

METAMATERIALS

“WHY LIGHT BENDS THE WRONG WAY” AND “WHY THINGS DON’T FALL DOWN”



Lectures at the European Summer Campus

Strasbourg, June 27 – July 5, 2010

UFR Physique et Ingénierie, Amphithéâtre Fresnel

Strasbourg, France **June 27 - July 5, 2010**

European Summer Campus

Metamaterials

“WHY LIGHT BENDS THE WRONG WAY”
“WHY THINGS DON’T FALL DOWN”



Negative refraction
“why light bends the wrong way”
Aloyse Degiron, Orsay

Photon sieve
Cyriaque Genet, Strasbourg

Photonic crystals and photonic metamaterials
Kurt Busch and Martin Wegener, Karlsruhe

Structural metamaterials
“why things don’t fall down”
Yves Brechet, Grenoble

Soft metamaterials
Sergei Obukhov, Gainesville

Cytoskeleton and motion of living cells
Ben Fabry, Erlangen

Elasticity of textile fabrics and yarns
Dominique Dupuis, Mulhouse

Auxetic metamaterials
Joseph N. Grima, Malta

Evening Lecture
Sir John Pendry, London

For Students in Physics having completed
3 years of university studies

Secretariat:
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Programme and Abstracts

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Institut Charles Sadron
Strasbourg



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Sunday, 27th June

Registration: 14:00 - 18:00

UFR des Sciences Physiques

3, rue de l'Université



UFR Physique et Ingénierie

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Monday June 28th

9:30 – 10:15	Opening Session in the presence of: Anne Klebes-Pelissier, Vice-President for International Relations of the Université de Strasbourg (UdS) Thomas Ebbesen, Director ISIS, Professor UdS	<i>Chair:</i> U. Goerlach
10:15 – 10:45	<i>Coffee</i>	
10:45 – 12:30	Negative refraction: “Why light bends the wrong way” Aloyse Degiron IEF, Orsay	
	<i>Lunch</i>	
14:30 – 16:00	Presentation of participants Poster session	<i>Chair:</i> U. Goerlach
	<i>Coffee, poster session</i>	
17:00 - 17:45	Tutorial Nicolas Rivier IPCMS, UdS	
18:00	Welcome Reception <i>at the UFR de Sciences Physiques</i>	



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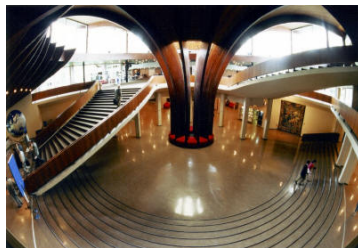
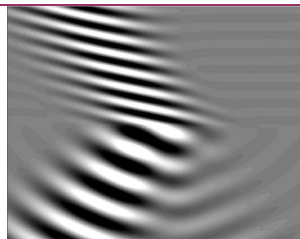


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Tuesday June 29th

8:30 – 9:10	Modulated materials for photonic physics Zbigniew Kuznicki, Patrick Meyrueis, Bernard Kress , LSP, UdS	Chair: N. Rivier
9:15 – 10:15	Auxetic metamaterials (materials with a negative Poisson's ratio) Joseph N. Grima University of Malta	
	<i>Coffee</i>	
10:45 - 12:30	Soft metamaterials Sergei Obukhov , University of Florida, Gainesville	
	<i>Lunch</i>	
14:30 15:00	Departure from UFR Physique et Ingénierie Visit to the Council of Europe:   For this visit explicit registration by name is required in order to obey to the strict security regulations of the Council of Europe! You have to bring your passport or identity card!! The visit will start at 15:00 sharp at the main Entrance of the Council of Europe, which is an about 20-25 min walk from the Institute. Bus lines 6, 30, 72 leaving from Brant/Université; get off the bus at station “Palais de l’Europe”	
17:00	Coffee	
17:30	Evening lecture together with the French Physical Society (SFP)  Negative Refraction Sir John Pendry , Imperial College, London	

