

Imaging Terahertz Spectroscopy of Stratified Structures in Reflection Mode

or: "Detecting explosives with lasers"

Trygve R. Sørgård¹

Supervisor: Magnus W. Haakestad^{1,2}

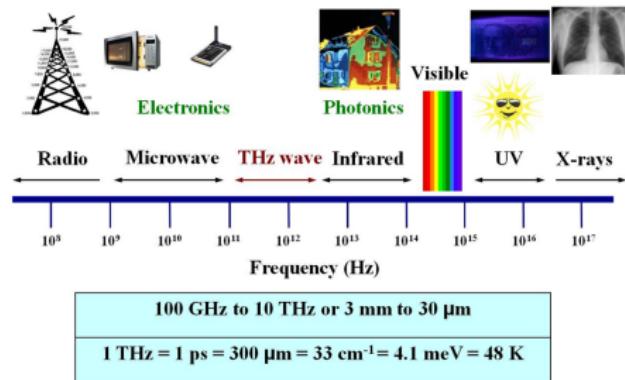
¹Institute of Physics
Norwegian University of Technology and Science(NTNU)

²Air and Space Systems Division
Norwegian Defence Research Establishment(FFI)

25.11.2014

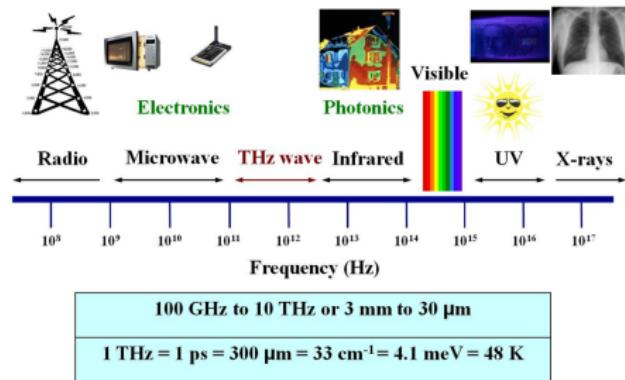
Terahertz Radiation

Basic properties - Why is it interesting?

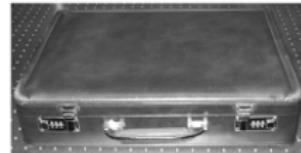


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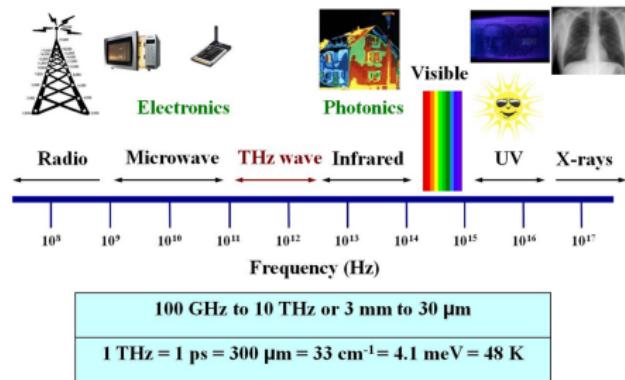


- Reflected by metal

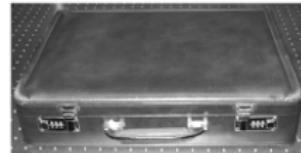


Terahertz Radiation

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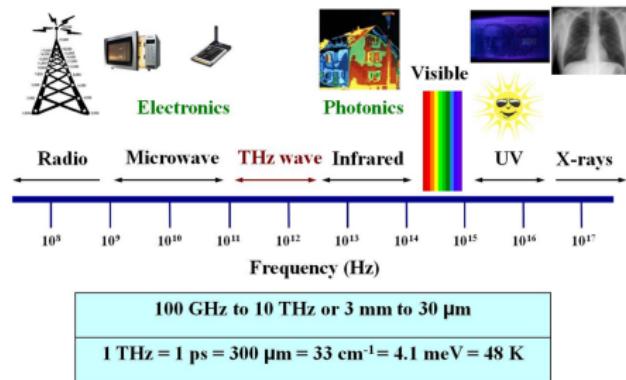


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Terahertz Radiation

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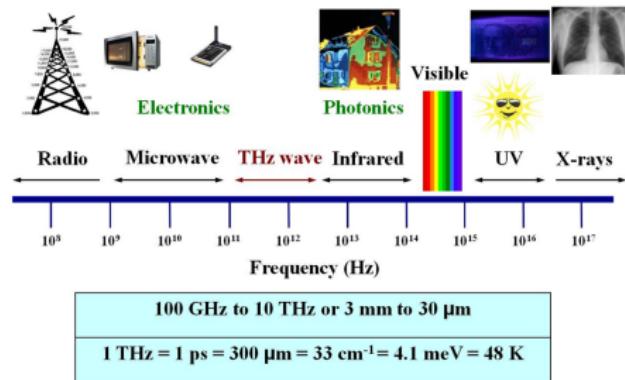


- Reflected by metal
- Absorbed by water vapor (rotational lines)

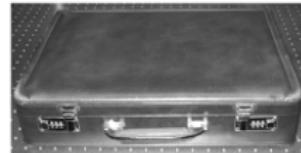


Terahertz Radiation

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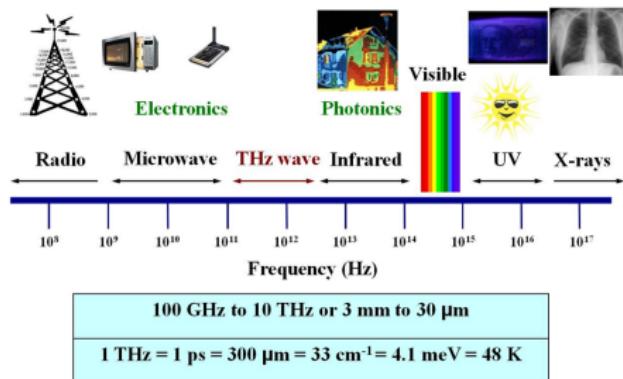


- Reflected by metal
- Absorbed by water vapor (rotational lines)
- Phonon resonances in solids



Terahertz Radiation

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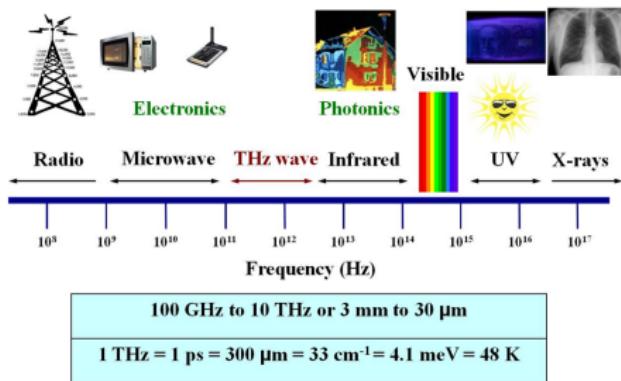


- Reflected by metal
- Absorbed by water vapor (rotational lines)
- Phonon resonances in solids
- Absorption lines of some illicit materials



Terahertz Radiation

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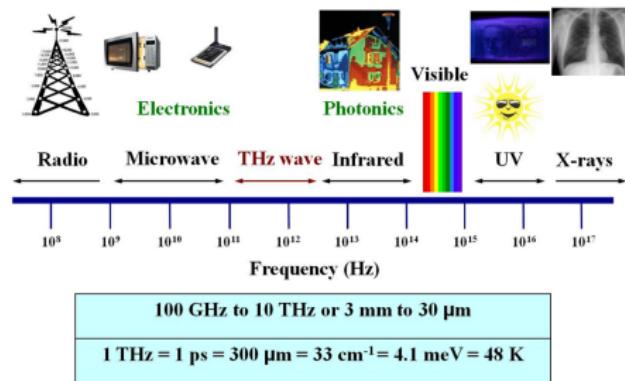


- Reflected by metal
- Absorbed by water vapor (rotational lines)
- Phonon resonances in solids
- Absorption lines of some illicit materials
- Non-ionizing (Medical applications)



Terahertz Radiation

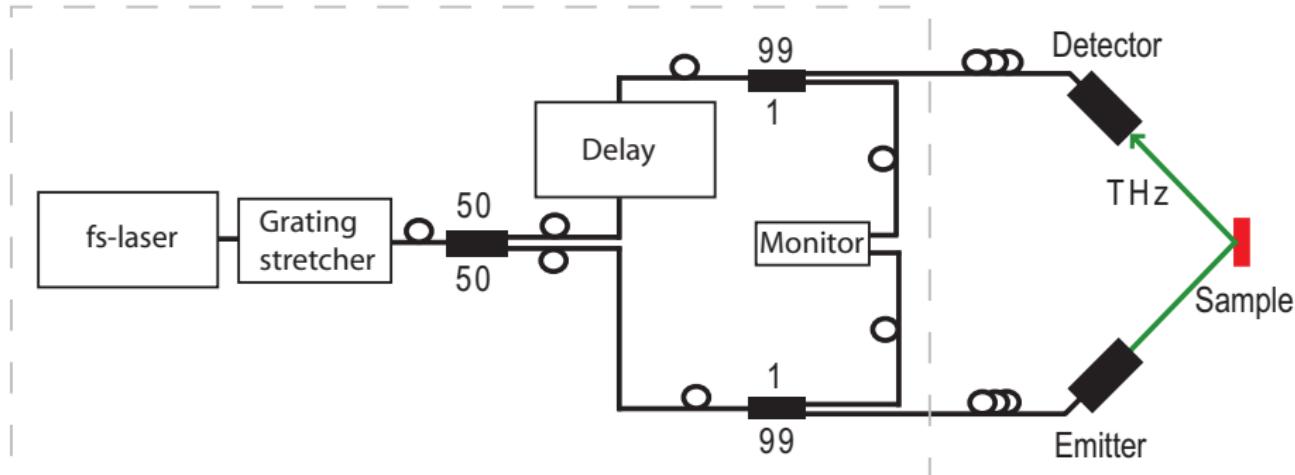
Basic properties - Why is it interesting?



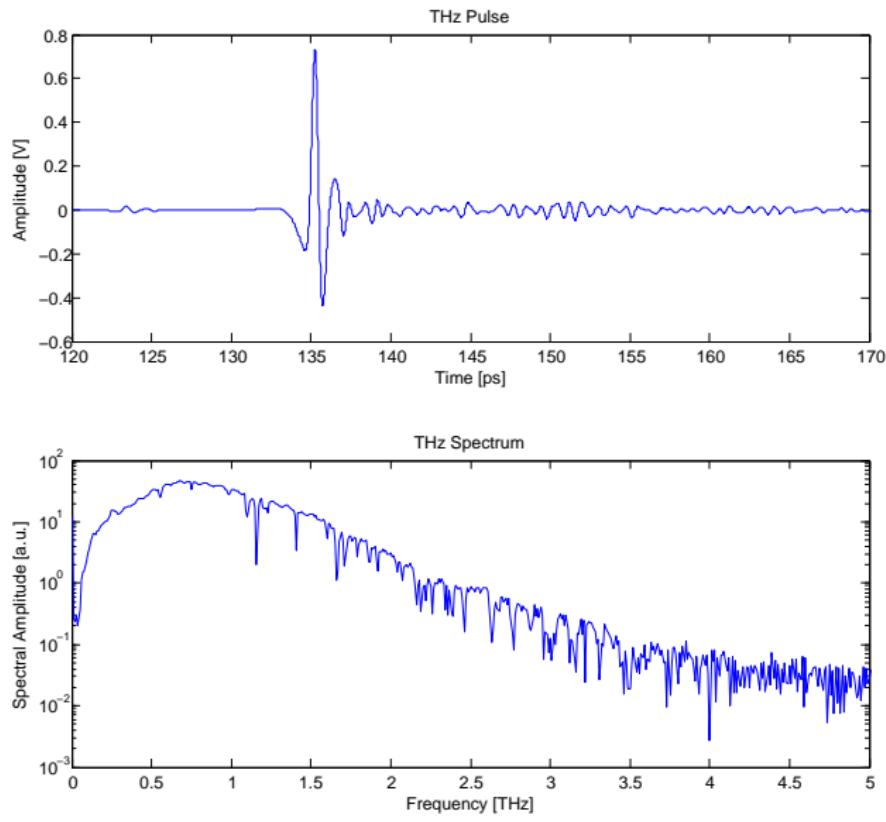
- Reflected by metal
- Absorbed by water vapor (rotational lines)
- Phonon resonances in solids
- Absorption lines of some illicit materials
- Non-ionizing (Medical applications)
- Passes through optically opaque "barrier" materials such as plastic, paper, clothing etc.

Experimental setup

THz Time-Domain Spectroscopy



Sample Pulse and Spectrum



Summary



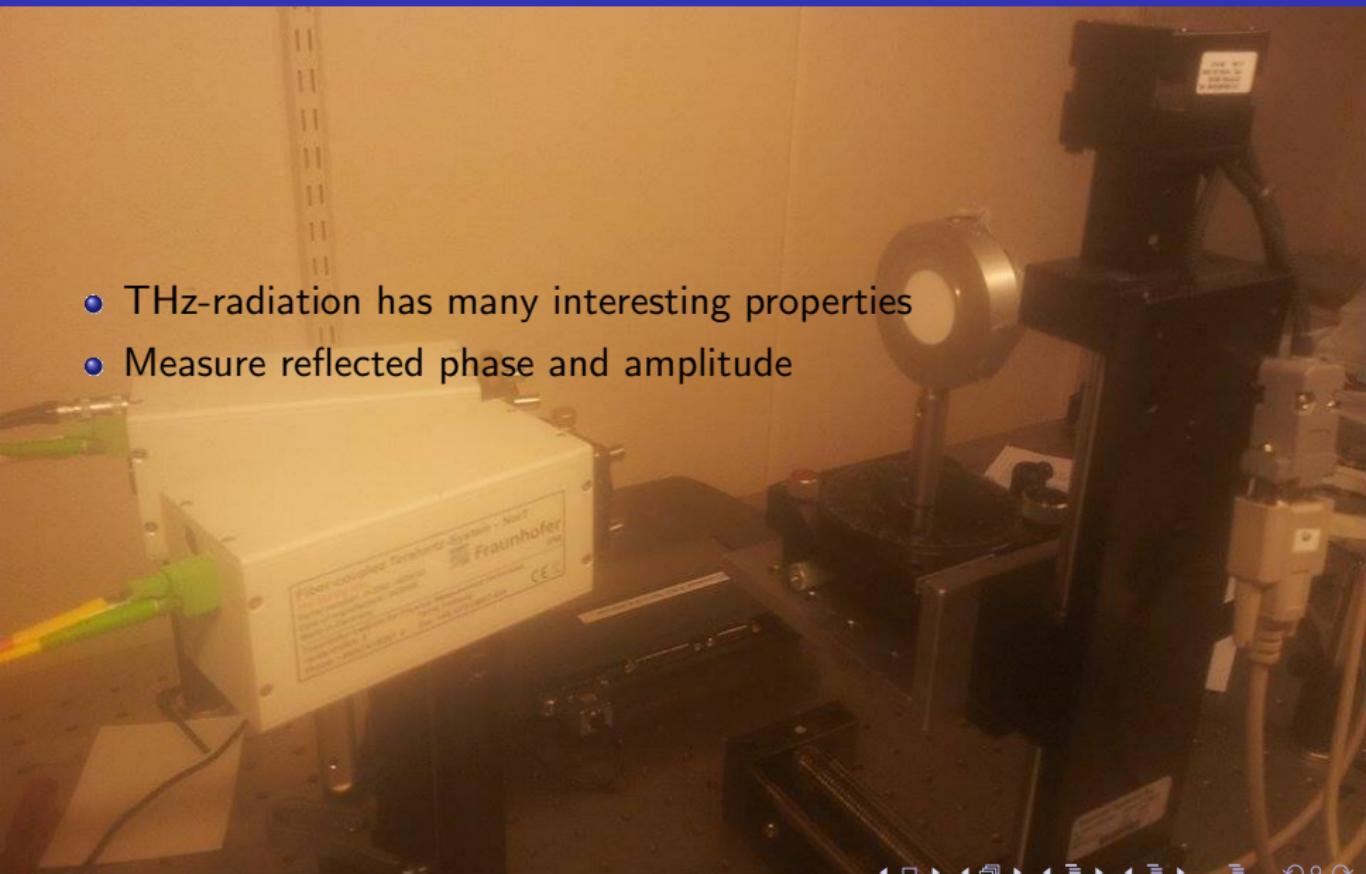
Summary

- THz-radiation has many interesting properties



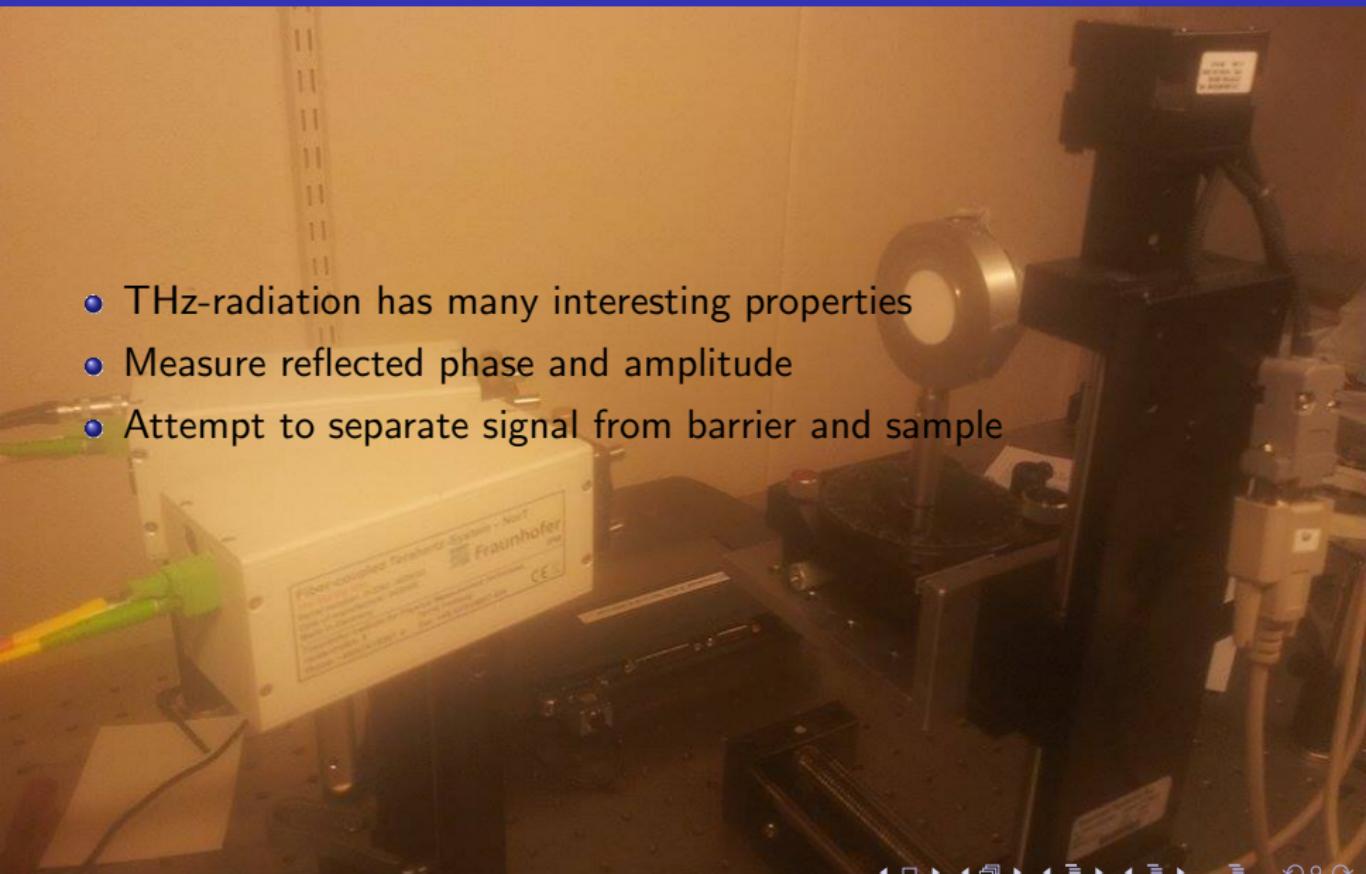
Summary

- THz-radiation has many interesting properties
- Measure reflected phase and amplitude



Summary

- THz-radiation has many interesting properties
- Measure reflected phase and amplitude
- Attempt to separate signal from barrier and sample



Summary

- THz-radiation has many interesting properties
- Measure reflected phase and amplitude
- Attempt to separate signal from barrier and sample
- Thank you for your attention!



Symmetries and symmetry breaking

How group theory can be applied to describe low energy physics.

F. N. Krohg

NTNU Department of physics
Advisor: Prof. Jens O. Andersen

November 2014

Symmetries and Field theory

- Mathematical symmetries in equations $f(-x) = f(x)$.
- Symmetries lead to conserved quantities.
- Euler-Lagrange equations for classical systems

$$\frac{d}{dt} \frac{\partial L}{\partial \dot{q}^i} = \frac{\partial L}{\partial q^i}$$

q^i : coordinates of the system.

- In quantum field theory $q^i \mapsto \phi_i$, $L \mapsto \mathcal{L}$.
 \mathcal{L} : Lagrangian density, ϕ_i : Field
- $L = T - V$

Potential

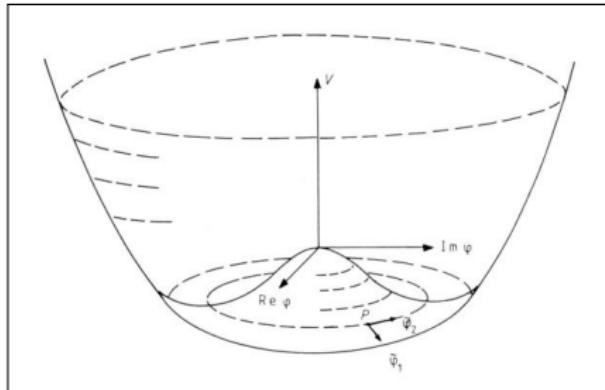


Figure: The sombrero potential plotted as a function of $\phi = \phi_1 + i\phi_2$

- Oscillations of the field \sim particle.
- Curvature of the potential \sim mass.
- Minimum gives ground state.
- Ground state breaks the rotational symmetry of \mathcal{L} .

Goldstones theorem and Spin Waves

Theorem (Goldstones)

If there is a spontaneously broken continuous symmetry, then spin 0 massless bosons appear.

- Goldstone bosons live on coset spaces \Rightarrow need for group theory.
- Ex: pions, phonons and magnons

- Magnetic systems have rotational symmetry
- Magnetic ground state does not.

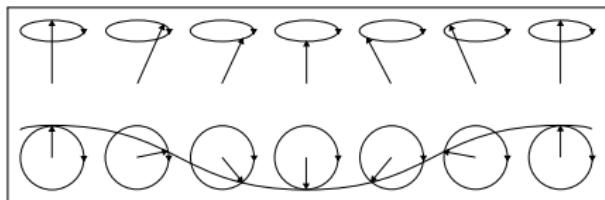


Figure: Spin wave from individual spin oscillations

A MATHEMATICAL MODEL OF A FLEXIBLE PEM NANOPORE

Magnus Dahle Peter Berg

Department of Physics,
Norwegian University of Science and Technology

November, 2014



System Geometry

We wish to obtain a better understanding for proton transport and conductivity in PEM Fuel Cells.

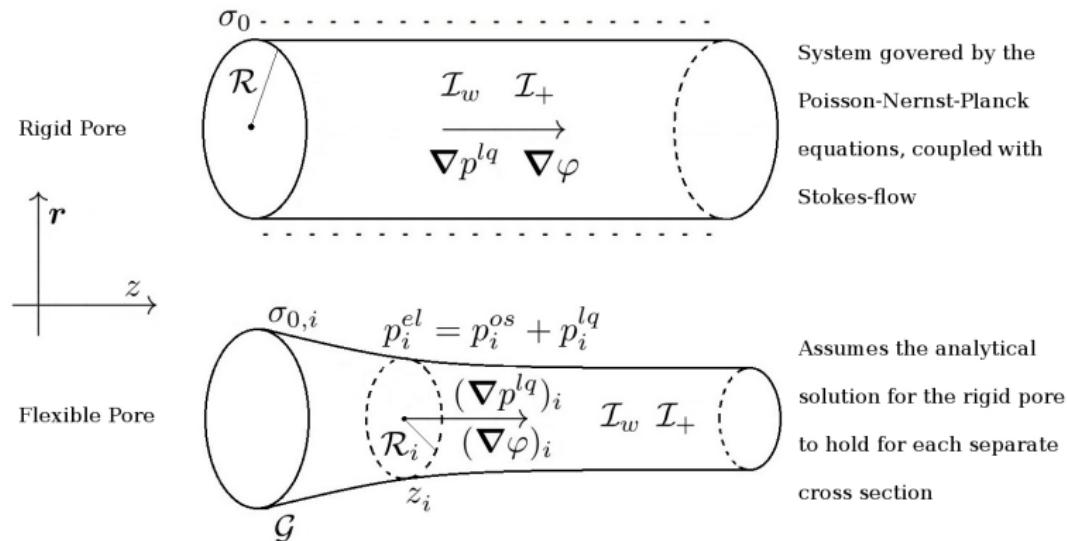


Figure: Schematic overview of a PEM Nanopore as it is modeled.

