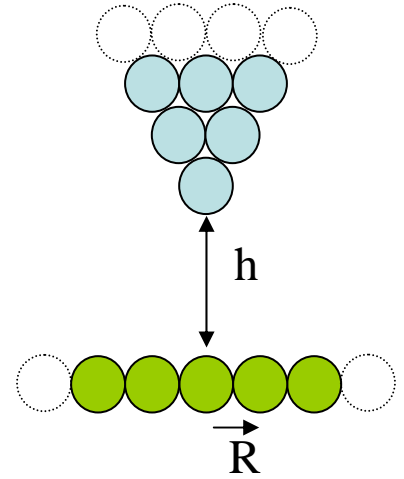


About the STM lateral resolution

We aim calculating the lateral resolution of an STM tip in the simplified model sketched in the right side.

a) Calculate the total tunneling current assuming that electrons can tunnel only perpendicularly to the surface and assuming both tip and surface as a continuum. Which is the contribution of the apex atom in respect to the total current (Assume the tip described by an equilateral triangle as in the figure with $R = 2 \text{ \AA}$)?

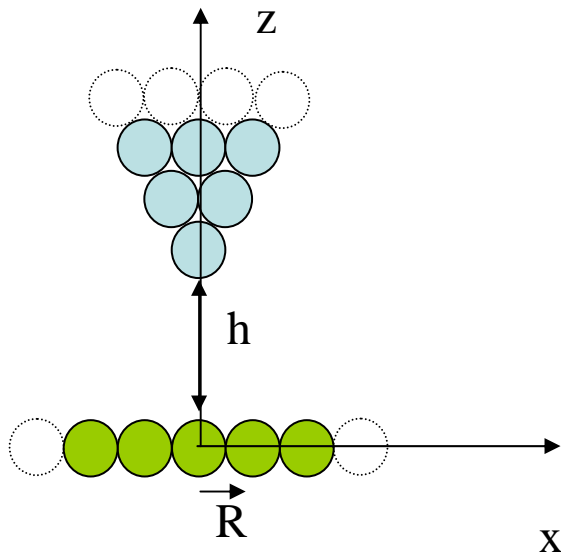


b) Making use of the previous result and assuming the atoms point-shaped calculate the tunneling current due to the 5 green surface atoms and compare with the value due to the surface atom under the tip. Consider $h = 0.5 R$ and $h = 10 R$

c) You are running your STM in the topographic mode (scanning with constant tunnel current) and you aim achieving atomic resolution. Do you choose high or low value of the tunneling current? Why?

Remember: this is a very simplified model which intent is simply to highlight the relevant aspect of STM

Solution: about the STM lateral resolution



$$z(x) = h + x \sqrt{3}$$

a) $I(x) \sim \exp(-2kz)$ where $k \sim 1 \text{ \AA}^{-1}$

$$I_{tot} = 2 \int_0^{\infty} e^{-2z(x)} dx = \frac{e^{-2h}}{2\sqrt{3}}$$

$$I_{apex} = 2 \int_0^{R/2} e^{-2z(x)} dx = \frac{1 - e^{-R\sqrt{3}}}{2\sqrt{3}} e^{-2h}$$

$$I_{apex} = 97\% I_{tot}$$

We can just consider the tunneling current due to the apex atom

b)
$$I = e^{-2h} + 2[e^{-2\sqrt{h^2+R^2}} + e^{-2\sqrt{h^2+4R^2}}]$$

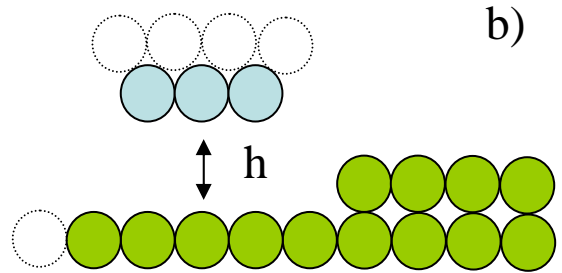
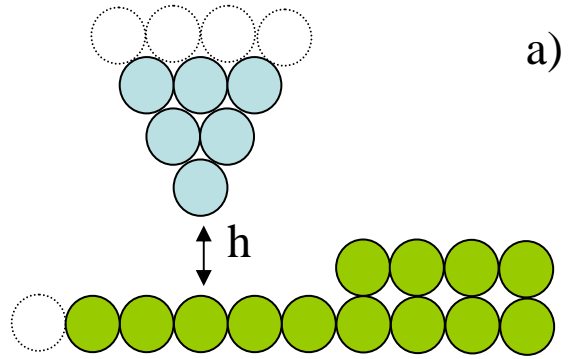
$$h = 0.5 R \rightarrow \text{ratio} = 80\%$$

$$h = 10 R \rightarrow \text{ratio} = 20\%$$

c) To achieve atomic resolution we want maximize the contribution of the surface atom just under the tip. This means that the tip has to be close to the surface or equivalently that high tunneling current ($> 10 \text{ nA}$) has to be used

How the STM tip affect the resolution of the microscope?

