

## Pre-Week 0

We offer optional (i.e. not mandatory) introduction days on 14-15 October (online) on basic wave physics/solid state physics/magnetism, as well as the use of complex numbers for students not familiar with these concepts (or feel that they need a recapitulation). Further, the most fundamental and crucial components of solid-state physics and magnetism will also be introduced.

| Time / Date   | Morning Session I<br>08:30 – 10:00                   | Morning Session II<br>10:30 – 12:00                  | 12:00<br>-<br>14:00 | Afternoon Session I<br>14:00 – 15:30                      | Afternoon Session I<br>16:00 – 17:30                 |
|---------------|--|--|---------------------|---|--|
| Thu<br>14 Oct | Mathematical<br>Foundation 1<br><b>Kim Lefmann +</b> | Mathematical<br>Foundation 2<br><b>Kim Lefmann +</b> | Lunch               | Mathematical<br>Foundation 3<br><b>Kim Lefmann +</b>      | Mathematical<br>Foundation 4<br><b>Kim Lefmann +</b> |
| Fri<br>15 Oct | Mathematical<br>Foundation 5<br><b>Kim Lefmann +</b> | Mathematical<br>Foundation 6<br><b>Kim Lefmann +</b> | Lunch               | Solid State Physics<br>Foundation<br><b>Kim Lefmann +</b> | Magnetism<br>Foundation<br><b>Kim Lefmann +</b>      |

*The introductory days (“Week 0”) are performed as live lectures via zoom (link will be sent out only to registered participants)*

*For the main introductory course (“Weeks 1-3”) the lectures (L) will be conducted either live via zoom or through pre-recorded lectures in zoom.*

*Most of the exercises (Ex.) are conducted on your own time via our e-learning platform ( <https://pan-learning.org/> ). The location of the exercises in the schedule is to indicate the point where the lecture content will allow you to successfully understand/follow the exercises.*

*A couple of specific exercises (TUTORIALS) are, however, conducted live via zoom and will need your attendance*

