Modelling Far-UV Photoevaporation in Protoplanetary Disks

Speaker: Dr Jon Ramsey (Institut für Theoretische Astrophysik, Heidelberg)
Time: July 10, 2014 - 2:01 PM
Location: AT101

It is well-established that protoplanetary disks transition from optically thick to thin in ~10 ^5 yr, much faster than the viscous accretion timescale. One of the proposed mechanisms to explain this rapid clearing is photoevaporation by stellar UV and X-ray photons. While extreme-UV and X-ray photoevaporation have been well-studied in the literature, due to its complexity, far-UV photoevaporation has so far been limited to 1D viscous evolution or static 2D thermochemical models. In this talk, I will present the first self-consistent radiation hydrodynamic models of far-UV photoevaporation in disks, and discuss the resulting consequences for disc structure and evolution.

Unveiling Fundamental Physics from the Cosmic First Light, revealing Simplicity and Complexity in the Universe at Large

Speaker: Dr J. Richard Bond (CITA)
Time: April 4, 2014 - 3:00 PM
Location: AT 101

The remarkable precision-cosmology results from the satellites Planck and WMAP and the the earth-bound higher resolution ACT and SPT unveiled over the past two years follow two decades of experimentation since the COBE satellite discoveries and the first proposal for Planck. We have revealed a story of simplicity at the time the first-light photons were freed from matter 380000 years after the (so-called) Big Bang, 13.8 billion years ago, encoded in seven (or so) numbers which so-far fully characterize the photon distribution then. Even more astounding is currently just two numbers characterize the energy-density-phonons whose condensate drives the accelerated inflation of the ultra-early Universe and whose fluctuations grow into the Cosmic Web of galaxies we observe. A third number is the long-sought amplitude of quantum-generated primordial gravity waves, apparently now revealed by the South-Pole-based BICEP/KECK. I'll talk about the glorious experimental ride we have been on, our near-term future, and the theoretical implications we derive, with a focus on early Universe physics. Data-tensions exist which may point to more early-Universe complexity.

X-ray Astrophysics with Innovative Non-Dispersive Imaging Spectroscopy

Speaker: Dr. Megan Eckart, NASA Goddard Space Flight Centre
Time: March 28, 2014 - 3:00 PM
Location: AT101

Abstract: High-resolution imaging spectroscopy in the soft x-ray waveband (0.1-10 keV) is an essential tool for probing the physics of the x-ray universe. Unique line diagnostics available in this waveband allow transformative scientific observations of a wide array of sources. For example, measurements of outflow processes from supermassive black holes may identify the key mechanism that regulates the co-evolution of host galaxies and their central black holes, and measurements of turbulence in the intra-cluster medium of galaxy clusters can be used to calibrate hydrodynamic simulations used in cosmology. I will introduce the microcalorimeter, a low-temperature detector capable of x-ray photon counting with high spectral resolution, and I will talk about the scientific potential of upcoming space-based experiments using arrays of such detectors, including the Soft X-ray Spectrometer, a pioneering microcalorimeter instrument that will launch aboard the Japanese-led Astro-H mission in 2015. Finally, I will discuss our recent advances in detector technology development that will enable the next-generations of x-ray spectrometers.

Life and Death at Cosmic High Noon

Speaker: Dr. Marcin Sawicki, Saint Mary's University
Time: March 24, 2014 - 10:17 AM
Location: AT101

Abstract: Galaxies are giant machines that turn gas into stars and the rate at which they were doing this was highest around redshift z=2, when the universe was only 1/4 of its present age. This is "cosmic high noon", and I will discuss both starforming (live) and quiescent (dead) galaxies at z~2. My choice of this live/dead terminology here is not just a fanciful analogy but is central to my

talk: I will show how the starforming-to-quiescent transition follows rules that are very similar to those that govern human death, leading not only to a well-justified "live/dead" terminology for star forming and quiescent galaxies, but to a simple and direct explanation for the Schechter-like stellar mass function for massive galaxies along with potential insights into the quenching mechanism itself.

