The History of Auroral Research

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Introduction

People were always very interested in the Nordic lights since it is a very spectacular phenomenon that is not so easy to understand. In the beginning there were only legends and myths about the source of the auroral lights. These legends described them for example as a helping spirit or the souls of murdered people. It took mankind till the end of the 20th century to be able to explain the aurora and it is still very hard to predict them.

The Ancient Ages

There were such huge magnetic storms that even the ancient Greeks could observe. Two known Greeks who observed them were Seneca and Aristoteles. Aristoteles’ idea was that earth particles rise up from the ground and are burned by the sun.

Aristoteles’ theory of the auroral lights
**The Middle Ages**

Since there wasn’t a lot of research in the middle ages in general the main idea about the aurora often was that the lights are a harbinger of war or miseries. Another thesis is that there are armies of fire fighting in the sky but all these theories were not grounded on a scientific base.

**The Modern Ages**

**The Name “aurora borealis”**

The person who named the Northern lights “aurora borealis” was Galileo Galilei (1564-1642). He used the name of the roman goddess of dawn “aurora” because the auroras he observed were as red as the sundown. The word “borealis” is the Latin word for “northern”. Even if the name is not very “scientific” if accomplished and was used until now.

**The earth’s magnetic field**

In the second half of the 15th century the instrument maker and seaman Robert Norman observed magnetic fields and improved the measuring instruments for magnetic fields. He discovered that there is a component of the earths magnetic field that points downwards towards the earth by observing a “free” compass needle. To find out more about the Earth’s magnetic field he wanted seamen to measure it systematically.

William Gilbert did also observations on the Earth’s magnetic field and in his book “De Magnete, Magnetique Corporibus, et de Magno Magnete Tellure” he described that the interior of the Earth is iron and that the Earth so is a huge bar magnet.

**Observing Auroras and Gathering Informations**

There were only sporadic observations of the auroras made in the 16th century for example by Tycho Brahe and Johannes Kepler. In the 17th century the sun activity was very low and people didn’t care a lot about the auroral lights. Then in 1716 there was a huge aurora in Europe and people got interested again and started to do more and more observations.

One popular person of them was Anders Celsius who did many observations of the aurora. He was convinced that it wouldn’t be possible to explain the aurora during his lifetime because many more knowledge about physics was needed. So ha started to gather all information about the auroral lights he could get and published them in the article “316 observations of Nordic lights from 1716 till 1732”.

One time George Graham and Celsius observed the same auroral light from different places and concluded that the aurora couldn’t be a local phenomenon. He discovered also disturbances in the Earth’s magnetic field.

In the beginning of the 18th century Samuel von Triewald did the first known auroral experiment. He send a sunbeam through a prism and a glass of snaps. The result was a light that could remind of a auroral light but as we know now the experiment had nothing to do with the real aurora.

**Electricity**

To understand what causes the auroral lights it is crucial to know how charged particles behave in a magnetic and electric field. Therefore were Maxwell’s equations needed which were published
in 1865. People knew that it is possible that electric currents can flow in the atmosphere and so Henri Poincaré (1854–1912) started to study the motion of charged particles in a magnetic field. To be able to calculate the motion of charged particles in the Earth’s magnetic field it is necessary to have a mathematic description of it. This was what Carl Friedrich Gauss worked on in 1839 beneath organising a network for magnetic observations together with Wilhelm Weber.

The Auroral Spectrum

Until the 19th century most theories were based on the idea that the auroral light is scattered or refracted sunlight. When Jean Biot studied the polarization of light in 1817 he noticed that the auroral light is unpolarized but reflected light is polarized.

Then some years later Anders Ångström studied the auroral spectrum and discovered discrete spectral lines in the auroral light whereas the sunlight spectrum is continuous. He concluded that the lights source was a gas but he had no idea from which gas the light came. It took until 1925 when scientists discovered that the bright yellow green line at $\lambda = 557.7 \text{ nm}$ is caused by a oxygen transition.

The auroral and the sun spectrum

The Connection to the Sun

In 1835 Samuel Heinrich Schwabe observed sunspots and noticed that their number varies in time. Some years later in 1851 Edward Sabine recognized that disturbances in the Earth’s magnetic field are connected to the sun cycle. Then in 1859 there was a huge sun eruption which was observed by Richard Carrington. Two days later he saw a strong aurora and assumed that there can be a connection between the solar activity and the auroral lights.

The number of auroras compared to the number of sunflares

In the end of the 19th century did Kristian Birkeland an important auroral experiment. He put a metal ball containing a bar magnet inside a box and shot with an electron beam on this “small earth”. The result was that it began to glow where the auroral ovals are positioned. Birkeland was convinced that the electrons that cause the real aurora come from the sun but
Arthur Schuster argued that electron clouds could because of their repulsion never reach the earth in such a high density. The solution to this problem found Frederick Lindemann in 1930 who proposed that neutral clouds of electrons and protons are sent out by the sun.

Kristian Birkeland and his assistant creating an aurora in the laboratory

**Plasma Physics**

This was an appeal for many people to study plasma physics right now. Sidney Chapman & Vincent Ferraro analyzed the behaviour of plasma clouds in the Earth’s magnetic field and showed that the clouds are shielded by the magnetic field and so the particles can not reach the earth. While his studies Carl Störmer predicted that charged particles can be trapped in the Earth’s magnetic field. So he theoretically discovered what was later named “Van Allen Belts”. He also was the first person who estimated the heights of the auroral lights by taking pictures from two different places.

**The Rocket Ages**

All the knowledge of the auroras described above is based on ground observations and theoretical thoughts. For the further auroral research the rockets that were developed in the 20th century were very important. One of the first people who started developing rockets was Konstantin Tsiolkovski. He worked on the theoretical basics for space flight and proposed to use liquid hydrogen and oxygen as fuel. The first rockets that were build were just a hobby and not officially supported but during the first and second world war the rockets were improved and after the second world war the americans reconstructed a German V2 rocket for scientific use which could reach the height of about 160 km.

In 1953 James Van Allen and his team used “rockoons” to measure aurora particles. A “rockoon” is a balloon combined with a rocket. First the ballon carried the device up to a
height of 17 km when the rocket is launched to reach a final height of about 100 km. Van Allen discovered that most of the aurora particles are electrons and just about 10% – 20% are protons.

After the first satellites were launched in 1957 (Sputnik) and 1958 (Explorer I) there were unexpected high doses of radiation measured in a certain height. Those were the trapped particles which Störmer predicted theoretically before. There are two belts, an inner and an outer belt. The inner belt contains particles with high energies which are trapped for a long time as many decades. The outer belt contains particles with lower energies and this belt is much more dynamic. It can be charged and discharged in a relatively short time (days up to weeks) and can so cause auroral lights.

People knew already that there are plasma clouds sent out by the sun, but in 1951 Ludwig Biermann observed a comet tail and discovered that there has to be a steady flow of plasma particles. Then in 1959 the probe “Lunik 1” first measured the solar wind which is the last big piece of puzzle to the question of what causes the aurora. Eugene Parker and many others did now a lot of theoretical work on the solar corona and the solar wind.

The main picture of the auroral processes was established and in the newer history more and more details of the auroral lights were discovered.

It took mankind a long time to understand the auroral lights and finally they were one of the main phenomenons that lead to space physics research.

**Literature**
