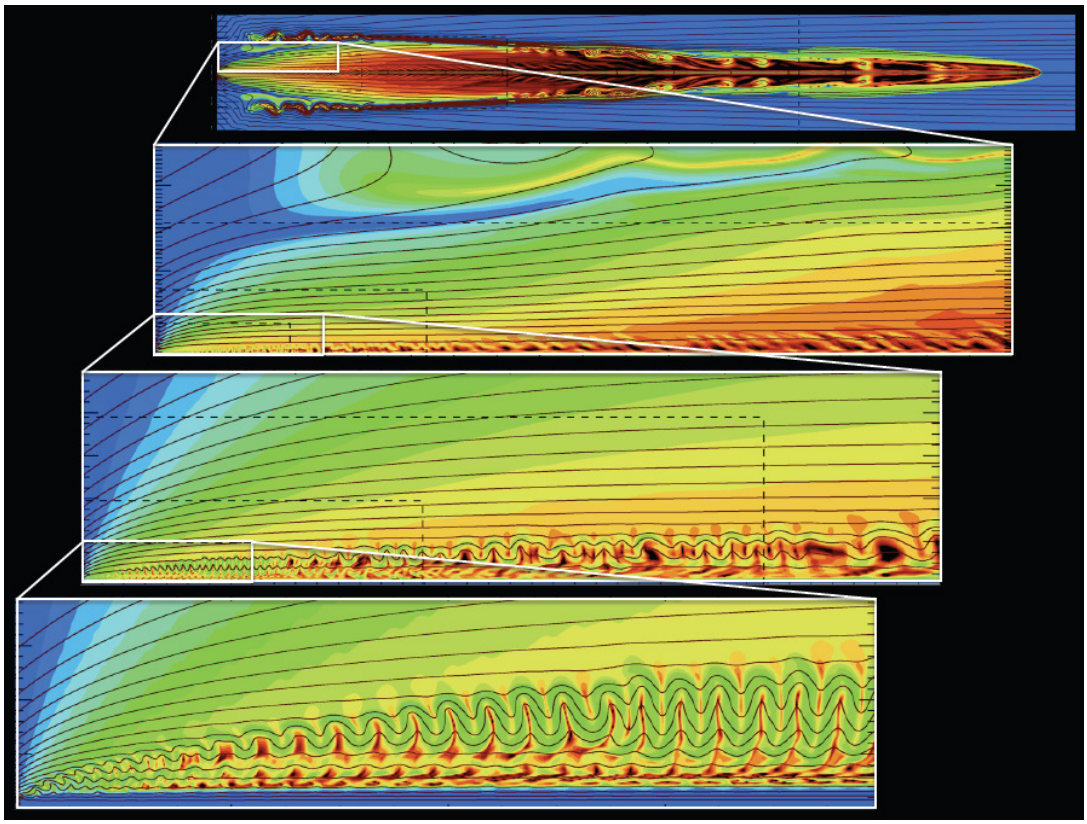
Institute for Computational Astrophysics ICA

ANNUAL REPORT 2009



Compiled by:
Robert G. Deupree, Director
Florence Woolaver, ICA Assistant

(Cover Photo by David A. Clarke & Jon P. Ramsey)

SAINT MARY'S UNIVERSITY SINCE 1802
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Institute for Computational Astrophysics

Saint Mary's University

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Introduction

The Institute for Computational Astrophysics (ICA) was formed in late 2001 by Saint Mary's University in response to a proposal by Drs. David Clarke and David Guenther to promote research into astrophysical problems using high performance computing. Saint Mary's dedicated two of its Canada Research Chairs (CRC) allotment to the Institute in addition to creating a third new position from University funds. These first hires were completed in 2003. Since then effort has been spent in recruiting both graduate students and post doctoral fellows and on obtaining the resources necessary to perform and comprehend numerical solutions of astrophysical problems. The ICA has played a very prominent role in the establishment of ACEnet, the regional high performance computing capability for Atlantic Canada. The local ACEnet facilities and staff, Phil Romkey and Sergiy Khan, are supported administratively by the ICA. The current faculty members are Drs. Robert Deupree (Director), David Clarke, David Guenther, Ian Short, and Rob Thacker. Ms. Florence Woolaver is completing her third year as the ICA Administrator.