X-ray Astrophysics with Innovative Non-Dispersive Imaging Spectroscopy

Speaker: Dr. Megan Eckart, NASA Goddard Space Flight Centre
Time: March 24, 2014 - 10:35 AM
Location: AT101

Abstract: High-resolution imaging spectroscopy in the soft x-ray waveband (0.1-10 keV) is an essential tool for probing the physics of the x-ray universe. Unique line diagnostics available in this waveband allow transformative scientific observations of a wide array of sources. For example, measurements of outflow processes from supermassive black holes may identify the key mechanism that regulates the co-evolution of host galaxies and their central black holes, and measurements of turbulence in the intra-cluster medium of galaxy clusters can be used to calibrate hydrodynamic simulations used in cosmology. I will introduce the microcalorimeter, a low-temperature detector capable of x-ray photon counting with high spectral resolution, and I will talk about the scientific potential of upcoming space-based experiments using arrays of such detectors, including the Soft X-ray Spectrometer, a pioneering microcalorimeter instrument that will launch aboard the Japanese-led Astro-H mission in 2015. Finally, I will discuss our recent advances in detector technology development that will

enable the next-generations of x-ray spectrometers.

Discovering Rare AGN with the Stripe 82X Survey

Speaker: Dr. Stephanie LaMassa, Yale University
Time: March 21, 2014 - 4:00 PM
Location: AT301

Abstract: Supemassive black holes grow by accreting matter in a phase where they are observed as active galactic nuclei (AGN). Astronomical surveys are key for studying representative samples of AGN at various luminosities and redshifts. AGN at high luminosity and high redshift are rare and can only be identified when large volumes of the Universe are explored through wide area surveys. Until recently, no large area X-ray survey has existed, meaning that a key phase in SMBH growth and SMBH/galaxy co-evolution is missing. To rectify this gap, we have begun a wide area X-ray survey in the Sloan Digital Sky Survey region Stripe 82 which contains a veritable treasure trove of multi-wavelength coverage, expediting follow-up of identified X-ray sources. In this talk, I will review the highlights of our first release of "Stripe 82X" which covers ~16.5 deg^2 with ~3300 X-ray sources identified. I will discuss our current ground-based follow-up campaigns to target interesting classes of AGN a! nd will comment on what we expect to learn with the addition of 20 deg^2 awarded to our team in the upcoming XMM-Newton observing cycle.

Lorentz Contraction in Electron Interferometry

Speaker: Dr. Peter Marzlin, St Francis Xavier University
Time: March 14, 2014 - 3:00 PM

Location: AT101

Abstract: Over a century after its discovery, Special Relativity stills inspires scientists and laymen alike because its predictions often defy common sense. This is highlighted by thought experiments such as Bell's spaceship paradox, which is a direct consequence of Lorentz contraction. Special Relativity has been confirmed in many experiments, but surprisingly Lorentz contraction has so far only been confirmed indirectly.

In this talk I will describe a proposal to measure Lorentz contraction by means of electron interferometry. The proposed experiment may also be viewed as a realization of Bell's spaceship paradox. We suggest to use the Kapitza-Dirac effect to split and recombine a beam of relativistic electrons by transferring momentum and energy from the photons in a laser beam to the electrons. Lorentz contraction will then prevent a perfect recombination of the electron beam and thus be visible by the appearance of an additional peak in the interference pattern.

<< Back

Winds Launched Near the Event Horizons of Supermassive Black Holes

Speaker: Dr. George Chartas, College of Charleston
Time: March 7, 2014 - 3:00 PM
Location: AT305

Abstract: Some of the most fascinating properties of quasars arise from the strong gravitational field that dominates over all other forces near the supermassive black hole SMBH). Observations of the X-ray spectra of quasars have the potential of testing the theory of General Relativity in a region of strong gravity, constraining the structure of the X-ray emitting region, and further our understanding of the quasars' role in feedback, quenching of star formation and galaxy evolution.

I will present results from the detection of near-relativistic winds launched near the innermost stable circular orbits of SMBHs. The two main mechanisms proposed for accelerating the ultra-fast outflows observed in active galactic nuclei are radiation and magnetic driving. I will briefly review these acceleration mechanisms and test them against current observations of ultra-fast outflows.

Relativistic magnetospheres of spinning bodies

Speaker: Dr. Ted Jacobson, University of Maryland
Time: February 28, 2014 - 3:00 PM
Location: AT305

Abstract: Some of the most spectacular and mysterious astrophysical processes involve spinning magnetized neutron stars and black holes, whose rotational energy is converted via plasma to electromagnetic flux, accelerated particles and jets. In this setting, the energy of the matter in the plasma is often negligible compared with that of the field, allowing a "force-free" description via non-linear equations for the field alone. In this talk I will discuss some of the basic physics of these phenomena and their

description using force-free electrodynamics.

