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Off-resonance scheme for highly coupled lattice design in the diffraction-limited light sources

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Round beam operation offers significant benefits for synchrotron radiation experiments and reduces intra-beam scattering effects in diffraction-limited light sources. This paper proposes a method for round beam generation based on global skew quadrupole settings and the application of the Non-Dominated Sorting Genetic Algorithm (NSGA). Two coupling schemes, large emittance coupling via betatron coupling and vertical dispersion, are explored in a candidate lattice for the Shanghai Synchrotron Radiation Facility upgrade. We investigate the impact of lattice imperfections and beam optics distortions on emittance variations and beam dynamics. The results demonstrate precise control of beam coupling (from 10% to 100%) under low optics distortion, with full coupling generation and robustness achieved by adjusting skew quadrupoles in dispersion-free sections. Additionally, the method leads to a 2-2.5x increase in Touschek lifetime.

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