# Erratum: High Temperature Ferromagnetism in GaAs-Based Heterostructures with Mn $\delta$ Doping [Phys. Rev. Lett. 95, 017201 (2005)]

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In III-V-based magnetic semiconductors, the anomalous Hall effect (AHE) [1–5] has been playing a pivotal role in characterizing the magnetic properties, as was the case in our recently published Letter [6]. Since it was not made sufficiently clear that the Hall resistance loops presented were not raw data, we describe how the Hall resistance loops were obtained in our AHE measurements. In our magnetic semiconductor heterostructures, the longitudinal magnetoresistance (MR) effect is large. When we measure the Hall voltage of our samples in patterned Hall bars or in van der Pauw geometry, a large MR contribution is always superimposed on the Hall voltage data. This MR contribution results from the nonideal measurement geometry of the samples [1–4]. Thus, the raw Hall resistance $R^{\mathrm{raw}}$ data (the raw Hall voltage divided by the current) in our case can be expressed as $R^{\mathrm{raw}}(B) = R_{\mathrm{H}}(B) + R_{\mathrm{MR}}(B)$. Here, $R_{\mathrm{H}}$ is the intrinsic Hall resistance and $R_{\mathrm{MR}}$ is the magnetoresistance (MR) contribution, which gives a nonzero value at $B = 0$ (offset) to the raw Hall resistance $R^{\mathrm{raw}}$, and its magnetic-field dependence is an even function. Since the Hall resistivity in magnetic materials under a magnetic field applied perpendicular to the sample plane consists of the ordinary Hall effect and AHE [7], the sheet Hall resistance $R_{\mathrm{H}}$ of our heterostructures can be expressed as $R_{\mathrm{H}} = R_{\mathrm{O}}B + R_{\mathrm{S}}M$ [6,8,9]. Here, $R_{\mathrm{O}}$ is the ordinary Hall coefficient, $R_{\mathrm{S}}$ is the anomalous Hall coefficient, and $M$ is the perpendicular component of magnetization of the sample. In the AHE, $R_{\mathrm{H}}(B)$ is an odd function with respect to the polarity of the $B$ (and also $M$), and thus, it is antisymmetric (or ''odd symmetric'') when a full field sweep is performed, i.e., $R_{\mathrm{H}}(B) = -R_{\mathrm{H}}(-B)$ [9]. On the other hand, $R_{\mathrm{MR}}(B)$ is an even function with respect to the polarity of $B$ (and also $M$) [1,2], and thus, it is even symmetric, i.e., $R_{\mathrm{MR}}(B) = R_{\mathrm{MR}}(-B)$. Therefore, one can decompose the raw Hall resistance data $R^{\mathrm{raw}}$ into the Hall resistance $R_{\mathrm{H}}(B) = [R^{\mathrm{raw}}(B) - R^{\mathrm{raw}}(-B)]/2$ and the magnetoresistance $R_{\mathrm{MR}}(B) = [R^{\mathrm{raw}}(B) + R^{\mathrm{raw}}(-B)]/2$.

Figures 1(b), 1(d), 1(f), 1(h), 1(j), 2(a), 2(d), 2(g), and 2(j) show the raw Hall data $R^{\mathrm{raw}}$ taken from Hall bars [as shown in Fig. 1(a), the channel width and length are 50 $\mu$m and 200 $\mu$m, respectively] of sample $A$ and sample $B$, respectively, of Ref. [6] under a full field sweep of $-0.5\ \mathrm{T} \le B \le +0.5\ \mathrm{T}$, which are the superposition of the intrinsic Hall resistance ($R_{\mathrm{H}}$) and the MR contribution ($R_{\mathrm{MR}}$). Note that the $R^{\mathrm{raw}}$ curves in the figures are qualitatively similar to those observed in other III-V ferromagnetic semiconductors [1,3] reported earlier. Figures 1(c), 1(e), 1(g), 1(i), 1(k), 2(b), 2(e), 2(h), and 2(k) show the decomposed $R_{\mathrm{H}}$ data of sample $A$ and sample $B$, respectively. Figures 2(c), 2(f), 2(i), and 2(l) show the decomposed $R_{\mathrm{MR}}$ data of sample $B$. In our Letter [6], we focused on the Hall resistance $R_{\mathrm{H}}$. In this way, we eliminated the MR contribution from the raw Hall resistance data using the method mentioned above, and plotted the intrinsic Hall resistance. Given the fact that the magnetotransport data show clear ferromagnetic hysteretic behavior and its temperature dependence together with the supporting data [10], we believe that there is ferromagnetic order at high temperatures in our heterostructures.

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[10] As shown in Ref. [6], the $T_C$ estimated from the Curie-Weiss plot in the paramagnetic state for sample *A* and the temperature for the local maximum of resistance due to critical scattering for sample *B* are in good agreement with the $T_C$ estimated from the temperature dependence of the hysteresis.

