PhD studentship at the EPSRC DTG Center for Complex Systems and Processes – outline proposal

Title: *Electromagnetic compatibility in complex environments – predicting the propagation of electromagnetic waves using wave-chaos theory*

Project description:

Electromagnetic systems and devices are often complicated, irregular in their geometry and heterogeneous in their electrical characteristics. Such a system could be a PC, a mobile phone, or even an airplane cockpit. The prediction of the energy distribution becomes hard when using traditional analytical and numerical tools, especially if the wavelength is small compared to the size of the structure. Statistical methods are often more appropriate to describing the physical process under investigation in such cases. Appropriately chosen, such methods can lead to surprisingly simple and physically understandable characterization of the problem, which can be used to exploit complexity and then turn collective behaviors into beneficial engineering technology. This field is often referred to as Electromagnetic Compatibility (EMC). Another example of electromagnetic complexity is in the characterization of complex or random media immersed in complex fields, which can be tackled conveniently through the use of statistical electromagnetics.

This PhD project is closely linked to an ongoing EPSRC project aimed at developing the mathematical framework in which to study the propagation of field-field correlation functions in closed environments. Using a phase-space representation, the Wigner distribution function (WDF), the wave mechanics of complex sources of radiation can be unveiled using tools of dynamical systems. An exact evolution operator for the transport of these Wigner functions can be derived, and approximation schemes are obtained by using ray families that include reflections from arbitrary, irregular, or chaotic electromagnetic environments. The project will explore the possibility of linking the WDF operator to existing semiclassical approximations of quantum mechanics, used to transport densities of quantum particles. The challenge lies in constructing a phase space picture of those operators through the WDF before including the source operator. The project will also consider experimental measurement techniques for providing the necessary input and verification data.

The PhD student will liaise with experts in computational and experimental electromagnetics to continuously guide and validate theoretical procedures. In particular, theoretical algorithms will be tested through engineering problems that are of practical interest and reproducible in laboratory.

Participating Departments and Supervisors:

The proposal is a joint bid from the School of Mathematical Sciences and the George Green Institute for EM Research at the University of Nottingham. Supervision of the student will be shared between:

Stephen C. Creagh (Associate Professor, School of Mathematical Sciences)
Gregor Tanner (Associate Professor, School of Mathematical Sciences)
David Thomas (Full Professor, George Green Institute for EM Research)
Gabriele Gradoni (Research Fellow, School of Mathematical Sciences)

Christopher Smartt (Research Fellow, George Green Institute for EM Research)

Strategic Importance:
The studentship will further strengthen the existing ties between the School of Mathematical Sciences and the George Green Institute for EM Research which has been thriving since establishing a joint EPSRC project on *Characterising electromagnetic fields of integrated electronic systems in enclosures - a ray-wave approach* (EP/K019694/1) in Sept 2013. The research is fundamental in nature, bridging the gap between Dynamical System and Chaos theory as well as Wave Chaos/ Asymptotic wave theories and the field of Statistical Electromagnetics, both from a theoretical and experimental perspective. It has far reaching implications for EM-field simulation and characterization in an applied setting, creating impact in the electronics industries from the perspective of safety standards (EMC) as well as from a wireless communication and material science perspective.