Appendix B

Phase-retrieval Software: FROGGUI

This appendix describes the software used in the present work to calculate (retrieve) the amplitude and phase of the laser pulse from the initially measured FROG traces (spectrograms). The software containing the phase-retrieval algorithm (FROGGUI) is commercially available.

The FROGGUI algorithm (F*requency*-R*esolved* O*ptical* G*ating* G*raphic* U*ser* I*nterface*) with a friendly-user interface was developed by J. Nicholson [25, 168]. Since no manual is available, except Ref. [23] in German language, a detailed explanation of the program follows.

The program requires a *.`bmp` file containing the FROG picture measured by the CCD array. The x-axis is the wavelength axis and the y-axis corresponds to the time delay. In the subprogram `delaycal.exe`, delivered with the FROGGUI package, the data obtained from the calibration measurements has to be inserted. `delaycal.exe` can also be used for calibrating the FROG time axis, by directly introducing the position of the micrometer screw and the corresponding position of the FROG trace. The program calculates then the calibration value in fs/pixel. Similarly, the subprogram `speccal.exe` can be used for the wavelength axis, whereas the result is given directly in nm/pixel. `speccal.exe` requires also a spectrum in ASCII format. In the *General* menu of the FROGGUI program, one has to input the FROG trace to be calculated, the spectrum, the initial file `froggui.ini` (which contains previous saved information) and the location where the output files should be saved. The path to the files should not contain a very large number of characters.

The user can chose between two phase-retrieval strategies (generalized projections (recommended) and genetic algorithm), different FROG beam geometries (SHG or PG FROG) and data type (experimental or theoretically

generated FROG trace). In the *Grid* menu the user can set the grid-window and input the calibration data. To "grid" the data means to put on the data a grid that is compatible with the Fourier transform relationship. Usually a value of 64 or 128 is sufficient for a transform-limited Gaussian pulse. The higher the grid size the more complex pulses can be represented without being truncated, but the slower the speed of the algorithm.

The output files contain columns of ASCII characters, whereby `*_f.dat` indicates the generated FROG trace, `*_e.dat` the retrieved amplitude and phase of the electric field, `*_spec.dat` the corresponding spectrum, `*_stats.dat` contains statistical information about the reconstructed FROG trace, `*_dm.dat` the retrieved auto-correlation, `*_tf.dat` contains the three-dimensional calculated FROG trace and `*_tfm.dat` the "gridded" pulse spectrum.