Erratum

Erratum: Wannier exciton in quantum wells [Phys. Rev. B 28, 4878 (1983)]

Y. Shinozuka and M. Matsuura

Recently we have found mistakes in the numerical calculation of the binding energies of excitons in quantum wells. There are corrections in the results for $n=1s$, $2s$, and $2p_x$ states (but not for $2p_z$). Figures 2–5 should be replaced by the revised Figs. 2–5, respectively (see below). In addition, the following points should be noted.

(a) The statement on the restriction of two variational parameters $\alpha_n=\beta_n$ in the original paper is incorrect. The correct calculation shows that, as the well becomes thinner, the dependence of binding energies on β_n becomes weaker. Then, as seen in Fig. 2(a), the wave functions with the restriction of $\alpha_n=\beta_n$ (which, for $n=1s$, reduce to the second trial function of Bastard, Mendez, Chang, and Esaki[1] give the exact values of the two-dimensional situation in the thin limit $(L/a_B=0)$ and can be used in the entire well-thickness range. The statement, on page 4879 (left column, line 35 through and including right column, line 4), "Recently, similar. . . the entire well-thickness range." should be deleted. Use of two independent variational parameters α_n and β_n can yield larger binding energies when the well thickness is finite. Calculated binding energies are imporved by 4.3% at $L/a_B=1$ for $n=1s$, 6.2% at $L/a_B=2$ for $n=2s$, and 3.2% at $L/a_B=4$ for $n=2p_x$ in comparison with those with the restriction of $\alpha_n=\beta_n$.

(b) For $n=1s$, as the well becomes thinner, the value of $\bar{\beta}_{1s}$ decreases for $L/a_B \gtrsim 1$ and then increases for $0.05 \lesssim L/a_B \lesssim 1$. When $L/a_B \lesssim 0.05$ we obtain $\bar{\beta}_{1s}=0$.

(c) For excited states, the inequality in binding energies $E^B_{2p_z} \leq E^B_{2s} \leq E^B_{2p_x}$ holds for the entire well-thickness range.

(d) The quantities $(\langle x^2\rangle_n)^{1/2}$, $(\langle y^2\rangle_n)^{1/2}$, and $(\langle |z_e-z_h|^2\rangle_n)^{1/2}$ decrease monotonically as the well becomes thinner, except $(\langle x^2\rangle_{2s})^{1/2}$ and $(\langle y^2\rangle_{2s})^{1/2}$. There is no large dip in the quantity

$$|\psi_{1s}(0,0,z_e,z_h=z_e)|^2/|\psi_{2s}(0,0,z_e,z_h=z_e)|^2$$

in Fig. 5.

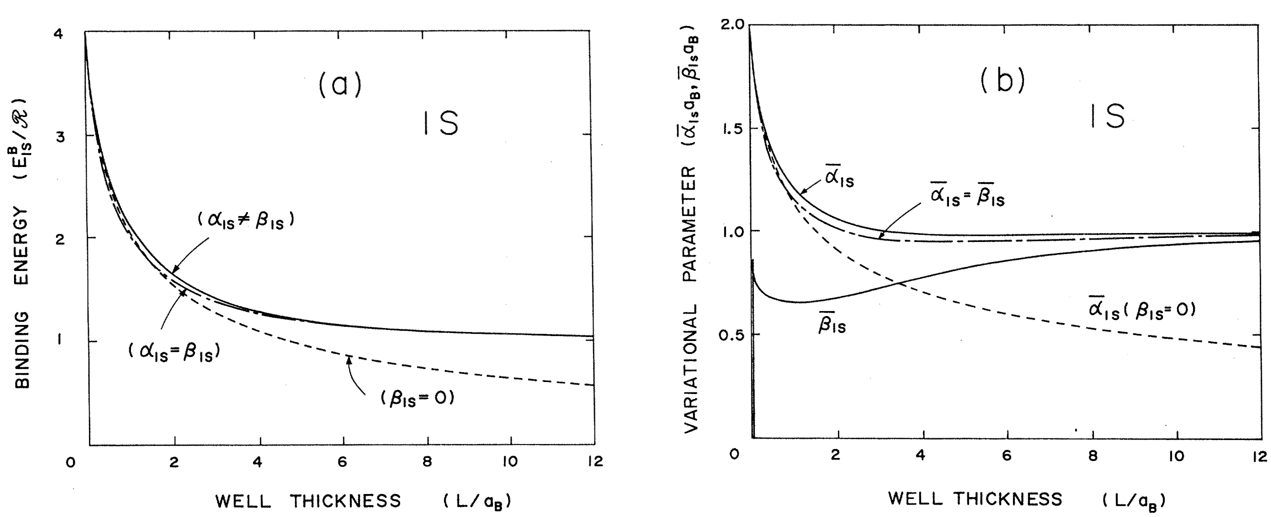

FIG. 2. (a) Dimensionless binding energy of the $1s$ exciton $(E^B_{1s}/\mathcal{R})$ and (b) variationally determined parameters $\bar{\alpha}_{1s}a_B$ and $\bar{\beta}_{1s}a_B$, are plotted (full line) vs dimensionless well thickness (L/a_B). Broken lines have been obtained with the restriction of $\beta_{1s}=0$ and chain lines with the restriction of $\alpha_{1s}=\beta_{1s}$.

