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Developing Stabilized Lasers, Measuring their Frequencies, demoting the Metre, inventing the Comb, and further consequences

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Michelson's 1907 proposal to define the SI Metre in terms of an optical wavelength was realized only in 1960, based on a ^{86}Krypton discharge lamp. The same year saw the cw HeNe laser arrive and a future redefinition based on laser technology assured. Separation in the late 60's of the laser's gain and spectral-reference-gas functions led to unprecedented levels of laser frequency stability and reproducibility. In addition to HeNe:CH_4 system at 3392 nm and HeNe:I_2 at 633 nm, systems at 514 nm and 10600 nm were studied. Absolute frequency measurement became the holy grail and some NBS team experiences will be shared. We measured both frequency and wavelength in 1972, and so obtained a speed of light value, improved 100-fold in accuracy. During the next decade, the NBS value of c was confirmed by other national labs, and frequency metrology was extended to the 473 THz (633 nm) Iodine-based wavelength standard. This frequency to $\sim$10 digit accuracy was obtained in 1983, thus setting the stage for redefining the SI Metre. By consensus choice the value 299 792 458 m/s was adopted for the speed of light, effectively reducing the Metre to a derived SI quantity. Knowledge of the frequency of the particular laser being utilized was controlled by International intercomparisons, but the need for a fast and accurate means to make these laser frequency measurements was obvious. Creative proposals by Hänsch and by Chebotayev were to use ultra-fast repetitive pulses to create an "Optical Comb," but it was years before any technical basis existed to implement their Fourier dreams. Finally, in 1999 the last needed capability was demonstrated – continuum production at 100 MHz rates and non-destructive power levels. By May 2000 phase-locked combs were operational in both Garching and Boulder, substantially accelerated by their collaborative interactions. Within 18 months all the known proposed "optical frequency standards" had been accurately measured via Comb techniques.