Eight Years of Science with Chandra

23-25 October, 2007
Marriott Huntsville
Huntsville, Alabama

This is the fourth symposium in a series highlighting unique imaging and spectroscopic results from NASA's Chandra X-Ray Observatory. The symposium also covers recent results from the XMM-Newton, Suzaku, Swift, INTEGRAL, RXTE and AGILE missions, as well as related theoretical results.

	Oct-23 Tuesday Title — Session Opening and Welcome	Day 1 Presenter — Chair
8:30am	Chandra Project Science	Martin Weisskopf
8:35am	MSFC Management	Dave King
8:40am	HQs Astrophysics Division	Jon Morse
	Solar System	
9:00am	X-rays from comets, Venus, and Mars	Konrad Dennerl
9:30am	The morphology of the X-ray emission above 2 keV from Jupiter's aurora	Ron Elsner
	Normal Stars	**Leisa Townsley**
9:45am	Who's afraid of a stellar superflare?	Rachel Osten
10:15am	Spatially resolving X-ray emission from a class-I pre-main-sequence binary system	Kenji Hamaguchi
10:30am	"Chandra, Spitzer, and VLA observations of young stellar clusters"	Scott Wolk
10:45am	Refreshments break	
	Normal-Galaxy Populations	**Mike Garcia**
11:15am	A legacy study of stellar lifecycles in the Galactic Center	Franz Bauer
11:45am	The Chandra ACIS survey of M33 (ChASeM33)	Ben Williams
12:15pm	Do ultraluminous X-ray sources exist in dwarf galaxies?	Doug Swartz
12:30pm	Lunch break	
	Surveys & AGN Searches	**Ann Hornschemeier**
1:30pm	Stacking photons in deep and large X-ray surveys	Marcella Brusa
2:00pm	Chandra COSMOS survey analysis	Simonetta Puccetti
2:20pm	Demographics of black holes in nearby galaxies	Smita Mathur
2:35pm	AMUSE-Virgo: on the survival of super-massive black holes infaint spheroids	Elena Gallo
2:50pm	Searching for AGN in the outskirts of clusters	Gregory Sivakoff
3:05pm	The AGN Butcher-Oemler effect	Paul Martini
3:20pm	Refreshments break	
	Galaxies & ISM	**Jelle Kaastra**
3:50pm	Comparing X-ray emission from ultraviolet-luminous galaxies and Lyman-break galaxies	Ann Hornschemeier
4:05pm	The low-metallicity ISM of X-ray-faint elliptical galaxies	Jimmy Irwin
4:20pm	Limits on hot Galactic-halo gas from X-ray absorption lines	Yangsen Yao
	SN & SNR	**Dan Patnaude**
4:35pm	Shock physics in SNRs: an observational perspective	Cara Rakowski
5:05pm	HETG spectral-imaging of SN 1987A	Dan Dewey
5:25pm	X-ray emission from supernovae as probes of stellar environments	Stefan Immler
5:40pm	A deep Chandra observation of Kepler's supernova remnant: An anomalous Type-Ia supernova	Steve Reynolds
6:00pm	Poster reception	

	Oct-24 Wednesday Title	Day 2 Presenter — Chair
	SNR, GRB, & Isolated NS	**Chryssa Kouveliotou**
8:30am	The late-time light curves of GRB X-ray afterglows with Chandra	Dirk Grupe
8:45am	Chandra and Spitzer constraints on the evolution of G54.1+0.3 and 3C 58	Patrick Slane
9:00am	Chandra observation of HESSJ1640-465 reveals an X-ray nebula and its putative pulsar	Anne Lemiere
9:15am	X-ray emission properties of old pulsars	Werner Becker
9:30am	Target-of-opportunity Chandra observations of anomalous X-ray pulsars	Victoria Kaspi
9:50am	An X-ray view of the GRB-SN connection	Alicia Soderberg
10:20am	Refreshments break	
	Microquasars	**Victoria Kaspi**
10:50am	Properties of the accretion-disk corona in Her X-1	Li Ji
11:05am	HETG observations of AC211 in the globular cluster M15	Tim Kallman
11:20am	Cygnus X-3's 'little' friend	Michael McCollough
11:35am	Spectral transition of an ultra-luminous X-ray source, NGC 2403 Source 3	Naoki Isobe
11:50am	Warm absorbers in galactic X-ray binaries	Norbert Schulz
12:05pm	Lunch break	
12:50pm	Constellation-X Town Hall	Nick White & Harvey Tananbaum
	AGN	**Gordon Garmire**
1:35pm	Resolved jets in quasars and radio galaxies	Yasunobu Uchiyama
2:05pm	Insights on Jet Physics & High Energy Emission Processes from Optical Polarimetry	Eric Perlman
2:20pm	Imaging AGN using gravitational microlensing	George Chartas
2:35pm	Chandra and XMM monitoring of NGC 1365: unveiling the structure of the compact circumnuclear absorber	Guido Risaliti
2:50pm	Probing unification with Chandra and XMM-Newton imaging andspectroscopic observations of NGC 2110	Dan Evans
3:05pm	Refreshments break	
	AGN interaction with host galaxy	**Dan Evans**
3:35pm	A deep Chandra observation of Centaurus A	Ralph Kraft
3:55pm	Modeling the supermassive black hole driven shocks in M87	Bill Forman
4:10pm	The unusual X-ray morphology of NGC 4636: cavities, off-center outbursts and shocks revealed by deep Chandra observations	Alessandro Baldi
4:25pm	How luminous was the Galactic supermassive black holein the past?	Fred Baganoff
5:00pm	Transit to Museum of Art	
6:00pm	Museum of Art patio reception	
7:00pm	Toast and Remarks	
7:15pm	Dinner	
8:45pm	Viewing Museum of Art	
9:00pm	Viewing and transit from Museum of Art	
10:00pm	Adjourn Day-2 events	

