

**University of Toronto**  
**Canadian Institute for Theoretical Astrophysics**  
*Toronto, Ontario M5S 3H8*

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The following is an abbreviated version of the 1998 CITA Annual Report. Due to space constraints, we have not included more than a very brief summary of the scientific activities at CITA in 1998. The full report is available on request (from citadmin@cita.utoronto.ca) or on the web at <http://www.cita.utoronto.ca>.

## 1. FOREWORD

The Canadian Institute for Theoretical Astrophysics is a nationally supported research center for studies in theoretical astronomy and related subjects, hosted by the University of Toronto and receiving research support from an NSERC collaborative special project grant as well as the Canadian Institute for Advanced Research. CITA's primary missions are to foster interaction within the Canadian theoretical astrophysics community and to serve as an international center of excellence for theoretical studies in astrophysics. This report has been prepared by John Dubinski and Doug Johnstone.

Research at CITA covers a broad range of fields in astrophysical theory. In 1998 the areas of study included: • cosmology: early universe, inflation, cosmic defects, big bang nucleosynthesis, microwave background anisotropies, large-scale structure, gravitational lensing, galaxy formation, Lyman alpha clouds; • dynamics: galactic warps and bars, galaxy interactions and mergers, galaxies in clusters, globular clusters; • intergalactic and interstellar medium: AGN winds, Galactic HI distribution, molecular clouds, star-forming regions, dust physics; • stars and compact objects: accretion disks, protoplanetary disks, stellar winds, white dwarf cooling, pulsar magnetospheres; • planetary systems: chaos, planet migration, asteroid belt, extra-solar planets, Uranian moons.

## 2. PERSONNEL

The research staff of CITA for the year 1998, along with their primary research interests, is listed below. (Notes: †has left CITA during 1998; ‡joined CITA during 1998.)

### 2.1 CITA Faculty

• J. R. Bond, Professor and Director (Ph.D. Caltech, 1979) - *Cosmology: Very Early Universe, Evolution of Cosmic Structure, Dark Matter, Cosmic Background Radiation, Particle Theory* • P. G. Martin, Professor (Ph.D. Cambridge 1972) - *Interstellar Matter; H<sub>2</sub>: Collisional Rate Coefficients, Galactic Plane Survey; H II Regions: Orion, Chemical Abundances; Dust: Interstellar Polarization* • N. Murray (Ph.D. Berkeley 1986) - *Active Galactic Nuclei, Cataclysmic Variable Stars, Solar System Dynamics, Solar Physics* • L. Kofman (Ph.D. Tartu 1985) - *Cosmology, Very Early Universe, Inflation, Large Scale Structure* • U. Pen, (Ph.D. Prin-

cton, 1995) - *Cosmology, Simulations, Sunyaev-Zeldovich Effect, Galaxy Spin Correlations, Damped Lyman Alpha Systems*

### 2.2 Senior Research Associates 1998

• J. Dubinski, (Ph.D. Toronto 1991) - *Galaxy Dynamics and Formation, Cosmology, Parallel N-body and Hydro codes* • A. Lazarian, (Ph.D. Cambridge 1995) - *Alignment of Interstellar Dust, Microwave Emission from Dust, Molecular Clouds, Interstellar Turbulence, Star Formation, MHD: Reconnection and Dynamo* • D. Yu. Pogosyan (Ph.D. Tartu 1990) - *Cosmology, Large-scale Structure, Microwave Background Radiation, Interstellar Medium*

### 2.3 Research Associates 1998

• P. J. Armitage, (Ph.D. Cambridge 1996) - *Accretion Disks, Black Holes, Star Formation, Computational Hydrodynamics* • S. Basu, (Ph.D. Illinois 1993) - *Star Formation, Interstellar Medium, Solar Physics* • A. R. Crittenden, (Ph.D. Pennsylvania 1993) - *Cosmology, Large-scale Structure, Microwave Background Radiation, Cosmic Defects* • B. J. Gladman‡, (Ph.D. Cornell 1996) - *Solar System Formation, Kuiper Belt Observations, Globular Cluster Systems, Meteorite Transport* • B. M. S. Hansen, (Ph.D. Caltech 1996) - *Stellar Evolution: White Dwarfs and Pulsars, Globular Clusters, Planetary Formation and Dynamics, Gamma Ray Bursts* • D. Johnstone, (Ph.D. Berkeley 1995) - *Destruction of Circumstellar Disks, Molecular Clouds, Star Formation, Galactic ISM, Globular Clusters* • L. Knox, (Ph.D. Chicago 1995) - *Cosmology, Early Universe, Large Scale Structure, Cosmic Microwave Background* • M. Y. Lyutikov, (Ph.D. Caltech 1998) - *Plasma Astrophysics, Pulsars, GRB, Chaos in Planetary Systems, Inflation* • S. J. Magorrian, (D.Phil. Oxford 1995) - *Galactic Dynamics* • C. Murali, (Ph.D. UMass-Amherst 1996) - *Galaxy formation, Galactic structure and dynamics, ISM* • P. Natarajan, (Ph.D. Cambridge 1998) - *Gravitational lensing, clusters of galaxies, accretion physics and active galactic nuclei, the growth of black holes and the physics of galaxy formation.* • S. Prunet, (PhD Orsay 1998) - *Cosmology, Large Scale Structure, Microwave Background, ISM: Microwave foregrounds* • R. Scoccimarro, (Ph.D. Chicago 1996) - *Cosmology, CMB, Large Scale Structure, Numerical Simulations, Weak Lensing* • T. Souradeep, (Ph.D. IUCAA 1995) - *Cosmology, Large-scale Structure, Microwave Background Radiation, Early Universe* • A. L. Van Waerbeke, (Ph.D. Toulouse, France 1997) - *Cosmology, Gravitational lensing, Large-scale structure, Quasars: Evolution*

Although the bulk of the support for CITA's research staff comes from our NSERC Collaborative Special Program grant and from research grants to individual faculty members, support in 1998 also came from an NSERC Postdoctoral Fellowship (Gladman).

**Changes In 1998** Four new research fellows joined CITA in 1998: Priyamvada Natarajan (Cambridge), Simon Prunet (IAS, Orsay), Ludovic van Waerbeke (Toulouse) and Alex Lazarian (Cambridge) as senior associate. They joined senior research associates Dmitry Pogosyan and John Dubinski, and research fellows Phil Armitage, Shantanu Basu, Brad Hansen, Douglas Johnstone, Lloyd Knox, Chigurupati Murali, and Roman Scoccimarro.

A number of our research fellows left during the past year. Rob Crittenden took up a 5 year SERC position at DAMPT but returned in the 1998-99 academic year to CITA as an RA. Tarun Souradeep took up a post doctoral fellowship at the University of Kentucky, Brett Gladman took up a position at l'Observatoire de Nice, Lloyd Knox became a senior RA in Chicago, and John Magorrian left for a post doctoral position at Cambridge.

#### 2.4 National Fellows 1998

A program started in 1988 solicits nominations from universities across Canada for "CITA National Fellows." These are research fellows who are jointly supported by CITA and the nominating university; although they work primarily at the nominating university, visits to CITA and collaboration with CITA staff are encouraged. CITA Council awards these fellowships using the same selection criteria as those for CITA research fellowships. The National Fellows in 1998 were:

- S. Ansoldi (Ph.D. Trieste), held at University of Victoria and University of Alberta (1998-2000)
- E. Pierpaoli (Ph.D. International School of Advanced Studies), held at University of British Columbia (1998-2000)
- P. Wiegert (Ph.D. Toronto), held at York University (1998-2000)
- R. Ouyed (Ph.D. 1997, McMaster), held at St. Mary's University (1997-1998).