In addition to the permanent faculty, the ICA membership in 2009 included four post doctoral fellows: Alex Razoumov, Eduard Vorobyov, Chris Cameron, and Fernando Peña and six graduate (Ph.D.) students: Mike Casey, Chris Geroux, Michael Gruberbauer, Jon Ramsey, David Williamson, and James Wurster. Dr. Razoumov left in March for a position with SHARCNET, the high performance academic computing resource provider for southwestern Ontario, and Dr. Peña arrived in November after completing his Ph.D. in the Astronomy and Astrophysics Department at the University of Toronto. Ms. Jenna Hurry continues as a Research Associate working with Dr. Thacker.

Events in 2009

Possibly the most significant ICA event in 2009 was hosting the 2nd Halifax Conference on Computational Astrophysics. The first Halifax Conference was held in 1996 not long after the Saint Mary's Department of Astronomy and Physics experienced several new hires. The meeting this year was also the 18th Kingston meeting, and received funding support from CITA and ACEnet in addition to that provided by the University. About 50 attendees heard more than 30 talks in two and a half days. The sessions were on Galaxy Formation & Dynamics, ISM and Star Formation, Solar System Dynamics, Stellar Astrophysics and Cosmology, including five invited talks from Drs. Fabio Governato (Galaxy Formation Ain't Like Dusting Crops, Boy!), Evan Scannapieco

(The Challenge of Turbulent Mixing in Computational Structure Formation), Richard Klein (Feedback Effects in the Formation of High Mass and Low Mass Star Formation), Ed Thommes (From Gas Disks to Gas Giants: Simulating the Birth of Planetary Systems), and Robert Deupree (Structure, Evolution, and Oscillations of Rotating Stars), who replaced Dr. Chris Fryer who had to cancel because of jury duty. All the ICA faculty plus Drs. Alex Razoumov and Eduard Vorobyov served on the Local Organizing Committee, and Ms. Florence Woolaver handled the administrative work and established the friendly environment commented on by several attendees.

(Photo by Dr. Michael Dunlavy)

Figure 1: Group photo from the ICA Conference on Computational Astrophysics.

(Photo by Dr. David Guenther)

Figure 2: Dr. Colin Dodds, President of Saint Mary's University, welcomes the attendees to Saint Mary's at the beginning of the ICA conference.

(Photo by Dr. David Guenther)

Figure 3: Attendees take in the first session in the ScotiaBank Theatre.

(Photo by Dr. David Guenther)

Figure 4: Drs. Adam Frank & Tom Jones enjoy a discussion at a break.

The ICA's first student to complete her PhD, Dr. Catherine Lovekin, was awarded the Plaskett medal jointly by the Royal Astronomical Society of Canada and the Canadian Astronomical Society. The award is made annually to the Ph.D. graduate from a Canadian university who is judged to have submitted the most outstanding doctoral thesis in astronomy or astrophysics in the preceding two calendar years. Dr. Lovekin is currently a post doctoral fellow at Meudon working in asteroseismology.

The ICA and the Department of Astronomy and Physics took possession of the entire third floor of the nearly completed Atrium Building in late 2009. This not only provides space for ICA faculty and students but also includes an enlarged ICA Resource Room. The new quarters are bright and open, and people seem quite satisfied with them so far. Another advantage of the new location is that it is much closer to the ACEnet Remote Collaboration Room, the Graphics Workroom, and the Data Cave.

Figure 5: The Atrium Building as seen from Inglis Street. The ICA & the Department of Astronomy & Physics share the top floor.

Figure 6: Looking from the Director's office into the ICA Administrator's space a few weeks before moving day.

After obtaining input from various prospective users of the Data Cave, Dr. Deupree worked with the Mechdyne Corporation, the data cave vendor, to modify their software to include volume rendering and a number of enhancements. Volume rendering is required to view the results of 3D hydrodynamic simulations. A statement of work was issued in March and several intermediate versions of the vGeo software were examined to verify that the changes and additions performed the needed activity. It was found that volume rendering for large data sets was too slow, so the four graphics cards for the three walls and floor were replaced with the newest generation cards. Although obtaining the capability to perform volume rendering was the primary motivation for the software development, a number of other capabilities were included to make the software more easy to use from inside the cave and to provide more flexibility. Specific enhancements allow the user to change the transfer function with which the volume rendering is done interactively in the cave, isolate regions in the data for closer examination, and follow specific paths through the data (e.g., such features as streamlines) and obtain an output file of the results. The acceptance test was performed successfully in the middle of December, and user training on the updated software is scheduled to take place in early February, 2010.