	Oct-25 Thursday Title	Day 3 Presenter — Chair
8:30am	X-ray opportunities with GLAST	Julie McEnery
	Clusters of Galaxies	**Max Bonamente**
9:00am	Feedback in clusters of galaxies	Brian McNamara
9:30am	X-ray and radio observations of galaxy groups: the history of AGN heating	Jan Vrtilek
9:45am	Why do only some galaxy clusters have cool cores?	Jack Burns
10:00am	Refreshments break/Poster removal	
	Cosmology	**Larry David**
10:45am	Toward cluster cosmology: A review of observational problems, progress and prospects	Mark Bautz
11:15am	Constraints on dark energy from the observed growth of X-ray luminous galaxy clusters	Adam Mantz
11:30am	Scaling Relations from Sunyaev-Zel'dovich effect and Chandra X-ray measurements of high-redshift galaxy clusters	Max Bonamente
11:45am	Probing the WHIM through OVII K-alpha fluctuations	Fabrizio Nicastro
	Conclusion and Thanks	
12:00pm	Chandra X-ray Center	Harvey Tananbaum
12:05pm	CCW pizza lunch	
1:00pm	CCW start	Vinay Kashyap
1:00pm	Chandra Calibration Workshop (CCW) [See CCW schedule]	
6:00pm	CCW end	

Name	Institution	Abstract #
Aarnio, Alicia	Vanderbilt University	99
Adams, Mitzi	NASA/MSFC	
Airhart, Carol	Dynetics, Inc.	62
Aldcroft, Tom	SAO	94
Allen, Glenn	MIT Kavli Institute	63
Baganoff, Frederick	MIT Kavli Institute	41
Baldi, Alessandro	SAO	40
Bauer, Franz	Columbia University	6
Bautz, Marshall	MIT Kavli Institute for Astrophysics	46
Becker, Werner	Max Planck Institut fr extraterr. Physik	26,64
Beikman, Stephen J.	SAO	
Bonamente, Max	UA - Huntsville	48,106
Boudreaux, Mark	NASA, Marshall Space Flt Cntr	
Bressert, Eli	SAO	100
Brissenden, Roger	SAO	
Broos, Patrick	Penn State University	101
Brusa, Marcella	Max Planck Institut fuer Extraterrestrische Physik	9
Buckley, Patricia	SAO	
Bulbul, Gul	University of Alabama in Huntsville	
Bullock, Blake	Northrop Grumman	
Burns, Jack	University of Colorado	45
Cardamone, Carolin	Yale University	85
Cavagnolo, Ken	Michigan State University	74
Chartas, George	Penn State	35
Connelly, Jean	SAO	
Coulter, Dauna	MSFC	
David, Laurence	SAO	107
Davis, William	Computer Sciences Corp.	
DeLaney, Tracey	MIT Kavli Institute	65
den Herder, Jan-Willem	SRON	105
DePasquale, Joseph	SAO	108
Dennerl, Konrad	MPE	1
Dewey, Daniel	MIT Kavli Inst.	19
Dobrzycki, Adam	ESO	
Douglass, Edmund	Boston University	75
Drake, Jeremy	SAO	51,52,66,109
Dupke, Renato	University of Michigan	76
Edgar, Richard	SAO	110
Edmonds, Peter	SAO	
Elsner, Ronald	NASA MSFC	2
Evans, Dan	SAO	37
Fanelli, Michael	TCU	
Fishman, Jerry	NASA-MSFC	
Forman, William	SAO	39
Fuse, Christopher	TCU	77
Gaetz, Terrance	CXC/SAO	95,111
Gallo, Elena	UCSB	12
Garcia, Michael	SAO	
Garmire, Gordon	Penn State University	67
Garmire, Audrey	Penn State University	
Gaskin, Jessica	NASA MSFC	

