A Novel Method of Determining Air Shower Muon Half-Life Using Time of Flight

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Muons are less understood elementary particles that have applications such as interference-proof navigation and structural analysis through tomography. The goal of this project was to find a new way to measure their half-life rather than mean-life by utilizing time of flight over large altitude changes. Self-constructed coincident scintillating detectors derived from available plans were taken on a commercial plane flight and used to measure muon count rate as a function of altitude. An equation was derived to convert altitude into time of flight in the muon's frame of reference, as time dilation plays a significant factor on the muons measured in this project. This time of flight was then used to find the half-life of the particles. The closest half-life values were found to be ~ 15% lower than the actual half-life of the muon. As lower altitude ranges were used, lower half-life values were observed. Poisson statistics were used to ensure that background radiation was not the cause of the disparity. The most likely cause of the disparity was physical phenomena not able to be measured with the detectors used in this project; a correction was therefore applied for these phenomena. These corrections were found to be statistically significant toward the actual half-life of the muon through a single-factor ANOVA test. This project not only effectively demonstrates Einstein’s theory of special relativity, but also a novel method of determining elementary particle lifetime that can be applied to further research.

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