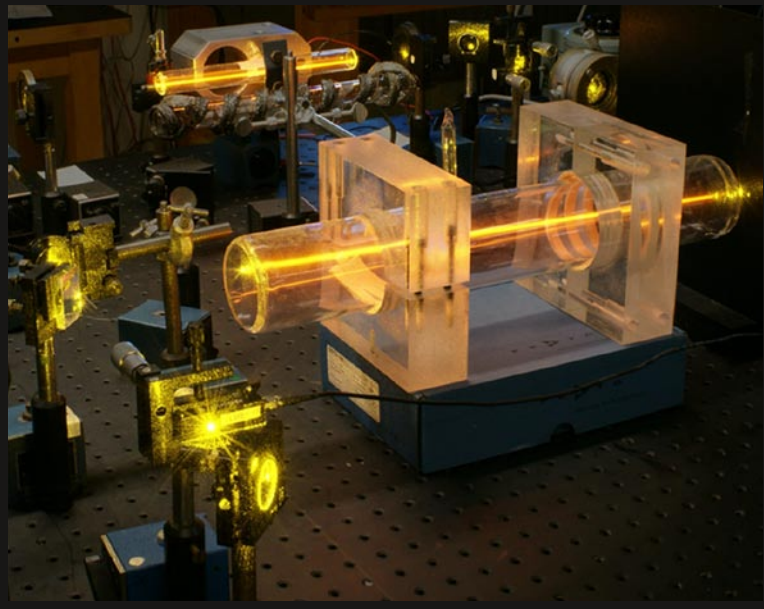
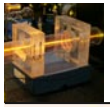


When the laser came to Lund

On how it happened and how it eventually led to a world record.

