Adaptive Numerical Simulation of Streamer Propagation in Atmospheric Air

Shailendra Singh[1,2], Yuriy V. Serdyuk[2], Raimund Summer[1]
1. Schneider Electric GmbH, Rathenaustrasse 2, Regensburg, Germany, 93051
2. Chalmers University of Technology, High Voltage Engineering, Gothenburg, Sweden 41296

Introduction: Study presents electrical breakdown of gaseous high-voltage insulation by streamer discharge. The simulation is performed by utilizing a space adaptive numerical scheme based on logarithmic representation in atmospheric air for a needle-plane gap of 15 mm.

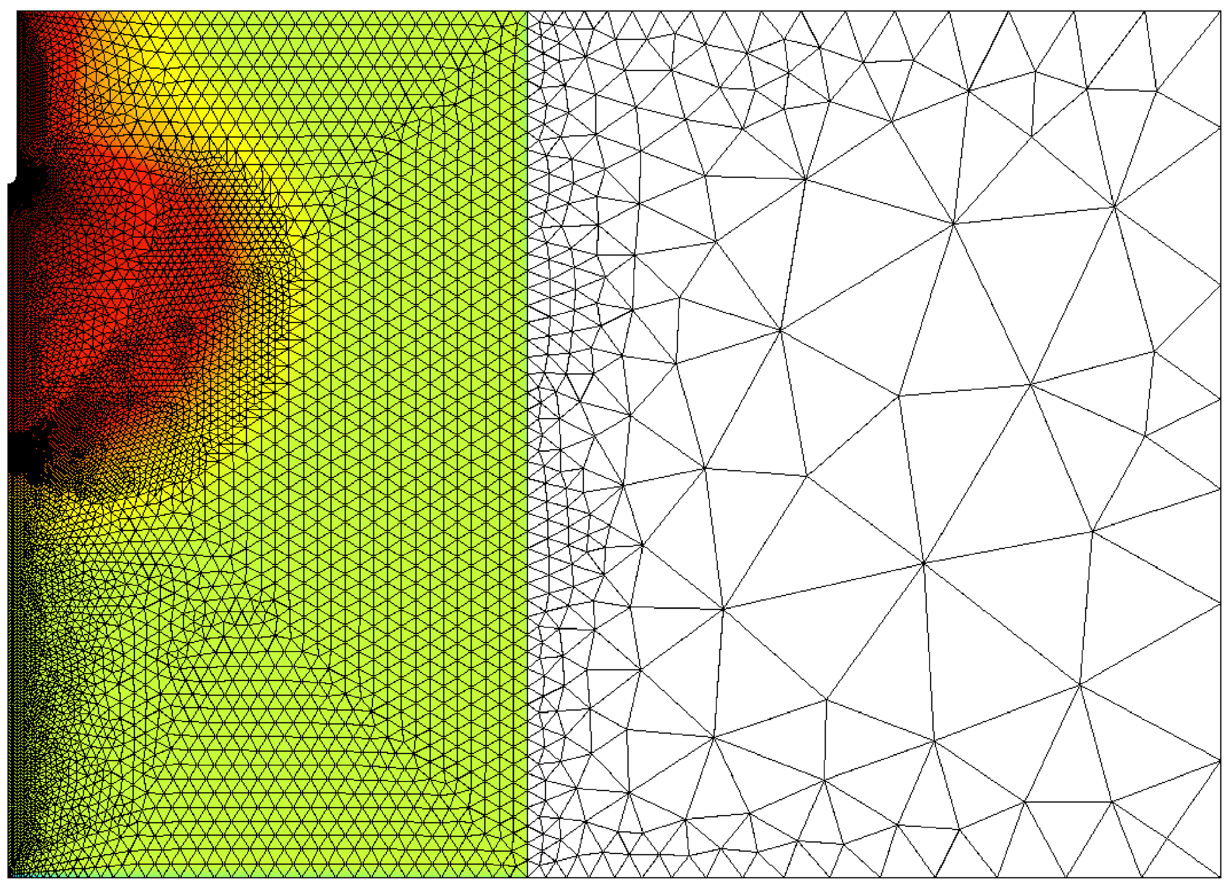


Figure 1. Adaptive mesh at streamer head

Computational Methods: The mass conserving transport equations for electrons, positive and negative ions coupled with Poisson equation for E field and Helmholtz equations for photoionization are solved.

$$\frac{\partial N_e}{\partial t} + \nabla \cdot (-D_e \nabla N_e + \mu_e N_e \mathbf{E}) = S_e + S_{photo} \quad (1)$$

$$\frac{\partial N_p}{\partial t} + \nabla \cdot \left(-D_p \nabla N_p + \mu_p N_p \mathbf{E}\right) = S_p \quad (2)$$

$$\frac{\partial N_n}{\partial t} + \nabla \cdot (-D_n \nabla N_n + \mu_n N_n \mathbf{E}) = S_n \quad (3)$$

