1. **Sources of synchrotron radiation**
   BETREUER: H. Franz
   The use of synchrotron radiation started as parasitic use of the X-rays and VUV radiation from bending magnets. Meanwhile dedicated magnetic structures are inserted into storage rings to deliver "customs made" X-ray beams. The talk should give an overview on the types of sources (bending magnets, wigglers, undulators) and describe the spectral and angular characteristics. Different approaches for the analytic treatment of the problem may be used.

   Literature:

   - J.D. Jackson, Classical Electrodynamics, J. Wiley & Sons
   - P. Ilinski, PhD, available at HASYLAB
   - K.J. Kim, Optical and power characteristics of synchrotron radiation sources, Optical engineering, 34, 342 (1995)

2. **Focusing X-Rays: Towards 1nm resolution**
   BETREUER: M. Sprung
   Nanoscience is one of the most dynamic and rapidly developing areas of interdisciplinary research. It addresses the unique physical and chemical properties of nanometer-sized (less than 100 nm) materials and phenomena occurring at the nanoscale. In order to understand, and eventually design, the properties of materials at the nanoscale, many materials synthesis, manipulation, characterization, and modeling/simulation tools need to be developed. This is a compelling reason to develop x-ray based nanoprobes at new synchrotron sources around the world. It is of utmost importance to develop focusing capabilities down to 10nm or below for these instruments. Several different approaches (diffractive, refractive and mirror optics) are currently pursued to reach this challenging goal. The seminar should give an overview of three x-ray focusing techniques (multilayer Laue Lens, Kirkpatrick-Baez mirrors and compound refractive lenses) and compare them.

   Literature:

   - TDR of Petra III and NSLS II
   - References of Jörg Maser about the nanoprobe at CNM/ANL (http://nano.anl.gov/research/nanoprobe.html)
   - References of Peter Cloetens as starting point
   - References of Christian Schroer's group

3. **Ultraschnelle dynamische Prozesse und Röntgenstrahlung**
   BETREUER: M. Martins
   Es sollen die Methoden beschrieben werden, um Lichtpulse auf der as (10^{-18}s) Skala zu erzeugen und welche dynamischen Prozesse damit untersucht werden können.

4. **Laserbasierte Teilchenbeschleuniger**
   BETREUER: M. Martins
   Ultrastarke Lasersysteme ermöglichen eine vollständig neue Möglichkeit, Teilchen auf ultrarelativistische Geschwindigkeiten zu beschleunigen. Hiermit könnten in Zukunft table-top Röntgenquellen möglich werden. Im Rahmen des Vortrages soll das Prinzip dieser Beschleuniger und die aktuellen Experimente an diesen Systemen beschrieben werden.

5. **Doppelspaltexperimente an einzelnen Molekülen**
   BETREUER: S. Klumpp
   Rumpflöcher werden i.A. als lokalisierte Zustände angesehen. Neuere Experimente zeigen, dass diese jedoch als delokalisert angesehen werden müssen und dass dies auch Auswirkungen auf den Verlust von Kohärenz in Quantensystemen haben kann. Es sollen die Experimente, die dabei angewandten Methoden und die Ergebnisse dargestellt und diskutiert werden.

6. **Materie in ultrastarken elektromagnetischen Feldern**
   BETREUER: S. Klumpp
   Der Photoeffekt stellt einen der grundlegenden Prozesse der Wechselwirkung von Strahlung mit Materie dar. Im Fall von sehr starken elektromagnetischen Feldern, wie sie mit Lasern realisiert werden können, treten jedoch Effekte auf, die nicht mehr in diesem einfachen Bild erklärt werden können. Im Vortrag soll ein Überblick über die aktuellen Experimente sowie die verwendeten Modelle gegeben werden.

