Determination of the ionization energy of the metastable $2\,^1S_0$ state of ^{4}He through Rydberg series extrapolation

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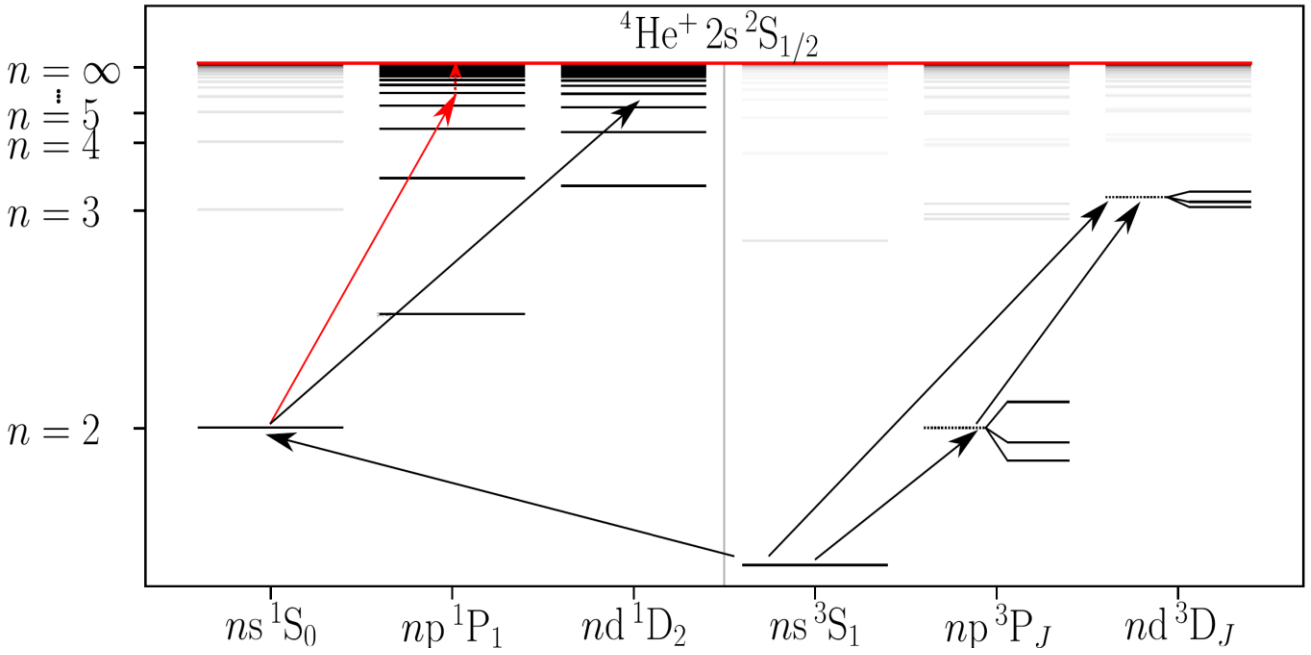

Complete $\alpha^7 m$ Lamb shift of helium triplet states[1]

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We have derived the complete formula for the $\alpha^7 m$ contribution to energy levels of an arbitrary triplet state of the helium atom, performed numerical calculations for the $2\,^3S$ and $2\,^3P$ states, and thus improved the theoretical accuracy of ionization energies of these states by more than an order of magnitude. Using the nuclear charge radius extracted from the muonic helium Lamb shift, we obtain the theoretical prediction in excellent agreement with the measured $2\,^3S - 2\,^3P$ transition energy [X. Zheng *et al.*, Phys. Rev. Lett. **119**, 263002 (2017)]. At the same time, we observe significant discrepancies with experiments for the $2\,^3S - 3\,^3D$ and $2\,^3P - 3\,^3D$ transitions.

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$$E(\alpha) = \alpha^2 m E^{(2)} + \alpha^4 m E^{(4)} + \alpha^5 m E^{(5)} + \alpha^6 m E^{(6)} + \cdots$$

