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Strong Forward-Backward Asymmetries in Electron Emission from Overlapping Resonance States in Fast C^{3+} on He Collisions+

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Autoionizing electrons from the configuration $1s^2 2pnl$ produced by transfer and excitation were measured for 2.5-5.0MeV C^{3+} + He-gas collision employing the method of zero-degree Auger spectroscopy[1]. The electron analyser was operated with an energy resolution of 300 meV(FWHM), which corresponds to the projectile rest frame energy resolution ~40meV.

In figure 1, are shown the electron spectra referring the energy scale to the projectile rest frame for both the electrons emitted in forward(0°) and backward(180°) directions. Autoionization peaks corresponding to the Coster-Kronig transitions $1s^2 2pnl \rightarrow 1s^2 2s\varepsilon l'$ are clearly resolved up to n=10. For n=5 and 6 each group splits into several lines due to the quantum defect and the term splitting produced by the coupling of the nl electron with the 2p electron. At higher energies a step-like decrease at the series limit ($n\rightarrow\infty$) appear for ~8 eV. Surprisingly, for n=5 to 7 the fourth line in each group is strongly enhanced in the backward direction. At these peaks which show strong 90° asymmetry in projectile rest frame, it is found that two autoionizing states with opposite parities ($1s^2 2pnp\ ^1S$ and

$1s^2 2pnd\,^1F$) overlap within their natural widths (i.e., overlapping resonances). Coherent superposition of two electronic states, which have opposite parities, can be represented by a spatially polarized electron cloud. This cloud oscillates with the period corresponding to the energy difference between the two states and the states decay in a time corresponding to the natural widths. If the lifetimes of the states are shorter than the oscillation period, the decay occurs before there is a significant oscillation of the electron cloud, and the distribution of the decay products (e.g., ejected electrons) may show strong forward-backward asymmetry.

It is noted that this experiment indicates that electrons captured into bound states, may be strongly polarized at the time of capture and that the method of zero degree electron spectroscopy may, in some cases, be used to measure this polarization.

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1. The experiment was performed at Oak Ridge National Laboratory EN Tandem facility using the apparatus temporarily transported from Hahn-Meitner-Institut fuer Kernforschung Berlin (see e.g., A.Itoh, D.Schneider, T.Schneider, T.J.M.Zouros, G.Nolte, G. Schiwietz, W.Zeitz, and N.Stolterfoht, Phys.Rev.A31, 684(1985)).

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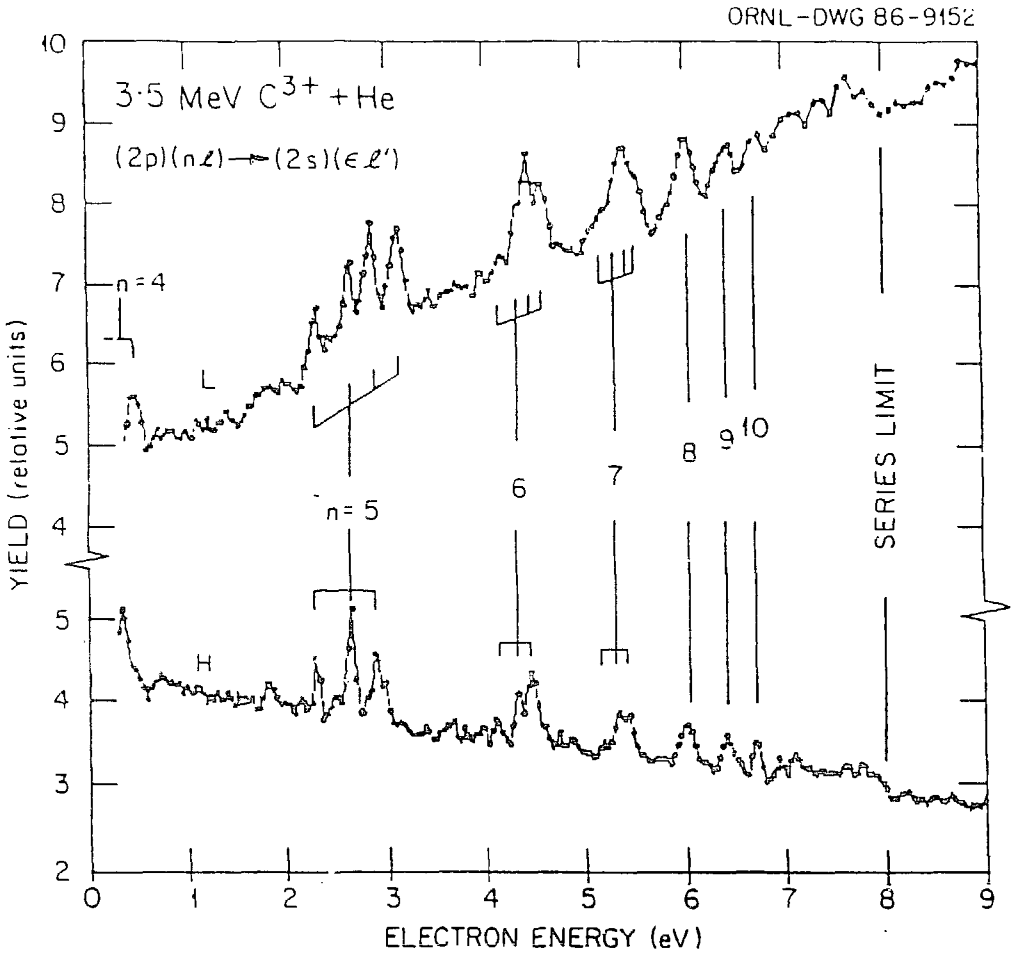

Figure 1. Electron spectra produced in 3.5 MeV C^{3+} + He collisions. A number of peaks due to the Coster-Kronig transitions $1s^2 2pnl \rightarrow 1s^2 2s\varepsilon l'$ are observed. The electron energy refers to the projectile rest frame. H and L correspond to the spectra of electrons emitted in forward(0°) and backward(180°) directions, respectively.