Berciu and Bhatt Reply: The point raised by the authors of the Comment [1] regarding the hopping term $t(r)$ we use [2] to describe the impurity band (IB) of holes in $Ga_{1-x}Mn_xAs$ needs clarification. A proper description of the hopping between impurity states in such alloys is a complicated and, to our knowledge, unsettled issue. In our work, we used a hopping parameter $t(r) > 0$ of magnitude corresponding to two isolated s-wave impurities. This parametrization captures two important length scales—the inter Mn-Mn distance and the impurity Bohr radius—present in a complete model of the experimental system. With our parameters, in the absence of magnetization, we obtain an impurity band for holes whose density of states (DOS) is plotted in Fig. 1 (left), for $x = 0.93\%$ using the impurity Rydberg as a unit (1 Ry = 112 meV for Mn in GaAs). The top of the hole impurity band is 3 Ry above the valence band, while the Fermi energy E_F for holes lies 2.5 Ry above the top of the valence band. These appear to be reasonable numbers; recent optical spectroscopy studies [3] find an impurity band about 250 meV above the valence band. In the mean-field approach, this is the situation above T_c, while for $T < T_c$ the coupling to the Mn spins causes the spin up and down bands to split, leaving the system fully polarized at $T = 0$ (see inset).

Additionally, with the parameters used by us the IB shows a mobility edge close to E_F, as demonstrated by computing the inverse participation ratio IPR = $\sum_i |\phi(i)|^4$, where $\phi(i)$ is the wave function amplitude at site i. For an *extended* wave function, IPR $\sim 1/N_d$, where N_d is the number of sites of a finite sample. For *localized* wave functions, the IPR is independent of system size. The average IPR for the wave functions of our hopping Hamiltonian is shown in Fig. 1 (right) for $N_d = 125$ and 1000. The occupied states at the top of the hole IB are localized, with size-independent IPR implying extents from 3–10 holes, whereas states of lower energy are extended with IPRs dependent on the system size. Thus, our model also captures the proximity of the metal-insulator transition, seen in experiment.

On the other hand, the choice suggested in the Comment [1] $t(r) < 0$, which inverts the IB ($E \rightarrow -E$), is not suitable to describe the IB because it leads to an unphysical, very long tail inside the gap, with a very low DOS at E_F. Moreover, *all* the occupied states are extended (there is no mobility edge). These unphysical characteristics are a consequence of the simplified formula used for $|t(r)|$; a more realistic calculation of the IB, including the Coulomb potential from the other Mn impurities as well the charged impurities responsible for the large compensation, and using the more complicated structure of a *hole* impurity wave function, will remove the unphysical tail and yield a DOS similar to the one used in our calculation, with proximity to a mobility edge [4]. Since the nature of compensation in GaMnAs is still an open question, we opted to use the simple model
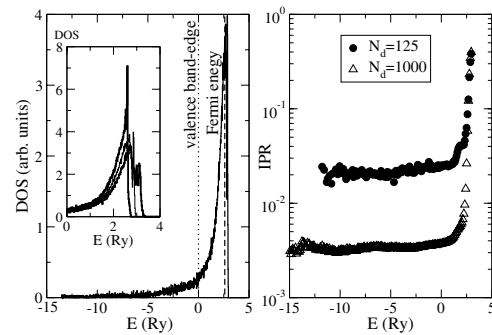

FIG. 1. Left: DOS for hopping Hamiltonian with $t(r) > 0$. The inset shows the effect of the AFM coupling ($J = 15$ meV): the $\sigma = \uparrow$ and $\sigma = \downarrow$ bands (thick lines) are no longer degenerate at low temperatures. For comparison, we plot the $J = 0$ DOS as well (thin line). Right: dependence of the average IPR on the energy. In both pictures $x = 0.0093$.

with $t(r) > 0$ that gives a physically acceptable description of the IB.

Our goal in Ref. [2] was to use this simple IB model to point out nontrivial effects of disorder in Mn positions on the shape of the magnetization curve $M(T)$ and the critical temperature T_c. To our knowledge, all previously published studies neglected this aspect. Studies appearing since support our claim of increased T_c with increased Mn disorder [5]. More importantly, recent optical [3], STM [6], and ARPES studies [7] confirm the existence of the IB in these compounds. While we agree that a better modeling of the IB and inclusion of the valence band states and other factors such as screening (on a proper, local scale, taking into account strong charge inhomogeneities) are necessary to achieve a proper *quantitative* description especially in the metallic regime $x > 0.03$, we maintain that the underlying physics captured by our simple model of Ref. [2] is essentially correct.

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