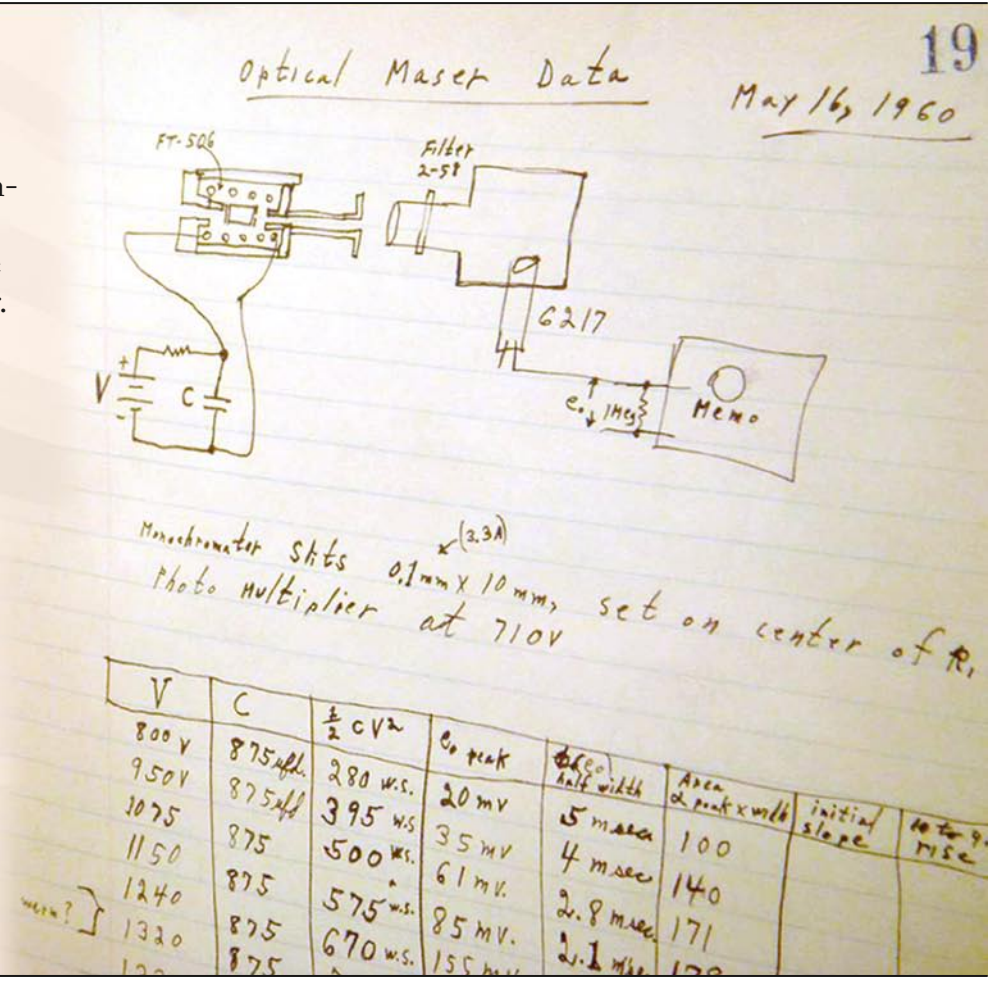


The world's first laser

In 1917 Albert Einstein realised that the new phenomenon of stimulated radiation emission should exist.

In 1954 the phenomenon could be demonstrated in an experiment for the first time and in 1960 American physicist Theodore Maiman constructed the world's first laser.

The world's first laser in front of Maiman's notebook with the experimental protocol.



19

Optical Maser Data

May 16, 1960

FT-506

Filter 2-58

6217

V

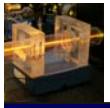
C

Memo

Monochromator slits 0.1 mm x 10 mm, set on center of R1 (3.3A)

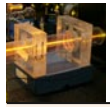
Photo multiplier at 710V

V	C	½ CV²	e₀ peak	Half width	Area & peak x width	initial slope	10 to 90 rise
800 V	875 μf.	280 w.s.	20 mv	5 msec	100		
950 V	875 μf	395 w.s	35 mv	4 msec	140		
1075	875	500 w.s.	61 mv.	2.8 msec	171		
1150	875	575 w.s.	85 mv.	2.1 msec			
1240	875	670 w.s.	155 mv				
1320	875						



What can a laser be used for?

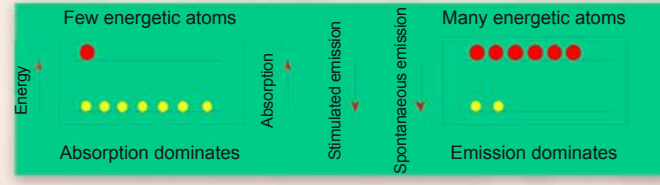
The laser quickly became an effective aid for basic research and over time also turned out to have many different applications. Today lasers are used in many diverse fields, such as medical laser treatment, fusion research and entertainment.



What is a laser?

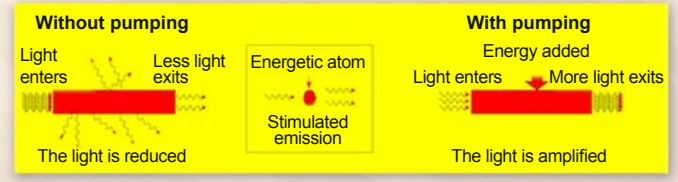
Unlike a normal light source, where the light shines out in all directions and with many colours, the light in a laser has been concentrated to a narrow beam with a specific colour.

The usual state in a material is a normal population, whereas in a laser there is an inverted population. The inverted population is achieved with the help of pumping, for example with a strong flash lamp, which means that instead of the light being muted it is intensified.

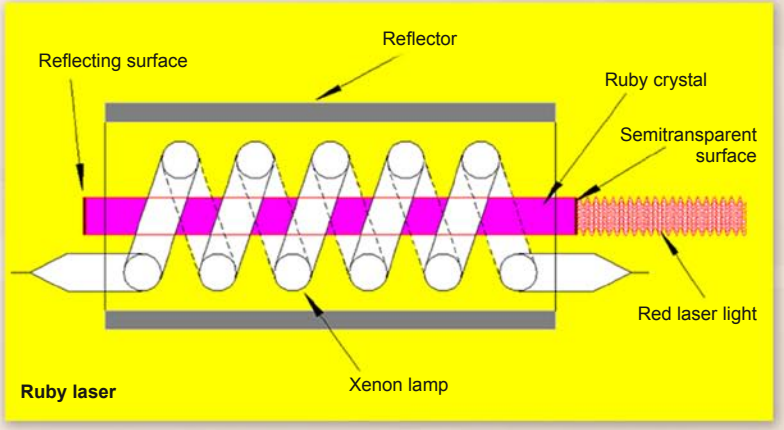


Various atomic systems.

