physikalisches Kolloquium

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Exploiting collective electrostatic effects for the design of the electronic properties of low-dimensional and porous materials

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For realizing the promises of organic nano-electronics, it is crucial to control the nature of electronic states within materials and at interfaces. This is commonly achieved through functional chemical substitutions tuning the properties of individual molecules. Deviating from that approach, we here portray a largely unexplored strategy that exploits collective electrostatic effects arising from the superposition of the electrical fields of assembled polar groups. Such effects typically determine the electronic and transport properties of organic monolayers, and their consequences are not always advantageous. When employing them in a well-defined manner, they can, however, be used for realizing materials with novel properties, as discussed on the basis of DFT-type simulations and first steps towards their experimental realization.

For example, collective electrostatic effects can be employed to develop a modular toolbox for organic quantum-systems at interfaces, to tune the electronic properties of 2D electron systems and van der Waals heterostructures, or to develop design strategies for electrostatically tuned, porous organic frameworks. Common to all those cases is a pronounced localization of the frontier electronic states in different spatial regions of the materials and a controlled shift of their energies controlled via the distribution of local dipoles within the materials.