Endpoints and Interactions: SNR Workshop Program

May 24, 2007

Time	Speaker	Title
Remnant Type Summary		
8:30-9:10	Carles Badenes	The Type Ia SN/SNR Connection
9:10-9:50	Roger Chevalier	The Core Collapse SN/SNR Connection
9:50-10:20	Break/Poster Viewing	
10:20-10:45	Tea Temim	Infrared Observations of Supernova Remnants: Spitzer and Beyond
10:45-11:10	Jong-Ho Shinn	Far-ultraviolet Views of a Mixed-Morphology Supernova Remnant-Antlia
11:10-11:35	Kelly Korreck	Balmer Remnants: Constraints on SN Progenitors
11:35-12:00	Tom Pannuti	A Search for Chandra-Detected Counterparts to Optically-Identified Supernova Remnants and Candidate Radio Supernova Remnants in Nearby Spiral Galaxies
Noon-2pm	Lunch	
ISM/CSM Interaction		
2:00-2:40	John Raymond	Collisionless Supernova Remnant Shocks in the ISM
2:40-3:20	Claes Fransson	Shocks in SN 1987A and the relation to other SNe
3:20-3:50	Break/Poster Viewing	
3:50-4:15	Klara Schure	What does the jet of Cas A tell us about its progenitor star?
4:15-4:40	Steve Reynolds	Type 1a Remnants with Circumstellar Interactions: A New Subclass?
4:40-5:05	Tracey Delaney	Jets, Rings, And Holes In Cassiopeia A: New Insights Into The Explosion
5:05-5:30	Fabrizio Bocchino	On The origin of Asymmetries in Bilateral supernova Remnants

May 25, 2007

Time	Speaker	Topic
Shock Physics		
8:30-9:10	Martin Laming	Shock Physics in Supernova Remnants
9:10-9:50	Gamil Cassam-Chenai	Cosmic Ray Acceleration at the Blast Waves of Supernova Remnants
9:50-10:20	Break/Poster Viewing	
10:20-10:45	Dan Patnaude	The Hydrodynamics and Thermal X-ray emission of Cosmic Ray Modified Shocks
10:45-11:10	Cara Rakowski	Shock Physics in SNR: An Observational Perspective
11:10-11:35	Sangwook Park	Ultra-Deep Chandra Observation of Galactic Oxygen-Rich Supernova Remnant G292.0+1.8: The First Images
11:35-12:00	Aya Bamba	X-ray Studies on SNRs with Suzaku
Noon-2pm	Lunch	
2:00-2:40	Salvatore Orlando	MHD interaction of SN shock waves with thermally conducting, radiative ISM clouds
2:40-3:20	Marco Miceli	An X-ray study of metal abundances behind the Vela SNR shock
3:20-3:45	Break/Poster Viewing	
3:45-5:00	Workgroup Discussions on SNR Campaigns	
5:00-5:30		Summary of Meeting: Future Plans

The Type1a SN/SNR Connection

Carlos Badenes, Rutgers University.

Despite their pivotal role in cosmology and other fields of Astronomy, Type Ia Supernovae (SNe) remain mysterious in many ways. Among the fundamental issues that are still being debated are the identity of the progenitor systems and the detailed physics involved in the explosion. Decades of efforts devoted to observing and interpreting the light curves and spectra of Type Ia SNe have only provided partial answers to these questions. I will present some results obtained using a different approach: the study of the X-ray observations of young supernova remnants originated in Type Ia explosions. Careful modeling of these observations based on hydrodynamic and nonequilibrium ionization simulations can rule out several scenarios for the explosion mechanism and the presupernova evolution of the progenitors with a high degree of confidence.

The Core Collapse SN/SNR Connection

Roger Chevalier, University of Virginia

The type of core collapse supernova can be related to the amount of mass loss leading up to the supernova explosion, going from Type IIP (plateau light curve) with little mass loss to the Type Ib/c in which the H envelope has been lost. The very early (age ~ year) supernova remnant evolution can be observed in radio and X-ray emission for all types of core collapse supernovae. There are also optical signatures of interaction for the denser winds. The inferred mass loss properties are generally consistent with expectations from stellar evolution. The mass loss properties should still be imprinted on Galactic remnants with ages of a few thousand years or less, allowing the remnants to be typed. The presence of a central pulsar nebula can be useful because of its illumination of the central ejecta.

