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The Workshop will be held in:

Großer Hörsaal (2nd floor)
Institute of Physics
Universitätsplatz 3
18055 Rostock

Preface

The generation and diagnostics of extreme states of matter as appearing in the interior of planets, Brown Dwarfs and stars is one of the key scientific challenges at FLASH, the future European XFEL and the High Pressure Extreme Conditions beamline at PETRA III. This interdisciplinary research field combines problems and methods from planetary and astrophysics, and high-pressure and plasma physics. In the field of planet detection, the CoRoT and Kepler missions have found more than one thousand extrasolar planets and several thousand candidates. Future missions like Kepler-2, CHEOPS, TESS and PLATO will lead to a more detailed knowledge about planetary formation, evolution and structure. Therefore, a workshop series has been established by DESY, XFEL GmbH, DLR Berlin, University of Rostock and University of Bayreuth that brings together scientists from these fields to discuss related topics and problems. Earlier workshops were held at DESY Hamburg (2012) and DLR Berlin (2013).

The aim of the present workshop is to discuss scientific questions with relevance for extreme planetary environments in terms of high pressure (HP) and high temperature (HT). These conditions are prevalent in the deep interiors and atmospheric envelopes of solar system planets and satellites and massive solid and gas giant extrasolar planets, respectively, and are not fully accessible by conventional experimental and theoretical methods. New and enabling techniques to be used in the HP/HT regime are based on the combination of intense pulsed x-ray sources with pulsed sample excitation, in particular but not exclusively related to high energy optical lasers. Simultaneously, ab initio simulations for matter under extreme conditions provide a more and more predictive data set for planetary interiors in this HP/HT regime.

The program addresses the following topics

- Evolution and structure of giant planet interiors,
- Interior structure, bulk composition, and internal geodynamics of solid planets,
- Deep volatile cycles and exchange processes between geochemical reservoirs,
- Physics and chemistry of impact processes,
- Equations of state, petrology, and geochemistry of planetary materials,
- Melting relations and phase transformations of materials at extreme states,
- Dynamic and ultrafast processes in strongly excited solids or similar,
- Compression experiments using high-power optical and free electron lasers
- Laboratory experiments using multi-anvil and diamond-anvil cells,
- Ab initio simulation studies for matter under extreme conditions.

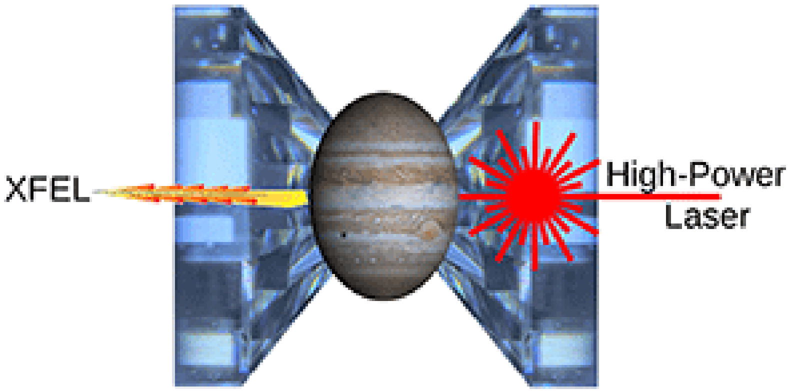
3rd Joint Wokshop on High Pressure, Planetary and Plasma Physics

Conference program

Wednesday, Sep 24		
12:00	Registration and light lunch	
13:45	Opening	
Session I: Facilities & future missions		
14:00	I1 Eggert	Some results / status of dynamic-compression experiments using high-energy lasers, at Omega, NIF, LCLS, and DCS
14:30	T1 Appel	Perspectives for studying planetary matter using intense X-ray pulses at the high energy density science instrument at the European XFEL
14:50	T2 Neff	Experimental facilities for plasma physics experiments at FAIR
15:10	T3 Liermann	Current Capabilities and Future Plans for Time-Resolved X-ray diffraction at Extreme Conditions at the ECB and PETRA III.
15:30	Coffee break	
Session II: Ab initio molecular dynamics simulations & planetary interiors		
16:00	I2 Hamel	Recent progress on the equation of state of carbon and silicon dioxide at extreme conditions
16:30	T4 Steinle-Neumann	Crystallizing the Hermean Core - Thermodynamics of Fe Melting
16:50	T5 Wicht	Explaining Mercury's peculiar magnetic field
17:10	T6 French	Thermodynamically constrained correction to ab initio equations of state
17:30	Poster Session (in the seminar room across the hall)	HIBEF - SAC and TAC meeting (University Main Building, Room 217)

Thursday, Sep 25		
Session III: Helmholtz International Beamline for Extreme Fields at the European XFEL		
09:00	T7 McBride	Reaching Planetary-Core Conditions with Dynamic and Double-Stage Diamond Anvil Cells at the Helmholtz International Beamline for Extreme Fields (HIBEF)
09:20	T8 Higginbotham	Dynamic compression experiments using the DiPOLE laser system at the European XFEL
09:40	T9 Pelka	Probing of Complex Interaction Dynamics of Ultra-Intense Lasers with Solid Matter using XFELs
10:00	T10 Strempfer	Pulsed magnetic fields at the HED instrument
10:20	Coffee break	
Session IV: Plasma diagnostics		
11:00	I3 Recoules	Ab initio calculation of X-ray absorption spectra for iron up to 430 GPa
11:30	T11 Kraus	Probing the complex ionic structure of warm dense carbon
11:50	T12 Zastrau	Spatially-resolved X-ray scattering off shock-compressed carbon at the LCLS
12:10	T13 Rüter	Investigation of the ion dynamics in warm dense aluminum by ab initio simulations
12:30	Light Lunch	
Session V: Interior structure of rocky planets		
14:00	I4 Sanchez-Valle	High pressure experiments on icy moon materials and planetary geophysics
14:30	T14 Dorn	An Inversion Technique for Constraining the Interior Structure of Rocky Exoplanets
14:50	T15 Wagner	Modelling the interior structure, composition, and mass-radius relationships of solid exoplanets
15:10	T16 Breuer	Dynamics and plate tectonics on rocky exoplanets
15:30	Coffee break	
Session VI: Diamond anvil cells		
16:00	I5 McMahon	High Pressure, Planetary and Plasma Physics: What Can You Do With a DAC?
16:30	T17 Bethkenhagen	Superionic water-ammonia mixtures
16:50	T18 Ovsyannikov	Unusual properties of 'simple' oxides prepared at HP-HT conditions
17:10	T19 Müller	Recent Advancement in High Pressure Falling Sphere Viscosimetry in DIA-type Large Volume Presses
19:30	Dinner and evening program at the restaurant "Trotzenburg", Tiergartenallee 6, 18059 Rostock (Take tram number 6, direction "Neuer Friedhof", from stop "Lange Straße", exit at station "Zoo".)	

Friday, Sep 26		
Session VII: Hot dense matter		
09:00	I6 Döppner	Generating and Studying Matter at Extreme Pressures on the National Ignition Facility
09:30	T20 Becker	Interior structure of Brown Dwarfs and their material properties
09:50	T21 Mintsev	Estimations of shear viscosity of nonideal plasma
10:10	T22 Hou	The average atom model combined with the hypernetted chain approximation applied to warm dense matter
10:30	Coffee break	
Session VIII: High-pressure phase transitions		
11:00	I7 Knudson	Dynamic compression experiments on liquid deuterium above the melt boundary to investigate the insulator-to-metal transition
11:30	I8 Brygoo	Observation of H/He demixing under deep Jovian planetary conditions
12:00	T23 Püstow	H-He demixing and the interior and evolution of Saturn
12:20	T24 Spohn	Future space missions of potential interest to the HP4 community
12:50	Closing remarks and light lunch	



Abstracts of talks Wednesday 24.09.2014, 14:00 - 17:30

I1: Wednesday 24.09.2014, 14:00 - 14:30

Some results / status of dynamic-compression experiments using high-energy lasers, at Omega, NIF, LCLS, and DCS

Jon Eggert[1]
[1]*Lawrence Livermore National Laboratory, USA*

Recent ramp-compression equation-of-state (EOS) experiments using free-surface wave-profile measurements on laser facilities have yielded stress-density results at record stresses and short time scales. This work has been extended to compression-rate effects on phase transitions, but it has been very difficult to gain in-situ structural information in these experiments. Over the past five years there has been a gradual shift from integrated wave-profile measurements to in-situ structure-sensitive x-ray diffraction (XRD) measurements.

In this talk I will review some of our wave-profile EOS results, as well as some recent XRD results for laser-driven diffraction. I will show results from a wealth of XRD Omega data, 17 NIF XRD shots, several campaigns at the Linac Coherent Line Source (LCLS), and current plans for the Dynamic Compression Sector (DCS) at the Advanced Photon Source (APS). As the experimental diffraction techniques improve to allow observation of more diffraction lines, the phase and stress-density uncertainties will improve. Ultimately, the primary experimental probe for ramp-compression EOS experiments will be x-ray diffraction, as it is for diamond-anvil-cell experiments. A final, very exciting expected payoff from the many developing sources for dynamic x-ray diffraction experiments is the potential, for the first time, to do dynamical pump-probe in-situ structural measurements of a wide variety of phase transitions on a nano-second time scale.

T1: Wednesday 24.09.2014, 14:30 - 14:50

Perspectives for studying planetary matter using intense X-ray pulses at the high energy density science instrument at the European XFEL

Karen Appel[1], Motoaki Nakatsutsumi[1], Alexander Pelka[2], Gerd Priebe[1], Ian Thorpe[1], Thomas Tschentscher[1]

[1]*European XFEL, Hamburg, Germany*

[2]*Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Germany*

Free-electron laser facilities enable new applications in the field of high-pressure research including planetary materials. The European X-ray Free Electron Laser (European XFEL) in Hamburg, Germany will start user operation in 2017 and will provide photon energies of up to 25 keV. The high-energy density science instrument (HED) at the European XFEL is dedicated to the study of dense material at strong excitation in a temperature range from eV to keV and pressures > 100 GPa which is equivalent to an energy density > 100 J/mm^3. It will enable studying structural and electronic properties of excited states with hard X-rays at a repetition rate of up to 4.5 MHz. The instrument is currently in its technical design phase and first user experiments are foreseen for end of 2017.

In this contribution, we present the X-ray instrumentation and the foreseen X-ray techniques at HED. In addition, we discuss prototype hard-condensed matter experiments in the field of planetary research as proposed during recent user consortium meetings for this instrument. These include optical laser induced quasi-isentropic (ramped) compression and shock compression experiments and diamond anvil cell experiments.

T2: Wednesday 24.09.2014, 14:50 - 15:10

Experimental facilities for plasma physics experiments at FAIR

Stephan Neff[1]
[1]*Facility for Antiproton and Ion Research (FAIR), Darmstadt, Germany*

The next-generation accelerator facility FAIR that is currently being built in Darmstadt will provide heavy-ion and proton beams with high energies and high intensities, which will make novel plasma physics experiments possible. The heavy-ion beams can be used to heat targets for equation-of-state studies of warm dense matter. The proton beam will be used for proton microscopy, which will provide density diagnostics with high spatial resolution at high densities. The presentation will give an overview of the planned experimental facilities and the planned experiments at the plasma physics experimental area at FAIR.

T3: Wednesday 24.09.2014, 15:10 - 15:30

Current Capabilities and Future Plans for Time-Resolved X-ray diffraction at Extreme Conditions at the ECB and PETRA III.

Hanns-Peter Liermann[1], Emma McBride[2], Zuzana Konopkova[1]
[1]*PETRA-III, Deutsches Elektronen Synchrotron (DESY), Hamburg*
[2]*Deutsches Elektronen Synchrotron (DESY), Hamburg*

Time resolved X-ray diffraction experiments at extreme conditions of high-pressure and simultaneous high-temperatures have become a growing field of research in the past decades. In particular this technique may be used to study: a) the effect of meteorite impact on geological and planetary environments (e.g. Carl et al. 2014); b) the compression and strain-rate dependence of phase space to systematically understand nucleation path (e.g. Wang et al. 2014, ...); and, c) the materials at pressures and temperatures beyond those encountered at the Earth's core by employing dynamic-, double-stage Diamond Anvil Cells (DAC) and shock-compression laser drivers to study super-Earths and gaseous planets. In fact, it has become apparent that pressures and temperatures present at the center of these giant planets can only be reached when conducting experiments on a time scale of pico to nano seconds. Under these shock and/or quasi-isentropic compression conditions, the effect of high strain-rates may have a significant effect on the interpretation and extrapolation of the results to planetary conditions that are a likely to be a lot less dynamic. Hence, an integral knowledge of the effect of strain-rates on cold condensed and warm dense matter is urgently needed.
Extremely brilliant light sources at large-scale facilities are the only experimental means to explore both the effect of fast compression on geological and planetary-relevant materials and provide data for meaningful extrapolations to "less dynamic" planetary environments. Thus, beamlines at 3rd generation sources are adjusting their capabilities to enable time-resolved X-ray diffraction experiments within the framework of the dynamic DAC and double-stage DACs (e.g. GSECARS and HPCAT at the APS, ECB at PETRA III, DESY) as well as shock-compression (DCS at the APS). At the same time these techniques are also being employed and developed at 4th generation sources (e. g. MEC at the LCLS and the HED at the European XFEL) that offer the ultimate brilliance at a time scale of femtoseconds.
Within this talk we are presenting the current capabilities to conduct time- resolved X-ray diffraction experiments in the fast compression DAC (membrane DAC and dDAC) at the ECB as well as our near and long-term plans to use fast area detectors, such as the GaAs bonded LAMBDA detector or the AGIPD, in conjunction with the full width of the 3rd undulator harmonic, to conduct time-resolved powder and single-crystal diffraction experiments in the kHz to MHz time regime. We will also give an outlook of the extension of these capabilities in the context of the proposed planning of further beamlines at PETRA III.

I2: Wednesday 24.09.2014, 16:00 - 16:30

Recent progress on the equation of state of carbon and silicon dioxide at extreme conditions

Sebastien Hamel[1]

[1] *Lawrence Livermore National Laboratory, USA*

Shock compression experiments provides us with a direct measurement of the equation of state of materials such as silicon dioxide at the pressure and temperatures relevant to planetary science. The high-pressure response of materials to shock compression is cast in the form of a Hugoniot curve which is one of the key experimental inputs to equation of state models used in various hydrodynamic simulations of materials under extreme conditions of pressure and temperature. States on the principal Hugoniot also happen to be the collection of thermodynamic states reached during giant impacts between astrophysical bodies, including the one thought to be responsible for the formation of the Earth-Moon system [1,2]. The relevant pressure range for such impacts are in the hundreds of GPa, conditions that can be reached on several platforms such as the Omega Laser facility, NIF, the Z machine, and LCLS. The adiabatic expansion of the shocked material and its eventual partitioning into a vapor and/or a liquid phase is determined by the entropy reached during the shock compression. Entropy is a difficult quantity to extract from first-principles simulations and its accurate evaluation is one of the important recent development in electronic structure calculations. We present first-principles results for the entropy of silicon dioxide on the principal Hugoniot. The calculations are based on quantum molecular dynamics and thermodynamic integration using the coupling constant method. Comparisons are made to recent experimental results [3] and to several equation of state models and a high pressure melting line is determined.
We will also present a 5-phase equation of state for elemental carbon which addresses a wide range of density and temperature conditions. The phases considered are diamond, BC8, simple cubic, simple hexagonal, and the liquid/plasma state. The solid phase free energies are constrained by density functional theory (DFT) calculations. The liquid free energy model is constrained by fitting to a combination of DFT molecular dynamics performed for $T < 10$ eV, and path integral quantum Monte Carlo calculations for $T > 10$ eV. The liquid free energy model includes an atom-in-jellium approach to account for the effects of ionization due to temperature and pressure in the plasma state, and an ion-thermal model which includes the approach to the ideal gas limit. The precise manner in which the ideal gas limit is reached is greatly constrained by both the highest-temperature DFT data and the path integral data, forcing us to discard an ion-thermal model we had used previously in favor of a new one. This is found to be a common feature of the liquid free energy and not restricted to carbon.

[1] M. Cuk, S.T. Stewart. Making the Moon from a Fast-Spinning Earth: A Giant Impact Followed by Resonant Despinning. Science 338 pp. 1047-1052 (2012).
[2] R.M. Canup. Forming a Moon with an Earth-like Composition via a Giant Impact. Science 338 pp. 1052-1055 (2012).
[3] R.G. Kraus, S.T. Stewart, D.C. Swift, C.A. Bolme, R.F. Smith, S. Hamel, B.D. Hammel, D.K. Spaulding, D.G. Hicks, J.H. Eggert and G.W. Collins. Shock vaporization of silica and the thermodynamics of planetary impact events. J. Geophys. Res. 117 E09009 (2012).

T4: Wednesday 24.09.2014, 16:30 - 16:50

Crystallizing the Hermean Core - Thermodynamics of Fe Melting

Gerd Steinle-Neumann[1], David Dolejs[2]

[1] *Bayerisches Geoinstitut, University of Bayreuth, Germany*

[2] *Institute of Petrology and Structural Geology, Charles University, Prague, Czech Republic*

Aside from the Earth, Mercury is the only other terrestrial planet that possesses a self-generated magnetic field. Its magnitude and character are quite different from the magnetic field of the Earth, which – among other aspects – could be caused by the different nature of inner core crystallization in Mercury. With a central pressure that does not exceed 40 GPa the solid phase of Fe that is in equilibrium with the liquid is the fcc phase rather than the hcp phase, with a relatively shallow melting curve slope. The melting curve may be even shallower than the liquid isentrope. This would cause a crystallization to occur not from the bottom up but from the top down or starting at intermediate depths in the core. This process of iron snow/hail has been discussed in the Fe-S system based on the shape of the binary phase diagram [e.g. 1], but the application of a fully self-consistent thermodynamic model of the Fe phase diagram reveals that this is a plausible scenario for pure Fe as well.

