LETTER

REPLY TO SVENSSON:
Quantum violations of the pigeonhole principle

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In our paper in PNAS (1), we describe a quantum violation of the pigeonhole principle. We describe a situation (involving pre- and postselection) in which we put three particles in two boxes and we never find two particles in the same box. We presented both a "strong measurement" analysis and a "weak measurement" one. In his comment, Svensson (2) makes two points. The first refers to our strong measurement experiment and the second to the weak measurement one.

In his first point, Svensson (2) notes that if we (strongly and simultaneously) measure the location of all three particles, then we will always find two in the same box. This is true, but its meaning was discussed in the paper: When we try to measure simultaneously whether particles 1 and 2, 1 and 3, and 2 and 3 are in the same box, then the measurements disturb each other. However, the fact that these measurements disturb each other and cannot be performed simultaneously does not mean that we cannot gather information by separately measuring each pair. What is crucial in our experiment is the fact that both the preselection and the postselection are fixed from the beginning and do not depend on the selection of which pair of particles we decide at random to measure. For such a situation in classical physics (unless we endow the particles with supplementary internal degrees of freedom that can be used to spy on us), we always have a nonzero probability of finding the two test particles in the same box. Such is not the case in our quantum experiment.

It is also important to emphasize that the strong measurements discussed above are only one way of testing what is going on in our setup. We can actually test all three pairs simultaneously by making the measurements less disturbing by decreasing the strengths of the measurement interaction (and accepting some inevitable degree of uncertainty), as illustrated in the "first" and "second" experiments presented in the paper. These experiments show that, indeed, no two particles are in the same "box"; the effects that should occur when two particles are in the same box do not occur in our setup.

The second part of the comment from Svensson (2) (his third paragraph) is based on a factual error: There is no "dark port" in our experiment. Both detectors have the same probability (1/2) to record each particle. The interferometer is not balanced due to the presence of the phase shifter; hence, the comment does not apply.

1 Aharonov Y, et al. (2016) Quantum violation of the pigeonhole principle and the nature of quantum correlations. *Proc Natl Acad Sci USA* 113(3):532–535.

2 Svensson BEY (2016) Even quantum pigeons may thrive together. *Proc Natl Acad Sci USA*, 10.1073/pnas.1601890113.

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The authors declare no conflict of interest.

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