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591 MHz single-cell cavity optimization using evolutionary algorithms

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A 591 MHz superconducting RF cavity is designed for the Electron Storage Ring (ESR) of the Electron-Ion Collider (EIC), providing an accelerating voltage of up to 4 MV. Based on the requirements for Robinson stability and suppression of multipacting effects, four key physical parameters are specified: the fundamental mode frequency should be 591 MHz ± 0.1 MHz; the R/Q of the fundamental mode (591 MHz) must be less than 80 Ω; the peak electric field should be less than 40 MV/m; and the peak magnetic field should be less than 80 mT. To meet these goals with minimal computation time, we propose using the multi-objective optimization algorithm NSGA-III (Non-dominated Sorting Genetic Algorithm III) for cavity geometry design. We combined the Poisson Superfish electromagnetic simulation with the genetic algorithm in a Python environment. A Pareto-optimal front was obtained after about 50,000 iterations. The peak electric field was successfully reduced by 20% without deteriorating the other three objectives. In the future, these datasets can be analyzed using machine learning algorithms to identify patterns relevant to various axisymmetric cavities for different beam manipulation applications.

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Yes

Footnotes

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