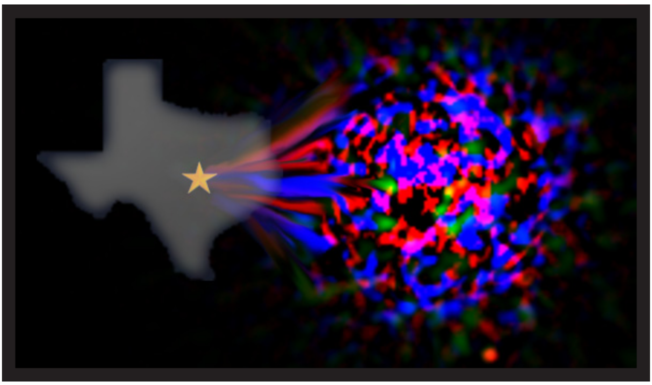
Frank N. Bash Symposium
2009



October 18-20, 2009

New Horizons in Astronomy

University of Texas at Austin
Avaya Auditorium
ACES 2.302

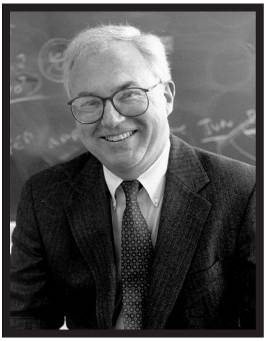
Frank N. Bash Symposium 2009
Sponsored by the Board of Visitors

We would like to thank The McDonald Observatory and Astronomy Department Board of Visitors (BoV) for their generous contributions that made this event possible.

The BoV includes business leaders, educators, attorneys, scientists, artists, architects, and engineers. In fact, this diversity is considered one of the greatest strengths of the Board of Visitors. While many BoV members share an interest in amateur astronomy, few have specialized knowledge of the subject. They all, however, share the love of astronomy as a science that explores and expands the frontiers of human knowledge.

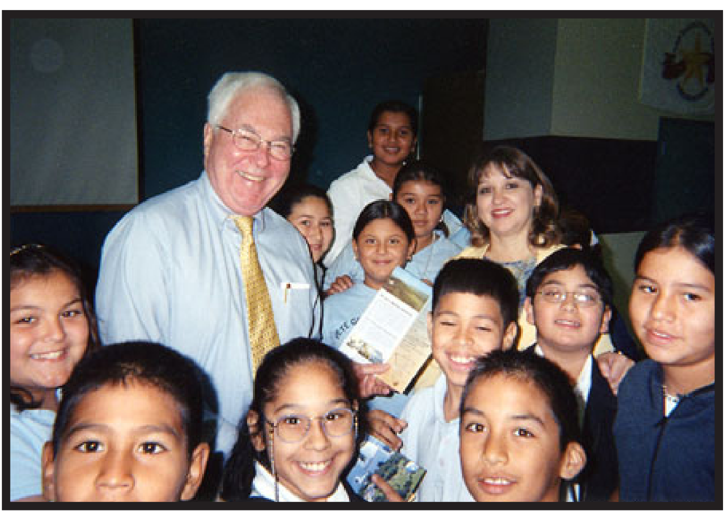
Private philanthropy created the Observatory, and it has continued to play a major role in sustaining the excellence of the program. Private giving supports faculty chairs and awards, graduate student endowments, workshops for K-12 educators, standards-based programs (both onsite and via video conference) for K-12 students. It also helps recruit top astronomy graduate students, supports an annual teaching excellence award, funds undergraduate scholarships, and provides development seed money. In addition various BoV committees assist the group and the Observatory in their work. This includes the *HETDEX Advancement Task Force* which is working to raise funds for The McDonald Observatory's Dark Energy Experiment.

Dean Mary Ann Rankin says, of the Board of Visitors, "The involvement of the McDonald Observatory Board of Visitors in supporting the Astronomy Program at UT is absolutely critical for our success. I deeply appreciate [BoV] support to allow us to continue our mission to provide excellent, research-oriented education in astronomy and to discover important new knowledge through our continuing research program."



Frank Bash joined the faculty of the University of Texas at Austin in 1969. In 1985, he was named the Frank N. Edmonds Regents Professor of Astronomy. His research focused on large-scale star formation processes in spiral galaxies. Dr. Bash has won numerous awards for the quality of his teaching, and was named to the teaching excellence Hall of Fame at UT Austin in 1984.

As the Director of McDonald Observatory from 1989-2003, Bash led the effort for the design, funding and construction of the 11-meter Hobby-Eberly Telescope at the Observatory in West Texas. The telescope, optimized for spectroscopy, was dedicated in 1997, and it has the largest primary mirror in the world. He also led the work to expand the public outreach programs of the Observatory. These programs include the Observatory's Frank N. Bash Visitors Center, the Texas Astronomy Education Center and Stardate radio broadcast. Before retiring, he devoted most of his time to teaching popular undergraduate astronomy classes.



McDONALD OBSERVATORY
THE UNIVERSITY OF TEXAS AT AUSTIN®

The second biennial symposium on the topic of

New Horizons in Astronomy

brings active young researchers working on frontier topics in astronomy and astrophysics together to exchange research idea, experiences, and share their visions for the future. The symposium will focus on invited review talks given by postdoctoral fellows, followed by open panel discussions, and a limited number of poster papers from postdoctoral fellows and graduate students.

This symposium is held in honor of Professor Frank N. Bash to acknowledge his commitment to the future of astronomy through the support of postdoctoral fellows and graduate students.

Sunday 18th October

7:30	Reception (Appetizers and drinks) Etter-Harbin Alumni Center, UT Austin Campus

Monday 19th October

9:00	Welcoming Statements *Neal Evans, Chairman, Department of Astronomy* *Peter Riley, College of Natural Sciences* Avaya Auditorium, ACES 2.302, UT Campus

Session I (ACES 2.302)

Chair: Neal Evans

9:20-10:00	Young Star/Protostellar Evolution *Manoj Puravankara, University of Rochester*	
10:00-10:40	Planets *Ruth Murray-Clay, CfA*	
10:40-11:20	Coffee Posters	ACES Connector Lobby ACES 2.402
11:20-12:00	AGB Stars *Jason Nordhaus, Princeton*	
12:00-12:40	Supernova *Maryam Modjaz, UC Berkeley*	
12:40-2:10	Lunch* and posters *Includes a 1 hour Q&A session with postdoc speakers and graduate students.	

