University of Victoria | Graduate Studies

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

of

KATE TAYLOR

BSc (University of Victoria, 2016)

"Exploring energy extraction from Kerr magnetospheres"

Department of Physics and Astronomy

Tuesday, April 9, 2019
10:00 A.M.
Clearihue Building
Room B017

Supervisory Committee:
Dr. Adam Ritz, Department of Physics and Astronomy, University of Victoria (Supervisor)
Dr. Pavel Kovtun, Department of Physics and Astronomy, UVic (Member)

External Examiner:
Dr. Gabor Kunstatter, Department of Physics, University of Winnipeg

Chair of Oral Examination:
Dr. Sylvia Pantaleo, Department of Curriculum and Instruction, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

The aim of this thesis is to reconsider energy extraction from black hole magnetospheres, and more specifically the Blandford-Znajek (BZ) process from an effective field theory (EFT) perspective. Superradiant instabilities of scalar and vector bound states in the presence of a rotating black hole will be reviewed when the inverse mass of the black hole is much smaller than the Compton wavelength of the bound state particle. Two different matching calculations will be described for the vector bound state case and the overall decay rate will be compared. Force-free electrodynamics will be motivated and discussed in the context of the BZ process. Using a perturbation expansion, the Blandford-Znajek process will be reviewed up to second order in the rotation parameter. The absolute-space/universal-time (3+1) viewpoint will be discussed and applied to the BZ process and an EFT-like description will be discussed when the black hole horizon is parametrically small. Using differential forms, a simplified framework for the BZ process will be introduced in the (3+1) formalism and the field strength F will be simplified in the slow-rotation limit up to first-order in the rotation parameter. Finally, the Blandford-Znajek process will be considered as a superradiant process in the massive vector limit and the total energy flux in this regime will be compared to the known BZ energy flux.