Saint Mary's will host the annual meeting of the Canadian Astronomical Society in May 2010, and planning has already begun. Dr. Thacker is one of three Department of Astronomy and Physics faculty members who are the primary organizers, with Drs. Deupree and Short, in their roles as the Director of the ICA and the Chair of the Department of Astronomy and Physics, respectively, providing support as needed.

Individual ICA members participated with other members of the Astronomy and Physics Department in conducting International Year of Astronomy (IYA) activities. The main focus at Saint Mary's was a series of public lectures given by both ICA and other SMU faculty and guest lecturers. Lectures were given by ICA members Dr. Rob Thacker ("Computing the Cosmos"), Dr. Ian Short ("Snow White and the Brown Dwarfs") and Dr. David Guenther ("What are stars? And how do we know?") Dr. David Clarke also helped with logistics for these events including handling of tickets for some lucky prize draw winners.

Drs. Thacker and Clarke also gave presentations to school students either in school or at IYA related events about IYA related events. Visited schools included Citadel High School and Prince Arthur Junior High School, Dartmouth. Presentations focused primarily on a "Top Ten" list of events happening during the year, but were also an opportunity to give away some of the "Galileoscopes" bought by the Saint Mary's Faculty of Science as part of the IYA events.

Dr. Thacker also participated in two "Cafe Scientifiques" at Uncommon Grounds on South Park Street. The first of the two events packed over 50 people into one corner of the coffee shop and was jointly hosted with Dr. Doug Welch of

McMaster University, live by Skype from Hamilton. Local news media were extremely interested in this event with radio and news interviews appearing.

Dr. Thacker was also invited to Calgary to give his "Computing the Cosmos" lecture at Mount Royal University. This was partially the result of his attending a workshop on science communication at the Banff Centre. This was Mount Royal's only IYA event for the year and was a resounding hit, with over 45 minutes of questions following a 1 hour presentation.

ICA faculty members continue to serve the wider astronomical community in a variety of ways. Dr. Thacker serves both on the CITA Council and on the CASCA Board of Governors. He will also serve as a member of the authors panel for the Long Range Plan for Canadian Astronomy (LRP 2010). Dr. Deupree completes his time as the Principal Investigator of ACEnet on January 1, 2010, but continues as a member of the Advisory Board of the Hertzberg Institute of Astrophysics. Dr. Deupree's Tier 1 Canada Research Chair was renewed for a second seven-year term in 2009.

Undergraduate Researchers

Mr. Mark Richardson worked with ICA faculty on various IYA projects, and Mr. Wilfried Beslin worked with Dr. Deupree studying non-azimuthal stellar oscillation mode identification issues for rapidly rotating stars. Mr. Michael Hiland is working on his undergraduate honours thesis in stellar structure and asteroseismology with Dr. Guenther. Mr. Hiland will analyze two pulsating stars in the delta Scuti; instability strip, one pre-main sequence and one post-main sequence. Dr. Guenther, with the assistance of post doctoral fellow Chris Cameron, supervised the honours thesis of Ms. Heather Pickup on roAp stars.

Research

Dr. David Clarke and Ph.D. student Jon Ramsey continue to develop AZEuS, the adaptive-mesh version of ZEUS-3D. AZEuS (the Adaptive Zone Eulerian Scheme) is designed to solve the equations of astrophysical fluid dynamics with essentially arbitrary resolution. Much of the code is now working to within tolerances, and their first application has been to follow the development of a stellar jet from its launch site at the scale of 0.05 AU to where it can be observed at several thousand AU in length.

Figure 7 shows a snapshot of this simulation using AZEuS with eight nested grids. This is the first simulation performed anywhere that includes both the region near the stellar disc from which the jet is launched magnetocentrifugally, and the observable large-scale where the jet excites a bow shock in the ambient medium through which it propagates supersonically. It has been known for some time how a jet may be launched near a massive compact object by the combined actions of magnetism, gravity, and rotation, but it has not

been known whether this mechanism is capable of developing a jet that resembles those widely observed to be associated with proto-stellar objects. This is the first simulation to demonstrate that connection.

