THE NORWEGIAN ACADEMY OF SCIENCE AND LETTERS

DRAMMENSVEIEN 78, OSLO
TUESDAY 24 SEPTEMBER, 17:30

The Birkeland Lecture 2019

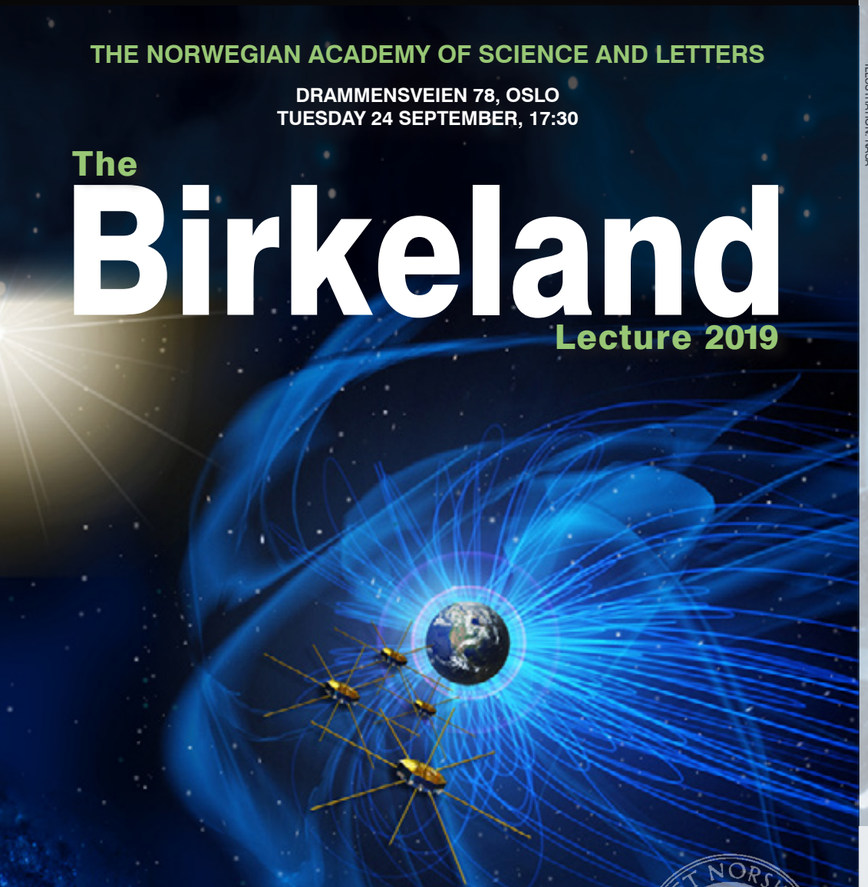
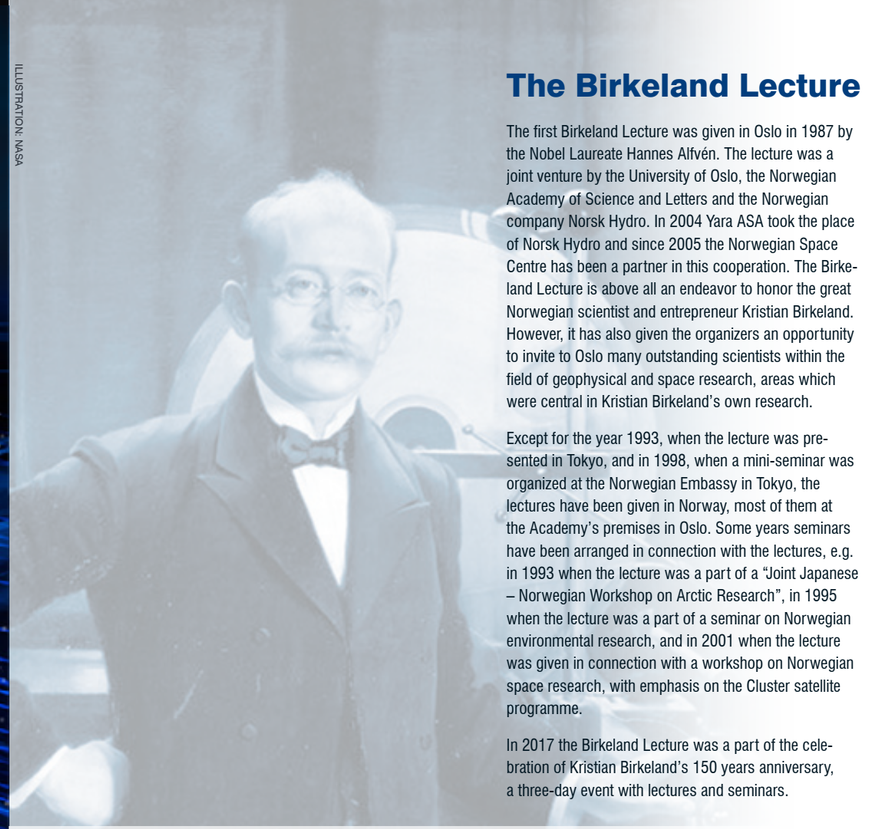