To look into this behavior we have adopted a thermodynamic description of the P-T phase diagram of Fe from the literature [2,3] and investigated its consequences for inner core growth in Mercury. We compare results on thermodynamic variables with available experimental data for the fcc and the liquid phases. We find that the liquid isentrope is indeed steeper than the melting curve, at least for pressures up to the fcc-hcp-liquid triple point. This implies that fcc crystallizes at intermediate depths in the Hermean core (12 GPa) and that the Fe crystallites sink to the center of the planet to form a solid inner core. This behaviour is fundamentally different from inner core growth in the Earth, strongly affecting the energy/buoyancy that is supplied to the dynamo process. In addition to the thermodynamics of the process we consider the implications of such behavior on the thermal evolution and state of the planet.

[1] T. Rückriemen et al. (2014), 45th Lunar and Planetary Science Conference, Abstract 2454.
[2] X.-G. Lu et al. (2005), Calphad 29, 49.
[3] X.-G. Lu et al. (2005), Calphad 29, 68.

T5: Wednesday 24.09.2014, 16:50 - 17:10

Explaining Mercury's peculiar magnetic field

Johannes Wicht[1], Daniel Heyner, Hao Cao, Ulrich R. Christensen
[1] *Max Planck Institute for Solar System Research, Göttingen, Germany*
[2] *Technische Universität Braunschweig, Germany*
[3] *University of California, Los Angeles, California, USA*

MESSENGER magnetometer data revealed that Mercury's magnetic field is not only particularly weak but also has a peculiar geometry. The MESSENGER team finds that the location of the magnetic equator always lies significantly north of the geographic equator, is largely independent of the distance to the planet, and also varies only weakly with longitude. The field is best described by an axial dipole that is offset to the north by about 20% of the planetary radius. In terms of classical Gauss coefficients, this translates into a low axial dipole component of g_1^0= -190 nT but a relatively large axial quadrupole contribution that amounts to roughly 40% of this value. The axial octupole is also sizable while higher harmonic contributions are much weaker. Very remarkable is also the fact that the equatorial dipole contribution is very small, consistent with a dipole tilt below 0.8 degree, and this is also true for the other non-axisymmetic field contributions. We analyze several numerical dynamos concerning their capability of explaining Mercury's magnetic field.
Classical schemes geared to model the geomagnetic field typically show a much weaker quadrupole component and thus a smaller offset. The onset only becomes larger when the dynamo operates in the multipolar regime at higher Rayleigh numbers. However, since the more complex dynamics generally promotes all higher multipole contributions the location of the magnetic equator varies strongly with longitude and distance to the planet. The situation improves when introducing a stably stratified outer layer in the dynamo region, representing either a rigid FeS layer or a sub-adiabatic core- mantle boundary heat flux. This layer filters out the higher harmonic contributions and the field not only becomes sufficiently weak but also assumes a Mercury like offset geometry during a few percent of the simulation time. To increase the likelihood for the offset configuration the north-south symmetry must be broken and we explore two scenarios: Increasing the heat flux through the northern hemisphere of the core-mantle boundary is an obvious choice but is not supported by current models for Mercury's mantle. We find that a combination of internal rather than bottom driving and an increased heat flux through the equatorial region of the core-mantle boundary also promotes the required symmetry breaking and results in very Mercury like fields. The reason is that the imposed heat flux pattern, though being equatorially symmetric, lowers the critical Rayleigh number for the onset of equatorially anti-symmetric convection modes. In both scenarios, a stably stratified layer or a feedback coupling to the magnetospheric field is required for lowering the field strength to Mercury-like values.

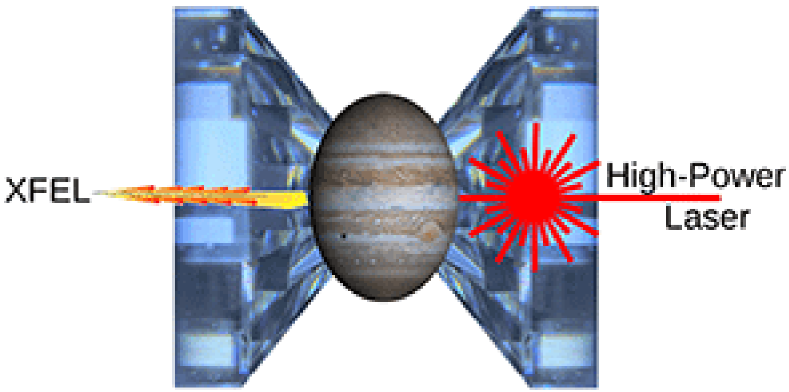
T6: Wednesday 24.09.2014, 17:10 - 17:30

Thermodynamically constrained correction to ab initio equations of state

Martin French[1], Ronald Redmer[1], Thomas Mattsson[2]
[1] *University of Rostock, Germany*
[2] *Sandia National Laboratories, USA*

The construction of accurate multi-phase equations of state (EOS) for matter at high pressure and high temperature is a challenging problem. State-of-the-art theoretical EOS calculations are based on a combination of density functional theory (DFT) for the electrons and molecular dynamics (MD) for the ions. However, the results for EOS from such DFT-MD simulations depend on the exchange-correlation functional selected and employed in the calculations. For example, lattice constants and bulk moduli of solids can only be calculated to a finite accuracy, often leaving significant residual deviations to experimental data at ambient conditions [1].
Here we present a thermodynamically consistent approach to correct EOS from DFT-MD in such a way that they coincide with experimental data at a reference state while preserving their correct high- and low-density limits from DFT-MD [2]. We investigated several different classes of sample materials and show that the resulting EOS in the liquid and experimentally accessible solid regime is largely independent from the XC functional utilized. Excellent agreement with diamond-anvil cell experiments is achieved as well.
Going beyond solids, we apply the EOS correction technique to merge a DFT-MD EOS of water [3] with the well-established EOS from Wagner and Pruß [4]. The resulting principal Hugoniot curve of this combined water EOS reproduces the experimental shock compression data from ambient pressure to the Mbar regime significantly better than the pure DFT-MD EOS model [3].
This work was supported by the NNSA ASC/PEM program at Sandia. Sandia National Laboratories is a multiprogram laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under Contract No. DE-AC04-94AL85000.

[1] P. Haas, F. Tran, P. Blaha, Phys. Rev. B 79, 085104 (2009).
[2] M. French, T. R. Mattsson, J. Appl. Phys. 116, 013510 (2014).
[3] M. French, T. R. Mattsson, N. Nettelmann, R. Redmer, Phys. Rev. B 79, 054107 (2009).
[4] W. Wagner, A. Pruß, J. Phys. Chem. Ref. Data 31, 387 (2002).



Abstracts of talks Thursday 25.09.2014, 9:00 - 17:30

T7: Thursday 25.09.2014, 9:00 - 9:20

Reaching Planetary-Core Conditions with Dynamic and Double-Stage Diamond Anvil Cells at the Helmholtz International Beamline for Extreme Fields (HIBEF)

Emma E. McBride[1], Zuzana Konôpková[1], Hanns-Peter Liermann[1], Will Evans[2], Choong-Shik Yoo[3], Leonid Dubrovinsky[4], Alex Goncharov[5], Ulrich Schramm[6], Edgar Weckert[1], Tom Cowan[6]

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[2]*Lawrence Livermore National Laboratory, USA*
[3]*Washington State University, Pullman, USA*
[4]*Bayerisches Geoinstitut, University of Bayreuth, Germany*
[5]*Geophysical Laboratory, Carnegie Institute of Washington, USA*
[6]*Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Germany*

When considering planets, high pressures are clearly evident in two contexts: the conditions occurring deep inside large planetary bodies, and the transient stresses caused by high-velocity impacts among planetary materials. Accessing such states has long been an experimental challenge.

For decades, the diamond anvil cell has been an indispensible tool in studying matter under at extreme conditions. However, the upper pressure limit of this device is typically 300-400 GPa, and may be lower when coupled with heating techniques. Furthermore, this device is a static compression technique, and is not capable of the precise application of pressure with time necessary to study strain rate dependence of phase transitions. Reaching extreme pressures beyond 400 GPa and investigations of phase transition kinetics relevant to giant impact processes have primarily been conducted using shock compression techniques, leading to a large increase in sample temperature, taking them far from the planetary isentrope.

Two recent advances in diamond anvil cell technology – the double-stage and the dynamic DACs [1,2] – have greatly extended the upper pressure limit accessible with such techniques, and have allowed studies of phase transition kinetics and dynamics. By combining these techniques with pulsed laser heating techniques, one may re-create conditions at planetary interior conditions, that have not been achievable by other techniques.

In this talk I will give an introduction to the Helmholtz International Beamline for Extreme Fields (HIBEF) and give an update on the status of proposal. I will present plans to implement the double-stage and dynamic DACs at the HIBEF at the High Energy Density (HED) instrument at the European XFEL. Furthermore, I will suggest potential first experiments, which have the capacity to revolutionise, our understanding of planetary interiors.

[1] Dubrovinsky & Dubrovinskaia, Nat. Comm. 3, 1163 (2012)
[2] Evans et al., Rev. Sci. Instrum., 78, 073904 (2007)

T8: Thursday 25.09.2014, 9:20 - 9:40

Dynamic compression experiments using the DiPOLE laser system at the European XFEL

Andrew Higginbotham[1], John Collier[2], Jon Eggert[3], Hanns-Peter Liermann[4], Emma McBride[4], Malcolm McMahon[5], Justin Wark[1]

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[2] *Central Laser Facility, Rutherford Appleton Laboratory, Harwell Science and Innovation Campus, Didcot, United Kingdom*
[3] *Lawrence Livermore National Laboratory, USA*
[4] *Deutsches Elektronen Synchrotron (DESY), Germany*
[5] *The University of Edinburgh, United Kingdom*

A complete understanding of planetary structure, formation and evolution requires an understanding of the behaviour of solid material at pressures ranging from ambient to several terapascals. One approach which allows generation of material of the pertinent conditions is dynamic laser compression, with pressures of 5TPa in diamond having been recently demonstrated [1].
As part of the HiBEF consortium the European XFEL will be equipped with a 100J, 10Hz, nanosecond diode pumped laser system; one of the first of its kind. DiPOLE will provide high repetition, high fidelity, shaped laser pulses capable of driving solid targets into the 1TPa regime, allowing, for the first time, for detailed phase space scans at conditions to relevance for planetary core materials.
In this talk we will give an overview of the state of dynamic compression research, discussing the most recent results on both conventional laser systems and XFEL's. We will also present the DiPOLE laser system and outline its capabilities.

[1] R.F Smith et al, Nature, 511, 330–333 (2014)

T9: Thursday 25.09.2014, 9:40 - 10:00

Probing of Complex Interaction Dynamics of Ultra-Intense Lasers with Solid Matter using XFELs

Alexander Pelka[1], Thomas Kluge[1], Christian Gutt[2], Lingen Huang[1], Josefine Metzkes[1], Michael Bussmann[1], Ulrich Schramm[1], Thomas E. Cowan[1]

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[2]*Deutsches Elektronen Synchrotron (DESY), Germany*

The interaction of ultra-intense lasers with solid foils can be used to accelerate ions to high energies well exceeding 60 MeV [1]. The non-linear relativistic motion of electrons in the intense laser radiation leads to their acceleration and later to the acceleration of ions. Ions can be accelerated from the front surface, the foil interior region, and the foil rear surface (TNSA, most widely used), or the foil may be accelerated as a whole if sufficiently thin (RPA). For increasing laser intensity especially in the latter case it is well known that the growth rate of instabilities emerging from the non-linear electron motion can be large enough to influence and disturb the acceleration process [2].

A time-resolved experimental investigation with nanometer resolution is crucial for understanding the laser absorption, creation of energetic electrons and electron transport in matter with respect to the afore mentioned instability physics but also for ambipolar expansion and shock formation at the surfaces at buried layers. The novel intense and coherent X-ray sources in combination with ultra-intense short-pulse lasers that will be provided at the Helmholtz Beamline at European XFEL will allow probing of plasmas on time and spatial scales otherwise not accessible. We investigate the feasibility of various X-ray techniques for this purpose, such as the small angle x-ray scattering (SAXS), XPCS and the local change of index of refraction by bound-bound resonances in ionized matter.

[1] S.A. Gaillard et al., Phys. Plasmas 18, 056710 (2011)

[2] F. Pegoraro and S.V. Bulanov, Phys. Rev. Lett. 99, 065002 (2007)

T10: Thursday 25.09.2014, 10:00 - 10:20

Pulsed magnetic fields at the HED instrument

J. Strempfer[1], M. v. Zimmermann[1], T. Herrmannsdoerfer[2], J. Wosnitza[2]
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Within HIBEF, a pulsed magnetic field setup is planned at the HED instrument at the European XFEL. Pulsed fields of up to 60 T will be accessible. Temporal pulsed field profiles in the millisecond scale are chosen to match the X-ray pulse train structure at the XFEL. This will allow conduction of complete field sweeps of a sample system within a single bunch train sequence. Two types of magnets are envisaged for spectroscopic and resonant-scattering experiments. Non-resonant and resonant diffraction techniques will be used for the investigation of the lattice, non-equivalent lattice sites, and magnetic ordering. Resonant small angle scattering will allow the study of ordering phenomena on a longer scale, e.g. the magnetic flux line lattice in a superconductor. Absorption spectroscopy and XMCD will give insight to electronic degrees of freedom, i.e. valence transitions and magnetization. Moreover, the hard X-rays available at the HED instrument are crucial for investigating correlated electron systems in pulsed magnetic fields, due to complex sample environments. In this presentation, the instrumental layout, with the phase-retarder for manipulation of incident polarization and the diffractometer setup as well as possible experiments will be discussed.

I3: Thursday 25.09.2014, 11:00 - 11:30

Ab initio calculation of X-ray absorption spectra for iron up to 430 GPa

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The prospect of extending the characterization of dense plasmas and shock compressed matter to near edge absorption spectroscopy is very appealing both from a theoretical and an experimental side. Measurements of near edge absorption spectra of shock compressed matter brings invaluable information on the evolution of the electronic structure as the system is subject to a significant increase in both pressure and temperature. From the theoretical side, the use of ab initio electronic structure approaches based on density functional theory (DFT) combined with molecular dynamics simulations and linear response theory has been rather successful at providing a satisfying description of this complex state of matter. Recently, we have developed a first principle approach to calculate the near edge absorption spectrum (XANES) of dense plasmas based on these ab initio molecular dynamics simulations. This method was first applied for the calculation of the XANES spectra of warm dense aluminium and was compared to experimental results showing how XANES spectra can be used to diagnose solid-solid and solid-liquid phase transition.

We have then applied this method to the calculation of the XANES spectra of iron at pressure up to 430GPa. In parallel, an experiment was performed at LCLS to measure the XANES spectra of shocked iron. Using the calculations to support the interpretation of the measured XANES spectra, we were able to put an upper constrain on the melting curve of iron at high pressure.

T11: Thursday 25.09.2014, 11:30 - 11:50

Probing the complex ionic structure of warm dense carbon

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The carbon phase diagram at extreme pressure conditions has received broad interest for modeling planetary interiors and high energy density laboratory experiments. Numerous theoretical models and simulations have recently been performed but critical experimental data at the phase boundaries and of the microscopic physical properties remain very scarce. In this work, we present novel experimental observations of the complex ion structure in warm dense carbon at pressures from 20 to 220 GPa and temperatures of several thousand Kelvins. Our experiments employ powerful x-ray sources at kilo-joule class laser facilities and at the Linac Coherent Light Source to perform spectrally and angularly resolved x-ray scattering from shock-compressed graphite samples; the absolute static ion structure factor is directly measured by resolving the ratio of elastically and inelastically scattered radiation. Using different types of graphite and varying drive laser intensity, we were able to probe conditions below and above the melting line, resolving the shock-induced graphite-to- diamond and graphite-to-liquid transitions on nanosecond time scale. Our results confirm a complex ionic structure predicted by QMD simulations and demonstrate the importance of chemical bonds at extreme conditions similar to those found in the interiors of giant planets. The evidence presented here thus provides a firmer ground for modeling the evolution and current structure of carbon-bearing icy giants like Neptune, Uranus, and a number of extra-solar planets.

T12: Thursday 25.09.2014, 11:50 - 12:10

Spatially-resolved X-ray scattering off shock-compressed carbon at the LCLS

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The diversity of the electronic properties of carbon makes it of key interest to the material science community; nowhere is this more evident than in the myriad potential applications of structured allotropes like graphene and nano tubes. By contrast, at the high pressures typical of planetary and stellar interiors, the behavior of carbon is poorly understood with large uncertainties in the conductivity and even the material phase. There is growing evidence of the abundance of diamond in the interiors of the ice giant planets Uranus and Neptune; the conductivity of which could potentially influence models for the origin of the unusual magnetic fields of these planets.
Tremendous efforts have been made to measure properties of warm dense matter (WDM) in extreme conditions, e.g. temperatures in excess of 1000 K of temperature and pressures in the Mbar regime. In laboratory experiments, practical issues with gradients in the temperature and density of shock compressed matter have hindered accurate measurement and further from distinguishing theoretical models. Here, we present spatially and spectrally resolved x-ray scattering experiments using LCLS free electron laser to examine and understand the gradients of thermal properties under dynamic shock loading. We used curved mosaic and perfect imaging crystals for spatially-resolved x-ray scattering off different shock-compressed carbon configurations. Compared with hydro-dynamic simulations, we present first preliminary results of identified phase transitions in the high-pressure phase of carbon.

