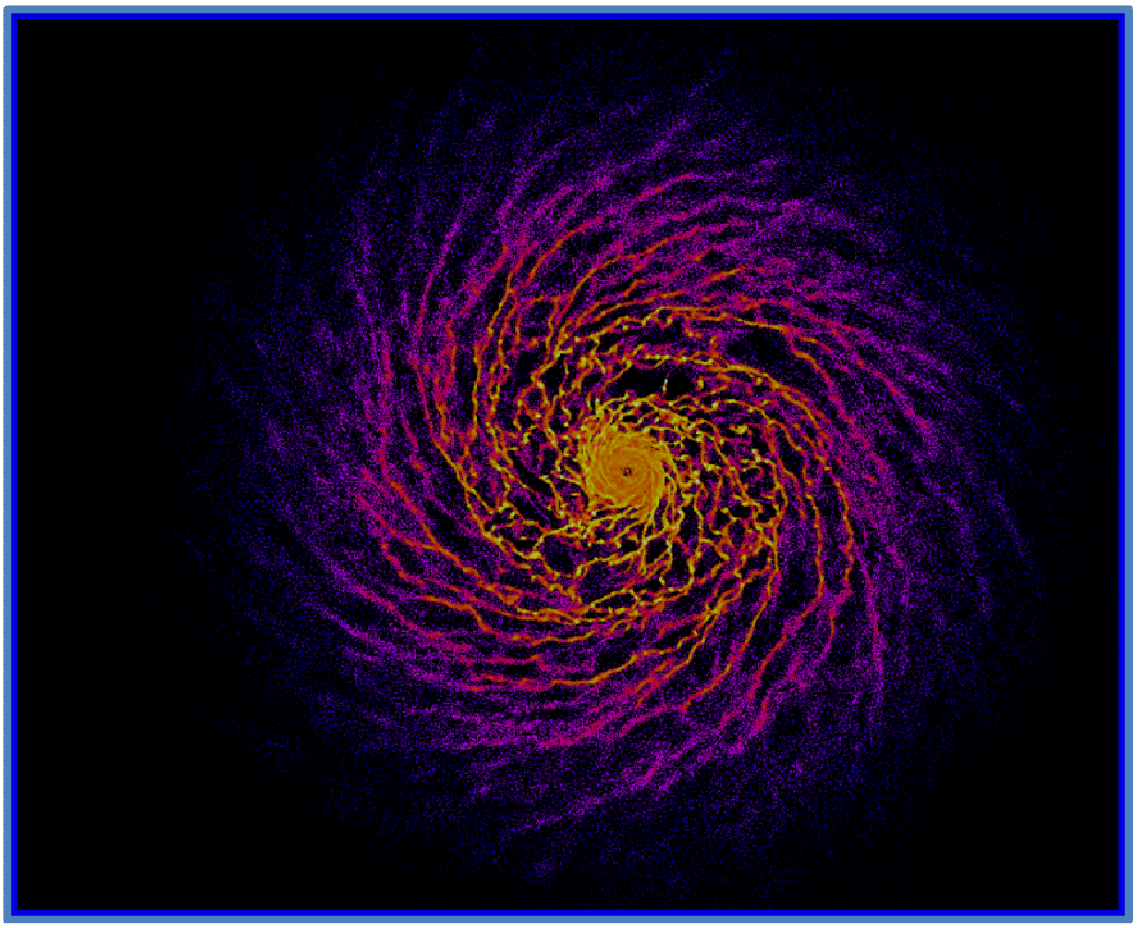
Institute for Computational Astrophysics ICA

ANNUAL REPORT 2011



Compiled by:

Robert G. Deupree, Director

Florence Woolaver, ICA Assistant

Cover Photo: Dave Williamson, PhD Student, ICA (see next page for caption)

SAINT MARY'S UNIVERSITY SINCE 1802

One University. One World. Yours.

Front Cover Photo Caption

This is a picture of a galaxy simulation - a model of a galaxy quite similar to our own Milky Way. It looks somewhat different to most pictures of galaxies because most of the visible light that comes from a galaxy is from the bright stars, and this is what we see with our telescopes. However, what is presented here is the *gas* in the simulated galaxy. The light that comes from this gas is much easier to see with an infrared telescope. Note that the gas in the galaxy is very clumpy, like the giant molecular clouds one observes in real galaxies. The purpose of the simulation is to see how the clouds form, interact with each other, and influence the rest of the galaxy. These simulations are difficult and time consuming because the scale of the molecular clouds, which must be resolved in the simulation, is about 0.0001 to 0.00001of the size of the entire galaxy.

ICA Annual Report 2011

Mandate and Goals

The original preliminary proposal for the ICA was submitted to Academic Planning 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: "The purpose of the *Institute of Computational Astrophysics* (ICA) is 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." In order to meet this purpose, one concrete activity the proposal called for was "the ICA would attract and support several Postdoctoral Fellows (PDFs) and doctoral students, both of which are key to a successful academic research environment." Other concrete steps contemplated included instituting a visitor program, hosting conferences on computational astrophysics, and acquiring significant computational resources required to perform research in computational astrophysics. The original proposal is accessible on the ICA website (www.ica.smu.ca and then to "Key Documents").

This year the ICA slightly extended its mandate to include the use of high performance computing for increasingly complex area of data reduction and analysis. This has led to the addition of Drs. Marcin Sawicki (Department of Astronomy and Physics faculty member), Taro Sato (postdoctoral fellow), and Dr. Sawicki's graduate students to the ICA membership.

