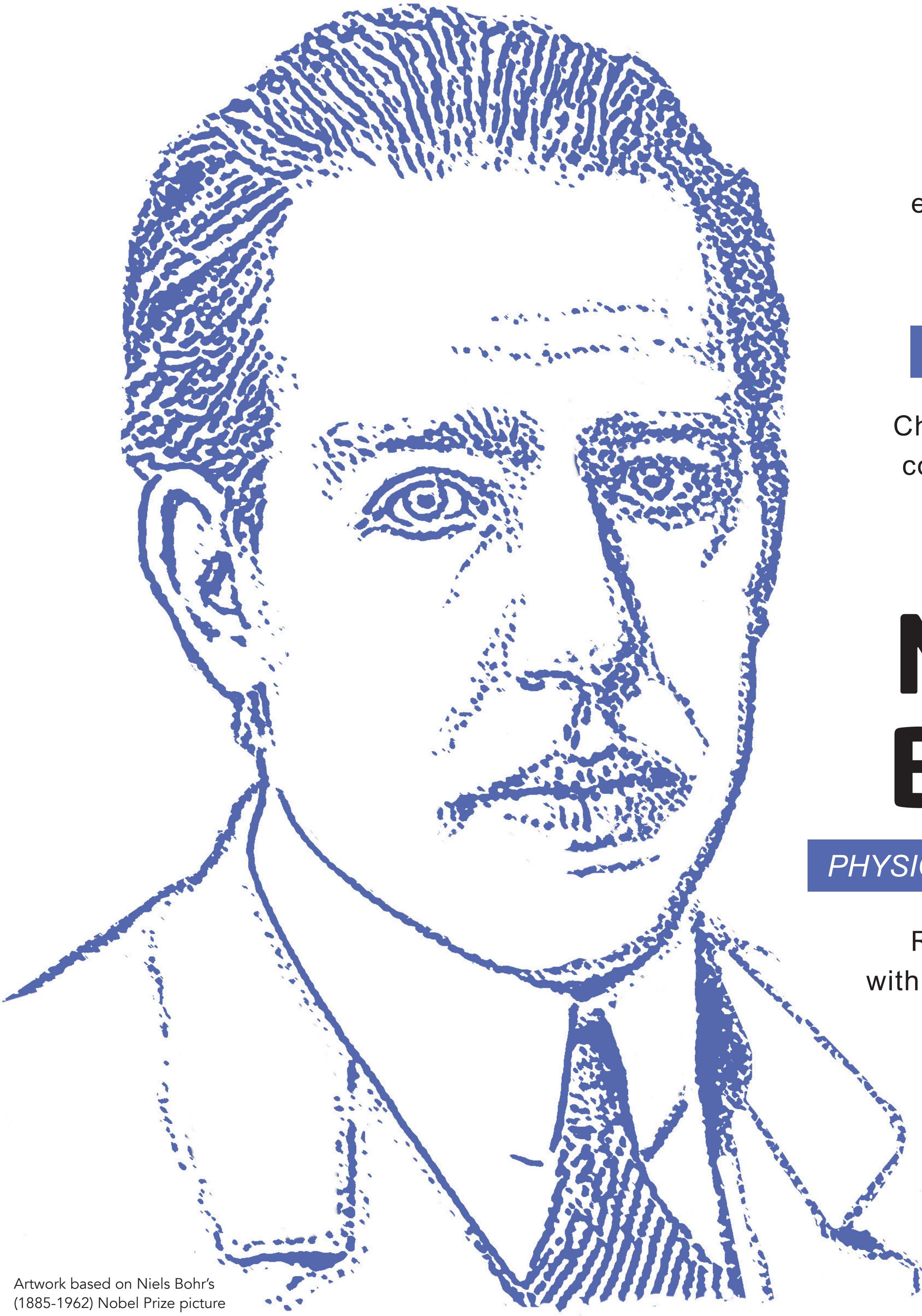
IPhO
44th
MONDAY JULY 8 // ISSUE #1
Copenhagen Denmark 7-15 July 2013

# HAFNIUM



## TOMORROW

Theoretical examination and fun afterwards.

