Atomically thin perfect mirrors

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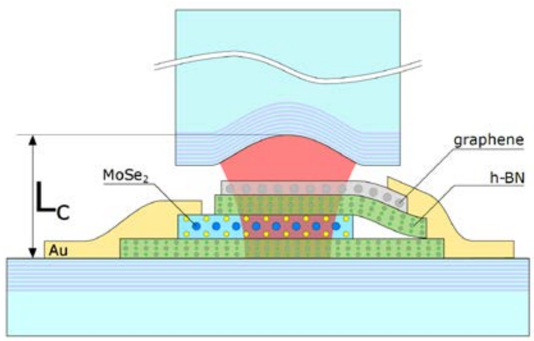
Transition Metal Dichalcogenides (TMDs) have recently gained a lot of interest in multiple research areas in physics including solid state physics and quantum information processing. It basically constitutes of a transition metal atom chemically bonded to two chalcogen atoms (S, Se) in a hexagonal structure. Interestingly, when stripped down to a monolayer, the material exhibits a direct band gap. This occurs at the K points at the edge of the Brillouin zone (usually termed K and -K valleys). Consequently, the time reversal symmetry is broken. The 2D geometry also gives rise to valley dependent selection rules. Hence, in addition to a larger binding energy, exciton (bound electron hole state) also enjoys a valley pseudospin.



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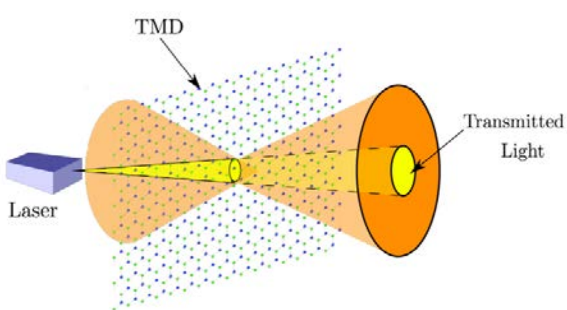
A single dipole when driven resonantly leads to extinction of the incident light field. This happens because of the interference between the incident photon and the coherent florescence. Up to 10% extinction ratios have been demonstrated in many quantum systems: single molecules, atoms, quantum dots, ions etc. A regular array of dipoles can significantly alter this behavior due to a collective cooperative behavior amongst the dipoles. The dipoles can be arranged to give perfect extinction when all dipole emissions collectively destructively interfere in transmission leading to a perfect reflection. The excitons in a TMD monolayer can act as such an array of dipoles when excited resonantly and hence the monolayer can be used as an atomically thin perfect mirror. This requires radiatively broadened exciton resonances and very high coupling efficiencies between the incident light and excitons.



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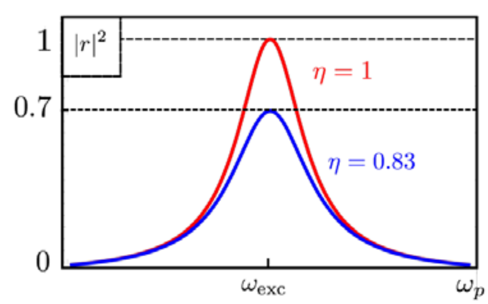

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[1] arXiv:1701.08228 (2017)
[2] Nat Phys; doi:10.1038/nphys3949 (2016)