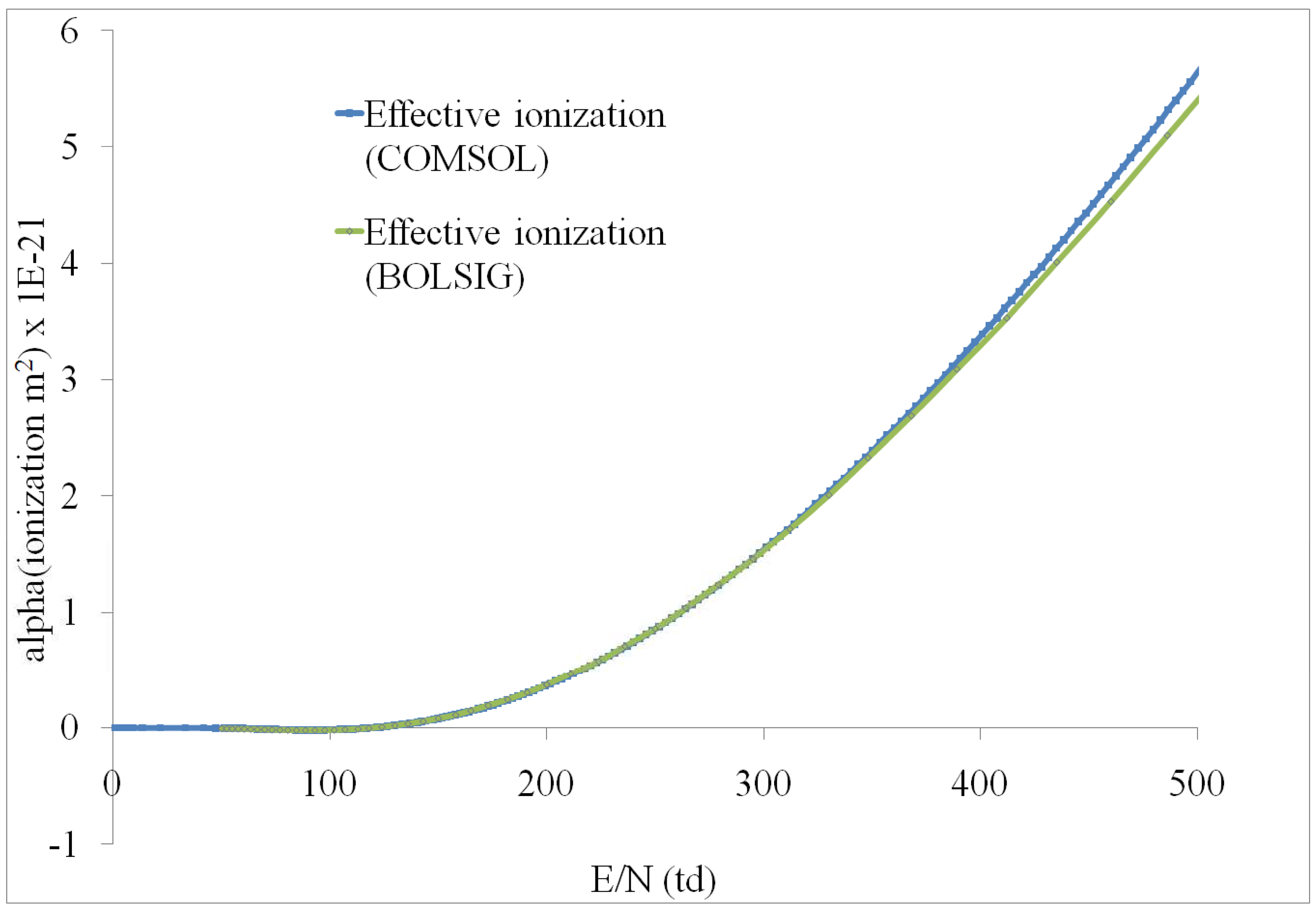


Figure 2. Ionization rates calculated from Boltzmann two term approximation

Results: The simulation of streamer propagation in nanosecond timescale is compared with experiments [1] as shown in Figure 3.

