NON-THERMAL STABILIZATION OF LARGE SODIUM DENSITIES

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Abstract

We implement a compact, cheap and fully automatic system to create and stabilize large densities of Na vapor at room temperature by means of the so-called Light-Induced Atomic Desorption (LIAD) effect from porous surfaces, thus overcoming all the limitations of conventional heating techniques.

Our system is able to stabilize optically atomic densities corresponding to about 400 K with a precision better than 1% while maintaining the sample at room temperature; moreover, it allows for atomic density modulation according to preset functions.

The compactness, cheapness and flexibility of our system open a new perspective both for experimental use and practical applications.

Introduction

Key requirements for photonic sensing:
- **creation** of atomic vapor densities
- **stabilization** with known precision

Conventional heating techniques suffer from drawbacks:
1. **thermal inertia**
2. **power consumption**
3. **potentially harmful high temperatures**

The LIAD Effect

Non-thermal effect due to **photoejection** of atoms trapped in **porous surfaces**, such as organic coatings [1,2], nanoporous silica [3] or alumina [4].

Under **weak**, **incoherent** and **non-resonant illumination**, a sudden release of atoms increases the atomic density up to **several orders of magnitude over the thermal equilibrium value**.

Key features:
- **increasing desorbing efficiency with (E_{photon})^2**
- **exponential relaxation to equilibrium** with τ =104 s in our case

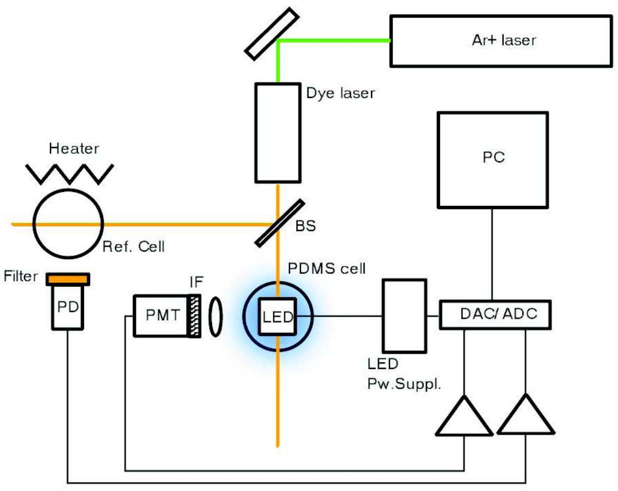
Need for optical density stabilization

LIAD applications sofar limited to create "bursts" of atoms for:
- MOT loading [5]
- atom chips for BECs [6]
- nanoparticles creation and manipulation [7]
- photonic band gap fibers core loading [8]

For further achievements:
- **long time** range density control
- **flexible and fast** density control
- **compact and cost-effective** devices
- **harmless** techniques for critical applications (biomedical)

Experimental apparatus

Fig. 1: Experimental apparatus
- Pyrex cell with Na vapor in equilibrium with its solid phase and **poly-dimethyl-siloxane [SiO(CH$_3$)$_2$]$_n$ (PDMS) coating**
- Uncoated heated reference cell for monitoring laser stability
- Ar$^+$ pumped dye laser tuned to the Na D$_2$ line at 589.0 nm
- **Cheap and compact 435 nm (FWHM=40 nm) LED array**, I_{max}= 2 mW/cm^2
- Fluorescence signal as **density monitor** and **feedback for fully automatic control**



Experimental results

► Na density enhancement at room temperature (RT) by LIAD

Fig. 2: Images of the PDMS coated cell at RT. **Left**: 200 mW dye laser; **center**: 200 mW dye laser, LIAD system on; **right**: 200 mW dye laser, LIAD system on, seen trough optical filter.

► Na density stabilization

5.6x10^9 atoms/cm^3 (372 K) at RT stable for more than 20 min with a precision better than 1%.

LED intensity rises from 0.77 to 1.13 mW/cm^2 **to compensate for PDMS depletion**.

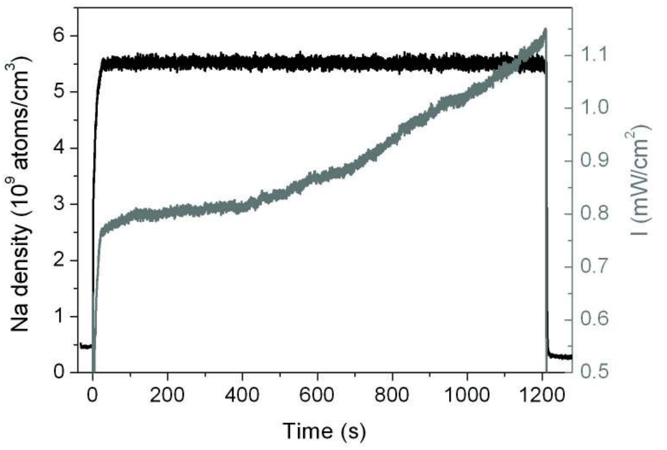


Fig. 3: Na density versus time with LIAD stabilization (black line); desorbing LED intensity (gray line). 30% cell surface illumination.

► Fast Na density modulation

Sinusoidal modulation of atomic density between 1.6x10^9 atoms/cm^3 (359 K) and 4.5x10^9 atoms/cm^3 (370 K).
- **Response time** depending on actual **desorption rate**.
- **Maximum frequency** depending on the **amount of modulation**.

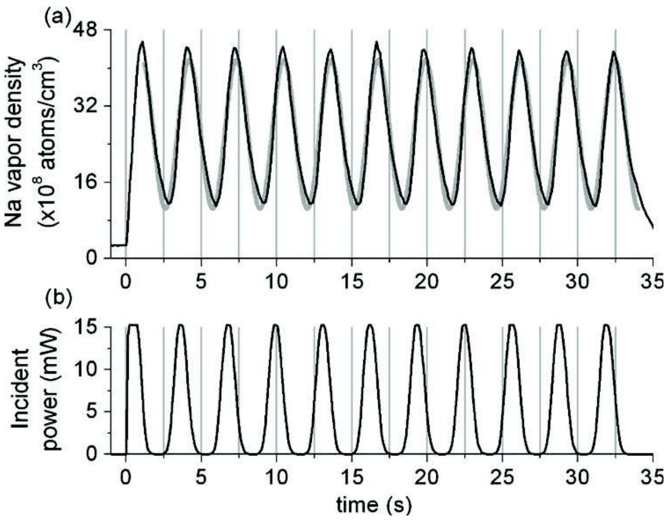


Fig. 4: **(a)**: Na density (black line) modulated at 0.3 Hz with a sinusoidal function (gray line) by LIAD. **(b)**: corresponding desorbing LED power. 100% cell surface illumination.

Conclusions

We implemented a compact, cheap, harmless, power-saving and fully automatic system based on LIAD to create and stabilize high alkali atoms vapor densities at RT. Its characteristics and its flexibility make our system particularly appealing for photonic sensing, but also for more fundamental fields where a controlled atomic density is required, such as in CPT-related experiments [9].

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