ENERGY SPECTRUM OF He I AND H− IN A STRONG MAGNETIC FIELD

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The energy spectrum of He I is calculated by a variational method for magnetic fields \( B \) in the range \( 0 - 3 \times 10^{11} \) gauss. Improved results for the electron affinity of \( H^- \) are also presented.

The binding energy of \( H^- \) in magnetic fields \( B \) in the range \( 0 - 3 \times 10^9 \) G has been calculated using a variational method [1]. We now apply the same technique to a calculation of the energy spectrum and the binding energy of the ground state of He I. \( B \) values \( \leq 10^7 \) G were considered in [2] but, as we shall see, \( B \) does not have a pronounced effect below \( \sim 10^8 \) G.

Our notation and method of calculation follow that of [1]. At \( B = 0 \), we calculate the energies of the five lowest levels and obtain results which agree with Pekeris et al. [3, 4] to within 1%. This accuracy was achieved by the use of 24 Slater orbital terms in the sum over the index \( \Gamma \). For the largest \( B \) values (\( \sim 3 \times 10^{11} \) G) reported here, we use 125 terms, with a maximum \( L \) of nine.

Fig. 1 gives the energies of some of the lowest states of He I as a function of \( B \). The lowest energy state goes from the singlet, even-parity state \( \gamma = (000+)^{-1} \) to the triplet, odd-parity state \( \gamma = (1−1 1−)^{-1} \) at \( B \approx 1.7 \times 10^9 \) G. The binding energy of the ground-state of He I is given by

\[
I(\text{He I}) = -E(\text{He I}) - I(\text{He II}),
\]

where \( E(\text{He I}) \) is the ground-state energy of He I and \( I(\text{He II}) \) is the binding energy for He II in the ground state [5].

The results for \( I(\text{He I}) \) are presented in fig. 2. It decreases with increasing \( B \) to \( B \approx 1.7 \times 10^9 \) G, where the lowest-energy state now corresponds to both electrons having their spins opposite to the direction of the \( B \) field. From \( B = 1.7 \times 10^9 \) G to \( B = 3 \times 10^{11} \) G,

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I(\text{He I}) \approx -E(\text{He I}) - I(\text{He II}),
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which is obtained from the difference of two quantities, $-E(H^-)$ and $I(H)$, both of which are relatively large but whose difference is relatively small. Fig. 3 gives $I(H^-)$. As before [1], we note that $H^-$ is unbound for an intermediate range of $B$ values. However, in this region there is a "quasi-bound" singlet state — "quasi" in the sense that it is embedded in the "continuum" of the system consisting of a single-electron atom with spin down and a "free" (from the Coulomb but not from the magnetic field) electron with spin down. In the other $B$ regions for $H^-$ (and also for He I) this "quasi-bound" state is lower than the triplet bound state (because of the large energy of $2\hbar\omega_L$ released in flipping the electron spin). Further details may be found in ref. [6].

References