Superfluid $p$-$\text{H}_2$ Monolayer in Carbon Nanostructures

MILEN KOSTOV, Florida State University — A fluid of para-hydrogen ($p$-$\text{H}_2$) molecules is a prime candidate for potential superfluid, due to the light mass (half the mass of helium) and the existence of a compound boson ground state. In bulk $p$-$\text{H}_2$ superfluidity is not observed because, unlike helium, molecular hydrogen solidifies at a temperature (triple point $T=13.8$ K) significantly higher than that ($T\sim2$K) at which such phenomena as Bose Condensation and, possibly, superfluidity (SF) might occur. This is due to the fact that $\text{H}_2$-$\text{H}_2$ interaction is significantly stronger than the He-He one (more than a factor of three in the well depth). One way to attain a liquid ground state at low $T$ is to reduce the effective attraction between the $\text{H}_2$ molecules. Here a novel solution to the problem is proposed, which implies that a SF monolayer $p$-$\text{H}_2$ can be achieved in a carbon slit-pore with height $H \sim5.8$ Å, where the alignment of the graphitic planes corresponds exactly to the AB stacking sequence in a pristine hexagonal graphite crystal. Our approach is based on the idea to attain a liquid ground state of $p$-$\text{H}_2$ monolayer at low $T$ ($T\sim2$K), through a substantial renormalization of the pair interaction of $p$-$\text{H}_2$ molecules due to their interaction with the surface electrons of the carbon slit pore. In this environment, the resulting de Boer quantum parameter $\eta$ for the adsorbed $p$-$\text{H}_2$ film lies in the vicinity of the threshold value for zero-temperature Bose liquid.