

Aurorae Borealis Studia Classica

Vol. IV

Lucis Boreæ Theoria nova (MS, c. 1770)
Aurorae Borealis Theoria Nova (1776)
Neue Theorie des Nordlichtes (1792)

by Maximilianus Hell

digitized by UiT, with a biographical introduction
and summary of contents by Per Pippin Aspaas

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- The editor

Items digitized for this volume:

The manuscript *Lucis Boreæ Theoria nova* from the Fachbereichsbibliothek Astronomie at the Institut für Astrophysik, University of Vienna (see [digitized manuscript](#))

Copy of *Ephemerides Astronomicae, Anni 1777* with the appendix *Aurorae Borealis Theoria Nova* from the Ultima Thule collection of the University Library, UiT in Tromsø (see [e-book](#))

Copy of *Beyträge zur Praktischen Astronomie, Zweiter Band* with the article *Neue Theorie des Nordlichtes* from the Bayerische Staatsbibliothek in Munich, Call Number 10293914 Astr.u. 75-1/2 10293914 Astr.u. 75-1/2, urn:nbn:de:bvb:12-bsb10060951-3 (see [e-book](#))

MAXIMILIANUS HELL (1720–1792)

Biographical introduction

by Per Pippin Aspaas

Maximilianus Hell was born in May 1720 close to the mining town Schemnicium in the Kingdom of Hungary (today Banská Štiavnica, Slovakia; also known as Schemnitz [German] or Selmecebánya [Hungarian]). The son of a mining engineer, he entered the Jesuit order at the age of eighteen (baptised Maximilianus Rudolphus Höll, he used the name Maximilianus or Maximilian *Hell* from 1755 onwards; he is also known as Maximilien [French], Miksa [Hungarian], or Maximilián [Slovak]). After studies at Vienna University and various other institutions in the Habsburg territories, Hell became a professor of astronomy at the Jesuit University of Claudiopolis in Transylvania (or Klausenburg, Kolozsvár; today Cluj-Napoca in Romania). From the year 1755, however, he served as the director of the University Observatory in Vienna, with the title Imperial and Royal Astronomer. He remained the court astronomer of Vienna until his death in April 1792.

Maximilianus Hell had broad research interests, including observational and theoretical astronomy, meteorology, physics, history, etc. His chef-d'oeuvre was the *Ephemerides (Astronomicae) ad Meridianum Vindobonensem*, a large-format, combined almanac and journal, in which scientific reports and treatises were included in the form of appendices. It soon acquired an international readership ranging far beyond Habsburg territories. The first volume covered the year 1757; the series continued until long after Hell's death.

In the year 1767, the Kingdom of Denmark and Norway approached him with an invitation to observe a Transit of Venus in front of the disc of the Sun from Vardøhus (now Vardø) on the extreme, north-eastern periphery of the Dano-Norwegian Realm. Hell accepted, and conducted from April 1768 to August 1770 a large-scale expedition that won him considerable fame. The first winter, 1768/69, was spent in Vardø; the next, 1769/70, in Copenhagen. Hell planned to publish a diary of the entire expedition as well as all its principal results in a three-volume work titled *Expeditio litteraria ad Polum arcticum*. In 1773, however, the Society of Jesus was abolished, its priests secularized, and all its possessions taken over by the state. This, along with other problems, made it impossible for Hell to finish the project. Various parts of the *Expeditio litteraria* were, however, published in other contexts, including hundreds of pages on the transit of Venus of 1769; a famous

‘Demonstration that the Language of the Hungarians and the Lapps is the Same’ by Hell’s travel companion Joannes (János) Sajnovics; and the first and fundamental part of Hell’s own ‘New Theory of the Northern Light’, the *Aurorae Borealis Theoria Nova*.

