INTRODUCTION

The optical spectra of dimers [1-3] and trimers [4-6] of alkali and other [7] metal clusters have been explored in molecular beams with considerable success. It was expected that the spectra of larger clusters would be complex and congested with thermal broadening by vibrational and rotational effects. Few data are yet available for larger clusters except for measurements of ionization potential. The IP represents transitions to an ion state from the highest occupied state of a neutral cluster. The variation of IP with cluster size is related to the behavior of the highest occupied levels in a series of clusters. These transitions form an important first chapter in the development of cluster spectroscopy [7-11]. Experiments on series of clusters demonstrate the existence of energy levels which may be investigated within individual clusters, and represent the uniqueness of the metal cluster state.

IONIZATION POTENTIALS AND ABUNDANCE SPECTRA

Ionization potentials (IP) have recently been measured, Fig. 1, for K clusters containing from N = 3 to 101 atoms [9-10]. While local maxima in the curve appear at the spherical clusters $n_s$, local minima occur for all the clusters $n_s+1$ immediately succeeding the spherical

![Fig. 1](image-url)  
Fig. 1  Ionization potentials for potassium clusters N = 3 - 101, showing major shell closings and fine structure.
ones. These adjacent maxima and minima result in the observed sharp drops at the shell closings. These features in the IP curve correlate well with the patterns in the abundance spectra, Fig. 2, and are related to the relative binding energies of neighboring clusters [12].

The abundance spectra were taken by sweeping the mass selective detector at fixed detector ionizing photon energy. A cluster ionization potential was derived from the threshold of a PIE [13] curve of detected intensity vs photon energy for constant mass. The location of the IP discontinuity at a spherical cluster in the series may also be found [10] by taking a succession of abundance spectra over a given mass range, with a slightly different photon energy for each spectrum. In Fig. 3 we can see the general shift in IPs between the adjoining lg

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Fig. 2 Abundances for potassium clusters (a) N = 3 - 51, ionization by filtered xenon arc lamp; (b) N = 50 - 98, ionization by CW dye laser.