Name	Institution	Abstract #
Georganopoulos, Markos	University of Maryland Baltimore County	86
Getman, Konstantin	Penn State University	53,54
Ghosh, Kajal	USRA, NASA/MSFC/NSSTC	96
Graessle, Dale	SAO	112
Grant, Catherine	MIT Kavli Institute	113
Grant, Paul	SAO	
Grupe, Dirk	Pennsylvania State University	23
Hamaguchi, Kenji	NASA/GSFC/ASD	4
Harnden, F Rick	NASA Headquarters	
Hasler, Nicole	UAH	
Hayes, Jeffrey	Hayes	
Hefner, William Keith	NASA	
Henson, Michelle	SAO	
Hood, David	NASA/MSFC	
Hornschemeier, Ann	NASA Goddard	15
Huang, Hsiu-Hui	Max Planck Institute for Extraterrestrial Physics	67,102
Immler, Stefan	NASA/CRESST GSFC	20
Irwin, Jimmy	University of Michigan	16
Isobe, Naoki	RIKEN	31
Isobe, Takashi	SAO	114
Jerius, Diab	SAO	115
Ji, Li	MIT Kavli Institute	28
Johnson, Charles	NASA	
Joy, Marshall	NASA/MSFC	
Juda, Michael	SAO	116
Kaastra, Jelle	SRON	
Kallman, Tim	Laobratory for X-ray Astrophysics	29
Kashyap, Vinay	SAO	55,117
Kaspi, Victoria	McGill University	27
Kellogg, Edwin	SAO	
Kim, Dong-Woo	SAO	97
Kirsch, Marcus	ESA/ESAC	118
Kolodziejczak, Jeff	NASA/MSFC	
Kouveliotou, Chryssa	NASA/MSFC	
Kraft, Ralph	SAO	38
Kress, Martin	NSSTC	
LaMarr, Beverly	MKI	119
Lemiere, Anne	SAO	25
Lestition, Kathleen	SAO	
Little, John	SAO	
Mantz, Adam	KIPAC/Stanford	47
Marcum, Pamela	NASA Headquarters & TCU	
Marshall, Herman	MIT Kavli Institute	120
Martini, Paul	The Ohio State University	14
Mathur, Smita	The Ohio State University	11
Mattson, Barbara	UMD/GSFC/ADNET	87
McCollough, Michael	SAO	30,121
McEnery, Julie	NASA/GSFC	42
McNamara, Brian	University of Waterloo	43
Mehta, Kushal	University of Maryland Baltimore County	88
Miller, Eric	MIT Kavli Institute	78
Misanovic, Zdenka	Pennstate University	69,70
Morcone, Jennifer	NASA Marshall	
Morse, Jon	NASA HQ	
Moscibrodzka, Monika	Department of Physics and Astronomy, UNLV	89