Monday 19th October

Session II

Chair: Craig Wheeler

2:10-2:50	GRB (accretion discs) & Compact Objects *Brian Metzger, UC Berkeley*	
2:50-3:30	Micro-Poster Presentations *Multiple speakers*	
3:30-4:00	Coffee Posters	ACES Connector Lobby ACES 2.402
4:00-4:40	ISM, ALMA & Herschel *Thomas Greve, MPIA*	
4:40-5:20	Posters, Informal Discussion	
7:00	Conference Dinner & Talk *Professor Hans Mark, University of Texas* Clay Pit 1601 Guadalupe St Austin	

Tuesday 20th October

Session III

Chair: Frank Bash

9:00-9:40	Long Baseline Optical & Near-IR Interferometry *Tabetha Boyajian, Georgia State*	
9:40-10:20	Missing Satellite Problem, Local Group Dwarfs *Josh Simon, OCIW Carnegie Observatory*	
10:20-11:00	Coffee Posters	ACES Connector Lobby ACES 2.402
11:00-11:40	N-body Galaxy Formation, Cold Flow Accretion *Alyson Brooks, Caltech*	
11:40-12:20	Lyman-alpha Emitters *Steven Finkelstein, Texas A&M*	
12:20-1:50	Lunch* & Posters *Includes a 1 hour Q&A session with postdoc speakers and graduate students	

Tuesday 20th October

Session IV

Chair: Eiichiro Komatsu

1:50-2:30	Dark Matter, Theory *Pearl Sandick, University of Texas*	
2:30:3:20	Beyond the power spectrum: primordial and secondary non-Gaussianity in the CMB *Kendrick Smith, Princeton*	
3:20-4:10	Coffee Posters	ACES Connector Lobby ACES 2.402
4:10-5:00	Cosmic Reionization and 21cm Cosmology *Matt McQuinn, CfA*	
5:00-5:30	The Astronomy Job Market Discussion *Peter Yoachim, moderator*	
5:30-6:00	Concluding Remarks *Frank Bash*	

Presentation Abstracts

Young Star/Protostellar Evolution

Manoj Puravankara, University of Rochester

In this talk I will briefly review the recent advances made in the field of star and planet formation. In particular, I will focus on the recent results from the Spitzer observations of young protoplanetary disks and their implications for disk evolution and planet formation.

Planets

Ruth Murray-Clay, CfA

With almost 400 planets currently known, the study of extra-solar planetary systems has blossomed into a rich field. Still, large classes of planets are predicted to exist but remain to be discovered. I will review the state of exoplanetary science and focus on three observational driven frontiers, each offering an exciting window into both the phenomenological question of what types of planets and planetary systems exist and the theoretical question of how they came to be. Massive planets at wide separations from their host stars have been directly imaged. Ever smaller planets are being detected as they transit their stars, with the discovery of an Earth-like planet possible in the next few years. And finally, proto-planetary and debris disks and small bodies in our solar system provide tracers of planets and probes of proto-planetary material. I will discuss how the interplay between theory and observation at these frontiers promises to clarify and expand our understanding of the formation and evolution of planetary systems.

AGB Stars

Jason Nordhaus, Princeton

This talk touches on topics in low-mass and high-mass evolved star physics. For low-mass stars, recent evidence suggests that binary interactions play a substantial and necessary role in producing bipolarity in planetary nebulae. I will discuss mechanisms for shaping mass-loss including common envelopes, tidal interactions and large-scale magnetic fields. For high-mass stars, I will present new results in core collapse supernovae theory. In particular, I will focus on pulsar kicks and detail first results from our new 3d radiation-hydrodynamics code CASTRO.

Supernova

Maryam Modjaz, UC Berkeley

Massive stars die violently. Their explosive demise gives rise to brilliant fireworks that constitute supernovae and long GRBs, and that are seen over cosmological distances. However, we still do not fully understand the conditions that lead to each kind of explosion in a massive star with significant mass loss. I will discuss a number of observational venues that attempt to probe the progenitors and explosion conditions of SN, GRB and SN-GRBs. Specifically I will discuss SN 2008D, which was discovered serendipitously in January 2008 with the NASA Swift satellite via its X-ray emission and has generated great interest by astronomers (10 papers and counting). I will discuss the significance of this SN, whether it harbored a jet, and its implications for the SN-GRB connection.

GRB (accretion discs) & Compact Objects

Brian Metzger, UC Berkeley

Despite being discovered over forty years ago, Gamma-Ray Bursts (GRBs) remain one of the forefront mysteries in astrophysics. Although the past few decades of observations have revealed much about these enigmatic events, with the most recent advances thanks to the Swift and Fermi satellites, a number of key questions remain unanswered. One of the most fundamental questions associated with GRBs is the nature of the astrophysical agent (or agents) that ultimately powers them: the central engine. In this review, I will focus on the possible central engines of both long and short duration GRBs, and the constraints that present observations place on these models. Long-duration GRBs are definitively associated with the deaths of massive stars, but whether the central engine is an accreting black hole or a rapidly-spinning neutron star remains unsettled. Thanks to Swift we now appreciate that short-duration GRBs are associated with a more evolved progenitor population than long GRBs, but their origin remains even more enshrouded in mystery. I will discuss the most well-studied model for short GRBs: accretion following the coalescence of neutron star/black hole binaries. I will describe both the successes and problems with this model in light of recent observations, as well as some promising alternative ideas.

ISM, ALMA & Herschel

Thomas Greve, MPIA

The interstellar medium (ISM) contains the gas that fuels star formation as well as accretion onto supermassive black holes (SMBHs) in galaxies. As such the ISM is a key piece in the puzzle of galaxy formation and evolution: how and when did the first galaxies and their SMBHs form, and what physical processes regulate the star formation rate and black hole accretion? Finding the answers to these fundamental questions constitute the overarching challenge for extragalactic astronomy in the years to come, and will require characterizing in detail the microscopic (e.g. densities, temperatures, abundances) and macroscopic (e.g. star formation, morphology, kinematics) physical properties of the ISM in galaxies across cosmic time - from the first proto-galaxies emerging less than one billion years after the Big Bang to starburst galaxies in our cosmic backyard. The Atacama Large Millimeter Array (ALMA) and the recently launched Herschel Space Telescope are major facilities specifically designed to study the gas and dust content in galaxies, and in this talk I will outline how they, each in their own unique way, will have a ground-breaking impact on this endeavour.

