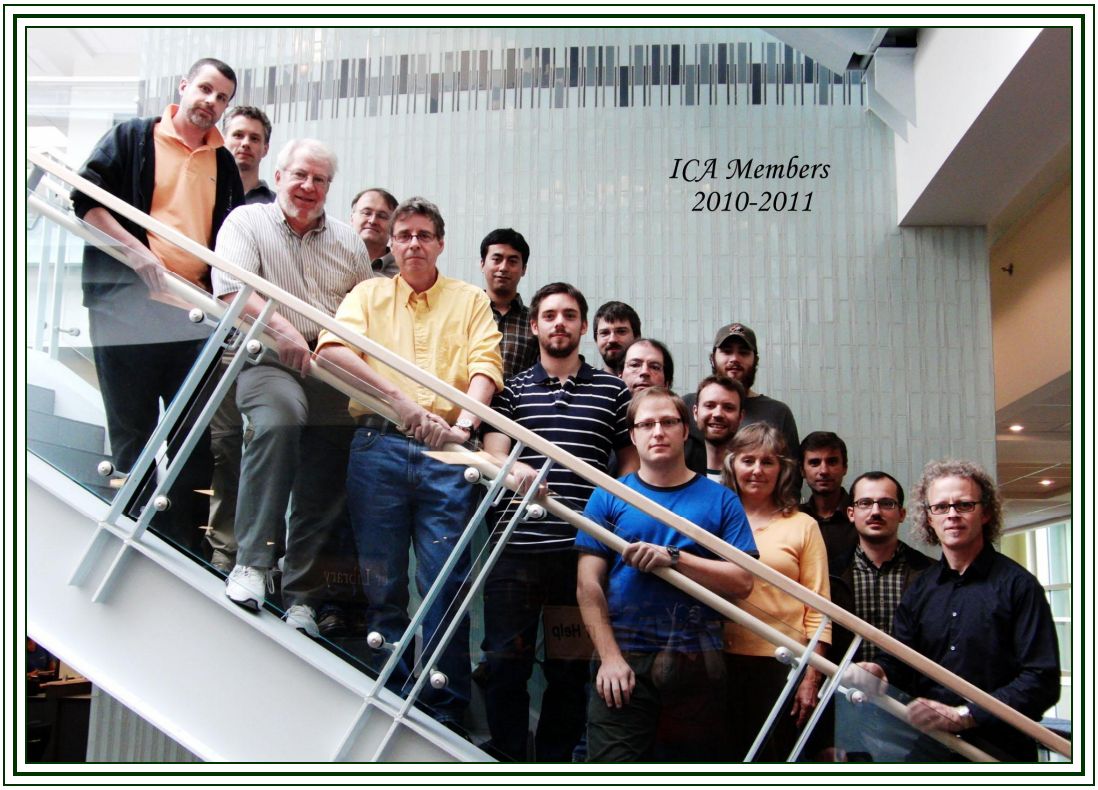
Institute for Computational Astrophysics ICA

ANNUAL REPORT 2010



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SAINT MARY'S UNIVERSITY SINCE 1802

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ICA 2010 Annual Report

Institute for Computational Astrophysics
Saint Mary's University

Introduction

The original preliminary proposal for the ICA was submitted to Academic Planning at Saint Mary's University in November, 2001, and the formation of the ICA was approved by the University Faculty Senate in December, 2002. The original proposal defined the purpose of the ICA: "… to promote, in the broadest terms possible, the rapidly growing field of computational astrophysics, that is, the study of complex astronomical phenomena by use of computer simulation and modelling. Its primary objective is to provide the stimulating, intellectual environment and the resources necessary for its full-time faculty to make rapid and important progress in key areas of computational astrophysics." To help realize this objective, in the past few years the ICA has brought in nine postdoctoral fellows and eleven graduate students and has obtained significant computational resources both internal to the ICA and through ACEnet, the high performance computing consortium for Atlantic Canada (now part of Compute Canada).

The ICA has five full time faculty members, each of whom is also a faculty member in the Department of Astronomy and Physics. They are Dr. Robert Deupree, Director and Tier 1 Canada Research Chair, Dr. David Clarke, Dr. David Guenther, Dr. Ian Short, and Dr. Rob Thacker, Tier 2 Canada Research Chair. Three post doctoral fellows were also ICA members during this past year: Dr. Eduard Vorobyov, Dr. Fernando Peña, both of whom are also ACEnet Fellows, and Dr. Pascal Elahi. There are six Ph. D. students currently associated with the ICA: Mr. Mike Casey, Mr. Chris Geroux, Mr. Michael Gruberbauer, Mr. Jon Ramsey, Mr. David Williamson, and Mr. James Wurster. Mr. Gruberbauer holds a prestigious Vanier Fellowship, and Mr. Wurster holds an NSERC Postgraduate Scholarship for his Ph. D. work. Five of these students have passed their Ph. D. comprehensive exams and are working full time on their thesis research. Mr. Diego Castañeda will join the ICA as a Master's level student in January, 2011.

