# A Contactless Route to 2D Acoustics, Mechanics, and Photoelasticity: Brillouin Light Scattering from Bulk to Few-Layer vdW Crystals

**Bartlomiej Graczykowski**
Aleksandra Trzaskowska, Adam Krysztofik
*Faculty of Physics and Astronomy, Adam Mickiewicz University, Poznan, Poland*
bartlomiej.graczykowski@amu.edu.pl

Recent progress in synthesizing single-crystal van der Waals (vdW) materials and supported two-dimensional (2D) layers has enabled the commercial availability of high-quality, large-area samples. This has expanded opportunities to study a wide range of physical properties, such as structural, electronic, optical, magnetic, thermal, and vibrational, that are highly sensitive to variables such as thickness, strain, and interlayer stacking. Despite these advances, achieving comparable experimental confidence in elastic behavior remains challenging, leaving a persistent knowledge gap. This raises a key question: do current experimental approaches provide sufficient precision and reliability to comprehensively characterize the mechanical properties of vdW systems, from bulk crystals to atomic layers and complex nanoscale assemblies?

In this work, we investigate the anisotropic acoustic and elastic properties of vdW single crystals using spontaneous Brillouin light scattering (BLS). BLS is a well-established, all-optical technique that measures frequency shifts arising from the inelastic scattering of monochromatic light on thermally populated hypersonic (GHz) acoustic phonons/waves. These shifts are directly linked to phonon velocities at a geometrically selected wavevector, enabling quantitative access to elastic anisotropy without mechanical contact.

We demonstrate two experimental workflows tailored to the optical character of the specimen. As a representative transparent vdW crystal, α-$MoO_3$ enables measurements in geometries where both acoustic velocities and polarization/intensity behavior can be analyzed, providing access not only to elastic information but also to the anisotropic refractive index and photoelastic features. As a representative non-transparent material, $MoSe_2$ illustrates the opaque-sample workflow, in which surface-sensitive light-scattering geometries and data processing are used to reliably extract acoustic velocities and elastic anisotropy. Importantly, we extend the methodology to the size/thickness regime relevant to 2D membranes, examining how mechanical properties evolve as thickness is reduced from bulk crystals to few-layer flakes. In particular, we discuss signatures of elastic softening with decreasing membrane thickness, and outline how BLS measurements on micrometer-scale specimens can be used to track such thickness-dependent trends in a contactless manner[1].

Overall, this work establishes a versatile experimental platform for contactless characterization of vdW materials linking bulk crystals to micron-scale flakes and helps close a longstanding experimental gap in quantitative mechanical metrology for 2D material systems.

References
[1] V. Babacic, D. Saleta Reig, S. Varghese, et al. Advanced Materials 33 (23), 2008614, (2021)