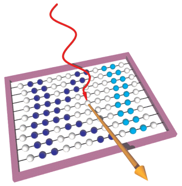

Spatial Origin of Photoelectrons

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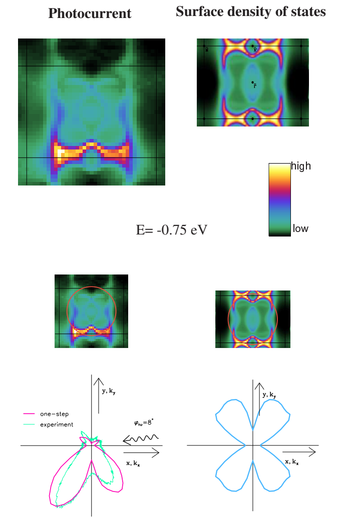
Information beyond Band Structure

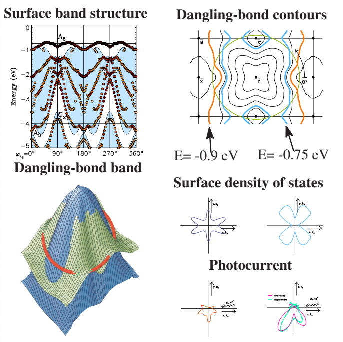
GaAs(110) dangling bond



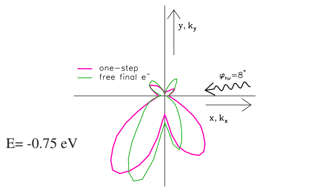
❑ The surface density of states shows possible positions of maxima in the photocurrent.

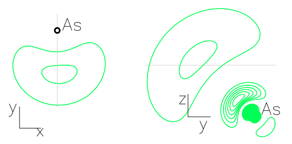
❑ Intensities and smaller structures are strongly modulated by other influences.

Band structure



Photocurrent and Charge Density



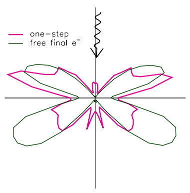


Photocurrent as Fourier transformation?

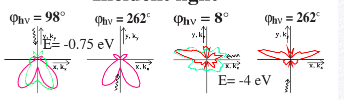
$$
\begin{aligned}
j &= C\,\left|\int \varphi^*_{fin}\,(\mathbf{p}\cdot\mathbf{A})\,\varphi_{in}(\mathbf{r})\,d^3\mathbf{r}\right|^2\\
&\approx C\,\left|\int e^{i\mathbf{k}\cdot\mathbf{r}}\,(\mathbf{p}\cdot\mathbf{A})\,\varphi_{in}(\mathbf{r})\,d^3\mathbf{r}\right|^2\\
&\approx C\,|(\mathbf{A}\cdot\mathbf{k})|^2\left|\int e^{i\mathbf{k}\cdot\mathbf{r}}\,\varphi_{in}(\mathbf{r})\,d^3\mathbf{r}\right|^2\\
&\approx C\,|(\mathbf{A}\cdot\mathbf{k})|^2\,|\widetilde{\varphi}_{in}(\mathbf{k})|^2
\end{aligned}
\qquad
\begin{array}{ccc}
\varphi_{in}(\mathbf{r}) & \xrightarrow{\text{Fourier}} & \widetilde{\varphi}_{in}(\mathbf{k})\\
\mathrm{s} & \rightarrow & \bar{\mathrm{s}}\\
\mathrm{p_x} & \rightarrow & \bar{\mathrm{p}}_{\mathrm{k_x}}\\
 & \vdots &
\end{array}
$$

❑ Angular momentum and spatial density modulate the angular distribution of intensities.

❑ A trivial interpretation based only on the initial state is not possible.

