University of Victoria | Graduate Studies

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

of

BENJAMIN GERARD

BA (University of Colorado, 2014)

"Observational and Numerical Methods in High Contrast Imaging"

Department of Physics and Astronomy

Friday, July 15, 2016
1:00 P.M.
Clearihue Building
Room A202

<u>Supervisory Committee:</u>
Dr. Christian Marois, Department of Physics and Astronomy, University of Victoria (Co-Supervisor)
Dr. Kin Venn, Department of Physics and Astronomy, UVic (Co-Supervisor)

<u>External Examiner:</u>
Dr. Colin Bradley, Mechanical Engineering, University of Victoria

<u>Chair of Oral Examination:</u>
Dr. Annalee Lepp, Department of Gender Studies, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

The search to directly image and characterize exoplanets that are initially hidden below the stellar and instrumental noise relies on the use of both extreme adaptive optics (AO) and a subsequent point spread function (PSF) subtraction pipeline. In this thesis I present my research on both real-time AO techniques and post-processing PSF subtraction techniques. First, I present a new PSF subtraction algorithm designed to image the HR 8799 debris disk using the *Hubble Space Telescope*. I find an over-luminosity after PSF subtraction that may be from the inner disk and/or planetesimal belt components of this system, but ultimately conclude that this is likely a non-detection as a result of telescope stability and broadband chromatic effects. Thus, assuming a non-detection, I derive upper limits on the HR 8799 dust belt mass in small grains, consistent with measurements of other debris disk halos. Next, I present a new PSF subtraction algorithm applied to current campaign data from the Gemini Planet Imager (GPI), designed to optimize the GPI planet detection sensitivity of narrow orbit planets. My results show a 60-65% gain in SNR when using my new algorithm compared to conventional methods. Finally, I apply a new realtime AO nulling technique, called super-Nyquist wavefront control (SNWFC), to be used on future 30 m class telescopes to image wide-orbit exoplanets. I demonstrate application of SNWFC in both a deterministic laboratory experiment and coronagraphic simulations using an interferometric nulling technique, suggesting that this technique would allow higher SNR characterization of wide-orbit exoplanets on future telescopes.