A Portable Hg Clock

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80 $^1S_0$
Hg
Mercury
200.59
$[Xe]4f^{14}5d^{10}6s^2$
10.4375

Frequency Standards

Precise time metrology has wide-ranging applications from GPS to the confirmation of measurements suggesting muon-neutrinos' superluminal speeds. Stable, precise, and portable atomic clocks are ideal tools for these measurements.

$$\sigma_\nu = \frac{\Delta\nu}{\nu}\sqrt{\frac{T}{\tau N}}$$

$\Delta\nu$ transition linewidth

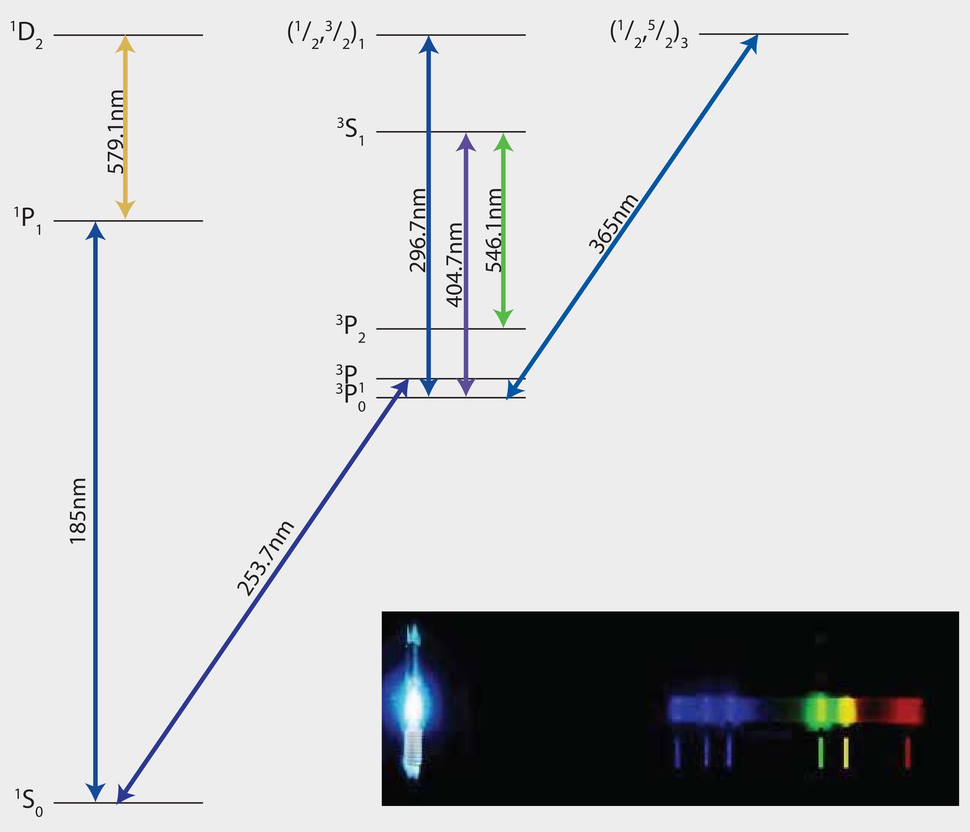
T experiment duty cycle

ν excitation laser frequency

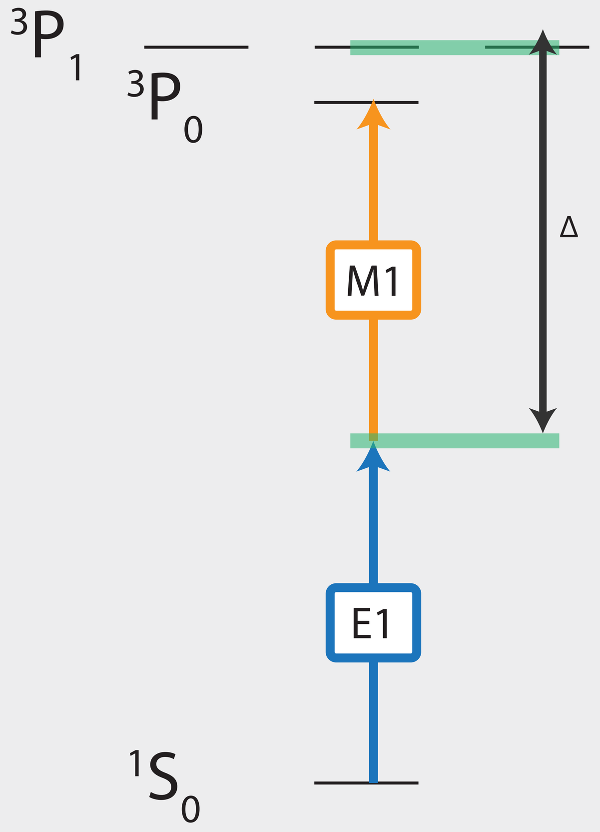
N sample size

τ total experiment time

Hg Electronic Structure



Nonlinear Excitation Scheme

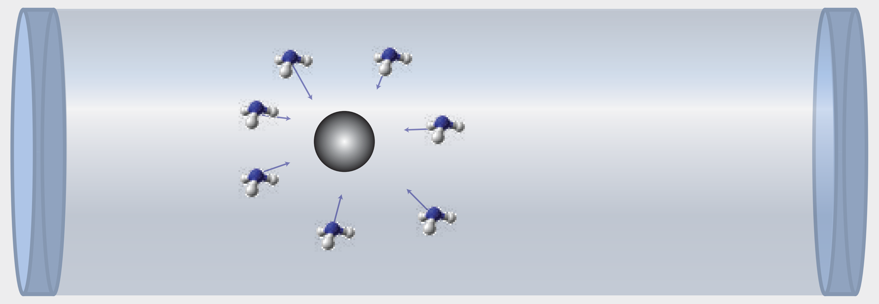


$$R_{2\gamma} \propto \frac{I^2\langle^3P_0|\mu|^3P_1\rangle^2_{M1}\langle^3P_1|\mu|^1S_0\rangle^2_{E1}}{\Delta^2}$$

By using two-photons to excite the transition, we can access a dipole-forbidden level with lifetimes > 1s. However, the two-photon transition is only permitted by coupling to an intermediate level which has large detuning.

An important virtue of the two-photon scheme is its insensitivity to Doppler broadening to first order. This means the clock can operate at room temperature or hotter unlke other atomic frequency standards.

