Coherent Transient Phenomena in the Mode-Locked Argon Laser

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Abstract

An investigation has been carried out into the operation of a mode-locked argon laser at a wavelength of 514.5 nm and a repetition rate of 76.8 MHz. The characteristics of the pulses from the laser have been found to depend on the intra-cavity power level in the laser, and at average intra-cavity power levels exceeding 4 W, the pulses from the laser have a duration of typically 35 psec accompanied by a characteristic double-peaked spectrum with a spectral width of 13 GHz. These pulse durations are approximately three times shorter than expected based on the inhomogeneously broadened transition bandwidth of 4 GHz.

The dependence of the pulse characteristics on the intra-cavity power level has been explained by a model of pulse propagation where the coherent coupling between the pulse and the atomic polarisation in the laser gain medium is included. Detailed examination of the pulse structure reveals the presence of afterpulses that have a typical intensity two orders of magnitude lower than the main pulse. These afterpulses are interpreted as ringing arising from coherent Rabi-type oscillation of the atomic polarisation associated with the circulating pulse in the laser.

Numerical simulations of the mode-locked laser have also been developed based on the fully coherent Maxwell-Bloch equations, and the results from the simulations reproduce well the experimentally observed variation in pulse characteristics. Based on results from the simulations, the short pulses observed at high intra-cavity powers are interpreted as the superfluorescent π-pulse solutions predicted in the long distant limit of pulse propagation in a swept-gain amplifying medium.

The laser operation has also been studied in a mode-locked cavity dumped configuration. In this case the combination of the coherent mode-locking processes described above with the cavity dumped operation at a repetition rate of 3.8 MHz results in the observation of stable pulses with peak power of 1.6 kW.

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Abbreviations

AM	Amplitude Modulation
AOM	Acousto-Optic Modulator
ASE	Amplified Spontaneous Emission
CW	Continuous Wave
FM	Frequency Modulation
FWHM	Full-Width at Half Maximum
GVD	Group Velocity Dispersion
HWHM	Half-Width at Half Maximum
MLCD	Mode-Locked Cavity Dumped
RF	Radio Frequency
SHG	Second Harmonic Generation
SPM	Self-Phase Modulation
SVEA	Slowly Varying Envelope Approximation
TPF	Two Photon Fluorescence