#### 2.5 Supervised Graduate Students

Faculty and research fellows have been involved in the supervision of several graduate students from the University of Toronto:

- D. Ballantyne (Peter Martin), Astronomy
- A. Dirks (Dick Bond), Astronomy
- P. Greene (Lev Kofman), Physics
- J. Karr (Peter Martin), Astronomy
- C. Kerton (Peter Martin), Astronomy
- R. McNaughton (Norm Murray), Astronomy
- M. Ruetalo (Dick Bond), Astronomy
- K. Verner (Peter Martin), Astronomy
- P. Zhang (Ue-Li Pen), Astronomy

#### 2.6 Summer Student Research Program

CITA instituted a highly successful summer student research program in 1996 which has brought undergraduates from a number of Canadian universities to CITA to work with Faculty and Research Associates. Summer 1998 participants were:

- Frederic Bealieu (U. Montreal)
- Momar Dieng (Macalster)
- Michael Forbes (University of British Columbia)
- Philip Komljenovic (York U.)

### 3. CITA VISITORS

CITA has a vigorous visitors program bringing a number of Astronomy and Physics faculty members from other Canadian universities and from abroad for both extended stays and shorter visits.

#### 3.1 Senior Visiting Fellows 1998

- Hugh Couchman, University of Western Ontario
- Dick Henriksen, Queen's University
- Kim Innanen, York University
- Lorne Nelson, Bishop's University
- Ralph Pudritz, McMaster University
- Larry Widrow, Queen's University

#### 3.2 Long Term Visitors

- T.T. Chia, Singapore
- G. Ferland, Kentucky
- P.A.M. van Hoof, Kentucky
- D. Verner, Kentucky
- D.H. Zhang, China

#### 3.3 Shorter Term Visitors

In addition there were over eighty short term visitors to CITA in 1998.

### 4. CIAR AND CITA

**The Canadian Institute for Advanced Research** supports a number of Programs chosen for their high intellectual promise and interdisciplinary character. The CIAR Cosmology and Gravity Program has nodes at UBC (Fellows Bill Unruh and Matt Choptuik), at the University of Alberta (Fellows Valery Frolov and Don Page), at the University of Victoria (Fellow Werner Israel and Scholar Julio Navarro), at the University of Toronto (Fellows Ray Carlberg and Simon Lilly) and at CITA, where Dick Bond and Lev Kofman are CIAR Fellows and Ue-Li Pen is a CIAR scholar. There is also a large distinguished network of CIAR Associates of this Program around the world. The Program is in its third five year period and Scott Tremaine is the Director. The academic interaction between CIAR Fellows and other CITA visitors and researchers, and the administrative cooperation between CITA and CIAR in attracting excellent cosmologists, continues to make Toronto and Canada a lively place for research in theoretical cosmology.

### 5. SACKLER VISITING ASTROPHYSICIST

CITA received a generous gift from the Raymond and Beverly Sackler Foundation to endow the **Raymond and Beverly Sackler Visiting Astrophysicist Program**. Each year CITA invites an internationally distinguished scholar conducting research in theoretical astrophysics to give two lectures at the University of Toronto. The researcher also meets informally with faculty and postdoctoral fellows at CITA as well as researchers and students in the Department of Astronomy and other departments. The visit is intended to be the highlight of the academic year at CITA.

The first Raymond and Beverly Sackler Visiting Astrophysicist (1997) was Sir Martin Rees from Cambridge University. The second Sackler Visitor was Peter Goldreich of Caltech who visited in September 1998 and gave a public lecture entitled "Planet Formation."

## 6. CONFERENCES SUPPORTED BY CITA

CITA supports scientific workshops and meetings in Canada on subjects of interest to theoretical astrophysics. Meetings supported by CITA in 1998 were:

- New Views of the Magellanic Clouds/ IAU 190, July 12-17, 1998 (Victoria), Organizer J. Hesser.
- New Perspectives on the Interstellar Medium, August 22-28, 1998 (Naramata), Organizes T. Landecker and A.R. Taylor.
- Gravitational Collapse Leading to Star Formation, October 4-6, 1998 (Toronto). Organizers D. Johnstone and S. Basu.
- 13th Kingston Meeting on Theoretical Astrophysics: Galaxy Formation and Cosmic Star Formation History, October 15-17, 1998 (Hamilton). Organizers R. Pudritz, A. Babul, P. Bastien, R. Carlberg, M. Rees, M. West. In addition, a collaboration between CITA, McMaster, Waterloo, and Queen's University has produced an active Star Formation Group in the Southern Ontario region which meets monthly to discuss current research topics.

## 7. FACILITIES

CITA occupies the 12th floor of the McLennan Physical Laboratories at the downtown campus of the University of Toronto.

CITA researchers have access to several powerful computers. CITA and CITA grantholders own a 45% share of an eight-processor, 4-gigabyte SGI Origin 2000 system, and 63% of a pair of older Compaq AlphaServer 2100 systems (one with four 200MHz EV4 processors and 256 megabytes of memory, one with four 250MHz EV5 processors and 1 gigabyte). There is also a dedicated cluster for dynamics calculations, funded by Martin in collaboration with M. Duncan (Queen's), and K. Innanen (York); this comprises 20 inexpensive but powerful Alpha PCs running Linux. Two additional Alpha PCs, owned by grantholders, are dedicated to computation. A major step upward in our computing is about to occur thanks to a "Canadian Fund for Innovations" grant, which will amplify our raw parallel computing power by more than tenfold.

Desktop computing resources include 17 Intel-based personal computers running Linux; six Compaq Alpha workstations; two SGI Indigo workstations; one Sun Ultra 1 workstation; six X terminals with colour screens; and a handful of older systems (SGI Personal IRISes, first-generation SUN SPARCstations). Two smaller Compaq Alpha systems serve as time-sharing systems for the X terminals and for other use. All of these systems are networked together, and much computation is done on the powerful desktop systems, singly and in concert.

All of these systems are supported by a Sun Ultra 5 back-end file and network server, with about 200 gigabytes of disk. CITA's network is fully switched, with 10 and 100 megabit connections to offices (depending on the computers present) and a 100 megabit link to the campus network and the Internet.

Researchers also have access to a number of peripheral devices, including a high-quality dye-sublimation colour printer; several inkjet colour printers; a high-speed black-and-white laser printer, capable of double-sided printing; an optical scanner; and Exabyte, DLT, and DAT tape drives.

## 8. CITA COUNCIL

CITA is both an Institute within the School of Graduate Studies of the University of Toronto, and a non-profit corporation (CITA, Inc.). Relations between the two CITAs are governed by a Letter of Agreement between CITA Inc. and the University of Toronto that was signed in 1989. The CITA Council consists of seven members, five selected from the CITA Inc. membership of over 50 researchers in co-operation with the Canadian Astronomical Society (of which they must also be members), and two *ex officio*: the Director of CITA and the Dean of the School of Graduate Studies of the University of Toronto or his designate.

Members of CITA Council for the second half of 1998 were:

- Richard Bond, CITA Director
- David Clarke, CAS rep., St. Mary's University
- Hugh Couchman, University of Western Ontario
- David Hartwick, University of Victoria
- Kim Innanen, York
- Donald Moggridge, (Vice-Dean, School of Graduate Studies, University of Toronto)
- Ralph Pudritz, McMaster University

## 9. SCIENTIFIC OVERVIEW 1998

The research program at CITA encompasses all the major areas in astronomy broken down in the main categories of cosmology, galaxies, interstellar medium, stars and planets. In this report, we review the main activities at CITA during 1998.

### 9.1 Cosmology

In the 1990's, cosmology has evolved into a mature, detailed science pushed forward by an enormous amount of observational data. Research in cosmology at CITA covers most areas of current interest including studies of the early universe and the origin of the primordial density fluctuations, the connection to the cosmic microwave background (CMB) temperature fluctuations and the nonlinear evolution via gravitational collapse into galaxies, clusters of galaxies and large-scale structure.

Inflation continues to be a lively area at CITA, especially how matter arose at the end (**Kofman**) and its impact on density fluctuations, both leading to observable tests. The alternative defect induced structure formation theory has also been much explored (**Pen**).

