NIELS BOHR INSTITUTETS
UNGDOMSLABORATORIET

ULAB

2018/19
Dear teachers,

We are Ungdomslaboratoriet (ULAB) based at the Niels Bohr Institute and we want to offer your students (and you!) a visit to our laboratory! This brochure describes the various experiments we offer and how you can book a visit. As an addition to your ULAB experience, the Niels Bohr Institute staff also offers a tour of the historical buildings, including an exciting visit to Niels Bohr’s office.

Our mission is to spark interest in physics in a fun and unconventional setting. We want to offer young students an insight into real scientific work, as well as spectacular natural phenomena. Through the experiments we will help guide you through, we aim to develop the students’ intuition of basic concepts in physics, as well as give them examples of how these concepts come into play in the world. In the laboratory, the ULAB strategy for solving problems is through both peer to peer discussions as well as discussions with our instructors and the physics teachers present.

We look forward to seeing you soon!

The ULAB Team
DIY CLOUD CHAMBER

Here’s a simple way to build a real particle detector. The equipment is easily accessible, so the students can even try to repeat the process at home! Don’t believe it? The top right image shows the model, which consists of an IKEA "Synas" box, some aluminum bits and a styrofoam base. Add some dry ice and it is ready to use. In the cloud chamber, the students will be able to see the tracks left by charged alpha and beta particles, and even muons coming from space! The top left image shows the tracks inside the cloud chamber.

This is an opportunity to learn about radiation and particle detectors. The lab exercise is suitable for grades 9 and up, as - although it deals with complex content - the data collected is qualitative.

As a contrast to the cloud chamber, we show another way of detecting radiation: the Geiger counter. With balloons! As we wait for the chambers to activate, the students charge up some balloons and leave them around the lab. After finishing up with the Cloud Chamber, we measure the balloons’ radioactivity using Geiger counters. Why? Visit us to find out!
Our team devised a 3D-printed planetary model which illustrates the process of detecting exoplanets - planets outside the Solar System. The principle of the transit method is based on measuring a distant star’s light intensity curve over time. The Kepler Telescope collected such data over several months. Now, the recently operational TESS satellite continues this mission. The method can show the orbital period of the exoplanets, together with other properties such as their size or albedo.

The model consists of a light-bulb (star) with interchangeable 3D-printed spheres (planets). The iOLab light sensor acts as the telescope. The top left image illustrates an example of light intensity data collected using the model.

This lab is recommended for high school level students. It offers working with new IT-devices, novel astrophysics concepts and a deeper understanding of what it means to experiment in astrophysics. Let us bring stars from the night sky right into our lab for you - try the Exoplanet Mystery Box!
We have developed a small, simple gamma ray detector which will allow you to measure gamma rays emitted from various sources and to determine the energy of these gamma rays. Participants will learn where gamma rays come from and what they tell us about how nuclei are built. Activities using the NBI BiGS (Billige Gamma Spectrometer) can be done at a variety of levels, from a 3 hour visit in which investigate which natural samples contain isotopes from Uranium and Thorium decay or determining the radioactivity of bananas, to more involved activities in which participants build their own detector and determine its resolution and efficiency.

Advanced participants can choose to build and understand a model PET scanner using two of our detectors. By combining the two detectors and requiring them each to give a signal within a short time of each other, one can detect the gamma ray signature of the electron-positron annihilation. This exercise not only illustrates how modern PET scanners work, it also allows participants to see, experimentally, that E=mc².
MOMENTUM

One way to create an (almost) frictionless system is using hoverballs. This serves as a fantastic opportunity to gain some intuition about the concept of momentum. With the use of iPads and apps we provide, it is possible to investigate the hoverballs colliding under various conditions.

The students are given the equipment: 2 hoverballs, a 1 meter long ruler and the iPads. They have to design an experiment that will explore the properties of momentum in different collisions. This can be, for example, a head-on collision or having one hoverball strike another one at rest. The app allows for tracking the hoverballs. In the experiments, students are confronted with the differences between the idealized model of the lecture hall and its realization in the laboratory.