Ms. Florence Woolaver is completing her fourth year as the ICA administrative assistant. Attached to the ICA are two ACEnet employees, Mr. Phil Romkey and Dr. Sergiy Khan. Mr. Romkey is the system administrator for the Mahone computer cluster and Dr. Khan provides computational researchers with support on issues related to using the ACEnet clusters. Dr. Khan's background is in astrophysics, and he has helped a number of ICA postdoctoral fellows and graduate students with specific code issues. Ms. Woolaver also supplies administrative support to local ACEnet personnel and acts as a key interface between SMU and the ACEnet administration in St. John's.

Events in the Past Year

A significant event this year was getting to feel at home in the ICA's new home in Saint Mary's University's Atrium building, into which the ICA moved in December, 2009. Emerging from boxes and the usual collection of new building woes, the ICA is now fully settled into its new surroundings.

The ICA was involved with organizing one conference in 2010. This was the annual conference of CASCA, the Canadian Astronomical Society, which was held at SMU in May. The official host for the CASCA meeting was the Department of Astronomy and Physics, but ICA members Deupree, Guenther, Short, and Thacker were on the local organizing committee (LOC), Ms. Woolaver helped in some aspects of conference organization, and the ICA contributed financially to the conference expenses.

Dr. Guenther also hosted meetings for the MOST Science Team and the BRITE Science team this spring.

Members of the ICA perform a variety of services for the wider astronomical and computational communities, as well as the public at large. Some of these are included below.

Dr. Deupree ended his service as the PI of ACEnet on March 19. This was the date on which Compute Canada, of which ACEnet is a part, submitted its mid term review to the Canada Foundation for Innovation (CFI). In addition to being ACEnet PI, Dr. Deupree also served as a member of Compute Canada's National Initiatives Committee, which includes the PI's of all seven of the regional computing consortia which make up Compute Canada. Serving as ACEnet PI since the spring of 2004, Dr. Deupree participated in the formation of ACEnet and Compute Canada, the writing of the ACEnet proposal to CFI in 2003, and the writing of the $120M CFI National Platform Fund proposal for Compute Canada in 2007. This second proposal was funded in its entirety and was also used by NSERC to award Compute Canada $2m per year for five years for programmer support. ACEnet receives $250k annually for this and employs five programmers (including one at Saint Mary's) to assist ACEnet users. Dr. Deupree continues to serve as the Chair of the Local Users Group of ACEnet users at Saint Mary's. This spring he was asked to serve a second term as a member of the Herzberg Institute of Astrophysics Advisory Board, where his major task is to provide input on computer matters.

Dr. Clarke participated in the Saint Mary's Science Open House and presented a talk for a group of high school students and their parents interested in space science. Dr. Guenther presented a public talk on how stars work as a part of the International Year of Astronomy. As noted above, Dr. Guenther organized two meetings related to the MOST and BRITE satellites. As part of the IYA, Dr. Guenther also presented a public talk on stars at Saint Mary's. Dr. Short presented a talk at Saint Mary's related to the Nobel Prize in Physics to Dr.

Willard Boyle, and Dr. Thacker presented three talks related to the International Year of Astronomy: in Kingston, Ontario; Calgary, Alberta; and Halifax in addition to seven colloquia he gave at various Canadian institutions: Saint Mary's, Queens, University of New Brunswick, Royal Military College of Canada, Dalhousie and Herzburg Institute of Astrophysics.

Dr. Thacker continues of serve as a member of Compute Canada's Community Planning and Advocacy Committee (CPAC) and as a member of Compute Canada's committee which is planning for CFI's expected National Platform Fund second round call for proposals. He continues to serve as a member of ACEnet's Research Directorate and ACEnet's Fellowships Committee as well as a member of the Canadian Institute for Theoretical Astrophysics (CITA) Council. A significant amount of time is spent by Dr. Thacker as a Director of the Canadian Astronomical Society and as the Vice-Chair of the panel for the Long Range Plan (LRP) for Canadian Astronomy. The resulting LRP document will be critical in setting both strategies for the community and policy for the government. The plan will address both ground-based and space-based facilities. Dr. Thacker's tasks related to the LRP included participation in determining the terms of reference and the selection of the panel chair as a CASCA Director. As a panel member he participated in five panel meetings, four town hall meetings, and reading the over 50 "white paper" submissions. As the Vice-Chair of the panel, he is heavily engaged in writing the LRP itself.

Undergraduate Researchers

Mr. Wilfried Beslin worked with Dr. Deupree this past summer to develop 3D astronomy related demonstrations for the ACEnet Data Cave located at Saint Mary's. Two demonstrations were completed, one being a demonstration of the space shuttle docking at the International Space Station, and the other showing the motion of the planets in the solar system. Mr. Beslin also worked with Dr. Deupree to develop 3D graphical programs for the analysis of 3D core helium flash simulations.

Mr. Alexander Mott worked with Dr. Short on synthetic UVRI and ubvy photometry of late type stars using synthetic spectral generated by the PHOENIX NLTE stellar atmospheres code.

