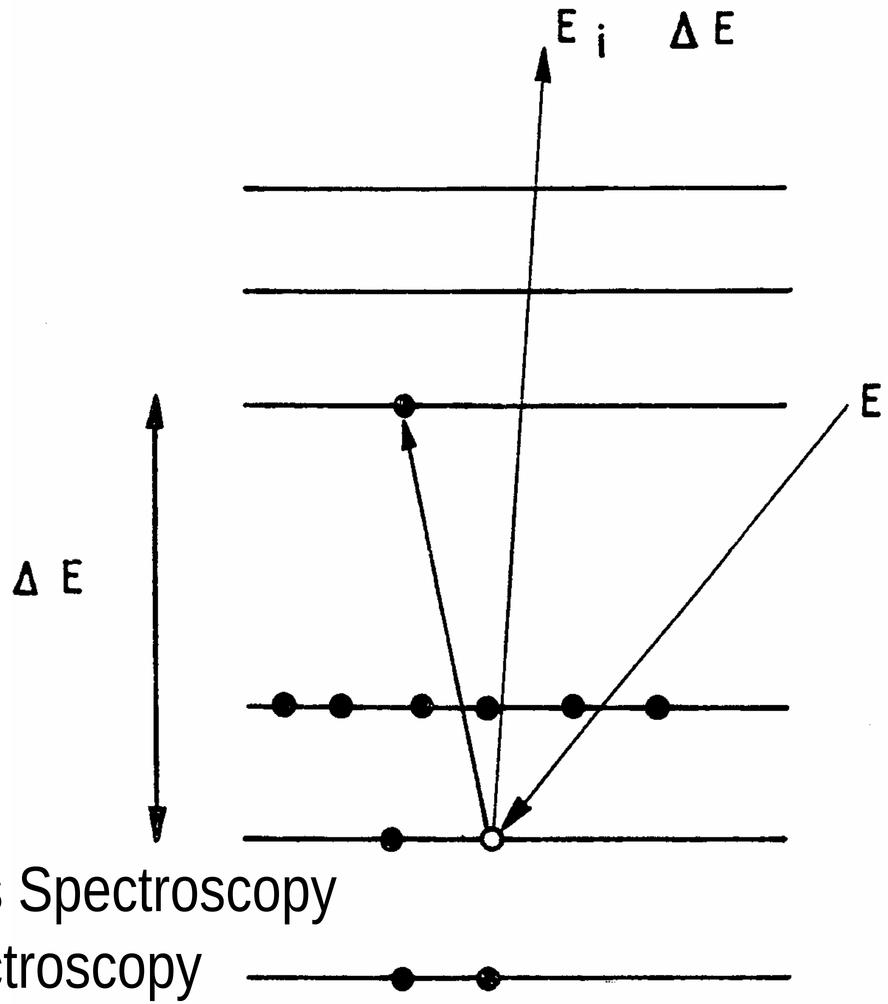
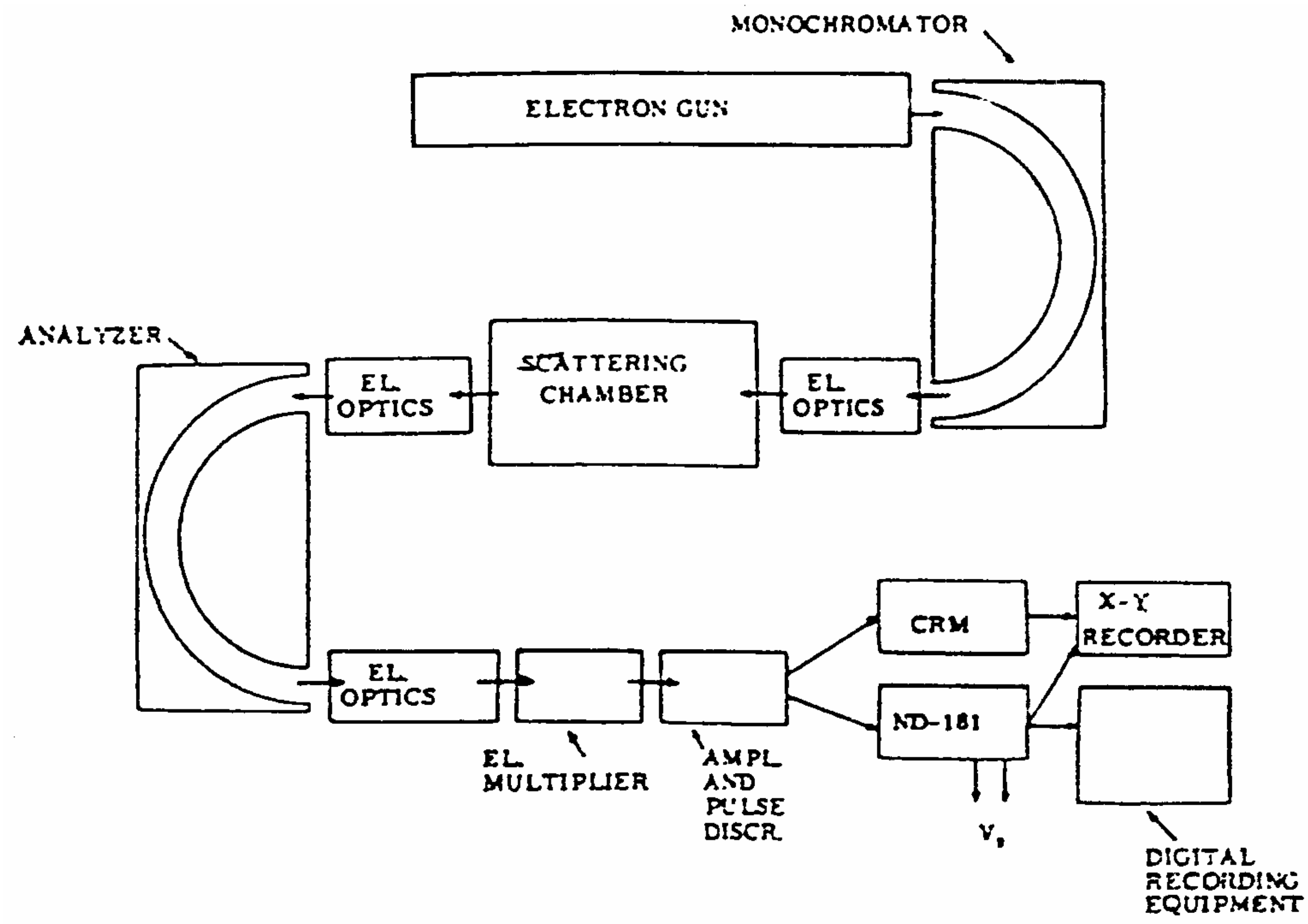
EELS