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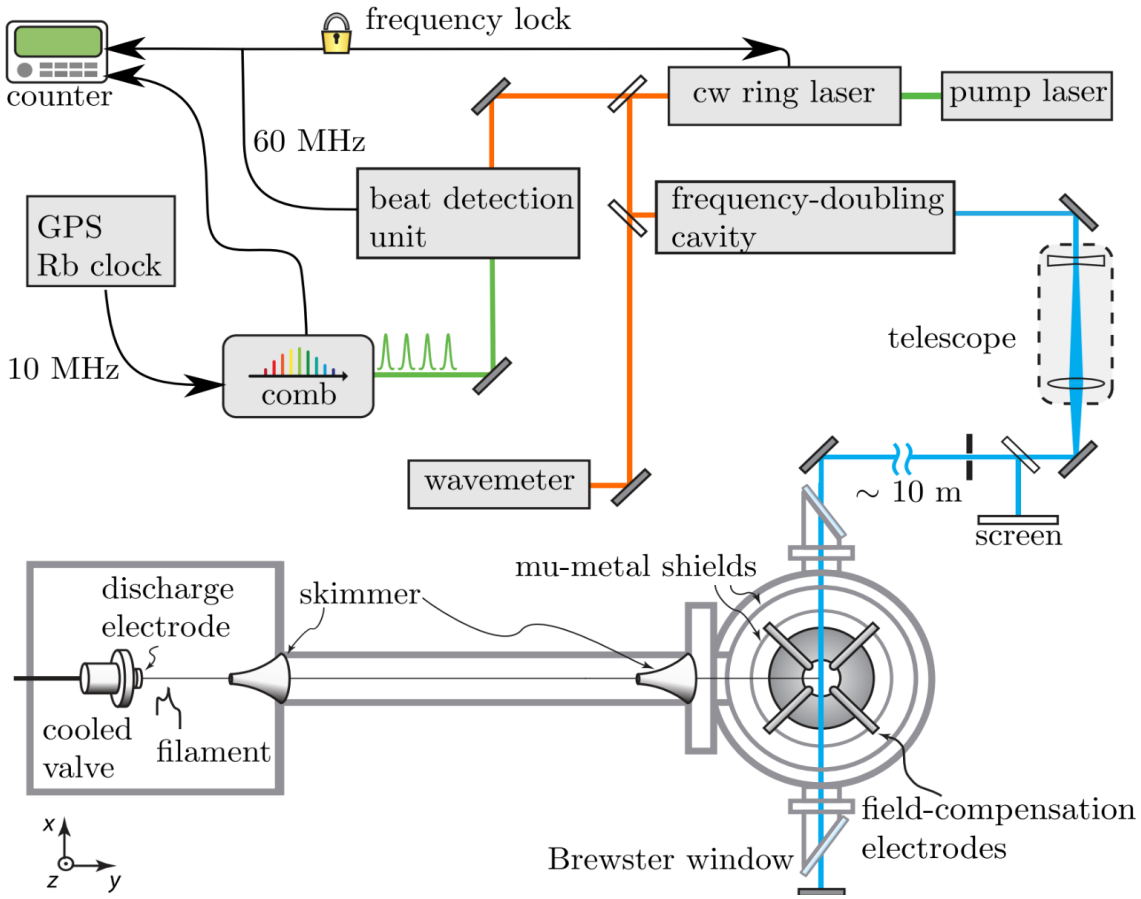
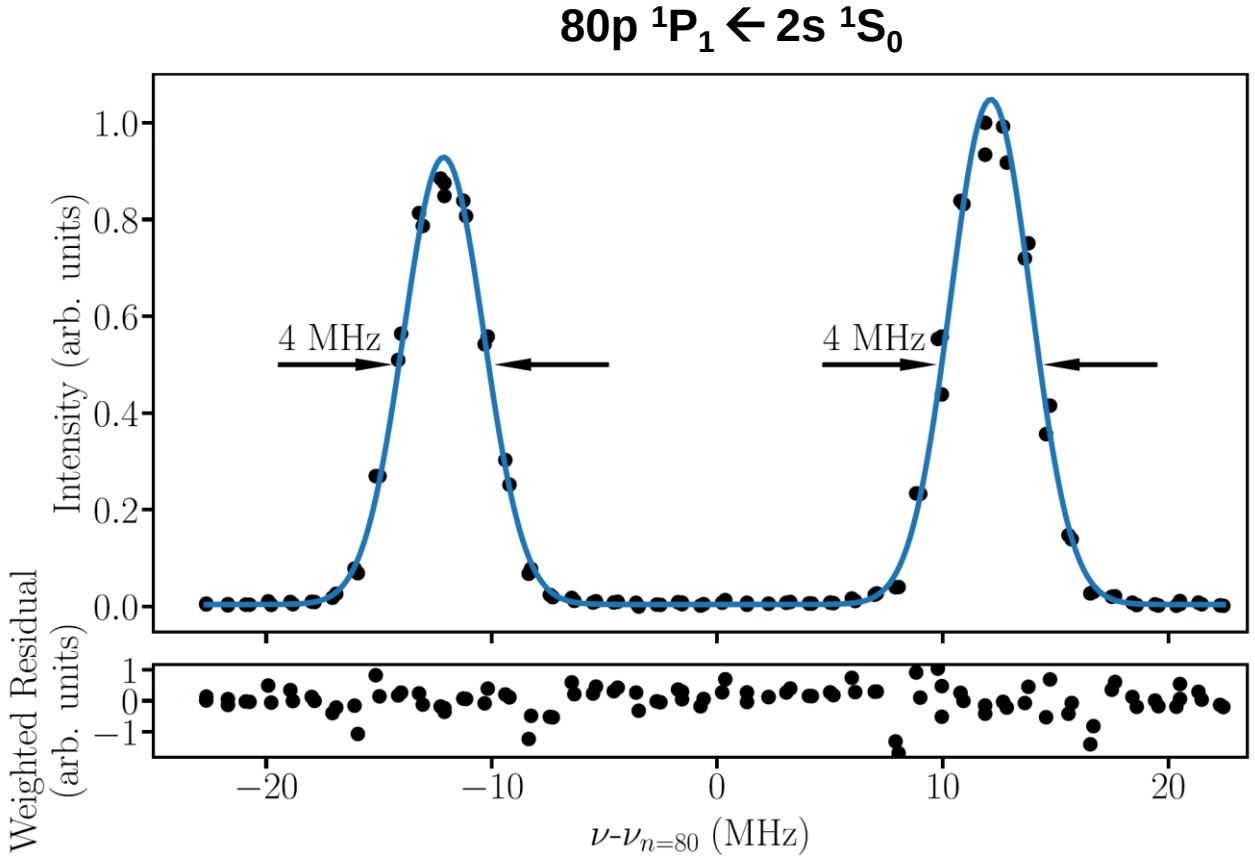
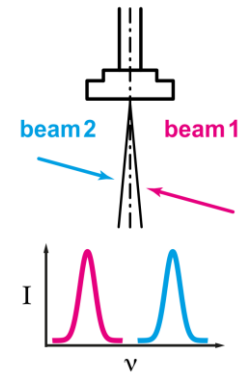
[1] Patkóš *et al.*, PRA **103**, 042809 (2021)

