Determination of πN scattering lengths from pionic hydrogen and pionic deuterium data

A. Deloff

Soltan Institute for Nuclear Studies, Hoza 69, 00-681 Warsaw, Poland
e-mail:deloff@fuw.edu.pl

The πN s-wave scattering lengths have been inferred from a joint analysis of the pionic hydrogen and the pionic deuterium x-ray data using a non-relativistic approach in which the πN interaction is simulated by a short-ranged potential. This potential is assumed to be isospin invariant and its range, the same for isospin I=3/2 and I=1/2, is regarded as a free parameter. The proposed model admits an exact solution of the pionic hydrogen bound state problem, i.e. the πN scattering lengths can be expressed analytically in terms of the range parameter and the shift (ϵ) and width (Γ) of the 1s level of the pionic hydrogen. We demonstrate that for small shifts and short ranges from the exact expression one retrieves the standard range independent Deser-Trueman formula. The πd scattering length has been calculated exactly by solving the Faddeev equations and also by using a static approximation. It has been shown that the same very accurate static formula for πd scattering length can be derived (i) from a set of boundary conditions; (ii) by a reduction of Faddeev equations; and (iii) through a summation of Feynman diagrams. By imposing the requirement that the πd scattering length, resulting from Faddeev-type calculation, be in agreement with pionic deuterium data, we obtain bounds on the πN scattering lengths. The dominant source of uncertainty on the deduced values of the πN scattering lengths are the experimental errors in the pionic hydrogen data.