Deliverable 15: Report on awareness and wider societal implications on metamaterials

Optics in particular and electromagnetic radiation in general pervades every aspect of our lives. We only have to think of mobile phones, optical fibers for telecoms, MRI, optical microscopy, GPS, satellite communications, laser surgery, THz imaging for security, keyhole surgery enabled by endoscopes: the list is endless. Yet whenever an application comes to be realized we have to ask what materials will be used to manufacture the device and therein lays a problem. Electromagnetic theory allows a wide range of material properties and indeed requires many of these properties to achieve some of the more exotic applications. However nature has not been so generous and many useful properties are missing from the list of naturally available materials.

So it is that metamaterials have come to be such an important and well-studied field. The concept is very simple: a material's properties can be changed not only by altering the chemistry of its constituents but also by altering its microscopy structure, structure on a scale much less than the wavelength. A good example with which we are familiar is silver. As a flat highly polished surface silver makes an excellent mirror. On the other hand very finely divided silver nanoparticles that are to be found in a black and white photographic negative absorb light and are black in appearance. This powerful concept can generate astonishing material properties such as negative refraction and chirality far more strong than found in any naturally occurring material. The concept is relatively simple to apply for RF applications because the wavelength is relatively large and the sub wavelength structures of the metamaterial are of easily manufactured dimensions. Greater challenges appear when pushing the concept into the THz, IR and visible regions of the spectrum where, arguable the greater societal rewards are to be found. In this respect the Karlsruhe partner is perfecting the technology for optical metamaterials where the length scales of the structures are on the nanoscale. At the same time the FORTH partner using computational techniques has been probing other limits to visible frequency metamaterials. Even metamaterials have to be manufactured from naturally occurring substances and ultimately their properties will limit what can be achieved with metamaterials. In particular the responsiveness of electrons at higher frequencies becomes sluggish leading to absorption of incident radiation. Conquering these limitations with clever designs was required to extend the applicability of metamaterials.

Not only do scientists find the new concepts stimulating, but also they have such a simple but powerful idea behind them that a popular audience can easily grasp their significance. Several of the team has spent much time giving popular lectures to general audiences, including outreaching to schoolchildren. Over the course of the project of the order of 100 lectures will have been delivered by members of the team provoking interest in and appreciated of not just our particular area of research but of the social significance of science in general.

An exciting field such as metamaterials often leads to strong debate. This is of course the stuff of scientific progress: identifying challenges and debating the way forward until an agreed solution is found. These debates often attract the attention of the press both for the scientific issues themselves, of course, but also for the interplay of personalities. This exposure to the general public of scientists as people who sometimes collaborate, sometimes disagree, sometimes quarrel, adds a human dimension to the public perception of science that is all to often missing from the reporting of science. Members of the PHOME team have been prominent in the many debates that have taken place and been reported. For example the work of the Karlsruhe group was reported in The New York Times: “Strides in Materials, but No Invisibility Cloak”, November 9th, 2010 and in The International Herald Tribune: “Dreaming Up Uses for a Giant Invisibility Machine”, November 29th, 2010. The work of the FORTH group was reported in many Greek newspapers, like Kathimerini, Eleftherotypia, Enthos and Patris.

In another recent instance, Pendry, Imperial College, delivered a series of lectures in Sydney Australia to the Harry Messel School. Exceptionally bright school children from all over the world are invited to Sydney to participate in 2 weeks of science. During their stay they are presented with a book containing write ups of the lectures that they hear, an enduring memento of their experiences.
The book of lectures for the 36^{th} Professor Harry Messel International School 2011, “Light and Matter”, is available from their web site at:
http://www.physics.usyd.edu.au/foundation.old/index_iss.html