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Comments on "First Results of the Phase II SIMPLE Dark Matter Search"

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The SIMPLE Collaboration has reported results from their superheated C_2ClF_5 droplet detectors [1, 2], including the first description of acoustic discrimination between α decays and nuclear recoils in the SIMPLE detectors. The acoustic discrimination is leveraged into impressive sensitivity to dark matter particles, but the SIMPLE paper invites questions that are not fully addressed by their publications nor in the recent exchange on the preprint server [3, 4].

These questions begin with Figure 1 of [1], which shows four classes of data points: α calibration, neutron calibration, α run, and neutron run. From the text it is clear that the solid symbols (α run and neutron run) are from the same dark matter search data, with α events defined solely as being those above the 100 mV threshold drawn on the plot. From the figure, one would guess the same to be true of the α and neutron calibration data, since both sets have tails that extend to their side of the 100 mV line and cut off abruptly. However, the text indicates that the two calibration sets are from separate detectors, meaning Fig. 1 shows three total datasets: an α-spiked set, a neutron calibration set, and the physics data.

The neutron calibration data (open circles in Fig. 1) represent "the high concentration SDD response to neutrons." Although the high concentration SDD is not mentioned elsewhere, we infer it is a detector with a different distribution of droplets from the detectors used in either the physics run or the α calibration. We understand that the process of calibration destroys the SIMPLE detectors, precluding irradiation before or during physics runs [4]; however, without a neutron calibration with the same style detector as those used to collect the other data, both the claim of acoustic discrimination against α decays and the reported sensitivity to nuclear recoils from dark matter particles are in question.

The difficulty in applying calibrations taken with one detector to another with different characteristics is evident in further examination of Figure 1. The authors acknowledge that their neutron calibration data and the events identified as background neutrons in their physics data do not match, noting that "the difference in the two distributions... results from performing the calibrations with a 15 cm water shield to enhance the tails on the moderated neutron spectrum." This statement suggests that acoustic emission from nuclear recoils is energy dependent. Two other experiments using superheated fluids, PICASSO [5] and COUPP [6] (of which we are members), have reported acoustic discrimination without observing any energy dependence. An alternative explanation offered in [4] suggests that the tail on the acoustic amplitude distribution is being enhanced through manipulation of the interaction rate. It seems most plausible that the different distributions can be attributed to differences in droplet size, droplet density or some other characteristic of the detectors.

In any of these scenarios, the better than 97% acceptance of the acoustic cut observed for the neutron calibration data would not appear to apply to the distribution of low amplitude events from the physics run identified as background neutron-induced recoils. The application of this cut efficiency to a potential dark matter signal and the resulting limits on that signal are therefore not justified.

Finally, the SIMPLE Collaboration claims that the acoustic power (amplitude squared) for α decays is 400 times larger than for nuclear recoils, while both PICASSO and COUPP have reported acoustic powers 4 times larger for α decays than for nuclear recoils over a wide frequency range. The width of the acoustic power distribution for nuclear recoils in the SIMPLE detectors is similarly inflated. Given the spread in technologies employed by COUPP and PICASSO (bubble chamber and superheated droplet detectors, respectively), it is surprising that the acoustic response of the SIMPLE detectors should be so different.

The calibrations presented in the letter do not adequately support the SIMPLE Collaboration's claims of acoustic discrimination between α decays and nuclear recoils, and we believe the observed acoustic distributions could be attributed to differences between detectors. Without neutron calibrations of the relevant detectors, we must call into question the reported dark matter sensitivity. We look forward to the resolution of these concerns as more information becomes available.

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