Information entropies calculation for the $1s^2$-state of helium-like ions

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August 7, 2020

Abstract

This work presents analytical and numerical results for the position- and momentum-space information entropies, of the $1s^2$-state of helium-like ions, using different interaction potentials. The potentials that we used are the Yukawa potential (YP), and the exponential-cosine-screened Coulomb potential (ECSCP). The investigated studies allow us to relate the position-space information with the momentum-space information of Shannon and Fisher, as well as Shannon entropy power, and the Fisher-Shannon information product, through different famous relations. The calculation is done using the one-electron charge density of entangled two-parameter wave function. On one hand, the results that are presented for ten members in the helium isoelectronic sequence demonstrate with precision the effect of correlation on bare charge distributions. On the other hand, it leads to some very important results for both the correlated and uncorrelated values of the informatic entropies. Analytical formula for the momentum-space information entropies are given. The effect of the nuclear charge and the screening parameter on the information expressions has been studied for both potentials. Detailed computational and numerical values and characteristics of these information quantities, as a function of the screening parameter, are reported here for the first time. New inequality has been proposed with Fisher's total value to measure the correlation of two electrons.

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