The scattering length difference between the $b_1$ and $b_0$ states of $n^3\text{He}$ using a neutron interferometer

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We report a determination of the $n^3\text{He}$ scattering length difference $\Delta b' = b'_1 - b'_0 = (-5.411 \pm 0.051) \text{ fm}$ between the triplet and singlet states using a neutron interferometer. This revises our previous result $\Delta b' = (-5.610 \pm 0.042) \text{ fm}$ obtained using the same technique in 2008. A sample placed in one of the beam paths of the interferometer causes a phase shift that is proportional to sample’s scattering length density, thickness and $n$ wavelength. For this experiment, polarized neutrons were incident on the interferometer and the relative phase shift caused by a spin-dependent interaction with a polarized $^3\text{He}$ target was measured. The neutron polarization and spin flipper efficiency were determined separately using helium-3 analyzers to $<0.1\%$ relative uncertainty. This re-evaluation comes from new phase shift data taken in 2013 and a partial reanalysis of the 2008 data that includes a systematic correction caused by magnetic field gradients which was previously underestimated. Scattering lengths of low Z materials are important for both providing inputs into effective field theories and testing nuclear models. This result along with other measured values of $b$ for $^3\text{He}$ will be compared to nucleon models.

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