Infrared Observations of Supernova Remnants: Spitzer and Beyond

T. Temim (University of Minnesota); Woodward, Charles E.; Gehrz, Robert. D.;
Polomski, Elisha F.;Rudnick, Lawrence; Roellig, Thomas L.

Supernova remnants (SNRs) are important laboratories for the study of a variety of astrophysically important processes, including shock interactions between the expanding remnant and the interstellar medium and the condensation of dust in chemically enriched ejecta. Infrared (IR) observations are crucial for the study of the dust content and grain processing and for determination of grain properties and elemental abundances in SNRs. The imaging and spectroscopic instruments on the Spitzer Space Telescope have provided a unique opportunity to study the composition and spatial morphology of SN ejecta and dust in SNRs. Recent Spitzer observations of SNRs are reviewed, including observations of the Crab and Cas A, spectroscopic monitoring of SN 1987A, and large surveys of global characteristics of SNRs in the IR. The role of IR observations in addressing future challenges and opportunities for progress in SNR research will also be discussed.

Far-ultraviolet Views of a Mixed-Morphology Supernova Remnant-Antlia SNR-

Jong-Ho Shinn[1†], K. Min[1], R. Sankrit[2], K. Ryu[1], I. Kim[1], W. Han[3], U. Nam[3], J. Park[3], J. Edelstein[2], E. Korpela[2]
[1]*Korea Advanced Institute of Science and Technology (KAIST), Republic of Korea,*
[2]*University of California, Berkeley,*
[3]*Korea Astronomy and Space Science Institute (KASI), Republic of Korea.*
[†]Current address: Seoul National University, Republic of Korea

Mixed-Morphology Supernova Remnants (MM SNRs) are well known for their unusual center-filled X-ray morphology. Two models have been explained such property, employing different distributions of cold-and-dense gas components around the supernova. To investigate the cooling features, expected to be generated as the cold and-dense gas interacting with the hot gas of the remnant, we observed the Antlia SNR, a large MM SNR (~24° in diameter), in far-ultraviolet domain with *Spectroscopy of Plasma Evolution from Astrophysical Radiation* (*SPEAR, aka FIMS*). We detected two efficient radiative cooling emission lines: C III l977 and C IV ll1548,1551. The C IV emission line map shows a clumpy distribution, and the temperature profile, inferred from the line ratio of C III and C IV, is increasing near the edge of the remnant. These results are more compatible with the thermal evaporation model than the thermal conduction model, which predicts the edge-concentrated C IV feature and the decreasing temperature profile near the edge of the remnant.

Balmer Observations of Supernova Remnants: Shock Physics and Constraints on Supernova Progenitors

K. E. Korreck, Harvard-Smithsonian Center for Astrophysics

H-alpha Balmer filaments associated with SNR have been used to gain insight into the interaction of the blast wave from the supernova and the surrounding CSM. In addition to reviewing the shock and ISM physics that is revealed through these filaments, new work will be discussed that link the environment in which these Balmer filaments exist with the progenitor of the SNR. Using estimates of ionizing radiation from possible SN progenitors and modeling the ISM with CLOUDY we discuss the use of Balmer filaments as constraints on the progenitor systems.

A Search for Chandra-Detected Counterparts to Optically-Identified Supernova Remnants and Candidate Radio Supernova Remnants in Nearby Spiral Galaxies

T. Pannuti, Morehead State University

We present the results of a search for Chandra-detected counterparts to optically-identified and candidate radio supernova remnants (SNRs) in nearby galaxies. The unsurpassed angular resolution of the Chandra X-ray Observatory (approximately one arcsecond) has proven to be essential for the identification of X-ray counterparts to SNRs located in regions of high confusion in external galaxies. We will present comparisons of the properties of SNRs with and without Chandra-detected counterparts. In the case of the optically-identified SNRs with and without Chandra-detected counterparts, we will compare such properties as line ratios and diameters. Likewise, in the case of candidate radio SNRs with and without Chandra-detected counterparts, we will compare such properties as radio luminosities and spectral indices. We will also identify SNRs with Chandra-detected counterparts which are either time-variable or which feature harder spectra which are more consistent with X-ray binaries than SNRs. Initial results and preliminary conclusions are presented and discussed.

