

# POWER OF FOURIER PHOTOSPECTROSCOPY IN IMAGING ELECTRONICALLY DELOCALIZED FINITE SYSTEMS

Himadri S. Chakraborty\*, Mohamed E. Madjet<sup>†</sup> and Jan-Michael Rost<sup>‡</sup>

\*James R. Macdonald Laboratory and Department of Physics  
Kansas State University, Manhattan, Kansas 66506-2604, USA

<sup>†</sup>Freie Universitaet, Institut für Chemie (Kristallographie), Takustrasse 6, D-14195 Berlin, Germany

<sup>‡</sup>Max Planck Institut für Physik Komplexer Systeme, Nöthnitzer Strasse 38, 01187 Dresden, Germany

Quantum systems containing electrons bound by a positively charged core of finite extension acquire significant delocalization in the electronic orbitals. These electrons become quasi-free over most of the interior region of the system but feel a confining force at the system edge. Consequently, the ionization of such electrons by photon impact largely occurs from the edge region where they receive enough recoil force to transit to the continuum. Hence, predominant contributions to the photoamplitude from *equivalent* sites at the edge quantum-interfere to induce oscillations in the emitted electron intensity. The ensuing spectra, therefore, become rich in the geometric information of immense use in structural modelings.

For example, in a recent joint theory-experiment pilot study[1] we have shown that geometric properties of the  $C_{60}$  electronic hull, such as its diameter ( $2R$ ) and thickness ( $\Delta = R_{\text{out}} - R_{\text{in}}$ ), are contained in the HOMO and HOMO-1 partial photoionization cross sections by examining their ratio as a function of the photon wave number in the Fourier conjugated space (see Fig. 1).

Going beyond the spherical symmetry, we here extend our study to the photoionization of non-spherical systems having the degree of non-sphericity within a perturbative limit over the corresponding spherical model. Our analysis indicates that the phenomenology described above is also operative for such systems, but being somewhat less pronounced than the corresponding spherical case. Indeed, recent measurements[2] on  $C_{70}$  photoemission corroborate this prediction.

In order to broaden the applicability of the method we also investigate the photoionization from quantum dots. We demonstrate that the current of photoelectrons (photoholes) from a dot exhibits oscillations as a function of the pho-

ton energy owing to the predominant ionization from the dot boundary. In the Fourier reciprocal space of the photocurrent carrier wave vector these oscillations reveal frequencies connected to the confinement range. Angle-resolved and angle-integrated experiments with the focus on directly imaging the confining potential are suggested.

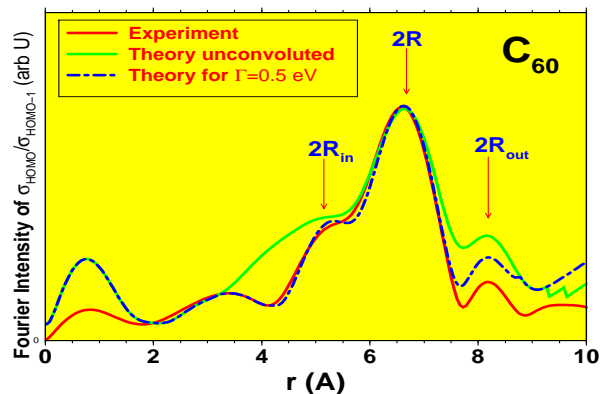


Fig. 1. Fourier transform of the ratio of valence subshell photo cross sections of  $C_{60}$  revealing peaks at positions connected to the inner and outer radii.

The studies emphasize that the Fourier photospectroscopy is an extremely useful tool to obtain valuable information about the geometric properties of a wide range of finite systems with large number of delocalized electrons.

## References

- [1] Andy Rüdél, Rainer Hentges, Uwe Becker, Himadri S. Chakraborty, Mohamed E. Madjet, and Jan M. Rost, Phys. Rev. Lett. **89**, 125503 (2002).
- [2] Uwe Becker, *Private Communication*.