New Insights into the Formation and Evolution of the Most Massive Galaxies

Speaker: Dr. Danilo Marchesini, Tufts University
Time: February 14, 2014 - 3:00 PM
Location: AT305

Abstract: In the past decade, our understanding of the galaxy population in the last 12 billion years of cosmic history (i.e., since z=4) has improved significantly, thanks to the increasing ability to construct representative snapshots (in time) from z=4 (when the universe was ~1.5 billion years old) to the local universe. I will summarize our current knowledge of the evolution of massive galaxies since z=4, with an emphasis on the recent results from the the UltraVISTA survey. I will conclude by presenting new findings on the evolution since z=3 of the progenitors of local ultra-massive galaxies, challenging previously proposed pictures for the formation and evolution of elliptical galaxies.

Planck and Inflation

Speaker: Dr. Joel Meyers, CITA, University of Toronto
Time: February 13, 2014 - 3:00 PM
Location: AT101

Abstract: The results from the Planck satellite have provided excellent constraints on many cosmological parameters allowing us to probe the physics of inflation. While all observations are currently consistent with the simplest models of inflation, many more complicated scenarios are also consistent with the data. In

this talk, I will focus on the theoretical aspects of inflation in light of the Planck data. I will highlight a few observables which are measured by Planck and discuss how future observations will give us non-trivial information about the physics of the early universe.

The Dynamics of Galaxy Pairs in a Cosmological Setting

Speaker: Dr. Jorge Moreno, University of Victoria & CITA, Canada
Time: January 31, 2014 - 3:00 PM
Location: AT101

Abstract: Galaxy pairs provide a unique view of the interaction sequence experienced by merging galaxies. Observationally, interactions have a dramatic influence on galaxies, even during the earliest stages. Theoretically, a large industry of numerical merger simulations has developed. Unfortunately, the latter depend on the assumption that interacting galaxies evolve in isolation. A central goal of this work is to investigate the validity of this assumption. Using the Millennium Simulation, we built a large catalogue of simulated galaxy pairs. For each pair, we searched for a more massive 'third' galaxy in the vicinity. A comparison of the binding-energy of the pair to the binding energy to the third galaxy allows us to rank pairs in terms of their probability of merging. The results are as follows: (a) 10% of the pairs are inevitable mergers in isolation; (b) 35% are likely mergers, with minimal influence of a third massive galaxy in the vicinity; (c) 25% will most likely interact, but not merge because the third galaxy will split them apart; and (d) 30% are chance pairs orbiting a third massive galaxy, and will never merge. This work demonstrates the importance of connecting galaxy pairs to the rest of the Universe, and provides

guidance to both observers and simulators on how realistic it is to treat merging galaxies in isolation. Lastly, I will discuss ongoing work based on binary merger simulations. These two complementary methods (semi-analytics and hydro-simulations) will help us bridge the gap between galactic and cosmological scales, and enrich our understanding of the physical processes governing the interaction sequence.

The Canadian ASTRO-H Metrology System - Laser-Based Image Correction and Calibration for an X-Ray Telescope

Speaker: Dr Casey Lambert, CSA and SMU
Time: January 24, 2014 - 3:00 PM
Location: AT101

Abstract: ASTRO-H is an x-ray astronomy telescope being built by the Japan Aerospace and Exploration Agency and it is designed to improve the sensitivity of wideband observations of high energy radiation. The Canadian contribution to this mission, through the Canadian Space Agency and built by Neptec Design Group, is an internal alignment measurement tool termed the Canadian ASTRO-H Metrology System (CAMS). This instrument uses a pair of lasers to actively measure thermo-elastic distortions of the spacecraft during x-ray observations. Specifically the lateral motion between the telescope mirror (HXT) and the imager (HXI), which are separated by a focal length of 12-m, will be measured by each laser. The two measured offsets will be used to estimate the in-plane translation as well as the rotation about the boresight axis. This information will be used to correct and enhance images obtained by the telescope.

The presentation will feature a brief description of the CAMS

hardware, an overview of the data processing algorithms with simulation results, results of the ground calibration, and the procedure for in-flight calibration. The introduction includes background information for the ASTRO-H mission and the general design and operation of the CAMS, highlighting the advanced technology of its laser transmitter, corner-cube reflector, and image sensor. The geometric relationships required to obtain the three required relative-motion variables from the two CAMS measurements will be established. The performance of the image correction algorithm based on CAMS data will be studied as simulated x-ray images will first be corrupted by structural distortions of the telescope and then corrected using simulated CAMS data.

