A new time-dependent scattering theory: application to the capture of antiprotons by hydrogen atoms and helium atoms

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We developed a time-dependent scattering theory [1, 2] to study a general Coulomb three-body scattering problem in the low collision energy region. The working equation of the theory

$$|\Psi^+(0)>=-i\int_{-\infty}^{0} e^{i(E-H+i\eta)t}V|\Psi_0>dt+|\Psi_0>,$$

which is equivalent to the formal time-independent scattering equation, provides an intuitive physical picture. To solve the above equation numerically, we (1) discretize the space in the pseudo-spectra grid, in which we can put denser grids in the inner region; (2) use an energy-dependent absorber to filter out the outgoing wavepacket in the outer region smoothly; (3) propagate the wave-function by the split-operator-method, which makes the problem solvable with a reasonable computation afford. By this *non-perturbative full quantum* method, we studied the state-specified capture process of antiprotons by hydrogen atoms, which was not solved by any other method. Figure 1 shows the cross sections of the antiproton captured to the (n, ℓ) states at 2.72 eV and 10 eV incident energies. For the lower incident energy (2.72 eV), the antiproton is mainly captured to the highest possible n ($n = 33$) from the energy conservation and highest possible ℓ. For the higher incident energy (10eV), the antiproton is captured to a broad region in the n, ℓ-space. The detailed numerical method and the comprehensive results will be presented in the workshop. The preliminary results of the capture cross section of antiprotons by helium atoms will also be presented.

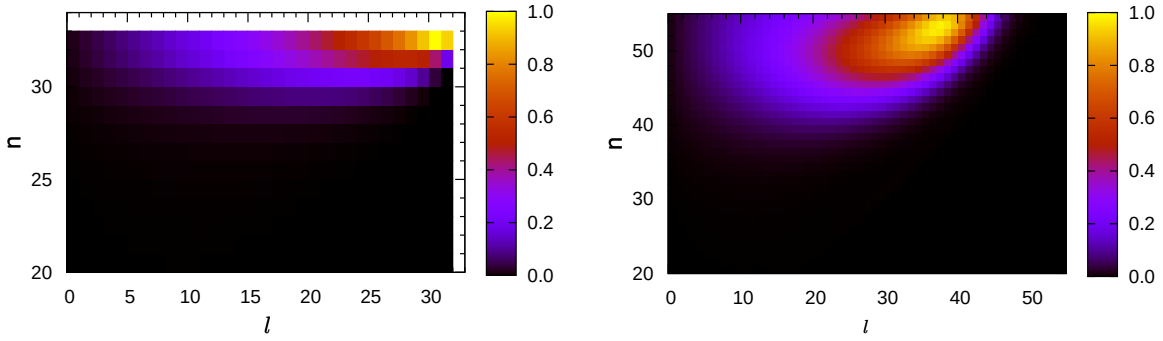

Figure 1: The state-specified (n, ℓ) capture cross sections of antiprotons by hydrogen atoms at 2.72 eV (right) and 10.0 eV (left) incident energies in the center of mass frame.

References

[1] X. M. Tong, K. Hino, and N. Toshima, Phys. Rev. Lett. **97**, 243202 (2006).

[2] X. M. Tong, T. Shirahama, K. Hino, and N. Toshima, Phys. Rev. A **75**, 052711 (2007).