to inverted experiments such as the *experimentum lucis* and, thus, proving the heterogeneity of darkness (Müller 2015a; 2016). As a result, Müller claims that Newton's proof is based on the hypothesis that light causes vision, while darkness does not (Müller 2015a, 149, Hypothesis (K)). This hypothesis could be replaced by the hypothesis that darkness causes vision, while light does not (Müller 2015a, 150, Hypothesis ($\overline{K}$)). For Müller, the theories based on these alternative hypotheses are examples of two empirically equivalent but incompatible theories and, thus, concrete (non-universal) theories that exemplify Quine's thesis of underdetermination in Quine (1975).

Quine was unable to give clear examples of underdetermined theories. He was content to state his thesis for universal theories, which face a maximum of data. Since such universal theories do not exist and clear examples of non-universal theories for specific data are lacking, Quine's thesis has been criticised as speculative, e.g. by Earman (1993, 31–32; cf. Lyre 2018 for a detailed discussion). Thus, Müller's exemplification of Quine's thesis by an

✉ Timm Lampert
timm.lampert@fernuni-hagen.de

[1] Philosophical Department, Hagen University, Universitätsstraße 47, 58097 Hagen, Germany

empirically equivalent alternative for Newton's theory would indeed be an important contribution to the notorious problem of specifying examples for Quine's thesis.

Falkenburg (2015), Strohbach (2015), and Lyre (2018) argue that a theory of darkness is at best an example of weak (transient) underdetermination that is based on the empirical data concerning prismatic experiments and outdated by modern physics, e.g. thermodynamics or big bang theory.[1] However, they do not argue against the possibility of inverting Newton's prismatic experiments (cf. Falkenburg 2015; Strohbach 2015; Lyre 2018, 579, 585, Sect. 4). I argue below that a theory of darkness is not even an example of weak underdetermination because an explanation of the prismatic experiments by a theory of darkness is not empirically equivalent to their explanation by a theory of light.

Furthermore, Falkenburg (2015), Strohbach (2015), and Lyre (2018) consider that Müller's argument is an argument for ontological relativity rather than for underdetermined theories in the sense of empirically equivalent but incompatible theories. Similarly, Lampert (2017) argues that Newton's understanding of light as the source of vision is not a hypothesis but part of his *definitions*, which precede his proofs by experiment. Lampert (2017) thus defends Newton's claim to proof without questioning its underdetermination in terms of Quine's later understanding, which does not imply incompatibility of theorems but rather unreducibility of alternative ontologies (Quine 1992, §41–42). Rather than conceding empirical equivalence and underdetermination in terms of ontological relativity due to theoretical termini, I argue below that a theory of darkness is not empirically equivalent to a theory of light.

2 The Empirical Evidence of the Existence of Light Rays

Both "light rays" and "rays of darkness" are theoretical concepts. One might wonder how far it is possible to decide on the existence of these entities by experience. The purpose of this section is to explain the empirical evidence for the existence of light rays. On this basis, the following section will discuss whether inverse experiments provide likewise empirical evidence for the existence of rays of darkness emitted by dark sources.

We have no direct experience of light rays; we cannot see them. Light rays are the physical entities that cause vision (see the quote from Newton below) but they are not visible themselves. This is why "light ray" is a theoretical concept. This, however, is not to say that there is no empirical evidence for their existence.

Newton begins his *Opticks* by defining a ray of light. This definition comes from a letter to Pardies in which Newton also defines the basic concept of light. I quote Turnbull's English paraphrase of Newton's Latin definition (Turnbull 1959, 179):

> I understand Light to be any being or power of a being, (whether a substance, or any power, action, or quality of it) which proceeding directly from a lucid body is adapted to excite vision: and I understand rays of light to be the least, or the indefinitely small parts of it, which are mutually independent, as are all rays which luminous bodies emit in straight lines either synchronously or in succession. For those parts of light are independent, be they collateral or successive, as they can be intercepted singly and apart from others, and be reflected in any direction.

[1] Müller replied to Falkenburg (2015) and Strohbach (2015) in Müller (2015b) and to Lyre (2018) in Müller (2018).