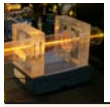
Normal population. Inverted population.



Amplified light.



With the addition of mirrors, it is possible to create a light source, such as a ruby laser, with very special properties. The light from the laser becomes extremely intense and useful.

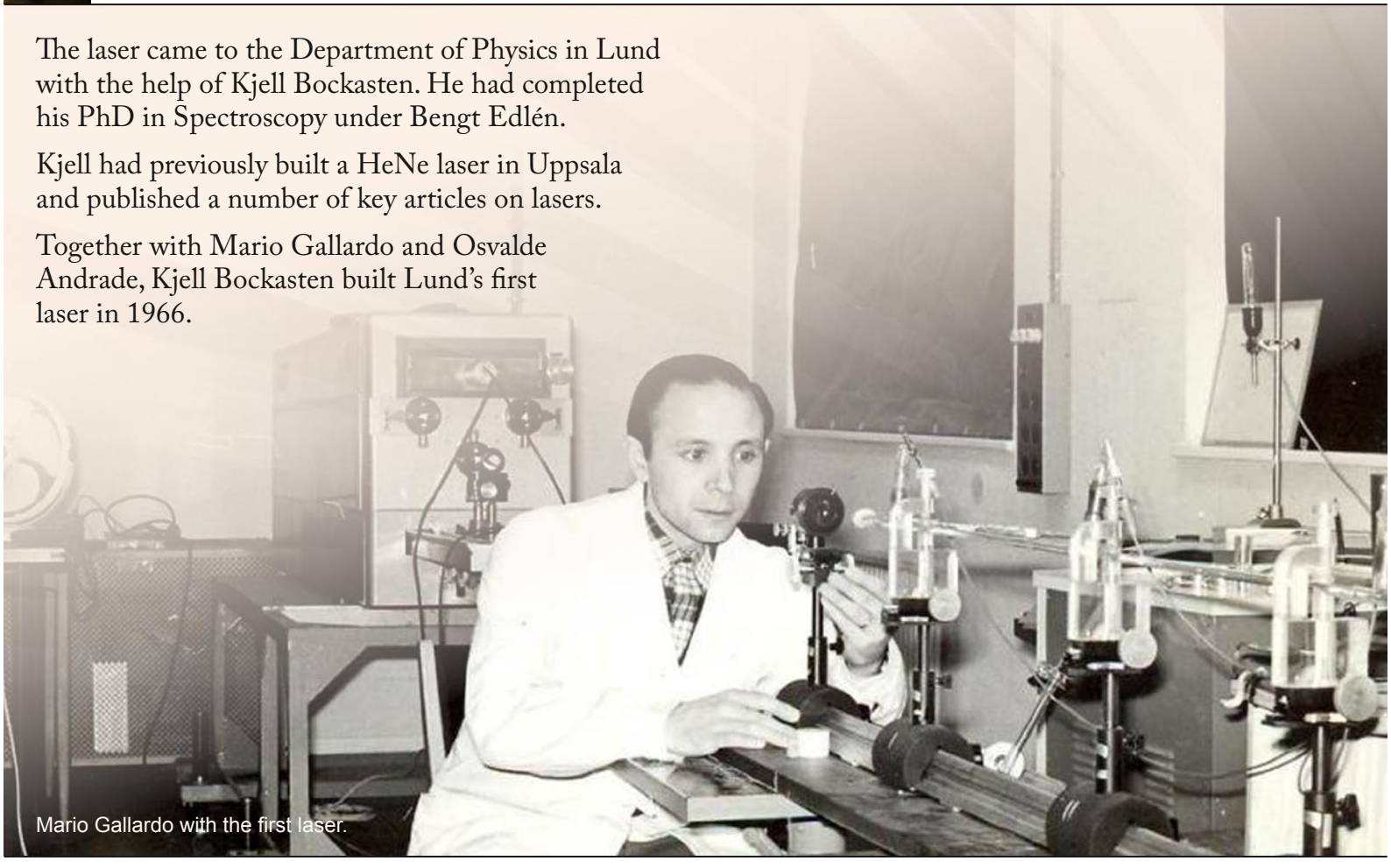


The first laser to be built in Lund

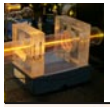
The laser came to the Department of Physics in Lund with the help of Kjell Bockasten. He had completed his PhD in Spectroscopy under Bengt Edlén.