Personnel

The ICA has six full time faculty members, each of whom is also a faculty member in the Department of Astronomy and Physics. This includes Dr. Robert Deupree, Director and Tier 1 Canada Research Chair, Dr. David Clarke, Dr. David Guenther, Dr. Ian Short, Dr. Marcin Sawicki, and Dr. Rob Thacker, Tier 2 Canada Research Chair. Two post doctoral fellows were also ICA members during this past year, both of whom are ACEnet Fellows: Drs. Fernando Peña and Taro Sato. Six Ph. D. students were associated with the ICA during the year (not including new graduate students beginning in September, 2011): Mr. Mike Casey, Mr. Chris Geroux, Mr. Michael Gruberbauer, Mr. Jon Ramsey, Mr. David Williamson, and Mr. James Wurster. Mr. Ramsey successfully defended his Ph. D. thesis in July and has now joined Heidelberg University as a postdoctoral fellow working with Dr. Cornelius Dullemond. Mr. Casey successfully defended his Ph. D. thesis in September and will be remaining in Halifax for family reasons. Mr. Gruberbauer holds a prestigious Vanier Fellowship, and Mr. Wurster held an NSERC PGS for the first part of his Ph. D. research. Ph. D. students Wurster and Gruberbauer passed their comprehensive exams during the past year. There were three Master's students associated with the ICA during this past year: Ms. Liz Arcilla, Mr. Diego Castañeda, and Ms. Anneya Golob.

The Department of Astronomy and Physics has five new graduate students entering in the fall of 2011, several of whom are expected to be associated with the ICA.

In addition, members of the ICA hired three undergraduates to help with their research over the summer: Mr. Eamonn Campbell, working with Dr. Ian Short, Mr. Wilfried Beslin, working with Dr. Robert Deupree, and Mr. Xavier Talbot-Thiebaux**,** working with Dr. Rob Thacker.

The ICA is supported administratively by Ms. Florence Woolaver. Also 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 supplies administrative support to local ACEnet personnel and acts as a key interface between SMU and the ACEnet administration in St. John's, NL. Mr. Dave Lane provides support for two relatively small computer clusters obtained by ICA faculty through CFI awards over the last few years. These are used for special purposes, such as code development, for which the ACEnet clusters are unsuitable.

Key ICA Events of the Past Year

The ICA acquired a small computer cluster to replace the aging Pluto cluster this past year. The Lachesis cluster was obtained for Dr. Deupree and his coworkers through a CFI grant with matching funds from the Nova Scotia Research Innovation Trust (NSRIT) and Saint Mary's. The approximately $25k bought a machine which looks much like a smaller version of the ACEnet MPI clusters, and is mostly used for code development.

The ICA hosted two meetings this past year. One of these was a two day session in which the Data Cave software vendor provided training and discussion of the capabilities of the software which had been upgraded the previous year to meet our needs. The second meeting was the first ACEnet annual meeting, held near the end of April. This provided a forum for approximately 30 ACEnet users from the eleven ACEnet associated universities to discuss the level of success of the ACEnet high performance computing facilities in meeting user needs, the future of ACEnet, and the future of high performance computing in Canada as a whole.

A major effort was expended on the ICA web site this year. In addition to the general Saint Mary's overhaul of all its websites, the ICA worked to revamp, expand, and improve its own web site content. One feature which has brought significant positive comment is the "Image of the Month". Each month one of the ICA members posts a (hopefully catchy) image and explanation on the website. Most ICA members (faculty, post docs, and graduate students) have had one turn now, and we expect to begin a second round in a couple of months. Other upgrades include a description of the major simulation codes created and/or used by ICA members, a reworking of the table of ICA students who have completed their graduate degrees, putting pdf's of ICA member posters presented at conference on our web site, and a

reorganization of the presentation of the ICA publications. The last of these was required because the number of ICA publications is now sufficiently large that they need to be subdivided by year and the ones submitted or in press handled separately.

Another goal for this year was to increase the number of visitors, particularly longer term visitors. This summer the ICA was pleased to host Dr. Brad Gibson and two of his graduate students, Ms. Kate Pilkington and Mr. Gareth Few, for most of the summer. Mr. Mark Richardson, a Ph. D. student at Arizona State University, also spent a month in the ICA this summer. Shorter term visitors for the year included Drs. Matt Browning (CITA) and Tom Jones (Univ. of Minnesota).

ICA Member Service

Members of the ICA play significant roles in service to the university, the community, and to the astronomical community on both the national and international scale. Here we summarize key components of this service.

Dr. Deupree continues to serve on the Advisory Board of the NRC's Herzberg Institute of Astrophysics. He is now midway through his second and final term and brings his experience in high performance computing to the Board. He also serves as a member of the ACEnet's Chairs of the Local Users Group and is the Chair of the Saint Mary's Local Users Group.

Dr. Clarke serves on the Science Curriculum Committee and on the Science Space Committee.

Dr. Guenther is a member of the BRITE Constellation consortium. BRITE Constellation is a proposed set of four nano-satellites designed to observe oscillations on the brightest stars in the sky. The project represents a joint collaboration of Canadian and Austrian asteroseismologists. The first two satellites are scheduled for launch in 2011. He is also a member of the MOST Science Team. He continued to analyze the data coming from Canada's first space telescope, MOST. He is in part responsible for the stellar modeling, oscillation modeling, and interpretation of the data obtained from the satellite.

Dr. Sawicki served on a number of national and international astronomy committees, such as the Canadian Astronomical Society's Working Group on Canadian ESO membership, the Canadian Gemini Science Committee, the Canadian ALMA Science Advisory Committee, and on the Extragalactic Science team for the ngCHFT project. He is also active in committees related to several ongoing or proposed space missions, including the James Webb Space Telescope, The Japanese WISH telescope, and possible Canadian participation in a dark energy mission. He also serves on the Boards of the Canadian Astronomical Society and the Association of Canadian Universities for Research in Astronomy.

