

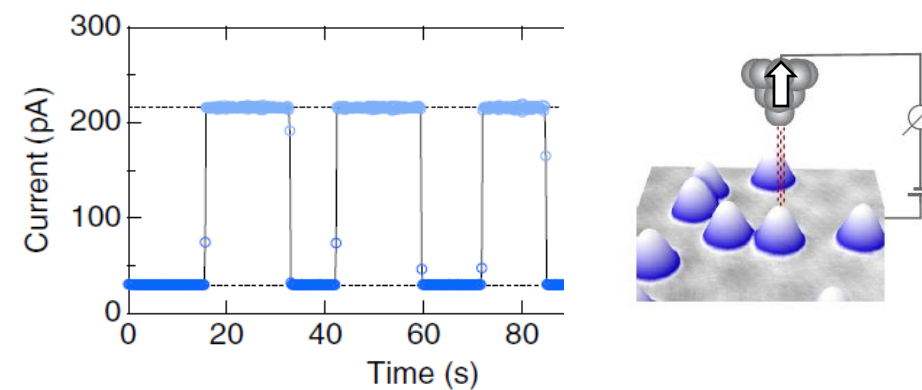


13.1 Atom spin polarization

We are interested in measuring the spin polarization of a magnetic adatom, namely Dy/graphene.

The spin polarization P is defined as $P = \frac{\rho(up) - \rho(down)}{\rho(up) + \rho(down)}$ where ρ is the density of states for up and down spins.

We perform a SP-STM experiment using a magnetic MnNi tip, which magnetization is assumed to be perpendicular to the surface and stable over time. We place the STM tip over a Dy atom and we record the tunneling current vs time, measured with $V_{bias} = 1mV$. As shown in figure, the current is bi-stable and assumes two values: $I_{low} = 30 pA$ and $I_{high} = 220 pA$.

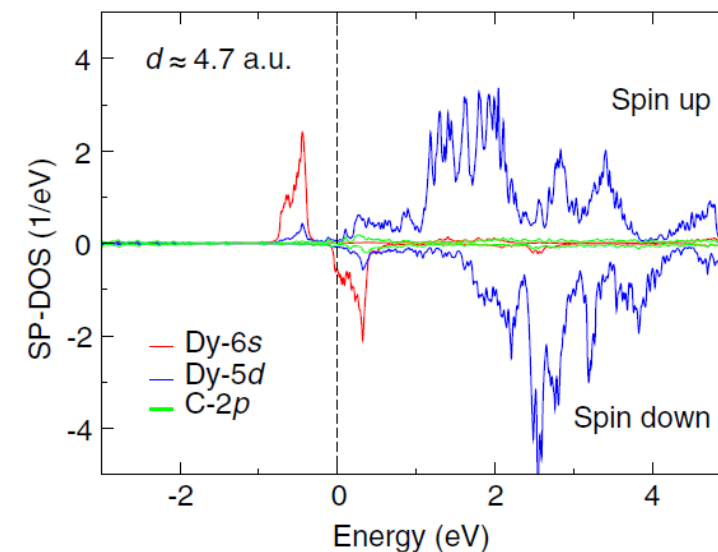


1) Why the current is bistable?

2) Demonstrate that the tunnel junction polarization $P_{jun} = \frac{I_{high} - I_{low}}{I_{high} + I_{low}} = P_{atom} P_{tip}$

3) Assuming a tip fully polarized, calculate the atom spin polarization

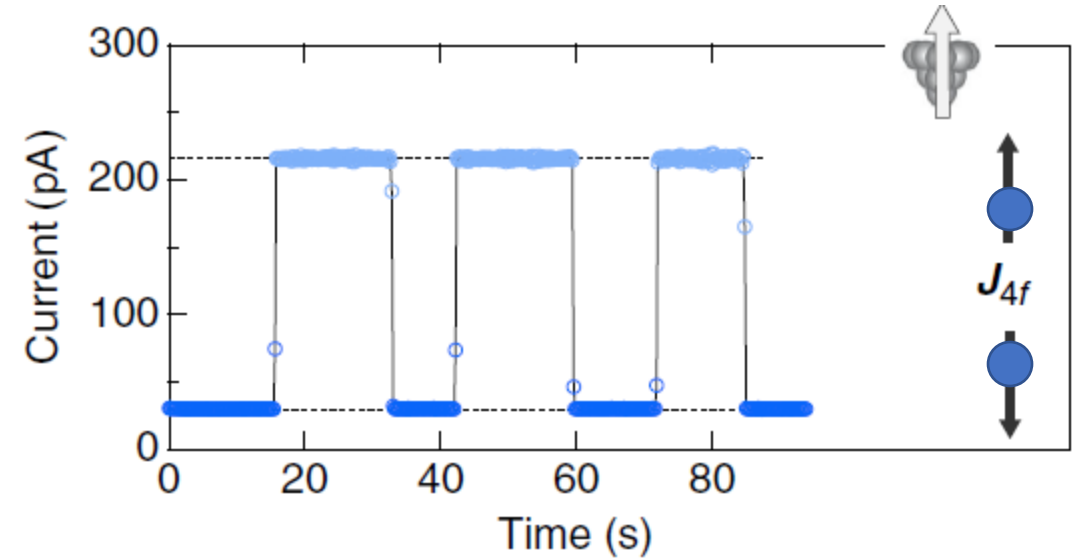
4) Theoretical calculations predict the spin polarized DOS shown in figure. Is this compatible with the experiment?





13.1 Atom spin polarization - Solution

1) The atom magnetization is not stable over time, but it fluctuates between pointing up and down. Because the tip magnetization is stable over time and pointing for example up, the current is high (low) when the atom magnetization is pointing up (down), corresponding to parallel (antiparallel) alignment of tip and adatom magnetization



2) The tunneling current is given by $I \propto \rho_T \rho_A$ with ρ_T the density of states of the tip, and ρ_A the one of the atom

$$I_{high} \propto \rho_T(u)\rho_A(u) + \rho_T(d)\rho_A(d)$$

$$I_{low} \propto \rho_T(u)\rho_A(d) + \rho_T(d)\rho_A(u)$$

$$\frac{I_{high} - I_{low}}{I_{high} + I_{low}} = \frac{\rho_T(u)\rho_A(u) + \rho_T(d)\rho_A(d) - \rho_T(u)\rho_A(d) - \rho_T(d)\rho_A(u)}{\rho_T(u)\rho_A(u) + \rho_T(d)\rho_A(d) + \rho_T(u)\rho_A(d) + \rho_T(d)\rho_A(u)} = \frac{(\rho_T(u) - \rho_T(d))(\rho_A(u) - \rho_A(d))}{(\rho_T(u) + \rho_T(d))(\rho_A(u) + \rho_A(d))} = P_{atom} P_{tip}$$



13.1 Atom spin polarization - Solution

3) From the values in figure we obtain $P_{jun} = 76\%$. Because we assume $P_{tip} = 100\%$, then $P_{atom} = 76\%$

(in reality, the tip polarization is not always 100%, and this is reflected by different spin-polarized signals in different sets of measurements on the same system)

4) The tunneling current has been measured with a $V_{bias} = 1$ mV, meaning that we are measuring the atom spin polarization very close (1 mV) to Fermi level. The SP-DOS in figure show a strong asymmetry in the number of spin up and down at Fermi level, thus it supports the measurements

