The Search for Galactic Halo Axions

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We outline the progress of the Axion Dark Matter eXperiment (ADMX) to search for axions trapped in the halo of the Milky Way galaxy. Axions, originally postulated to solve the strong CP problem in particle physics, would have been created as cold (non-relativistic) very weakly interacting particles in the early stages of the expansion of the universe. If their mass is in the range 1-100 μeV, axions could be a significant component of the dark matter in the universe. The discovery of the axion, or placing limits on its abundance, would therefore have very important implications for understanding the nature of dark matter, which is one of the most significant problems in contemporary physics.

Axions can be detected by their conversion to microwave photons in a strong magnetic field (via the inverse Primakoff effect). The ADMX experiment employs a high-Q ($\sim10^5$) 200 L microwave cavity that can be tuned slowly through the expected axion mass range. The cavity is held at low temperatures (< 2K) in a field of ~7 T. If the density of axions is close to the value required to account for all of the dark matter ($\sim10^{14}$ cm^{-3} in our galaxy), the signal detected would be of the order of 10^{-22} W. SQUID pre-amplifiers followed by broad-band HEMT amplifiers are used to obtain the required sensitivity and the frequency is swept at a rate of the order of 2 MHz/day.

To date, ADMX has ruled out axions with masses in the 2.0-3.6 μeV range (mc^2/h of 480-860 MHz) as predicted by the stronger of two axion models. Future experiments will use cavities cooled to dilution refrigerator temperatures in order to increase the signal-to-noise ratio by 20x, allowing the full band of the expected axion mass and coupling space, even in the case of pessimistically coupled models, to be scanned by the next generation of ADMX.

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