Abstract

Measurement of Paraphotons in the Double Chooz Experiment Using Articulated Arm Calibration Methods
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This thesis details the design, development, and use of a novel calibration system for the Double Chooz experiment, the Articulated Arm. The Articulated Arm is capable of making radioactive source deployments throughout the volume of the Double Chooz Neutrino Target with a precision of < 1 cm. The Articulated Arm is a powerful asset, able to validate detector response through direct comparison of on-axis and off-axis points.

This thesis also details a search for paraphoton signals in the Double Chooz 3rd publication dataset. The paraphoton is a light, electrically neutral, axion-like particle, generated from adding a new $U(1)$ symmetry of Baryon number - Lepton Number, with a Lagrangian of the form: $\mathcal{L} = -\frac{1}{4}F^{\mu\nu}F_{\mu\nu} - \frac{1}{4}B^{\mu\nu}B_{\mu\nu} - \frac{1}{2}\chi F^{\mu\nu}B_{\mu\nu} + \frac{1}{2}m^2_{\gamma'}B_\mu B^\mu$. We search for decays of these particles inside the Double Chooz Far Detector using a rate-based method. We observed no events in excess of background, giving a new laboratory limit on the photon-paraphoton mixing angle χ at the 95% confidence level for paraphoton masses between 26 and 30 keV. Our limiting value was $\chi > 4.23 \times 10^{-3}$ for $m_{para} = 26$ keV paraphotons.