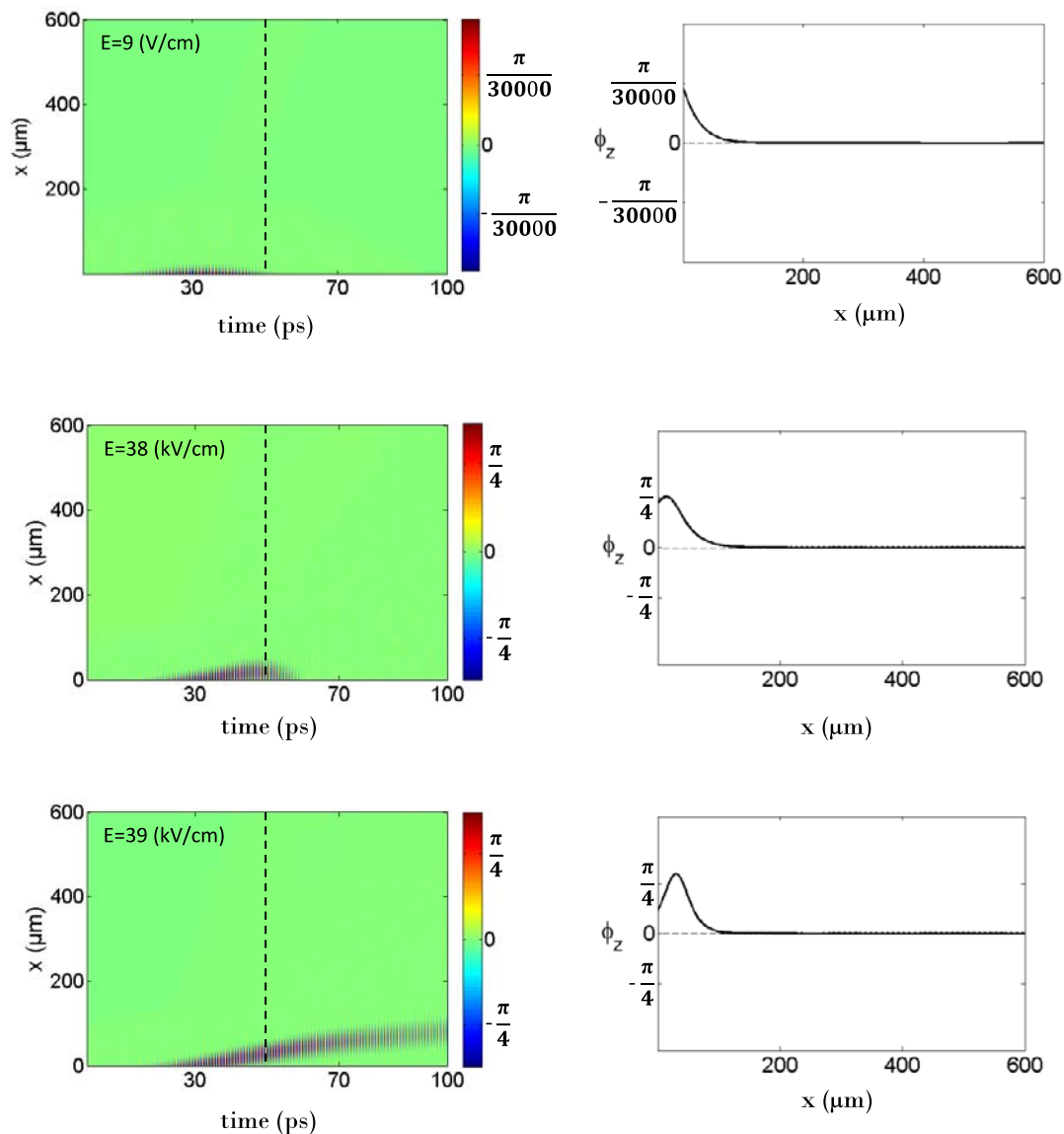


Optical excitation of Josephson plasma solitons in a cuprate superconductor

For $\omega_{FEL} = 0.97 \omega_{JPR}$ the space and time dependent response exhibits more than one regime of excitation. In here we expand on what displayed in figure 2, including excitation at $E=50$ kV/cm and 75 kV/cm.



