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The magic of ferroelectric materials: from novel quasiparticles to next-generation computing

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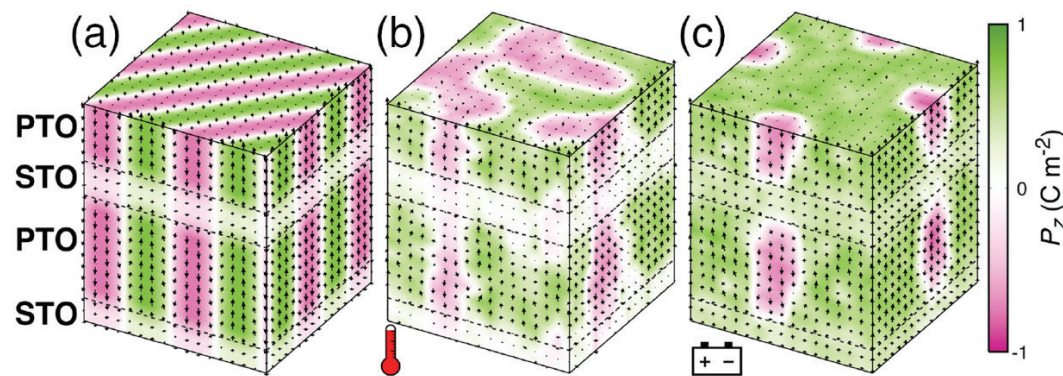


Figure: Electric bubbles in ferroelectric nanostructures. (a) Superlattice formed by ferroelectric (PbTiO₃ or PTO) and dielectric (SrTiO₃ or STO) layers, with up (green) and down (pink) polarization domains. (b) Stochastic movement of the domains upon heating. (c) An external electric field yields favors the green domains and leads to the formation of electric bubbles (in pink). (Adapted from Aramberri and Íñiguez-González, Phys. Rev. Lett. 132, 136801 (2024).)

My main collaborators in these works are M.A.P. Gonçalves (formerly at LIST, now at the Czech Academy of Sciences) and Hugo Aramberri (LIST). Collaborators at the University of Cantabria (Junquera), UC Berkeley/Rice (Ramesh, Martin) and elsewhere were involved in some of the projects. Work in Luxembourg was funded by the Luxembourg National Research Fund. For published articles and further information, please visit <https://sites.google.com/site/jorgeiniguezresearch/>

Ferroelectricity has been studied for over a century, yet it still captivates us with an endless parade of novel materials and striking behaviors. In this talk I will share the current excitement in the field through an overview of the theoretical and simulation activities in my group. Specifically, I will focus on an ongoing breakthrough where we are playing a pivotal role: the prediction and experimental demonstration of electric quasiparticles with non-trivial topological properties – “electric bubbles” (see figure). I will present simulation evidence showing that these bubbles can exhibit spontaneous stochastic motion, behaving as long-lived Brownian quasiparticles. Applying realistic electric field waves allows us to bias their movement, achieving net drift velocities in the range of 100 m/s. Finally, I will also outline the exciting scientific and technological prospects these electric quasiparticles open, e.g., in the field of unconventional computing.

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