## STUDENT MAP

Check out your fellow contestants and your skills in geography.

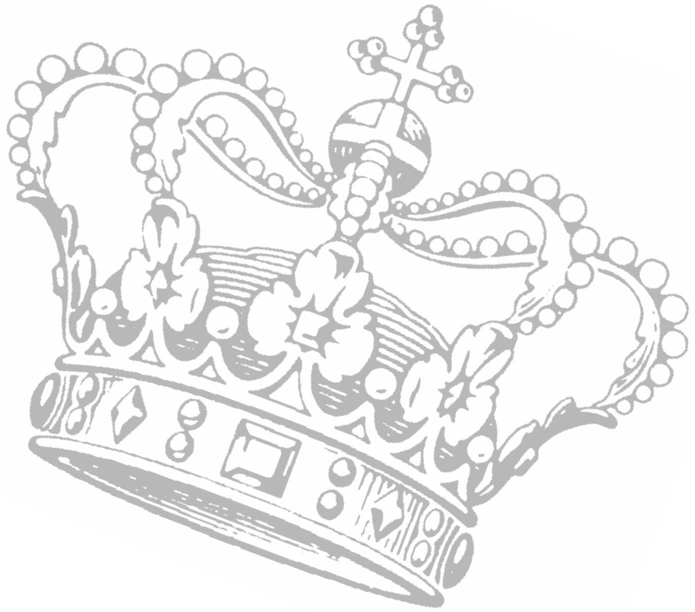
# NIELS BOHR

## PHYSICIST OF THE DAY

Read about the man with the model and how he figured it all out.

Artwork based on Niels Bohr's (1885-1962) Nobel Prize picture

# A ROYAL WELCOME



A few words from His Royal Highness Crown Prince Frederik, patron of IPhO in Denmark.

As patron of the 44th International Physics Olympiad in Denmark, it is a great pleasure for me to bid each of you from all over the world a cordial welcome to this inspiring event. At the opening ceremony of IPhO 2013, physicists from more than 80 countries are present; physicists on all levels including professors, researchers, teachers from high schools and universities, and, not least, about 400 young and very talented students. A special welcome to you.

In the coming days you are going to engage each other in an academically demanding, but friendly competition involving a series of challenging physics problems. I wish you the best of luck in your endeavors. Regardless of your achievements in the competition, remember that you have already, through your qualification to your national team, shown an outstanding talent for physics.

In addition to the competition itself, you will enjoy several days here in Denmark as visitors, and hopefully you will carry home dear memories that will one day make you wish to return. Most importantly, during the coming week you will have a unique opportunity to create an international network and to initiate lasting friendships with other people sharing your passion for physics.

Physics is a unique subject that is above political, cultural, and societal differences between people. Physics provides an exceptional insight into nature and its inner workings, and physics is a crucial prerequisite for technology, which is a pivotal part of modern societies. Your talent can be of great personal joy for you in your future life, and it will most likely be of benefit for those countries that you represent here today.

I hope you will enjoy your stay in Denmark and represent your country well at the 44th International Physics Olympiad.

> ”How wonderful that we have met with a paradox. Now we have some hope of making progress.“
>
> - Niels Bohr



Miriam (left) & Turi (right) in the ball sea at Experimentarium where you are going on Friday 12 July.

# INTRODUCING HAFNIUM

Meet the two faces that will be following you around, taking photos and bringing you the latest IPhO news.

Welcome to the daily newsletter Hafnium. We are Miriam and Turi and we will be around all week taking pictures and asking questions. Half of you already met us yesterday at the photo-shoot, and the rest of you will meet us at your photo-shoot.

Miriam is a designer from the Royal Danish Academy of Fine Arts and she will take most of the pictures with her big camera and she is also the Art Director of the newsletter.

Turi is a master student at the Niels Bohr Institute and she will primarily be interviewing and writing the articles as the Editor in Chief.

Hafnium will be released every day during IPhO 2013 – the last circulation is on Monday July 15.

