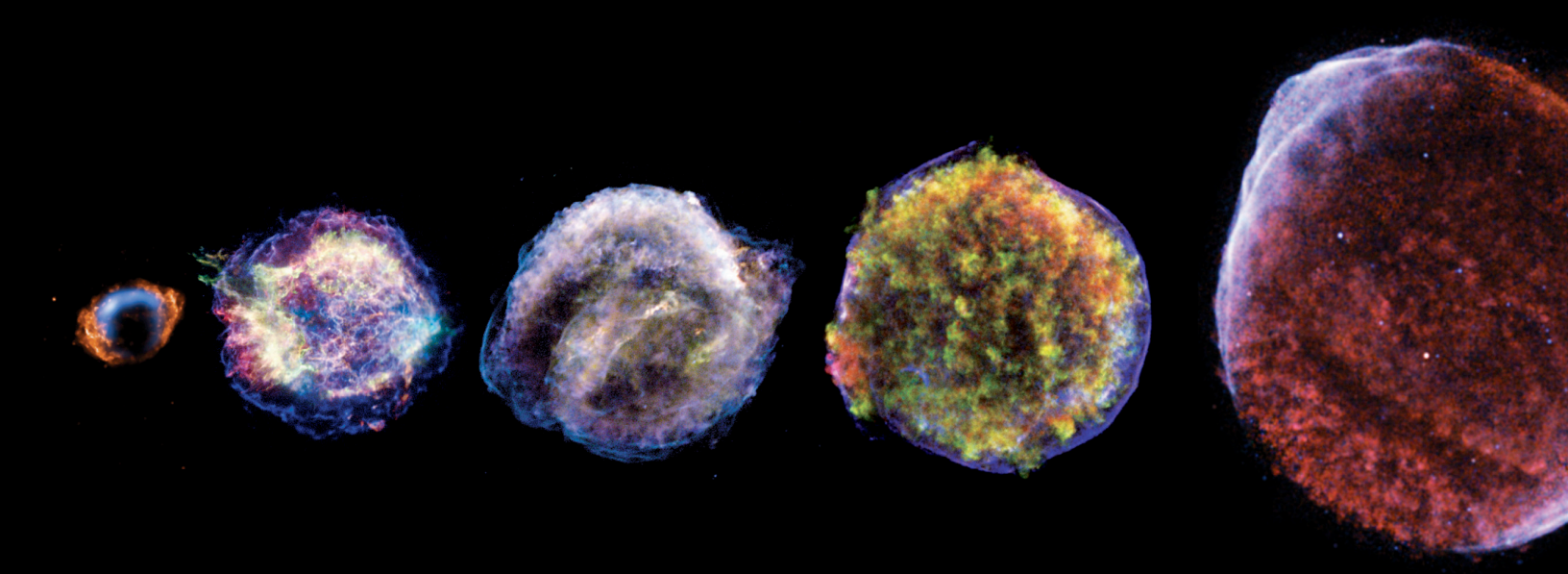

Supernova Remnants & Pulsar Wind Nebulae in the Chandra Era

Chandra X-ray Observatory

July 8 - 10, 2009

Boston, Massachusetts

Boston Doubletree Guest Suites

Hosted by the Chandra X-ray Center

Smithsonian Astrophysical Observatory

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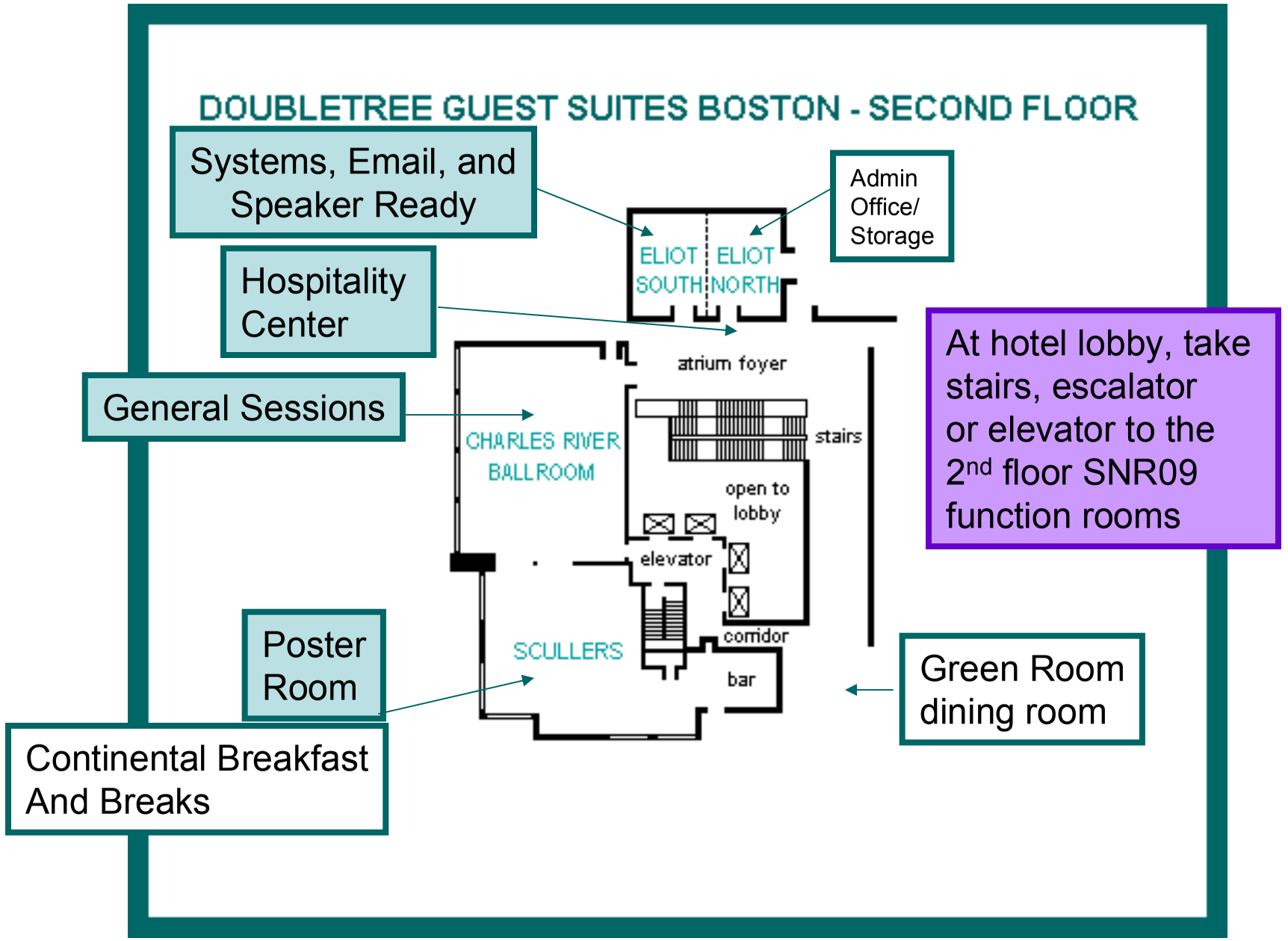
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SUPERNOVA REMNANTS AND PULSAR WIND NEBULAE IN THE CHANDRA ERA
July 8-10, 2009
PROGRAM
WEDNESDAY JULY 8

SESSION I - X-RAY OBSERVATIONS OF SUPERNOVA REMNANTS
CHAIR: DAN PATNAUDE

8:45-9:00 Opening Remarks: Dan Patnaude and Harvey Tananbaum

9:00-9:30 **Invited Talk: Anne Decourchelle**
X-ray Observations of Supernova Remnants

9:30-9:45 Talk I-1: Miguel Araya
Spectral Analysis of Nonthermal Filaments in Cas A

9:45-10:00 Talk I-2: Knox Long
The X-ray Supernova Remnant Population in M33

10:00-10:15 Talk I-3: Harsha Kumar
X-ray Properties of the SNR G292.2-0.5 Using Chandra and XMM-Newton

10:15-10:30 Talk I-4: Daniel Castro
An X-ray Study of the Bright Supernova Remnant G296.1-0.5 with XMM-Newton

10:30-11:30 Break and Poster Viewing

11:30-12:00 **Invited Talk: Armin Rest**
Optical Light Echoes from Historical Supernovae

12:00-12:15 Talk I-5: Laura Lopez
X-ray Line Morphology as a Tracer for SNR Histories

12:15-12:30 Talk I-6: Gilles Maurin
A Large XMM-Newton Program on SN 1006

12:30-1:30 – LUNCH

SESSION II - PULSAR WIND NEBULAE: THEORY AND OBSERVATIONS
CHAIR: ROGER CHEVALIER

1:30-2:00 **Invited Talk: Elena Amato**
PWNe and Relativistic Shocks

2:00-2:15 Talk II-1: Maxim Lyutikov
High-sigma Model of Pulsar Wind Nebulae

2:15-2:30 Talk II-2: Roland Kothes
A Comparison of Radio and X-ray Observations of Evolved Pulsar Wind Nebulae

2:30-2:45 Talk II-3: Eric Gotthelf
SNR G12.82-0.02: Radio Shell, X-ray Pulsar, TeV Wind Nebula

2:45-3:00 Talk II-4: Tea Temim
Infrared Observations of the Shell Surrounding the Pulsar Wind Nebula G54.1+0.3

3:00-3:15 Talk II-5: Joseph Gelfand
Modeling the Dynamical and Radiative Evolution of a PWN Inside a SNR

3:15-3:30 Talk II-6: Bernhard Glück
The Vela X Pulsar Wind Nebula in the TeV Regime

3:30-4:00 Break and Poster Viewing

SESSION II - CONTINUED
CHAIR: FABRIZIO BOCCHINO

4:00-4:30 **Invited Talk: Oleg Kargaltsev**
Pulsar-Wind Nebulae in the Chandra Era

4:30-4:45 Talk II-7: Mallory Roberts
The Pulsar Wind Nebulae of Three Radio Quiet Gamma-Ray Pulsars

4:45-5:00 Talk II-8: Yoichi Yatsu
Discovery of Temporal Changes in the Torus around PSR B1509-58

5:00-5:15 Talk II-9: Pat Slane
Observations of Bow–Shock Pulsar Wind Nebulae

5:15-5:30 Talk II-10: Heather Matheson
Exploring the Plerionic Supernova Remnant G21.5-0.9 with Chandra

5:30-5:45 Talk II-11: Zaven Arzoumanian
A Pulsar Wind Nebula in the Radio SNR G76.9+1.0

5:45-6:00 Talk II-12: Aya Bamba
Chandra View of Pulsar Wind Nebula Tori

THURSDAY JULY 9

SESSION III - SUPERNOVA REMNANTS AND PULSAR WIND NEBULAE ACROSS THE ELECTROMAGNETIC SPECTRUM
CHAIR: PAUL PLUCINSKY

9:00-9:30 **Invited Talk: Robert Fesen**
Multiwavelength Observations of Supernova Remnants

