Polychromatic mirrorless lasing from two-photon excited Na vapours

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The commonly used laser guide star (LGS) method developed for probing atmospheric turbulences and image correction in optical astronomy is based on the detection of near-isotropic fluorescence from mesospheric Na atoms excited by resonant laser light [1]. Despite the great progress in developing the LGS technique in recent years, there is a widely recognized need for stronger return signals that could make image correction faster and more accurate. Low-divergence backward-directed emission generated in the mesospheric sodium layer could constitute a solution of the problem. Backward cooperative emissions from a very dense sodium vapor was studied using ultrashort pulses produced by an amplified femtosecond laser [2]. We present a study of the spectral and spatial characteristics of the directional emission from warm Na atoms in a cell excited to the 4D level by cw resonant laser light at 589 and 569 nm at modest, less than100 mW, power in co- or counter-propagating configurations. The observed polychromatic laser-like emission at 2.34, 2.20, 1.14 and 0.33 μm originates from amplified spontaneous emission (ASE), as steady-state population inversion is created on several transitions (Fig. 1a), and following wave mixing, as was also shown previously in Rb vapors [3]. In particular, the threshold-type dependences for all new generated fields were observed (Fig. 1b). Also, we show that the divergence of both forward and backward radiation is determined by the aspect ratio of the interaction region inside the cell (Fig.1c) and could as small as 3.5 mrad.

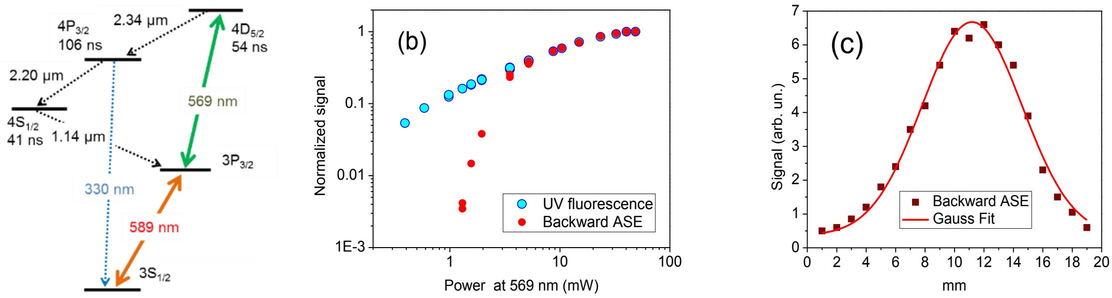

Figure 1. (a) Relevant energy levels of Na atoms. (b) Backward emission at 2.20 μm and isotropic fluorescence at 330 nm as a function of laser power at 589 nm. (c) Spatial profile of backward-directed lasing at 2.20 μm obtained by shifting the detector across the beam 1.2 m from the Na cell.

The results of our study could provide decisive information for choosing an optimal excitation scheme for achieving directional return from mesospheric sodium atoms, as directional polychromatic backward emission promises a dramatic enhancement of LGS signals.

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