Name	Institution	Abstract #
Mroczkowski, Tony	Columbia University	79
Mueller, Martin	KIPAC/SLAC	90
Murray, Stephen S.	SAO	
Nicastro, Fabrizio	SAO/INAF-OAR	49
Nishikawa, Ken-Ichi	NSSTC/UAH	91
O'Dell, Stephen	NASA MSFC	
Osten, Rachel	University of Maryland	3
Patnaude, Daniel	SAO	71
Perlman, Eric	Florida Institute of Technology1	34
Plucinsky, Paul	SAO	80
Posson-Brown, Jennifer	SAO	122,123,124
Puccetti, Simonetta	ASI Science Data Center (ASDC)-INAF	10
Rakowski, Cara	Naval Research Lab (NRC fellow)	18
Reynolds, Stephen	North Carolina State University	21,72
Risaliti, Guido	SAO	36
Saez, Cristian	PSU	92
Sanders, Wilton	NASA Headquarters	
Schulz, Norbert	MIT	32,125
Schwartz, Dan	SAO	
Seward, Fred	SAO	
Shukla, Sonali J.	Vanderbilt University	56
Sivakoff, Gregory	The Ohio State University	13
Slane, Patrick	SAO	24
Smale, Alan	NASA HQ	
Smith, Randall	JHU & NASA/GSFC	103
Soderberg, Alicia	Princeton University	22
Spitzbart, Brad	SAO	57
Swartz, Douglas	NASA/MSFC	8
Tananbaum, Harvey	SAO	
Tennant, Allyn	NASA/MSFC	
Testa, Paola	MIT	58
Townsley, Leisa	Penn State University	59
Trischitta, Michael	SAO	
Tsujimoto, Masahiro	Pennsylvania State University	60
Tuellmann, Ralph	SAO	98
Tuttle, Susan	SAO	
Uchiyama, Yasunobu	ISAS/JAXA	33
van der Horst, Alexander	UAH	
Vikhlinin, Alexey	SAO	81,126
Virani, Shanil	Yale University	82
Vrtilek, Jan M.	SAO	44
Wachter, Stefanie	SSC/Caltech	
Wargelin, Brad	SAO	127
Watzke, Megan	SAO	
Weisskopf, Martin	NASA/MSFC	
White, Raymond	University of Alabama	83
White, Nicholas	NASA-GSFC	
Williams, Benjamin	University of Washington	7
Wilson-Hodge, Colleen	NASA/MSFC	
Wolk, Scott	SAO	5,50
Xiang, Jingen	SAO	104
Yaji, Yuichi	Department Physics, Saitama University	93
Yao, Yangsen	MIT Kavli Institute	17
Yukita, Mihoko	UAH	84
Zavlin, Vyacheslav	NASA/MSFC	73
Zhao, Ping	SAO	128

X-rays from Comets, Venus and Mars

Konrad Dennerl, MPE

The discovery of cometary X-ray emission has demonstrated that X-rays provide a powerful tool for studying the interaction between the solar wind and low density gas in the solar system. This is due to the fact that the solar wind contains a small fraction of highly charged heavy ions, which capture electrons with a high cross section whenever they encounter neutral or weakly ionized atoms. As a consequence of the charge exchange, the solar wind ions attain highly excited states and radiate a large fraction of the excitation energy in the X-ray range. Thus, these X-rays contain a wealth of information: the distribution of low density gas can be globally mapped with high sensitivity, details of the interaction are revealed by spatially resolved X-ray spectroscopy, and temporal studies provide additional information about the dynamic properties of the interaction. The talk will present X-ray observations of the solar wind interaction with gas around objects where this process can be studied in an environment which is not affected by the presence of an intrinsic magnetic field. These are the comets and the planets Venus and Mars. For planets, the study of solar wind induced X-rays is more challenging than for comets, because planetary atmospheres also scatter solar X-rays. While the presence of solar wind induced X-rays could already be well established for Mars, the talk will present the first evidence that this component is also present in the X-ray emission of Venus.

The Morphology of the X-ray Emission above 2 keV from Jupiter's Aurora

Ronald Elsner, NASA MSFC

G. Branduardi-Raymont (MSSL), M. Galand (ICL), D. Grodent (U. Liege), G. R. Gladstone & J. H. Waite (SwRI), T. Cravens (U. Kansas), P. Ford (MIT)

The discovery in XMM-Newton X-ray data of X-ray emission above 2 keV from Jupiter's aurorae has led us to reexamine the Chandra ACIS-S observations taken in Feb 2003. Chandra's superior spatial resolution has revealed that the auroral X-rays with $E < 2$ keV are emitted from the periphery of the region emitting those with $E > 1$ keV. We are presently exploring the relationship of this morphology to that of the FUV emission from the main auroral oval and the polar cap. The low energy emission has previously been established as due to charge exchange between energetic precipitating ions of oxygen and either sulfur or carbon. It seems likely to us that the higher energy emission is due to precipitation of energetic electrons, possibly the same population of electrons responsible for the FUV emission. We discuss our analysis and interpretation.

Who's Afraid of a Stellar Superflare?

Rachel Osten, University of Maryland/NASA GSFC

The ability of late-type stellar outer atmospheres to produce X-ray emissions shaped by reconnecting magnetic fields is now known to be a commonplace phenomenon. Such stars are also prolific producers of transient X-ray emissions, but these emissions represent only the tip of the iceberg of flare energetics. The surprising recent detection of a flare from a nearby active binary with the Swift satellite (under the guise of a GRB) has revealed new insights in stellar flare physics, made possible only by the unique design of Swift. I will describe this singular event, and use it as a starting point to discuss new insights gained in stellar flare physics as well as the consequences of large explosive events on stellar environments. The effect of large releases of stellar ionizing radiation, at levels 150,000 times more powerful than the largest solar flares, has implications in a variety of stellar environments, from young hyperactive stars surrounded by a planet-forming disk, to superflares from normal solar-like stars and their effects on terrestrial planet atmospheres (and life!).

