Multipole X-ray Spectroscopy Using Non-resonant X-ray Raman Scattering

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— The information obtained by non-resonant inelastic x-ray scattering, commonly known as non-resonant x-ray Raman scattering (XRS), has both similarities and key differences when compared with that obtained by traditional x-ray spectroscopies such as from XAFS measurements. In the dipole limit ($q_a << 1$), the matrix elements for XRS is proportional to that for x-ray absorption spectroscopy but with the direction of the momentum transfer playing the role of the polarization vector. However, XRS measurements at high $q$ can often go beyond the dipole limit—leading to “forbidden” multipole excitations. This $q$-dependence can help separate various contributions to the local density of states, providing new information on the symmetries of a material. A primary drawback to XRS is its low cross-section, which is compounded measurements at multiple values of $q$ are needed. In response, we have built a multi-element apparatus to measure up to 10 values of $q$ simultaneously. We apply this instrument to a range of problems, including the valence-band exciton in LiF and the $L$- and $M$-edges of transition metals, transition metal oxides, and several minerals for the purpose of prototyping future measurements under high pressure.

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