Electron Energy Loss Spectroscopy
Electron Impact Spectroscopy
Inelastic Electron Scattering

$$M + e_{(E_i)} \longrightarrow M^* + e_{(E_i - \Delta E)}$$



Schematic diagram of the electron-impact spectrometer.

Electron Energy Loss Spectroscopy EELS

I. EELS of molecules

Valence transitions — core transitions

EELS	Resolution	ISEELS Res $\approx$ 100 meV
E_{ex}<100eV	$\sim$ 30 meV	$E_{ex} \approx$ keV

II. High resolution EELS or HREELS

For Surfaces

$E_{ex} \sim$ eV	Res $\sim$ 3-10 meV
	Best $\sim$ 1.8 meV = 14.5cm^{-1}

EELS of molecules

Complementary to optical spectroscopy with several advantages over optical methods.

Light/molecule interaction is electromagnetic.
Electron/molecule is also electromagnetic.
Major component in this is Coulombic
Electron/molecule collisions occur at large distances and electrons suffer only small deviations from their original path
Angular distribution will be forward peaked.
These transitions are similar to optical ones.

Differences occur when the impact energy is comparable to excitation energy.

1. Electron exchange

    singlet $\rightarrow$ triplet
    great cross section enhancement
    isotropic scattering

2. Polarization

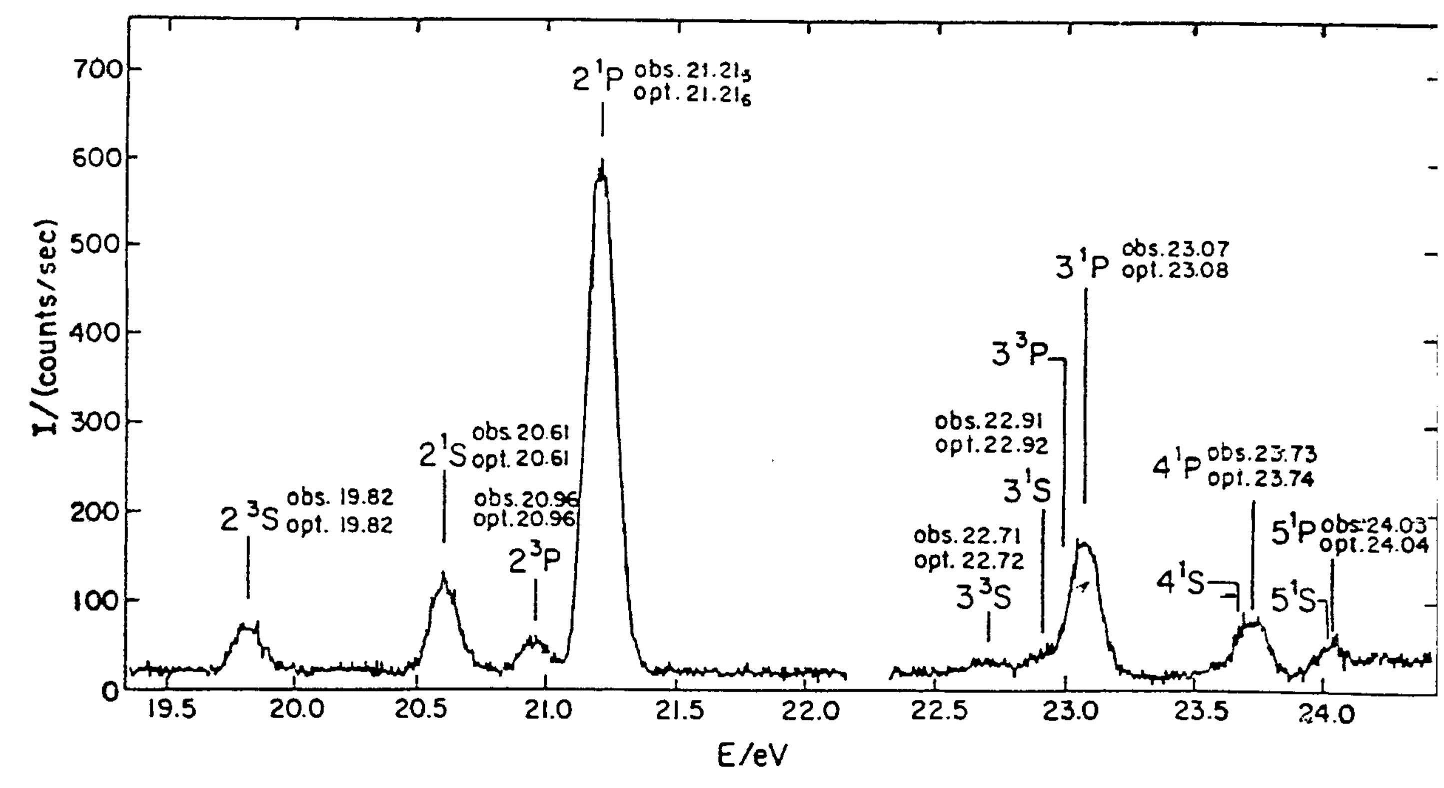
    symmetry forbidden
    complex angular distribution

How to determine such transitions?

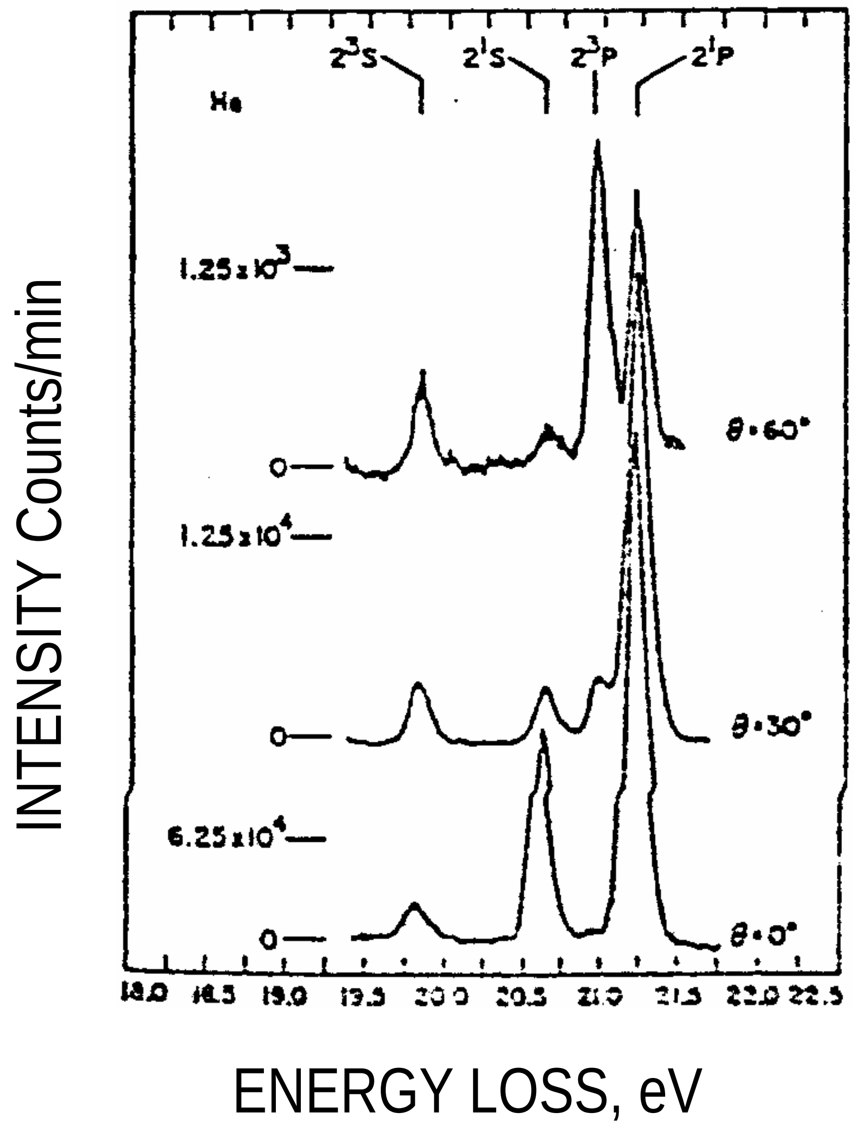
1. Angular dependence
2. Impact energy dependence