Research

Dr. Clarke is working on upgrades to his magnetohydrodynamical (MHD) code, ZEUS-3D, to incorporate subroutines and modifications first started by his former M.Sc. student, Mr. Nick MacDonald. These will allow him to perform 3D simulations of extragalactic jets and outflows (that can extend a million light years and beyond from the centre of a galaxy) with an innovative new way to compute the emission such objects give. This new capability will provide him with the opportunity of making unprecedented comparisons with extensive radio telescope observations of these objects gathered over the past three decades. In particular, he is currently interested in revisiting a fascinating idea first put forth

by Drs. Debra Katz-Stone and Larry Rudnick some 15 years ago that one can actually pull from the radio observations maps showing the distributions of mass, energy, and magnetic field. This was something never suggested by anyone before or since, and was done from a purely observational standpoint. To date, no one has checked these ideas from a computational physics standpoint either. The work that Mr. MacDonald did for his Masters thesis was a start toward this end, and Dr. Clarke is currently working to complete this comparison and check.

Dr. Clarke continued to work with his Ph.D. student, Mr. Jon Ramsey, to develop a new research computer code, AZEuS, that combines his main research tool, ZEUS-3D, with a technique known as Adaptive Mesh Refinement. This is a technology that few in the world have. AMR allows a fluid simulation to be carried out at essentially any resolution (level of detail) needed. This has been a particularly difficult task as they are applying AMR in a situation for which it was not necessarily designed. Nevertheless, they have succeeded in creating a code that has been stable for about six months, and is currently running on the ACEnet facilities generating never before performed simulations of protostellar outflows.

Their early results are exciting and conclusions from the first simulation have just been submitted to the Astrophsyical Journal Letters. The main conclusion is that, for the first time, it is possible to state with some certainty that a physical method to launch a protostellar jet first proposed 28 years ago by Drs. Roger Blandford and David Payne is indeed capable, by itself, of driving a jet with the observed morphology, outflow speeds, and mass flow rates, although the details of how this is actually accomplished were not foreseen in their seminal work.

One of Dr. Clarke's main interests and principle research contributions is maintaining a website from which other astrophysicists from around the world can download ZEUS-3D and all its extensive documentation and support software (www.ica.smu.ca/zeus3d) for their own scientific use. Indeed, providing the research community with such research software is one of the founding objectives of the ICA. In the 2 1/2 years since this page has been posted, there have been over 150 downloads of ZEUS-3D (by students and senior faculty alike, and from six continents). Downloads are currently at several per week, having picked up recently after the publication of a methods paper Dr. Clarke wrote defending the code against some criticisms leveled at it in the recent literature. Dr. Clarke is currently working on the first major code upgrade since the site launch, which will include many improvements in the numerical techniques having to do with conservation of energy and momentum, the introduction of so-called "Lagrangian tracers", and an overhaul of the graphics. He hopes to have this updated version on-line within six months. On the horizon is a website for AZEuS, though this is still a few years off.

Dr. Deupree used his 2D stellar structure and evolution code to compute uniformly rotating Zero Age Main sequence models at ten different masses and

twenty-one different rotation rates (including zero). These calculations show that the variation of a number of features with mass and rotation may be separated into the product of two functions, one of which depends only on the mass and one of which depends only on the rotation, if all the masses at a given rotation rate have the same surface shape. This criterion takes into account the nonspherical nature of the gravitational potential and is somewhat akin to, but not equal to, the rotation being specified by the ratio of the rotation rate to the critical rotation rate being constant.

Mr. Chris Geroux, working with Dr. Deupree, is nearing completion of the development of a code to compute full amplitude RR Lyrae stellar pulsation in 3D. The 3D nature of the calculation will allow the simulation of the hydrodynamic interaction of convection and pulsation and will hopefully allow the calculation of full amplitude solutions of pulsation modes in models near the red edge of the RR Lyrae gap. A comparison of such results with the light curves of RR Lyrae stars could provide constraints on the reliability of such simulations. To date the code has shown that it can conserve the peak kinetic energy per period in adiabatic simulations, and a full amplitude 1D nonadiabatic simulation has been successfully completed. Of course, because this calculation is 1D, there is no hydrodynamic convection included.

Dr. Fernando Peña, who joined the ICA in November, 2009 has been working with Dr. Deupree to extend the capability of the NRO nonradial stellar oscillation code to compute nonadiabatic oscillations as well as adiabatic ones. This involves adding one more equation, plus some other terms, and allowing the eigenvalues to be complex. Thus, it is a fairly major change to the code. Dr. Peña is also preparing his thesis research on oscillations in gaseous planets for publication. This work may explain the almost circular orbits for a number of the discovered extrasolar planets.

Dr. Guenther continues to work as a member in several collaborations. He is a member of the BRITE Constellation consortium of Canadian and Austrian asteroseismologists who will use a proposed set of four nano-satellites to observe oscillations of the brightest stars in the sky. The first two satellites are scheduled for launch in 2010. He continues to be a member of the MOST Science Team and is in part responsible for stellar and oscillation modeling and interpretation of the data obtained by the satellite. Dr. Guenter continues his work with the Yale Convection Group, which is calculating stellar convection zones in 3D. Former ICA Master's student Mr. Joel Tanner is finishing his Ph. D. on convection modeling, and Dr. Guenther and current ICA Ph. D. student, Mr. Michael Gruberbauer, will be investigating the asteroseismological improvements offered by these 3D simulations.