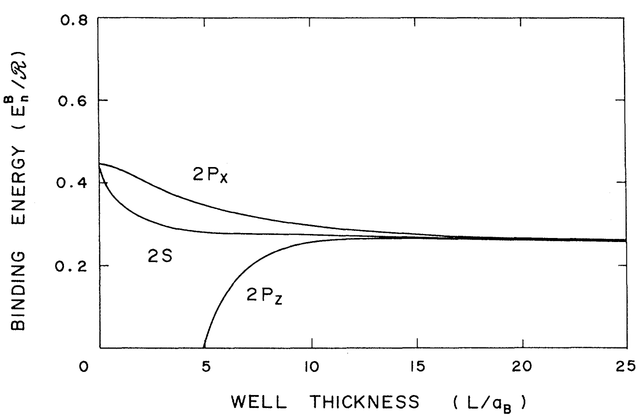

FIG. 3. Dimensionless binding energies $(E_n^B/\mathscr{R})$ of $n=2s$, $2p_x$, and $2p_z$ exciton states are plotted vs dimensionless well thickness (L/a_B).

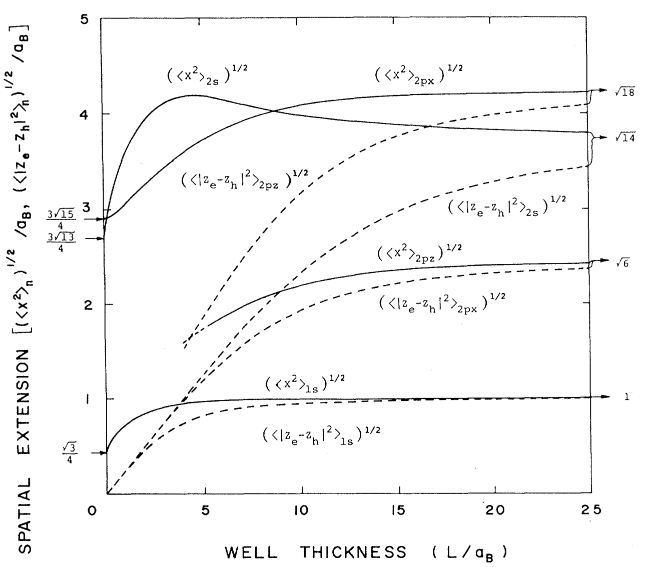

FIG. 4. Dimensionless transverse extensions $(\langle x^2\rangle_n)^{1/2}/a_B$ (full line) and longitudinal extensions $(\langle |z_e-z_h|^2\rangle_n)^{1/2}/a_B$ (broken line) of $n=1s$, $2s$, $2p_x$, and $2p_z$ states are plotted vs dimensionless well thickness (L/a_B). Numerical values indicated with arrows are those in two- and three-dimensional situations.

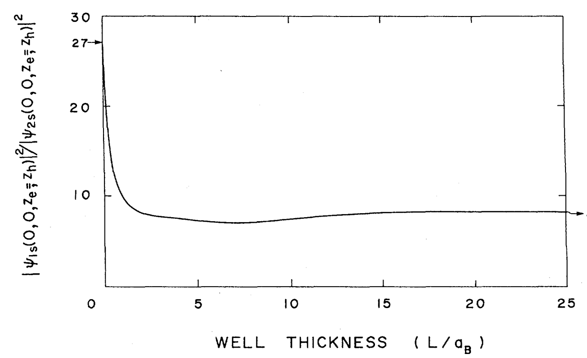

FIG. 5. The ratio of the absolute square of the wave functions at the origin of the relative motion coordinate of the $1s$ and $2s$ states

$$|\psi_{1s}(0,0,z_e,z_h=z_e)|^2/|\psi_{2s}(0,0,z_e,z_h=z_e)|^2$$

is plotted vs dimensionless well thickness (L/a_B). Numerical values indicated with arrows are those in two- and three-dimensional situations.

---

[1]G. Bastard, E. E. Mendez, L. L. Chang, and L. Esaki, Phys. Rev. B 26, 1974 (1982).