Antiproton collisions with excited positronium

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We discuss the recent progress in the calculation of antihydrogen formation via excited positronium (Ps) colliding with antiprotons using the fully quantum mechanical convergent close-coupling (CCC) and the classical trajectory Monte Carlo (CTMC) methods. The goal is to provide the cross section data to maximise the production of antihydrogen in the experiments currently being undertaken at CERN [1, 2, 3]. The motivation for undertaking these difficult experiments has been given by Charlton *et al.* [4], and includes tests of symmetry as searches for departures from the Standard Model of Particle Physics, and antimatter tests of the Weak Equivalence Principle of General Relativity.

From the theoretical perspective, the antihydrogen formation process is the time-reverse of positronium formation in positron-hydrogen scattering. The details of the corresponding two-centre CCC theory have been given by Kadyrov and Bray [5], while the details of the CTMC approach have been given by Abrines and Percival [6]. Given the diverse approaches it is interesting to observe where the two theories agree and where they don't. In particular, at what stage does the generalised correspondence principle [7] bring the two theories together.

Preliminary results of the calculations, aggregated over the orbital angular quantum numbers, have been recently reported [8], which allow for estimates of all relevant cross sections at arbitrary energies and arbitrary excited states Ps(nl). Here, we shall present the cross sections for specific initial states, and discuss the agreement of the two theoretical approaches to the problem of antihydrogen formation.

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