Kjell had previously built a HeNe laser in Uppsala and published a number of key articles on lasers.

Together with Mario Gallardo and Osvalde Andrade, Kjell Bockasten built Lund's first laser in 1966.



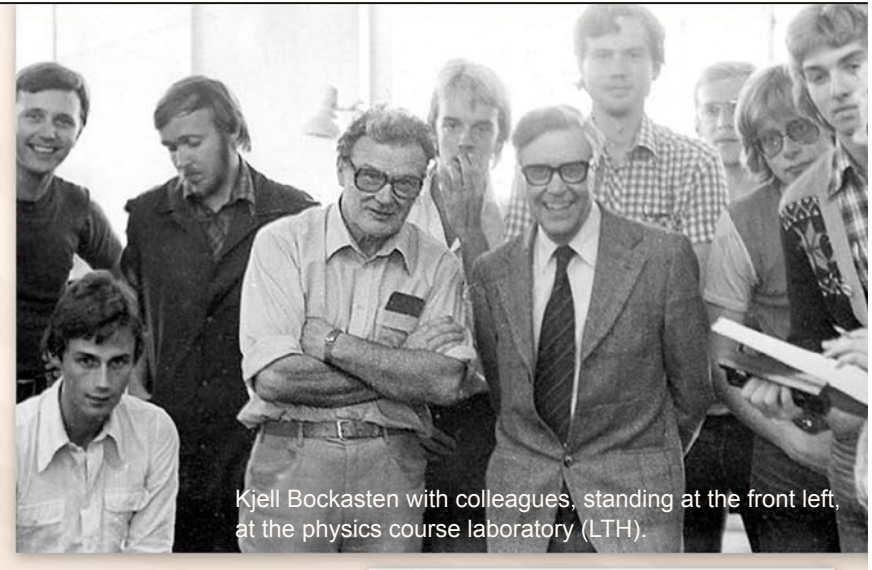
Mario Gallardo with the first laser.



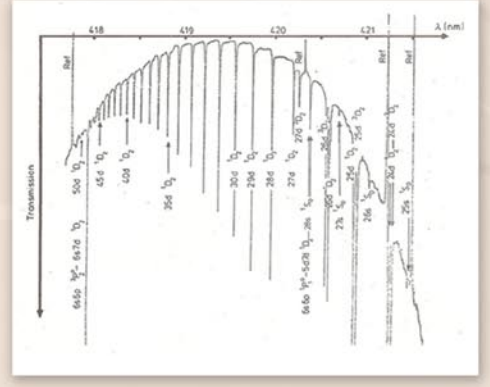
The laser group

Kjell Bockasten built up a new research group at the Division of Atomic Physics that initially constructed nitrogen lasers, which produce short pulses in UV (337 nm). Nitrogen lasers could be used to study absorption spectra in the element barium among others.

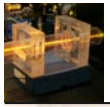
The laser group's measurements of Rydberg series produced new values for the ionisation energies of a number of elements.



Kjell Bockasten with colleagues, standing at the front left, at the physics course laboratory (LTH).



Registered Rydberg series in barium with n-quantum numbers up to n=62.



When Sune came to Lund

Sune Svanberg with new Nobel Prize Laureate Artur Schawlow in 1981.

When Sune Svanberg came to Lund in 1981 the focus of the atomic physics research at LTH changed.

From having principally been about classic atomic spectroscopy, the focus moved to laser spectroscopy and applications of lasers.

With Sune's broad knowledge and great inventiveness, the laser activities in Lund got off to a fantastic start.

New, modern laboratory exercises in combination with Sune's inspiring lectures attracted a lot of students to the Division of Atomic Physics.

Laboration om NdYag-lasern.

Four doctoral students and a bus

The stone table arrives for Marcus's laser system.

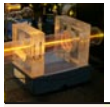
Sune Svanberg brought four doctoral students with him from Chalmers.

One of these was Marcus Aldén, who continued his measurements in combustion; this research would lead to an entirely new division and eventually to a combustion engineering research centre.

Another doctoral student was Hans Edner, who concentrated on LIDAR measurements.

