Simulation Study of Laser Ionization of Muonium by 1S-2S Excitation for the Muon $g-2$/EDM Experiment at J-PARC

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(Received January 10, 2020)

The laser ionization of muonium is studied as a method for the muon $g-2$/EDM experiment and also for the precision measurement of muonium 1S-2S laser spectroscopy experiment, both being prepared at the Japan Proton Accelerator Research Complex (J-PARC). Ionization of thermal muonium via 1S-2S transition will be firstly demonstrated by pulsed 244 nm laser. This paper presents the simulation study to estimate the muon yield of the demonstration experiment, including the surface muon transmission, the muonium formation, the yield from the silica aerogel target and the extraction of the thermal muon.

KEYWORDS: muon, $g-2$, muonium, laser ionization

1. Introduction

The muon $g-2$/EDM experiment proposed at J-PARC [1] aims to measure muon's anomalous magnetic moment and electric dipole moment with a precision of 0.1 ppm by utilizing the thermal muon beam, a source of room-temperature muons. The surface muons with the momentum of 28 MeV/c will be firstly generated by proton beam (3 GeV) at J-PARC Materials and Life Science facility (MLF) and then extracted to one of the muon beamline, H-line [2]. Surface muons will be stopped in the silica aerogel and then form thermal muoniums atoms (μ^+e^-, or Mu). Mu will diffuse into the vacuum, where it will be ionized by laser and converted into thermal muon (25 meV) for the further acceleration. The scheme of the re-accelerated thermal muon beam is summarized in Fig. 1.

The laser ionization of Mu is a crucial step to the entire experiment, which consists of two process. The first is Mu 1S-2S two-photon excitation with a 244 nm laser. The second is a subsequent ionization with a 355 nm laser to generate thermal muons. It will be the first time to realize the ionization of Mu by using the silica aerogel material combined with the 244 nm laser. Comparing with other laser systems such as Lyman-α (122 nm) laser to excite