Dr. Guenther continued his collaboration with Dr. Konstanze Zwintz (University of Vienna) on modeling the oscillation spectra of pre-main-sequence stars obtained from CoRoT and MOST. They are studying, in particular, the effects of rotation on pre-main-sequence star oscillations.

Dr. Guenther continues his collaboration with Dr. Thomas Kallinger (University of British Columbia), preparing models to interpret the oscillation spectra of red giant stars observed by CoRoT, Kepler, and MOST. Dr. Guenther is also studying the effects of g-mode like behavior in the interiors of red giant and horizontal branch stars.

Ph. D. candidate, Mr. Mike Casey, is working on oscillations in pre main sequence stars with Dr. Guenther. Mr. Casey is collecting all current seismic observations of pre-main-sequence stars, and analyzing them for systematic trends.

Dr. Guenther's Ph. D. candidate, Mr. Michael Gruberbauer is developing Bayesian techniques to separate axisymmetric modes from nonaxisymmetric modes. The methodology will also used to determine corrections for non-specific surface layer effects on the oscillation modes observed in Sun-like stars.

Mr. Michael Gruberbauer has also been involved in several international working groups of the KASC (Kepler Asteroseismic Science Consortium) to study the structure and evolution of stars, using data of unprecedented quality obtained by the NASA's planet-hunting Kepler mission. Based on these data, and in collaboration with dozens of national and international experts, he has been analyzing stars across the Hertzsprung-Russel Diagram. He modelled the granulation signature of Red Giants and main sequence stars , the pulsation and spotted surfaces of rapidly oscillating Ap stars, and the p-mode spectra of stars showing solar-type pulsation. In particular, he uses the ICA's parallel computing resources to perform Bayesian inference on the highly-dimensional parameter spaces of analytical and numerical models. Using these approaches on the best data currently available, he contributes to our understanding of stellar surfaces, outer layers, and interiors, as well as stellar evolution. Apart from modelling, he also contributed to data analysis efforts of hundreds of delta Scuti and gamma Doradus stars observed with Kepler.

Mr. Gruberbauer worked on similar analyses based on data of the French CoRoT satellite and the Canadian MOST satellite. He continues his efforts on theoretical approaches to improve the Bayesian and other inference processes, in order to use the ICA's resources more effectively, and to apply them to many additional problems in stellar (and non-stellar) astrophysics.

Dr. Short, with collaborator Dr. P.H. Hauschildt (Hamburg Observatory), computed a large grid of atmospheric models (over 400) and high resolution synthetic spectra for late-type dwarf and giant stars (spectral class G and K, luminosity class from V to III). The grid densely samples stellar parameter space (effective temperature sampling is 62.5 K, logarithmic surface gravity sampling is 0.5), and two scaled solar metallicities (solar and 1/3 solar). For this initial investigation all models were computed in local thermodynamic equilibrium (LTE). Models were computed with two choices of input atomic line list, both based on Kurucz lists: the "big" list that allows ATLAS9 models of the Sun to match the observed near UV solar flux level, and the "small" list of higher quality

lines that provide a better match to high resolution solar spectra. They compared the model spectra in the 320 to 800 nm region to mean observed spectra derived from data selected with great attention to quality control from the uniformly re-calibrated spectrophotometric catalogue of Burnashev (1985). From this comparison they derived spectroscopic effective temperature (Teff) values for each spectral type based on global fits to the entire wavelength region, and on local fits to the blue and red spectral regions. They compared these derived Teff scales with empirically determined scales based on photometry from Ramirez et al. (2005) and on interferometry from Baines et al. (2010) and found that the models computed with the "small" line list provide greater internal consistency between the blue-band and red-band fits, and closer agreement with the empirical Teff scale of Ramirez et al. (2005).

Dr. Short has performed calculations with PHOENIX of the solar intensity variation with sky position very close to the solar limb with very fine spatial sampling, as a function of wavelength throughout the visible band. In collaboration with Drs. G. Thuillier (LATMOS-CNRS, France), S. Sofia (Yale), and seven other collaborators, he has compared the results with measured limb profiles from a variety of instruments, and with computed limb profiles from other solar atmospheric and radiative transfer codes. The goal is to assess the dependence of the computed solar limb profile on model properties in preparation for results from the PICARD satellite (launched 15 June 2010), which will measure variations in the solar radius with unprecedented precision by recording the limb profile with high accuracy.

In August Dr. Short participated in an international workshop to compare the ability of PHOENIX and other atmospheric modelling codes such as MARCS and ATLAS9 to each other, and to observed spectra of Alpha Taurus (Aldebaran, K5 III). The results of the experiment will be submitted to Astronomy and Astrophysics in 2011.