First signal will come from relaxation after collisions with NH_3. This cascades emits broadly in the UV centered on 350nm. See Kaitlin Moore's poster: "Developing a Room-Temperature Atomic Clock with Hg."



References

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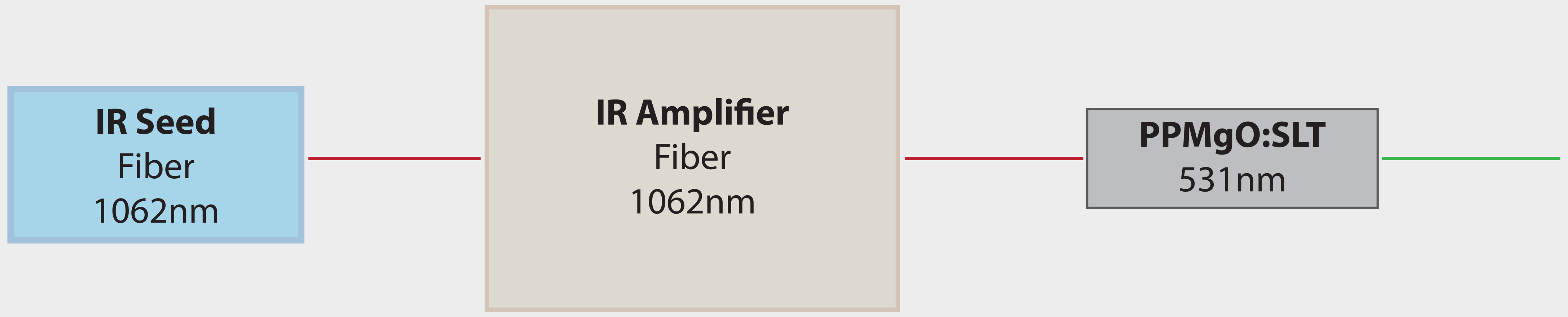
G. K. Samanta, S. Chaitanya Kumar, and M. Ebrahim-Zadeh, "Stable, 9.6 W, continuous-wave, single-frequency, fiber-based green source at 532 nm," Opt. Lett. 34, 1561-1563 (2009)

M. Petersen et al., Phys. Rev. Lett. 101, 183004 (2008)

Fiber Laser System

This experiment relies critically on the ability to access high powers in the visible. Recent leaps in technology have made these levels achievable at reasonable cost. We're using fiber laser systems with narrow linewidth and periodically poled crystals for efficient doubling.



IR Seed	IR Amplifier	PPMgO:SLT
Features	**Features**	**Features**
<1kHz linewidth	2mW->52W linewidth preserving	2.67%/W efficiency

I^2 Reference Spectroscopy

In our search for Hg, it will be helpful to have an atomic frequency reference. Molecular Iodine spectrum is dense in the visible and has several lines near the Hg spectrum we're probing. We've scanned the region of interest and measured Doppler broadened I^2 with our laser system.