9:30-9:45 Talk III-1: John Dickel
Radio and X-ray Properties of Magellanic Cloud Supernova Remnants

9:45-10:00 Talk III-2: Laura Chomiuk
The Luminosity Function of Supernova Remnants at 20 cm

10:00-10:15 Talk III-3: Yves Gallant
A non-thermal X-ray shell coincident with the gamma-ray source HESS J1731-347

10:15-10:30 Talk III-4: Reshmi Mukherjee
Observations of Supernova Remnants with VERITAS

10:30-11:15 Break and Poster Viewing

11:15-11:45 **Invited Talk: Marianne Lemoine-Goumard**
H. E. S. S. Observations of SNRs and PWNe

11:45-12:00 Talk III-5: Ester Aliu
TeV Gamma-ray Observations of Pulsar Wind Nebulae with VERITAS

12:00-12:15 Talk III-6: Jules Halpern
Two Magnetar Candidates in HESS Supernova Remnants

12:15-12:30 Talk III-7: Arache Djannati-Atai
HESS discovery of VHE gamma-ray emission from a remarkable young composite SNR

12:30-1:30 – LUNCH

SESSION IV - SUPERNOVAE SHOCKS AND PLASMA PHYSICS
CHAIR: PAT SLANE

1:30-2:00 **Invited Talk: Adam Burrows**
What the Emerging Theory of Core-Collapse Supernova Explosions May Say About the Morphology of Their Remnants

2:00-2:15 Talk IV-1: Gilles Ferrand
3D Simulations of Supernova Remnant Evolution with Particle Acceleration

2:15-2:30 Talk IV-2: Jae-Joon Lee
Outer Shock Interaction with Progenitor Winds in Young Core-Collapse SNRs

2:30-3:00 **Invited Talk: Martin Laming**
Electron Heating Mechanisms and Temperature Diagnostics in SNR Shocks

3:00-3:15 Talk IV-3: Mario Riquelme
Magnetic Field Amplification by Cosmic Rays Near SNR Shocks

3:15-3:30 Talk IV-4: John Raymond
Non-Maxwellian Velocity Distributions in Tycho's SNR

3:30-4:00 Break and Poster Viewing

SESSION IV - CONTINUED
CHAIR: CARA RAKOWSKI

4:00-4:30 **Invited Talk: Anatoly Spitkovsky**
Particle Acceleration in Shocks

4:30-4:45 Talk IV-5: Klara Schure
Cosmic Ray Acceleration in Supernova Remnants

4:45-5:00 Talk IV-6: Dan Patnaude
Thermal Emission from Cosmic Ray Modified Shocks

5:00-5:15 Talk IV-7: Salvatore Orlando
Inverse-Compton Gamma-ray Emission from SNRs Evolving in a Non-uniform Interstellar Magnetic Field

5:15-5:30 Talk IV-8: Lorenzo Sironi
Acceleration of Particles in Relativistic Magnetized Electron–Ion Shocks

5:30-5:45 Talk IV-9: Eveline Helder
Measuring the Cosmic Ray Acceleration Efficiency of a Supernova Remnant

5:45-6:00 Talk IV-10: Marco Miceli
X-ray Signature of Shock Modification in SN 1006

FRIDAY JULY 10

SESSION V - SUPERNOVA REMNANTS AND THEIR ENVIRONMENTS
CHAIR: ERIC GOTTHELF

9:00-9:30	**Invited Talk: Richard McCray** ***SN 1987A at 22 Years***
9:30-9:45	Talk V-1: Franz Bauer *X-ray Constraints on the Nearby SN 1996cr*
9:45-10:00	Talk V-2: Vikram Dwarkadas *Using X-ray and Radio Data to Constrain the Ambient Medium around Core-Collapse SNe*
10:00-10:15	Talk V-3: Tracey DeLaney *The 3D Model of Cassiopeia A and Its Flattened Ejecta Distribution*
10:15-10:30	Talk V-4: Adele Plunkett *Three–Dimensional Kinematics of the Oxygen–Rich Supernova Remnant G292.0+1.8*
10:30-11:30	Break and Poster Viewing
11:30-12:00	**Invited Talk: Carles Badenes** ***Type Ia Supernova Remnants: The Persistence of Memory***
12:00-12:15	Talk V-5: Fabrizio Bocchino *Constraints on the Galactic Magnetic Field from the Synchrotron Radio Emission of SN 1006*
12:15-12:30	Talk V-6: Manfred Pakull *Supernova Remnants and ULX Bubbles*

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POSTERS

- Glenn Allen - A Chandra Measurement of the Expansion Rate of G266.2-1.2
- Alanna Connors - Advanced Methods of "Deconvolving" PWN Shape vs Energy in X-rays and Gamma-rays
- You-Hua Chu - Supernova Remnants and Superbubbles in the Large Magellanic Cloud
- Joseph DePasquale - From Calibration to Astrophysics with the SMC SNR 1E0102.2-7219
- Daniel Dewey - Comparing Multi-component Models of SN 1987A X-ray Emission with HETG Data
- Richard Edgar - Shock Speed, Cosmic Ray Pressure, and Gas Temperature in the Cygnus Loop
- Erica Franzmann - Mapping the Ejecta in the Peculiar SNR 3C 397
- Michael Garcia - Science with the International X-ray Observatory
- David Green - A Revised Galactic SNR Catalogue
- Eveline Helder - Characterizing the Nonthermal X-ray Emission of Cassiopeia A
- John Hughes - Supernovae and SNRs in the Era of IXO
- Karl Isensee - Variability and the High Resolution Three Dimensional Structure of Cassiopeia A
- Seth Johnson - Pulsar B2224+65 and its Jet-like Emission: A Two Epoch X-ray Analysis
- Ji-hyun Kang - Revealing Old Supernova Remnants Through H I 21cm Line Emission
- Matthew Klimek - A Multi-wavelength Study of Newly Discovered Faint SNRs in the LMC

- Daria Kosenko - Examination of the X-ray Spectra from the SNR 0519-69.0
- Harsha Kumar - Examining the SN Progenitors of High Magnetic Field Pulsars: The Case for Kes 75
- Denis Leahy - H I Distances to Supernova Remnants
- Vincent Marandon - Chandra Observations of the Unidentified TeV Source HESS J1858+020
- Fabio Mattana - The Hard X-ray Spectrum of Vela-X Observed by INTEGRAL
- Stephen Ng - A New Chandra View of SN 1987A
- Thomas Pannuti - Radio and X-ray Observations of the Northwestern Rim of G156.2+5.7
- Paul Plucinsky - A Suzaku Observation of a Region in the NE of The Monogem Ring
- Cara Rakowski - In-situ Tests of Cosmic-Ray Mediated Electron Heating at Collisionless Shocks
- Stephen Reynolds - Infrared Observations of Pulsar Wind Nebulae
- Samar Safi-Harb - Unveiling the Properties of the Supernova Remnant G63.7+1.1
- Destry Saul - A Deep Radio Survey of M33: Implications for the SNR Population
- Brian Schmitt - XMM-Newton Observations of Two Candidate Supernova Remnants
- Michael Smith - Radio and X-ray Observations of Two Double-Shell Galactic Supernova Remnants
- Michael Stage - Using Chandra to Understand the High Energy X-ray Spectrum of the Cas A SNR
- Martin Stuhlinger - New X-ray Analysis of the Supernova Remnants in the Neighbourhood of SNR 1ES0102

- Regis Terrier - The Crushed Nebula of PSR B1706-44
- Nicholas White - The International X-ray Observatory (IXO) Mission Configuration
- Brian Williams - X-ray and IR Spectroscopy of the Young Type Ia SNRs 0509-67.5 and 0519-69.0
- Annop Wongwathanarat - A Two-Patch Overset Grid for Simulating 3D Instabilities in Supernova Envelopes
- Anna Zajczyk - Near Infrared Study of the Pulsar Wind Nebula in G21.5-0.9

TeV Gamma-ray Observations of Pulsar Wind Nebulae with VERITAS

Ester Aliu
Bartol Research Institute

Pulsar wind nebulae have proved to be the single most common sources of TeV gamma rays in our Galaxy based on observations obtained from the southern hemisphere. We report on a complimentary northern survey for TeV nebular emission towards a selection of energetic and/or close pulsars using the VERITAS Cerenkov telescope array located in southern Arizona.

A Chandra Measurement of the Expansion Rate in G266.2-1.2

Glenn Allen
MIT

We reobserved the bright northwestern rim of G266.2-1.2 with Chandra five years after our first Chandra observation of this region. We will present a comparison of the data from the two epochs to determine the angular expansion rate of the remnant. This rate constrains the age and distance of the source, which are controversial.

PWNe and Relativistic Shocks

Elena Amato
INAF-Osservatorio Astrofisico Arcetri

I will review the current status of our theoretical understanding of Pulsar Wind Nebulae (PWNe). In recent years, axisymmetric models of pulsar winds with a latitude dependent energy flux have proved very successful at explaining the jet-torus morphology seen in X-ray observations of PWNe. This success has prompted developments aimed at using multi-wavelength observations of these nebulae as a diagnostic of the hidden physics of the pulsar wind and of the mechanism(s) through which particles are accelerated at the highly relativistic shock that terminates the wind. I will discuss how information can be inferred on the wind composition and structure and on the particle acceleration process at the wind termination shock based on detailed comparison of simulated synchrotron and inverse Compton emission with current and upcoming high energy observations.

Spectral Analysis of Nonthermal Filaments in Cas A

Miguel Araya
Purdue University

We have used data from the 1 Ms Chandra observation of Cassiopeia A to study the spectral evolution across thin non-thermal regions in the outer parts of this young remnant. For the 9 filaments that we examined, we found that the X-ray spectrum hardens, at about the 10% level, going outward. We attempted to explain the results with a model that takes into account both diffusion and advection. It was found that the data require relatively strong diffusion and we placed constraints on how important it might be. From the model, an estimate of the magnetic field can be derived for each filament.

A Pulsar Wind Nebula in the Radio SNR G76.9+1.0

Zaven Arzoumanian
CRESST/NASA-GSFC/USRA

The radio source G76.9+1.0 was suggested, upon its discovery, to be a Crab-like nebula despite its unusual double-lobed morphology and atypically steep spectrum. With a Chandra observation of G76.9+1.0, we have discovered nonthermal arcsec-scale X-ray nebulosity surrounding a hard unresolved source, strong evidence for a pulsar wind nebula and a neutron star that lies, figuratively and energetically, at the heart of the radio SNR. In many respects, the G76.9+1.0 system bears a strong resemblance to the radio and X-ray nebulae associated with the Vela pulsar, and to the DA 495 supernova remnant, within which Chandra also detected a candidate neutron star and PWN. These similarities suggest that Chandra is helping to reveal, for the first time, the time-evolution of Crab-like nebulae.