With Ph. D. student Mr. David Williamson Dr. Thacker recently started investigating the evolution of galactic disk collapses at high resolution. The computing cluster purchased with Dr. Thacker's CFI funds is designed specifically for conducting this research as it will require many hundreds of thousands of time steps to complete these simulations. Mr. Williamson has made significant progress on both technical details within the code and the physics of disk evolution. They have been comparing the predictions of viscous disk evolution models (in particular a model proposed by Lin and Pringle) to results from simulations. Preliminary results at low resolution show that the disk evolves through separate phases where viscosity due to cloud-cloud collisions is important, to one where it is not. A paper on this research should be submitted soon.

With Ph. D. student, Mr. James Wurster, Dr. Thacker has begun research on modeling of AGN outflows with radiative transfer. Mr. Wurster is currently learning how to use the ZEUS simulation code in preparation for simulating more complex model AGN outflows that include both magnetohydrodynamics and

radiative transfer. This research is expected to be conducted in collaboration with Dr David Clarke and Dr Daniel Proga (UNLV).

A collaborative project is being led by Dr. Diego Saez (Universidad de Valencia, Spain) on weak lensing of the Cosmic Microwave Background. Dr. Saez and collaborators developed a numerical analysis tool for predicting the impact of weak lensing by foreground galaxy clusters on measurements of the CMB. Dr. Thacker provided a parallel version of the simulation code the collaboration has been using and together they are now running a series of simulations to make predictions for the Planck satellite. The overall impact of weak lensing on the CMB is actually comparatively small and restricted to small scales ("high ℓ's"). However, Planck will be the first space-borne experiment capable of measuring the impact of weak lensing. The primary motivation for making these measurements is that accurate estimation of cosmological parameters is dependent upon being able to disentangle the impact of weak lensing on the primary CMB signal. Following publication of their first work in this field they are now investigating the possibility of extending the work to investigate the impact of physics on the CMB. In particular they are interested in further detailing the impact of AGN on both lensing and the Sunyaev-Zel'dovich effect. This would be an extension of previous work conducted in 2006, and would also be the most advanced simulation of these effects to date.

The publications and talks based on ICA members' research and outreach are listed in Appendix 1. Included are research papers in refereed journals, research papers currently submitted but not yet published, non-refereed publications (mostly having to do with contributions to the astronomy long range plan), colloquia and presentations by ICA members, and poster contributions by ICA members. All of these attest to the very active research programs carried out by ICA personnel.

Appendix 1: **Publications and Talks of ICA Members**

Refereed Publications

Clarke, D. A., "On the Reliability of ZEUS-3D", 2010, ApJS, 187, 119

Deupree, R. G. & **Beslin, W.**, “Rotational Splitting of Pulsation Modes”, 2010, ApJ, 721, 1900

Elahi, P., Widrow, L., & **Thacker, R. J.**, “Can substructure in the Galactic Halo explain the ATIC and PAMELA results?”, 2009, Physical Review D, 80, 123513

Fullana, M. J., Arnau, J. V., **Thacker, R. J.**, Couchman H. M. P., Saez, D., “Estimating small angular scale CMB anisotropy with high resolution N-body simulations: weak lensing”, 2010, ApJ, 712, 367

Gruberbauer, M., Kallinger, T., Weiss, W. W., **Guenther, D. B.**, “On the detection of Lorentzian profiles in a power spectrum: A Bayesian approach using ignorance priors”, 2009, A&A, 506, 1043

Guenther, D. B., Kallinger, T., Zwintz, K., Weiss, W. W., Kuschnig , R., **Casey, M. P.**, Matthews, J. M., Moffat, A. F. J., Rucinski, S. M., Sasselov, D., Walker, G.A. H., “Asteroseismic Analysis of the Pre-Main Sequence Stars in NGC 2264”, 2009, ApJ, 704, 1710

Handler, G., Matthews, J. M., Eaton, J. A., Daszy´nska-Daszkiewicz, J., Kuschnig, R., Lehmann, H., Rodr´ıguez, E., Pamyatnykh, A. A., Zdravkov, T., Lenz, P., Costa, V., D´ıaz-Frail, D., Sota, A., Kwiatkowski, T., Schwarzenberg-Czerny, A., Borczyk, W., Dimitrov, W., Fagas, M., Kami´nski, K., Ro˙zek, A., van Wyk, F., Pollard, K. R., Kilmartin, P. M., Weiss, W. W., **Guenther**, **D. B.,** Moffat, A. F. J., Rucinski, S. M., Sasselov, D. D., Walker, G. A. H., “Asteroseismology Of Hybrid Pulsators Made Possible: Simultaneous Most Space Photometry And Ground-Based Spectroscopy of g Peg”, 2009, ApJ, 698, 56

Huber, D., Matthews, J. M., Croll, B., Obburugger, M., **Gruberbauer, M.**, **Guenther, D. B.**, Weiss, W. W., Rowe, J. F., Kallinger R., Kuschnig, R., Scholtz, A. L., Moffat, A. F. J., Rucinski, S., Sasselov, D., Walker, G. A. H., "A search for p-modes and other variability in the binary system 85 Pegasi using MOST photometry", 2009, A&A, 505, 715