Spatially resolving X-ray emission from a Class I Pre-Main Sequence Binary System

Kenji Hamaguchi, NASA/GSFC/ASD

Minho Choi (International Center for Astrophysics, Korea Astronomy and Space Science Institute), Ken'ichi Tatematsu (National Astronomical Observatory of Japan), Chul-Sung Choi (International Center for Astrophysics, Korea Astronomy and Space Science Institute), Rob Petre (NASA/GSFC), Michael F. Corcoran (CRESST and X-ray Astrophysics Laboratory NASA/GSFC)

Many, if not most, stars are born as a member of a binary system through fragmentation of the parent molecular cloud. Because pre-main sequence (PMS) stars that form as a binary system are the same age, any variation in their X-ray activity would be due to their mass difference or the presence of the companion star. PMS binaries are therefore a useful probe to test models of the dependence of X-ray activity on stellar parameters. Separations of binary PMSs are less than ~10 arcsec at the typical distance to nearby star forming regions. Chandra's spatial resolution down to ~1 arcsec can be used to study the X-ray properties of individual components of PMS binaries for the first time. Using a sub-pixel event repositioning technique, we spatially resolved X-ray emission from the Class I PMS binary system IRS5 in the R Corona Australis molecular cloud with ~0.8 arcsec separation. As far as we know, this result - obtained from 8 Chandra archival observations between 2000 and 2005 - is the first X-ray study of individual sources in a Class I PMS binary system with a projected separation less than 200AU. We extracted light curves and spectra of the individual sources with a two-dimensional image fitting method using Sherpa. The brighter near-infrared source (IRS 5a) showed three X-ray flares lasting $>$ 20 ksec, while the fainter source (IRS 5b) was quiescent almost through the observations. In quiescence, these sources showed almost identical X-ray spectra, with NH ~4e22 cm-2, kT ~2 keV and Lx ~1e30 ergs s-1. Their X-ray properties are typical of Class I protostars although variable cm radio emission with circular polarization from IRS 5 favors it to be a pair of young T-Tauri stars behind a molecular cloud. We discuss their evolutionary stages and the connection between their radio and X-ray activity.

Chandra Spitzer and VLA observations of Young Stellar Clusters.

Scott Wolk, Smithsonian Astrophysical Observatory

R. Osten (UMD), T. Bourke (CfA), S.T. Megeath (U. Toledo), B.D. Spitzbart (CfA), E. Winston (U. Dublin)

We examine the properties of embedded clusters within 2 kpc using new data from the Chandra X-ray Observatory and the Spitzer Space Telescope, as well as data from the VLA for the closest systems. We use surveys of entire molecular clouds to understand the range and distribution of cluster membership, size, and surface density. The data demonstrate clearly that there is a continuum of star-forming environments, from relative isolation to dense clusters. Using the combined Spitzer and CXO data allows a very accurate assessment of cluster size. We have detected differences in the spatial distributions of Class II and Class III objects (a.k.a. classical and naked T Tauri stars). Comparison of the class fraction as a function of cluster age is crucial to understanding disk evolution. The simultaneous radio and X-ray data reveal a disconnect between the two magnetic activity signatures in comparison with nearby active stars and the Sun. This evidence comes from both the lack of correlations of time-averaged luminosities as well as simultaneous measures of radio and X-ray variability which show the absence of the Neupert effect. Further the radio flux is anti-correlated with spectral index in variable sources. Taken together this indicates that the variability in these very young stars is non-solar in nature. We have also detected a radio flare from a Class II object and a score of transition objects in X-rays. These latter data allow us to start the process of understanding the high energy environment in this crucial planet building stage.

A Legacy Study of Stellar Lifecycles in the Galactic Center

Franz Bauer, Columbia University

We report on a multi-wavelength project to study the life-cycles of massive stars in the central 300 pc of the Galaxy. The centerpiece of the project is 680 ks of deep (40 ks each) Chandra observations, which we compare to radio maps at 90, 20, and 1.4 cm taken with the VLA; mid-infrared images at 8.0, 5.8, 4.5 and 3.6 micron taken with Spitzer; and J,H,K images from the SIRIUS camera on the IRSF. The images reveal a wide variety of diffuse phenomena, including iron fluorescence from molecular clouds that have reflected past outbursts of the supermassive black hole Sgr A*, thermal X-ray emission from young supernova remnants, non-thermal X-ray emission from several of the mysterious radio-emitting filaments, and shocks produced by stellar sources at the centers of HII regions. We also report the results of a campaign to identify the infrared counterparts to X-ray sources, using spectra taken with a number of 3-5 m class telescopes. These spectra have revealed several dozen young, massive colliding-wind binaries and high-mass X-ray binaries.