Hell had seen some aurorae from Central Europe during the 1750s and 60s. In his correspondence with fellow Jesuits, he then argued strongly for an electric cause of the phenomenon. During his stay in Vardø, as well as during the journey through northern parts of Norway, Hell witnessed the aurora on a regular basis. Based on this first-hand experience from the north, he rejected his former theory and became convinced that the aurora must be a purely optical phenomenon, with no relation whatsoever to either electricity or magnetism. His ‘New Theory’ was first presented in an elaborate form during five consecutive sessions of the Royal Danish Society of Sciences in Copenhagen, in March 1770.

Hell planned to expand his treatise to include a comprehensive treatment of auroral observations made at more southern latitudes. This seems to have come to nothing. Among Hell’s surviving manuscripts in Vienna, only the first and fundamental part of the treatise is preserved. This text was later printed, in a slightly longer form, as an appendix to his *Ephemerides Astronomicae* for the year 1777 (published in 1776). In the early 1790s, Hell’s colleague at the University of Breslau (or Vratislavia, Wrocław; now Wrocław in Poland), Longinus Antonius Jungnitz published most of Hell’s treatises in German translation, as *Beyträge zur Praktischen Astronomie, in verschiedenen Beobachtungen, Abhandlungen, Methoden aus den astronomischen Ephemeriden des Herrn Abbe’ Maximilian Hell* (‘Contributions to Practical Astronomy, in the Form of Various Observations, Treatises and Methods taken from the Astronomical Ephemeris of Herr Abbed Maximilianus Hell’, 4 vols., Breslau & Hirschberg, 1790–93). Hell’s northern light theory was included in the second set of *Beyträge*, published in 1792. In his preface, the translator presents his plans for an enlarged edition of Hell’s treatise, updated with comments and new ideas provided by both Hell and Jungnitz. This did not materialize, however, possibly because Hell died in the same year.

Bibliography

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Aspaas, Per Pippin: “The auroral zone versus the zone of learning: a brief history of early modern theories on the aurora borealis”, in Silje Gaupseth, Marie-Theres Federhofer & Per Pippin Aspaas (eds.), *Travels in the North: A Multidisciplinary Approach to the Long History of Northern Travel Writing*, Hannover: Wehrhahn Verlag, 2013, pp. 113–135.



W. Bohl ad Vivum del.

J. G. Heide aeri radebat Vannus. Austria. 1771.

R. P. MAXIMILIANUS HELL, e. S. I.

Astronomus Regio Cesareus, observato feliciter Transitu Veneris ante Discum Solis die 5^{to} Junij 1769.
Wardoehusii in Laponia Finnmarchica, Votis CHRISTIANI VII. Danica et
Norvegiae Regis impletis, in Veste sua Laponica.

C. 2. Maj.

Zu finden bey C. A. Comp in Wien.

Portrait of Maximilianus Hell. © Nasjonalbiblioteket, Oslo. Billedsamlingen.
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LUCIS BOREÆ THEORIA NOVA

Summary of Contents (manuscript version)

by Per Pippin Aspaas

The entire treatise was intended to consist of four parts, namely, the characteristics of the aurora in regions between the 80th and the 66th latitude (part I); between the 66th and the 60th latitude (part II); between the 60th and the 50th latitude (part III); and between the 50th and the 40th latitude (part IV).

Hell never published more than an introduction to the entire treatise plus its first and fundamental part. The manuscript appears to represent the original series of lectures presented at the Royal Society of Sciences in Copenhagen in 1770; a slightly expanded version was printed in 1776 (hereafter referred to as **LAT**); the German translation of 1792 (**GER**) contains no further additions.

[Title page]

Lucis Boreæ Theoria nova à Maximiliano Hell S.J. Pars I.^{ma} Societati Regiæ Scientiarum Haffniensi per quinque sessiones. hoc est die 2^{da}, 9, 16, 23 et 30 Martij 1770 prælecta ('New Theory of the Northern Light, by Maximilianus Hell of the Society of Jesus, Part I, Presented to the Royal Society of Sciences in Copenhagen on five sessions, namely, on 2, 9, 15, 23 and 30 March 1770'). [*Lux borea* is a synonym of the more widespread designation *aurora borealis*.] On the verso of the title page there are quotes from Newton's *Principia Mathematica* and Musschenbroek's chapter *De Philosophia et Regulis Philosophandi*, which both emphasize empirical science.

