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技术及应用

强流束晕-混沌的模糊逻辑控制研究

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摘要 以周期性磁场聚焦传输通道中的K-V(Kapchinskij-Vladimirskij)分布离子束为例，引入带偏置的升余弦函数近似刻画实际磁场，理论分析了通道中强流离子束的束晕-混沌动力学行为。针对束晕-混沌的控制问题，提出了束晕-混沌的模糊逻辑控制方法。模糊控制器采用Mamdani推理系统，其输出作为控制因子线性调整外部磁场强度。用模糊相平面法分析了控制系统的稳定性。仿真结果显示：在控制条件下，混沌变化的束包络半径被稳定控制；将该方法应用于多粒子模型，消除了束晕及其再生现象，束的品质获得较大提高。该模糊控制方法具有不依赖束输运数学模型、控制器简单、磁场调节呈线性关系、易于工程实现等优点。

关键词 强流离子束 周期聚焦磁场 束晕-混沌 模糊控制

分类号

Control of Beam Halo-Chaos Using Fuzzy Logic Controller

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Abstract Considering the ion beam with initial K-V distribution in the periodic focusing magnetic filed channels (PFCs) as a typical sample, a fuzzy control method for controlling beam halo-chaos was studied. A fuzzy proportional controller, using output of fuzzy inference as a control factor, was presented for adjusting exterior focusing magnetic field. The stability of controlled system was proved by fuzzy phase plane analysis. The simulation results demonstrate that the chaotic radius of envelope can be controlled to the matched radius via controlling magnetic field. This method was also applied to the multi-particle model. Under the control condition, the beam halos and its regeneration can be eliminated effectively, and that both the compactness and the uniformity of ion beam are improved evidently. Since the exterior magnetic field can be rather easily adjusted by proportional control and the fuzzy logic controller is independent to the mathematical model, this method has adaptive ability and is easily realized in experiment. The research offers a valuable reference for the design of the PFCs in the high-current linear ion accelerators.

Key words high-current ion beam periodic-focusing magnetic filed beam halo-chaos fuzzy control

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