System of equations

Proton and water flow, Berg&Findlay (2011)¹

$$\mathcal{I}_+ = \mathcal{C}_E^+ \cdot \nabla \varphi - \mathcal{C}_p^+ \cdot \nabla p^{lq} \quad (1)$$

$$\mathcal{I}_w = \mathcal{C}_E^w \cdot \nabla \varphi - \mathcal{C}_p^w \cdot \nabla p^{lq} \quad (2)$$

Pore swelling, Eikerling&Berg (2011)²

$$p^{el} = \frac{2}{3} \mathcal{G} \left[\left(\frac{1}{\eta + 1} \right)^{1/3} - \left(\frac{1}{\eta + 1} \right)^{7/3} \right] \quad (3)$$

$$p^{os} = 2\sigma_0 \left(\frac{\xi}{\eta} \right)^{\frac{2\alpha}{1+\alpha}} \left[\frac{\sigma_0}{4\varepsilon\varepsilon_0} - \frac{R_g T}{\mathcal{F}\mathcal{R}_r} \left(\frac{\xi}{\eta} \right)^{\frac{1-\alpha}{1+\alpha}} \right] \quad (4)$$

$$p^{el} = p^{lq} + p^{os}, \quad \eta = \xi \left(\frac{\mathcal{R}}{\mathcal{R}_r} \right)^{1+\alpha} \quad (5)$$

¹DOI: 10.1098/rspa.2011.0080

²DOI: 10.1039/c1sm05273j, *Soft Matter*, 2011, 7, 5976

Solving the pressure equation

Magnus Dahle,
Peter Berg

The PEM
Nanopore

System of
equations and
assumptions

Solution

Results

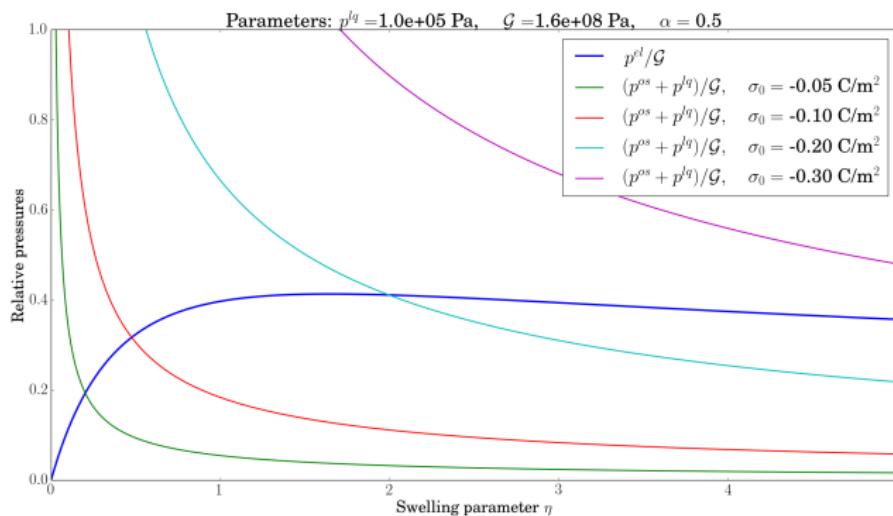


Figure: Graphical solution to equation (5).

Pore Swelling

Magnus Dahle,
Peter Berg

The PEM
Nanopore

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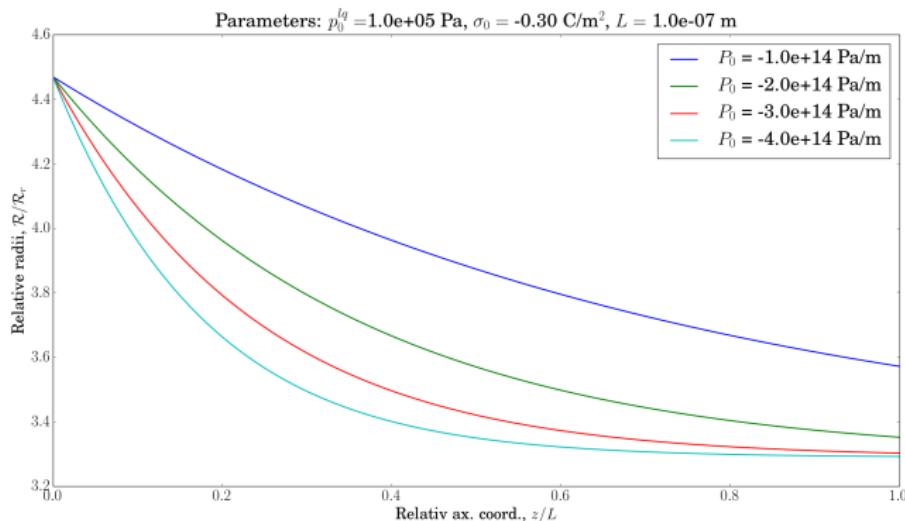


Figure: Solution to equations (1)-(5), $\mathcal{R}(z)$; $\mathcal{R}_r = 10^{-9} \text{ m}$.

Next step: estimate the effective conductivity, and how non-uniform doping may be used to control the flow.

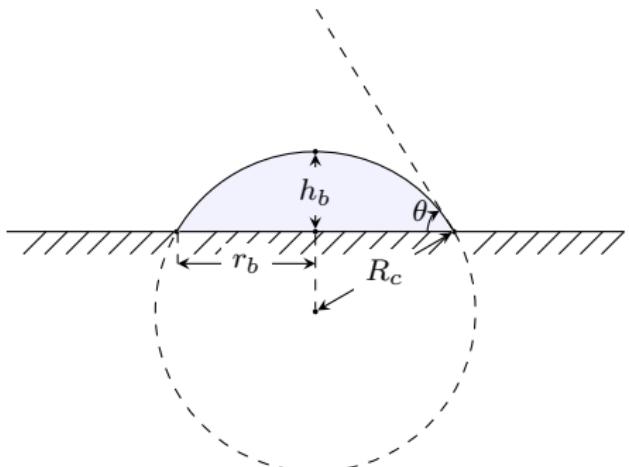
Numerical Simulation of Dynamical Equilibrium Model for Nanobubble Stability in Electrolysis

Knut Sverdrup Kleppestø
Supervisor: Peter Berg

25. November 2014

Surface Nanobubbles^[1,2]

- Gaseous domains on liquid-solid interface
 - Cause reduced effect in PEM fuel cells, but have positive applications such as nanoscopic cleaning in semiconductor industry and slip-control in microfluidics
 - Radii $r_b \sim 20 - 300$ nm,
heights h_b a tenth of this
 - Radii of curvature $R_c \sim 100 - 1500$ nm
and gas-side contact angles $\theta \sim 10^\circ$
 - Laplace pressure $\Delta p = \frac{2\gamma}{R_c}$
Pressure difference of several atm
 - Expect short lifetimes $\tau \sim \mu s$
 - Experimental results show super-stability with $\tau \sim$ days!
 - What is going on?

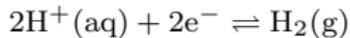
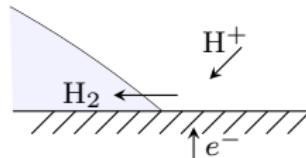
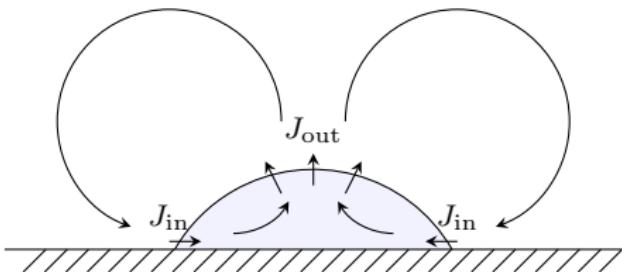


Dynamic Equilibrium Model [3,4]

- One of a few proposed explanations for nanobubble stability
- Suggests that large Δp is balanced by continuous flux into and out of the bubble, i.e. no chemical equilibrium
- Net flux across bubble surface is zero, i.e.

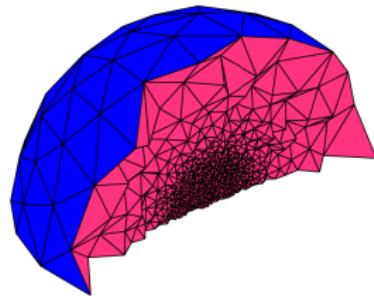
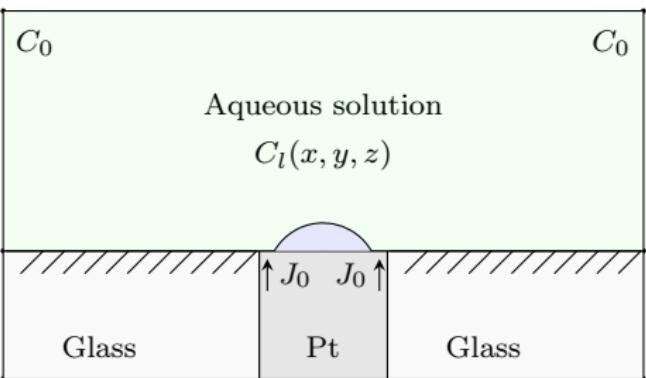
$$J_{in} = J_{out}$$

- Electrolysis: supplied current to substrate allows gas production near bubble edge
- Existence and footprint of nanobubbles investigated using AFM, but the spatial scales are too small for concentration and flux measurements
- Solution(?): computational physics!



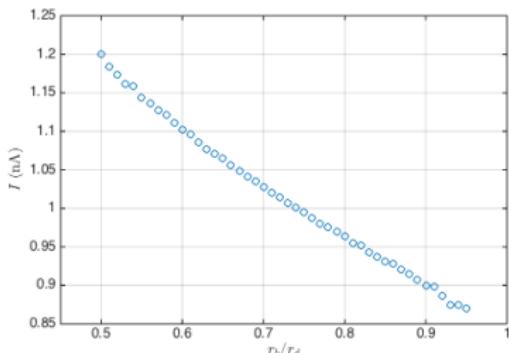
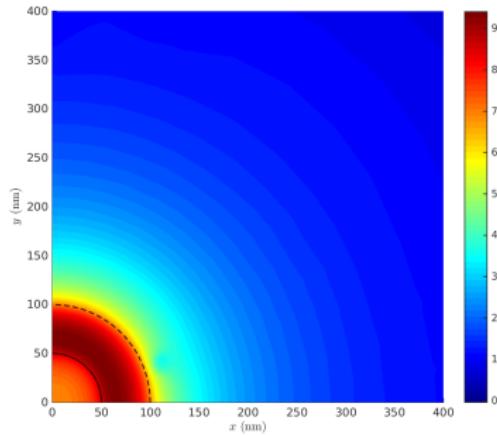
Numerical Scheme

- Consider single nanobubble on nanoscopic platinum disk with current [5]
- Dynamic equilibrium $\Rightarrow \nabla^2 C_l = 0$
- Dirichlet and Neumann BCs on different parts of domain boundary
- Discretization and numerical solution for concentration distribution using FEM
- Integrate flux over bubble surface
- Compare with expected value, alter J_0 , repeat until $J_{\text{in}} = J_{\text{out}}$
- Goal: compare $J_0(r_b)$ with experimental results. Does the dynamic equilibrium model make sense?



Summary

- Surface nanobubbles have an extremely high stability yet to be explained in the literature
- The dynamic equilibrium model is the best theoretical explanation
- We simulate the thermodynamics in a single nanobubble system using FEM to investigate the validity of this model
- Things are going well, further work:
 - Discard flat-bubble approximation
 - Thorough irreversible-thermodynamics approach
 - Bubble interaction: substrate with multiple bubbles
 - Numerical investigation of scaling laws



- [1] William A. Ducker. Contact angle and stability of interfacial nanobubbles. *Langmuir*, 25(16):8907–8910, 2009. PMID: 19624143.
- [2] James R. T. Seddon, Detlef Lohse, William A. Ducker, and Vincent S. J. Craig. A deliberation on nanobubbles at surfaces and in bulk. *ChemPhysChem*, 13(8):2179–2187, 2012.
- [3] Michael P. Brenner and Detlef Lohse. Dynamic equilibrium mechanism for surface nanobubble stabilization. *Phys. Rev. Lett.*, 101:214505, Nov 2008.
- [4] Nikolai D. Petsev, M. Scott Shell, and L. Gary Leal. Dynamic equilibrium explanation for nanobubbles' unusual temperature and saturation dependence. *Phys. Rev. E*, 88:010402, Jul 2013.
- [5] Long Luo and Henry S. White. Electrogeneration of single nanobubbles at sub-50-nm-radius platinum nanodisk electrodes. *Langmuir*, 29(35):11169–11175, 2013.

Commercializing of PEM water electrolysis (PEMWE)

Conductive coatings for bipolar metal plates in PEM water electrolysis

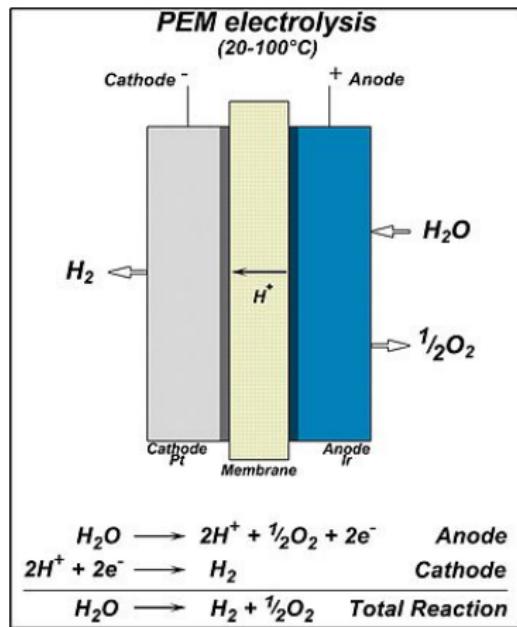
Kjersti Krakhella - MTFYMA

External supervisor (SINTEF-New energy solutions): Anders Ødegård
Co-supervisor (IFY): Peter Berg

Presentation of project work, 2014

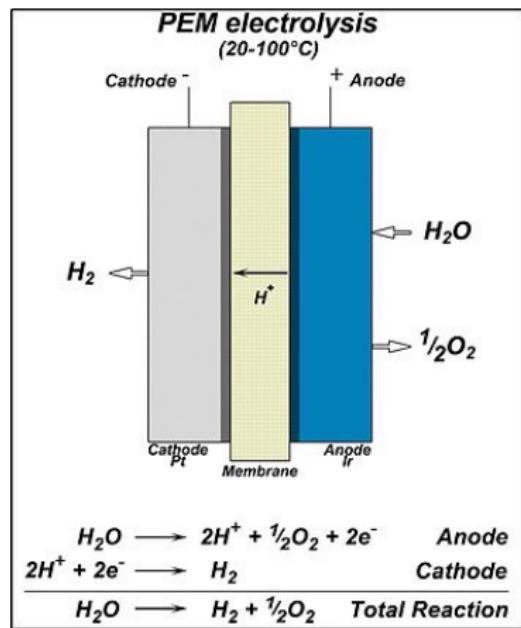
PEMWE: Functionality and Use

- PEMWE is a PEM fuel cell backwards

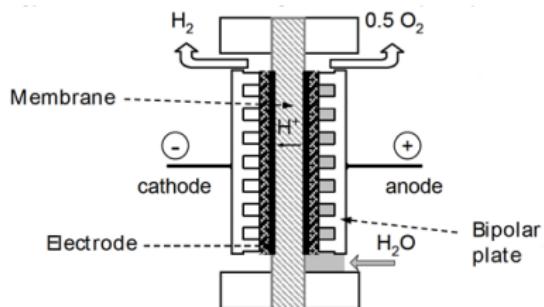


PEMWE: Functionality and Use

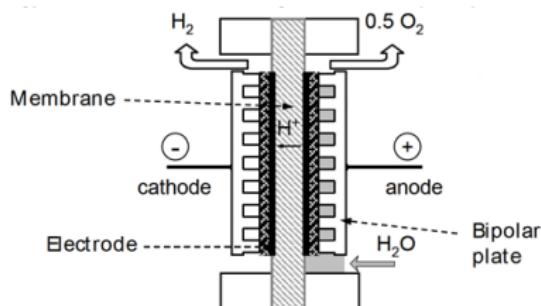
- PEMWE is a PEM fuel cell backwards



A key part of the PEMWE: Bipolare plates



A key part of the PEMWE: Bipolare plates



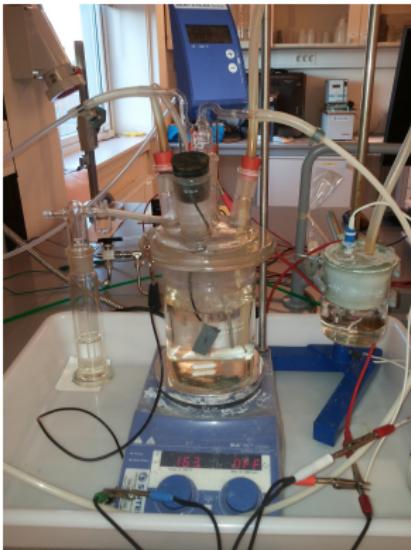
Demands from US Department of Energy for an BPP (by 2015):

- Low corrosion current ($<1 \mu A/cm^2$)
- Low interfacial contact resistance (ICR) ($<0.01 \Omega cm^2$)
- Low cost ($<3\$/kW$)
- Chemically stable in the environment of the electrolysis

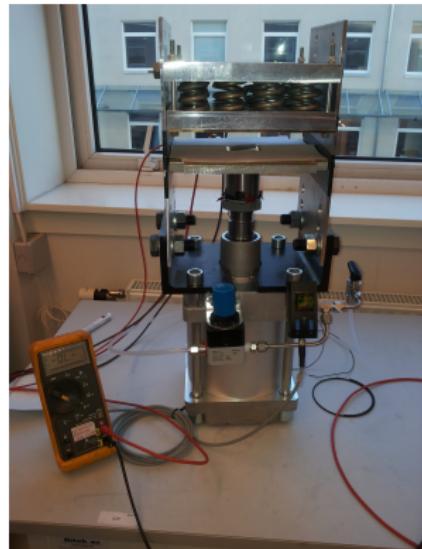
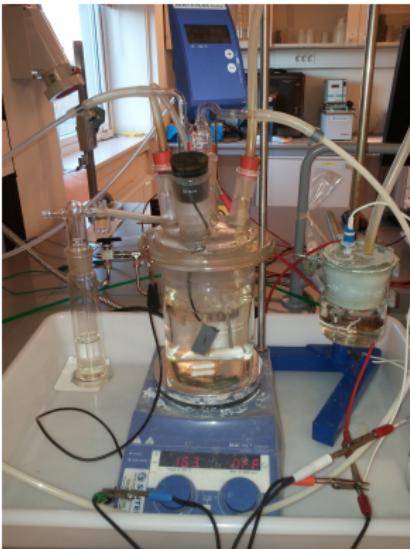
A typical day in my project work



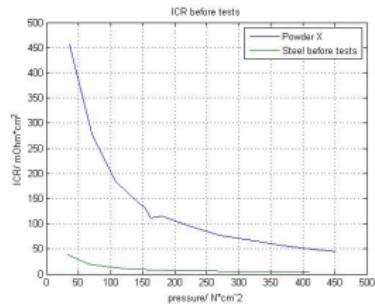
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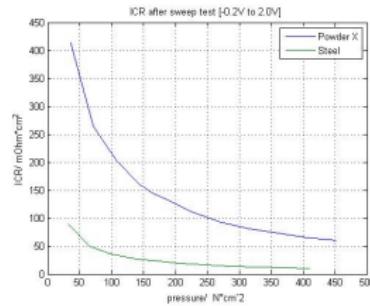
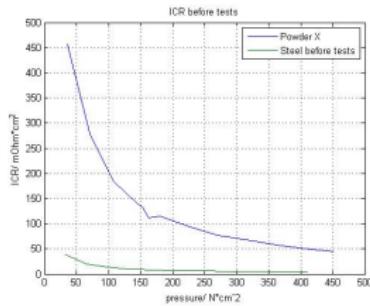
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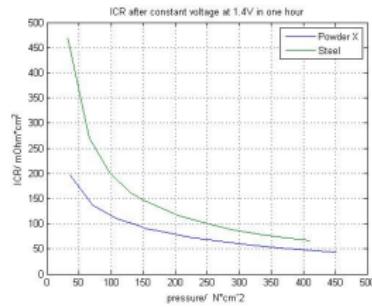
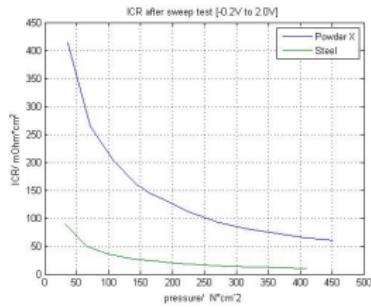
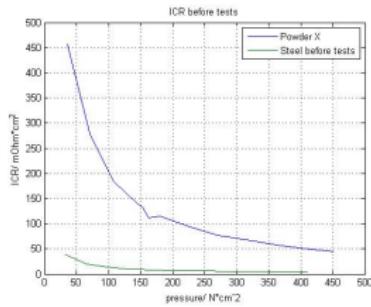
Results from ICR



Results from ICR



Results from ICR



Sources I

-  ENERGY.GOV - Office of Energy Efficiency & Renewable Energy
FUEL CELL TECHNOLOGIES OFFICE, 2014.
-  Novel materials and system designs for low cost, efficient and durable
PEM electrolysers
FUEL CELL TECHNOLOGIES OFFICE, 2013.
-  Wikipedia - picture of basic principle behind PEMWE
Polymer electrolyte membrane electrolysis, 2014.
-  Amazon
Horizon Fuel Cell Technologies Fuel Cell Car Science Kit, 2014.
-  Driving
Toyota expected to name FCV hydrogen vehicle 'Mirai', 2014.
-  Kevin Credible
Water is Fuel for your body, 2014.

Thank you for your attention



New Models for Electric Double Layer

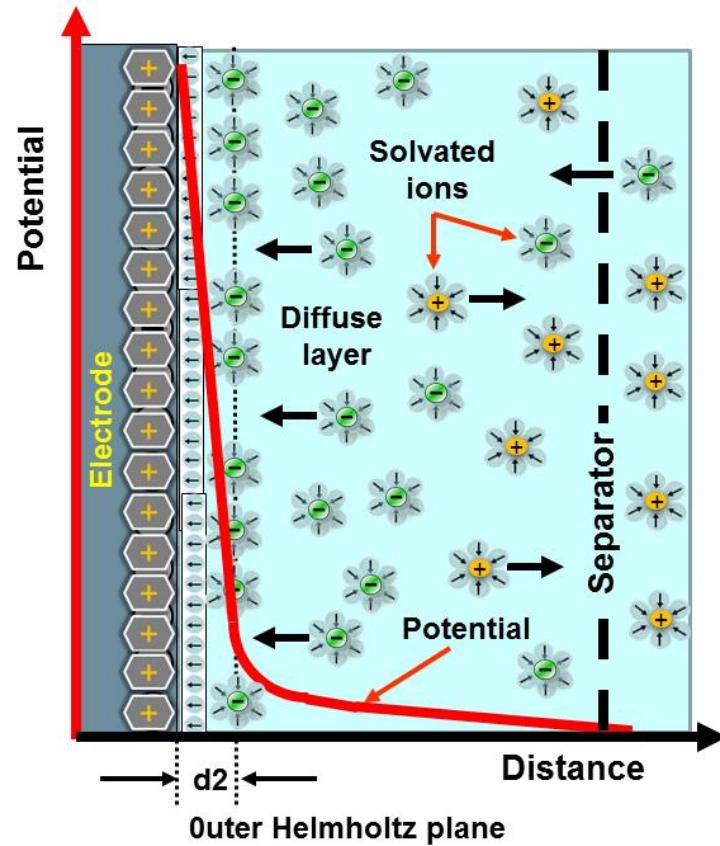
Endre Skeie

Dr. Peter Berg

25.11.2014

Electric Double Layer

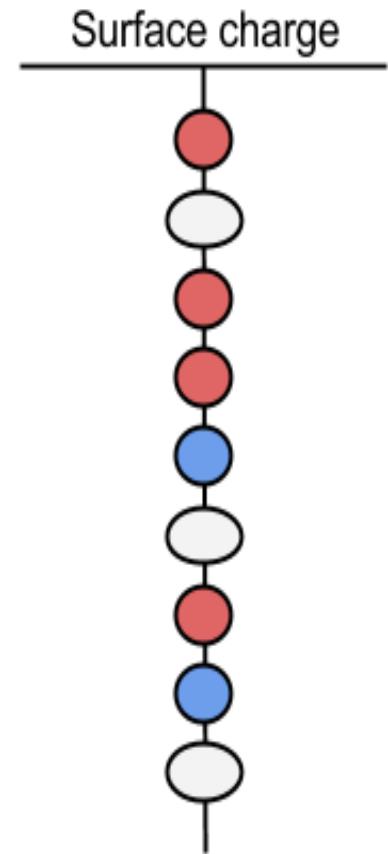
- Everywhere!
- Brief history



[http://en.wikipedia.org/wiki/Double_layer_\(interfacial\)](http://en.wikipedia.org/wiki/Double_layer_(interfacial))

My Model

- Charged surface
- Assumptions
- 1D dynamic grid



Monte Carlo Simulations

- Huge number of possible states
- Importance sampling
- Metropolis algorithm
- Error analysis – correlated
- Exact solution for small system

Summary and questions

- 1D dynamic grid
- Monte Carlo simulations

Electromagnetic plane-wave analysis of the Magnetotelluric Field

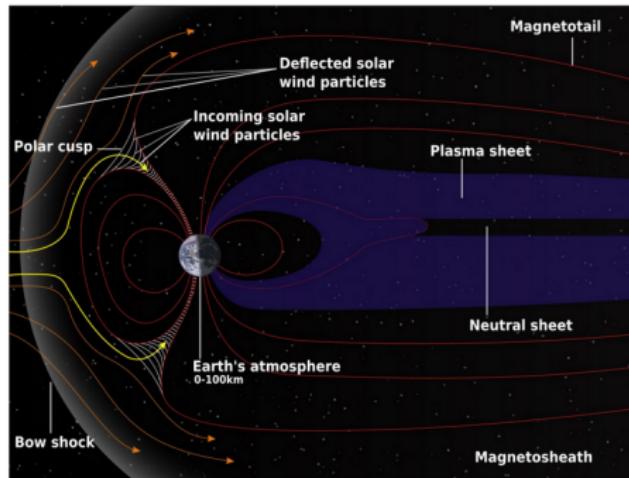
Jean-Michael Poudroux

A Specialization Project in Applied Physics/Geophysics
In cooperation with
Electromagnetic Geoservices (EMGS) ASA

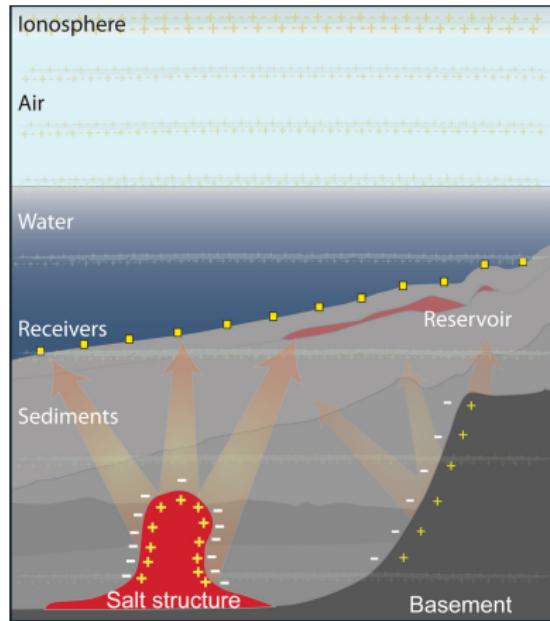
Supervisors:
Arne Brataas (NTNU)
Rune Mittet & Vidar Markhus (EMGS)

November 24, 2014

Short intro MT



MT Source (www.emgs.com)



System overview (www.emgs.com)

Goal: get a model of σ , which represents the subsurface conductivity
This is done via solving the Maxwell Equations

Maxwell Equations

$$\nabla \cdot \mathbf{D} = \rho_f \quad (1a)$$

$$\nabla \cdot \mathbf{B} = 0 \quad (1b)$$

$$\nabla \times \mathbf{E} = -\partial_t \mathbf{B} \quad (1c)$$

$$\nabla \times \mathbf{H} = \sigma \mathbf{E}_f + \partial_t \mathbf{D} \quad (1d)$$

measuring \mathbf{H} and \mathbf{E} in \mathbf{E}^{obs} perform a minimization we can get estimates for σ

$$\epsilon(\sigma) = \sum_{r, \omega, r'} |W(\mathbf{E}(\sigma) - \mathbf{E}^{obs})| + r(\mathbf{x}). \quad (2)$$

Problem 1: How should we model $\mathbf{E}(\sigma)$?

