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Interaction of multiply charged ions with single layer graphene Part II: electron emission

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Synopsis A new setup is used to measure the number statistics of electrons emitted during the transmission of slow multiply charged ions through single layers of graphene and 1 nm thick carbon nanomembranes.

Single layer graphene (SLG) is an ultimately thin membrane made of sp^2-hybridized carbon atoms with unique electronic properties. Since its discovery [1] SLG has been considered as an excellent candidate for future nanoelectronics. Disorder, as induced e.g. by collisions with energetic electrons or ions, effects the electronic structure and opens the possibility to modify and tailor the properties of this true 2D material. Collision studies between ions and free-standing SLG are also of fundamental interest, because they bridge the gap between atomic collisions in gaseous and those in solid targets.

For the transmission of slow highly charged ions through slightly thicker 1 nm carbon nanomembranes (CNMs) we have recently observed two distinct exit charge state distributions accompanied by a strong charge state dependent energy loss [2] as well as the creation of nano-sized pores for Xe^{q+} projectiles in charge states $q \geq 25$ mainly by deposition of their potential energy [3].

To learn more about the microscopic interaction mechanism we have built a new experimental setup (figure 1), which allows us to determine the numbers statistics of electrons emitted during the transmission of slow multiply charged Ar^{q+} ions through SLG (and CNMs in comparison). Slow Ar^{q+} ions ($q \leq 11$) are extracted from an ECR-ion source [4], mass analyzed and collimated before traversing a free standing SLG or CNM target (mounted on a TEM grid which is fixed onto a rotatable manipulator) and being registered by a position sensitive multichannel plate detector (MCP). Electrons emitted from the interaction region are extracted by a weak electric field through a highly transparent grid and accelerated onto a surface barrier type detector biased at +30 kV, where their statistical distribution is measured in the usual way (see, e.g. [5, 6]). By changing the orientation of the target film from 45° to 135° with respect to the incident beam direction, electrons emitted from the front (= ion entrance side) and back side (= ion exit side) can be distinguished. To separate emission events originating from ion transmission through SLG from ion impact on the (solid) TEM grid support, only electrons registered in coincidence with an ion signal on the MCP are counted.

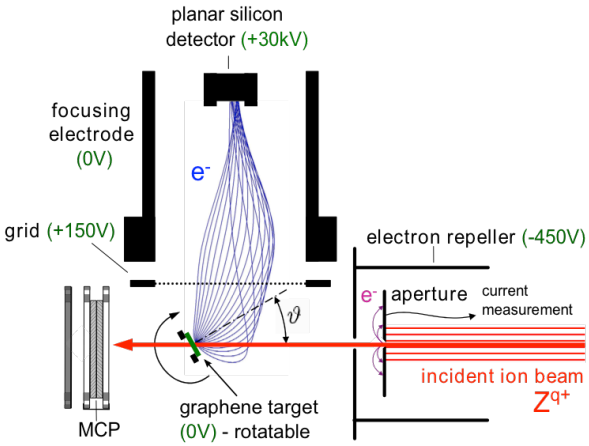


Figure 1. Experimental setup (c.f. text).

Since electron emission and projectile charge exchange are closely related, in a next step it is planned to register the electrons in coincidence with a particular projectile exit charge state.

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