Liu and Zou Reply: In the preceding Comment [1], the authors criticize our calculation [2] of $pp \to pK^+\Lambda$ near threshold for not taking into account the Λp final state interaction (FSI), and consequently question our conclusions based on the large $N^*(1535)$ coupling to the $K\Lambda$ system. It is true that the Λp FSI is important for $pp \to pK^+\Lambda$ near threshold as clearly shown by a recent COSY experiment [3] and should not be neglected. However, since there are large uncertainties for other elements in calculations of $pp \to pK^+\Lambda$, here we will show that the large $N^*(1535)$ coupling to the $K\Lambda$ deduced from the BES data on $J/\psi \to \bar{p}K^+\Lambda$ [4] and $J/\psi \to \bar{p}p\eta$ [5] is still compatible with the COSY results on $pp \to pK^+\Lambda$ after including the Λp FSI.

Some ingredients with large uncertainties for calculating $pp \to pK^+\Lambda$ are the following: (i) forms and parameters of form factors for hadronic coupling vertices; (ii) parameters of resonances such as mass, width, and coupling constants; (iii) interference terms between different resonances; (iv) parameters for the Λp FSI. Although these ingredients need to be considered consistently for all possible relevant processes, there is always some room for adjustment.

In our previous calculation [2] of $pp \to pK^+\Lambda$, following Ref. [6], we neglected the interference terms between different resonances and the Λp FSI. We added the $N^*(1535)$ contribution with $g_{N^*(1535)K\Lambda} = 1.3 g_{N^*(1535)\eta N}$, $g^2_{\eta NN}/4\pi = 5$ and $\Lambda_\eta = 2.0$ GeV for the corresponding form factor.

Now in order to incorporate the Λp FSI effect, we just need to adjust these parameters within their uncertainties. In the modified calculation, we use $g_{N^*(1535)K\Lambda} = g_{N^*(1535)\eta N}$ which is allowed by uncertainty of BES data [2], $g^2_{\eta NN}/4\pi = 3$ and $\Lambda_\eta = 1.5$ GeV, which are well within the uncertainties by relevant processes [7]; for the Λp FSI we use the same approach as in Ref. [8] by adopting the parameters $\beta = 201.7$ MeV and $\alpha = -76.8$ MeV ($a = -1.59$ fm and $r = 3.16$ fm). Here we also include the contribution from ρ meson exchange, which only gives significant contribution at higher energy. Without changing any other parameters, the results are shown in Fig. 1, which already produce both total cross sections and the Λp helicity angle spectra quite well. Note we have not used the freedom of adjusting more parameters, allowing free interference terms and including the initial state interaction [9] yet. It just serves as an example to show that the large coupling of $N^*(1535)$ to $K\Lambda$ deduced from BES results is still compatible to the $pp \to pK^+\Lambda$ experiment results within the uncertainties after including the Λp FSI. In fact, by comparing the Dalitz plots shown by Figs. 5(a) and 5(b) in Ref. [3], it is obvious that the calculation with the adjusted model of Sibirtsev without including the contribution of the $N^*(1535)$ underestimates the part near $K\Lambda$ threshold. The inclusion of the $N^*(1535)$ may reduce the $N^*(1650)$ contribution necessary to reproduce the data.

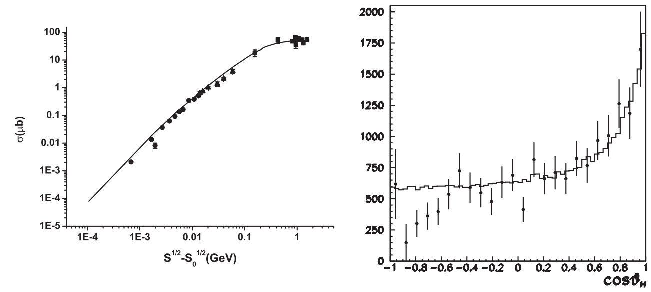

FIG. 1. The total cross section vs the excess energy (left) and the Λp helicity angle spectra for $K^+\Lambda$ masses $M_{K\Lambda} > 1.74$ GeV at $p_{\text{beam}} = 2.8$ GeV (right) for $pp \to pK^+\Lambda$.

In the reaction $J/\psi \to \bar{p}K\Lambda$, the $K\Lambda$ invariant mass spectrum divided by the phase space factor shows a clear peak at the $K\Lambda$ threshold without peak at 1650 MeV [see Fig. 9(b) in Ref. [4]], so the peak is most likely due to the subthreshold $N^*(1535)$ resonance. For the solution using resonance mass of 1650 MeV without including the $N^*(1535)$, the fit is worse meanwhile with the fitted width and $K\Lambda$ branching ratio well out of the PDG range [4].

The $N^*(1535)$ is the most outstanding signal in both $J/\psi \to \bar{p}K^+\Lambda$ [4] and $J/\psi \to \bar{p}p\eta$ [5], and is produced back-to-back against $\bar{p}$ with large relative momenta without the complication caused by t-channel exchange of various mesons as in $pp \to pK^+\Lambda$. Hence the ratio between its decay branching ratios to $K\Lambda$ and ηN can be determined [2] more reliably than other processes.

B. C. Liu and B. S. Zou
Institute of High Energy Physics
P.O. Box 918(4), Beijing 100049, China

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[1] A. Sibirtsev, J. Haidenbauer, and Ulf-G. Meißner, preceding Comment, Phys. Rev. Lett. **98**, 039101 (2007).
[2] B. C. Liu and B. S. Zou, Phys. Rev. Lett. **96**, 042002 (2006).
[3] S. Abd El-Samad *et al.*, Phys. Lett. B **632**, 27 (2006).
[4] H. X. Yang *et al.* (BES Collaboration), Int. J. Mod. Phys. A **20**, 1985 (2005).
[5] J. Z. Bai *et al.* (BES Collaboration), Phys. Lett. B **510**, 75 (2001).
[6] K. Tsushima, A. Sibirtsev, and A. W. Thomas, Phys. Rev. C **59**, 369 (1999).
[7] S. L. Zhu, Phys. Rev. C **61**, 065205 (2000).
[8] A. Sibirtsev, J. Haidenbauer, H. W. Hammer, and S. Krewald, Eur. Phys. J. A **27**, 269 (2006).
[9] K. Nakayama, J. Speth, and T. S. H. Lee, Phys. Rev. C **65**, 045210 (2002); V. Baru *et al.*, Phys. Rev. C **67**, 024002 (2003).