Answer 1: Green functions

$$E_i(\mathbf{x}, \omega) = \int d^3x' G_{ij}^{\text{ES}}(\mathbf{x}, t | \mathbf{x}', t') S_j(\mathbf{x}') \quad (3)$$

Problem 2: What should we use for the source term for the field? $S_j(\mathbf{x}')$?

Answer 2: The most common answer used in MT is a plane-wave formalism

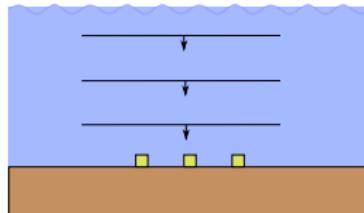
$$\mathbf{S} = \epsilon_{ijk} \hat{\mathbf{x}}_i F_0(x') \delta(\mathbf{x}' - \mathbf{x}'') \quad (4)$$

Problem 3: Is this a good assumption?

Answer 3: This is my project-topic!

My Project

A plane-wave can be written as $\mathbf{E} = \mathbf{E}_0 e^{i\phi}$ and assuming it is incident on receivers embedded in the subsurface



Amplitudes $|\mathbf{E}_0|$ and phases ϕ at the different receivers should correlate

$$C(x, y) = \frac{\sum_j^N (x_j - \bar{x}) \cdot (y_j - \bar{y})}{\sqrt{\sum_j^N (x_j - \bar{x})^2} \sqrt{\sum_j^N (y_j - \bar{y})^2}} \sim 1.0 \quad (5)$$

Should also have the same amplitude and phase

$$A_1 = A_2 = A_3 = A_4 \dots = A_n$$

$$\phi_1 = \phi_2 = \phi_3 = \phi_4 = \dots = \phi_n$$

There's a lot of challenges in dealing with real data (it's noisy!) and MT is low frequency ~ 0.001 Hz thus quite sensitive! This require a sensitive analytical approach combining physics, statistics and programming!

Courses I've found of relevance

- TPG4250 - Electromagnetic Methods in Oil Exploration (Inst. Geophys)
- TFY4240 - Electromagnetic Theory (Inst. Phys)
- TFY4235 - Numerical Physics (Inst. Phys)
- TFY4275 - Classical Transport Theory (Inst. Phys)
- TMA4285 - Time Series (Inst. Math, Statistics)
- TMA4120 - Calculus 4K (Inst. Math)
- General Programming (C++, Python, R)

Thanks for listening!

Any questions?

(jeanmichael.poudroux@gmail.com)



NTNU

Det skapende universitet

Karakterisering av mikroskopiske polymerkuler under mekanisk kompresjon

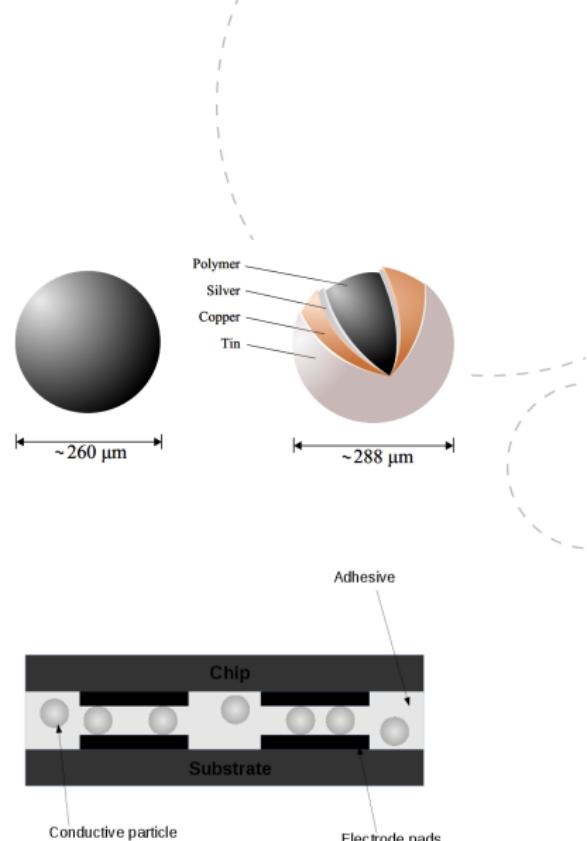
Anette Bakkland
Institutt for fysikk
25. november 2014

Introduksjon

— Bakgrunn:

- Ugelstadkuler
- Industrielle bruksområder
- LCD teknologi

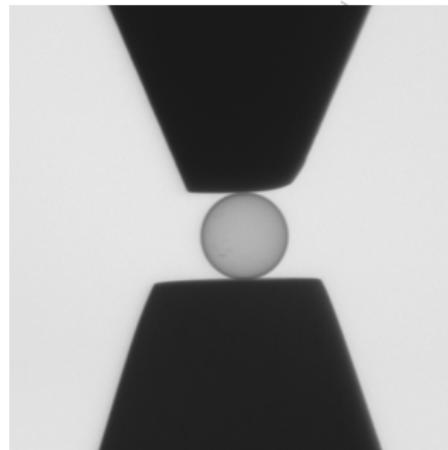
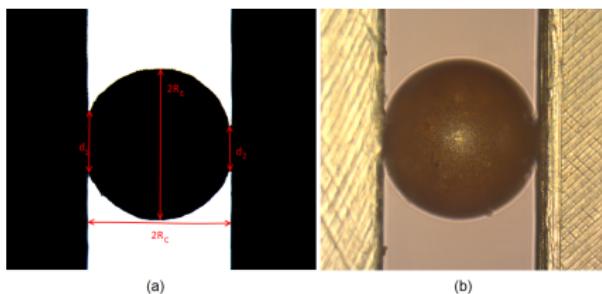
— Problemstilling



Metode

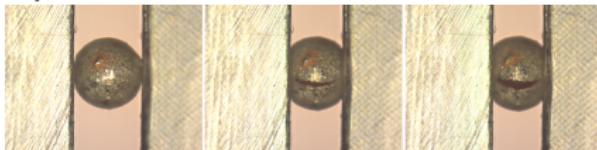
Optisk mikroskopi og X-ray tomografi

- Brudd av overflate
- Ekspansjon vs. kompresjon
- Kontaktareal
- Elastisitet/Viskoelastisitet
- Dataanalayse

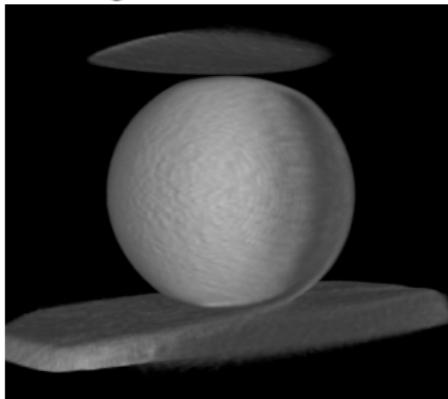


Resultater og konklusjon

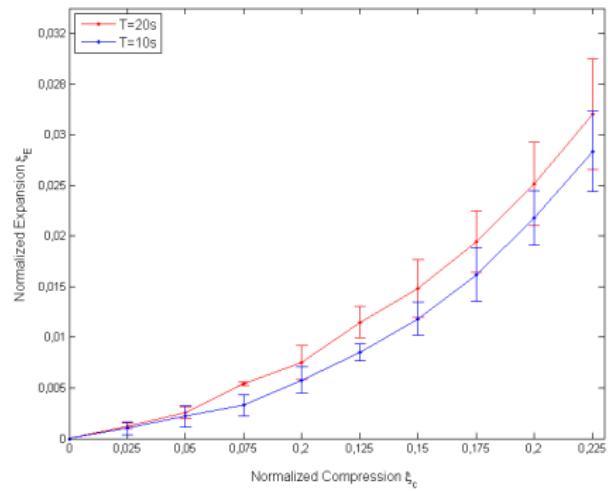
Sprekksdannelse:



Tomografi:



Viskoelastisitet:



Simulated Detection of Atmospheric Gravity Waves by Telescope

Irene Bakken, 25.November 2014

Project supervisor: Prof. Patrick Espy,
Department of Physics, NTNU, Trondheim

What are (atmospheric) gravity waves?

- Restoring force: gravity/buoyancy
- Sources: mountains, thunderstorms ++
- Influence: energy transport in atmosphere
- Detection: radar, CCD-imager

The airglow layers

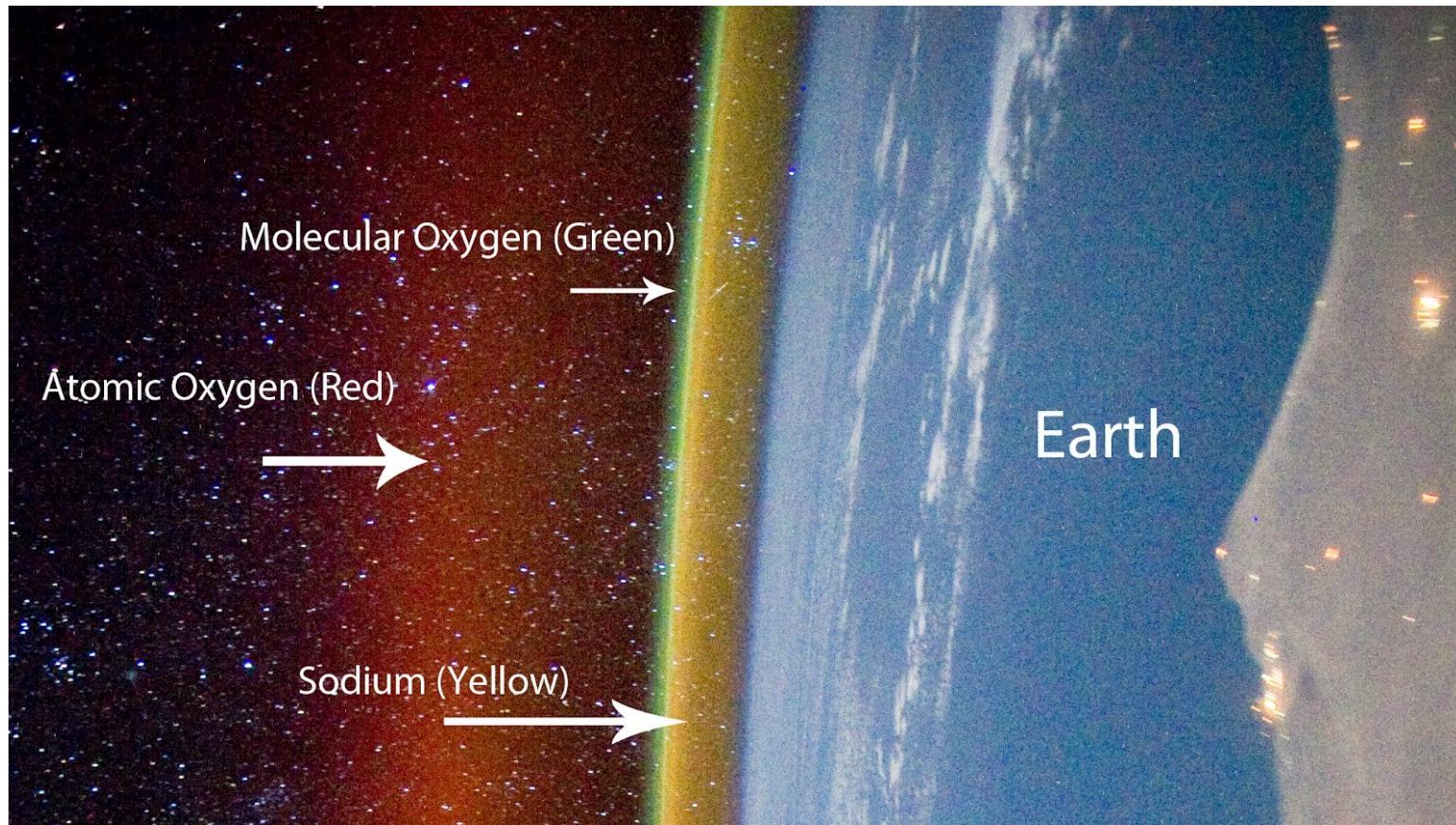


Image source: <http://aurorilightglow.blogspot.no/2012/05/night-glow.html>

Gravity wave moving through airglow layer

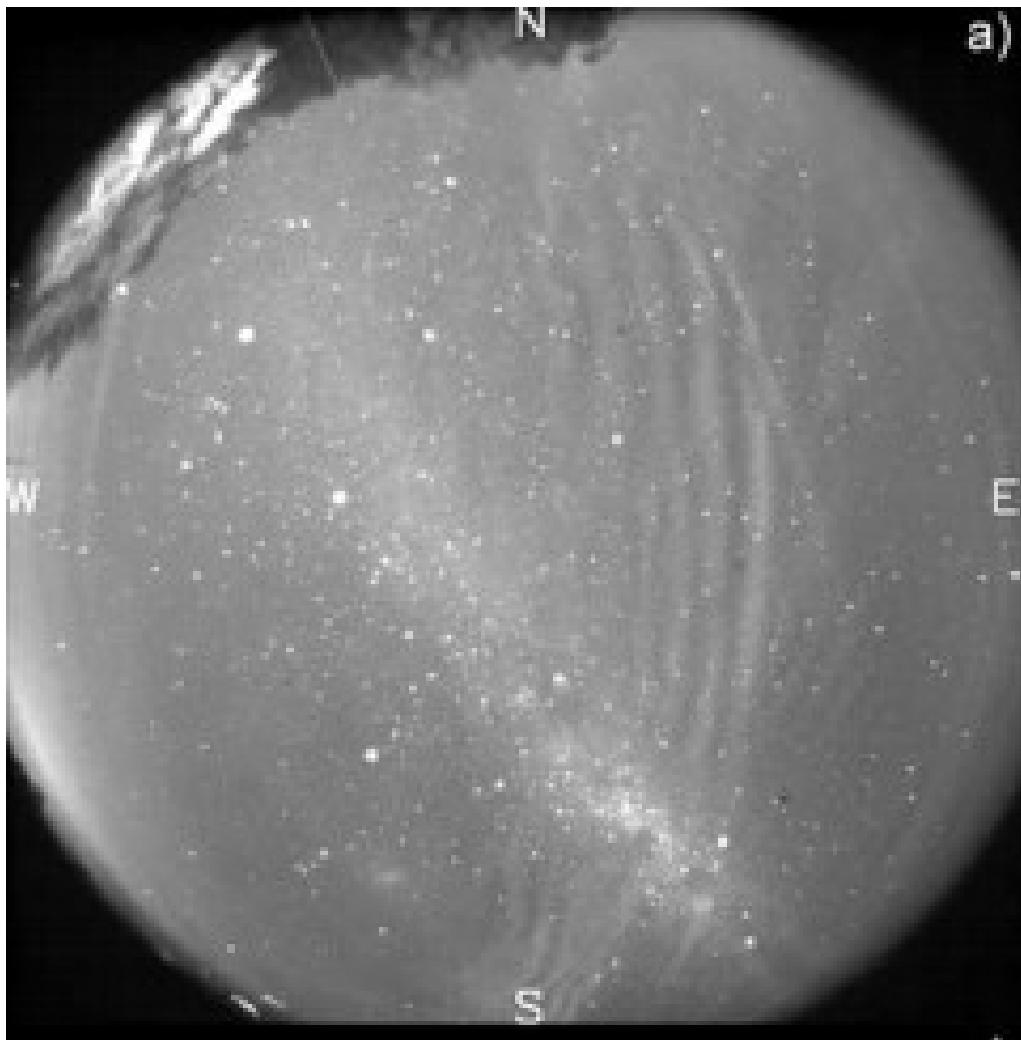
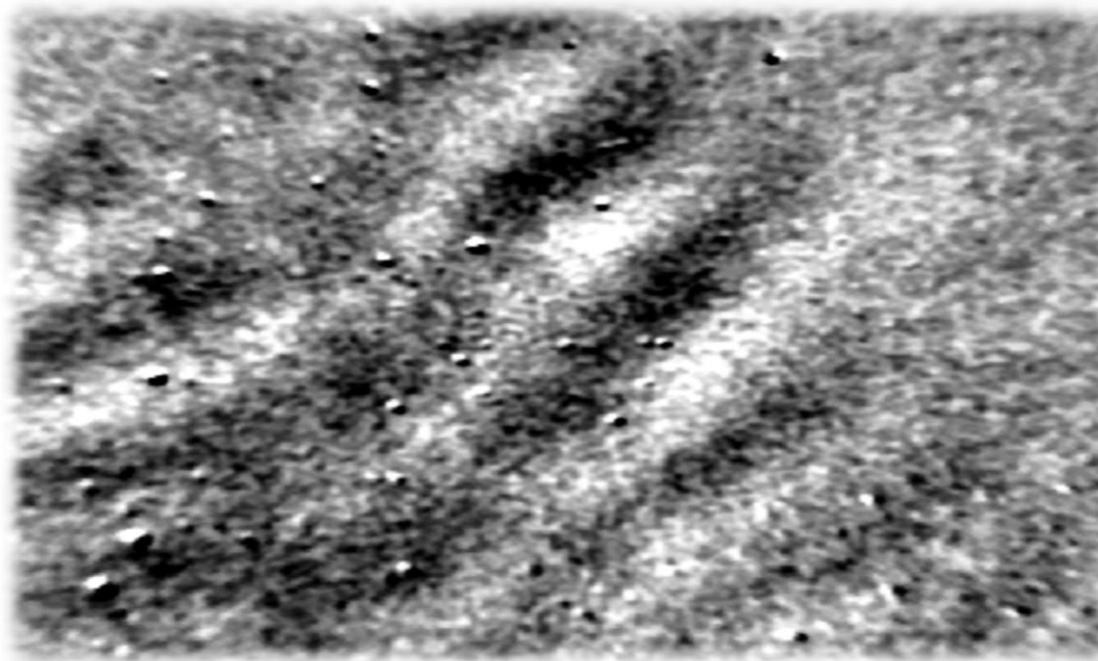


Image source: Medeiros, Taylor, Takahashi, Batista, Gobbi, (2003), «An investigation of gravity wave activity in the low-latitude upper mesosphere (...»), *Journal of Geophysical Research*, vol. 108

My project: Simulation

- Measure intensity at a few «points»
- Estimate error
 - Direction
 - Wavelength
- Detection scheme for the Nordic Optical Telescope

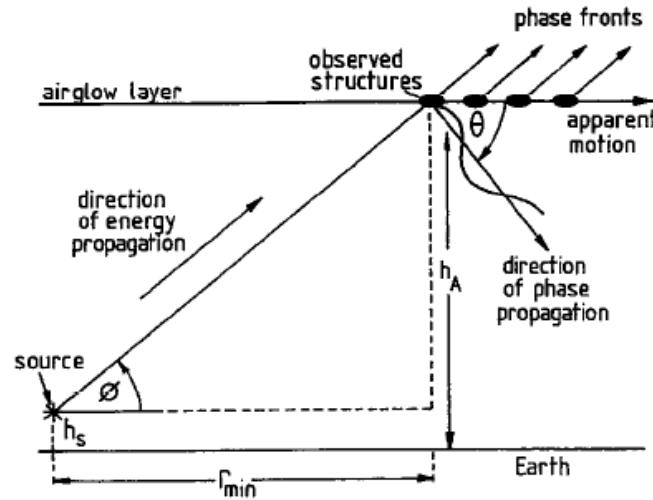
Tracing gravity waves



Sjur Vorkinn

Gravity waves

- Observe them at ~ 90 km
- Done with a CCD camera
- 3-6 hrs. travelling time
- Measure height, speed, direction, phase etc.



Task

- Don't know sources, and how they vary
- Problems with weather models and static atmosphere
- Use ray-tracing program to trace the waves
- To use GROGRAT, we need an atmospheric model that vary with time, with correct parameters
- NRLMSISE-00 Model, HWM07

References

- Nærø, Karoline; Gravity Wave Refraction in the Atmosphere: Ray tracing versus Geometric Location from a Single Image, 2013
- <http://ccmc.gsfc.nasa.gov/modelweb/>
- Supervisor: Patrick Joseph Espy, IFY

TFY4510
Active matter and collective motion

Supervisors: J.O Fossum, P. Dommersnes, A. Mikkelsen

November 24, 2014

Abstract

By taking advantage of a phenomenon known as Quincke rotations, it is possible to make PMMA particles, suspended in a conducting uid, undergo collective motion. While the experiments have yielded results, it is currently unknown if the observed motion is due to Quicke rotations or due to electrohydrodynamic flow in the conducting fluid

1 Introduction

This project has been centered on active matter and collective motion using Quincke rotations[?]. The main purpose of these initial experiments have been to check the results presented by Bartolo et al. in the article [?], by using particles of a different size, and different container geometry and dimensions.

2 Active matter

Active matter is defined as a system consisting of several objects, each of which consumes energy in order to move. Most such systems are biological in origin, for example schools of fish or a swarm of mosquitos, but there are also non-biological systems which exhibits these properties. In our experiments, we have used micrometer sized PMMA (poly(methyl methacrylate)) particles. Non-biological active matter is a relatively new field within soft matter physics[?].

3 Collective motion

When discussing the movement of active materials, we are predominatly interested in their collective momements as opposed to individual particle movements. When studying active matter one is therefore more interested in flock behaviour and self organizing formations. Thus, collective motion is something usually associated with biological systems.

4 Quincke Rotations

In order to propell the PMMA particles, we make use of the phenomenon refered to above, called Quicke rotations. When non-conducting particles are suspended in a conducting fluid, and an external electric field is applied, opposite charges will begin to accumulate on either sides of the particle. This creates an dipole across the particle. This dipole will seek to align itself with the external field causing the particle to rotate. If the electric field exceeds a critical value, E_Q , then the particle will not stop rotating as longs as the field remains on, we then have Quincke rotations¹. The rotating particles interact with each other both electrostatically and hydrodynamically. Using this it is possible to set up equations of motion for the system.

The electrostatic field and the induced hydrodynamic flow field will compete with each other. This means that the system can exists in two states, an isotropic

¹It is assumed that the charge relaxation time of the particles exceeds that of the fluid

state and an macroscopic ordered state², with the latter state being the source of the observed collective motion. The transition from the isotropic state to the ordered state occurs when the particle density exceeds a critical fraction ϕ_c , the following two videos demonstrate the effect of particle density and collective motion Band propagation (close view) Band propagation.

5 Experimental setup

The experimental setup we used involves PMMA particles with a radius of $40\mu\text{m}$. The particles are dispersed in an 0.15mol l^{-1} AOT/Hexadecane solution. The solution is then placed inside a chamber cut out from a PVC plates. Several plates featuring different chamber geometries were made, the thickness of the plates were 2mm and 1.5mm. The plates were covered by two ITO-coated glass plates which served as electrodes. The electrodes were then connected to an voltage source. In some experiments we used castor oil instead of hexadecane.

6 Results

The following video demonstrates one of the results we have gotten so far Good result?. We have observed circular like flow patterns in the suspending fluid that are not caused by the Quincke rotations, and may influence our results. These circulations are very prominent along the edges of the chamber and may be electro-hydrodynamic in nature. We are therefore investigating ways minimizing the effect of these circulations.

