Exploring multicolor mirrorless lasing in sodium: advancing to next-generation laser guide stars

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The study of mirrorless lasing (ML) has been of great interest in recent years because of its potential application to remote sensing of magnetic fields in the upper mesosphere [1]. ML is achieved by stepwise excitation of sodium atoms with resonant laser beams leading to the generation of infrared light in the backward direction [2]. The highly directional nature of ML ensures larger collection efficiency as compared to fluorescence based techniques [3,4] leading to the possibility of brighter laser guide stars. The use of this phenomenon for on-sky measurement necessitates simulating the mesospheric conditions in a laboratory setting. In a previous work [1], the study was conducted with a sodium vapor cell in vacuum leading to the generation of ML at 2.21 μm. In this work, we explore the possibility of simultaneous ML generation at 9.1 μm, which has an advantage of better atmospheric transmission and hence can be a suitable candidate for next-generation laser guide stars. Moreover, we investigate the fundamental properties of ML such as the threshold condition and the effect of buffer gas to find the parameter range optimized for enhanced sensitivity of the ML process demonstrated with a home-made sodium vapor cell.

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