**All times are given in Central European Time (CET)**

## Week 1

| Time / Date   | Morning Session I<br>08:30 – 10:00  | Morning Session II<br>10:30 – 12:00   | 12:00<br>-<br>14:00 | Afternoon Session I<br>14:00 – 15:30   | Afternoon Session I<br>16:00 – 17:30   |
|---------------|---|---|---------------------|--|--|
| Mon<br>18 Oct |   |   |                     |  |  |
| Tue<br>19 Oct |   |   |                     |  |  |
| Wed<br>20 Oct | <p><b>L0 “Welcome”</b></p> <ul style="list-style-type: none"> <li>Course information</li> <li>Examination Procedure</li> </ul> <p><b>Martin Månsson, KTH</b></p>  | <p><b>L1 “Course Overview”</b></p> <ul style="list-style-type: none"> <li>The Neutron/scattering experiment</li> <li>Neutron Technologies</li> <li>Elastic/Inelastic</li> <li>Brief overview of the techniques</li> </ul> <p><b>Martin Månsson, KTH</b></p>                                   | Lunch               | <p><b>L2.1 “Intro”</b></p> <ul style="list-style-type: none"> <li>Basic interaction mechanism (+x-rays)</li> </ul> <p><b>Kim Lefmann, NBI</b><br/>(Recorded Lecture)</p>   | <p><b>L2.2 “Intro”</b></p> <ul style="list-style-type: none"> <li>Scattering from 1 &amp; 2 Nuclei</li> <li>Coherent / Incoherent</li> </ul> <p><b>Kim Lefmann, NBI</b><br/>(Recorded Lecture)</p>             |
| Thu<br>21 Oct | <p><b>L2 “Neutron Sources &amp; Technology”</b></p> <ul style="list-style-type: none"> <li>Sources Moderators</li> <li>Monochromators / choppers</li> <li>Collimation / Filters / Guides</li> <li>Detection</li> </ul> <p><b>Kim Lefmann, NBI</b></p> | <p><b>Ex. 1</b></p> <ul style="list-style-type: none"> <li><a href="#">Wiki problem: Pinhole collimation</a></li> <li><a href="#">Quiz: Neutron detection</a></li> <li><a href="#">Quiz: Test your knowledge of neutron sources and instrumentation</a></li> </ul> <p><b>(e-learning)</b></p> | Lunch               | <p><b>L3 “Neutron Interaction with Matter”</b></p> <ul style="list-style-type: none"> <li>Cross Section, Isotope Sensitivity</li> <li>Elastic / Inelastic</li> <li>X-rays/electrons</li> <li>Multiple Scattering</li> </ul> <p><b>Kim Lefmann, NBI</b></p> | <p><b>Ex. 2</b></p> <ul style="list-style-type: none"> <li><a href="#">Quiz: The neutron cross section</a></li> <li><a href="#">Wiki problem: Selection of materials</a></li> </ul> <p><b>(e-learning)</b></p> |
| Fri<br>22 Oct | <p><b>L4 “Magnetic Scattering”</b></p> <ul style="list-style-type: none"> <li>Magnetism</li> <li>Nuclear/Magnetic Scattering</li> </ul> <p><b>Kim Lefmann, NBI</b></p>  | Catch up on assignments and inquire about things you did not understand.  | Lunch               | <p><b>L5 “Crystallography”</b></p> <ul style="list-style-type: none"> <li>Crystallography</li> <li>k-space</li> </ul> <p><b>Magnus H. Sørby, IFE</b></p>   | <p><b>Ex. 2 “Reciprocal lattice of Ni”</b></p> <ul style="list-style-type: none"> <li><a href="#">Quiz: Reciprocal lattice of Ni</a></li> </ul> <p><b>(e-learning)</b></p>                                     |
| Sat<br>23 Oct | Free Weekend  |   |                     |  |  |
| Sun<br>24 Oct | Free Weekend  |   |                     |  |  |

