APPENDIX A

Quantitative estimate of the free carrier lifetime from time-resolved microscopy images

Following the principles developed in Sec. 2.3.2, tracking the free electron gas absorbance provides quantitative estimates of the free carrier density on the propagation axis as well as informations about its temporal evolution. The absorbance through a L-thick electron gas is defined as (see Eq. 2.29)

$$A = -\ln \frac{I}{I_{bkg}}. \tag{A.1}$$

The background intensity I_{bkg} and the intensity of the attenuated light I are directly measured from the transient transmission microscopy pictures.

Since the background is noisy due to speckle formation, I_{bkg} actually corresponds the mean gray value of all the pixels outside the absorption cone. The determination of a background value is performed with MatLab by thresholding the original image, i.e. all the pixels considered below a certain arbitrary grey value are counted as black pixels. Because of the speckle, the result of thresholding is a collection of group of black pixels on a white background. The absorption cone is easy to discriminate among all the other groups as it is formed by the highest amount of neighboring pixels. The result of this two step procedure is encoded in a binary matrix and used as a mask. The matrix representing the original picture is multiplied by the mask, and the final value of I_{bkg} is simply the average of all the non-zero pixels.

From Eq. 2.31, the free carrier density N_e writes

$$N_e = \frac{A}{\sigma L}. \tag{A.2}$$

By assuming a 3-dimensional absorption profile symmetric with respect to the propagation axis, the value of L is deduced from the transversal dimension of the absorption cone. The cross-section for inverse bremsstrahlung is estimated by using Eq. 2.31:

$$\sigma = \frac{ke^2 t_D}{m_{opt}\epsilon_0\omega\left[1 + (\omega t_D)^2\right]}. \tag{A.3}$$

The optical mass of the electron m_{opt} was chosen equal to the free electrons mass, the collision time t_D has been fixed at 3 fs, close to the 2.5 fs estimated by Sun et al. [92] for fused silica and ω corresponds to the probing frequency of about 4.71×10^{15} rad/s.