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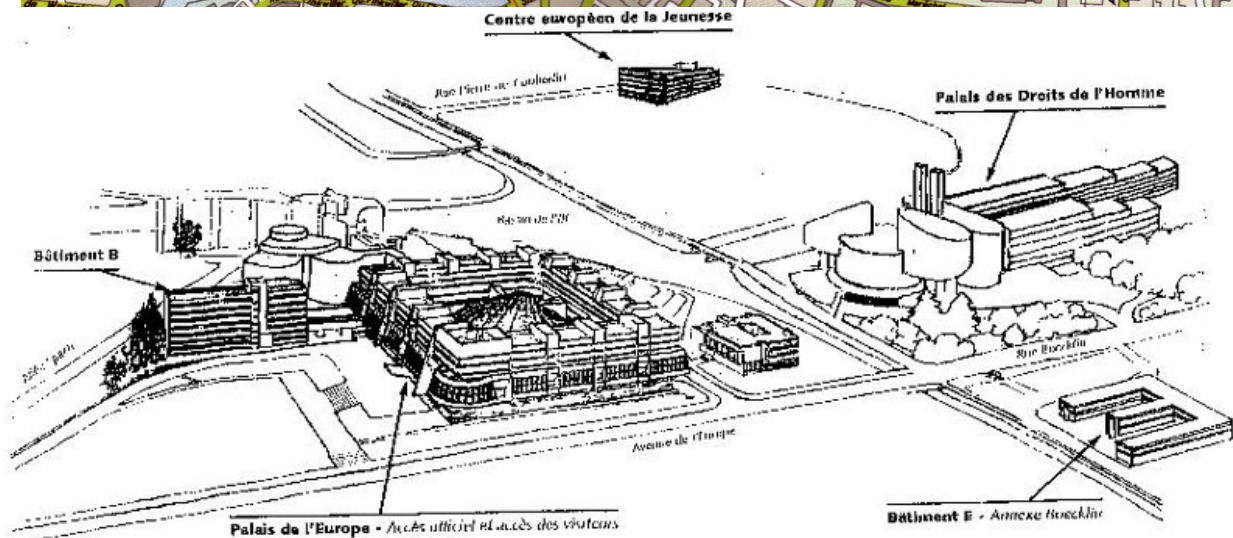
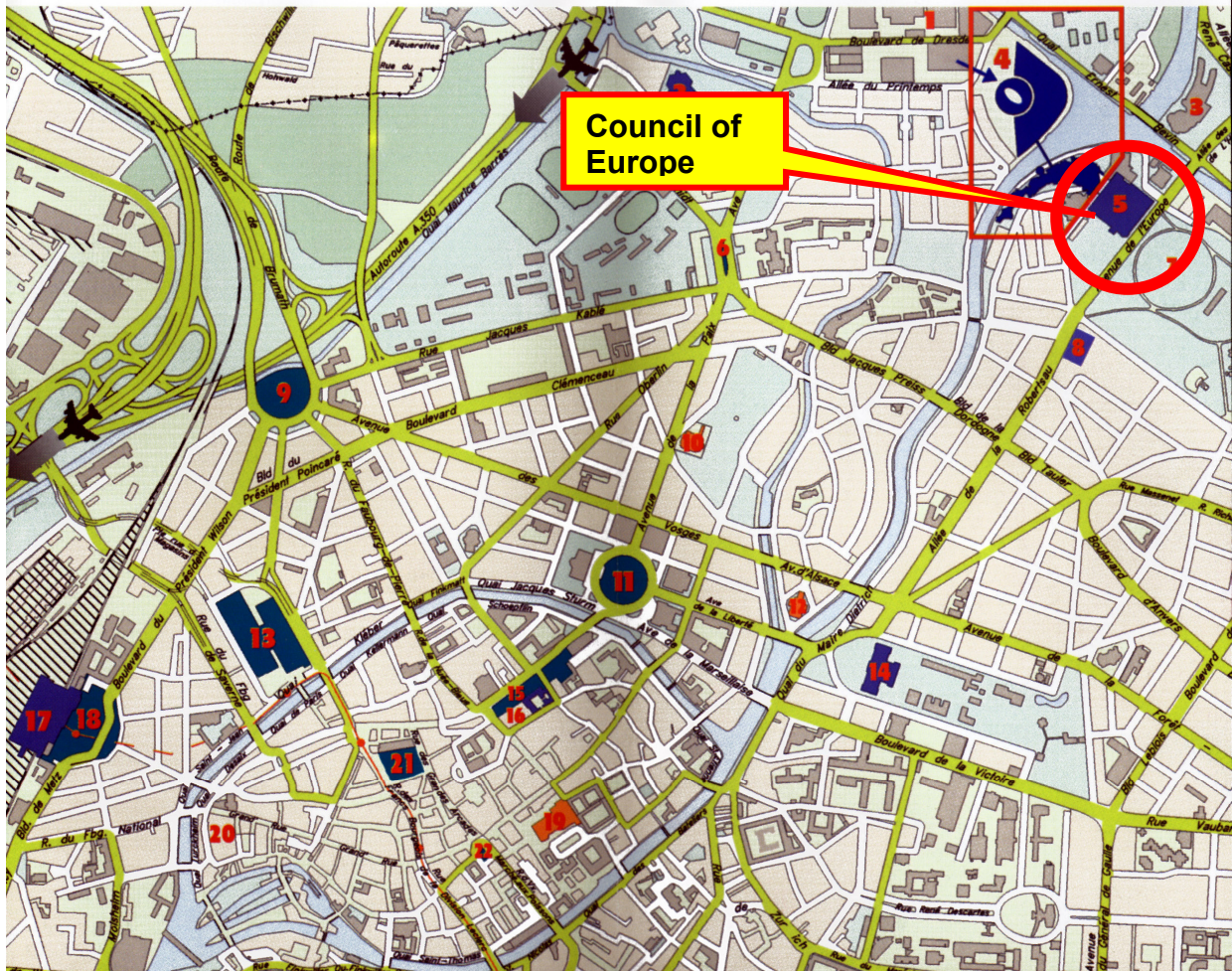


