Analysis of Nuclear Scattering Through Polology.

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Summary. — The analyticity of the S-matrix in the complex momentum (k) plane is utilized for studying the elastic scattering of alpha-particles by $^{12}$C using a representation for the S-matrix expressed as a product over its poles and zeros in the complex k-plane. Differential cross-sections are calculated with this representation for the S-matrix and compared with experiment. The effect of the phase factor in the representation for the S-matrix on the angular distributions is also studied.

1. Introduction.

The analyticity of the S-matrix in the complex momentum and angular-momentum planes can be exploited for the analysis of nuclear scattering. The nuclear scattering can be studied in terms of the poles of the S-matrix in the momentum (k) plane for physical values of the angular momentum $l$ or in terms of the poles in the $\lambda$ (= $l + \frac{1}{2}$) plane when k is either real or purely imaginary. These are just two different mathematical procedures for analysing the same phenomenon. In a number of recent papers $(^1)$ the method of complex angular momentum has been applied to describe low-energy nuclear scattering. The advantages of the complex angular-momentum technique

over the momentum-plane approach has been discussed and established in some cases in ref. (6). However the study of nuclear scattering through $k$-plane poles presents a simple and straightforward approach and facilitates a fairly good fit to experimental data in a few cases. The purpose of this paper is to elucidate these cases.

There are two principal ways of expressing the $S$-matrix in the $k$-plane. One is by expanding the $S$-matrix according to Mittag-Leffler Theorem (7) as a sum over pole terms and a nonresonant background term which is due to potential scattering. If the potential scattering is known, then the partial-wave amplitude and hence the cross-section can be determined by simply knowing two parameters, namely the position and width of the resonance. However such a calculation involves the determination of residues which is quite tedious especially if a many-level formula is used for the $S$-matrix. Another representation (8,9) for the $S$-matrix $S_i(k)$ is to express it as a product extended over all the poles and zeros of $S_i(k)$ in the $k$-plane multiplied by a phase factor $\exp[-2ikR]$ where $R$ can take a certain maximum value equal to the radius of the target. In the present paper this product expansion for the nuclear $S$-matrix is utilized in fitting experimental cross-sections. This method is used in preference to the former one as it does not involve the evaluation of residues and is quite easy to handle. The ambiguity of $R$ can be utilized in fitting theoretical cross-sections to experimental data. In this paper the $\alpha$-$^{12}$C elastic-scattering data is considered (10). This is a case of charged-particle scattering where Coulomb forces are present in addition to nuclear interaction. The analytic properties of the Coulomb nuclear $S$-matrix for complex angular momenta has been investigated in detail (11-13). In the complex momentum plane the Coulomb nuclear $S$-matrix has been shown (13-14) to have a discontinuity along the entire Im$k$ axis and hence one can study only the part of the amplitude obtained by taking the difference between the full amplitude and the Coulomb amplitude by this method. The differential cross-sections are calculated by assuming a product representation for the nuclear part of the $S$-matrix. The only factors that we need for these calculations are the energy levels and widths of the $^{16}$O compound nucleus which decays by alpha emission, and the radius of the $^{12}$C target nucleus.