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Application of autoresonance in rapid beam extraction of synchrotrons

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Ultra-high dose rate (FLASH) radiotherapy is emerging as a novel cancer treatment due to its tumor-killing efficacy and superior normal tissue protection compared to conventional therapy. However, in compact synchrotrons, achieving the required FLASH dose rates is challenging, since conventional RF-KO extraction struggles to achieve the short (tens of milliseconds) extraction times needed. To address this, we introduce autoresonance to third-order resonant extraction for the first time. With this method, a frequency-swept, low-amplitude excitation efficiently drives the whole beam into resonance, enabling rapid extraction within a single sweep period. This technique only requires adding an octupole magnet, unlike conventional approaches that simply increase excitation amplitude. Conventional RF-KO uses repetitive frequency sweeps, driving individual particles at separate times, while autoresonance RF-KO excites the entire beam simultaneously. We analyze the autoresonance threshold and demonstrate, through simulation, the feasibility of millisecond-scale extraction.

Footnotes

Funding Agency

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Yes

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