Type Ia Supernova Remnants: The Persistence of Memory

Carles Badenes
Princeton University

Several observational features of Type Ia Supernova Remnants can probe different aspects of the Type Ia SN phenomenon, such as the nature of the progenitor systems, the explosion mechanism, or the relationship between metallicity and peak SN brightness. I will review these features, and discuss them in the context of specific examples of Type Ia SNRs.

CHANDRA VIEW OF PULSAR WIND NEBULA TORI

Aya Bamba
ISAS/JAXA

The results from a systematic study of eleven pulsar wind nebulae with a torus structure observed with Chandra are presented. A significant observational correlation is found between the radius of the tori (r) and the spin-down luminosity of pulsars ($\dot{E}$) with a correlation coefficient of 0.87. A logarithmic linear fit between the two parameters yields $\log(r) = 0.57 \log(\dot{E}) - 22.2$. The value obtained for the $\dot{E}$ dependency of r agrees well with a theoretical expectation of square root. This is the first observational confirmation of this dependency and provides a useful tool to estimate the energetics of pulsars without direct detections of pulsation. Applications of this dependency to some other samples are also shown.

X-RAY CONSTRAINTS ON THE NEARBY SN 1996CR

Franz Bauer
Columbia University

SN1996cr is the one of the five closest SNe to explode in the past 30 yr, yet lay undiscovered for many years. Due to its fortuitous location in the Circinus Galaxy at 3.7 Mpc, we have a wealth of serendipitous archival data available to piece together its early evolution. Like SN1987A, it appears to have exploded into a wind-blown bubble structure, sparking a unique temporal evolution. SN1996cr, however, is several orders of magnitude more luminous and a factor of several more compact. I will describe current X-ray constraints on SN1996cr, focusing on a new 500ks Chandra HETG spectrum, and discuss the physical interpretations the data imply.

CONSTRAINTS ON THE GALACTIC MAGNETIC FIELD FROM THE SYNCHROTRON RADIO EMISSION OF SN1006

Fabrizio Bocchino
INAF-Osservatorio Astronomico di Palermo

Synchrotron radio emission may be very informative about the local magnetic field and the layout of bilateral supernova remnants in the 3D space. We quantitatively compared the 1.5 GHz radio maps of SN1006 with synthesized radio maps obtained for a SNR expanding in a magnetic field gradient, testing both polar-caps and barrel-like morphologies. An excellent agreement is obtained for polar-caps, with B parallel to the galactic plane, along the direction of the Sagittarius arm, a gradient pointing down to the plane toward the same arm and an aspect angle of about 48 degrees. The gradient of B is a key ingredient to overcome the difficulties of old polar-caps models in reproducing the radio emission of SN1006.

What the Emerging Theory of Core-Collapse Supernova Explosions May Say About the Morphology of Their Remnants

Adam Burrows
Princeton University

Using modern numerical tools and platforms to perform multi-dimensional radiation/hydrodynamic simulations, theorists are actively investigating the elusive mechanism of core-collapse supernova explosions. With increasing fidelity, these numerical experiments have provided physical insight into the variety of phenonoma that attend stellar death and explosion. The core of the emerging theoretical synthesis is the centrality of asphericity and the breaking of spherical symmetry. In this talk, I will review the state of the field, the contending explosion models, and the generic morphological features seen in these blast simulations. I will highlight the computational astrophysics that has been applied to date, and that may be necessary in the future, to unravel this mystery and to credibly connect the mechanism with its observational signatures.

An X-ray Study of the Bright Supernova Remnant G296.1-0.5 with XMM-Newton

Daniel Castro
CfA – USB

We present a detailed study of the observations of the supernova remnant G296.1-0.5 performed with the EPIC instrument of the XMM-Newton satellite. G296.1-0.5 is a bright remnant that displays an incomplete multiple-shell morphology in both its radio and X-ray images. An earlier X-ray observation, with the ROSAT PSPC instrument, revealed a multicomponent spectrum whose characteristics may be associated with emission from plasma with two different thermal components, or a combination of thermal and non-thermal emission. We used a set of observations towards G296.1-0.5, from three distinct pointings of EPIC, in order to perform a thorough spatial and spectral analysis of this remnant. In this presentation we discuss the results of this X-ray study of the nature of this remnant.

The Luminosity Function of Supernova Remnants at 20 cm

Laura Chomiuk
University of Wisconsin, Madison

We explore the supernova remnant luminosity function (LF) at 20 cm in 19 nearby galaxies ranging from the SMC to Arp 220. As radio synchrotron emission declines more slowly than X-ray emission after the Sedov time, the radio LF complements X-ray observations by constraining diffusive shock acceleration (DSA) and magnetic field amplification (MFA) in more evolved remnants. We find that the LF is well fit by a power law that has constant index and scaling that depends linearly on star formation rate. It appears that radio supernova remnant populations are strikingly invariant across a wide range of galaxies, and can be well fit with current models of DSA+MFA.

SUPERNOVA REMNANTS AND SUPERBUBBLES IN THE LARGE MAGELLANIC CLOUD

You-Hua Chu
University of Illinois

A large numbers of SNRs and superbubbles have been observed in the Large Magellanic Cloud (LMC). Because of its close proximity and nearly face-on view, these SNRs and superbubbles can be studied without much obscuration and confusion along the lines of sight. We will present X-ray observations of SNRs and superbubbles, and show the relationship between stellar energy feedback and subsequent star formation.

ADVANCED METHODS OF "DECONVOLVING" PWN SHAPE VS ENERGY IN X-RAYS AND GAMMA-RAYS

Alanna Connors
Eureka Scientific

Pulsar Wind Nebulae show structured emission that changes shape and extent as a function of energy. However, such diffuse emission can be hard to model and quantify. Here we demonstrate a multi-scale (wavelet-like) method tailored for Poisson data. Termed EMC2, this (Bayesian) likelihood-based "deconvolution" method: 1) is fully correct down to low or no counts per bin; 2) Uses a Haar-wavelet-like structure (with cycle-spinning) to model the unknown structure of the PWN; 3) takes into account a background model (e.g. instrumental, Galactic diffuse); and 4) in a principled way gives "error bars" on the shape. We use this to quantitatively observe the differences, as a function of narrow energy slices, in X-ray and gamma-ray bands, for emission from several Pulsar Wind Nebulae of interest.

X-RAY OBSERVATIONS OF SUPERNOVA REMNANTS

Anne Decourchelle
CEA-Saclay

The X-ray satellites currently in orbit, with complementary performances, are providing a harvest of results on supernova remnants thanks to their ability to perform spatially resolved spectroscopy. They have opened a new observational window on particle acceleration at shocks in supernova remnants. They are also providing a new insight into the supernova explosion mechanism through in-depth studies of nucleosynthesis products. I will review the X-ray observations of supernova remnants obtained with Chandra, XMM-Newton and Suzaku satellites. In light of these observations, I will discuss the current status of our understanding of supernova remnants.

THE 3D MODEL OF CASSIOPEIA A AND ITS FLATTENED EJECTA DISTRIBUTION

Tracey DeLaney
MIT Kavli Institute

We combine X-ray, infrared, and optical observations of the supernova remnant Cassiopeia A to produce a kinematic model of the explosion. The three-dimensional model is based on a Doppler reconstruction of both shocked and unshocked ejecta from different nucleosynthetic layers. We find that the reverse shock is spherical, but the ejecta distribution is flattened and oriented approximately 20-30 degrees from the plane of the sky. The well-known northeast and southwest jets are also found in this plane. The distribution of the Fe-rich emission suggests that the ejecta were expelled in a series of "blowouts" in the flattened ejecta plane.

From Calibration to Astrophysics with the SMC SNR 1E0102.2-7219

Joseph DePasquale
SAO

The oxygen-rich supernova remnant (SNR) 1E0102-7219, the brightest SNR in the Small Magellanic Cloud, has been continually observed throughout the Chandra X-ray Observatory's mission as a calibration source for ACIS. Its strong O, Ne, and Mg spectral lines, coupled with the weakness or absence of L-shell Fe, help to characterize the spectral response below 1.5 keV, compensating for the lack of strong lines in this energy range in the on-board calibration source. Through an extensive cross-calibration effort among several X-ray observatories, the spectrum of E0102 has been well modeled. Using the high-resolution grating instruments on-board XMM-Newton and the CXO, we have developed a consistent model which can be used to fit the lower resolution CCD spectra and is sensitive to any problems with the gain calibration and the spectral redistribution model of the CCD instruments as well as the effective area models in the regions of the bright lines. In addition to its effectiveness as a calibration tool, this model also provides a useful diagnostic tool for measuring spectral differences spatially within the remnant in an effort to identify the forward and reverse shock regions. The large catalog of Chandra observations of E0102 also provides a unique opportunity to explore temporal changes in both the physical structure and overall spectral properties of the remnant. Using a 9 year baseline of Chandra data, we investigate the expansion rate of the remnant as well as its spectral evolution. This work was supported by NASA contract NAS8-39073.

COMPARING MULTI-COMPONENT MODELS OF SN 1987A X-RAY EMISSION WITH HETG DATA

Daniel Dewey
MIT Kavli Institute

The interaction of SN 1987A with its environment leads to X-ray shock emission from multiple components of the system, including: the H II region, the dense protrusions of the inner ring, oblique ring interactions, inter-protrusion emission, "shock-cloud" interactions with clumpy material, and a growing contribution from the reverse-shocked SN ejecta itself. The emission signature (spatial, spectral and velocity) of each of these components is estimated with hydrodynamic models and X-ray emission calculations; these signatures are then compared with existing HETG data sets.

RADIO AND X-RAY PROPERTIES OF MAGELLANIC CLOUD SUPERNOVA REMNANTS

John Dickel
University of New Mexico

A total of 52 SNRs have been identified in the LMC and 18 in the SMC using criteria of X-ray emission and/or [S II]/Halpha > 0.5 and non-thermal radio emission. Seven candidates in the LMC (13%) may show evidence of compact stellar remains: two composite SNRs with pulsars in pulsar wind nebulae plus a shell, one pulsar at the edge of an SNR, two possible compact central objects, a radio and X-ray wake behind an escaping point X-ray source, and one SGR in a remnant. Comparison of the radio and X-ray luminosities yields a relation of X-ray proportional to Radio$^{(0.36)}$ but with a correlation coefficient of only 0.25 so there is at least large scatter in any such relation. As expected from previous studies, there is no apparent correlation between radio luminosity and diameter.

HESS DISCOVERY OF VHE GAMMA-RAY EMISSION FROM A REMARKABLE YOUNG COMPOSITE SNR

Arache Djannati-Atai
APC - CNRS

Pulsar wind nebulae constitute the most prominent population of TeV gamma-ray emitting objects revealed by the HESS Galactic Plane Survey. Most of these sources are very extended and associated with energetic middle-aged pulsars. On the other hand, in addition to the Crab nebula, a much smaller number of younger and composite objects have up to now been detected in the TeV band: MSH 15-52, G0.9+0.1, G21.5-0.9 and Kes 75. The TeV signal of these sources, appearing to originate in their plerionic core, rather than in their shell (although this is not clear-cut, e.g. for Kes 75) provides for additional constraints on their theoretical modeling. We will report on the discovery of TeV gamma-ray emission from another remarkable young composite SNR, and will discuss its implications.