Interestingly, Newton gives this definition just after making it clear that he is not giving a hypothesis. According to Newton, hypotheses only come into play when the properties of light rays are specified in order to explain phenomena by hypothetical deduction, for example by a theory of waves or, alternatively, a theory of corpuscles: this alternative cannot yet be decided by induction directly deduced from experimental data, but at best by an indirect argument of the best explanation in Newton's time. However, Newton's definition of light and light rays is based on the following empirical evidence:

1. the existence of luminous bodies, e.g. the sun or candles, as sources of brightness in the dark universe or dark chambers,
2. the fact that we can (i) make light visible, e.g. by boards or dust, (ii) separate it, e.g. by pinholes, and (iii) reflect it, e.g. by mirrors, and in doing so we can see that light comes directly from luminous bodies to the eye (thus exciting vision),
3. that we can separate parts of light synchronously, e.g. by pinholes, or successively, e.g. by intercepting parts of light with boards (thus stopping and passing parts of light).

Newton's definition of light rays as the smallest independent parts of light does not define a mathematical entity that cannot be made visible.[2] For Newton, rays of light are not infinitely small mathematical entities, nor are they hypothetical entities that are merely postulated to explain phenomena without being able to be deduced from experience by induction. Rather, light rays are physical entities that can be inferred from vision because their path can be made visible and manipulated, e.g. "stopped" and "passed" (Newton 1730, 1 from Definition 1).

Put in Quinean terms, we can reduce Newton's talk of light and light rays to true observational conditionals concerning pegged observational statements (cf. Quine 1975, 316), about lucid bodies and colored spots that can be made visible in the region of those bodies and in the direct path between the lucid bodies and the eye. We could thus reduce the causal statement that light causes vision to conditionals with pegged observational statements about luminous bodies as necessary conditions of vision. In this way, we can get rid of the causal statement, which is controversial from a Quinean point of view.

Müller claims that empirical evidence is also compatible with the assumption that it is not rays of light but rays of darkness that emanate from sources of darkness and produce vision. In what follows, I argue that this is not true, by showing that we cannot infer rays of darkness inductively from inverse experiments.

[2] (Holtsmark 2012, 28, 52) argues that Newton's conception of light rays oscillates between a non-causal geometrical and a causal physical understanding. However, this judgement is based on a misunderstanding of Newton's direct attribution of colors to rays. When Newton speaks "grossly" of "rays of divers colors" he means "rays that cause diverse visual colors" as Newton himself stresses (Newton 1730, 108–109). Furthermore, Holtsmark provides no evidence for his belief that Newton's conception of light rays is not purely physical. For example, Newton's experiments take place in a "dark surround" because Newton assumes a physical understanding of light that excludes the concept of a "beam of shadow" because there are no sources in our world that emit such beams according to Newton. The statements that "the geometrical-optical ray is illustrated equally well by a narrow beam of light as by a narrow beam of shadow" (Holtsmark 2012, 28), and that "[w]hat Newton has demonstrated for colors seen in a black surround might equally well have been shown for other colors in other surrounds" (Holtsmark 2012, 30), attribute to Newton a conception of rays that he does not hold.

3 Inverting Experiments

According to Müller, the success of Newton's theory is only due to the dominant role of darkness in Newtonian experiments. However, inverting the roles of darkness and light in these experiments suggests that the proposed alternative – a theory of the heterogeneity of darkness – follows from the very same Newtonian methodology. This argument rests on the assumption that such an inversion is empirically possible. As we shall see, Müller himself admits that inverting the prismatic experiments is not as easy as it seems at first glance.

3.1 Suggestive One-Prism Experiments

In the second chapter of Müller (2015a), Müller presents a subjective and an objective inversion of one-prism experiments that evoke a spectrum In the subjective version, one looks at a dark circle on a white sheet of paper to evoke the Goethean spectrum (Müller 2015a, 146), while one looks at a white circle on dark paper to evoke a Newtonian spectrum, (Müller 2015a, 69).

