Chapter 11

ELASTIC SCATTERING AND ITS INTERPRETATION

11.1. Introduction

In this chapter we are concerned with the observed characteristics of elastic scattering cross sections, their interpretation, and their description by means of phenomenological models. The model most widely used for this purpose is the optical model, and we give a detailed discussion of this in Chap. 12. There are also descriptions which do not invoke potentials but directly parameterize the scattering matrix. Here we discuss these, the insights they provide, and their relationship to scattering by a complex potential.

Considerable attention is given to the interpretation of the scattering of heavy ions (including alpha particles). This is partly because their short wavelengths and moderate-to-large angular momenta make reasonable a semiclassical approach with its attendant insights. It also reflects the amount of analysis done on these systems. It is entirely possible that the methods developed will later lead to further insights into light-ion scattering; for an early example, see Brink and Takigawa (1977).

11.2. Some qualitative characteristics of elastic scattering

11.2.1. Angular distributions

Although a wide variety of angular distribution shapes are observed for elastic scattering, depending on the energy, the masses, and the charges of the colliding pair, we can distinguish some 'typical' ones and discuss them qualitatively in terms of the physical processes involved. (A more detailed picture will emerge later.) Figure 11.1 indicates four of these, three for protons, alphas, and ^{16}O ions, each with an energy of 10 MeV per nucleon, and one for protons of 40 MeV, all incident on ^{58}Ni. Each cross section is expressed in ratio to the corresponding Rutherford cross section (4.12) for the scattering of point charges, as is often done for charged particles.[1] This procedure somewhat obscures the rate at which the differential cross section decreases with increasing scattering angle; note that the Rutherford cross section itself decreases by more than four orders of magnitude between $\theta = 10°$ and $\theta = 180°$.

Two basic influences are present. One may be represented by a real

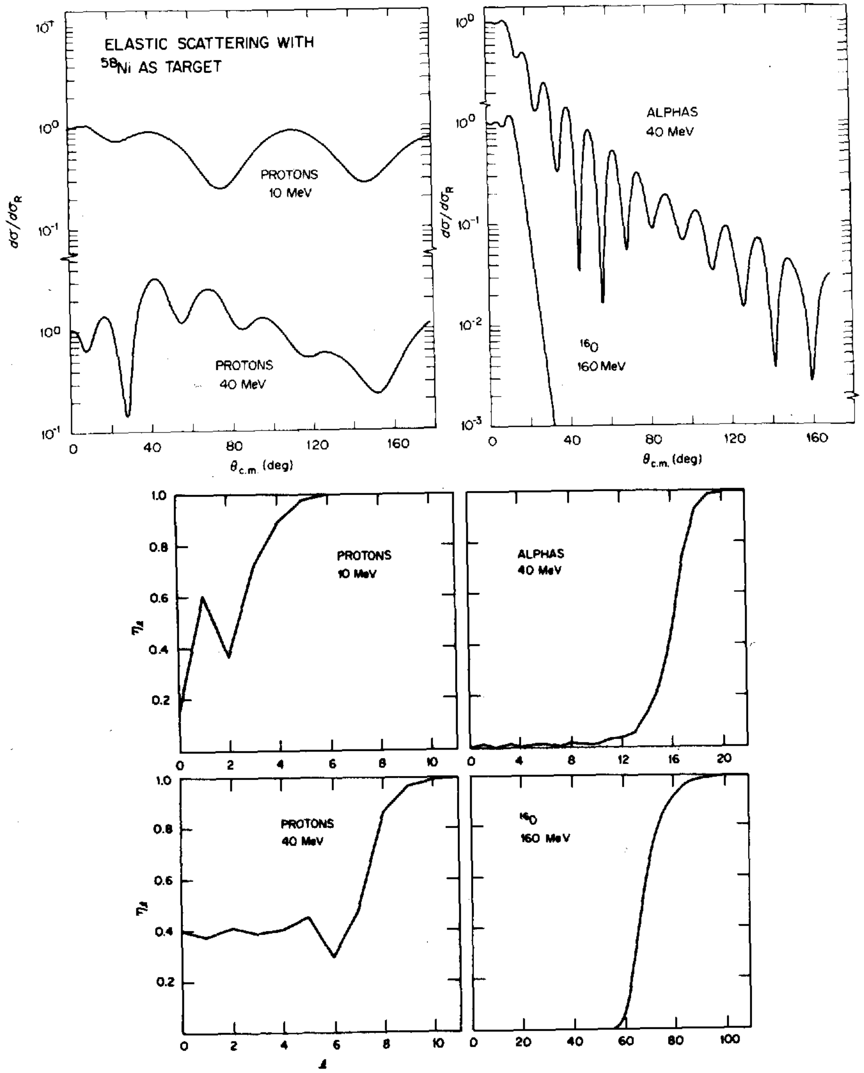

FIG. 11.1. Some typical examples of (a) the differential cross sections (in ratio to the Rutherford cross section), and (b) the reflection coefficients for the elastic scattering of protons, alphas, and ^{16}O ions with energies of 10 MeV per nucleon, and also protons of 40 MeV. Note the changes in scale for the angular momenta.

(conservative) potential of short range arising from the basic nuclear interactions between the projectile and the target. This potential is attractive, at least for peripheral encounters, and causes refraction and reflection of the incident waves. This would be the only influence if the target and projectile were inert, but they are not. Then there is another influence, absorption,