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Detecting multiple timescales and computing high-order phase reductions

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In this talk, I will present a new mathematical method for computing slow manifolds in geometric singular perturbation problems. Our method, which is reminiscent of the so-called computational singular perturbation method, works by computing expansions of embeddings of slow manifolds, together with the dynamics on them in a local coordinate chart. In this way, one can approximate slow manifolds to arbitrarily high precision, which makes our method particularly suitable for the study of systems with multiple (i.e., three or more) timescales. I will show for example how it helps to uncover surprising hidden timescales in nonstandard slow-fast systems. Applications to reaction network problems will also be presented.

In addition, I will discuss an extension of the method that allows us to compute high-order phase reductions of coupled oscillator networks. This extension is then applied to predict remote synchronization and multi-stability in a network of delay-coupled Stuart-Landau oscillators.

This is joint work with Chris Bick, Sören von der Gracht, Ian Lizarraga, Eddie Nijholt, Martin Wechselberger and Babette de Wolff.