The Birkeland Lecture

The Nobel Laureate Hannes Alfvén gave the first Birkeland Lecture in Oslo in 1987. The lecture was a joint venture by the University of Oslo, the Norwegian Academy of Science and Letters and the Norwegian company Norsk Hydro. In 2004 Yara ASA took the place of Norsk Hydro and since 2005 the Norwegian Space Centre has been a partner in this cooperation. The Birkeland Lecture is above all an endeavor to honor the great Norwegian scientist and entrepreneur Kristian Birkeland. However, it has also given the organizers an opportunity to invite to Oslo many outstanding scientists within the field of geophysical and space research, areas which were central in Kristian Birkeland's own research.

Except for the year 1993, when the lecture was presented in Tokyo, and in 1998, when a mini-seminar was organized at the Norwegian Embassy in Tokyo, the lectures have been given in Norway, most of them at the Academy's premises in Oslo. In 1993 the lecture was given in a "Joint Japanese – Norwegian Workshop on Arctic Research". In 1995 the lecture was a part of a seminar on Norwegian environmental research, and in 2001 the lecture was given in connection with a workshop on Norwegian space research, with emphasis on the Cluster satellite program.

In 2017 the Birkeland Lecture was included in the program for the celebration of Kristian Birkeland's 150 years anniversary, a three-day event with lectures and seminars. Due to the Corona pandemic the lecture in 2020 was cancelled.

Yara's Birkeland Prize in Physics and Chemistry

In 1905, Kristian Birkeland's research formed an basis for the foundation of the world's first company to manufacture fertilizer on an industrial scale, Norsk Hydro.

Birkeland was a visionary scientist with the ability and commitment to carry out large scale projects in the laboratory and the field, to follow up with theoretical studies, and to see the application of his results. Today Yara carries this heritage forward and takes great pride in being part of the effort to improve food security. A company's continued success depends upon its ability to innovate. To honor the innovative spirit of its cofounder, Yara established the Birkeland Prize in Physics and Chemistry in 2009.

Yara's Birkeland Prize will be awarded to a Ph. D. candidate from a Norwegian university who has carried out a scientific study that is in accordance with the innovative mind of Kristian Birkeland. The prize has an emphasis on the environment and technology, and encourage research across traditional borders. The prize will alternate between physics and chemistry, with chemistry in even-numbered years and physics in odd-numbered years. The award ceremony will take place in connection with the Birkeland lecture.

This portrait of Professor Kristian Birkeland was painted by Asta Nørregaard in 1906.

Organizing committee:

Professor *Jann A. Holtet*, Department of Physics, University of Oslo
Professor *Alv Egeland*, Department of Physics, University of Oslo
Professor *Susanne Viefers*, Department of Physics, University of Oslo
Øyvind Sørensen, Chief Executive, the Norwegian Academy of Science and Letters
Camilla Nyhuus Christensen, Strategic Corporate Sponsorship and Event Manager Corporate Communication, Yara
Pål Brekke, Lead Space Science, Norwegian Space Agency

A list of former Birkeland lecturers is found on https://www.dnva.no

UNIVERSITY OF OSLO

Norsk Romsenter
Norwegian Space Agency

DET NORSKE VIDENSKAPS-AKADEMI
THE NORWEGIAN ACADEMY OF SCIENCE AND LETTERS

YARA
Knowledge grows

PHOTO: JOY NG, NASA

THE NORWEGIAN ACADEMY OF SCIENCE AND LETTERS

DRAMMENSVEIEN 78, OSLO
TUESDAY 20 SEPTEMBER, 17:30

The Birkeland Lecture 2022

Dr. **Douglas Rowland**
Chief, Ionosphere, Thermosphere, Mesosphere Physics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD, USA:

Fountains in the sky Following Earth's leaky atmosphere into space

Dr. **DOUGLAS ROWLAND**

Chief, Ionosphere, Thermosphere, Mesosphere Physics Laboratory,
NASA Goddard Space Flight Center, Greenbelt, MD, USA

Dr. Douglas Rowland has worked at NASA's Goddard Space Flight Center since 2003, and currently serves as the Chief of the NASA's Laboratory for Ionosphere, Thermosphere, Mesosphere Physics. His scientific research uses "sounding rockets" that probe Earth's upper atmosphere from 100 to 1000 kilometers altitude, to understand variations in the space environment that have importance for understanding impacts on human society and technology.

