The project aims to study a special class of quantum correlations which can exhibit strange and counterintuitive behaviours not present in classical systems. These correlations are the so-called Bell correlations named after the scientist who first described them in 1964. They refer to correlations between the outcomes of measurements performed on two or more particles that any local hidden variable theory cannot explain. These correlations are often used to demonstrate the non-classical nature of quantum mechanics and the limitations of classical theories.

Nowadays, such non-trivial quantum correlations are a key element in developing quantum technologies exploiting the unique properties of quantum systems to perform tasks that are not possible using classical technologies, including quantum teleportation, quantum cryptography, and quantum computing. However, the generation and certification of many-body Bell correlated states is still a very difficult task and require fitting the Bell inequalities.

SPIN1BELL proposes theoretical and experimental studies of Bell correlations in spin-1 Bose-Einstein condensates near absolute zero temperatures when the atoms are strongly degenerate. The aim of the project is to define protocols for Bell correlations and entanglement witnesses for these systems with more than two measurement outcomes and to establish the experimentally relevant Bell tests. The main motivation is the unique experimental control over the system, which facilitates the study of physics in parameter ranges not available in any other known systems. In particular, the recent experiments of the Chinese partner showed the possibility of creating a special class of entangled states that should exhibit Bell correlations. The research proposed in the SPIN1BELL project focuses on the theoretical development of appropriate Bell tests for spin-1 particles and their experimental demonstration of what will be the main result of the project.