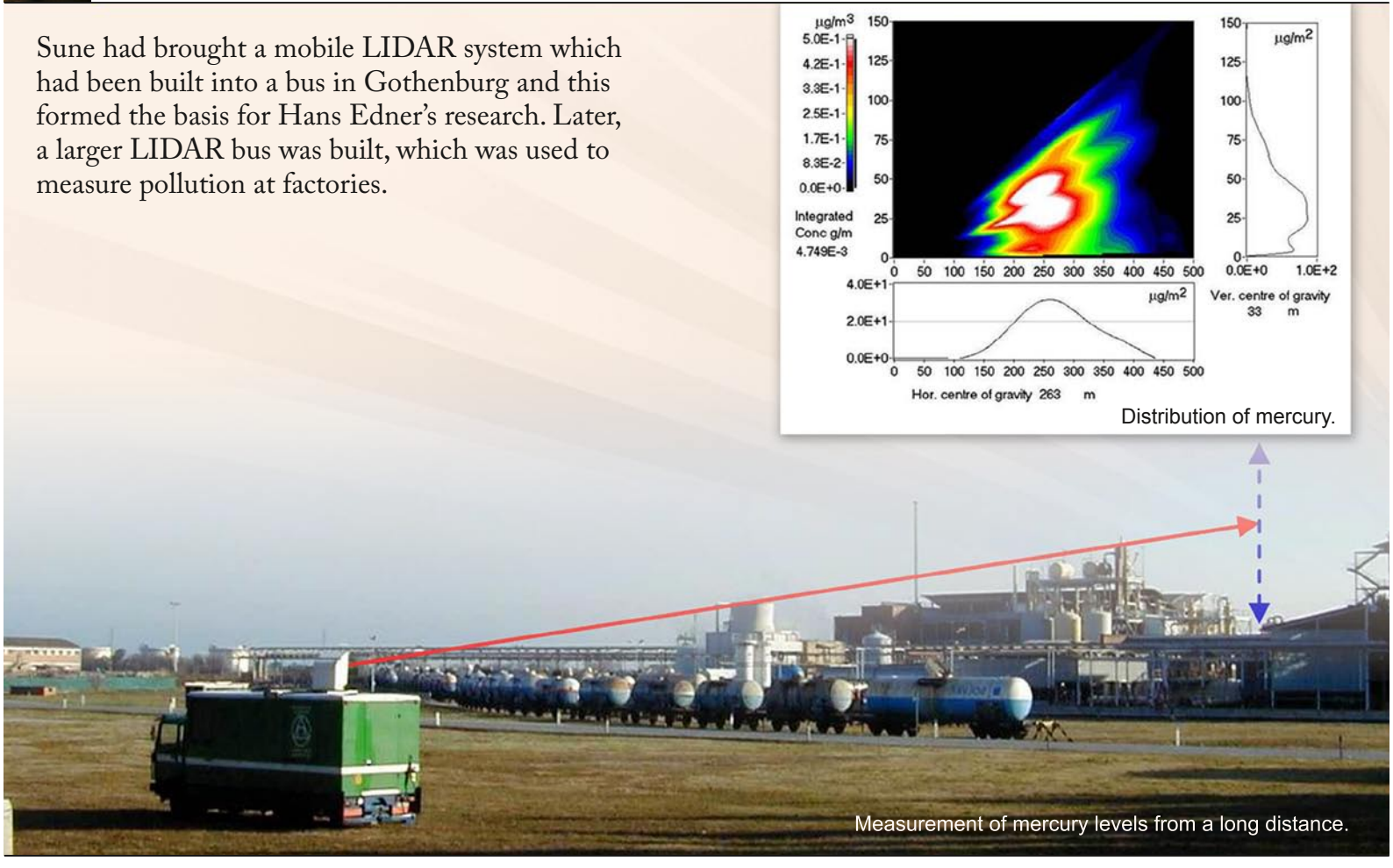
The first LIDAR bus.

LIDAR (Light detection and ranging) is a technique used to measure an object's properties by illuminating it, for example with laser pulses.



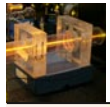
Measuring air pollution

Sune had brought a mobile LIDAR system which had been built into a bus in Gothenburg and this formed the basis for Hans Edner's research. Later, a larger LIDAR bus was built, which was used to measure pollution at factories.



Distribution of mercury.