USING X-RAY AND RADIO DATA TO CONSTRAIN THE AMBIENT MEDIUM AROUND CORE-COLLAPSE SNE

Vikram Dwarkadas
University of Chicago

Interaction of the SN shock wave with the surrounding medium leads to radio and X-ray emission. Analysis of the radio and X-ray light curves and spectra can be used to trace the density structure of the ambient medium, and thereby the progenitor mass-loss. In this work we compute the evolution of the SN shock wave in the ambient medium using numerical simulations. We then compute X-ray and radio light curves, and X-ray spectra using non-equilibrium ionization calculations as appropriate. Comparison is made with Chandra, XMM and radio data. The process is refined until a good match is obtained, allowing a determination of the ambient medium structure. We will demonstrate our calculations of circumstellar medium structure with examples including SN 1987A, SN 1996cr and SN 1993J.

SHOCK SPEED, COSMIC RAY PRESSURE, AND GAS TEMPERATURE IN THE CYGNUS LOOP

Richard Edgar
SAO

We have measured proper motions (from two epochs of Palomar Observatory Sky Survey plates) and post-shock temperatures (from ROSAT pointed observations) for 18 positions around the forward shock in the Cygnus Loop. The differences between shock velocity derived from the two methods constrain the efficiency of cosmic ray acceleration. Our measurements show a ratio of cosmic ray pressure to gas pressure consistent with zero. In some cases, our formal upper limits are negative. This suggests that the distance to the Cygnus Loop may be underestimated, the electron temperatures are lower than measured with ROSAT, or an additional source of heating for the electrons is present.

3D SIMULATIONS OF SUPERNOVA REMNANT EVOLUTION WITH PARTICLE ACCELERATION

Gilles Ferrand
CEA/Irfu/SAp

We report on a project aimed at simulating the morphological and spectral evolution of supernova remnants undergoing particle acceleration. We are developing a time-dependent 3D code which enables us to study the development of the Rayleigh-Taylor instability at the contact discontinuity, concomitantly with the shrinking of the region between the forward and the reverse shocks - which is expected when a sizeable fraction of the energy is channeled into energetic particles (as suggested by observations with Chandra). To model acceleration at the shock fronts, we use a semi-analytical kinetic model. As a first step we vary the effective adiabatic index of the fluid, the next step will be a multi-fluid approach in order to derive both the thermal and non-thermal emission from the remnant.

MULTI-WAVELENGTH OBSERVATIONS OF SUPERNOVA REMNANTS

Robert Fesen
Dartmouth College

Considerable advancement in our understanding of the properties of supernova remnants has occurred over the last several years from multi-wavelength observations. I will attempt to review some recent outstanding discoveries and new insights gained from X-ray, optical, infrared, & radio observations, especially on relatively young Galactic remnants including Cas A, Kepler's SNR, the Crab Nebula, 3C58, and G292.0+1.8. Asymmetries in both pulsar wind nebulae and ejecta will be discussed as will the nature of the compact central objects seen in several core-collapse SNRs.

MAPPING THE EJECTA IN THE PECULIAR SNR 3C 397

Erica Franzmann
University of Manitoba

The SNR 3C397 has a peculiar morphology with a central X-ray 'hot spot' and a sharp boundary in the west. Earlier studies showed that the column density increases from east to west and that the X-ray spectrum is dominated by thermal emission from (at least) two components: a low-temperature plasma with a high ionization timescale, mixed with a high-temperature, ejecta-dominated plasma (mainly Fe-K), with a low ionization timescale. This, together with millimeter observations of the environs of 3C 397, suggests that 3C 397 is a $\sim$5 kyr old SNR, encountering a molecular cloud towards the west, and evolving into a mixed-morphology SNR. We present an analysis of 3C 397 with Chandra and XMM-Newton targeted to map the ejecta distribution and thus shed light on the nature of the progenitor star.

A non-thermal X-ray shell coincident with the gamma-ray source HESS J1731-347

Yves Gallant
LPTA Montpellier, France

HESS J1731-347 was discovered in the Galactic plane survey by the H.E.S.S. telescopes, and was subsequently shown to coincide with a newly discovered radio shell-type SNR, G353.6-0.7. We present the results of Chandra, XMM-Newton and Suzaku observations of part of this object. These reveal rims of nonthermal emission, most likely synchrotron emission from shock-accelerated electrons, and a point-like source which may be a CCO associated with the SNR. The strong gradient in absorption across the X-ray source is used with available CO data to yield a minimum distance. We also present results on the morphology of the TeV gamma-ray source. If HESS J1731-347 is indeed a new shell-type SNR with non-thermal X-ray and TeV emission, it would be the first one discovered in gamma-rays.

Science with the International X-ray Observatory

Michael Garcia
SAO

The International X-ray Observatory (IXO) is an X-ray observatory dedicated to high resolution X-ray spectroscopy, with 100 times the throughput for high resolution spectroscopy of previous X-ray observatories. This poster will detail some of the IXO science objectives, which aim to answer the following questions: How do super-massive Black Holes grow and evolve? Does matter orbiting close to a Black Hole event horizon follow the predictions of General Relativity? What is the Equation of State of matter in Neutron Stars? How does Cosmic Feedback work and influence galaxy formation? How does galaxy cluster evolution constrain the nature of Dark Matter and Dark Energy? Where are the missing baryons in the nearby Universe? When and how were the elements created and dispersed?

Modeling the Dynamical and Radiative Evolution of a PWN Inside a SNR

Joseph Gelfand
New York University

A pulsar wind nebula (PWN) inside a supernova remnant (SNR) is a unique laboratory to determine the properties of the central neutron star, pulsar wind, and progenitor supernova. This is difficult due to the complex evolution of such a PWN, which is sensitive to the physical properties of the objects listed above. In this talk, I will present a new semi-analytic model for the evolution of a PWN inside a SNR throughout its lifetime. This model predicts both the dynamical and radiative properties of the pulsar wind nebula during this period. As a result, it is well suited for using the observed properties of a pulsar wind nebula to constrain the physical characteristics of the objects listed above - which I will demonstrate.

The Vela X Pulsar Wind Nebula in the TeV Regime

Bernhard Glück
Erlangen Centre of Astroparticle Physics

Vela X is a pulsar wind nebula (PWN) driven by the pulsar PSR B0833-45. With a characteristic age of 11 kyrs, the Vela pulsar is the prototype of a middle-age pulsar. The PWN has been observed with the imaging atmospheric Cerenkov telescope array H.E.S.S. in 2004 and 2005; a counterpart in TeV gamma-rays to the cocoon-like X-ray structure was discovered. New observations from 2006 to 2009 allowed to more precisely determine the energy spectrum and the spatial extension of the TeV emission. The presentation will give an overview of the recent H.E.S.S. results and a comparison to other wavelengths.

SNR G12.82-0.02: RADIO SHELL, X-RAY PULSAR, TEV WIND NEBULA

Eric Gotthelf
Columbia University

The young, shell-type radio supernova remnant G12.82-0.02 overlaps the compact TeV source HESS J1813-178. Recent studies have revealed evidence of a pulsar generating a wind nebula that in turn powers the TeV emission. Within the shell lies a bright, non-thermal X-ray nebula surrounding a Chandra point source. We report the discovery of a 44.7 ms signal from this source that allows us to consider the energetics of this system. PSR J1813-1749 may be the second most energetic rotation-powered pulsar in the Galaxy. In the dipole model, the surface B-field is $\sim 3\times\ 10^{12}$ G and the spin-down age is 5 kyr. The pulsar also coincides with INTEGRAL and Fermi sources. We consider the spin-down luminosity efficiency, discuss likely production mechanisms, and explore the interactions between the SNR and PWN.

H. E. S. S. OBSERVATIONS OF SNRS AND PWNE

Marianne Lemoine-Goumard
CENBG, Bordeaux

H.E.S.S. is currently the most sensitive instrument in the VHE gamma-ray domain and has revealed many new sources along the Galactic Plane, a significant fraction of which seems to be associated with PWNe and SNRs. In only a few years, several SNRs were detected, either with shell-type morphology or with apparent correlation with the ambient target material rather than with the radio/X-ray emission of the shell itself. A large part of detected H.E.S.S. sources are also associated with energetic pulsars, HESS J1825-137 and Vela X being the prototypes of such sources. In this context, updated H.E.S.S. results on SNRs and PWNe will be presented as well as their possible implications.

A Revised Galactic SNR Catalogue

David Green
University of Cambridge

A revised catalogue of 274 Galactic supernova remnants (SNRs) is presented, based in the literature published up to the end 2008. This includes 43 more objects than in the previous version of the catalogue from 2004. Simple statistics of the parameters of identified remnants will be discussed, along with the selection effects that apply.

Two Magnetar Candidates in HESS Supernova Remnants

Jules Halpern
Columbia University

We have identified two new candidate magnetars in HESS detected shell-type SNRs. This potentially doubles the number of magnetar/SNR associations in the Galaxy. We will consider whether an early evolutionary stage of a magnetar can contribute to diffuse TeV emission, a heretofore unknown channel.

CHARACTERIZING THE NONTHERMAL X-RAY EMISSION OF CASSIOPEIA A

Eveline Helder
Astronomical Institute Utrecht

Forward shocks of a number of young shell-type supernova remnants are known to emit synchrotron emission in the X-ray wave band, revealing the presence of TeV electrons. Chandra observed that the X-ray synchrotron emission for some of these remnants is confined to a thin ring at the forward shock. Cassiopeia A is such a shell-type supernova remnant with X-ray synchrotron emission at the forward shock. At the inside of Cassiopeia are filamentary structures which show spectra similar to that of the forward shock. We performed a deprojection-projection of the inner non-thermal filaments and show that their flux can not be explained solely by the emission at the forward shock. This implies that the reverse shock is also emitting X-ray synchrotron emission. This suggests that, in addition to the forward shock, the reverse shock of Cas A is capable of accelerating cosmic rays as well.

MEASURING THE COSMIC RAY ACCELERATION EFFICIENCY OF A SUPERNOVA REMNANT

Eveline Helder
Astronomical Institute Utrecht

We present the analysis of Chandra data of the supernova remnant RCW 86. This remnant has been observed in TeV gamma-rays in 2007 and emits both thermal and non-thermal X-ray emission in different parts of its shock front. The high angular resolution of Chandra enabled us to measure the proper motion of the shock front. Combined with the post-shock proton temperature, calculated from optical VLT spectra, the standard shock equation between post-shock temperature and shock velocity appears no longer valid. Since this is a non-radiative shock, the explanation for this is that the shock is cosmic ray modified. We use both the temperature and the shock velocity to determine quantitatively the fraction of the post-shock pressure contributed by cosmic rays.

