

Rational functions yield better approximations than polynomials in HEP applications

Scientific Achievement

Numerical approach for computing multi-variate rational approximations (RAs) with and without poles based on linear algebra and semi-infinite programming (SIP).

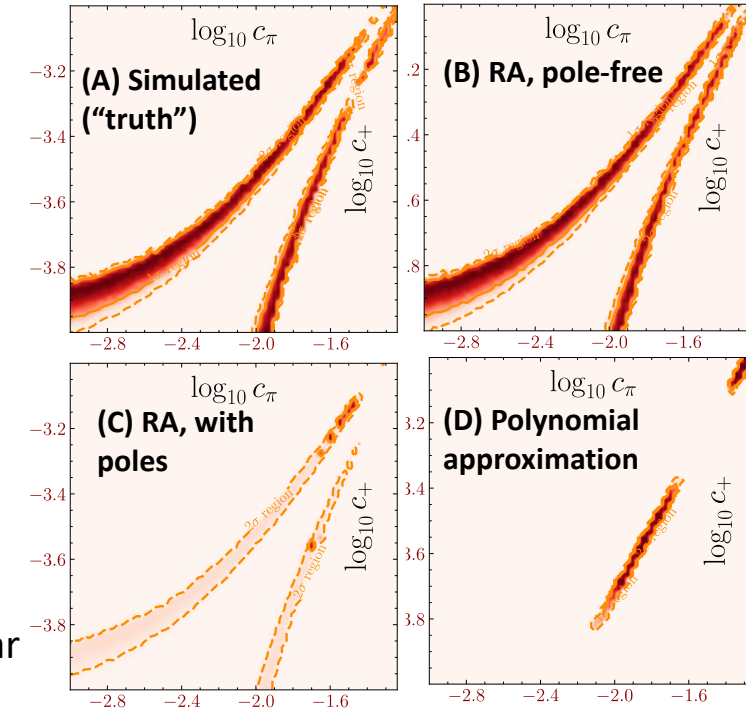
Significance and Impact

RAs are more flexible and accurate than polynomials. RAs are particularly useful for approximating expensive-to-compute HEP simulations, which enables us to gain further physics insights.

First algorithm for pole-free multivariate rational approximations.

Research Details

- Physics simulations are commonly used to understand observed phenomena, but simulations are computationally expensive, which makes direct optimization of the simulation's parameters difficult
- We use rational functions (polynomial divided polynomial) to approximate the simulated data
- Two methods for computing RAs: Stieltjes process (may lead to RAs with poles, *Fig. C*); SIP (iterative removal of poles, *Fig. B* at 1/50 the CPU cost)
- SIP yields significantly better approximations of the true data (*Fig. A*) than RAs based on Stieltjes process (*Fig. C*) and polynomial (*Fig. D*); shown is data of direct detection of dark matter
- Fermilab preprint **FERMILAB-PUB-19-330-CD** to be published in SIAM



Techniques for approximation that are used widely do not work well at all when there are poles