Kallinger, T., **Gruberbauer, M., Guenther, D. B.**, Fossati, L., Weiss, W. W., “The nature of p-modes and granulation in HD 49933”, 2010, A&A, 510, 106

Pribulla, T., Rucinski, S., Latham, D. W., Siwak, M., Matthews, J. M., Kuschnig, R., Rowe, J., **Guenther, D. B.,** Moffat, A. F. J., Sasselov, D.; Walker, G. A. H., Weiss, W. W., "Eclipsing binaries in the MOST satellite fields", 2010, AN, 331, 397

Rowe, Jason F., Matthews, Jaymie M., Seager, Sara, Sasselov, Dimitar, Kuschnig, Rainer, **Guenther, David B.**, Moffat, Anthony F. J., Rucinski, Slavek M., Walker, Gordon A. H., Weiss, Werner W., “Towards the Albedo of an Exoplanet: MOST Satellite Observations of Bright Transiting Exoplanetary Systems”, 2009, IAUS, 253, 121

Rucinski, S., Zwintz, K., Hareter, M., Pojmanski, G., Kuschnig, R., Matthews, J. M., **Guenther, D. B.**, Moffat, A. F. J., Sasselov, D., Walker, G. A. H., Weiss, W. W., “Photometric variability of the Herbit Ae star HD 37806”, 2010, A&A, arXiv1008.4599

Short, C. Ian & Hauschildt, P. H., “Modeling the Near-ultraviolet Band of GK Stars. I. Local Thermodynamic Equilibrium Models”, 2010, ApJ, 718, 1416

Short, C. Ian & Hauschildt, Peter H., "Modeling the Near-UV Band of GK Stars, Paper I: LTE Models", 2010, ApJ, arXiv1007.1433S

Siwak, M., Rucinski, S., Matthews, J. M., Kuschnig, R., **Guenther, D. B.**, Moffat, A. F. J., Sasselov, D., Walker, G. A. H., Weiss, W. W., “Analysis of the MOST light curve of the heavily spotted K2IV component of the single-line spectroscopic binary II Pegasi”, 2010, MNRAS, 408, 314

Strassmeier, K. G., Granzer, T., Kopf, M., Weber, M., Reegen, P., Rice, J. B., Matthews, J. M., Kuschnig, R., Rowe, J. F., **Guenther, D. B.**, Moffat, A. F. J., Rucinski, S. M., Sasselov, D., Walker, G. A. H., Weiss, W. W., “Rotation and magnetic activity of the Hertzsprung-gap giant 31Comae”, 2010, A&A, 520A, 52

Thacker, R. J., “Planet B”, Alternatives Journal, 2010, 36, 4, 63

Tilvi V., Malhotra S., Rhoads J., Scannapieco E., **Thacker R. J.**, Iliev I. T., Mellema G., "A Physical Model of Lyman Alpha Emitters", 2009, ApJ, 704, 724

Vasiliev, E. O., **Vorobyov, E. I.**, and Shchekinov, Yu.A., "Cooling and Fragmentation in Protogalaxies with Rotation", 2010, ARep, 54, 890

Vorobyov, E. I., "Embedded protostellar disks around (sub-)solar protostars. I. Disk structure and evolution", 2010, ApJ, 723, 1294

Vorobyov, E. I., "Lifetime of the Embedded Phase of Low-Mass Star Formation and the Envelope Depletion Rates", 2010, ApJ, 713, 1

Vorobyov, E. I., Basu, S., "Formation and Survivability of Giant Planets on Wide Orbits", 2010, ApJL, 714, 133

Vorobyov, E. I., Basu, S., "The burst mode of accretion and disk fragmentation in the early embedded stages of star formation", 2010, ApJ, 719, 1

Zwintz, K., **Guenther, D. B.**, Kallinger, T., “Asteroseismology of pre-main sequence stars”, 2009, CoAst, 159, 59

Zwintz, K., Hareter, M., Kuschnig, R., Amado, P. J., Nesvacil, N., Rodriguez, E., Diaz-Fraile, D., Weiss, W. W., Pribulla, T., **Guenther, D. B.**, Matthews, J. M., Moffat, A. F. J., Rucinski, S. M., Sasselov, D. and Walker, G. A. H., "MOST observations of the young open cluster NGC 2264", 2009, A&A, 502, 239

Zwintz, K., Kallinger, T., **Guenther, D. B., Gruberbauer, M.**, Huber, D., Rowe, J., Kuschnig, R., Weiss, W. W., Matthews, M., Moffat, A. F. J., Rucinski, S. M., Sasselov, D., Walker, G. A. H., **Casey, M. P.,** "MOST photometry of the enigmatic PMS pulsator HD 142666", 2009, A&A, 494, 1031

