2004 ANNUAL REPORT

Compiled by:
Dr. Robert G. Deupree, Director
Julee Adams, Secretary
Institute for Computational Astrophysics

Saint Mary's University
Halifax, Nova Scotia, Canada

Institute for Computational Astrophysics
Annual Report
2004

HISTORY

The Institute for Computational Astrophysics (ICA) was formed by an act of the Saint Mary's University Faculty Senate in December 2002 on the basis of a proposal generated by Drs. David Clarke and David Guenther. Prior to this time the University had agreed to dedicate two Canada Research Chair (CRC) positions to the ICA, as well as making an additional faculty hire out of University funds. The searches to fill these three positions went on during the first half of 2002 with the result that Dr. Ian Short joined the faculty in the fall of 2002, Dr. Robert Deupree, CRC Tier 1 chair and Director of the ICA, in February of 2003, and Dr. Joseph Hahn, CRC Tier 2, in July of 2003. Two post doctoral personnel, Dr. Amanda Karakas and Dr. Alexander (Sasha) Men'shchikov, joined the ICA in August of 2003. Two incoming graduate students in 2003 and one in 2004 have joined the ICA by selecting ICA faculty as their supervisors: Ms. Catherine Lovekin is working with Dr. Deupree on rotating stars, Mr. Jonathan Ramsey with Dr. David Clarke, Dr. Deupree and Dr. Short, and Mr. Chris Capobianco with Dr. Hahn. Most importantly, Ms. Julee Adams joined the ICA to provide administrative services in November 2004.

EVENTS IN 2004

The ICA has progressed in a number of areas during 2004. Significant among these is the extensive participation of Dr. Guenther in the MOST satellite mission. Also of importance is the growing acceptance of the ICA throughout the Canadian astrophysical community. Perhaps this is exemplified this year by the Canadian Astronomical Society (CASCA) asking Dr. Deupree to serve as the CASCA representative on the Board of the Canadian Institute for Theoretical Astrophysics (CITA). Dr. Deupree was also asked to be a member of the Canada Foundation for Innovation (CFI) College of Reviewers. Dr. Deupree's two-year term with the CITA Board began in August, 2004 and he began to serve for the CFI in the spring, 2004.

Included here are discussions on resources, visitors to the ICA, seminars at other institutions given by ICA members, publications by ICA members, and brief statements of research progress for the ICA members.

Resources

Space is in short supply for the ICA, just as for everyone else at Saint Mary's. Last year money was obtained from the Nova Scotia Research Innovation Trust (NSRIT) which was used to provide suitable environmental conditions for much of the computer resources provided by the CFI as part of Dr. Deupree's and Dr. Hahn's CRC funding. We were able to provide ventilation to several other rooms as well, converting them from space that could only be used for storage to space suitable for human habitation. Three

offices in the Department of Astronomy and Physics were generated, as well as one for the Faculty of Arts. Also, the quality of life in several other offices was improved by this effort. This work was completed near the end of the first quarter of 2004. The new space is now used by an ICA post doc, the ICA administrative assistant, and ICA visitors.

The Beowulf computer cluster purchased with CFI money associated with the CRC awards was set up and enhanced by a CFI New Opportunities award to Dr. Ian Short. There are currently 48 processors available. Examples of projects which have used this new resource include calculations of model stellar atmospheres by Dr. Short, calculations of synthetic spectra and spectral energy distributions by Ms. Lovekin, N body simulations by Dr. Hahn, and simulations of stellar interiors and their associated pulsation periods for comparison with MOST satellite data by Dr. Guenther. With the comparatively small number of people (nearly five processors per ICA member) using the resource, the resource has been undersubscribed, but there have been several occasions when the machine was 100% utilized. This past summer the cluster was used by two undergraduate students, Mr. Nick MacDonald and Mr. Patrick Rogers, to explore the types of programs that could be effectively made to work on parallel computers. Other undergraduates used this facility this summer in support of research for individual professors. This autumn, time was spent preparing all five current graduate students in Astronomy and Physics to perform research with this machine.

