OBSERVATION OF THE AURORA BOREALIS performed on Spitsbergen, 1882–83.

Northern lights, paper and pencil

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A sheet of paper, some pencils and coloured chalks, a watch: hardly the equipment that most of us associate with frontline empirical physics. We are more likely to think of a physics laboratory's range of instruments or an astronomical observatory's complex telescopes when we reflect on the physical sciences of the late 19th century, a time when physics had undergone technical development in laboratories and observatories, moving towards increasingly more complicated apparatus. Even then, physics was a game for gadget-lovers, with far more technology than the natural history disciplines.

But this was not true for all of physics. A folder at the Center for History of Science preserves the material remains of an almost year-long study of the aurora borealis. This study was conducted at a time when pen and paper were important tools for auroral research and the observer's eye, without the support of any optical instruments, was still the basis for research into the forms of the northern lights.

The photographic plate, otherwise so cherished by the astronomers and cloud researchers of the day, had not yet replaced the human eye. There was no better way of depicting the aurora borealis than by drawing them. They move quickly and their light is fairly weak, something that photo plates were not then able to capture. Here, it is also worth pointing out that the pencil – such a trivial object for us – has not always existed in its present form; the changes it underwent in the early 19th century, not least the development of pencils with different degrees of hardness, improved opportunities for depicting heavenly objects in observation journals.

The northern lights can stretch over large areas of the sky. While the optical engineering arts celebrated their triumphs and provided 19th-century astronomers with increasingly large telescopes, allowing the study of smaller areas of heavenly phenomena with greater sharpness of detail, the opposite perspective had long been an optical dead end; really wide-angle optics were still in the future, and the human eye was still unsurpassed when it came to perceiving large areas of the celestial sphere at one and the same time.

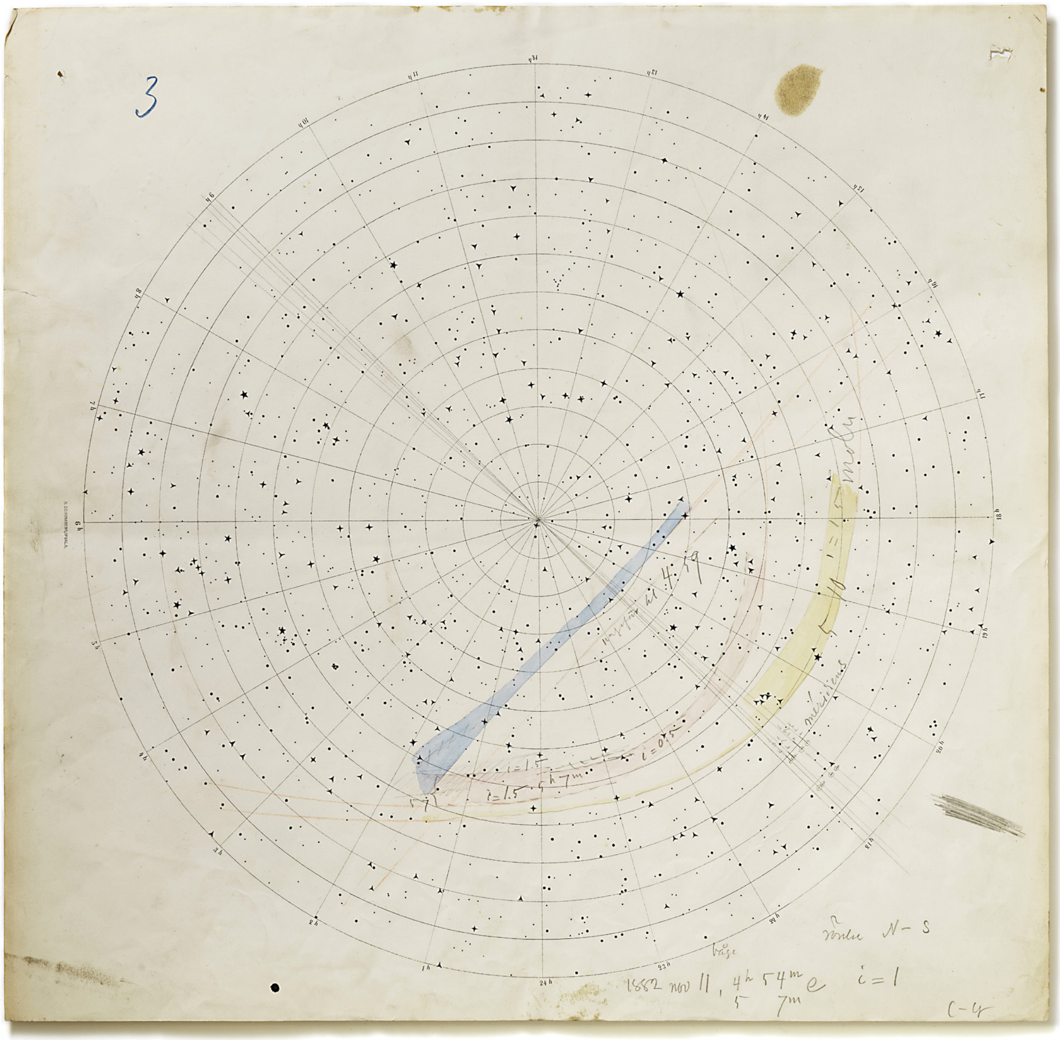
But let us return to the material remains of the abovementioned observations. They comprise a sheaf of around 60 papers, measuring 53 × 55 cm, and have printed astronomical maps of the northern night sky, with the stars that are visible to the naked eye. On these, observers have drawn the northern lights' formations as observations were made; the stars on the maps form the reference points for the observer and are the skeleton that allows the drawings to be used for determining the shapes of the northern lights on the heavens.