Every day you will find the following in Hafnium:

- Today's physicist.
- Student map
- Pictures and interviews from the excursions and happenings yesterday.
- A teaser about what will happen tomorrow.

We are looking forward to meeting all of you, so do not hesitate to say hi when you see us.

Best wishes,

Miriam & Turi

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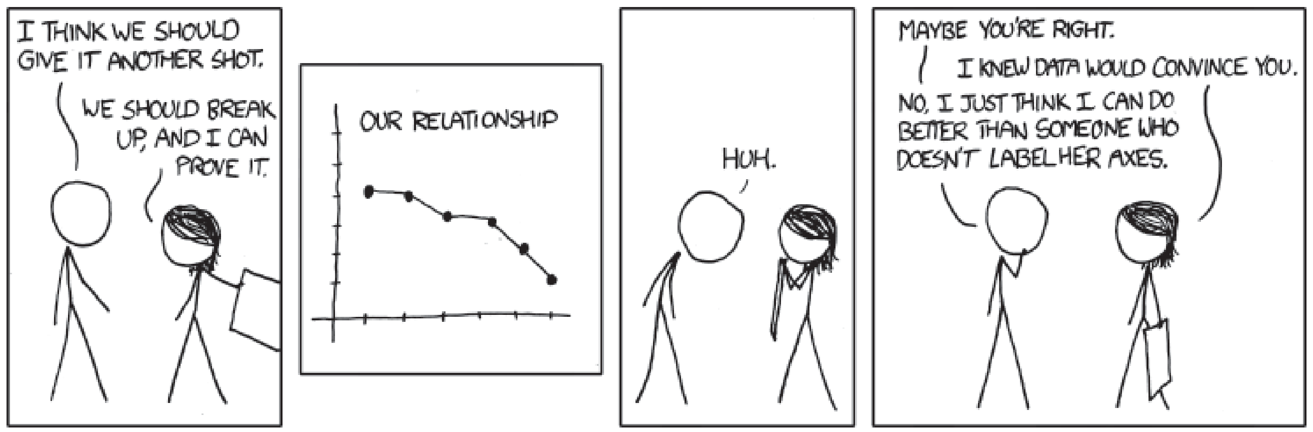
# STUDENT MAP

Meet the faces of your fellow contestants and see where in the world they are from.

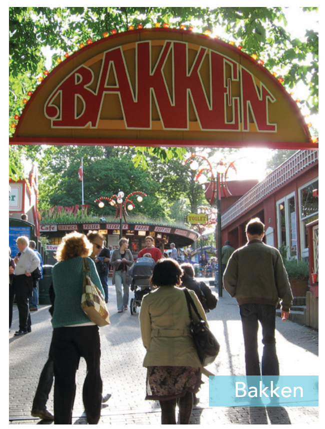

**XKCD**
„CONVINCING"




## TODAY...

**Read more in IPhO Info**


Dyrehaven



Bakken


Eremitagen

# THE BOHR MODEL

## -celebrating 100 years

In 1913 the Danish scientist Niels Bohr formulated a model for the atom that would change the perception of the world.

Niels Bohr was only 26 years old when he in 1911 went to Cambridge as a postdoc to meet the famous physicist Joseph Thomson. Bohr had in his thesis "Studies of the Electron Theory of Metals" found mistakes in previous work done by other physicists – amongst them Thomson – and the young Bohr was very interested in discussing his critique with Thomson himself. But Thomson was busy and not interested in reading Bohr's thesis, probably because Bohr's English was very bad.

Fortunately other great physicists visited University of Cambridge and Bohr met Ernest Rutherford there. Rutherford's field of research was radioactivity and he invited Bohr to visit the Cavendish Laboratory in Manchester. Bohr accepted the invitation and followed some radioactivity courses, but none of his work was publishable. Bohr was running out of time – his doctorial time in England was almost up and he had yet to publish anything.

