Recent advances in path sampling: accurate reaction coordinates, likelihood maximization, and diffusive barrier crossing dynamics

Professor Baron Peters
Department of Chemical Engineering, University of California, Santa Barbara

Because transition states are too rare and transient to observe in experiments, simulations are among the best sources of molecular-level insight on transition states and reaction mechanisms. A first step in many rare event simulations is to identify a reaction coordinate. For reactions that break and make strong bonds, the reaction coordinate is the unstable eigenmode at a saddle on the potential energy surface. However, processes like nucleation and protein folding may disrupt and reorganize thousands of interactions, so identifying a reaction coordinate is a major challenge. An accurate reaction coordinate should result in a free energy profile that is consistent with the projected dynamics. Ten years ago, this intuitive requirement led to committor analysis, a trial-and-error procedure for testing putative reaction coordinates. Since then, our ability to identify accurate reaction coordinates has dramatically improved. First, new versions of committor analysis are quantitative and more efficient. Second, likelihood maximization can systematically and efficiently identify accurate reaction coordinates from thousands of candidates using only the shooting point data from a path sampling simulation. Finally, the new Aimless Shooting version of transition path sampling retains a high sampling efficiency even for systems with highly diffusive barrier crossing dynamics.