References

- [1] Ueber Rotationen im constanten electrischen Felde. Quincke, G. Ann. Phys. Chem. 59, 417486 (1896)
- [2] Emergence of macroscopic directed motion in populations of motile colloids. Antoine Bricard , Jean-Baptiste Caussin, Nicolas Desreumaux , Olivier Daucho & Denis Bartolo, Nature, 503, 95-98 (2013)
- [3] Hydrodynamics of soft active matter. M.C. Marchetti, J.F. Joanny, S. Ramaswamy,T.B. Liverpool, J. Prost, M. Rao, R.A. Simha, Reviews of Modern Physics, 85, 1143 (2013)

²The electrostatic field promotes rotational diffusion, while short range hydrodynamic interactions promotes polar ordering

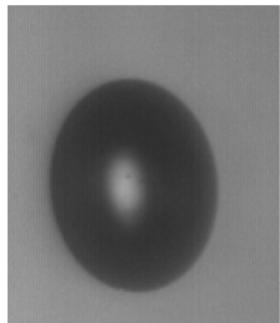
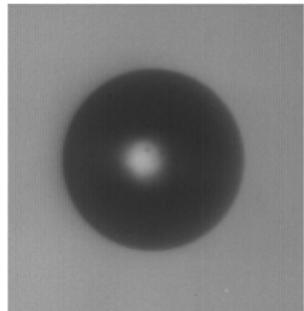
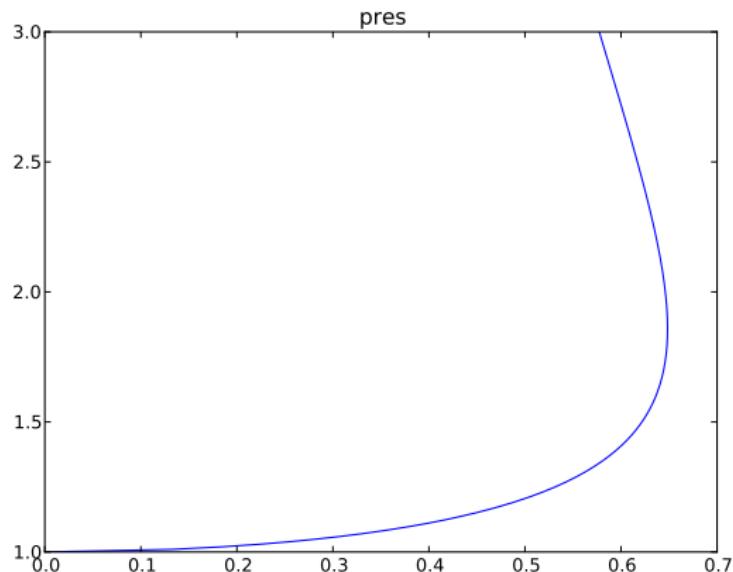
Elektrisk eksitasjon av vanndråper i olje

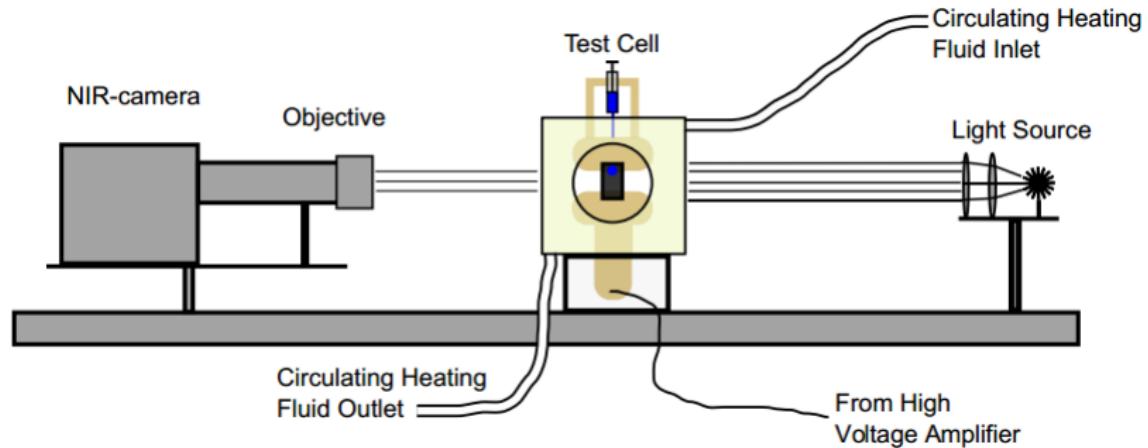
Torstein Eidsnes Penne – NTNU

I samarbeid med SINTEF Energi

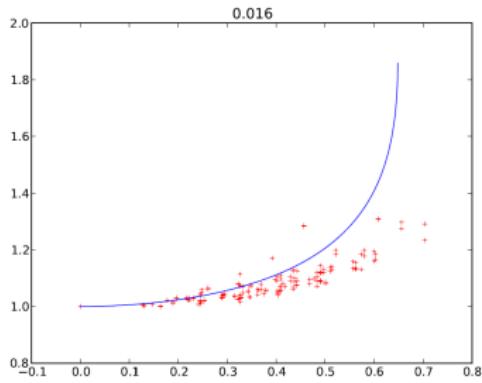
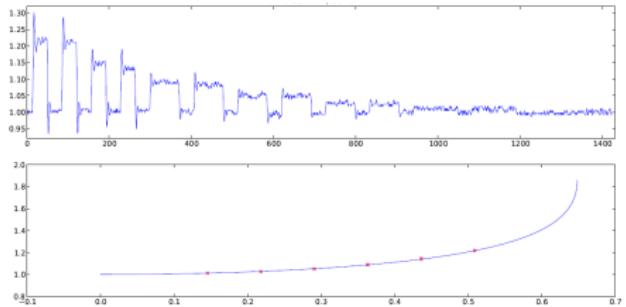
25. november, 2014

Teori





Resultater



- Økt oljeutvinning
- Effekt av forskjellig feltform
- Modellolje vs råolje

Correlation between the NAO and winter temperatures over Norway

Student: Hanne Linde

Supervisor: Prof. Robert Hibbins

Atmosfærefysikk

- * Høytrykk-lavtrykk system i Atlanteren (NAO) påvirker vinteren i Norge
- * Ser på temperaturendringer i perioden 1980-2014
- * Finner så korrelasjonen mellom disse to
- * Enkelt ved bruk av MATLAB

NAO - North Atlantic Oscillation

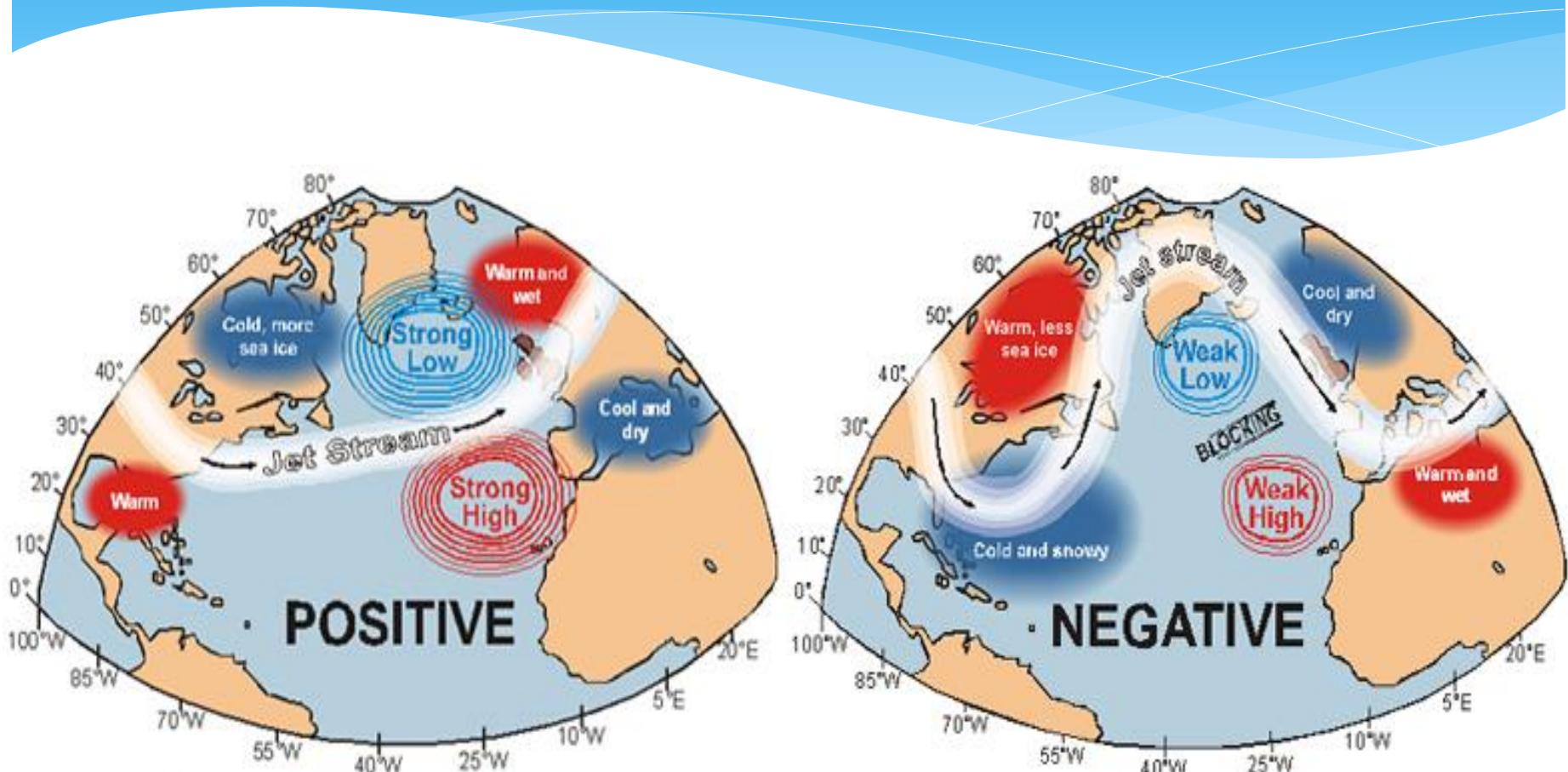
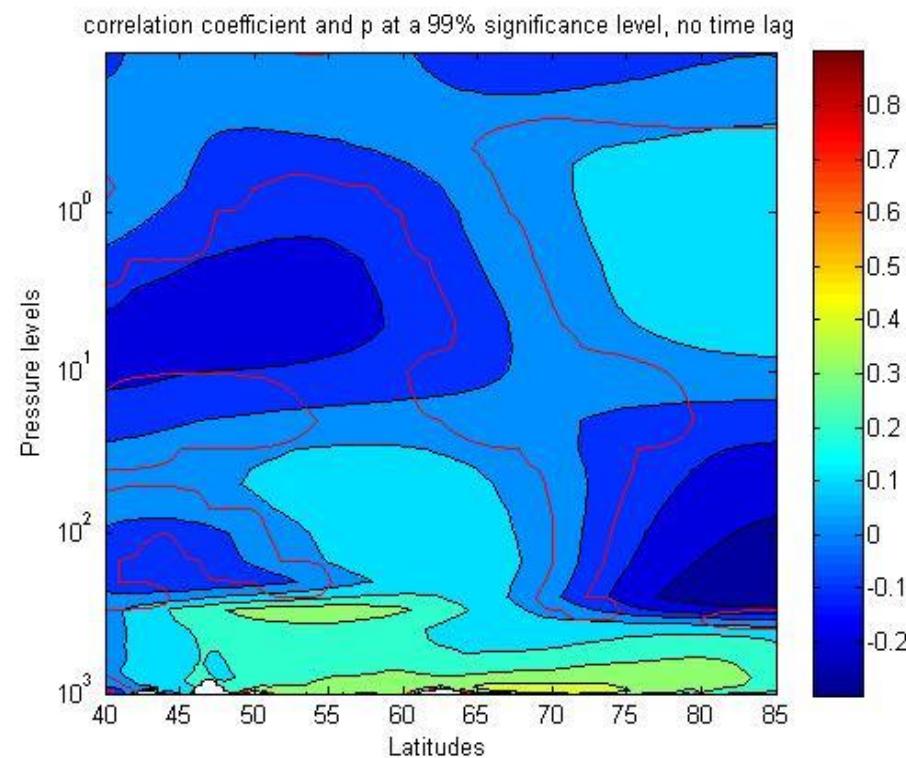
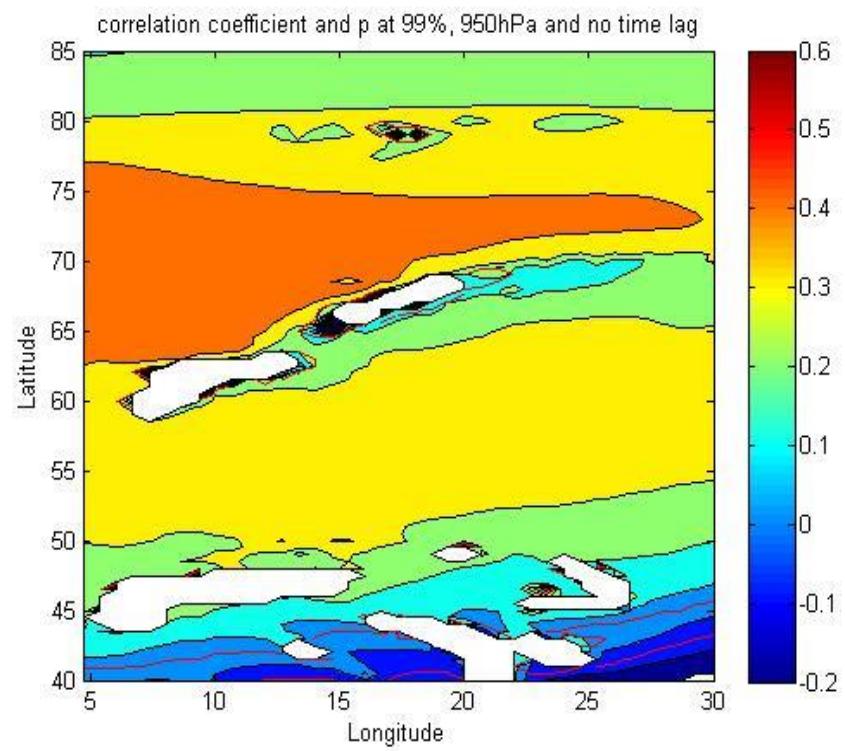


Fig. 2. Diagram showing the NAO in the positive mode.
© Severn Estuary Partnership, 2012.

Fig. 3. Diagram showing the NAO in the negative mode. © Severn
Estuary Partnership, 2012

Noen resultater

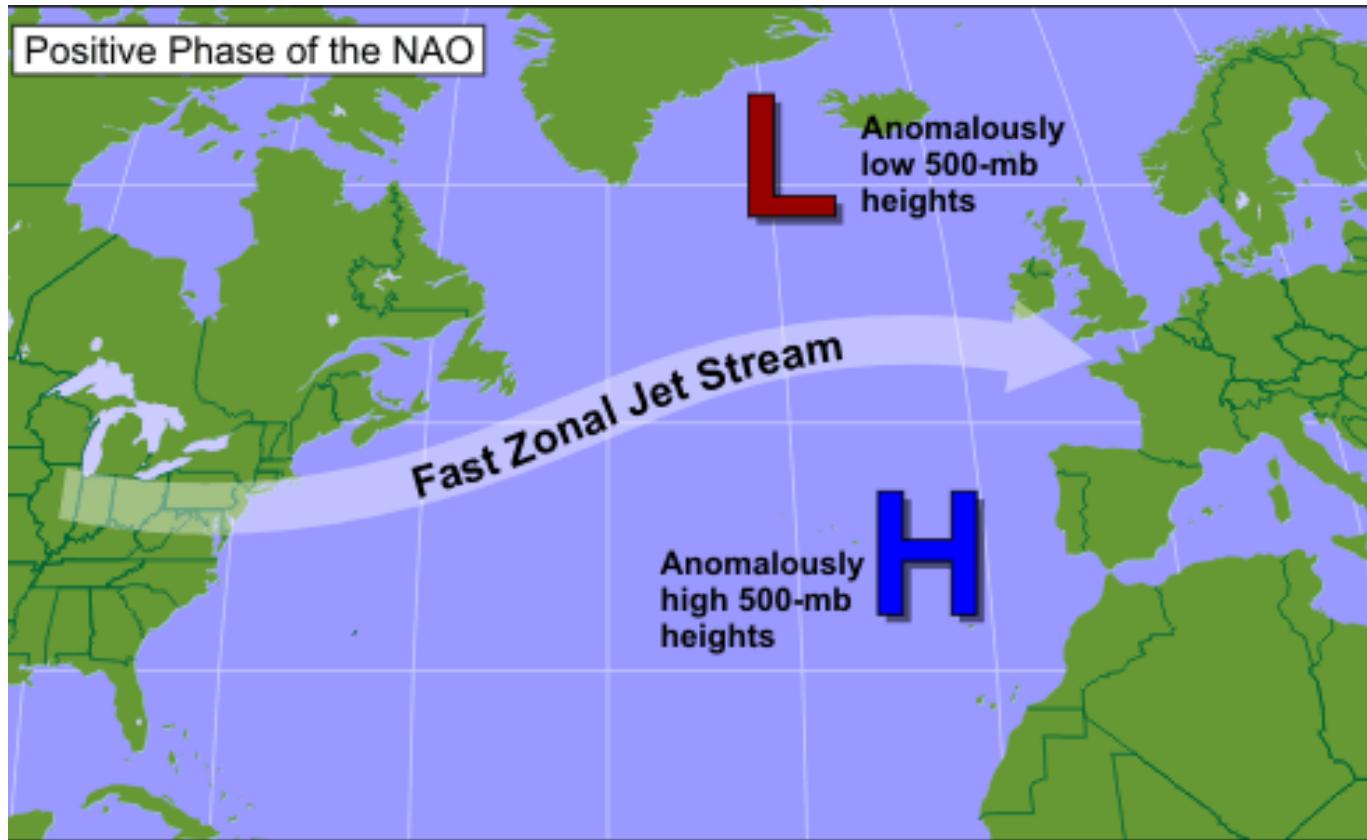


Korrelasjon mellom NAO og norske vintertemperaturer

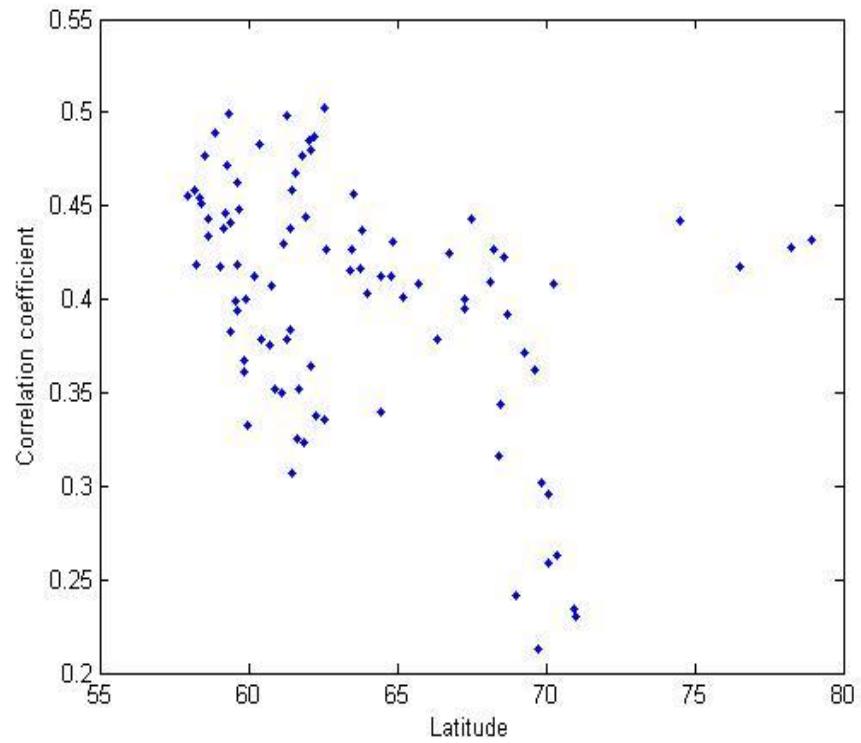
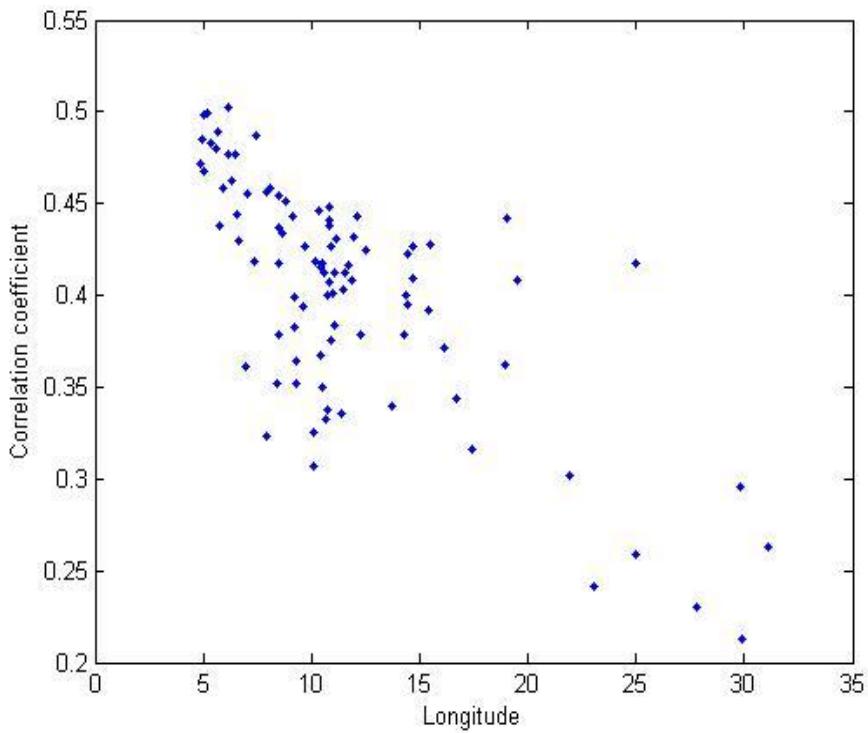
Mats Nordhagen



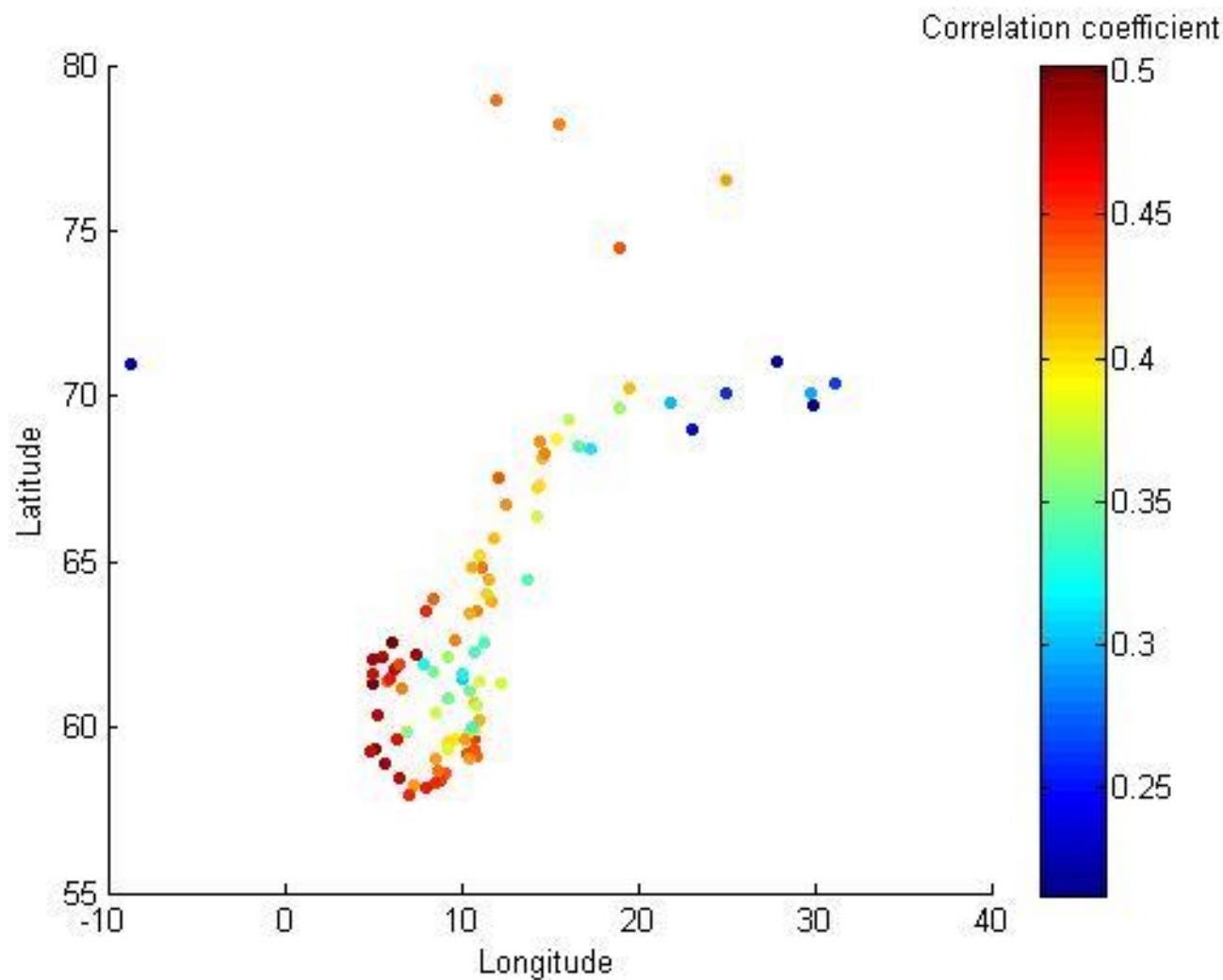
North Atlantic Oscillation



Lengde-/breddegrad vs. korrelasjon



Lengde- vs. Breddegrad vs. korrelasjon



Oppsummering

- NAO påvirker norske vintertemperaturer
- Høyest korrelasjon sørvest – avtar østover og nordover
- Kort kystavstand virker å gi høy korrelasjon



NTNU

PROSJEKTOPPGAVE

**TEM av Cr dopet ZnS tynnfilm
for mellombånd solceller.**

Student:

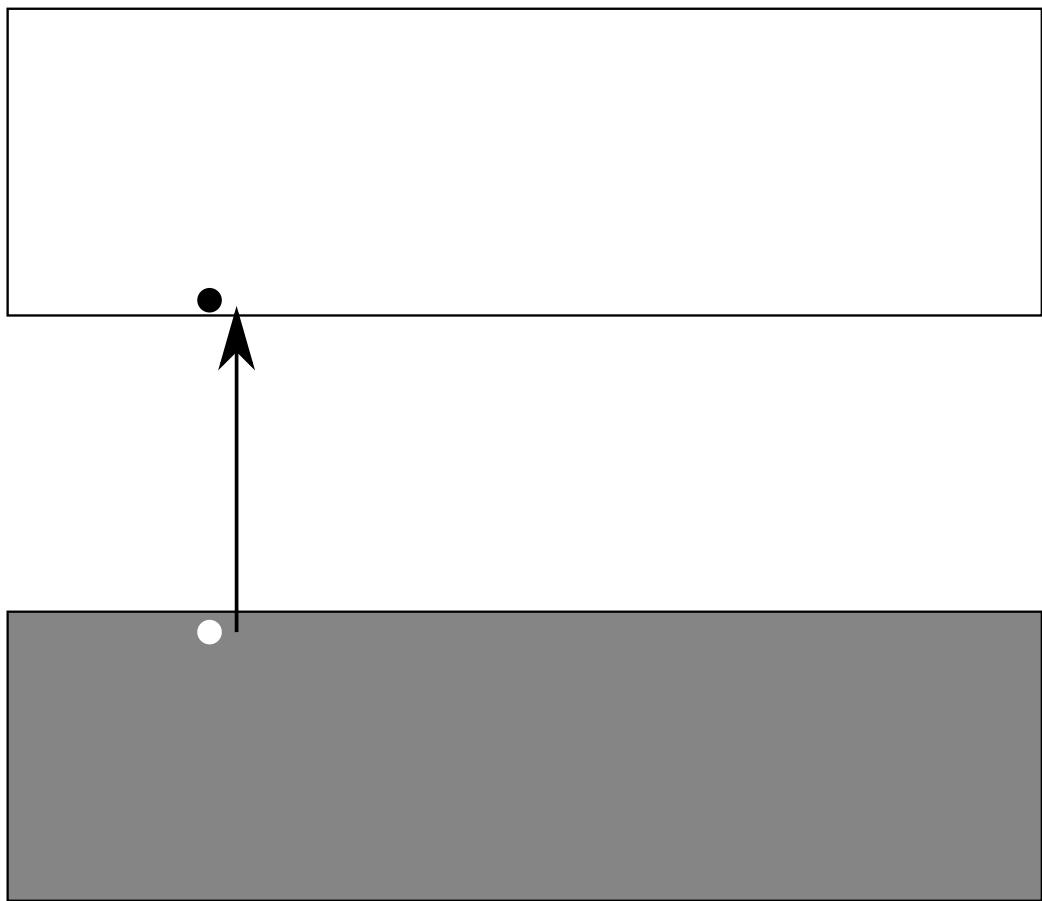
Joakim LARSEN

Veileder:

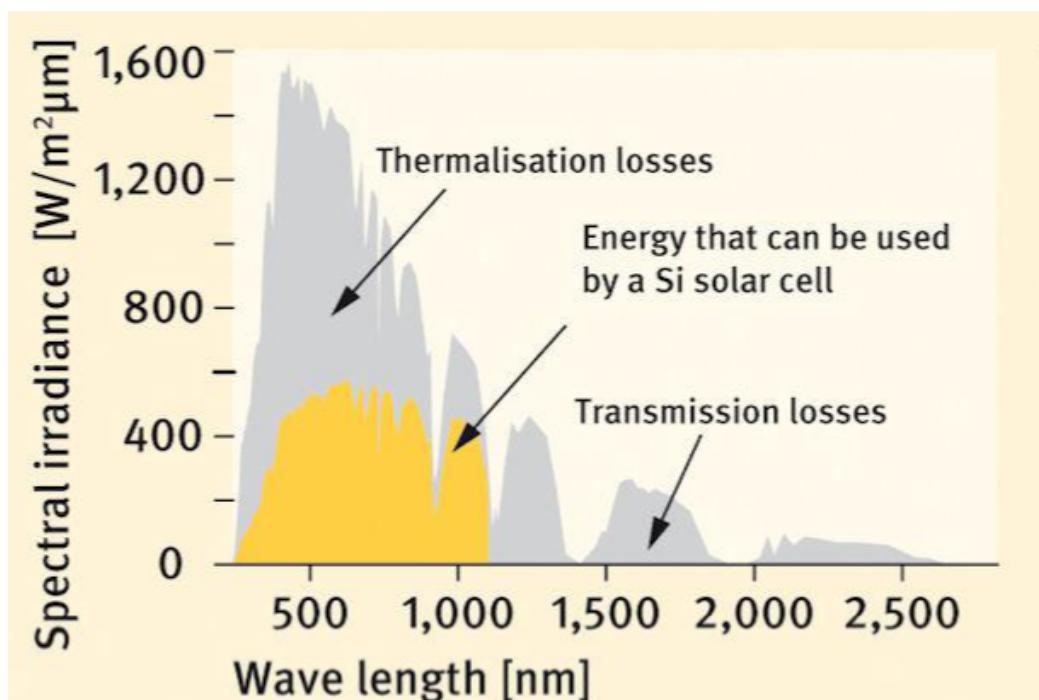
Randi HOLMESTAD

25. november, 2014

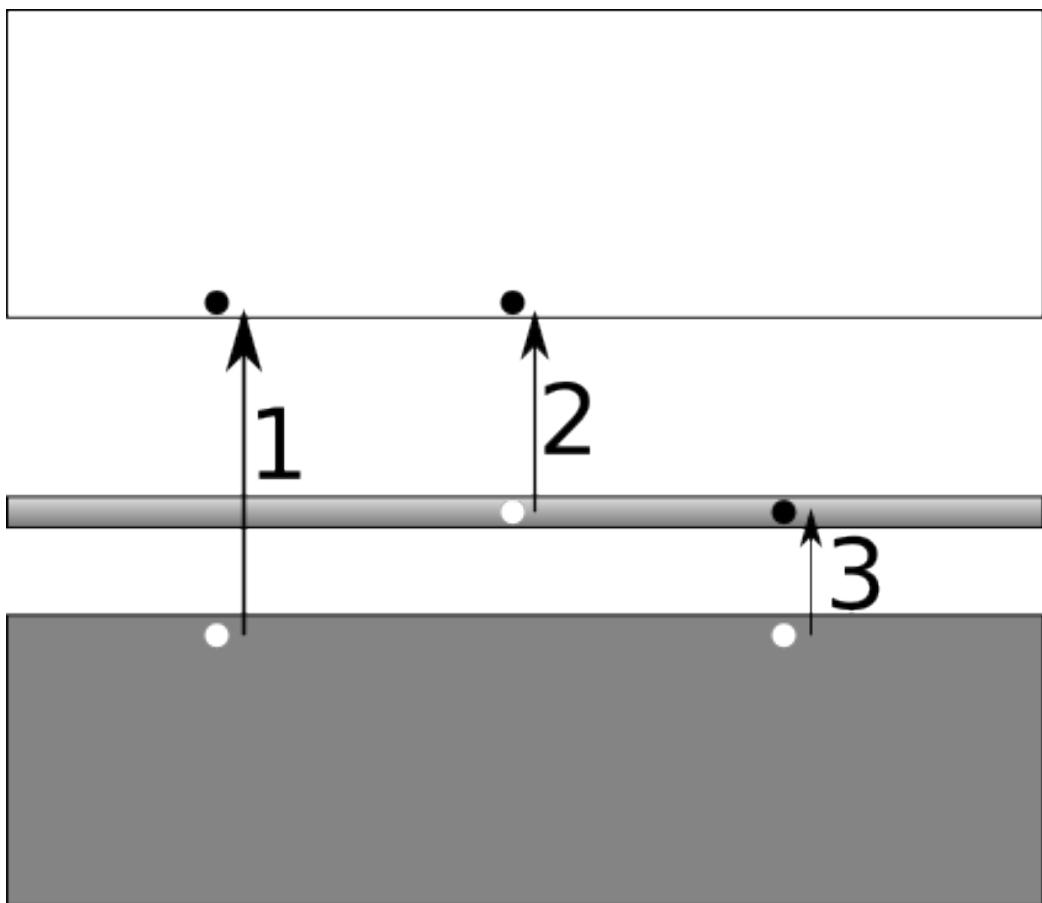
TEM av Cr dopet ZnS tynnfilm for mellombånds solceller.



TEM av Cr dopet ZnS tynnfilm for mellombånds solceller.



TEM av Cr dopet ZnS tynnfilm for mellombånds solceller.



Cancellation of infrared divergences in QCD

Daniel Wennberg

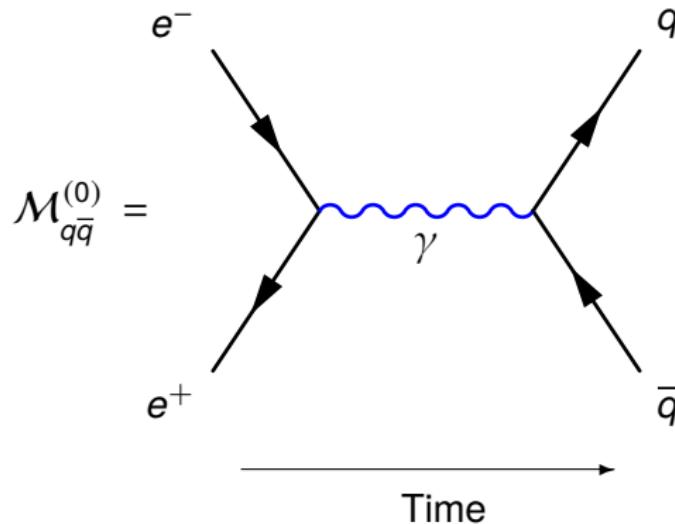
TFY4510 Specialization project, fall 2014

Quantum Chromodynamics (QCD)

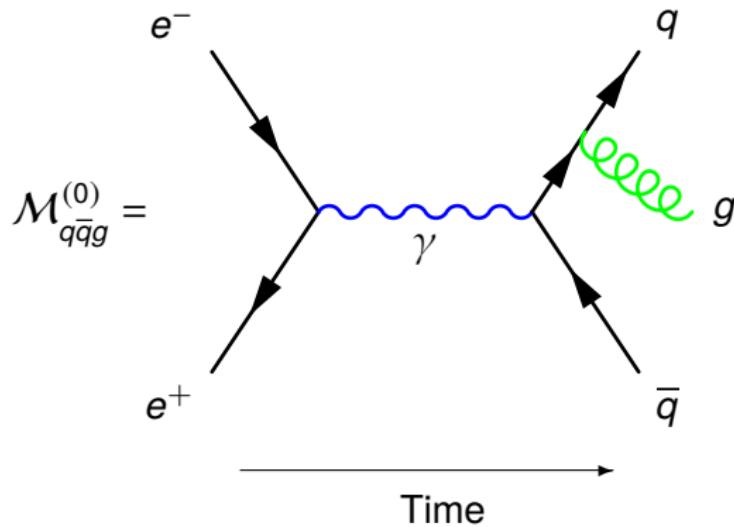
- The theory of strong interactions between *quarks* and *gluons*
 - the constituents of protons and neutrons

QCD		QED	
color charge	r, g, b	\pm	electric charge
quarks	q 	e^-	electrons
gluons		γ	photons

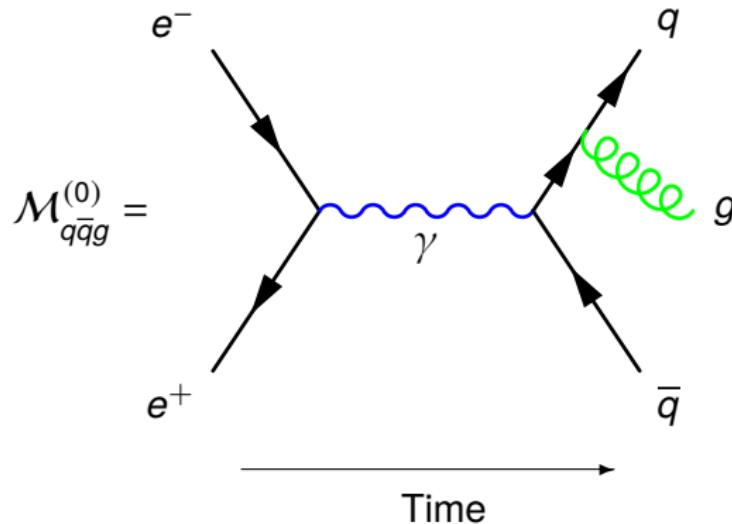
Example: $e^+e^- \rightarrow q\bar{q}$



Example: $e^+e^- \rightarrow q\bar{q}g$



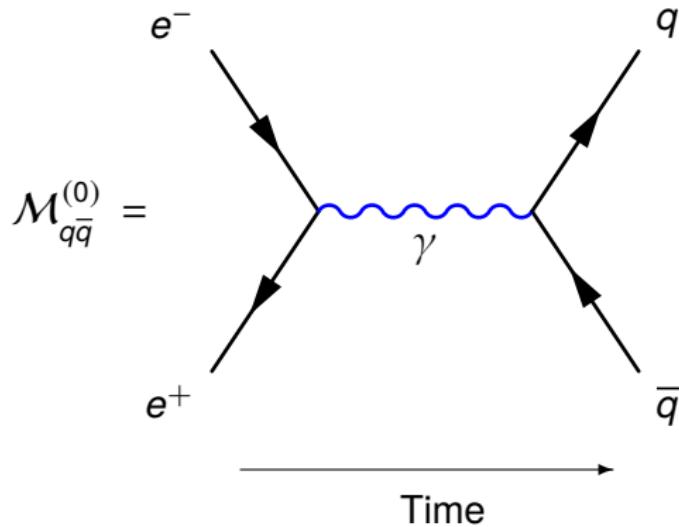
Example: $e^+e^- \rightarrow q\bar{q}g$



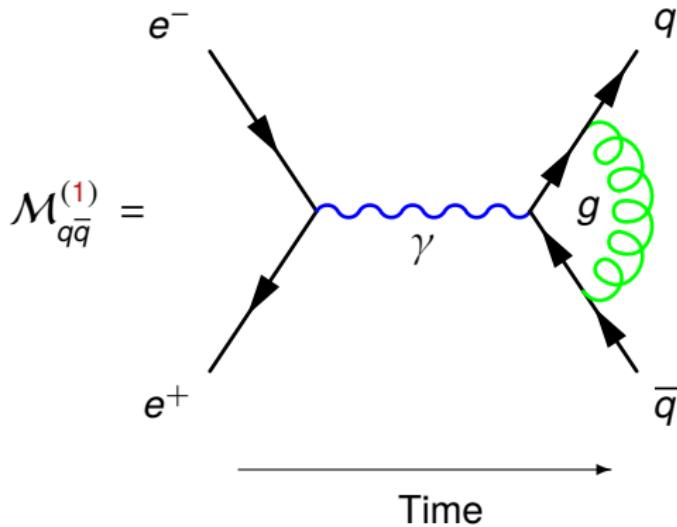
Infrared divergence

$$\left| \mathcal{M}_{q\bar{q}g}^{(0)} \right|^2 \rightarrow \infty \text{ as } E_g \rightarrow 0$$

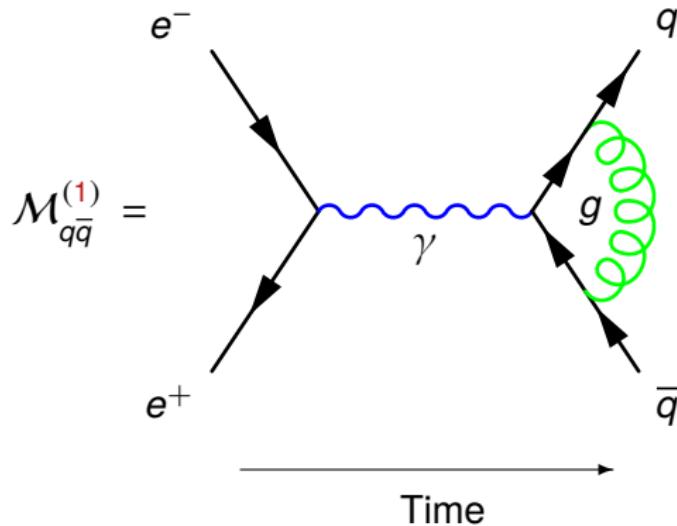
Add all the terms!



Add all the terms!

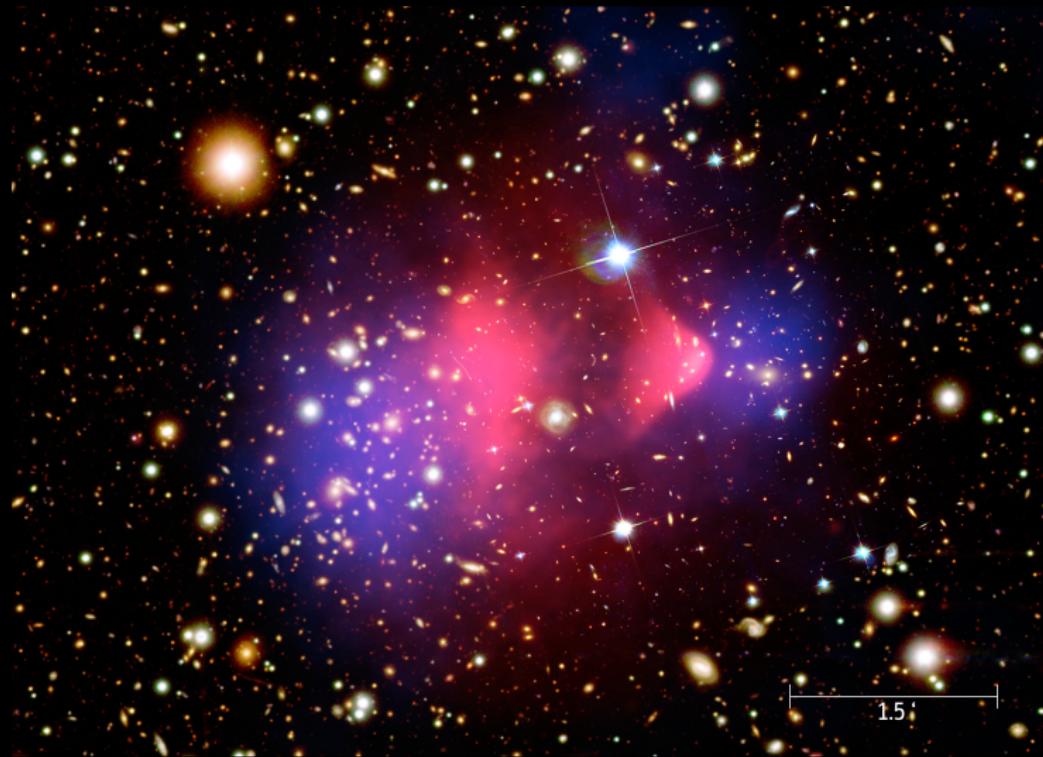


Add all the terms!



Cancellation

Combining $\left| \mathcal{M}_{q\bar{q}}^{(0)} + \mathcal{M}_{q\bar{q}}^{(1)} \right|^2$ and $\left| \mathcal{M}_{q\bar{q}g}^{(0)} \right|^2$ gives a finite result

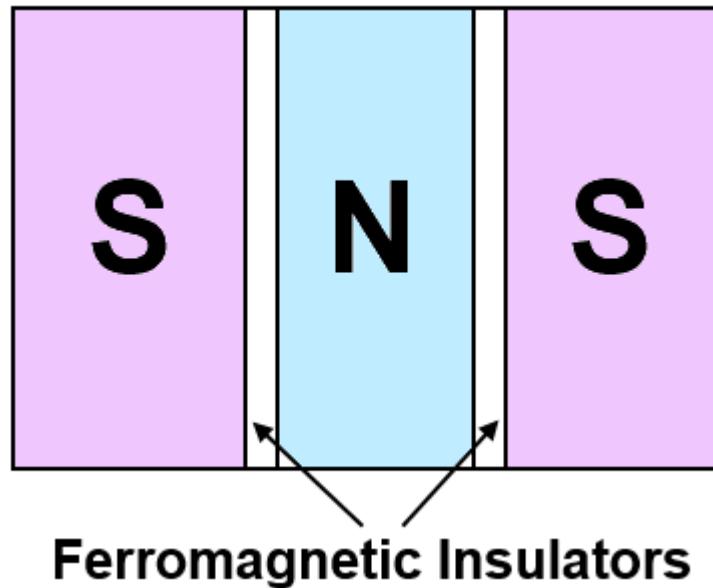


Dark Matter

Introduction to Odd-Frequency Superconductivity in Josephson Junctions

Ingvild Ruud Gomperud
Theoretical Physics

Josephson Junction

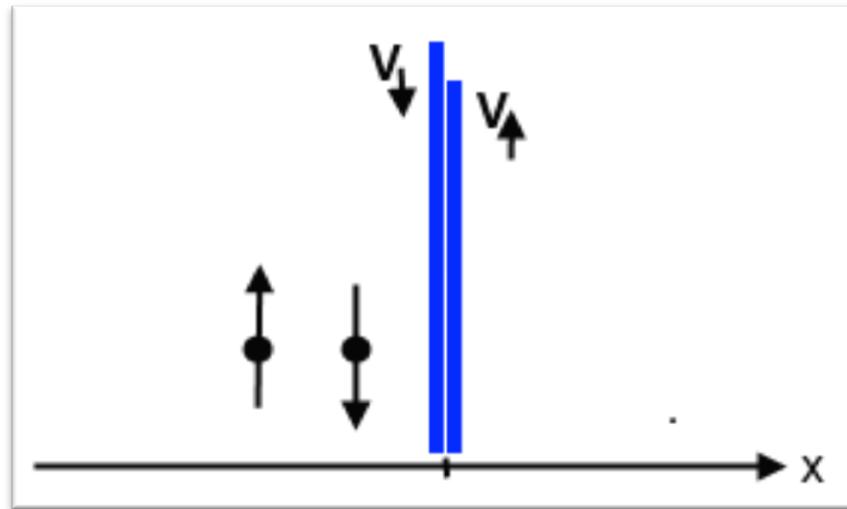


◎ Superconductivity:

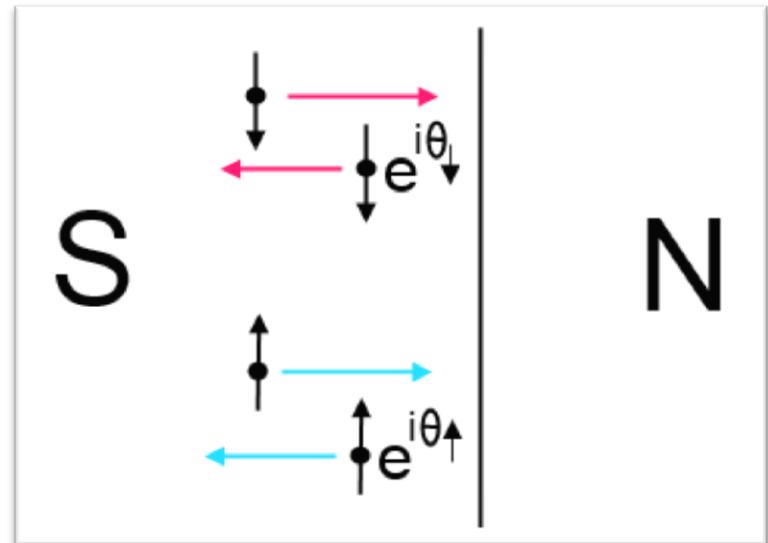
- We have an energy gap.
- The Cooper pairs are phase coherent.

Spin-Active Interfaces

- ◎ Spin-dependent barrier.



- ◎ Interfacial phase shift.



Green's Functions and Symmetry

$$f(1,2) \propto \langle \varphi_{\sigma_1}(t_1, k_1) \varphi_{\sigma_2}(t_2, k_2) \rangle$$

$$f(1,2) = -f(2,1)$$

	Frequency	Spin	Impulse
Even frequency spin singlet	+1	-1	+1
Even frequency spin triplet	+1	+1	-1
Odd frequency spin singlet	-1	-1	-1
Odd frequency spin triplet	-1	+1	+1

+1 = sym, -1 = anti-sym

Triplet from Singlet

- ◎ Singlet: $\frac{1}{\sqrt{2}}(\uparrow\downarrow - \downarrow\uparrow)$
- ◎ After reflection with interface:

$$\frac{1}{\sqrt{2}}(\uparrow\downarrow e^{i(\theta_{\uparrow}-\theta_{\downarrow})} - \downarrow\uparrow e^{-i(\theta_{\uparrow}-\theta_{\downarrow})})$$

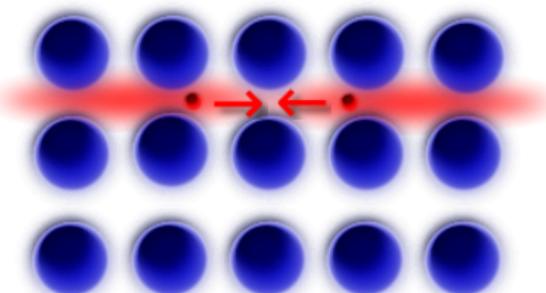
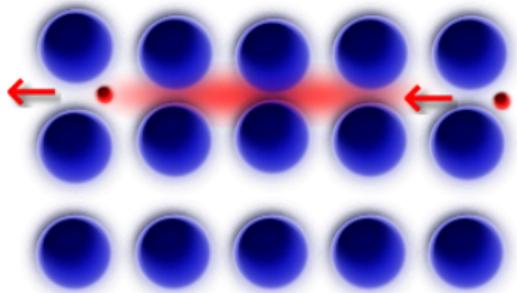
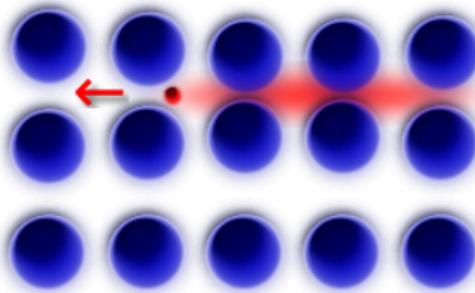
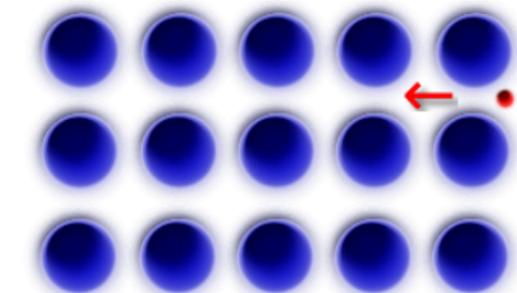
$$= constant_1(\uparrow\downarrow - \downarrow\uparrow) + constant_2(\uparrow\downarrow + \downarrow\uparrow)$$

Full Proximity Effect in Spin-Textured Superconductor/Ferromagnet Bilayers

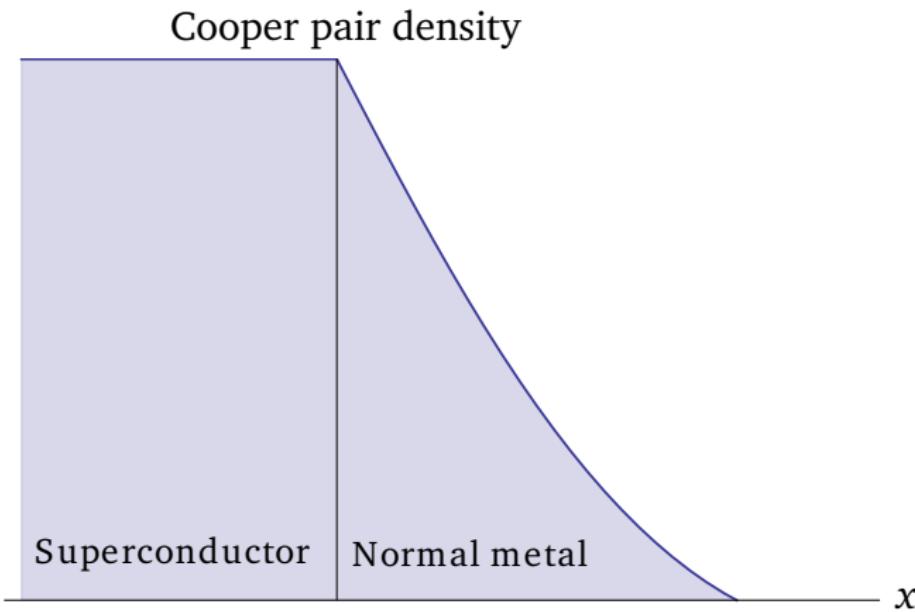
Candidate:
Jabir Ali Ouassou

Supervisor:
Prof. Jacob Linder

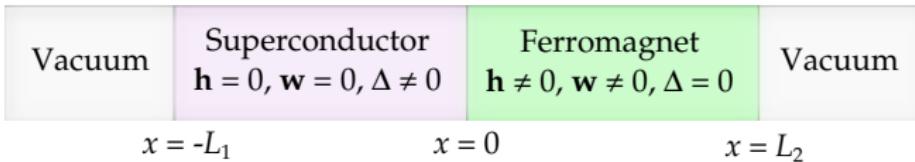
Superconductivity in a nutshell



Proximity effect



Superconductor/Ferromagnet Bilayer



- ▶ Superconductivity:

$$H_{\text{SC}} = \int dx \Delta(x) \{ \psi_{\uparrow}(x) \psi_{\downarrow}(x) + \psi_{\downarrow}^{\dagger}(x) \psi_{\uparrow}^{\dagger}(x) \}$$