Dr. Short served as the Chair of the Department of Astronomy and Physics until July 2011 and is currently on Administrative Leave. He also serves on the Canadian Astronomical Society`s Awards and Education and Public Outreach Committees and has agreed to serve as Saint Mary's member of the ACEnet Research Directorate.

Dr. Thacker became the Chair of the Department of Astronomy and Physics in July. In a follow up to his service as a member of the Canadian Astronomical Society's Long Range Plan 2010, Dr. Thacker is serving a one year term as a member of the Long Range Plan Implementation Committee, whose task is to deal with the rapidly changing landscape relating to international astronomical facilities.

In addition, several members have given talks oriented for the public in schools, libraries, and colleges, and Dr. Thacker has answered science questions on the curiocity.ca web site.

ICA Member Research Contributions

All of the ICA faculty members maintain very active research programs involving not only themselves, but also postdoctoral fellows, graduate students, and occasionally undergraduate summer researchers. All participate in publishing papers, as well as serving as referees for various astrophysical journals. Here we present a brief summary of ICA members' research accomplishments for the past year.

Dr. Deupree performed an extensive study of the structure of rotating Zero Age Main Sequence (ZAMS) stars, covering twenty rotation rates and ten masses. For nonrotating stars, the mass is the variable distinguishing members of the ZAMS, and a key finding of this work is that the rotation variable most "orthogonal" to the mass is actually the surface shape of the model. Dr. Deupree also explored the effects of the nonspherical contribution to the gravitational potential for ZAMS rotating stars.

Pulsation frequencies for many of these models were computed by ICA postdoctoral fellow, Dr. Fernando Peña and undergraduate student Mr. Wilfried Beslin. Studies on the accuracy of the frequencies and trends between different models were presented at the stellar pulsation conference in Granada, Spain by Dr. Peña in September.

Dr. Deupree evolved rotating models of stars to obtain a good approximation for the rapidly rotating δ Scuti star, α Ophiuchus. This star has been observed interferometrically so that its surface shape and the inclination between the rotation axis and the observer are known, and it has also been observed with the MOST satellite, which found the star oscillates

with 55 frequencies. Together, these results sufficiently constrain the model properties so that one might have a decent chance to match the oscillation frequencies with frequencies computed from these models. However, the rotational splitting of the pulsational frequencies of nonaxisymmetric modes makes the frequency spectrum so dense that almost any collection of frequencies can be matched reasonably well by more than one model.

Dr. Deupree also worked with Master's student, Mr. Diego Castañeda, and Dr. Ian Short on using the rotating models to compute the spectral energy distribution which could be compared with that of α Ophiuchus. This uses the PHOENIX stellar atmospheres code to compute the intensity spectrum and a code written by Dr. Catherine Lovekin, former ICA graduate student, to integrate the resulting flux over the observable stellar surface to predict what the observer would see. This work has been applied to the observed spectrum of α Ophiuchus to determine how well models of rotating stars can reproduce the observations. They find that a particular 2.25 $M_\odot$ model with the observed oblateness placed at the distance of the star produces a better fit to the spectral energy distribution (ultraviolet and visible) than does any spherical model. Drs. Deupree and Peña then computed p mode oscillation frequencies for this model and found modes that are equatorially symmetric and azimuthally symmetric match the frequencies of the four largest amplitude observed p modes and of seven out of the nine largest amplitude observed p modes to within the observational error. All other observed p modes can be matched to within the observational error with other modes with $|m| \leq 2$ except for the lowest amplitude mode (which requires $m = 3$). However, this result is colored by the relatively high density of modes in the computed spectrum.

Mr. Chris Geroux, a Ph. D. student working with Dr. Deupree, has developed a multidimensional hydrodynamics code to compute full amplitude RR Lyrae pulsation models in one and two spatial dimensions. These calculations simulate the interaction of turbulent convection and stellar pulsation. The first paper, which focuses on the numerical method and test cases, was published this year. This is the first time that such 2D models of convection have ever been carried to full pulsation amplitude. Mr. Geroux is modifying the code to include the third spatial dimension, which needs only certain eddy viscosity terms to be complete. Mr. Geroux presented his results at the stellar pulsation conference in Granada, Spain this September.

Dr. Clarke and the now Dr. Ramsey have made some interesting discoveries on the relationship between the site where protostellar jets are launched, and the much larger scale (by about five orders of magnitude) where they are routinely observed. These are the first simulations of their kind, in which both the launching and observed regions are part of the same simulations. They find a hitherto unknown relationship between the jet's advance speed and its rotation speed, which are coupled via the magnetic field. This relationship is not developed well enough yet to serve as a useful observational tool, but with further study it could be used to confirm the magnetic origin of protostellar jets. They also find that observable properties of the jet such as advance speed, mass flux, angular momentum, *etc.*, are all linked

to the magnetic field strength near the origin of the jet in fairly simple ways (*e.g.*, by a power law). On the other hand, the jet radius and most surprisingly the magnetic field strength in the large-scale jet have little to do with the magnetic field strength at the base of the jet. Indeed, all jets, regardless of the magnetic field at their launch site, evolve into a β~1 plasma. Furthermore, the work confirms both types of jet launching mechanisms (Blandford and Payne's "bead on a wire" for strong fields, and a "coiled spring" mechanism for weaker fields) exist, and finds for the latter that jets continue to be accelerated well past the fast point. A simple harmonic knot generator is established near the launch site of the jet whose period is tightly coupled with the magnetic field strength. For future, high-resolution observations, this may provide a means by which the magnetic field strength can be measured.

Dr. Clarke continues his interest in developing and maintaining "community astrophysical codes", such as ZEUS-3D and AZEuS (the AMR-ZEUS-3D hybrid Mr. Ramsey developed for his thesis work), and distributing them via public web-sites. The main site, www.ica.smu.ca/zeus3d, has had nearly 250 downloads of the code (~120,000 lines of FORTRAN) by students and faculty alike from all six continents in the nearly 3½ years since it was posted. A similar site for AZEuS will be made available once that code becomes sufficiently robust for public use.

