

Electron impact excitation of hydrogen and helium in Coulomb-projected Born methods

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Abstract. Coulomb-projected Born methods for the theoretical study of electron impact excitation of hydrogen and helium are reviewed. The results obtained by using different forms of Coulomb-projected Born methods are compared with other theoretical and experimental results and analyzed. The inadequacy of the variable charge Coulomb-projected Born approximation (VCCPB)—the most recent form of the Coulomb-projected Born methods—in giving good results in processes where exchange is dominant is discussed in detail. The 'modified' VCCPB approximation obtained by modifying the VCCPB method to remove its shortcomings is also discussed and its application to electron impact excitation of 2^3s state of helium is studied.

Keywords. Electron impact excitation; hydrogen; helium; Coulomb projection; screening; distorted wave; exchange potential; antisymmetrized.

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1. Introduction

The Coulomb-projected Born approximation consists basically of modifying the usual Born approximation by taking an explicit account of the Coulomb interaction between the projectile and the target nucleus. Different ways of taking this Coulomb interaction into account have led to different CPB methods—Geltman's Coulomb-projected Born approximation (CPB) (Geltman 1971, 1976), generalized Coulomb-projected Born approximation (GCPB) (Stauffer and Morgan 1975) and variable-charge Coulomb-projected Born approximation (VCCPB) (Schaub-Shaver and Stauffer 1980a). Geltman's CPB method has been applied by Geltman and Hidalgo (1971) and Hidalgo and Geltman (1972) to evaluate the direct scattering amplitude for electron impact with hydrogen and helium. No account of exchange was taken. A better CPB study of e^- -H scattering was carried out by Stauffer and Morgan (1975) who also included exchange contributions. These authors extended the CPB approximation by introducing a screening parameter which takes partial account of the screening of the nuclear charge by the bound electrons. Calculations were carried out for several values of the screening parameter and results in (reasonable) agreement with experiment were obtained. More recently Schaub-Shaver and Stauffer (1980a) generalized this model by making the screening parameter a function of the distance between the incident particle and the target atom. This VCCPB approximation has been applied to electron impact excitation of hydrogen (Schaub-Shaver and Stauffer 1980a) and hydrogen-like ions (Schaub-Shaver and Stauffer 1980b) and it was found that the calculated total cross-