Exercise 4: Measuring surface state dispersion by low-temperature scanning tunneling microscopy (STM)

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| Student | Date | Assistant |

Attach the graphs, which you base your analysis on, to the answer form.

The level of detail of a complete answer is such that the answer fits in the box if typed in average handwriting.

Instead of typing in the boxes below, you may write on separate sheets.

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| (a) Show a large scale (typically 100 nm x 100 nm) and a small scale image (typically 10 nm x 10 nm) of Cu(111) image. Find the step height of the Cu(111) surface from the line profile. Comment on the features present on the image. Why can we not use topographic image to extract wavelength (**k**|| vector) of the standing wave? |
| (b) Show a d*I*/d*V*b point spectrum recorded on the surface to show the surface state onset. Discuss the shape of the spectra. |
| (c) Show constant height LDOS maps at different bias values (*V*b) to cover the energy range tentatively. Use either the line profile or the fast Fourier transform (FFT) to obtain the wavelength (or **k**|| vector) of the surface standing waves. Extract the wavelength (or **k**|| vector) from the raw data provided to you in a similar way. |
| (d) Make the *E*–**k||** plot to generate the dispersion curve. Extract the electron effective mass by fitting with dispersion relation given in equation (6). Comment on the calculated effective mass. |
| (e) Extract the surface state onset energy from the *E*–**k||** plot and compare it to value extracted from d*I*/d*V*b point spectrum. |