AstroFest 2011
Columbia University
Department of Astronomy and Astrophysics
September 16, 2011
9:00 am - 5:15 pm

Breakfast: 9:00-9:30
Session 1: 9:30-10:20

**Josh Peek**
Post-doc, Columbia Astronomy

*New insights into the magnetized ISM with machine vision*

There are two existing avenues to interpreting the diffuse ISM: the theorist’s approach in which real data is interpreted numerically in the context of simulations, and the observer’s approach in which objects are found and categorized by eye. We are pioneering a middle way, following the fast-growing science of machine vision to extract shape information from complex maps of the diffuse Galactic HI ISM. In this work we show a proof of concept in which newly discovered needle-like ISM features can be detected with a machine vision algorithm and shown to be oriented with magnetic fields in the ISM.

**Jule Stuetzel**
Post-doc, Columbia Astronomy

*Laboratory studies of electron driven chemistry in molecular clouds*

Our knowledge of molecular clouds and protoplanetary disks rests in part on understanding the underlying astrochemistry which controls the chemical composition, charge balance, spectra and thermal structure of these environments. Of particular importance is the electron recombination process with molecular ions, known as dissociative recombination (DR). Theoretical calculations of the required rate coefficients are beyond current quantum chemical computational capabilities. So far, laboratory measurements are the most reliable way to generate the needed DR data. Here, we present a sample of our recent experimental results and briefly discuss their astrophysical implications.

**David Schiminovich**
Professor, Columbia Astronomy

*A Next Generation Ultraviolet Balloon Experiment for Mapping the Cosmic Web*

I describe a "next generation" version of the Faint Intergalactic Redshifted Emission balloon (FIREBall-2), an ultraviolet instrument/spectrograph payload designed to detect faint Lyman alpha and metal-line emission from the low density intergalactic and circumgalactic medium. We have recently developed novel detector technology which—when combined with other design improvements—should boost our "cosmic web" detection sensitivity by x100 over the first-generation flight instrument.

**Lia Corrales**
Graduate Student, Columbia Astronomy

*Cosmological X-ray Scattering from Intergalactic Dust*

X-ray astronomy provides a unique opportunity to detect and characterize micron scale “grey” populations of dust, which are missed by evaluating the colors of background objects. I will discuss X-ray scattering by dust in a cosmological context and insights it may yield concerning star formation and structure in the high-z universe.

**Aodh O’Connor**
Post-doc, Columbia Astronomy

*A new laboratory apparatus to study the cosmic origins of organic chemistry*

The cosmic pathway towards life is thought to begin in molecular clouds when atomic carbon
is “fixed” into molecules, initiating organic chemistry and the synthesis of complex organic species. We are currently constructing a novel merged beams laboratory instrument to study interactions of neutral atomic C with molecular ions, with initial investigations focusing on the reaction \( C + H_3^+ \rightarrow CH^+ + H_2 \). As \( H_3^+ \) is ubiquitous in both diffuse and dense molecular clouds, this reaction is one of the first steps towards organic chemistry yet presents a significant challenge to measure experimentally.

Erika Hamden  
Graduate Student, Columbia Astronomy

I will briefly describe a project that aims to look for and model the FUV signatures of diffuse galactic objects. This project uses the GALEX AIS survey in combination with the 100 micron dust maps from Schlegel, Finkbeiner, Davis (1998) and surveys of diffuse clouds in the galaxy.

Jacqueline van Gorkom  
Professor, Columbia Astronomy

An EVLA HI Deep Field

Why?

Destry Saul  
Graduate Student, Columbia Astronomy

Pigs in Space (An Update)

Our search for ultra-compact neutral hydrogen clouds near the Galaxy was a success with over 2000 clouds identified. I will highlight our results and explain how we are separating the clouds into different populations based on observed properties.

Doug Brenner  
Research Scientist, AMNH

Astronomical Entomology or Daddy: ‘Why is the Sky Blue’

In an attempt to entrap a first year student, I will make some upcoming observations at SALT seem like the best thing since ham on rye.

2nd session: 10:35-11:25

Jeff Andrews

Graduate Student, Columbia Astronomy

A Search for Wide Double White Dwarfs in SDSS

Wide binaries are typically found by matching the proper motion of stars. I will explain how we have used this technique with SDSS data to find 81 wide double white dwarfs, more than tripling the known number of such binaries.