This spring the CFI announced a nearly $10 million award to ACEnet, a consortium of seven Atlantic Canada research universities, for a $25 million project to provide high performance computer infrastructure to serve all of Atlantic Canada. The fraction of this $10 million award for hardware to be placed at Saint Mary's is approximately $2.1 million, which would grow to more than $5 million with the anticipated matching funds. These funds will be used primarily to purchase a data cave, a visualization center, a sizeable Beowulf cluster, and multi-site video teleconferencing equipment. With the departure of Dr. Mark Whitmore, the original ACEnet Principal Investigator (PI), to become the Dean of Science at the University of Manitoba, Dr. Deupree assumed the role of ACEnet PI. Dr. Clarke serves on the ACEnet Science Directorate. Activities during the past year have included hiring the ACEnet Executive Team (Mr. Graham Mowbray as Executive Director, Mr. Mark Staveley as Chief Technology Officer, and Ms. Debbie Earles as Administrator), preparing the Request for Proposals (RFP) for the purchase of ACEnet hardware, conveying our requirements to high performance computing vendors, and discussing financing with provincial and other sources. It is expected that the coming year will see the purchase and installation of hardware and the hiring of the technical team to assist the users in adapting to ACEnet and getting the most benefit out of it.

Dr. Deupree was the PI for a proposal to C3.ca to provide technical support to ACEnet. This proposal was funded at about $130K. Dr. Deupree is a W-PI on a C3.ca proposed to NSERC for three years funding for technical support to the regional consortia. ACEnet's part of the $1.4 million per year is about $300K per year, but a realistic expectation of funding would be about $200 - $250K per year.

Summer Students

Faculty within the ICA employed summer students during 2004. They are as follows:

Faculty	Student
Dr. Robert G. Deupree	Mr. Patrick Rogers, Mr. Nick MacDonald
Dr. David Guenther	Mr. Chris Geroux
Dr. C. Ian Short	Mr. Joel Tanner
Dr. Joseph Hahn	Mr. Daniel Majaess, Mr. Adam Chaffey, Mr. Gary Hubertise

ICA Visitors

The ICA has developed a visitor's program to attract potential and actual collaborators. This year we were successful in having a number of visitors. Typical lengths of visits were one week although there were several longer visits. The visitor log is as follows:

February 29th through to March 7th, 2004
Dr. Matt Templeton
American Association of Variable Star Observers

May 4th through to May 8th, 2004
Dr. Maurice Clement
Emeritus, University of Toronto

May 16th through to June 14th, 2004
Dr. Pavel Denissenkov
University of Victoria

June 21st through to June 29th, 2004
Dr. Brian Chaboyer
Physics and Astronomy Department, Dartmouth College

July 25th through to July 30th, 2004
Dr. John Lattanzio
Monash University, Australia

August 9th through to August 20th, 2004
Dr. Adam Frank
University of Rochester

August 29th through to September 5th, 2004

Dr. Onno Pols
Astronomical Institute Utrecht, the Netherlands

August 30th through to October 1st, 2004
Dr. Robert Izzard
University of Cambridge, UK

November 1st through to November 21st, 2004
Mr. Richard Stancliffe
University of Cambridge, UK

ICA Sponsored Seminars at Saint Mary's

February 6th, 2004
Nucleosynthesis in Asympototic Giant Branch Stars
Dr. Amanda Karakas, Institute for Computational Astrophysics and
Department of Astronomy & Physics, Saint Mary's University

February 13th, 2004
Clementine Observations of the Zodiacal Light, and the Dust Content of the Inner Solar System
Dr. Joseph Hahn, Institute for Computational Astrophysics and
Department of Astronomy & Physics, Saint Mary's University

March 5th, 2004
Astrophysics with Long-Term Variable Star Databases: Mira stars and AGB evolution
Dr. Matthew Templeton, AAVSO