The Chandra ACIS Survey of M33 (ChASeM33)

Benjamin Williams, University of Washington

The ChASeM33 Team

We have performed a survey of M33 covering 7 ACIS-I fields, each with 200 ks of exposure. These data provide the deepest and highest resolution X-ray data for M33 available out to a projected galactocentric distance of 4 kpc. The data contain several hundred individual X-ray sources to a limiting luminosity of $\sim 10^{35}$ erg/s (0.35-8.0 keV) as well as soft diffuse emission from the hot interstellar medium. The observations were spread over multiple epochs to allow variability studies. We have performed detailed analysis on several point sources of interest, including eclipsing X-ray binaries and transients. We have also completed analysis on several diffuse sources, including supernova remnants and H II regions. An overview of the data, the results of these first detailed studies, and our plan for future work will be presented. Support for this work was provided by the National Aeronautics and Space Administration through *Chandra* Award Number G06-7073A issued by the *Chandra* X-ray Observatory Center, which is operated by the Smithsonian Astrophysical Observatory for and on behalf of the National Aeronautics Space Administration under contract NAS8-03060.

Do Ultraluminous X-Ray Sources Exist in Dwarf Galaxies?

Douglas Swartz, NASA/MSFC

A thorough search for Ultraluminous X-ray source candidates within a distance of approximately 8 Mpc is made. The search spatially matches potential ULXs detected in X-ray images or cataloged in the literature with galaxies tabulated in the *Catalog of Neighboring Galaxies* compiled by Karachentsev et al. (2004). The specific ULX rate (occurrence rate per unit mass) is found to be a decreasing function of host galaxy mass for host masses above $M_{dg} \sim 10^{8.5}$ $M_\odot$. There is too little mass in galaxies below M_{dg} to determine their ULX content in a statistically meaningful way. Possible reasons for and implications of an increase in specific ULX rate with decreasing galaxy mass are presented.

Stacking photons in deep and large X-ray surveys

Marcella Brusa, Max Planck Institut fuer Extraterrestrische Physik (MPE - Garching), UMBC

Using the stacking technique, it is possible to study, at least in a statistical sense, the X-ray properties of sources individually undetected even in the deepest observations and down to extremely faint fluxes. Given the very low background of the Chandra satellite, such a technique has been routinely adopted in Chandra works since the beginning of the mission, and successfully used in a variety of studies. Here we present an overview of a few selected results, focused on: 1) the average X-ray properties of the sources responsible for the XRB; 2) the detection of a sizable poulation of Compton Thick AGN at z˜2; and 3) the study of the intensity and profile of the 6.4 keV iron line and its evolution with redshift. We also briefly outline the perspectives for these studies for the Chandra mission, and for other present and future X-ray facilities, in the framework of the deepest (Chandra Deep Fields) and largest (e.g. COSMOS) surveys.

Chandra COSMOS Survey Analysis

Simonetta Puccetti, ASI Science Data Center (ASDC)-INAF

on behalf of the C-Cosmos collaboration

The 1.8 Msec Chandra COSMOS Survey (C-COSMOS) is the largest Chandra GO program at the time of award. COSMOS is a pan-chromatic survey of the extragalactic sky designed to be both large and deep enough to study galaxy and quasar evolution in typical environments with minimal 'cosmic bias'. The location of COSMOS near the equator (10h +02deg) allows all major and future facilities (esp. EVLA, ALMA) to target this 2 sq. deg.region. Both space - HST, Spitzer, GALEX, XMM - and ground-based - VLA, Subaru, CTIO, KPNO, CFHT, Magellan, VLT - have already surveyed the area to faint limits. The central region of the COSMOS field observed in C-COSMOS is now the target of deeper surveys by the VLA and VLT, and proposed for GALEX and VISTA. We present the current status of the analysis of the C-COSMOS dataset. We focus on source detection and validation, which are complicated by the offset tiling structure of the survey. The 6x6 array of 50ksec observations gives a uniform 200ksec exposure, and a well-defined cut-off in flux. The depth of C-COSMOS was chosen to detect significant numbers of galaxies, up to z 0.9, comparable with the depth of the COSMOS galaxy surveys. About 2000 sources have been detected using both a wavelet algorithm and a PSF fitting algorithm. The present catalog includes about 100 sources with 0.5-2 keV flux smaller that 3E-16 cgs, one of the largest sample of faint X-ray sources so far. Particular care was put in the detection, validation and identification of sources with a separation ¡12" right down to the limit imposed by the Chandra PSF. This will allow us to put robust constraints on the X-ray source correlation function down to tens of kpc (for a typical z=1). Preliminary results on source number counts, cosmic variace and source clustering will be presented.

