# SURFACE PLASMON POLARITONS OF CONTROLLED COHERENCE

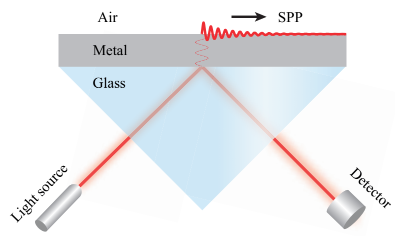
A. Norrman[1], S. A. Ponomarenko[2], and A. T. Friberg[1]

[1] University of Eastern Finland, P.O.B. 111, FI-80101 Joensuu, Finland
[2] Dalhousie University, Halifax, Nova Scotia, B3J 2X4, Canada
email: ari.friberg@uef.fi

Surface plasmon polaritons (SPPs) were the workhorse that ushered in plasmonics as a separate field covering cross-disciplinary physics and applications [1]. So far plasmonics has chiefly dealt with monochromatic (fully coherent) SPPs. However, partial coherence is a valuable degree of freedom governing the properties and interactions of wave fields.

SPPs are known to greatly alter the statistical features of optical near fields. Also, SPPs have been demonstrated to modify the coherence of light in Young's two-slit arrangement [2, 3], and conversely, Young's setup combined with leakage radiation microscopy enables the measurement of SPP coherence evolution on propagation. Further, the coherence properties of bi-modal fields composed of long-range and short-range SPPs on metal slabs have recently been assessed [4]. However, no systematic theory of multimode, spatially and spectrally partially coherent, polychromatic SPPs has up to now been advanced.

In this work we determine the electromagnetic space-time and space-frequency coherence matrices of multicomponent SPP fields at a metal-air boundary in terms of the spectral correlations among the monochromatic constituents [5]. The key result is the demonstration how such polychromatic SPP fields of controlled coherence can be excited using tailored (stationary or pulsed) partially coherent beamlike light sources (see the Figure). We also establish several useful properties of such SPP wave fields. In particular, narrowband SPPs are fully polarized and virtually propagation invariant, but broadband SPPs, while still highly polarized, may show coherence lengths that are short compared to the (mean) plasmon propagation distance. Strong coherence modulations may be achieved, e.g., through SPP excitation by two independent lasers [5]. Our work represents a new paradigm in statistical plasmonics that we refer to as 'plasmon coherence engineering'.




SPP excitation in the Kretschmann configuration. The metal film is thick enough to suppress all reflections within the slab. The light source is polychromatic and its spatial-spectral coherence is judiciously tailored to create the desired controlled-coherence SPP.

[1] S. A. Maier, *Plasmonics: Fundamentals and Applications* (Springer, 2007).
[2] C. H. Gan, G. Gbur, and T. D. Visser, Phys. Rev. Lett. 98 (2007) 043908.
[3] S. Divitt, M. Frimmer, T. D. Visser, and L. Novotny, Opt. Lett. 41 (2016) 3094.
[4] A. Norrman, T. Setälä, and A. T. Friberg, Opt. Express 23 (2015) 20696.
[5] A. Norrman, S. A. Ponomarenko, and A. T. Friberg, EPL (2017) in press.