The maps were printed at Robert Schumburg's printers, established in Uppsala in 1878 and a specialist at producing printed matter that was part of that time's information infrastructure: receipts, forms, labels and business cards. Scientific activities also required forms and prefilled material to capture the world, and these map sheets, in a specially printed small edition, could be acquired from this printers that focused on standard printing.

Someone has filled in the constellations by hand on one of the first sheets, drawing lines between the stars, perhaps a mnemotechnical aid for one of the less experienced observers – who included physicists, a doctor and an army lieutenant. The positions of the brighter planets – Jupiter and Saturn – have also been drawn in by hand, as well as the meridian's location at various times and the contours of the surrounding mountaintops, all to aid the eye and hand when the northern lights' formations were to be drawn on the sheets of paper. Sometimes the passage of shooting star is noted. Otherwise the papers are mainly filled with pencil drawings of the northern lights' shifting shapes.

The drawings are supplemented by written descriptions of the northern lights' forms and movement patterns, and information about their brightness. Their dynamics have been captured by the observers making several sketches of their details on the same sheet over the space of a few minutes. By using numbers, writing and drawings, the observer tried to pin down this evasive natural phenomenon on paper. "Diffuse stripes only in E, some rays, changing quite rapidly, direction of movement S–N then forming a corona Light strength 1–3. Colour white and yellow-white." "Strength 3 throws a weak shadow on the snow behind objects. Colour, white-yellow, transparent, also rosy-red Light movement very lively, jumping."

There are holes in the corners of the paper; the maps have been attached to a board during observations, providing a flat surface and fixing the papers in the night winds. There are sometimes blurry areas in the margins, from the observer's attempts to get the right direction by angling the pencil.



A SHEET FROM A LARGE COLLECTION of observations of the aurora borealis by Vilhelm Carlheim-Gyllensköld on Spitsbergen during the International Polar Year of 1882–83.

It is not quite true that the northern lights' observers on the expedition only used pen and paper. Observations of the northern lights' forms, which indeed comprise most of the material, were supplemented by studies of its spectrum. They also had three northern lights theodolites for more accurate positioning.

