Abstract: Approximate message passing (AMP) emerges as an effective iterative algorithm for solving high-dimensional statistical problems. However, prior AMP theory, which focused mostly on high-dimensional asymptotics, fell short of predicting the AMP dynamics when the number of iterations surpasses $o(\log n / \log \log n)$ (with $n$ the problem dimension). To address this inadequacy, this talk introduces a non-asymptotic framework towards understanding AMP. Built upon a new decomposition of AMP updates in conjunction with well-controlled residual terms, we lay out an analysis recipe to characterize the finite-sample convergence of AMP up to $O(n / \text{polylog}(n))$ iterations. We will discuss concrete consequences of the proposed analysis recipe in the $\mathbb{Z}_2$ synchronization problem; more specifically, we predict the behavior of randomly initialized AMP for up to $O(n / \text{poly}(\log n))$ iterations, showing that the algorithm succeeds without the need of a careful spectral initialization and also a subsequent refinement stage (as conjectured recently by Celentano et al.)

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