Multilevel Parareal Methods and Standard Form Transformations for Weakly Nonlinear Problems

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The Parareal algorithm is a well-established parallel-in-time method, promising for multiscale oscillatory problems. In this talk, I present a multilevel extension of the two-level Parareal method with exponential transformation and averaging. The two-level versions were introduced by Peddle, Haut, and Wingate [SIAM J. Sci. Comput., 2019] and Haut and Wingate [SIAM J. Sci. Comput., 2014], whereas the multilevel approach was first established in Rosemeier, Haut, and Wingate [SIAM J. Sci. Comput., 2024]. This multilevel approach generalizes the method to arbitrarily many levels, each with its own averaging window. This flexibility makes the method particularly promising for weakly nonlinear problems with fast oscillations, where multiple interacting scales must be resolved efficiently.

Additionally, I will outline ongoing work on a new transformation into standard forms, which is related to WKB methods. This transformation can possibly be used to construct new coarse propagators by leveraging structural properties of highly oscillatory problems. While this aspect is still under development, I will discuss preliminary insights.