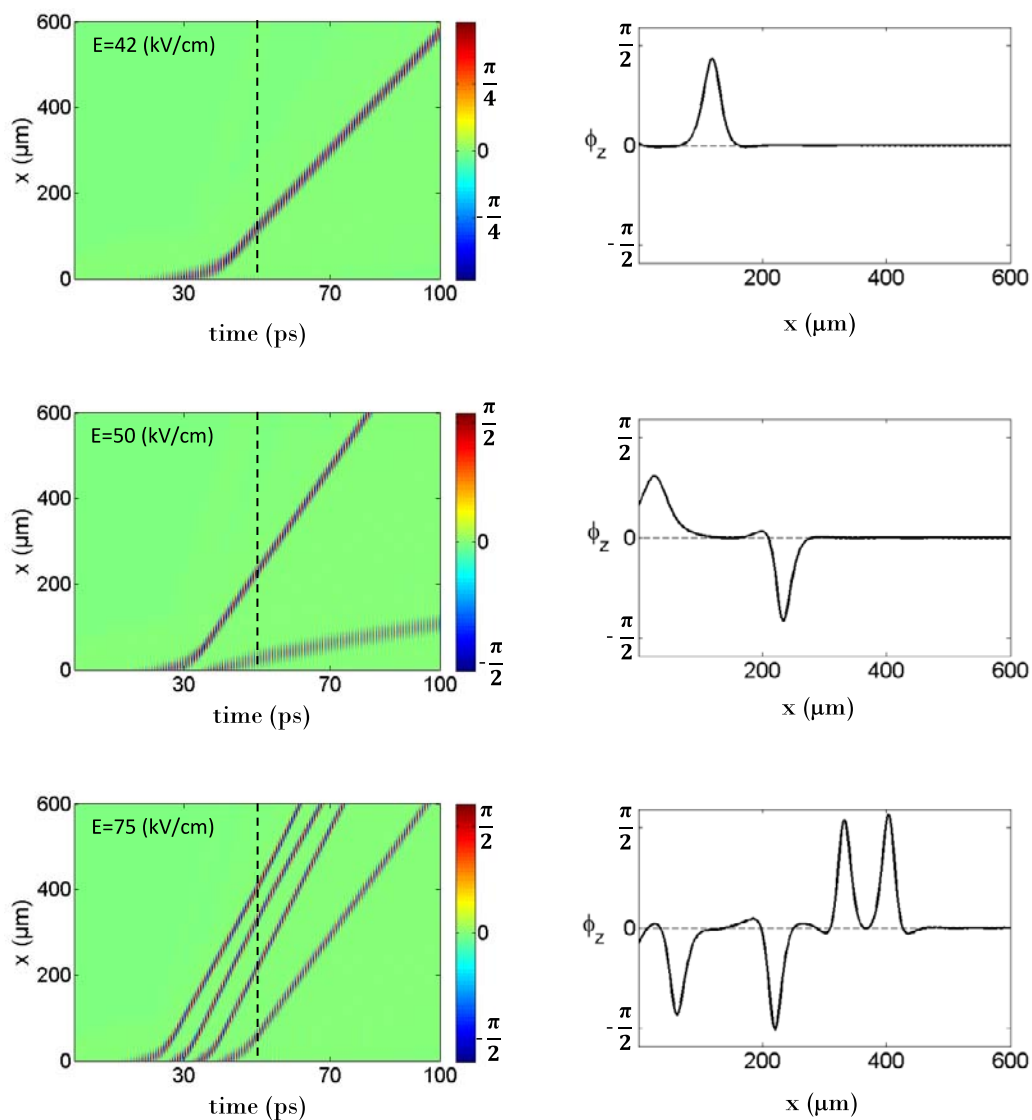


Figure S1. Calculated space and time-dependent interlayer phase for $\phi_z(x, t)$ for $\omega_{\text{FEL}} = 0.97\omega_{\text{JPR}}$ and six pump strengths: 9 V/cm, 38 kV/cm, 39 kV/cm, 42 kV/cm, 50 kV/cm, 75 kV/cm. One dimensional spatially dependent phase profiles (right hand side) are plotted for 60 ps time delay (see vertical dashed line on the colour plot).

In figure S1, we observe an evanescent wave for the lowest fluences, becoming progressively modified as the field strength is increased. For higher fields ($38 \text{ kV/cm} < E < 50 \text{ kV/cm}$) a single soliton is excited, propagating at a speed that strongly depends on the excitation conditions. For the highest field strengths ($E > 50 \text{ kV/cm}$), soliton trains are excited.

From the simulations of figure S2, we calculate the frequency and time dependent loss functions,

expanding on what presented in figure 6.