Measurement of mercury levels from a long distance.

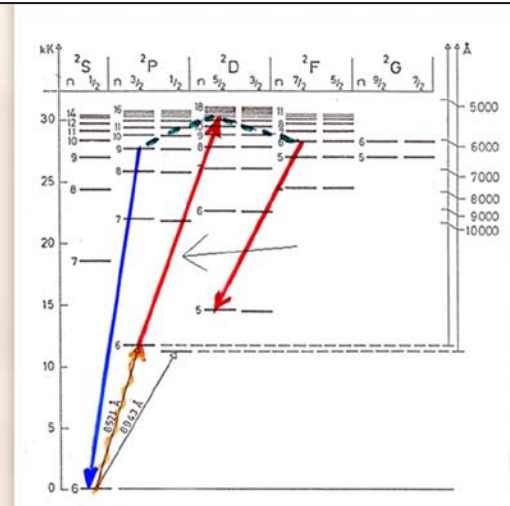


Basic research

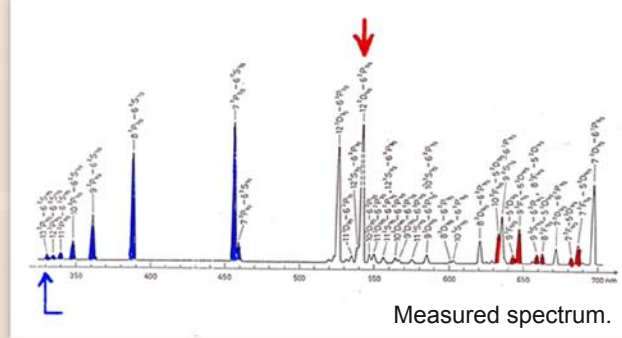
During the 1980s, a lot of basic research was also carried out. Initially, the research was on laser spectroscopy with broadband lasers, but later researchers including Stefan Kröll carried out Doppler-free measurements with continual narrowband dye lasers and time-resolved spectroscopy on hyperfine levels with pulsed lasers.

Claes-Göran Wahlström was responsible for the theoretical calculations at the division.

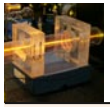
Anders Persson, who completed a PhD on laser measurement of lifetimes showed himself to be good with all types of lasers and gained an important position when the high-power laser was installed and brought into operation in 1992.



Laser spectroscopy in Cs I.



Measured spectrum.



Medical applications

In the early 1980s, Sune Svanberg and his wife, doctor Katarina Svanberg, carried out experiments with medical lasers.

An important method developed by Katarina was photodynamic therapy in combination with fluorescence measurements.

In 1987 the first patients were treated with photodynamic therapy and nowadays the method is routinely used to treat certain types of skin cancer.

Katarina Svanberg

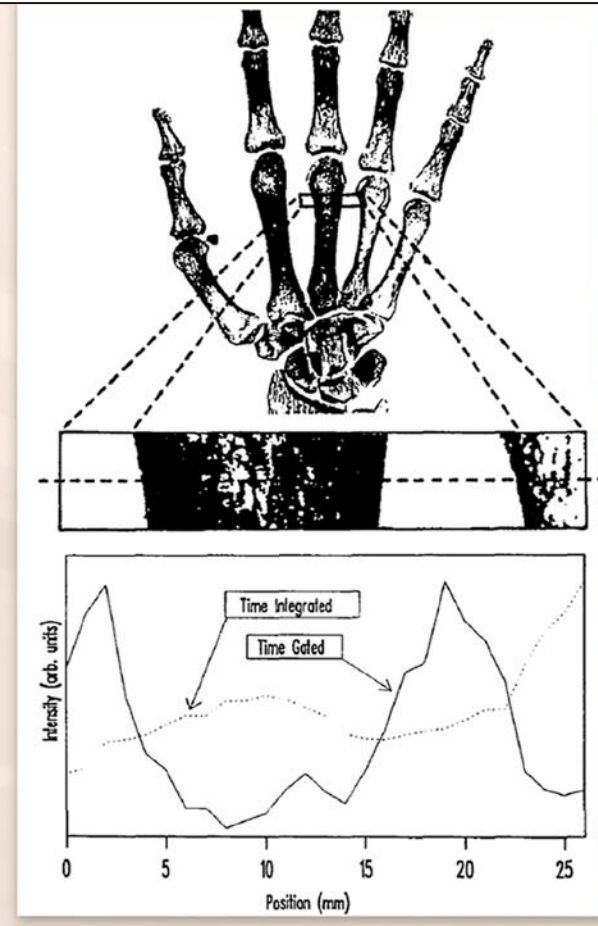
Katarina Svanberg treating a patient.

