Optical Atomic Clocks
David Wineland, National Institute of Standards and Technology

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Kane Hall 130

For many centuries, and continuing today, a primary application of accurate clocks is for precise navigation. For example, GPS enables us to determine our distance from the (known) positions of satellites by measuring the time it takes for a pulse of radiation emitted by the satellite to reach us. The more accurately we can measure this time, the more accurate our position is known. Atoms absorb electromagnetic radiation at precise discrete frequencies. Knowing this, a recipe for making an atomic clock is simple to state: we first need an oscillator to produce the radiation and a device that tells us when the atoms absorb it. To make a clock from this setup, we then simply count cycles of the oscillator; the duration of a certain number of cycles defines a unit of time, for example, the second. Today, the most accurate clocks count cycles of radiation corresponding to optical wavelengths, around a million billion per second. At this level, many interesting effects, including those due to Einstein’s relativity, must be accounted for.

About Dr. Wineland
David Wineland received a BA degree from the University of California, Berkeley in 1965 and a Ph.D. from Harvard University in 1970. He has been a member of the Time and Frequency Division of NIST (National Institute of Standards and Technology) in Boulder, Colorado since 1975, where he is a group leader and NIST Fellow. Starting with graduate school, a long-term goal of his work has been to increase the precision of atomic spectroscopy. This research has applications to making better atomic clocks and has led to experiments showing precise control of the energy levels and motion of atoms. Such control is now being applied to measurements whose precision is limited only by the constraints of quantum mechanics and to demonstrations of the basic building blocks of a quantum computer.
He completed his PhD in 1970, supervised by Norman Foster Ramsey, Jr. His doctoral dissertation is entitled "The Atomic Deuterium Maser". He then performed postdoctoral research in Hans Dehmelt's group at the University of Washington where he investigated electrons in ion traps.

He shared the 2012 Nobel Prize in Physics with French physicist Serge Haroche "for ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems."

Resource Material for the Lecture

- Study Guide for Optical Atomic Clocks (PDF)

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