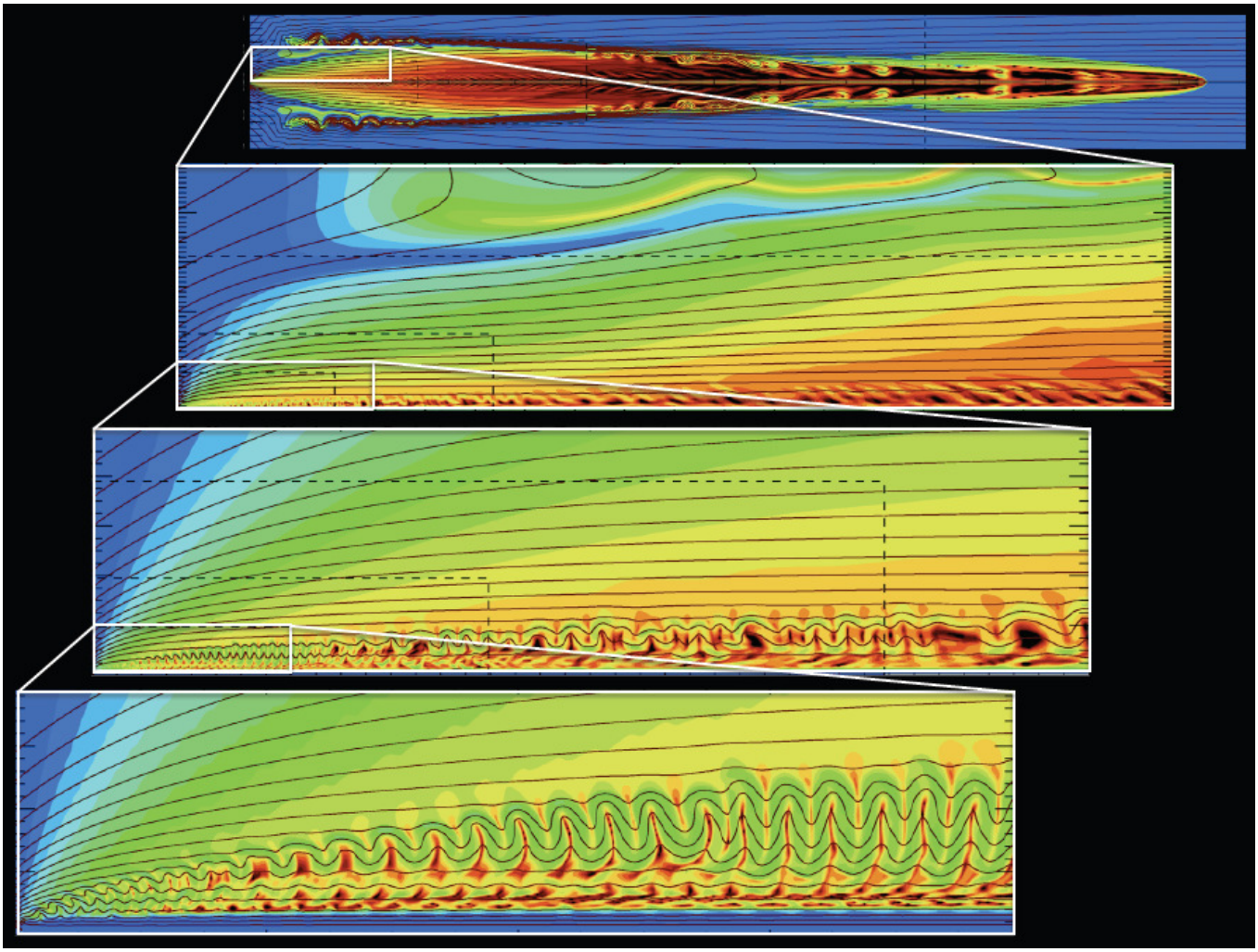

Figure 7: Numerous scales of a stellar jet being launched from a Keplerian (rotating) disc, maintained as boundary conditions on the left. Colour contours represent Alfv´enic Mach number, solid black lines magnetic field, and dashed lines indicate nested grids, where each grid has twice the resolution of the grid containing it. Grids are fixed, though AZEuS is capable of adaptively adding, modifying, and eliminating grids as needed. In this image, the jet is launched along the bottom quarter of the left boundary of the bottom panel. As it propagates, it establishes a steady-state production of “knots” at the smallest scale, which merge and form the larger clumps frequently observed in proto-stellar jets. It also makes the transition from a trans-Alfv´enic jet at the launch site, to a supersonic jet as it propagates to the larger scales accessible by telescope (top panel).

Dr. Clarke continues to develop the site http://ica.smu.ca/zeus3d from which his research code dzeus35 can be downloaded, including user manual, installation instructions, and numerous support libraries, etc. This site was "officially" launched in March 2008, though a preliminary version has been available since December 2007. To date, nearly 100 astrophysicists from around the world including graduate students, PDFs, and senior researchers have downloaded the software.

Dr. Deupree continued development of his 2D stellar evolution code for computing hydrodynamic and secular evolution of rotating stars. Problems associated with comparatively high velocity secular motion near the stellar surface have been resolved, and reasonable meridional circulation velocities now result. These models are being used to examine the dependence of asteroseismological oscillation p-mode frequencies on the internal angular momentum distribution of the stellar model. Previous calculations performed by Dr. Catherine Lovekin as part of her Ph. D. thesis had shown that the azimuthal mode frequencies were not very sensitive to the internal angular momentum distribution (as opposed to the total amount of angular momentum). However, work this year, conducted with summer undergraduate researcher Mr. Wilfried Beslin, showed that the pattern of nonazimuthal mode frequencies is noticeably dependent on this distribution.

