

## Tunable ferroelectric polarization and its interplay with spin-orbit coupling in tin iodide perovskites

Alessandro Stroppa<sup>1</sup>, Domenico Di Sante<sup>1,2</sup>, Paolo Barone<sup>1</sup>, Menno Bokdam<sup>3</sup>, Georg Kresse<sup>3</sup>, Cesare Franchini<sup>3</sup>, Myung-Hwan Whanbgo<sup>4</sup>, Silvia Picozzi<sup>1</sup>

<sup>1</sup>Consiglio Nazionale delle Ricerche—CNR-SPIN, I-67100 L'Aquila, Italy,

<sup>2</sup>Department of Physical and Chemical Sciences, University of L'Aquila, I-67100 L'Aquila, Italy.

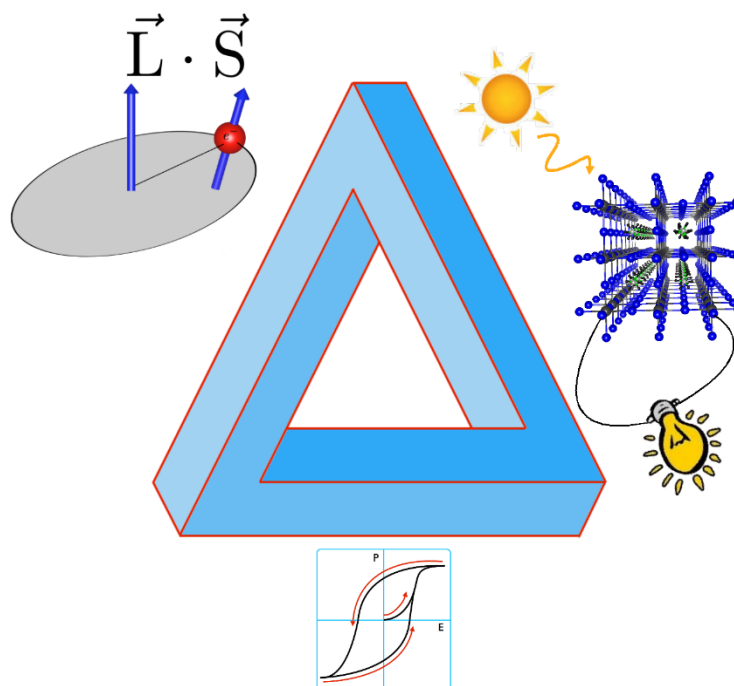
<sup>3</sup>Faculty of Physics, Center for Computational Materials Science, University of Vienna, A-1090 Wien, Austria

<sup>4</sup>Department of Chemistry, North Carolina State University, Raleigh, North Carolina 27695-8204, USA

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Halide perovskites represent an emerging photovoltaic technology. Using density functional theory simulations and symmetry analysis, we discuss the properties in lead-free perovskite iodide (FA)SnI<sub>3</sub>, containing the polar formamidinium cation FA, (NH<sub>2</sub>CHNH<sub>2</sub>)<sup>+</sup>. We have shown that the perpendicular arrangement of FA molecules, leading to a 'weak' ferroelectric polarization, is energetically more stable than parallel arrangements of FA planes, being either antiferroelectric or 'strong' ferroelectric. Moreover, we show that the 'weak' and 'strong' ferroelectric states with the polar axis along different crystallographic directions are competing in energy, thus suggesting that, at least at low temperatures, an electric field could stabilize different states with the polarization rotated by 45°, resulting in a highly tunable ferroelectricity appealing for multistate logic. Intriguingly, the relatively strong spin-orbit coupling in noncentrosymmetric (FA)SnI<sub>3</sub> gives rise to a co-existence of Rashba and Dresselhaus effects and to a spin texture that can be induced, tuned and switched by an electric field controlling the ferroelectric state.

### Spin-Photo-Ferroelectric triangle



A pictorial triangle representing the interplay of dipolar ordering, photovoltaic properties and spin-orbit related phenomena in lead-free solid-state organic-inorganic halide perovskite solar cells.