The details of the EA implementaWon are given in [4-7].

Beam transport models include synchrotron damping techniques to locate high-luminosity colliders. It combines the parallelized beam-beam simulations and an EA model. The beam transport model includes synchrotron radiation damping and associated quantum fluctuations for electrons.

The EA suite consists of two separate programs: var and spe2 [4,5]. var generates the initial population, recombinds and mutates parents in order to form the offspring, and calls BeamBeam3D which computes the luminosity for each WP. spe2 is the selector: a set of WPs (and their luminosities) provided by var, it selects first the WPs that are combined to form offspring, and later the WPs that are retained as the next generation. The details of the EA implementation are given in [4-7].

RESTRICTING THE SEARCH SPACE

We restrict the search space by imposing that it contains no destabilizing resonances. Figure 1 shows both unstable (black lines) and stable (green) resonances in the betatron tune space of up to order 7.

Resonant lines are defined as $m_1 \nu_1 + k_2 \nu_2 \in n$ where $m$, $k$, and $n$ are integers and $n$ is the order of the resonance. The shaded regions are entirely devoid of destabilizing resonances. The 16 regions cover only about 3.6% of the entire 2D tune space, which reduces the search space and computational load by a factor ~1000, thus making the multidimensional search computationally tractable.

SIMULATION CODES

We developed a suite of programs for optimization of a WP in particle colliders. It combines the parallelized beam-beam simulations and an EA techniques to locate high-luminosity WPs. While it was originally designed for the MEIC project at Jefferson Lab, it is sufficiently modular and can be modified to address other optimization problems in collider design.

Beam-beam simulations are carried out using BeamBeam3D [3]; a 3D, self-consistent, particle-in-cell, parallel beam-beam code. In the present beam-beam simulations, collisions take place at one IP, while the transport of beams through the collider rings is modeled by one-turn linear maps. The beam transport model includes synchrotron radiation damping and associated quantum fluctuations for electron.

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SEARCHING FOR THE OPTIMAL WORKING POINT OF THE MEIC AT JLAB USING AN EVOLUTIONARY ALGORITHM

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### SUMMARY

We implemented a search for an optimal working point in the betatron tune space based on an EA. After incorporating the constraint that the optimal WP must lie in one of the small regions along the diagonal of the tune space devoid of unstable resonances, the search space is reduced by about three orders of magnitude, which, in turn, makes the problem computationally tractable. The first results are quite encouraging: we were able to find a number of WPs that yield luminosities which are substantially higher than the design luminosity of the MEIC.

This study serves as a proof-of-concept that the powerful EA can be successfully used in a variety of optimization problems in collider design and beyond.

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