Jason Koglin  
Research Scientist, Columbia Astronomy

First results from the ground calibration of the NuSTAR flight optics

NuSTAR is a hard X-ray satellite experiment to be launched in February 2012. Two optics with 10.15 m focal length focus X-rays with energies between 5 and 80 keV onto CdZnTe detectors located at the end of a deployable mast. The FM1 and FM2 flight optics were built and calibrated at Columbia’s Nevis Laboratory. We describe initial results from the ground calibration performed at the 163 m long RaMCaF calibration facility that was custom built for this purpose at Columbia.

Jia Liu  
Graduate Student, Columbia Astronomy

Search for Super Massive Black Hole Binaries

Aiming to find super massive black hole binaries (BHBs), we did follow-up optical spectroscopy(using MDM 2.4 meter telescope) of 21 quasars which showed displaced broad lines in SDSS spectra. We fitted multiple Gaussians to the line profile(centering at narrow H-beta line) and compared MDM and SDSS spectra, and found: i) 2 potential BHBs candidates showing binary AGNs signals; ii) 5 objects with no change(BHBs with long period? Recoiling BH?); and iii) 9 quasars showing comoving peaks implying single AGN scenario. The rest showed changes but we could not identify them as BHBs. We also test a simple Keplerian BHBs model for 3 long-term monitored objects and rejected 2 of the quasars(3C 390.3, Mrk 668) as BHBs, and found minimum period of 51 yr for 3C 227’s orbit.

Manel Errando  
Post-doc, Columbia Physics

The VERITAS gamma-ray observatory
VERITAS is an array of four imaging atmospheric Cherenkov telescopes located at the Fred Lawrence Whipple Observatory (FLWO) in southern Arizona, sensitive to very high energy gamma-rays of energies from 100 GeV to 30 TeV. We will describe the research activities of the VERITAS group at Columbia University and Barnard College, which includes studies of very high energy gamma-ray emission from blazars, pulsars and pulsar wind nebulae, with a close synergy with Fermi-LAT.

Güneş Şentürk
Graduate Student, Columbia Physics

**VERITAS Observations of Unidentified GeV-Bright FERMI-LAT Targets**

We selected TeV gamma-ray source candidates among unidentified targets from Fermi 1 year catalog. We observed these sources with VERITAS and had no detection. I will describe our selection criteria, give VERITAS and MDM results and discuss possible explanations of our nondetection.

Jennifer Weston
Graduate Student, Columbia Astronomy

*Observing Iron in Neutron Star Atmospheres*

The densities and pressures in the atmospheres of neutron stars is considerably higher than those in standard stellar atmospheric models. The effect of pressure broadening on iron lines in the resulting spectra should be significant, perhaps even observable within the next few generations of X-ray telescopes. Detailed understandings of these atomic absorption features could provide us with a method to measure rotation speeds, gravitational acceleration, and composition of the surface of neutron stars. But exactly what do we need to take into account when we look at these features, and can we rely on them?

Dan D’Orazio
Graduate Student, Columbia Astronomy

*Accretion onto Supermassive Black Hole Binaries?*

The coalescence of super-massive black hole binaries (SMBHBB) may be the loudest source of gravitational radiation in the universe. We consider SMBHBB’s within the astrophysical context of a gas filled galactic nucleus, and ask: are there signatures of the binary in the electromagnetic spectrum? We run hydro-dynamical simulations of a thin circum-binary gaseous disk to determine this.

Kyle Parfrey
Graduate Student, Columbia Astronomy

*Magnetospheric reconnection driven by stellar surface twisting*

A neutron star’s magnetosphere can be deformed by differential motion of its crust, into which the field lines are frozen. Using numerical simulations, we show that this deformation can lead to large-scale magnetic reconnection, accompanied by dramatic anti-glitches in the spin-down power.

Josh Schroeder
Graduate Student, Columbia Astronomy

*A New Way For Stars To Die: Eaten Alive and Spit Out.*

Is the end-product of stellar evolution either a white dwarf, neutron star, and black hole? Or can stars die in other ways? Can a vicious neighbor act in nefarious ways to cause a death by wind ablation? I will show evidence that this such a bizarre scenario may be happening and happening quite frequently to boot!

3rd Session: 11:40-12:30

Cameron Hummels
Graduate Student, Columbia Astronomy

*The Search for Flat Rotation Curves*

Hydrodynamic computer simulations of galaxies in a larger cosmological environment almost all suffer from the angular momentum problem, an unrealistic buildup of material in their cores. There are ways to avoid this spurious build up, but almost all of them are artificial. Come see what seems to work, and what seems to not, as well as the future directions for fixing this issue.