- ▶ Ferromagnetism:

$$H_{\text{FM}} = \int dx \sum_{\sigma\sigma'} \psi_{\sigma}^{\dagger}(x) [\mathbf{h}(x) \cdot \boldsymbol{\sigma}]_{\sigma\sigma'} \psi_{\sigma'}(x)$$

- ▶ Spin-orbit coupling:

$$H_{\text{SO}} = \int dx \sum_{\sigma\sigma'} \psi_{\sigma}^{\dagger}(x) [\mathbf{p} \cdot \mathbf{w}\boldsymbol{\sigma}]_{\sigma\sigma'} \psi_{\sigma'}(x)$$

Diffusion equation

- ▶ Green's functions:

$$G_{\sigma\sigma'}(x, t; x', t') = -i\Theta(t - t') \langle \{\psi_\sigma(x, t), \psi_{\sigma'}^\dagger(x', t')\} \rangle$$

$$F_{\sigma\sigma'}(x, t; x', t') = -i\Theta(t - t') \langle \{\psi_\sigma(x, t), \psi_{\sigma'}(x', t')\} \rangle$$

- ▶ Usadel equation:

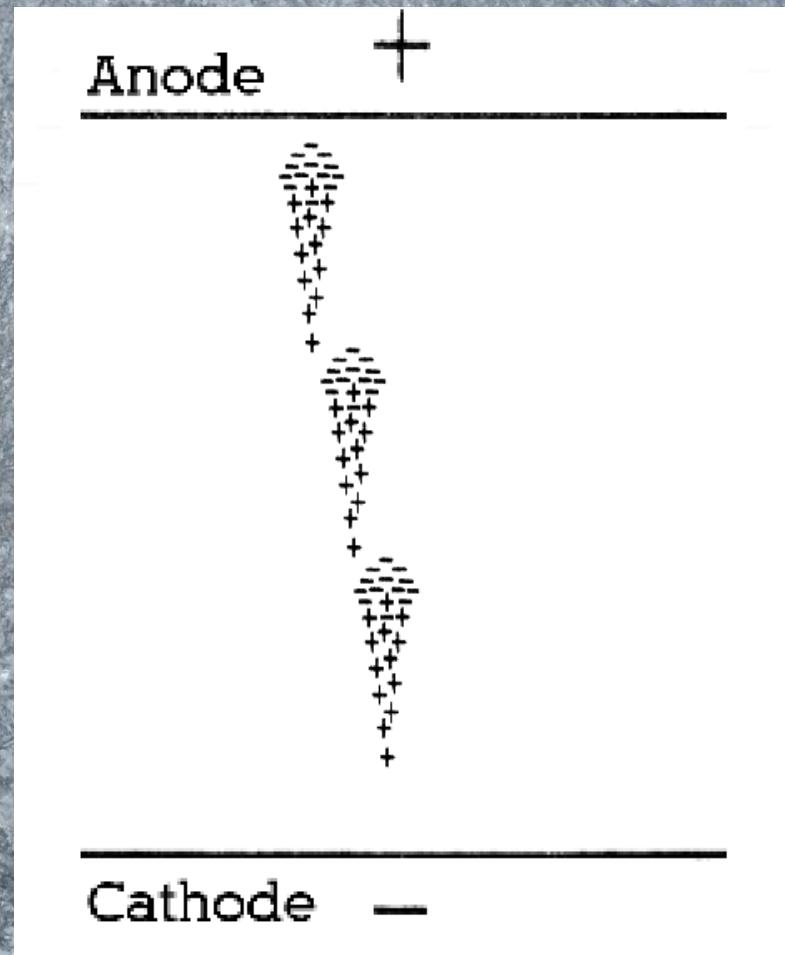
$$iD\tilde{\nabla}(\check{\mathbf{g}}\tilde{\nabla}\check{\mathbf{g}}) = [\epsilon(\tau^3 \otimes \sigma^0) + \Delta(\tau^1 \otimes i\sigma^2) + \mathbf{h} \cdot \hat{\boldsymbol{\sigma}}, \check{\mathbf{g}}]$$

Modeling propagation of streamers in dielectric liquids

Au-Dung Vuong

The Streamer Mechanism in Gas

- Electron avalanches
 - collisions
 - photo ionization
 - thermal ionization
- Electrons move towards the anode
- Heavier positive ions are left behind



The Streamer Mechanism in Liquids?

- The electrons' mean free path sufficient for ionization?
- Joule Heating
 - Gas cavities are created
 - Streamers form in gas bubbles

**Reasonable to assume that most of
the energy will heat the liquid?**

Summary

- A streamer is a filamentary discharge
- Want to explain how streamers propagate through liquid
- Assume a small percentage of the collisions leads to ionization. The rest leads to heating.

Luminescence Analysis of Solar Cells

Peter Kristoffersen

Supervisor: Turid Worren Reenaas

How regular solar cells work

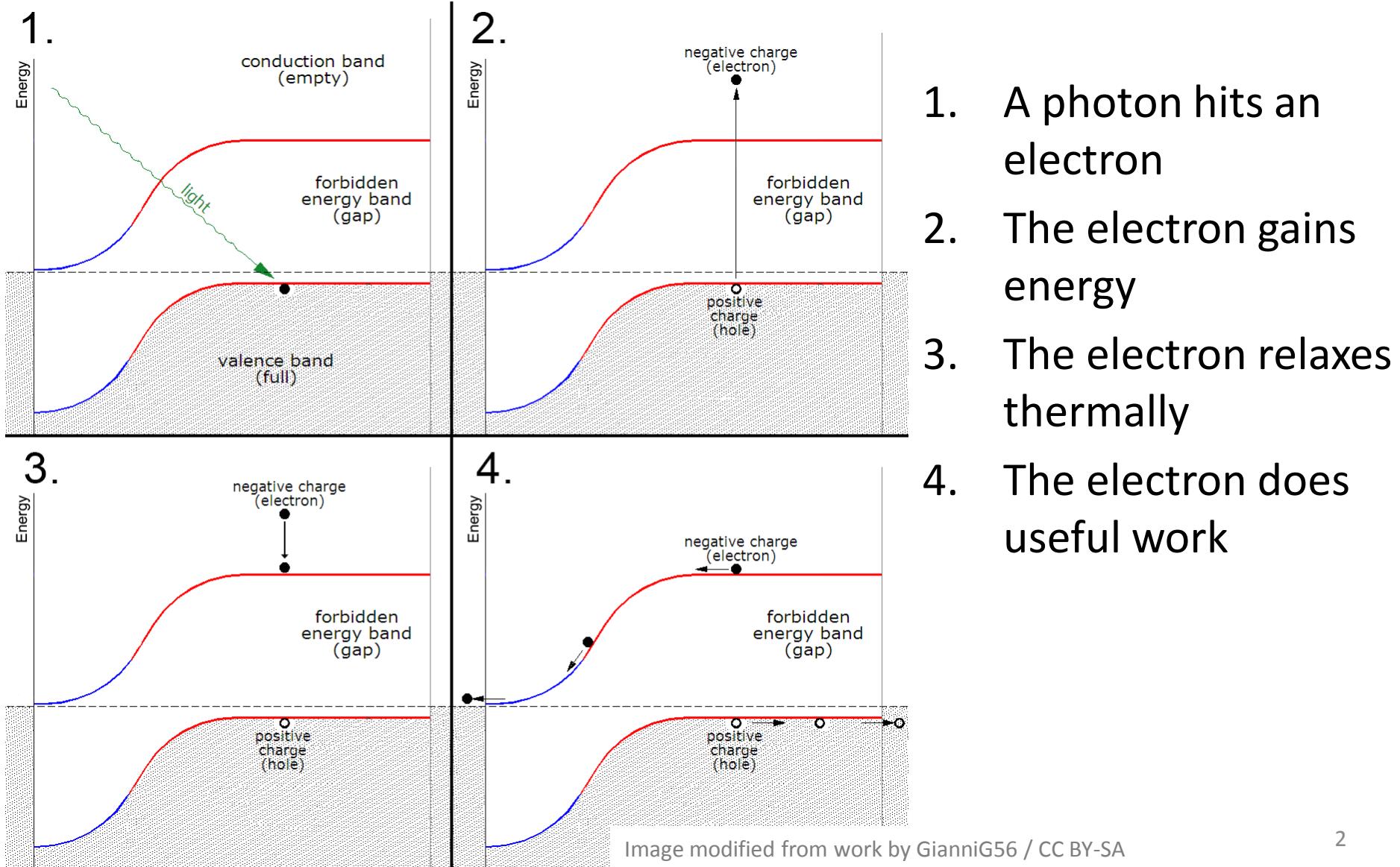


Image modified from work by GianniG56 / CC BY-SA

Luminescence

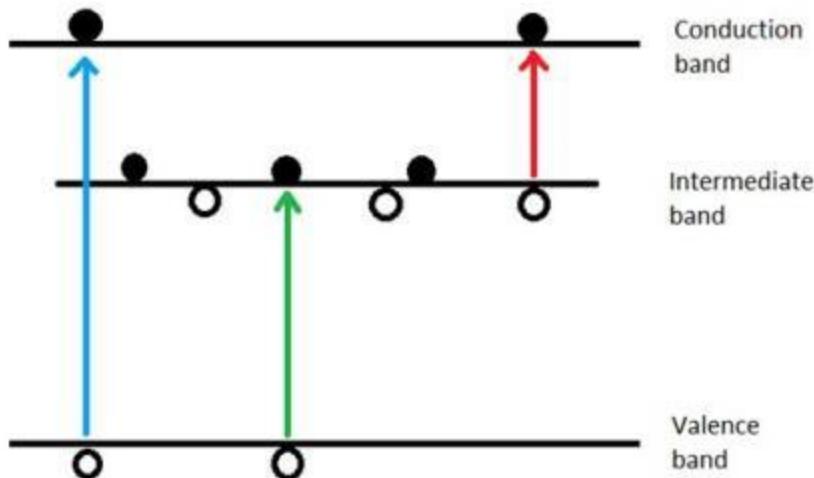


- Many types of luminescence
 - Photoluminescence
 - Cathodoluminescence
 - Electroluminescence
- Instead of electric work, emits light
- Running solar cells backwards, LED
- Non-radiative recombination



Chemiluminescence: Mgranja9 / CC BY-SA
Electroluminescence: Adafruit
Oscilloscope: Falcorian / CC BY-SA

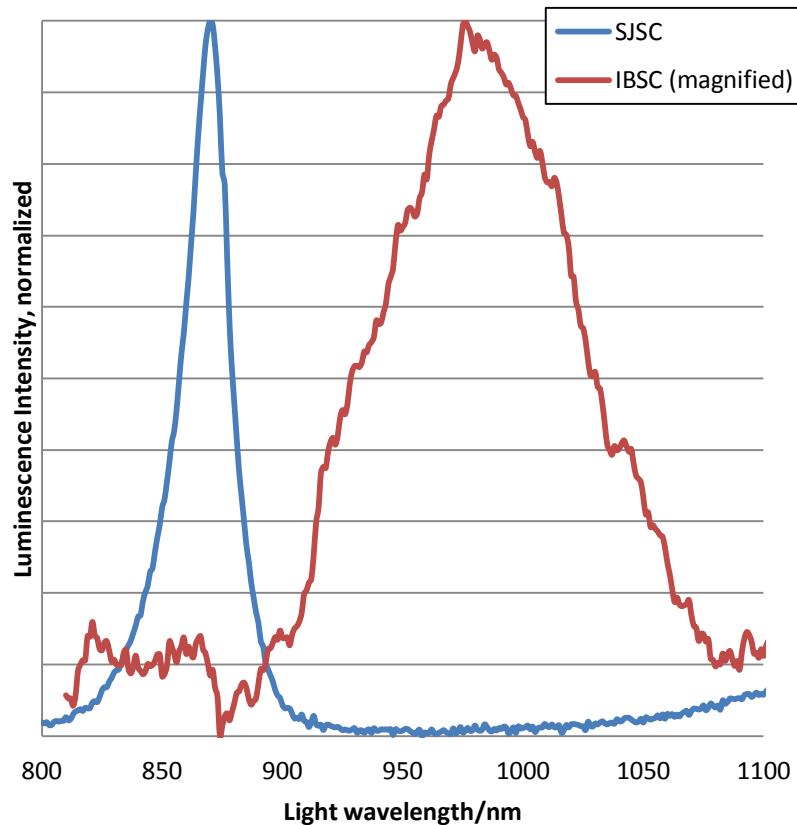
Intermediate Band Solar Cells



- Additional band in the bandgap
- Benefits:
 - Can absorb shorter wavelengths
 - Less waste of high energy light
 - $37\% \rightarrow 56\%$ Efficiency
 - Cheaper than similar concepts
- Problems:
 - Nonradiative loss
 - Absorption
 - Many more...

Summary

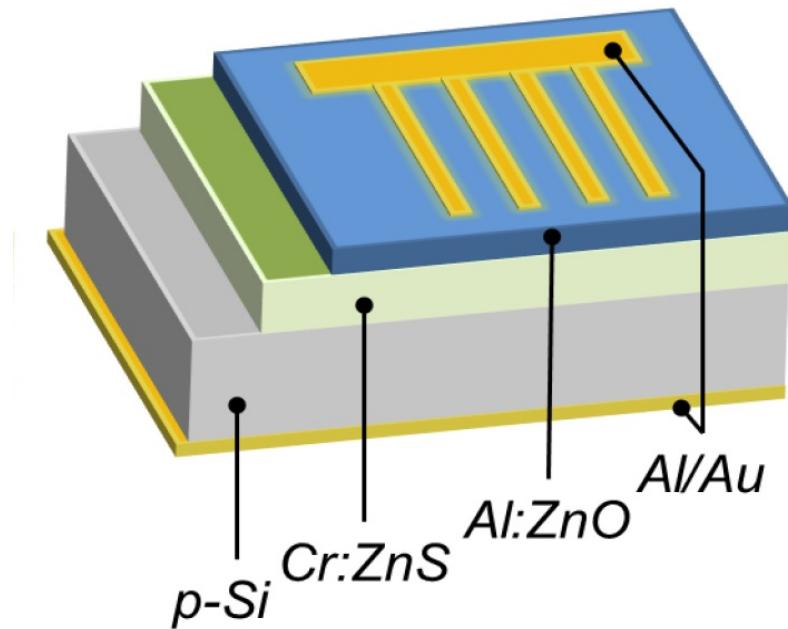
Electroluminescence of GaAs



- High efficiency solar cells, cheaper
- Information about band structure
- Luminescence is easy and non-destructive

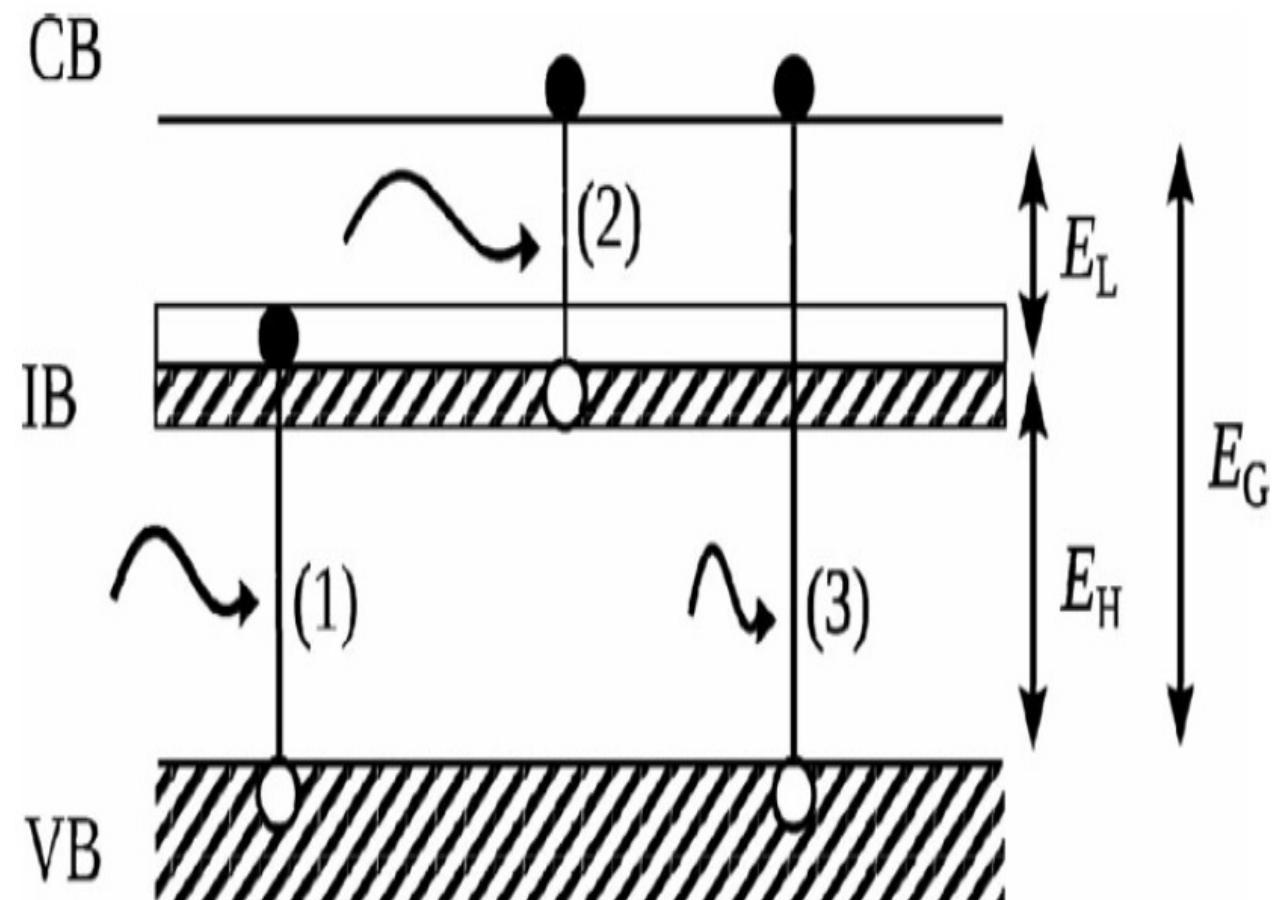
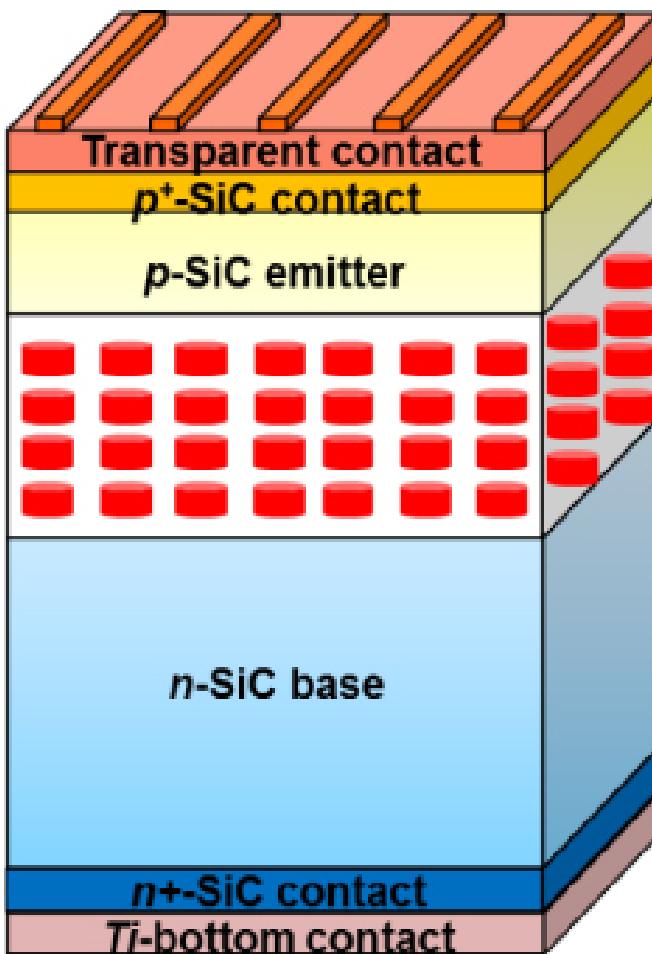
“Analyzing Intermediate Band materials with ellipsometry”

Benjamin Hope



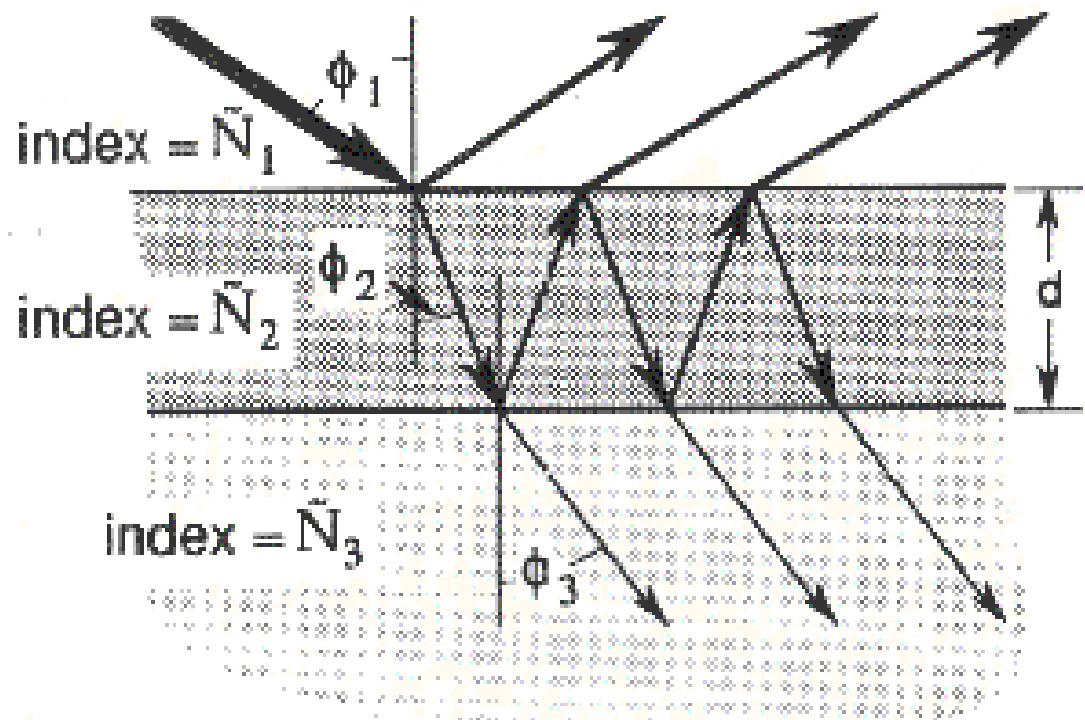
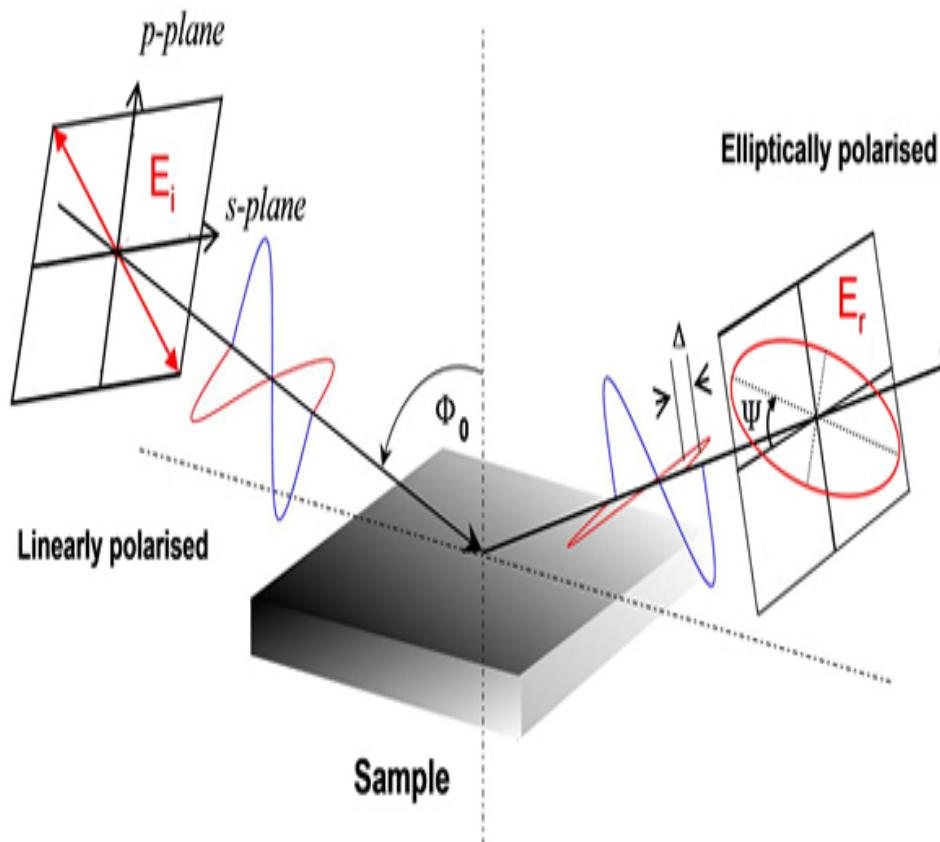
Cr doped ZnS Solar Cell

The IBSC high efficiency concept

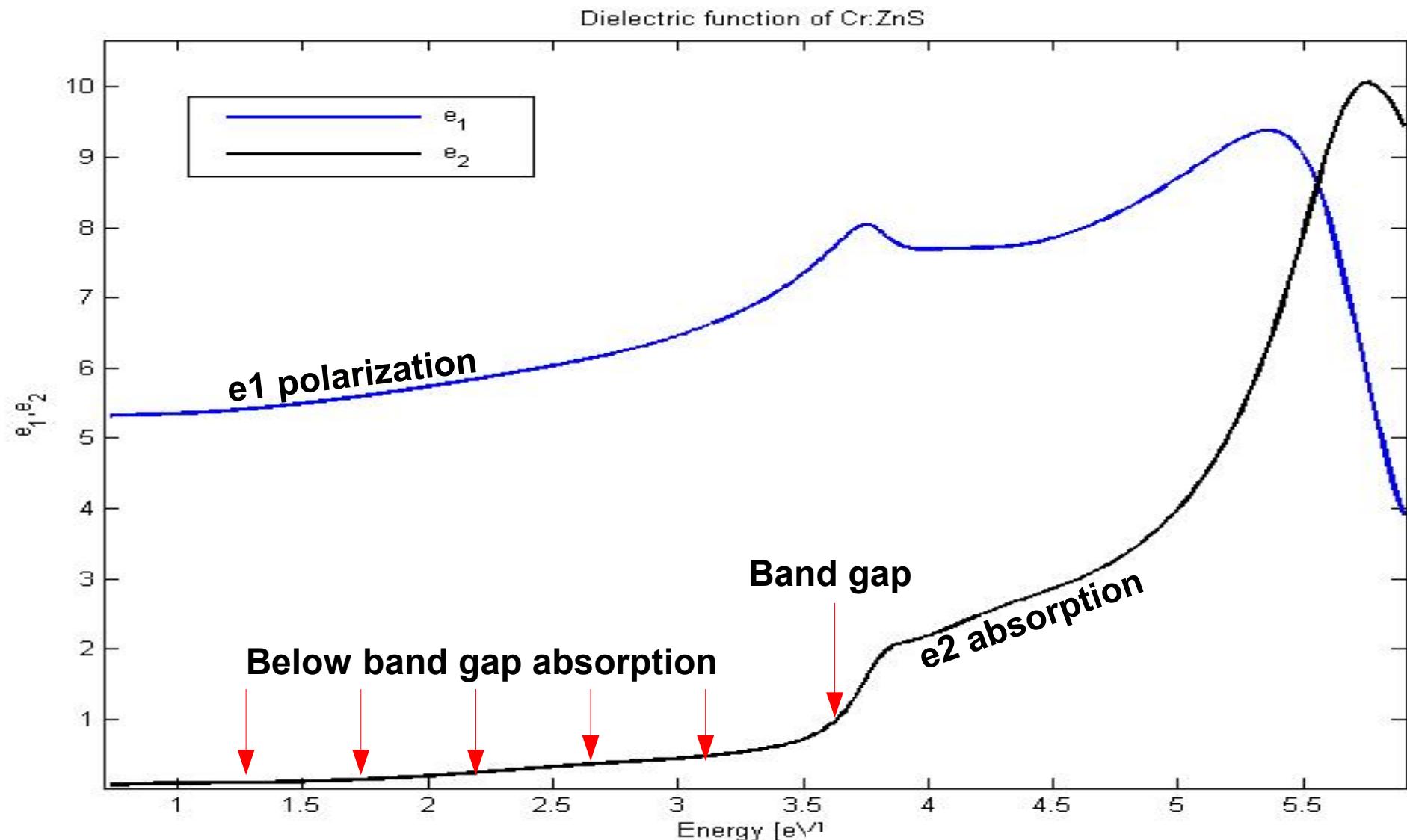


What is ellipsometry?