## Week 2

| Time / Date   | Morning Session I<br>08:30 – 10:00  | Morning Session II<br>10:30 – 12:00   | 12:00 - 14:00 | Afternoon Session I<br>14:00 – 15:30   | Afternoon Session I<br>16:00 – 17:30   |
|---------------|---|---|---------------|--|--|
| Mon<br>25 Oct | <p><b>L6 “Diffraction I”</b></p> <ul style="list-style-type: none"> <li>The Rietveld Method</li> </ul> <p><b>Magnus H. Sørby, IFE</b></p>   | <p><b>Ex. 3</b></p> <ul style="list-style-type: none"> <li><a href="#">Simulation quiz: Diffraction from powder</a></li> </ul> <p><b>(e-learning)</b></p>   | Lunch         | <p><b>L7 “Diffraction II”</b></p> <ul style="list-style-type: none"> <li>Instrumentation</li> <li>Total Scattering</li> </ul> <p><b>Magnus H. Sørby, IFE</b></p>   | <p><b>Ex. 4</b></p> <ul style="list-style-type: none"> <li><a href="#">When is Xray or Neutron diffraction suitable?</a></li> <li><a href="#">Wiki problem: Bragg scattering from non-Bravais lattices</a></li> </ul> <p><b>e-learning</b></p> |
| Tue<br>26 Oct | <p><b>Ex. 5:<br/>TUTORIAL<br/>Fullprof Refinement I<br/>Magnus H. Sørby, IFE</b></p>  | <p><b>Ex. 6:<br/>TUTORIAL<br/>Fullprof Refinement II<br/>Magnus H. Sørby, IFE</b></p>   | Lunch         | <p><b>L8 “Reflectometry I”</b></p> <ul style="list-style-type: none"> <li>Instrumentation</li> <li>Specular/off-specular</li> <li>Optical Matrix</li> <li>Kinematic Approximation</li> <li>Applications</li> </ul> <p><b>Adrian Rennie, UU</b></p> | <p><b>Ex. 7</b></p> <ul style="list-style-type: none"> <li><a href="#">Simulation quiz: Reflectometer</a></li> <li>Optical matrix fits</li> </ul> <p><b>e-learning</b></p>   |
| Wed<br>27 Oct | <p><b>L9 “Reflectometry II / GISANS”</b></p> <ul style="list-style-type: none"> <li>Distorted Born approximation</li> <li>GISANS Instrumentation</li> <li>In plane / out of plane</li> <li>Applications</li> </ul> <p><b>Adrian Rennie, UU</b></p>  |   | Lunch         | <p><b>L10 “Imaging”</b></p> <ul style="list-style-type: none"> <li>Instrumentation</li> <li>Radiography / Tomography</li> <li>In operando</li> <li>Neutrons / x-rays</li> </ul> <p><b>Luise Theil Kuhn, DTU</b></p>                                | <p><b>Ex. 8</b></p> <ul style="list-style-type: none"> <li><a href="#">Simulation quiz: Bragg Edge Imaging on Viking Sword</a></li> </ul> <p><b>e-learning</b></p>   |
| Thu<br>28 Oct | <p><b>L11 “SANS I”</b></p> <ul style="list-style-type: none"> <li>Instrumentation</li> <li>Scattering Length Density</li> <li>Form-/Structure Factor</li> <li>Approximations</li> </ul> <p><b>Andrew Jackson, ESS/LU</b></p>  | <p><b>Ex. 9</b></p> <ul style="list-style-type: none"> <li><a href="#">Simulation quiz: Small Angle Neutron Scattering</a></li> <li>Resolution (wavelength vs. angle)</li> <li>Data Treatment</li> </ul> <p><b>e-learning</b></p> | Lunch         | <p><b>L12 “SANS II”</b></p> <ul style="list-style-type: none"> <li>Geometrical models</li> <li>Contrast Variations</li> <li>Time-resolved / stroboscopic</li> <li>Applications</li> </ul> <p><b>Andrew Jackson, ESS/LU</b></p>                     |  |
| Fri<br>29 Oct | <p><b>L13 “INS I: Intro”</b></p> <ul style="list-style-type: none"> <li>Instrumentations (TAS/ToF)</li> <li>Direct / Indirect geometry</li> <li>Pulsed/Continuous</li> <li>E/p conservation / k-space (reminder)</li> <li>Examples (nuclear / magnetic)</li> </ul> <p><b>Kim Lefmann, NBI</b></p> |   | Lunch         | <p><b>L14 “INS II: Nuclear”</b></p> <ul style="list-style-type: none"> <li>Phonons (basics)</li> <li><math>\Omega/\tau</math> domain</li> <li>Cross sections</li> <li>Applications</li> </ul> <p><b>Gediminas Simutis, PSI</b></p>                 | <p><b>Ex. 10</b></p> <ul style="list-style-type: none"> <li><a href="#">Simulation quiz: Ni single crystal in a Triple Axis Spectrometer</a></li> <li><a href="#">Quiz: Phonons of Ni</a></li> </ul> <p><b>e-learning</b></p>                  |
| Sat<br>30 Oct | Free Weekend  |   |               |  |  |
| Sun<br>31 Oct | Free Weekend  |   |               |  |  |