But then something happened. Charles Darwin (as formulated by Bohr: "the grandchild of the real Darwin") had calculated the loss of speed when alpha-particles passed through thin gold foil. He had calculated the speed using Rutherford's new model for the atom that stated that the positive charge of the atom was collected in a small volume called the nucleus. The model was a result of experiments where the trajectories of some of the alpha-particles were bent drastically when passing through thin gold foil. The electrons around the atom were not important in this experiment, so Rutherford did not comment on them in his model. In Darwin's experiment, on the other hand, the electrons were very important and he decided to treat them as free particles when they were hit by an alpha-particle. His results were dependent on the number of electrons and on the radius of the atom.

Bohr went through the calculations and saw that Darwin's result for the radius of the atom did not agree with earlier calculations. Bohr immediately realized why: The fact that electrons are not free, but bound to the nucleus, needed to be accounted for in the calculations.

The first thing Bohr did when formulating his model was to place the electrons in circular orbits around the nucleus. But there was a problem – the atom ought to be unstable. Immediately after being created, the electron should spiral inwards to the nucleus while emitting radiation continuously, and finally the system should break down. Experiments showed that this did not happen, but no one could explain why.

The next step in Bohr's model was proposing that the energy $E$ of the electron was proportional to the orbital frequency $f$ with proportionality constant $K$. Within classical physics it was, however, impossible to calculate the radius of the orbit using this hypothesis. Now Bohr was at a dead end.

Not until Bohr saw Balmer's formula for the frequencies in the line spectrum of hydrogen did he know what was wrong. He needed to postulate the existence of stationary orbits with energies $E_n$, being the only orbits electrons are allowed to occupy. Combining this with Planck's quantization of energy, he could then predict the frequency $\nu$ of light emitted when an electron jumped from orbit $n=n_1$ to $n=n_2$ to be

$$\nu = cR\left(\frac{1}{n_2^2}-\frac{1}{n_1^2}\right)$$

independent of the orbital frequency $f$, but in full agreement with experiments by Balmer, Rydberg and others. The emission spectrum of hydrogen, the Balmer lines, is incorporated in this year's IPhO logo as a tribute to the Bohr Model.

For some physicists it seemed impossible that Bohr's explanation for the line spectra of the atoms was true. This new quantum theory conflicted with the previous theory that the radiation from atoms originated from the vibration of the electrons. One of the physicists who believed that Bohr's explanation was true early in the process was Albert Einstein.

Bohr's model had some minor mistakes, but his revolutionary idea that the frequency of the radiation of atoms is given by the energy difference between two energy levels of the atom, still holds 100 years later.

Absorption (above) and Emission spectra of hydrogen. The Emission lines are called the Balmer Series.

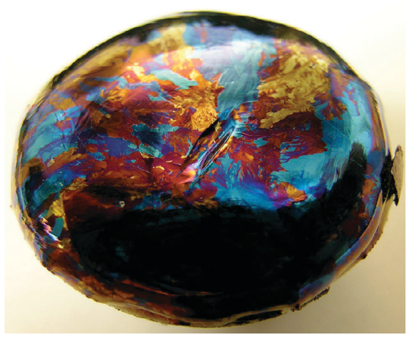
IPhO 44th

The IPhO 2013 logo. The Balmer lines and the related transitions in the hydrogen atom are incorporated in the logo.



# HAFNIUM

This year's IPhO newsletter is named after the 72th element in the periodic table, which was discovered at the Niels Bohr Institute on the 9th of December 1922 by the two chemists G.C. de Hevesy and D. Coster. Hafnium is a derivative of Hafnia, Copenhagen's Latin name. Niels Bohr received the Nobel Prize for the Bohr Model a few days after the discovery of the element and he ended his written speech in Stockholm by announcing that the 72th element was finally found. The Bohr Model, with its explanation of atomic spectra, had been the main reason for the discovery of the element. Hafnium was the second to the last stable element in the periodic table to be found.



A lump of hafnium that has been oxidized. The colours are due to thin film optical effects.

Hafnium is a silvery gray metal.

