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Spin selective recombination as the source of hyperfine exitation of hydrogen atoms

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Hydrogen is the active participant of physics and chemical processes in space as well as on the Earth. Recombination of hydrogen atoms is the electron spin selective process producing diamagnetic molecules H_2 . Spin selectivity of recombination is determined by the Pauli's principle and the angular momentum conservation law.

If hydrogen atoms are initially in the ground singlet state $|S_H\rangle = 2^{-1/2}|\alpha_e\beta_n - \beta_e\alpha_n\rangle$ (α_e,β_e - electron spin states, α_n,β_n- nuclear spin states) then molecules H_2 have been proved to be created in *para* -H_2 state only. If atomic pairs (H + H) are in triplet electron states, they can't recombine and produce separated atom H. These atoms H are shown to be in the statistical mixture of the ground singlet and exited triplet hyperfine states and can be described by the spin density matrix only

$$\rho = \frac{9}{16}|S\rangle\langle S| + \frac{1}{16}\{|T_+\rangle\langle T_+| + |T_0\rangle\langle T_0| + |T_-\rangle\langle T_-|\},$$

here $\rho_H = Tr_2\rho^T$ (Tr_2 - the trace over variables of the second atom). The probability of excitation is determined by the probabilities P_T of triplet hyperfine states; all P_T = 1/16 if the magnetic field is absent. The other hydrogen atoms leave the contact state being in the ground singlet state.

Magnetic field makes the hydrogen ground state the mixture of the singlet $|S\rangle$ and the triplet $|T_{\pm 0}\rangle$ sates. The admixture of the triplet state decreases the probabilities of recombination W_r and excitation W_{ex} : $W_r = 4^{-1}a^2/\left(a^2 + (\omega_n + \omega_e)^2\right)$, $W_r = 4^{-1}a^2/\left(a^2 + (\omega_n + \omega_e)^2\right)$,

here a – *HFI* constant, $\omega_{e,n}$ – electron and nuclear Zeeman frequencies. Thus, magnetic field decreases the recombination and excitation probabilities.

Conclusions

1. The "unsuccessful" attempts of spin selective recombination can be the source of excited hydrogen atoms.
2. Populations of excited hyperfine states are determined by coefficients of the spin density matrix.
3. Strong magnetic fields decrease the recombination probability and populations of hydrogen excited states simultaneously.
4. Recombinational excitation can be the origin of excited hyperfine states in hydrogen atoms in the Universe which are the source of the space radio frequency emission (ν = 1428,5714 MHz).
5. Components of hydrogen radio emission will allow to determine magnetic fields in space and in the vicinity of star clusters.

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