Asteroseismology continues to take great leaps forward as satellites find progressively more types of stars which oscillate at low amplitude, and Dr. Guenther and his collaborators are performing the theoretical calculations to compare with the observations. He and Dr. Konstanze Zwintz (University of Vienna) are working on modeling the oscillation spectra of pre main sequence stars obtained from CoRoT and MOST, and Mr. Mike Casey collected all the asteroseismic information for pre main sequence stars and analyzed them for trends for his Ph. D. research. Dr. Guenther continued his collaboration with Dr. Thomas Kallinger (U.B.C.) on modeling the oscillation spectra of red giants obtained from CoRoT, Kepler, and MOST, and is preparing models of horizontal branch and giant stars for future asteroseismological analysis, including studying the effects of g mode behaviour in these stars.

Dr. Sawicki has three primary research activities. The first of these studies the properties of faint Lyman Break Galaxies from z=2 to z=5. This is a large ongoing series of projects that stems from the deep imaging survey of the Keck Deep Fields, of which Dr. Sawicki was the Principal Investigator. In collaboration with colleagues in the US (Dr. D. Thompson, University of Arizona) and Japan (Drs. K. Ohta and K. Yabe, Kyoto University; Dr. I. Iwata, National Astronomical Observatory of Japan), Dr. Sawicki is carrying out a follow-up study of the properties of the hitherto neglected, extremely faint Lyman Break Galaxies whose importance to the story of galaxy star formation in the universe Dr. Sawicki and collaborators first demonstrated in the KDF series of papers. They are now working to understand the nature of these objects, focusing on studies of their broadband spectral energy distributions. Their work at redshift z~2 is being led by Dr. Sawicki and the z~5 work is led by Drs. K. Yabe, S.Yuma, and K. Ohta at Kyoto University. Both these studies make extensive use of the well-established broadband SED-fitting technique that Dr. Sawicki pioneered. Furthermore, Mr. Jonathan Savoy

(former SMU Astronomy & Physics Master's student) has been working under Dr. Sawicki's supervision on the clustering of these very faint UV-selected galaxies at redshifts z=4, 3, and 2.

The second of Dr. Sawicki's primary research projects concerns Lyman alpha emitters at z>4. This is a series of projects that use a different selection technique to complement the Lyman Break Galaxies work described above by studying what appear to be *extremely* young objects in the early universe. In collaboration with Drs. Crystal Martin and Alaina Henry (UCSB), and Drs. Alan Dressler and Pat McCarthy (OCIW) Dr. Sawicki is carrying out a large spectroscopic search for such very faint objects at z~5.7 (project PI: Martin); a complementary large survey at slightly lower redshifts, z~4-5, (PI: Sawicki) in collaboration with Drs. Raja Guhathakurta (UCSC) and Brian Lemaux (UCDavis) is also underway.

The third primary research topic involves large-area studies of high-z galaxies using CFHT Legacy Survey data. This is a new set of projects that Dr. Sawicki has started to work on with Master's student Ms. Liz Arcila Osejo and postdoctoral fellow Dr. Taro Sato. The ultimate goal is to constrain galaxy evolution using clustering and SED studies to an unprecedented level using the wide-area CFHTLS. It is noteworthy that Dr. Sawicki secured $40,000 from the ACEnet research fellowship program in support of this work and - indeed - given the large quantities of data involved, much of the work is being done on ACEnet machines.

Dr. Short used ACEnet facilities to calculate a grid of 85 atmospheric models and synthetic spectra for red giant stars of solar and 1/3 solar metallicity with 35 chemical species and thousands of atomic transitions in non-LTE. This grid is unprecedented in the range of stellar parameter spaced spanned with models that have so many opacity sources treated in non-LTE. He is currently comparing synthetic spectra to observational data to assess the accuracy of these spectra compared to less realistic LTE spectra that were published in his previous work, and is assessing the impact of these non-LTE results on the effective temperature calibration of the G and K III spectral classes.

Dr. Short has also computed intensity spectra for the limb of the Sun with 35 opacity sources treated in non-LTE to aid in the interpretation of solar limb measurements made by the French-lead PICARD space-borne solar telescope. This is a refinement to work published by the group previously.

The main highlight of Dr. Thacker's research during this period is the completion of work on the impact of viscosity during collisions on molecular clouds in galaxies. This is an ongoing project on which graduate student Mr. David Williamson has been working. Using full 3d simulations, they have shown that in fact the impact of the viscosity is greater than had been anticipated in earlier work. While earlier estimates suggested that this process would only occur on timescales as long as 1000 Gyr (far, far longer than the age of the Universe) they have shown that in numerical models it can act on timescales as short as a few Gyr, which is long enough for there to be some impact on galactic disk evolution.

Dr. Thacker and Mr. James Wurster have been working on a detailed examination of the different behaviour of models of AGN feedback. Unlike sub-resolution models of star formation where the inputs and outputs are fairly well understood, AGN modelling presents much more significant difficulties: one does not know the intermediate states well at all. They have thus undertaken a somewhat challenging project of reproducing and then comparing the results of four different approaches to modelling AGN feedback. In addition Mr. Wurster has also elucidated the impact of numerical effects such as rounding error on these solutions. The calculations exhibit a level of chaos that means runs on different numbers of processors slowly start to diverge and produce different results. Quantifying the impact of this is as important as determining the differences between the different algorithms.

