Vibrational excitation in a nanosecond discharge

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The vibrational distribution function of nitrogen is measured in a nanosecond discharge (200-250 ns, conducting electrodes) by coherent anti-Stokes Raman scattering (CARS). It is found, that for vibrational states with $v < 8$ a two temperature distribution function is a very good approximation to the vibrational distribution. The excitation conditions for vibrational states are constant during the discharge pulse and agree very well with the excitation rates from the literature for the given electric field - measured by E-FISH. The development of the vibrational states during the afterglow is compared to a state-to-state kinetic model, which is dominated by VV transfer and transport losses. Good agreement was found for rates available in the literature. Additionally, particle-in-cell (PIC) simulations are performed for the same conditions as in the experiments. The PIC results are used to derive analytical models for the discharge. The models can explain the value of the reduced electric field in the plasma bulk (about 80% of the discharge volume), which favors vibrational excitation.