Two-dimensional Fano resonances on Si(001)

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The interference between different indistinguishable excitation paths is a fundamental quantum mechanic phenomenon in cooperative systems. The coupling between discrete and continuum states can significantly modify its interaction with light resulting in Fano resonances. These interference phenomena have enabled the understanding of many systems in atomic and nuclear physics and artificial structures have been built to explore the nature of Fano resonances in the solid state.

We present a two-dimensional extension of Fano's theory for the description of two discrete states both degenerate with the continuum. As a model system we have studied transitions between the dangling-bond and image-potential states at the (100) surface of silicon, which are degenerated with the bulk continuum of valence and conduction bands. Tuning the photon energy reveals Fano line-shapes of the intensities in both the initial- and intermediate-state signals. These double state - double continuum interference phenomena allow us to deduce coupling strengths between surface and bulk states in silicon, and to estimate the lifetime of single hole excitations in an inhomogeneously broadened system.