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Sign problem and the Worldvolume Hybrid Monte Carlo method

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The numerical sign problem is one of the major obstacles to first-principles calculations in a variety of important systems. Typical examples include finite-density QCD, some condensed matter systems such as strongly correlated electron systems and frustrated spin systems, and real-time dynamics of quantum fields. Until very recently, individual methods were developed for each target system, but over the past decade there has been a movement to find a versatile solution to the sign problem. In this talk, starting with the basics of Markov chain Monte Carlo methods, I first explain the essence of the sign problem and outline some of the approaches proposed in line with the movement. I then focus on methods based on the Lefschitz thimble, and argue that the "Worldvolume Hybrid Monte Carlo method" [Fukuma and Matsumoto, arXiv:2012.08468] is a promising method due to its reliability and versatility. If I have time, I also briefly discuss recent topics related to thimbles, such as resurgence and quantum cosmology.

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