Laser produces infrared beams over an unprecedented range of wavelengths

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A*STAR scientists have developed a unique fast-pulsing fiber laser that has the widest wavelength output to date. This type of laser could replace several fixed-wavelength lasers and form the basis of compact devices useful for a range of medical and military applications.

The team developed an all-fiber laser, constructed similarly to a fiber-optic cable. The key component is a glass tube, whose core is doped with atoms that act as a gain medium—a material from which energy is transferred to boost the output power of the laser—through which light particles, or 'photons', travel. The doping atoms are selected according to the specific wavelengths of light that they will absorb, store and then release, creating an efficient, controllable output beam.

"To date, most tunable all-fiber pulsed lasers achieve a maximum tuning range of about 50 nanometers," says Xia Yu from the A*STAR Singapore Institute of Manufacturing Technology, who worked on the project with her team and her collaborator Qijie Wang from Nanyang Technological University. "We have achieved a widely-tunable laser in the mid-infrared wavelength band, with a range of 136 nanometers (from 1,842 to 1,978 nanometers). We used thulium as the doping atom; this generates a laser that operates in the eye-safe range, meaning it could have medical and military applications."

The researchers combined two techniques to create their laser and ensure the output was tunable. They used nonlinear polarization evolution, a filtering effect that picks out pulses of light at the desired wavelength and channels them into the output beam. This simultaneously ensures that the output can be adjusted to a specific wavelength while generating ultrafast pulsed light. They also used bidirectional pumping—injecting energy into the gain medium from both ends of the fiber—to ensure a high optical power for as wide a range of wavelengths as possible. The gain occurs when thulium ions are excited to higher-energy states; they then release more photons when they return to lower-energy states.

"This is the state-of-the-art, widely-tunable all-fiber laser with pulsed output at this wavelength," says Yu. "We have shown that every parameter, from the pumping scheme to the use of nonlinear polarization evolution, is critical to the final output."

Yu's team believe that their simple, inexpensive and compact laser could one day be used in combination with high power amplifiers to generate other forms of laser, including extreme ultraviolet and soft X-ray beams.

More information: Zhiyu Yan et al. Widely tunable Tm-doped mode-locked all-fiber laser, *Scientific Reports* (2016). DOI: 10.1038/srep27245

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