PRÆFATIO (pp. 3–13) [=LAT, 3–22; GER, 123–144]

Introduction to the entire treatise. Hell presents the prevalent theories on the aurora in contemporaneous science, dividing the prevalent theories into three 'classes': 1) the theories of the 'mathematicians'; 2) the 'physicists'; and 3) the 'minor philosophers'. Among the mathematicians he considers the likes of De Mairan, who argued that the aurora takes its rise from some sort of mixture of the atmosphere of the Earth and the (alleged) atmosphere of the Sun. The physicists would argue that the electricity or magnetism of the earth, exhalations of sulfurous substances or the like, were the cause of the aurora. The minor philosophers would



point to eruptions of volcanoes or reflections from icebergs of the far north, or even frozen moisture in the atmosphere, capable of illuminating the night sky when hit by the sun's rays from below the horizon. Hell then gives an account of his own investigations of the phenomenon, thereby mentioning how he has come to the conclusions that he is about to present. The structure of the entire (unfinished) treatise is presented on pp. 7–9 [LAT, 11–14; GER, 132–136]. After quoting some prevalent theories from the existing literature, Hell concludes that his own theory is unique and thus merits comparison with the *Astronomia Nova* of Copernicus; this explains the word *nova* in the title of his treatise.

PARS I. Complectens Phœnomena, Observationes, et Proprietates Lucis Borealis in Zona frigida apparentis, atque ex his deductam Theoriam explicandis omnibus Lucis Borealis Phœnomenis congruam (pp. 14–67) [=LAT, 23–118; GER, 145–251]

(‘Part I, containing phenomena, observations and properties of the Northern Light as it appears in the cold climate zone, as well as the theory, which has been drawn from these appearances and which is fitting to explain all kinds of Northern Light phenomena’)

Caput I. Phœnomena et Proprietates Lucis Borealis in Zona frigida a me observata (pp. 14–32) [=LAT, 23–54; GER, 145–178]

(Chapter I, on ‘phenomena and properties of the Northern Light, observed by me in the cold climate zone’) Begins by emphasizing that Hell’s theory is based on observations that he has done himself in parts of Norway stretching from the 66th to the 71st latitude, i.e. in the counties today known as Finnmark, Troms and Nordland, approximately from the island of Dønna and northwards to the North Cape (pp. 14–15) [LAT, 23–26; GER, 145–148]. §§. I.–III. Contains descriptions of the various visual characteristics of the aurora in the region in question (pp. 15–20) [LAT, 26–33; GER, 148–156]. §§. IV. & V. Arguments in favour of the connection between the aurora and the sun and/or moon (pp. 20–24) [LAT, 33–41; GER, 156–164]. §§. VI. & VII. Arguments in favour of the aurora consisting of frozen particles of moisture, precisely like snow, something the local inhabitants – including the Sami (*Lappones*) – support (pp. 24–28) [LAT, 41–48; GER, 154–171]. §. VIII. The height of the aurora above the surface of the Earth. Hell argues that it sometimes descends as far down as the clouds and that it can be audible (pp. 29–31) [LAT, 48–51; GER, 172–175]. §. IX. A list of corollaries (i.e., logical conclusions) of the above arguments. Hell concludes that “the auroral substance quite often falls down to earth in the form of snowflakes [...], accordingly, the theory must be based upon a substance of such a nature that it both emits and produces snowflakes” and that “the auroral substance is usually observed to be far more dense in the cold climate zone [i.e., between 66th and 80th latitude] than in the temperate zone, accordingly, the theory should

identify a substance of a kind that will render this circumstance self-evident” (pp. 31–32, here, corollary IV. & XI.) [LAT, 52–54; GER, 176–178].