Summary :
We use the MEC nanosecond lasers to launch counter-propagating shock waves in carbon (pyrolytic graphite, rigid graphite, and glassy carbon). At shock coalescence, pressures in excess of 1 Mbar are reached. At given time delay, we measure scattering off the sample using 5070 eV x-ray pulses from the LCLS FEL. We observe scattering at three distinct wavennumbers, where the elastic strength varies differently with time. Spatially resolved scattering at 90° scattering angle allows resolving the compressed target properties.

T13: Thursday 25.09.2014, 12:10 - 12:30

Investigation of the ion dynamics in warm dense aluminum by ab initio simulations

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The properties of aluminum have been widly analysed at low temperatures. In the field of warm dense matter (WDM), however, investigation of aluminum only started recently with the improvement of x-ray thomson scattering techniques leading to first experimental results [1]. At the same time the advance in computer capacity allows us to perform ab initio simulations using finite-temperature density functional theory molecular dynamics(FT-DFT-MD) incorporating the electron dynamics which is important under the strong correlations in this regime [2]. We compare results from FT-DFT-MD calculations with the recent data obtained by orbital free calculations [3] in the regime of WDM at solid density. A number of material properties can be derived from the dynamic structure factor, e.g. the dispersion relation and the speed of sound as well as the damping coefficients for the diffusive and the collective modes. At low wave numbers these quantities can be obtained by fitting the numerical data to hydro dynamic or generalized hydrodynamic models, leading to new insights on the ion dynamics in WDM.

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I4: Thursday 25.09.2014, 14:00 - 14:30

High pressure experiments on icy moon materials and planetary geophysics

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The icy moons of Jovian planets are remarkable in their diversity and distinct evolutionary paths, and represent a challenge for our understanding of planetary formation and evolution. Although some of these planetary bodies have been subject to close-up geophysical exploration over the last decades, their formation conditions, structure, geophysical evolution and current state remain sources of questions.
Current and past spacecraft missions (e.g., Galieo and Cassini-Huygens) have provided unique information about the bulk and surface properties of icy moons. The expansion on the geophysical datasets has encompassed progresses on geodynamical models able to compute the heat fluxes through the satellite and to reconstruct their thermal history. However, the ability of these models to interpret unambiguous the information encoded in the spacecraft observations is seriously limited by the paucity of laboratory data on the properties of candidate icy moon materials at relevant pressure-temperature conditions.
In the first part of this talk we will briefly review the gaps in knowledge on the thermophysical properties of candidate icy moon materials (i.e., clathrate hydrates, salt hydrates, aqueous solutions, ice-rock mixtures). This review will set the bases to outline comprehensive laboratory research programs on material properties to support geophysical models and to define new exploration strategies for future missions (e.g., JUICE).
Then, we will present geodynamical models supported by new laboratory experiments to constrain the effect of volatile compounds on the crystallization of primordial oceans and on the thermal evolution of large icy moons. Specifically, we will describe new experiments designed to determine the melting temperature of ice phases (Ih and VI) and the fluid density in the binary methanol-water system (0-20 wt% methanol) using Brillouin scattering spectroscopy. Methanol has been recently detected in several comets and at the surface of Europa, and may be an important chemical component of subsurface oceans. The explored pressure-temperature range, 230 - 300 K and 10-4 - 1.2 GPa, spans the conditions that prevail in the icy crust and primordial ocean of Titan. The experiments were conducted in a membrane-type diamond anvil cell outfitted for low temperature studies employing an in-house designed Peltier cooling system. Melting and crystallization in the system were monitored by changes in the Brillouin spectral features and in the pressure dependence of the measured sound velocities. The density of fluids ρ(P, T, x) in the binary methanol-water system was determined from the inversion of sound velocities measured in the fluids as a function of pressure along isotherms from 230 to 300 K. The results are combined with advanced numerical modeling to examine the effect of methanol on the survival and thermo-chemical evolution of the subsurface ocean. The implications of these results for the thermal and structural evolution of icy moons, with particular applications to Titan, will be further discussed.

T14: Thursday 25.09.2014, 14:30 - 14:50

An Inversion Technique for Constraining the Interior Structure of Rocky Exoplanets

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Characterizing the interior structure of exoplanets is key to understand planet formation and to evaluate the probability of the existence of habitable planets outside our solar system. Several studies have been dedicated to examine effects of composition and distribution of material on exoplanet mass and radius, while few have tried to solve this as an inverse problem. Here we proceed along these lines and propose an inverse technique to constrain the physicochemical structure of an exoplanet given its observations (mass, radius, stellar photospheric element abundances Mg/Si and Fe/Si) and preconceived model assumptions. We are able to determine model parameter and their uncertainties, i.e. core sizes and mantle compositions that are compatible with the observations. Our assumptions are the following: (1) only rocky silicate exoplanets are considered, i.e. no oceans nor atmospheres; (2) bulk exoplanet composition is dictated by stellar photospheric abundance measurements (=CI-chondrites in the case of the Sun); (3) exoplanet cores are assumed to be made of pure iron. We apply a Markov chain Monte Carlo (McMC) algorithm to constrain model parameters: core radius, mantle Mg/Si, mantle Fe/Si and mantle Si-content. In order to predict data, we use thermodynamic modeling methods to compute stable mantle mineralogy and density as a function of the considered composition, temperature, and pressure profile. For the core we employ an equation-of-state (EoS) approach for pure iron to compute the density profile. We have tested our integrated methodology on the terrestrial planets (Venus, Earth and Mars) and are able to reproduce their internal physico-chemical structure as inferred from independent data. Furthermore we applied our method to a series of planetary bodies of masses between 0.1 and 10 M_E and radii between 0.4 and 2 R_E, assuming both specific stellar and unconstrained bulk compositions. Overall, we find that core radius and mantle composition of rocky exoplanets can be constrained by the sparse available data. The stellar Fe/Si and Mg/Si abundance constraints are key to constrain the interior structure. However, the degree to which model parameters can be constrained depends critically on the magnitude of observed mass and radius and their uncertainties. We note that for higher mass bodies, the choice of EoSs becomes critical. At high pressures, the uncertainty of the EoS should ideally be taken into account. In the future we will extend the methodology to include hydrogen- and water-rich exoplanets, i.e., containing oceans and atmospheres. This study is a key step towards the statistical analysis about the occurrence of interior structure types, because the proposed scheme is formulated in a general manner and may be extended to other more general cases.

T15: Thursday 25.09.2014, 14:50 - 15:10

Modelling the interior structure, composition, and mass-radius relationships of solid exoplanets

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The growing number of planet discoveries has revealed the broad structural and compositional diversity of more than one thousand confirmed exoplanets to date with important implications for their formation, orbital evolution, and possible habitability. Current detection limits of ground-based observational methods have limited the discovery of solid exoplanets to only a few, although, according to predictions of planet formation models, those should be quite abundant. Structural models of planetary interiors are chemically layered, including subsurface water oceans and high-pressure ice layers in case of icy bodies, and composed of volatile constituents, rock-forming elements, and metals such as iron and nickel, the latter concentrated in central cores. For low-mass, close-in solid exoplanets transiting their host stars, these models are required to be consistent with the planetary masses and radii as provided by radial velocity and photometric observations. These models are constructed by using equations of state for the radial density distribution, which are compliant with the thermodynamics of the high-pressure limit. Calculated models can be used to derive mass-radius relationships for low-mass solid exoplanets and scaling laws for key physical and chemical properties. Structural models of planetary interiors still suffer from inherent degeneracy or non-uniqueness problems owing to the incomplete knowledge of light and heavy constituents, their degree of internal separation, intrinsic energy sources, melting relations, thermal and electrical material properties, chemical reactions, pressure-induced phase transformations, and/or the possible presence of an optically thick atmosphere. We will thereby address the robustness of mass-radius relationships and their usage for the classification of low-mass exoplanets and their characterization in terms of interior structure and bulk composition.

T16: Thursday 25.09.2014, 15:10 - 15:30

Dynamics and plate tectonics on rocky exoplanets

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In the present talk, we will review the status of work on the interior dynamic of rocky exoplanets and in particular focus on the controversial discussion about whether a massive exoplanet can be expected to have plate tectonics or not. The pressure at the core-mantle boundary (CMB) of a ten Earth mass super-Earth is about ten times the pressure at Earth's CMB suggesting that for large exoplanets the influence of pressure on transport properties such as viscosity and thermal conductivity but also on the thermal expansivity is most crucial. In general, viscosity and thermal conductivity increase with pressure while thermal expansivity decreases with pressure, all of which should result in lower convective vigor in the deep mantle. In most previous studies this has been neglected and only the temperature dependence of the viscosity has been considered. Other parameters such as the thermal expansion coefficient and the thermal conductivity have been assumed constant. Other models that consider the pressure effect assume thermal equilibrium to calculate the interior temperature distribution and/or mantle flow rates. In general, as has been repeatedly shown, planets cannot be expected to be in thermal equilibrium and the time scale for heat transfer matters. When the viscosity becomes very large – for instance as has been proposed for the deep mantles of super-Earths – the time scale may become larger than the age of the universe. In that case, the temperature distribution in the interior will depend on the initial conditions and the evolution in addition to the rate of heat generation. We will discuss some scenarios and the consequences for the interior temperature and the tectonic modes. We will include the core and the thermodynamics of dynamo action in the discussion.

I5: Thursday 25.09.2014, 16:00 - 16:30

High Pressure, Planetary and Plasma Physics: What Can You Do With a DAC?

Malcolm I. McMahon[1]

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The diamond anvil cell (DAC) revolutionised high-pressure science, and when combined with x-ray radiation, particularly synchrotron radiation, is has provided the great majority of what we know about the structural behaviour of matter at high densities. For many years, it was assumed that the structures adopted at high pressure would be simple, and probably close-packed. But DAC studies, and developments in computation, have revealed that the true structural behaviour of almost all systems at very high pressures is very complex, and this complexity extended to pressures as yet unachievable.

In this talk I will review the current state-of-the-art in structural studies using DACs, including recent developments that have greatly extended the upper pressure range that is accessible. I will also give a personal view of the opportunities offered by both current and future technique and facility developments [1].

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T17: Thursday 25.09.2014, 16:30 - 16:50

Superionic water-ammonia mixtures

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The interior of the Giant Planets Uranus and Neptune contains large amounts of water, ammonia and methane (referred to as planetary ices). Many observable properties of these planets, such as luminosity, gravitaional moments and magnetic fields, are thought to be determined by the physical and chemical properties of matter within this ice layer. Hence, the phase diagrams, equations of state and structural properties of these materials and their respective mixtures are of great interest. Especially the phase diagrams of water and ammonia gained much attention since Cavazzoni et al [1] proposed superionic phases, which are characterized by highly mobile hydrogen ions in a lattice of oxygen and nitrogen ions, respectively. [2-4] For water, the influence of such a phase on the properties of the Giant Planets as well as on exoplanets has been discussed widely. [5,6]
Nevertheless, it is an open question how the properties of such a water layer change when another compound, e.g., ammonia is introduced. Considering a 1:1 mixture, we have performed ab initio simulations based on density functional theory using the VASP code [7] heating up structures which we had found from evolutionary random structure search calculations with XtalOpt [8]. We propose possible superionic water-ammonia structures present up to several Mbar in comparison to structures earlier found by Griffiths et al. [9] Moreover, we investigate the equation of state and transport properties of this mixture such as diffusion coefficients and electrical conductivities in order to compare with the pure compunds. These results are essential to construct new interior models for Neptune-like planets and to perform more realistic dynamo simulations.

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T18: Thursday 25.09.2014, 16:50 - 17:10

Unusual properties of 'simple' oxides prepared at HP-HT conditions

Sergey Ovsyannikov[1], Alexander Karkin[2], Natalia Morozova[2], Vladimir Shchennikov[2], Artem Abakumov[3], Alexander Tsirlin[4], Leonid Dubrovinsky[1]

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Technological needs require creating novel materials, and newly fabricated materials with advanced properties or unusual electron band structure features may, in turn, lead to emergent industrial applications. High-pressure high-temperature synthesis is known to be a powerful tool for fabrication of new unusual materials. In this presentation we will report on preparation and characterization of new polymorphs of simple oxides of earth-abundant elements, like Ti, Mn, Fe and others. In particular, we will display several spectacular examples, including follows:
(i) 'Golden' Ti_2O_3, a dense high-pressure polymorph of Ti_2O_3 adopting a Th_2S_3-type of structure. This polymorph has been recently discovered [1,2] and further studies showed that its electronic and optical properties are rather unusual [3,4].
(ii) Perovskite-type Mn_2O_3, a recently revealed high-pressure polymorph of Mn_2O_3 crystallizing in a triclinically-distorted quasi-cubic double-perovskite-type lattice [5]. The electronic and magnetic properties of this polymorph are dictated by an intricate charge disproportionation reaction ($2Mn^{3+} \rightarrow Mn^{2+} + Mn^{4+}$) between ions taking different positions in this structure, $Mn^{2+}Mn_3^{3+}Mn_4^{3.25+}O_{12}$. This system seems to be a very promising semiconductor.
(iii) Fe_4O_5, a recently discovered new simple iron oxide, having a structural similarity with the high-pressure polymorphs of magnetite [6]. This system has the equal amounts of the Fe^{2+} and Fe^{3+} ions, and upon cooling it demonstrates a rather remarkable correlation between the magnetism, charge ordering and structural distortions.

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T19: Thursday 25.09.2014, 17:10 - 17:30

Recent Advancement in High Pressure Falling Sphere Viscosimetry in DIA-type Large Volume Presses

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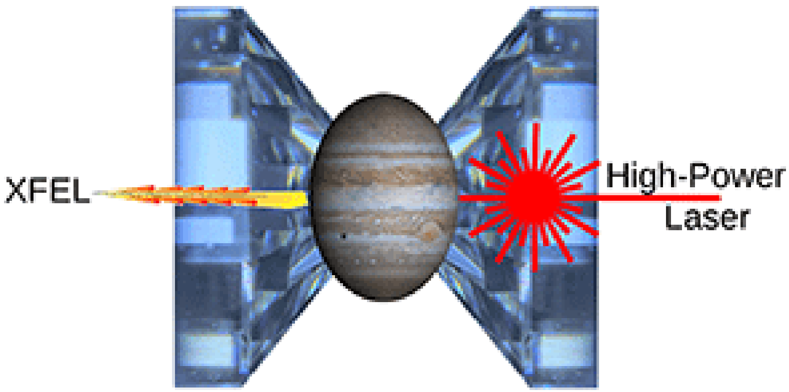
[2] *HZG Helmholtz Centre Geesthacht, Germany*
[3] *University College London, England*
[4] *Univeresity of Western Ontario, Canada*

In situ falling sphere technique viscosity measurements in two DIA-type multi-anvil apparatus - the single-stage MAX80 at beamline F2.1 and the double-stage MAX200x at beamline W II at DESY / HASYLAB, Hamburg, Germany - have been performed. The deformation of the experimental set-ups were analyzed by X-ray attenuation contrast tomography at beamline W II at DESY/HASYLAB after the high pressure runs. The single- stage set-up used for the first series of high pressure runs was modified and further developed this way. The optimized assemblies could used at much higher pressures without blow outs. At higher pressures the smaller gap between the anvils called for X-ray transparent cBN-anvils. The optimized single-stage assembly was the base for the new development of a falling-sphere viscosity measurement set-up for double-stage DIA-type multi-anvil apparatus. The geometrically required peak-to-peak position (vertical) of the melting chamber necessitates a lateral power supply. The slotted carbide anvils recently tested at beamline W II were used to make the whole melting chamber accessible for the high pressure X-radiography system. The viscosity was measured following Stokes law by evaluation of X-radiography sequences taken by a CCD-camera. Powdered basalt, dacite, and diabase samples were measured at pressures of 0.5, 1, 5 and 10 GPa and temperatures of 1890 K. After pressurization the temperature produced by an internal graphite heater was increased up to sample melting was observed by X-ray diffraction and X-radiography. Our results cover a data range from 195.5 Pa s (diabase at 0.5 GPa) and 0.042 Pa s (dacite at 10 GPa) and and are in good agreement with published data.



Abstracts of talks
Friday 26.09.2014,
9:00 - 12:40

I6: Friday 26.09.2014, 9:00 - 9:30

Generating and Studying Matter at Extreme Pressures on the National Ignition Facility

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The National Ignition Facility (NIF) has been in operation for five years. First experiments during the National Ignition Campaign (NIC) were focused on achieving ignition in the laboratory. For this purpose, 192 laser beams deliver up to 1.9 MJ energy at up to 500 TW peak power in precisely-tuned pulse shapes into a gold hohlraum, a cylindrically shaped radiation cavity, that converts the laser energy into a nearly Planckian x-ray bath to indirectly drive and implode the fuel capsule at the center of the hohlraum with the goal of achieving hot spot pressures on order of 300 Gbar. Early experiments were geared towards bringing up diagnostic capabilities at the NIF and developing a wide range of tuning platforms [1]. Thanks to these early achievements, in recent years the applications on the NIF have multiplied and, among others, a growing fundamental science program has been established that enables facility access to outside users.