A large effort at CITA has centered around establishing and calculating the cosmological constraints that precise measurements of the CMB fluctuations will allow (**Bond, Crittenden, Knox, Pogosyan, and Souradeep**). **Bond, Knox, and Souradeep** have been studying how well one can reconstruct the primordial power spectra and the inflation potential from measurements to be done with Plank and MAP, while **Bond, Pogosyan, and Souradeep** have developed a completely general method for calculating CMB anisotropy in models with non-trivial topology. Understanding the effect of foreground emission on the high quality observations now available is particularly important and CITA has a number of researchers involved in this pursuit (**Knox, Prunet, and Soccimarro**).

Cosmologists at CITA are building new tools and techniques for interpreting the coming deluge of new CMB data. The band-power method developed by **Bond** has been refined and should become the standard method for the presentation of power spectrum constraints by observers (**Bond** and **Knox**). Various pixelization schemes for use with Planck and other experiments have been also been analyzed (**Crittenden**). Given the detail expected in these future high precision measurements of the CMB it is imperative to understand all possible secondary sources of anisotropy including the impact of inhomogeneous reionization on the cosmic microwave background (**Knox** and **Scoccimarro**). CITA researchers are also involved with the experiments themselves. **Knox** is a co-investigator on the MSAM Tophat balloon-borne experiment to measure CMB anisotropy and is also involved in analysis of the Python data set taken by the south pole telescope. **Crittenden** is aiding the establishment of the Cambridge Planck Analysis Center (CPAC) at the University of Cambridge.

The size and depth of galaxy redshift surveys will increase dramatically in the next few years and new statistics on the large-scale distribution of galaxies will be available for direct comparison to cosmological theories. CITA researchers are advancing the Cosmic Web paradigm (**Bond**, **Kofman** and **Pogosyan**) and studying the observability of these structures by weak-lensing (**Van Waerbeke**), secondary CMB fluctuations such as the Sunyaev Zel'dovich effect and x-ray emission (**Bond**, **Kofman**, **Pen**, and **Pogosyan**). Other studies at CITA include: analysis of gravitational instability in mildly non-linear regimes (**Scoccimarro** and **Couchman**); simulations of Lyman-alpha absorption at high redshift (**Bond**); and development of sophisticated N-body and hydrodynamic codes for simulating the complex interplay between gravity, gasdynamics, atomic physics and magnetic fields (**Bond**, **Pen**, **Dubinski**, and **Couchman**). The main problems that are being tackled with these codes are the evolution of the Lyman- $\alpha$  forest, the formation of galaxy clusters, and the study of galaxy interactions in merging pairs and in clusters. The recent acquisition of a multi-processor Silicon Graphics Origin supercomputer has aided in these studies and has offered high-resolution simulated views of formation of galaxies in clusters.

## 9.2 Galaxies

Understanding the complexity and richness of Newtonian mechanics and gravity in stellar systems such as galaxies and dense star clusters is another major focus of research at CITA. There are many open problems on the dynamics of disk galaxies, galactic dark halos, globular clusters and galactic nuclei. CITA dynamicists have been working on various problems including: the gravitational response of galaxies and globular clusters to tidal perturbations (**Dubinski** and **Murali**), warps and azimuthal distortions in disk galaxies (**Dubinski**), using interacting galaxies to constrain dark halo mass (**Dubinski**), using the observed spin of galaxies to probe the gravitational field (**Pen**), the modeling of spectroscopic and photometric data from galactic nuclei to search for giant blackholes (**Magorrian**), globular cluster systems

around ellipticals (**Gladman**), and micro-lensing by MA-CHOS in simulated dark halos (**Dubinski** and **Widrow**).

Both analytical and numerical N-body methods are being applied to the studies of galaxies and clusters. Analytical, linear calculations are more appropriate for studying the cumulative effect of many, low amplitude perturbations such as expected in interaction of globular clusters with low-mass blackholes (**Murali**). CITA researchers (**Dubinski** and **Murali**) have compared an analytical, linear response calculation of a tidal perturbation on a spherical system with a 1 million particle N-body simulation and while the agreement is good, the discreteness of the N-body system introduces new effects which may be important for globular cluster evolution.

## 9.3 The Interstellar Medium

At CITA, active research on chemical processes in the ISM continues. Fundamental analysis of collision cross-sections between hydrogen molecules in ISM settings will aid in determining the rate of excitation of this most abundant molecule (**Martin** and **Mandy**). Determination of the chemical enrichment of star-forming clouds from observations of spectral lines has resulted in constraints on the iron content within the Orion nebula (**Martin**).

Computations of the collapse of magnetized cloud cores and the initial growth of stars produce a dynamic mass accumulation rate an order of magnitude larger than predicted by equilibrium theory (**Basu**). Magnetic fields in the Galaxy may also aid in the formation of dense star-formation sites based on models of the Parker instability, a process which funnels initially diffuse gas into small dense regions (**Basu**). Combining theory with multi-wavelength observations, is leading to insights on the modes of star formation and the environment surrounding star-formation sites.

CITA researchers are active in the ongoing DRAO Canadian Galactic Plane Survey (CGPS) (**Basu**, **Johnstone**, **Kertin**, and **Martin**), modeling the evolution and structure of Galactic chimneys and superbubbles (**Basu**, **Johnstone**, and **Martin**), studying the interstellar environment around compact HII regions (**Kertin** and **Martin**), and constraining the accuracy of kinematic distance measurements (**Johnstone**).

Turbulence in molecular clouds is an important pressure support mechanism and yet the input mechanism and the eventual decay are not well understood. Researchers at CITA are examining several aspects of turbulence, including measuring turbulence in HI (**Lazarian** and **Pogosyan**), theoretical understanding of the non-linear interaction of waves (**Lyutikov**) and determining decay rates and energy loss (**Basu** and **Murali**). Another area of research is theoretical modeling of the emission and polarization properties of dust grains, required to understand the high sensitivity observations now possible (**Lazarian**). Additionally, the new continuum bolometer (SCUBA) at the JCMT has provided a tool for probing the cold, dense interstellar medium where stars form at sub-millimeter wavelengths (**Martin**, **Johnstone**).

## 9.4 Stars and Compact Objects

While much is understood about the basic structure and evolution of stars, there are still many fundamental questions left unanswered. A number of the questions relate to associated circumstellar material occupying disk-like structures around many stars. Research at CITA has focused on warps in these disks, the interaction of stellar magnetic fields with disks, accretion through disks, and disk destruction.

Some disks produce distinct emission line features which can be attributed to disk winds providing insight to their energetics and structure. Using recent Hubble Space Telescope images of the Orion star-forming region, the hostile environment around massive stars has been analyzed (**Johnstone**). Nearby young stars have their protoplanetary disks heated and evaporated by the energetic neighbor (**Johnstone**).

The stellar graveyard also provides many astrophysical enigmas. White dwarf cooling models provide age estimates for milli-second pulsars, allowing for a determination of their evolution. The most detailed white dwarf models are being computed at CITA (**Hansen**). Other research focuses on the retention and evolution of neutron stars in globular clusters (**Hansen**), the mass-transfer history of compact objects in binaries (**Hansen**), and the implementation of fundamental plasma physics methods to study pulsars (**Lyutikov**). Accretion disks around black holes have been investigated by **Armitage** and **Natarajan** in order to understand the observability of the accretion process and the warps induced in the disk.

## 9.5 Planetary Systems

The Solar System poses both a local concern and a rich source of observational data. CITA continues to provide leading research in this field conducting both analytic and detailed numerical simulations. Recent results include an understanding of the chaotic nature of the outer asteroid belt (**Murray** and **Lyutikov**), the possibility of a long-lived belt of mass between Uranus and Neptune, the tidal-disruption of Earth-crossing asteroids (**Gladman**), and the evolution of long-period comets (**Wiegert** and **Murray**).

Investigations into the formation of planetary systems has concentrated on the inward migration of planets through interaction and ejection of planetesimals, providing a mechanism for the creation of short-period planets (**Hansen** and **Murray**). Other studies include the formation mechanism for planets around pulsars (**Armitage** and **Hansen**).

