# Comment on "Pinning Strength Dependence of Mixed-State Hall Effect in $YBa_2Cu_3O_7$ Crystals with Columnar Defects"

In their Letter, Kang *et al.* [1] report that pinning induced by heavy ion irradiation modifies the mixed-state Hall conductivity $\sigma_{xy}$. The purpose of this Comment is to attract the attention to the fact that it is a misleading statement. Over a wide temperature range where pinning is important, $\sigma_{xy}$ is practically not changed by irradiation [1]. The difference between the data on the Hall conductivity before and after irradiation is actually within the accuracy of the experiment by Kang *et al.* [1].

For the sample irradiated with the matching field $B_\Phi = 2$ T ($B_\Phi$ is the field at which the number of vortices matches the number of columnar defects produced by irradiation) there is no observable difference in $\sigma_{xy}$ before and after irradiation above $T/T_c \approx 0.924$ for $H = 4$ T and above $T/T_c \approx 0.9525$ for $H = 2$ T (Fig. 4) (all figures cited refer to Ref. [1]). On the other hand, pinning sets in at $T/T_c \approx 0.97$ for $H = 4$ T and $T/T_c \approx 0.97$ for $H = 2$ T (Figs. 1 and 2), as seen from the irradiation-induced change in the longitudinal and Hall resistivities, $\rho_{xx}$ and $\rho_{xy}$, respectively. Therefore, in the temperature range $T/T_c = 0.924-0.95$ for $H = 4$ T and $T/T_c = 0.9525-0.97$ for $H = 2$ T, the effect of pinning on both $\rho_{xx}$ and $\rho_{xy}$ is significant (for instance, the absolute value of $\rho_{xy}$ decreases from $5 \times 10^{-7}$ $\Omega$ cm before irradiation, see Fig. 2, to $4 \times 10^{-9}$ $\Omega$ cm after irradiation, see Figs. 1 and 3, at $T/T_c \approx 0.9525$ for $H = 2$ T, see Figs. 1–3), whereas the Hall conductivity remains the same before and after irradiation.

There is a narrow temperature window where some difference in $\sigma_{xy}$ before and after irradiation can be seen ($T/T_c \approx 0.921-0.924$ for $H = 4$ T and $T/T_c \approx 0.949-0.9525$ for $H = 2$ T) (Fig. 4). Let us estimate the accuracy in determining the Hall conductivity $\sigma_{xy} = \rho_{xy}/(\rho_{xx}^2 + \rho_{xy}^2)$ at these temperatures. Typical scatter of points for $\rho_{xy}$ (Fig. 3) is $3 \times 10^{-9}$ $\Omega$ cm. At $T/T_c \approx 0.921$ for $H = 4$ T and $T/T_c \approx 0.949$ for $H = 2$ T, the longitudinal resistivity (Fig. 1) drops below 2% of its normal state value $\approx 70$ $\mu\Omega$ cm (Fig. 3), i.e., 1.4 $\mu\Omega$ cm. The accuracy in $\sigma_{xy}$ is $\Delta\sigma_{xy} \approx 3 \times 10^{-9}/(1.4 \times 10^{-6})^2$ $(\Omega\ \mathrm{cm})^{-1} \approx 1.5 \times 10^3$ $(\Omega\ \mathrm{cm})^{-1}$, which is larger or comparable to the difference in the Hall conductivity before and after irradiation (Fig. 4).

Thus, the paper by Kang *et al.* [1] actually confirms our statement about pinning independence of the mixed-state Hall conductivity $\sigma_{xy}$ in $Tl_2Ba_2CaCu_2O_8$, $YBa_2Cu_3O_7$ [2], and $Bi_2Sr_2CaCu_2O_8$ [3], in agreement with theory by Vinokur *et al.* [4]. Pinning independence of $\sigma_{xy}$ has also demonstrated by angular scaling of $\sigma_{xy}$ in $YBa_2Cu_3O_7$ [5,6], $Tl_2Ba_2CaCu_2O_8$, $Nd_{1.85}Ce_{0.15}CuO_4$ [6], by high-current measurements in $Mo_3Si$ [6], and by observations of a $1/H$ dependence of the Hall conductivity in $Tl_2Ba_2CaCu_2O_8$ [7] and in $YBa_2Cu_3O_7$ [5,6]. Related work on the thermomagnetic coefficients has been recently performed in $YBa_2Cu_3O_7$ by Clinton *et al.* [8].

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