Caput II. De Nonnullis Proprietatibus Zonæ frigidæ ad Theoriam Lucis boreæ spectantibus (pp. 32–42) [=LAT, 54–72; GER, 178–199]

(Chapter 2, ‘on various properties of the cold climate zone that are of relevance to the Northern Light theory’) §§. I.–III. contain discussions of the properties of snow and cold, as well as a range of visual phenomena that according to Hell arise from refraction of light in the atmosphere, such as *corona* (ring around the sun), *halo* (ring around the moon), *parhelius* (spurious sun, or “sun dogs”) and *paraselene* (spurious moon). §. IV. argues that the said phenomena are analogous to the aurora.

Caput III. Complectens Theoriam Lucis Boreæ, ejusque Demonstrationem, atque omnium Phænomenorum Zonæ Frigidæ explicationem, Quæstionumque præcipuarum de luce borea occurrentium Resolutionem (pp. 43–67) [=LAT, 73–118; GER, 199–251]

(Chapter 3, ‘containing the theory of the Northern Light, including its demonstration, as well as an explanation of all phenomena of the cold climate zone, along with a solution to the most important questions regarding the Northern Light’) provides a synopsis of the theory based on all observations made by Hell between the 66th and 71st latitude. §. I. consists of three proposals (*propositiones*), each followed by evidence (*demonstrationes*) and further argumentation (*scholia*) and, at the end, a defining conclusion (*conclusio*): “The Northern Light is, therefore, a purely optical phenomenon in our atmosphere. It consists of frozen particles of moisture, of various shapes, most often flat, extremely smooth and light, capable of densification as well as rarefaction. These particles float into the atmosphere at different distances from the earth. They may be moved by any kind of movement in the air, for example, be tossed back and forth by winds. Furthermore, they can condense or disintegrate completely; in the manner of the lightest of clouds, they can be transported to various locations; heaped together into a thousand forms they exhibit different optic patterns, etc. etc. This light of the north is usually caused by the rays of the sun, at other times, by the rays of the moon, or even by a combination of rays from the two celestial bodies simultaneously. The rays in question are reflected in the surface of the variously formed, frozen particles. Sometimes, the rays are both reflected and refracted simultaneously, depending on the conditions such as light, colour, or the shape of the patterns. The different phenomena will be explained in coming parts of this work according to the laws of optics and physics” (p. 46) [LAT, 79–80; GER 206–207]. §. II. contains a discussion of several observations made further south. Hell compares these with his own experiences from the cold climate zone. Observations that have been pointed out by others, seemingly at odds with Hell’s theory, are refuted. Among the points under

discussion are the actual height of the atmosphere, the properties of twilight, the difference between sunset and sunrise near the Equator as opposed to the Arctic, the influence of humidity on the degree of refraction in the atmosphere, the possibility of lunar rays as cause of the aurora, the illusory auroral arc, the most common position of the aurora in the sky, and its seemingly illogic movement [in LAT and GER, the discussion continues to include the colours of the aurora and various methods to measure its height above the ground, cf. LAT, pp. 113–118; GER, 245–251].

AURORAE BOREALIS THEORIA NOVA

Summary of Contents (Latin edition) by Per Pippin Aspaas

The entire treatise was intended to consist of four parts, namely, the characteristics of the aurora in regions between the 80th and the 66th latitude (part I); between the 66th and the 60th latitude (part II); between the 60th and the 50th latitude (part III); and between the 50th and the 40th latitude (part IV).

Hell never published more than an introduction to the entire treatise plus its first and fundamental part. The first and only Latin edition was issued in 1776. A manuscript that appears to represent the original series of lectures presented at the Royal Society of Sciences in Copenhagen in 1770 is also preserved (hereafter referred to as **MS**); this text is slightly shorter than the printed version and includes no illustrations. Furthermore, a German translation was published in 1792 (**GER**), with essentially the same contents as the Latin edition of 1776.

