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Experimental Verification of Stop-Band Distributions in Doublet Focusing Channels

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Almost all modern particle accelerator systems exploit the principle of strong focusing. Not only focusing but also defocusing forces are employed there, so that we can spatially confine a large number of charged particles more effectively than the case where only focusing forces are used. Needless to say, the most standard strong focusing channel is the so-called "doublet (or in other words, FODO lattice)"in which the beam receives linear focusing and defocusing forces alternately. Doublets have been very often adopted for beam transport channels and linear accelerators including a possible heavy ion fusion driver and common drift tube linacs. A non-scaling fixed field alternating gradient ring also consists of many doublet cells. These facts indicate practical importance of understanding the collective nature of high-quality hadron beams traveling in long doublet channels. While we can find a number of numerical and analytic works on this subject in past literature, little has been done experimentally. In the present work, we investigate the dynamical property of doublet focusing by employing a compact linear Paul trap system. Since the collective motion of a non-neutral plasma in the trap is physically almost equivalent to that of a charged-particle beam in strong focusing channels, we can use the former to study the latter. We here systematically explore the stability of ion beams focused by a series of doublets, changing the waveform of the plasma confinement field over a wide range. It is shown that a few stop bands of coherent resonance appear depending on the beam intensity. When there is an imbalance between the horizontal and vertical focusing, those stop bands split. The experimental observations are compared with WARP simulation results.

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