March 12th, 2004
Probing Sunspot Magnetic Fields With Solar Oscillations
Dr. Ashley Crouch, Département de Physique, Université de Montréal

May 19th, 2004
Globular Cluster Archaeology: Nucleosynthesis and Extra Mixing in Extinct Stars
Dr. Pavel Denissenkov, University of Victoria, Canada

June 25th, 2004
The Evolution of Metal Poor Stars
Dr. Brian Chaboyer, Physics and Astronomy Department, Dartmouth College

July 29th, 2004

From Lithium to Lead – Stellar Nucleosynthesis in Red Giants
Dr. John Lattanzio, Centre for Stellar & Planetary Astrophysics, Monash University Australia

August 11th, 2004
Holding Footpoints to the Fire: The Fluid-dynamics of Protoplanet-Disk Interactions
Dr. Adam Frank, Department of Physics & Astronomy, University of Rochester, US

August 30th, 2004
AGB Stars in Binary Systems and Their Progeny
Dr. Onno Pols, Astronomical Institute, Utrecht, Netherlands

September 24th, 2004
The Dark Energy Problem
Dr. Carolina Odman, Universita di Roma "La Sapienza"

September 30th, 2004
Population Nucleosynthesis
Dr. Robert Izzard, Carolune Institute for Quality Astronomy (CIQuA)

November 19th, 2004
The Case of the Carbon Star Mystery
Richard Stancliffe, IoA, University of Cambridge, UK

Seminars Presented Elsewhere by ICA Personnel

January, 2004 Southwest Research Institute in Boulder, Coloroda, USA
Bill Ward @ 60: Still Makin' Waves After All These Years,
Dr. Joseph Hahn

March 24th, 2004, Institute of Astronomy, University of Cambridge, UK
The Production of the Ne, Na, Mg, and Al Isotopes in AGB Stars
Dr. Amanda Karakas

March 29th, 2004, Saint Francis Xavier University
Modelling Stars
Dr. Robert Deupree

April 21st, 2004, Astronomical Institute, Utrecht University, Netherlands
The Production of the Ne, Na, Mg, and Al Isotopes in AGB Stars
Dr. Amanda Karakas

April 27th, 2004, Department of Astronomy, University of Indiana, USA
Asteroseismology Through the Ages, January to April
Dr. David Guenther

April 30th, 2004, Department of Astronomy & Physics, University of Toronto
Asteroseismology Through the Ages, January to April
Dr. David Guenther

June 1st, 2004, Max Planck Institute for Astronomy in Heidelberg, Germany
Properties of the Close Binary and Circumbinary Torus of the Red Rectangle
Dr. Alexander Men'shchikov

July 9th, 2004, US Naval Observatory, Washington DC, USA
Sculpting the Kuiper Belt via Neptune's Orbital Migration
Dr. Joseph Hahn

July 18th – 23rd, 2004 – Vancouver
The Eighth International Symposium on Nuclei in the Cosmos, held in Vancouver.
The Uncertainties in the 22Ne + Alpha-Capture Reactions and Magnesium Production in Intermediate-Mass AGB Stars.
Dr. Amanda Karakas

August 2nd – 6th, 2004 – UK
The Seventh Torino Workshop on AGB Stars, held in Cambridge, UK.
The Uncertainties in the 22Ne + Alpha-Capture Reactions and Magnesium Production in Intermediate-Mass AGB Stars.
Dr. Amanda Karakas

September 27th, 2004 – Mount Allison University
Modeling Stars
Dr. Robert Deupree

September 29th, 2004 – University of Prince Edward Island
Modeling Stars
Dr. Robert Deupree

October 1st, 2004 – Acadia University
Modeling Stars
Dr. Robert Deupree

October 29th, 2004 –University of Toronto, Astronomy and Astrophysics Department,
Stellar atmospheric models and the problem of chemical composition
Dr. C. Ian Short

November 5th, 2004 – University of Victoria, Astronomy Seminar,
Stellar atmospheric models and the problem of chemical composition
Dr. C. Ian Short

November 8th, 2004 – University of British Columbia
Stellar atmospheric models and the problem of chemical composition
Dr. C. Ian Short

Refereed Publications

Fenner, Y.; Campbell, S.; Karakas, A. I.; Lattanzio, J. C.; Gibson, B. K., "Modelling self-pollution of globular clusters from asymptotic giant branch stars", 2004, MNRAS, 353, 789.