7. **Photoionization freier Ionen mit der Merged Beams Technique**
   BETREUER: S. Klumpp
   Literature:

   - H. Kjeldsen: J. Phys. B **39**, R325-R377 (2006)
   - R. Phaneuf et. al., Rep. Prog. Phys. **62**, 1143-1180 (1999)

8. **Quality assessment of surfaces and interfaces with x-ray reflectivity (Qualitätsbestimmung von Ober- und Grenzflächen mit Röntgenreflektivitäten)**
   BETREUER: O.H. Seeck
   X-ray reflectivity is a very important tool to investigate the properties of surfaces and interfaces. This method enables the possibility to determine characteristics such as film thickness, interface roughness and interdiffusion. Big advantages over other methods are the material sensitivity, the large penetration depth up to some micrometer and, most prominent, that x-ray reflectivity is mostly non-destructive. Also, it is usually not required to specially prepare the sample for the measurement. In this seminar, the student should explain the x-ray reflectivity, especially the experimental details, theoretical aspects and refinement methods. Examples from semiconductor thin film technology should illustrate the potentials and the limits of x-ray reflectivity.

Literature:

- M. Tolan X-ray scattering from soft matter thin films, Springer: Berlin, Heidelberg, 1999
- Y. Huai, et al. X-Ray diffraction studies of Co/Re superlattices, Phys.Rev.B 48, 2568 (1993)
- R. Weber, et al. X-ray reflectivity study on the surface and bulk glass transition of polystyrene, Phys.Rev.E 64, 061508 (2001)
- S. Körber Untersuchung von ionenimplantierten Kobaltdisilizidschichten mit Synchrotronstrahlung, Diplomarbeit an der Universität Kiel, 1994
- Ch. Jensen Untersuchung vergrabener MBE Silizidschichten mittels Röntgenbeugung, Diplomarbeit an der Universität Kiel, 1993

9. **Statistical properties of interfaces determined by diffuse x-ray scattering (Bestimmung statistischer Eigenschaften von Grenzflächen mittels diffuser Röntgenstreuung)**
BETREUER: O.H. Seeck
X-ray diffuse scattering is sensitive to the lateral structure of surfaces and interfaces. It is used to investigate statistical properties of interfaces such as typical in-plane length scales, the jaggedness of interfaces and auto- and cross-correlation functions. The statistical parameters are usually connected to physical properties of the sample. For example, various models for layer growth exist which make predictions on the autocorrelation function of the surface. Another important example is appearance of liquid surfaces which are slightly rough due to capillary wave effects. The nature of the different rough interface can perfectly be investigated by x-ray diffuse scattering. In this seminar, the student should first explain the appearance of rough surfaces and the modelling by auto- and cross-correlation functions. The self-affine surfaces and the capillary waves should be introduced as an example together with the x-ray diffuse scattering in Born- approximation. Examples from semiconductor thin films and/or liquid surfaces should illustrate the use of the diffuse scattering in science.

   Literature:

   - M. Tolan X-ray scattering from soft matter thin films, Springer: Berlin, Heidelberg, 1999
   - S.K. Sinha et al. X-ray and neutron scattering from rough surfaces, Phys.Rev.B 38, 2297 (1988)
   - O.H. Seeck. Capillary Waves on Polymer Thin Films, in Soft Matter: complex materials on mesoscopic scale Eds.: J.K.G Dohnt, G. Gomper, D. Richter, Forschungzentrum Jülich GmbH, Jülich, 2002
   - M. Lütt et al. Kadar-Parisi-Zhang growth of amorphous silicon on Si/SiO2 , Phys.Rev.B 56, 4085 (1997)

- M. Lütt Untersuchung des Skalenverhaltens wachsender Halbleiterschichten mit Röntgenstreuung, Diplomarbeit an der Universität Kiel, 1993
- T. Seydel Glasoberflächen: Einfrieren von Kapillarwellen? Dissertation an der Universität Kiel, 2000

10. **Structure and Dynamics of Colloidal Suspensions (Struktur und Dynamik kolloidaler Suspensionen)**
BETREUER: G. Grübel
Colloidal systems acting as a model system for condensed matter have been thoroughly studied during the last years. While the observed particle interactions in the case of a hard-sphere system are well explained by theory, this is not the case for indirect particle interactions between charge-stabilized colloids. The status of experimental work as well as our theoretical understanding is discussed.