The calibration of the CAMS system is a two-step process. The internal CAMS optics are calibrated on the ground while the overall calibration using observations from the x-ray telescope will be performed on-orbit. Results of the ground calibration will be presented and details of the in-flight calibration will be included also. The in-flight calibration involves observations of known x-ray sources to estimate the angular and translational shifts of laser metrology system experienced during integration and launch. Simulation results will be presented to assess the expected performance of the calibration procedure.

The X-ray View of Galaxies in High-Density Environments

Speaker: Tyler Desjardins, University of Western Ontario
Time: January 17, 2014 - 3:00 PM
Location: AT305

Abstract: The environments of galaxies strongly influence their evolution. In the local Universe, more than half of galaxies live in groups and clusters, therefore understanding how this environment affects galaxies is important. Using multi-wavelength observations, we can quantify many aspects of the galaxies from the neutral gas to the stellar mass. I will present results of Chandra and XMM-Newton X-ray observations of the diffuse X-ray emission in groups and the X-ray point sources in the Coma infall region, respectively. In groups, we see the formation of the hot IGM and I will show how the IGM scales with other parameters. Regarding cluster infall galaxies, I will discuss known galaxy X-ray scaling relations and how the Coma cluster compares to other environments. I will also comment on the fraction of active galaxies in the Coma infall region in contrast to high-redshift clusters and field galaxies.

Perfect retrieval of quantum information from black holes

Speaker: Dr Kamil Bradler
Time: November 29, 2013 - 9:00 AM
Location: Saint Mary's University

Abstract: Black hole information puzzle is a longstanding open problem concerned with the fate of information thrown into the black hole. In this talk, I will introduce the problem and reformulate it in the language of quantum information theory. I will argue that this is the right branch of physics to finally settle the whole issue. Quantum information theory takes the inspiration from computer science and Shannon's theory of communication and offers a new perspective on certain fundamental problems in physics. The black hole information puzzle is the most prominent example. It is really a quantum communication problem and as

such it could not had been resolved before the era of quantum information theory - only now we have the right tools at our disposal.

Directly Determined Linear Radii,

Speaker: Dr. Gerard van Belle, Lowell Observato
Time: November 22, 2013 - 3:00 PM
Location: Effective Temperatures, and Shapes of Stars from Long-Baseline Optical Interferometry

Abstract: A brief introduction to the concepts of long-baseline optical interferometry (LBI) will be presented, followed by a review of fundamental stellar parameters as directly determined using LBI. Special attention will be paid to the progression of precision over the years of the observables of linear radius and effective temperature, with the current state-of-the-art measures approaching sub-percent levels for hundreds of stars (and being limited primarily by the ancillary data products of distance and bolometric flux, not measured angular size). Discussion will also be presented on the diminishing meaning of these gross parameterizations of stellar atmospheres, as higher-order surface details such as shapes, limb darkening, gravity darkening, and spotting are beginning to be imaged with LBI.

Cepheids, Binaries, and Star Formation: Making the Connection

Speaker: Dr. Nancy Evans, CfA

Time: November 15, 2013 - 3:00 PM
Location: AT101

Abstract: Cepheids provide insight into both star formation and stellar evolution. Multiwavelength studies supply binary/multiple properties for these reasonably massive stars, which allow the exploration of differences between high and low mass stars formation. A 3 part program to derive binary parameters is underway. We are conducting a survey of Cepheids with the Hubble Space Telescope Wide Field Camera 3 (WFC3) to identify possible resolved companions, for example Eta Aql. X-ray observations (Chandra and XMM-Newton) can confirm whether possible low mass companions are young enough to be physical companions of Cepheids, hence providing constraints on star formation. In a related study of intermediate mass stars, Chandra X-ray observations of late B stars in Tr 16 have been used to determine the fraction which have low mass companions (which are X-ray active in contrast to the late B stars which are X-ray quiet). Finally, velocity data from the Groynya, et al. is being combined with CORAVEL data develop statistics on long period orbits.

The Nature of Neutrinos

Speaker: Dr. David Radford, Oak Ridge National Laboratory
Time: November 8, 2013 - 3:00 PM
Location: Oak Ridge National Laboratory

Abstract: First hypothesized by Wolfgang Pauli in 1931, the elusive neutrino is an electrically neutral elementary particle that

interacts only very weakly with matter. Produced in copious amounts in nuclear reactions and radioactive decays, neutrinos play key roles in the state of the early universe, in cosmology and astrophysics, and in nuclear and particle physics. In the 1970's and 80's, an experiment a mile underground in a gold mine in South Dakota measured the flux of neutrinos from the Sun's core. It detected only about one-third of the neutrinos predicted by theory, and ultimately led to a much deeper understanding of particle physics. The current status of neutrino experiments will be reviewed, and a new experiment under construction in that same SD gold mine will be described. This experiment aims to show that the neutrino and its antiparticle (the anti-neutrino) are in fact the same particle.

