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Early auroral photography and observations at the Sodankylä Geophysical Observatory in Finland, 1927–1929

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Abstract

Auroral photography started in 1927 at the Sodankylä Geophysical Observatory (SGO) by the initiative of famous Norwegian scientist Carl Störmer. In less than two years about 600 photographs of auroras were taken at Sodankylä. Some of the images were obtained simultaneously at auxiliary stations for parallactic determinations of the height of auroral arcs. Most of the pictures of auroras were vanished in the destruction of the SGO during the war in 1944. About 200 images were rescued in the archive of the Finnish Meteorological Institute where they have been recently found. These pictures of auroras are the first ones taken in Finland.

During the Polar year period 1932–1933, auroral photographing was mostly discontinued but visual observations of auroras were made instead at several sites in Lapland.

Eyvind Sucksdorff´s contribution to studies of auroras was a pioneering effort, with minimal resources. In Finland, regular observations of auroras started again during the International Geophysical Year (IGY) 1957–1958.

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1. Introduction

One of the main tasks in the auroral research in the last centuries was the determination of the height of auroral features. For achieving this goal visual observations were usually carried out at different sites using triangulation technique (Egeland and Burke, 2013). No satisfactory results were achieved in spite of a vast number of scientific efforts. One of the most reliable height determinations was obtained by visual triangulation methods by Sophus Tromholt in Norway in the late 1870s (Moss and Stauning, 2012). Trials of height measurements and photography of auroras were made at the Sodankylä Polar year observatory 1882–1884 but without any success (Simojoki, 1978).

First successful photographs of auroras were taken in the 1890s in Norway (Egeland and Burke, 2013). This technique opened a new and quantitative way for more exact determinations of the heights of auroral displays.

The Norwegian team of scientists lead by the Professor Carl Störmer (1874–1957) maintained in Norway in the 1910s a network of special designed auroral cameras. The cameras were installed for parallactic positions at several sites connected with telephone lines for ensuring simultaneous photographing. After analysing thousands of simultaneous photographs Störmer was capable to make the conclusion that the lower border of auroral forms is located about 100 kilometres above the Earth's surface. Using these parallactic auroral photographs it was possible to determine the heights of individual auroral features, but also their locations and orientations in time and space (Chapman and Bartels, 1940; Egeland and Burke, 2013).

The Sodankylä geophysical observatory (SGO) (Lat 67.35 °N; Lon 26.55 °E) was founded in 1913 by the Finnish Academy of Sciences and it was on that time the only magnetic observatory inside the Arctic Circle thus a suitable place for observations of polar auroras. In the early years of operations, the main tasks of the Sodankylä Observatory were continuous magnetic recordings, regional magnetic surveys in Lapland, auroral observations as well as daily meteorological readings for the Finnish Meteorological Institute in Helsinki. The permanent staff of the observatory consisted of a scientist, an assistant and a janitor. Eyvind Sucksdorff (1899–1955) was elected in 1927 as the director of the Sodankylä observatory. He

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was a skilled photographer and astronomer. His wife, Annikki Sucksdorff (1904–1986), was appointed assistant of the observatory (Sucksdorff, 1952).

This paper gives a short description of the auroral photography and related observations carried out in the SGO in the 1920s and 1930s. Some of the first auroral photographs are presented as examples of early space weather work.

2. First auroral photographs at Sodankylä

Carl Störmer visited Sodankylä magnetic observatory in September 1927. He proposed to Eyvind Sucksdorff, that parallactic auroral photographs should be started in North Finland for extending the auroral photograph network in Norway in cooperation between Finnish and Norwegian scientists. According to Stömer's plan, photographing of auroras started in Sodankylä and in a nearby station in November 1927.

Störmer´s auroral camera consisted of glass plate (10 x 14 cm) coated with photographic emulsion. The lens of the camera was manually movable in such a manner that six individual frames could be taken on the same plate. The Norwegian auroral cameras were not suitable for taking all-sky pictures because the field of view was typically limited to about 25 x 25 degrees on the sky. The exposure time was selected according to the brightness of auroras visible on the sky. Usually the time was 1–20 seconds.