Collisionless Supernova Remnant Shocks in the ISM

J.C. Raymond, Harvard-Smithsonian Center for Astrophysics

Collisionless shocks have been extensively studied in the solar wind, but for the most part supernova remnant studies make simple assumptions as to their properties. Properties that matter for the interpretation of observations are; the degree of thermal equilibration among electrons, protons and other ions; the fraction of energy dissipated by the shock that goes into nonthermal particles; the amplification of magnetic fields; the degree of turbulence generated by the shock; and the ripples in the shock front caused by density inhomegeneities associated with interstellar turbulence.

Shocks in SN 1987A and the relation to other SNe

Claes Fransson, Stockholm University

The collision between the circumstellar ring and the ejecta in SN 1987A offers a unique opportunity to study shock physics in real time. In this talk I will discuss ground based and space observations, their interpretation in relation to shock models, and what we can learn from these. I will also mention the possibilities with future instruments, as well as the relation to other supernovae, in particular to SNe which have undergone strong mass loss.

What does the jet of Cas A tell us about its progenitor star?

K.M.Schure, J.Vink, G.García-Segura, A.Achterberg, Hydrodynamics Inc.

The shape of a supernova remnant (SNR) is largely determined by its circumstellar medium, which is formed by the supernova's progenitor star. In the Cassiopeia A SNR, a jet is apparent in the North-East and, less prominently, in the South-West. The progenitor of Cas A is thought to have had a red supergiant phase followed by a Wolf-Rayet (WR) phase. With 2D-hydrodynamical simulations of an axisymmetric explosion and the progenitor wind, using the ZEUS-3D code, we try to reproduce the morphology of Cas A and put restrictions on its progenitor history and the energy budget of the jet.

In our simulations, the main variables are the duration of the WR phase and the jet energies. The other variables, such as density and explosion energy, are constrained by demanding that the main shock radius and velocity match those observed for Cas A. We find that the presence of a jet severely constrains the duration of the WR phase. For a long duration the contrast in density between the WR wind and the surrounding shell, and the mass and thickness of the shell, become so large that the jet is destroyed as soon as it hits the shell. Our main conclusion is therefore that the WR phase must have been short (<5000 yrs), if present at all. Since the actual jet length is unknown, we can only derive a lower limit for the jet energy, which is 1050 erg. We report on an analytical formula for the jet length as a function of jet energy that fits the results from simulations quite well.

Type Ia Remnants with Circumstellar Interaction: A New Subclass?

Steven Reynolds, North Carolina State University

In the traditional accreting single-degenerate scenario for thermonuclear supernovae, one expects little circumstellar material (CSM), consistent with lack of detection of prompt radio or X-ray emission from extragalactic SNe Ia. However, several recent lines of evidence indicate the presence of CSM interaction in a few SNe Ia, or suggest the existence of more massive SN Ia systems, which should be accompanied by more significant mass loss. CSM interaction can also be identified from remnants of SNe Ia. I shall describe two such lines of evidence: two evolved remnants in the Large Magellanic Cloud with dense, highly ionized iron in their centers; and Kepler's SNR, the subject of a recent 0.75 Ms Chandra observation, where a Type Ia origin and clear CSM interaction are both confirmed. A significant fraction of Type Ia supernovae may result from a more massive, younger population, with significant impact on chemical evolution of galaxies and the cosmological use of SNe Ia. SNR studies can confirm the existence of such a population and examine its properties.

Jets, Rings, And Holes In Cassiopeia A: New Insights Into The Explosion

Tracey DeLaney (1), J. D. Smith (2), L. Rudnick (3), J. Rho (4), W. Reach (4), J. Ennis (3), H. Gomez (5), T. Kozasa (6)
(1) MIT Kavli Institute, (2) Steward Observatory, (3) University of Minnesota, (4) Spitzer Science Center, (5) University of Wales, United Kingdom, (6) Hokkaido University, Japan.

