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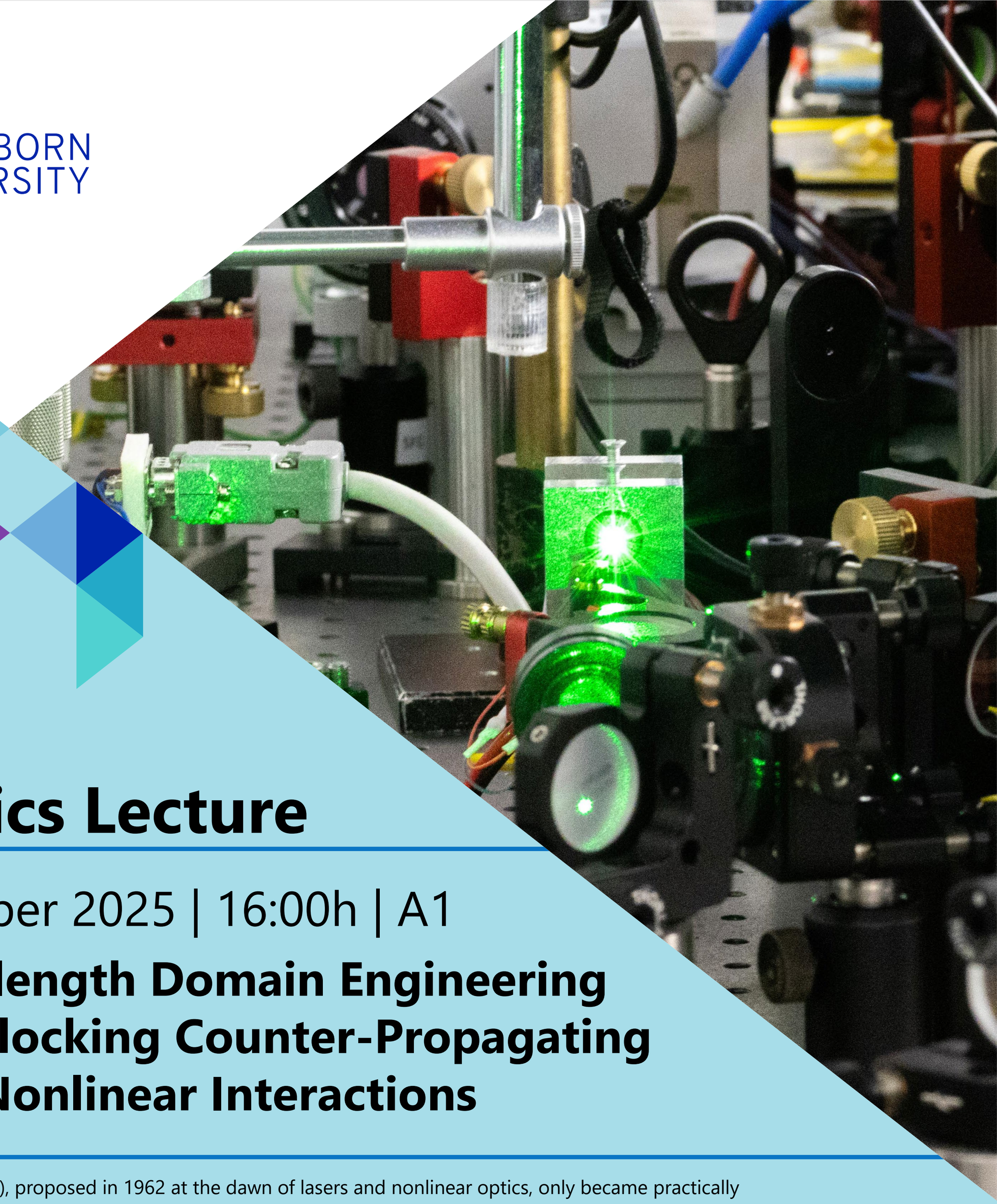

Photonics Lecture

10 September 2025 | 16:00h | A1

Sub-Wavelength Domain Engineering in KTP: Unlocking Counter-Propagating Photons Nonlinear Interactions

Quasi-phase-matching (QPM), proposed in 1962 at the dawn of lasers and nonlinear optics, only became practically viable in the early 1990s with the advent of electric-field poling of ferroelectric crystals. By enabling precise compensation—and even design—of momentum mismatch in second-order interactions, QPM revolutionized frequency conversion of coherent light. Traditionally, QPM structures are realized in bulk ferroelectric crystals by periodically inverting the spontaneous polarization every coherence length, with device efficiency hinging on uniformity of the domain structure across the crystal and along the beam path. Today, fabrication technologies for QPM in ferroelectric oxides are mature enough to meet the demands of most standard low-power and low-pulse-energy applications.

When the poling period approaches the sub-wavelength regime, however, an entirely new landscape emerges: QPM processes involving counter-propagating waves become accessible. These interactions—impossible in conventional nonlinear media—open the door to novel optical effects and devices, such as mirrorless optical parametric oscillators (MOPOs) and amplifiers. In such systems, distributed feedback is provided directly by the counter-propagating nonlinear interaction, eliminating the need for mirrors or resonant cavities. MOPOs display distinctive features, including perfect frequency translation of pump phase modulation in the forward wave and intrinsically narrow linewidths in the backward wave.

In this talk, I will present our advances in domain structuring of KTP isomorphs, including recent breakthroughs in periodic poling that enable bulk domain features as small as 200 nm—once considered unattainable. These achievements have allowed us to realize counter-propagating frequency-conversion schemes and device architectures that were purely theoretical just a few years ago. I will also outline future challenges and opportunities for integrating such devices into optical circuits.

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