Title: Controllability methods: solving time-harmonic problems iteratively using time-domain solvers

Abstract: In this talk I will describe controllability methods using the example of time-harmonic Maxwell's equations. Standard "frequency domain" approaches directly characterize the numerical approximation of the time-harmonic problem as the solution to a (usually large and ill-conditioned) linear system using orthogonality conditions of Galerkin type. In contrast, controllability methods seek a time-periodic approximate solution, which eventually leads to a linear system with very different properties. This linear system is actually never explicitly assembled. Instead, the multiplication vector of degrees of freedom by the matrix amounts to simulating the time-dependent wave equation during one period with given initial conditions. The goals of the talk are threefold. First, I will explain how controllability methods work, what are the key properties of the obtained linear system, and how it can be solved iteratively by the Jacobi, conjugate gradient, or GMRES iterations.

Second, I will show how the time-harmonic solution can be recovered from the time-periodic solution obtained by the controllability method through an inexpensive post-processing. I will also explain how "almost" periodic solutions lead to "almost" harmonic solutions. Finally, I will present a set of numerical examples highlighting how the method performs in practice.