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Quantitative analysis of tensor effects in the relativistic Hartree-Fock theory*

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Tensor force is one of the important components of the nucleon-nucleon interaction. With the advance of radioactive-ion-beam facilities around the world, much progress has been made in the study of the structure of exotic nuclei, and the critical role of the tensor force in the shell evolution of the exotic nuclei has been of great interest in the new century.
The nuclear density functional theory (DFT) is the only approach that can cover almost the whole nuclear chart. In the framework of non-relativistic DFT, the tensor force is isolated from other components and its effects can be identified clearly. However, in the case of relativistic DFT, it is naturally contained through the Fock terms and mixed together with other components. Thus, a quantitative analysis of tensor effects in the relativistic DFT, i.e., relativistic Hartree-Fock (RHF) theory and fair and direct comparison with the results from non-relativistic DFT has been missing for long.
In this work, we have identified the tensor force up to the $1/M^2$ order in each meson-nucleon coupling in the RHF theory, by the non-relativistic reduction for the relativistic two-body interactions. With the present formalism, for the first time, we achieved a fair comparison between the tensor effects in relativistic and non-relativistic DFT. Through the investigation of the isotopes and isotones $Z, N = 8, 20$, and 28, we found that the total tensor effects in the RHF effective interaction PKA1 is weaker than those in the Skyrme SLy5wT and Gogny GT2 effective interactions. This work is supposed to promote the developments of the relativistic DFT.

*Zhiheng Wang, Qiang Zhao, Haozhao Liang, Wen Hui Long, arXiv:1806.11270

Primary author: Mr WANG, Zhiheng (Lanzhou University and University of Tsukuba)

Co-authors: Dr LIANG, Haozhao (RIKEN); Mr ZHAO, Qiang; Prof. LONG, Wenhui (Lanzhou University)

Presenter: Mr WANG, Zhiheng (Lanzhou University and University of Tsukuba)

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