**Acoustic Control of Quantum Emission: Toward Time-Bin Encoded Single-Photon Sources**

S. Djurdjic Mijin1, 2, S. Lazić1, 3

1*Departamento de Física de Materiales, Universidad Autónoma de Madrid, 28049 Madrid, Spain*

2*Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, Belgrade, Serbia*

3*Instituto ‘Nicolás Cabrera’ and Instituto de Física de Materia Condensada (IFIMAC), Universidad Autónoma de Madrid, 28049 Madrid, Spain*

e-mail: sanja.djurdjic@uam.es

Photons are excellent carriers of quantum information, with multiple internal degrees of freedom available for qubit encoding. Although polarization encoding is widely used, it is highly sensitive to polarization mode dispersion in optical fibers, which limits its scalability over long distances. To address this, we present a pathway toward robust time-bin qubit implementation by acoustically modulating the emission properties of single-photon sources using surface acoustic waves (SAWs). SAWs are launched on piezoelectric LiNbO₃ substrates patterned with delay lines, onto which GaN/InGaN core-shell nanowires containing quantum-dot-like emitters have been mechanically placed. These emitters, formed by indium fluctuation-induced localization in the InGaN shell, demonstrate pronounced linear polarization and clear photon antibunching, confirming their quantum nature via polarization-resolved micro-photoluminescence and photon correlation measurements. Upon excitation with SAWs at ~330 MHz, the excitonic transitions undergo dynamic spectral modulation through acousto-mechanical coupling, with tuning amplitudes of approximately 2 meV. Stroboscopic time-resolved experiments reveal emission oscillations synchronized with the SAW phase, attributed to the simultaneous injection of photo-excited electrons and holes - unlike previously reported systems dominated by sequential carrier capture. By spectrally selecting SAW-shifted emission states, we achieve precise control over photon emission timing, effectively enabling time-bin qubit encoding. This approach circumvents polarization-related decoherence in optical fibers and supports secure quantum communication protocols such as quantum key distribution. Furthermore, the detection of biexcitonic emission opens the door to chip-integrated generation of entangled photon pairs at elevated operational temperatures. Our results demonstrate the potential of III-nitride-based, acoustically tunable quantum light sources as scalable components for future quantum information systems.