Tune-out wavelength calculation for helium

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The tune-out wavelength is the wavelength at which the frequency dependent polarizability of an atom vanishes. It can be measured to very high precision by means of an interferometric comparison between two beams. This paper is part of a joint theoretical/ experimental project with K. Baldwin et al. (Australian National University) [1] and L.-Y. Tang et al. (Wuhan Institute of Physics and Mathematics) [2] to perform a high precision comparison between theory and experiment as a probe of atomic structure, including relativistic and quantum electrodynamic effects. We will report the results of calculations for the tune-out wavelength that is closest to the $1s2s\ ^3S - 1s3p\ ^3P$ transition of ^{4}He at 413 nm. Our result for the $M = 0$ magnetic substate, obtained with a fully correlated Hylleraas basis set, is $413.084\,109\,440(12)$ nm, where the figures in brackets indicate the computational uncertainty. This includes a leading relativistic contribution of $-0.059\,218\,5(16)$ nm from the Breit interaction as a perturbation, and a relativistic recoil contribution of $-0.000\,044\,47(17)$ nm. A leading QED correction of 0.004 150 93 nm is also included, but not higher-order corrections or their uncertainty. The results will be compared with recent relativistic CI calculations [2].

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[1] B. M. Henson et al., Phys. Rev. Lett. **115**, 043004 (2015).
[2] Y.-H. Zhang et al., Phys. Rev. A **93**, 052516 (2016).