    Literature:

    - P.N. PUSEY Colloidal Suspensions, J.P. Hansen, D. Levesque, J. Zinn- Justin, eds., Les Houches Session LI, 1989, Liquids, Freezing and Glass Transition, Elsevier 1991
    - G. Nägele, Theories of Fluid Microstructures, J.K.G. Dhont, G. Gompper, G. Nägele, D. Richter, R.G. Winkler, Soft Matter, 39th IFF Spring School 2008, ISSN 1866-1807

11. **Grundlagen der Röntgenkleinwinkelstreuung unter streifendem Einfall - Strukturuntersuchungen dünner Polymer- und Nanokompositfilme**
BETREUER: S.V. Roth und R. Gehrke
Kleinwinkelstreuung unter streifendem Einfall ist eine wichtige Methode zur Untersuchung der Struktur von dünnen, nanostrukturierten Filmen. In Verbindung mit Synchrotronstrahlung erlaubt sie eine oberflächenempfindliche Bestimmung von Ordnung auf Längenskalen von Nanometer bis zu Mikrometern. Diese Methode hat sehr großen Einfluss zur Optimierung der Struktur- Eigenschaftsbeziehung in technisch relevanten Systemen.

    Literature:

    - Müller-Buschbaum, Anal. Bioanal. Chem. 376, 3 (2003)
    - Yoneda, Phys. Rev. 131, 2010 (1963)
    - Roth et al., Appl. Phys. Lett.88, 021910 (2006)

12. **Charakterisierung industrieller Fertigungsprozesse mittels Röntgenkleinwinkelstreuung**
BETREUER: S.V. Roth und R. Gehrke
Industrielle Fertigungsprozesse reichen von der Herstellung atomar dünner Filme durch Deposition bis zu großvolumigen Systemen in Spritzgußverfahren. Die

erreichten Eigenschaften werden durch die gebildeten Strukturen bestimmt, die wiederum von den Herstellungsparametern abhängen. Röntgenkleinwinkelstreuung ist ein ideales Werkzeug, um die Herstellungsparameter und die gebildete Struktur zerstörungsfrei untersuchen zu können.

Literature:

- Schroer et al., Appl. Phys. Lett. 88, 164102 (2006)
- Metwalli et al., Langmuir 24, 4265 (2008)

13. **X-ray Photon Correlation Spectroscopy**
BETREUER: C. Gutt
Correlation spectroscopy uses coherent X-rays and allows investigating dynamic properties of samples in real time. The method measures fluctuations of X-ray intensities and the correlations between the intensities yield information about dynamic and structural properties of the sample. Correlation spectroscopy is today routinely used to study the dynamics of a wide variety of samples ranging from hard condensed matter to soft matter and magnetic materials. The measurement in the time domain allows to study non-equilibrium dynamics at phase transitions and new phenomena as aging in soft matter systems. In this seminar the student should explain the techniques of correlation spectroscopy. The theoretical background and experimental setups used shall be explained. Examples from current research should illustrate the potential and limitations of the techniques.

Literature:
Relevant literature will be provided.

14. **Challenges of magnetic x-ray scattering**
BETREUER: J. Strempfer
Magnetic x-ray scattering is a tool of increasing importance, since the microscopic investigation of magnetic materials can give fundamental information towards the development of new technologies. A recent example is the underlying magnetic order in multiferroic materials, which show a strong interaction of magnetism and electric polarization. Both non-resonant and resonant scattering at the absorption edges is used increasingly in combination with varying incident polarized synchrotron radiation. The method allows to separately explore spin and orbital magnetic moment, but also to perform element sensitive investigations of magnetic order. In tuning the x-ray energy to an absorption edge the very weak magnetic signal is dramatically enhanced. This coupled with the brightness of third generation synchrotron sources and modern polarization manipulation and analysis, makes it possible to get insights into the magnetic ordering mechanisms.