In my talk I will first briefly review progress on the path towards ignition. In recent fully integrated implosion experiments it was demonstrated that by increasing the first-shock strength, which comes at the cost of setting the fuel at a higher adiabat and thus making it less compressible, the implosions become less susceptible to hydrodynamic instabilities. This resulted in significantly improved performance with fusion yields for the first time exceeding the energy absorbed by the deuterium-tritium fuel [2] and a significant portion of the yield being the result from additional hot spot heating thanks to alpha particle stopping.

In the second part of my talk I will present the results of a series of fundamental science experiments at the NIF aiming at absolute equation of state (EOS) and opacity measurements of CH plastic along the principal Hugoniot at unprecedented pressures approaching 1 Gbar [3]. Such experiments are important to benchmark atomic and plasma physics models and improve simulations of indirectly-driven ICF implosions in which CH currently is the primary ablator material. In these experiments, a hohlraum drive with 290 eV peak radiation temperature launches a strong shock wave into a 2.2 mm diameter plastic ball. The induced pressures by the spherical shock wave increase as the shock converges allowing to obtaining a range of Hugoniot states in a single experiment. Pressures reach $\sim$1 Gbar as the shock wave coalesces at the center of the CH target, which is more than an order of magnitude greater than previously recorded for CH [4]. We measure the radiography contrast at the shock front with a powerful Zn He-alpha backlighter source to infer compression. The measured EOS locus is consistent with the previous measurements [4]. The opacity along the Hugoniot is also deduced, which is essential in Gbar experiments as it changes significantly from its initial value due K-shell ionization of carbon. We observe an opacity decrease of an order of magnitude between 100 and 300 Mbar, approximately as expected from atomic physics calculations. However, the K-shell ionization does not show up as a pronounced signature in the Hugoniot curve as predicted by Purgatorio-based EOS models.

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T20: Friday 26.09.2014, 9:30 - 9:50

Interior structure of Brown Dwarfs and their material properties

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We present wide-range equations of state (EOS) for hydrogen and helium including accurate data derived from finite-temperature density functional theory molecular dynamics (DFT-MD) simulations for the warm dense matter regime using the VASP package [1]. This hydrogen/helium Rostock EOS (H/He-REOS) cover a wide range of temperatures and densities with a maximum error of 5% and reproduce data from high pressure experiments, for example the principal and precompressed Hugoniot curve and the 300 K isotherme derived from diamond anvil cell measurements, see [2] and [3].

Based on this ab initio data set we calculate interior models for Giant Planets and in particular for Brown Dwarfs. The latter need EOS data for the 10-bar level ($\rho \sim 10^{-5}$ g/cm^3, T$\sim$1000 K) as well as for central conditions with $\sim$ 200 Gbar ($\rho \sim$430 g/cm^3, T$\sim$1.1 MK). We compare our interior models with those based on the EOS of Saumon-Chabrier and van Horn [4]. Furthermore we present heat capacities, the speed of sound, electrical and thermal conductivities, viscosities and opacities for the interiors of representative Brown Dwarfs, similar to the work of French et al. [5].

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T21: Friday 26.09.2014, 9:50 - 10:10

Estimations of shear viscosity of nonideal plasma

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String theory methods led to the hypothesis that the ratio of shear viscosity coefficient to volume density of entropy of any physical system has a lower bound. Systems with strong coupling have a small viscosity compared to weakly coupled plasmas in which the viscosity is proportional to the mean free path. Today a huge array of experimental data on the thermodynamic, transport and optical properties of nonideal plasma was received, but there are no direct measurements of viscosity. For our purposes experimental data on measurements of electrical conductivity of hydrogen, deuterium and rare gases under intense shock compression and under quasiisentropic compression in multistep loading up to megabar pressures are the most interesting. The data on hydrogen, deuterium and helium-hydrogen mixture, received in the region of "metallization" at P$\sim$150 GPa in different experimental systems by the method of quasiisentropic compression reach the values η/s $\sim$(0.3-10). Thereby, the hydrogen plasma in the region of "metallization" possesses the lowest values of the shear viscosity to the entropy ratio. Note that in this case we have an extremely high value of the coupling parameter - Γ $\sim$20-80. It is shown, that the data on electrical conductivity of strongly coupled electromagnetic plasma, confirm the tendency of decreasing of the viscosity η/s with an increase in the correlation (Γ) and thus confirm trend of the transition of the physical system to the perfect frictionless fluid with the increasing of the interparticle interaction.

T22: Friday 26.09.2014, 10:10 - 10:30

The average atom model combined with the hypernetted chain approximation applied to warm dense matter

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We have combined the average-atom model with the hypernatted chain approximation (AAHNC) to describe the electronic and ionic structure in the warm dense matter regime. On the basis of the electronic and ionic structures, the x-ray Thomson scattering (XRTS) spectrum is calculated using the random phase approximation (RPA). The electronic structures are described by using our average-atom (AA) model, and at the same time, the effects of other ions on the electronic structures are considered using the integral equation of fluid theory. The ionic structures are obtained through the hypernatted chain approximation (HNC), where the ion-ion pair potentials are calculated using the modified the Gordon-Kim (GK) model based on the electronic density distributions. And the electronic and ionic structures are given using the self- consistent field method. The XRTS spectrum is calculated according to the Chihara formalism, where the scattering contributions are divided into three components: elastic, bound-free, and free-free. Comparison with the results of other theoretical models and experiments shows that the XRTS spectra obtained are in very good agreement, thus the AAHNC model can give a reasonable description of the electronic and ionic structures in the warm dense matter regime.

I7: Friday 26.09.2014, 11:00 - 11:30

Dynamic compression experiments on liquid deuterium above the melt boundary to investigate the insulator-to-metal transition

Marcus Knudson[1], Michael Desjarlais[1], Ray Lemke[1], Andreas Becker[2], Ronald Redmer[2]

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[2] *University of Rostock, Germany*

Recently we have been exploring various pulsed power experimental concepts to access off-Hugoniot states in liquids at the Sandia Z Accelerator. One very promising technique utilizes a so-called shock-ramp platform. Here a relatively small gap is introduced between the ramp compression load electrode and a liquid sample cell. The accelerator is configured to deliver a two-step current pulse; the first step accelerates the electrode to a reasonably constant velocity, which upon impact with the sample cell creates a well-defined shock, while the subsequent current rise produces ramp compression from the initially shocked state. This technique makes it possible to achieve relatively cool (∼1000-2000 K), high pressure (>300 GPa), high compression states (∼10-15 fold compression), allowing experimental access to the region of phase space where hydrogen is predicted to undergo a first-order phase transition from an insulating molecular-like liquid to a conducting atomic-like fluid. In this talk we will discuss the development of the liquid shock-ramp platform, survey the various theoretical predictions for the liquid-liquid transition in hydrogen, and present the results of initial experiments performed that access this region of phase space. Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

I8: Friday 26.09.2014, 11:30 - 12:00

Observation of H/He demixing under deep Jovian planetary conditions

S. Brygoo[1], P. Loubeyre[1], M. Millot[2], J.R. Rygg[3], P.M. Celliers[3], J. Eggert[3], T.R. Boehly[4], G.W. Collins[3] and R. Jeanloz[2]

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Giant gas planets, such as Jupiter, Saturn and most of the exoplanets discovered so far, consist mostly of hydrogen and helium. A major source of influence for their interior models is the possibility of demixing in the warm dense hydrogen/helium mixtures. As proposed 30 years ago by Salpeter and Stevenson, such a H/He phase separation should completely change the interior structure and the evolution of the planets when it happens (sometimes pictured as a He rain). Recently, various ab- initio calculations have predicted the location of the H/He miscibility gap, but the accuracy of these calculations is questioned due to two difficulties: the underestimation of the temperature and pressure conditions needed to dissociate the hydrogen molecules and the poor estimation of the mixing entropy. The approach of laser shocks in pre-compressed targets has enabled us to directly measure the equation of state of H/He mixtures at thermodynamic conditions of deep planetary interiors. A new target design has been developed for achieving pre-compressions of the order of 4 GPa. Discontinuity of the reflectivity versus temperature along the Hugoniot of H/He at 11 mol%H has been interpreted as the signature of phase separation. The boundary lines of the demixing region are now determined. The experimental approach will presented and comparison of the results with the most advanced calculations and the implications for planetary interiors will be discussed.

T23: Friday 26.09.2014, 12:00 - 12:20

H-He demixing and the interior and evolution of Saturn

Robert Püstow[1], Ronald Redmer[1]
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Despite the enormous progress in undestanding the interior structure of the solar giant planets, the correct description of their evolution remains a serious challenge. The most prominent example is Saturn for which the simplest model of homogeneous evolution yields an age between 2 and 3 billion years (Gyr), i.e. much shorter than the age of the solar system of 4.56 Gyr. Additionally the homogeneous model predicts a much lower luminosity than the mesuared value. Concequently we look for another energy source inside the planet. The phase seperation of hydrogen and helium has already been discussed in previous work [1,2]. They assume that the outfalling helium droplets release gravitational energy heating the planet. We employ the data of the H-He phase diagram by [3] and compare with the data of [4].

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T24: Friday 26.09.2014, 12:20 - 12:50

Future space missions of potential interest to the HP4 community

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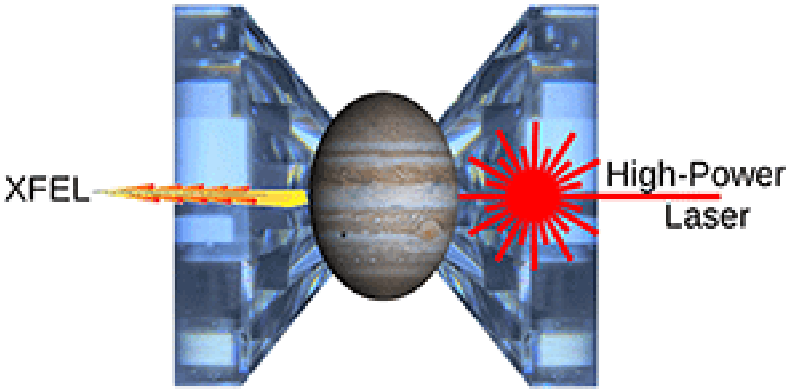
There a number of space missions that should provide data of interest to studies of the deep interior of planets. Among these are missions to planets in the solar system and space telescopes aimed at observing exoplanets. Among the upcoming missions to solar system objects is InSight, the first geophysical observatory for Mars to be launched in 2016. The mission will bring a lander to Mars with a seismometer, a heat flow probe, magnetometer and radio science equipment. Jupiter will be the target of the JUNO and JUICE missions. The NASA JUNO mission is on its way to Jupiter to arrive in about two years time and will among other observations accurately map the gravity and magnetic fields of the planet.
ESA's JUICE mission is expected to launch by 2024 and, although primarily targeted at the Jovian satellites, will study the atmosphere and the magnetic field of Jupiter. Of particular interest is the study of the long-term gravitational interactions of the satellites with the planet since these will constrain the planets internal dissipation rate. Other planets of interest in the solar system where we will see missions are Mercury with BepiColombo scheduled for arrival in 2014 and missions to Venus and Uranus.

Exoplanet detection and observation missions are K2, the extension of NASA's Kepler mission, CHEOPS, a European transit-follow-up space telescope to be launched in 2017, NASA's TESS, also to be launched in 2017, and ESA's PLATO mission, to be launched 2024. Both TESS and PLATO perform extensive surveys of the sky and should detect many new exoplanet candidates. A major difference between the latter two is that TESS aims mainly at planets with short orbital periods (within about 30 days orbital periods) while PLATO 2.0 can detect terrestrial planets up to the habitable zone of solar-like stars. Both missions target bright stars and therefore explore much of the parameter field that the radial velocity observations can cover to determine planetary masses. Together with radii derived from transit observation, these upcoming missions will significantly enlarge the set of planets of which both radius and mass will be known. Furthermore, the PLATO 2.0 mission will also include stellar seismology for a large number of planet host stars, which allows the age of the parent stars to be determined and that of the planets inferred.



Abstracts of posters Wednesday 24.09.2014, 17:00 - 20:00

Nr.	Name	Title of contribution
P1	A. Bossmann	Magnetic field morphology of the ice giants linked to their internal structure
P2	R. Bredow	Classical-map hypernetted chain calculations for multi-component plasmas
P3	E.-R. Carl	Crystal structure transformations in SiO_2 under dynamic compression and decompression
P4	D. Cebulla	Uniaxial compressed MgO
P5	M. Harmand	Melting of iron near to Earth's inner core conditions probed with ultrafast XANES in laser shock experiments at LCLS
P6	C. Kellermann	Mass-radius relations and interior structure of rocky planets
P7	Z. Konopkova	Towards time-resolved studies using synchrotron x-ray diffraction
P8	S. Ovsyannikov	HP-HT synthesis and properties of new unusual perovskite, $CaCo_3V_4O_{12}$
P9	K.-U. Plagemann	Static and dynamic structure factors for warm dense matter
P10	H. Reinholz	Plasma diagnostics using K-line emission profiles of argon
P11	A. Rivoldini	Insights into Mercury's interior structure from geodesy measurements and global contraction
P12	F. Wagle	Electrical resistivity and compressibility of metals near the melting point and implications for the Earth's core
P13	F. Wagner	Plate Tectonics on Earth-like Exoplanets
P14	J. Helfrich	Investigation of warm dense carbon near the solid-liquid phase transition
P15	W. Evans	Dynamic-DAC and time-resolved studies of phase transition dynamics

P1

Magnetic field morphology of the ice giants linked to their internal structure

Andrea Bossmann[1], Johannes Wicht[1], Thomas Gastine[1], Ulrich Christensen[1]

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The magnetic fields of the ice giants are multipolar and non-axisymmetric. Voyager-II-data and aurorae-observations suggest magnetic power spectra with similar power in the first three spherical harmonic degrees and a peak in the order m=1.
Multipolar, non-axisymmetric fields can be modeled with several different approaches including a high density stratification in the dynamo region, strongly turbulent convection, a dynamo generated by fast zonal jets and a geometrical setup with a deep stably stratified fluid layer below the dynamo region. Earlier studies with this geometry found multipolar fields and in a few cases reproduced the peak in the magnetic power spectra at order m=1 (Stanley and Bloxham, 2006). Here we explore the robustness of the multipolarity (similar power for l=1,2,3) and the m=1-peak for a range of parameters and geometrical setups using 3D numerical dynamo models. We compare our results to internal structure models of the ice giants in order to constrain the parameters and geometrical setups that are in accordance with the magnetic field observations.

P2

Classical-map hypernetted chain calculations for multi-component plasmas

Richard Bredow[1], Thomas Bornath[1], Wolf-Dietrich Kraeft[1], M.W.C. Dharma-wardana[2], Ronald Redmer[1]

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[2]*National Research Council of Canada, Ottawa, Canada*

Warm dense matter is of interest for the modeling of planetary interiors and experiments on matter under extreme conditions. Corresponding experiments are performed at free electron laser facilities such as FLASH, LCLS or the future XFEL in Hamburg. In this connection X-ray Thomson scattering is of special interest [1]. In order to explain or predict the X-ray Thomson scattering spectra simulations on the structural properties of plasmas are performed, some of them being expensive. A semi-classical approach can deliver fast results for pair distribution functions and static structure factors even for dense systems.
We solve the Ornstein-Zernike equation within the hypernetted chain (HNC) approximation for dense multi-component plasmas using the classical-map method [2]. This approach proposes to treat the quantum features of the electrons using an adapted temperature for the electron system while the ions are treated classically. Results for pair distribution functions and static structure factors are presented for dense hydrogen, beryllium, carbon and CH plasmas.

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P3

Crystal structure transformations in SiO_2 under dynamic compression and decompression

Eva-Regine Carl[1], Andreas Danilewsky[2], Ghislain Trullenque[3], Thomas Kenkmann[1], Hanns-Peter Liermann[4], André Rothkirch[4], Lars Ehm[5]

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A meteorite impact is a highly dynamic process that encompasses the formation of shock waves in minerals and rocks. This abrupt increase in pressure and temperature leads to phase transitions under non-equilibrium conditions. The rock-forming mineral α-quartz is analysed in order to gain a better understanding of this dynamic compression of the material.
Pressure and temperature required for the formation of high-pressure polymorphs of α-quartz, such as coesite [1] and stishovite [2], are considerably different in comparison to environments with quasi-static conditions. According to observations made in the field [3, 4], stishovite forms at lower shock pressure conditions than coesite under dynamic compression. Thus, it is believed that stishovite may nucleate from an amorphous phase and grow during shock compression, whereas coesite crystallizes upon release.
Proceeding to high-pressure experiments, α-quartz transforms to a monoclinic (P21/c space group) post-quartz phase [5] along with amorphization. This new structure is in competition with stishovite, both being very close in energy.
To investigate the effect of rapid loading and unloading in quartz on phase transitions we are using a membrane driven Diamond anvil cell (mDAC) for moderate compression rates (up to 3 GPa/s) at the Extreme Conditions Beamline (ECB) at PETRA III. During the SiO2 powder compression and decompression, diffractograms were taken every 1-2 seconds. After surveying all experimental data, single interesting diffractograms were selected for further analysis with the Rietveld method [6].
The experiments reveal that α-quartz transforms to a new phase with the phase transition pressure shifting from 23 to 30 GPa with increasing compression rate. This new phase stays stable upon decompression and α-quartz does not recrystallize. According to observations made in the field and fitting of the peak positions, stishovite may be formed but the obtained diffraction patterns of the phase are too weak to unambiguously identify the present of stishovite by means of a Rietveld analysis. With respect to the obtained peak positions at low diffraction angles (5 - 15 $°2\theta$), the monoclinic post-quartz phase might also be formed instead of stishovite. To gain further information of this phase formed, we are currently analyzing the run products with the TEM.
These experiments for the first time give an inside to the kinetics of dynamically compressed quartz. Although the loading rates in the context of impact cratering are much higher, these in-situ real time investigations of phase transitions are a necessary first step to understand the much faster compression at the centre of the impact. Latter can only be analysed accurately with a laser shock compressed sample at free electron lasers in the future.

