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Coherent stability and dynamic aperture with strong space charge for the FAIR SIS100 synchrotron

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Employing octupole magnets for Landau damping of transverse single-bunch instabilities in synchrotrons often restricts the dynamic aperture due to the excitation of betatron resonances. The situation complicates in the presence of strong direct space charge fields. A notable case is the 1-second accumulation plateau of the heavy-ion synchrotron SIS100 at the Facility of Antiproton and Ion Research (FAIR), which is designed to operate at beam intensities near the space charge limit. This study presents numerical simulations that establish the proposed stabilisation scheme, incorporating self-consistent space charge effects, beam coupling impedance and full lattice tracking. The analysis combines requirements for Landau damping of the resistive-wall instability and tolerable octupole current in relation to dynamic aperture. The results demonstrate effective control of collective effects for the most demanding beam production scheme with $^{238}U^{28+}$ beams.

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