Mr. Chris Geroux is working with Dr. Deupree to develop a 3D hydrodynamic code to compute the interaction of convection and pulsation in classical radially pulsating variable stars. The radial coordinate of the calculation is allowed to change in such a way to keep the mass in spherical shells constant throughout the calculation, even though the material in the shells is not spherically symmetric. Preliminary adiabatic test calculations indicate the method is very successful, with the coordinate system returning to the same location at the same pulsation phase over many periods. Calculations of up to 700 pulsation periods indicate numerical stability is obtainable.

Dr. David Guenther continued to analyze the data coming from Canada's first space telescope, MOST. He shares responsibility with the other seven science team members for the stellar modeling, oscillation modeling, and interpretation of the data obtained from the satellite. Dr. Guenther is also a member of the BRITE Constellation consortium. BRITE Constellation is an Austrian/Canadian proposal to build and launch four nano-satellites designed to observe oscillations on the brightest stars in the sky. Dr. Guenther will analyze the oscillation spectra of red giant stars. The first two satellites are scheduled for launch in late 2009/early 2010. Dr. Guenther has been granted special access to some of the CoRoT (French asteroseismic satellite) data on pre-main sequence and giant stars before general release, and is a member of the Kepler (US planet detection and asteroseismic satellite) science team analyzing observations of delta Scuti stars and is currently awaiting data.

Dr. Guenther continued his collaboration with the Yale Convection Group (P. Demarque, P.I.) on calculating three-dimensional stellar convection zones. His former M.Sc. student, Joel Tanner, presently enrolled in the Ph.D. program at Yale, has joined this project and is currently computing detailed models of the surface layers and lower atmospheres of stars. The results will be incorporated into stellar models (Tanner's Ph.D. thesis) and used by Guenther and his Ph.D. student Michael Gruberbauer to study stellar oscillations. Using 3D numerical convection models computed by the Yale group compared to MOST asteroseismic observations of Procyon Guenther and his colleagues finally resolved the mystery/controversy surrounding Procyon's oscillation spectrum.

