Small is different: physics and chemistry in the non-scalable nano regime

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When the scale of materials structures is reduced to the nanoscale, emergent physical and chemical behavior often occurs, that is not commonly expected, or deduced, from knowledge learned at larger sizes. Such new behavior may be found when the size of the interrogated physical system becomes comparable to a phenomena-dependent characteristic length-scale; for example, the width of a quantum wire approaches the Fermi wave- length of the conducting electrons, or the dimensions of a liquid bridge, or a nanojet, approach the wave-length of a hydrodynamical instability underlying collapse or breakup into droplets. Using computer-based simulations [1] we highlight and illustrate such diverse emergent phenomena. Systems that we discuss include: electronic states and correlated electron quantum Hall phenomena in 2D semiconductor quantum dots and graphene, chemical nanocatalysis, charged water nanocluster droplets, liquid nanobridges and stochastic hydrodynamics, and molecular organization in lipid bilayers as well as trans-membrane transport processes investigated with large-scale molecular dynamics simulations of immersed capillary nanojet injection of a liquid through a bilayer membrane, illustrating membrane puncture and subsequent molecular self-healing processes.

References

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