About the possibility of proton ferromagnetism in DA white dwarfs

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The research is done according to the suggestion of V.G. Baryshevsky and V.V. Tikhomirov. Considering the energy of free protons, nuclear, Coulomb exchange and correlation energies, we find expressions for Stoner criterion [1] and energy density at finite degrees of proton spin polarization $p_{0p} = (n_p \uparrow - n_p \downarrow)/(n_p \uparrow + n_p \downarrow)$ in degenerate (D) and non-degenerate (ND) metallic hydrogen (i.e. proton-electron plasma). Here $n_p \uparrow, n_p \downarrow$ are proton densities with spins up and down. We consider densities at which ferromagnetism of electrons is impossible.

Table 1 - Possibilities for ferromagnetism at different conditions in hydrogen

System	Ferromagnetism is possible at	Correlation energy
D	$n_p \leq 3.9 \cdot 10^{31}$ cm^{-3}	decreases the region of ferromagnetism
ND	$n_p \leq 6.8 \cdot 10^{30}$ cm^{-3}, $T \leq 2.1 \cdot 10^8$ K	

The results can be one of the explanations of the origin of magnetic field B of white dwarfs (WD). It is shown that $B \sim 10^4$ Gs is possible in liquid metallic hydrogen envelopes, and the question of magnetic field amplification in inner layers with crystal hydrogen is also important (though we don't consider Anderson localization for electrons). We consider 2 types of DA (i.e. with hydrogen) WD. I. A Single WD. II. A cool WD got into a close binary system causing accretion of hydrogen from a massive companion star. Let's introduce the notations: A) $\alpha = T_i/T_o$, where T_i, T_o are the temperatures T of inner and outer layers, respectively; B) $\zeta = \gamma_p \mu_N B (kT)^{-1}$, where $\gamma_p = 2.7928$, μ_N is nuclear magneton, k is Boltzmann constant.

Table 2 - Magnetic fields of DA white dwarfs

WD	α	explanation	ζ	can B be amplified in inner layers
I	> 1	it is natural for an isolated star	< 1	no, it remains $\sim 10^4$ Gs
II	< 1	outer layers are hotter due to accretion	> 1	yes, and it can reach $\sim 10^9$ Gs

[1] L.S. Levitov, A.V. Shitov.*Green Functions* [in Russian]: Moscow, Fizmatlit (2003).