Several Current Issues in Quantum Mechanics

Tamaz Kereselidze

During the last year, our theoretical group has authored three articles [1-3]. Two have been published [1,2], while the third is under peer review in an international journal. These works explore several current issues in quantum mechanics.

In 1929, Morse and Stueckelberg addressed the two-Coulomb center problem [4], proposing that the number of nodes in wavefunctions remains unchanged as the distance between Coulomb centers varies. Morse intended to prove this principle in the subsequent paper but focused on introducing the famous Morse potential instead. Despite the lack of rigorous proof, the assumption of node conservation of wavefunctions became widely used in studies of diatomic molecules.

We have revisited this problem and, using quantum mechanical principles, have demonstrated that the number of nodes in one-electron diatomic molecules remains unchanged as the Coulomb centers move apart [1].

Our other two articles [2,3] investigate hydrogen atom formation during the early Universe's recombination stage. Between 2019 and 2022, we proposed and analyzed a non-standard quasimolecular mechanism of recombination [5-7]. In this process, an electron interacts with two nearest neighboring protons, forming an excited hydrogen molecular ion H_2^+, which either cascades to lower energy states or dissociates into a hydrogen atom and a proton.

A 2023 study by Flower argued that the three-body recombination rate is 12 orders of magnitude lower than that of two-body recombination, suggesting that the quasimolecular mechanism has a negligible impact on hydrogen formation [8]. However, Flower's analysis does not account for the fact that recombination occurs in an excited state. Our research shows that incorporating this factor increases the three-body recombination rate by seven orders of magnitude [3], indicating that the nonstandard quasimolecular mechanism plays a significant role in hydrogen atom formation and must therefore be considered in relevant studies.

References:

1. T. Kereselidze, I. Noselidze, Eur. Phys. J. D (2024) 78:134
2. T. Kereselidze, I. Noselidze, Z. Machavariani, Eur. Phys. J. D (2024) 78:59
3. T. Kereselidze, I. Noselidze, Eur. Phys. J. D (2024) (submited)
4. P. M. Morse, E.C.G. Stueckelberg, Phys. Rev. (1929) 33, 932
5. T. Kereselidze, I. Noselidze, J. F. Ogilvie, MNRAS (2019) 488, 2093–2098
6. T. Kereselidze, I. Noselidze, J. F. Ogilvie, MNRAS (2021) 501, 1160–1167
7. T. Kereselidze, I. Noselidze, J. F. Ogilvie, MNRAS (2022) 509, 1755-1763
8. D. R. Flower, MNRAS (2023) 523, L1-L3