[Title page] & Monitum [*Ephemerides Astronomicae* 1777]

The treatise is mentioned on the title page as well as in a brief *Monitum* introducing the entire 1777 volume of Hell's *Ephemerides Astronomicae* (published 1776).

[Title page] & Monitum [Appendix, *Ephemerides Astronomicae* 1777] (pp. [1]–2)

Appendix ad Ephemerides Anni 1777. Aurorae borealis theoria nova, a Maximiliano Hell, Astronomo Caesareo-Regio Universitatis Vindobonensis, Societatum Regiarum Scientiarum, quæ Hafniæ, Stokholmia, Göttingæ, et Nidrosiæ florent, itemque Instituti Scientiarum Bononiensis socio, atque Academia Regiæ Scientiarum Parisinæ membro correspondente. Anno 1770. Mense Martio, illustrissimæ Academia Regiæ Scientiarum Hafniensi prælecta. Pars I. ('Appendix to the *Ephemerides* for the year 1770: New Theory of the Aurora Borealis, by Maximilianus Hell, Imperial and Royal Astronomer, member of the Royal Scientific Societies in Copenhagen, Stockholm, Göttingen and Trondheim, as well as member of the Institute of Sciences in Bologna, and corresponding member of the Académie Royale des Sciences in Paris, Presented to the Royal Society of Sciences in Copenhagen in the month of March in the year 1770, Part I'). On the back of the title page there is a short *Monitum*,

explaining that the text is “exactly the same” (*eandem prorsus*) as the paper that Hell presented in Copenhagen in 1770. It figures as the appendix of an astronomical ephemeris because the theory of the Aurora, although a phenomenon belonging to physics, requires a great deal of astronomical insight in order to be properly understood. Beneath the *Monitum*, there are quotes from Newton’s *Principia Mathematica* and Musschenbroek’s chapter *De Philosophia et Regulis Philosophandi*, which both emphasize empirical science.

PRÆFATIO (pp. 3–22) [=MS, 3–13; GER, 123–144]

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Errata corrigenda (p. 119) [=GER, no pages; *missing in MS*]

Errata.

Tab. I–V (no pages) [=GER, no pages; *missing in MS*]

Altogether 21 figures divided over five plates.

NEUE THEORIE DES NORDLICHTES

Summary of Contents (German edition) by Per Pippin Aspaas

The entire treatise was intended to consist of four parts, namely, the characteristics of the aurora in regions between the 80th and the 66th latitude (part I); between the 66th and the 60th latitude (part II); between the 60th and the 50th latitude (part III); and between the 50th and the 40th latitude (part IV).

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[Title page], [Dedication], Vorrede & Inhalt [*Beyträge zur Praktischen Astronomie Zweiter Band*]

Title page, dedicatory texts, Preface and Table of Contents to the second volume of the *Beyträge zur Praktischen Astronomie* ('Contributions to Practical Astronomy'), i.e. a collection of treatises by Maximilianus Hell translated by Longinus Antonius Jungnitz. The translator's dedication, dated Breslau, December 1791, emphasizes the role of the University of Breslau in the advancement of the sciences in Silesia (*Schlesien*). In his Preface (*Vorrede*), Jungnitz explains that while he has followed the originals closely in his translations, he has taken notes on ideas that have been put forward since the publication of the Latin treatises in question. He hopes to be able to publish these notes separately at a later stage. Regarding Hell's treatise on the Aurora, he states that has "The first among these [publications] should be the treatise on the Northern Light, published as a separate book, with additions and enlargements by the famous author himself as well as some ideas and comments from the part of the translator [i.e. Jungnitz]" (*Vorrede*, no page).

