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Spatial Holeburning Stabilizes Single-Frequency Ytterbium-Doped Fibre Laser

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Fibre lasers in a simple standing-wave geometry can not usually generate a single-frequency output because the well-known effect of "spatial holeburning" reduces the mode selectivity in the gain medium. However, it has been noted that spatial holeburning in a doped but unpumped, thus reabsorbing section within the laser cavity has the opposite effect: the lasing longitudinal mode suffers a lower loss than all competing modes. This effect has previously been used for linewidth narrowing of an erbium-doped fibre laser [1], although stable single-frequency operation was not achieved in that case. In a more complicated ring laser [2], spatial holeburning in an unpumped standing-wave section has been shown to improve the stability of single-frequency operation.

We have found that stable single-frequency operation can be achieved even in a very simple standing-wave configuration of an ytterbium-doped fibre laser, pumped at 975 nm and lasing (in our case) at 1040 nm. We use a 7 m long doped fibre where the pump power is absorbed within 1 m. The cavity is formed by a dielectric mirror at the input end and a fibre grating spliced to the other end. The beneficial holeburning effect in the 6 m long absorbing section more than compensates for the destabilizing effect of spatial holeburning in the pumped section: we measured that the lasing mode acquires a net gain advantage of about 1 dB against any competing longitudinal mode. This leads to remarkably stable single-frequency operation and we have been able to tune over 300 free spectral ranges without any mode hop. Fluctuations of pump power or ambient temperature (no temperature stabilization or insulation was used) also do not induce any mode hops.

This result is of considerable importance because extraordinary stability is achieved in a most simple laser configuration without the need for expensive components like Faraday isolators, fibre couplers, or narrow-band optical filters. In addition, it is expected that this laser will have a very narrow linewidth.

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[1] M. Horowitz, R. Daisy, B. Fischer, and J. Zyskind, Electron. Lett. **30**, 648 (1994).
[2] Y. Cheng, J.T. Kringlebotn, W.H. Loh, R.I. Laming, and D.N. Payne, Opt. Lett. **20**, 875 (1995).

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We have exploited spatial holeburning to achieve remarkably stable single-frequency operation and mode-hop-free tuning over 300 free spectral ranges in an ytterbium-doped fibre laser with a simple standing-wave geometry.