Demographics of black holes in nearby galaxies

Smita Mathur, The Ohio State University

Himel Ghosh (Ohio State)

The cumulative mass function needed to explain the energetics of high redshift quasars implies that all galaxies in the local universe should host supermassive black holes (SBHs). Low-mass SBHs, however, are impossible to detect dynamically because their sphere of influence cannot be resolved with current telescopes. On the other hand, the "downsizing" of AGN activity with cosmic epoch suggests that the lowest-mass SBHs should be active now, and therefore should be X-ray sources. Given the M_BH - M_Bulge relationship, we expect the low-mass SBHs to be in late-type spirals. We present results from a Chandra archival study – preliminary to an ongoing bigger Chandra survey – of six nearby "quiescent" spirals that shows that all six indeed harbor nuclear X-ray sources. We use available multiwavelength data to weigh the arguments for and against each object being in fact an accreting SBH. We show how X-ray observations are effective in uncovering hidden SBHs.

AMUSE-Virgo: on the survival of super-massive black holes in faint spheroids

Elena Gallo, UCSB

T. Treu, J.-H. Woo, J. Jacob, P. Marshall, R. Antonucci (UCSB)

I will present the first Chandra results from the AGN Multiwavelength Survey of Early-type galaxies in the Virgo cluster (AMUSE-Virgo). This large program targets 100 early-type Virgo galaxies with Chandra ACIS-S and Spitzer MIPS, with the aim to provide an unbiased census of super-massive black hole (SMBH) activity in the local universe. The sample covers over 4 orders of magnitude in black hole mass as estimated from the mass-velocity dispersion relation, large enough that it can be divided in SMBH mass bins to test whether the nuclear activity duty cycle is mass dependent. I will report on the Chandra observations of the first 16 targets, combined with results from archival data of other, more massive, 16 targets. Hard X-ray emission from a position coincident with the galaxy nucleus is detected in 50 per cent of the galaxies, and ascribed to low-level accretion-powered activity from a SMBH. Two of the detected nuclei are hosted in galaxies with absolute B magnitudes fainter than -18, indicating that SMBHs are still being harbored in such faint, low-mass objects.

Searching for AGN in the Outskirts of Clusters

Gregory Sivakoff, The Ohio State University

Paul Martini (OSU), Daniel D. Kelson, John Mulchaey (Carnegie Observatories), Ann Zabludoff (Steward Observatories)

With the Chandra X-ray Observatory, it is possible to identify AGN down to low X-ray luminosities. While optical emission-line surveys of clusters of galaxies indicate a low fraction of AGN (1%) compared to the field (5%), a factor of five times as many cluster AGN have been found using X-ray techniques. Thus, X-ray surveys of cluster AGN can be used to test the mechanisms of AGN fueling, and have obvious implications to how AGN feedback could be distributed throughout clusters. Under the major-merger paradigm for AGN fueling, one predicts higher fractions of AGN should be found in the outskirts of clusters and in low velocity-dispersion clusters. However, most Chandra observations of nearby clusters have concentrated on their cores. We present wide-field observations of Abell 85 and Abell 754, which we combine with archival data to create a sample of X-ray AGN from six $z < 0.08$ clusters. We find no evidence that the fraction is higher in the outskirts of clusters. While this seems counter to the standard AGN fueling paradigm, we find hints that the fraction is higher in lower velocity dispersion clusters. The AGN fraction ($L_X > 1E41, M_R < -20$) varies from 2-14% from cluster to cluster, but is consistent with an AGN fraction of 4%. This sample indicates the clear need for studies that sample a wide range of velocity dispersions.

The AGN Butcher-Oemler Effect

Paul Martini, The Ohio State University

G. Sivakoff (OSU), J. Mulchaey (OCIW), D. Kelson (OCIW)

We have studied the evolution of the AGN population in clusters of galaxies with spectroscopic observations of X-ray sources in archival Chandra data. Our low-redshift sample of eight z=0.06-0.3 clusters of galaxies contains only one AGN more luminous than 10^{43} erg/s in the hard X-ray band, while in contrast there are eight AGN above this luminosity range in a sample of four clusters at z=0.6. This is strong evidence for a pronounced increase in the fraction of AGN in higher-redshift clusters of galaxies, analogous to the increase in the number of blue galaxies in clusters at higher redshift known as the Butcher-Oemler effect. The AGN evolution is clusters is also more rapid than observed for field AGN, which indicates differential evolution in the cluster AGN population relative to the field, and not merely a different normalization in the number of AGN per galaxy.