The problem with the inversion of this experiment is not that it is subjective, but that it merely inverts the black and white parts of a sheet of paper, without inverting the source of light that illuminates the sheet of paper. A dark piece of paper is no more a candidate for a source of rays that excites vision than is a white piece of paper: a white piece of paper does not make a dark room light, and a dark piece of paper does not make a light room dark. Although Müller calls the subjective experiment an "inverted experiment", he admits that it does not invert the *source* of light (Müller 2015a, 37). Nevertheless, he conceives it as a proper approximation of inversion (Müller 2015a, 37) that does not deviate from Newtonian standards (Müller 2015a, 146). In the same way, he regards Lucas' subjective one-prism experiments with white and black sheets of paper as the first examples of inverted experiments (Müller 2015a, 162–169). But inverting white and black parts of a sheet of paper while the paper is illuminated by light is not evidence for dark rays emitted by a source of darkness and inducing vision. This would require inverting the entire distribution of light and dark in the whole environment.

3.2 Experiments With a Shade Provider

In Müller (2015a, §II.2.2), Müller describes Goethe's objective variant of an inverted one-prism experiment. Instead of producing a Newtonian spectrum in a dark chamber with a hole in a closed shutter, a Goethean spectrum is produced in a chamber with open shutters and a dark circular sheet of paper attached to the prism or shutter. This sheet of paper serves as a "shadow-provider" ("Schattenspender"), as Müller himself explains (e.g. Müller 2015a, 135). Similarly, Ingo Nussbaumer's creation of complementary spectra uses a slide stack (Müller 2014, 20, Fig. 3). This slide stack serves as a shadow-provider, while the slide projector is the light source (Nussbaumer 2008). Influenced by these experiments, Müller (2015a, 205) opposes "black shadow" ("schwarzer Schatten") to "white light" in his table for the inversion of phenomenological concepts.

However, black shadow is not the inversion of a light source nor can a shadow-provider be understood as a source of "dark rays", but at most of black shadow. There are several ways to illustrate this within prismatic experiments. First, the shadow cast by a shade-provider depends on its relation to a source of light; it cannot be thought of as the starting point of dark rays, since changing the position of a source of light changes the position of

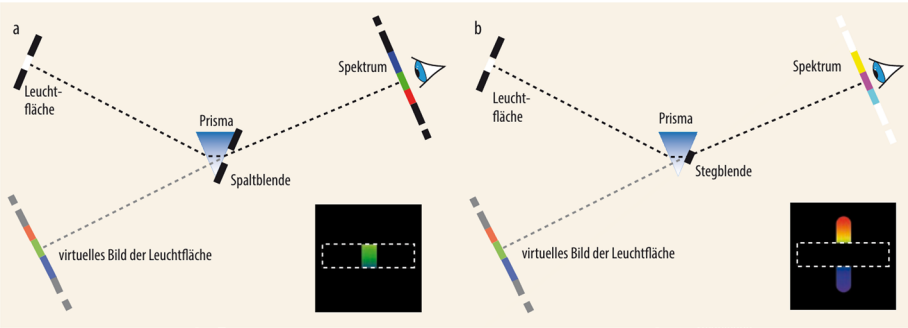


Fig. 1 Inversion using a shadow-provider: the eye sees the magenta in the experiment on the right exactly at the position where it sees all the colors of the virtual Newtonian spectrum except green, which makes evident that the magenta is a mixture of the Newtonian spectral lights without green. The figure is taken from (Rang et al. 2017, 45, Fig. 3)

the shadow. In contrast, the direction of the light emitted by a light source does not depend on other sources (of light or dark). Second, a shadow-provider does not produce "presorted black" behind a prism (Rang and Müller 2009, Sect. 3): placing a board with a pinhole behind a prism does not produce a Goethean spectrum evolving from the shadow, whereas in the similar case, e.g. in the *experimentum crucis*, a Newtonian spectrum evolves from the presorted white.[3] Therefore, "inverted" experiments using a shadow-provider either do not produce Goethean spectra, or parts of them, at all or, if they do (e.g. by omitting the board with the hole close behind the first prism in an inverted *experimentum crucis*), they do not provide evidence for a source of darkness, and thus evidence for a theory of heterogeneity of darkness. Instead, such experiments depend on a source of light.

