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The Muon Capture in Nuclear Physics

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Abstract

An intriguing probe for examining nuclear characteristics is the muon. Negative muons can be stopped inside a substance, which makes it simple to create muonic atoms. Following its capture by the nucleus, the muon orbits the nucleus at extremely close distances because of its far higher mass than the electron.

Keywords: Muon; Muonic Atoms; Synchrocyclotrons

Introduction

The study of muon capture in nuclei has traditionally taken a backseat to other areas of particle and nuclear physics. There haven't been many significant discoveries there, but it has frequently served as a haven where people could appreciate the wonders of nature and test theories that had been developed elsewhere. Subatomic physics has benefited from the strong interaction. There have been several significant discoveries made there that serve as the basis for many of our paradigms of particle physics, including "The Standard Model." Muon physics has played a significant role in this progress, with muon capture in nuclei serving as a helpful auxiliary. Most of the fundamental ideas in the area stem from the 1950s and 1960s, when it developed from research conducted at the old synchrocyclotrons [1,2].

The meson factories experienced a second coming in the 1980s and 1990s; many old issues were rectified, though many still exist. We contend that the complexity of the nuclear environment, not a lack of knowledge of weak interactions, is to blame for these unanswered questions [3]. As a result, we can now employ muon capture as a great way to test how well we comprehend complex nuclei. There is a very real possibility that our understanding will significantly advance thanks to recent advancements in calculation technology for the shell model in quite heavy nuclei.

Experiments on the interesting muon particle are being done in the fields of nuclear, atomic, and particle physics. By monitoring the spin precession and dynamics of muons inside of materials using the SR technique, one can also conduct applied research while investigating the interior magnetic fields of the sample under investigation.

According to the Standard Model of particle physics, muons are categorised as so-called leptons, like electrons, and belong to the second family. Since the muon was discovered in 1936, it has undergone substantial research into its properties [4].

Muonic Atom Spectroscopy

A negatively charged muon is caught by a nucleus to form a muonic atom. A target substance is irradiated with a negative muon

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beam to create such an atom [5]. Through their interactions with the target's outer atomic electrons, muons gradually lose kinetic energy. The muon is drawn to the nucleus Coulomb force and creates a muonic atom when it is sufficiently slowed down to have atomic electron-like velocity.

Conclusion

Due to the muon's tight orbits around the nucleus, muonic atoms can be employed to analyse nuclear characteristics with high sensitivity. The entire muonic energy level system may be easily recreated by measuring the energy of the distinctive X-rays that the caught muon emits as it cascades down to the ground state using a method known as muonic atom spectroscopy. In this manner, the absolute nuclear charge radius and the quadrupole moment of the nucleus can be derived from the recorded X-ray spectra. The quadrupole moment causes a hyperfine structure of the muonic transitions, whereas the nuclear charge radius causes general shifts in the energy levels.

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