Ximena Fernández
Graduate Student, Columbia Astronomy

*The Origin and Distribution of Cold Gas in the Halo of a Milky Way-sized Galaxy*
We use a high-resolution simulation to study the cold gas in the halo of a Milky Way-sized galaxy. HI observations of the Milky Way and other nearby spirals have revealed the presence of such gas in the form of clouds and other extended structures, which could be evidence for on-going accretion. I will discuss the distribution of the gas at $z=0$, compare it with observations, and comment on its origin.

Jana Grcevich
Graduate Student, Columbia Astronomy

We do not have a complete census of Local Group dwarf galaxies. I have identified possible unknown gaseous Local Group dwarf galaxies via their HI content, a method with complimentary observational biases to those of optical searches. Dwarf candidates are identified by examining a catalog of compact, isolated neutral hydrogen clouds in the Galactic Arecibo L-band Feed Array (GALFA-HI) survey.

Ryan Joung
Post-doc, Columbia Astronomy

Gas Condensation in the Galactic Halo

There have been debates about whether or not the hot halo gas of spiral galaxies like the Milky Way can simultaneously cool out and accrete onto their disks. We examine, using adaptive mesh refinement (AMR) hydrodynamic simulations of vertically stratified hot halo gas, the conditions under which clouds can form and condense out of the hot halo medium to potentially fuel star formation in the gaseous disk.

Jenna Lemonias
Graduate Student, Columbia Astronomy

Gas content and star formation in massive galaxies

I will present results of the GALEX Arecibo SDSS Survey (GASS), an HI survey of massive galaxies currently ongoing at Arecibo. When completed, GASS will produce a statistically representative sample of $1000$ massive ($M_* > 10^{10} \, M_\odot$) local ($0.025 < z < 0.05$) galaxies with homogeneously measured HI masses, stellar masses, and star formation rates. This sample allows us to investigate the interplay between these three quantities. We have constructed bivariate HI mass and star formation rate distribution functions that show how the relationship between gas content and star formation rate change with stellar mass. We also discuss a sample of gas-rich galaxies.

Hugh Crowl
Post-doc, Columbia Astronomy

Color Changing Galaxies in the Virgo Cluster

I will show results from a study combining SDSS data with data from the VIVA HI study of the nearby Virgo Cluster. Broadly, it appears that the global colors of spiral galaxies is dictated by the overall HI content. More interestingly, it seems that gas stripped from relatively far out in the galaxies affects the overall broadband color. I will also describe constraints on the timescale over which the color transformation takes place.

Joo Heon Yoon
Graduate Student, Columbia Astronomy

Warm IGM in the Virgo Cluster is first studied by Lyα absorbers toward background quasars. Overall distribution of warm gas in the Virgo Cluster will be presented.

Yuan Li
Graduate Student, Columbia Astronomy

Simulating the Cooling Flow of Cool-Core Clusters

We carry out high-resolution adaptive mesh refinement simulation of a cool core cluster, resolving the flow from Mpc scales down to pc scales. We do not (yet) include any heating, focusing instead on the development of the cooling instabilities in order to understand how gas gets to the supermassive black hole (SMBH) at the center of the cluster. We find that, as the gas cools, the cluster develops a very flat temperature profile, undergoing a global cooling instability only in the central 100 pc of the cluster. Outside of this region, the flow is smooth, with no local cooling instabilities, and naturally produces very little low-temperature gas (below a few keV), in agreement with observations. The gas cools and condenses in the very center of the cluster, rapidly forming a thin accretion disk. Isotropic heat conduction does not affect the result, but we show that it is very sensitive to resolution, requiring very high mass resolution to correctly reproduce the small transition radius. The amount of cold...
gas produced at the very center grows rapidly until a reasonable estimate of the resulting AGN heating rate (assuming even a moderate accretion efficiency) overwhelms cooling. We argue that this naturally produces a thermostat which links the cooling of gas out to 100 kpc with the cold gas accretion in the central 100 pc, potentially closing the loop between cooling and heating.