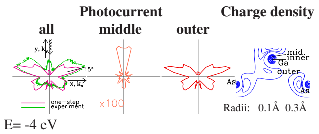


Incident light



Spatial Sensitivity and Kinetic Energy

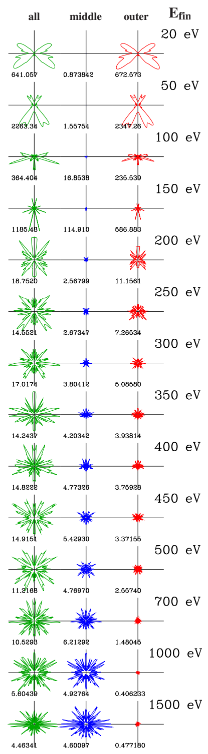
Photocurrent from different spatial regions



❑ ARUPS probes the bonding region.

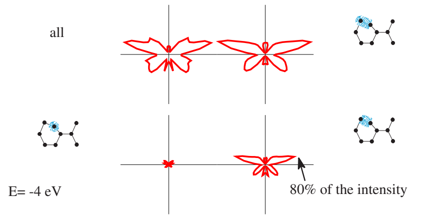
❑ High kinetic energies cause an effective localization at the cores.

Photocurrent with free final state



Local Emissivity in Extended States

Photocurrent from selected spatial areas



❑ The origin of photoelectrons can be traced into single bonds.

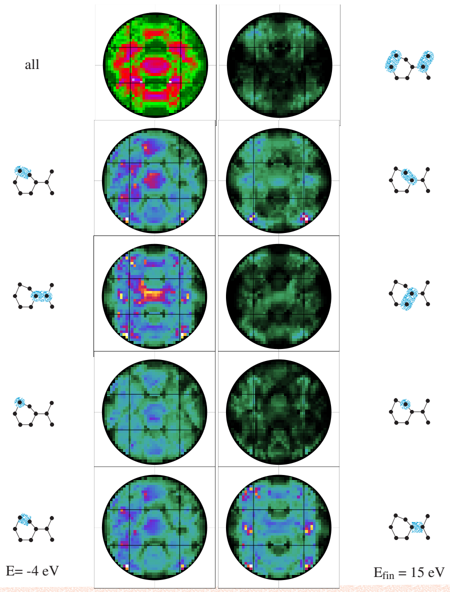
❑ The amplitude of the initial state appears as the local emissivity of the electrons to be scattered.

Interpretation:

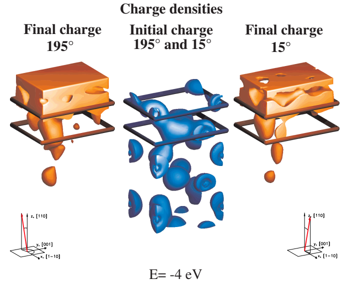
$$|\Psi\rangle = \sqrt{D}\,G(E_{fin},\vartheta,\varphi)\,\overbrace{(\mathbf{A}\cdot\mathbf{p})\,|\Psi_{in}\rangle}^{\text{Source}}$$

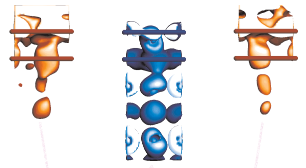
$$j \propto \left|\int \varphi^*_{fin}\,\underbrace{(\mathbf{A}\cdot\mathbf{p})\,\varphi_{in}(\mathbf{r})}\,d^3\mathbf{r}\right|^2$$

Photocurrent from selected spatial areas

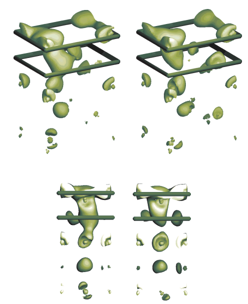


Final State as Selector?





Product: final charge * initial charge



❑ Data analysis methods for extracting spatial information have to be developed.

C. Solterbeck, W. Schattke, J.-W. Zahlmann-Nowitzki, K.-U. Gawlik, L. Kipp, M. Skibowski, C. S. Fadley, M. A. Van Hove, Phys. Rev. Lett. **79**, 4681 (1997)

URL: http://www.tp.cau.de/schattke/