- Measure polarization:
 - Find film thicknesses and surface roughness
 - Find layer optical constants n & k

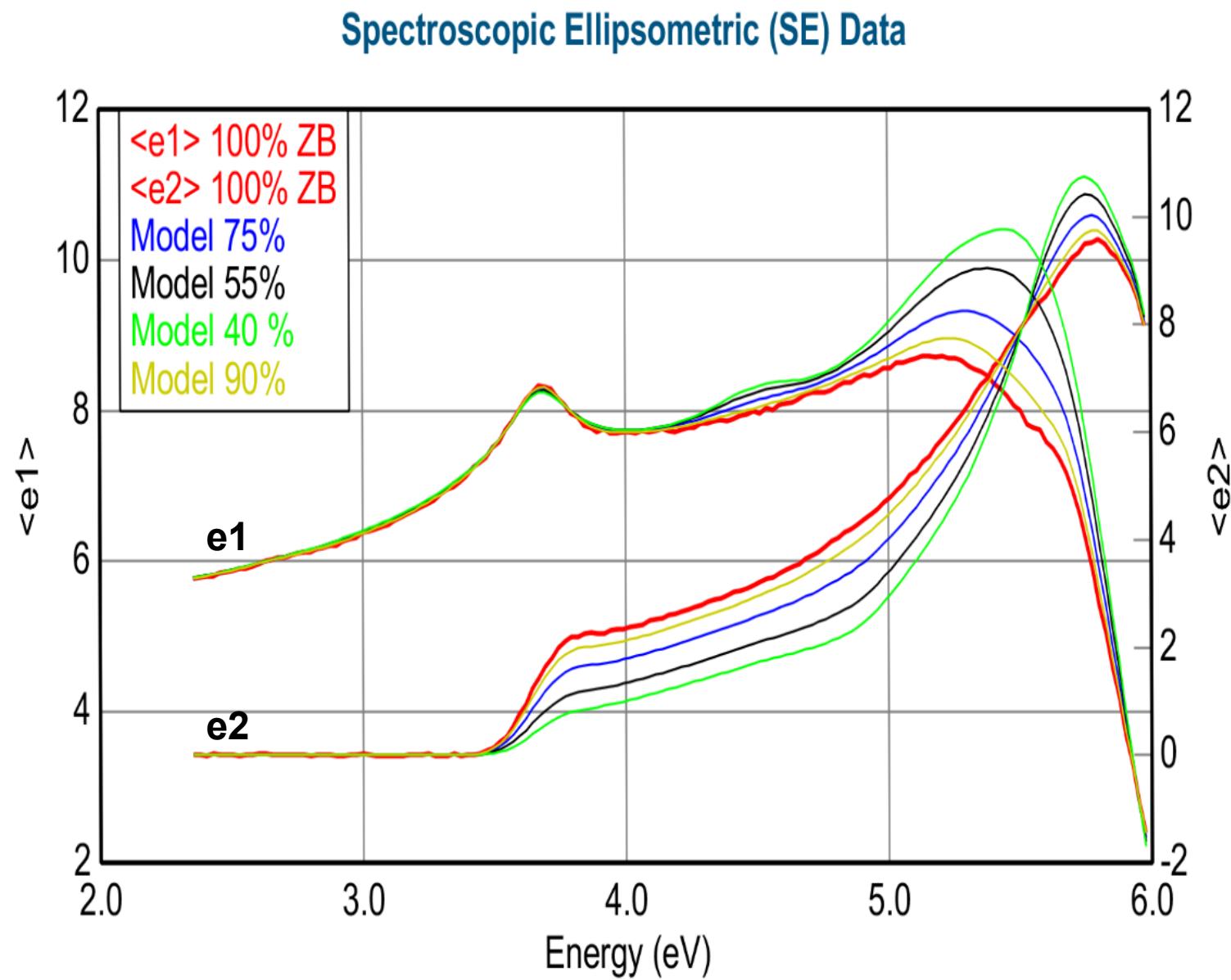
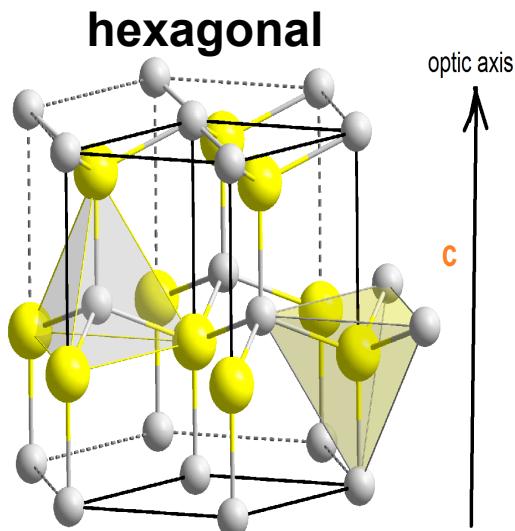
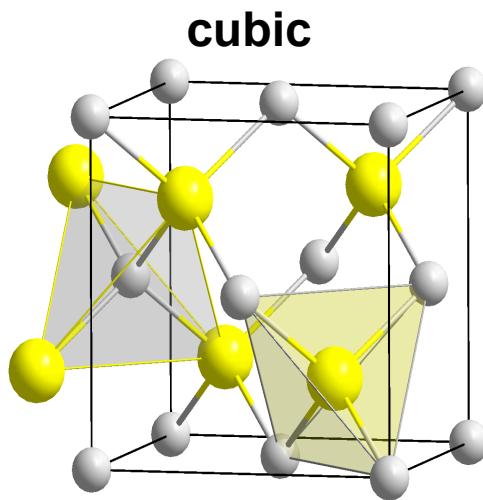


Dielectric function of Cr:ZnS



$$\epsilon = \epsilon_1 + i \epsilon_2 = (n + ik)^2$$

Find % of cubic/hexagonal phases



Bruk av lysrefleksjon for å innhente statistisk informasjon om en svakt ru overflate.

Ane N Johansen

November 2014

Introduksjon

Oppgaven min går ut på å finne informasjon om en overflate ved å se på hvordan den reflekterer innkommende lys. Størrelsen man er interessert i å finne er flatens rms-høyde, transvers korrelasjonslengde, og i noen tilfeller også den relative permittiviteten til materialet lyset reflekteres fra.

Jeg har blitt presentert for hvordan dette ser ut ved normalt infall på planet, og skal undersøke hvordan det blir når dette ikke er tilfellet.

Det fysiske systemet

Jeg ser på en tilfeldig ru overflate sentrert rundt planet $x_3 = 0$ som beskrives av $\zeta(x_1, x_2)$. Over flaten er det vakuum, mens det under er et dielektrisk materiale med relativ permittivitet ϵ . $\zeta(x, y)$ er antatt å være deriverbar mhp. x_1 og x_2 , og følger en normal tilfeldig prosess som oppfyller:

$$\langle \zeta(\mathbf{x}_{||})\zeta(\mathbf{x}'_{||}) \rangle = \delta^2 W(|\mathbf{x}_{||} - \mathbf{x}'_{||}|)$$

$$\langle \zeta^2(\mathbf{x}_{||}) \rangle = \delta^2$$

Her er δ overflatens rms-høyde og $W(|\mathbf{x}_{||}|)$ er den normaliserte overflatehøyde-autokorrelasjonsfunksjonen. Disse to beskriver altså overflatens statistiske egenskaper. $x_{||}$ er x-komponenten projisert ned i x_3 -retning. Systemet er vist i figur 1, men her bare for en en-dimensjonal ru overflate, x_1 i figuren svarer altså til $x_{||}$ i dette tilfellet.

En typisk form på autokorrelasjonsfunksjonen vil være at den er gaussisk; $W(x_{||}) = \exp(-(x_{||}/a)^2)$. Her er 'a' den transverse korrelasjonslengden, og sammen med rms-verdien, en av parameterene man er interessert i å finne. En gaussisk form vil ofte være passende for en faktisk overflate.

Metode

Metoden jeg bruker går ut på å anta formen på overflate-høyde-autokorrelasjonsfunksjonen $W(x_{||})$ med justerbare parametere, for deretter å bestemme disse parameterne ved å minimere en passende kostfunksjon. Størrelsen som brukes i kostfunksjonen er den gjennomsnittlige differensial-refleksjons-koeffisienten, denne angir den delen av totalt tids-gjennomsnittlig flux som spres med vinkelen θ_s og ϕ_s . Og den kan uttrykkes ved spredningsampiltudene $R_{\alpha\beta}(\hat{\mathbf{q}}_{||}|\hat{\mathbf{k}}_{||})$. Spredningsampiltudene for den svakt ru overflatene finner man ved å bruke fasesperturbasjonsteori på de reduserte Rayleigh-ligningene. Indeksene α og β angir om det dreier seg om s- eller p-polarisasjon. Det er s-polarisasjon jeg jobber med i denne oppgaven, polarisasjonen er altså vinkelrett på innfallsplanet.

For den gjennomsnittlige differensial-refleksjons-koeffisienten får man følgende uttrykk:

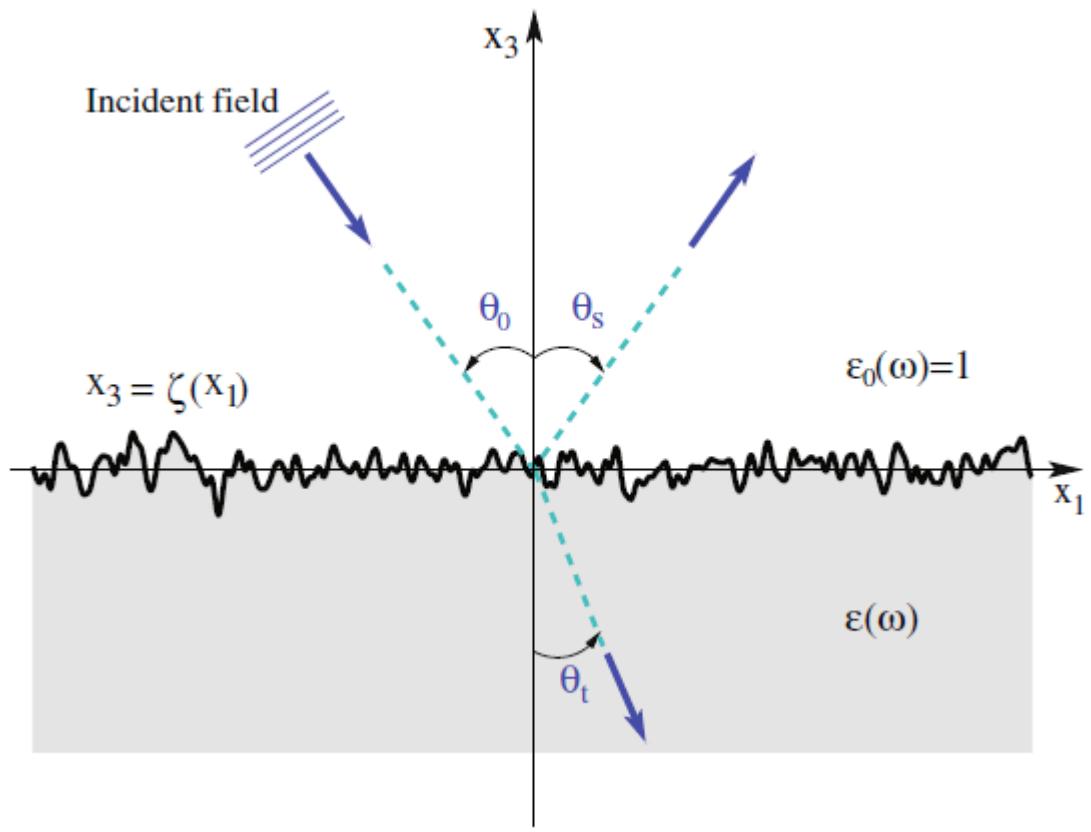


Figure 1: Figuren viser et system hvor en ru overflate ligger sentrert rundt $x_3 = 0$. Over overflaten er det vakuum, mens det under er et dielektrisk materiale.

$$\left\langle \frac{\partial R_{ss}(\mathbf{q}_{||}|\mathbf{k}_{||})}{\partial \Omega_s} \right\rangle_{\text{incoh}} = \frac{(\epsilon - 1)^2}{(2\pi)^2} \left(\frac{\omega}{c}\right)^6 \frac{\cos \theta_s}{[d_s(q_{||}d_s(k_{||}))]^2} \exp[-2M(\mathbf{q}_{||}|\mathbf{k}_{||})] \\ \times \sum_{n=1}^{\infty} \frac{[4\delta^2 \alpha_0(k_{||})(\hat{\mathbf{q}}_{||} \cdot \hat{\mathbf{k}}_{||})^2]^n}{n} \int d^2 u_{||} W^n(u_{||}) \exp[-i(\mathbf{q}_{||} - \mathbf{k}_{||}) \cdot \mathbf{u}_{||}]$$

med

$$M(\mathbf{q}_{||}|\mathbf{k}_{||}) = 2\delta^2 \sqrt{\alpha_0(q_{||}\alpha(k_{||}))} \int d^2 p_{||} Re F(\mathbf{q}_{||}|\mathbf{q}_{||}|\mathbf{k}_{||}) g(|\mathbf{p}_{||} - \mathbf{k}_{||}|)$$

$$F(\mathbf{q}_{||}|\mathbf{q}_{||}|\mathbf{k}_{||}) = \frac{1}{2} [\alpha(q_{||}) + \alpha(k_{||})] (\hat{\mathbf{q}}_{||} \cdot \hat{\mathbf{k}}_{||}) \\ + (\epsilon - 1) (\hat{\mathbf{q}}_{||} \times \hat{\mathbf{p}}_{||})_3 \frac{\alpha_0(p_{||})\alpha(q_{||})}{d_p(p_{||})} (\hat{\mathbf{p}}_{||} \times \hat{\mathbf{k}}_{||})_3 \\ - (\epsilon - 1) \left(\frac{\omega}{c}\right)^2 \frac{(\hat{\mathbf{q}}_{||} \cdot \hat{\mathbf{p}}_{||})(\hat{\mathbf{p}}_{||} \cdot \hat{\mathbf{k}}_{||})}{d_s(p_{||})}$$

Dette kan forenkles noe ved blant annet å bruke at autokorrelasjonsfunksjonen ikke er avhengig av vinkel, men kun av lengden av $x_{||}$, men det blir fortsatt en del å regne ut nummerisk.

$g(\mathbf{Q})$ er fouriertransformen av korrelasjonsfunksjonen, og dermed effektspekteret av overflate-ruheten.

I kostfunksjonen kan man finne uttrykket som skal settes opp mot den gjennomsnittlige differensial-refleksjons-koeffisienten man har kommet fram til, ved rent nummeriske, ikke-perturberte løsninger av de reduserte Rayleigh-ligningene, over et ensemble av tilfeldig genererte overflater som følger den gaussiske formen for autokorrelasjonsfunksjonen.

Resultater

Jeg har selv ikke kommet fram til noen resultater enda, men ut ifra resultater jeg har sett fungerer denne metoden bra så lenge det er snakk om svakt ru overflater.



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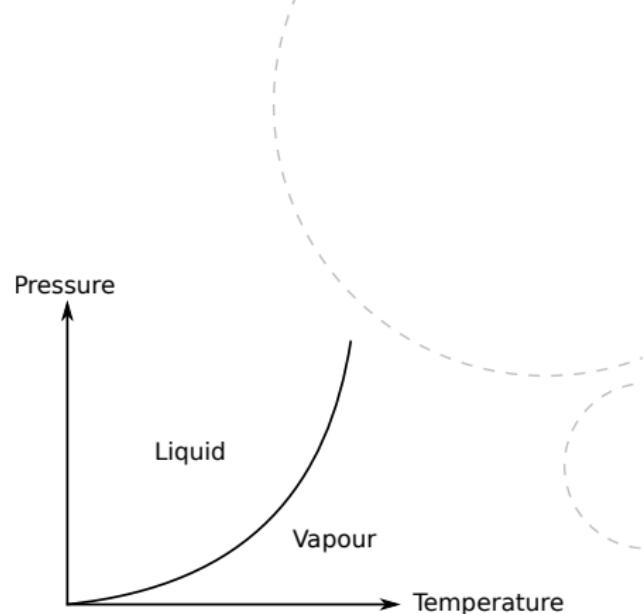
Simulation of Two phase flow

Sigbjørn Løland Bore

Department of physics and SINTEF Materials and
Chemistry

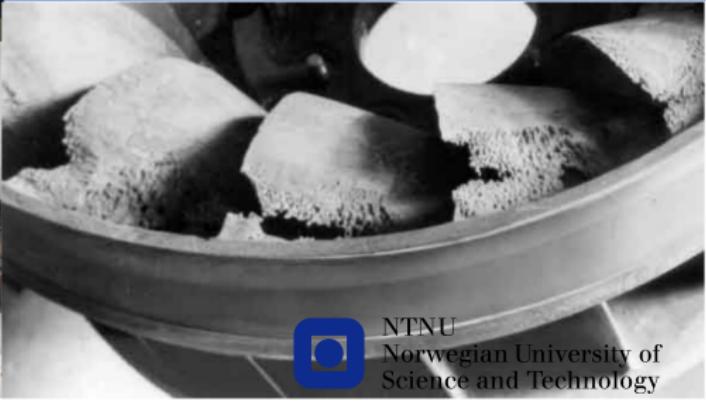
November 24, 2014

Cavitation



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7|7 7|8 7|9 8|0 8|1 8|2 8|3 8|4 8|5 8|6 8|7 8|8

Model

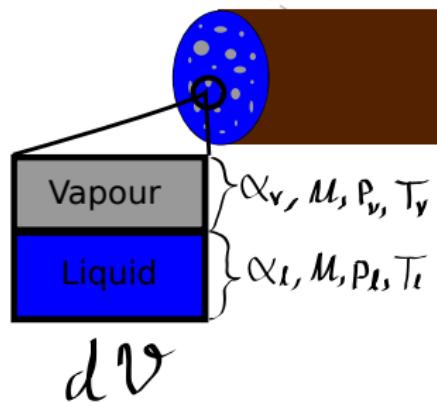
- Model should address
 - Fluid mechanics
 - Interaction between phases



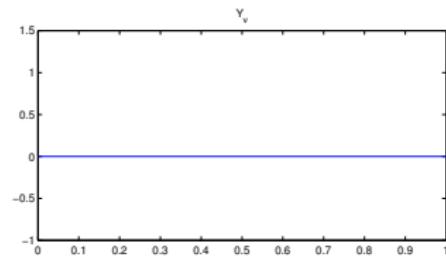
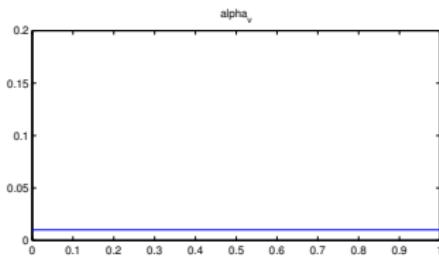
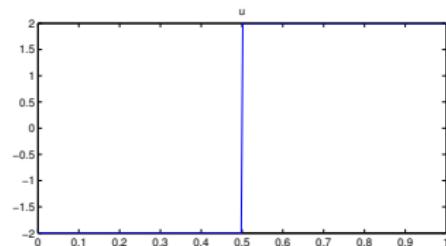
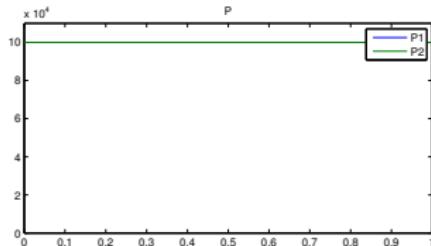
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Model

- Model should address
 - Fluid mechanics
 - Interaction between phases
- Simplified model
 - 1-d
 - Continuum model
 - Euler equations
 - Stiffened gas equation of state
 - Pressure equilibrium
- System of six equation
- Solved numerically

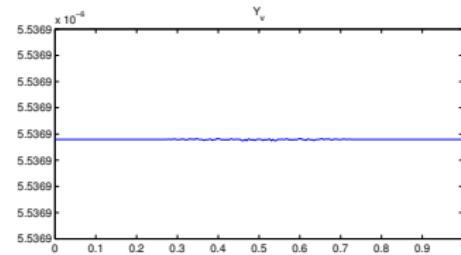
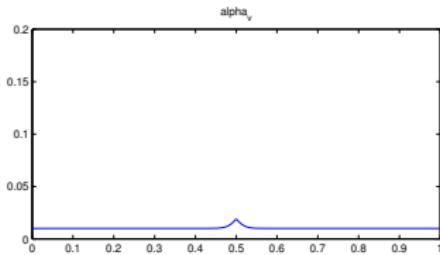
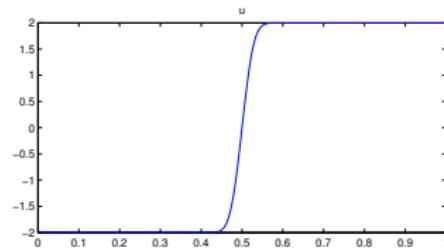
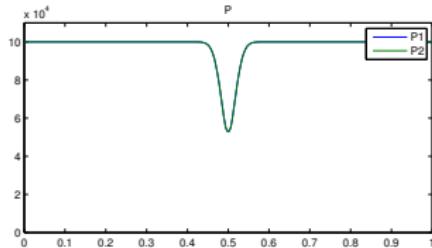


Preliminary results Cavitation Tube



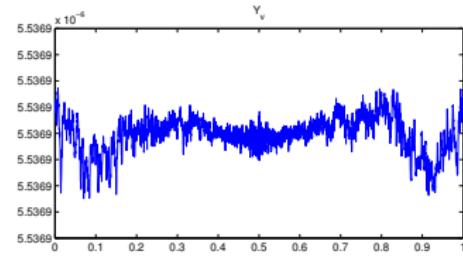
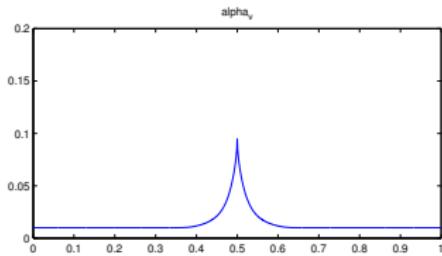
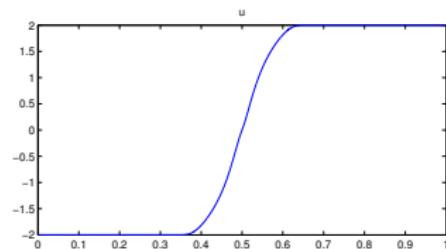
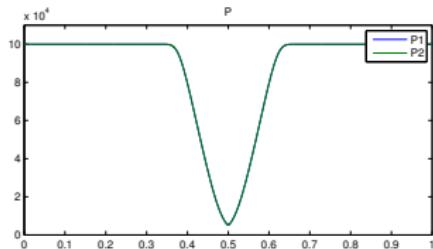
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Preliminary results Cavitation Tube



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Preliminary results Cavitation Tube



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Summary

- Cavitation important to industry
- Continuum model
- Solve numerically
- Method works
- Generalization to two dimensions



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TFY4510 Fysikk fordypningsprosjekt

**Studie av en ny type
takdiffusor i auditorier**

av

Asta Rønning Fjærli

FAKULTET FOR NATURVITENSKAP OG TEKNOLOGI
NTNU

Problemstilling

I de fleste større auditorier er lydforholdene ikke så avvikende fra klassisk diffusfeltteori, hvilket blant annet gir forventede forhold mellom tidlig og sen energi osv. Romform og bruk av reflektorer påvirker tidlig energi, men i begrenset omfang.

I en artikkel av Arau-Puchades (2012) demonstreres det at den spesielle type takdiffusor, en regulær grid av vertikale plater, virker å kunne gi forlenget etterklangtid samtidig som den subjektivt oppfattede klarheten økes.

I dette prosjektet skal det studeres om Arau-Puchades resultater kan gjenskapes i en skalamodell.