CITA researchers have also been involved in the discovery and followup analysis of the two new moon's discovered around Uranus (**Gladman**). The new moons appear to be on retrograde orbits around the planet and one has a highly elliptical path. The diameters, deduced from brightness and an assumed albedo, are 60 and 120 kilometers.

## PUBLICATIONS

*The publication list includes all papers published or submitted in 1998 by the CITA staff, or by visitors if a substan-*

*tial portion of the work was done at CITA. Some papers published in this period were included as "submitted" or "in press" in the 1997 annual report.*

- Aghanim, N., **Prunet, S.**, Forni, O., Bouchet, F.R. 1998, "Moving gravitational lenses: imprints on the cosmic microwave background," *Astron. Astrophys.*, **334**, 409.
- Armitage, P.J.** 1998, "Turbulence and Angular Momentum Transport in a Global Accretion Disk Simulation," *Ap. J. Lett.*, **501**, 189-192.
- Armitage, P.J.** 1999, "Disc Dispersal around Young Stars," in Proc. of *Astrophysical Discs*, ed. J.A. Sellwood, and J. Goodman, (ASP Conf. Ser. 160), p. 176-185.
- Armitage, P.J.**, Clarke, C.J. and Tout, C.A. 1999, "Accretion Disc Evolution in Single and Binary T Tauri Stars," *M.N.R.A.S.*, **304**, 425-433.
- Armitage, P.J.** and **Hansen, B.M.S.** 1999, "A Propagating Mode of Planet Formation in Massive Discs," *Nature*, submitted.
- Armitage, P.J.** and Livio, M. 1999, "Black Hole Formation via Hypercritical Accretion during Common Envelope Evolution," *Ap. J.*, submitted.
- Armitage, P.J.** and Murray, J.R. 1998, "Simulations of Spiral Structure in the Accretion Disc of IP Pegasi during Outburst," *M.N.R.A.S.*, **297**, L81-L85.
- Armitage, P.J.** and **Natarajan, P.** 1999, "Lense-Thirring Precession of Accretion Disks around Compact Objects," *Ap. J.*, in press.
- Armitage, P.J.** and **Natarajan, P.** 1999, "The Blandford-Znajek Mechanism and Emission from Isolated Accreting Black Holes," *Ap. J. Lett.*, submitted.
- Armour, M.-H., D.R. **Ballantyne**, G.J. **Ferland**, J. **Karr**, & P.G. **Martin** 1999, "Emission-line Helium Abundances in Highly Obscured Nebulae," *P.A.S.P.*, in press.
- Bally, J., Sutherland, R.S., Devine, D., and **Johnstone, D.** 1998, "Externally Illuminated Young Stellar Environments in the Orion Nebula: Hubble Space Telescope Planetary Camera and Ultraviolet Observations," *A. J.*, **116**, 293.
- Basu, S.** 1998, "Constraints on the Formation and Evolution of Circumstellar Disks in Rotating Magnetized Cloud Cores," *Ap. J.*, **509**, 229-237.
- Basu, S.** 1999, "The Formation of Protostellar Disks in Magnetized Cloud Cores," in Proc. of 8th Annual Maryland Astrophysics Conference, *Accretion Processes in Astrophysical Systems*, eds. S. S. Holt and T. R. Kallman, (Woodbury: AIP Press), p. 505-508.
- Basu, S.**, **Johnstone, D.**, and **Martin, P.G.** 1999, "Dynamical Evolution and Ionization Structure of an Expanding Superbubble: Application to W4," *Ap. J.*, **516**, 843-862.
- Bercik, D. J., **Basu, S.**, Georgiobani, D., Nordlund, A., and Stein, R. F. 1999, "Solar Magneto-Convection," in Proc. of Tenth Cambridge Workshop on *Cool Stars, Stellar Systems, and the Sun*, eds. J. A. Bookbinder and R. Donahue, (San Francisco: ASP), p. 568-572.
- Bernardeau, F., Mellier, Y. and **Van Waerbeke, L.** 1998, " $\Omega$  from Weak Lensing Survey," in Proc. of *Wide Field Surveys in Cosmology*, ed. S. Colombi and Y. Mellier (Frontière), p. 183.

