Final State Three-Body Coulomb Effects in the ^{208}Pb(^{8}B,^{7}Be p)^{208}Pb Coulomb Breakup

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The knowledge of the ^{7}B(p,( )^{8}B fusion rate is crucial for the determination of the high-energy solar neutrino flux. For this reason, both direct and indirect measurements have been performed to determine the astrophysical factor $S_{17}(0)$ of this reaction [1]. There are two types of indirect measurements, the Coulomb dissociation and the method of asymptotic normalization coefficients (ANC). The Coulomb dissociation of ^{8}B at an incident energy of ~50 MeV/A as measured in RIKEN [2] gave $S_{17}(0)=18.9 \pm 1.8$ eVb while the most recent measurement of the same reaction but at an incident energy of 250 MeV/A at GSI [3] resulted in a slightly higher value of $S_{17}(0)$.

The theoretical analysis of the Coulomb breakup is complicated by the E2-contribution and by the post-decay Coulomb acceleration (PCA) of the fragments ^{7}Be and p in the Coulomb field of the target nucleus. In our previous work [4] we had developed a novel approach to treat correctly the final state Coulomb rescattering of ^{7}Be and p in the Coulomb field of a ^{208}Pb nucleus, by taking into account the leading term of the three-body Coulomb scattering wave function in the relevant asymptotic region. The latter is characterized by the fact that the distance between two of the particles, in the present case the two fragments of ^{8}B, is much smaller than the distance between their center of mass and the third particle, which is the target nucleus. There we had approximately estimated the double differential cross section for the ^{208}Pb(^{8}B,^{7}Be p)^{208}Pb breakup for the kinematic conditions of the first RIKEN experiment [5] and had pointed out the importance of three-body Coulomb effects in the final state which are responsible for the PCA.

In this work we present a DWBA calculation of the double differential cross section for the ^{208}Pb(^{8}B,^{7}Be p)^{208}Pb reaction in RIKEN kinematics [5]. The reaction amplitude in the prior-form of the DWBA is given by M_{if} = +$Q_f^{(-)}$|) U|$M_i^{(+)}$$_{,}$, where $Q_f^{(-)}$ is the full final-state three-body scattering wave function,) U is the DWBA transition operator, and $M_i^{(+)}$, is the initial state wave function given as the product of the ^{7}Be-p bound state wave function times the scattering wave function of ^{8}B in the Coulomb field of ^{208}Pb. In the conventional approach the final state wave function is taken as a product of the continuum wave function for the relative motion of the fragments ^{7}Be and p times the scattering wave function of the center of mass of these two fragments in the Coulomb field of the target nucleus. However, such a wave function does not generate any PCA. The novelty of our approach consists in using a genuine three-body scattering wave function for the final state [6,7]. In the present calculations we took into account only its leading asymptotic term in the relevant region when the relative distance between the fragments is much smaller than the distance between their center of mass and the target nucleus. Both E1- and E2-multipoles are included. When calculating the radial matrix element, the integration over the impact parameter is carried out from its classical value, which is defined by the scattering angle, up to infinity. For sufficiently small scattering angles the minimal impact parameter is significantly larger than the distance between the fragments, *i.e.*; the conditions of validity of the asymptotic form of the three-body Coulomb scattering wave function are satisfied.

Calculations of the double differential cross section $d^2F/dS_f dE_{Bep}$ have been performed for a ^{8}B beam energy E_i of 46.5 MeV/A, for scattering angles ranging from 1E to 4E. The results show that the influence of three-body Coulomb effects (PCA) is important for relative kinetic energies of the fragments of 300 keV and less. For example, at 300 keV for a scattering angle of 2.5E the final state three-body Coulomb interaction increases the double differential cross section by . 7.5% over that calculated in the conventional approach, while at 600 keV the double differential cross section increases only by . 1.3%. Since this increase is nothing but the manifestation of the PCA it is quite obvious that the latter has to be taken into account in accurate determinations of the astrophysical factor $S_{17}(0)$ from double differential Coulomb breakup cross sections. When E is decreasing and the scattering angle is increasing the PCA effect gets larger. As expected the contribution of the $E1$-transition to the cross section is dominant.

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