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Stochastic modelling of dielectric breakdown

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Using a 2D stochastic dielectric breakdown model, patterns of lightning discharges and surface discharges were studied. The model based on a Laplacian growth, develops the breakdown process stepwise, choosing one lattice point at a time out of all possible lattice points. The probability of lattice points being chosen was weighted according to the cell potentials. The potential 'ϕ' at each cell was calculated by solving the discrete Laplace equation subjected to the boundary conditions using the finite difference method. The simulated tree patterns were analysed using fractal techniques.

The fractal dimension of the simulated tree patterns varied depending on the cell configuration chosen for the breakdown. Fractal dimensions of the three possible cell configurations for the simulated lightning were 1.57±0.02, 1.43±0.02 and 1.50±0.02. The inclusion of the cells in the diagonals with reference to the growth site produced less branched trees with smaller fractal dimensions. The production of branches depended highly on 'η', which is the exponent of the probability distribution. When η is equal to 1, a highly complex tree pattern with many branches was observed. The 'sparse' nature of the breakdown pattern reduced rapidly with increasing exponent and produced patterns which were closer to the experimental observations. The most time consuming part of the simulation was the solving of Laplace equation for each new growth site. The model can be easily extended to study the tree growth in 3D.

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