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A fast and robust physics-informed machine learning force field for peptide simulations

Machine learning force fields (MLFFs) have emerged in the past two decades aiming to combat the cost-accuracy trade-off of molecular simulations. Despite growing success, many MLFFs are still not able to reliably simulate flexible organic molecules at elevated temperatures. Addressing these challenges, DL_FFLUX [1] is a mature MLFF that maps atomic energies and multipole moments to geometries. By using the rigorous framework of quantum chemical topology [2] to define atoms and calculate their properties by partitioning the electron density, our method is physics-informed and future-proof. To ensure the robustness of our models, the training data is generated using well-tempered metadynamics [3] and sampled to contain the most diverse structures. Our Gaussian process regression (GPR) models are trained using the in-house software FEREBUS [4]. We demonstrate the performance of our models here on a short peptide of 42 atoms, Ac-Ala3-NHMe (TALA), exhibiting numerous local minima. Our GPR models of TALA demonstrate exceptional robustness in gas phase molecular dynamics simulations at temperatures as high as 1000 K, despite being trained only on 1000 geometries. The excellent extrapolation capability of the models is confirmed by their ability to relax unrealistic internal coordinates through the prediction of restoring forces. Achieving these results on a challenging molecule with high computational efficiency makes FFLUX a strong contender in the list of MLFFs.

[1] B.C. Symons, M.K. Bane, and P.L.A. Popelier, Journal of Chemical Theory and Computation, 2021, 17(11), 7043-5 7055.

[2] P. L. A. Popelier, Challenges and Advances in Computational Chemistry and Physics dedicated to 'Applications of Topological Methods in Molecular Chemistry', edited by R. Chauvin et al., Switzerland: Springer, 2016, 23-52.

[3] A. Barducci, G. Bussi, and M. Parrinello, Physical Review Letters, 2008, 100, 20603.

[4] M.J. Burn, P.L.A Popelier, Digital Discovery, 2023, 2, 152-164.

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