**Munier Salem**  
Graduate Student, Columbia Astronomy  
*Simulating Galactic Cosmic Rays with Enzo*  

Simulations of quiescent disk galaxies reveal that thermal pressure support alone cannot prevent cold gas in the disk from fragmenting. We modified enzo — an adaptive mesh refinement, grid-based, hydrodynamic code — to include a two-fluid approach to modeling the interaction between ultra-relativistic cosmic rays and thermal gas. Working with a Milky Way-style quiescent gaseous disk, we found substantial evidence that physically realistic levels of cosmic ray pressure can significantly suppress fragmentation in the disk.

**Lunch and Poster Session:**  
12:30-1:30  
The poster titles and participants are listed in the back of this program.

**4th session: 1:30-2:15**  
**Jeno Sokoloski**  
Research Scientist, Columbia Astronomy  
*The Kepler Satellite’s View of an Accretion Disk*  

**Gray Kanarek**  
Graduate Student, Columbia Astronomy  
*A Deep NIR Survey for Galactic WR Stars*  

A massive NIR survey for WR stars in the Galactic plane has already contributed 25% of the currently known Milky Way WR stars. By applying a new method of image subtraction to the same images, along with MIR and NIR color cuts to improve candidate selection, 40 new Galactic WR stars were discovered this summer.

**Emily Bowsher**  
Visiting Research Assistant, Columbia Astronomy  
*Component Spectral Types of Brown Dwarf Binaries from Combined-Light Spectroscopy and Resolved Photometry*  

Brown dwarf binaries are predominantly tightly-bound systems, generally resolved through high-resolution imaging. While resolved photometry allows some characterization of the components of these systems, resolved spectroscopy is necessary to study their atmospheres in detail. However, such data has been difficult to obtain due to the tightly-bound nature of brown dwarf binaries. Here we present an alternative method of extracting component spectroscopic information, through the application of a constrained spectral template matching technique. We compare combined-light near-infrared spectra of 19 brown dwarf binaries to binary templates drawn from the SpeX Prism Spectral Libraries, with each template constrained by at least three relative magnitude measurements. For these, we infer...
the component spectral types and relative JHK magnitudes of the binaries.

**Or Graur**  
Graduate Student, Tel Aviv University  
*Identifying the Progenitors of Type Ia Supernovae through their Delay-Time Distribution*

I have recently finished a supernova survey in the Subaru Deep Field, in which we’ve discovered some of the oldest supernovae ever observed. I’m currently part of CLASH, a 3-year galaxy-cluster survey with HST, during which we’ll be looking for even older supernovae.

**Marcel Agüeros**  
Professor, Columbia Astronomy  
*ARAR: An Update*

I said it once, I’ll say it again: surprisingly little is known about the evolution of stellar rotation and activity in Sun-like stars after they reach the age of the Hyades, or roughly 0.5 Gyr. We’ve been busy trying to rectify this situation in order to close in on a well-calibrated age-rotation-activity relation (ARAR)... and I will provide a whirlwind tour of our work on Praesepe, NGC 752, Alpha Persei, the Pleiades, and M37.

**Mordecai Mac Low**  
Adjunct Professor, AMNH  
*Structure of the Diffuse Interstellar Medium*

Ultraviolet radiation and supernova explosions dominate the structure of the diffuse interstellar medium. Comparison of observations in X-ray and H-alpha to numerical models using the adaptive mesh refinement code Flash revealed notable points of agreement, but also some discrepancies. X-ray observations with XMM of the galactic halo agree in their surface brightness with the models, but have cooler temperatures. H-alpha observations with WHAM agree in the peak of the emission measure distribution, but have a narrower width than the models (fewer very low or very high emission measure lines of sight). To address these discrepancies, we have redone the models including magnetic fields and an extended domain. Surprisingly, the extended domain appears to be the more important of these changes, revealing the very dynamical nature of the galactic halo. Future work will focus on explicitly including ionization heating and self-gravity of the gas.

**5th Session: 2:30-3:15**

**Michael Way**  
Professor, Hunter College/NASA - Goddard/Ames  
*Characterizing 3-D Structure in the Sloan Digital Sky Survey*

Using a volume limited slice of the Sloan Digital Sky Survey we have built three multi-scale (not just "large-scale") structure catalogs based on three algorithms. The first algorithm is a simple Kernel Density Estimator. The second and third algorithms rely on an initial Voronoi Tessellation of the data, but then combine the Voronoi cells in two unique ways never before used: Bayesian Blocks and Self-Organizing Maps. I will briefly describe the data sets and mention some projects that may be possible with this unique catalog, although any additional ideas will be very welcome.