The spectral mapping of Cassiopeia A with Spitzer has allowed us to use Doppler measurements to construct a 3-D model of the remnant structure. Combined with Doppler measurements from X-ray spectra and the locations of optical ejecta beyond the forward shock, we have gained new insights into the explosion that caused Cas A. The structure of Cas A can be characterized into "holes", "rings", and "jets". The holes refer to gaps between the front and back surfaces of the unshocked infrared ejecta that occur mostly in the plane of the sky. The shocked IR ejecta and the Si-rich X-ray ejecta form ring-like structures that line the holes in the unshocked ejecta. The well-known northeast and southwest jets extend through two of the holes in the unshocked ejecta. The Fe-rich X-ray ejecta has a different distribution from the other ejecta in that it is oriented approximately 90 degrees from the jet axis. The Fe-rich X-ray ejecta can be described as forming two jets that also extend through holes in the unshocked ejecta. The outer optical ejecta beyond the forward shock appears mostly in the plane of the sky and is certainly associated with the holes in the unshocked ejecta. Taken together, these clues indicate a series of blow-outs or jets in the plane of the sky where the highest velocity ejecta are found. The distribution of the Fe-rich ejecta provides a tidy explanation for the offset of the point source from the expansion center of the remnant and challenges the idea of overturning in the ejecta layers.

We would like to thank J. Lazendic and D. Dewey for their HETG Doppler data and M. Stage and G. Allen for their ACIS Ms Doppler data.

On the origin of asymmetries in bilateral supernova remnants

F. Bocchino, S. Orlando, F. Reale, G. Peres, O. Petruk, INAF-Osservatorio Astronomico di Palermo

Bilateral supernova remnants (BSNRs; a.k.a. "barrel shaped" or "bipolar" SNRs) are incomplete radio shells with two opposite bright limbs, separated by a region of almost no emission. Quite often, the limbs have different luminosity and/or are converging on one side ("asymmetric" BSNRs). Their appearance is the result of the local density and magnetic field, of the dependence from the line of sight of the synchrotron emission and of the dependence of the injection efficiency from density, shock speed and obliquity. Here we aim at investigating the origin of asymmetries in the radio band observed in BSNRs. To this end, we developed a MHD model describing the expansion of SNRs in large-scale density or magnetic field gradients and we synthesized, from the models, the synchrotron radio emission, making different assumptions about the details of acceleration and injection of relativistic electrons. We found that, on one hand, our model reproduces in a natural way most of the asymmetries commonly observed in BSNRs, on the other hand, it may provide clear-cut diagnostic on the behaviour of the electron injection efficiency along the shell.

Shock Physics in Supernova Remnants

J. M. Laming, Naval Research Laboratory

Shock physics in supernova remnants covers a multitude of sins. In this talk I will attempt to give an overview of the problems once faces in modeling or understanding a collisionless shock, where the transition from unshocked to shocked conditions occurs of a length scale much shorter than the usual collisional mean free path. Energy is transferred among particle species (thermal and suprathermal ion and electrons) by the action of MHD and plasma kinetic instabilities. I will review what is known (or believed) about the important processes of this sort, and highlight the various observational signatures that might be available for us to detect.

Cosmic Ray Acceleration at the Blast Waves of Supernova Remnants

G. Cassam-Chenai, Rutgers University

Collisionless shocks in supernova remnants can be highly efficient accelerators, placing 10-50% of the ram kinetic energy into relativistic particles. With such efficiencies, nonlinear effects are expected: modification of the shock structure and hydrodynamics, increase of the overall shock compression ratio, amplification of the magnetic field at the shock, modification of the particle spectra, lower shocked gas temperature. Related to those different aspects, I will show what we can learn from the recent observations of synchrotron emission from young shell-type supernova remnants.