During less than two years in 1927–1929 Eyvind Sucksdorff and his assistants took about 600 photographs of auroras at the SGO using special cameras designed by the Störmer´s scientific team. A few photos were taken at the auxiliary stations. The major part of these photos were lost during the war 1944 when German military troops destroyed totally all buildings and archive of the Sodankylä geophysical observatory (Sucksdorff et al. 2001; Bösinger, 2021). However, paper copies of about 200 photographs were rescued before the war and archived in the library of the Finnish Meteorological Institute in Helsinki. Recently, this historical material was found, and the present presentation is based on this collection of pictures of auroras.

First parallactic auroral photographs were taken simultaneously at the Sodankylä observatory and at the auxiliary station Kelujärvi some 20 km to the north from the observatory. Both sites were connected with a telephone line for

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simultaneous communications during the operations with cameras. Up to the end of 1927 more than 100 auroral pictures were taken at the Sodankylä observatory alone.

Fig. 1 shows the Norwegian aurora camera on the top of the main building of the Sodankylä observatory in the early 1930s.

Figure 1. Annikki Sucksdorff (1904–1986) was the assistant of the Sodankylä observatory 1927–1945. In the photo she is working with auroral observations on the roof of the observatory building. An Störmer camera is in the front of her. The river Kitinen can be seen in the background. (Photo: Finnish Meteorological Institute).

The first simultaneous photographs at Sodankylä and Kelujärvi sites were taken in January 1928. During one night more than 20 successful exposures were captured on films. They were sent to Störmer´s laboratory in the Oslo University for determinations of auroral heights using special constructed projector for the photographs. Such a device was not in use in Sodankylä. Unfortunately, no information exists about the results of the height analysis in Oslo.

During winter 1927–1928 there were nine nights suitable for photographing at the Sodankylä observatory, and almost 200 auroral photographs were taken. In the winter 1928–1929 the number of auroral pictures collected was almost 400. Later in the 1930s auroral photography was only in a minor part in the work at the Sodankylä observatory and very few pictures were taken.

Figs. 2 and 3 show examples of historical images of auroras at Sodankylä taken in March 1928. They belong to the first photographs of auroras in Finland. Fig. 4 depicts simultaneous auroral arcs at Sodankylä observatory and at the auxiliary site Kelujärvi lying some 20 kilometres north from Sodankylä.

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Figure 2. An auroral arc photographed at Sodankylä observatory on March 13, 1928 20:32 UT. Faint spots on left upper corner belong to the star cluster Pleiades in the constellation of Taurus. The exposure time was 39 seconds. The centre of the photo is towards the west and about 30° from the horizon. (Photo: E. Sucksdorff`s collection SGO).

Figure 3. An auroral arc at the Sodankylä observatory on March 13, 1928 20:13 UT. The bright star on the centre is Arcturus in the constellation of Boötes. The exposure time was 9 seconds. The centre of the photo is towards the east and about 20° from the horizon (Photo: E. Sucksdorff`s collection SGO).

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Figure 4. Left: Auroral arc at Sodankylä on January 27, 1928 19:25 UT. Right: The same at the auxiliary Station Kelujärvi at a distance of 20 kilometres from Sodankylä. The exposure time was 25 seconds. The centre of the photos is towards west. (Photo: E. Sucksdorff ̎s collection SGO).

3. Great magnetic storm, February 27, 1929

The period 1927–1929 during which photographs of auroras were taken at the Sodankylä observatory coincided the maximum phase of the sunspot cycle 16. The second greatest magnetic storm during this cycle, as recorded by magnetometers at Sodankylä, occurred on February 27, 1929. According to the visual observations made by E. Sucksdorff, the auroral storm started around 21:30 UT with a magnificent corona display at the zenith covering the sky from east to west. A new corona appeared at midnight illuminating even the snow-covered landscape. First magnetic signals of the storm occurred already one day earlier on February 26 around midnight (Fig. 5). During the most intensive period of the storm around midnight Feb 27–28, the magnetic K-index increased up to 8/9 as derived from the Sodankylä magnetic records. The greatest deviation in the hourly means of the magnetic north component (X) was about 1 000 nT in the late night on February 27 (Fig. 5).