Guenther, D. B., "Quantitative Analysis of the Oscillation Spectrum of eta Bootis", 2004, ApJ, 612, 454.

Guenther, D. B. and Brown, Kevin I. T., "Matching Stellar Models to Oscillation Data", 2004, ApJ, 600, 149.

Hahn, J.M., and Malhotra, R., 2004, "Neptune's Migration into a Stirred-Up Kuiper Belt: A Detailed Comparison of Simulations to Observations, AJ, submitted.

Izzard, R.G.; Tout, C.A.; Karakas, A.I. and Pols, O.R., "A New Synthetic Model for Asymptotic Giant Branch Stars", 2004, MNRAS, 350, 407.

Kallinger, Th., Zwintz, K., Guenther, D.B., Pamyatnykh, A.A., Weiss, W.W. 2004, "Pulsation of the K 2.5 giant star GSC 09137-03505?," ApJ, submitted.

Lovekin, C.C., Deupree, R.G., & Short, C.I. "Synthetic Spectral Energy Distributions for Non-Spherical Stars", 2004, ApJ, submitted.

Lugaro, M., Ugalde, C., Karakas, A. I., Görres, J., Wiescher, M., Lattanzio, J. C., Cannon, R. C., "Reaction Rate Uncertainties and the Production of 19F in Asymptotic Giant Branch Stars", 2004, ApJ, 615, 934.

Matthews, J. M.; Kusching, R.; Guenther, D. B.; Walker, G. A. H.; Moffat, A. F. J.; Rucinski, S. M.; Sasselov, D. and Weiss, W. W. "No stellar p-mode oscillations in space-based photometry of Procyon", 2004 Nature, 430, 51.

Miroshnichenko, A.S.; Levato, H.; Bjorkman, K.S.; Grosso, M.; Manset, N.; Men'shchikov, A.B.; Rudy, R.J.; Lynch, D.K.; Mazuk, S.; Venturini, C.C.; Puetter, R.C.; and Perry, R.B., "Properties of galactic B[e] supergiants. III. MWC 300", 2004, A&A, 417, 731.

Murphy, E. J.; Demarque, P. and Guenther, D. B., "A Preliminary Seismic Analysis of 51 Pegasi: Large and Small Spacings from Standard Models", 2004, ApJ, 605, 472.

Renda, A., Fenner, Y., Gibson, B. K., Karakas, A. I., Lattanzio, J. C., Campbell, S., Chieffi, A., Cunha, K., Smith, V. V., "On the origin of fluorine in the Milky Way", 2004, MNRAS, 354, 575.

Riechers, D., Balega, Y., Driebe, T., Hofmann, K.-H., Men'shchikov, A. B., and Weigelt, G., "High-resolution near-infrared speckle interferometry and radiative transfer modeling of the OH/IR star OH 104.9+2.4", 2004,A&A, 424, 165.

Robinson, F. J.; Demarque, P.; Li, L. H.; Sofia, S.; Kim, Y.-C.; Chan, K. L. and Guenther, D. B., "Three-dimensional simulations of the upper radiation-convection transition layer in subgiant stars", 2004 MNRAS, 347, 1208.

Rucinski, S., Walker, G.A.H., Matthews, J.M., Kushnig, R., Shkolnik, E., Marchenko, S., Bohlender, D.A. Guenther, D.B., Moffatt, A.F.J., "Differential Rotation of the Active G5V Star Kappal Ceti: Photometry from the MOST Satellite," 2004, PASP, December

Short, C. I., & Hauschildt, P. H. "A NLTE line blanketed model of a solar type star", ApJ 2005, astro-ph/0409693

Shutz, O.; Boehnhardt, H.; Pantin, E.; Sterzik, M.; Els, S.; Hahn, J. and Henning, Th., "A Search for Circumstellar Dust Disks with ADONIS", 2004, A&A, 424, 613.

