

Fiber Phase Locking for Optical Clocks

Optical clocks are pushing the boundaries of human capability of precision measurements, currently measuring time at the accuracy of 18th decimal place. This project involves one of the key requirements for the standardization of optical clocks: phase noise cancellation in an optical fiber.

Since the beginning of civilization, timekeeping devices, such as Stonehenge, Egyptian obelisks or hourglasses, have always been an integral part of mankind. The essence of all clocks lies in observing a regular periodic event and then counting the number of cycles or the frequency. Periodic motions of astronomical bodies such as earth's rotation around its own orbit or the sun, have been telling us about time for many centuries. For shorter timescales, pendulums were invented which, even in 16th century, measured time with enough accuracy that time measurement becomes more precise than other physical quantities and since then even more accurate time measurement systems have been searched for by many scientists and researchers.

As first pointed out by Maxwell, oscillations in atoms are ideal frequency references since atoms are available in exact copies throughout the universe and their oscillations are not easily affected by environment. At present, the S.I. definition of second is based on Cesium atomic clocks where the oscillations are in microwave frequency. The unprecedented accuracy of atomic clocks have already transformed our lives by providing accurate GPS and navigation system, synchronizing communication links throughout the world and so on.

Optical Clocks

The optical regime contains 50 thousand times higher number of cycles per second than microwave regime and hence, clocks based on atomic oscillations in optical regime have potentials to be even more accurate. In fact, current state-of-the-art optical clocks have already achieved accuracy to the 18th decimal place and in future, there is high probability that optical clocks will become the standard of time.

One of the key requirements for standardization of optical clocks is to transmit light to far places and optical fibers are the most convenient way to do that. This project is about designing and building a system (a phase locking feedback system) to transmit laser light through a fiber in such a way that the light preserves its phase information. Another crucial element of the optical clocks is laser stabilization. The thesis also involves designing an experimental setup for laser stabilization by slowing down the group velocity of light.