Müller (2015a, 292–298, §III.5.5 - §III.5.7) discusses the phenomenon of white shadows as empirical evidence for sources of darkness. Indeed, this phenomenon suggests an explanation in terms of a theory of darkness, since such an explanation would not have to refer to complicated superpositions of light rays, but simply to the prevention of the passage of dark rays. The experiment to which Müller refers, however, requires diffuse light from a fluorescent tube and a shadow-provider in terms of a square bar to produce white shadows of a cubic skeleton. Contrary to what Müller says (Müller 2015a, 294), the square bar cannot be understood as a source of darkness similar to a torch light. This can be seen, for example, from the fact that turning a square bar by 180 degrees does not turn the shadow, whereas turning a torch that only emits light in one direction will emit light in the opposite direction. Therefore, the phenomenon of white shadows cannot be explained by sources of darkness that cast not black but white shadows. It is the Newtonian theory and not a theory of darkness that explains the phenomenon of white shadows.

3.3 Experiments with the Mirror-Split Diaphragm

Indeed, Müller concedes that "in the standard case" it is not sufficient to use a shade-provider to invert Newtonian experiments (cf. Müller 2015a, 204, my translation):

[3] A third illustration of the fact that a shadow-provider is no inversion of a source of light is given in Fig. 1 explained in the next section.

> In order to invert any arbitrary Newtonian experiment, it is not sufficient in the standard case to replace a pinhole at the entrance to a darkroom with a shadow-provider.

Instead, two things have to be done: (i) the darkroom has to be replaced by a chamber of diffuse light, and (ii) the distribution of light and darkness in the whole universe has to be inverted (cf. Rang and Müller 2009). (i) is empirically realizable, and Rang and Müller (2009, Sect. 6) show that this makes it possible to produce "presorted black" and the Goethean spectrum. However, the experimental realization they propose in Rang and Müller (2009, Sect. 7) makes use of "a strip of black paper as a complement to the sun". A strip of black paper, however, is no complement to the sun, because – as shown in Sect. 3.1 – black paper is an equivalent of white paper, and white paper is not a source of light. Therefore black paper is not a source of darkness.

Müller is well aware that "ideally the whole sky must be inverted" (Müller 2015a, 204) for strictly inverting experiments. As Müller mentions, Goethe and even Lucas already considered that (cf. Goethe 1810b, 273, 275 and Turnbull 1959, 108). But this is empirically impossible. Müller must therefore refer to some realizable equivalent.

As Müller himself mentions (Müller 2015a, 104), the best candidates for inverted experiments are experiments of the physicists Mathias Rang and Johannes Grebe-Ellis. Rang and Grebe-Ellis criticize traditional attempts to invert Newton's experiments as "ineffective" because the inversions were based on an "incomplete, mechanical" (Rang et al. 2017, 45) understanding of inversion based on the use of a shadow-provider. They nicely illustrate why such experiments are not proper inversions of Newtonian experiments by placing the eye in a position in the experiments that makes it clear that the Goethean spectrum results from the mixing of spectral lights (cf. Fig. 1).

Rather than "mechanically" inverting Newton's experiments, Rang and Grebe-Ellis offer an "optical inversion" that does not use a shadow-provider or black paper. Instead, Rang developed a special type of pinhole, the "mirror slit diaphragm" ("Spiegelspaltblende"), which allows light to pass on one side and reflects it on the other. The use of the mirror slit diaphragm makes it possible to produce the Newtonian spectrum in a dark environment on one side of the slit, and the Goethean spectrum in a diffuse light environment on the other side of the slit (cf. Fig. 2). Rang and Grebe-Ellis installed the *experimentum lucis* simultaneously with the *experimentum crucis* in such a dual setting by using a mirror slit diaphragm on several occasions (cf. Grebe-Ellis and Rang 2010). They even generalized this experimental setting to verify inversion beyond the range of light, i.e. in the infrared and ultraviolet regions (Rang and Grebe-Ellis 2018).

