

VORPAL Computations Support Lower-Cost Design of Electron Cooling System

Problem Description

Novel high-energy electron cooling systems have been proposed to dramatically increase the luminosity of 100 GeV per nucleon Au^{+79} beams in the Relativistic Heavy Ion Collider (RHIC) [1,2]. While lower energy ion beams can be cooled by continuous electron beams, the 55 MeV electron beam needed by RHIC would have to be a bunched beam, with consequently higher temperature electrons. The requirements for an electron cooler are stringent enough that, if cooling estimates are off by a factor of two, the cooling will not be sufficient to combat emittance growth from intra-beam scattering. Thus, careful calculations of dynamical friction from numerical simulations are critical [3].

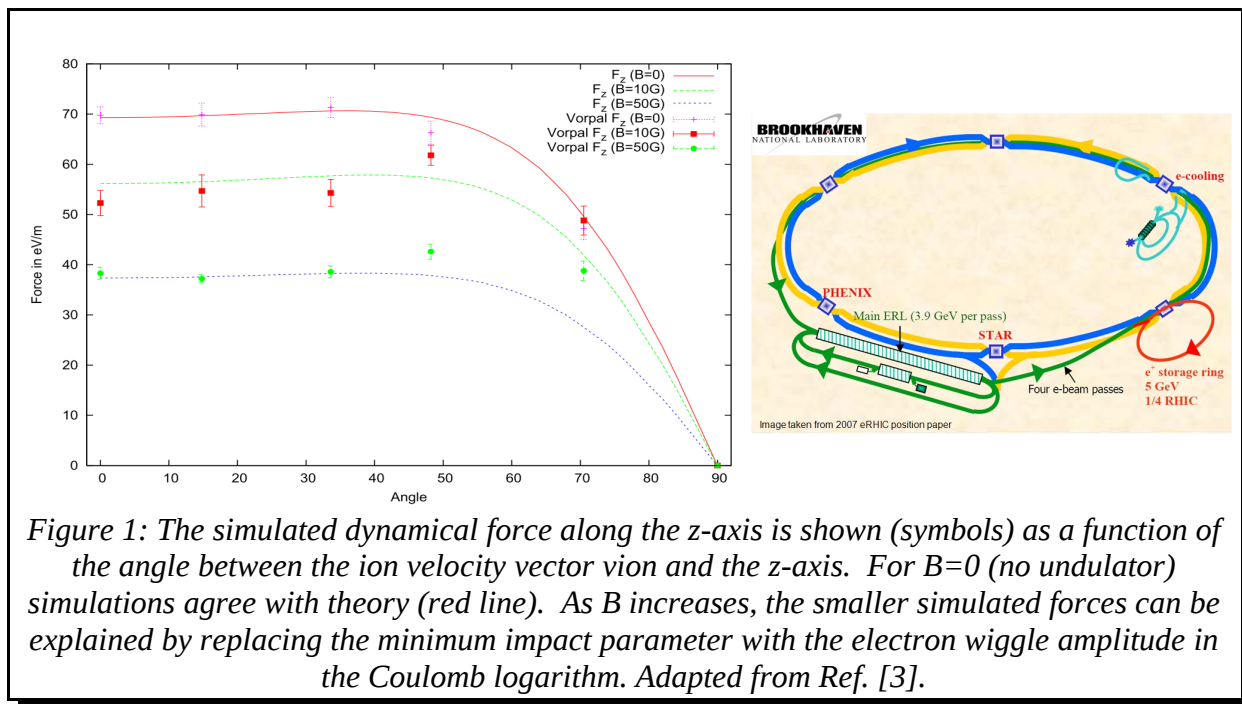
Solution

VORPAL computations provided key support for design modifications of an earlier electron cooling proposal for RHIC. Rather than using a technically challenging high-field solenoid magnet and 20 nC magnetized electron bunches [1], the new design specified conventional undulator magnet technology with 5 nC electron bunches [2]. This modified design, if constructed, would have lowered technical risk and reduced costs, with potential cost reductions estimated in the tens of millions of dollars. Tech-X Corporation worked collaboratively with Brookhaven National Laboratory scientists to simulate dynamical friction forces from first principles with VORPAL. Subsequently, VORPAL was used to confirm the hypothesis [3] that the magnetic fields of the undulator would only reduce the friction force logarithmically (Fig. 1) and, thus, be a much cheaper yet viable cooling system.

Why VORPAL?

BNL scientists needed a way to implement the algorithms in parallel and VORPAL provides the distributed parallel computing necessary to complete large simulations in realistic time frames. More importantly, VORPAL is reliable enough to be validated against theory in simple cases.

"Tech-X staff worked closely with my team in the electron cooling group to understand our modeling needs and to develop innovative algorithms for simulating dynamical friction with a minimum of underlying assumptions," said Ilan Ben-Zvi of BNL. "In that, they were acting as team members; we had a seamless effort. Members of the VORPAL development team provided training and support for BNL scientists to run the simulations on our local clusters. Together we solved a very challenging problem, verifying the hypothesis that oscillations of the electron beam inside a wiggler magnet would, in the correct circumstances, only weakly reduce the dynamical friction force. This result gave us the confidence that a simpler cheaper electron cooling design could be adopted. That meant a great deal for my project."



References

- [1] I. Ben-Zvi *et al.*, Electron Cooling of RHIC, *Proc. Particle Accel. Conf.* (2005), p. 2741.
- [2] I. Ben-Zvi *et al.*, Status of the R&D towards electron cooling of RHIC, *Proc. Particle Accel. Conf.* (2007), p. 1938.
- [3] George I. Bell, David L. Bruhwiler, Alexei Fedotov, Andrey Sobol, Richard S. Busby, Peter Stoltz, Dan T. Abell, Peter Messmer, Ilan Ben-Zvi and Vladimir Litvinenko, Simulating the dynamical friction force on ions due to a briefly co-propagating electron beam, *Journal of Computational Physics*, 227, 8714-8735 (2008)

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<http://www.bnl.gov/cad/ecooling/>