**Lam Hui**  
Professor, Columbia Physics  
*Astronomical Tests of Gravity*

I will discuss some ideas on how to test gravity using red giants and cepheids.

**Xiuyuan Yang**  
Graduate Student, Columbia Physics  
*Impact of Baryons on the Cosmological Information in Weak Lensing Peaks*

Recent studies have shown that the number of peaks in weak lensing (WL) maps, obtained from large forthcoming surveys such as LSST, will contain useful cosmological information. The number of peaks as a function of their height, in particular, complements more traditional statistics, such as the WL power spectrum, and will tighten constraints on cosmological parameters. These conclusions were derived from N-body simulations that neglect changes in the lensing potential due to the presence of baryons. Here we model the effect of baryons, by modifying the dark matter halo profiles in ray-tracing N-body simulations by hand, mimicking the cooling and condensation of baryons and star-formation in halos. This allows us to study (i) the impact
of baryons on the WL peak counts, and (ii) to assess how much the inferred cosmological parameters would be biased if the data were fit ignoring the baryons.

Matt Turk
Post-doc, Columbia Astronomy

*Next Generation Simulations of the First Stars in the Universe*

Ideas about how the first stars in the universe formed are currently undergoing a transition; while previous generations of studies have suggested that they formed in isolation and were massive, recent indications have been that these stars in fact formed in pairs, groups or even clusters. I will describe current efforts designed to leverage next generation computing techniques and computational algorithms to push forward our understanding of these how these metal-free stars formed, lived, died and enriched their surroundings.

Ken Miller
Post-doc, Columbia Astronomy

*Forming the first stars: Laboratory studies of the H$_2$ chemistry that led there*

Cooling by H$_2$ molecules led to the formation of the first stars. A key reaction forming H$_2$ during this epoch is the associative detachment reaction H$^-$ + H -> H$_2$ + e$^-$. Uncertainties in this reaction have hindered our understanding the formation of structure during this epoch. We have performed the first energy-resolved measurement of this AD reaction. Here we report our results and discuss the cosmological implications of our findings.

Imre Bartos
Graduate Student, Columbia Physics

*Observational Constraints on Multi-messenger Sources of Gravitational Waves and High-energy Neutrinos*

It remains an open question to what extent many of the astronomical sources of intense bursts of electromagnetic radiation are also strong emitters of non-photon messengers, in particular gravitational waves (GWs) and high-energy neutrinos (HENs). Such emission would provide unique insights into the physics of the bursts; moreover some suspected classes, e.g. choked gamma-ray bursts, may in fact only be identifiable via these alternative channels. Here we explore the reach of current and planned experiments to address this question. We derive constraints on the rate of GW and HEN bursts per Milky Way equivalent (MWE) galaxy based on independent observations by the initial LIGO and Virgo GW detectors and the partially completed IceCube (40-string) HEN detector. We take into account the blue-luminosity-weighted distribution of nearby galaxies, assuming that source distribution follows the blue-luminosity distribution. We then estimate the reach of joint GW+HEN searches using advanced GW detectors and the completed km$^3$ IceCube detector to probe the joint parameter space. We show that the combination of individual and joint GW+HEN searches undertaken by advanced detectors will already be capable of detecting, constraining or excluding, several existing models with one year of contemporaneous observations.

Zoltan Haiman
Professor, Columbia Astronomy

*Forming Billion-Solar-Mass Black Holes in the Early Universe*

The supermassive black holes (SMBHs) that are believed to power the bright quasars observed at the highest redshifts ($z > 6$) have masses of $\gtrsim$ few$\times$10$^9$M$_\odot$. How these SMBHs formed so rapidly, within $< 1$ Gyr after the Big Bang, is a challenging unsolved problem in cosmology. I will discuss a possible solution, in which the gas collapsing into a $\sim 10^8$M$_\odot$ protogalaxy at redshift $z \sim 10$ remains 'warm', avoids fragmenting, and rapidly forms a $\sim 10^5$M$_\odot$ BH. Such a heavy seed BH can then (hopefully) grow leisurely into a $\sim 10^9$M$_\odot$ by $z \sim 6-7$.

