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Muon Cooling for Muonium Spectroscopy and Interferometry

Muonium, a pure leptonic two-body system, is a powerful probe for precise QED tests and new physics searches. High-precision spectroscopy of muonium provides the best determination of the muon-to-electron mass ratio. For instance, muonium ground-state HFS microwave spectroscopy determined the mass ratio to 120 ppb [1]. Uncertainty in theoretical predictions for QED tests and new physics searches using muonium HFS [2] or 1S-2S spectroscopy is predominantly limited by the precision of the mass ratio. Thus, an independent muon mass determination would be a breakthrough for new physics searches with muonium spectroscopy. We propose determining the muon mass by constructing a Ramsey-Bordé interferometer involving muonium [3]. This requires a low-energy, high-brightness muon beam. Such a beam is useful not only for muonium interferometry but also for μSR measurements and in-flight spectroscopy of excited muonium. A two-stage muon cooling scheme combining a solid rare-gas moderator (LEM) and muonium laser ionization (USM) would be effective for this purpose [4]. In this contribution, we report on the muon moderator development, the scheme's first stage.
[1] W. Liu et al., Phys. Rev. Lett. 82 711 (1999).
[2] M.I. Eides, Phys. Lett. B 795, 113 (2019).
[3] S. Kanda, J. Phys.: Conf. Ser. 2462 012029 (2023).
[4] S. Kanda, in Proceedings of J-PARC2024, accepted for publication.

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