Surface-integral approach to scattering theory

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It is customary to define the scattering amplitude in terms of the scattering wavefunction and the potential of interaction. Despite the fact that the Coulomb wave function and the Coulomb potential are both known analytically, the conventional theory is not able to provide a standard definition for the amplitude of scattering of two charged particles, which yields the Rutherford cross section. Such a definition has been given only recently [1] in a so-called surface-integral approach. Consider now breakup of a bound state of two particles in collisions with a third particle when all particles are charged. Here again the conventional theory fails to give a formal definition for calculating the breakup amplitude in post form in terms of the total wavefunction with outgoing scattered-wave boundary conditions describing this breakup process. For the atomic three-body problem such a form of the breakup amplitude has also been given recently [2,3] in the same approach.

The goal of our work is to extend the general formalism of scattering theory to cover two-body and three-body systems with long range interactions with Coulombic tails. The extension is based on a surface-integral approach. New definitions for the potential scattering amplitude valid for arbitrary interactions are presented. For the Coulomb potential the generalized amplitude gives the physical on-shell amplitude without recourse to a renormalization procedure. New representations for the breakup amplitude in a three-body system are derived. This is shown to resolve a long-standing problem about the missing conventional *post* form of the breakup amplitude for the long-range Coulombic interactions. The new forms are found to have equivalent surface-integral forms well suited for practical calculations. Finally, we derive the surface-integral representations for amplitudes for all other possible scattering processes taking place in an arbitrary three-body system.

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