[Title page, treatise as such] (pp. [121]–[122]) [=MS, no pages; LAT, [1]–2]

Neue Theorie des Nordlichtes, vorgelesen in der Königlichen Akademie der Wissenschaften zu Kopenhagen, im Monat März 1770 ('New Theory on the Northern Light, presented at the Royal Society of Sciences in Copenhagen, in the Month of March, 1770'). In a note beneath the title, the translator argues that the treatise deserves a place in a collection of astronomical treatises because Hell's theory requires a great deal of astronomical insight in order to be properly understood. On the next page, there are quotes from Newton's *Principia Mathematica* and Musschenbroek's chapter *De Philosophia et Regulis Philosophandi*, which both emphasize empirical science.

Vorrede (pp. [123]–144) [=MS, 3–13; LAT, 3–22]

Hell's introduction to the entire treatise. He presents the prevalent theories on the aurora in contemporaneous science, dividing the prevalent theories into three 'classes': 1) the theories of the 'mathematicians'; 2) the 'physicists'; and 3) the 'minor philosophers'. Among the mathematicians he considers the likes of De Mairan, who argued that the aurora takes its rise from some sort of mixture of the atmosphere of the Earth and the (alleged) atmosphere of the Sun. The physicists would argue that the electricity or magnetism of the earth, exhalations of sulfurous substances or the like, were the cause of the aurora. The minor philosophers would point to eruptions of volcanoes or reflections from icebergs of the far north, or even frozen moisture in the atmosphere, capable of illuminating the night sky when hit by the sun's rays from below the horizon. Hell then gives an account of his own investigations of the phenomenon, thereby mentioning how he has come to the conclusions that he is about to present. The structure of the entire (unfinished) treatise is presented on pp. 132–136 [MS, 7–9; LAT, 11–14]. After quoting some prevalent theories from the existing literature, Hell concludes that his own theory is unique and thus merits comparison with the *Astronomia Nova* of Copernicus; this explains the word *Neu* ('new') in the title of his treatise.

Erster Theil. Welcher die Phänomene, Beobachtungen und Eigenschaften des in der kalten Zone erscheinenden Nordlichts enthält; so wie die aus ihnen abgeleitete Theorie, welche alle Erscheinungen des Nordlichts anpassend erkläret (pp. 145–251) [=MS, 14–67; LAT, 23–118]

('Part I, containing phenomena, observations and properties of the Northern Light as it appears in the cold climate zone, as well as the theory, which has been drawn from these appearances and which is fitting to explain all kinds of Northern Light phenomena')

Erstes Hauptstück. Erscheinungen und Eigenschaften des Nordlichts, die ich in der kalten Zone beobachtet habe (pp. 145–178) [=MS, 14–32; LAT, 23–54]

(Chapter I, on ‘phenomena and properties of the Northern Light, observed by me in the cold climate zone’) Begins by emphasizing that Hell’s theory is based on observations that he has done himself in parts of Norway stretching from the 66th to the 71st latitude, i.e. in the counties today known as Finnmark, Troms and Nordland, approximately from the island of Dønna and northwards to the North Cape (pp. 145–148) [MS, 14–15; LAT, 23–26]. §§. I.–III. Contains descriptions of the various visual characteristics of the aurora in the region in question (pp. 148–156) [MS, 15–20; LAT, 26–33]. §§. IV. & V. Arguments in favour of the connection between the aurora and the sun and/or moon (pp. 156–164) [MS, 20–24; LAT, 33–41]. §§. VI. & VII. Arguments in favour of the aurora consisting of frozen particles of moisture, precisely like snow, something the local inhabitants – including the Sami (*Lappländer*) – support (pp. 154–171) [MS, 24–28; LAT, 41–48]. §. VIII. The height of the aurora above the surface of the Earth. Hell argues that it sometimes descends as far down as the clouds and that it can be audible (pp. 172–175) [MS, 29–31; LAT, 48–51]. §. IX. A list of *Folgerungen* (i.e., logical conclusions) of the above arguments. Hell concludes that “the auroral substance quite often falls down to earth in the form of snowflakes [...], accordingly, the theory must be based upon a substance of such a nature that it both emits and produces snowflakes” and that “the auroral substance is – according to observations – far more dense in the cold climate zone [i.e., between 66th and 80th latitude] than in the temperate zone, accordingly, the theory must identify a cause of a kind that will render this circumstance self-evident” (pp. 176–178, here, *Folgerung* 4. & 11.) [MS, 31–32; LAT, 52–54].

