Oscillations in the Double-Photoionization Cross Section of Li Near Threshold

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Introduction:
The threshold region of the double-photoionization (DPI) cross section of lithium was investigated using monochromatized synchrotron. Two conceptually different theories, namely the Wannier theory [G. H. Wannier, Phys. Rev. 90, 817 (1953)] and the Coulomb-Dipole theory [A. Temkin, Phys. Rev. Lett. 49, 365 (1982)], were developed to describe the near-threshold DPI cross sections \( s^1 \). The Wannier theory predicts \( s^1 = s_0 \exp(-aE) \) where \( a=1.056 \) is the Wannier exponent, \( s_0 \) a proportionality constant, and \( E \) the excess energy. In contrast to this power law, the Coulomb-dipole theory by Temkin predicts an oscillating but nevertheless monotonically increasing cross section \( s^1 \sim E^{0.5} \). The in the case of DPI, this equation is not strictly valid but may be a good approximation as recent calculations show. So far, only DPI experiments that tested the Wannier power law on atoms by measuring ions was performed on He [H. Kossmann, V. Schmidt, and T. Andersen, Phys. Rev. Lett. 60, 1266 (1988)] and oxygen (Z. X. Ho, R. Moberg, and J. A. R. Samson, Phys. Rev. A 52, 4595 (1995)].

First we tried to apply the Wannier power law to our data. The resulting fit curve along with our data is shown in Fig. 1. Then we applied the Coulomb-dipole theory and achieved a much better fit with \( s^1 \) decreasing from 81.8 to 26.3.

Experiment:
The experiment was performed at the Synchrotron Radiation Center (SRC) at the U3 undulator beamline. The photons were monochromatized with a 1200 line/mm plane grating. The entrance and exit slits were set at 170 \( \mu \text{m} \) and 100 \( \mu \text{m} \), respectively, yielding a photon-energy resolution of approximately 30 meV at 80 eV.

The vacuum chamber consists mainly of a standard conical 8" six-way cross and an 8" tee. It accommodates an ion time-of-flight (TOF) spectrometer, a metal vapor oven, an LN\(_2\) cooled trap, and a 1000 l/s turbo molecular pump.

In order to measure partial ion yields of \( \text{Li}^+ \) and \( \text{Li}^{2+} \) ions we employed an ion time-of-flight (TOF) spectrometer. The ion TOF was operated in the pulsed extraction mode. A pulsed electric field across the interaction region provided a start pulse, while the detection of an ion on a Z-stack MCP detector provided a stop pulse for the flight-time measurement. Details of the apparatus can be found in Wehlitz et al., Rev. Sci. Instrum. 73, 1671 (2002).

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