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New Pathways in Material Science

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I am very happy to adopt the role of Editor-in-Chief and I am excited that our journal has a broad remit and covers many disciplines. We are, therefore, not only capable of strengthening interest in many areas but also embracing research activities that will reveal new pathways and revolutionize the way in which we adopt our scientific outcomes. In this context, it is interesting that, even in this modern age, some areas in physical science, are sometimes questioned about their actual real value in practical terms. Such disbelief goes back a long way back to 1850 when Sir William Gladstone, who was then responsible for the UK finances, and who later became Prime Minister, asked Faraday what was the real value of studying electricity. Faraday replied to him by saying that there is every possibility that one day he would be able to tax it. Today, we should not have our curiosity diminished by too much, initial, emphasis on the details of practical applications because they will, inevitably, become apparent. In the context of all of this, it is the global area of metamaterials, to be described, briefly, below, that drives my research, interests. It is a beautiful broad field that has emerged in the last two decades, and it is always offering new pathways in many areas of physical science. Metamaterials uses the word "meta" because it is like metamorphosis that denotes a change of condition translated with the Greek word meaning "after". It has breathed life into modern research and many benefits will flow from our strong interest in which we recognize, unreservedly, that the whole world is indebted to the pioneers John Pendry and Victor Veselago and Rodger Walser who introduced the word metamaterial. We should expect our journal to set up a strong lead in this area.

In a very potent way, metamaterials ignited the world at the beginning of the last decade, and the flame was fanned by the idea of embracing negative refractive index materials, some aspects of which will be outlined below. The ignition point occurred at a much earlier time than the last decade, however, through the seminal negative index work of Victor Veselago. To this has been added the ground-breaking work of John Pendry that magnificently stoked the fires of both curiosity- and application-driven search for negative refractive index media at the turn of the new millennium. The

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world truly became enthused by the pivotal experimental observation of this type of refraction. The inspiration of the world of metamaterials is, indeed, founded on the introduction of negative refractive index. Everybody is aware, at a very elementary level, that a refractive index is the square root of the product of the electric permittivity and magnetic permeability. Mathematically, a square root has a plus and minus sign so anyone can ask why should we always take the positive sign? The challenge to take the negative sign was put forward by Veselago and this idea was met by disbelief because no natural materials behaved like this. It took until the last two decades to believe that we could make artificial materials with these properties, using wires and split-rings. In the present day, the family of artificial materials, called metamaterials, is growing nicely. Veselago reminds us of Heaviside, because he was openly criticized for using his operator analysis before the mathematical world got around to showing that it was patently all right to do so. It is recorded that Heaviside simply retorted 'Why should I refuse a good dinner simply because I do not understand the digestive processes involved?'. The metamaterials area is quite often exactly like having a good dinner, in the Heaviside sense, because there are still things that need to be sorted out and understood. Eventually they will be, and the world of science will stand in debted, for ever, to Pendry and Veselago.

Electromagnetic wave propagation in metamaterials is such an important area that it is not surprising that it is a vital feature of a global revolution in science. Like many new ideas in science, the suggestion that dramatic artificial materials could be created that could cloak objects and lead to perfect lenses was already known before it was launched properly in 1999. As asserted earlier, metamaterial is a fascinating name for an artificial material that exhibits properties deriving from its composition, as opposed to its fundamental intrinsic physical property. This means, in the visible light domain, for example, that the size of the intrinsic components of metamaterials must be well below the excitation wavelength of operation. Hence, this implies the need to build nanostructures for the optical domain. The metamaterial family is growing, nicely, and the hyperbolic members are popular because they have uniaxial symmetry and an isofrequency surface that is a hyperboloid. Physically, they are relatively easy to construct in layered form, with the optic axis pointing along z, for example. This means that they could have a permittivity tensor that is diagonal, with positive x and y components and a negative z component. However, there is much versatility for this type of construction.

It will impact upon the delightful discussions of what have become known as rogue waves. Basically, these can be created by a special input condition for the nonlinear Schrodinger equation, consisting of a constant background being disturbed by small periodic perturbations. This kind of input can be a Peregrine soliton, named after Howell Peregrine, who, back in 1983, at the University of Bristol, looked brilliantly at these waves and found that they appear to come out of nowhere and then disappear quite suddenly again. In hydrodynamics this has been known for some time with waves leaping suddenly out of what seems to be a calm sea. They have attracted the name 'rogue waves' because they do appear from, apparently, nowhere, rise up to a dangerous height, potentially do damage to shipping, and then disappear from sight, without a trace.

Quite apart from rogue waves, metamaterials have applications in the design of antennae, which use metamaterial coating, absorbers, super-lenses, and sensors in agriculture and medicine. Recently, it is stated that metamaterials can be made to switch between hard and soft states so they could be used in the motor industry to minimize the effect of car crashes.

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