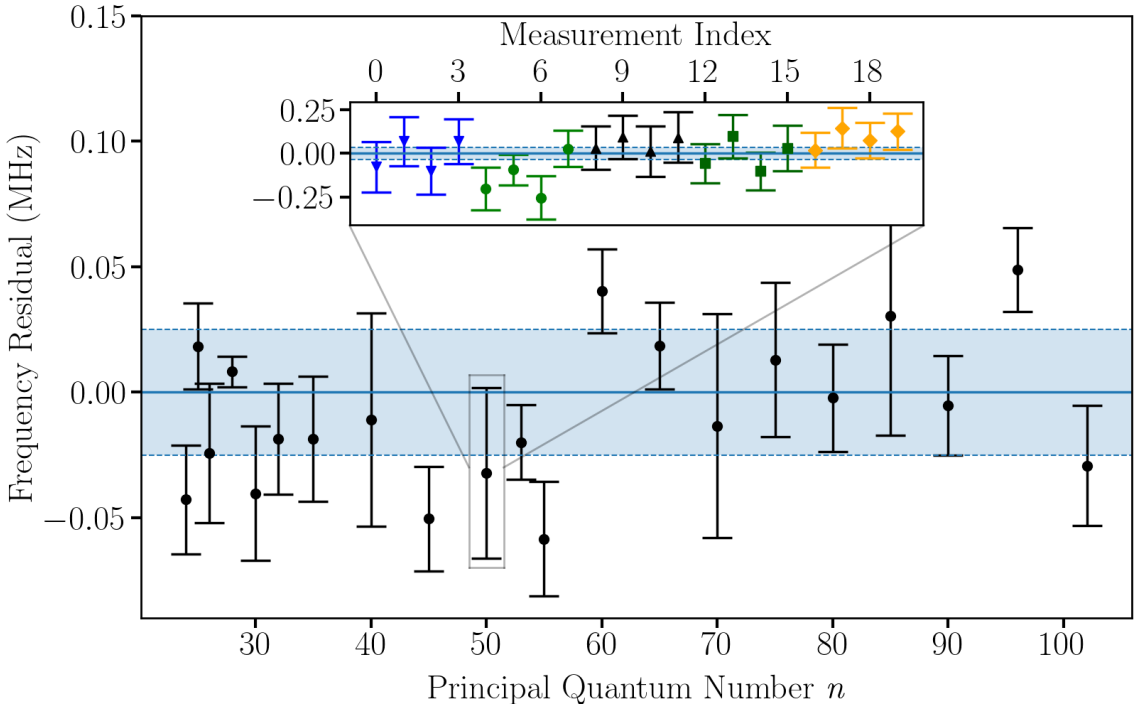
Experimental Methods







Results and Discussion



	Experiment	Theory	ΔE_I
$2\,^3S_1$	1 152 842 742.640(32)	1 152 842 742.231(52)	0.409(61)
$2\,^3P$	876 106 247.025(32)	876 106 246.611(16)	0.414(42)
$3\,^3D_1$	366 018 892.638(65)	366 018 892.691(23)	-0.053(69)
$3\,^1D_2$	365 917 748.688(34)	365 917 748.661(19)	0.027(38)

„we conclude that the most plausible explanation of the discrepancy would be some unknown theoretical contribution shifting the 2 ^{3}S and 2 ^{3}P states by approximately the same value" [1]

$$E_{\mathrm{I}}/h = 960\,332\,040.491(0.025)_{\mathrm{stat}}(0.020)_{\mathrm{syst}}\ \ \mathrm{MHz}^{2}$$

[1] Patkóš *et al.*, PRA **103**, 042809 (2021)
[2] Clausen *et al.*, PRL **127**, 093001 (2021)