Other low energy electron impact spectroscopy

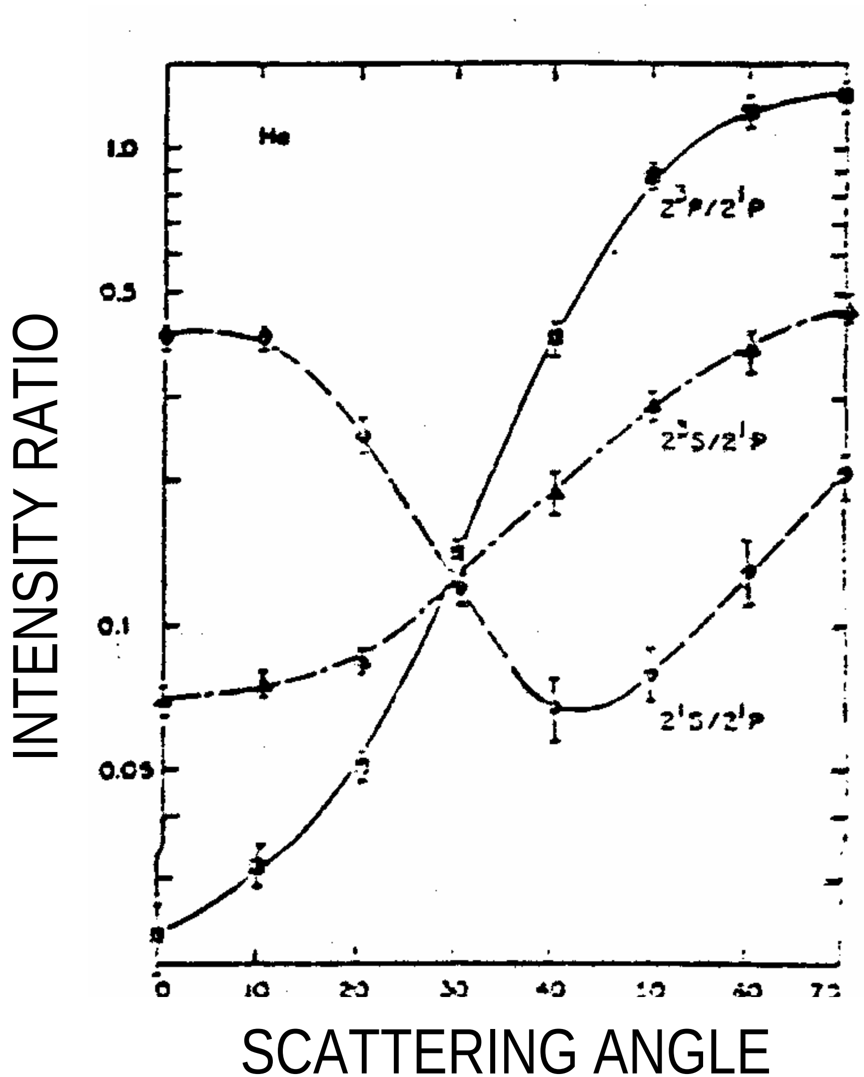
Threshold excitation spectroscopy
Neutral and negative ion states
Resonances in the integral cross sections
Due to –ve ion formation