Colin McNally
Graduate Student, Columbia Astronomy

*Getting Pedantic about Verification of Numerical Methods for Kelvin-Helmholtz Instability*

During our work on Phurbas (an adaptive Lagrangian meshless method for magnetohydrodynamics) we have needed to verify the results of a Kelvin-Helmholtz instability test. The behaviour of both grid codes and Smooth Particle Hydrodynamics has been questioned on this class of problem, which has been of particular interest to the cosmology and galaxy formation communities. One of the major complicating factors has been shortcomings in the design
and analysis of tests in the literature. We show how this can be remedied, and present results from a few types of code. In particular this careful testing highlights the poor convergence behaviour of Smooth Particle Hydrodynamics in the subsonic regime.

6th session: 3:30-4:15

Ben Oppenheimer
Associated Curator and Professor, AMNH

Mike Hahn
Post-doc, Columbia Astronomy

Observational Evidence for Wave Damping in the Solar Corona at Low Heights

Non-thermal broadening of spectral lines is believed to be a signature of Alfven waves propagating through the solar corona. This broadening is proportional to the amplitude of the waves. For undamped waves, energy conservation implies that the amplitude should increase with height as the plasma density decreases. However, our observations show that spectral line widths begin to decrease at heights below where wave damping is theoretically predicted. This could indicate that Alfven waves are damped by transferring energy to the solar wind at lower heights than shown by current models.

Andreas Svedin
Graduate Student, Columbia Astronomy

The hidden variable problem

What do you do if you have a 3D simulation of the solar surface and your observation is only a 2D satellite picture and you want to estimate the state at all depths. What if you have a solar cycle or dynamo model in several statistically uncorrelated variables and you only have the scalar Sun Spot Number record to constrain your model. Both these are example of the hidden variable problem of data assimilation; what to do with the things we have not directly observed. Going beyond the normal paradigm of correlation and looking at dynamical consistency we have explored a way to obtain these hidden states, something that appears to be impossible. The limit, as always, is quality of our models. This approach can also help us to estimate where our model breaks down, instead of assuming the model error properties upfront. We show some preliminary results and indicate where this could be used in the future.

Sebastien Lepine
Research Scientist, AMNH

Finding planets around nearby stars through microlensing?

The nearby, high-proper motion star VB 10 will move within just 50 milliarcsecond of a background star in December of this year. Calculations show that the 'encounter' will produce a microlensing event, but it will be too small to be detected. However, if VB 10 hosts a Jupiter-mass planet on a moderately wide orbit, that planet could produce a high-magnification event, detectable with intensive photometric monitoring on a 1-meter class telescope.

Michael Allison
Adjunct Professor, NASA - GISS

Juno and the Search for Primordial Water – New Thoughts Toward a Solar Enriched But Low Relative Humidity Mix of Condensibles in Jupiter’s Deep Atmosphere

On August 5, 2011 at 12:25 am EDT, an Atlas V thundered into the sky above Cape Canaveral, launching Juno toward its multi-orbit tour of Jupiter, to begin in 2016. Our primary objective – the measurement of the giant planet’s global water abundance. The on board MWR (a five channel, 1 – 20cm microwave radiometer) has already seen first light and is working perfectly. Now the science team has only five years to prepare to interpret pole-to-pole maps of brightness emission originating more than 100km below Jupiter’s cloud tops. Among the outstanding questions: Why are infrared and Galileo probe measurements of the jovian water abundance apparently so depleted with respect to the solar mixture? Why do VLA measurements show an upper tropospheric depletion, but a deeper super-solar enrichment and differentiation of ammonia below its saturation level? How is this reminiscent of terrestrial moist convection? And why is this so important to both the planetary meteorology and the history of the Solar System? Please stand by for a few new thoughts on all this and more!

Brandon Horn
Graduate Student, Columbia Astronomy

Orbital Migration of interacting Planets in Evolutionary Radiative Turbulent Models
Non-isothermal disks have been shown to have regions where the net torque on a planet is positive, leading to outward migration of the planet. When a region with negative torque is directly exterior to this, planets in the inner region migrate outwards and planets in the outer region migrate inwards, converging where the torque is zero. We incorporate the torques from an evolving non-isothermal disk into an N-body simulation, and find that the bodies do converge to the zero torque region, but effects of neighboring planets prevent the planets from merging. Though N-body interactions prevent complete merging to form one core, the addition of a weak stochastic force to simulate turbulence in the disk allows for orbit crossings and mergers near the convergence zone. In this way, it is possible to move from the sub-Earth mass regime into the 10 Earth mass planetary core regime in 2-3 million years.