Long Baseline Optical & Near-IR Interferometry

Tabetha Boyajian, Georgia State

A review of advances in the field of long baseline, optical and near-IR interferometry. One gains high spatial resolution in astronomical observations through the use of an interferometer, and today, acquiring sub-milliarcsecond resolution images of celestial objects is readily doable. With the advances of long baseline, optical and near-IR interferometry in recent years, we have revisited the field of fundamental astrophysics, adding a wealth of knowledge about stars otherwise unresolved with ordinary telescopes. For nearby, bright stars, this includes accurately measuring their sizes, temperatures, and masses. Additionally, when imaging stars with interferometry we are able to see temperature gradients, spots, disks, mass transfers, and spatial distortions (oblateness) due to rapid rotation.

Missing Satellite Problem, Local Group Dwarfs

Josh Simon, OCIW Carnegie Observatories

The recent discovery by the Sloan Digital Sky Survey of a large new population of dwarf galaxies near the Milky Way has completely changed our picture of star formation in low-mass dark matter halos. I will review the latest observations of these ultra-faint dwarfs, particularly their masses and metallicities, and consider the implications for the missing satellite problem. The SDSS results point to a clear way forward: upcoming deeper surveys will reveal the remainder of the Milky Way's dwarf satellites, and accurate mass measurements for the full population will then determine whether these systems account for all of the dwarf galaxies expected in ΔCDM.

N-body Galaxy Formation, Cold Flow Accretion

Alyson Brooks, Caltech

Cold gas accretion, particularly along filaments, modifies the standard picture of shocked gas accretion and cooling onto galaxy disks. Even when a hot halo is able to develop in more massive galaxies, there exist dense filaments that penetrate inside of the virial radius and deliver cold gas to the central galaxy, leading to star formation at higher redshifts than predicted by the standard model. For galaxies up to ~L*, cold accretion gas is responsible for the star formation in the disk at all times to the present. In concert with supernovae feedback, star formation in the disk is regulated, leading to the development of a cold gas reservoir that helps to quickly reform disks despite disruption in major mergers. I will highlight the necessity of both 1) a physically motivated prescription for star formation and feedback and 2) very high numerical resolution in fully cosmological simulations to achieve a successful model for the formation of disk galaxies.

Lyman-alpha Emitters

Steven Finkelstein, Texas A&M

As some of the first known objects to exist in the Universe, Lyman alpha emitting galaxies (LAEs) naturally draw a lot of interest. First discovered over a decade ago, they have allowed us to probe the early universe, as their strong emission line compensates for their faint continuum light. While initially thought to be indicative of the first galaxies forming in the universe, recent studies have shown them to be increasingly complex, as some fraction appear evolved, and many LAEs appear to be dusty, which one would not expect from primordial galaxies. Presently, much interest resides in discovering not only the highest redshift LAEs to constrain theories of reionization, but also pushing closer to home, as typical ground-based studies have only found LAEs at $z > 3$ due to observational limitations. In this review talk I will cover everything from the first theoretical predictions of LAEs, to their future prospects for study, including the HETDEX survey here in Texas.

Dark Matter, Theory

Pearl Sandick, University of Texas at Austin

I review the phenomenology of particle dark matter and the properties of some of the most popular dark matter candidates. Recent developments in direct and indirect dark matter searches are discussed.

Beyond the power spectrum: primordial and secondary non-Gaussianity in the CMB

Kendrick Smith, Princeton

Measurements of the power spectrum, or two-point function, of the cosmic microwave background have had an enormous impact on cosmology during the last 20 years. To a good approximation, the CMB is a Gaussian field, which implies that all cosmological information is contained in its power spectrum. However, as future generations of experiments measure the CMB with increasing sensitivity, small non-Gaussian signals can be uncovered which contain qualitatively new information. Models of inflation with multiple fields, large interaction terms, or low sound speed can generate three-point correlations which can be classified and estimated from data. Secondary anisotropes generated after recombination such as gravitational lensing and reionization also imprint higher-point signals which can be statistically separated from each other. We will describe different sources of non-Gaussianity, statistical techniques, results from WMAP, and forecasts for upcoming experiments.

Poster Abstracts

Dark halo modeling with stellar kinematics in NGC 2976

Joshua J. Adams, University of Texas at Austin

We present integral field spectroscopy on the dwarf late-type galaxy NGC 2976. A previous model from the gas kinematics of NGC 2976 suggests it hosts a cored dark matter halo. NGC 2976 is the best studied out of a few dozen galaxies that have been modeled as having a cored dark matter halo. N-body galaxy formation simulations indicate contrarily that dissipationless dark matter halos should be cuspy. We investigate whether the stellar and gaseous kinematics tell the same story. Our data has 4”” resolution 30 km/s instrumental dispersion and extends across the galaxy to 2 kpc on each side of the major axis. We measure simultaneously the gaseous kinematics with [OII] and the stellar kinematics primarily around the G-band. We find that the two kinematic tracers do not agree. An alternate model in NGC 2976 with a bar disrupting the gas from circular rotation has previously been proposed and our data supports that case. Finally we give a new dark halo mass model based solely on our stellar kinematics and from solving the Jeans equations.

The Spatially Resolved Star Formation Law from Integral Field Spectroscopy: VIRUS-P Observations of NGC 5194

Guillermo A. Blanc, University of Texas at Austin

VIRUS-P integral field spectroscopy of the central 4.1 kpc x 4.1 kpc of NGC 5194 (M51) is used to measure H-alpha, H-beta, [NII]6548,6584, and [SII]6717,6731 emission line fluxes for 735 regions ~170 pc in diameter. We use the Balmer decrement to calculate nebular dust extinctions, and correct the observed fluxes in order to measure the SFR surface density in each region. HI 21cm and CO J=1-0 maps are used to measure the atomic and molecular gas surface densities. Line ratios are used to separate the contribution to the H-alpha flux from the DIG and the HII regions in the disk. We present a new method for fitting the Star Formation Law (SFL), which includes the intrinsic scatter in the relation as a free parameter and allows the inclusion of non-detections in both SFR and gas surface densities. After removing the DIG contribution from the H-alpha fluxes, we measure a slope N=0.82+/-0.05 and an intrinsic scatter epsilon=0.43+/-0.02 dex for the molecular gas SFL. We also measure a typical depletion timescale tau=2 Gyr, in good agreement with recent measurements by Bigiel et al. 2008. The disagreement with the previous measurement of a super-linear molecular SFL by Kennicutt et al. 2007 is most likely due to differences in the fitting method. Integral field spectroscopy allows a much cleaner measurement of H-alpha emission line fluxes than narrow-band imaging, since it is free of the systematics introduced by continuum subtraction, underlying photospheric absorption, and contamination by the [NII] doublet. The data shows an excellent agreement with the recently proposed model of the SFL by Krumholz et al. 2009. The large intrinsic scatter observed implies the existence of other parameters, beyond the availability of gas, which are important at setting the SFR.

