A Compact 461-nm Laser Source for Sr^+ Trapped-Ion Experiments

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Strontium can be efficiently photoionized in a two-step process[1] that requires light at 461 nm (excitation) and 405 nm (ionization via a broad auto-ionizing state). The latter step is easily achieved using cheap, free-running laser diodes; however, the first step is more demanding since the laser frequency should, preferably, be correct to within a few hundred MHz. Here we describe a compact, stabilized source of 461 nm radiation appropriate for a future transportable Sr^+ single-ion clock.

The setup is shown in Fig. 1. A 921-nm, 100-mW DBR laser diode (Photodigm PH921.7DBR) is frequency doubled in a fiber-coupled PPLN waveguide[2]. After beam shaping by an anamorphic prism pair and optical isolation, about 50 mW is available for fiber coupling and second-harmonic generation. For low input powers, the conversion efficiency of the waveguide is 230%/W, yielding >2mW of light at 461 nm. A chromatic beam splitter separates the second harmonic beam from the fundamental, the latter of which is sent to a frequency comb (optional stabilization). About 90% of the second harmonic is sent to the ion trap, while the remaining 10% is used for frequency stabilization, that is, for measuring the absorption in a beam of Sr atoms emitted from a dispenser in a small vacuum cell[3]. To maximize the lifetime of the dispenser, balanced lock-in detection is used; however, the sensitivity of this scheme is compromised by the sensitivity of the PPLN waveguide to frequency modulation; the resulting amplitude modulation cannot fully be corrected by the balanced detector. In a future upgrade, the vacuum cell should be equipped with another view port (top side) to be used for background-free imaging of the scattered light using a low cost CCD camera. In the beam direction, the scattering is position dependent due to the Doppler effect, i.e., the frequency is mapped into a position enabling frequency stabilization via spatial imaging.

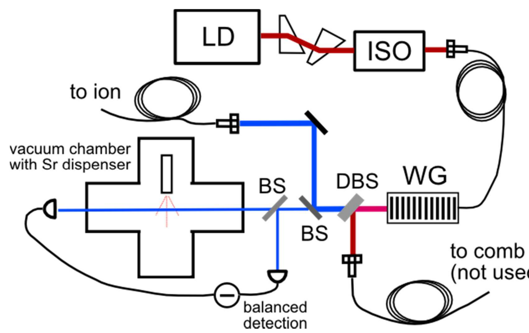

Fig. 1: Experimental setup. LD: laser diode; ISO: isolator; WG: PPLN waveguide; DBS: dichroic beam splitter; BS: beam splitter. The physical size of the setup is approximately 30 cm x 45 cm x 10 cm.

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