University of Victoria | Graduate Studies

Notice of the Final Oral Examination
for the Degree of Master of Science

of

YI LIN (KYLE) GAO

BSc (University of Waterloo)

"A Study on HL-LHC Beam-Beam Resonances Using a Lie Algebraic Weak-Strong Model"

Department of Physics and Astronomy

Friday, October 11, 2019
1:00 P.M.
Clearihue Building
Room B007

Supervisory Committee:
Dr. Shane Koscielniak, Department of Physics and Astronomy, University of Victoria (Co-Supervisor)
Dr. Dean Karlen, Department of Physics and Astronomy, UVic (Co-Supervisor)

External Examiner:
Dr. Alex Dragt, Department of Physics, University of Maryland

Chair of Oral Examination:
Dr. Monica Prendergast, Department of Curriculum and Instruction, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

This thesis studies the resonances driven by beam-beam interactions of the planned High Luminosity upgrade to the Large Hadron Collider (HL-LHC) using a Lie algebraic formalism. With the suggested lattice for the HL-LHC, using the accelerator code MadX, bunch data for 70 bunches over the two interaction regions (IRs), ATLAS and CMS, was computed. This data was used to create a 70 impulse beam-beam Weak-Strong model combining both long-range and head-on interactions. An effective Hamiltonian was derived for the system. Along with a width formula, these are used to analyze the system in frequency space. As algebraically derived in this thesis, resonances of order q can be removed by phase-shifting the both vertical and horizontal phase advances between interaction points by $\frac{\pi}{q}$. Namely, the 16th order resonances close to the proposed working point of (62.31,60.32) can be weakened by phase advances close to $\frac{\pi}{16}$. This is reflected in frequency space plots of the effective Hamiltonian and of the width formula. Resonances are significantly weakened if phase advances are within 10^{-3} of the ideal ones; the phasing needs not be exact. The effect of crossing angle was briefly investigated; according to the effective Hamiltonian and width formula, beam-beam resonances cannot be significantly improved by increasing the tentative crossing angle of 590 μrad, yet decreasing the angle significantly strengthens the resonances of the system. A new working point (0.475,0.485) suggested from a previous study was investigated; it lies away from dangerous resonances according to the tools used in this thesis, and should be investigated further.