Properties of over luminous SNe and peculiar transients

Emmanouil A. Chatzopoulos, University of Texas at Austin

We revisit the physical properties of the five brightest supernovae ever most of them discovered by the ROTSE collaboration and present results on the recently-discovered supernova SN 2008am an ultra-bright Type-IIn at a red shift of 0.234. We investigate a variety of models based on diffusion or shock interaction for each object. We also present analyses of the peculiar transient events SCP06F6 and a peculiar transient discovered by the ROTSE collaboration that has an unusual spectral and light curve evolution. This event is consistent with neither an AGN outburst nor a SN nor a tidal disruption event and its true nature remains a mystery.

A Cepheid Distance to the Antennae

Joy M. Chavez, Texas A&M University

An accurate measurement of the Hubble constant provides important constraints on the equation of state of dark energy. Currently the most robust determination of H0 is based on Cepheid distances to nearby type Ia supernovae. The occurrence of SN 2007sr in the Antennae (NGC 4038/39) provides an important additional calibrator for this method since this galaxy pair is within a distance that Cepheid variables can be resolved with HST. We have recently obtained a set of 12 epochs of WFPC2 images which we have analyzed using a previously obtained set of ACS data as reference. An earlier WFPC2 image was also included in our study. We present preliminary periods and magnitudes of Cepheids in this galaxy pair and derive a tentative distance.

Chemistry in Class 0/I protostars

Jo-Hsin Chen, University of Texas at Austin

We have surveyed 10 Class 0 objects and 8 Class I objects with 15 lines of 10 molecules. The depletion factor deuterium enhancement and ionization degrees are calculated to find correlations of their physical and chemical properties.

Investigating Timescales for Planet Formation in Ophiuchus

Casey P. Deen, University of Texas at Austin

The Ophiuchus cloud is an ideal laboratory to study the process of star and planet formation as it is one of the youngest (~1-3 Myr) and closest (120 pc) regions actively forming stars. We present results of a magnitude limited near IR spectroscopic study of the L1688 core. Using medium resolution (R~ 2000) 0.8-2.4 micron spectra we thoroughly characterize the photospheres in our sample in anticipation of studying how the properties of disks around these objects evolve with age. Our study uses higher resolution spectra and a wider near IR wavelength range than previous studies to determine spectral types independent of reddening and veiling in a consistent way for class II and III objects. Spectral types allow us to determine effective temperatures luminosities extinctions K-band veilings and accretion rates for most objects in our sample. We confirm one candidate class III object as a YSO and reject another as a background giant. We then place the objects on the HR Diagram to determine masses and ages. Even at the young age of Ophiuchus there is significant overlap in distribution of photospheric luminosities between class II and class III objects of the same spectral types.

Evolutionary Models of the Formation of Protostars out of Low-Mass Dense Cores: Towards Reconciling Models and Observations

Michael M. Dunham, University of Texas at Austin

We present a set of evolutionary models describing the collapse of low-mass dense cores into protostars. We use as our starting point the evolutionary model following the inside-out collapse of a singular isothermal sphere as presented by Young & Evans (2005). We calculate the radiative transfer of the collapsing core throughout the full duration of the collapse in two dimensions and from the results we calculate evolutionary indicators to directly compare to observations. We incorporate several modifications and additions to the original Young & Evans model in an effort to better match observations with model predictions: (1) we include the opacity from scattering in the radiative transfer (2) we include a circumstellar disk directly in the two-dimensional radiative transfer (3) we include a two-dimensional envelope structure taking into account the effects of rotation (4) we include mass-loss and the opening of outflow cavities and (5) we include a simple treatment of episodic accretion. We find that two-dimensional geometry mass-loss and outflow cavities all affect the model predictions as expected but none resolve the discrepancies between model predictions and observations specifically the long-standing luminosity problem whereby the models fail to capture all but the upper end of the distribution of observed sources in luminosity. On the other hand we find that a cycle of episodic mass accretion similar to that predicted by recent theoretical work can resolve this luminosity problem and bring the model predictions in better agreement with observations.

Spitzer Observations of Star Formation in Four HII Region Environments

Keely D. Finkelstein, Texas A&M University

We present an analysis of star formation in four galactic HII region environments using Spitzer IRAC and MIPS 24 micron observations. In each study young stellar objects (YSOs) are identified and the spatial distribution of these objects are measured. In order to classify the effect ionization fronts have on the star formation in these regions we calculate the distance of the YSOs from the ionization fronts identified in the region as well as to the nearby massive OB stars. The distributions show that there is a correlation between the locations where YSOs are forming and the locations of ionization fronts created by the nearby massive stars. A total of 624 YSOs were detected in the four regions. The candidate YSOs were classified into protostellar evolutionary classes based on their colors and spectral energy distributions (SEDs). An online YSO SED fitter from Robitaille et al. (2007) was used to analyze the physical properties of the YSOs. These properties along with the distribution of the YSOs are used to calculate the amount of triggered star formation occurring in each region. Calculated triggered star formation rates range from 14 - 58 percent of the total star formation rate demonstrating that triggering due to HII region expansion of new protostars is occurring in multiple H II regions and may be an important mode of star formation in these types of environments.

Cepheid and Long-Period Variables in NGC 4258

Samantha L. Hoffmann, Texas A&M University

We present preliminary results of a survey for Cepheids and long-period variables in NGC 4258. This galaxy plays a key role in the Extragalactic Distance Scale due to its very precise and accurate maser-based distance. Our observations were obtained at the Gemini North Observatory in the gri bands over 22 epochs spanning 4 years. We have discovered long-period Cepheids which we have used to extend the Period-Luminosity (PL) relation in this galaxy beyond its previous limit of P<45 days. This will enable a more accurate calibration of the PL relation in this important galaxy. Additionally we have identified long-period variables and present their properties.

Memory Effects in Turbulent Transport

Alexander Hubbard, Nordic Institute for Theoretical Physics

In the mean-field theory of magnetic fields, turbulent transport, i.e. the turbulent electromotive force, is described by a combination of the α effect and turbulent magnetic diffusion, which are usually assumed to be proportional respectively to the mean field and its spatial derivatives. For a passive scalar there is just turbulent diffusion, where the mean flux of concentration depends on the gradient of the mean concentration. However, these proportionalities are approximations that are valid only if the mean field or the mean concentration vary slowly in time. Examples are presented where turbulent transport possesses memory, i.e. where it depends crucially on the past history of the mean field. Such effects are captured by replacing turbulent transport coefficients with time integral kernels, resulting in transport coefficients that depend effectively on the frequency or the growth rate of the mean field itself. In this paper we perform numerical experiments to find the characteristic timescale (or memory length) of this effect as well as simple analytical models of the integral kernels in the case of passive scalar concentrations and kinematic dynamos. The integral kernels can then be used to find self-consistent growth or decay rates of the mean fields. In mean-field dynamos the growth rates and cycle periods based on steady state values of α effect and turbulent diffusivity can be quite different from the actual values.

