Tailoring direction-dependent photon statistics with arrays of quantum emitters

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Classical antenna arrays take advantage of interference phenomena to combine the signals radiated by several antennas, thus providing control over the directional properties of the collectively emitted radiation. This effect extends the functionalities of the system beyond those that could be attained with their single antenna elements. For this reason, antenna arrays are nowadays a successful technology that empowers high-gain antenna systems, dynamically steering the radiation pattern, spatial diversity, and a reduction of the detrimental impact of noise and interference.

We conjecture that similar techniques and methodologies can be applied to the quantized electromagnetic field and arrays of quantum emitters, with direct applications in nonclassical light sources. In our talk, we will provide a summary of our most recent results on applying antenna array theory to the radiation of ensembles of quantum emitters. Specifically, we have developed a formalism that uses a generalized quantum array factor to link the quantum theory of radiation to antenna array theory. Importantly, the degrees of freedom of arrays of quantum emitters transcend those of classical antenna arrays, and photon statistics of any order (i.e., not just the emitted intensity) can be manipulated and designed by changing the geometry of the array. This enables identifying configurations with no classical counterparts and with potential applications as sources of nonclassical radiation. As an example, we will show a configuration in which the emission pattern in terms of the average number of photons (i.e., the emitted intensity) is not affected by the number and position of the quantum emitters, while the second-order directional correlation has a directive behavior related to the array geometry. This effect provides the basis for generating directionally entangled photon bunches.