Straka, C.W., Demarque, P., Guenther, D.B. 2004, "Core Overshoot: An Improved Treatment and Constraints from Procyon A," ApJ, submitted.

Weigelt, G., Wittkowski, M., Balega, Y. Y., Beckert, T., Duschl, W. J., Hofmann, K.-H., Men'shchikov, A. B. and Schertl, D., "Diffraction-limited bispectrum speckle interferometry of the nuclear region of the Seyfert galaxy NGC 1068 in the H and K' bands", 2004A&A…425..77

Contributed Papers

Demarque P., Basu, S., Guenther, D. B., Li, L. H., Robinson F. J., 2004, "Convection in the envelope of Procyon A," AAS meeting 2004

April, 2004 – Poster presentation
at the AAS Division on Dynamical Astronomy meeting, Observatoire Nice C te d'Azur, Cannes, France
Neptune's Migration into a Dynamically Hot Kuiper Belt by J. Hahn & R. Malhotra

June 13th – 17th, 2004 – Poster presentations
at the Annual CASCA conference, held in Winnipeg

1. Models and Periods of AV Cetei by Robert Deupree
2. The Structure of Close Binaries in 2D by A. Karakas and R.G. Deupree
3. 2D Evolution of the Rapidly Rotating Be Star Achernar by C. Lovekin & R.G. Deupree
4. Synthetic flux spectra of rotationally deformed stars by C.I. Short and C. Lovekin
5. Neptune's Smooth Migration into a Hot Kuiper Belt by J. Hahn and R. Malhotra

July 5th – 9th , 2004 – Poster presentation
at the Cool Stars, Stellar Systems and the Sun 13, held in Hamburg, Germany
NLTE models of extremely metal poor stars by C.I. Short

July 12th – 16th, 2004 – Poster presentation
Disks, jets and Outflows in Low and High Mass Star Forming Environments, held in Calgary
Launching Jets from Keplerian Discs: The Role of the Equation of the State by J. Ramsey and D. Clarke Cores.

November 9th, 2004 – Oral presentation
A Detailed Comparison of Simulations of Neptune's Migration to Observations of the Kuiper Belt by J. Hahn and R. Malhotra

Scientific Research

Here we present summaries of ICA faculty research performed over the past year.

Dr. Alexander Men'shchikov has been working with Dr. Clarke on the development of the 3-dimensional (3D) MHD code ZEUS-3D and an adaptive mesh refinement (AMR) version (called AZEuS) of the same code. Very good progress has been made in the last few months with the MHD code. The main achievement is that the code works now for a specific example, although there is clearly a large amount of work ahead to make it work in the general case, carefully test it on known problems, and publish first results.

Dr. Men'shchikov is also working on 2-dimensional (2D) radiative transfer modeling of dusty envelopes of stars in collaboration with German colleagues (Bonn: Gerd Weigelt, Thomas Driebe, Dominik Riechers) and an American colleague (Toledo, OH: Anatoly Miroshnichenko). They modeled the B[e] supergiant MWC 300, the OH/IR star OH 104.9+2.4, and they performed speckle-interferometry near-infrared imaging of the Seyfert galaxy NGC 1068. Now Dr. Men'shchikov is in the process of the modeling other stars with dusty envelopes (disks). Such modeling is very important for understanding the properties and for the derivation of correct physical parameters of these stars.

Mr. Ramsey has been studying the effects of the equation of state in simulations of magnetic disk-winds launched from Keplerian discs with Dr. Clarke. In particular the use of a strict polytrope creates non-physical effects as its use strictly conserves entropy. While a polytropic equation of state has been used for numerical reasons, it is only slightly more work to use an adiabatic equation of state, and the undesirable effects arising from the use of a polytrope can be avoided. To showcase these effects, Mr. Ramsey has been running simulations for a few different astrophysical problems.