The Hunt for the First Supernovae

Jacob A. Hummel, University of Texas at Austin

Theoretical models predict the supernova explosions ending the lives of some of the first stars to have been extremely energetic pair instability supernovae (PISNe) with energies approaching 1053 ergs. Detecting these first supernovae and the first luminous sources in general is one of the key objectives of the upcoming James Webb Space Telescope. With this in mind we present effective search strategies and carry out an improved calculation of the source density based on realistic cosmological simulations.

New Constraints on the self-interacting cold dark matter (SIDM) model from a comparison of galaxy and cluster observations with an improved theory

Jun Koda, University of Texas at Austin

We study the effect of Self-Interacting Dark Matter (SIDM) hypothesis on the density profiles of halos. Collisionless CDM predicts cuspy density profiles toward the center while observations of low mass galaxies prefer cored profiles. SIDM has been proposed as a possible solution to this cuspy core problem on low-mass scales. On the other hand observations and collisionless CDM agree on mass scales of galaxy clusters. It is also known that the SIDM hypothesis contradicts with X-ray and gravitational lensing observations of cluster of galaxies if the cross section were too large. Our final goal is to find the range of SIDM scattering cross section models that are consistent with those astrophysical observations in two different mass scales. There are two theoretical approaches to compute the effect of self-interacting scattering -- Gravitational N-body simulation with Monte Carlo scattering and the conducting fluid model; those two approaches however had not been confirmed to agree with each other. We first show that two methods are in reasonable agreement with each other for halos with realistic mass assembly history in an expanding LCDM universe the value of cross section necessary to have a maximally relaxed low-density core in LCDM is in mutual agreement. We then develop a semianalytic model that predicts the time evolution of SIDM halo. Our semianalytic relaxation model enables us to understand how a SIDM halo would relax to a cored profile and obtain an ensemble of SIDM halos from simulations without scatterings with reasonable computational resources. We apply the semianalytic relaxation model to CDM halos and compare the resulting statistical distribution of SIDM halos with astrophysical observations. Our results improve the constraints on SIDM cross section from observations of relaxed galaxy clusters. We show that there exists a range of scattering cross section that simultaneously solve the cuspy core problem on low-mass scales and satisfy the galaxy cluster observations.

The Properties of Local Barred Disks in the Field and Dense Environments: Implications for Galaxy Evolution

Irina S. Marinova, University of Texas at Austin

Recent results suggest that major mergers play a less important role in driving galaxy evolution since z~2 than previously thought. Instead more quiescent processes such as minor mergers and internal secular evolution may play an important part in galaxy assembly and activity. Bars are the most important internal drivers of evolution and a key step in quantifying the effects of bar-driven secular evolution over the past 8 Gyr is to determine the frequency and properties of bars in the local Universe in both the field and in dense environments. We present results from three studies: Marinova & Jogee 2007 Barazza Jogee & Marinova 2008 and Marinova et al. and STAGES collaboration (2009). We find that the bar fraction among intermediate Hubble types at z~0 based on ellipse fits is 44% in the optical and 60% in the NIR giving an extinction correction factor of approximately 1.4 at z~0. We find that at z~0 most (68% in the optical and 76% in the NIR) bars have sizes below 5 kpc. If such a distribution of bar sizes is present at a redshift z~1-2 then only observations with angular resolutions better than 0.3 arcsec can adequately resolve the majority of bars. We also explore the properties of barred disks in the Abell 901/902 cluster system at z~0.165 from the HST ACS survey STAGES. We find that the optical bar fraction is a strong trend of both absolute magnitude and morphological type increasing for galaxies that are brighter and/or more disk-dominated. The latter trend is also found in the field from SDSS. In addition to having implications for theoretical models of disk galaxy evolution we discuss how our results provide a low-redshift reference point for ACS surveys out to z=1 in rest-frame optical and for WFC3 and JWST surveys out to z~3 in the rest-frame NIR.

Exploring Correlations Between Near Infrared Spectral Features and the Intrinsic

Howie Marion, University of Texas at Austin/TAMU

We compare measurements of absorption features in a sample of 35 near infrared (NIR) spectra from Type Ia supernovae (SNe) and the intrinsic brightness of the supernovae as characterized by the light curve parameter Î”m15(B). We find that the line depths of OI and MgII features become deeper as Î”m15(B) increases. Thus spectra from faster declining (intrinsically dimmer) SNe Ia display stronger signatures of OI and MgII than found in spectra from slower decliners. CaII absorption does not exhibit this correlation. OI and MgII are nuclear burning products created under burning conditions of lower temperatures and densities such as may be found in the outer layers of the progenitor. The spectra in this sample were obtained between -11d and +6d with respect to the date of Bmax during which time a SN Ia has a well defined photosphere in the outer layers of the explosion envelope.

Results from the Freshman Research Initiative Astronomy Stream

Michael H. Montgomery, University of Texas at Austin

We present results from the first year of the Astronomy Stream of the Freshman Research Initiative at the University of Texas. This program is designed to involve freshmen directly in our research on white dwarf stars. We describe the progress the students have made in the last year on (a) planet detection using pulsating white dwarfs including identifying a promising new candidate (b) improving our data analysis techniques (c) updating our web page interface for remote participation and (d) making preliminary calculations for 3D hydrodynamic modeling of convection in white dwarf stars.

Keeping the Universe ionized: Photo-heating and the clumping factor of the high-redshift intergalactic medium

Andreas H. Pawlik, University of Texas at Austin

The critical star formation rate density required to keep the intergalactic hydrogen ionised depends crucially on the average rate of recombinations in the intergalactic medium (IGM). This rate is proportional to the clumping factor C = <rho_b^2> / avg(rho_b)^2, where rho_b and avg(rho_b) are the local and cosmic mean baryon density, respectively, and the brackets < > indicate spatial averaging over the recombining gas in the IGM. We perform a suite of cosmological smoothed particle hydrodynamics simulations that include radiative cooling to calculate the volume-weighted clumping factor of the IGM at redshifts z >= 6. We focus on the effect of photo-ionisation heating by a uniform ultra-violet background and find that photo-heating strongly reduces the clumping factor because the increased pressure support smoothes out small-scale density fluctuations. Because the reduction of the clumping factor makes it easier to keep the IGM ionised, photo-heating provides a positive feedback on reionisation. We demonstrate that this positive feedback is in fact very strong: even our most conservative estimate for the clumping factor (C ≈ 6) is five times smaller than the clumping factor that is usually employed to determine the capacity of star-forming galaxies to keep the z = 6 IGM ionised. Our results imply that the observed population of star-forming galaxies at z ≈ 6 may be sufficient to keep the IGM ionised, provided that the IGM was reheated at z & 9 and that the fraction of ionising photons that escape the star-forming regions to ionise the IGM is larger than ≈ 0.2.