However, Rang and Grebe-Ellis do not intend their experiments to support a theory of darkness that prescribes sources of darkness. They are interested in a phenomenological theory of complementary color phenomena that does not use the concept of rays at all (cf. Rang 2015). In such a framework, the concepts of homogeneous and heterogeneous rays emitted by a source make no sense. In describing their inverted experiments, they make it clear that they are not inverting a light source, but the dark room. Rang and Grebe-Ellis describe the complementary phenomena by making use of intensity levels of illumination without referring to a source of light or darkness emitting rays. This allows for a formalism that does justice to the symmetry of the phenomena, where darkness in terms of shadow (low or negative illumination level) is opposed to brightness (high and positive illumination level). Müller sees this inversion as a "simulation of the inversion of the whole sky" (Müller 2015a, 204). But Müller himself admits in the same sentence that Rang's experiments are based on "artificial light": it is this light that is reflected by the mirror slit diaphragm to simulate an inversion of the dark room (cf. the light source L in Fig. 2). This

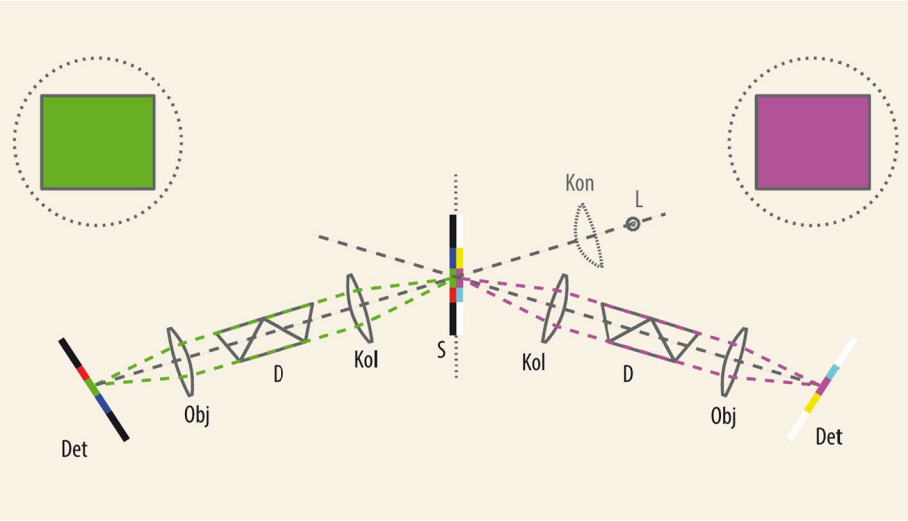


Fig. 2 Newtonian and Goethean spectra produced simultaneously using a mirror slit diaphragm. Unlike in Fig. 1, the virtual image of the magenta in the spectrum on the right is also a virtual magenta in a virtual Goethean spectrum at the mirror slit diaphragm. The figure is taken from (Rang et al. 2017, 48, Fig. 8)

simulation may well justify the conclusion that if the distribution of light and dark in the universe *were inverted*, then the Goethean spectrum would be the primary phenomenon induced by homogeneous dark rays and the Newtonian spectrum would be the secondary phenomenon induced by a heterogeneous mixture of superimposed homogeneous rays of darkness. However, this is a counterfactual. There is, therefore, no evidence for a theory of darkness as long as sources of light and not sources of darkness are essential for real-world experiments, producing the colors of the Newtonian spectrum as well as the colors of a Goethean spectrum.

3.4 Counter-Factual Inversion

Thus, the only inverted experiments that were actually based on a source of darkness emitting rays of darkness instead of a source of light are counterfactual *thought* experiments that invert the whole universe, including the sun and the dark background of the universe. To illustrate the physical circumstances of such an inverted universe, Müller (2015a, 288–290, §III.5.2) speculates that heat would dominate coldness in this universe, and so energy might be needed to cool down bodies, which would thus emit rays of darkness in a bright universe. In this universe, vision would indeed be caused by dark rays and the theory of the heterogeneity of darkness would be the correct theory.

