1064 nm injection mode-locked Nd:YAG laser
optimized for guide star applications

by

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Thesis submitted for the degree of
Doctor of Philosophy
in
the University of Adelaide
Department of Physics
December, 2009
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Abstract

In recent years, the emergence of powerful, sodium-resonant laser sources has led to a dramatic improvement in resolution at many of the world’s large aperture observatories. The lasers are used to create artificial beacons (or guide stars) by fluorescing atmospheric sodium. Light from the beacon, returning from altitude, probes the intervening turbulence and the phase distortions detected are subsequently corrected using adaptive optics. Near-diffraction limited imaging has now been achieved on observatories with diameters up to 8 m using this technique. Future 30-100 m diameter telescopes will require new laser sources having higher average powers and innovative pulse formats to implement new forms of atmospheric tomography and correction. In this thesis I present the design and development of a new laser system for this purpose.

The laser design that I describe uses sum frequency generation (SFG) of 1064 nm and 1319 nm Nd:YAG lasers to produce the sodium wavelength, and introduces the novel application of injection mode-locking as a robust method to control the lasers wavelength and bandwidth. The high peak power and low timing jitter of the mode-locked (micro) pulses allows for efficient SFG of the 1064 and 1319 nm beams. Each slave laser is Q-switched and the duration of the Q-switched (macro) pulses are optimised to reduce star elongation and bleaching of the sodium.

The experimental work presented in this thesis is focused on the realization of a 1064 nm injection mode-locked slave laser, whose performance is optimised for use in the SFG guide star system. The work can be roughly divided into two sections. Firstly, results are presented from a low average power proof of principle laser which was used for risk reduction experiments, then secondly, a higher average power laser using a new laser head design is presented.

With the proof of concept laser it is shown that the injection mode-locking technique is robust and can be used to generate an ideal pulse burst with both wavelength and bandwidth control. A new method of Q-switched pulse stretching was implemented and the results show that the Q-switched pulses can be extended by a factor of 4.5 without a reduction in pulse energy.

The later part of the experimental work consists of a description of the design, construction and testing of a new high average power laser head used to generate the power levels required for the final guide star system. The laser head uses a zigzag Nd:YAG slab, pumped from each side by high average power laser diode arrays. This laser is shown to be capable of generating one of the highest average powers reported in the literature for an electro-optically Q-switched, diffraction limited Nd:YAG laser in a stable cavity.
This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Thomas Rutten and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Publications resulting from this work:


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Supervisors: Prof. J. Munch and A/Prof. P. Veitch
Acknowledgments

It is tough road to travel when undertaking a PhD. When I first started, I stood back and observed what seemed to be an impenetrable wilderness, with tangled undergrowth and dangerous creatures lurking within. My supervisors, Jesper and Peter were the first to show me where I had to go. They pointed to a region far on the horizon and, with promises of great rewards and adventure, they showed me the direction in which to travel and set me upon the road to completion. Thank you Jesper and Peter for your guidance and support, without your help I would surely have been lost along the way.

To my colleagues in the optics group: Alex H, Alex D, Damian M, David H, Francois, Keiron, Nikita, Mihtar, Nick, Sean, Shu, Aidan, Mathew and Ka, you provided so much helpful advice, thankyou for your assistance and for providing a place to rest where I could forget about work and relax.

Damien, Murray and Dave O., we had many helpful discussions and you contributed a great deal to the solution of many important problems I faced.

I would also like to thank all the technical staff who provided assistance with this project. Neville, I am deeply indebted to you for being so generous with your time and for having the patience to teach me. To Blair and Trevor, your assistance in the workshop was essential and without your assistance I could not have progressed. I also thank the two Bobs and Peter A. for the excellent contributions and advice you gave.

To Eva and my colleagues at the RAH, your encouragement and support while writing was greatly appreciated.

I would like to thank the Gemini Observatory for providing funding for this work and Northrop Grumman for the loan of vital hardware.

Lastly I would like to thank my Family and friends. You provided the personal support and encouragement I needed to stick to my goals and keep going when times were tough. Thank you.