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P4

Uniaxial compressed MgO

Daniel Cebulla[1], Siegfried Glenzer[2], Luke Fletcher[2], Sebastien Hamel[3], Ronald Redmer[1]

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[3] *Lawrence Livermore National Laboratory, USA*

Recent experiments at the MEC end station at SLAC National Accelerator Laboratory have shown the appearance of a new B8 structured phases in shock-compression experiments on B1 structured MgO which do not appear in ordinary theoretical equilibrium calculations [1]. One possible explanation of that phenomena might be the the dynamic nature of this kind of experiments where uniaxial compression plays a key role to investigate matter at high temperatures and pressures.
Additionally the results might lead to a new understanding of shock experiments and the dynamics of crystal transformations under extreme conditions and therefore MgO is due to the appearance of simple structures, a prototyping material to study such transitions.
To resolve such a dynamic we applied phonon calculations with the Phonopy code [2] based on ab-initio DFT ground-state simulations (VASP, [3]) to determine the finite temperature behavior of MgO in the quasi-harmonic approximation for different uniaxial compressed phases. The phase transition from uniaxial compressed MgO to the B8 phase is determined calculating the Gibbs free energy. Therefore the Gibbs free energy calculation of equilibrium phases is extend to be applicable to uniaxial distorted phases under non-hydrostatic pressures using the deviatoric stress and strain tensor [4]. The hexagonal B8 phase is optimized with respected to hydrostatic compression thus the transition from uniaxial distorted B1 is expected to happen to equilibrium B8. The theoretical description is compared to the experimental results [5].

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P5

Melting of iron near to Earth's inner core conditions probed with ultrafast XANES in laser shock experiments at LCLS

M. Harmand[1,2], A. Ravasio[1], S. Mazevet[3,4], J. Bouchet[4], A. Denoeud[1], F. Dorchies[5], Y. Feng[6], C. Fourment[5], E . Galtier[6], J. Gaudin[5], F. Guyot[2], R. Kodama[7], M. Koenig[1], H.J. Lee[6], K. Miyanishi[7], G. Morard[2], R. Musella[3], B. Nagler[6], M. Nakatsutsumi[8], N. Ozaki[7], V. Recoules[4], S. Toleikis[9], T. Vinci[1], U. Zastrau[6,10], D. Zhu[6], A. Benuzzi-Mounaix[1,3]

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[2] *IMPMC, CNRS, UPMC, MNHN, IRD, Paris, France*
[3] *LUTH, Observatoire de Paris, CNRS, Université Paris Diderot, Meudon, France*
[4] *CEA, DAM, DIF, Arpajon, France*
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[7] *Graduate School of Engineering, Osaka University, Japan*
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[9] *FLASH, Desy, Hamburg, Germany*
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An accurate knowledge of the properties of iron alloys at high pressures and temperatures is crucial for geophysics and planetary science. In particular, detailed information on melting curves and solid phases are required to anchor the Earth's thermal profile at the Inner Core Boundary (ICB) and to assess the solid or liquid nature of exoplanets cores. In that context, XFEL sources coupled with high-energy lasers are affording unique opportunities to measure microscopic structural properties at extreme condtions.
Here we present a recent study devoted to investigate the solid-liquid transition in laser-shocked iron using X-ray Absorption Near-Edge Spectroscopy (XANES). The experiment was performed at the MEC end-station of the LCLS facility at SLAC in Stanford. In parallel, a detailed theoretical study based on ab-initio calculations has been performed and will be presented against experimental measurements.

P6

Mass-radius relations and interior structure of rocky planets

Clemens Kellermann[1], Andreas Becker[1], Ronald Redmer[1]

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Immense studies have been conducted on the interior structure of our planet. But because direct measurements are not possible (the deepest borehole, the Kola Deep Borehole, is only about 12km deep) indirect measurements, e.g. via seismic waves, are necessary. Such data lead to the Preliminary Reference Earth Model [1] (PREM). However, for other planets, especially extrasolar planets, even this kind of data is not available and we therefore have to rely on theoretical calculations (e.g. [2] and [3]). In this Masters thesis we follow the procedure described by [2] to develop models for rocky exoplanets. The earth, with the PREM for comparison, serves as a test case for our code. We will show the development of our calculations starting with the simplest case, the isothermal homogeneous sphere, up to models with a temperature profile that depends strongly on the equation of state (EOS) and the material properties.

For isothermal homogeneous spheres the mass-radius relation comparing several EOSs is shown as well.

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P7

Towards time-resolved studies using synchrotron x-ray diffraction

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Not all geological environments on the Earth or extraterrestrial planets are static. For instance, shearing in the subduction zones or meteorite/asteroid impacts are highly dynamic as well as extremely non-hydrostatic, creating different stress/strain fields. While highly dynamic conditions of a meteorite/asteroid impact can be simulated in a gas gun or laser shock experiments, which are capable of creating strain rates in the order of 10^4 to 10^7 s^{-1}, less dynamic environments can be simulated in fast compressing DAC. Recently, both membrane driven DAC (mDAC) and dynamically driven DAC (dDAC) techniques have been advanced to bridge the gap between quasi-static conditions and dynamic shock loading by reaching strain rates in the range of 10^{-2}-10^2 s^{-1}. The advent of new 3rd generation light sources with unprecedented brilliance such as PETRA III in Hamburg, Germany as well as introductions of fast area detectors optimized for high energies such as PerkinElmer XRD1621 have made it possible to conduct time-resolved angle-dispersive XRD experiments on continuously compressed materials in DAC with time resolution of tens of milliseconds. Within, we present a pilot study on the fast compression of iron in order to explore the maximum compression (strain) rates that can be realized in mDAC and its effect on the compressional behavior under different levels of hydrostaticity. Phase transition from body-centered cubic iron (bcc, α-Fe) to the hexagonal closed-packed structure (hcp, ϵ-Fe) and compression of ϵ-Fe up to 70 GPa has been tracked by continuous X-ray diffraction acquisition with 100 and 200 ms time resolution. Using diffraction peak breadths of ϵ-Fe we have derived the lattice strain and uniaxial stress component t, which is a measure of strength as a function of pressure. The time- resolved diffraction patterns give an insight into the transformation kinetics.

P8

HP-HT synthesis and properties of new unusual perovskite, $CaCo_3V_4O_{12}$

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Perovskites, with general formula ABO_3 (where A = alkali, alkali-earth, rare-earth, Pb, Bi, and B = transition metals, Ga, Ge, Sb, Sn), are a very common class of oxide materials that find applications in a wide range of technologies. Double perovskites with the $AA'_3B_4O_{12}$ formula comprise an additional cation site A' that has a square-planar oxygen coordination. It accommodates small-sized cations of transition metals (Cu^{2+} or Mn^{3+} ions). A close location of the B and A' sites facilitates electronic interactions through the A'-O-B chains.
In this work we have synthesized a new perovskite, $CaCo_3^{2+}V_4^{4+}O_{12}$ at high-pressure high-temperature (HP-HT) conditions extensively examined its properties by a range of techniques [1]. $CaCo_3V_4O_{12}$ is a first example of perovskite in which the sites A' are fully occupied by the Co^{2+} ions. We found that $CaCo_3V_4O_{12}$ adopts a cubic lattice of the Im3 symmetry and undergoes an abrupt antiferromagnetic transition around 98 K. The electrical resistivity data suggest the semimetallic conductivity in the temperature range of 1.6 – 370 K. We have established that the Co^{2+} ions in $CaCo_3V_4O_{12}$ are in the high-spin state with a sizable orbital moment, even though their square-planar oxygen coordination could be more suitable for the low-spin state, which is prone to the Jahn-Teller distortion.

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P9

Static and dynamic structure factors for warm dense matter

Kai-Uwe Plagemann[1], Hannes Rüter[1], Thomas Bornath[1], Carsten Fortmann[2], Michael P. Desjarlais[3], Ronald Redmer[1]

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Warm dense matter of solid-like densities and temperatures of several eV is relevant for planetary interiors and inertial confinement fusion experiments. A versatile and reliable tool to probe such extreme states of matter is X-ray Thomson scattering (XRTS) from which information about plasma parameters like electron density, electron temperature and mean ionization state can be inferred directly from the dynamic structure factor [1]. Pioneering XRTS experiments were performed for beryllium [2,3] and later also for other materials such as boron, carbon and aluminum. The evaluation of the X-ray scattering spectra is usually based on the Chihara formula

[4] that accounts for electronic free-free, bound-free, and bound-bound transitions. We present results for the static and dynamic structure factor based on ab initio molecular dynamics simulations. First, the static ion-ion and electron-ion structure factors, which are relevant for the description of elastic scattering of X-rays (ion feature), are calculated from simulation data. We determine the slope of the screening cloud around the ions and compare with analytical expressions [4] that have been used so far. Second, we calculate the dynamic ion-ion structure factor via the time-dependent intermediate scattering function, for the first time using a full Kohn-Sham DFT schema [5]. We compare our results with XRTS experiments for Be and Al. Third, the dynamic electron-electron structure factor is derived in linear response theory using the fluctuation-dissipation theorem and the Kubo-Greenwood formula for the dynamic conductivity. We observe an almost perfect Drude-like for Be [6].

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P10

Plasma diagnostics using K-line emission profiles of argon

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K-line profiles emitted from a warm dense plasma environment are used for diagnostics of Ar droplet plasmas created by high energy laser pulses. We observe temperature gradients within the Ar droplet from cold temperatures of the order of some 10 eV up to higher temperatures of about 170 eV. Non-perturbative wave functions are calculated as well as ionization energies, binding energies and relevant emission energies using a chemical ab initio code. The plasma screening is considered within a perturbative approach to the Hamiltonian. The plasma effect influences the many-particle system resulting in energy shifts due to electron- ion and electron-electron interaction. With this approach we get a good reproduction of spectral features that are strongly influenced by ionization and excitation processes within the plasma. Comparing with the widely known FLYCHK code, counting for internal degrees of freedom (bound states) and treating pressure ionization within our quantum statistical approach leads to different results for the inferred temperature distribution.

P11

Insights into Mercury's interior structure from geodesy measurements and global contraction

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The measurements of the gravitational field of Mercury by MESSENGER and improved measurements of the spin state of Mercury provide important insights on its interior structure. In particular, these data give strong constraints on the radius and density of Mercury's core. However, present geodesy data do not provide strong constraints on the radius of the inner core. The data allow for models with a fully molten liquid core to models which have an inner core radius that is almost as large as the radius of the core, if it is assumed that sulphur is the only light element in the core. Models without an inner core are, however, at odds with the observed internally generated magnetic field of Mercury since Mercury's dynamo cannot operate by secular cooling alone at present.

The present radius of the inner core depends mainly on Mercury's thermal state and light elements inside the core. Because of the secular cooling of the planet, the temperature inside the core drops below the liquidus temperature of the core material somewhere in the core and leads to the formation of an inner core and to the global contraction of the planet. The amount of contraction depends mainly on the temperature decrease, on the thermal expansion of the materials inside the planet, on the volume of crystallised iron-rich core liquid, and on the volume of crystallised crust.

In this study we use geodesy data, the recent estimate about the radial contraction of Mercury, and thermo-chemical evolution calculations taking into account the formation of the crust, a growing inner core, and modeling the formation of iron-rich snow in the core in order to improve on our knowledge about Mercury's inner core radius and thermal state. Since data from remote sensing of Mercury's surface indicate that Mercury formed under reducing conditions we consider models that have sulfur and silicon as light elements inside their core.

P12

Electrical resistivity and compressibility of metals near the melting point and implications for the Earth's core

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Upon melting at ambient conditions, metals exhibit a discontinuous increase in both electrical resistivity ρ_{el} and isothermal compressibility β_{T}. In this work, we present a survey of experimental data on the dimensionless ratios of these quantities $\rho_{\mathrm{el}}^{\mathrm{liquid}}/\rho_{\mathrm{el}}^{\mathrm{solid}}$ and $\beta_{\mathrm{T}}^{\mathrm{liquid}}/\beta_{\mathrm{T}}^{\mathrm{solid}}$ just above and below the melting point for a number of metals and thereby check to which degree they are determined by a change of their structure factor $S(k)$ in the long wavelength limit. This approach is expected to work fine for some monovalent metals and has not yet been tested systematically, with a focus on geophysically relevant materials.

We observe that—amongst other metals with a much simpler electronic structure—for iron this fairly crude assumption holds very well. Assuming that it continues to do so with pressure, including the pressure at the Earth's inner core boundary (ICB), we can use the change of compressibility at the ICB from the *preliminary reference earth model* (PREM) and estimates for $\rho_{\text{el}}^{\text{liquid}}$ from computational studies to infer the resistivity in the solid inner core $\rho_{\text{el}}^{\text{solid}}$.

P13

Plate Tectonics on Earth-like Exoplanets

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Plate tectonics is a complex process that primarily requires lithospheric failure, deformation, and subduction. On Earth, plate tectonics is widely viewed as essential to sustain the conditions vital for life (e.g., [1]). The discovery of rocky exoplanets has prompted questions about their ability to preserve active plate tectonics, similar to Earth.

Although the physics of plate tectonics is poorly understood, studies commonly parameterize the complex processes involved as a simple yield strength that has a Byerlee's law dependence on pressure. It is generally agreed that higher Rayleigh numbers lead to higher convective stresses available to overcome the yield strength of the lithosphere (e.g., [2], [3]). However, new numerical simulations have shown that strong thermal effects outweight the convective stresses prevalent inside of massive Earth-like exoplanets and plate tectonics will be absent [4]. Furthermore, the initial temperature distribution plays a crucial role in the development of plate tectonic-like surface mobilisation [5].

In the present study, exoplanet interior modeling ([6], [7]) together with analytically derived scaling laws is used to investigate under which conditions plate tectonics can be maintained on massive Earth-like planets. In doing so, we focus on calculating a realistic viscosity distribution which is temperature- and pressure- dependent. First results indicate that for certain sets of rheological parameters plate tectonics should be feasible on rocky bodies slightly more massive than the Earth.

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P14

Investigation of warm dense carbon near the solid-liquid phase transition

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To measure the phase transition of carbon we used laser-induced shock waves (12TW/cm^2) to achieve these conditions and investigated the material with spectrally resolved X-ray Thomson scattering. To get more informations about the point of the phase transition we used different carbon types to reach different final states: flexible graphite (1.3 g/cm^3), rigid graphite (1.82 g/cm^3) and HOPG (2.2 g/cm^3) . As probe radiation we used the vanadium k-alpha line at 4952 eV. The phase transition was identified with the show up of an elastic scattering feature from the probe radiation. We saw an elastic scattering feature for the flexible and rigid graphite. The HOPG shows no signs for a phase transition. By measurements of the shock velocity and 1D hydrodynamic simulations we can predict the final conditions to a density of 3.29 g/cm^3 for FG, 3.72 g/cm^3 for RG and 3.90 g/cm^3 for HOPG, temperatures of 1.25 eV for FG, 0.79 eV for RG and 0.49 eV for HOPG and pressures of 115 GPa for FG, 143 GPa for RG and 141 GPa for HOPG.

P15

Dynamic-DAC and time-resolved studies of phase transition dynamics

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Studies of the dynamics of pressure-induced phase transitions hold strong potential for new discoveries and developing strategies for increased control of material properties. New diagnostic instrumentation and experimental platforms are enabling increased levels of detail and sophistication beyond simply identifying a transition pressure and the crystal structure of the phases. Time-resolved x-ray scattering measurements of transitions provide unique microscopic insights into the dynamics of pressure-induced phase transitions; including nucleation, growth and the observations of intermediate and/or metastable phases. In addition, tenability of the pressure drive permits evaluations of the influence of compression rate. In this presentation we will discuss our use of the dynamic diamond anvil cell (dDAC) to study the dynamics of phase transitions under various compression rates in simple metals.

Portions of this work were performed under the auspices of the U.S. DOE by LLNL under Contract DE-AC52-07NA27344 and funded by the LLNL LDRD program under project tracking code 11-ERD-046. Portions of this research were carried out at Petra-III at DESY, a member of the Helmholtz Association (HGF). We thank the experimental support team lead by H.-P. Liermann for assistance in using the Extreme Conditions Beamline (ECB) P02.2. Portions of this work were performed at HPCAT (Sector 16), Advanced Photon Source (APS), Argonne National Laboratory. HPCAT operations are supported by DOE-NNSA under Award No. DENA0001974 with partial instrumentation funding by NSF. APS is supported by DOE-BES, under Contract No. DE-AC02-06CH11357.

