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Two-photon laser spectroscopy of antiprotonic helium

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The precision of laser spectroscopy of antiprotonic helium (a helium atom with one of its electrons replaced by an antiproton) has improved by almost 4 orders of magnitude over its 20 years of history. Experimental transition frequencies can be compared to 3-body QED calculations to derive the antiproton-electron mass ratio.

In the latest measurements of the Asacusa experiment at CERN, two-photon transitions of antiprotonic helium were excited using two counterpropagating laser beams. This method reduces the Doppler-broadening caused by the thermal motion of the atoms, and allowed us to measure the transition frequencies with a fractional precision of 2.5-5 parts in 10^9. From these frequencies, we derived an antiproton-electron mass ratio of 1836.1526736(23). Our precision approaches that of the experimental value of the proton-electron mass ratio, and agrees with the latter within errors. Assuming CPT symmetry (i.e. $m_p=m_pbar), we further derived the electron's atomic mass as m_e=0.0005485799091(7)u from the more accurately known atomic mass of the proton.

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