Reg. No: 2015/18/E/ST2/00760; Principal Investigator: dr Emilia Witkowska

The most precise clocks are atomic clocks which use for time keeping the energy difference between two given states. This can be measured with an uncertainty as small as a few parts over 10^{15}! Going down to such fantastic precisions scientists are facing fundamental limits coming from the quantum nature of matter, in particular when an ensemble of independent atoms is used.

Quantum metrology is about various parameter estimation tasks, and finding measurements schemes that allow to reach the precision of measurements dictated by quantum mechanics. This limit can be achieved by using squeezed or entangled states. In this project we propose to study theoretically novel quantum metrology schemes which could be used both in atomic clocks working in the optical domain and in atomic interferometry. In what follows we plan to consider two most promising systems: spinor Bose-Einstein condensates with dipolar interactions, and ultra-cold atoms in optical lattices. Quantum properties of the systems allow us to develop unique schemes for the generation of entangled states.

The interest in increasing further the precision of measurements is twofold. It allows advances in fundamental science, for example through the test of fundamental physical theories, and it has direct consequences in applications such as navigation and positioning on the Earth and in space, and also in applied uses such as accelerometers, rotation sensors, and gravity gradiometers.