Photoexcitation of a dipole-forbidden resonance in helium

Working at the University of Wisconsin's Synchrotron Radiation Center, a multi-institutional collaboration led by a group from the Chemistry Division has, for the first time, observed the dipole-forbidden $1s^2\ ^1S_0 \rightarrow 2p^2\ ^1D_2$ resonance in helium by vuv photoionization. In photoabsorption measurements, this quadrupole resonance is normally 5 orders of magnitude weaker than the underlying background dipole cross section and hence considered "forbidden". However, the angular asymmetry of the photoelectrons resulting from the autoionization of the resonance, which vanishes in the dipole approximation, is a direct result of the interference of the weak quadrupole amplitude with the much stronger dipole amplitude. The interference magnifies the quadrupole contribution and thus, when viewed in this way, the quadrupole resonance becomes comparable in intensity to a nearby dipole resonance. With this technique, the group was able to extract the lineshape parameters of both the dipole and previously unobserved quadrupole resonance. Beyond demonstrating a new method for observing higher multipole resonances in photoionization, a powerful feature of the present experiment lies in the ability to measure the *phases* of the complex matrix elements contributing to the interference. The experimental quantities which were deduced provide a rigorous test, not previously available, for calculations of He wavefunctions and dynamic processes.

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