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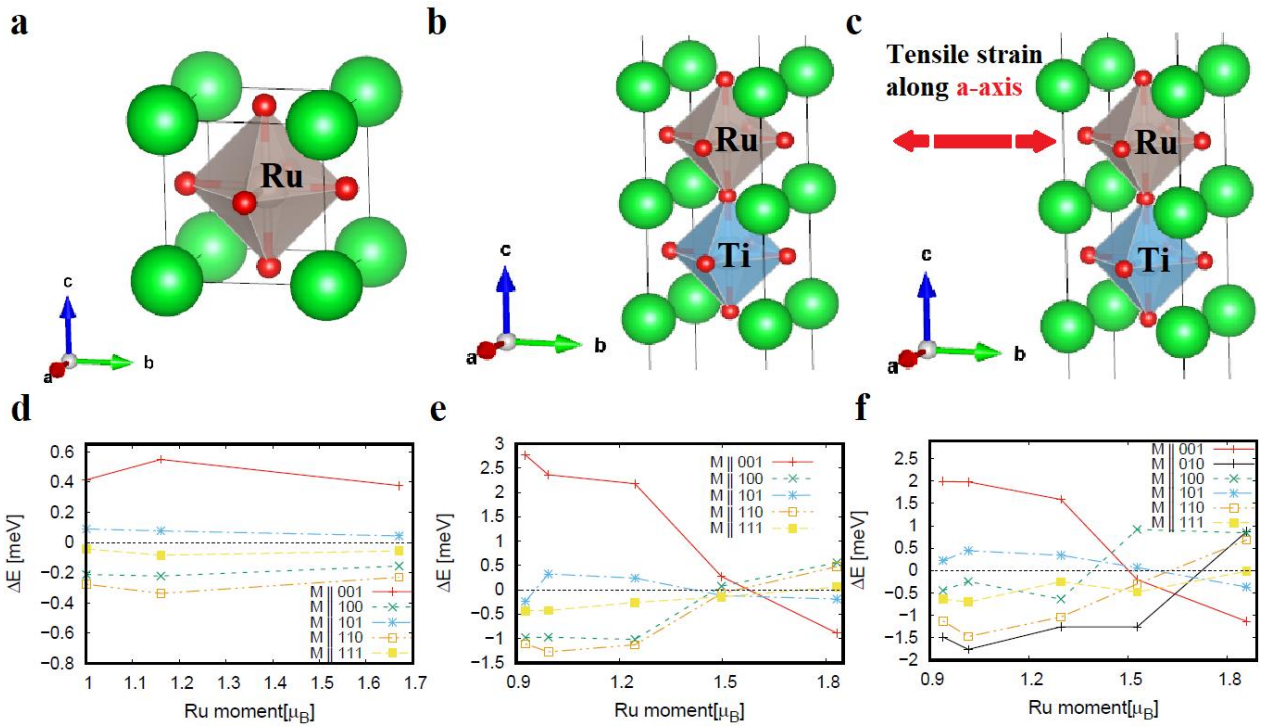
From 25.04.2022 until 13.05.2022 I was visiting Dr. Mario Cuoco, Director of the unit of Salerno of the Centro Nazionale delle Ricerche-SPIN, with whom I have a very active collaboration. The objective of the Erasmus mobility was the training in the investigation of non-collinear magnetism, Berry curvature, Spin-Hall and orbital effect in magnetic and non-magnetic thin films with large spin-orbit coupling.

The main discussion faces the comprehension of the nature of magnetic domains in ferromagnetic films as a key route toward a rational design of new spintronics devices. For that, we can use ferrromagnets that exhibit non-trivial topological properties due to the perspective of engineering magnetic domains with topological electronic modes at the domain wall. Experimental results image the magnetic domain patterns in perpendicularly magnetized ultrathin films of $SrRuO_3$ (SRO), an itinerant ferromagnet hosting momentum-space sources of the Berry curvature. Experiments find a distinct sequence of magnetic phases with a robust stripy state evolving into the uniform ferromagnetic phase. Our theoretical results show that this evolution is driven by strong in-plane anisotropy. Experiments show a real-space modulation of the current-induced magnetic flux amplitude occurring at the magnetic domain wall of the stripes. This behavior is ascribed to the topological character of the ferromagnetic $SrRuO_3$. The combination of experimental and theoretical results illustrates how magnetic domains and topological features of oxides can be manipulated.

During my stay, using numerical simulations within density functional theory, I learned to evaluated the magnetocrystalline anisotropy for different cases as shown in the Figure. Together with the topological band structure, a deep comprehension of the magnetocrystalline anisotropy for the different cases is necessary to assess the unusual properties of the domains in SRO.

We particularly enjoyed scientific discussions and brainstorming with all the members of the unit led by the Director Dr. Mario Cuoco. The layouts for forthcoming three papers have been laid down. Other directions of our joint collaboration have been identified. Another project will be related to the AHE in SrRuO3 thin film, other two are related to the spin-Hall effect in Nb-based superconductors with A15 crystal structure.



Magnetocrystalline anisotropy of SRO bulk and ultrathin films under strain. Schematic of the crystal structure of the SRO bulk (**a**), SRO/STO interface (**b**), and SRO/STO interface under tensile strain (**c**) along (100). **d**. Comparison of the total energy of the SRO bulk system with magnetization (M) along different symmetry axes. **e**. Comparison of the total energy for the 4 unit cell SRO thin films interfaced with STO for magnetic orientations along different axes. **f**. Comparison of the total energy of the 4 unit cell SRO thin-film under tensile strain along (100) with magnetization along different symmetry directions.