Zweites Hauptstück. Von einigen Eigenschaften der kalten Zone, die zur Theorie des Nordlichtes gehören (pp. 178–199) [=MS, 32–42; LAT, 54–72]

(Chapter 2, ‘on various properties of the cold climate zone that are of relevance to the Northern Light theory’) §§. I.–III. contain discussions of the properties of snow and cold, as well as a range of visual phenomena that according to Hell arise from refraction of light in the atmosphere, such as *Sonnering* (ring around the sun), *Mondsring* (ring around the moon), *Nebensonne* (spurious sun, or “sun dogs”) and *Nebenmond* (spurious moon). §. IV. argues that the said phenomena are analogous to the aurora.

Drittes Hauptstück. Die Theorie des Nordlichts, ihre Beweise, die Erklärung aller Phänomene des Nordlichts in der kalten Zone, und die Auflösung der vorzüglichsten Fragen, die in Betref des Nordlichtes vorkommen (pp. 199–251) [=MS, 43–67; LAT, 73–118]

(Chapter 3, ‘The theory of the Northern Light, including its demonstration, as well as an explanation of all phenomena of the cold climate zone, along with a solution to the most

important questions regarding the Northern Light’) provides a synopsis of the theory based on all observations made by Hell between the 66th and 71st latitude. §. I. consists of three proposals (*Sätze*), each followed by evidence (*Beweise*) and further argumentation (*Anmerkungen*) and, at the end, a defining conclusion (*Schlußfolge*): “The Northern Light is, therefore, a purely optical phenomenon in our atmosphere. It consists of frozen particles of moisture, of various shapes, most often flat, extremely smooth and light, capable of densification as well as rarefaction. These particles float around in the atmosphere at different distances from the earth. They are shaken by any kind of movement in the air, get tossed back and forth by winds, become condensed or disperse altogether; in the manner of the lightest of clouds, they can be transported from one place to another; they can be heaped together into a thousand forms and exhibit a variety of optic displays, etc. The light of the aurora borealis is usually caused by the rays of the sun, at other times, by the rays of the moon, or even by a combination of rays from the two celestial bodies simultaneously. The rays in question are either reflected in the surface of the variously formed, frozen particles, or both reflected and refracted simultaneously; and, depending on the conditions such as light, colour, or the shape of the patterns, manifest themselves differently. The various, singular phenomena will be explained in coming parts of this work according to the laws of optics and physics” (pp. 206–207) [MS, 46; LAT, 79–80]. §. II. contains a discussion of several observations made further south. Hell compares these with his own experiences from the cold climate zone. Observations that have been pointed out by others, seemingly at odds with Hell’s theory, are refuted. Among the points under discussion are the actual height of the atmosphere, the properties of twilight, the difference between sunset and sunrise near the Equator as opposed to the Arctic, the influence of humidity on the degree of refraction in the atmosphere, the possibility of lunar rays as cause of the aurora, the illusory auroral arc, the most common position of the aurora in the sky, and its seemingly illogic movement [in the MS version, the two last aspects are not included].

Anzeige einiger merklichen den Sinn ändernder Druckfehler die wegen Entfernung des Druckortes stehen geblieben sind (no pages) [=LAT, p. 119; *missing in MS*]

(‘List of several notable *errata*, which affect sense and which, as a result of the remoteness of the place of printing, have remained’)

Tab. I–V (no pages) [=LAT, no pages; *missing in MS*]

Altogether 21 figures divided over five plates.