The arrival of Dr. Brad Gibson and Ms. Kate Pilkington at the ICA over the summer prompted Dr. Thacker to become involved in looking at the state of both cold gas in galaxy simulations and also examining in detail how precisely how galactic disks form and the impact of this on the metallicity gradients. This is a challenging subject since numerical simulations have a number of deficiencies while the observational picture is quite specific to individual galaxies. Their approach has been to examine how different simulation codes and different initial conditions compare, thereby giving a wider understanding of the kind of variances expected within the simulation models, and then interpreting this information in the context of current observations. This study finds that most models evolve in a similar fashion although there are some reasonably strong systematic differences depending upon the various assumptions used in the star formation models.

Dr. Thacker has continued work with Dr. Diego Saez and collaborators at the University of Valencia. They are currently extending the research they conducted over the past three years on gravitational lensing to also include the effect of other processes on the signal from the Cosmic Microwave Background. In particular they are bringing together work on the Sunyaev Zel'dovich effect with gravitational lensing and also plan to add the impact of heating from quasar-phase blackholes. This work is challenging and has taken some time to complete, but coding is mostly done now.

Dr. Thacker has started a project to look at the dynamical evolution of stars in galactic disks. The Gaia project is set to revolutionize knowledge of stellar motions and yet the astronomical community's capacity to use this upcoming data is comparatively small at the moment. In collaboration with Dr. Hugh Couchman at McMaster University, Dr. Thacker is developing a new code to run on the soon to be installed supercomputer at the University of Alberta. This model should allow them to conduct simulations of individual galaxies where the mass of the stars is close to that of our own Sun - this would be a notable first in this area. The goal of this research is then to create mock-observations to be used for comparison with Gaia data to better understand the evolution of spiral structure in our galaxy. The secondary goal is to understand how spiral evolution can change the overall metallicity gradient within the disk.

From the above one can see that the ICA members remain very active in research in a variety of areas in astrophysics.

Appendix 1: Publications and Talks of ICA Members
October 2010 – December 2011

Refereed Publications

Balona, L. A., Cunha, M. S., **Gruberbauer, M.**, Kurtz, D. W., Saio, H., White, T. R., Christensen-Dalsgaard, J., Kjeldsen, H., Christiansen, J. L., Hall, J. R., Seader, S. E., "Rotation and oblique pulsation in Kepler observations of the roAp star KIC 10483436", 2011, MNRAS, 413, 2651

Balona, L. A., Cunha, M. S., Kurtz, D. W., Brandão, I. M., **Gruberbauer, M.**, Saio, H., Östensen, R., Elkin, V. G., Borucki, W. J., Christensen-Dalsgaard, J., Kjeldsen, H., Koch, D. G., Bryson, S. T., "Kepler observations of rapidly oscillating Ap, δ Scuti and γ Doradus pulsations in Ap stars", 2011, MNRAS, 410, 517

Basu, S., Grundahl, F., Stello, D., Kallinger, T., Hekker, S., Mosser, B., García, R. A., Mathur, S., Brogaard, K., Bruntt, H., Chaplin, W. J., Gai, N., Elsworth, Y., Esch, L., Ballot, J., Bedding, T. R., **Gruberbauer, M.**, Huber, D., Miglio, A., Yildiz, M., Kjeldsen, H., Christensen-Dalsgaard, J., Gilliland, R. L., Fanelli, M. M., Ibrahim, K. A., Smith, J. C., "Sounding Open Clusters: Asteroseismic Constraints from Kepler on the Properties of NGC 6791 and NGC 6819", 2011, ApJ, 729, 10

Bedding, T. R., Huber, D., Stello, D., Elsworth, Y. P., Hekker, S., Kallinger, T., Mathur, S., Mosser, B., Preston, H. L., Ballot, J., Barban, C., Broomhall, A. M., Buzasi, D. L., Chaplin, W. J., García, R. A., **Gruberbauer, M.**, et al., "Solar-like oscillations in low-luminosity red giants: first results from Kepler", 2010, ApJ, 713, 176-181

Brook, C. B., Stinson, G. S., **Gibson, B. K.,** Roskar, R., Wadsley, J. & Quinn, T., "Hierarchical Formation of Bulgeless Galaxies II: Redistribution of Angular Momentum via Galactic Fountains", 2011, MNRAS, tmp, 1697

Chaplin, W. J., Appourchaux, T., **Gruberbauer, M**., et al., "The asteroseismic potential of Kepler: first results on solar-type stars", 2010, ApJ, 713, 169-175

Deupree, R., "Structure of Uniformly Rotating Stars", 2011, ApJ, 735, 69

Deupree, R., "Theoretical p Mode Oscillation Frequencies for the Rapidly Rotating δ Scuti Star α Ophiuchi", 2011, ApJ, 742, 9

Dressler, A., Martin, C.L., Henry, A., **Sawicki, M.** & McCarthy, P., "Detections of Faint Ly-α Emitters at z=5.75: Galaxy Building Blocks and Engines of Reionization", 2011, ApJ, 740, 71

Elahi, P., **Thacker, R. J.**, Widrow, L., "Peaks above the Maxwellian Sea: A New Approach to Finding Substructure in N-Body Haloes", 2011, MNRAS, arXiv:1107.4289

Geroux, C. M., & Deupree, R., "Radial Stellar Pulsation and 3D Convection.1. Numerical Methods and Adiabatic Test Cases", 2011, ApJ, 731, 18

Gibank, D. G., Bower, R. G., Glazebrook, K., Balogh, M. L., Baldry, I. K., Davies, G. T., Hau, G. K. T., Li, I. H., McCarthy, P., & **Sawicki, M.**, "A Spectroscopic Measurement of Galaxy Formation Timescales with ROLES", 2011, MNRAS, 414, 304

Gruberbauer, M., Huber, D., Kuschnig, R., Weiss, W. W., **Guenther, D. B.**, Matthews, J. M., Moffat, A. F. J., Rowe, J. F., Rucinski, S. M., Sasselov, D., Fischer, M., "MOST observations of the roAp stars HD 9289, HD 99563, and HD 134214", 2011, A&A, 530, 135

