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On the separability of microscopic optical model potentials and emerging bell-shape Perey–Buck nonlocality

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After nearly sixty years since its introduction, the phenomenological bell-shape Perey–Buck spatial nonlocality in the optical model potential for nucleon–nucleus scattering has remained unaccounted for from a microscopic standpoint. In this article we provide a quantitative account for such nonlocality considering fully nonlocal optical potentials
in momentum space. The framework is based on a momentum-space in-medium folding model, where infinite nuclear matter g matrices in Brueckner–Hartree–Fock approximation are folded to the target one-body mixed density. The study is based on chiral next-to-next-to-next-to-leading order (N3LO) as well as Argonne nucleon–nucleon bare interaction models. Applications focus on Ca(p, p) scattering at beam energies in the range 11–200 MeV, resulting in the identification of a separable structure of the momentum-space optical potential of a form we coin as JvH, with a nonlocality form factor as one of its terms. The resulting nonlocaliy form factor features a bell-shape with nonlocality range between 0.86 and 0.89 fm, for both proton and neutron beams at energies below 65 MeV. An analytic toy model is introduced to elucidate the underlying mechanism for the nonlocality in the optical model, providing an estimate of its range based on the Fermi motion of the target nucleons and the long-range part of the NN interaction.

Author: BLANCHON, G. (CEA)

Co-author: ARELLANO, H.F.

Presenter: BLANCHON, G. (CEA)

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