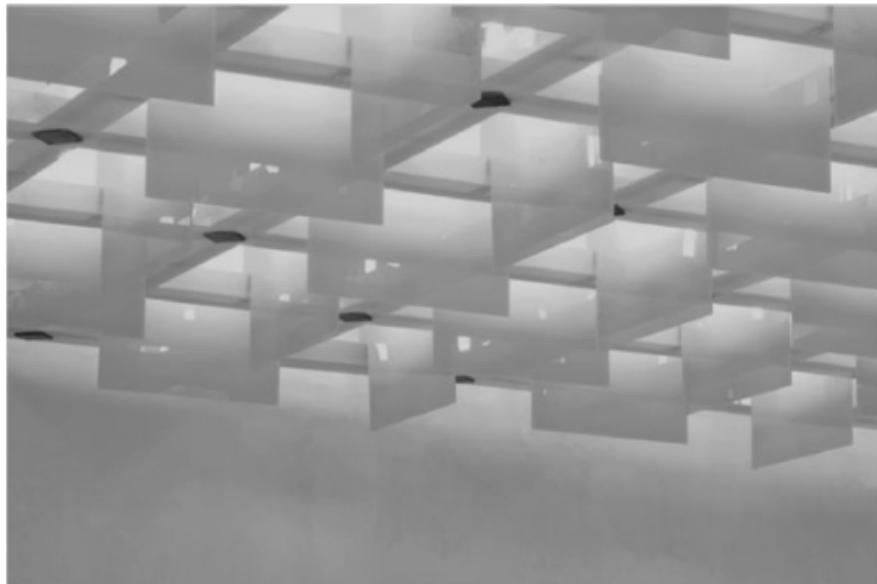


Figure 1: Takdiffusoren til Arau-Puchades

Øvingsrommet i Liceu, Barcelona

Teateret i Liceu:

- Øvingsrommet var kun egnet for et lite eller mellomstort orkester: for lite volum og for høyt lydnivå
- $V = 1433.60 \text{ m}^3$
Snitthøyde $h = 5.16 \text{ m}$
- Higin Arau installerte en diffusor formet som en labyrint av horisontale plater festet i et 3D-rutenett, med formål å redusere styrken på refleksjonene fra taket
- Resultat: økt etterklangstid, lettere for musikerne å kommunisere, økt subjektiv romstørrelse



Figure 2: Øvingsrommet i Liceu

Skalamodellen

- Gjøre identiske målinger i fullskala? Beslaglegge et auditorium et helt semester?
Nei, vi bygger en skalamodell!
- Dimensjoner: $1.47 \text{ m} \cdot 2.37 \text{ m} \cdot 0.85 \text{ m} = 2.96 \text{ m}^3$
- Kryssfiner, harde, flate veggger
- Skalerer opp med faktor 1:8, til $11.8 \text{ m} \cdot 19.0 \text{ m} \cdot 6.80 \text{ m} = 1516 \text{ m}^3$



Figure 3: boksen

Målinger i skalamodellen

Ni ulike målekombinasjoner;

- Gulv: hardt, orkesterstoler, fullt orkester
- Tak: hardt, aluminiumsgrid, full diffusor
- Tre høytallerposisjoner, seks mikrofonposisjoner

Romakustiske parametre:

- Etterklangtid: T_{30} og EDT
- Clarity, C_{80}
- Strength, G

TFY4510
SPECIALIZATION PROJECT IN TECHNICAL PHYSICS

SCALE MODEL MEASUREMENTS FOR CEILING ABSORBERS

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Trondheim, 2014

FACULTY OF NATURAL SCIENCES AND TECHNOLOGY
NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

Etterklangstid

- Den viktigste parameteren
- Direkte lyd og reflektert lyd
- Sabines likning:

$$T_{60} = \frac{24 \cdot \ln(10) \cdot V}{c \cdot A} \quad (1)$$

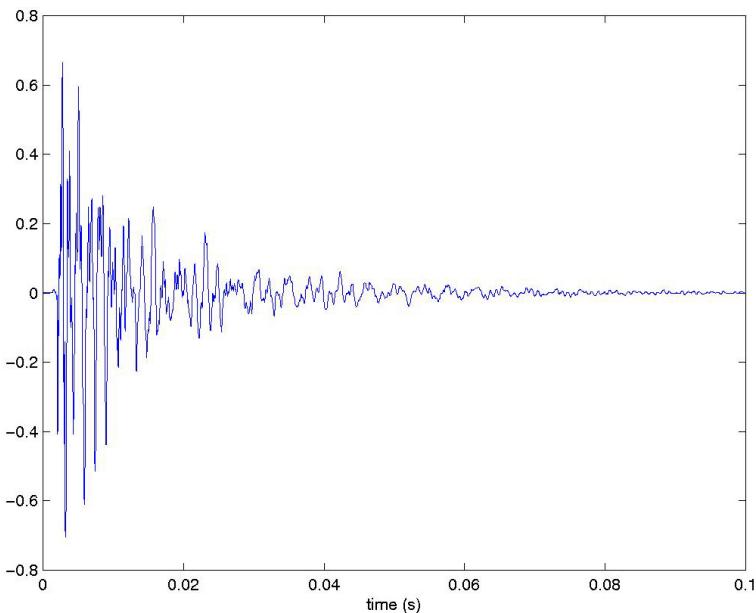


Figure 1: Impuls respons

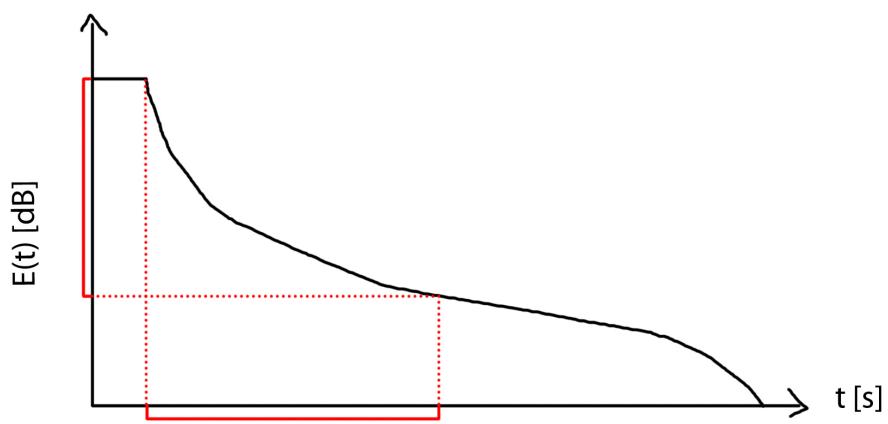


Figure 2: T_{60}

Kuboide rom

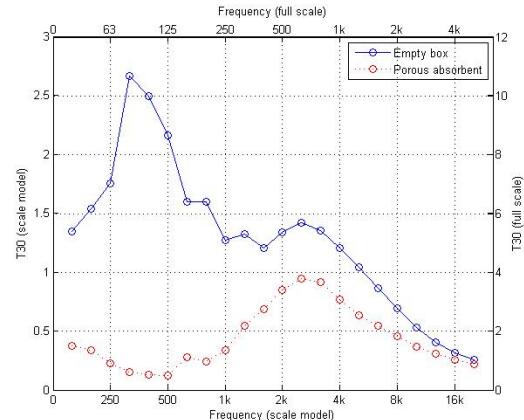
- Statistisk vs. bølgeteoretisk tilnærming
- Sabines likning antar diffusivitet
- Romabsorpsjon $A \approx S \cdot \bar{\alpha}$
- Stående bølger mellom veggger: 2D klangfelt

Scale model

- $2.37 \cdot 1.47 \cdot 0.854 \text{ m}^3 \sim 9.5 \cdot 5.9 \cdot 3.4 \text{ m}^3$ Ratio 1:4
- Tidligere arbeid
 - absorbenten fungerer bra for LF, men dårlig for HF
 - LF: som om det var diffust felt
 - HF: forventet ikke-diffus oppførsel
- Eksisterende teori tar ikke høyde for dette



(a) Skalamodell



(b) Repliserte resultater, tidligere arbeid

Figure 3: Skalamodell og repliserte resultater fra tidligere arbeid

- Mistenkt #1: Skalamodellen
- Mistenkt #2: Absorbenten
- Mulig forklaring:

Er absorpsjonen til absorbenten frekvensavhengig når innfallsvinkel nærmer seg 90° ?

Hva går oppgaven ut på?

- Måle etterklangstiden i skalamodellen
- Måle etterklangstiden med absorbenten fra i fjar
- Måle etterklangstiden med en helt annen type absorbent
- HVIS begge absorbentene gir samme type absorpsjon:
Gjøre en ”klangromsmåkling” i skalamodellen
Gjøre en ”klangromsmåkling” i fullskala klangrom
- undersøke om eksisterende programvare tar høyde for fenomenet

Hvordan måler man etterklangstid?

- Lydtrykksmålinger
- Fouriertransform
- Transfer function
- exponential sine sweep:

$$e_{in}(t) = \sin \left[\frac{\omega_1 t}{\ln(\omega_2/\omega_1)} \left(e^{\frac{t}{T} \ln\left(\frac{\omega_2}{\omega_1}\right)} - 1 \right) \right] \quad (2)$$

Initielle måleresultater

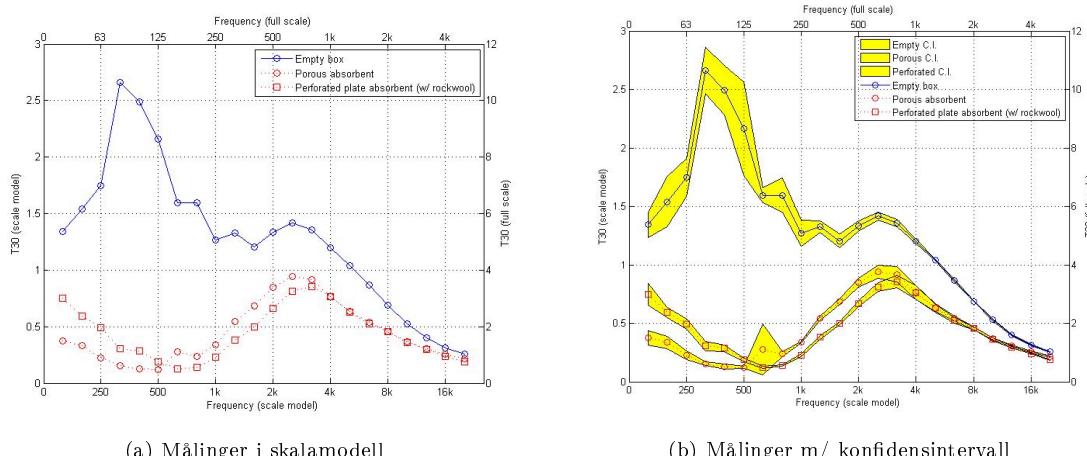


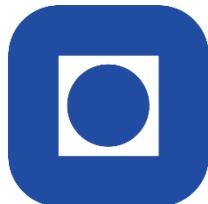
Figure 4: Initiale målinger

Oppsummering

- ”Dårlig” akustikk i kuboide rom skyldes lang etterklangstid
- Etterklangstiden predikeres i liten grad av eksisterende teori
- Akustiske tiltak hjelper mye mindre enn man regner med, uten at man vet hvorfor.
- Måleresultater indikerer frekvensavhengige absorpsjonsegenskaper ved innfallsvinkler som nærmer seg 90°

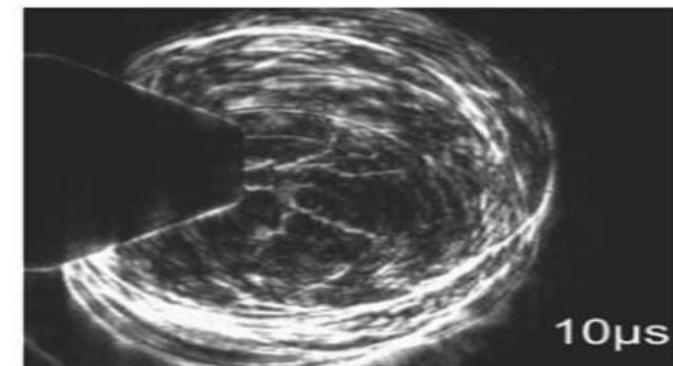
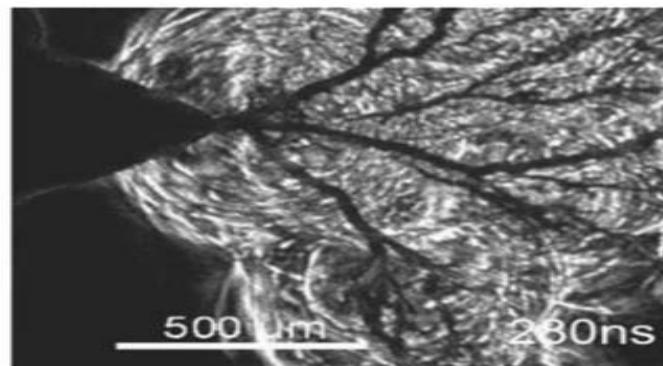
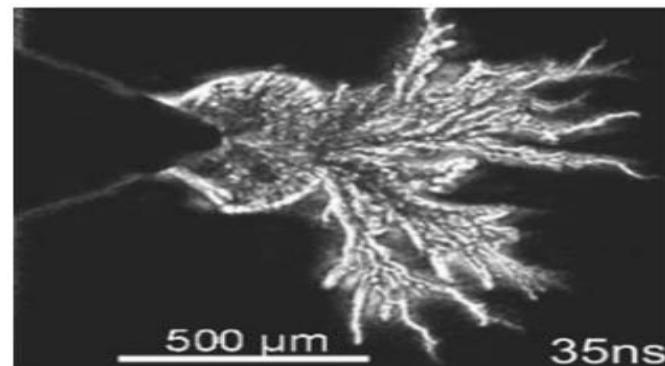
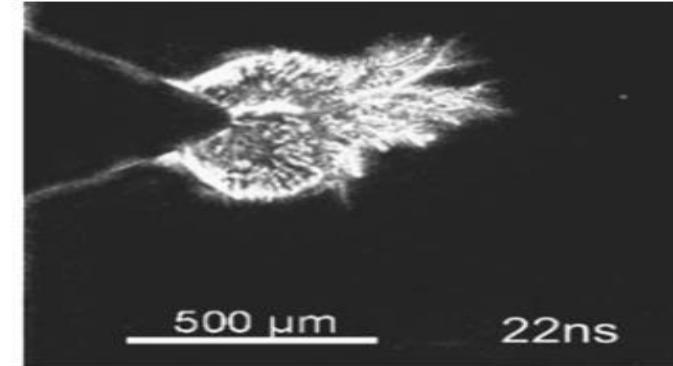
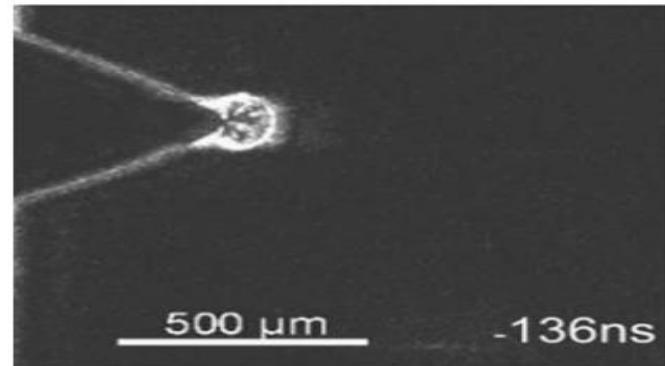
Spørsmål?

Electrical Breakdown in Insulation Liquids



NTNU

Modeling the Propagation of Streamers in Liquids
by Inge Madshaven
in cooperation with SINTEF Energy



Basic properties

- Gas/plasma channel
- Propagation modes
- Effect of additives
 - Filament shape and number
 - Somewhat lower breakdown voltage
 - Higher Acceleration voltage

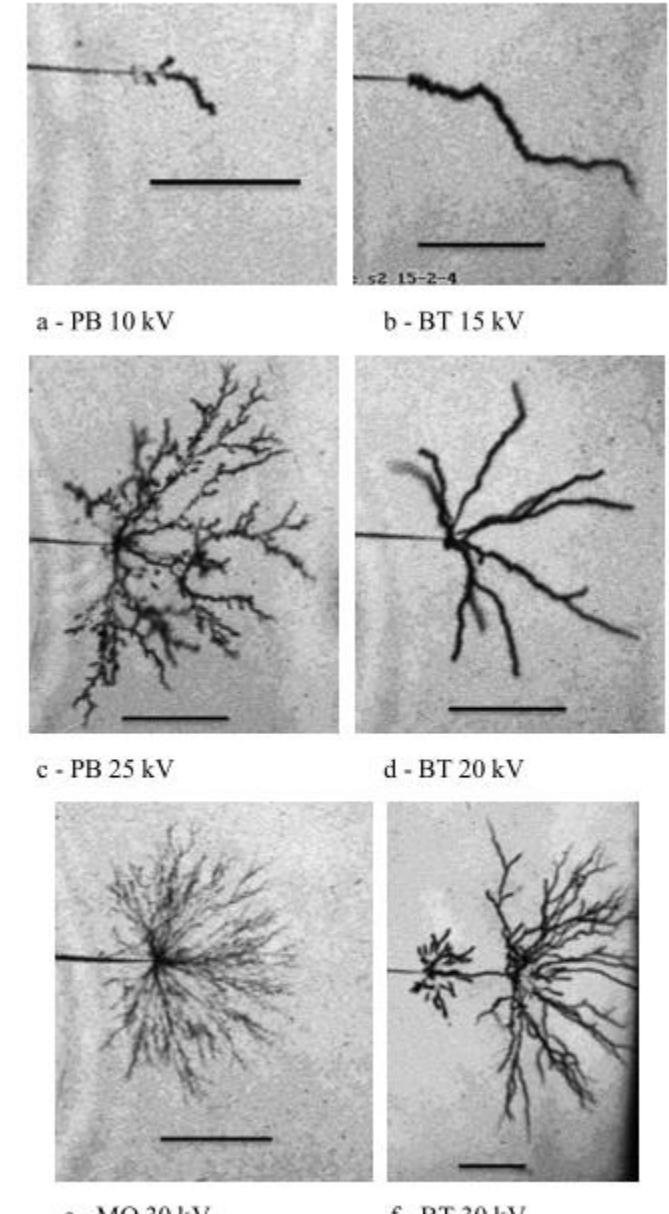
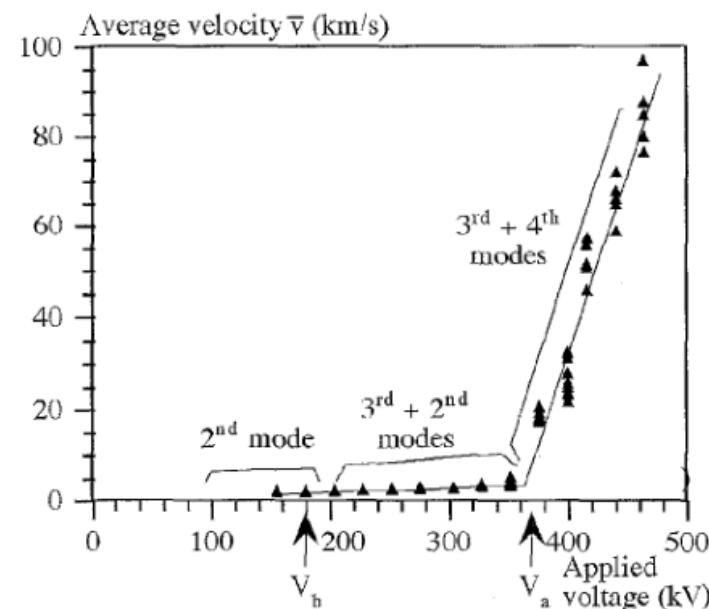
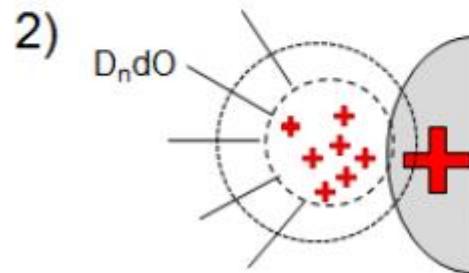
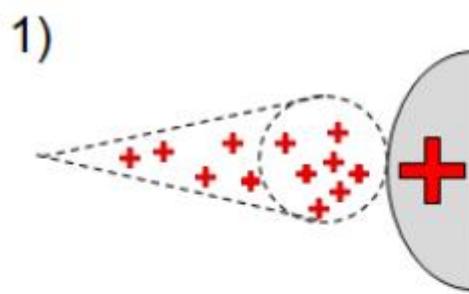


Fig. 4 Typical shapes of 2nd mode positive streamers. Black line: 1 mm scale.

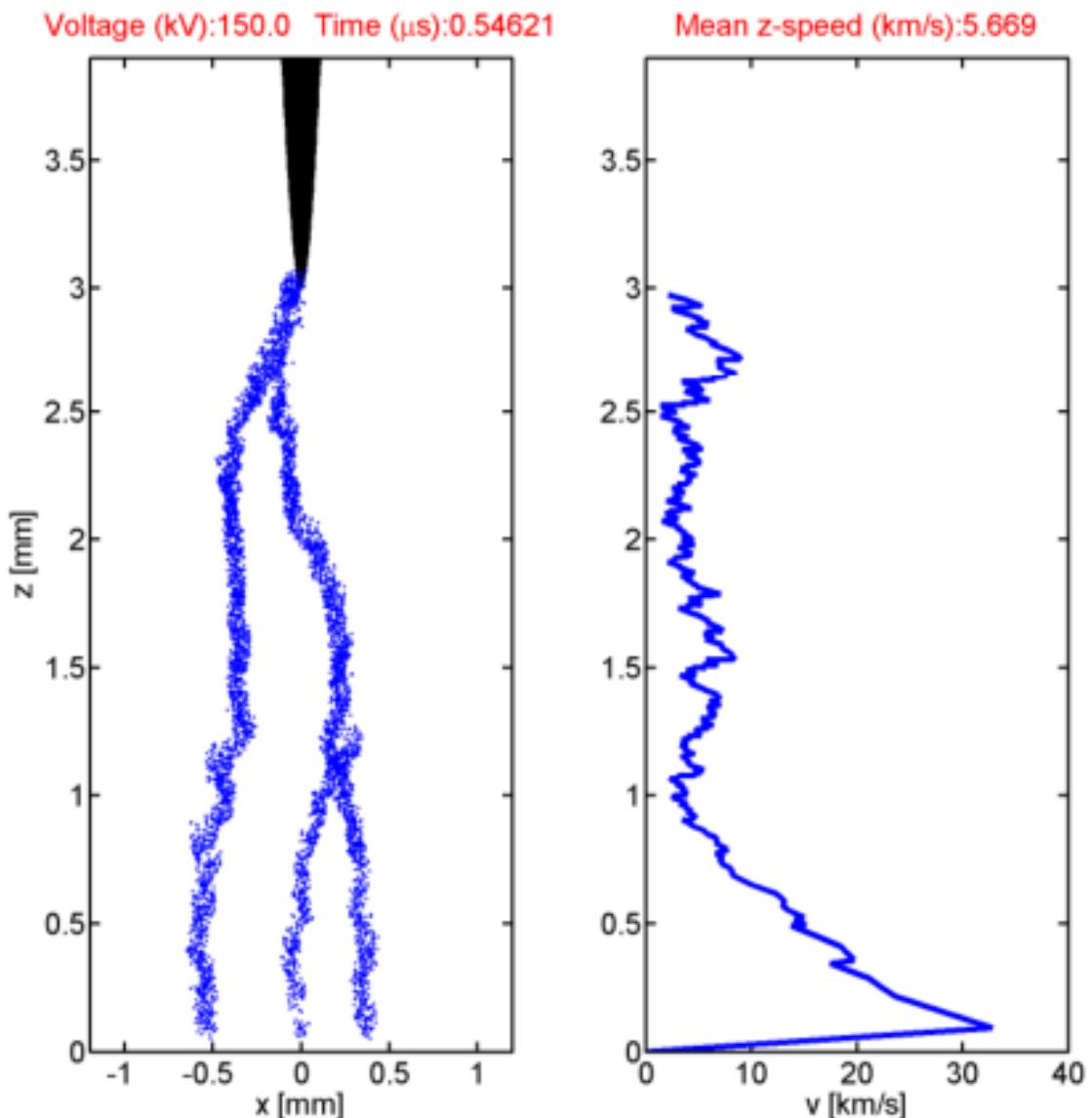
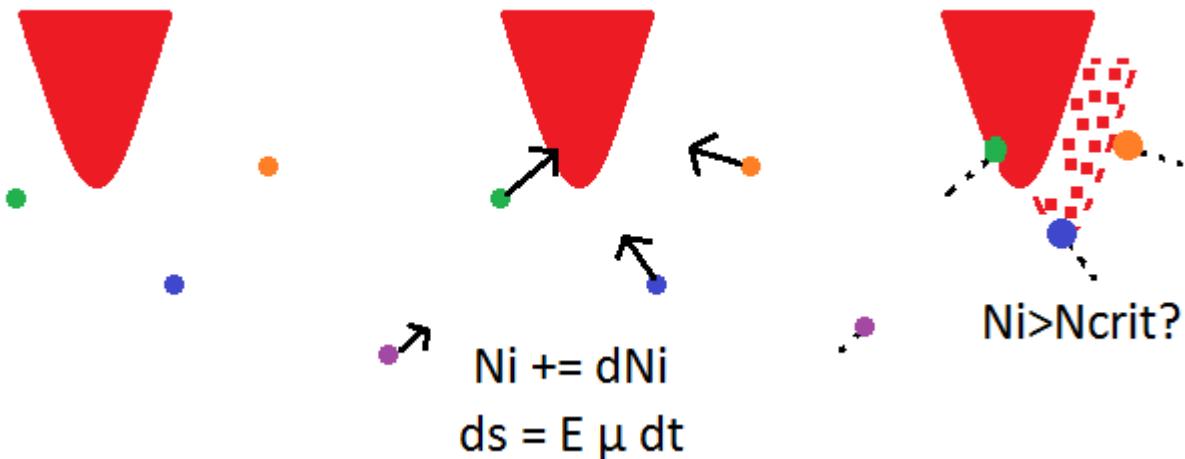
Basic mechanisms

- Electron avalanches
 - Impact ionization due to strong electric field
 - Leaving slow ions behind
- Seed electrons
 - Negative streamer
 - Cosmic radiation
 - Photoionization



Numerical model

- Place seed electrons at random
- Loop:
 - Calculate field
 - Move electrons
 - Increase N (number of electrons)
 - If $N > N_{crit}$ → Move tip to new location



Actual tasks

- Field dependent Ionization Potential
 - Increase speed?
- Photoionization
 - Branching?
 - Feed-forward mechanism?

