European Summer Campus 2013 **26/08/2013 – 05/09/2013**
Strasbourg, France

Energy on all scales

Scientific Programme

Lectures (typically 2h=2x45 minutes)

Introduction

Energy, the rise of a concept (2h)

Joël Pouthas, LPC- ENSICAEN, Caen

Even if the word "energy" could be associated with the idea of vis viva (living force, i.e. kinetic energy) in mechanics, the real importance of the concept emerged with the birth of thermodynamics in the middle of the nineteenth century. However, the historical sequence of events is surprising. The industrial revolution and the steam age were largely on the way when the roots of the Second Law appeared in the "Réflexions" of Carnot. The First Law formulated as an equivalency between heat and work was formulated twenty years later by several physicists in different countries.

The main property of energy is to be conserved as stated by the first law. How can be understood a degradation of energy? It is the aim of the second law, which states that the entropy of an isolated system never decreases. Besides those phenomenological approaches and their developments in thermo chemistry and the philosophy of Energetics, a minority of physicists tried to connect the concepts of heat to the motion of atoms and molecules in gases. For Boltzmann, the increase of entropy is only a law of statistics. More generally, what means irreversibility of time? Starting in nineteenth century physics, the understanding of the concept of energy is still a challenge as underlined by Feynman in his famous Lectures on Physics.

Thematic "Energy Consumption, distribution and storage and impact on environment"

Energy challenge for the 21st century (2h)

Sandra Bouneau, IPN Orsay

The energy problem is complex and difficult to set down in a proper way. Today, 80 % of our energy consumption comes from fossil fuels (coal, gas and petrol) responsible of massive emissions of Greenhouse Gas (GHG), which represent the main contribution to the climate change. The emerging countries are in full economical expansion and the part of the population claiming rightfully the same life level than the one of actual developed countries will increase significantly. How to face the growing world energy demand when the middle of the century will probably see the decrease of petrol and gas production? What are the alternatives to replace the use of fossil fuels with "clean" and renewable energy sources to minimize the human activities impact on climate change?

The lectures will present an overview of new energy sources, production potentials and constraints. We will propose a simplified construction of an energy world in 2050, assuming constraints of society development and climate change. This study is based on simple hypotheses, which take into account the inequalities of energy consumption in

the world and propose an energy mix adapted to different types of population (rural and urban), and will help to set down the energy/climate challenge in a proper way.

Climates of the Earth (2h)
Gilles Ramstein, LSCE Gif sur Yvettes
How much Energy is available at the top of the atmosphere? How this quantity evolved during Earth History? What are the mechanisms that regulate the temperature and water cycle at the surface of the Earth to allow sustainable biology?
In the first part of the talk we will consider large time scales for climate variations, while in the second part, we will focus on Quaternary (much more documented) and future climates. In particular we shall describe the past and future evolution of ice sheets.
All these questions will be illustrated with simulations using a hierarchy of climate models.

Thematic "Energy production, technologies" *(from eV, keV and MeV to infinite kWh)*

Conventional power plants using fossil combustion (2h)
Th. Schulenberg, KIT
Coal fired steam cycle plants:
Coal fired power plants are among the cheapest producers of electric power. Steam is generated in a larger boiler house and supplied to a high, medium and low pressure turbine train driving the generator. The flue gas is cleaned from NO_x, SO_2 and dust before it is released to the stack. A lignite-fired power plant with supercritical steam conditions is taken as an example to show latest technologies.
Gas fired combined cycle power plants:
Combined cycle power plants, usually fired with natural gas, are combining gas turbines, which are driving a generator producing electric power, with a heat recovery steam generator using the hot exhaust gas of the gas turbine, such that a steam turbine train can be driven additionally without any additional fuel. One of the latest power plant designs with a net efficiency of more than 60% is taken as an example.

"Energy efficiency: a topic with multi-scale and multi-disciplinary challenges" (2h)
Jean-Sébastien Broc, Consultant and researcher, Nantes
The economic development of the XIXth and XXth centuries was fueled by cheap, easy-to-access and abundant energy resources. This model came to an end with the oil crises of the 1970's. From this time on, the energy demand has gradually stopped being considered as an input data whose growth was an external parameter to be met. Alternative approaches for energy planning have been developed so that the energy demand could be taken into account as one of the variables it is possible to act upon. Energy efficiency is one of the key concepts for these approaches.
This part summarizes main global trends about energy consumption and end-uses. The evolutions in the definitions related to energy efficiency also highlight changes in the way to manage the energy demand.
This leads to look at the different dimensions that energy efficiency can take, in terms of scale (from micro (technical process) to macro (society)) and of scientific fields (from engineering sciences to social and economic sciences).
The review of these issues is made using a historical perspective combined with an evaluation approach. They will be illustrated by examples in the building sector,

representing the priority of the current European energy efficiency policies. Present research issues for the energy efficiency field will also be pointed out.