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List of available songs for the karaoke evening

(Thursday evening at the restaurant “Trotzenburg”, after the Dinner)

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2raumwohnung	36 Grad
2 Unlimited	No Limit
3 Doors Down	Here Without You
3 Doors Down	Kryptonite
30 Seconds To Mars	A Beautiful Lie
30 Seconds To Mars	Closer To The Edge
30 Seconds To Mars	Kings And Queens
30 Seconds To Mars	The Kill
50 Cent	In Da Club
A Day To Remember	Have Faith In Me
A Day To Remember	Here's To The Past
A Fine Frenzy	Almost Lover
A Perfect Circle	3 Libras
A Perfect Circle	Hollow
A Perfect Circle	Imagine
A Perfect Circle	Judith
A Perfect Circle	Passive
A Perfect Circle	The Outsider
A Perfect Circle	Weak And Powerless
Aaliyah	Try Again
ABBA	Chiquitita (spanisch)
ABBA	Dancing Queen
ABBA	Honey Honey
ABBA	Money Money Money
ABBA	Super Trouper
ABBA	Thank You For The Music
ABBA	Waterloo
Absolute Beginner	Hammerhart
Absolute Beginner	Liebeslied
AC/DC	Highway To Hell
AC/DC	Thunderstruck
AC/DC	TNT
Accept	Fast As A Shark
Ace Of Base	All That She Wants
Adele	Chasing Pavements
Adele	Make You Feel My Love
Adele	Rolling In The Deep
Adele	Set Fire To The Rain
Adele	Someone Like You
Adele	Skyfall
Aerosmith	Crazy
Aerosmith	I Don't Want To Miss A Thing
Aerosmith	Pink
Aerosmith	Walk This Way
Afroman	Because I Got High
Aha	Take On Me
Alanis Morissette	Ironic
Alanis Morissette	Uninvited
Alanis Morissette	You Oughta Know
Alannah Myles	Black Velvet
Alexandra Burke	Hallelujah
Alex Clare	Too Close
Alexisonfire	This Could Be Anywhere In The World
Alice Cooper	Poison

Alice Cooper	School's Out
Alice In Chains	Again
Alice In Chains	Check My Brain
Alice In Chains	Man In The Box
Alice In Chains	Rooster
Alice In Chains	Would
Alice In Chains	Your Decision
Alicia Keys	Fallin'
Alien Ant Farm	Smooth Criminal
Alison Krauss & James Taylor	Oh, Atlanta
All Saints	Never Ever
All That Remains	This Calling
Alphaville	Big In Japan
Alphaville	Forever Young
America	Horse With No Name
Amy MacDonald	This Is The Life
Amy Winehouse	Rehab
Amy Winehouse	Valerie
Amy Winehouse	You Know I'm No Good
Anastasia	I'm Outta Love
Andrew W.K.	Party Hard
Animals	House Of The Rising Sun
Anna Kendrick	Cups (When I'm Gone)
Annie Lennox	Into the West
Annie Lennox	Walking On Broken Glass
Annie Lennox	Why
Anthrax	Indians
Anti-Flag	You've Got To Die For Your Government
Aqua	Barbie Girl
Aqualung	Brighter Than Sunshine
Arcade Fire	Ready To Start
Arctic Monkeys	I Bet You Look Good On The Dancefloor
Aretha Franklin	Natural Woman
Aretha Franklin	Respect
Asia	Heat Of The Moment
Asking Alexandria	A Prophecy
Ataris	Boys Of Summer
ATC	Around The World (La La La La La)
Atomic Kitten	Whole Again
At The Drive-In	One Armed Scissor
Audioslave	Cochise
Audioslave	Out Of Exile
Avenged Sevenfold	Buried Alive
Avicii	Wake Me Up
Awolnation	Sail
Avril Lavigne	Complicated
Avril Lavigne	Sk8er Boi
Backstreet Boys	Everybody (Backstreet's Back)
Backstreet Boys	I Want It That Way
Backstreet Boys	Larger Than Life
Backstreet Boys	Quit Playing Games With My Heart

*Songs die fett gedruckt sind, sind dieses mal neu dabei!

1

Bad Religion	Generator
Bad Religion	Sorrow
Baha Men	Who Let The Dogs Out
Bangles	Eternal Flame
Bangles	Manic Monday
Baseballs	I Don’t Feel Like Dancin’
Beach Boys	Kokomo
Beach Boys	Surfin' USA
Beastie Boys	Fight For The Right To Party
Beastie Boys	Sabotage
Beatles	Can't Buy Me Love
Beatles	Drive My Car
Beatles	Get Back
Beatles	Help
Beatles	Hey Jude
Beatles	In My Life
Beatles	Let It Be
Beatles	She's Leaving Home
Beatles	Twist And Shout
Beatles	Yesterday
Beatsteaks	Hand In Hand
Beatsteaks	Milk And Honey
Bee Gees	How Deep Is Your Love
Bee Gees	Night Fever
Bee Gees	Stayin' Alive
Bell Biv Devoe	Poison
Beyoncé & Jay Z	Crazy In Love
Beyoncé	Halo
Beyoncé	If I Were A Boy
Biffy Clyro	Captain
Biffy Clyro	God And Satan
Bill Withers	Ain't No Sunshine
Bill Withers	Lean On Me
Billy Idol	Dancing With Myself
Billy Idol	Flesh For Fantasy
Billy Idol	Mony Mony
Billy Idol	Rebel Yell
Billy Idol	White Wedding
Billy Joel	Piano Man
Billy Stewart	Summertime
Billy Talent	Fallen Leaves
Billy Talent	Saint Veronica
Billy Talent	Viking Death March
Birdy	People Help The People
Birdy	Skinny Love
Björk	Army Of Me
Björk	Bachelorette
Björk	It's Oh So Quiet
Björk	Violently Happy
Black Eyed Peas	Let's Get It Started
Black Flag	Nervous Breakdown
Black Keys	Gold On The Ceiling
Black Keys	Lonely Boy
Black Keys	Tighten Up
Black Sabbath	Iron Man
Black Sabbath	Paranoid

Black Sabbath	War Pigs
Blink 182	All The Small Things
Blink 182	I Miss You
Blink 182	What's My Age Again
Blondie	The Tide Is High
Bloodhound Gang	Bad Touch
Bloodhound Gang	Fire Water Burn
Blümchen	Boomerang
Blue Oyster Cult	Burnin’ For You
Blue Oyster Cult	Don't Fear The Reaper
Blues Brothers	Everybody Needs Somebody
Blues Brothers	Rawhide
Blur	Coffee And TV
Blur	Song 2
Bobby Hebb	Sunny
Bob Dylan	Mr. Tambourine Man
Bob Dylan	The Times Are Changing
Bob Marley	Bad Boys
Bob Marley	Buffalo Soldier
Bob Marley	Could You Be Loved
Bob Marley	Get Up Stand Up
Bob Marley	Jammin
Bob Marley	No Woman No Cry
Bob Marley	Redemption Song
Bobby Vinton	Mr. Lonely
Boleros	Bésame Mucho
Bon Jovi	Always
Bon Jovi	It's My Life
Bon Jovi	Keep The Faith
Bon Jovi	Living On A Prayer
Bon Jovi	Run Away
Bon Jovi	You Give Love A Bad Name
Boney M	Brown Girl In The Ring
Boney M	Daddy Cool
Boney M	Ma Baker
Boney M	Rivers Of Babylon
Bonnie Raitt	I Can't Make You Love Me
Bonny Tyler	It’s A Heartache
Boston	More Than A Feeling
Boxtops	The Letter
Boyzone	All That I Need
Boyzone	No Matter What
Brad Paisley & Alison Krauss	Whiskey Lullaby
Breaking Benjamin	Diary Of Jane
Bring Me The Horizon	Anti-Vist
Britney Spears	Baby One More Time
Bruno Mars	Just The Way You Are
Bryan Adams & Melanie C	When You're Gone
Bryan Adams & Rod Stewart & Sting	All For Love
Bryan Adams	Everything I Do
Bryan Adams	Summer Of '69
Buena Vista Social Club	Candela
Bullet For My Valentine	Tears Don’t Fall

*Songs die fett gedruckt sind, sind dieses mal neu dabei!

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Bush	Chemicals Between Us
Bush	Glycerine
Calling	Wherever You Will Go
Cardigans	Love Fool
Cardigans	My Favorite Game
Carl Douglas	Kung Fu Fighting
Carly Rae Jepsen	Call Me Maybe
Carly Simon	Nobody Does It Better (James Bond Theme)
Carpenters	Close To You
Cat Stevens	Father and Son
Cat Stevens	Wild World
Cats (Musical)	Memory
Cee Lo Green	Fuck You
Celine Dion	It’s All Coming Back To Me
Celine Dion	My Heart Will Go On
Cher	Believe
Cher	Shoop Shoop Song
Chesney Hawkes	The One And Only
Children Of Bodom	If You Want Peace Prepare For War
Chris Cornell	You Know My Name
Chris Isaak	Wicked Game
Christina Aguilera & Pink	Lady Marmalade
Christina Aguilera	Beautiful
Christina Aguilera	Genie In A Bottle
Christina Perri	A Thousand Years
Christina Perri	Jar Of Hearts
Chuck Berry	School Days
Chumbawamba	Tubthumping
Clash, The	I Fought The Law
Clash, The	London Calling
Clash, The	Should I Stay Or Should I Go
Clueso	Gewinner
Coheed and Cambria	Welcome Home
Coldplay	Clocks
Coldplay	In My Place
Coldplay	The Scientist
Coldplay	Yellow
Connie Francis	Stupid Cupid
Coolio	Gangstas Paradise
Counting Crows	Mr. Jones
Corey Hart	Sunglasses At Night
Corpse Bride	Remains Of The Day
Cranberries	Dreams
Cranberries	Linger
Cranberries	Ode To My Family
Cranberries	Zombie
Crash Test Dummies	Mmm Mmm Mmm
Creed	One Last Breath
Creed	Higher
Creed	My Sacrifice
Creedence Clearwater Revival	Bad Moon Rising
Creedence Clearwater Revival	Have You Ever Seen The Rain

Creedence Clearwater Revival	I Heard It Through The Grapewine
Creedance Clearwater Revival	Looking Out My Back Door
Creedance Clearwater Revival	Proud Mary
Cro	Einmal Um Die Welt
Culture Club	Do You Really Want To Hurt Me
Culture Club	Karma Chameleon
Cure, The	A Forest
Cure, The	Boy's Don't Cry
Cure, The	Close To Me
Cure, The	Love Cats
Cure, The	Love Song
Cure, The	Lullaby
Cyndi Lauper	Girls Just Wanna Have Fun
Cyndi Lauper	Time After Time
Cyndi Lauper	True Colors
Cypress Hill	Insane In The Brain
Daft Punk & Pharell	Get Lucky
Damien Rice	Cannonball
Dandy Warhols	Bohemian Like You
Danzig	Mother
Darkness	I Believe In A Thing Called Love
Darkness	Get Your Hands Off My Woman
Darkness	Love Is Only A Feeling
Darkness	One Way Ticket
Dashboard Confessional	Hands Down
David Bowie	Heroes
David Bowie	Under Pressure
David Bowie	Space Oddity
David Hasselhoff	Looking For Freedom
Death Cab For Cutie	I Will Follow You Into The Dark
Deee Lite	Groove Is In The Heart
Deep Blue Something	Breakfast At Tiffanys
Deep Purple	Smoke On The Water
Def Leppard	Pour Some Sugar On Me
Deftones	Around The Fur
Deftones	Back To School
Deftones	Change
Deftones	Digital Bath
Deftones	Engine No. 9
Deftones	My Own Summer
Deftones	Xerces
Deichkind	Arbeit Nervt
Del Funky Homosapien	If You Must
Depeche Mode	Enjoy The Silence
Depeche Mode	Everything Counts
Depeche Mode	I Just Can't Get Enough
Depeche Mode	Never Let Me Down Again
Depeche Mode	People Are People
Depeche Mode	Personal Jesus
Depeche Mode	Somebody

*Songs die fett gedruckt sind, sind dieses mal neu dabei!

Depeche Mode	A Question Of Time
Desirless	Voyage Voyage
Destiny's Child	Say My Name
Dick Brave bzw Bobby Vee	Take Good Care Of My Baby
Dido	Here With Me
Die Apokalyptischen Reiter	Friede Sei Mit Dir
Die Fantastischen Vier	Mit freundlichen Grüßen
Die Fantastischen Vier	Sie Ist Weg
Die Prinzen	Alles Nur Geklaut
Die Prinzen	Bombe
Die Prinzen	Küssen Verboten
Die Prinzen	Millionär
Die Toten Hosen	Alles aus Liebe
Die Toten Hosen	Eisgekühlter Bommerlunder
Die Toten Hosen	Nur Zu Besuch
Die Toten Hosen	Zehn Kleine Jägermeister
Die Ärzte	Der Graf
Die Ärzte	Elke
Die Ärzte	Junge
Die Ärzte	Lasse Redn
Die Ärzte	Manchmal Haben Frauen
Die Ärzte	Schrei Nach Liebe
Die Ärzte	Westerland
Die Ärzte	Zu Spät
Dinah Washington	What A Difference A Day Makes
Dio	Holy Diver
Dire Straits	Money For Nothing
Dire Straits	Sultans Of Swing
Dirty Dancing	I've Had The Time Of My Life
Disturbed	Decadence
Disturbed	Down With The Sickness
Disturbed	Land Of Confusion
Disturbed	Prayer
Disturbed	Remember
Dixie Chicks	Cold Day In July
Dixie Chicks	Don't Waste Your Heart
Dixie Chicks	Heartbreak Town
Dixie Chicks	Landslide
DJ Bobo	Chihuahua
Dolly Parton	Jolene
Donna Summer	Hot Stuff
Donna Summer	She Works Hard For The Money
Doors	Alabama Song
Doors	Break On Through
Doors	Light My Fire
Dream Theater	Constant Motion
Dredg	Sang Real
Drew Barrymore & Hugh Grant	Way Back Into Love
Dritte Wahl	Greif Ein
Dropkick Murphys	Shipping Up To Boston
Dropkick Murphys	World Full Of Hate
Drowning Pool	Bodies

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Dubliners	Fields Of Athenry
Dubliners	Irish Rover
Dubliners	Whe Wild Rover
Duffy	Warwick Avenue
Duncan Dhu	A un minuto de ti
Duran Duran	Notorious
Duran Duran	Ordinary World
Duran Duran	Union Of The Snake
Dusty Springfield	Son Of A Preacher Man
Duvet	**Serial Experiments Lain**
Dynamite Deluxe	Grüne Brille
DÖF	Codo
Eagles, The	Hotel California
East 17	It's Alright
Ed Sheeran	I See Fire
Ed Sheeran	Sing
Edeka Werbung (Der Tourist)	Supergeil
Editors	Papillon
Eels	Novocaine For The Soul
Eiffel 65	Blue (Da Ba Dee)
Ellie Goulding	Burn
Elton John & Blue	Sorry Seems To Be The Hardest Word
Elton John & Kiki Dee	Don't Go Breaking My Heart
Elton John	Don't Let The Sun Go Down On Me
Elton John	Goodbye Yellow Brick Road
Elton John	Rocket Man
Elton John	Your Song
Elvis Presley	Always On My Mind
Elvis Presley	Blue Suede Shoes
Elvis Presley	Jailhouse Rock
Elvis Presley	Return To Sender
Elvis Presley	Suspicious Minds
Emeli Sandé	Clown
Emeli Sandé	Next To Me
Emeli Sandé	Read All About It
Eminem & Dido	Stan
Eminem	Lose Yourself
Eminem	My Name Is
Eminem	Rap God
Eminem	Real Slim Shady
Eminem	Without Me
Enej	Skrzydlate ręce
Enrique Iglesias	Hero
Enrique Iglesias	Heroe
Enter Shikari	Sorry You're Not A Winner
En Vogue	Don't Let Go Love
Erasure	Always
Erasure	A Little Respect
Eric Clapton	Cocaine
Eric Clapton	Tears In Heaven
Europe	Final Countdown
Eurythmics	Sweet Dreams
Eurythmics	There Must Be An Angel

Evanescence	Bring Me To Life
Evanescence	My Immortal
Evergreen Terrace	New Friend Request
Everlast	What It's Like
Extreme	More Than Words
Faith Hill	There You'll Be
Faith No More	Epic
Faith No More bzw Lionel Richie	Easy
Faith No More	We Care A Lot
Falco	Egoist
Falco	Der Kommissar
Falco	Jeanny
Falco	Rock Me Amadeus
Fall Out Boy	This Ain't A Scene, It's An Arms Race
Fatboy Slim	Praise You
Fettes Brot	Emanuela
Fettes Brot	Jein
Filter	Best Things
Filter	Take A Picture
Five Finger Death Punch	Hard To See
Five Finger Death Punch	The Bleeding
Flogging Molly	Devil's Dance Floor
Flogging Molly	Drunken Lullabies
Flogging Molly	Tobacco Island
Florence & The Machine	Dog Days Are Over
Florence & The Machine	Shake It Out
Foo Fighters	All My Life
Foo Fighters	Best Of You
Foo Fighters	Big Me
Foo Fighters	Everlong
Foo Fighters	My Hero
Foo Fighters	The Pretender
Foo Fighters	**Times Like These**
Foo Fighters	Walk
Fools Garden	Lemon Tree
For Non Blondes	What's Up
Foreigner	Cold As Ice
Frank Sinatra	**I Got A Kick Out Of You**
Frank Sinatra	My Way
Frank Sinatra	New York New York
Frank Sinatra & Nancy Sinatra	**Something Stupid**
Frankie Valli	Can't Take My Eyes Off Of You
Franz Ferdinand	Take Me Out
Fray, The	How To Save A Life
Fray, The	Over My Head
Freddie Mercury	Living On My Own
Frieda Gold	Wovon Sollen Wir Träumen
Fugees, The	Killing Me Softly
Fun	Some Nights
Fun	We Are Young
Garth Brooks	To Make You Feel My Love
Gary Jules	Mad World
Gary Moore	Still Got The Blues

