Abstract for IAS Focused Program on Reticular Quantum Matter (Nov 30 - Dec 4, 2026)

Single Sheet Reticular Materials: Controlling Quantum Behaviour by Host-Guest Interactions

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In single layer reticular materials, the effects of reduced dimensionality on physico-chemical properties can be investigated by surface-sensitive spectroscopies and local probe techniques. Here we use on-surface coordination networks interacting with 2D surface states of atomically clean coinage metal surfaces to fabricate periodic arrays of quantum wells and explore their interaction with guest atoms or molecules. Angle resolved photoelectron spectroscopy shows that this system comprises a super-band formed by the periodic superposition of the 2D periodic quantum well states in analogy to the emergence of bands from the periodic arrangements of atoms [1-2].

The quantum wells in this periodic array are caused by ~1nm sized pockets containing a localized electronic state below E_F. With Xe as the guest-atom, we control the overall occupancy of the pores by precise dosing of the adsorbate, but also by scanning tunneling microscope repositioning of individual atoms [3]. Each pore can host 1 to 12 atoms, which incrementally perturb the underlying quantum well state via Pauli repulsion and thereby disturb the 2D periodicity of the system. [4] In our more recent work we have investigated other noble gases and different molecules, among them a series of cyclo-alkane in their site-specific condensation and assembly. The local and non-local effects induced by gradual filling go far beyond what has been achieved by e.g. substitutional doping of graphene and other 2D materials. Our approach demonstrates that self-assembled two-dimensional reticular materials may serve as quantum state analogues of breadboards commonly employed in electronic circuitry allowing for the hardware programming of electronic states and the exploration of functional electronic states.

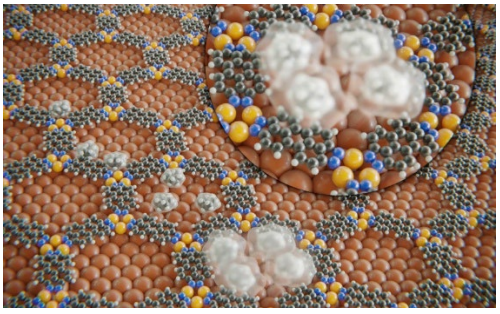


Figure 1. Adsorption of cyclooctane into the confinements provided by an on-surface metal organic network: One to three molecules rest on the bottom substrate within the confinement.

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As four molecules gather in a single pore, they are lifted into a dynamic adsorption mode, -- unexpected at 5K substrate temperature for a molecule that melts at ~300 K higher temperatures.

References:

[1] Lobo Checa et al., *Science*, **325**, 300-303 (2009)
[2] M. Matena et al., *Physical Review B*, **90**, 125408-125415 (2014)
[3] S. Nowakowska et al., *Nature Communications*, **6**, 6071 (2015)
[4] S. Nowakowska et al., *Small*, **12**, 3757–3763 (2016)
[5] A. Ahsan et al., *J. Phys. Chem. Lett.* 2022, 13, 7504−7513