Reply to "Comment on 'Optically pumped spin-exchange polarized-electron source' "

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In this Reply, we respond to the above Comment.

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In the preceding Comment [1] on our recent report of a Rb spin-exchange polarized-electron source [2], Williams *et al.* contend: (a) that our source is poorly characterized compared with modern GaAs sources, (b) that we have overstated the difficulties of using GaAs photoemission sources, and (c) that our explanation of various physics issues related to the source's operating principles are not cogent. We consider these issues in turn.

We concur that our source is not completely characterized. This was also true of the GaAs source after the seminal report on it by Meier and Pierce [3] immediately following its invention. That our source has many opportunities for improvement is not a drawback; the multiple, independent paths for improvement and better characterization of the spin-exchange source are straightforward and will reveal a great deal of interesting source physics. We look forward to when the spin-exchange source is a mature laboratory tool rather than the result of one graduate student's thesis work. In any event, it is not reasonable to withhold a report on a viable new interesting technology until every bug has been eliminated and a final engineered product is ready for commercialization.

Williams *et al.* take our statement that GaAs sources (can be) "unusable or, at best, highly problematic" out of context; the full sentence in our report is as follows: "In tabletop experiments with vapor targets, such as ours, destruction of the photocathode's NEA surface conditions by organic and other vacuum contaminants can make GaAs sources unusable or, at best, highly problematic." We were referring to the use of GaAs photocathodes in environments with heated vapor targets of organic halocamphors that have aggressively shortened the lifetime of our photocathode activations. Williams *et al.* offer no evidence from their own laboratory to the contrary. The experiments they cite from Perth involved targets of ultraclean UHV surfaces, noble gases, and Zn vapor. These are much more benign targets than the ones to which we specifically referred. We have used GaAs sources in the same types of experiments performed by Williams' group. In these cases, we too found the GaAs source to be reliable and relatively easy to use. At one point, we ran uninterrupted with such a source for the better part of a year.

We disagree that our discussion of the physics in the optical pumping and spin-exchange processes on which our source relies lacks cogency. We have not performed enough experiments yet to fully understand the fine details of the polarization mechanisms in our source and were quite careful to note when our explanations should be characterized as plausible but speculative due to our current lack of experience with the source.

Finally, we respond to a few specific points made in the above Comment. In a short Communication, there is not enough space to address any but the most relevant and/or novel details. The laser beam tuning for frequency, power, and polarization and the subsequent electron-beam characteristics were quite stable. The Comment's references to radiation trapping and magnetic-field variations do not counter our straightforward measurements of Rb and electron polarizations under various source operating conditions. Our paper only makes claims about electron thermalization by the buffer gas (not the thermalization of a "gas mixture"), and we provide references for the mechanisms we propose.

Williams *et al.* mention that GaAs sources are commercially available. They are only sold as part of a system that costs ∼1.45-million Australian dollars for use in pristine UHV environments involving surface physics experiments, and are essentially the same as the GaAs sources we have been using in our group since 1987 (and those used by William's group in Perth since the early 1990s). We have operated both spin-exchange and GaAs sources and are confident that our optically pumped spin-exchange source can serve a real need in university research laboratories. The fact remains that a simple reliable user-friendly polarized electron source would significantly broaden the possibilities for polarized electron research in many laboratories.

[1] J. F. Williams, S. Samarin, and L. Pravica, Phys. Rev. A **91**, 056703 (2015).
[2] M. Pirbhai, J. Knepper, E. T. Litaker, D. Tupa, and T. J. Gay, Phys. Rev. A **88**, 060701(R) (2013).
[3] F. Meier and D. T. Pierce, Phys. Rev. B **13**, 5484 (1976).