When ALA (aminolevulinic acid) is injected into tissue, a tumour can be detected as it fluoresces in the light of a laser. Laser light of another wavelength can then be used to burn away the tumour.

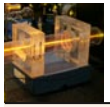
Medical applications

In 1990 the medicine group at the Division of Atomic Physics, which by then had been reinforced with, among others, Stefan Andersson-Engels, Jonas Johansson, and Roger Berg, successfully scanned a hand using snake-like light. This method was an important step forward for optical mammography.

The successes with laser applications in medicine, such as treatment with photodynamic therapy and diagnosis with fluorescence, led to the establishment of the Lund Medical Laser Centre in 1991 to coordinate the research and teaching in the field.



Scanning of a hand with snake-like light. The method produced much better contrast than normal measurement over time.



A high-risk project …

Having completed a PhD in Theoretical Atomic Physics under Sune Svanberg, Claes-Göran Wahlström worked for a while at Imperial College London. There he learnt to work experimentally with high power laser physics.

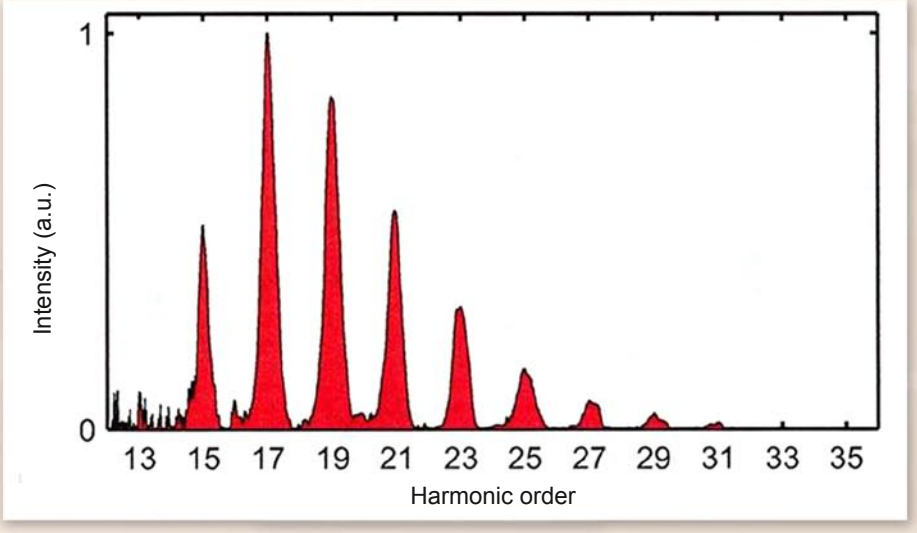
In the meantime Sune had applied to the Wallenberg Foundation for a high power laser system. Together with Anders Persson he visited various laser laboratories to study possible solutions for such a system.

Despite warnings from experts, they chose a new type of system.

Sune Svanberg, Anders Persson, and Claes-Göran Wahlström with the TW laser system.

… that became a success!

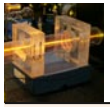
Anne L'Huillier



When the laser system was ready to be brought into operation in autumn 1992, physicist Anne L'Huillier was invited to Lund.

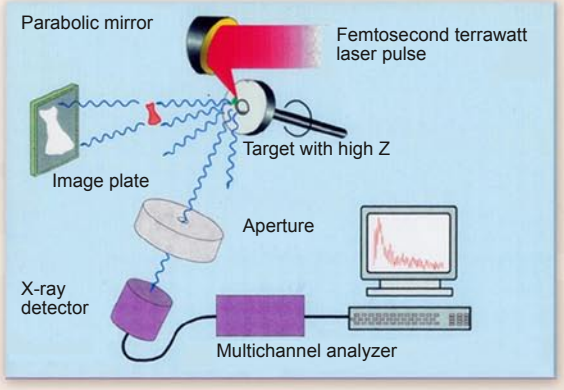
She had started the development and generation of high harmonics of the laser frequency at home in France.