This exercise can be very open, giving students plenty of freedom in forming testable hypotheses and in the design, construction, and performance of their experiments. This experiment is suitable from grade 9, though less experienced students may need slightly less freedom and more scaffolding to benefit optimally from their experience.
SUPERCONDUCTORS

Certain materials, when supercooled, have 0 resistance, which makes them interesting to investigate. The students will have an opportunity to learn about those materials and test at which temperature their resistance becomes 0 Ω (critical temperature, or T\textsubscript{c}). The students learn about circuits and conductivity, as well as having the ability to observe other fun physical phenomena involving liquid nitrogen.

To find the T\textsubscript{c} value, the students will put together a circuit using 2 multimeters. This is an advanced quantitative experiment, therefore we also include other activities. One of them is observing the Meissner effect (top left image), where the superconductor causes a small magnet to levitate. We also bring marshmallows to enjoy frozen by the liquid nitrogen (LN\textsubscript{2}).

This is one of our most complex experiments, therefore it is most suitable for high school level and higher. We aim to provide hands-on examples of circuits and magnetic phenomena, which can prove challenging to learn. And eating LN\textsubscript{2} frozen marshmallows is fun!
A simple concept well known from mechanics can help us estimate the speed of light. The speed of any object is defined by its displacement per unit time. In this experiment, we reflect an impulse of light and measure the time delay between its transmission and detection. Varying the distance, the students can read the time delay from the oscilloscope (top left image). When at least 10 sets of distance and time data are collected, all left to do is plot it! The slope of the resulting linear curve is the speed of light.

Constructing the setup correctly gives a good training at experimental methods, especially recognizing sources of uncertainty. The question of why the value is not exactly $c$ will surely arise, sparking a discussion about how a theoretical model differs from reality. Using the oscilloscope for data collection will be a good challenge for the students, with an appropriate balance provided by a simple theoretical model, $v = \frac{2d}{t}$.

Due to its technical nature, the lab is most suitable for high school level and higher.
THE GREENHOUSE GASES

We demystify the concept of climate change with a light-bulb, tube full of air and a multimeter. This qualitative lab exercise shows directly the effects of greenhouse gases (CO$_2$, CH$_4$, H$_2$O) interacting with infra-red light. Using a light sensor which transforms light intensity into voltage difference, the students can determine how much light passes through the tube (see top left image). In 2 stages of the experiment, the students test how good the greenhouse gases are at absorbing UV and visible light, compared to heat.

The experiment allows for becoming more familiar with the use of a multimeter. The students get to collect and interpret quantitative experimental data. In the lab, we discuss the importance of the greenhouse effect and the risks of allowing too many greenhouse gases in our atmosphere. We touch upon general patterns in the interaction of light and matter. We have done the greenhouse gases lab with university and high school level students. It can be also suitable for engaged 9th grade students.
PLAY WITH LIGHT

Did you know when turmeric is dissolved in alcohol, it becomes fluorescent? Did you know that green laser becomes red in olive oil? Check it yourself!

Or come to ULAB to play with light. This lab is a set of experiments we usually offer to our younger visitors, students from 9th and 10th grade. The experiments are largely qualitative and aim to spark an excitement for physics in the younger students.

The lab is structured for work in small groups that alternate between 3 different stations. At each station the groups are given equipment to investigate. The experiments include:

• light passing through different media and how that affects the light’s properties,
• observing invisible light through an infra-red camera and fluorescent or phosphorescent materials,
• getting familiar with the electromagnetic spectrum through investigating spectral lamps. And more!
BOOKING AND PRACTICAL INFO

All the experiments take 2.5 to 3 hours.

For more information about ULAB, visit our homepage at the NBI website. If you have any more questions, contact Professor Ian Bearden at bearden@nbi.ku.dk.