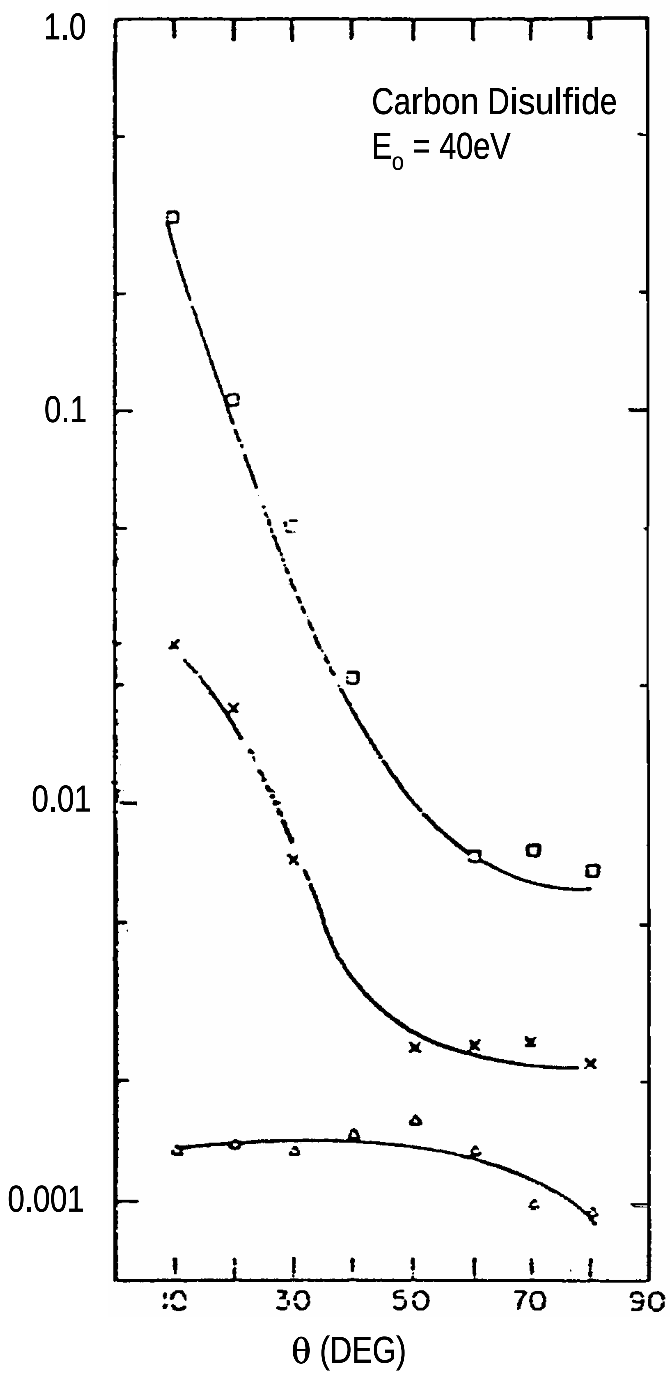
Electron energy-loss spectrum of helium; 35-eV incident electron energy; 25^{o} scattering angle; torr pressure gauge reading; $4x10^{-9}$ A incident beam current; 0.15-eV resolution (FWHM of the elastic peak) voltage step of 5 mV/channel and a scan rate of 2 sec/channel.



