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Experiments on Collisions of Electrons or Protons with Hydrogen Atoms or Molecules Shed Light on the Possible Nature of Dark Matter

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Analysis of atomic experiments related to the distribution of the linear momentum in the ground state of hydrogen atoms revealed a huge discrepancy: the ratio of the experimental and previous theoretical results was up to tens of thousands. This motivated a theoretical study resulting in the following discovery: for the states of zero angular momentum (S-states), the so-called "singular"solution of the Dirac equation outside the atomic proton, which was usually disregarded, can be matched without any problem with the regular solution inside the proton with the allowance for the experimental fact that the charge density inside protons has the maximum at r = 0. This solution eliminated the above huge discrepancy between the theoretical and experimental results (J. Phys. B: At. Mol. Opt. Phys. 34 (2001) 2235). Hydrogen atoms having only the S-states were called the Second Flavor of Hydrogen Atoms (SFHA) –by analogy with the flavors of quarks (Atoms 8 (2020) 33).

The 2nd experimental evidence of the existence of the SFHA was found by analyzing experiments on charge exchange of hydrogen atoms with incoming protons (Foundations 1 (2021) 265).

The 3rd experimental proof of the existence of the SFHA was obtained by analyzing experiments on the excitation of n=2 states of atomic hydrogen by the electron impact (Foundations 2 (2022) 541).

The 4th experimental proof of the existence of the SFHA was obtained by analyzing experiments on the excitation of the lowest triplet states of molecular hydrogen by the electron impact (Foundations 2 (2022) 697).

The primary property of the SFHA is that, since they have only the S-states, then according to the selection rules they cannot emit or absorb the electromagnetic radiation: they remain dark (except for the 21 cm spectral line). This and other properties of the SFHA led to important cosmological consequences.

First, there was a puzzling observation of the redshifted 21 cm spectral line from the early Universe where it was found that the absorption in this spectral line was about two times stronger than predicted by the standard cosmology (Nature 555 (2018) 67). The qualitative and quantitative explanation of this puzzle by using the SFHA made the latter the candidate for dark matter or a part of it (Research in Astron. and Astrophys. 20 (2020) 109).

Second, there were perplexing observations that the distribution of dark matter in the Universe is smoother than predicted by Einstein's gravitation (Monthly Not. Roy. Astron. Soc. 505 (2021) 4626). However, it turned out that this puzzle can be also explained qualitatively and quantitatively by using the SFHA (Research in Astron. and Astrophys. 21 (2021) 241). This reinforced the status of the SFHA as the candidate for dark matter or a part of it.

The theoretical discovery of the SFHA was based on the standard Dirac equation of quantum mechanics without any change of physical laws.

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