

## Electronic correlations in excitations revealed by the scanning tunneling microscope

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Degenerate open-shell structures can undergo spin-flips when they are in contact with an electron reservoir giving rise to the Kondo effect. If the orbital structure is also degenerate, flips between different orbitals can be possible. This generally boosts the Kondo effect and changes the nature of the many-body ground state. When the degeneracy is lifted, inelastic effects can still connect the different state taking the extra energy from an applied bias. The consequence is that a new electron conduction channel opens when the applied bias matches the difference in energy between the non-degenerate levels. This has been shown for spins: lifting the spin degeneracy destroys the Kondo effect and two steps appear at positive and negative bias in the conductance. A similar effect takes place when the orbital degeneracy is lifted. Populating one level or another is like changing the sign of a pseudospin, also known as isospin. These orbitals show strong electronic correlations, because double occupancies lead to large charging energies. Hence, over the threshold to populate the higher-lying orbital, there is a competition to fill either orbital. This leads to a clear inelastic step in the conductance with orbital information. At positive bias a new channel is open that corresponds to a different orbital from the one at negative bias. This leads to spatially resolved steps in the conductance that are not symmetric with respect to bias. This isospin-flip inelastic effect has been recently observed in phthalocyanine molecules [1].

### References

- [1] Jens Kügel et al. Phys. Rev. Lett. **121**, 226402 (2018)