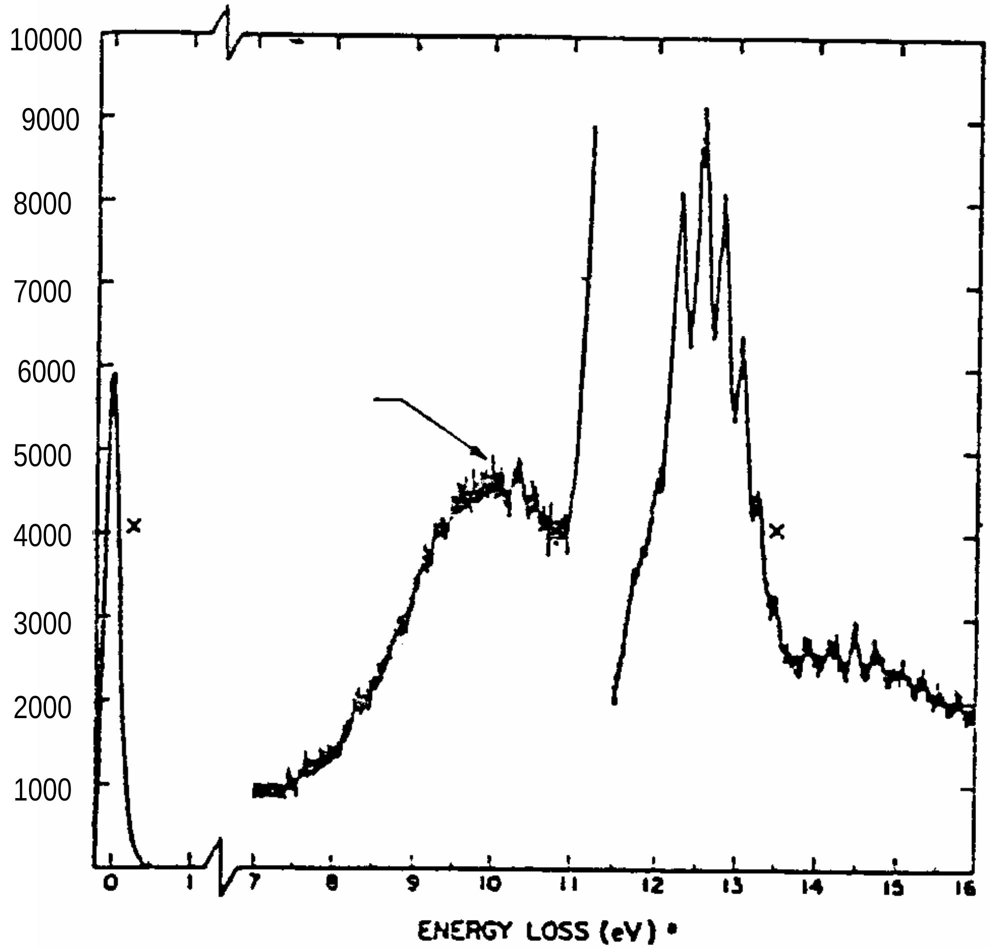
He
2³S
2¹S
2³P
2¹P
1.25 x 10³
1.25 x 10⁴
6.25 x 10⁴
0
0
0
θ = 60°
θ = 30°
θ = 0°
18.0 18.5 19.0 19.5 20.0 20.5 21.0 21.5 22.0 22.5
INTENSITY Counts/min
ENERGY LOSS, eV



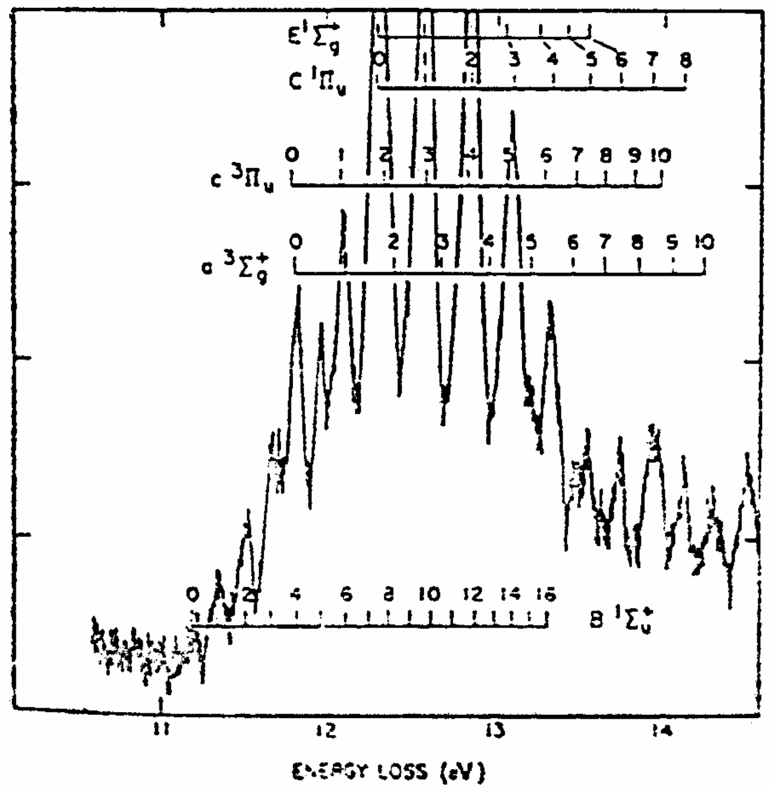
Peak intensity as a function of scattering angle for the three lowest transitions in helium with respect to that of the $1^1S \rightarrow 2^1P$ transition.