The Hydrodynamics and Thermal X-ray emission of Cosmic Ray Modified Shocks

D.J. Patnaude, Harvard-Smithsonian Center for Astrophysics

Efficient cosmic ray acceleration in supernova remnants results in both higher shock compression and lower post shock temperatures compared to cases where cosmic ray production is ignored. These changes in the properties of the shocked plasma will translate into changes in the thermal X-ray emission in the interaction region between the forward and reverse shocks. Furthermore, the relativistic cosmic ray electrons produced in the diffusive shock acceleration process generate nonthermal X-ray synchrotron emission which is self-consistently determined with the thermal emission through the nonlinear shock acceleration mechanism. We present results from simulations where the remnant hydrodynamics are coupled to efficient cosmic ray acceleration and to a nonequilibrium ionization calculation of thermal X-ray emission. By varying the particle injection efficiency, ambient density, and the electron heating mechanism, we produce a grid of models which show variations in the resultant X-ray spectra where the thermal and nonthermal contributions are determined self-consistently.

Shock Physics in SNRs: an observational perspective

Dr. Cara E. Rakowski, Naval Research Laboratory
National Research Council Fellow

The outer blast-waves of supernova remnants (SNRs) are an example of ``collisionless shocks'', i.e. the width of the shock transition is tiny compared to the Coulomb mean-free-path. In these shocks the particle heating to postshock temperatures and acceleration to cosmic ray energies must be mediated by plasma waves arising from instabilities, and not just from random Coulomb collisions. The 1/1835 mass ratio of electrons to protons makes the heating and acceleration of electrons particularly difficult. In this talk I will explain the spectroscopic techniques for determining the proton, ion and electron temperatures at a variety of supernova remnant shocks, and present the latest data on the electron to proton temperature ratio from this survey. The observed inverse square dependence of the electron to proton temperature ratio with shock velocity can be explained by a physical model for the electron heating, whereby lower hybrid waves excited in the shock cosmic-ray precursor damp by accelerating electrons along the local magnetic field, echoing recent suggestions in the literature that the cosmic rays are an integral part of the collisionless shock structure.

Ultra-Deep Chandra Observation of Galactic Oxygen-Rich Supernova Remnant G292.0+1.8: The First Images

Sangwook Park, David N. Burrows (Penn State), John P. Hughes (Rutgers),
Patrick O. Slane (SAO), Bryan M. Gaensler (Sydney), Parviz Ghavamian
(Johns Hopkins)

We present the first images of Galactic O-rich supernova remnant (SNR) G292.0+1.8 from our ultra-deep 0.5 Msec Chandra observation. The deep Chandra ACIS data cover the entire SNR, revealing all the detailed substructures of the outermost boundary of the blast wave and new metal-rich ejecta features which were not detected by previous Chandra observation that had a 10 times shorter exposure and a small field of view. Our deep Chandra data also discover the spectacular structure of a torus and a jet in the central pulsar wind nebula (PWN), reminiscent of the Crab nebula. Utilizing extremely rich photon statistics, we present high-quality images of O-, Ne-, Mg-, and Si-rich ejecta, dense circumstellar medium produced by the massive progenitor's stellar winds and then shocked by the blast wave, the blast wave shock front propagating into a low-density ambient medium all around the SNR, and the fine-structure of the central PWN.

X-ray Studies on SNRs with Suzaku

A. Bamba, ISAS/JAXA

Suzaku is the fifth Japanese-US X-ray satellite with X-ray CCDs (XIS) and a hard X-ray detector (HXD). XISs have large quantum efficiency and good energy response in the 0.2--12 keV band, thus are good at detecting faint sources and their emission lines. HXD has good detection limit in the 10--70 keV band, implying that HXD is the first detector with enable to make maps of hard X-ray emission in SNRs. Thus, Suzaku is good for the studies on thermal and nonthermal properties of SNRs. We will talk on some new topics of SNRs with Suzaku in this paper.

