The ultrafast revolution: How ultrashort optical pulses revolutionized optical metrology

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Lasers producing pulses as short as a few femtoseconds (1 fs = 10^{-15} s) have led to tremendous advances in a large variety of scientific and commercial disciplines. Besides the obvious benefit of unprecedented temporal resolution, the optical spectrum emitted from such ultrafast lasers profoundly changed the way we measure time, distances, and optical frequencies to date. The recent developments in this field have been so substantial that it will likely affect the cornerstones of metrology: the definition of the SI-units, namely the definition of the second and all related units (time, distance, frequency, and possibly also mass, density, and temperature). Ultrashort pulses and optical frequency combs have seeped out from the domain of pure science into commercial applications, such as medical diagnostics, trace gas analysis, or fs-micromachining.

In these four lectures, I will give an introduction to modern femtosecond technology by discussing the fundamentals of ultrashort pulse generation followed by an introduction to optical combs, which are at the heart of this rapid progress. In the second half I will cover some of the ongoing research in the fields of ultrafast physics, AMO physics, and optical metrology.