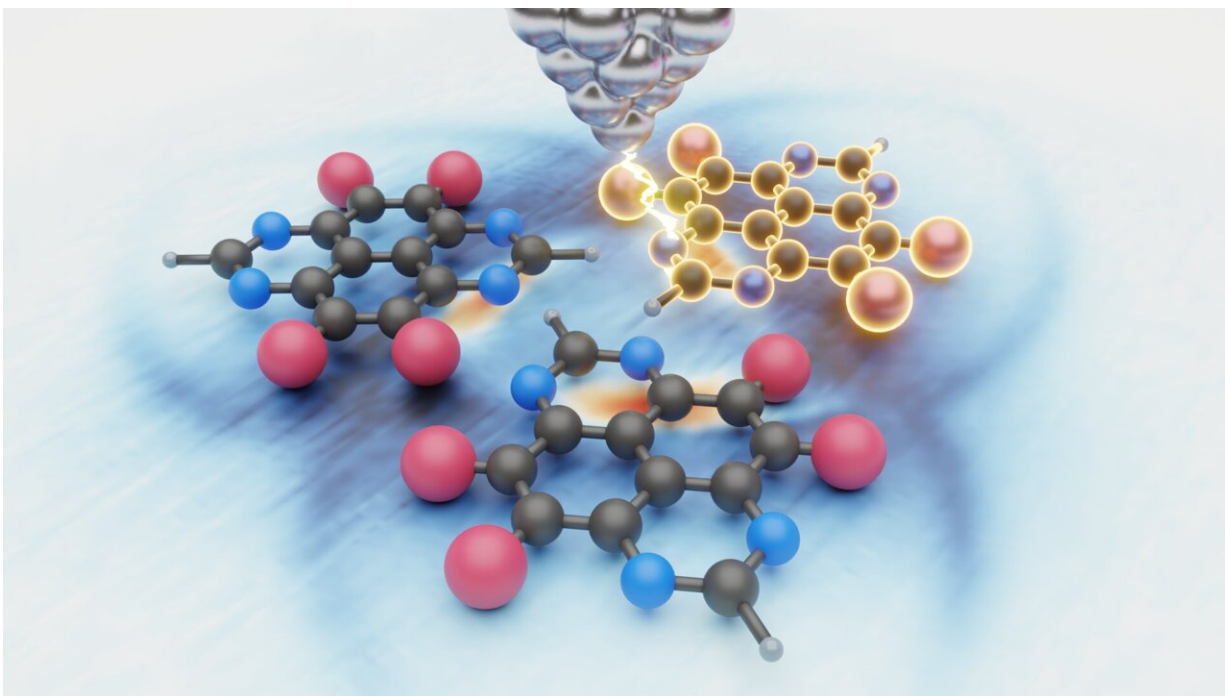


Schrödinger-like charges in six-molecule clusters point to new quantum components

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The researchers used a scanning tunneling microscope to arrange molecules into specific clusters. After applying a voltage, they determined the charge distribution at various locations within the cluster. This led to the identification of various charge rings, proving that unpaired electrons are interacting with one another and are present at different locations at the same time. Credit: R. Pawlak (University of Basel) and P. Hapala (Czech Academy of Sciences, Prague)

Researchers from the University of Basel have published details of how

electrons within a cluster of molecules interact with one another and can be controlled. Their [findings](#) pave the way for new approaches to developing quantum components and electronic circuits on the nanometer scale.

Electronic components are becoming increasingly small—so small, in fact, that quantum phenomena such as the superposition of states play a key role. Understanding this phenomenon is vital for the further development of molecular components and tiny circuits on the nanometer scale.

The behavior of paired electrons within molecules is already well understood. However, for radicals—molecules with an unpaired electron in their outer shell—there were no theoretical models describing interactions between molecules and the associated charge redistribution in small molecule clusters.

Electrons influence one another

Now, a team led by Professor Ernst Meyer from the Swiss Nanoscience Institute and the Department of Physics at the University of Basel has carried out an experimental and theoretical investigation into the dynamics of electrons in clusters of the specially synthesized molecule tetrabromo-tetraazapyrene (TBTAP).

Using a scanning tunneling microscope (STM), they arranged the molecules in groups of three and six. After applying various voltages, they determined the charge and current at different positions in the cluster.

"We found that, rather than being independent, the unpaired electrons in neighboring molecules influenced one another," explains Dr. Chao Li, first author of the publication from Meyer's team. The STM images

showed ring-shaped, flower-like patterns of charge distribution.

According to the laws of quantum mechanics, nature favors a mixed state with a uniform distribution across all molecules. However, the repulsion between charges within the clusters is so strong that one or two electrons are released into the substrate. There is no fixed charge distribution within the clusters, though. In the three-molecule cluster with two electrons, several combinations occur simultaneously as a superposition (e.g., 011, 101, 110). In some cases, the researchers also observed only a single charge—simultaneously distributed across multiple molecules (001, 010, 100)—depending on the measurement location and the applied voltage.

With six molecules, the behavior was slightly different: The inner molecules were found to be neutral, and the outer three were charged.

"The charges are no longer localized on an individual molecule but are instead present at several locations at the same time—just as Schrödinger's cat is simultaneously dead and alive," summarizes Dr. Rémy Pawlak, from Meyer's team, who supervised the work.

The researchers encountered another surprise: a phenomenon known as negative differential conductivity occurred at certain voltages and positions—in other words, the electrical current decreased even though the voltage increased. Effects of this kind, which are almost inconceivable in the macroscopic world, could in the future be put to targeted use—for example, in mobile phones or quantum computers when voltage-controlled oscillators are required.

Quantitative theoretical model

In *Nature Communications*, the researchers also describe how they were able to simulate and quantitatively explain their experimental

measurements with the help of a combined theoretical model. This allows them to make predictions about the behavior and dynamics of charges in similar clusters. Such precise models are needed to control the properties of molecular clusters—and subsequently make further advances in the field of nanoscopic components. One key finding is that collective properties, known as multi-electron states, are of vital importance.

Meyer summarizes the findings: "We've shown here that we not only understand complex interactions in molecular clusters but could also use them in a targeted manner. That's a key step toward developing a new generation of electronic components on the molecular level."

The work was carried out as part of a collaboration between researchers from Basel, Bern, Nanjing, China, and Prague, Czech Republic.

More information: Chao Li et al, Non-equilibrium correlated electron dynamics in triangular molecular assemblies, *Nature Communications* (2026). [DOI: 10.1038/s41467-026-75051-3](https://doi.org/10.1038/s41467-026-75051-3)

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