MHD interaction of SN shock waves with thermally conducting, radiative ISM clouds

S. Orlando, F. Bocchino, F. Reale, G. Peres, P. Pagano, INAF-Osservatorio Astronomico di Palermo

We explore the role of anisotropic thermal conduction in the MHD interaction of a supernova shock wave with radiative gas clouds, and in determining the mass and energy exchanges between the cloud and the hot surrounding medium. To this end, we developed a MHD model describing the impact of a strong shock onto an isolated ISM cloud, taking into account anisotropic thermal conduction and radiative cooling. We present simulations in both the strong and weak magnetic field limits, considering different magnetic field configurations. We found that, in general, the thermal conduction is not completely suppressed by an organized ambient magnetic field but its effect is quenched by a factor depending on the initial field configuration, leading to important consequences on the mass and energy exchanges between the cloud and the surrounding medium. We discuss our results in the framework of current SNR evolutionary models, like the White & Long (1991) evaporating cloud model and the Cox et al. (1999) thermally conducting SNR model.

An X-ray study of metal abundances behind the Vela SNR shock

M. Miceli, F. Bocchino
INAF-Osservatorio Astronomico di Palermo

We present the preliminary results of the combined analysis of three XMM-Newton EPIC observations of the northern rim of the Vela SNR. The three pointings cover an area of ~11 pc^2 (at 250 pc) behind the main shock front and allow us to study with high resolution the spatial distribution of the physical and chemical properties of the X-ray emitting plasma on this large scale. We perform spatially resolved spectral analysis and we also produce equivalent width images of the Ne IX and Mg XI emission blends. We find inhomogeneous patterns of abundances of O, Ne, Mg, and Fe with locally highly enhanced abundances of Ne and Mg. These results support a possible association of a few X-ray emitting knots with residuals of stellar fragments that (at odds with what happens for the Vela shrapnels) are located BEHIND the main shock front and are maybe partially mixed with the ambient shocked interstellar medium.

Poster Session:

HETG spectral-imaging of SN 1987A

D. Dewey (MIT), C.R. Canizares, R. McCray, S. Zhekov, K. Borkowski, D. Burrows, E. Dwek, and S. Park

We are undertaking deep, high-resolution observations of SN 1987A at ~ 20 years after its explosion with HETG and LETG observations. In March-April of 2007 HETG observations totaling 370 ks are being taken as part of the HETG GTO program. Later in the Fall 2007, deep complementary LETG observations (McCray, P.I.) will be taken as well; with the full set of deep line-images we can do detailed fitting of spatial-velocity-ionization models of the SN 1987A emission.

The HETG data presented here provide the highest-resolution X-ray spectra of SN1987A with high signal-to-noise in the 6A to 20A bandpass which includes the H-like and He-like lines of Si, Mg, Ne, as well as the O VIII line and bright Fe XVII lines. Using simple 3D geometric models including Doppler velocity effects we can fit the spectral-images of individual lines to obtain information relevant to the CSM interaction(s) taking place around SN1987A.

The High-Energy X-Ray Spectrum of Cas A: Nonthermal Bremsstrahlung v. Synchrotron Radiation

Allen, G. E. (MIT), Stage, M. D., and Houck J. C.

We performed a joint spectral analysis of some Chandra and RXTE data for the supernova remnant Cas A. A 1.1 Ms ACIS data set is used to identify regions dominated by synchrotron radiation. The best-fit spectral models for each of these regions are combined to obtain a composite synchrotron model for the entire remnant. The difference between this model and the observed RXTE flux is fitted with a nonthermal bremsstrahlung model. The results of this analysis can be used to determine (1) the ratio of the synchrotron radiation to nonthermal bremsstrahlung in the RXTE energy band, (2) the shape of the electron spectrum at energies just above the thermal Maxwellian distribution, (3) the fraction of the electrons that are nonthermal and (4) the balance of energy between thermal and nonthermal electrons.

Observations of X-rays and Thermal Dust Emission from the Supernova Remnant Kes 75

Patrick O. Slane(1), T. D. Morton(2), K. J. Borkowski(3), S. P. Reynolds(3),
D. J. Helfand(4), B. M. Gaensler(5), J. P. Hughes(6)
(1) Harvard-Smithsonian, CfA, (2) Harvard College, (3) NC-State, (4) Columbia,
(5) University of Sydney, Australia, (6) Rutgers.