Curiously, however, Müller does not admit that by matter of fact there are no sources of darkness in *our* world (Müller 2015a, 298). Instead, he merely admits that darkness prevails in our universe due to the contingent initial conditions of our world (Müller 2015a, 299). For this reason, Müller argues, Newtonian experiments dominate, while inverted experiments were only discovered later and did not play a decisive role in the history of optics (Müller 2015a, Part III). For Müller, this is only a pragmatic reason to accept Newton's theory, not an empirical one (Müller 2015a, 299). In this argument, however, Müller

refers to inconclusive versions of inverted experiments that cannot support a theory of darkness. As we have seen, all empirically realized candidates for inverted experiments are in fact based on a source of light, not a source of darkness. All the phenomena of these experiments can be explained by the Newtonian theory of the superposition of homogeneous lights, but cannot be explained by a theory of darkness, because there is no empirical evidence for sources of darkness in our world.

It is true that this is a contingent matter of empirical fact due to the initial conditions of our empirical world. But the theories of physics are intended to explain this world and no other. Müller (2015a, 299–300) makes a strange distinction between the laws of our world and its initial conditions. He admits that one cannot argue against an established physical theory by referring to other possible worlds that obey different *laws* than those of our world.[4] But he seems to claim that the same does not hold for worlds starting with different initial conditions. However, it is well known that the slightest difference in initial conditions at the big bang (or shortly after) has a huge impact on the physical development of the world, including the natural constants and laws. Newton's theory of the heterogeneity of light does justice to the one empirical world we live in, including its initial conditions. This is not true of a theory of darkness. For this reason, such a theory is not an empirical equivalent of Newton's theory. Similarly, Newton's theory would not be empirically equivalent to its opponent if the initial conditions of the universe concerning the distribution of brightness and darkness were inverted. These contingent conditions determine which theory is empirically adequate and which is not.

4 Conclusion

Müller admits that a clear inversion of Newton's experiments would amount to inverting the lighting conditions of the whole universe. However, he does not seem to realize that this is the only way for sources of darkness to exist and, thus, justify a theory of darkness. For this reason he mistakenly regards a theory of darkness as an empirically equivalent theory to Newton's theory of light. However, any inversion of the experimental settings of our world that would justify a theory of darkness is counterfactual. Therefore, these two theories are not examples of a concrete version of Quine's theses of underdetermination. Moreover, Newton's claim to have proved his theory experimentally is not undermined by a theory of darkness.

Acknowledgements I am grateful to the participants of my recent seminars on the topic and to Victor Rodych for comments on an earlier draft of this paper.

Funding Open Access funding enabled and organized by Projekt DEAL.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

[4] He explicitely says this in an unpublished preversion of Müller (2015a, 849).

References

Cohen, I. Bernhard. 1958. *Isaac Newton's Papers and Letters on Natural Philosophy and Related Documents*. Harvard: Harvard University Press.

Earman, John. 1993. Underdetermination, Realism, and Reason. *Midwest Studies in Philosophy* 18: 19–38.

Falkenburg, Brigitte. 2015. Wohin fliegt die Eule der Minerva? Über die Verkehrung von Licht und Finsternis. *Zeitschrift für philosophische Forschung* 69 (4): 574–580.

Goethe, Johann Wolfgang von. 1810a. Erklärung der zu Goethes Farbenlehre gehörigen Tafeln. In *Leopoldina-Ausgabe. Die Schriften zur Naturwissenschaft. Vollständige mit Erläuterungen versehene Ausgabe im Auftrage der Deutschen Akademie der Naturforscher Leopoldina*, Vol. 1, eds. Dorothea Kuhn, Wolf von Engelhardt, and Irmgard Müller, 41-114. Weimar: Böhlau.

Goethe, Johann Wolfgang von. 1810b. Materialien zur Geschichte der Farbenlehre. Des zweiten Bandes erster, historischer Teil. In *Leopoldina-Ausgabe. Die Schriften zur Naturwissenschaft. Vollständige mit Erläuterungen versehene Ausgabe im Auftrage der Deutschen Akademie der Naturforscher Leopoldina*, Vol. 1, eds. Dorothea Kuhn, Wolf von Engelhardt, and Irmgard Müller, VII-450. Weimar: Böhlau.

