Protonium atom $Pn(n = 30,\ l)$ formation in $\bar{p} + \mathrm{H}(1s)$ collisions at very low energies

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We are interested in very low energy collisions of antiprotons with hydrogen atoms, $\bar{p} + \mathrm{H}(1s)$, for which a full quantum mechanical calculation is desired. If we assume the kinetic energy of the antiproton to be less than 11.12 K the protonium (Pn) will be formed preferably in states with principal quantum number n given by $n = \sqrt{\mu_{p\bar{p}}} \sim 30$, where $\mu_{p\bar{p}}$ is the reduced mass of the protonium. We shall focus on the formation in specific individual Pn-states, which is needed if the properties of protonium are to be studied.

Recently, Esry and Sadeghpour (2003) have started calculations of protonium formation in $\bar{p} + \mathrm{H}$ collisions at very low energies, using hyperspherical coordinates in a hyperradial adiabatic approach, where for the representation of the adiabatic eigenfunctions a Jacobi-channel direct product of basic splines has been used [1].

Here, in a similar approach, we utilize a natural generalization of the spheroidal coordinates, namely the hyperspheroidal coordinates [2, 3].

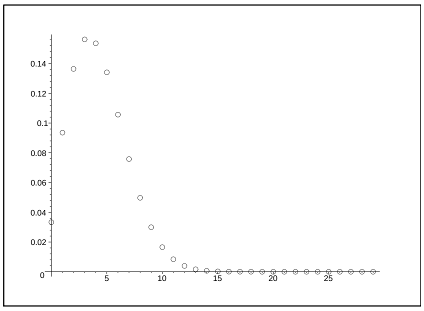

Figure 1: The $Pn(n = 30, l = 0\text{–}29)$ formation probability in $\bar{p} + \mathrm{H}(1s) \to e + Pn(nl)$ collisions.

From the Figure we can conclude that the states with $l = 0 - 9$, where l is the $Pn(n = 30,\ l)$ orbital angular momentum, are expected to be rather densely populated. Details of the calculations will be presented.

[1] B. D. Esry, and H. R. Sadeghpour, Phys. Rev. **A67**, 012704 (2003).
[2] A. V. Matveenko, Phys. Lett. **B129**, 11 (1983).
[3] A. V. Matveenko, and H. Fukuda, J. Phys. **B29**, 1575 (1996).