Supernovae and SNRs in the Era of IXO

John Hughes
Rutgers University

The International X-ray Observatory (IXO), a joint mission under study by NASA, ESA, and JAXA, offers dramatic improvements over existing missions in terms of effective area and spectral resolution for the X-ray waveband. In this poster we present several studies that highlight the power of IXO to make fundamental advances in understanding the mechanisms of supernova explosions, constraining predictions of nucleosynthesis calculations, studying the behavior of high-speed collisionless shocks, and investigating the injection of metals and energy into the surrounding ambient medium.

VARIABILITY AND THE HIGH RESOLUTION THREE DIMENSIONAL STRUCTURE OF CASSIOPEIA A

Karl Isensee
University of Minnesota

Using the Chandra ACIS observations of Cassiopeia A, we report on the presence of seven medium scale regions ($>200''$) which exhibit intensity changes of $>10\%$ over a 4 year time span. These regions are an order of magnitude larger than previously reported intensity changes and feature abnormal changes in ionization timescale and temperature. We place these regions in the global context of the remnant by utilizing recent 3D models. Previous authors have combined Spitzer IRS and Chandra spectral mappings of the remnant, which we supplement with new, higher resolution IRS observations, to make Doppler measurements and construct 3D models of the remnant. We compare our 3D maps to models of supernovae and find that no supernova model correctly predicts the observed structure and asymmetries.

PULSAR B2224+65 AND ITS JET-LIKE EMISSION: A TWO EPOCH X-RAY ANALYSIS

Seth Johnson
University of Massachusetts, Amherst

We present an X-ray morphological and spectroscopic study of the pulsar B2224+65 and its apparent jet-like X-ray feature based on two epoch Chandra observations. The X-ray feature shows a proper motion similar to that of the pulsar ($\sim$180 mas yr^{-1}). There is also evidence for possible X-ray spectral softening in the opposite direction of the proper motion, consistent with synchrotron-driven evolution of electrons injected at different times. The combined data set further shows evidence for a counter-stream, albeit fainter and shorter than the main one. These results seem to confirm the speculation that the feature represents a relativistic particle stream confined by a highly-organized magnetic field in the surrounding medium with a largely inhomogeneous density distribution.

REVEALING OLD SUPERNOVA REMNANTS THROUGH H I 21 CM LINE EMISSION

Ji-hyun Kang
NAIC

Most of the old supernova remnant population in the Milky Way has not been identified because of intrinsic faintness and background contamination in both the radio continuum and X-ray emission. We have suggested that the faint, wing-like, H I emission features that extend to velocities beyond the limits allowed by Galactic rotation (Forbidden Velocity Wings; FVWs) in the large H I surveys could represent H I gas accelerated by supernova explosions. We have carried out high-resolution observations of some of these FVWs, and found that many of them could be old SNRs that are too faint to be visible in the radio continuum or by X-rays, but which are nevertheless revealed via their H I emission. We discuss the properties for these SNR candidates, including their X-ray characteristics.

PULSAR-WIND NEBULAE IN THE CHANDRA ERA

Oleg Kargeltsev
The University of Florida

Most of the pulsar rotational energy is lost via the wind comprised of relativistic particles and magnetic fields. The wind shocked in the ambient medium produces synchrotron nebulae observable from the radio through gamma-rays. To date Chandra resolved more than 60 pulsar-wind nebulae (PWNe) whose appearances, spectra and luminosities vary dramatically. The shape, spectrum, and radiative efficiency of a PWN depend on the angular distribution, magnetization and energy spectrum of the unshocked wind, particle acceleration mechanism, pulsar velocity and the properties of the ambient medium. We will overview and summarize recent observational results on PWNe and pulsars, paying special attention to the cases where the observational results challenge our current understanding of pulsar winds.

A MULTI-WAVELENGTH STUDY OF NEWLY DISCOVERED FAINT SNRS IN THE LMC

Matthew Klimek
CTIO/NOAO

The Large Magellanic Cloud (LMC) is an ideal site to study a large sample of supernova remnants (SNRs) in detail. We have identified new SNRs in multi-wavelength data. These SNRs are generally fainter than the known sample. We obtained X-ray images and spectra of these SNRs with XMM-Newton. We use these data along with optical emission-line images and echelle spectra to determine the properties of the SNRs. We compare the morphologies of the SNRs in the different bands. The properties of the warm ionized shell are determined from the Hα surface brightness and expansion velocity. The X-ray spectra are fit with a background model and a thermal source component. The properties of the hot gas are derived from the model fit. We compare our observations with simulations of SNR evolution.

EXAMINATION OF THE X-RAY SPECTRA FROM THE SNR 0519-69.0

Daria Kosenko
Astronomical Institute Utrecht

We present detailed analysis of X-ray emission of the young supernova remnant 0519-69.0 in Large Magellanic Cloud. We studied the data from both XMM-Newton (EPIC and RGS) and Chandra (ACIS) observatories. We used the high resolution RGS spectra to measure line velocity broadening. High spatial resolution of the ACIS data allowed us to investigate emission features from different parts of the remnant.

A COMPARISON OF RADIO AND X-RAY OBSERVATIONS OF EVOLVED PULSAR WIND NEBULAE

Roland Kothes
Dominion Radio Astrophysical Observatory

The X-ray synchrotron emission we receive from pulsar wind nebulae is mainly generated by young short lived relativistic electrons of high energy reflecting the current characteristics of its driving engine, the central pulsar. Electrons producing synchrotron emission in radio have much longer lifetimes and are mainly produced in the early life of the PWN, reflecting the total energy and magnetic field content of the nebula. Hence, the comparison of observations in both frequency regimes is a powerful tool to study not only the current status of the PWN but also its historical development, in particular for evolved PWNe. I will present the comparison of radio and CHANDRA X-ray observations of several PWNe and discuss results about their historical developments.

EXAMINING THE SN PROGENITORS OF HIGH MAGNETIC FIELD PULSARS: THE CASE FOR KES 75

Harsha Kumar
University of Manitoba

We examine the environment of the high magnetic field pulsars (HBPs) associated with supernova remnants (SNRs) in order to shed light on their evolutionary link with magnetars. Motivated by the growing evidence of massive progenitors for the magnetars, this study aims at investigating the mass of the progenitor star that formed the SNR Kes 75 and its associated HBP PSR J1846-0258, which recently exhibited magnetar-like bursts. Additionally, we compare the Kes 75 supernova explosion properties with those of the SNR G292.2-0.5, harboring the HBP PSR J1119-6127 characterized by spin properties similar to those of PSR J1846-0258. By performing a spatially resolved spectroscopic study with Chandra, we find that Kes 75 also originates from a massive progenitor.

X-RAY PROPERTIES OF THE SNR G292.2-0.5 USING CHANDRA AND XMM-NEWTON

Harsha Kumar
University of Manitoba

We investigate the X-ray properties of the SNR G292.2-0.5, associated with the high-B pulsar (HBP) J1119-6127, to determine the supernova explosion parameters and the progenitor's mass. The X-ray images reveal an unusual morphology with diffuse emission concentrated in "lobes" within the radio shell. The western side appears brighter than the eastern side with the column density and temperature decreasing towards the west, confirming the presence of a molecular cloud to the east. We find above-solar abundances for regions near the pulsar, suggesting the evidence of ejecta heated by the reverse shock. The progenitor's mass is estimated as $\sim 30 M_{\odot}$, suggesting that HBPs are associated with massive progenitors and further strengthening their link to magnetars.

Electron Heating Mechanisms and Temperature Diagnostics in SNR Shocks

Martin Laming
Naval Research Laboratory

Understanding the heating of electrons to quasi-thermal energies at collisionless shocks has broad implications for plasma astrophysics. It directly impacts the interpretation of X-ray spectra from shocks, is important for understanding how energy is partitioned between thermal and cosmic ray populations, and provides insight into the structure of the shock itself. We review the mechanisms by which electrons have been postulated to be heated at shocks in supernova remnants, and discuss the extent to which observations allow us to discriminate between them. We argue that for fast SNR shocks, electron heating in a cosmic ray precursor appears so far to be the most plausible scenario.

H I Distances to Supernova Remnants

Denis Leahy
University of Calgary

H I absorption features in the radio continuum spectra of supernova remnants (SNR) can provide useful lower and upper limits to the distance of the radio continuum source (the SNR). Lower limits result from observed absorption features, and upper limits result if a known H I cloud does not yield an absorption feature. We have analyzed the H I absorption spectra of a number of supernova remnants and also compare to CO emission spectra to further help constrain distances. This paper is a summary of results to date for several SNR, including some which have a pulsar wind nebula at their center.

Outer Shock Interaction with Progenitor's Winds in Young Core-Collapse SNRs

Jae-Joon Lee
Pennsylvania State University

Studying the environments in which core-collapse supernovae (SNe) explode and then subsequently evolve is essential to establish the nature of the mass loss and the explosion of the progenitor star. The spatial structure of the outer shock in young core-collapse SNR provides an excellent opportunity to study the nature of the medium into which the remnant has been expanding. We present our detailed study of the outer shocks in G292.0+1.8 and Cas A using Chandra X-ray observations, where we find that both remnants have been likely interacting with dense red supergiant winds produced by the massive progenitor. We discuss the nature of the winds and the progenitor stars.

The X-ray Supernova Remnant Population in M33

Knox Long
Space Telescope Science Institute

M33 contains at least 100 SNRs, identified primarily through optical imaging studies. Many of these SNRs have been detected with Chandra in the (1.4 Msec) ChASeM33 study of that galaxy. Here we describe the X-ray sample, comparing the X-ray characteristics of the M33 SNRs to their properties at other wavelengths. We classify SNRs based on their optical morphology, environment and size, and explore what characteristics may be predictors of X-ray detectability. Finally, we compare the SNRs found in M33 to those that have been observed in the Galaxy and the Magellanic Clouds, to make global comparisons of the SNRs populations in these galaxies.

X-ray Line Morphology as a Tracer for SNR Histories

Laura Lopez
University of California, Santa Cruz

We present results from a campaign to quantify the X-ray morphologies of supernova remnants (SNRs) observed with Chandra. We have applied standard techniques to archival ACIS images of 18 SNRs of all types and ages to measure chemical segregation and mixing, distribution asymmetries, and substructure. In this talk, I will discuss our results related to the X-ray line emission of SNRs. Application of our methods to remnants with multiple lines reveals that SNRs from both core-collapse and Type Ia events are chemically well mixed overall. Nonetheless, we find that small-scale variations of the elements can reveal the explosion and expansion history. Additionally, I will demonstrate the dependence of sub-structure properties on SNR characteristics, such as ionization state and environment.

