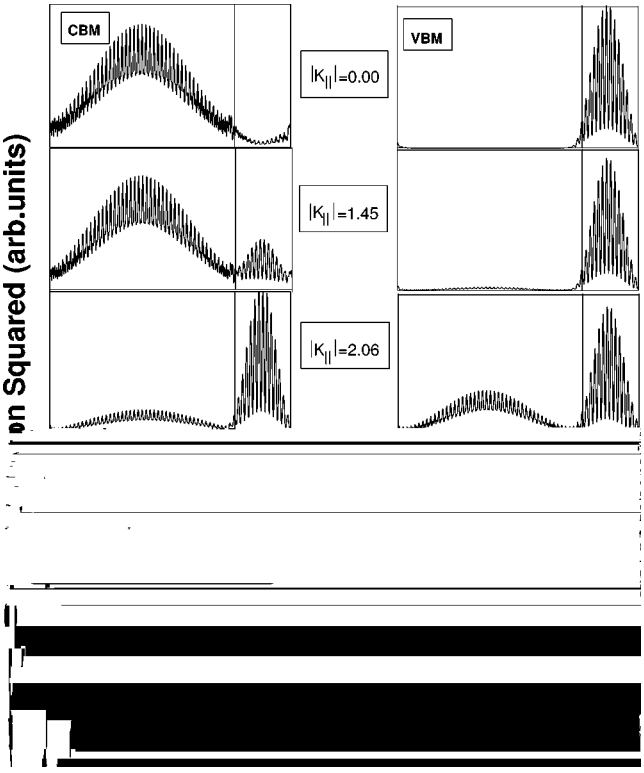

FIG. 3. Evolution of the wave function of the last occupied state (left column) and the first unoccupied state (right column) of the $(InAs)_{46}(GaSb)_{14}$ (001) superlattice along the in-plane $\mathbf{k}_\parallel=(k_x=k_y)$ direction at $k_z=0$. Wave functions are averaged over the in-plane coordinates.

thicknesses n and m are changed. We have considered a $(InAs)_{30}/(GaSb)_{30}$ superlattice with the same total $n+m$ period as the previously studied $(InAs)_{46}/(GaSb)_{14}$ superlattice. The pseudopotential calculated in-plane dispersion relations of the two superlattices along the $k_x=k_y$ direction at $k_z=0$ are compared in Fig. 4. Since the well widths determine the confinement energies, using the (30,30) period rather than (46,14) leads to a more confined electron (since the InAs electron well is now narrower) and to a less confined heavy hole (since the GaSb hole well is now wider). Thus, the (30,30) superlattice has a smaller (negative) gap at $\mathbf{k}_\parallel=0$ than the (46,14) superlattice. The negative gap at $\mathbf{k}_\parallel=0$ is now 17 meV, i.e., about one-fourth of the corresponding gap of the (46,14) superlattice. Since the electron and heavy-hole bands are already closer to each other at $\mathbf{k}_\parallel=0$ than in the (46,14) case, the anticrossing point $\mathbf{k}_\parallel^*$ occurs

TABLE I. Pseudopotential (P) and $\mathbf{k}\cdot\mathbf{p}$ calculated hybridization (H) gaps for a $(InAs)_{46}(GaSb)_{14}$ (001) superlattice. The band offset between the strained InAs CBM and GaSb VBM is 190 meV. In parentheses we give the band gaps obtained with a 150-meV offset.

Method	$E(\mathbf{k}_\parallel=0)$ (meV)		$E_H(\mathbf{k}_\parallel=\mathbf{k}^*)$ (meV)	
	$k_z=0$	$k_z=\frac{\pi}{L_z}$	$k_z=0$	$k_z=\frac{\pi}{L_z}$
P theory	65	45	25	8
$\mathbf{k}\cdot\mathbf{p}$	68(32)	38(8)	29(22)	8(1.5)

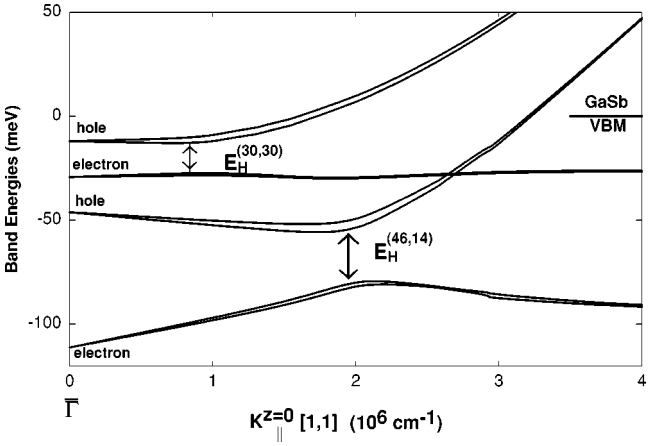

FIG. 4. Comparison between the pseudopotential calculated dispersion relations of a $(InAs)_{46}(GaSb)_{14}$ superlattice and of a $(InAs)_{30}(GaSb)_{30}$ along the $(k_x=k_y)$ direction at $k_z=0$.

closer to the Brillouin zone center. However, we see that the interaction $V_{e\text{-}hh}$ in this region given by the pseudopotential theory is relatively strong, and, as a consequence, the hybridization gap is 15 meV wide, not much smaller than the negative gap at $\mathbf{k}_\parallel=0$.

We have also examined the interband transition dipole matrix elements for the (30,30) superlattice and found that, while the transitions at $\mathbf{k}_\parallel=0$ have the same intensity as those in the (46,14) superlattice, both the intensity and the polarization anisotropy of the transitions at $\mathbf{k}_\parallel^*$ are smaller that those we have found in the (46,14) superlattice. Thus, we see that, the closer E_H is to $\mathbf{k}_\parallel=0$, the less intense and anisotropic are the interband transitions.

E. Comparison of pseudopotential and model calculations

Figure 5 compares the pseudopotential results with the model calculation of de-Leon *et al.*[6] for the $(InAs)_{46}(GaSb)_{14}$ system. The model of Ref. 6 describes the system as an InAs electron well interacting with a GaSb hole well, both wells being sandwiched between infinite barriers. Although two coupled quantum wells are a very simplified model of the system we are studying here, it is instructive to compare qualitatively our calculation with this model. The two systems are different in that the $(InAs)_{46}(GaSb)_{14}$ superlattice is a periodic system, showing a dispersion of the electron and hole bands along the k_z direction while there is no k_z dependence in the model of Ref. 6. The existence of the dispersion along k_z in our calculation reveals a coupling with other bands. In Ref. 6 the only allowed coupling is limited to the two electron and hole ground states of the uncoupled wells.

In Fig. 5 we compare the in-plane dispersions of the model in Ref. 6 with the superlattice dispersion for $k_z=0$. We see that the values of $\mathbf{k}_\parallel^*$ at the anticrossing points are similar in both calculations. We can think of our $k_z=0$ superlattice wave function as a periodic repetition of the corresponding quantum well wave function without any complication of additional phase factors. Now, however, in addition to the mixing due to the perturbation at the InAs/GaSb interface, which is present in the model of Ref. 6, we have an additional perturbation at the GaSb/InAs interface. As a re-

sult, the anticrossing gap at **k**