Speaker: Dr. **Stephen Power** (School of Physical Sciences, DCU).

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Title: **Valley, spin and electronic transport phenomena in two-dimensional nanostructures**

Abstract: The discovery of graphene, and other atomically-thin two-dimensional materials, allows exotic new electron behaviours to be investigated. These properties motivate a range of new devices and technologies, and can be linked to unusual interplays between the various symmetries that emerge in graphene systems. Here I present a few recent examples of how we can take advantage of these properties to control charge, spin and valley currents.

First, I show how perturbations (edges, perforations and strain) affect electron flow in graphene systems and how quantum transport simulations are ideal tools to explain complex or exotic transport behaviour that can emerge in experimental measurements.

The valley degree of freedom can be linked to mechanical strain, and I show how a number of valleytronic functionalities could be realised using nanobubble structures. Signatures of valley-dependent phenomena have also been reported in controversial experiments based on stacked heterostructures. I will discuss how the topological mechanism invoked to interpret these experiments leads to an apparent paradox, before highlighting alternative proposals to create and manipulate valley behaviour in this type of system.

Finally, I discuss the formation of local magnetic moments near the edges of graphene flakes and ribbons. A large number of proposed spintronic devices are predicated on this behaviour, and recent experimental progress allows edge geometries to be engineered with previously-unprecedented precision. Simulations play a key role in both interpreting experimental measurements and confirming the presence of desired magnetic behaviour. However, computational costs prevent the simulation of large-scale disorders that can occur in experiment and could quench the desired behaviour. We have developed a machine-learning approach which removes this computational bottleneck. I will discuss its performance on a range of geometries, and show how spin currents in graphene nanoribbons unexpectedly survive in the presence of long-ranged edge roughness.