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High-brightness switchable multi-wavelength remote laser in air

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Remote laser in air based on amplified spontaneous emission (ASE) has produced rather well-collimated coherent beams in both backward and forward propagation directions, opening up possibilities for new remote sensing approaches. The remote ASE-based lasers were shown to enable operation either at ~391 and 337 nm using molecular nitrogen or at ~845 nm using molecular oxygen as gain medium, depending on the employed pump lasers. To date, a multi-wavelength laser in air that allows for dynamically switching the operating wavelength has not yet been achieved, although this type of laser is certainly of high importance for detecting multiple hazard gases. In this Letter, we demonstrate, for the first time to our knowledge, a harmonic-seeded switchable multi-wavelength laser in air driven by intense mid-infrared femtosecond laser pulses. Furthermore, population inversion in the multi-wavelength remote laser occurs at an ultrafast time-scale (i.e., less than ~200 fs) owing to direct formation of excited molecular nitrogen ions by strong-field ionization of inner-valence electrons, which is fundamentally different from the previously reported pumping mechanisms based either on electron recombination of ionized molecular nitrogen or on resonant two-photon excitation of atomic oxygen fragments resulting from resonant two-photon dissociation of molecular oxygen. The bright multi-wavelength laser in air opens the perspective for remote detection of multiple pollutants based on nonlinear spectroscopy.

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