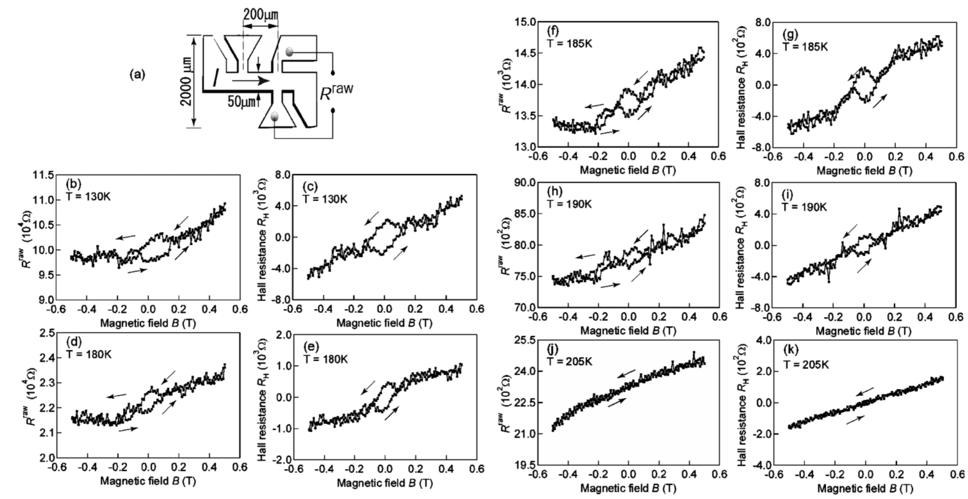


FIG. 1. (a) The Hall bar measurement geometry. (b), (d), (f), (h), (j) Full magnetic-field sweep of the raw Hall data $R^{\mathrm{raw}}$ (the arrows indicate the field sweep directions) of the structure of sample *A* of Ref. [6]. (c), (e), (g), (i), (k) Hall resistance ($R_{\mathrm{H}}$) loops obtained by eliminating the offset MR contributions, which are shown in Figs. 3(a)–(e) in Ref. [6].

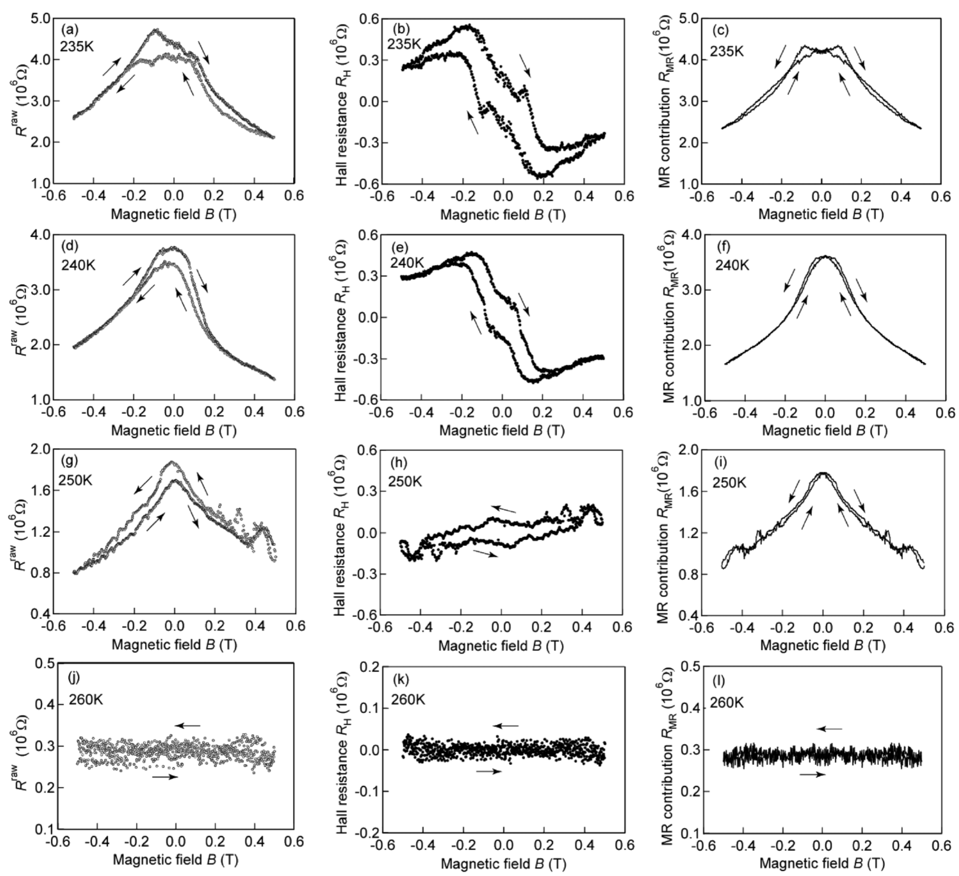


FIG. 2. (a), (d), (g), (j) Full magnetic-field sweep of the raw Hall data $R^{\mathrm{raw}}$ (the arrows indicate the field sweep directions) of the structure of sample *B* of Ref. [6]. (b), (e), (h), (k) Hall resistance ($R_{\mathrm{H}}$) loop obtained by eliminating the magnetoresistance contribution (c), (f), (i), (l) from the raw Hall data $R^{\mathrm{raw}}$ of (a), (d), (g), (j), which are shown in Figs. 4(b)–(e) in Ref. [6].