To book a laboratory class, fill out our registration form.

In order to book a tour around the Niels Bohr Institute in addition to your ULAB experience, please contact Marta at gsl536@alumni.ku.dk with the expected date and time of the visit, as well as the number of students and their preferred language (English or Danish). A tour around the Niels Bohr Institute takes up to an hour.

Special thanks to Ola Jakub Joensen, the Niels Bohr Institute’s Web Director, for providing images used in this brochure.
THE ULAB TEAM

Prof. Ian G. Bearden
Ian is a particle physicist and a professor at the Niels Bohr Institute. He collaborates with CERN on projects such as ALICE and is responsible for both bachelor and candidate level courses at KU. Under his leadership, ULAB continues to produce new and exciting ways to teach physics, as well as educational models that gained international interest.

Anna Kristina
My name is Anna Kristina, I’m 23 years old and I’m currently doing my master’s degree in Physical Chemistry at KU. I’m interested in the area where physics and chemistry meet. I like teaching, so I thought ULAB would be a fun challenge – allowing me to practice, as well as a chance to do some cool and fun physics. In my spare time I like reading fiction and traveling.

Erik
I am a master student at NBI’s quantum physics specialisation. My interest lies mainly with the experimental work. I love being able to change and improve a setup and to implement new designs. Thus I am concentrating on electronic systems and optical experiments at the moment. The work at ULAB allows me to tinker with interesting labs, as well as come up with designs for future experiments.

Freja
Hi, my name is Freja and I am 23 years old. I am doing a master’s degree in quantum physics. I have been very curious about the world my whole life and I have been eager to understand the natural laws that surround us all every day. My biggest interest lies in the world of quantum mechanics in which all everyday intuition breaks down. I love to spread exciting knowledge in creative ways.
THE ULAB TEAM

Jo
My name is Jo and I’m 23 years old. I just finished my bachelor thesis in theoretical cosmology. When I saw the beauty and mystery the Universe has to offer, I knew I had to spend my life doing astrophysics. I love to communicate science and how amazing physics can be, and ULAB is a great opportunity to inspire young students and work with cool and fun people.

Jonas
My name is Jonas and I’m 22 years old. I’m currently on my 3rd year of my bachelors in physics with a focus on condensed matter physics and simulations. I love teaching and I love experiments, so ULAB affords a fantastic opportunity to combine the two. In my spare time I like building electronics and I volunteer writing software for Roskilde Festival.

Marta
I’m Marta and I’m 23 years old. I am studying biophysics, but my interests in science go far and wide. At the moment, my focus in science is on animals. ULAB is an amazing opportunity to learn how to share my ideas and knowledge with others in a fun and relaxed environment. In my free time, I like to swim and play with different types of visual arts.

Mikkel
My name is Mikkel Oglesby and I am a physics master student with a minor in math. My goal upon finishing my degree is to teach at a gymnasium. My love for teaching is exactly why I have joined ULAB. I love to help others see the beauty of physics. I especially like optics, waves and thermo dynamics. I also have love for astronomy.
THE ULAB TEAM

Nana
I’m Nana and I’m 22 years old. I’m a physics student who is especially interested in quantum optics and as of late also computational physics. I have just finished my bachelor project in quantum optics and have begun my fourth year of studies. I love to play and experiment with things, and doing physics is the best way to do both!

Sif
Hey, my name is Sif and I’m 21 years old. I’m a 3rd year physics and mathematics student. I knew I wanted to study physics since I was 13, to become an environmental scientist and save the world from climate change. What I love about physics is the feeling of clarity after trying to understand a certain concept for a long time, and suddenly it clicks.

Troels
Hello! My Name is Troels and I am 28 years old. I have a bachelor’s degree in physics and am now on my second year of a bachelor in mathematics. I love to teach and share my interest in physics with others and I plan to teach at a gymnasium, which is why I am at ULAB. Aside from the studies, my interests include movies and storytelling in general, as well as animals and biology.