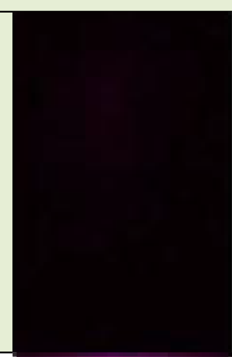
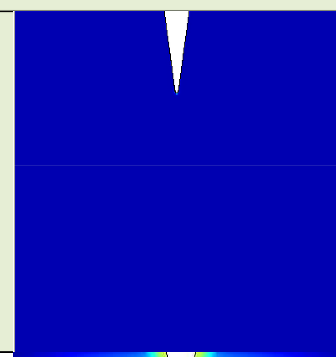
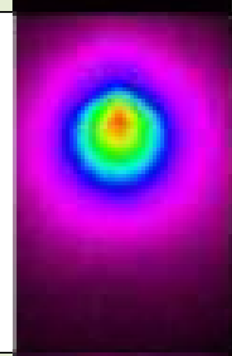
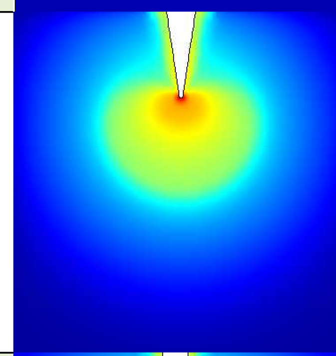
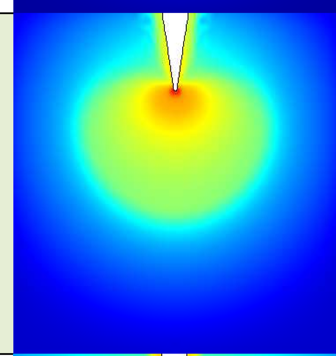
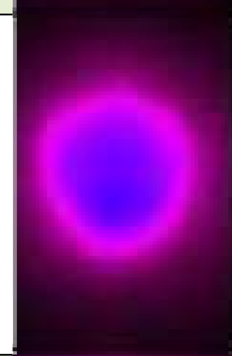
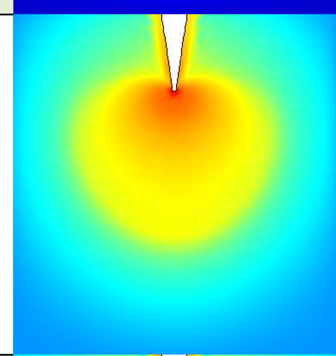
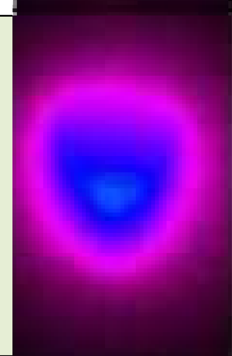
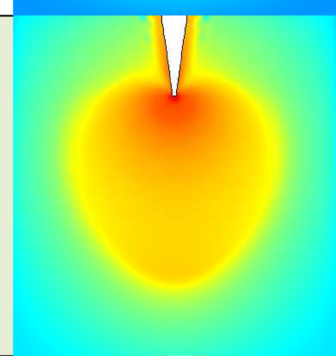
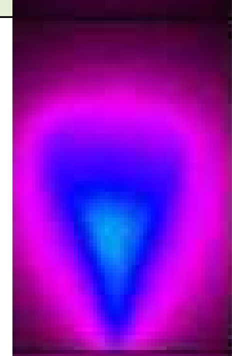
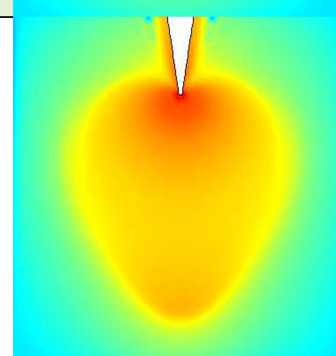
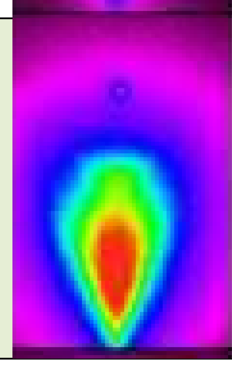
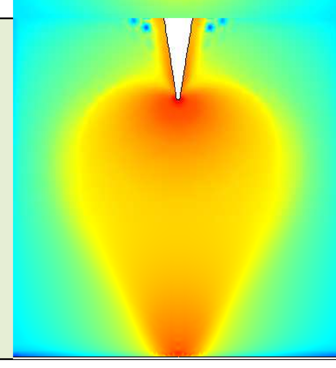
Time (ns)	Experiment	Simulation
0		
1		
2		
3		
4		
5		
6.0 (exp) 5.8 (sim)		

Figure 3. Streamer propagation

Conclusions: The developed approach allows for improving strongly the efficiency of the simulations and thus opens a possibility to model real life problems including complicated geometries, presence of solid insulating elements, complex gas mixtures, etc.

References:

1. A. Starikovskiy, Fast ionization wave development in atmospheric pressure air, IEEE Transactions on Plasma Science, 39. N 11, 2602-2603 (2011).