Testing a New Method of Detecting RR Lyrae Variable Star

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We have submitted for publication a new method of selecting candidate RR Lyrae stars using out-of-phase single epoch photometric and spectroscopic observations contained in SDSS Data Release 6 (DR6). The technique detects variability by exploiting the large disparity between the (g - r) color and the strength of the Hydrogen Balmer lines when the two observations are made at random phase. The SDSS Stripe 82 allowed us to show that our method has a discovery efficiency of ~85%. This technique has yielded over a thousand candidates fainter than g = 14.5. We present the results of observations of several of these candidates made on the 0.8m telescope at McDonald Observatory with 10 of 11 confirmed as variable and one labeled as a likely RRc. We also examine the use of clumping in the suspected variables to probe galactic structure both known and new.

Vortices (and the Angular Momentum Problem) in Bose-Einstein-Condensed Cold Dark Matter Halos

Tanja Rindler-Daller, University of Cologne

Several suggestions have appeared in the literature that cold dark matter (CDM) may be in the form of a Bose-Einstein condensate (BEC), including axionic and other forms of CDM. This has important implications for the physics of structure formation, notably at small scales where one expects significant deviations from the more standard CDM, due to the superfluidity exhibited by BECs. However, even on the scales of individual galactic halos, the issue of acquiring angular momentum during galaxy formation is affected. Laboratory BECs are known to develop vortices when rotated with sufficient angular velocity. In cosmology, simulations of structure formation in the CDM model show that halos acquire angular momentum as they form, consistent with that expected from gravitational tidal torquing by the surrounding large-scale structure. Vortices could, in principle, then result if the CDM is a BEC. We address this point by calculating the critical angular velocity for vortex creation in some simple models of BEC/CDM galactic halos and comparing the results with the angular velocity expected from cosmological N-body simulations of CDM. We start from the Gross-Pitaevskii equation of motion for the BEC wave function, coupled self-consistently to the Poisson equation, to describe self-gravitating BEC halos of ellipsoidal shape with varying degrees of rotational support. The implications of these results for cosmological models of CDM involving BECs will be discussed.

Testing GM=tc3 Variation in Space/Time

Louisa M. Riofrio, Oceaneering Space Systems, NASA Johnson Space Center

A cosmology of scale R=ct suggests that speed of light is further related to t by GM=tc3. These expressions form a solution to Einstein-Friedmann equations with k=0. Previous work suggested a solution to cosmological puzzles like the apparent acceleration of Type Ia supernovae and predicted 4.507034% baryons. Data using the Lunar Laser Ranging Experiment and the “”Faint Young Sun”” suggest that speed of light c may vary as predicted. In Planck units M=R=t may be considered an alternative to more speculative energies.

Characterizing the Chemistry of the Milky Way Stellar Halo: Detailed Chemical Abundances in a Metal-Poor Stellar Stream

Ian U. Roederer, University of Texas at Austin

To what extent does stellar nucleosynthesis trace the hierarchical merger history of the Galaxy and to what degree is it necessary to know the kinematics of a star in order to correctly interpret its chemical enrichment history? We examine the composition of one of the confirmed building blocks of the halo a stellar stream. Chemically the stream does not resemble any present-day Milky Way dwarf galaxies. The stream may share a common origin with the globular cluster M15 which has similar kinematics and whose stars show unusually large variations in bulk neutron-capture enrichment relative to other metal poor globular clusters.

Fate of Cold Flow Accretion Streams into the First Galaxies

Chalence T. Safranek-Shrader, University of Texas at Austin

Motivated by recent simulations of galaxy formation in which protogalaxies acquire their baryonic content through cold accretion, we study the gravitational fragmentation of cold streams flowing into a typical first galaxy at high redshift (z ~ 10-20) to predict the expected fragmentation mass scale and thus a characteristic mass of the first population of stars to form by shock fragmentation. Our model accurately describes the chemical and thermal evolution of gas as we are specifically concerned with how the chemical abundance and initial conditions of low density, metal enriched, cold accretion streams following an accretion shock will alter cooling properties and tendency to fragment. The cold flows shock heat close to the center of the protogalaxy, isobarically cool, and subsequently fragment. Without molecular cooling, we find there to be a sharp drop in the fragmentation mass (set by the Jeans' mass) due to the addition of metals. If molecules are present, then they are the predominant coolants given a physically realizable fraction of metals and allow only one possible fragmentation mass scale, metallicity having no effect; the distinction will be entirely dependent on the level of molecule dissociating, LW flux present. For a solar abundance pattern of metallicity, OI is the most effective metal coolant throughout the evolution, while for a PISN metallicity yield (200 solar masses), SiII is the most effective coolant. We also find this scenario naturally explains the formation of stellar clusters, such as globular clusters, and puts constraints on the metallicity of assembling halos.

Surprising Metallicity of a Newly Discovered M79 Post-AGB Star

Timur Sahin, University of Texas at Austin

A detailed chemical composition analysis based on a high-resolution (R = 35000) CCD spectrum is presented for a newly discovered post-AGB star in the globular cluster M79 for the first time. The elemental abundance results of M79 Post-AGB star are found to be [C/Fe]≈-0.7, [O/Fe]=+1.4, [α-process/Fe]≈0.5 and [s-process/Fe]≈-0.1. The surprising result is that the iron abundance of the star is apparently about 0.6 dex less than that of the cluster's red giants as reported by published studies including a recent high-resolution spectroscopic analysis by Carretta and colleagues. Abundances relative to iron appear to be the same for the post-AGB star and the red giants for the 15 common elements. It is suggested that the explanation for the lower abundances of the post-AGB star may be that its atmospheric structure differs from that of a classical atmosphere; the temperature gradient may be flatter than predicted by a classical atmosphere.

