Probing quantum plasmonics and the ultimate limits of light compression with Van der Waals heterostructures

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Van der Waals materials have emerged as a toolbox for in-situ control of a wide range of collective excitations coupled to light: polaritons[2]. In this talk, we will show several examples of near-field microscopy for exciting, controlling and detecting polaritons[3,4]. Plasmon modes propagating almost as slow as the electron Fermi velocity show a strong quantum non-local response, which can be further exploited to study many-body effects.

We further show that a graphene-insulator-metal heterostructure can overcome the trade-off of optical confinement and loss, and we demonstrate plasmon confinement down to the ultimate limit of the lengthscale of one atom[1]. Record strong normalized mode volume confinement of the range 10^9 - 10^{10} was achieved by far-field excitation of plasmon modes squeezed into an atomically thin h-BN spacer between graphene and metal rods. These ultra-confined plasmonic modes, addressed with far-field light excitation, enables a route to new regimes of ultra-strong light-matter interactions.

References

1. Probing the Ultimate Plasmon Confinement Limits with a Van der Waals heterostructures. Alcarez et al., **Science (2018)**
2. Polaritons in layered two-dimensional materials. Low et al., **Nature Materials 16 (2) pp 182 (2017)**
3. Tuning quantum non-local effects in graphene plasmonics. Lundeberg et al., **Science (2017)**
4. Electrical 2pi phase control of infrared light in a 350-nm footprint using graphene plasmons. A. Woessner et al., **Nature Photonics 11, 421-424 (2017)**