High-sigma Model of Pulsar Wind Nebulae

Maxim Lyutikov
Purdue University

Pulsar winds are predicted to be Poynting flux dominated by models of pulsar magnetospheres, yet, surprisingly, one cannot construct an ideal MHD model for the interaction of a highly magnetized supersonic wind with a dense surrounding plasma, hence the so-called sigma-problem. The resolution suggested by Kennel & Coroniti is that pulsar winds must become particle dominated on the way to the nebular. We address a question of how the sigma-problem can be resolved if the wind stays highly magnetized: excessive magnetic flux should be destroyed in reconnection-type events. We construct an idealized PWN model in which the plasma flows towards two reconnection sites: the equator and the jet; this may produce the observed jet-tori structures.

CHANDRA OBSERVATIONS OF THE UNIDENTIFIED TEV SOURCE HESS J1858+020

Vincent Marandon
Laboratoire APC, Paris

The TeV source HESS J1858+020 has been discovered in 2008 by the High Energy Stereoscopic System (H.E.S.S) and has been classified as unidentified, due to the lack of obvious counterparts. The small extension and the hard spectrum of the TeV source, is reminiscent of a young and energetic pulsar wind nebulae (PWN), such as G0.9+0.1 or HESS J1813-178. We present here the results of a 30ks Chandra observation of the region and discuss the implications on the nature of the TeV emission. We also give an upper limit on the X-ray flux from the recently rediscovered SNR G35.6-0.4

EXPLORING THE PLERIONIC SUPERNOVA REMNANT G21.5-0.9 WITH CHANDRA

Heather Matheson
University of Manitoba

G21.5-0.9 is a plerionic SNR powered by one of the youngest pulsars in our Galaxy. Early in the Chandra mission, a halo was found surrounding the PWN. Using Chandra calibration data, we compiled an effective exposure of 580 ks with ACIS and 280 ks with HRC-I. The resulting image revealed, at the limit of the X-ray halo, a shell that likely traces the SNR forward shock. In addition, bright knots detected in the halo likely trace ejecta heated by the reverse shock. In this presentation, we discuss our detailed study of all components of the SNR, and highlight new results. In particular, the high resolution images revealed for the first time variable wisps in the PWN. Spectroscopy on the pulsar PSR J1833−1034 also revealed a thermal component that was previously undetected.

THE HARD X-RAY SPECTRUM OF VELA X OBSERVED BY INTEGRAL

Fabio Mattana
APC (CNRS - Universite Paris 7)

Vela X is the best example of a pulsar wind nebula (PWN) in an evolved state, offering the possibility to access both the dynamics of the interaction with the supernova ejecta, and the integrated history of particle production by the pulsar. Vela X is second only to the younger Crab Nebula as far as the observational coverage is concerned. However its hard X-ray radiation ($E > 10$ keV) is poorly known and still controversial. The sensitivity and angular resolution of INTEGRAL allow us to study the Vela pulsar, its compact PWN, and, for the first time in hard X-rays, the so-called cocoon. We present the combined IBIS/ISGRI, Jem-X, and SPI spectrum of the pulsar/PWN system. We also apply this measurement to the broadband S. E. D., to constrain the particle energies and the magnetic field.

A LARGE XMM-NEWTON PROGRAM ON SN 1006

Gilles Maurin
SAp/IRFU/CEA-Saclay

SN 1006 is an historical type Ia SNR, which exhibits in X-rays a bipolar non-thermal morphology, superposed on a fainter extended thermal emission. It is one of the best examples of shock acceleration of cosmic-ray electrons to energies approaching the knee of the cosmic-ray spectrum, as strengthened by its recent detection in the TeV energy range by HESS. We present preliminary results on a large 500 ks program of observations on SN 1006 recently performed with XMM-Newton. These data have been complemented by all previous XMM-Newton observations on this source. As they are spanning a large time interval, a particular attention is given to the subtraction of the background, whose level has increased since 2000. We report on the determination of the synchrotron roll-off along the shock.

SNR1987A AT 22 YEARS

Richard McCray
University of Colorado

I will review the evolution of the newborn supernova remnant SNR1987A, interpreting Chandra imaging and spectroscopic observations and their relationship to observations in radio, infrared, and optical bands. I will also discuss theoretical models and make some predictions about the future evolution of this system.

X-RAY SIGNATURE OF SHOCK MODIFICATION IN SN 1006

Marco Miceli
Universita' di Palermo, INAF-OAPa

Recent theoretical studies have shown that X-ray thermal emission from modified shocks in SNRs can be a powerful diagnostic tool of particle acceleration processes. By using XMM-Newton archive data, we present the first complete description of the thermal X-ray emission at the rim of SN 1006, separating it from the non-thermal contribution. We find that thermal X-ray emission is not associated with shocked ISM, but with the the ejecta, and we identify anisotropies in their temperature and chemical composition. We trace the position of the contact discontinuity over the entire shell and compare it with that expected from 3-D MHD models of SNRs with an unmodified shock, concluding that the shock is modified everywhere in the rim.

OBSERVATIONS OF SUPERNOVA REMNANTS WITH VERITAS

Reshmi Mukherjee
Barnard College, Columbia University

The detection of TeV gamma-rays from supernova remnants has opened a new window on high-energy processes occurring in their shock fronts. We highlight our latest TeV results for Cas A, IC 443, and of the "Forbidden Velocity Wing" remnant FVW 190.2+1.1, obtained with the VERITAS gamma-ray telescope array. For IC 443, the extended VERITAS emission is coincident with the site of interaction between the SNR shell and a nearby molecular cloud. We discuss the VERITAS results in the context of current models for producing the TeV emission.

A NEW CHANDRA VIEW OF SN 1987A

Stephen Ng
The University of Sydney

We present the first HRC observation of SN 1987A, which provides the highest resolution images of the remnant, revealing its detailed structure and allowing us to constrain the flux of any possible central compact objects. Quantitative spatial modeling suggests that the remnant morphology can be well-described by a thin ring plus a thin spherical shell, with the outer boundary slightly larger than the radio emission, confirming the physical picture that the X-ray emission traces the forward shock while the radio emission originates near the reverse shock.

Inverse-Compton Gamma-ray Emission from SNRs Evolving in a Non-uniform Interstellar Magnetic Field

Salvatore Orlando
INAF – Osservatorio Astronomico di Palermo

Observations of SNRs in the gamma-ray band promise to contribute important information to our understanding of the kinematics of charged particles and magnetic fields in the vicinity of strong non-relativistic shocks and, therefore, on the nature of galactic cosmic rays. Here we investigate some properties of inverse-Compton gamma-ray emission from SNRs expanding through a non-uniform interstellar magnetic field. We perform 3-D MHD simulations of a spherical SNR shock, and synthesize the inverse-Compton gamma-ray emission, making different assumptions about the details of acceleration and injection of relativistic electrons. We discuss the results derived from our simulations, with particular emphasis on those relevant to SN 1006.

Supernova Remnants and ULX Bubbles

Manfred Pakull
Observatoire Astronomique de Strasbourg

Ultraluminous X-ray sources in nearby galaxies are often surrounded by huge shock-ionized bubbles that resemble SNR, albeit with larger extent and much higher energy content. We conjecture that ULX bubbles are inflated by powerful jets similar to the famous microquasar SS433/W50. Recent Chandra observations reveal that many large SNR candidates are indeed ULX bubbles. The 250 pc diameter optical/radio nebula S26 in NGC7793 is resolved into a linear triple X-ray source that is perfectly aligned with the optical and radio contours, strikingly resembling the radio galaxy Cyg A. We discuss the interaction of the ULX/microquasar jets with the interstellar medium, and we propose that large/energetic SNR candidates rather represent (fossil) ULX/microquasar jet-inflated bubbles.

RADIO AND X-RAY OBSERVATIONS OF THE NORTHWESTERN RIM OF G156.2+5.7

Thomas Pannuti
Morehead State University

We present a broadband X-ray spectral study of the northwestern rim of the Galactic supernova remnant (SNR) G156.2+5.7. This SNR belongs to the class of sources which feature a significant non-thermal component to their observed X-ray emission. Recent X-ray observations have established that the non-thermal X-ray emission is broadly localized to the northwestern region of the SNR, but a true understanding of the process responsible for this emission has yet to be achieved. To investigate a possible synchrotron origin for this emission, we are analyzing archival X-ray observations made of this northwestern rim with XMM-Newton and RXTE as well as radio observations made with the 21-Meter Morehead State University Radio Telescope and Space Tracking Antenna.

THERMAL EMISSION FROM COSMIC RAY MODIFIED SHOCKS

Daniel Patnaude
Harvard–Smithsonian Center for Astrophysics

We present model simulations which show clear evidence for changes in the NEI behind a SNR forward shock undergoing efficient DSA. The efficient acceleration of particles lowers the shock temperature and raises the density of the shocked gas, thus altering the ionization state of the plasma. These changes are reflected in both the plasma ionization age (i.e. $n_e t$) and the emitted X-ray spectra. We also present results which demonstrate increased ionization in efficiently modified shocks. We compare the resultant spectra to the nonthermal emission from these shocks and show that in some cases, the modified thermal emission may be observable by current and future X-ray missions.

A SUZAKU OBSERVATION OF A REGION IN THE NE OF THE MONOGEM RING

Paul Plucinsky
SAO

The "Monogem Ring" (MR) is a large (D$\sim$ $25\,\mathrm{deg}$), old ($t \sim 10^5$ yr) SNR located above the Galactic plane close to the anti-center direction. The MR is one of the most prominent features in the ROSAT C Band (0.10-0.28 keV) map. We have previously modeled the MR as the remnant of a single SNe with a distance of 300-600$\sim$pc, an explosion energy of E_o = 0.2 - 1.1 $\times$ 10^{51} ergs, an initial ambient density of 3.5-5.2 $\times$ 10^{-3} cm^{-3}, and an age of 0.9-1.7$\times 10^5$ yr. We observed one region in the NE with Suzaku for 50 ks. Our spectral fits indicate that the temperature is about kT=0.20 keV and the plasma is close to CIE with a sub-solar O abundance. We compare these characteristics to the Local Bubble and speculate that the MR is a slightly younger, single SNe version of the Local Bubble.

THREE–DIMENSIONAL KINEMATICS OF THE OXYGEN–RICH SUPERNOVA REMNANT G292.0+1.8

Adele Plunkett
Middlebury College

Through a series of [O III] 5007 Å images taken from CTIO at epochs 1986–2008, we have measured proper motions for 67 ejecta knots in the core-collapse SNR G292.0+1.8. Our analysis shows that the transverse velocities of the filaments are linearly proportional to their distances from a common expansion center, and thus the O-rich filaments have been traveling with little deceleration since the initial SN event found to occur 3000 years ago. We use optical spectra from CTIO to measure radial velocities for more than 70 knots. For un-decelerated expansion, the radial velocity is proportional to the distance from the center, so we can map the three-dimensional structure and kinematics of the SNR. We will discuss the implications of the SNR's present geometry for core-collapse SNe.

