As the global energy crisis intensifies, finding sustainable and affordable energy solutions has never been more pressing. Our heavy reliance on fossil fuels drives up costs, harms the environment, and pushes the world to search for cleaner alternatives. The STARSHIP project addresses this challenge by developing a novel experimental-computational framework designed to explore and control the properties of complex materials essential for renewable energy technologies. The project focuses on Hybrid Organic-Inorganic Perovskite (HOIP) materials, which have immense potential for renewable and emerging technologies, including solar cells, green cooling, and soft, efficient optoelectronics.

HOIPs hold great promise due to their high efficiency and low production costs, which could revolutionise how we harvest solar energy. These materials combine the advantages of both organic semiconductors (low cost, flexibility) and inorganic ones (high efficiency). In just a decade, their ability to convert sunlight into electricity has surpassed 25%, putting us on the verge of a solar energy revolution. However, their structural instability remains a significant bottleneck, preventing widespread technological utilisation. Over time, these materials degrade, reducing their effectiveness and limiting their potential as reliable energy sources. Solving this issue is essential to unlocking the full potential of HOIPs for real-world energy applications.

An urgent need is to develop efficient methods to improve their physicochemical and operational stability. STARSHIP aims to tackle these critical challenges by concentrating on chemically tailored, intercalated HOIPs designed to enhance resistance to destabilisation factors. The project seeks to comprehensively understand the atomistic origins of their enhanced stability and improved optoelectronic performance. As such, the project will focus on three key pillars: material structure, intermolecular interactions, and nuclear dynamics, using advances in spectroscopy and computational materials science. The project aims to achieve the following objectives:

- To unravel the atomic-scale mechanisms that underpin the exceptional stability of reduced-dimensional HOIPs, which are critical for advancing photovoltaic and optoelectronic technologies,
- To thoroughly explore their complex phase behavior and associated structural transformations, with a particular focus on underlying nuclear dynamics and molecular mobility,
- To create an innovative experimental-computational framework that integrates nuclear spectroscopic data with ab initio modelling to predict and control the physical-chemical properties of these emerging complex materials.

In addition, STARSHIP aims to establish a new research group focused on the structural dynamics of emerging functional materials. Collaborations with leading international research centres and national academic networks will enhance the project’s capacity for cutting-edge research. STARSHIP will also play a crucial role in training the next generation of scientists, providing exposure to advanced materials characterisation techniques and computational modelling. The project will collaborate with top international research centres to conduct pioneering experiments that could significantly advance the development of renewable energy materials.

This project's outcomes will help pave the way for new, more efficient materials that can power homes, businesses, and industries in a cleaner, more sustainable way. Ultimately, this will reduce our dependence on fossil fuels and help address the global energy crisis.