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Dark Hydrogen Atoms as Baryonic Dark Matter

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From the most detailed map of the cosmic microwave background at the end of the recombination epoch, the Plank Collaboration deduced the existence of the baryonic dark matter (DM) in the ratio 1:5 to the non-baryonic DM. So, the baryonic DM does exist. The explanation of a puzzling observation by Bowman et al (2018) 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 and thus the primordial hydrogen gas was significantly cooler than predicted by the standard cosmology, required as the cooling agent, a baryonic DM with the mass of the order of baryon masses (Barcana, 2018; McGaugh, 2018). Initially, this narrowed candidates for baryonic DM to just dibaryons (hexaquarks). However, there was a strong criticism in the literature of the dibaryon hypothesis; plus, they were not discovered experimentally. Then in paper (Oks, 2020) there was given both qualitative and quantitative explanation of the puzzling observation by Bowman et al (2018) based on the DM in the form of the second flavor of hydrogen atoms (SFHA), corresponding to the 2nd solution of the Dirac equation for hydrogen atoms. In distinction to dibaryons and to even more exotic hypothetical particles never discovered experimentally, the existence of the SFHA is evidenced by four different types of atomic experiments, which I will briefly describe. (More details can be found, e.g., in my reviews on DM published in New Astronomy Reviews in 2021 and in 2023.) 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). One of important applications of the SFHA is to solving the neutron lifetime puzzle and to its cosmological consequences. The discrepancy between the measured lifetime of trapped ultracold neutrons τtrap = (877.75 ± 0.28stat + 0.22/-0.16syst) s and the measured lifetime of neutrons in the beam experiments (τbeam = 888.0 ± 2.0 s) remained unresolved for many years (the difference was well beyond the experimental error margins). There are two channels of neutron decay: in the primary channel the outcome is a proton and an electron as free particles plus an antineutrino (three-body decay), while in the secondary channel the outcome is a hydrogen atom plus an antineutrino (two-body decay). In 1990 an idea was brought up that the two-body decay of neutrons, producing hydrogen atoms rather than protons, affects the measured lifetime of neutrons in the beam experiment because in these experiments only the resulting protons are counted. However, the Branching Ratio (BR) for this process, known at that time, was 4x10-6
, thus lacking over 3 orders of magnitude for the quantitative
explanation of the neutron lifetime puzzle. In our paper of 2024, it was demonstrated that in the two-body decay of neutrons the resulting hydrogen atoms with the overwhelming probability are the SFHA. As a result, the corresponding BR increased to ˜ 1% in the excellent agreement with the "experimental"BR of ˜ 1% necessary for resolving the puzzle. We also showed that the two-body decay of neutrons has profound cosmological implications. Namely, it is the mechanism by which neutron stars, in three different situations, are slowly but continuously producing baryonic DM in the form of the SFHA. There is an indirect astrophysical evidence of this process. It is important to emphasize that the discovery of the SFHA was based on the standard Dirac equation of quantum mechanics without going beyond the Standard Model and without any change of physical laws –in distinction to the overwhelming majority of hypotheses on DM.

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