NONDIPOLE PHOTOELECTRON ASYMMETRIES

S. H. Southworth\textsuperscript{1}, E. P. Kanter\textsuperscript{1}, B. Krässig\textsuperscript{1}, R. Guillemin\textsuperscript{2}, O. Hemmers\textsuperscript{2}, D. W. Lindle\textsuperscript{2}, R. Wehlitz\textsuperscript{2}, and N. L. S. Martin\textsuperscript{2}

\textsuperscript{1}Argonne National Laboratory, Argonne, IL 60439
\textsuperscript{2}University of Nevada, Las Vegas, NV 89154
\textsuperscript{3}Synchrotron Radiation Center, University of Wisconsin, Stoughton, WI 53589
\textsuperscript{4}University of Kentucky, Lexington, KY 40506

The dipole approximation to the photon-electron interaction is often adopted in photoionization studies to describe angle-integrated cross sections and the dipole anisotropy parameter. Nondipole interactions produce additional asymmetries in photoelectron angular distributions, for example, due to interference between photoionization amplitudes for electric-dipole and electric-quadrupole interactions. Recent theoretical studies predicted energy variations of nondipole asymmetries in low-energy photoionization of rare-gas atoms resulting from many-electron interactions [1-3]. Autoionization of dipole- and quadrupole-quasi-bound states produce resonant features in nondipole asymmetry parameters over narrow energy ranges [1], and interchannel coupling among continuum states produces features over broad energy ranges [2,3]. Nondipole asymmetries are therefore sensitive to many-electron interactions and provide information on quadrupole excitations as well as complementary information to partial cross sections and dipole anisotropies on dipole excitations.

Motivated by the theoretical studies, we have measured the energy variations of nondipole asymmetries in selected cases using the PGM undulator beamline at the SRC. We observed photoexcitation of the dipole-forbidden $1s^2 1S_0 \rightarrow 2p^2 1D_2$ autoionizing resonance in He by mapping out the energy variation of the resulting nondipole asymmetry parameter. The Fano line shape parameters and the relative phase of the $1s \rightarrow \epsilon p$ and $1s \rightarrow \epsilon d$ continua were determined from the data [4]. A similar study was made of dipole and quadrupole autoionizing resonances in Ne $2p$ photoionization. Photoionization of the Xe 5s subshell has long been a prototype system for studies of many-electron and relativistic interactions. We measured the nondipole asymmetries of Xe 5s photoelectrons through the energy region of its Cooper minimum, where it's photoionization dynamics are modified by interactions with 5p and 4d excitations. We find qualitative agreement with theories [2,3], but quantitative discrepancies indicate that additional many-electron interactions need to be included. We also measured the nondipole photoelectron asymmetries of the $3\sigma_g$, $1\pi_u$, and $2\sigma_u$ valence molecular orbitals of N\textsubscript{2}. While the asymmetries of the $3\sigma_g$ and $1\pi_u$ photoelectrons increase monotonically with energy, the $2\sigma_u$ asymmetry passes through a maximum. The different energy variations of the photoelectron asymmetries may result from the nodal structures of the molecular orbitals.

References