DEPARTMENT OF MATHEMATICS

MATHEMATICS COLLOQUIUM

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The Topology of Circuit-Field Coupling

Imagine an electromagnetic wave impinging on a small electric device. The wave is governed by Maxwell's equations and propagates in a "field domain", whereas the device occupies a "circuit domain" and is described by a circuit model with well-defined ports located on the common interface. I am going to discuss how to incorporate ports into (finite-element discretized) variational formulations of Maxwell's equations. It turns out that two types of ports have to be distinguished, electric and magnetic. Each of them is linked to two port quantities, one "potential" and one "current". A key insight concerns the close relationship of the port quantities with generating fundamental cycles of the relative cohomology of the common interface minus the port areas. These cycles become instrumental for linking the circuit to Maxwell field models also in the context of finite-element discretization. Therefore I am going to elaborate the construction of fundamental cycles on triangulated surfaces by means of spanning-tree techniques. Another key insight is that in case of non-trivial topology of circuit domain ports alone are not sufficient to connect fields and circuits. "Linked fluxes" associated with handles of circuit domain also have to be taken into account and this entails knowledge about the topological properties of the circuit beyond the scope of customary descriptions. For demonstration I am going to give a striking numerical example. (Joint work with J. Ostrowski)

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Via Zoom (contact hirani@illinois.edu for Zoom link)