Grunhut, J.H., Rivinius, Th., Wade, G.A., Townsend, R.H.D., Marcolino, W.L.F., Bohlender, D.A., Szeifert, Th., Petit, V., Matthews, J.M., Rowe, J.F., Moffat, A.F.J., Kallinger, T., Kuschnig, R., **Guenther, B.D.**, Rucinski, S.M., Sasselov, D., Weiss, W.W., the MiMeS Collaboration, "HR 5907: Discovery of the most rapidly rotating magnetic B-type star by the MiMeS Collaboration", 2011, MNRAS, arXiv:1109.3157v1

Hambleton, K. M., **Gibson, B. K.**, Brook, C. B., Stinson, G. S. & Conselice, C. J., "Advanced Morphological Galaxy Classification: A Comparison of Real and Simulated Galaxies", 2011, MNRAS, arXiv1107.6045

Henry, A. L., Martin, C. L., Dressler, A., McCarthy, P., & **Sawicki, M.**, "New Results from the Magellan IMACS Spectroscopic Lyα Survey: NICMOS Observations of Lyα Emitters at z=5.7", 2010, ApJ, 719, 685-690

Huber, D., Bedding, T. R., Arentoft, T., **Gruberbauer, M.**, **Guenther, D. B.**, Houdek, G., Kallinger, T., Kjeldsen, H., Matthews, J. M., Stello, D., Weiss, W. W., "Solar-like Oscillations and Activity in Procyon: A Comparison of the 2007 MOST and Ground-based Radial Velocity Campaigns", 2011, ApJ, 731, 94

Kallinger, T., Mosser, B., Hekker, S., Huber, D., Stello, D., Mathur, S., Basu, S., Bedding, T. R., Chaplin, W. J., De Ridder, J., Elsworth, Y. P., Frandsen, S., García, R. A., **Gruberbauer, M.**, Matthews, J. M., Borucki, W. J., Bruntt, H., Christensen-Dalsgaard, J., Gilliland, R. L., Kjeldsen, H., Koch, D. G., "Asteroseismology of red giants from the first four months of Kepler data: Fundamental stellar parameters", 2010, A&A, 522, 1

Karoff, C., Chaplin, W. J., Appourchaux, T., Elsworth, Y., Garcia, R. A., Houdek, G., Metcalfe, T. S., Molenda-Żakowicz, J., Monteiro, M. J. P. F. G., Thompson, M. J., Christensen-Dalsgaard, J., Gilliland, R. L., Kjeldsen, H., Basu, S., Bedding, T. R., Campante, T. L., Eggenberger, P., Fletcher, S. T., Gaulme, P., Handberg, R., Hekker, S., Martic, M., Mathur, S., Mosser, B., Regulo, C., Roxburgh, I. W., Salabert, D., Stello, D., Verner, G. A., Belkacem, K., Biazzo, K., Cunha, M. S., **Gruberbauer, M**., Guzik, J. A., Kupka, F., Leroy, B., Ludwig, H.-G., Mathis, S., Noels, A., Noyes, R. W., Roca Cortes, T., Roth, M., Sato, K. H., Schmitt, J., Suran, M. D., Trampedach, R., Uytterhoeven, K., Ventura, R., "Asteroseismology of solar-type stars with Kepler I: Data analysis", 2010, AN, 311, 972

Kurtz, D. W., Cunha, M. S., Saio, H., Bigot, L., Balona, L. A., Elkin, V. G., Shibahashi, H., Brandão, I. M., Uytterhoeven, K., Frandsen, S., Frimann, S., Hatzes, A., Lueftinger, T., **Gruberbauer, M.**, Kjeldsen, H., Christensen-Dalsgaard, J., Kawaler, S. D., "The first evidence for multiple pulsation axes: a new rapidly oscillating Ap star in the Kepler field, KIC 10195926", 2011, MNRAS, 414, 2550

Lovekin, Catherine, **Deupree, Robert G.**, "Mass loss in 2D rotating stellar models", 2011, IAUS, 272, 93

Pilkington, K., Gibson, B. K., Calura, F., Brooks, A. M., Mayer, L., Brook, C. B., Stinson, G. S., **Thacker, R. J.**, Few, C. G., Cunnama, D & Wadsley, J., "The Cold Gas Content of Bulgeless Dwarf Galaxies", 2011, MNRAS, arXiv1107.2922

Pisano, D. J., Barnes, D. G., Staveley-Smith, L., **Gibson, B. K.**, Kilborn, V. A. & Freeman, K. C., "An HI Survey of Six Local Group Analogs. II. HI Properties of Group Galaxies", 2011, ApJ, 197, 28

Ramsey, Jon P. & Clarke, David A., "Simulating protostellar jets simultaneously at launching and observational scales", 2011, ApJ, 728L, 11

Saio, Hideyuki, **Deupree, Robert G.**, "A comparison of oscillation frequencies of rotating stars obtained by one- and two-dimensional calculations", 2011, ASP Conference Series, arXiv:1109.2373

Sanchez-Blazquez, P., Marcolini, A., **Gibson, B. K.**, Karakas, A. I., **Pilkington, K.** & Calura, F., "The Chemical Evolution of Globular Clusters - II. Metals and Fluorine", 2011, MNRAS, tmp.1792

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 γ-ray binary LS 5039: mass and orbit constraints from MOST observations", 2011, MNRAS, 411,1293

Savoy, J., **Sawicki, M.,** Thompson, D., & **Sato, T.**, "Keck Deep Fields. IV. The Mass-Dependent Clustering of UV-Selected Galaxies at z~4, 3, and 2", 2011, ApJ, 737, 92

Sawicki, M., "Stars, Dust, and the Growth of UV-Selected Sub-L* Galaxies at Redshift z~2", 2011, MNRAS, arXiv:1108.5186