Here and there are signs of some subsequent work (perhaps in the warmth of the cabin after finishing an observation shift), such as colouring with watercolours or chalks, but in general this is a collection of raw material gathered under open skies. More precisely, on Spitsbergen, where a Swedish

POSTER FROM WORK that was the result of the observations on Spitsbergen, published by Vilhelm Carlheim-Gyllensköld in 1886.

expedition spent the winter during the International Polar Year of 1882–83. A total of six observers contributed to these observations of the northern lights.

Later, back in Stockholm, Vilhelm Carlheim-Gyllensköld edited and published the material. He was a young physicist, newly awarded a doctoral degree (Uppsala) and the participant on the expedition who focused most on studying the northern lights. An entire volume of the Academy of Sciences' ambitious expedition publication is solely dedicated to observations of the northern lights. In addition to more than 400 folio pages of text, tables and sketches, there are 30 lithographic plates which, as finished pictures, show a selection of the formations observed by the expedition.

The drawings may represent an apparently simple observation technique, but the organisational framework around Vilhelm Carlheim-Gyllensköld and the other northern lights' sketchers was more complex: supporting the observers who stood drawing under an Arctic night sky was a bigger context that made their work possible. The Swedish physical-meteorological Spitsbergen expedition was part of the International Polar Year of 1882–83, an international network of stations that gathered meteorological and geomagnetic data and observed the northern lights at 14 stations over the course of a year. Historians of science have described this as an example of the large-scale mobilisation of science – a type of inductivism focusing on creating data series that would make it possible to transcend the local station's perspective, instead creating knowledge of geophysical phenomena on a global scale.

Science's national dimensions also come into play here: the desire to give names to distant places, and the somewhat heroic ideals of masculinity expressed in the dangers that Arctic exploration naturally entails. The expedition was mostly financed by donations – the state was somewhat unwilling to fund Swedish participation in the International Polar Year of 1882–83, but did contribute a navy vessel for transport, the necessary weapons and some personnel. It was orchestrated by the Academy of Sciences, which appointed an organising committee that included Adolf Erik Nordenskiöld, Erik Edlund, Robert Rubenson and Daniel Georg Lindhagen. In the decades around 1900, the Academy was extremely active in organising polar travel with a not-insignificant element of science. There was also a theoretical side to Stockholm-based geophysics in the form of Svante Arrhenius' work in cosmic physics, which included, among other things, a theory of the causes of the northern lights. Without these contexts, Vilhelm Carlheim-Gyllensköld could hardly have stood and sketched the rapidly changing shapes of the northern lights for almost a year at a latitude of 80 degrees.

For several decades to come, paper and pencil would remain the only really functional method of depicting the northern lights. It was only well into the 20th century that they would be observed with all-sky cameras that were able to capture them using wide-angle optics and light-sensitive photographic materials, and eventually even in moving images. But, at that time, people and their ability to draw the northern lights were the best means available; the tip of the pencil was the cutting edge of the technological arsenal for observers of the northern lights.

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The expedition of 1882–83 and its context in the history of science is discussed in Susan Barr, "The Swedish expedition to Svalbard" and Aant Elzinga, "An evaluation of the achievements of the First International Polar Year", both in Susan Barr & Cornelia Lüdecke (eds.), *The History of the International Polar Years* (Berlin/Heidelberg, 2010). See also Roger Launius, James Flemin & David DeVorkin (eds.), *Globalizing Polar Science: Reconsidering the International Polar and Geophysical Years* (New York, 2010), Urban Wråkberg, *Vetenskapens vikingatåg: Perspektiv på svensk polarforskning 1860–1930* (Uppsala, 1995), and Gösta H. Liljequist, *High Latitudes: A History of Swedish Polar Travels and Research* (Stockholm, 1993). Vilhelm Carlheim-Gyllensköld can be read about in Anders Carlsson, "Ingenjörsvetenskapens skugga: Vilhelm Carlheim-Gyllensköld och vetenskapshistorien", in Marika Hedin & Ulf Larsson (eds.), *Teknikens landskap: En teknikhistorisk antologi tillägnad Svante Lindqvist* (Stockholm, 1998), and Anders Carlsson & Gustav Holmberg, "Vilhelm Carlheim-Gyllensköld på Stockholms observatorium", *Lychnos*, 1995.