Probabilistic well-posedness for a stochastic fluid-structure interaction problem

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As a first step in understanding stochastic fluid-structure interaction (SFSI) involving incompressible viscous fluids, we consider the flow of a viscous, incompressible fluid in a 2D channel, driven by the inlet and outlet pressure data, interacting with a 1D stretched stochastically forced membrane located at the top lateral channel wall. The fluid flow is modeled by the 2D time-dependent Stokes equations, and the membrane elastodynamics by the 1D wave equation stochastically forced by the time-dependent white noise. The fluid and structure are linearly coupled. The motivation for this study was derived from the fact that most real-life problems have a stochastic component and understanding their well-posedness is important. In this talk we will present the main steps in a constructive proof of existence of a unique weak solution in the probabilistically strong sense. The proof is based on a time-discretization via an operator splitting approach, which gives rise to a sequence of approximate solutions, which are random variables. To show almost sure convergence of a subsequence of the random approximate solutions to a weak solution in the probabilistically strong sense, energy estimates in terms of expectation of energy norms are obtained and used as a backbone for a weak compactness argument giving rise to a weakly convergent subsequence of probability measures associated with approximate solutions. To obtain almost sure convergence, probabilistic techniques based on the Skorohod representation theorem, and the Gyongy-Krylov lemma are employed. This result shows that the deterministic benchmark FSI problem is robust to stochastic noise, even in the presence of the rough white noise in time.