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Isolation of Molecules in Helium Nanodroplets: Spectroscopy and Dynamics at Ultra-cold Temperatures

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The isolation of atoms, molecules, clusters or nano-sized complexes in helium nanodroplets allows detailed spectroscopic studies at temperatures in the millikelvin range. Moreover, femtosecond real-time spectroscopy has been introduced to study dynamical processes in the ultracold helium environment. On the one hand, wave packet propagation opens a window to dynamical processes, allowing even a view to superfluid properties at the nanoscale. This is exemplified at decoherence effects in the wave packet propargation of small molecules attached to the droplets. On the other hand, high-resolution mass spectra using both femtosecond photoionisation (PI) as well as electron impact ionization enable us to characterize reactive processes at temperatures in the millikelvin range. As an example, alkali cluster – water complexes are formed in helium droplets. By recording multi-photon PI spectra we can distinguish between reactive processes of the neutral clusters and ionic reactions occurring after ionisation of the alkali cluster component. These studies pave the way to time-resolved reaction dynamics at very low temperatures.