- Bond, J.R.** 1998, "Cosmic Microwave Background Overview," *Class. Quantum Grav.*, **15**, 2573-2587
- Bond, J.R.** 1998, "Cosmic Microwave Background Theory," *Proc. National Acad. Sci. US*, **95**, 35-41.
- Bond, J.R., Crittenden, R., Jaffe, A.H. and Knox, L.** 1999, "Computing Challenges of the Cosmic Microwave Background," *Computing in Science and Engineering*, vol. 1, no. 2, 21.
- Bond, J.R., Jaffe, A.H.** 1999, "Constraining Large Scale Structure Theories with the Cosmic Background Radiation," *Phil. Trans. R. Soc. London*, **357**, 57-75
- Bond, J.R., A.H. Jaffe and Knox, L.** 1998, "Estimating the Power Spectrum of the Cosmic Microwave Background," *Phys. Rev. D* **57**, 2117.
- Bond, J.R., A. H. Jaffe and Knox, L.** 1999, "Radical Compression of Cosmic Microwave Background Data," *Ap. J.*, in press.
- Bond, J.R., Kofman, L. Pogosyan, D., Wadsley, J.W.** 1999, "Theoretical Tools for Large Scale Structure," in "Wide Field Surveys in Cosmology," *Proc. XIV IAP Colloquium Conf.*, ed. S. Colombi & Y. Mellier, (Paris: Editions Frontieres), p. 17
- Bond, J.R., Pogosyan, D. and Souradeep, T.** 1998, "Computing CMB anisotropy in Compact Hyperbolic Spaces," *Class. Quantum Grav.*, **15**, 2671-2687.
- Bond, J.R., Pogosyan, D. and Souradeep, T.** 1999, "CMB anisotropy in Compact Hyperbolic universes-I: Computing Correlation functions," *Phys. Rev. D*, submitted.
- Bond, J.R., Pogosyan, D. and Souradeep, T.** 1999, "CMB anisotropy in Compact Hyperbolic universes-II: COBE maps and limits," *Phys. Rev. D*, submitted.
- Bouchet, F.R., **Prunet, S., Sethi, S.K.** 1999, "Multi-frequency Wiener filtering of CMB data with polarisation," *M.N.R.A.S.*, **302**, 663.
- Boughn, S. and **Crittenden, R.** 1999, "The Integrated Sachs-Wolfe Effect: Correlation of the Cosmic Microwave and X-ray Backgrounds," contributed to "Microwave Foregrounds," eds. A. De Oliveira-Costa & M. Tegmark (ASP, San Francisco, 1999).
- Chiang, J., Reynolds, C.S., Blaes, O.M., Nowak, M.A., **Murray, N., Madejski, G., and Marshall, H.M.** 1999, "Simultaneous EUVE/ASCA/RXTE Observations of NGC 5548," *Ap. J.*, submitted.
- Ciolek, G. E., and **Basu, S.** 1999, "Consistency of Ambipolar Diffusion Models with Infall in the L1544 Protostellar Core," *Ap. J.*, submitted.
- Crittenden, R.**, 1998, "Igloo Pixelizations," To appear in *Astrophys. Lett. & Comm.*, proceedings of "The CMB and the Planck Mission," Santander, Spain.
- Davies, M.B., & **Hansen, B.M.S.** 1998, "Neutron Star Retention and Millisecond Pulsar Production in Globular Clusters," *M.N.R.A.S.*, **301**, 15-24.
- Draine, B., & **Lazarian, A.** 1998, "Diffuse galactic emission from spinning dust grains," *Ap. J.Lett.*, **494**, L19-L22.
- Draine, B., & **Lazarian, A.** 1998, "Electric dipole radiation from spinning dust grains," *Ap. J.*, **508**, 157-179.
- Draine, B., & **Lazarian, A.** 1998, "Dipole radiation from spinning dust grains," *B.A.A.S.*, Vol. 29, No. 5, 1298, 51.19.
- Draine, B., & **Lazarian, A.** 1999, "Magnetic dipole microwave emission from dust grains," *Ap. J.*, **512**, 740-759.
- Draine, B.T., & **Lazarian, A.** 1999, "Microwave emission from galactic dust grains," in "Microwave Foregrounds" (in press).
- Dubinski, J.** 1998, "The Origin of the Brightest Cluster Galaxies," *Ap. J.*, **502**, 141.
- Dubinski, J.** 1999, "The Dynamical Evolution of Galaxies in Clusters," in *Galaxy Dynamics*, proceedings of a conference held at Rutgers University, 8-12 Aug 1998, eds. D. R. Merritt, M. Valluri, and J. A. Sellwood, ASP.
- Dubinski, J., Mihos, J.C., & Hernquist L.** 1998, "Constraining dark halos with tidal tails," in Galactic Halos: A UC Santa Cruz Workshop, Santa Cruz 11-15 August 1997, ed. Dennis Zaritsky, ASP 136, 260.
- Dubinski, J., Mihos, J.C., & Hernquist L.** 1999, "Constraining dark halo potentials with tidal tails," *Ap. J.*, in press.
- Eales, S., Lilly, S., Gear, W., Dunne, L., **Bond, J.R., Hammer, F., Le Fevre, O., Crampton, D.** 1999, "The Canada-UK Deep Submillimetre Survey I: First Submillimetre Images, the Source Counts, and Resolution of the Background," *Ap.J.*, **515**, 518
- Efstathiou, G., **Bond, J.R.** 1999, "Cosmic Confusion: Degeneracies among Cosmological Parameters Derived from Measurements of Microwave Background Anisotropies," *M.N.R.A.S.*, **304**, 75
- Ehrenfreund P., van Dishoeck E.F., Burgdorf M., Cami J., **van Hoof P., Tielens A.G.G.M., Schutte W.A., Thi W.F.** 1998, "Evolution of Southern Star-Forming Regions", in 'ISO's View on Stellar Evolution,' eds. Waters L.B.F.M., Waelkens C., van der Hucht K.A., Zaal P.A., Kluwer, Dordrecht, p. 83-89.
- English, J., Taylor, A.R., Irwin, J.A., Dougherty, S.M., **Basu, S., Beichman, C., Brown, J., Cao, Y., Carignan, C., Crabtree, D., Dewdney, P., Duric, N., Fich, M., Gagnon, E., Galt, J., Germain, S., Ghazzali, N., Gibson, S.J., Godbout, S., Gray, A., Green, D.A., Heiles, C., Heyer, M., Higgs, L., Jean, S., Johnstone, D., Joncas, G., Landecker, T., Langer, W., Leahy, D., Martin, P., Matthews, H., McCutcheon, W., Moriarity-Scheiven, G., Pineault, S., Purton, C., Roger, R., Routledge, D., St- Louis, N., Tapping, K., Terebey, S., Vaneldik, F., Watson, D., Willis, T., Wendker, H., and Zhang, X.** 1998, "The Canadian Galactic Plane Survey," *Pub. of the Astronomical Society of Australia*, **15**, 56.
- English, J., Taylor, A.R., Mashchenko, S.Y., Irwin, J.A., **Basu, S., and Johnstone, D.** 1999, "Galactic Worm 123.4-1.5: A Mushroom-shaped HI Cloud," *Ap. J.*, submitted.
- Erben, T., **Van Waerbeke L., Mellier, Y., Schneider, P., Cuillandre, J.C., and Castander, F.** 1999, "Mass-Detection of a Matter Concentration Projected near the Cluster Abell 1942: Dark Clump or High-Redshift Cluster?," *Astron. Astrophys.*, submitted.
- Felder, G., **Kofman, L., & Linde, A.** 1999, "Instant Preheating" *Phys.Rev. D*, **59**, 123523
- Felder, G., **Kofman, L., & Linde, A.** 1999, "Inflation and