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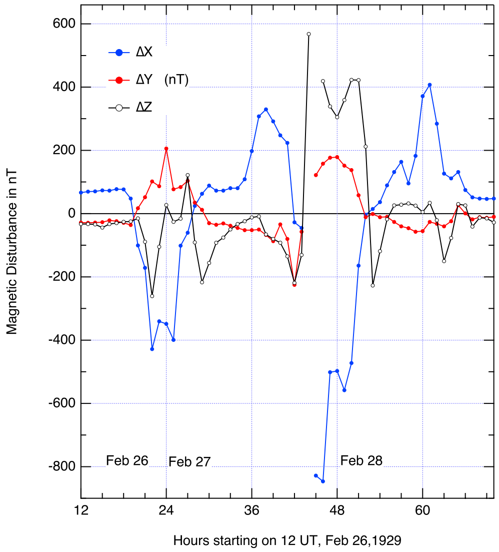

Figure 5. Three component (X, Y, Z) hourly magnetic variations as reproduced from the magnetic recordings of the Sodankylä geophysical observatory from February 26–28, 1929. The great magnetic auroral storm occurred around the midnight on February 27–28. A minor storm occurred about 24 hours earlier.

During the storm on February 27, E. Sucksdorff took about 150 photos of the auroral displays during 17–23 UT. These photographs cover about 25 % of the 600 auroral images taken during 1927–1929. However, only a few pictures are now available because the rest of these photos were vanished during the war in 1944.

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Figure 6. Auroral displays on February 27, 1929 as captured by a camera at the Sodankylä observatory. Each frame on the photographic plate represents auroras every 30 seconds at about 20 h (UT) to the west. The first photograph is on the top left. The two top pictures show auroral lights over the frozen river Kitinen. The black belt under the auroral lights is tree line across the river. Next four pictures show rapidly changing auroral forms, veils and spirals. Two bright spots are planets Jupiter (upper) and Venus (lower) on the west and about 15° from the horizon. The exposure time varies from 1 to 30 seconds. (Photo: E. Sucksdorff´s collection SGO).

Fig 6. Shows an example of temporal changes of the auroral storm of February 27 as recorded by the auroral camera in a short time interval of about 5 minutes. In Fig. 6 there are six single pictures captured on the same glass plate taken in about 30 seconds intervals. In the figure one can see bright veils and patches of auroras as well as spiral shapes. On the background of auroral lights one can see two bright planets, Venus and Jupiter.

The February 27 storm was largely reported in contemporary newspapers in Finland and in international scientific studies (i.e., Goldie, 1929; Rowland, 1929; Chapman and Bartels, 1940).

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4. Visual observations of auroras during the polar year 1932–1933

For the International polar year 1932–1933 the scientific programme of the Sodankylä geophysical observatory was extended by new observations such as earth currents, atmospheric electricity and magnetic pulsations (Sucksdorff, 1952; Bösinger, 2021). SGO was equipped by modern magnetic registration devices provided by the Danish meteorological institute and designed by Dan Barfod la Cour. La Cour was the President of the Polar year programme and the director of the Danish meteorological institute. By his initiative Sodankylä observatory was selected as a training place for the scientists involved with magnetic measurements in the Arctic.

Two full-scale manned magnetic observatories were set up for the polar years in Finland. Systematic observations of auroras by means of visual sightings were also included in the programme. One goal of this work was to achieve a more accurate description of the occurrence of auroras and magnetic variations both in time and space around Earth's arctic area.

E. Sucksdorff introduced for Polar year plan of visual observations of auroras special graphical symbols for different types of auroras. There were about 20 different symbols for various manifestations of auroral shapes, colours and their occurrence times. Sucksdorff made visual observation of auroras during the Polar year 1932–1933 but continued observations up to 1944 at the Sodankylä observatory. The material accumulated contains coded information of auroral appearances from about 750 nights.

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Figure 7. Eyvind Sucksdorff demonstrates a device (quadrant) for visual determinations of the height of auroral arcs. It consists of a thin wooden plate with a scale and a plumb line suspended to the plate showing the elevation angle of auroral arcs visible. The observer turns the quadrant until the upper edge of the plate points to the arc of an auroral display. (Photo: Finnish Meteorological Institute).

