Gapped momentum states in shocked condensed matter

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There are 2 conventionally-discussed dispersion relations (DRs): the gapless phonon-like DR and the DR with the energy or frequency gap. The third and intriguing type of DR has been emerging in different areas of physics: the gapped momentum states (GMSs), when the DR with the gap in momentum, or k-space. Increasing interest to GMSs is related to important implications for dynamical and thermodynamic properties of the system. The structural image of the k-gap can be introduced as a localized shear corresponding to the coordinated movement of groups of structural units (group of molecules in liquid) in the elastic field of shear stresses. Statistical thermodynamics of the microshear ensemble established specific type of criticality (the structural-scaling transition) leading to the generation of two types of collective modes (solitary and blow-up) as new mechanism of the k-gap related to new spatial (the lengths of the solitary wave front and blow-up localization lengths) and temporal scales [1]. These results allowed the explanation of paradox, that low shear viscosities indicate significant interaction strength [2, 3]. There is estimation of a fundamental lower limit $\eta/s = \hbar/(4\pi k_B)$ (KSS—Kovtun–Son–Starinets) universal lower bound. Ordinary substances like water have η/s ratios that lie well above the KSS value [4]. The existence of viscosity limit is related to the GMSs corresponding to the blow-up collective modes of slips.

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