Preface

In the first part of this book we review diffraction theory, and introduce its asymptotic form. Whereas diffraction theory rests on two assumptions – (i) a small angle of deflection and (ii) the de Broglie wavelength of the incident particle must be small compared to the size of the target from which it is scattered – the asymptotic form requires a further condition: the wavelength associated with the momentum transfer must also be small compared to the size of the scattering target.

We introduce the concept of "trajectories," which are essential for a semiclassical description. In fact, scattering along a semiclassical trajectory that passes the target nucleus at a certain point in the impact plane will often account for a dominant part of the scattering amplitude. This phenomenon is illustrated by a couple of simple examples. Next, we show that it is useful to extend the trajectory concept to the complex impact parameter plane. This is not only a necessity for scattering situations involving absorption, it is also equally useful for purely nonabsorptive cases, when extended into the angular domain of nonclassical scattering.

In the second part, realizing that the nuclear surface region plays a very important role for the scattered intensity distribution, we systematically compare phase shift functions with Gaussian, exponential and more complicated surface falloffs. For each of the cases of Gaussian and exponential edges, we compare several different phase shift functions having exactly the same edge, but a different internal structure. The importance of singularities of the phase shift functions will be stressed and illustrated. Since the derivative of the phase shift function is central to these considerations, we also present examples where this derivative is the starting point, and the phase shift function itself is constructed by the corresponding integration.

In the third part we discuss composite phase shift functions. The basic example is Coulomb plus nuclear scattering; we supplement this with a discussion of scattering from an extended Coulomb charge. In this case, we show how singularities analogous to rainbows appear at the maximum classically allowed scattering angle. Inside the rainbow, there are often oscillations superimposed on the Rutherford

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cross section, due to the interference of contributions from two stationary points, whereas outside, in the classically forbidden regime, the cross section falls off in a more exponential fashion.

Furthermore, we discuss sums and differences of two phase shift functions that have different edge falloffs, as well as combinations of two phase shift functions that have different analytic properties, or singularities of different degrees. All these features lead to more complicated intensity distributions than the more regular patterns seen in Part II.

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