

SPACE AND TIME RESOLVED CONTINUUM CORRELATION IN THE POST-COLLISION INTERACTION OF CORE-PHOTOIONIZED NEON

A.L. Landers<sup>1</sup>, F. Robicheaux<sup>1</sup>, T. Osipov<sup>2</sup>, T. Jahnke<sup>4</sup>, M. Schoffler<sup>4</sup>, J. Titze<sup>4</sup>, A. Bhandary<sup>1</sup>, M. Hertlein<sup>2</sup>, P. Ranitovic<sup>3</sup>, I. Bocharova<sup>3</sup>, M.H. Prior<sup>2</sup>, A. Belkacem<sup>2</sup>, C.L. Cocke<sup>3</sup>, R. Dorner<sup>4</sup>

<sup>1</sup>Auburn University, Auburn, Alabama, USA

<sup>2</sup>Lawrence Berkeley National Laboratory, Berkeley, California, USA

<sup>3</sup>Kansas State University, Manhattan, Kansas, USA

<sup>4</sup>University of Frankfurt, Frankfurt, Germany

For a single multi-level atom such as Ne, the photoionization process is yet to be understood in full detail. In particular, just above the core photoionization threshold two interesting phenomena can occur: (1) the three body post-collision interaction (PCI) between the photoelectron, residual ion and subsequent Auger electron [1]; and (2) the possible recapture of the photoelectron [2]. Both processes are associated with the change in potential caused by the fast Auger decay of the core-excited  $\text{Ne}^{*+}$  that occurs after photoionization. Shortly after emerging from the atom, the outgoing photoelectron is subject to a change in potential associated with the change of parent ion from  $\text{Ne}^{*+}$  to  $\text{Ne}^{2+}$ . Within the sudden approximation, the loss in energy (in atomic units) of the photoelectron is simply the change in potential energy given by  $1/r$ , where  $r$  is the distance traveled from the ion before Auger decay occurs. If this energy loss is less than the original continuum energy, then the electron simply remains in the continuum with reduced kinetic energy (process 1). In this case, all three bodies can exchange momentum and energy. If, however, the energy loss is greater than the photoelectron's initial energy, the electron can be recaptured into Rydberg state orbiting the  $\text{Ne}^{2+}$  core (process 2).

At the LBNL-ALS in Berkeley, California, we have used the COLTRIMS technique to investigate in detail both processes (1) and (2) above along with the associated fundamental physics. We have measured the full momentum vectors of both the slow photoelectron and the recoiling neon ion in coincidence. For case (1), the momentum of the faster Auger electron has been determined by conservation laws. Furthermore, the measurement of the final photoelectron energy determines the radial coordinate at the time of Auger decay, which in turns yields the actual decay time, giving us an attosecond stopwatch on the decay process.

An illustrative example of the detail in these measurements is the plot of the photoelectron momentum distribution in the frame of the Auger

electron in order to directly observe the continuum correlation between the two particles (Fig 1). Faint underlying discrete isotropic bands correspond to the recapture/re-emission channel. The ‘‘C’’ shaped feature corresponds to escaping photoelectrons that are repelled as they are overtaken by the faster corresponding Auger electrons, providing a direct and revealing look at the post-collision interaction.

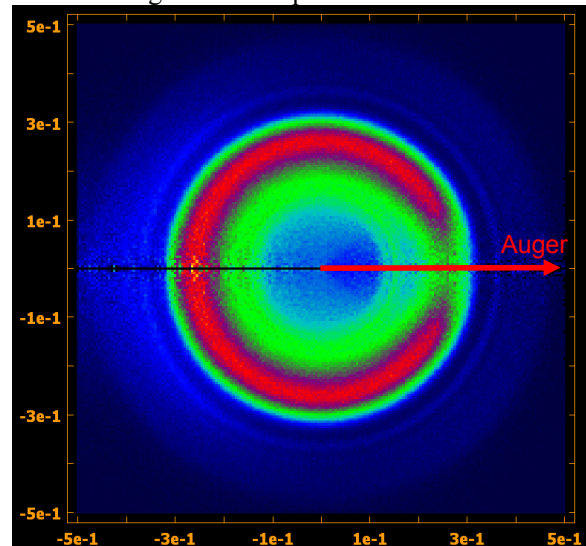


Fig. 1 Plot of the correlated photoelectron momentum in the plane defined by the photo- and Auger electron momentum vectors.

In addition to the continuum correlation and recapture process above, we will present details of the simultaneous measurement of all other ionization decay pathways. These include single ionization of the outer shell, core ionization followed by radiative decay and core ionization followed by Auger cascades up to  $\text{Ne}^{4+}$ . Model calculations will be presented to help interpret our results.

#### References

- [1] A. Russek and W. Mehlhorn, *J. Phys. B* **19** 911 (1986), and references therein.
- [2] T. W. Gorczyca, O. Zatsarinny, H.-L. Zhou, S. T. Manson, Z. Fel and A. Z. Msezane, *Phys Rev A* **68**, 050703(R) (2003).