The first stars: formation of binaries and small multiple systems

Athena R. Stacy, University of Texas at Austin

We investigate the formation of metal-free Population III (Pop III) stars within a minihalo at z ~ 20 with a smoothed particle hydrodynamics (SPH) simulation starting from cosmological initial conditions. Employing a hierarchical zoom-in procedure we achieve sufficient numerical resolution to follow the collapsing gas in the center of the minihalo up to number densities of 1012 cm-3. This allows us to study the protostellar accretion onto the initial hydrostatic core which we represent as a growing sink particle in improved physical detail. The accretion process and in particular its termination governs the final masses that were reached by the first stars. The primordial initial mass function (IMF) in turn played an important role in determining to what extent the first stars drove early cosmic evolution. We continue our simulation for 5000 yr after the first sink particle has formed. During this time period a disk-like configuration is assembled around the first protostar. The disk is gravitationally unstable develops a pronounced spiral structure and fragments into several other protostellar seeds. At the end of the simulation a small multiple system has formed dominated by a binary with masses ~ 40 M_Sun and ~ 10 M_Sun. If Pop III stars were to form typically in binaries or small multiples the standard model of primordial star formation where single isolated stars are predicted to form in minihaloes would have to be modified. This would have crucial consequences for the observational signature of the first stars such as their nucleosynthetic pattern and the gravitational-wave emission from possible Pop III black-hole binaries.

Magnetic Fields and the Formation of the First Stars

Matthew C. Wilde, University of Texas at Austin

We explore to the effects of magnetic fields on the formation of the first stars with redshifts around z ~ 15-20. We expect that magnetic fields present in the early universe should influence cooling and collapse of primordial gas clouds in minihalos. Magnetic effects should create a pressure which opposes gravitational collapse and we predict this will increase the Jeans mass and therefore delay collapse in the first halos until they reach this requisite mass. We include the effects of cosmic rays created by the first supernovae explosions.

Biographies

Tabetha Boyajian, Georgia State

Tabetha Boyajian is a Hubble Fellow at Georgia State University. She received her BS in Physics with a concentration in Astronomy from the College of Charleston, and her MS and PhD in Astronomy from Georgia State University, finishing in the summer of 2009. Her work has concentrated on stellar Astronomy, with main foci in the fields of optical spectroscopy and long baseline optical and near-IR interferometry. Her dissertation work involved observing a significant sample of A, F, and G dwarfs using the longest baselines of GSU's CHARA Array in order to extract their precise physical parameters, namely, effective temperatures, radii, absolute luminosities, and ages. For the duration of her Fellowship, she will continue her work in interferometry to measure accurately the fundamental properties of exoplanet host stars, main sequence K and M stars, and select metal poor stars.

Alyson Brooks, Caltech

Dr. Brooks is currently the Fairchild Postdoctoral Prize Fellow in Theoretical Astrophysics at Caltech. She received her PhD from the University of Washington in 2008.

Neal Evans, Chair, UT Astronomy Department

Dr Neal Evans has focused his research on the origins of stars and planets. He earned his bachelor's degree and doctorate in physics, at the University of California, Berkeley and did a year and a half of post-doctoral work at Caltech. Although initially interested in high-energy and particle physics, he later became interested in astrophysics and worked with a research group started at Berkeley by Nobel laureate Charles Townes. Evans joined The University of Texas faculty in 1975, and teaches several astronomy courses there, including a class about the search for extraterrestrial life. One of his overarching goals in teaching is to share his interest in how things have come to be. For Dr. Evans, the journey is more important than the destination. Dr. Evans has worked with an international team of scientists that is using data from NASA's Spitzer Space Telescope to study the formation of low-mass stars and their accompanying planets. He also leads a team that has a large key project on the Herschel Space Telescope and he is working with a team to map the plan of our galaxy in the emission from dust at 1 mm.

Steven Finkelstein, Texas A&M

Steven Finkelstein is currently a Postdoctoral Research Associate at Texas A&M University. After obtaining his B.S. in Astronomy and Physics at the University of Washington in 2003, he attended graduate school at Arizona State University, defending his Ph.D. on the physical properties of Lyman alpha emitting galaxies in 2008 with his advisor James Rhoads. His current research interests involve all aspects of high-redshift galaxies. He continues to study LAEs, with an emphasis on spectroscopic studies, as well as pursuing new studies on the properties of lensed and dusty galaxies at high-z. Aside from astronomy, he also enjoys reading, running, baseball, football, and spending time with his wife Keely, and their two dogs, Jasmine and Bella.

Thomas Greve, MPIA

Born and raised in the kingdom of Denmark, Thomas Greve did his undergraduate studies in physics and mathematics at the Niels Bohr Institute in Copenhagen. In 2000 Thomas moved to the UK to do his thesis work on dust and gas at high redshifts under the supervision of Prof. Rob Ivison, obtaining his PhD from the Royal Observatory Edinburgh in 2004. Thomas then spent three years as a post-doc in the submillimeter group of Prof. Tom Phillips at Caltech. Since September 2007 he have been a Max-Planck fellow at the MPIA in Heidelberg, Germany. His main area of research has focused on studying the properties of dusty, gas-rich massive galaxies in the distant as well as local Universe. One of his greatest passions is the beautiful sport of table tennis! As a former Danish top 12 juniors player and Caltech 2006 champion, Thomas still grabs every opportunity that comes along to humiliate his fellow astronomers in a game of table tennis! And it's a great way to make friends.

David Lambert, Director, McDonald Observatory

David L. Lambert is the Director of the McDonald Observatory and holds the Isabel McCutcheon Harte Centennial Chair in Astronomy at the University of Texas at Austin. He was Chair of the Department of Astronomy from 2002-2003. Born and educated in England, David Lambert obtained a B.A. in Physics in 1960 and a D. Phil. in Solar Physics in 1965 from the University of Oxford. His contributions to research in astronomical spectroscopy have been recognized with numerous prestigious awards and appointments, including a John Simon Guggenheim Memorial Fellowship (1990-91), the Dannie Heineman Prize for Astrophysics from the American Institute of Physic and the American Astronomical Society (1987(, and the Henry Norris Russell Lectureship, the top award of the American Astronomical Association (2006-07). Dr. Lambert is one of the most productive and innovative astronomers in the world. In over 40 years of research, Dr. Lambert has more than 480 publications. Dr. Lambert has established the fields of Cosmochemistry and Galacto-chemodynamics and continues to lead them. His current research emphasized precise analyses of the composition of evolved stars to determine how the chemical elements are synthesized by stars, along with studies of the chemical evolution of the Galaxy as revealed by the chemical composition of unevolved stars.