Since 1998 Dr. Rowland has been involved in over a dozen rocket missions to study phenomena, taking rockets to Andøya, Ny Alesund, Alaska, the Marshall Islands, and Virginia, to study the aurora, lightning, and a host of other fascinating phenomena in near-Earth space. In 2013 and 2018, he led the VISIONS and VISIONS-2 missions to study the processes that heat Earth's atmosphere and eject it into space in "atmospheric fountains".

Dr. Rowland lives with his wife and son just outside of Washington, DC, and enjoys traveling and music. When not launching rockets, he spends his time science fiction novels, including an alternative history of the life of Catherine Barton, the niece of Isaac Newton.

PHOTO: ANDØYA SPACE

Dr. **DOUGLAS ROWLAND:**

Fountains in the sky Following Earth's leaky atmosphere into space

Humanity has discovered thousands of planets beyond our solar system. The more we learn about these worlds, the more we realize how many different ways there are for planets to be – based on their size, their history, how close they are to their sun, whether they have a magnetic field, and many other factors. These factors control whether these planets might be expected to support life, either now or in the past. Even our nearest neighbors, Mars and Venus, have wildly different present conditions but may have had conditions suitable for life at some point in their past. Understanding how planets evolve over billion year timescales is critical to understanding their habitability and also gaining a better understanding of our home planet.

One of the major determinants of habitability is the presence of an atmosphere that is thick enough, but not too thick. Venus has too much atmosphere, leading to a runaway greenhouse effect that makes its surface uninhabitable. Mars has lost much of its atmosphere and water to space, leaving it dry and barren. Earth is in a sweet spot, with (for now) just the right level of atmosphere and plenty of water. Where did Mars' atmosphere go? And why has Earth retained its atmosphere?

A huge surprise of the space age was the observation that some of Earth's oxygen is being expelled into space by giant "atmospheric fountains". This are mysterious, because Earth is massive enough that oxygen should be held in by Earth's gravity. And yet somehow a portion of the oxygen was getting superheated, by a factor of ten or more. This would be like driving from Oslo to Tromsø, but making it in under two hours! Similar processes have been seen to operate on Venus, and may be responsible for Mars losing much of its atmosphere over its lifetime.

These "atmospheric fountains" represent a steady "leak" in our atmosphere. Not to worry – even with this leak our atmosphere will last for billions more years! But these fountains, if they are strong on exoplanets, may render such planets uninhabitable over billions of years.

I will present measurements of such atmospheric fountains that we have observed near Svalbard, and in Alaska, which were observed by NASA sounding rockets in 2013 and 2018. I will describe the excitement of developing these missions, the launch campaigns, and the wonderful international partnerships that have led to advancing our scientific understanding of Earth's "leaky" atmosphere.

From Andoya Rocket Range to Andoya Space

"We empower explorers"

KETIL OLSEN,
CEO and President of Andøya Space

When you walk outside on a clear winter night in northern Norway and the aurora borealis dances across the sky, one cannot help but wonder what it really is that creates such a magnificent and mysterious light.

In the late 1890es Kristian Birkeland developed the first complete auroral theory in which energetic particles were ejected from sunspots, directed to the Earth, and guided to the polar regions by the geomagnetic field where they produce the visible aurora. The particle currents also explained the geomagnetic disturbances associated with aurora. Birkeland's theory was not generally accepted. It was too advanced, and too little was known about the Sun and the interplanetary medium.

The space age provided new tools to get in situ observations in space. Birkeland's auroral model proved to be right.

The first Norwegian research rocket was ready to be launched from a launch pad at Andøya in 1962, 45 years after Birkeland's death. That was the first rocket in Europe, instrumented for auroral research. Hundreds of research rockets, both Norwegian and international, have flown through aurora displays since this beginning.

From the auroral research roots, Andøya Space has grown into other areas; space related education, testing and verification of new technologies, scientific ground-based instrumentation, drones and now, satellite launch services.

On the western side of Andøya a new kind of facility is being constructed: a spaceport. A place where rockets can launch satellites into low Earth orbits. In connection with the spaceport new investments in space technologies is appearing in Norway. Birkeland planted the seed, which led to Norway now seriously taking the step out into space.