Short, C. Ian and Hauschildt, P. H., "CoolGrid: Modelling the right half of the Hertzsprung-Russell Diagram", 2011, ASPC, 445, 173

Siwak, M., Slavek, M. R., Matthews, J. M., Kuschnig, R., **Guenther, D. B.**, Moffffat, A. F. J., Sasselov, D., Werner, W. W., "Analysis of MOST light curves of five young stars in Taurus-Auriga and Lupus 3 Star Forming Regions", 2011, MNRAS, 415, 1119

Sorba, R. & **Sawicki, M.**, "How Future Space-Based Weak Lensing Surveys Might Obtain Photometric Redshifts Independently", 2011, PASP, 123, 777

Sorba, R. & **Sawicki, M.**, "Using the 1.6μm Bump to Study Rest-Frame H-band Selected Galaxies at Redshift 2", 2010, ApJ, 721, 1056-1078

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", 2011, SoPh, 268, 125-149

Uytterhoeven, K., Moya, A., Grigahcene, A., Guzik, J.A., Gutierrez-Soto, J., Smalley, B., Handler, G., Balona, L., Niemczura, E., Fox Machado, L., Benatti, S, Chapellier, E., Tkachenko, A., Szabo, R., Suarez, J.C., Ripepi, V., Pascual, J., Mathias, P., Martin-Ruiz, S., Lehmann, H., Jackiewicz, J., Hekker, S., **Gruberbauer, M.**, Garcia., R.A., Dumusque, X., Diaz-Fraile, D., Bradley, P., Antoci, V., Roth, M., Leroy, B., Murphy, S.J., De Cat, P., Cuypers, J., Kjeldsen, H., Christensen-Dalsgaard, J., Breger, M., Pigulski, A., Kiss, L.L, Still, M., Thompson, S.E., van Cleve, J., "The Kepler characterization of the variability among A- and F-type stars. I. General overview", 2011, MNRAS, 534, 125

Vorobyov, E. I., "Destruction of massive fragments in protostellar disks and crystalline silicate production", 2011, ApJ, 728, 45

Vorobyov, E. I., "Embedded Protostellar Disks Around (Sub-) Solar Stars. II. Disk Masses, Sizes, Densities, Temperatures and the Planet Formation Perspective", 2011, ApJ, 729, 146

Winn, J. N., Dawson, R. I., Fabrycky, D., Holman, M. J., Matthews, J. M., Kallinger, T., Kuschnig, R., Dragomir, D., **Guenther, D. B.**, Moffat, A. F. J., Rowe, J. F., Rucinski, S. M., Sasselov, D., Werner, W. W., "A Super-earth, Transiting a Naked-eye Star", 2011, ApJL, 737, 18

Yuma, S., Ohta, K., Yabe, K., Shimasaku, K., Yoshida, M., Ouchi, M., Iwata, I., & **Sawicki, M.**, "Stellar Populations of Lyα Emitters at z = 4.86: A direct comparison to LBGs", 2010, ApJ, 720, 1016-1029

Zwintz, K., Kallinger, T., **Guenther, D. B., Gruberbauer, 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", 2011, ApJ, 729, 20

Zwintz, K., Lenz, P., Breger, M., Pamyantnykh, A. A., Zdravkov, T., Kuschnig, R., Matthews, J. M., **Guenther, D. B.**, Moffat, A. F. J., Rowe, J. F., Rucinski, S. M., Sasselov, D., Werner, W. W., "Regular frequency patterns in the classical delta Scuti star HD 144277 observed by the MOST satellite", 2011, A&A, 533,133

Papers Submitted to Refereed Journals

Beck, P.G., Montalban, J., Kallinger, T., De Ridder, J., Aerts, C., Garcia, R.A., Hekker, S., Dupret, M.-A., Mosser, B., Eggenberger, P., Stello, D., Elsworth, Y., Frandsen, S., Carrier, F., Hille, M., **Gruberbauer, M.**, Christensen-Dalsgaard, J., Miglio, A., Valentini, M., Bedding, T.R., Kjeldsen, H., Girouard, F.R., Hall, J.R., Ibrahim, K.A., "Fast core rotation in red-giant stars as revealed by gravity-dominated mixed modes", 2011, Nature, in press

Deupree, Robert G., Castañeda, Diego, Peña, Fernando and **Short, C. Ian**, "Matching the Spectral Energy Distribution and p Mode Oscillation Frequencies of the Rapidly Rotating Delta Scuti Star α Ophiuchi with a 2D Rotating Stellar Model", 2011, ApJ, submitted

Calura, F., **Gibson, B. K.**, Michel-Dansac, L., Stinson, G. S., **Pilkington, K.**, House, E. L., Brook, C. B. & Few, C. G., "The Stellar Metallicity Distribution of Disc Galaxies and Bulges", 2011, MNRAS, submitted

David-Uraz, A., Moffat, A. F. J., Chené, A.-N., Rowe, J. F., Lange, N., **Guenther, D. B.**, Kuschnig, R., Matthews, J. M., Rucinski, S. M., Sasselov, D., and Weiss, W. W., "Using MOST to reveal the secrets of the mischievous Wolf-Rayet binary CV Ser", 2011, MNRAS, submitted

Lebzelter, T., Heiter, U., Abia, C., Eriksson, K., Ireland, M., Neilson, H., Nowotny, W., Merle, T., Mora, A., Peterson, R., Plez, B., **Short,** C. I., Wahlgren, G., Worley, C., Aringer, B., Bladh, S., Goswami, A., Maldonado, J., Neyskens, P., Norris, R., Th´evenin, F., Tsuji, T., van Eck, S. and Wing, R. F., "Comparative Modelling of the Spectra of Cool Giants", 2011, A&A, in preparation to be submitted

