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Helium atom scattering, a suitable tool for studying electron-phonon coupling, bending rigidity and substrate coupling strength of 2D materials

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Helium atom scattering (HAS) is a powerful, well-established technique for investigating the structural and dynamical properties of crystalline solid surfaces. Because of the low energies used (10-200 meV), monoenergetic beams of neutral He atoms probe the topmost surface layer of any material in an inert, completely nondestructive manner. Diffraction measurements allow the determination of the size and orientation of the surface unit cells, whereas time-of-flight spectra provide information on the surface phonon dynamics [1]. The energy resolution in the acoustic phonons region (up to ~50 meV) is 0.5 meV, whereas the angular resolution is typically 0.1 deg.

In the case of 2D materials, measurement of the surface phonon dispersion curves with HAS at low energies allows determining the substrate bond strength as well as the bending rigidity, a piece of information difficult to get with other experimental techniques. We will present results obtained for graphene grown on different metal substrates and sapphire [2].

Recent theoretical studies showed how the thermal attenuation of the He specular peak from metal surfaces, described by the Debye-Waller exponent, can be directly related to the electron-phonon coupling constant λ, also known as the mass correction factor of superconductivity [3]. We will show how HAS is ideally suited to measure λ exclusively in the low energy range (< 0.1 eV) for 2D materials and van der Waals heterostructures. The energy range can be tuned by changing the energy and/or the angle of incidence of the incoming He beam. Results obtained recently in our laboratory for 1T-$PdTe_2$, 1T-$PtTe_2$ and 2H-MoS_2 will be presented [4-6].

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