Dr. Guenther analyzed the asteroseismic data coming from Canada's first space telescope, MOST. He also analyzed the published asteroseismic data obtained from several ground-based telescopes. In addition, Dr. Guenther provided stellar modeling and oscillation analysis to several research groups. Saint Mary's Undergraduate student Mr. Chris Geroux and Dr. Guenther continued their research into recent claims that the solar metal abundance is significantly lower than previously reported. They are testing the new abundance by computing carefully calibrated solar models and comparing the helioseismic age of the solar models with the known meteoritic age of the sun.

Borrowing from DNA classification techniques, Dr. Guenther incorporates vast and detailed stellar model and stellar pulsation grids to classify the observed oscillation spectra of stars. Starting with an observed stellar oscillation spectrum Dr. Guenther's computer codes systematically scan through the grids looking for stellar models whose oscillation spectra closely match the observed oscillation spectrum. The resultant matched models are then used in more detailed analyses of the star. The model grids currently consist of more than 100 Gigabytes of data located in over ten million files. A number of processors of the ICA's Beowulf computer cluster are in nearly constant use extending the grid to new masses and compositions.

For MOST, Dr. David Guenther has used the stellar model grids to study the oscillation spectra of several solar type stars including Procyon and eta Boo. The analysis of Procyon yielded the unexpected result that its acoustic modes have much lower amplitudes than predicted by simple scaling arguments.

The analysis methodologies and model grids have also been applied to recent high quality ground based stellar oscillation data where they have provided confirmation of the stellar-seismic origin of the observed oscillations. Research on eta Boo observations were completed and research on alpha Cen A and B are in progress.

Dr. Guenther provided stellar models and seismic analysis to the Yale Convection Group (Dr. P. Demarque, PI) to help test their three-dimensional stellar convection modeling. The group has produced the first convective models of a subgiant. They are also finishing up models of Procyon's thin convective envelope, the results of which will be used to explain the low oscillation amplitudes observed by MOST. Dr. Guenther also provided stellar models and pulsation data to the Vienna Stellar Pulsation Group (Dr. W. Weiss, P.I) to help them in their interpretation of several newly identified pulsating K giants.

Dr. Guenther updated the stellar evolution code (YREC) to use the current equation of state tables from OPAL and to use the latest nuclear energy generation cross-sections. He also added a routine to enable the code to iterate on composition and mixing length parameter to produce tuned solar models. Dr. Guenther made extensive revisions to the grid searching program to increase its performance, to adapt it to a greater variety of stellar modeling parameters, and to increase the robustness of the oscillation spectrum matching algorithm.

Dr. Short has used the PHOENIX model atmosphere and spectrum synthesis computer code on the ICA Beowulf Cluster to created new computational models of the atmospheres and spectra of stars that are like the Sun and the red giant Arcturus. In these models the thermodynamic state of the gas and radiation is treated with an unprecedented degree of realism, with tens of thousands of the most important spectral lines being allowed to depart from the simplifying approximation of local thermodynamic equilibrium. These models show that iron and iron-group elements are by far the most important ones to treat realistically for accurate simulation of the star's atmospheric structure and the overall stellar spectrum. Another important result is that the opacity of the atmosphere of the Sun and of other cool stars in the violet and near UV spectral bands is still poorly understood.

Dr. Hahn is examining Neptune's migration into the Kuiper Belt, which is the vast swarm of comets that inhabit the outer edge of our Solar System. This bulk of this activity has been the analysis of hundreds of N body simulations of the Solar System's 4.5 billion--year history; these simulations consumed a total of about two years worth of CPU time, but were executed in only a week of `real time' on the ICA's Beowulf cluster. These simulations are in very good agreement with astronomical observations of the Kuiper Belt, and the results are also providing some new insight into the early evolution of the outer Solar System.