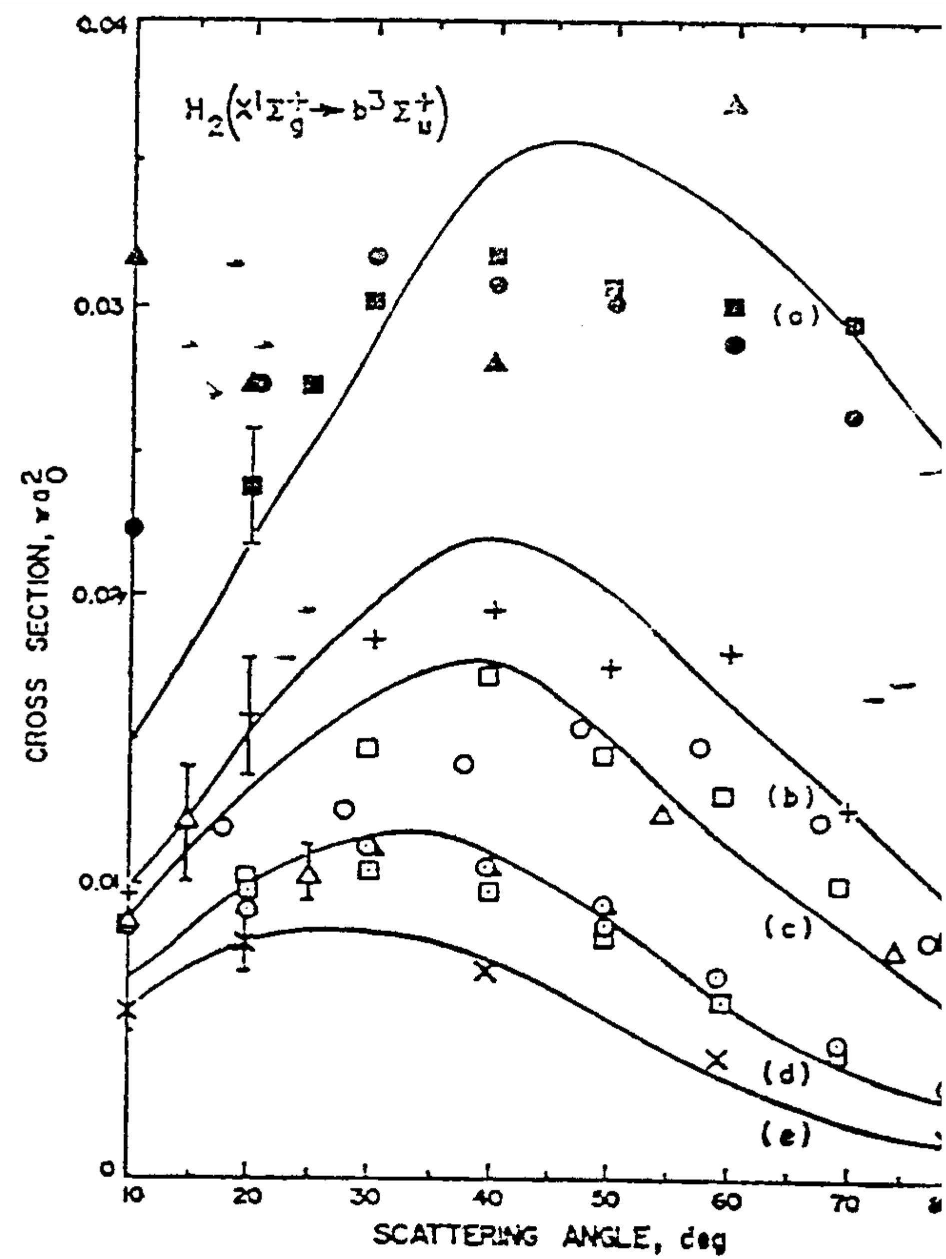
Differential cross sections (DCS) for three Kinds of electronic transitions in carbon disulfide, As a function of scattering angle (θ), or an incident electron energy (E_0) of 40 eV. The arbitrary units in the ordinate are the same for all transitions. The one at 6.27 eV energy loss is optically allowed, the one at 3.91 eV energy loss is spin-allowed but symmetry-forbidden, and the one at 3.36eV is spin-forbidden. Scale factors are numbers by which DCS values were multiplied before being plotted.