WISH: Wide-field Imaging Surveyor for High Redshift

Speaker: Dr. Toru Yamada, Tohoku University
Time: November 1, 2013 - 9:42 AM
Location: AT101

Abstract: WISH, Wide-field Imaging Surveyor for High-redshiftt, is a space mission concept to conduct very deep and wide-field surveys at near infrared wavelength at 1-5μm to study the properties of galaxies at very high redshift beyond the epoch of cosmic reionization. The concept has been developed and studied since 2008 to be proposed for future JAXA/ISAS mission with international collaboration now being developed. PRIMARY SCIENTIFIC GOALS of WISH are to search for the most-distant first-generation galaxies and revealing the galaxy distribution and properties in the era of cosmic re-ionization, to study of the

expansion history of the universe and properties of dark energy by using a very large sample of high-redshift Type-Ia Supernovae, and to conduct extensive study in many other field of astronoy utilizing the unique wide-area NIR observations from space.WISH has a 1.5m-diameter primary mirror and a wide-field imager covering 850 arcmin2. The pixel scale is 0.155 arcsec for 18μm pitch, which properly samples the diffraction-limited image at 1.5μm. The main program is Ultra Deep Survey (UDS) covering 100 deg2 down to 28AB mag at least in five broad bands.We expect to detect >>10^4 galaxies at z=8-9, 10^3-10^4 galaxies at z=11-12, and 50-100 galaxies at z>14, many of which can be feasible targets for deep spectroscopy with Extremely Large Telescopes. With recurrent deep observations, detection and light curve monitoring for type-Ia SNe in rest-frame infrared wavelength is also conducted, which is another main science goal of the mission. During the in-orbit 5 years observations, we expect to detect and monitor >2000 type-Ia SNe up to z~2. WISH also conducts Ultra Wide Survey, covering 1000deg2 down to 24-25AB mag as well as Extreme Survey, covering a limited number of fields of view down to 29-30AB mag.

In this talk, we introduce the basic capability of WISH and examples of science applications as well as reporting the current status of the development of the base-line design model.

Applying Physics to Air Quality and Climate Problems

Speaker: Dr. Aldona Wiacek, Saint Mary's University
Time: October 25, 2013 - 9:47 AM
Location: AT101

Abstract: Desert dust is the most abundant aerosol species in the atmosphere and it is also the most efficient ice nucleating material, commonly found in the ice crystal residuals of cirrus and mixed-phase clouds. While dust source regions are increasing due to human activity, it is difficult to measure or model the concentration of dust particles in the upper troposphere with the certainty necessary for global modeling of clouds and their radiative effects on climate. In this talk I will discuss my work on the Lagrangian transport modeling of mineral dust, as well as on the challenges of measuring this aerosol species remotely from space. Finally, I will outline my plans for a Tropospheric Remote Sensing Laboratory at Saint Mary's University.

On the behavior of entanglement in systems of massive particles under relativistic transformations.

Speaker: Mr. Esteban Castro, Universidad Nacional Autuónoma de México
Time: October 25, 2013 - 10:29 AM
Location: AT305

Abstract: We analyze the entanglement change, as seen by different relativistic observers, for a system consisting of two spin-1 particles, considering different partitions of the Hilbert space, which has spin and momentum degrees of freedom. We show that there exists a complete set of states of the spin subspace in which the entanglement change of any state in the set is zero for all partitions and all values of the Wigner angle. Moreover, these states only change by a global phase factor under the Lorentz boost. Within this basis, maximally entangled invariant states, interesting for quantum information purposes, are explicitly obtained. On the

other hand, the entanglement in the particle-particle partition is Lorentz invariant, thus protecting the consistency of quantum correlations and teleportation results. We show how our results may be generalized to arbitrary spin.