Literature:

- M. Blume and D. Gibbs, Phys. Rev. B 37, 1779 (1988)

- J. P. Hill and D.F. McMorrow, Acta Cryst. A52, 236 (1996)
- S. W. Lovesey and S. P. Collins, 'X-ray Scattering and Absorption by Magnetic Materials', Oxford Series on Synchrotron Radiation 1, Clarendon Press, Oxford, 1996
- R.D. Johnson et al, Phys. Rev. B 78, 104407 (2008)

15. **Structure of metallic glasses**
BETREUER: H. Franz·
Metallic glasses (alloys of metallic compounds with amorphous structure) show some rather interesting mechanical properties: high strength, low ductility, high formability. The talk should give an overview on structural characterisation of typical metallic glass compounds. In particular the virtue of combined evaluation of different characterisation techniques using Reverse Monte-Carlo methods should be highlighted. Also the relation between mechanical load and structural evaluation should be explained using some recent experiments.

Literature:

- A.L. Greer, Metallic Glasses, Science 267,1947 (1995)
- H. Poulsen et al, Measuring strain distributions in amorphous materials, Nature Materials 4, 33 (2005)
- M. Stoica, J. Das, J. Bednarcik, H. Franz, N. Mattern, W. H. Wang, J. Eckert Strain distribution in Zr64.13Cu15.75Ni10.12Al10 bulk metallic glass investigated by in-situ tensile tests using synchrotron radiation, Journal of Applied Physics 104, 013522 (2008)

16. **Near Field Speckle: A new approach to perform ultra small angle scattering**
BETREUER: M. Sprung
Very recently, M. Giglio and coworkers presented an exciting new approach to perform scattering experiments in the ultra small angle x-ray scattering (USAXS) regime1. Their experiments show that high quality x-ray speckles are observable by detecting the scattered radiation and the transmitted beam in the near field. Correct analysis of near field speckle (NFS) data retrieves the following information:

(a) The scattering intensity distribution is obtained in absolute units
(b) The range of observable Q vectors is extended towards lower Q by an order of magnitude compared with state of the art USAXS instruments such as a Bonse-Hart camera
(c) Dynamic behavior can be obtained (similar to X-Ray Photon Correlation Spectroscopy experiments)

This seminar should give an overview of this new NFS method and discuss advantages and limitations compared to traditional USAXS methods. It should also discuss beam and detector requirements.

Literature:

- R. Cerbino, L Peverini, M. A. C. Potenza, A. Robert, P. Bösecke and M. Giglio, “X-ray scattering information obtained from near field speckle”, Nature Physics 4 (2008) 238-243 and references therein.

17. **Einleitung in Röntgenabsorptionsspektroskopie**
BETREUER: W. Caliebe

- Absorptionskanten, Energieniveau-Schema
- Experimenteller Aufbau: Transmission, Fluoreszenz, Detektoren, Probenumgebung
- Nahkantenspektroskopie (XANES), unbesetzte Zustände
- EXAFS, Strukturuntersuchung, Abstände von nächsten Nachbarn
- woher kommt die EXAFS-Gleichung, was bedeuten und bewirken die einzelnen Terme?
- Datenauswertung, FEFF-Programm
- Anwendungen in Physik und anderen Fächern

Literature:

- Ferienschule Jülich 1992
- Aktuelle Ergebnisse: Publikationen von EXAFS-Messplätzen
- Haw, Experimental Methods in Catalysis

18. **Dichroismus und andere Methoden der Spektroskopie**
BETREUER: W. Caliebe

- zirkular polarisierte Röntgenstrahlen
- Zirkulardichroismus, Lineardichroismus
- magnetisierte Probe, Drehen Magnetfeld oder Polarisation, elementspezifische Magnetisierung, Differenzmessung
- Summenregeln
- Inelastische Röntgenstreuung
- DAFS, ASAXS (anomale Streuung)
- Anwendung

Literature:

- Kofersche Doktorarbeit
- Bücher: Lovesey-Collins, Schülke, FMF DeGroot & A. Kotani

19. **Fluoreszenzspektroskopie**
BETREUER: W. Caliebe

    - Atomphysik, Orbitalmodell
    - Energiedispersiv, Wellenlängendispersiv
    - hohe Energieauflösung, Festköpreffekte, Spinaufspaltung
    - Bildgebung, Anwendungen in anderen Fächern

    Literature:

    - Buch über Atomphysik
    - Paper und Bücher von Frank, Schülke