Brian Metzger, UC Berkeley

Brian Metzger is currently a NASA Einstein Fellow at Princeton University. He recently completed his Ph.D. at UC Berkeley, which focused on theoretical models of gamma-ray burst central engines. Metzger's primary research interests include transient astrophysics, including gamma-ray bursts, supernovae, accretion physics, and magneto-hydrodynamical outflows. His research interests also include the origin of heavy, neutron-capture elements.

Maryam Modjaz, UC Berkeley

Maryam Modjaz is a Miller Postdoctoral Fellow in Astronomy at UC Berkeley. Her research consists of understanding the explosive deaths of massive stars, including Type Ib/c Supernovae (SN Ib/c), Gamma-ray Bursts (GRBs), and their host environments, in collaboration with Profs Alex Filippenko and Josh Bloom. In 2007, she completed her PhD at Harvard University working with Prof. Bob Kirshner and was awarded the Fireman Prize from the Astronomy Department for outstanding dissertation work.

Ruth Murray-Clay, CfA

Ruth Murray-Clay is an Institute for Theory and Computation Postdoctoral Fellow at the Harvard-Smithsonian Center for Astrophysics. She studies proto-planetary disks, the formation and evolution of planetary systems, and the dynamics of the outer solar system. Ruth received her bachelor's degree from Harvard University. In 2008, she earned her doctorate in Astrophysics from the University of California, Berkeley, where she won the Mary Elizabeth Uhl Dissertation Prize.

Jason Nordhaus, Princeton

Jason Nordhaus is a post-doctoral fellow in the Department of Astrophysical Sciences at Princeton University. He received his Ph.D. from the University of Rochester in 2008 under the supervision of Eric Blackman. He is currently interested in the theory of core collapse SNe, nucleosynthesis in RGB/AGB stars, the evolution and dynamics of magnetic fields in evolved stars and the effects of binarity on post-MS evolution.

Manoj Puravankara, University of Rochester

Manoj Puravankara received his Ph.D. (2005) in Astronomy from Indian Institute of Astrophysics (Bangalore University), Bangalore, India. He was a postdoctoral Fellow at Inter-University Center for Astronomy and Astrophysics (IUCAA), Pune, India and at Academia Sinica Institute of Astronomy and Astrophysics (ASIAA), Taipei, Taiwan between 2005 and 2007. He is currently a research associate at the Dept. of Physics and Astronomy at University of Rochester. His primary research interests are in the field of star and planet formation. He is a member of the SPITZER IRS_disk team led by Dan Watson at the University of Rochester.

Peter Riley, Dean of the College of Natural Sciences

Dr. Riley is an experimental high-energy nuclear and particle physicist whose most recent research interests were focused on rare kaon decay measurements and relativistic heavy ion collider experiments at Brookhaven National Laboratory, Long Island, New York. He has also served in a number of administrative capacities, including that of Program Director, Intermediate Energy Nuclear Physics, National Science Foundation, Washington, D.C., Chairman of the LAMPF User's Group, and Chairman of the UT Department of Physics. He continues to serve on a number of UT committees. Since 1995 he has served as Associate Dean, Research and Facilities, for the College of Natural Sciences, UT Austin. In that capacity he interacts constantly with UT researchers all across the College, in areas from Astronomy to Neurobiology. He and his office staff work with users and with UT Project Managers in the design and implementation of science laboratory renovations and with new science building construction projects. He was a design team member for the Molecular Biology Building (1997), the Neural and Molecular Sciences Building (2005), the Nano Science and Technology Building (2006), the Dell Pediatric Research Institute Building (2007), and the Norman Hackerman Building (2008).

Pearl Sandick, University of Texas at Austin

Pearl Sandick earned a BA in Mathematics from New York University in 2003, after which she moved to the University of Minnesota to pursue physics. She obtained her Ph.D. in August, 2008, and is currently a Postdoctoral Fellow in the Theory Group at the University of Texas at Austin. Her research focuses on topics at the interface of particle physics and cosmology.

Josh Simon, OCIW Carnegie Observatory

Josh Simon grew up in Ann Arbor, Michigan, but moved west for college and has only occasionally looked back. He earned a BS from Stanford and MA (don't ask him why there is a master of arts degree in astrophysics) and PhD degrees from UC Berkeley. He has since spent 3 years as a Millikan Fellow at Caltech and 1 year as a Carnegie Fellow at Carnegie Observatories, where his research focuses on dark matter, chemical evolution, and star formation in nearby galaxies. Although his sister graduated from UT with a PhD in 2008, as a Big Ten native and Pac 10 convert he finds himself unable to root for anyone in the Big 12.

Kendrick Smith, Princeton

Kendrick Smith received his PhD at University of Chicago (2007) and was a GSFC postdoctoral fellow at Cambridge for two years, before starting a Spitzer Fellowship at Princeton this September. He is broadly interested in the intersection between theory and data in cosmology. Most of his work has been in CMB phenomenology, lensing, and non-Gaussianity. He am on the analysis teams for the CAPMAP, QUIET, and WMAP experiments.

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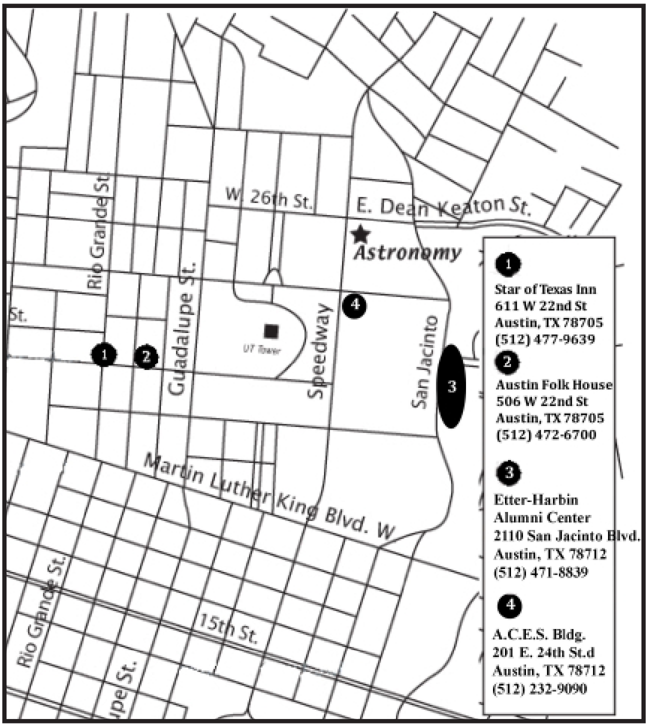
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