- Preheating in NO models” *Phys.Rev. D*, **60**, 103505
- Ferland, G.J.** 1999, “On HeI 2.06  $\mu$ m emission from Nebulae,” *Ap. J.*, 512, 247-249
- Ferland, G.J.** 1999, “Hydrogen emission from optically thin clouds: Case C.” *P.A.S.P.*, in press.
- Ferland, G.** & Baldwin, J. (eds.) 1999, “Quasars and Cosmology,” ASP Conference Series vol 162.
- Ferruit, P., Wilson, A.S., Whittle, M., Simpson, C., Mulchaey, J. & **Ferland, G.** 1999, “HST/FOS spectroscopy of spatially resolved narrow line regions in the Seyfert 2 galaxies NGC 2110 and NGC 5929,” *Ap. J.*, in press.
- Frenk, C.S., White, S.D.M., Bode, P., **Bond, J.R.**, Bryan, C.L., Cen, R., Couchman, H.M.P., Evrard, A.E., Gnedin, N., Jenkins, A., Khokhlov, A.M., Klypin, A., Navarro, J.F., Norman, M.L., Ostriker, J.P., Owen, J.M. Pearce, F.R., **Pen, U.-L.**, Steinmetz, M., Thomas, P.A., Villumsen, J.V., **Wadsley, J.W.**, Warren, M.S., Xu, G., Yepes, G. 1999, “The Santa Barbara cluster comparison project: a test of cosmological hydrodynamics codes,” *Ap.J.*, in press
- Garcia-Ruiz, I., Kuijken, K., & **Dubinski, J.** 1998, “Warps and Secondary Infall,” in Galactic Halos: A UC Santa Cruz Workshop, Santa Cruz 11-15 August 1997, ed. Dennis Zaritsky, ASP 136, 385.
- Garcia Ruiz, I., Kuijken, K., **Dubinski, J.**, & Balcells, M. 1999, “Warps and Satellite Galaxies,” in *Galaxy Dynamics*, proceedings of a conference held at Rutgers University, 8-12 Aug 1998, eds. D. R. Merritt, M. Valluri, and J. A. Sellwood, ASP.
- Greene, P.B., **Kofman, L.**, & Starobinsky, A.A. 1999, “Sine-Gordon Parametric Resonance” **Nucl.Phys. B**, **543**, 423-443
- Hansen, B.M.S.** 1998, “Old and blue white dwarfs as a detectable source of microlensing events,” *Nature*, **394**, 860-862
- Hansen, B.M.S.** 1999, “Cooling Models for Old White Dwarfs,” *Ap. J.*, **520**, 680-695.
- Hansen, B.M.S.** 1999, “On the Frequency and Remnants of Hypernovae,” *Ap. J. Lett.*, **512**, L117 -L120.
- Hansen, B.M.S.** 1999, “The Origin of Primordial Dwarf Stars and Baryonic Dark Matter,” *Ap. J. Lett.*, **517**, L39-L42.
- Hansen, B.M.S.** & **Murali, C.** 1998, “Gamma Ray Bursts from Stellar Collisions,” *Ap. J. Lett.*, **505**, L15-L18.
- Hollenbach, D., Yorke, H., and **Johnstone, D.** 1999, “Disk Dispersal Around Young Stars,” to appear in *Protostars and Planets IV*, eds. V. Mannings, A. Boss, S. Russel, (University of Arizona Press), in press.
- Holman, M. and **Wiegert, P.** 1999, “Long-term Stability of Planets in Binary Systems,” *A. J.*, **117**, 621-628.
- Hui, L., **Kofman, L.**, Shandarin, S.F. 1999, “Multiple-streaming and the Probability Distribution of Density in Redshift Space,” submitted to *Ap. J.*
- Innanen, K., Mikkola, S. and **Wiegert, P.** 1998, “The Earth/Moon and the Dynamical Stability of the Inner Solar System,” *A. J.*, **116**, 2055-2057.
- Jaffe, A.H., **Bond, J.R.**, Ferreira, P., **Knox, L.** 1999, “CMB Likelihood Functions for Beginners and Experts,” Proc. Rome 3K Conference, October 1998,
- Johnstone, D.**, and Bally, J. 1999, “JCMT/SCUBA Submillimeter Wavelength Imaging of the Integral-shaped Filament in Orion,” *Ap. J.*, **510**, L49-L53.
- Johnstone, D.**, and Bally, J., 1999, “SCUBA-Mapping at the JCMT: The Orion Molecular Ridge,” in *The Physics and Chemistry of the Interstellar Medium Proceedings of the 3rd Cologne-Zermatt Symposium held in Zermatt September 22-25 1998*, eds. V. Ossenkopf, J. Stutzki, and G. Winnewisser, (GCA-Verlag Herdecke), 180.
- Johnstone, D.** and Bertoldi, F. 1999, “Ultraviolet Radiation and Circumstellar Environments,” to appear in *The Orion Complex Revisited*, eds. M. McCaughrean, in press.
- Johnstone, D.**, Hollenbach, D., and Bally, J. 1998, “Photoevaporation of Disks and Clumps by Nearby Massive Stars: Application to Disk Destruction in the Orion Nebula,” *Ap. J.*, **499**, 758.
- K. Coble, M. Dragovan, J. Kovac, N. W. Halverson, W. L. Holzapfel, **L. Knox**, S. Dodelson, K. Ganga, D. Alvarez, J. B. Peterson, G. Griffin, M. Newcomb, K. Miller, S. R. Platt, G. Novak 1999, “Anisotropy in the Cosmic Microwave Background at Degree Angular Scales: Python V Results,” *Astrophys. J. Lett.*, in press.
- Kaiser, N., Wilson, G., Luppino, G., **Kofman, L.**, Gioia, I., Metzger, M., Dahle, H. 1999, “A Photometric and Weak Lensing Analysis of the  $z=0.42$  Supercluster MS0302+17,” submitted to *Ap. J.*
- Kallosch, R., **Kofman, L.**, Linde, A., & Van Proeyen, A. 1999, “Gravitino Production After Inflation,” submitted to Phys Rev D
- Kerton, C. R., Ballantyne, D., & **Martin, P.G.**, “Classification of O Stars in the Yellow-Green: The Exciting Star VES 735,” *Astron. J.*, **117**, 2485-2493
- Kerton, C. R., & **Martin, P. G.** 1999, “A Mid-Infrared Galaxy Atlas (MIGA),” *Ap. J.S.*, in press
- Kerton, C. R., & **Martin, P.G.**, 1999, “A Mid-infrared HIRES Atlas of the Galactic Plane,” in *Astrophysics with Infrared Surveys: A Prelude To SIRTf*, eds. M.D. Bica, C. A. Beichman, R. M. Cutri, & B. F. Madore, *ASP Conference Series 177*, 336
- Kerton, C.R., & **Martin, P.G.**, 1999, “Multiwavelength Studies of Interstellar Dust using WIRE and MIGA,” in *New Perspectives on the Interstellar Medium*, eds. A. Taylor, T. Landecker and G. Joncas, ASP Conference Series, in press
- Kingdon, J. & **Ferland, G.** 1999, “The Effects of Charge Transfer on the Thermal Equilibrium of Photoionized Nebulae” *Ap. J.*, 516, L107-109.
- Knox, L.**, **Bond, J.R.**, Jaffe, A.H., **Segal, M.** and Charbonneau, D. 1998, “Comparing Cosmic Microwave Background Experiments,” *Phys. Rev. D* **58**, 083004.
- Knox, L.**, **Scocimarro, R.** and Dodelson, S. 1998, “Impact of Inhomogeneous Reionization on Cosmic Microwave Background Anisotropy,” *Phys. Rev. Lett.* **81**, 2004.
- Komljenovic, P. T., **Basu, S.**, and **Johnstone, D.** 1999, “Using Numerical Simulations to Gain Insight into the Structure of Superbubbles,” in ASP Conf. Series No. 168, *New Perspectives on the Interstellar Medium*, eds. A. R. Taylor, T. L. Landecker, and G. Joncas, (San Francisco: ASP), p. 299-303.

