Axion Detection via CNNs: A Computational Approach to Unveiling Dark Matter

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The ADMX experiment utilizes a microwave haloscope to directly detect axions, a theoretical particle that is the proposed solution for the Strong CP problem and a strong candidate for dark matter. Because axions are so elusive and rare, a high detection probability is crucial. This project proposes a convolutional neural network (CNN), a deep learning framework commonly used for image recognition, to distinguish signal from noise in an axion haloscope. An axion lineshape model was combined with a haloscope noise model to simulate plots of axion signals as well as pure background noise. Specifically, a residual neural network (ResNet) was trained on 10,000 simulated images. Overall, the ResNet was able to differentiate signal from noise with a training accuracy rate of 89% and a testing accuracy rate of 84%. These results conclude that deep learning-based methods, like the ResNet CNN, can serve as powerful tools to increase the detection probability of axion signals in the haloscope setting. From using this model, axion searches in the future can operate at a higher sensitivity and efficiently and advance the understanding of dark matter and the Standard Model.

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