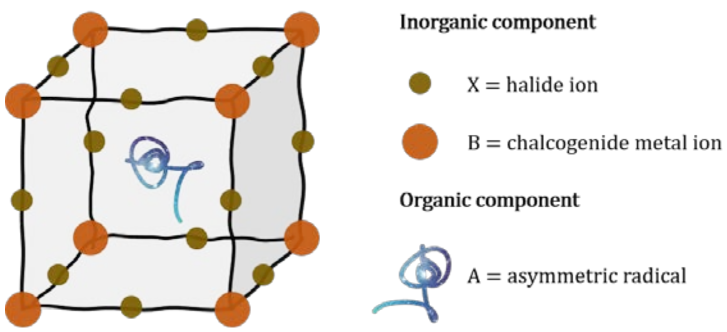
Dynamics within colloidal hybrid perovskites

Hybrid perovskites serve as an excellent candidate for understanding the fundamental physics of molecular hybrids of soft organic components and hard inorganic counterparts. The synergistic interactions of the inorganic and organic components start from the fluid precursor[1] from which perovskite materials are processed. The precursor is prepared by choosing solvents which can combine and transfer the building blocks of final structures (organic and inorganic reactants) in a single medium. A range of forces direct the dynamic of the precursor system which are sensitive to physicochemical parameters, especially the concentration and chemical composition of the fluid. The precursor fluid itself reflects multiple structural entities, from nanoparticles to mesoscale solvent-solute complexes. Exciting physics underlies the transformation of the complex fluids to crystalline thin films, processes which give rise to cooperative systems behaviour and lead to complex thin-film morphologies[2]. By systematic understanding of the versatile precursor and the interactions of its components, novel aspects of condensed matter behaviour are explored which impact any functional architectures utilizing the phase of materials in its solid form.



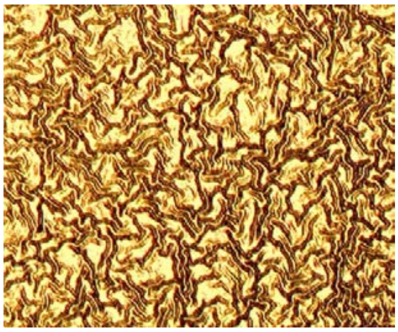


Fig. left: Molecular composite of organic and inorganic entities within crystallographic solid. Fig. right: Optical microscopy of the morphological self-assembly in spin-coated thin-film of mixed halide hybrid perovskite

The presence of organic species introduces additional degrees of freedom to the system and accounts for fascinating intersectional behaviour. The materials exhibit characteristics of soft materials while maintaining the functionalities of inorganic materials.

By altering the nature of the chemical components of the entities it is possible to impact the chemical nature and physical properties of the materials, making for a large toolbox to investigate alloyed structures. The intermixing of distinct chemical entities affects the free volume within structures and leads to the emergence of glassy behaviour, similar to those of polymeric systems. Owing to their strong interaction with electromagnetic radiation and their functional response to a wide range of stimuli, there exist several well-established characterization tools to study the material.

In order to gain a holistic understanding of material behaviour and the impact on functional properties, a range of multimodal characterizations[3], including synchrotron experiments are utilized within our group. These experiments combined with theoretical understanding open the door towards the rapid commercialization of an excellent material class for several sustainable energy harvesting applications.

S. Pratap, E. Keller, P. Müller-Buschbaum: *Emergence of lead halide perovskite colloidal dispersions through aggregation and fragmentation: insights from the nanoscale to the mesoscale,* Nanoscale, **11**, 3495-3499 (2019)

L. Oesinghaus, J. Schlipf, N. Giesbrecht, L. Song, Y. Hu, T. Bein, P. Docampo, P. Müller-Buschbaum: *Toward Tailored Film Morphologies: The Origin of Crystal Orientation in Hybrid Perovskite Thin Films,* Adv. Mater. Interfaces, **3,** 1600403 (2016)

S. Pratap, N. Tamura, C. Stan, Z. Yuan, H. Goudey, A. MacDowell, T.-B. Song, N. Barchi, P. Müller-Buschbaum, C. Sutter-Fella, J. Slack: *Probing the in situ dynamics of structure–property evolution in* *hybrid perovskite thin films spincoated from complex fluids by a custom-designed beamline-compatible multimodal measurement chamber*, *Acta Cryst.*, **A75**, a155-a156 (2019)