- Lazarian, A.** 1999, "Statistical properties of HI, in *Interstellar Turbulence*, eds. Jose Franco & Alberto Caraminana, CUP, 95-104.
- Lazarian, A.** 1999, "Microwave emission by dust: mechanisms, properties and prospects for ISM studies," (in press).
- Lazarian, A.** 1999, "Resonance paramagnetic relaxation and alignment of ultrasmall grains," (in press).
- Lazarian, A.,** Draine, B. 1998, "Polarization of the dipole radiation from spinning dust grains," *B.A.A.S.*, Vol. 29, No. 5, 1299, 51.20.
- Lazarian, A.,** Draine, B. 1999, "Reconnection and Star Formation," *B.A.A.S.*, Vol. 30, No. 3, 946.
- Lazarian, A.,** Draine, B. 1999, "Thermal flipping of dust grains," *B.A.A.S.*, Vol. 30, No. 4, 1339
- Lazarian, A.,** & Draine, B. 1999, "Nuclear internal relaxation within interstellar grains," *Ap. J. Lett.*, **520**, 67-70.
- Lazarian, A.,** & Draine, B. 1999, "Thermal flipping and thermal trapping - new elements of dust grain dynamics," *Ap. J. Lett.*, **516**, 37-40.
- Lazarian, A.,** & Efrogmsky, M. 1999, "Inelastic relaxation in a rotating body. Application to cosmic dust," *M.N.R.A.S.*, **303**, 673-685.
- Lazarian, A.,** & Vishniac, E. 1999, "Reconnection in weakly stochastic field," *Ap. J.*, **517**, 700-718.
- Lesgourgues, J., **Prunet, S.,** Polarski, D. 1999, "Parameters extraction by Planck for a CDM model with BSI steplike primordial spectrum and cosmological constant," *M.N.R.A.S.*, **303**, 45.
- Lilly, S., Eales, S., Gear, W., Hammer, F., Le Fevre, O., Crampton, D., **Bond, J.R.,** Dunne, L. 1999, "The Canada-UK Deep Submillimetre Survey II: First Identifications, Redshifts and Implications for Galaxy Evolution," *Ap.J.*, in press
- Lilly, S., Eales, S., Gear, W., Webb, T., **Bond, J.R.,** Dunne, L. 1999, "Deep sub-mm surveys: High redshift ULIRGs and the formation of the metal-rich spheroids," in "Formation of Galactic Bulges," Proc. STScI Workshop Oct., 12 pages, astro-ph/9903157
- Lyutikov M** 1998, "Induced Raman scattering in pulsar magnetospheres," *M.N.R.A.S.*, **298**, 1198-1206.
- Lyutikov M** 1998, "Transverse quasilinear relaxation in an inhomogeneous magnetic field," *Phys. Rev. E*, **58**, 2474-2480.
- Lyutikov, M.,** 1999, "Depolarization of Pulsar Radio Emission," CITA preprint 99-24, *Ap. J. Lett* submitted.
- Lyutikov M** 1999, "Beam Instabilities in Magnetized Pair Plasma," *J. Plas. Phys.*, in press.
- Lyutikov M** 1999, "Coherent Emission Mechanisms in Radio Pulsars," *Lindau Workshop and VII International Conference on Plasma Astrophysics and Space Physics*, in press.
- Lyutikov M,** Blandford RD, Machabeli G 1999, "On the nature of pulsar radio emission," *M.N.R.A.S.*, **305**, 338-352.
- Lyutikov M,** Machabeli G, Blandford R. 1999, "Cherenkov-curvature radiation and pulsar radio emission generation," *Ap. J*, **512**, 804-826.
- Magorrian, S.J.** 1999, "Kinematical Signatures of Hidden Stellar Discs," *M.N.R.A.S.*, **302**, 530-536.
- Magorrian, S.J.** and Tremaine, S. 1999, "Rates of Tidal Disruption of Stars by Massive Central Black Holes," *M.N.R.A.S.*, in press.
- Magorrian, J., Tremaine, S.,** Richstone, D., Bender, R., Bower, G., Dressler, A., Faber, S.M., Gebhardt, K., Green, R., Grillmair, C., Kormendy, J. and Lauer, T. 1998, "The Demography of Massive Dark Objects in Galaxy Centres," *A. J.*, **115**, 2285-2305.
- Mandy, M. E., & **Martin, P.G.** 1999, "State-to-state Rate Coefficients for  $H^+ H_2$ ," *J. C. Phys.*, **110**, 7811-7820
- Mandy, M. E., **Martin, P. G.,** & Keogh, W. J., 1998, "Collisional Energy Transfer in  $H_2(v_{ab}, j_{ab}) + H_2(v_{cd}, j_{cd})$ ," *J. C. Phys.*, **108**, 492-497.
- Martin, P.G.,** 1999, "Interstellar Dust in the WIRE to Planck Era," in *New Perspectives on the Interstellar Medium*, eds. A. Taylor, T. Landecker and G. Joncas, ASP Conference Series, in press
- Martin, P. G.,** Clayton, G. C., & Wolff, M. J. 1999, "Ultraviolet Interstellar Linear Polarization V. Analysis of the Final Data Set," *Ap. J.*, **510**, 905-914
- Martin, P. G.,** Keogh, W. J., & Mandy, M. E. 1998, "Collision-induced Dissociation of Molecular Hydrogen at Low Densities," *Ap. J.*, **499**, 793-798
- Mellier, Y., **it Van Waerbeke, L.,** Bernardeau, F. and Le Fèvre, O. 1998, "Weak Lensing with MEGACAM and the VLT," in Proc. of *Looking Deep in the Southern Sky*, ed. M. Raffaella and W.J. Couch, (Springer-Verlag), p. 59.
- Mihos, J.C. and **Dubinski, J.** and Hernquist, L. 1998, "Tidal Tales Two: The Effect of Dark Matter Halos on Tidal Tail Morphology and Kinematics," *Ap. J.*, 494, 183.
- Murali, C.** 1999, "Constraints on the mass of dark objects in the Galactic halo," in *ASP Galactic Dynamics*, eds. D. R. Merritt, M. Valluri, and J. A. Sellwood, in press.
- Murali, C.** 1999, "Transmission and Amplification of Disturbances by Massive Halos," *Ap. J.*, **519**, 580-589
- Murali, C.,** Arras, P. and Wasserman, I. 1999, "Constraints on the Mass and Abundance of Black Holes in the Galactic Halo: the High-mass Limit," *M.N.R.A.S.*, in press.
- Murali, C.** and **Dubinski, J.** 1999, "Determining the Galactic Mass Distribution Using Tidal Streams from Globular Clusters," *A.J.*, in press.
- Murali, C.** and Tremaine, S. 1998, "Linear Response of Galactic Halos to Adiabatic Gravitational Perturbations," *M.N.R.A.S.*, **296**, 749-762
- Murray, J.R. and **Armitage, P.J.** 1998, "Tilted Accretion Discs in Cataclysmic Variables: Tidal Instabilities and Superhumps," *M.N.R.A.S.*, **300**, 561-566.
- Murray, J.R., **Armitage, P.J.,** Ferrario, L. and Wickramasinghe, D. 1999, "Spiral Waves and Periodic Accretion in Intermediate Polars," in Proc. of *Annapolis Workshop on Magnetic CVs*, ed. C. Hellier, and K. Mukai, (ASP Conf. Ser. 157), p. 25-30.
- Murray, J.R., **Armitage, P.J.,** Ferrario, L. and Wickramasinghe, D. 1999, "The Effects of Tidally Induced Disc Structure on White Dwarf Accretion in Intermediate Polars," *M.N.R.A.S.*, **302**, 189-196.

- Murray, N.**, and Holman, M. 1999, "The origin of chaos in the outer solar system," *Science*, **283** 1877-1881.
- Murray, N.**, Holman, M., and **Potter, M.** 1998, "On the origin of chaos in the asteroid belt," *A.J.*, **116** 2583-2589.
- Myers, P., & **Lazarian, A.** 1998, "Turbulent Cooling Flows in Molecular Clouds," *Ap. J.Lett.*, **507**, 157-160.
- Natarajan, Priyamvada** 1999, "Consequences of feedback from early supernovae for disk assembly," *Ap. J. Lett.*, **512**, 105-108.
- Natarajan, Priyamvada** 1999, "Accretion history of supermassive black holes," in *Astrophysical Disks - An EC Summer School*, ed. Sellwood & Goodman, ASP. Conf. Series, Vol. 160, pg. 297-306.
- Natarajan, Priyamvada** 1999, "Gravitational lensing as a probe of dark matter," in Proceedings of *COSMO-98: International Workshop on Particle Physics and the Early Universe*, Asilomar, California.
- Natarajan, Priyamvada** 1999, "Massive X-ray binaries and the X-ray background," in Proc. of the October conference in Maryland, *When galaxies were young*, College Park, Maryland.
- Natarajan, Priyamvada** 1999, "Stellar contributors to the X-ray background?" *M.N.R.A.S.*, submitted.
- Natarajan, Priyamvada**, and **Armitage, P.J.** 1999, "Warped discs and the directional stability of jets in Active Galactic Nuclei," *M.N.R.A.S.*, submitted.
- Natarajan, Priyamvada**, and J. E. Pringle 1998, "The alignment of disk and black hole spins in active galactic nuclei," *Ap. J. Lett.*, **506**, 97-100.
- Normandeau, M., and **Basu, S.** 1999, "Observations and Modeling of the Disk-Halo Interaction in our Galaxy," in ASP Conf. Series No. 168, *New Perspectives on the Interstellar Medium*, eds. A. R. Taylor, T. L. Landecker, and G. Joncas, (San Francisco: ASP), p. 287-298.
- Pen, U.** 1998, "A High-resolution Adaptive Moving Mesh Hydrodynamic Algorithm," *Ap. J. Sup.*, **115**, 19-34.
- Pen, U.** 1998, "Normalizing the Temperature Function of Clusters of Galaxies," *Astrophysical Journal*, **498**, 60-66.
- Pen, U.** 1998, "Reconstructing Non-linear Stochastic Bias from Velocity Space Distortions," *Ap. J.*, **504**, 601-606.
- Pen, U.** 1999, "Application of Wavelets to Filtering of Noisy Data," *Phil. Trans. Roy. Soc. London*, in press.
- Pen, U.** 1999, "Brief Note: Analytical Fit to the Luminosity Distance for Flat Cosmologies with a Cosmological Constant," *Ap. J. Sup.* in press.
- Pen, U.** 1999, "Heating of the IGM," *Ap. J. Let.*, **510**, L1-L5.
- Pen, U.**, Loeb, A. and Turok, N. 1998, "Gamma Ray Bursts from Baryon Decay in Neutron Stars," *Ap. J.*, **509**, 537-543.
- Pogosyan, D.**, **Bond, J.R.**, **Kofman, L.** **Wadsley, J.W.** 1998, "Cosmic Web: Origin and Observables," in "Wide Field Surveys in Cosmology", Proc. XIV IAP Colloquium Conf., ed. S. Colombi & Y. Mellier, (Paris: Editions Frontieres), p. 61, astro-ph/9810072
- Prunet, S.**, Blanchard, A. 1999, "Warm photo-ionized IGM: a clue for galaxy and cluster formation history?" *Astron. Astrophys.*, submitted.
- Prunet, S.**, & **Lazarian, A.** 1999, "Polarized Foreground from thermal dust emission," in "Microwave Foregrounds" (in press).
- Prunet, S.**, Sethi, S.K., Bouchet, F.R. 1999, "CMB Polarization Data and Galactic Foregrounds: Estimation of Cosmological Parameters," *Astron. Astrophys.*, submitted.
- Prunet, S.**, Sethi, S.K., Bouchet, F.R., Miville-Deschênes, M.A. 1998, "Galactic dust polarized emission at high latitudes and CMB polarization," *Astron. Astrophys.*, **339**, 187.
- Richer, H.B., **Hansen, B.M.S.**, Limongi, M., Chieffi, A., Straniero, O. & Fahlman, G.G. 1999, "Isochrones and Luminosity Functions for Old White Dwarfs," *Ap. J.*, submitted.
- Richstone, D., Ajhar, E.A., Bender, R., Bower, G., Dressler, A., Faber, S.M., Filippenko, A.V., Gebhardt, K., Green, R., Ho, L.C., Kormendy, J., Lauer, T.R., **Magorrian, J.** and **Tremaine, S.** 1998, "Supermassive Black Holes and the Evolution of Galaxies," *Nature*, 395A, 14-19.
- Rines, K., Forman, W., **Pen, U.**, Jones, C. 1999, "Determination of  $\Omega$  from the Cluster Gas Mass Fraction," *Ap. J.*, submitted.
- Roberge, W., & **Lazarian, A.** 1999, "Davis-Greenstein alignment of oblate spheroidal grains," *M.N.R.A.S.*, **305**, 615-635.
- Rubin, R. H., **Martin, P.G.**, Dufour, R. J., Ferland, G. J., O'Dell, C. R., Baldwin, J. A., Hester, J. J., & Walter, D. K. 1998, "Temperature Variations and N/O in the Orion Nebula from HST Observation," *Ap. J.*, **495**, 891-904
- Soccimarro, R.** 1998, "Transients from Initial Conditions: A Perturbative Analysis," *M.N.R.A.S.*, 299, 1097.
- Soccimarro, R.**, Colombi, S., Fry, J.N., Frieman, J. A., Hivon, E. and Melott, A. 1998, "Non-Linear Evolution of the Bispectrum of Cosmological Perturbations," *Ap. J.*, 496, 586.
- Soccimarro, R.**, Couchman, H., and Frieman, J.A. 1999, "Hyperextended Cosmological Perturbation Theory: Predicting Non-Linear Clustering Amplitudes," *Ap. J.*, in press.
- Soccimarro, R.**, Couchman, H., and Frieman, J.A. 1999, "The Bispectrum as a Signature of Gravitational Instability in Redshift-Space," *Ap. J.*, 517, 531.
- Soccimarro, R.**, Zaldarriaga, M., and Hui 1999, L., "Power Spectrum Correlations Induced by Non-Linear Clustering," *Ap. J.*, in press.
- Souradeep, T.**, **Bond, J.R.**, **Knox, L.** and Efstathiou, G. and Turner, M. 1998, "Prospects for measuring Inflation parameters with the CMB," in Proc. of *COSMO-97* ed. L. Roszkowski, (World Scientific), p. 389-391.
- Souradeep, T.**, **Pogosyan, D.** and **Bond, J.R.** 1998, "Probing Cosmic topology using CMB anisotropy," in Proc. of *XXXIIIrd Recontres de Moriond, 'Fundamental Parameters in Cosmology'*, ed. J. Tran Thanh Van, Y. Giraud-Heraud, F. Bouchet, T. Damour, Y. Mellier (Editions Frontieres), p. 131-134.
- van Hoof P.A.M.** 1998, "A Comprehensive Line List for Atomic Transitions on the WWW," in *Stellar Evolution, Stellar Explosions, and Galactic Chemical Evolution*, ed. Mezzacappa A., IOP Publishing, Bristol, p. 67.