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## Week 3

| Time / Date  | Morning Session I<br>08:30 – 10:00   | Morning Session II<br>10:30 – 12:00  | 12:00<br>-<br>14:00 | Afternoon Session I<br>14:00 – 15:30  | Afternoon Session I<br>16:00 – 17:30   |
|--------------|--|--|---------------------|---|--|
| Mon<br>1 Nov | <p style="color: blue; text-align: center;"><b>L15 “INS III: Magnetic”</b></p> <ul style="list-style-type: none"> <li>Spin waves</li> <li>Magnetic Cross Section</li> <li>Applications</li> </ul> <p style="color: blue; text-align: center;"><b>Kim Lefmann, NBI</b></p>  | <p style="color: magenta; text-align: center;"><b>Ex. 11 Spin-waves</b></p> <ul style="list-style-type: none"> <li>Pen-and-paper problem</li> </ul> <p style="color: magenta; text-align: center;"><b>Kim Lefmann, NBI</b></p> | Lunch               | <p style="color: brown; text-align: center;">Ex. 12: TUTORIAL - SpinW/OMDB</p> <ul style="list-style-type: none"> <li>Modelling phonons/spin waves</li> <li>Extract J's</li> <li>Spin-W</li> </ul> <p style="color: brown; text-align: center;"><b>Simon Ward, ESS/DMSC</b><br/><b>Johan Hellsvik, KTH</b></p>  | <p style="color: brown; text-align: center;">Ex. 13: TUTORIAL - SpinW/OMDB</p> <ul style="list-style-type: none"> <li>Modelling phonons/spin waves</li> <li>Extract J's</li> <li>Spin-W</li> </ul> <p style="color: brown; text-align: center;"><b>Simon Ward, ESS/DMSC</b><br/><b>Johan Hellsvik, KTH</b></p> |
| Tue<br>2 Nov | <i>Help Session for Proposal Writing</i>   | <i>Help Session for Proposal Writing</i>   | Lunch               | <p style="color: blue; text-align: center;"><b>L16 “QENS”</b></p> <ul style="list-style-type: none"> <li>Instrumentation</li> <li>Energy-/timescales</li> <li>Coherent / Incoherent</li> <li>Diffusion, Molecular dynamics</li> <li>Cross section &amp; Isotope labeling</li> </ul> <p style="color: blue; text-align: center;"><b>Aleksandar Matic, Chalmers</b></p> |  |
| Wed<br>3 Nov | <p style="color: blue; text-align: center;"><b>L17 “Polarized Neutron Scattering”</b></p> <ul style="list-style-type: none"> <li>Polarizing/Flipping/Detecting the neutron spin (theory &amp; technologies)</li> <li>Basic theory</li> <li>Examples (Elastic &amp; Inelastic)</li> </ul> <p style="color: blue; text-align: center;"><b>Werner Schweika, ESS</b></p> |  | Lunch               | <p style="color: blue; text-align: center;"><b>L18 Keynote Lecture</b><br/><i>Societal Challenges</i><br/><b>“Sustainable Energy”</b><br/><b>Martin Månsson, KTH</b></p>  |  |
| Thu<br>4 Nov | <p style="color: blue; text-align: center;"><b>L19 Keynote Lecture</b><br/><i>Societal Challenges</i><br/><b>“Quantum Materials”</b><br/><b>Henrik Rønnow, EPFL</b></p>  |  | Lunch               | <p style="color: blue; text-align: center;"><b>L20 Keynote Lecture</b><br/><i>Societal Challenges</i><br/><b>“Engineering Materials/Processes”</b><br/><b>Richard Moat, OU</b></p>  | <i>Help Session for Proposal Writing</i>   |
| Fri<br>5 Nov | <p style="color: blue; text-align: center;"><b>L21 Keynote Lecture</b><br/><i>Societal Challenges</i><br/><b>“Life-Science”</b><br/><b>Jeremy Lakey, Newcastle University</b></p>  |  | Lunch               | <p style="color: blue; text-align: center;"><b>L22 Keynote Lecture</b><br/><i>“Future Science at ESS”</i><br/><b>Andreas Schreyer, ESS</b><br/><b>Time: 15:00 – 16:30</b></p>   | <p style="color: green; text-align: center;">Closing Words<br/><b>K. Lefmann, NBI</b><br/><b>M. Månsson, KTH</b></p>   |
| Sat<br>6 Nov | END OF SCHOOL  |  |                     |   |  |
| Sun<br>7 Nov | END OF SCHOOL  |  |                     |   |  |

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