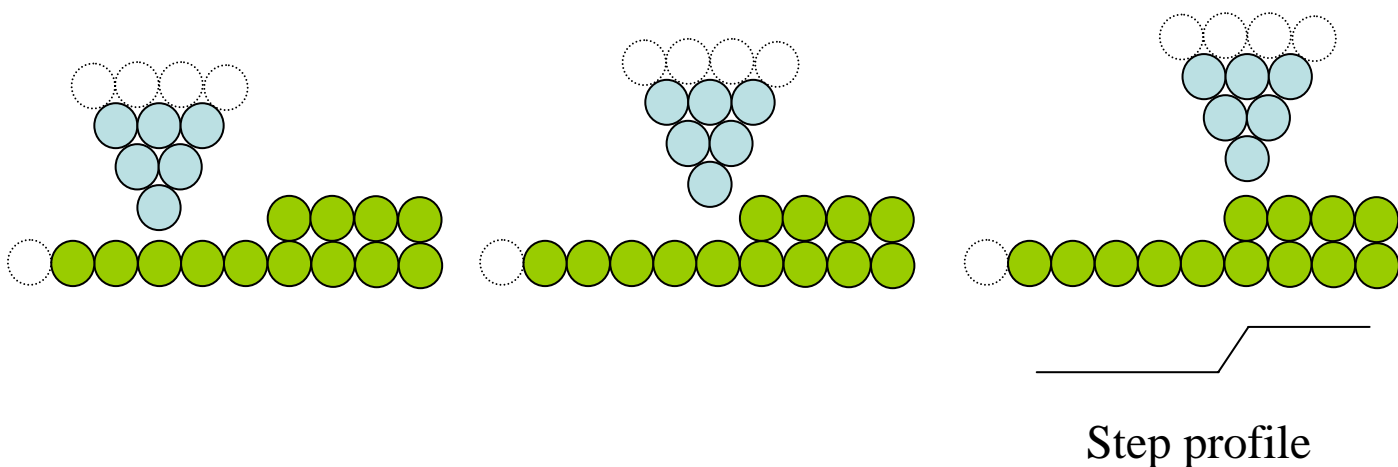
Consider the ideal cases sketched on the right. Using the results of the previous exercise, trace the step profile measured by the STM when the tip is moved close to the surface



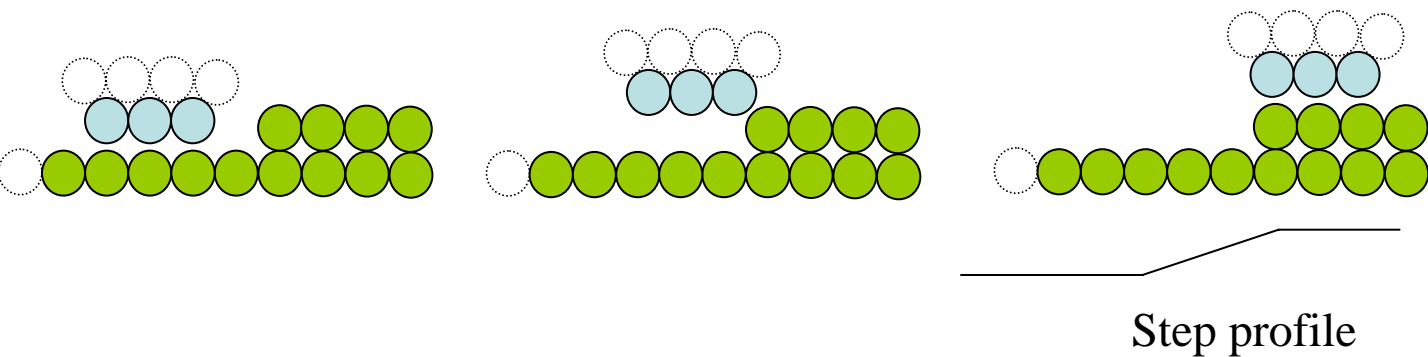
Solution: how the STM tip affect the resolution of the microscope?

We know that when the tip move close to the surface only the apex atom and the surface atom close to the tip contribute to the tunneling current

Case a



Case b



In this case the tunneling current on the terraces is given by the three apex atom. This implies that only when the three apex atoms have climbed the step the tunneling current on the two terraces is the same. So, the step is seen with a very smooth profile. In general the recorded topography is the convolution of the surface features and tip atomic structure