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Nonlinear Control of Beam Halo-Chaos in Accelerator-Driven Clean Nuclear Power System

FANG Jin-Qing,[1] CHEN Guan-Rong,[2] ZHOU Liu-Lai,[1] and WENG Jia-Qiang[3]

[1] China Institute of Atomic Energy, P.O. Box 275-27, Beijing 102413, China

[2] Department of Electronic Engineering, City University of Hong Kong, China

[3] Department of Physics and Electronic Science, Guangxi Normal University, Guilin 541004, China
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Abstract: Beam halo-chaos in high-current accelerators has become a key concerned issue because it can cause excessive radioactivity from the accelerators therefore significantly limits their applications in industry, medicine, and national defense. Some general engineering methods for chaos control have been developed in recent years, but they generally are unsuccessful for beam halo-chaos suppression due to many technical constraints. Beam halo-chaos is essentially a spatiotemporal chaotic motion within a high power proton accelerator. In this paper, some efficient nonlinear control methods, including wavelet function feedback control as a special nonlinear control method, are proposed for controlling beam halo-chaos under five kinds of the initial proton beam distributions (i.e., Kapchinsky-Vladimirsky, full Gauss, 3-sigma Gauss, water-bag, and parabola distributions) respectively. Particles-in-cell simulations show that after control of beam halo-chaos, the beam halo strength factor is reduced to zero, and other statistical physical quantities of beam halo-chaos are doubly reduced. The methods we developed is very effective for suppression of proton beam halo-chaos in a periodic focusing channel of accelerator. Some potential application of the beam halo-chaos control in experiments is finally pointed out.

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Key words: proton beam, halo-chaos, nonlinear control, wavelet-based feadback controller

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