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Map of Strasbourg



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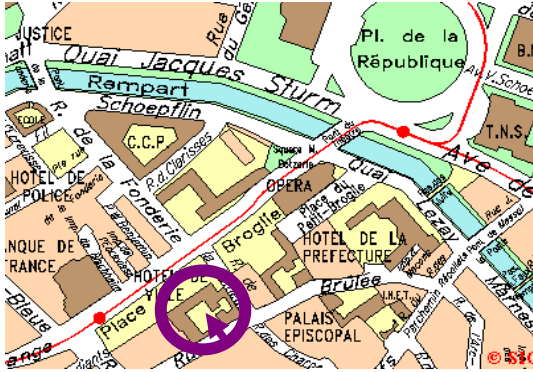
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Wednesday June 30th

Day at Karlsruhe Institute of Technology (KIT)

Institute of Applied Physics, Wolfgang-Gaede-Straße 1, 76131 Karlsruhe

7:45	Departure in front of the UFR Physique et Ingénierie 3 rue de l'Université	
9:00 - 10:45	Photonic crystals: experiment Martin Wegener Inst. for Applied Physics, KIT, Karlsruhe	
	<i>Coffee</i>	
11:15 - 13:00	Photonic crystals: Theory Kurt Busch Inst. for Theoretical Solid State Physics, KIT, Karlsruhe	
	<i>Lunch</i>	
14:30 - 16:30	Visit of the Institute for Applied Physics	
Around 16h30	Return to Strasbourg	
18:30	Reception Hôtel de Ville Strasbourg Place Broglie a good 10 minutes walk from the Institute	
21:00	Boat ride by night 21:00 Departure at Palais Rohan Place du Marché Aux Poissons (We have to be there 15 min. before)	

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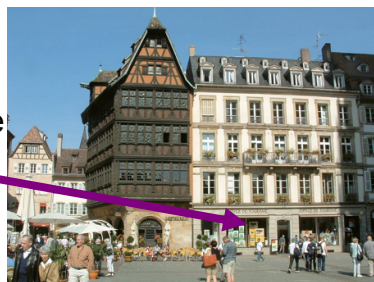