Complex Renewable Energy Networks (2h)

Martin Greiner, Department of Engineering, Aarhus University

Todays overall macro energy system based on conventional resources will transform into a future system dominantly relying on fluctuating renewable resources. At the moment it is not really clear what will be the best transitional pathway between the current and the future energy system. In this respect it makes sense to think backwards, which means in a first step to get a good functional understanding of fully renewable energy systems and then in a second step bridge from there to todays energy system. Based on state-of-the-art high-resolution meteorological and electrical load data, simple spatio-temporal modelling, and the physics of complex networks, fundamental properties of a fully renewable pan-European power system are determined. Amongst such characteristics are the optimal mix of wind and solar power generation, the optimal combination of storage and balancing, the optimal extension of the transmission network, as well as the optimal ramp down of fossil and nuclear power generation during the transitional phase. These results indicate that the pathways into future energy systems will be driven by an optimal systemic combination of technologies, and that economy and markets have to follow technology..

Renewable energy: Nanotubes to channel osmotic Power (2h)

A. Siria, Institut Lumière Matière, Université de Lyon 1

The salinity difference between fresh water and salt water could be a source of renewable energy. However, power yields from existing techniques are not high enough to make them viable. A solution to this problem may now have been found.A team led by physicists at the Institut Lumière Matière (CNRS / Université Claude Bernard Lyon 1), in collaboration with the Institut Néel (CNRS), has discovered a new means of harnessing this energy: osmotic flow through boron nitride nanotubes generates huge electric currents, with 1,000 times the efficiency of any previous system. To achieve this result, the researchers developed a highly novel experimental device that enabled them, for the first time, to study osmotic fluid transport through a single nanotube. Their findings are published in the 28 February issue of *Nature*.

PV electricity and its grid integration and storage (6h)

G. Willeke, J. Mayer, S. Rogalla and C. Hebling, Fraunhofer ISE

Lectures at ISE during visit,

Solar electricity generated by the photovoltaic effect plays an increasingly important rôle in future renewable energy scenarios because of its practically inexhaustible source, its widespread availability and most of all its recent rapid cost reductions. For example the German state of Bavaria produces already today 10% of its electricity from this source (compared with 5% for the whole of Germany) and it may be expected that 10% of the global electricity may be produced before 2025 by this means.

A series of lectures with additional lab tours at Fraunhofer ISE in Freiburg will introduce and illustrate the basic working principles and technological issues of the photovoltaic energy conversion, transport and storage and its perspectives as well as discuss the present challenges and opportunities connected with the German 'Energiewende' (energy transition), i.e. the transition from our present fossil and nuclear energy based system to a future energy system based on renewables.

Physics of nuclear fission reactors (2h)

G. Rudolf, IPHC Strasbourg

The nuclear forces are at the origin of all energy sources. Nuclear fusion reactions produce the solar radiation; radioactive decays are mostly responsible for the geothermic heat. At the atomic level, the energy of one nuclear reaction is measured in millions of eV, while reactions driven by electromagnetic forces remain in the eV range. Nuclear reactors are therefore able to produce million times more kWh per kg of fuel than those burning fossil fuels. They produce also much smaller masses of waste, but in which the nuclear forces are still active long after the reactor is stopped.

This lecture will give a short overview of the physics governing a nuclear reactor. The main phenomena, i.e. diffusion, capture, moderation, multiplication, will be explained. Their implication in fundamental aspects like kinetics, safety, waste production, fuel resources will be presented, with an emphasis on those aspects which are the most significant for a not specialized audience.

Risk management and safety, the accidents in Chernobyl and Fukushima

Wadim Jäger, Institute for Neutron Physics and Reactor Technology (INR-KIT)

The lecture will start with the introduction to nuclear risk, regulatory framework and historical development of nuclear safety. Then the fundamental safety principles such as Defense-in-Depth and Multi-barrier concept will be explained. The safety analysis methodology applied to assess the safety status of nuclear power plants including design basis accidents and severe accidents will presented. The sequence of events and the core degradation phenomena of major severe accidents (e.g., TMI-2, Fukushima) as well as the consequences will be illustrated together with the lesson learnt from such kind of accidents.