Papers Submitted to Refereed Journals

Desmet, M., Matthews, J. M., Aerts, C., Briquet, M., **Cameron, C.**, Bohlender, D., Yang, S., Kuschnig, R., Walker, G. A. H., Østensen, R., Degroote, P., Miglio, A., **Guenther, D. B.**, Moffat, A. F. J.; Rucinski, S. M., Sasselov, D., Weiss, W. W, "Spica is a grazing eclipsing binary: Simultaneous MOST photometry and two-site spectroscopy of this beta Cep pulsator", 2009, A&A, submitted

Geroux, C. & Deupree, R. G., "Radial Stellar Pulsation and 3D Convection I. Numerical Methods and Adiabatic Test Cases", 2010, ApJ, submitted

Moldovan, R., Matthews, J. M., Vokrouhlicky, D., Gladman, B., Bottke, W., Rowe, J. F., Walker, A., Kuschnig, R., **Guenther, D. B.**, Moffat, A. F. J., Rucinski, S. M., Sasselov, D., Weiss, W. W, "Searching for 'hot Trojans' in the HD 209458 exoplanet system: MOST photometry, dynamical models and detection limits", 2009, ApJ, submitted

Sarty, G. E., Szalai, T., Kiss, L. L., Matthews, J. M., Wu, K., Kuschnig, R., **Guenther, D. B.**, Moffat, A. F. J., Rucinski, S. M., Sasselov, D., Walker, G. A. H., Weiss, W. W., Huziak, R., Johnston, H. M., Phillips, A., Ashley, M. C. B., "The gamma-ray binary LS 5039: new evidence for the black hole nature of the compact object", 2010, MNRAS, submitted

Thuillier, G., Claudel, J., Djafer, D., Haberreiter, M., Mein, N., Melo, S., Schmutz, W., Shapiro, A., **Short**, **C. I.,** Sofia, S., "The shape of the solar limb: models and observations", 2010, Solar Physics, accepted for publication 10 August 2010

Vorobyov, E. I., "Embedded protostellar disks around (sub-)solar stars. II. Disk masses, sizes, typical densities and temperatures", 2010, ApJ, submitted

Vorobyov, E. I., Basu, S. "Embedded disks around low-mass protostars", 2010, to appear in the IAUS 270 Proceedings, Cambridge University Press (eds. Alves, Elmegreen, Girart, Trimble)

Zwintz, K., Kallinger, T., **Guenther, D. B., Grubebauer, M.**, Kuschnig, R., Weiss, W, Baglin, A., Jorda, A., and Matthews, J., "Pulsational analysis of V 588 Mon and V 589 Mon observed with the MOST and CoRoT satellites", 2010, ApJ submitted

Non-refereed publications

Bond, J. R., Afshordi, N., Babul, A., Couchman, H., Dobbs, M., Frolov, A., Halpern, M., Holder, G., Martin, P., Marleau, F., McNamara, B., Netterfield, B., Navarro, J., Pen, U-L., Pogosian, L., Pogosyan, D., Scott, D., Sigurdson, K., Turok, N., **Thacker R.**, Wadsley, J, "Cosmic Background Radiation Theory and Analysis: Whitepaper for the Canadian Long Range Plan in Astronomy", now archived at www.casca.ca

Crabtree, Dennis; Rosvick, Joanne; Cami, Jan; Connors, Martin; Edwards, Louise; Hesser, James E.; Lamontagne, Robert; Martimbeau, Nathalie; Newbury, Peter; Sarty, Gordon; **Short, Ian**; Theijsmeijer, Heather, "LRP2010 White Paper on Education and Public Outreach: Engaging Canadians From Main Street to Parliament Hill", 2010, to be published in the CASCA Long Range Plan 2010 for Canadian Astronomy

Deupree, R. G., book review of "The Life of Stars" by Giora Shaviv, 2010, to appear in Physics Today

Herwig, Falk; **Deupree, Robert; Guenther, David**; Ivanova, Natalia; Sills, Alison; VandenBerg, Don; Venn, Kim, "Stellar Evolution – The Multiple Roles of Stars" now archived at www.casca.ca

Willis, J. P., Abraham, R. G., Balogh, M. L., Crampton, D., Sawicki, M., **Thacker, R. J.**, Webb, T. M. A., Willott, C. J., "Galaxy Formation: A White Paper for the Canadian LRP 2010", now archived at www.casca.ca

Colloquia and Presentations Given by ICA Members

Deupree, R. G., "Structure, Evolution, and Oscillations of Rotating Stars", Invited talk, 2nd Halifax Meeting on Computational Astrophysics…the 18th Kingston Meeting, Halifax, 16-18 October 2009

Deupree, R. G. & Beslin, W., "Nonazimuthal Pulsation Modes in Rapidly Rotating Stars", Canadian Astronomical Society 2010 Annual Meeting, May 2010

Deupree, R. G., "Mode Splitting in Rapidly Rotating Stars" Canadian Institute for Theoretical Astrophysics Conference, May 2010

Elahi, P., Widrow, L., & Thacker, R. J., "Finding Streams in the Dark", Contributed conference paper, CASCA 2010, Saint Mary's University, May 2010

