Mode-locked laser with V-shaped geometry and complex gain dynamics

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10 ECTS (Bachelorarbeit/Masterarbeit)

Mode-locked semiconductor lasers are promising candidates for the generation of short pulses of light. Depending on the operation conditions different dynamical regimes, ranging from Q-switching to high order harmonic mode-locking, exist and are well understood [VLA11]. However, if the amplifying and the absorbing material are embedded in an external cavity with a V-shaped geometry (Fig.1a), e.g. done in [KLO09] to obtain pulses with a duration of 100 fs and repetition rates in the GHz ranges, new pulse cluster solutions emerge [WAL18][MAL18][LIN17d]. To understand the underlying dynamics, we theoretically model the device (Fig.1a) by a system of multi-delay differential equations [WAL18] which we derived from a travelling-wave approach similar previous models assuming a circular cavity [VLA04][VLA05].
Although these models enable a detailed bifurcation analysis of the pulse cluster solutions, they neglected the carrier dynamics in the reservoir of the gain chip. Due to the already investigated behaviour of quantum-dot-mode-locked semiconductor lasers, we expect additional dynamics to emerge e.g. trailing edge plateaus [RAD11], if these carrier dynamics are included.

The following steps will be carried out during the project:

- Backround reading into semiconductor lasers, mode-locking and non-linear dynamics.
- Extension of the DDE model for ML lasers with V-shaped geometry, including the carrier dynamics in the reservoir of the gain-chip.
- Implementation and numerical simulations to investigate the various dynamical regimes that rise in dependence additional carrier dynamics.
- Comparison of the results with pre-existing simulations including only one term for the gain carrier dynamics.
- If the project is carried out as master thesis, it is also possible to perform bifurcation analysis using specialized software.

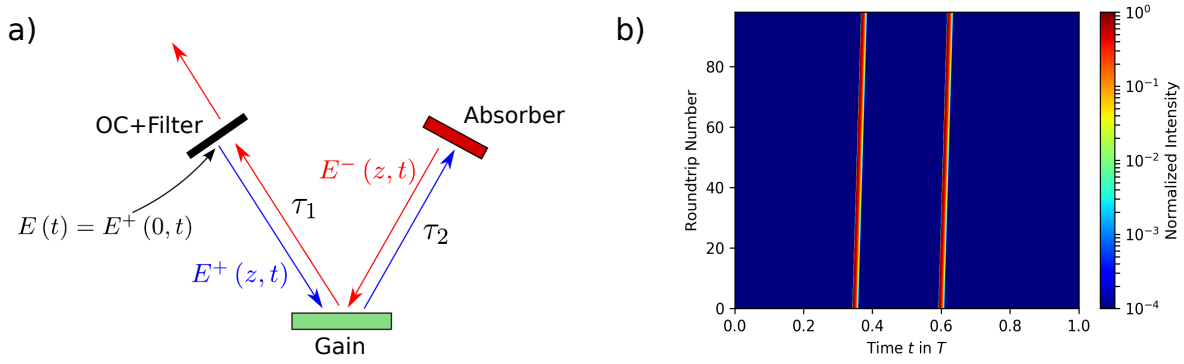

Figure 1: a) V-shaped cavity geometry with forward (backward) propagating field E^+ (E^-) indicated in blue (red). b) Space-time plot of the double-pulse solution.

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