ILLUSTRATION: NASA

Professor **Tuija Pulkkinen,**
University of Michigan, Ann Arbor, MI, USA:

Solar storms

Tracing storms from Sun to the Earth, including hazards on our technology



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

The Birkeland Lecture

The first Birkeland Lecture was given in Oslo in 1987 by the Nobel Laureate Hannes Alfvén. 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. Some years seminars have been arranged in connection with the lectures, e.g. in 1993 when the lecture was a part of a "Joint Japanese – Norwegian Workshop on Arctic Research", in 1995 when the lecture was a part of a seminar on Norwegian environmental research, and in 2001 when the lecture was given in connection with a workshop on Norwegian space research, with emphasis on the Cluster satellite programme.

In 2017 the Birkeland Lecture was a part of the celebration of Kristian Birkeland's 150 years anniversary, a three-day event with lectures and seminars.

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 odd-numbered years and physics in even-numbered years. The award ceremony will take place in connection with the Birkeland lecture.

Organizing committee:

Professor Jan A. Holtet, Department of Physics, University of Oslo
Professor Alv Egeland, Department of Physics, University of Oslo
Professor Jøran Moan, Department of Physics, University of Oslo
Øyvind Sørensen, Chief Executive, the Norwegian Academy of Science and Letters
Svein Flatebø, Yara International ASA
Pål Brekke, Senior Advisor, Norwegian Space Agency

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A list of former Birkeland lecturers is found on
https://www.dnva.no/detskjer/2019/06/birkelandforelesningen

UiO : University of Oslo

Det Norske Videnskaps-Akademi
The Norwegian Academy of Science and Letters

Norsk Romsenter
Norwegian Space Agency

YARA
Knowledge grows

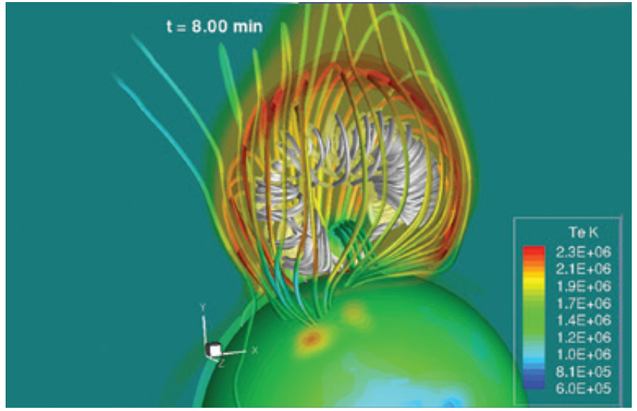
Professor **TUIJA PULKKINEN**
University of Michigan, Ann Arbor, MI, US

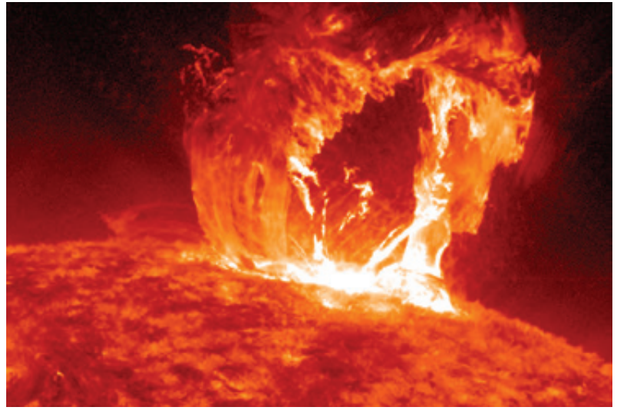
Professor Tuija Pulkkinen is the Chair of the Department of Climate and Space Sciences and Engineering of the University of Michigan. Before starting at Michigan in 2018, she was the Vice President for Research and Innovations and Dean of the School of Electrical Engineering at Aalto University in Finland (2011-2018), and held a variety of positions at the Finnish Meteorological Institute (1988-2010).