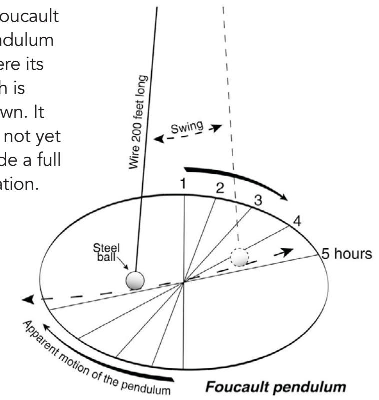
> "If quantum mechanics hasn't profoundly shocked you, you haven't understood it yet."
>
> - Niels Bohr

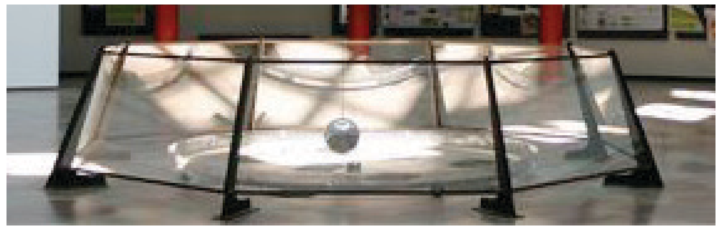
# TOMORROW...

## It is time for the Theoretical Examination.

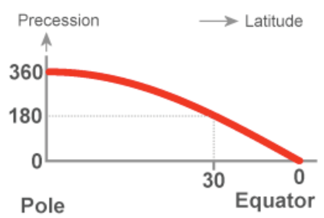
The theoretical examination will take place tomorrow in Copenhagen in a building that houses both a high school and the Geography and Geology Department of the University of Copenhagen. This building is known for its foyer where a Foucault pendulum extends from the ceiling. The first Foucault pendulums were manufactured by Léon Foucault and the most well-known one was suspended from the dome in the Panthéon in Paris in 1851. This pendulum consisted of a 28 kg lead sphere hanging from a 67 meter long wire. The purpose of the pendulum was to show the rotation of Earth around its own axis. Due to the rotation of the Earth, the oscillation plane of the pendulum will rotate. The time for a full 360 degree rotation depends on the latitude. At both the North Pole and the South Pole the rotation takes 24 hours (clockwise and anticlockwise,respectively) and at the equator, the plane of the oscillation is constant relative to Earth making the time of afull rotation infinite. In Paris the swing of the pendulum rotates clockwise 11 degrees per hour making a full circle in 32.7 hours. How long is a rotation where you live? If you have time during the examination, you can look at the pendulum which is visible from the examination tables.

A Foucault pendulum where its path is shown. It has not yet made a full rotation.

