Journal of Physics: Conference Series

Wigner time delay studies of photoionization of atomic zinc and cadmium

Wigner time delay studies of photoionization of atomic zinc and cadmium

S. Saha* [1], **A. Mandal*** [2], **P. C. Deshmukh*** [3],
A. Kheifets† [4], **V. K. Dolmatov**$ [5] **and S. T. Manson**# [6]

*Department of Physics, Indian Institute of Technology Madras, Chennai, 600036, India
†Research School of Physics and Engineering, The Australian National University, Canberra ACT 0200, Australia
$Department of Earth Science, University of North Alabama, Florence, AL 35632, USA
#Department of Physics and Astronomy, Georgia State University, Atlanta, 30303, USA

Synopsis Wigner time delay has been studied in the shape resonance region for the outer nd→εf photoionization transitions in atomic Zn and Cd.

Photoionization of atomic Zn and Cd has been studied earlier within the framework of Relativistic Random Phase Approximation (RRPA) [1, 2]. In the present work, we report on the time delay in photoionization using the Wigner-Eisenbud time delay formalism [3-5]. Our main objective is to study the importance of the *f*-wave shape resonance, induced by the centrifugal barrier, in nd→εf photoionization [6, 7]. In particular, RRPA calculations for the time delay for nd→εf in atomic Zn and atomic Cd have been performed with all 3*s*, 3*p*, 3*d*, and 4*s* relativistic dipole channels coupled for Zn; and 3*d*, 4*s*, 4*p*, 4*d*, and 5*s* for Cd.

The results are shown in Figs. 1 and 2 for Zn and Cd respectively; both time delay and phase for the $3d_{5/2}\rightarrow\varepsilon f_{5/2}$ channel (Zn) and the $4d_{5/2}\rightarrow\varepsilon f_{5/2}$ channel (Cd) are presented. In both cases, significant time delay in the region of the rapidly increasing phase is evident. The other nd→εf photoionization channels (not shown) exhibit exactly the same characteristics.

The *f*-wave dependence on energy, the rapid increase in the threshold region, is indicative of a resonance; a shape resonance in these cases. This well-known shape resonance comes about owing to the competition of the attractive Coulomb potential and the repulsive centrifugal potential which creates an effective double-well potential with a barrier between the two wells [8]. With increasing energy, the *f*-wave penetrates into the inner well creating the shape resonance. This increase in time delay should be a general phenomenon in the vicinity of shape resonances.

[1] E-mail: soumyajit@physics.iitm.ac.in
[2] E-mail: amankur@physics.iitm.ac.in
[3] E-mail: pcd@physics.iitm.ac.in
[4] E-mail: A.Kheifets@anu.edu.au
[5] E-mail: vkdolmatov@una.edu
[6] E-mail: smanson@gsu.edu

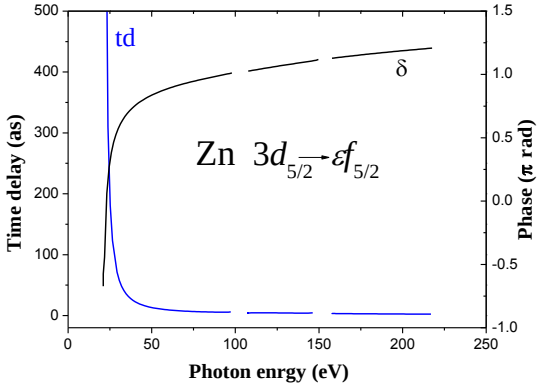

Figure 1. Wigner time delay (td) and phase (δ) for the $3d_{5/2}\rightarrow\varepsilon f_{5/2}$ photoionization channel in atomic Zn. The breaks in the curves represent regions of autoionizing resonances.

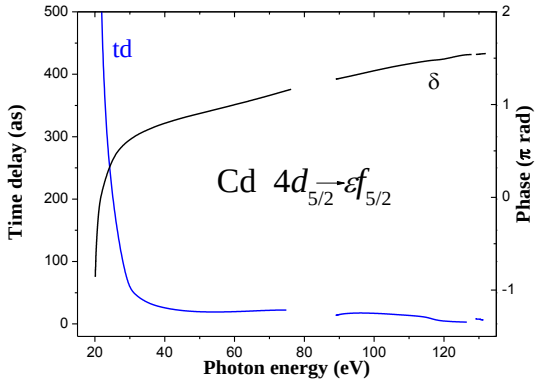

Figure 2. Wigner time delay (td) and phase (δ) for the $4d_{5/2}\rightarrow\varepsilon f_{5/2}$ photoionization channel in atomic Cd. The breaks in the curves represent regions of autoionizing resonances.

References

[1] W. R. Johnson *et al* 1982 *Phys. Rev. A* **25** 337
[2] W. R. Johnson and C.D. Lin 1979 *Phys. Rev. A* **20** 964
[3] M. Schultze *et al* 2010 *Science* **328** 1658
[4] L. E. Eisenbud 1948 *Ph. D. thesis*, Princeton Univ.
[5] E. P. Wigner 1955 *Phys. Rev.* **98** 145
[6] U. Fano and J. W. Cooper 1968 *Rev. Mod. Phys.* **40** 441
[7] A. Bohm 1986 *Quantum Mechanics* Springer: Berlin
[8] A. R. P. Rau and U. Fano 1968 *Phys. Rev.* **167** 7