Modelling the X-ray Spectra of Accreting Black Holes

Speaker: Dr. Chia-Ying Chiang, Saint Mary's University
Time: September 13, 2013 - 3:00 PM
Location: AT101

Abstract: X-ray emission from accreting black hole systems provide information on the accretion geometry of the innermost region of the black hole. Observational evidence indicates that black hole systems are consisted of an accretion disc around a central black hole with a hot illuminating corona above the disc plane. The resulting X-ray spectra can be decomposed by a powerlaw continuum, a reflection component and a thermal disc component if the accretion is hot. The reflection features (i.e. the 6.4 keV Fe K-alpha fluorescent line, the Compton hump) are frequently observed in the X-ray spectra of accreting black holes and can provide information on the black hole spin. This talk mainly focuses on modelling the X-ray spectra of accreting black holes, including black hole binaries (BHBs) and active galactic nuclei (AGN). The reflection model has been tested on sources with various masses and properties. I started by re-examining the XMM-Newton spectrum of the black hole candidate XTE J1652-453 and found that a self-consistent relativistic reflection model works well. The scenario was then applied on more massive objects, the Type 1 AGN. The analyses of these sources again reveal the importance of disc reflection. The large soft excess displayed in the spectrum of CBS 126 can be successfully

explained by blurred reflection. The complex spectrum of MCG-6-30-15 can be modelled by a model consisting of several absorbing zones, together with a relativistically blurred reflection component. The relativistic reflection model works well on data from all epochs and explains both the spectral and timing properties without difficulty, and partial-covering absorbers are not required in all analyses.

Upper Boundary Condition for Asteroseismological Modelling of Solar-type Stars

Speaker: MSc Defence: Christopher Cooke
Time: September 10, 2013 - 2:30 PM
Location: AT 305

Abstract: In asteroseismology, improper modelling of the near-surface layers of stars has led to a well known disagreement between observed and computed oscillation frequencies. We present a grid of line blanketed spherical LTE model atmospheres and high resolution extinction spectra for use in interpolating an accurate outer boundary condition for asteroseismology calculations at arbitrary *T*eff and log g. We investigate the accuracy of four interpolation methods by interpolating among our grid to solar values of *T*eff and log *g*and comparing the results to an exact solar model. We test the impact of the resolution of our grid on the accuracy of the interpolations by perform linear interpolations among our grid at different sampling rates in Teff and log *g*. We test whether interpolating $\varkappa$R within our grid and computing τR or calculating τR for each model and interpolating it directly produces more accurate results. We also present a NLTE exact solar model and compare the boundary condition resulting from it to those of the LTE exact model. We find that quadratic and linear interpolation methods produce

comparable results, that interpolation by cubic splines produces the best results, and that least-squares quadratic interpolation produces results of least accuracy. Increasing the sampling rate in log g by a factor of 3 was found to double the accuracy of interpolations within our grid, while increasing the sampling rate in Teff by a factor of 6 was found to improve the accuracy of interpolations by a between a factor of 1.25 and 1.5. Pre-calculating τ_R for each model and interpolating among the grid was found to be more accurate than interpolating $\varkappa_R$ among the grid and computing τ_R. We also find that the photosphere in the NLTE exact solar model is situated at a lower optical depth than in the LTE exact solar model.

Undergraduate Symposium

Speaker: Undergraduate Symposium
Time: September 6, 2013 - 10:00 AM
Location: SB160

Undergraduate Symposium

Magnetic Resonance Imaging of Complex Flow: Turbulent Rayleigh-Bénard Convection in a Supercritical Fluid

Speaker: Dr. Joshua M. Bray, Montana State University, Bozeman
Time: September 4, 2013 - 3:00 PM
Location: L176

Abstract: In pragmatic terms, the general populace recognizes Magnetic Resonance Imaging (MRI) as a premiere medical imaging modality because it permits three-dimensional examination of soft tissue—in knees, spines, brains, etc.—without

cutting them open or sticking things inside.

In actual fact, many things are better examined without cutting them open or sticking things inside!

As a non-destructive characterization technique, MRI has also emerged as an invaluable tool for engineering applications as diverse as functional materials, contaminant transport in geologic media, and carbon capture and storage. This talk will offer an introduction to MRI techniques aimed toward physicists and will explain how the interaction between nuclear spin and a magnetic field can yield detailed images and signal rich in information about molecular dynamics. Recent results on the application of MRI to a convecting supercritical fluid will also be highlighted, where pattern-forming dynamics and statistics of turbulent velocity fluctuations have been detected in a thermodynamic regime normally inaccessible to traditional flow measurement techniques. These measurements, in turn, provide experimental validation for emerging theories of “superstatistics” as a description of turbulence and other non-equilibrium phenomena.