Future scenarios for fission based reactors (2h)

S. David, IPNO-CNRS Orsay

The coming century will see the end of standard fossil fuels, coal, gas and oil, which represent today 80% of the world energy production. Moreover, their use will have induced important emission of greenhouse gas, and climate change. In this context, nuclear power could be able to respond significantly to the growing world energy demand. Some scenarios consider a nuclear energy production of around 5 Gtoe in 2050, which would represent 25% of the total energy generation.

But a large and significant nuclear energy generation requires a development of innovative systems, minimizing the natural resources consumption, the waste production, and increasing the safety and resistance to proliferation.

The talk will present the basics of the reactor physics focused on uranium consumption and breeding, as well as the different sustainable reactor technologies, based on uranium or thorium cycle, and their associated fuel cycle, considering waste transmutation or not.

Hydrometallurgical actinide separation processes for advanced nuclear fuel cycles

(Andreas Geist, INWD-KIT, 2h)

Strategies for advanced nuclear fuel cycles, recycling all transuranium elements (TRU) as nuclear fuel, are developed in many countries. These fuel cycles require separating TRU from irradiated fuels. Hydrometallurgy (a.k.a. solvent extraction) is a versatile technique for the separation of ionic solutes, thus offering possibilities for the required separation processes. This lecture gives an overview of the development of

hydrometallurgical TRU separation processes in the context of advanced nuclear fuel cycles with a focus on the achievements from past and current European research programmes.

Natural Oklo Reactors Dynamics and Inception Modelization
Evening lecture, Benoit Gall, IPHC and François Gauthier Lafaye, LHyGeS, Strasbourg
Spontaneous ignition and operating of about 15 natural nuclear reactors 2 billiards years ago in the Oklo site is still a scientific puzzle. Since its discovery in 1972, geologists, geochemists and physicists studied this exceptional phenomenon. Perfect preservation of the site during a long geological period of time, makes it the only natural analogue site for a nuclear waste deposit in a geological medium over geological times. Genesis of this site will be discussed in a first part. Thus appearance of Oxygen in our atmosphere 2300 to 2000 billions years ago induced major changes in life and geochemical cycles on earth. The Franceville bassin in Gabon kept all the signs of this major change. The natural nuclear reactors are perfect examples, but there are many others spectacular ones. We will demonstrate how this period was essential in the history of our planet and life development. Start-up of the reactors will be discussed in a second part.
Up to now only start up of the biggest reactors could be explained. We recently succeeded in solving the mystery of small reactor start up and we continue their study through the extension of a realistic numerical modelling of RZ9 reactor. This study finds its anchor points on relevant experimental parameters acting on geological conditions and neutron-transport physics such as ore homogeneity, initial reactor thickness, reflector effect and initial neutronics poison content.
After an overview of the Oklo phenomenon, the reactor inception will be discussed as well as operating and natural shut down.

Nuclear energy by fusion *(2h)*
Guenter Janeschitz , ITER Organisation, St Paul lez Durance, France
A short introduction will give some rationale why we need a new energy source, which can cover the energy needs for millions of years. The principle of fusion will be introduced emphasizing that fusion processes in the sun and on earth are utilizing the quantum mechanics tunnel effect. The low probability of fusion processes compared to elastic collisions is the reason why a hot gas (plasma) needs to be confined sufficiently at an adequate density to allow enough fusion processes per second for a positive energy output. The fusion processes in the sun and the ones possible on earth will be explained. The different ways of achieving confinement of a hot and dense plasma will be introduced focusing finally on magnetic confinement and the tokamak principle. The basics of tokamak physics will be explained culminating in the method how a reactor class machine like ITER is sized. This will mark the midway point of the lecture and questions on this part should be asked here.
The second part of the lecture will introduce the physics and technology challenges, which had to be overcome in order to be able to realize a reactor class machine like ITER. Several of the key technologies will be described showing that fusion needs a wide range of technologies and competences. Towards the end the path to a Demonstration power plant (DEMO) will be introduced and the additional technical challenges presented. Finally the possible time schedule until energy will be delivered into the grid will be discussed and what potential acceleration could be achieved.

Extension towards other fields
"Energy from the femto to cosmological scales"

Dark energy and cosmology (2h)
Dominique Aubert, Observatoire Astronomique Strasbourg
The dynamics and the geometry of the Universe is driven by its energy content. This energy is sequentially dominated by different types of physics, so the Universe evolves through different eras where radiation, matter and most intriguely dark energy determine its properties. Dark energy can be understood as a cosmological constant and is in particular responsible for the accelerated expansion of the Universe detected today. Combined with the issue of dark matter, dark energy represents one of the greatest challenges of today's physics.
During this lecture, we will discuss the observational facts that support the energetic history of the Universe and how our current theories can explain its origin and evolution.

