Project: **Quantum technologies for innovative economy and fundamental research (QuantumTech)**

We will develop cutting-edge quantum technologies exploring matter-light interaction, with applications ranging from metrology to the engineering of quantum systems. We will demonstrate purely optical trapping for low-polarizability species with narrow optical transitions (H_2, Hg). We will develop a unique anion source to produce exotic antiprotonic atoms and study matter-antimatter interactions. We will employ optical frequency combs for the characterisation of new materials with unprecedented precision. Example is crystalline mirror coating needed for the active frequency standards in the optical domain. Finally, we will pioneer purely frequency-based spectroscopy for high-precision metrology of temperature, pressure, and gas composition.

All these technological advancements will be supported by the state-of-the-art quantum chemistry modeling of molecular and crystal structures and interactions to enable precise predictions of spectral properties of various materials and aid in interpreting data from our newly developed spectrometers. Leveraging new mathematical methods and artificial intelligence will optimize these calculations for greater efficiency and accuracy.

Developed technologies and theoretical methods will allow new atmospheric applications including accurate determination of temperature, pressure, and gas composition. Additionally, they will support the characterization of novel materials applicable in the rapidly evolving field of photonics and lead to new optical references for time, temperature and pressure – stimulating development of metrology and standards which are critical for modern branches of industry. Finally, our innovative methodologies will be used to study fundamental properties of the Universe, including matter-antimatter interactions and interactions beyond the Standard Model, such as the study of exotic entities like dark matter.

To create new tools based on quantum technologies applicable in different fields, the interdisciplinary collaboration is crucial. Partnering with various fields will enable groundbreaking advancements: Earth Science – to apply cutting-edge spectroscopic tools in atmospheric research; Quantum Chemistry – to accurately describe molecular structures and atomic interactions; Mathematics and Informatics – to develop innovative approaches for efficient modeling complex systems; Electronics and Mechanical Engineering – to drive technological development, enhance signal detection, and optimize control of experiments.