Dr. Guenther also continued his collaborations with Dr. Werner Weiss's asteroseismology group at the University of Vienna. These collaborations were with several people on several specific subjects, one of which was working on oscillations in giants with recent Ph.D. recipient Dr. Thomas Kallinger (currently a research assistant at the University of British Columbia). Using MOST and CoRoT data, Drs. Kallinger and Guenther discovered that red giant stars exhibit non-radial oscillations, contrary to expectation, and that the oscillation modes have long lifetimes. Other collaborations were on oscillations in Procyon, alpha Cen A and other solar type stars with undergraduate Mr. Daniel Huber, on oscillations in pre-main-sequence stars with post-doctoral fellow Dr. Konstanze Zwintz, and on Bayesian asteroseismic analysis techniques with recent M.Sc. recipient Mr. Michael Gruberbauer (currently, a Ph.D. student with Dr. Guenther at SMU).

Dr. Guenther discovered, through his analysis of all known pre-main sequence pulsating stars in NGC 2264 observed by MOST (Zwintz), that intermediate mass pre-main sequence stars recently emerged from the stellar birthline have oscillation spectra that are not well modeled by classical stellar evolution. Lower mass stars further along in their evolution are well modeled. The distinction appears to be associated with mass infall that occurs early on during the star's formation phase.

Dr. Guenther served as an external thesis reader for M.Sc. candidate, Mr. Michael Gruberbaurer, University of Vienna, who graduated in the summer of 2009. Mr. Gruberbauer entered the Ph.D. program in Astronomy at Saint Mary's University in the fall of 2009, where he will study the effects of the surface layers on stellar oscillations under Dr. Guenther's supervision. Mr. Gruberbauer is also continuing his work on the parallelized numerical evaluation of posterior probability density in high-dimensional parameter spaces. The intent is to apply this to problems concerning stellar pulsation modeling and data analysis of high quality space photometry data from the MOST, COROT, and Kepler satellites. Dr. Guenther is supervising Ph.D. candidate Mr. Mike Casey, who is studying the seismic properties of pre-main sequence stars. Mr. Casey passed his comprehensive exam in 2009 and has had his thesis proposal approved. Dr.

Guenther also served as a co-supervisor to Ph.D. candidate Chris Cameron, University of British Columbia, on stellar models of roAp stars.

Dr. Short has computed a large grid of about 400 models in local thermodynamic equilibrium (LTE) spanning the right side of the Hertzsprung-Russell (H-R) diagram at solar and mildy metal-poor metallicities for comparison with a large catalogue of uniformly calibrated spectrophotometry that covers the entire visible band. The goal is to characterize the quality of the fits as a function of stellar parameters (effective temperature, surface gravity, and metallicity), particularly in the blue and near UV bands with respect to the red band. A further goal is to determine the nature of any opacity sources still missing from models in the problematic blue and near UV bands. This is the first step in a longer term project that will eventually include models with many chemical species and opacities treated in the more realistic non-LTE.

With Drs. Pierre Demarque, Sarbani Basu, Frank Robinson, and graduate student Mr. Joel Tanner (Yale University), Dr. Short is working on modeling the outer boundary condition of stellar interior structure models more realistically for stars that have convective envelopes, such as the Sun, by accounting for hydrodynamic atmospheric turbulence. He will be calculating mean radiative opacities suitable for radiation hydrodynamic simulations. One goal is to resolve the discrepancy between the observed and computed mass-radius relation among M dwarf stars.

With Drs. Gérard Thuillier (Centre national de la recherche scientifique (CNRS), France), Stella Melo (Canadian Space Agency, University of Toronto), Sabatino Sofia (Yale University), and Margit Haberreiter (Laboratory for Atmospheric and Space Physics (LASP), Colorado), Dr. Short is computing models of how the intensity of the Sun decreases with increasing off-set from solar disk centre near the solar limb to provide interpretation for results to be obtained with the PICARD space mission, to be launched in early 2010. The goal is to measure the Sun's radius as a function of wavelength with unprecedented precision, and to characterize variations in the solar radius and their correlation with solar activity level.

With PhD student Mr. David Williamson Dr. Thacker has 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 these calculations 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 a phase where it is not.

In collaboration with Dr. Evan Scannapieco at Arizona State University, Dr. Thacker has become involved in a number of projects focusing on high redshift galaxy formation. One of these projects has evolved into the primary research program of research associate Ms. Jennifer Hurry. She has been working on comparing composite observations of high redshift galaxies created by Hathi & Windhorst (ASU) to mock images produced from simulations via very detailed modeling. The results to date have been hampered by the difficulty in accurately mirroring the method used to produce observations, but as of June 2009 they have resolved a number of calibration issues and are preparing a manuscript. Early results suggest that galaxy formation models including feedback from supernovae are absolutely necessary to reproduce the observed surface brightness profiles at $z \sim 6$.