The high-energy frontier in particle physics, focus on the LHC results (2h)
Eric Chabert, IPHC
Particle Physics is also often referred as "High energy physics" and gives by definition a leading role to the concept of energy.
A review of the energy scales involved in particle physics both on the theoretical and experimental sides will serve as an introduction of the course.
Energy is required both to probe the structure of the matter and to recreate unstable and massive particles that have been produced during the first instants of the Universe.
Those general concepts will be illustrated in the context of the Large Hadron Collider, which is the actual main project in the field. The production and detection of the Higgs boson will be used as an example.

Bio-molecular reactions (2h)
Mounir Maaloum ICS
Protein structures, stability and dynamics in living cells, manipulation of single molecules

Laboratory visits

- **Fraunhofer Institute for Solar Energy Systems ISE, Freiburg**
  Program: Monday 02.09.2013,
  Fraunhofer ISE, Heidenhofstr. 2, D-79110 Freiburg, room A-108
  9-10 G. Willeke, Welcome, Basics of photovoltaic solar energy generation
  10-11 S. Rogalla, Basics of inverter technology and grid integration
  11-12 J. Mayer, Impact of PV and wind energy generation on the German electricity market
  12-12:45 lunch break (A-108)
  12:45-13 S. Rogalla, Visit Megawatt laboratory
  13-14 G. Willeke, Status of PV technology development and perspectives
  14-16 C. Hebling, Hydrogen technology and storage
  16-17 Guided tour of Fraunhofer ISE (C. Schmitz) including hydrogen fuel station

- **Nuclear Power Plant Fessenheim**, 29 and 30 August 9-12h00
- **Geothermal power plant in Soultz**, **Alsace**, 5 September 9h-11h00
- **Bioliq Pilot project and Energy Center at the KIT, Eggenstein-Leopoldshafen, Germany**, 3 September 9h-13h00

Student working groups

Several groups in parallel, short reports will be delivered by each group at the end of the school:

- **Nuclear power reactor simulation** (A. Bacquias, G. Rudolf, IPHC)
  Nowadays computer codes based on random numbers can calculate the physics of a nuclear reactor. These numbers are used to follow the fate of the neutrons on a microscopic scale, but are nevertheless able to calculate all aspects of the behaviour of existing nuclear reactors, to predict those of future ones and even to compare different scenarios of possible new generations of reactors.
  This training course is meant as an introduction to these methods. It shows how the basic interactions of neutrons with matter can be modelled, and how some of the most important characteristics of a reactor can be obtained.
- **Identifying radionuclides in the environment** (I. Rossini, IPHC)
  This workshop gives an experimental training on radiation measurements. Firstly a NaI(Tl) scintillator will be used for gamma ray detection. After an energy calibration, spectra with artificial sources can be performed allowing the experimental observation of photoelectric and Compton effects for instance. The gamma attenuation of different matters (aluminium, copper and lead) can be compared. Secondly a GeHP detector will be studied. The performances (energy resolution, efficiency) of both detectors will be discussed. A spectrum of a natural soil sample will be analysed revealing the presence of natural radionuclides.
- **Radio-chemistry** (A. Ouadi, IPHC)
- **Determination of spectral energy distributions of astronomical objects** (S. Derrière, Observatoire Astronomique de Strasbourg)
  Astrophysics covers a wide range of physical phenomena taking place at many different scales. The detailed study of astronomical objects requires measurements of photons from the lowest (radio) to the highest (X-rays, gamma-rays) energies. These measurements can be spectral or photometric data, and they are distributed in various archives.
  We will see how various observational measurements (images at various wavelengths, spectra, photometric measurements) can be retrieved from astronomical archives, and combined together in order to build the spectral energy distribution of different astronomical objects (galactic or extra-galactic). The underlying emission mechanisms (as well as photon propagation and absorption) will also be studied.
- **Silicon based solar cells: from Materials to devices.** (A. Slaoui et al., I-cube)
  An overview on the photovoltaic materials and technologies will be first presented, with an emphasis on silicon based solar cells and modules.
  As for the practical phase, the formation of a N+p junction will be carried out , and some solar cells will be tested.
- **Organic based solar cells**. (Th. Heiser et al., I-cube)

Principles of organic solar cells (OPV) and the related technologies will be presented in a seminar format. Polymer and small molecules based cells will be mentioned.
Some OPV devices will be fabricated (only some steps) and some of them will be tested under illumination conditions.