**Denton Ebel**  
Curator, AMNH

*MESSENGER at Mercury: Implications for Planet Formation Hypotheses*

The MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) mission has characterized the abundances of major elements and the ratios K/Th and K/U in surface rocks. One of the goals of the MESSENGER mission has been to test, by measurement of surface composition, hypotheses advanced to account for Mercury’s anomalously large core mass fraction (65%) compared to those for Earth and Venus (30%). One set of hypotheses requires primary chemical or mechanical fractionation of metal and silicates in the high-temperature inner annulus of the solar system’s nebular disk where Mercury accreted. Another hypothesis calls for the catastrophic loss of the earliest crust and a substantial fraction of the mantle in a high-velocity impact by a planetary-embryo-sized body of unknown composition. MESSENGER’s Gamma-Ray Spectrometer and X-Ray Spectrometer, respectively, indicate terrestrial K/Th abundance ratios and high S/Si ratios. Mercury is thus richer in volatiles than expected for some models, and may have a higher bulk S/Si ratio than Earth. Models for crust and mantle removal do not necessarily result in volatile depletion in what remains of the target body; the proposed catastrophic impact model for Mercury is less fractionating of volatiles than the Moon’s likely origin via accretion within a volatile-depleted disk of ejected material. Enrichment of S in Mercury (relative to Earth), however, points to initial accretion chemistry. Sulfur enrichment may have resulted from highly reduced accretion conditions, consistent with disk mid-plane enrichment in C-rich interplanetary dust, as modeled by Ebel and Alexander (in press). Observed correlations of Mg/Si and Ca/Si with S/Si may be due to the stability of Mg and Ca sulfides in a reducing mantle. MESSENGER’s orbital geochemical, geological, geophysical, plasma science, and other results constitute a diverse set of observations demanding explanation.

**Emily Rice**  
Post-doc, AMNH

*Young Brown Dwarfs as Exoplanet Analogs*

In the quest to understand the physical properties of late-M and early-L type objects (the lowest mass stars and relatively massive brown dwarfs), many objects with unusual spectral features are yet to be explained. One class of these objects are thought to be young and their spectral features the result of low surface gravity. Because brown dwarfs cool, fade, and shrink with time, they will be hotter, brighter, and more inflated than objects of the same mass at an older ages. The same evolution occurs for gas giant planets, and indeed the physical properties of exoplanets and brown dwarfs can overlap at different evolutionary stages. Therefore young brown dwarfs can be crucial tools for understanding the atmospheres of gas giant exoplanets. I will describe two young brown dwarfs we have recently confirmed and characterized and explain how they will advance our understanding of directly-imaged exoplanets.

**7th session: 4:30-5:15**

**Greg Bryan**  
Professor, Columbia Astronomy

*The Baryonic Content of Dwarf Galaxies*

I briefly review the evidence that galaxies are missing a substantial fraction of their baryonic mass, focusing particularly on dwarfs. Possible solutions will be discussed and critiqued. I will argue that it is difficult to hide much mass in a hot, ionized halo around a dwarf galaxy. In addition, although it is generally thought to be easy to eject mass from dwarf systems because of their relatively shallow potential
well, I will use detailed simulations to show that supernovae driven winds have a great deal of difficulty in actually doing this.

**Kerstin Perez**  
Post-doc, Columbia Astrophysics Laboratory

The General Antiparticle Spectrometer (GAPS) experiment aims to detect low-energy antideuterons that result from dark matter interactions in the galactic halo. This signature, which has essentially zero conventional astrophysical background, is predicted by many models of both supersymmetry and extra-dimensional theories. I will report on the status of the prototype GAPS (pGAPS) balloon experiment, scheduled to launch in spring 2012, which will test many key aspects of the detector design.

**Maureen Teyssier**  
Graduate Student, Columbia Astronomy

*Intergalactic Light and the Local Group Environment*

With the advent of repeated all-sky photometric surveys, such as PTF, we should be able to find intergalactic supernovae outside of galaxy clusters. But do we expect this population to exist? Predictions for such a population are made through analysis of the Via Lactea II Simulation. Our analysis suggests an intergalactic population of wandering stars on the order of $10^8 M_\odot$ to exist beyond the virial radius of a Milky-Way size dark matter halo — suggesting 0.1% of SNIA could be hostless. This population is created via dynamical interactions in dark matter halos.