Grebe-Ellis, Johannes, and Matthias Rang. 2010. *Experimentum Lucis*. Lüneburg: Ausstellungsbooklet zur gleichnamigen Veranstaltung an der Humboldt-Universität zu Berlin.

Holtsmark, Torger. 2012. *Colour and Image*. Berlin: Logos.

Lampert, Timm. 2017. Underdetermination and Provability. *British Journal for the History of Philosophy* 25 (2): 389–400.

Lampert, Timm. 2021. Newton's Experimental Proof. *Theoria, An International Journal for Theory, History and Foundations of Science* 36 (2): 261–283.

Lyre, Holger. 2018. Newton, Goethe and the Alleged Underdetermination of Ray Optics'. *Journal for General Philosophy of Science* 49: 525–532.

Müller, Olaf. 2014. Newton, Goethe und die Entdeckung neuer Farbspektren am Ende des Zwanzigsten Jahrhunderts. In *Erkenntniswert Farbe*, ed. Margit Vogt and André Karliczek, 45–82. Jena: Ernst-Haeckel-Haus.

Müller, Olaf. 2015a. *Mehr Licht. Goethe mit Newton im Streit um die Farben*. Frankfurt a.M.: Fischer.

Müller, Olaf. 2015b. Weltgemacht oder hausgemacht? Plädoyer für die Verschiedenheit zweier empirisch äquivalenter Theorien. *Zeitschrift für philosophische Forschung* 69 (4): 588–598.

Müller, Olaf. 2016. Prismatic equivalence - a new case of underdetermination: Goethe vs Newton on the prism experiments. *British Journal for the History of Philosophy* 24 (2): 322–346.

Müller, Olaf. 2018. Goethe's Polarity of Light and Darkness. *Journal for General Philosophy of Science* 49: 581–598.

Newton, Isaac. 2014. A letter of Mr. Isaac Newton, Professor of the Mathematicks in the University of Cambridge; containing his new theory about light and colors: sent by the author to the publisher from Cambridge, Febr. 6. 1671/72; in order to be communicated to the R. Society. *Philosophical transactions of the Royal Society of London* 6 (80): 3075–3087.

Newton, Isaac. 1730. *Opticks: Or a Treatise of the Reflections, Refractions, Inflections and Colours of Light*. 4th ed. London: Innys.

Newton, Isaac. 1962. *Mathematical Principles of Natural Philosophy and his System of the World*. Berkeley: University of California Press.

Nussbaumer, Ingo. 2008. *Zur Farbenlehre. Entdeckung der unordentlichen Spektren*. Wien: Edition Splitter.

Quine, Willard Van Orman. 1975. On Empirically Equivalent Systems of the World. *Erkenntnis* 9 (3): 313–328.

Quine, Willard Van Orman. 1990. *Pursuit of Truth*, Revised. Cambridge, MA: Harvard University Press.

Rang, Matthias, and Olaf Müller. 2009. Newton in Grönland. Das umgestülpte experimentum crucis in der Streulichtkammer. *Philosophia Naturalis* 46 (1): 61–114.

Rang, Matthias. 2015. *Phänomenologie der komplementären Spektren*. Berlin: Logos.

Rang, Matthias, Oliver Passon, and Johannes Grebe-Ellis. 2017. Optische Komplementarität. Experimente zur Symmetrie spektraler Phänomene. *Physik Journal* 16 (3): 43–49.

Rang, Matthias, and Johannes Grebe-Ellis. 2018. Power Area Density in Inverse Spectra. *Journal for General Philosophy of Science* 49: 515–523.

Strohbach, Nico. 2015. Goethe und Kroethe: Olaf Mullers Wissenschaftstheorie der Farbenlehre im Vergleich. *Zeitschrift fur philosophische Forschung* 69 (4): 581–587.

Turnbull, Herbert Westren. 1959. *The Correspondence of Isaac Newton*, 1661–1675. Cambridge: Cambridge University Press.

Turnbull, Herbert Westren. 1960. *The Correspondence of Isaac Newton*, 1676–1687. Cambridge: Cambridge University Press.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.