Professor Pulkkinen's research interests span the Sun-Earth connection physics in a wide sense. She has made major contributions in empirical magnetic field modeling of the time-evolving current systems in the magnetosphere to describe transition from stable to an unstable state; observational studies of energy transfer processes in the magnetosphere – ionosphere system; and global MHD simulations and development of quantitative analysis tools of the simulations to trace energy entering from the solar wind through the magnetopause, stored and processed in the magnetotail, and dissipated in the ionosphere.

Her recognitions include memberships in the US National Academy of Sciences, Academia Europaea, Royal Astronomical Society, and the Finnish Academy of Sciences and Letters. She is recipient of the Julius Bartels Medal of the European Geosciences Union and the James B. Macelwane Medal and fellowship of the American Geophysical Union.

Professor Pulkkinen has served on many national and international committees, including Science Advisory Council of the Deutsches GeoForschungsZentrum in Potsdam, Chair of the Norwegian Research Council Space Research Programme Committee, Academy of Finland, Research Council for Natural Sciences and Engineering, Swedish National Space Board Space Research Advisory Committee, European Space Agency, Solar System Working Group, and President of the European Geosciences Union.





Solar storms start as large eruptions of particles and magnetic fields at the solar surface. Advanced numerical models can trace their propagation through interplanetary space to the Earth's environment. (Image credit NASA)

Professor **TUIJA PULKKINEN,** University of Michigan, Ann Arbor, MI, USA

Solar storms

Tracing storms from Sun to the Earth, including hazards on our technology

Large solar eruptions eject vast clouds of charged particles to interplanetary space. As the cloud reaches the Earth, the particles are trapped by the geomagnetic field, they gain energy, and a portion of them make their way to the upper atmosphere creating colorful auroral displays. While the solar flares at the beginning and auroras at the end point of the process are visible to the human eye, the traversal through the interplanetary space and pathways in the Earth's space environment are not, and can only be inferred from the sparse in-situ space measurements or numerical models. Even if we understand the sequence of events in general terms, several physical questions remain open, to the effect that we do not yet have models that could predict solar storms or their geospacer effects.

Understanding and forecasting solar storms is important, because our society is increasingly dependent on technologies vulnerable to charged particle radiation and electromagnetic disturbances. For example, electronics and subsystems of satellites can be damaged by increased fluxes of high-energy electrons and protons. Beautiful auroral displays have as side effects strong and rapidly varying upper atmosphere currents, which disturb satellite navigation and radio communication systems, and cause unwanted spurious currents and voltages in power transmission systems or natural gas pipelines. Scandinavia, due to its location at high latitudes and highly advanced infrastructure, is particularly affected by these space weather hazards.

Recent satellite missions to monitor the Sun, the solar wind and the geospace, combined with novel modeling methods and increased computational capacity, make our time a golden era for solar-terrestrial science. This lecture will show recent observations and model results to introduce the basic sequence of events from the solar surface to the Earth, as well as highlight scientific breakthroughs and practical applications: Artificial intelligence and machine learning methods are entering solar flare forecasting, promising unprecedented advanced warnings. We demonstrate how a combined set of numerical models can be used to associate the flare with an erupting coronal mass ejection and to trace the disturbance throughout the heliosphere to the Earth environment.

We assess the role of reconnection and other processes in the transport of energy and acceleration of particles through the outer boundaries of the geospace to the inner magnetosphere and ionosphere.

Innovation in Solar Physics Research

MATS CARLSSON, director
Rosseland Centre for Solar Physics

There is an interplay between innovation and advances in basic research – innovation makes possible new lines of inquiry while identified obstacles can be a driving force behind innovation. In this talk some examples will be given from modern research in solar physics.

Sufficiently stable to nurture life during the last 4 billion years, and modern humans the last 100,000 years, the Sun is nevertheless a variable star. While the total solar irradiance only varies of order 0.1% during the 11-year solar cycle, the high-energy portion of the solar output can vary by several orders of magnitude on timescales of minutes. Solar activity – sun spots and active regions, UV and X-ray emission, the million degree corona, flares, coronal mass ejections, the acceleration of energetic particles – is increasingly interfering with human activity as our society's dependence on sensitive electronic equipment grows and as we venture beyond the Earth's magnetosphere and into the solar system proper. There is a pressing need to understand the workings of the energetic Sun.

Such understanding is now within reach thanks to developments in computing capacity, new technology enabling bigger telescopes, adaptive optics and post-processing techniques giving sharper images than ever before.

Mats Carlsson got his PhD from the University of Uppsala in 1987 and has since 1993 been a professor at the Institute of Theoretical Astrophysics of the University of Oslo. He has had numerous scientific management positions in Norway and Europe. He is the president of European Association for Solar Telescopes and the director of the Centre of Excellence, Rosseland Centre for Solar Physics at the University of Oslo.