ponentiation in this latter case is approximately two orders of magnitude longer than required for the exponentiation via the cascade.

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RESONANCE IN THE ELASTIC SCATTERING OF ELECTRONS IN HELIUM*

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Several authors have recently discussed the possibility that the elastic cross sections of atoms by electron impact exhibit one or more sharp resonances. Baranger and Gerjuoy[1] postulate the existence of a compound state (He^-) in order to interpret experimental excitation cross sections to the $2\,^3S$ level in helium. Subsequently they have urged[2] that the elastic scattering of electrons by helium be re-examined with better energy resolution, since observation of structure in the elastic cross section would support the idea of the compound model. Recent theories[3] on the elastic scattering of electrons in atomic hydrogen show a sharp resonance below the first electronic state of hydrogen.

Thus, it seemed desirable to examine experimentally the elastic cross section in helium, using electrons with an energy spread considerably narrower than used previously. A sharp resonance is found in the scattered electrons at 72 degrees at an energy of 19.3 ± 0.1 eV, i.e., below the onset of the first excited state, $2\,^3S$ (19.8 eV).

A double electrostatic analyzer, similar to that described previously,[4] is used for the experiment. Figure 1 shows the experimental arrangement. The first electrostatic analyzer is used for production of an electron beam with a half-width of 0.06 eV.[4] The electrons are accelerated into the collision chamber where they are crossed with a beam of helium atoms. Electrons elastically scattered at an angle of 72 degrees are admitted to the second electrostatic analyzer and passed through a slit into an electron multiplier. A vibrating reed electrometer operated at +2000 V is used to measure the current. A simple servomechanism brings the output of the electrometer to ground potential, and the signal is applied to the Y axis of an X-Y recorder.

The vacuum system consists of two 300-liter/sec oil diffusion pumps with liquid nitrogen traps. One pump is used for evacuating the chamber in which the double electrostatic analyzer is located, and the other reduces the pressure still further in the chamber in which the electron multiplier is located.

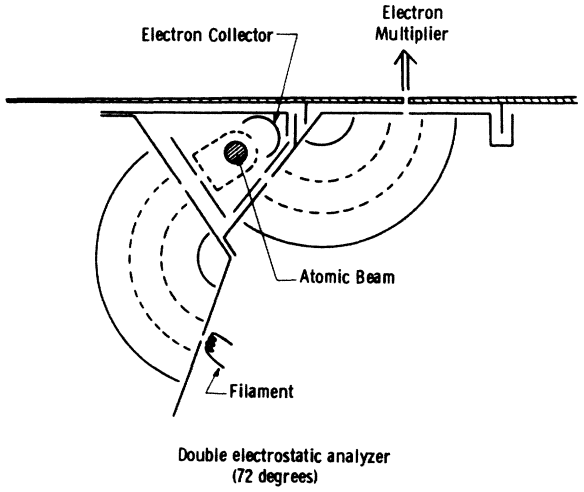

FIG. 1. Schematic diagram of double electrostatic analyzer.

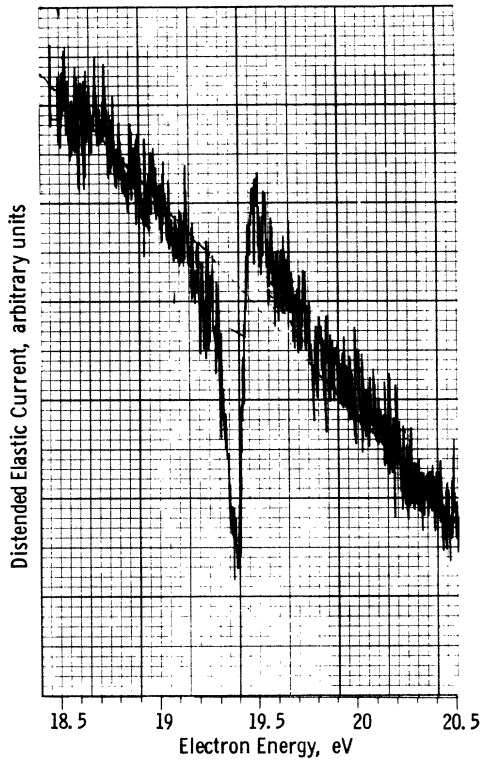

FIG. 2. X-Y recorder trace of elastic cross section vs electron energy. The zero of the elastic cross section is suppressed. The decrease in the cross section at 19.3 eV is approximately 14%.

All electrodes near the electron beam are gold plated, and the whole system is baked at 420°C. The pressure in the collision chamber is varied between approximately 5×10^{-4} and 5×10^{-3} Torr, and the electron beam current is varied between 10^{-10} and 10^{-9} A.

Figure 2 shows a reproduction of a trace obtained on the X-Y recorder. The zero of the elastically scattered electron current is suppressed for clarity, and a sharp resonance is evident. The average value of ten determinations gives 19.3 $\pm$ 0.1 eV for the energy at resonance. The energy scale is calibrated from the onset of He^+. The shape of this resonance, namely the initial sharp dip and subsequent increase, is reproducible. The half-width of the dip is about 0.06 eV and is thus instrumental; the true dip is probably sharper. The dip represents a decrease of about 14 percent of the total elastically scattered current at 72°. No other resonance of comparable magnitude is found in helium, and none at all in argon in the energy range 2-25 eV.

The detailed interpretation of these results must await a comprehensive theoretical analysis. The resonance may be the result of interference between potential scattering and resonance scattering[5] resulting from the formation of a temporary negative ion state.[6] The observed cross-section behavior is also consistent with the multichannel effective range theory[7] which predicts a narrow resonance in the "old" channel below the "new" channel threshold.

The observation of the resonance in the elastic cross section indicates that compound states play a role in electron scattering by atoms just as they have been shown to play a role in neutron scattering[5] by nuclei and in electron scattering[4,8] by molecules such as N_2 and CO. The existence of a compound state must necessarily have a bearing on calculations of atomic excitation cross sections, particularly near the threshold of excitation.

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