Dr. Thacker and collaborators Drs. Tilvi, Rhodes, Malhotra and Scannapieco (ASU) have developed a model for predicting the population of Lyman-alpha emitters at redshifts $z = 3$-7. Their models are motivated by the idea that Lyman-alpha emission is related to rapid accretion of new material on to host halos. This model borrows ideas from earlier work in 2003 that Dr. Thacker did with Dr. Scannapieco on the clustering of dark matter systems at $z = 3$.

Dr. Thacker's award winning research on AGN, conducted in collaboration with Drs. Scannapieco and Couchman (McMaster) has culminated in a series of three papers on the evolution and clustering of these unique systems. Current observational research is focused on understanding the evolution of these systems, both in terms of their underlying clustering, population statistics and the dependence of physical properties on the relative brightness of the AGN. They have been able to show that a simple theoretical model of feedback as a heating process on the gas surrounding these AGN is able to broadly explain many of the observations of these systems (such as the Sloan and 2df quasar surveys).

Dr. Thacker's PhD student, Mr. James Wurster, has begun research on modeling of AGN outflows in more detail. He is currently learning how to use the ZEUS simulation code in preparation for simulating more complex models AGN outflows that include both magnetohydrodynamics and radiative transfer. This research is expected to be conducted in collaboration with Dr. David Clarke.

With graduate student Mr. Pascal Elhai (Queen's), and collaborator Dr. Larry Widrow (Queen's) and Saint Mary's undergraduate student Mr. Mark Richardson, Dr. Thacker has continued research into gravitational clustering in the very early universe. The tool for this research has been large scale simulations in so called "scale-free" universes, which are theoretically simple to model and are a comparatively accurate representation the first Gyr of cosmic evolution. They have been able to show that current simulations of "first star" formation are probably grossly inaccurate in terms of their gravitational modeling, and solving these problems is extremely difficult because of some fundamental

issues in gravitational clustering theory. Their work has implications not only on the formation of the first stars, but also on the relative amount of gamma-rays expected from annihilation of dark matter in the galactic centre.

Dr. Thacker is also working on a collaborative project led by Dr Diego Saez (Universidad de Valencia, Spain). 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 they have been using and together the team is 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.

Dr. Thacker has continued collaboration with Dr. Linda Campbell (Queen's University) on mathematical modeling of bioaccumulation in food webs. A mathematical model he developed has now been applied to a number of the Great Lakes to determine the most probable fish diets on the basis of stomach contents and the carbon and nitrogen stable isotope ratios. They have shown that Ponto-Caspian invaders brought into the Lake Erie eco-system via ballast water have significantly altered the food web structure of the lake.

Dr. Vorobyov has continued numerical research into the self-consistent formation and long-term evolution of circumstellar disks around low-mass protostars with his specifically designed numerical hydrodynamics code. This 2D code uses the thin-disk approximation and can follow the evolution of a pre-stellar cloud core from a gravitationally unstable stage to the formation of a protostar-disk system and then evolve the resultant disk for up to several Myr. He updated the code to include essential thermal processes that are present in circumstellar disks, investigated disk masses in the early and late stages of star formation, and has found that the observationally derived disk masses around low-mass stars are likely to be significantly underestimated.

In collaboration with Dr. Basu (The University of Western Ontario), Dr. Vorobyov has numerically studied the gravitational collapse of a large set of cloud cores with various initial rotation rates and masses. Their modelling reveals evidence for bimodality in the correlation between mass accretion rates onto the star and stellar masses, with a steeper slope at lower masses and a shallower slope at intermediate and upper masses. Within the same set of models, Dr. Vorobyov has found that the mass accretion rates in the Class I stage of star formation have a log normal distribution, with its shape controlled by disk viscosity and disk temperature. The spread in the mass accretion rates is greater

in models with lower viscosity and smaller in models with higher viscosity and higher disk temperature.