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Gaslight Anthem	45
Genesis	I Can't Dance
George Michael	Careless Whisper
George Michael	Faith
Gipsy Kings	Baila Me
Glashaus	Wenn Das Liebe Ist
Glasperlenspiel	Echt
Glasperlenspiel	Ich Bin Ich
Glee	Deck The Rooftop
Glee	Loser Like Me
Gloria Gaynor	I Will Survive
Gnarls Barkley	Crazy
Godsmack	Awake
Golden Earring	Radar Love
Goo Goo Dolls	Iris
Good Charlotte	I Just Wanna Live
Goon Moon	Feel Like This
Gorillaz	Clint Eastwood
Gorillaz	Feel Good Inc
Gotye ft. Kimbra	Somebody That I Used To Know
Gozu	Bald Bull
Grease	Summer Nights
Grease	You're The One That I Want
Green Day	Are We The Waiting
Green Day	Basket Case
Green Day	Boulevard Of Broken Dreams
Green Day	Holiday
Green Day	When I Come Around
Guano Apes	Open Your Eyes
Guns N' Roses	Live And Let Die
Guns N' Roses	Paradise City
Guns N' Roses	Sweet Child O' Mine
Gwen Stefani	Hollaback Girl
Haddaway	What Is Love
Hatebreed	This Is Now
Helge Schneider	Katzenklo
Heroes Del Silencio	Entre Dos Tierras
HIM	Right Here In My Arms
HIM	Rip Out The Wings Of A Butterfly
Hives	Hate To Say I Told You So
Hole	Celebrity Skin
Hoobastank	Crawling In The Dark
Hoobastank	The Reason (spanisch)
Hoobastank	The Reason
Housemartins	**Caravan Of Love**
Human League	Don't You Want Me
Hurts	Wonderful Life
Ich und Ich	Du Erinnerst Mich An Liebe
Ich und Ich	Stark
Ich und Ich	So Soll Es Bleiben
Iced Earth	Watching Over Me
Icona Pop	I Love It
Idina Menzel	**Let It Go**

Iggy Pop	The Passenger
Il Pucino Pio	Küken Piept
Imagine Dragons	Demons
Imagine Dragons	On Top of the World
Imagine Dragons	Radioactive
Imogen Heap	Headlock
Imogen Heap	Hide And Seek
Incubus	Nice To Know You
Incubus	Pardon Me
Indina Menzel	Let It Go
Interpol	Slow Hands
INXS	Never Tear Us Apart
Iron Maiden	Number Of The Beast
Iron Maiden	Run To The Hills
Iron Maiden	The Trooper
Israel Kamakawiwo'ole	Somewhere Over The Rainbow
Jack White	Sixteen Saltines
James Arthur	**Impossible**
James Blunt	Goodbye My Lover
James Blunt	You're Beautiful
James Brown	Sex Machine
James Morrison	**Broken Strings**
Jamie Cullum	These Are The Days
Jamie Cullum	What A Difference A Day Made
Jamiroquai	Virtual Insanity
Janis Joplin	Me And Bobby McGee
Janis Joplin	Mercedes Benz
Jason Mraz	I'm Yours
Jay Z	99 Problems
Jay-Z & Alicia Keys	Empire State Of Mind
Jefferson Airlplane	White Rabbit
Jefferson Airplane	Somebody To Love
Jennifer Lopez	Love Don't Cost A Thing
Jennifer Lopez u Marc Anthony	No Me Ames
Jessie J feat. BoB	Price Tag
Jet	Are You Gonna Be My Girl
Jimi Hendrix	All Along The Watchtower
Jimi Hendrix	Hey Joe
Jimmy Eat World	Middle
Jimmy Eat World	Sweetness
Joachim Witt	Der Goldene Reiter
Joachim Witt	Die Flut
Joan Jett	Hate Myself For Lovin You
Joan Jett & The Blackhearts	I Love Rock'n'Roll
Joan Osborne	One Of Us
Joaquin Phoenix & Reese Witherspoon	Jackson
Joe Cocker	Up Where We Belong
Joe Cocker	You Are So Beautiful
John Legend	All Of Me
John Lennon	Imagine
Johnny Cash	Folsom Prison Blues
Johnny Cash	Hurt

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Johnny Cash & June Carter	Jackson
Johnny Cash	Ring Of Fire
Johnny Rivers	Secret Agent Man
Joni Mitchell	Big Yellow Taxi
José Martí	Guantanamera
José González	Heartbeats
Joshua Kadison	Jessie
Journey	Don't Stop Believing
Journey	Open Arms
Joy Division	Love Will Tear Us Apart
Juanes	La Camisa Negra
Judas Priest	Breaking The Law
Judas Priest	Painkiller
Juli	Dieses Leben
Julio Iglesias	Quiereme mucho
Jupiter Jones	Still
Justin Timberlake	Cry Me A River
Justin Timberlake	My Love
Justin Timberlake	Senorita
Kaiser Chiefs	I Predict A Riot
Kansas	Carry On My Wayward Son
Kansas	Dust In The Wind
Karel Gott	Die Biene Maja
Kate Nash	Foundations
Kate Nash	Pumpkin Soup
Kate Winslet	What If
Katie Melua	Just Like Heaven
Katrina n Whalers	Walking On Sunshine
Katy Perry	I Kissed A Girl
Katy Perry	Last Friday Night
Katzenjammer	I Will Dance (When I Walk Away)
Katzenjammer	Rock-Paper-Scissors
Keane	Is It Any Wonder
Keane	Somewhere Only We Know
Kelis	Milkshake
Kelly Clarkson	Because Of You
Kelly Clarkson	Breakaway
Kelly Family	An Angel
Kelly Osbourne	Papa Don't Preach
Kenny Rogers	Just Dropped In
Kid Rock	All Summer Long
Kid Rock	American Bad Ass
Kid Rock	Cowboy
Killers	Mr. Brightside
Killers	Somebody Told Me
Killswitch Engage	Holy Diver
Killswitch Engage	My Last Serenade
Kings Of Leon	Sex On Fire
Kings Of Leon	Use Somebody
Kinks	Lola
Kinks	You Really Got Me
Kiss	Detroit Rock City
Kiss	I Was Made For Loving You
Kiss	Rock & Roll All Nite

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Kiss	Strutter
KIZ	Bong Verkippt
KIZ	Pauch It
KIZ	Riesenglied
KIZ	Spasst
KIZ	Walpurgisnacht
Knorkator	Absolution
Knorkator	Alter Mann
Knorkator	Böse
Knorkator	Fans
Knorkator	Ma Baker
Knorkator	Weg Nach Unten
Kool Savas & Olli Banjo	Echo
Korn	Freak On A Leash
Korn	Here To Stay
Korn	Word Up
Kraftklub	Songs Für Liam
Kraftwerk	Das Model
KT Tunstall	Black Horse And Cherry Tree
KT Tunstall	Suddenly I See
Kylie Minogue	Can't Get You Out Of My Head
Kyuss	Demon Cleaner
Labrinth feat Emeli Sande	Beneath Your Beautiful
Lady Gaga	Applause
Lady Gaga	Bad Romance
Lady Gaga	Paparazzi
Lady Gaga	Poker Face
Lana Del Rey	Blue Jeans
La Roux	Bulletproof
Las Ketchup	Ketchup Song
LeAnn Rimes	Can't Fight The Moonlight
LeAnn Rimes	How Do I Live
Led Zeppelin	Black Dog
Led Zeppelin	Stairway To Heaven
Led Zeppelin	Whole Lotta Love
Lena Meyer-Landrut	Satellite
Lenny Kravitz	American Woman
Leona Lewis	Run
Lifehouse	**Hanging By A Moment**
Lily Allen	Fuck You
Lily Allen	Not Fair
Lily Allen	Smile
Limp Bizkit	Behind Blue Eyes
Limp Bizkit	Break Stuff
Limp Bizkit	My Generation
Limp Bizkit	Nookie
Limp Bizkit	Rollin'
Linkin Park	Breaking The Habit
Linkin Park	Crawling
Linkin Park	In The End
Linkin Park	Iridescent
Linkin Park	One Step Closer
Linkin Park	Waiting For The End
Linkin Park	What I've Done

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Liquido	Narcotic
Lit	Miserable
Live	Dolphin's Cry
LMFAO	Party Rock Anthem
LMFAO	Sexy & I Know It
London Grammar	Strong
Lonely Island	Motherlover
Lonestar	Walking In Memphis
Lorde	Royals
Lordi	Hard Rock Hallelujah
Lou Bega	Mambo No. 5
Lou Reed	Perfect Day
Louis Armstrong	Wonderful World
Lucilectric	Mädchen
Lumineers	Ho Hey
Lupe Fiasco	Kick Push
Lynyrd Skynyrd	Sweet Home Alabama
Lykke Li	I Follow Rivers
Macklemore & Ryan Lewis	Can't Hold Us
Macklemore & Ryan Lewis	Thrift Shop
Macy Gray	I Try
Madonna	American Pie
Madonna	Like A Prayer
Madonna	Like A Virgin
Madonna	Material Girl
Madsen	Du Schreibst Geschichte
Mamas And The Papas	California Dreamin
Mamas And The Papas	Dream A Little Dream Of Me
Manau	La Tribu De Dana
Mando Diao	Dance With Somebody
Manfred Mann	Blinded By The Light
Manfred Mann	Mighty Quinn
Manowar	Carry On
Manowar	Hail And Kill
Manowar	Warriors Of The World
Mariah Carey	Heartbreaker
Mariah Carey	Heroe (spanisch)
Mariah Carey	Without You
Marilyn Manson	Disposable Teens
Marilyn Manson	Sweet Dreams
Marilyn Manson	Tainted Love
Marilyn Manson	The Beautiful People
Marina And The Diamonds	Hollywood
Marina And The Diamonds	How To Be A Heartbreaker
Marky Mark and Funky Bunch	Good Vibrations
Martha & Vandellas	Dancin' In The Streets
Maroon 5	This Love
Marvin Gaye	Sexual Healing
Mastodon	Oblivion
Maximo Park	Apply Some Pressure
MC Hammer	U Can't Touch This
Meat Loaf	I'd Do Anything For Love
Meat Loaf	Paradise By The Dashboard
Mecano	Hijo De La Luna
Megadeth	Down Patrol

Megadeth	A Tout Le Monde
Megadeth	Holy Wars The Punishment Due
Megadeth	Sweating Bullets
Megadeth	Symphony Of Destruction
Men At Work	Down Under
Meredith Brooks	Bitch
Meshuggah	Stengah
Metallica	Enter Sandman
Metallica	Fuel
Metallica	Master Of Puppets
Metallica	Nothing Else Matters
Metallica	The Unforgiven
Metallica	Whiskey In The Jar
MGMT	Kids
MGMT	Time To Pretend
Mia	Hungriges Herz
Mia	Tanz der Moleküle
Michael Bublé	Feeling Good
Michael Jackson & Paul McCartney	Say, Say, Say
Michael Jackson	Bad
Michael Jackson	Beat It
Michael Jackson	Billie Jean
Michael Jackson	Black Or White
Michael Jackson	Earth Song
Michael Jackson	Give in to me
Michael Jackson	Man In The Mirror
Michael Jackson	Thriller
Mighty Bosstones	Impression I Get
Mika	Grace Kelly
Mika	Relax Take It Easy
Mike Oldfield	Moonlight Shadow
Milli Vanilli	Girl You Know It's True
Misfits	Attitude
Misfits	Bullet
Modern Talking	Cheri Cheri Lady
Modern Talking	You're My Heart You're My Soul
Moloko	Sing It Back
Moloko	The Time Is Now
Monkees	I'm A Believer
Montell Jordon	This is how we do it
Monty Python	Always Look On The Bright Side Of Life
Motley Crue	Girls, Girls, Girls
Motörhead	Ace Of Spades
Moulin Rouge	Elephant Love Medley
Mr. Big	To Be With You
Mumford & Sons	The Cave
Mumford & Sons	Winter Winds
Mumford & Sons	Little Lion Man
Muse	Bliss
Muse	Knights Of Cydonia
Muse	Plug In Baby
Muse	Resistance
Muse	Starlight

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Muse	Supermassive Black Hole
Muse	The Small Print
Muse	Time Is Running Out
Muse	Uprising
My Chemical Romance	Famous Last Words
My Chemical Romance	I'm Not Okay (I Promise)
My Chemical Romance	Welcome To The Black Parade
N'Sync	Bye Bye Bye
N'Sync	Tearin' Up My Heart
Nancy Sinatra	Bang Bang
Nancy Sinatra	These Boots Are Made For Walking
Natalie Imbruglia	Torn
Natasha Bedingfield	These Words
Neil Sedaka	Oh! Carol
Neil Young	Heart Of Gold
Neil Young	Let's Roll
Neil Young	Rockin' In The Free World
Nelly	Hot In Here
Nelly Furtado	I'm Like A Bird
Nelly Furtado	Powerless (Say What You Want)
Nelly Furtado	Try
Nena	99 Luftballons
Nena	Nur Geträumt
NERD	Lapdance
New Kids On The Block	Step By Step
Nick Cave And Kylie Minogue	Where The Wild Roses Grow
Nickelback	Hero
Nickelback	How You Remind Me
Nightmare Before Christmas	This Is Halloween
Nightwish	Nemo
Nightwish	Sleeping Sun
Nightwish	The Islander
Nightwish	Wish I Had An Angel
Nine Inch Nails	Closer
Nine Inch Nails	Head Like A Hole
Nine Inch Nails	Hurt
Nine Inch Nails	Only
Nine Inch Nails	The Hand That Feeds
Nine Inch Nails	The Perfect Drug
Nino Bravo	Cartas Amarillas
Nino Bravo	Libre
Nino Bravo	Noelia
Nirvana	Come As You Are
Nirvana	Lithium
Nirvana	Rape Me
Nirvana	Smells Like Teen Spirit
Nirvana	The Man Who Sold The World
Nirvana	Where Did You Sleep Last Night
Nirvana	You Know You're Right
No Doubt	Don't Speak

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No Doubt	Hella Good
No Doubt	Hey Baby
No Doubt	I'm Just A Girl
NOFX	Linoleum
Nonpoint	Bullet With A Name
Norah Jones	Don't Know Why
Norah Jones	Sunrise
Oasis	Don't Look Back In Anger
Oasis	Stand By Me
Oasis	Stop Crying You Heart Out
Oasis	Wonderwall
Offspring	Kids Aren't Alright
Offspring	Pretty Fly For A White Guy
Offspring	Why Don't You Get A Job
Of Monsters And Men	Little Talks
OMD	Sailing On The Seven Seas
Once	Falling Slowly
One Direction	What Makes You Beautiful
One Republic	Apologize
Oomph!	Augen Auf
Opeth	Coil
Opeth	Deliverence
Opeth	Harvest
Otto	Grund Zum Feiern
Outkast	Hey Ya!
Outkast	Ms Jackson
Ozzy Osbourne	**Crazy Train**
Ozzy Osbourne	Dreamer
P.O.D.	Alive
P.O.D.	Boom
Panic At The Disco!	I Write Sins Not Tragedies
Pantera	5 Minutes Alone
Pantera	Cemetary Gates
Pantera	Cowboys From Hell
Pantera	Domination
Pantera	Fucking Hostile
Pantera	This Love
Pantera	Walk
Papa Roach	Blood Brothers
Papa Roach	Broken Home
Papa Roach	Getting Away With Murder
Papa Roach	Last Resort
Paramore	Misery Business
Paramore	Monster
Paramore	Still Into You
Paramore	That's What You Get
Patrick Swayze	She's Like The Wind
Patti Smith	Because The Night
Paul McCartney	Live And Let Die
Paul Young	Love Is In The Air
Peaches & Herb	Reunited
Pearl Jam	Better Man
Pearl Jam	Black
Pearl Jam	Jeremy
Pearl Jam	Smile
Percy Sledge	Stand By Me

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Percy Sledge	When A Man Loves A Woman
Pet Shop Boys	Always On My Mind
Pet Shop Boys	Domino Dancing
Pet Shop Boys	Go West
Pet Shop Boys	It's A Sin
Pet Shop Boys	West End Girls
Peter Andre	Mysterious Girl
Peter Fox	Haus Am See
Peter Gabriel	Sledgehammer
Peter, Paul And Mary	Leaving On A Jetplane
Petula Clark	Downtown
Phantom Planet	California
Pharell Williams	Happy
Phil Collins	Against All Odds
Phil Collins	Another Day In Paradise
Phil Collins	You'll Be In My Heart
Pink	Don't Let Me Get Me
Pink	Get The Party Started
Pink	Just Give Me A Reason
Pink Floyd	Another Brick In The Wall
Pink Floyd	Wish You We're Here
Pixies	Here Comes Your Man
Pixies	Where Is My Mind
PJ Harvey	Down By The Water
Placebo	Every You Every Me
Placebo	Post Blue
Placebo	Pure Morning
Plain White T's	Hey There Delilah
Plan B	Ill Manors
Pogues	Dirty Old Town
Pogues	Streams Of Whiskey
Pogues and Dubliners	Irish Rover
Pointer Sisters	I'm So Excited
Police	Every Breath You Take
Police	Roxanne
Police	So Lonely
Porcupine Tree	Open Car
Portishead	GloryBox
Presidents Of The USA	Peaches
Prince	Kiss
Prince	Purple Rain
Proclaimers	I'm Gonna Be Five Hundred Miles
Prodigy	Firestarter
Psy	Gangnam Style (Englisch)
Psy	Gangnam Style (Koreanisch)
Puddle Of Mudd	Blurry
Puddle Of Mudd	She Hates Me
Puff Daddy	I'll Be Missing You
Pussycat Dolls & Busta Rhymes	Don't Cha
Queen	Another One Bites The Dust
Queen	Bohemian Rhapsody
Queen	Dont Stop Me Now
Queen	I Want To Break Free