Peña, Fernando and **Deupree, Robert G.**, "Oscillation Modes in Rotating, Intermediate Mass, ZAMS Models", 2011, in preparation to be submitted

Pilkington, K., Few, C. G., **Gibson, B. K**., Calura, F., Michel-Dansac, L., Molla, M., Matteucci, F., Rahimi, A., Kawata, D., **Thacker, R. J.**, Brook, C. B. & Stinson, G. S., "Metallicity Gradients in Disks: Do Galaxies Form Inside-Out?", 2011, A&A, submitted

Pilkington, K., **Gibson, B. K.**, Calura, F., Brook, C. B., Stinson, G. S. & **Thacker, R. J.**, "The Distribution of Metals in Cosmological Hydrodynamical Simulations of Dwarf Disc Galaxies", 2011, MNRAS, submitted

Ramsey, Jon P., Clarke, David A. & Men'shchikov, Alexander B., "AZEuS: An Adaptive Zone Eulerian Scheme", 2011, ApJS, submitted

Saio, H., **Gruberbauer, M.**, Weiss, W.W., Matthews, J.M., Ryabchikova, T., "Pulsation models for the roAp star HD 134214", 2011, MNRAS, in press

Sawicki, M., "SEDfit: Software for Spectral Energy Distribution Fitting of Galaxy Photometry", 2011, PASP, submitted

Snaith, O. N., **Gibson, B. K.**, Brook, C. B., Knebe, A. & **Thacker, R. J.**, "The Halo Shape of Polar Disc Galaxies", 2011, MNRAS, submitted

Williamson, D., & **Thacker, R. J.**, "Effective viscosity from cloud-cloud collisions in global galaxy simulations", 2011, ApJ, submitted

Non-refereed publications

Rowlands, N., **Sawicki, M.** et al., "Dark Energy Mission Contribution Study", 2011, Final technical report on the CSA-funded study for Canadian contribution options to a Dark Energy space mission

Sawicki, M., "The Build-up of Mass in UV-Selected Sub-L* Galaxies at z~2", 2011, in the proceedings of IAU Symposium No. 277, C. Carignan, K. Freeman, F. Combes, eds

Sorba, R. & Sawicki, M., "On the Impact of Adding Optical Wavelength Photometry to Euclid", 2010, technical report on a CSA/ComDev-comissioned study on the photometric redshift performance of a potential optical channel on the Euclid spacecraft

Colloquia and Presentations Given by ICA Members

Casey, Mike, "Pre-Main-Sequence δ-Scuti Stars: Confronting stellar models with observed frequencies", Pre-main-sequence Workshop 2011, Vienna, Austria, 10-13 May 2011

Casey, Mike, "Pre-Main-Sequence δ-Scuti Stars: Min and max frequencies", CASCA 2011, London, ON, 30 May-2 June 2011

Casey, Mike, "Pre-Main-Sequence δ-Scuti Stars Insights, ponderings and questions", University of Vienna, 12 October 2010

Clarke, David, "MHD simulations of protostellar jets", Acadia University, Wolfville, NS, March 2011

Clarke, David, "MHD simulations of protostellar jets", Saint Francis Xavier University, Antigonish, NS, February 2011

Deupree, R. G., "Model Comparison to the Oscillation Frequencies of the Rapidly Rotating Star Alpha Oph", Saint Mary's University, 4 March 2011

Geroux, Chris, "Full Amplitude Solutions of Stellar Pulsation with Convection in 2-Demension" "Impact of New Instrumentation & New Insights in Stellar Pulsations" conference, Granada, Spain, 5-9 September 2011

Geroux, Chris, "Modelling radial stellar pulsation and convection in 3D", "Stellar Lives" Symposium, UVic, BC, 13 May 2011

Guenther, D. B., "An introduction to the asteroseismology of pre-main-sequence stars", Pre-main-sequence Workshop 2011, Vienna, Austria, 10-13 May 2011

Guenther, D. B., "Asteroseismology of PMS stars", University of Vienna, May 2011

Peña, Fernando, Deupree, R. & Beslin, W., "Oscillation spectra and fast rotation", 20th Stellar Pulsation Conference Series "Impact of New Instrumentation & New Insights in Stellar Pulsations" conference, Granada, Spain, 5-9 September 2011

Sawicki, Marcin, "Low Mass Galaxies at Cosmic High Noon", CASCA 2011, London, ON, 1 June 2011

Sawicki, Marcin, “Mask of Our Ancestors: Tracing the Evolution of Galaxies”, IAU Symposium 277, Burkina Faso, Africa, December, 2010

Sawicki, Marcin, "Using time machines to study how galaxies made their stars", UNB, NB, October, 2010

Short, Ian, "Computational Modelling of Red Giant Spectra: Non-LTE vs LTE”, Saint Mary's University, 18 November 2011

Short, C. Ian, "The Sun and Solar Activity", Nova Scotia Agricultural College, Truro, NS, 16 March 2011

Thacker, R. J., "A Vision for Canadian Astronomy 2010-2020", Saint Mary's University, 7 January 2011

Williamson, Dave, "Do collisions between molecular clouds make a significant difference on a galactic scale?", Saint Mary's University, 25 November 2011

Contributed Poster Papers

Arcila Osejo, Liz, “Passive and Star-Forming Galaxies at z~2 from the CFHT Legacy Survey“, "The Physics of Galaxy Formation" conference, Durham, UK, 18-22 July 2011

Sawicki, Marcin, “The masses of sub-L* UV-selected galaxies at high redshift", "The Physics of Galaxy Formation" conference, Durham, UK, 18-22 July 2011

Short, C. Ian, “CoolGrid: Modelling the atmospheres and spectra of cool stars", Canadian Association of Physicists (CAP) Congress 2011, St. John's NL, 13-17 June 2011