**Liquid-crystal-based sources of quantum light**

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Quantum light sources generate light with distinct quantum features, most frequently single photons or photon pairs, essential in applications such as quantum communication, quantum computing, and quantum metrology. The most common way of generating (entangled) photon pairs is spontaneous parametric down-conversion (SPDC), where a nonlinear crystal (e.g., lithium niobate (LN), beta barium borate (BBO), etc.) is used to split a single incoming photon into two photons. No revolutionary advances have been made in recent decades regarding these nonlinear materials. In fact, LN is still one of the best and one of the most used nonlinear crystals for the generation of photon pairs more than 50 years after it was used for the first demonstration of SPDC. Further, current sources lack tunability and are designed to generate a particular quantum state.

Recently, ferroelectric nematic liquid crystals (FNLCs) have been discovered, with polar ordering, leading to a large dielectric constant, a strong response to an electric field, and a very high optical nonlinear response. FNLCs have strong potential for applications in tunable nonlinear devices, among other possible uses. A strong second harmonic generation (SHG) has been demonstrated in FNLCs, but they have never before been employed for generating photon pairs. Here, we demonstrate for the first time the generation of entangled photons from a FNLC [1]. This is also the first demonstration of SPDC in any organic material. The conversion efficiency is on par with the best nonlinear crystals available today, with the added benefit of tailoring and tuning the source's output. We show that by simply adjusting the twist of the molecular orientation along the sample, almost any polarization state can be generated, including states with maximum entanglement. Additionally, by applying only a few volts, we can drastically alter both the emission rate and the generated state of photon pairs, enabling real-time tunability. This is the first source of photon pairs that offers such tunability.

The rich self-assembled and topological structures in LC could, in the future, enable sources that emit tunable complex structured quantum light.

**References:**

[1] V. Sultanov, A. Kavčič, M. Kokkinakis, N. Sebastián, M. V. Chekhova, M. Humar, Tuneable entangled photon pair generation in a liquid crystal, *Nature* **631**, 294–299 (2024).