Stochastic p-Laplace equations with nonlinear convection: Well-posedness through time-discretization

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We consider nonlinear evolution equations of p-Laplace type with a nonlinear, first-order convection term and stochastic forcing on a bounded domain $D \subset \mathbb{R}^d$. The external force term is given by a stochastic integral in the sense of Itô.
Due to the nonlinear convection term, the classical theory for monotone SPDEs does not apply. Therefore approximate solutions are obtained by a semi-implicit time discretization. Since weak convergence is not compatible with the nonlinearities in the equation, we use the theorems of Prokhorov and Skorokhod to establish existence of martingale solutions. Then, pathwise uniqueness and existence of stochastically strong solutions follow from an L^1-contraction principle.

Keywords: stochastic p-Laplace equation, strongly continuous perturbation, martingale solutions