In Lund Anne developed her research further and quickly obtained good results. The fact that the new laser could be operated with a very high pulse frequency contributed to her results.



Creating X-rays

Carl Tillman used the new laser source in another way. He focused the light on a rotating metal plate. The high intensity of the light when it hit the metal produced a strong X-ray source. Since the radiation source was very small, he was able to create high resolution X-ray images.



X-ray image of a rat.

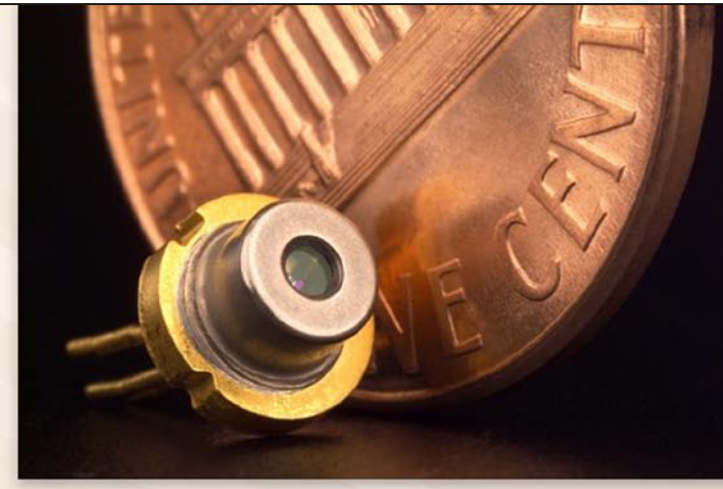
Diode laser spectroscopy

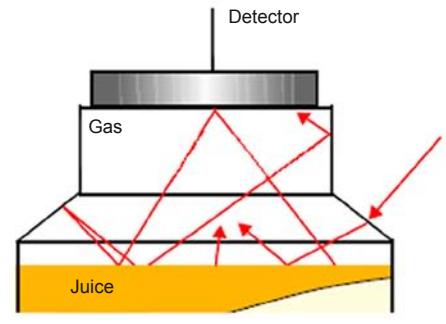
Diode lasers are small and cheap and their wavelength can be changed relatively easily.

One person who made use of the diode laser's properties was Peter Kaurannen. By modulating the frequency of the laser he was able to use it to analyse gases and also demonstrated this in laboratory experiments.

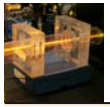
Gabriel Somesfalean and Ulf Gustafsson took the diode laser further and developed many new applications for diode laser spectroscopy. Gabriel also started the GASMAS project with Mikael Sjöholm; the project involved a method of measuring gases within porous materials.

Märta Lewander showed that it was possible to measure the gas content of sealed packaging.





Measurements of gas inside a package of juice.

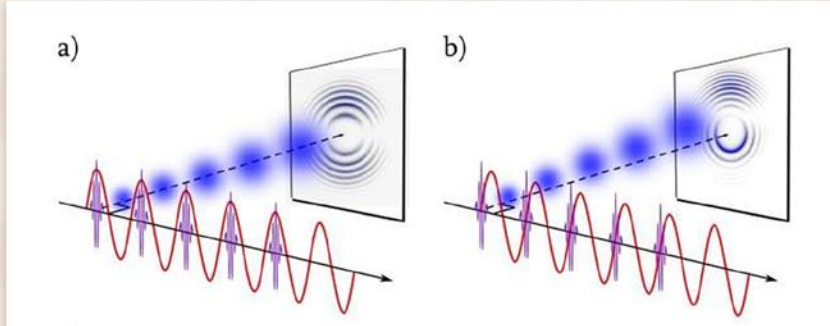


World record for short laser pulses

Nowadays, lasers are used in most divisions of the Department of Physics. At the Division of Atomic Physics, the picosecond laboratory has been converted into an attosecond laboratory.

Here, Anne L'Huillier's research group has generated extremely short laser pulses that last less than 170 attoseconds (as). In 2003 the pulse length 170 as was a world record!

Using these short pulses, it has been possible to measure the movement of electrons when they leave an atom and bob away on a light wave!



Stroboscopic registration with an attosecond pulse.

Electrons leavning the nucleus of the atom.