Because the results of the simultaneous photography of auroral arcs during 1927–1929 were not very successful, Sucksdorff developed a simple visual method instead. He constructed a special aiming device, called quadrant, by which the height of well defined and stable auroral arcs could be determined visually (Fig. 7). The height of arcs, as measured in elevation angles from the horizon, was read from a scale attached on the quadrant. Sucksdorff organized coordinated campaigns in Lapland in which 12 volunteer observers, like schoolteachers, made sightings with the quadrant at different places. If two or more observers have measured the same arc at the same time, its true height could be determined. Observations were made during the Polar year period and continued at some places up to 1936. At an auxiliary station scientists from the Danish meteorological institute made continuous observations of auroras up to 1936 according to Sucksdorff´s plan, and maintained magnetic recordings. However, the result of several years of measurements was that only very few relevant information about the appearance of simultaneous auroral arcs was revealed in the observations for accurate calculations of the location of auroral arcs.

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The observations collected have not been analyzed but the whole material is now in the archive of the SGO.

Independent from auroral studies, visual observations of the occurrence of auroras were made in connection with daily meteorological observations at the Sodankylä observatory since the founding of the observatory in 1914. Such routine observations were continued until 1954 when auroral observations were removed from the meteorological readings. The 40 years period of visual observations of auroras provide some information for long-term variations in the occurrence rate of auroras. Fig. 8 shows the annual number of nights illuminated by auroras during clear sky conditions. Also shown are sunspot numbers and magnetic activity at Sodankylä. There have been more than 1 800 nights with auroras during 1914–1954 in Sodankylä. One can see that the annual numbers of auroral nights follow the magnetic activity and varying sunspot numbers in the course of 11-year sunspot cycle in such a way that the largest amount of auroral nights are seen during the declining solar cycle phase, as expected (Tanskanen et al., 2005; Tanskanen, 2009). On the other hand there seem to an increasing decadal trend in the annual number of auroral nights connected with similar increasing tendency in the long-term magnetic activity ultimately associated with solar processes and e.g. interplanetary magnetic field (e.g., Lockwood, 2001; Tanskanen, 2022).

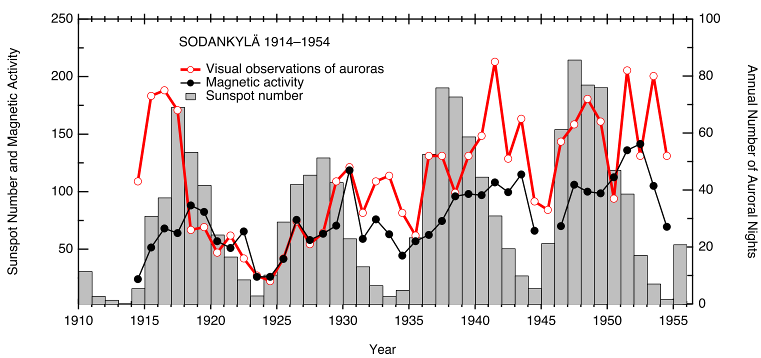

Figure 8. Red: Time variations in the number of auroral nights obtained by visual observations of auroras at Sodankylä 1914–1954 taken from meteorological yearbooks published by the Finnish Meteorological Institute
Black: Local magnetic activity index (SGO)
Histograms: Annual sunspot numbers

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5. Discussion

Although no significant scientific research was obtained from the aurora images taken at the Sodankylä geophysical observatory in 1927–1929, the cooperation with leading Norwegian scientists yielded a new area for the observatory's operations and contacts with the scientific community outside Finland. The high-quality photographs of auroras obtained are the first ones in Finland almost one hundred years ago. The entire observation material collected in 1920s and 1930s is now in the data archive of the SGO.

In Finland, Sucksdorff was quite alone in auroral studies in 1920s and 1930s. He had to work with very limited resources but the results were important for the future auroral work in Finland. The situation was totally different in Norway where several outstanding scientists with high reputation in the scientific community, like Kristian Birkeland, Carl Störmer, Ole Krogness, Lars Vegard, Leiv Harang and many others, were involved with observations and scientific studies of aurora and related cosmic phenomena. Space physics was in the teaching program in several Norwegian universities and institutions since 1910s. In Finland, there was no academic teaching or research at all in these fields before 1950s.

Regular auroral photography was restarted during the IGY (International Geophysical Year) 1957–1958 when a modern Stoffregen-type all-sky camera, constructed in the Finnish Meteorological Institute by Eyvind Sucksdorff´s son Christian (1928–2016), was set up at the Sodankylä Geophysical Observatory (Nevanlinna and Pulkkinen, 2001; Schlegel and Lühr, 2014; Bösinger, 2021).

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Competing interests

The authors declare that they have no conflict of interest