IN-SITU TESTS OF COSMIC-RAY MEDIATED ELECTRON HEATING AT COLLISIONLESS SHOCKS

Cara Rakowski
Naval Research Laboratory

In a series of papers on supernova remnant shocks, we demonstrated a relationship between the electron and ion temperatures to shock velocity: $T_e/T_i \propto v^{-2}$ for shock speeds above 400 km/s, implying that thermal electrons are heated to approximately 0.3 keV, regardless of shock speed. This suggests a heating mechanism in the cosmic-ray precursor. In Ghavamian et al (2007) and Rakowski et al (2008) we explored whether lower-hybrid waves could transfer energy from the cosmic ray protons to the thermal electrons. In-situ measurements of shocks in the solar wind allow us to test these ideas directly against the cosmic ray and thermal distribution functions. Here we present preliminary findings for low-Mach number shocks in the solar wind observed with ACE.

NON-MAXWELLIAN VELOCITY DISTRIBUTIONS IN TYCHO'S SNR

John Raymond
Harvard–Smithsonian Center for Astrophysics

Particle distributions in astrophysics are usually assumed to be Maxwellian. Hα profiles of non-radiative shocks in SNRs are fit with double Gaussian profiles to obtain the pre- and post-shock temperatures. But Balmer filaments in SNRs are faint, and the observational constraints on line profile shapes are not often stringent. New, high S/N Hα profiles of Tycho's SNR from the MMT and the Hobby-Eberly Telescope make it clear that in some places the broad components are non-Gaussian. We discuss whether these should be attributed to 1) different temperatures along the line of sight, 2) power law tails, or 3) bispherical velocity distributions like those of pickup ions in the solar wind. We also compare the proper motions and proton temperatures at positions around the remnant.

Light Echoes of Ancient and Historic Supernovae

Armin Rest
Harvard University

In recent years, the discovery of light echoes from ancient and historic supernovae (SNe) has opened the door to a host of new scientific opportunities that we have only just begun to pursue. Using the spectrum of its light echo we can determine the spectral classification of a SN hundreds of years after the light of the explosion reached first the Earth. This allows us to connect the spectral type of the SN with its SNR properties. Under some circumstances, the asymmetry of the SN explosion can also be observed by comparing spectra of light echos at different angles around the SNR. In addition, in cases where the scattering dust is favorably positioned, the geometric distance to the SNR can be determined using polarization measurements.

Infrared Observations of Pulsar Wind Nebulae

Stephen Reynolds
North Carolina State University

Broadband spectral-energy distributions of pulsar-wind nebulae have mostly been confined to radio and X-ray wavelengths, leaving unanswered many questions about spectral breaks and spatial inhomogeneities. I shall summarize Spitzer results on pulsar-wind nebulae, with particular attention to two objects. In 3C 58, nonthermal modeling of the entire nebula and of the torus region near the pulsar can be constrained by the Spitzer data, while in 0540-693 in the Large Magellanic Cloud, Spitzer observations of synchrotron radiation, line emission, and thermal emission from dust combine to give us an unprecedented view of the pulsar-wind nebula and its interaction with the inner ejecta from the supernova in which it was born.

Magnetic Field Amplification by Cosmic Rays Near SNR Shocks

Mario Riquelme
Princeton University

Cosmic rays (CRs) appear to cause magnetic amplification near forward shocks in SNRs. Using particle-in-cell simulations, we explore the possible mechanisms of this amplification. For quasi-parallel magnetic fields, CRs cause the growth of the non-resonant, current-driven (NRCD) instability (Bell 2004). This instability saturates when CRs get magnetized in the generated field, yielding amplification 10 times smaller than what is needed for SNRs. We propose a new amplification mechanism driven by magnetized CRs that is characterized by the formation of filamentary structures near the shock. This mechanism, which operates in a quasi-perpendicular field geometry, can complement the NRCD instability and lead to strong amplification in both quasi-perpendicular and quasi-parallel SNR shocks.

The Pulsar Wind Nebulae of Three Radio Quiet Gamma-Ray Pulsars

Mallory Roberts
Eureka Scientific

The Rabbit, Eel and Taz PWN were all discovered in an X-Ray search of unidentified EGRET sources. Subsequent high resolution observations have shown all three to be dominated by linear outflows in X-rays, with very small tori. At least two of them are also reported to be sources of extended TeV emission. X-ray and deep radio searches for pulsations from these sources were all unsuccessful. Fermi has now discovered gamma-ray pulsations from all three. I report on recent X-ray observations of these sources, and discuss what their X-ray morphologies tell us about their environment, their history, and how that might relate to their bright gamma-ray emission.

UNVEILING THE PROPERTIES OF THE SUPERNOVA REMNANT G63.7+1.1

Samar Safi-Harb
University of Manitoba

PWNe offer a valuable astrophysical laboratory to study the physics of pulsar winds and their interaction with their surroundings, and to search for missed pulsars. The SNR G63.7+1.1 has been classified as a plerionic remnant based on radio observations revealing a centrally peaked morphology and a spectral index of 0.3. We present the analysis of archival Chandra and new XMM-Newton observations of the SNR which confirm its nature as a PWN and reveal about a dozen point sources in the field, one of which is likely the neutron star associated with the SNR. We also discuss its multi-wavelength properties, including new radio and CO data, in order to shed light on many unknown properties of this object, including its distance, age, magnetic field, and interaction with a molecular cloud.

A DEEP RADIO SURVEY OF M33: IMPLICATIONS FOR THE SNR POPULATION

Destry R. Saul
Columbia University

We present a complete catalog of radio sources in M33 as a result of the most sensitive high-resolution observations of this galaxy to date. To complement the 1.5 Msec exposure of M33 with Chandra, we obtained 80 hours of VLA observations of this Local Group member. Specifically, we obtained eight-hour integrations on each of eight fields at 6cm in the A configuration as well as an eight-hour integration at 20cm, covering most of the area of the X-ray survey. We achieved a typical rms of 12 μJy and an angular resolution of $0\farcs4$, allowing us to directly compare our sources with those from the Chandra survey. We will report on the fraction of X-ray, radio, and optical coincidences, as well as on a search for bright pulsar wind nebulae in M33, none of which are known at the present time.

XMM-Newton Observations of Two Candidate Supernova Remnants

Brian Schmitt
Pennsylvania State University

Candidate supernova remnants G25.5+0.0 and G23.5–0.0 were observed by *XMM-Newton* in a survey of plerionic SNRs. In the field of G25.5+0.0, containing the TeV source HESS J1837–069, we detected PSR J1838–0655 embedded in a $1.3'$ PWN. The pulsar + PWN luminosity is $L_{2-10\,\mathrm{keV}} \approx 5 \times 10^{34}$ erg s^{-1} at an assumed distance of 6.6 kpc. We also detected a prospective PWN (AX J1837.3–0652) with an unabsorbed flux $F_{2-8\,\mathrm{keV}} \approx 9 \times 10^{-13}$ erg cm^{-2} s^{-1}. In the field of G23.5–0.0 we detected an extended source, likely a PWN of PSR B1830–08, with a PWN luminosity $L_{1-10\,\mathrm{keV}} \approx 4 \times 10^{33}$ erg s^{-1} at a distance of 5.7 kpc. We also provide detailed multiwavelength analysis and identifications of other field sources.

Cosmic Ray Acceleration in Supernova Remnants

Klara Schure
Utrecht University

Magnetic fields and the equation of state in supernova remnants are believed to be affected by the presence of cosmic rays. We adapted an MHD code to incorporate particle acceleration using a test-particle approach. With this code, we can get the precise spectrum of cosmic rays and its dependence on e.g. the type of diffusion, the topology of the magnetic field, and the location within the remnant. We will present our most recent results.

ACCELERATION OF PARTICLES IN RELATIVISTIC MAGNETIZED ELECTRON–ION SHOCKS

Lorenzo Sironi
Princeton University

We study particle acceleration in relativistic magnetized electron-ion shocks with 2.5D PIC simulations. We find that only "subluminal" shocks, where relativistic particles can escape ahead of the shock along the field, lead to particle acceleration. The downstream ion spectrum in such shocks consists of a relativistic Maxwellian and a high-energy tail. For increasing magnetic inclination, the tail accounts for an increasing fraction of ions (from 3% to 6%) and flow energy (from 12% to $\sim$30%). The ratio of suprathermal ions to electrons is $\sim$2-10 by number and $\sim$5-20 by energy, depending on the field inclination. Efficient acceleration in relativistic (gamma$>$5) magnetized (sigma$>$0.03) flows exists only for nearly parallel shocks (magnetic inclination in the upstream frame $<$30/gamma deg).

OBSERVATIONS OF BOW–SHOCK PULSAR WIND NEBULAE

Patrick Slane
Harvard–Smithsonian Center for Astrophysics

In the late phase of a pulsar's evolution within its parent SNR, its velocity may carry it to regions for which the motion is supersonic. The interaction of the pulsar wind with its surroundings is then dominated by this motion, forming a bow shock structure with a forward shock of hot ambient gas and a termination shock where the wind is decelerated. The ratio of the radii at different angles relative to the motion provide information on the Mach number of the shock. This effect becomes even more pronounced as the pulsar exits the SNR interior and moves through the ISM, where the sound speed is lower. Here I present a summary of observations of bow shock PWNe, including results on systems that may be in transition states between the subsonic and supersonic regimes of wind confinement.

Radio and X-ray Observations of Two Double-Shell Galactic Supernova Remnants

Michael Smith
ESAC

Galactic supernova remnants (SNRs) exhibit a wide variety of morphologies which may be the product of properties of the progenitor star, the explosion mechanism, the presence of a central compact object and the physical conditions of the surrounding interstellar medium (ISM). Multi-wavelength observations are useful tools to understand the role of those factors and the relevance of each of them in the present X-ray/radio emission distribution and spectra of the remnants. In this work we jointly analyze radio and X-ray observations of the galactic SNRs G7.7-3.7 and G344.7-0.1, looking for phenomenological explanations for the observed double-shell morphology seen in these SNRs in the radio band.

Particle Acceleration in Shocks

Anatoly Spitkovsky
Princeton University

I will review the physics of particle acceleration in shocks and the conditions necessary for efficient acceleration. Ab-initio particle-in-cell simulations of collisionless shocks now allow to test the acceleration theory and to self-consistently determine the fraction of particles injected into the acceleration process. I will demonstrate how this process unfolds for both relativistic and nonrelativistic shocks, and comment on the successes and challenges in simulations of nonrelativistic shocks in the regime relevant to supernova remnants.

USING CHANDRA TO UNDERSTAND THE HIGH ENERGY X-RAY SPECTRUM OF THE CAS A SNR

Michael Stage
Mount Holyoke College

The spatial resolution of Chandra allows us to identify and study individual regions of young supernova remnants dominated by emission from thermal and non-thermal sources, as well as the contributions of heated ejecta (thermal) and synchrotron radiation (non-thermal) to the total emission in the 0.5 – 8 keV Chandra band. Of interest now is to determine the components of the spectrum above 10 keV, known since prior to the Chandra era to appear non-thermal for several young remnants. Is this radiation primarily synchrotron or non-thermal bremsstrahlung? The spectral data for the non-thermal dominated regions in the Chandra band can be fit simultaneously with RXTE and Suzaku data of the whole remnant to understand the high energy spectrum and the particle dynamics in Cassiopeia A.

