Micro-integrated semiconductor laser modules for precision quantum optical experiments in space

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Motivation

Quantum sensor applications in μ-gravity
- time keeping, exploration, inertial navigation
- test of fundamental physics
- e.g. STE-QUEST

Laser requirements
- robust, compact, reliable, energy-efficient, space-compatible
- spectral availability: NIR to UV
- spectral stability: MHz to sub-kHz linewidth, free running
- optical power: up to 1 W

Typical performances
- DFB laser
  - intrinsic linewidth: < 30 kHz
  - output power: > 150 mW
- ECDL
  - intrinsic linewidth: < 3 kHz
  - output power: > 30 mW
- DFB laser with feedback1
  - intrinsic linewidth: 15.7 Hz
  - output power: > 50 mW

Motivation

Diode lasers: complete value chain ...

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Packaging
- hermetically sealed Kovar housing with optical and electrical feedthroughs

Technology transfer

Compact UV-laser system for 267 nm
- Local Oscillator + Pre-Amplifier (1070 nm)
  - extended cavity concept
  - very narrow free running linewidth
- Phase Modulator + Amplifier (1070 nm)
  - control bandwidth > 1.5 MHz
  - 750 mW output (fiber coupled)
- Single-Pass Doubling (1070 nm → 535 nm)
  - ppLN:MgO
  - 150 mW output (fiber coupled)
- Resonant Doubling (535 nm → 267 nm)
  - BBO, w/ cavity stabilization
  - 5 mW output

Ultra-narrow linewidth external cavity laser
- optical feedback from a monolithic cavity (F=200), expected linewidth <10 kHz
- long time stability due to active tracking of the cavity resonance frequency (Hänsch-Couillaud method)

Modulation-Transfer-Spectroscopy Setup
integrated on a micro-optical bench
- micro-integration of a phase modulator
  - chip, mirrors, beam splitters, a fiber coupler,
  - a miniaturized Rb spectroscopy cell and electrical interface

Volume: 80 x 30 x 10 mm³

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