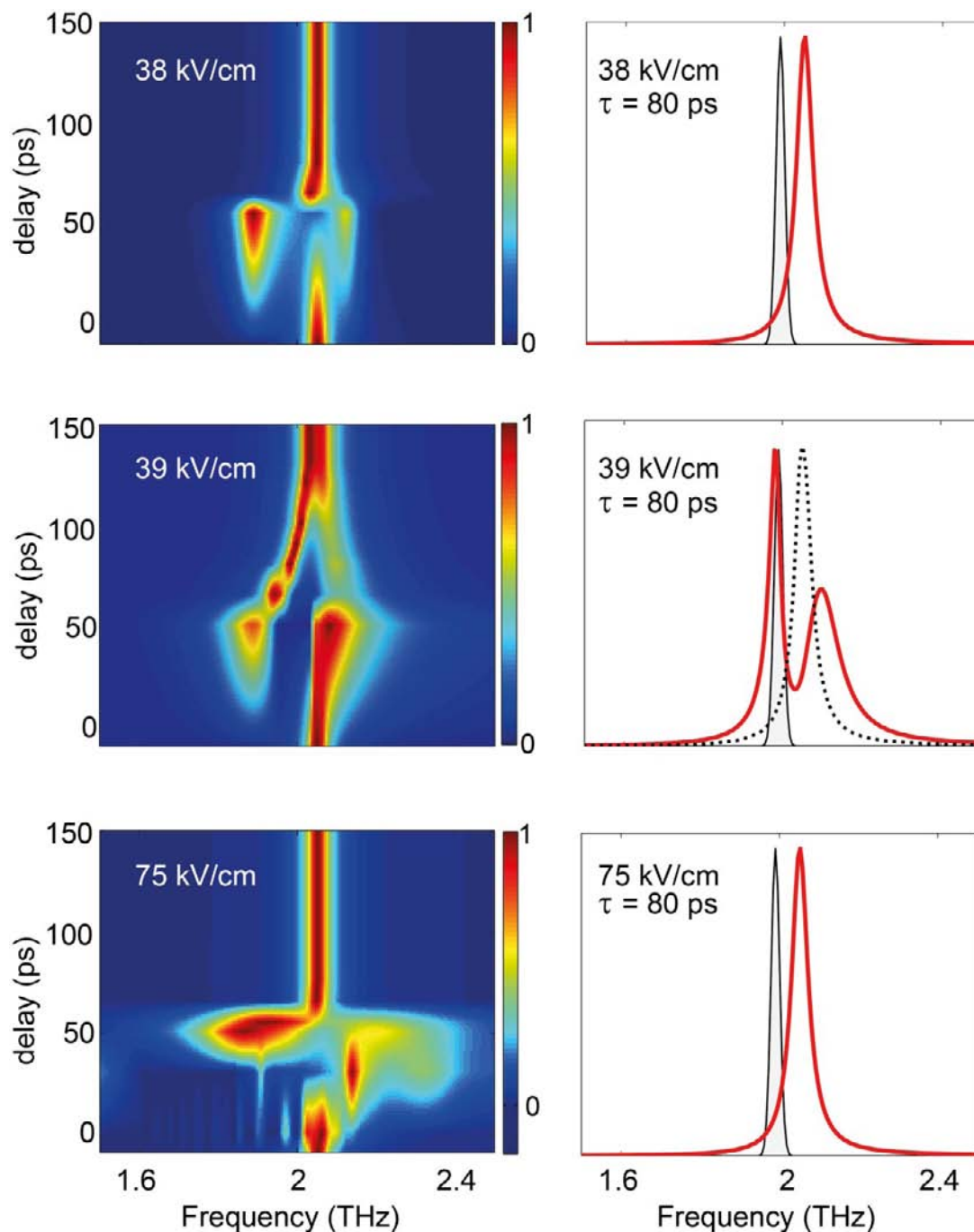


Figure S2. Color plots. Calculated frequency and time delay dependent loss functions for $\omega_{\text{FEL}}=0.97\omega_{\text{JPR}}$ and for three different excitation field strengths. The lineouts displayed on the right hand side display the perturbed loss function at 80 ps time delay (red curve), compared to a Gaussian fit to the pump spectrum black, shaded.

We find that only for the excitation regime near 39 kV/cm, a split linewidth is generated. In the case of lower (evanescent wave) or higher (fast train) excitation strength, no split linewidth is observed beyond the initial excitation regime.