1. INTRODUCTION

Atomic collision processes were actively studied in the early years of atomic physics (during the early 1930's), but then followed a rather dormant period during which the main activity in physics moved to other areas. During the past ten or so years the atomic collisions field has undergone a considerable revival, made possible by the existence of greatly improved experimental techniques, and stimulated by the need to obtain atomic collisions data for fusion and other purposes. It is the progress in this recent period that I shall discuss in these lectures. I shall concentrate on the spectroscopic aspects, and on those reactions which occur at low impact energies.

Let us start by listing the various processes that can occur when an electron hits a neutral atom. These are

(i) \( e + A \text{ (ground state)} \rightarrow A \text{ (ground state)} + e \)
- elastic scattering,

(ii) \( e + A \text{ (gs)} \rightarrow A^* \text{ (excited state)} + e \)
- inelastic scattering,
  which can be followed either by photoemission,
  \( A^* \rightarrow A^* \text{ (gs or lower excited state)} + hv \),
  or by autoionization
  \( A^* \rightarrow A^+ \text{ (atomic ion)} + e \),
(iii) $e + A \text{(gs)} \rightarrow A^+ + e + e$
- direct ionization,

and
(iv) $e + A \text{(gs)} \rightarrow A^{-*}$ (a temporary negative ion, or resonance),
which can then be followed by any of the reaction products occurring in (i), (ii) or (iii).

Additional processes occurring when the target is a diatomic molecule, $AB$, are

(v) $e + AB \rightarrow A + B + e$
- dissociation,

(vi) $e + AB \rightarrow A^{-} + B$
- dissociative attachment,

(vii) $e + AB \rightarrow A^+ + B + e + e$
- dissociative ionization,

and
(viii) $e + AB \rightarrow AB^{-*}$ (a resonance),
followed by the reaction products of (v), (vi) or (vii).

Examples of most of these processes will be given during the lectures. We shall start by giving a brief description of the type of apparatus typically used in these studies, and will then go on to discuss recent progress under the three headings of (a) elastic and inelastic scattering, (b) ionization, and (c) resonances.

2. EXPERIMENTAL TECHNIQUES

A schematic diagram of a typical electron scattering apparatus is shown in Figure 1. The source of electrons is often a directly heated tungsten 'hairpin' cathode, but indirectly heated thermionic sources and more elaborate sources (for example, from laser induced photoemission) are also sometimes used. The electron beam is focussed, shaped and directed by a set of electrostatic lenses, defining apertures and electrostatic deflectors, after which it enters an energy selector. This device selects a small slice of energy from the thermal distribution emitted by the original cathode. The selector shown in the figure is of the hemispherical electrostatic type, although other geometries of electrostatic energy selectors, and also magnetic energy selectors, are often used. An excellent review of energy selectors has recently been given by Roy and Carette\(^{(2)}\). The energy spread of the beam emerging from the selector can be as low as about 10 meV ($1 \text{ meV} = 10^{-3} \text{ electron volts}$), but is more usually 30 meV or higher. After passing further lenses, defining apertures and correcting deflectors, the electron beam is crossed.