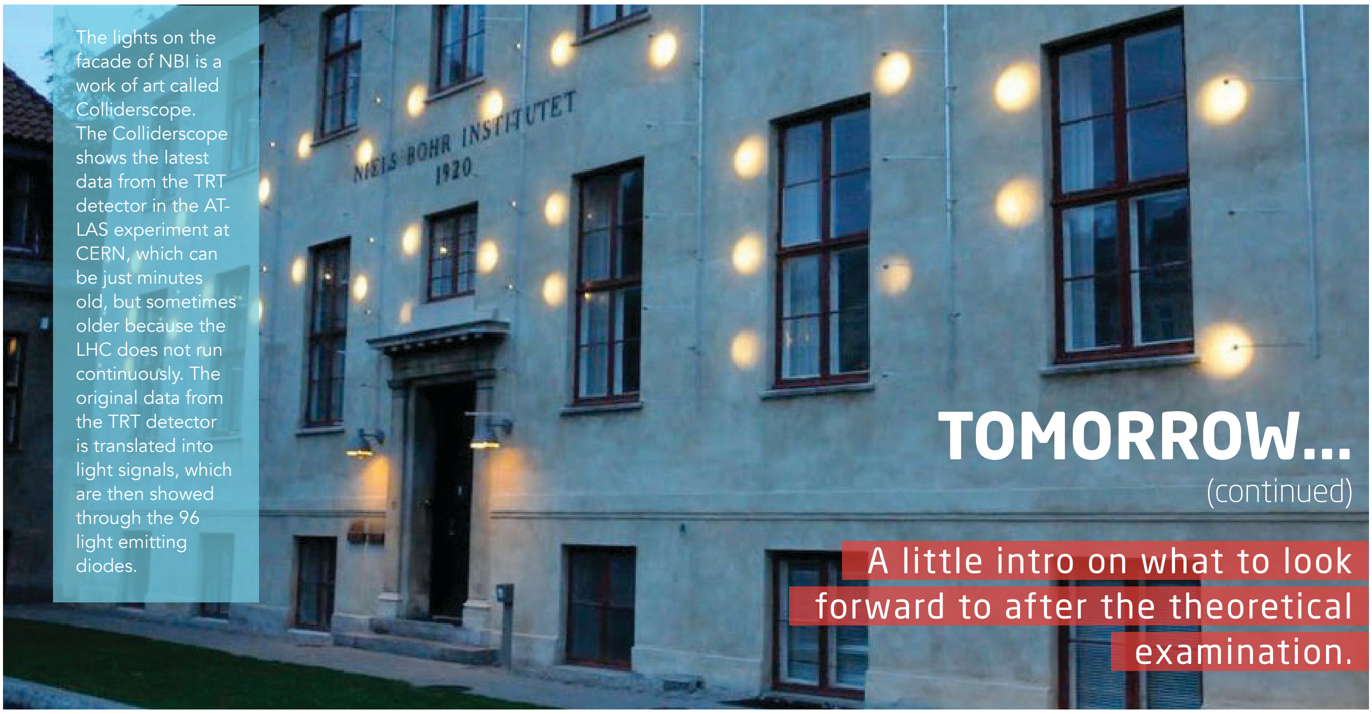


The Foucault pendulum at the Institute for Geography and Geology at the University of Copenhagen, where the theoretical examination takes place tomorrow.




Degrees of precession per 24 hours as a function of latitude. How fast is a full rotation where you live?




The lights on the facade of NBI is a work of art called Colliderscope. The Colliderscope shows the latest data from the TRT detector in the ATLAS experiment at CERN, which can be just minutes old, but sometimes older because the LHC does not run continuously. The original data from the TRT detector is translated into light signals, which are then showed through the 96 light emitting diodes.

# TOMORROW...

(continued)

**A little intro on what to look forward to after the theoretical examination.**

After the theoretical examination, and after you have had lunch, you are going to visit two of the buildings that house the physics department of the University of Copenhagen. First you will visit the old and famous Niels Bohr Institute (see more in IPhO Info) where a guide will show you around. After dinner, the evening's activities will take place at the H. C. Ørsted Institute (HCØ) where there will be a mixture of guided tours and interesting physics talks. From 18.20-19.20 you can go back and forth between two talks and one guided tour. At 19.30 we will all meet in the biggest auditorium, auditorium 1, at HCØ where there will be two evening lectures. Below you can find a quick overview of the evening entertainment.

## # 1 Mini Lectures

**Auditorium 3:** 15 minutes lectures on Exoplanets

**Title:** Discovering and Characterizing Exoplanets

**Speaker:** Lars A. Buchhave, post-doctoral researcher at the Niels Bohr Institute

## # 2 Mini Lectures

**Auditorium 2:** 15 minutes lectures on The Higgs

**Title:** Discovering the Higgs particle

**Speaker**: Troels C. Petersen, associate professor at the Niels Bohr Institute

## # 3 Lab-Tours

**Tour:** 15 minutes lab-tours through Center for Quantum Devises

**Guides:** Professor Charles M. Marcus, Professor Jesper Nygård and Professor Karsten Flensberg - all from NBI.

## #1 Evening Lecture 19.30

**Auditorium 1:** 30 minutes on the history of quantum mechanics

**Title:** Niels Bohr and the Birth of Quantum Physics

**Speaker:** Tomas Bohr, Professor at Technical University of Copenhagen (DTU) and grandson of Niels Bohr

## #2 Evening Lecture 20.00

**Auditorium 1:** 30 minutes on semiconductor chips

**Title:** Building Schödinger's Chip

**Speaker:** Charles M. Marcus, Professor at the Niels Bohr Institute and the director of Center for Quantum Devises