Scattering of one particle on another gives a 'kick', or what the physicist calls 'momentum transfer', to both particles. It is the magnitude of this momentum transfer which measures the scale to which the scattering process can give information on the structure of the particles. The relationship between the resolution Δx to which the spatial structure of the particles can be revealed by the scattering process and the momentum transfer Δp is given by Heisenberg's Uncertainty Principle, $\Delta p \Delta x \cong h/2\pi$ where h is the Planck constant. This relation, in turn, sets the practical energy required for the incident beam if structure down to a specified dimension is to be resolved.

It is well known that Rutherford's scattering experiment led to the discovery of the nucleus, that is the central core of the atom which is about 10000 times smaller in diameter than the atom itself, yet contains almost all of its mass. Figure 2 shows schematically how Rutherford reached his conclusion. It was observed that the number of particles scattered with large momentum transfer (that is, at a large angle) exceeded the amount predicted assuming that the atom was a continuous blob of matter.

It is interesting to note that the analytical tools available to Rutherford to predict how much scattering would occur at what angle had to be based on the then accepted laws of classical mechanics and classical electricity and magnetism. In other words, even though Rutherford's experiments probed matter at a scale smaller than had hitherto been accessible to experimental observation, he had to assume that the physical laws derived from large scale observation were still valid at small distances. Thus, using the same rules to analyse atomic collisions as would be used to analyse collisions between charged ping-pong balls, the conclusions about the existence of the atomic nucleus were drawn.

In retrospect, Rutherford's conclusions were right but his methods were wrong; we know that at the magnitude of momentum transfer which was involved in the collisions observed by Rutherford, the laws of classical mechanics would no longer be valid but that instead the laws of quantum mechanics, which were not established until more than a decade later, were to be applied.

It turns out, however, fortuitously, that the classical and quantum mechanical calculations for the probability of scattering give essentially the same answer provided the scattering is controlled by the laws of electromagnetism, and also provided that the

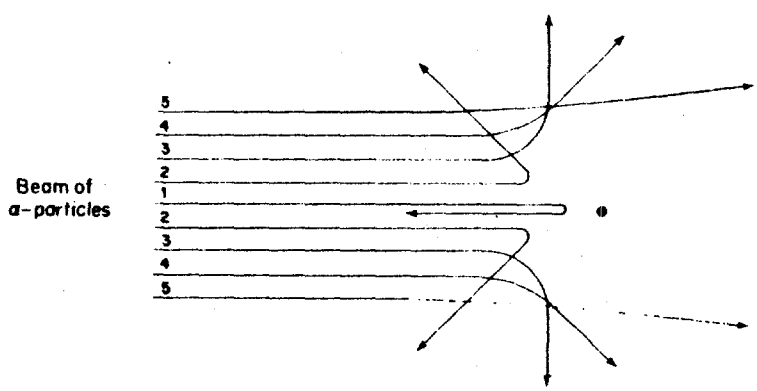

Fig. 2. Schematic representation of orbits of α-particles 'encountering' with a concentrated positively charged object. Note that close 'collisions' result in large angles of deflection, while collisions at a distance produce only a small change in direction of the incident particles.