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Non Linear Ionic Transport inside Nanoslits: Effect of the confinement on the correlations between electrolytes

Thanks to recent experimental advances, it is now possible to study the transport of water and ions confined up to one molecular layer. An example of such a system is the 2D nanoslit, made of sheets of 2D materials, like graphene or hexagonal boron nitride. Experimental measures of the ionic conduction under an external electric potential proves that the ionic transport is non linear and exhibit hysteresis phenomenons.

Because of this extreme confinement, the interaction between the ions are strongly enhanced, allowing them to associate to form pairs called Bjerrum pairs. Simulations showed that there is in fact a critical temperature, below which all the ions associate in pairs. The transition to this fully paired state is known as the Kosterlitz Thouless transition.

Adding an electric field to the slit will allows the Bjerrum pairs to dissociate. This will create additional free ions that will be able to conduct the current. This effect is called the second Wien effect and has already been studied in bulk water as a correction to the conductance at high ion concentration. Due to the strong correlations in the slit, it becomes the dominant contribution.

In addition to this effect, under an electric field, the isotropy of the system will be broken. This allows the formation of chains of ions along the electric field, called polyelectrolytes. The slow dynamics of these chains explains the hysteresis obtained in experimentation, a signature that the system is capable to store its conductance in memory for some times. This effect is known as the memristor effect and is an essential component to design a more complex ionic machinery.

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