Geroux, C. & Deupree, R. G., "Interior Mass as the Radial Independent Variable in Nonlinear Stellar Pulsation Calculations", 2nd Halifax Meeting on Computational Astrophysics…the 18th Kingston Meeting, Halifax, 16-18 October 2009

Lovekin, C. & Deupree, R., "Mass Loss in 2D Rotating Stellar Models", 2010, IAU Symposium 272, in press

Peña, Fernando, “Inertial modes in convective planets & their indirect detection: using Saturn's rings as a seismograph”, Pontifical Catholic University of Chile, 10 December 2009 (http://www.astro.puc.cl:8080/astropuc/seminars/inertial-modes-in-convective-planets-their)

Peña, Fernando, “Inertial modes in convective planets & their indirect detection”, Saint Mary's University, 15 January 2010 (http://www.smu.ca/academic/science/ap/Winter2010CollAbs.html)

Short, C. Ian, “2009 Nobel Prize in Physics: Willard Boyle and the invention of Digital Photography”, Halifax, 9 March 2010

Short, C. Ian, “Modeling M and K Giants with PHOENIX”, GREAT Workshop on Comparative Modelling of Stellar Spectra, Vienna, 23-24 August 2010

Thacker, R. J., “What Box? Lessons Learned at the 2009 Banff Science Communications Workshop”, Saint Mary’s University, 25 September 2009

Thacker, R. J., “The cosmic distribution of quasars: Where are they & how do they cluster?”, University of New Brunswick, 9 October 2009

Thacker, R. J., “Creation through the lens of history: CMB weak lensing at high l”, Queen’s University, 20 January 2010

Thacker, R. J., “Creation through the lens of history: CMB weak lensing at high l” Royal Military College of Canada, 26 January 2010

Thacker, R. J., “Creation through the lens of history: CMB weak lensing at high l” Dalhousie University, 11 February 2010

Thacker, R. J., “CMB Weak lensing at high ℓ”, Herzberg Institute of Astrophysics, Victoria, 11 March 2010

Thacker, R. J., “What Box? Lessons Learned at the 2009 Banff Science Communications Workshop” Herzberg Institute of Astrophysics, Victoria, 11 March 2010

Thacker, R. J., “CMB Weak lensing at high ℓ”, 19th Kingston Meeting, CITA25 Reunion, Canadian Institute for Theoretical Astrophysics, May 2010

Thacker, R. J., “CMB weak lensing”, Invited talk, 50th Birthday Celebration of the Institute for Theoretical Physics, University of Alberta, 17 September 2010

Vorobyov, Eduard, “Pre-main sequence disks around low-mass stars”, 270th IAU Symposium "Computational Star Formation", Barcelona, Spain, 1 June 2010

Vorobyov, Eduard, “Protostellar disks at the early stages of the formation of (sub-)solar-type stars”, Institute for Astronomy, Russian Academy of Sciences, Moscow, 15 July 2010

Contributed Poster Papers

Clarke, D. A., Ramsey, J., & Men'shchikov, A. B.,"AZEuS: Numerical methods for a staggered AMR MHD code", 2nd Halifax Meeting on Computational Astrophysics…the 18th Kingston Meeting, Halifax, 16-18 October 2009

Elahi, P., Widrow, L., & Thacker, R. J., “Finding Streams in the Dark”, 19th Kingston Meeting, CITA25 Reunion, Canadian Institute for Theoretical Astrophysics, May2010

Geroux, C. & Deupree, R. G., “Interior Mass as the Radial Independent Variable in Nonlinear Stellar Pulsation”, CASCA 2010, Halifax, 25-28 May 2010

MacDonald, N. & Clarke, D. A., "Bridging the Gap: Synthetic Radio Observations of Numerical Simulations of Extragalactic Jets", 2nd Halifax Meeting on Computational Astrophysics…the 18th Kingston Meeting, Halifax, 16-18 October 2009

Peña, Fernando, "On the Indirect Detection of Inertial Modes in Saturn Observing Its Rings", CASCA 2010, Halifax, 25-28 May 2010

Ramsey, J. & Clarke, D. A., "AZEuS: Numerical methods for a staggered AMR MHD code", CASCA 2010, Halifax, 25-28 May 2010

Short, C. Ian, & Hauschildt, Peter H., "Fitting cool star SEDs with PHOENIX models", 2nd Halifax Meeting on Computational Astrophysics…the 18th Kingston Meeting, Halifax, 16-18 October 2009

Short, C. Ian, "CoolGrid: Modelling the right half of the Hertzsprung-Russell Diagram", Saint Mary's University Research Day, Halifax, 4 March 2010

Short, C. Ian, "CoolGrid: Modelling the right half of the Hertzsprung-Russell Diagram", CASCA 2010 AGM, Halifax, 25-28 May 2010

Short, C. Ian, & Hauschildt, Peter H., "CoolGrid: Modelling the right half of the Hertzsprung-Russell Diagram", Why Galaxies Care About AGB Stars II, Vienna, 16-20 August 2010

Thacker, R. J., “CMB Weak lensing at high ℓ”, CASCA 2010, Halifax, 25-28 May 2010