In collaboration with Drs. Dettmar and Bomans (Ruhr-Universitat, Bochum), Shchekinov (South Federal University) and Bizyaev (New Mexico State University), Dr. Vorobyov has numerically investigated the long term (~13 Gyr) dynamical and chemical evolution of low surface brightness galaxies. These numerical models strongly suggest the existence of a minimum age for blue LSB galaxies. Model B – V colors and mean oxygen abundances set a tentative minimum age at 1.5–3.0 Gyr, whereas model Hα equivalent widths suggest a larger value of the order of 5–6 Gyr. However, these models provide no firm evidence that the age of blue LSB galaxies is significantly lower than 13 Gyr.

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Refereed Publications

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Thacker, Robert, “Where are the Aliens”, Saint Mary's University IYA Opening Celebration Cafe Scientifique, 9 January 2009

Thacker, Robert, “Computing the Cosmos – From the Big Bang to Galaxies”, Saint Mary's University International Year of Astronomy Lecture Series, 6 February 2009

Guenther, David, “Asteroseismology Through the Ages”, Université de Montréal, February 2009

Thacker, Robert, "AREPO: An adaptive unstructured mesh-scheme" Saint Mary's University, 5 March 2009

Short, Ian, “Snow White and the Brown Dwarfs” Saint Mary’s University International Year of Astronomy (IYA) Lecture Series, 7 March 2009

Cameron, Chris, “Asteroseismic Tuning of the Magnetic Star HR 1217: Understanding magnetism and stellar structure through MOST spacebased photometry" Saint Mary's University, 20 March 2009

Thacker, Robert, “Predictions of Quasar Clustering: Redshift, Luminosity and Selection Dependence”, Canadian Astronomical Society (CASCA) Annual Meeting, University of Toronto, 26-29 May 2009

Vorobyov, Eduard, “Disk masses and mass accretion rates in T Tauri stars and brown dwarfs”, Canadian Astronomical Society (CASCA) Annual Meeting, University of Toronto, 29 May 2009

Thacker, Robert, “Predictions of Quasar Clustering: Redshift, Luminosity and Selection Dependence”, University of Wisconsin, Madison, WI, 1-5 June 2009

Deupree, Robert, "Rotational Splitting of Pulsation Modes in Rapidly Rotating Stars", Santa Fe, New Mexico, USA, 3 June 2009

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Ramsey, Jon P., "Simulations of Protostellar Jets Extended to Observational Length Scales", 2nd Halifax Meeting on Computational Astrophysics…the 18th Kingston Meeting, Saint Mary's University, 16 October 2009.

Vorobyov, Eduard, “Numerical Hydrodynamics Modeling of Protostellar Disk Formation and Long-term Evolution”, 2nd Halifax Meeting on Computational Astrophysics…the 18th Kingston Meeting, Saint Mary's University, 17 October 2009

Deupree, Robert, "Structure, Evolution, and Oscillations of Rotating Stars", 2nd Halifax Meeting on Computational Astrophysics…the 18th Kingston Meeting, Saint Mary's University, 17 October 2009

Cameron, Chris, "Asteroseismic Tuning of the Magnetic Ap Star HR 1217", 2nd Halifax Meeting on Computational Astrophysics…the 18th Kingston Meeting, Saint Mary's University, 17 October 2009

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Gruberbauer, Michael, "APEMoST - A Software Package for Bayesian Astronomical Data Analysis ", 2nd Halifax Meeting on Computational Astrophysics…the 18th Kingston Meeting, Saint Mary's University, 17 October 2009

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Poster Presentations

Ian Short, “Fitting Cool Star SEDs with PHOENIX Models", Canadian Astronomical Society (CASCA) Annual Meeting, University of Toronto, 26-29 May 2009 and 2nd Halifax Meeting on Computational Astrophysics…the 18th Kingston Meeting, Saint Mary's University, 16-18 October 2009

Robert Thacker, “Simulation of Galaxy High Redshift Images”, 214th Meeting of the American Astronomical Society, Pasadena, CA, 8-11 June 2009

Michael P. Casey, David B. Guenther, “Matching the Pulsation Frequencies of Pre-main Sequence Delta-Scuti Stars to Their Theoretical Counterparts”, 2nd Halifax Meeting on Computational Astrophysics…the 18th Kingston Meeting, Saint Mary's University, 16-18 October 2009

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