We present Spitzer Space Telescope and Chandra X-ray Observatory observations of the composite Galactic supernova remnant Kes 75 (G29.7-0.3). We use the detected flux at 24 micron and hot gas parameters from fitting spectra from new, deep X-ray observations to constrain models of dust emission, obtaining a dust-to-gas mass ratio M_{dust}/M_{gas} ~10^-4. We find that a two-component thermal model, nominally representing shocked swept-up interstellar or circumstellar material and reverse-shocked ejecta, adequately fits the X-ray spectrum, albeit with somewhat high implied densities for both components. We surmise that this model implies a Wolf-Rayet progenitor for the remnant.

Examination Of The X-ray Spectrum From The SNR 0509-67.5

Daria Kosenko[1] , J. Vink[1] , S. Blinnikov[2] , A. Rasmussen[3]
(1) Astronomical Institute Utrecht, The Netherlands, (2) Institute for Theoretical and Experimental Physics, Russian Federation, (3) Netherlands Institute for Space Research, The Netherlands

We report on X-ray observations of the supernova remnant 0509-67.5 in Large Maggelanic Clouds with XMM-Newton. The Reflective Grating Spectrometer data show that the remnant has a very high expansion velocity of 6000 km/s. The imaging spectroscopy data (EPIC) show that the remnant has an asymmetric ejecta structure: the bright southwest region of the remnant shows an overabundance of Si, S, Fe. This could be a sign of an asymmetric explosion or it could be the result of a density enhancement of the ISM in the Southwest. In addition to the data analysis we also present a hydrodynamical modeling of the remnant. The simulations allow us to put some additional constraints on the SNR properties and density of the environment.

Are the X-ray synchrotron filaments in Cas A associated only with the shock front?

Eveline Helder & Jacco Vink, Astronomical Institute Utrecht, The Netherlands,

We present preliminary results of our research on the non-thermal continuum emission of Cassiopeia A. Chandra discovered in 2001 thin non-thermal rims at a distance of ~150” to the center of Cas A. These rims can be associated with the forward shock and contain a surprisingly high magnetic field 0.1 - 0.5mG. This feeds the thought that forward shocks of young shell-type supernova remnants are able to accelerate cosmic rays at least up to the knee, at ~10^{15} keV. The Chandra image shows that not all non-thermal filaments are associated with the forward shock.

A natural question is whether these filaments are due to forward shock filaments projected to the interior of the remnant, or whether the filaments have another origin. We investigated this issue by employing a deprojection technique. Assuming spherical symmetry, we deproject the surface brightness into the intrinsic emissivity as a function of the radius. A surprising result of this deprojection is that we see the reverse shock coming up in the (deprojected) emissivity. This might indicate cosmic ray acceleration in the reverse shock.

Far Ultraviolet Observation of the Monogem Ring

Il-Joong Kim[1], K.-W. Min[1], K.-I. Seon[2,3], J.-H. Shinn[4],
J. Edelstein[3], R. Sankrit[3], E. J. Korpela[3], J.-W. Park[1]
[1]*Korea Advanced Institute of Science and Technology, Daejeon, 305-701, South Korea*
[2]*Korea Astronomy and Space Science Institute, Daejeon, 305-348, South Korea*
[3]*Space Sciences Laboratory, University of California, Berkeley, CA 94720, USA*
[4]*Seoul National University, San 56-1 Shillim9-dong, Seoul, 151-747, South Korea*

We present the results of the far ultraviolet (FUV) observation of the Monogem ring made with the FIMS/SPEAR instrument. The global map constructed from the C IV λλ1548, 1550 emission lines reveals clear evidence of the interaction of the Monogem ring with the ambient medium. The image shows a half ring feature in the low latitude region, with its peak along the distorted boundary of the X-ray ring where the hot gas is in direct contact with the newly found Hα ring centered at (l, b) ~ (191°.5, +5°.0). On the other hand, only a small portion of the X-ray ring is bright in C IV in the high latitude region where hot gas is seen to extend to a great distance from the ring. We have also detected other ionic emission lines in several regions of the Monogem ring such as C III λ 977, O VI λλ1032, 1038, Si II* λ 1533, He II λ 1640, and O III] λ 1666.