Round table discussion on "Different Energy Policies; examples France, Germany and Japan"
Speakers already confirmed:
Maria Faury, Ministère de l'Enseignement Supérieur et de la Recherche
David Boiley, GANIL
Hubert Flocard, « sauvons le climat »
Johannes Mayer, Fraunhofer Institute for Solar Energy Systems ISE, Freiburg

…

Poster session of students
Students present either their research work (if applicable) or a personal contribution to the subject of the school

Visit of European Parliament

European Energy Policy – from 2007… to 2050… (Evening talk after the visit to the parliament + discussion, 1h30)

Marc Deffrennes, European Commission, Directorate General for Energy
The presentation will give an overall overview of the European Energy Policy, which really started to be constructed in 2007, with the setting of the 3x20 targets for 2020 and the launch of the Strategic Energy Technology Plan (Innovation in the energy field). Since then a number of studies and initiatives have been performed and taken at EU level trying to strike a good balance between the 3 drivers of a sound Energy policy: environment protection, security of supply and competitiveness. In 2010, the EU 2020 defined the 5 main priorities for the Energy Policy and financial means were proposed by the Commission in its proposal for the budget under the next Multilateral Financial Framework (2014-2020) today under intense negotiation between the EU Institutions (Council, Parliament, Commission. In 2012, the Commission wanted to provide a vision of what could be a low carbon energy mix in 2050, assuming a grand objective of reducing the overall GHG emissions by a factor 5 compared to 1990. This lead to the EU Energy Roadmap 2050, where different scenarios were analysed and compared, leading to some non regret options, for which immediate actions could be proposed. A specific look at the EU Energy Roadmap will be made for nuclear energy, a controversial issue at EU level. Finally the presentation will end with a state of play of the on-going works at EU level, with the preparation of the Energy 2030 perspectives and the initiatives to be proposed for the end of 2013. The presentation will be the occasion to raise and discuss a certain number of questions of principles – open for the debate: priority between sustainability and competitiveness, liberalised versus regulated market, global energy

system approach and need to be transparent on real costs of energy, nuclear: for or against, innovation reality or dreams,…

Validation of the Summer Campus 2013

Since 2010 we include a validation in the programme of the Summer Campus to help students to obtain ECTS points at their university from their participation at the Summer Campus. The validation is also part of the integration of the Summer Campus into the UdS Master teaching programme. For 2013 the contribution to the Poster session is acknowledged on the certificate of participation and we plan to use the student's participation in the working groups as an indicator to validate the Summer Campus.

20/08/13 4:45 pm

Preliminary calendar of the two weeks, dates may change!!

Day	Morning 8h30-10h15	Morning 10h45-12h30	Afternoon 14h00-15h45	Afternoon 16h15-18h00	Evening 18h30
26/08/2013 Monday	Registration		Opening *Energy the rise of a concept* J. Pouthas	Poster session	Reception UFR physique
27/08/2013 Tuesday	*Energy challenge* S. Bouneau	*Nuclear fission reactors* G. Rudolf	*Actinide separation processes* A. Geist	Presentation of Working groups	Reception Hôtel de ville, boat ride
28/08/2013 Wednesday	Visit Fessenheim Group 1 9h00-12h00 Working groups Group 2		*Risk management and safety* W. Jäger	*Future scenarios for fission based reactors* S. David	Round table discussion
29/08/2013 Thursday	Visit Fessenheim Group 2 9h00-12h00 Working groups Group 1		*The high-energy frontier, the LHC* E. Chabert	*Bio-molecular reactions* M. Maaloum	
30/08/2013 Friday	*Nuclear fusion* G. Janeschitz	*Conventional power plants* Th. Schulenberg	Caisse 14h30 *Climates of the Earth* J. Ramstein	free	
31/08/2013 Saturday	*Dark energy* D. Aubert	*Complex Networks* M. Greiner	Reserve	free	
01/09/2013 Sunday	9h00 departure	Walk Vosges From Kaysersberg to Ribeauvillé			Soirée Tartes flambées
02/09/2013 Monday	Visit Freiburg of ISE , Germany plus lectures 9h00- 17h00 *Solar energy and Photovoltaic*				Resto ?
03/09/2013 Tuesday	*Visite Bioliq and Energy Center* 9h00 – 13h00 Eggenstein-Leopoldshafen, Germany		15h30 Visit of European parliament 15h00-18h00		19h30 ? European Energy Policy M. Deffrennes
04/09/2013 Wednesday	*Energy efficiency* J.S. Broc	*Nanotubes to channel osmotic Power* A. Siria	Working groups 14h00-18h00		Evening lecture B. Gall F.G. Lafaye
05/09/2013 Thursday	Visit of Geothermal test plant in Soultz sous Forets, France 9h00-11h00		Reports from Working groups	fin	

Lectures: 15 slots de 2 hours, 2 evening lectures
Working groups will be in parallel
Visits of Laboratories/Institutions