**Duane Lee**  
Graduate Student, Columbia Astronomy

*A Mass-Dependent Yield Origin of Neutron-Capture Distributions in Ultra-Faint Dwarfs*

Chemical abundance data exhibit remarkable agreement between the distributions of $\alpha$/Fe ([Ti, Ca, Mg]/Fe) abundance ratios found in stars located in the Milky Way (MW) Halo and ultra-faint dwarf (UFD) galaxies. However, when contrasting the neutron-capture distributions [(Sr, Ba)/Fe), the peak of the small UFD sample ($\sim 20$ stars) reveals a statistically-significant negative offset in abundance ratios when compared to the large MW sample ($\sim 1000$ stars). In this study, we show that the apparent contradiction in neutron-capture distributions could be explained as the under-sampling of intrinsically-skewed distributions in UFDs. We emphasize that the UFD’s distributions can be achieved by simply appealing to stochastic pollution by star clusters that are systematically smaller than those in MW progenitors. Hence, there is no need to invoke other complex effects such as primordial abundance signatures, blowout of metals, and/or incomplete mixing.

**Lauren Corlies**  
Graduate Student, Columbia Astronomy

*Recent observations have revealed that abundance differences exist between low metallicity stars in the Milky Way stellar halo and those in the ultrafaint dwarf galaxies. We take a first look at what role the early environment might have played in in shaping these stellar populations. I’ll briefly discuss the analytic model of supernova-driven winds that was used and present the results. In general, we find that main halo progenitors cross-pollute each other more effectively whereas dwarf galaxy progenitors remain more isolated. Thus, inhomogeneous cross-pollution can reasonably be appealed to as part of an explanation for these observed differences.*

**Gurtina Besla**  
Post-doc, Columbia Astronomy

*The Importance of Dwarf-Dwarf Galaxy Interactions*

Broadly my research interests focus on the evolution of dwarf galaxies in various environments. More specifically, I aim to quantify the relative importance of interactions between dwarf galaxies to their morphological and kinematic evolution, versus interactions with massive hosts. In this short talk I’ll show some illustrative examples of interacting dwarfs and comment on their relevance to questions about how dwarf galaxies lose their baryons and the evolutionary connection between dwarf irregulars and dwarf spheroidal galaxies.

**Allyson Sheffield**  
Post-doc, Columbia Astronomy

*Disk Stars in the Halo*

Where did stars in the halo originate? The detection of stellar streams wrapping around the
outer realms of the Galaxy provides smoking-gun evidence that accretion has played an important role in the formation of the halo. However, the possibility also exists that some stars in the halo could have formed in the Galactic disk and subsequently been kicked onto more eccentric and more inclined orbits – rendering these stars members of the inner halo. I will present results from recent work using the chemodynamics of M giants aimed at studying the thick disk and nearby halo, and discuss the implications for understanding the origin of stars in the nearby halo.

**Christine Simpson**  
Graduate Student, Columbia Astronomy

*Physics of Dwarf Galaxy Formation*

Our standard model of the universe (lambdaCDM) predicts many more satellite dwarf halos around the Milky Way and within the Local Group than we see. The dwarfs we do see exhibit many unusual properties and trends such as extreme mass to light ratios and a common mass scale. We have conducted a series of high-resolution, hydrodynamical simulations of a single cosmological dwarf halo. We have varied the physical prescriptions for reionization and supernova feedback to understand their relative effects on star formation and gas evolution within the halo. I will describe the results of these simulations and their implications for our understanding of dwarf galaxies and how they form.
Undergraduate Poster Session

Vivienne Baldassare  
Hunter College  

*Studying Star Formation and AGN Activity in Ultraluminous Infrared Galaxies at $z > 1.15*

Daniel Feldman  
CUNY College of Staten Island,  

*Searching for Faint Kuiper Belt Objects in HST Archival Data*

Adam Greenberg  
Columbia University  

*Properties of the Low Density Gas in the Outer Reaches of the Galaxy Group NGC 5044*

Sam Grunblatt  
Columbia University  

*Time Resolved Spectroscopy of Bright Bursts from the Soft Gamma Repeater SGR J1550-5418*

Kay Hiranaka  
Hunter College  

*Application of Mie Theory to L Dwarf Spectra*

Daniel Horenstein  
Columbia University  

*Finding the First Stars*

Alejandro Núñez  
Hunter College  

*Application of Stellar Flare Model to Solar Flares*

Bryan Terrazas  
Columbia University  

*Analyzing Data from the Large Hadron Collider (LHC)*