- van Hoof P.A.M.** 1999, "Measuring Angular Diameters of Extended Sources; I. Theory," University of Kentucky, Dept. of Physics and Astronomy, Internal Report (astro-ph/9906051).
- van Hoof P.A.M.** 1999, "Measuring Angular Diameters of Extended Sources; II. Application to Observational Data," *M.N.R.A.S.*, submitted. van Hoof, P.A.M., Van de Steene, G.C., Beitema, D.A., **Martin**, P.G. 1999, Pottasch, S.R., & Ferland, G.J., "Properties of Dust Grains in Planetary Nebula. I. The Ionized Region of NGC 6445," *Ap. J.*, in press
- van Hoof P.A.M.**, Van de Steene G.C. 1999, "Photo-Ionization Modelling of Planetary Nebulae; I. Modelling of Very Low Excitation Nebulae," *M.N.R.A.S.*, submitted.
- van Hoof P.A.M.**, Van de Steene G.C., Beintema D.A., **Martin P.G.**, Pottasch S.R., **Ferland G.J.** 1999, "Properties of Dust Grains in Planetary Nebulae; I. The Ionized Region of NGC 6445," *Ap. J.*, submitted.
- van Hoof P.A.M.**, Van de Steene G.C. 1999, "Photo-Ionization Modelling of Planetary Nebulae; II. Galactic Bulge Nebulae, a Comparison with Literature Results," *M.N.R.A.S.*, in press.
- van Hoof P.A.M.**, Van de Steene G.C., Beintema D.A., **Martin P.G.**, Pottasch S.R., **Ferland G.J.** 1999, "Properties of the Dust Emission of the Planetary Nebula NGC 6445," in *The Universe as seen by ISO*, ESA Publications, Noordwijk, in press.
- Van Waerbeke, L.** 1998, "Measuring Galaxy Biasing with Gravitational Weak Lensing," in Proc. of *Wide Field Surveys in Cosmology*, ed. S. Colombi and Y. Mellier (Frontière), p. 189.
- Van Waerbeke, L.** 1999, "Accuracy of Gravitational Lens Mass Reconstruction," *M.N.R.A.S.*, in press.
- Van Waerbeke, L.** 1999, "Gravitational Lensing," in Proc. of *Gravitational waves and experimental gravity*, ed. Frontière.
- Van Waerbeke, L.**, Bernardeau, F. and Mellier, Y. 1999, "Efficiency of Weak Lensing Surveys to Probe Cosmological Models," *Astron. Astrophys.*, **342**, 15-33.
- Van Waerbeke, L.**, Bernardeau, F. and Mellier, Y. 1999, "Efficiency of Weak Lensing Surveys to Probe Cosmological Models," in Proc. of *19th Texas Symposium on Relativistic Astrophysics and Cosmology*, ed. J. Paul, T. Montmerle, and E. Aubourg (CEA Saclay), p. 302.
- Vishniac, E., & **Lazarian, A.** 1998, "Reconnection in ISM," *Ap. J.*, **511**, 193-203.
- Vishniac, E., **Lazarian, A.** 1999, "Reconnection in ISM," *B.A.A.S.*, Vol. 30, No. 4, 1377.
- Widrow, L. M., & **Dubinski, J.** 1998, "Searching for MACHOS in a Simulated Galaxy," in *Galactic Halos: A UC Santa Cruz Workshop*, Santa Cruz 11-15 August 1997, ed. Dennis Zaritsky, ASP, 136, 344.
- Widrow, L.M. and **Dubinski, J.** 1998, "Searching for Machos and other Dark Matter Candidates in a Simulated Galaxy," *Ap. J.*, 504, 12.
- Wiegert, P.**, Innanen, K. and Mikkola, S. 1998, "The Orbital Evolution of Near-Earth Asteroid 3753 (1986 TO)," *A. J.* **115**, 2604-2613.
- Wiegert, P.**, Innanen, K. and Mikkola, S. 1999, "Earth Trojan asteroids: a study in support of observation searches," *Icarus*, submitted.
- Wiegert, P.** and Tremaine, S. 1999, "The Evolution of Long-Period Comets," *Icarus*, **137**, 84-121.
- Wills, B.J., A. Laor, M. Brotherton, D. Wills, B. Wilkes, G. **Ferland**, & Z Shang 1999, "The PG X-Ray QSO Sample: Links between the Ultraviolet-X-Ray Continuum and Emission Lines," *Ap. J.*, 515L, 53-56

Doug Johnstone  
John Dubinski