Dr. Hahn is assessing the role of the Yarkovsky Effect in the Kuiper Belt. This project is being explored by Mr. Daniel Majaess, who will be reporting his results in his Honor's thesis with Dr. Hahn. The Yarkovsky effect is the very weak acceleration that a small asteroid or comet experiences due to the anisotropic re-radiation of incident sunlight. This effect is known to cause asteroid orbits to drift slowly over time, and Mr. Majaess' task is to determine whether this effect is of any consequence in the Kuiper Belt. In particular, Mr. Majaess will determine whether the Yarkovsky effect plays a role in the delivery of comets into the inner Solar System from the Kuiper Belt. To study this phenomena, Mr. Majaess is using an N body integrator to simulate the evolution of cometary orbits on CITA's McKenzie computer cluster, which is one of the largest computer clusters of its kind in Canada.

Dr. Hahn is also working with honors student Mr. Adam Chaffey to use an N body integrator to simulate the spiral density waves that a satellite can launch in a gravitating particle disk. This work is also being done on the ICA's Beowulf cluster. This is a rather challenging task since the computer must follow the motions of a very large number of interacting particles in order to resolve any wave action. This project is also

quite timely, since the Cassini spacecraft has just arrived at Saturn, and is now returning many images of the spiral density waves that Saturn's satellites are launching in that planet's rings. A long-term goal of Mr. Chaffey's project is to apply our N body simulations to these spacecraft observations in order to study these ring-satellite interactions.

Dr. Hahn is also studying the disk around the star Beta Pictoris with honors student Mr. Gary Hubertise, who is analyzing optical and infrared observations of this system. These telescopic images have been provided by Dr. Sara Heap (NASA Goddard Space Flight Center), who used the Hubble Space Telescope to observed this dust disk at optical wavelengths, and by Dr. Zahhad Wahhaj (University of Pennsylvania) who used the Keck 10m telescope to observe this system in the infrared. The well-known warp that has been observed in this dust disk is usually attributed to perturbations from unseen planets that are suspected to orbit within. Mr. Hubertise's task is to characterize the disk's radial variations and its perturbed appearance. The results of his data analysis will then be used by Master's student Mr. Chris Capobianco in his effort to model this system.

To better characterize this unseen planetary system, Mr. Capobianco is developing a model of a dust disk that is perturbed by embedded planets. Mr. Capobianco will then attempt to fit simulated images of this dust disk to the telescopic observations of this system. Mr. Capobianco will then scan the available parameter space to determine the range of planetary systems (i.e., the number of planets, their masses, and their orbits) that might account for the warp that is observed in the Beta Pictoris dust disk.

Dr. Karakas continues her work on the production of nuclear species in Asymptotic Giant Branch (AGB) stars. There are many important uncertainties in studies of AGB stellar nucleosynthesis including nuclear reaction rates. Whilst new experiments have reduced the errors associated with some reaction rates considerably, significant uncertainties remain for many reactions. The reaction rates involved in the production and destruction of the fluorine, neon, magnesium and aluminum isotopes are of particular interest because of recent high precision observations of fluorine in extra-galactic stellar systems and magnesium isotopic ratios in globular cluster stars. These observations provide a unique test of stellar evolution in low and intermediate mass stars and may provide constraints on nuclear reaction rates. Working with various collaborators, I have tried to constrain the uncertainties in reactions involved in fluorine and magnesium production in AGB stars.

Dr. Karakas is also working with Dr. Deupree on the nonspherical effects produced on one member by the second member of a binary pair of stars. Previous work on this problem has focused on the mass transfer between the binary star components by using 1D models for each member. The logic for this is that the stellar evolution is determined very deep inside each star that can be treated as spherical. This work has shown that the models are not spherical at layers sufficiently deep that this assumption is questionable, at least at some level. It is expected that this work will be able to define and quantify these differences and their importance.