Queen	One Vision
Queen	Somebody To Love
Queen	The Show Must Go On
Queen	We Are The Champions
Queen	We Will Rock You
Queen	Who Wants To Live Forever
Queens Of The Stone Age	Go With The Flow
Queens Of The Stone Age	Little Sister
Queens Of The Stone Age	No One Knows
Queens Of The Stone Age	The Lost Art Of Keeping A Secret
R.E.M.	Daysleeper
R.E.M.	Everybody Hurts
R.E.M.	Imitation Of Life
R.E.M.	Losing My Religion
R.E.M.	Man On The Moon
R.Kelly	I Believe I Can Fly
Raconteurs	Steady, As She Goes
Radiohead	All I Need
Radiohead	Creep
Radiohead	High And Dry
Radiohead	Karma Police
Radiohead	Paranoid Android
Radiohead	Street Spirit
Rage Against The Machine	Bulls On Parade
Rage Against The Machine	Killing In The Name
Rage Against The Machine	Testify
Rage Against The Machine	Wake Up
Rammstein	Amerika
Rammstein	Du Hast
Rammstein	Engel
Rammstein	Frühling In Paris
Rammstein	Ich Tu Dir Weh
Rammstein	Links 234
Rammstein	Mein Teil
Rammstein	Reise Reise
Rammstein	Pussy
Rammstein	Seemann
Rammstein	Waidmannsheil
Rammstein	Zerstören
Ramones	Blitzkrieg Bop
Ramones	I Wanna Be Sedated
Ramones	Sheena Is A Punk Rocker
Ray Charles	Hit The Road Jack
Ray Charles	I Got a Woman
Red Hot Chili Peppers	Aeroplane
Red Hot Chili Peppers	Around The World
Red Hot Chili Peppers	By The Way
Red Hot Chili Peppers	Californication
Red Hot Chili Peppers	Can't Stop
Red Hot Chili Peppers	Dani California
Red Hot Chili Peppers	Give It Away
Red Hot Chili Peppers	Otherside

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Red Hot Chili Peppers	Road Trippin
Red Hot Chili Peppers	Scar Tissue
Red Hot Chili Peppers	Snow
Red Hot Chili Peppers	Under The Bridge
Rednex	Cotton Eye Joe
Revolverheld & Marta Jandová	Halt Dich An Mir Fest
Rick Astley	Never Gonna Give You Up
Ricky Martin	Livin La Vida Loca (spanisch)
Ricky Martin	Livin' La Vida Loca
Ricky Martin	She bangs (spanisch)
Ricky Martin	Uno Dos Tres Maria (spanisch)
Right Said Fred	I'm Too Sexy
Rihanna	Don't Stop The Music
Rihanna	Pon De Replay
Rihanna	Russian Roulette
Rihanna	Take A Bow
Rihanna	Umbrella
Rio Reiser	Junimond
Rio Reiser	König Von Deutschland
Rise Against	Ready To Fall
Rise Against	Savior
Robbie Williams	Angels
Robbie Williams	Feel
Robbie Williams	Let Me Entertain You
Robbie Williams	Millennium
Robbie Williams	Misunderstood
Robbie Williams	Sexed Up
Robbie Williams	**Something Stupid**
Robin Sparkles	Let's Go To The Mall
Rocky Horror Picture Show	Time Warp
Rod Stewart	Sailing
Rolling Stones	Angie
Rolling Stones	Mothers Little Helper
Rolling Stones	Paint It Black
Rolling Stones	Ruby Tuesday
Rolling Stones	Satisfaction
Rolling Stones	Sympathy For The Devil
Rolling Stones	You Can't Always Get What You Want
Ronan Keating	Say Nothing At All
Ronan Keating	Tomorrow Never Comes
Rosenstolz	Ich Bin Ich
Rosenstolz	Liebe Ist Alles
Roxette	Joyride
Roxette	Listen To Your Heart
Roxette	The Look
Roy Orbison	Pretty Woman
Röyksopp	Vision One
Rupert Holmes	Escape
Sabrina Setlur	Du Liebst Mich Nicht
Sade	Kiss of Life
Sade	No Ordinary Love
Sade	Smooth Operator

Salt'n'Pepa	Push It
Salt'n'Pepa	Shoop
Sandi Thom	Wish I Was A Punkrocker
Santana	Black Magic Woman
Santana & Rob Thomas	Smooth
Sara Ramirez	The Story
Savage Garden	To The Moon And Back
Savage Garden	Truly Madly Deeply
Schandmaul	Walpurgisnacht
Scooter	Hyper Hyper
Scooter	Maria (I Like It Loud)
Scorpions	Rock You Like A Hurricane
Scorpions	Still Loving You
Scorpions	Wind Of Change
Script	Break Even
Script	For The First Time
Seal	Kiss From A Rose
Seal	Love's Divine
Selig	Ohne Dich
Sex Pistols	Anarchy In The UK
Shakira	Suerte
Shakira	Waka Waka (spanisch)
Shakira	Wherever, Whenever
Shirley Bassey	Hey Big Spender
Shirley Bassey	Kiss Me Honey Honey Kiss Me
Shocking Blue	Venus
Silverchair	Ana's Song
Silverchair	Anthem For The Year 2000
Silverchair	Freak
Silverchair	Tomorrow
Simple Minds	Don't you
Sinead O'Connor	Nothin Compares 2 U
Sir Mix A Lot	I Like Big Butts (And I Can Not Lie)
Sixpence None The Richer	Kiss Me
Skrillex	Bangarang
Skunk Anansie	Hedonism
Skunk Anansie	You Saved Me
Slayer	Raining Blood
Slipknot	Vermillion
Slipknot	Vermillion 2
Slipknot	Wait And Bleed
Smashing Pumpkins	Ava Adore
Smashing Pumpkins	Bullet With Butterfly Wings
Smiths	There Is A Light That Never Goes Out
Smiths	This Charming Man
Snoop Dogg & Pharell	Drop It Like It's Hot
Snow Patrol	Chasing Cars
Social Distortion	Bad Luck
Soft Cell	Tainted Love
Sonny & Cher	I Got You Babe
Soundgarden	Black Hole Sun
Soundgarden	Superunknown
Spandau Ballet	Gold

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Spandau Ballet	True
Spice Girls	Stop
Spice Girls	Wannabe
Spin Doctors	Two Princes
Sportfreunde Stiller	Ein Kompliment
Staind	Outside
Status Quo	Rockin All Over The World
Stealer's Wheel	Stuck In The Middle
Steel Panther	Community Property
Steppenwolf	Born To Be Wild
Stone Sour	Bother
Stone Sour	Inhale
Stone Sour	Through Glass
Stone Temple Pilots	Plush
Stone Temple Pilots	Vasoline
Stranglers	Golden Brown
Stranglers	Skin Deep
Stranglers	Strange Little Girl
Strokes	Last Night
Styx	Boat On The River
Sublime	Smoke Two Joints
Subway To Sally	Kleid Aus Rosen
Sum 41	In Too Deep
Supertramp	Breakfast In America
Supertramp	Goodbye Stranger
Supertramp	The Logical Song
Survivor	Eye Of The Tiger
Suzi Quatro & Chris Norman	Stumbling In
System Of A Down	Aerials
System Of A Down	B.Y.O.B.
System Of A Down	Chop Suey
System Of A Down	Roulette
System Of A Down	Toxicity
T.L.C.	No Scrubs
T.L.C.	Waterfalls
Take That	Back For Good
Tammy Wynette	Stand By Your Man
Tarkan	Adimi Kalbine Yaz
Tarkan	Dudu
Tasmin Archer	Sleeping Satellite
TATU	All The Things She Said
Taylor Swift	Love Story
Taylor Swift	Safe And Sound
Taylor Swift	We Are Never Ever Ever Getting Back Together
Taylor Swift	White Horse
Taylor Swift	You Belong With Me
Tears For Fears	Head Over Heels
Tenacious D	Beelzeboss
Tenacious D	Fuck Her Gently
Tenacious D	Kickapoo
Tenacious D	Master Exploder
Tenacious D	Tribute
Tenacious D	To Be The Best
Tenacious D	Wonderboy

Testament	Electric Crown
Temple Of The Dog	Hunger Strike
Temptations, The	My Girl
Three Days Grace	I Hate Everything About You
Tim Bendzko	Am Seidenen Faden
Tim Bendzko	Wenn Worte Meine Sprache Wären
Tina Turner	Nutbush City Limits
Tina Turner	What's Love Got To Do
Tito and Tarantula	After Dark
Tokens	The Lion Sleeps Tonight
Tokio Hotel	Durch Den Monsun
Tom Jones	It's Not Unusual
Tom Jones	You Can Leave Your Hat On
Tom Petty	Free Fallin'
Tom Waits	Going Out West
Tommy James N T	Crimson And Clover
Tool	Aenima
Tool	Prison Sex
Tool	Schism
Tool	Sober
Tool	The Pot
Toploader	Dancing In The Moonlight
Tori Amos	Winter
Toto	Africa
Tracy Chapman	Sorry
Traditional	Happy Birthday To You
Traditionell	La Cucaracha
Traveling Wilburys	End Of The Line
Travis	Why Does It Always Rain On Me
Trivium	In Waves
Turtles	Happy Together
TV Theme	American Dad
TV Theme	Biene Maja
TV Theme	Big Bang Theory
TV Theme	Digimon (Leb Deinen Traum)
TV Theme	Dragonball Z (Du wirst unbesiegbar sein)
TV Theme	Family Guy
TV Theme	Ghostbusters
TV Theme	Gummibärenbande
TV Theme	Kickers
TV Theme	MASH
TV Theme	Mila Superstar
TV Theme	Pinky und Brain (deu)
TV Theme	Pokémon (Ich Will Der Allerbeste Sein)
TV Theme	Prince of Bel Air
TV Theme	Spongebob
TV Theme	The Flintstones
TV Theme	Two And A Half Men
Twisted Sister	We're Not Gonna Take It
Type O Negative	Black No. 1
Type O Negative	Christian Woman
U2	Beautiful Day

U2	I Still Haven't Found What I'm Looking For
U2	Pride
U2	Sunday Bloody Sunday
U2	With Or Without You
Udo Lindenberg	Cello
Uncle Kracker	Follow Me
Uriah Heep	Easy Livin'
Usher	U Remind Me
Vanessa Carlton	A Thousand Miles
Vanessa Paradis	Joe Le Taxi
Van Halen	Jump
Van Halen	You Really Got Me
Van Morrison	Brown Eyed Girl
Vanilla Ice	Ice Ice Baby
Velvet Revolver	Fall To Pieces
Vengaboys	Boom Boom Boom Boom
Vengaboys	We Like To Party
Verve, The	Bittersweet Symphony
Village People	Macho Man
Village People	YMCA
Ville Valo & Natalia Avelon	Summer Wine
Vines	Get Free
Violent Femmes	Blister In The Sun
Volbeat	Fallen
Wallerts	Mandy Das Nazimädchen
Wallerts	Spätverkauf
Weather Girls	It's Raining Men
Weezer	Buddy Holly
Weezer	Hash Pipe
Weezer	Say It Ain't So
West Side Story	Maria
Westlife	You Raise Me Up
Wet Wet Wet	Love Is All Around
Wham	Wake Me Up Before You Go Go
Wheatus	A Little Respect
Wheatus	Teenage Dirtbag
White Stripes, The	Denial Twist
White Stripes, The	Fell In Love With A Girl
White Stripes, The	I Just Don't Know What To Do With Myself
White Stripes, The	Seven Nation Army
Whitney Houston & Mariah Carey	When You Believe
Whitney Houston	How Will I Know
Whitney Houston	I Wanna Dance With Somebody
Whitney Houston	I Will Always Love You
Whitney Houston	One Moment In Time
Whitney Houston & Mariah Carey	When You Believe
Who, The	Baba O Reiley
Who, The	Won't Get Fooled Again
Wigfield	Saturday Night
Will Smith	Men In Black
Wir Sind Helden	Denkmal

*Songs die fett gedruckt sind, sind dieses mal neu dabei!

Wir Sind Helden	Guten Tag
Wir Sind Helden	Nur Ein Wort
Within Temptation	Ice Queen
Within Temptation	Mother Earth
Wolfmother	Back Round
Wolfmother	Woman
Wombats	Let's Dance To Joy Division
Woodkid	Iron
Xavier Naidoo	Dieser Weg
Xavier Naidoo (Söhne Mannheims)	Und Wenn Ein Lied
Yellowcard	Lights And Sounds
Yellowcard	Ocean Avenue
Yes	Owner Of A Lonely Heart
Yes	Roundabout
Ylvis	Stonehenge
Ylvis	The Fox
Yolanda Be Cool & Dcup	We No Speak Americano
Yvonne Catterfeld	Für Dich
Zaz	Eblouie par la nuit
Zaz	Je veux
ZZ Top	Gimme All Your Lovin'
ZZ Top	Sharp Dressed Man

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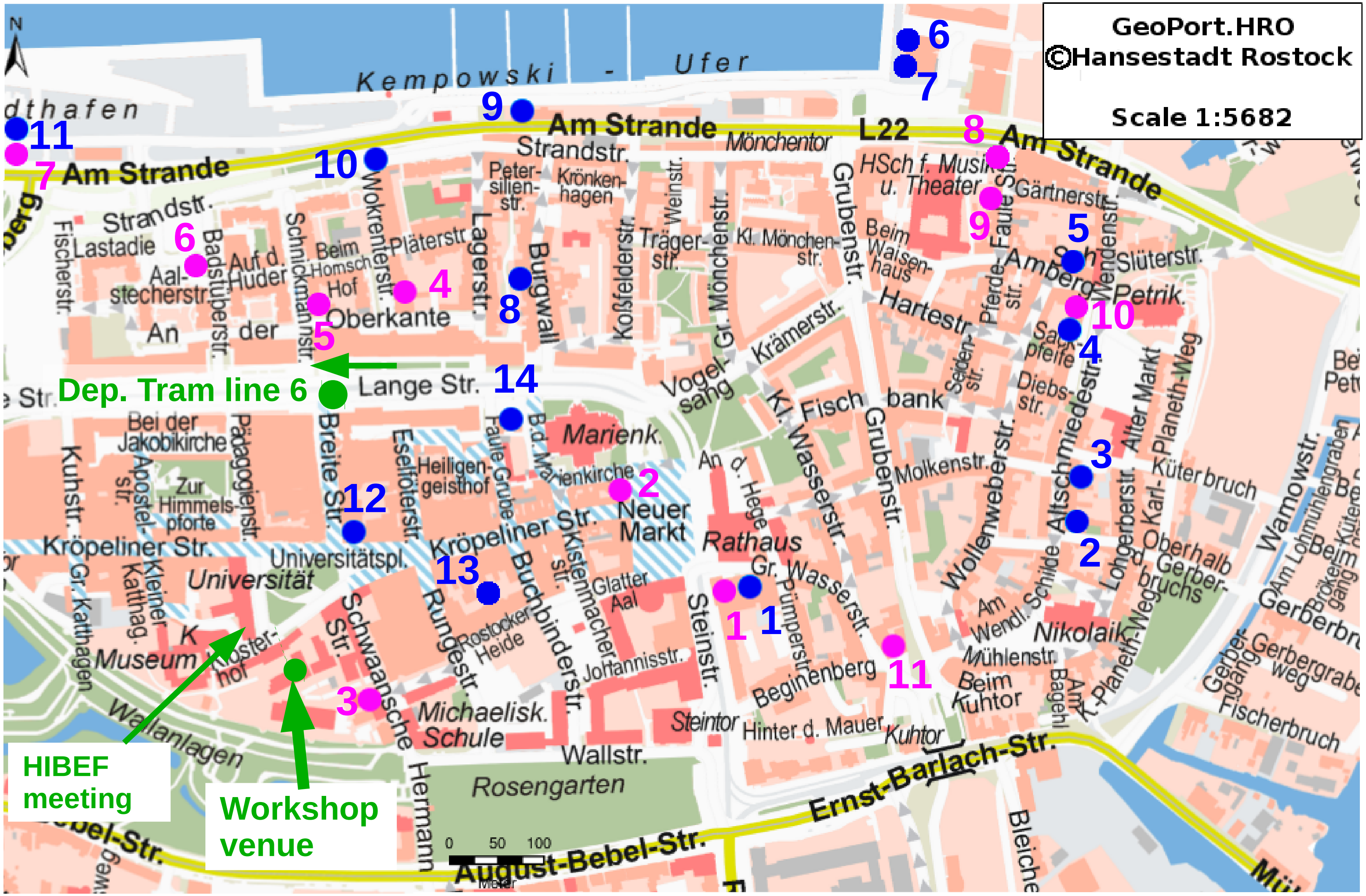

Bars & Pubs

1 Weinwirtschaft
2 ALEX
3 Heumond
4 Kölsch- und Altbierhaus
5 Zwanzig12
6 Salsarico
7 Braugasthaus „Alter Fritz“
8 Hemmingways
9 Zur Gemütlichkeit
10 Ursprung
11 Kranstöver

Restaurants:

1 Steigenberger Hotel Sonne
2 Albert & Emile
3 Altstädter Stuben
4 Ursprung
5 Amberg 13
6 Al Porto
7 Rosmarin'o
8 Kaminstube
9 Borwin
10 Zur Kogge
11 Braugasthaus „Alter Fritz“
12 Block House
13 Leon's
14 Old Western