Quantum Metrology

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Spin squeezing is a specific form of many-body entanglement which reduces the fluctuations in a clock measurement below the $N^{-1/2}$ limit, leading to an improvement of the clock frequency stability. Spin squeezing of neutral atoms has been achieved by either atom-light interaction or atom-atom interaction. The existing methods can be placed into three classes:
- Squeezing through quantum non-demolition
- Squeezing through interactions between atoms
- Squeezing through interaction between atoms and an optical cavity

To date, squeezing through atom-cavity interaction seems the most powerful for clock applications because it is well adapted to the use of ultra-cold thermal atoms, which, in contrast to BEC, have shown very long coherence times

The objective of this project is to implement spin squeezing in state-of-the-art a metrology instrument. The trapped atom clock on a chip operating on the 87Rb hyperfine transition will be used as test-bed. The first generation "traditional" clock set-up was brought to maturity (5.8 10-13 stability at 1s). Using spin squeezing we aim to push the performance below 10-13 stability. A second generation set-up will be built incorporating an on-chip miniature optical fibre cavity which will be fabricated through laser machining of the end facets of optical fibre. A new atom chip will be fabricated to accommodate for the cavity.

Using atom-cavity squeezing we will evaluate the ultimately improvement of the clock stability. We will investigate systematic frequency shifts related to the use of spin squeezing. In the long-term the results could be transferred to other atomic clocks and atomic sensors, which are under construction at SYRTE and Thales TRT.

In view of follow-up projects which could include technology transfer to an industrial partner, Thales TRT will evaluate the performances achieved by the squeezed-state atomic clock, and assess the potential interest of this technology regarding the practical applications in the fields of time keeping and inertial sensing. Thales TRT will also comment on the technologic issues related to industrial development.