Dr. Deupree has been working with Dr. Maurice Clement, now Emeritus after recently retiring from the University of Toronto, on perfecting his code to accurately determine pulsation periods of stars with arbitrary shape. With Dr. Deupree's 2D rotation code and Dr. Clement's pulsation code, it should be possible to calculate very accurate periods for stars which rotate at arbitrarily high rates, something that cannot now be done. This is an area in which successor satellites to MOST will need theoretical support. Dr. Deupree has been approached by the team that has proposed the BRITE satellite to play an analogous role to that of Dr. Guenther for the MOST satellite. Since the kinds of stars that the different satellites will observe are different, these are not competitive projects.

Dr. Deupree continues development of the 2D stellar structure, evolution, and hydrodynamics code. It was successfully modified to include the gravitational effects of a binary companion on the structure of a star and some improvements to the operation of the code have been made.

One of the areas in which the ICA hopes to make a difference is to promote collaborations where they might not otherwise occur. Members of the ICA have been working on one this past year and other members are expecting to begin another one this coming year.

The ongoing collaboration has been a joint project between Drs. Deupree and Short, and it also involves Ms. Lovekin's Master thesis work. The objective is to determine how the observed spectrum of a star is modified by rotation. Rotation alters both the surface shape and the conditions on the surface of the star. These modifications may be observable by their effect on light emitted by the stellar surface. The work has involved calculating and evolving rotating stellar models, calculating model atmospheres and spectra for specific locations on the stellar surface, and then writing and debugging a code to combine the individual spectra to produce the composite spectrum that would be observed. The observed modifications to the spectral energy distribution (SED) are fairly modest, but calculations which involve the spectra of individual lines may be more rewarding. Ms. Lovekin has developed the code to combine the results and has "parallelized" it to run efficiently on our Beowulf computer cluster. A paper on the SED results has been submitted, while work on individual lines in the spectrum is continuing.

In the other collaboration, Drs. Clarke and Hahn intend to use Dr. Clarke's Zeus hydrodynamic code to simulate the spiral density waves that a satellite can launch in a planetary ring. The intent is to simulate the spiral waves in Saturn's rings that are being monitored by the Cassini spacecraft that is presently in orbit about Saturn. Spiral waves play a major role in shaping that planet's rings, and the goal is use these simulations to address some of the outstanding questions about this system, namely, how old are these rings, and what is the nature of their origin? It is anticipated that these simulations will be executed on the ICA Beowulf cluster during the summer of 2005 by an undergraduate Honors student.

Other Activities

Last summer Dr. Adam Sarty of the Astronomy and Physics Department and Dr. Hahn organized the Astronomy and Physics Summer Undergraduate Research Conference. This gave the summer undergraduate students supporting faculty research the opportunity to present papers to the faculty and their peers on their research project much as is done at professional meetings. Six of these students were working for ICA faculty members. Next year the ICA expects to extend undergraduate research activity to include students from other institutions, as this has been proven to be an excellent graduate student recruitment tool.

The ICA and the Astronomy and Physics Department at Saint Mary's University have been selected to host the 2006 Annual Meeting of the American Astronomical Society's Division on Dynamical Astronomy (DDA). This international conference will be held sometime between April and July 2006, and approximately 80 participants are anticipated with Joe Hahn acting as the local host.

CONCLUDING REMARKS

The ICA is progressively gaining recognition amongst its peer groups as evidenced by the facts that 1) ICA members are in demand to give talks elsewhere, 2) external visitors want to come here, often at their own expense, 3) researchers wish to send their current graduate students to visit over several weeks to several months timescales, 4) the ICA is beginning to host international conferences. This recognition has come despite the need for some ICA members to spend a good deal of time bringing ACEnet to fruition. It is hoped that these gains can be accelerated as ACEnet makes the transition from a system on paper to a system in reality.

ICA CONTACT INFORMATION

www.ica.smu.ca

Dr. Robert G. Deupree, Director
Phone: (902) 420-5439
Fax: (902) 496-8218
Email: bdeupree@ap.smu.ca

Julee Adams, Secretary
Phone: (902) 420-5105
Fax: (902) 496-8218
Email: jadams@ap.smu.ca