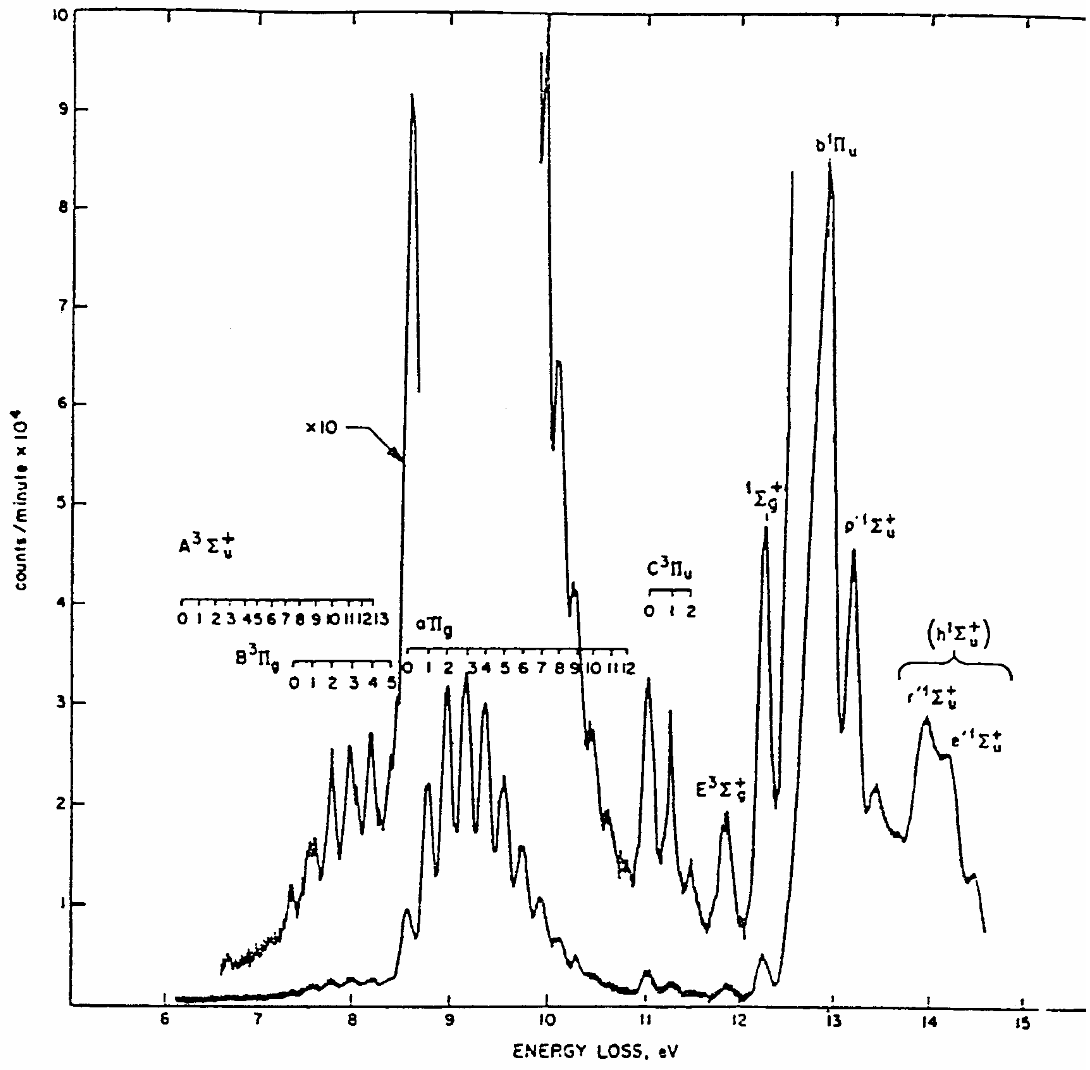
Electron energy-loss spectrum of molecular hydrogen; 50-eV incident electron energy; 40º scattering angle; 2x10^{-2} torr pressure; 2.8x10^{-3} A incident current; 0.20-eV resolution; rate meter mode.



E ¹Σg⁺
C ¹Πu
c ³Πu
a ³Σg⁺
B ¹Σu⁺
11
12
13
14
ENERGY LOSS (eV)



Differential scattering cross Sections for the transition $X^1\Sigma_x^+ \rightarrow b^2\,\Sigma_u^+$ in molecular Hydrogen as a function of Angle at (a) 25-eV, (b) 35-eV, (c)40-eV, (d) 50-eV, and (e) 60-eV impact energies. The solid curves are calculated values and the discrete points are experimentally determined



Electron energy-loss spectrum of nitrogen; 40-eV impact energy; 20^o scattering angle; 10^{-2} torr pressure; rate meter mode.

Core shell spectroscopy