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Thursday July 1st

8:30 - 10:15	Structural metamaterials I Yves Bréchet SIMAP, INP, Grenoble	Chair:
	Coffee	
10:45 - 12:00	Structural metamaterials II Yves Bréchet SIMAP, INP, Grenoble	
12:00 - 12:30	The astronomical clock of the Cathedral in Strasbourg Pierre Juillot IPHC-CNRS, Strasbourg	
	Lunch	
14:00 - 15:55	Reimbursement of travel expenses at the University Caisse de l'Agence Comptable Le Bel 1st floor, 4 rue Blaise Pascal A-N: 14:00-15:00 N-Z: 15:00-15:55	
16:15 -17:30	Guided tour of the cathedral and old town Office de Tourisme, 17 Place de la Cathédrale	
19:30 – 21h00	Round Table discussion (?) on Metamaterials - What is the smallest size of an object which can still be classified as a metamaterial? Metamolecule? Small protein as a metamaterial ? - How many atoms will form a critical cluster for nucleation? - Invisibility: is it science-fiction or can it become reality? - Any similarities between electromagnetic and structural metamaterials?	

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Friday July 2nd

8:30 - 10:15	Elasticity of textile fabrics and yarns Dominique Dupuis, Artan Sinoimeri, Jean-Yves Dréan, Marie-Ange Bueno, Corinne Jung, ENSISA-UHA, Mulhouse	Chair: N. Rivier
	Coffee	
10:45 - 12:30	Cytoskeleton and motion of living cells Ben Fabry, Center for Med. Phys. and Technology, Friedrich-Alexander-University, Erlangen-Nürnberg	Chair: C. Genet
	Pick up Sandwiches and drinks	
13:00	Excursion to the Vosges <u>13:00</u> Departure by bus from University, : 3-5 rue de l'Université  14:00 Arrival at the Château Kintzheim pique-nique 14:30 Volerie des Aigles - Château Kintzheim  Demonstration of flying eagles and other large birds 16:00-19:00 Either Walk through the Vosges Or Sight seeing in Kintzheim or village nearby	
19:30 – 23:00	Evening with “Tartes flambées” Restaurant Auberge Saint-Martin 80 Rue de la Liberté 67600 KINTZHEIM 03.88.82.04.78	
23h00	Return to Strasbourg	

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Saturday July 3rd

9:00 - 10:15	Tutorial II Open questions and problems (please contact N. Rivier) Nicolas Rivier IPCMS, UdS, Strasbourg	Chair: U. Goerlach
	<i>Coffee</i>	
10:45 - 12:30	Photon Sieve Cyriaque Genet ISIS, UdS, Strasbourg	
12:30	End of lectures of European Summer Campus Conclusions and Discussion FIN	
	<i>Lunch (sandwiches)</i>	
14:00	Free afternoon	

Sunday July 4th

<i>Free</i>

Monday July 5th

9:00 – 10:30	Test(optional) for the Validation of the Summer Campus (Questions given to us by the lecturers to be solved on paper)	U. Goerlach
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ABSTRACTS OF LECTURES

1) Negative refraction (“Why light bends the wrong way”)

A composite material with resonances of the electric and magnetic fields in the same frequency range has a negative refractive index. It bends the light the wrong way, and constitutes a perfect lens that is flat with a resolution beyond the diffraction limit.

Course: *Aloyse Degiron, IEF, Orsay*

2) Photon sieve

Light incident on a metallic plate transpierced with a lattice of nano-sized holes is reemitted on the other side with extraordinary efficiency. The plate is much more “transparent” than the total geometric cross section of the holes. It is the lattice of holes that makes the material super transparent.

Course: *Cyriaque Genet, ISIS, Strasbourg*

3) Photonic crystals and photonic metamaterials

Both photonic crystals and metamaterials can be viewed as artificial materials with tailored optical properties. In addition to negative refractive indices, photonic metamaterials also allow for giant chiral effects, enhanced nonlinear optics, and for shaping optical space via transformation optics. Photonic crystals enable photonic band gaps and a tailored “electromagnetic vacuum”. Theory (Kurt Busch) and experiment (Martin Wegener) will be covered. The visit to Karlsruhe also includes laboratory visits.