NEW X-RAY ANALYSIS OF SUPERNOVA REMNANTS IN THE NEIGHBOURHOOD OF SNR 1ES0102

Martin Stuhlinger
ESAC

The Small Magellanic Cloud (SMC), due to its small distance, is an optimal candidate to study supernova remnants (SNRs). Today a total number of about 20 SNRs are known in the SMC. XMM-Newton EPIC observations of the bright SNR 1ES0102-7219 cover also the fainter SNRs IKT25, IKT21 and DEM S128 in its field-of-view. We present morphology studies for IKT25, an update of the diameter estimate of IKT21 and DEM S128, as well as new discoveries based on XMM-Newton EPIC-MOS field-of-view data.

INFRARED OBSERVATIONS OF THE SHELL SURROUNDING THE PULSAR WIND NEBULA G54.1+0.3

Tea Temim
Harvard–Smithsonian Center for Astrophysics

G54.1+0.3 is a young pulsar wind nebula (PWN) for which no thermal shell emission has been detected in X-rays. Recent Spitzer observations revealed an infrared (IR) shell that contains a dozen point sources, suggested to be young stars that were formed during the late stage of the progenitors life. The pulsar's jet terminates at a bright IR region, possibly suggesting an interaction with the shell material. The spectrum resembles the spectrum of freshly formed dust in Cas A, and the emission lines are significantly broadened and most likely originate from the expanding supernova ejecta. I will discuss the recent IR observations of this unique remnant and propsose an alternative scenario for the origin of the IR emission and the embedded point sources.

THE CRUSHED NEBULA OF PSR B1706-44

Regis Terrier
APC CNRS/Paris 7

The PSR B1706-44, possibly associated with the SNR G343.1-2.3, is surrounded by a compact X-ray and radio nebula showing a jet and torus morphology (Romani et al 2005). A more extended X-ray nebula is trailing away to the west of the pulsar suggesting the presence of a larger offset nebula similar to e.g. PSR B1823-13. Using existing deep Chandra and XMM exposures of the pulsar, we study the morphology of this extended nebula. Comparing with interstellar matter distribution we discuss a "crushed" nebula scenario analogous to Vela X and try to constrain the physical evolution of particles advected away from the pulsar.

The International X-ray Observatory (IXO) Mission Configuration

Nicholas White
NASA/GSFC

IXO is an inter-agency mission with participation from ESA, JAXA and NASA. The IXO mission will be a major facility to be considered in the 2010 Astrophysics Decadal survey that will address three timely, high priority science topics: 1) Black Holes and Matter under Extreme Conditions; 2) Galaxy Formation, Galaxy Clusters and Cosmic Feedback; and 3) Life Cycles of Matter and Energy. The reference mission includes an effective area of 3 sq m at 1 keV with 5 arc sec angular resolution; a micro-calorimeter spectrometer array, wide field and hard x-ray cameras, a grating spectrometer, plus other possible options such as high time resolution spectroscopy and an x-ray polarimeter. This presentation will summarize the current mission implementation.

X-ray and IR Spectroscopy of Young Type Ia SNRs 0509-67.5 and 0519-69.0

Brian Williams
North Carolina State University

We present Spitzer IRS and XMM-Newton RGS spectroscopy of two LMC type Ia SNRs, 0509-67.5 and 0519-69.0. Model fits to IRS data give an independent determination of post-shock density, which we combine with emission measures determined from X-ray spectroscopy to determine the amount of shocked gas in a remnant. Both SNRs show strong X-ray lines of both Fe and Si, coming from ejecta, as well as strong O lines, which we assume come from shocked ambient medium (as in Kepler's SNR). We obtain swept-up gas masses of 6 and 10.5 $M_{\odot}$ in 0509 and 0519, which combined with electron densities estimated from IR, yield volume averaged pre-shock densities of 1.5 and 2.5 cm^{-3}, respectively. In principle, this X-ray/IR approach could determine the compression ratio, and constrain cosmic-ray modification of the shock front.

A Two-patch Overset Grid for Simulating 3D Instabilities in Supernova Envelopes

Annop Wongwathanarat
Max-Planck Institute for Astrophysics

Linking theoretical models and observations of core collapse supernovae ultimately requires detailed three dimensional simulations of these events. This particularly holds for studies of clumping and mixing in supernova envelopes. To this end we have implemented a so-called Yin-Yang grid into our multidimensional Eulerian hydrodynamics code PROMETHEUS. The Yin-Yang grid is a two-patched overset grid that is axis-free. The two grid patches consist of the low-latitude regions of a usual spherical polar grid that are combined together in a simple manner. Different from a spherical polar grid the Yin-Yang grid does not suffer from axis artifacts, and a strongly inhomogeneous angular grid resolution due to the convergence of angular coordinate lines. Thus, at a given angular resolution, the Yin-Yang grid also allows for considerably larger time steps than a spherical polar grid (by about a factor of 80 for 1 degree angular resolution). The code successfully passed a set of tests including equilibria of self-gravitating homogeneous spheroids and of rotating polytropes, shock tubes, Taylor-Sedov explosions, Rayleigh-Taylor instabilities, and is now ready for astrophysical applications.

DISCOVERY OF TEMPORAL CHANGES IN THE TORUS AROUND PSR B1509-58

Yoichi Yatsu
Tokyo Institute of Technology

We present a Chandra study of temporal changes seen in the pulsar wind nebula powered by PSR B1509-58. The four monitoring observations from 2004 to 2005 revealed temporal changes of the torus. The apparent velocity of the motion is 7 arcsec/yr outward from the pulsar. If we adopt an inclination angle for the spin axis 30 degree, the velocity of the moving structure corresponds to 0.5c, which is similar to the velocity 0.45c derived for the moving wisp observed in the Crab nebula. However it is difficult to explain the obtained velocity straightforwardly by the traditional 2D MHD model.

NEAR-INFRARED STUDY OF THE PULSAR WIND NEBULAE IN G21.5-0.9

Anna Zalczyk
Nicolaus Copernicus Astronomical Center

The near-infrared band provides a possible window on optically obscured Galactic PWNe; we illustrate its potential with the young PWN in G21.5-0.9. Imaging at ESO in the 1.64μm [Fe II] line revealed emission within the PWN, presumably from shocked ejecta; follow-up spectroscopy should yield information on the PWN dynamics. Polarimetric imaging revealed a compact, strongly polarized nebula coincident with the X-ray core observed by Chandra; polarization angle measurements should yield unique information on the magnetic geometry near the pulsar wind termination shock. More generally, we discuss prospects of the NIR for improving wavelength coverage of PWN synchrotron spectra, and of the [Fe II] line to detect thermally emitting material in optically obscured SNRs.

Chandra's First Decade of Discovery

Skyline Photo by:
Patrick Pletscher

Boston, Massachusetts September 22 – 25, 2009

INVITED SPEAKERS:

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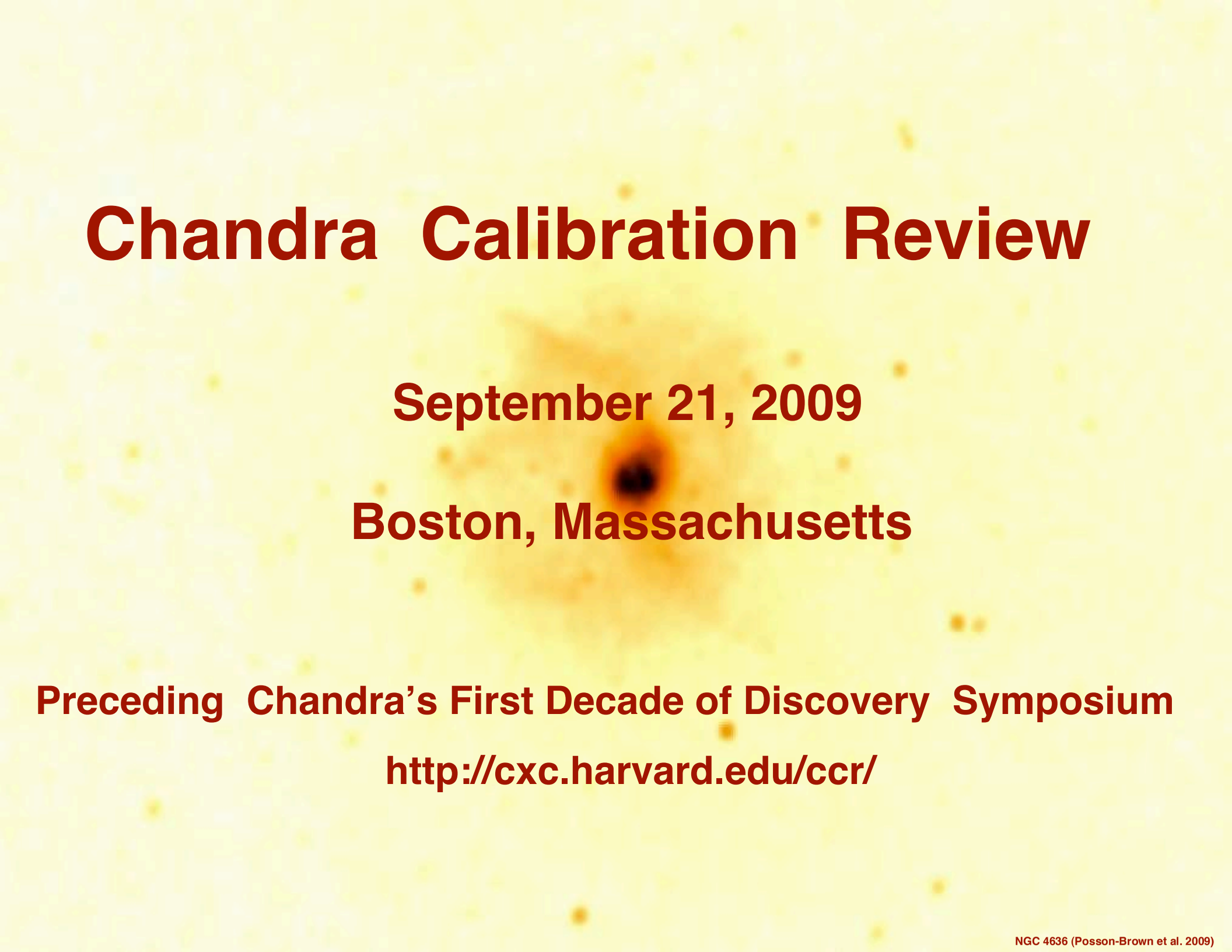

NGC 4636 (Posson-Brown et al. 2009)

NOTES