Course: *Kurt Busch and Martin Wegener, KIT Karlsruhe; Visit of laboratory: M. Wegener*

4) Structural metamaterials (“Why things don’t fall down”)

The manifold of available materials is not only an asset, it is also a challenge. This has led in recent years to the development of systematic material selection methods providing guidelines to select, for a given set of requirements, the best possible solutions. The first part of the course will deal with this manifold and with the material selection methods and software.

In spite of this huge manifold, the requirements are often contradictory, and for some of these contradictions there is no “single material solution”. This has led to the development of hybrid materials, or “metamaterials” where material associations, geometry and topology provide new strategies to “expand the material world”. The second part of the course will deal with these new developments in material science.

Course: *Yves Bréchet, SIMAP, Grenoble-INP, Grenoble*

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5) Soft metamaterials

Examples of soft metamaterials: Entropic elasticity, polymer melts, Casimir effect in vacuum and in polymers.

Course: Sergei Obukhov, Gainesville, University of Florida

6) Cytoskeleton and motion of living cells

Stress-strain and rheology of living cells through the nonlinear elasticity of a network of semi flexible, sliding filaments

Course: Ben Fabry, CMPT, University of Erlangen

7) Elasticity of textile fabrics and yarns

Why our clothes are made of textile materials? Answer to this interesting question needs to understand the specific structure of these materials. Indeed, fibres are assembled together to form yarns which are interlaced to give fabrics. Their mechanical properties strongly depend on the structure at different scale levels. And, while it is easy to define Young's modulus and Poisson ratio for homogeneous materials, these quantities are somewhat questionable in the textile area. Specialists of spinning (A. Sinoimeri), weaving (J. Y. Dréan) and knitting (M. A. Bueno) will explore these problems in order to explain the 3D body clothing (C. Jung). Small experiments will be proposed.

Artan Sinoimeri, Jean-Yves Dréan, Marie-Ange Bueno, Corinne Jung, Coordinator: Dominique Dupuis, ENSISA-UHA, Mulhouse

8) Auxetic Metamaterials (Materials with a negative Poisson's ratio)

A few materials and structures get fatter when stretched (i.e. exhibit a negative Poisson's ratio). Despite being rare, it is a desirable property since such materials offer an increased resistance to indentation, enhanced vibration absorption properties and an ability to curve like a dome under stress (instead of a saddle). We will present examples (natural and artificial), models and the mechanisms responsible for auxetic behaviour.

Course: Joseph N. Grima, University of Malta

9) Modulated material for photonics physics

Presentation of research at the Photonics Systems Laboratory (LSP):

Patrick Meyrueis, Zbigniew T. Kuznicki, Bernard Kress

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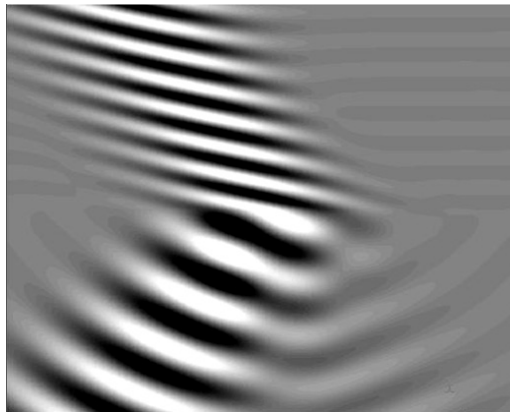
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Evening Lecture in common with the French Physical Society (SFP)

Negative Refraction

Sir John Pendry, Imperial College, London



Light bends the wrong way in materials where both ϵ and μ are negative as was pointed out in 1968, but the absence of natural materials with this property led to neglect of the subject until 1999 when it was shown how to make artificial materials, metamaterials, with negative μ .

The rapid advance of the subject since that date, both in theory and experiment, is reflected in the exponential growth of publications at the 200-per-year level in 2004 and still growing. The interest is explained by the sudden availability of a qualitatively different class of electromagnetic materials combined with the startling properties which these materials appear to have; all of which provokes debate as each new facet of their behaviour is revealed. Experiment has been vital to resolution of controversy and has chiefly been in the microwave region of the spectrum though there is potential in the optical region currently being explored by several groups.