Comparing X-ray emission from Ultraviolet-Luminous Galaxies and Lyman Break Galaxies

Ann Hornschemeier, NASA GSFC

Andrew Ptak (JHU), Timothy Heckman (JHU), John Grimes (JHU), Samir Salim (NOAO), John Sheets (Boston Univ.), David Strickland (JHU)

We discuss X-ray constraints on GALEX-selected Ultraviolet-Luminous Galaxies (UVLGs). An interesting subset of these UVLGs appear to be analogs to the distant ($3 < z < 4$) Lyman Break Galaxies (LBGs). The 2-10 keV X-ray emission of LBGs appear to be broadly similar to that of galaxies in the local Universe, possibly indicating similarity in the production of accreting binaries over large evolutionary timescales in the Universe. Given the very large distances to the LBGs, we have elected to use the the UVLGs as possible local-Universe comparison sample. This technique is showing promise; we have detected luminous X-ray emission from one UVLG that permits basic X-ray spectroscopic analysis, and have direct X-ray constraints on a total of 6 UVLGs (including two previously studied by Chandra). The luminous X-ray emitting galaxy is perhaps very interesting as it demonstrates a lack of emission from hot gas even though the inferred star formation rate is very high.

The Low Metallicity ISM of X-ray Faint Elliptical Galaxies

Jimmy Irwin, University of Michigan

Since the hot interstellar medium (ISM) of early-type galaxies is believed to originate primarily from stellar mass loss and supernovae, the metallicity of the ISM should reflect that of the stars contributing the mass to the ISM. This has been confirmed for gas-rich X-ray bright ellipticals, as both the X-ray-determined ISM abundances and optically-determined stellar abundances are approximately solar. However, this does not seem to be the case for gas-poor, X-ray faint ellipticals, for which very sub-solar abundances have been reported, although poor statistics and significant X-ray binary contamination have been listed as the cause of these (erroneously) low abundance measurements. We present Chandra + XMM-Newton spectra of one of the best-observed X-ray faint ellipticals, NGC4697, and confirm that O, Ne, Mg, Si, Fe, and Ni are all significantly subsolar, and are not the result of poor spectral fitting or poor statistics. We speculate that the low metal abundances are the result of dilution from the accretion over time of pristine metal-free gas that surrounds the galaxy. The implications of this accretion in the context of galaxy formation will be discussed.

Limits on Hot Galactic Halo Gas from X-ray Absorption Lines

Yangsen Yao, MIT

M. Nowak (MIT), Q. D. Wang (UMass), N. Schulz (MIT), C. Canizares (MIT)

Many theoretical calculations and numerical calculations for galaxy formation predict the existence of large-scale ($> 20kpc$) hot gaseous halos around individual galaxies. However, such halos are yet to be discovered observationally. We here present a differential study of searching for such a halo around our Galaxy. We compared the highly ionized X-ray absorption lines observed in sight-line of a Galactic source 4U 1957+11 (distance $D > 10kpc$) with those observed toward extragalactic sources LMC X-3 (D˜50 kpc) and Mrk 421. We found that all the line absorptions observed in the extragalactic sources can be attributed to the hot gas in a thick Galactic disk, as traced by the absorption lines in the spectra of 4U 1957+11. We then obtained a firm upper limit of the absorption due to the putative Galactic halo and estimated the halo mass and metallicity. These results provide a direct observational test of galaxy formation theories.

Shock Physics in SNRs: an observational perspective

Cara Rakowski, Naval Research Lab (NRC fellow)

J. Martin Laming (NRL), Parviz Ghavamian (Johns Hopkins)

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 post-shock 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. New results including the growth rate for lower-hybrid waves in the cosmic-ray precursor will be discussed.

HETG spectral-imaging of SN 1987A

Daniel Dewey, MIT Kavli Institute

S. Zhekov (U Colorado), C.R. Canizares (MKI), R. McCray (U Colorado)

We have completed taking deep, high-resolution observations of SN 1987A at 20 years after its explosion with Chandra's grating spectrometers. In March-April of 2007 HETG observations totaling 355 ks were taken as part of the HETG GTO program. Just recently in the Fall of 2007, deep complementary LETG observations (McCray, P.I.) were 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. Presented here are the HETG data which give the highest-resolution X-ray spectra of SN1987A to date. High signal-to-noise is achieved in the 6A to 20A bandpass which includes the H-like and He-like lines of Si, Mg, Ne, as well as bright Fe XVII lines and lines of O VIII. 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 shock interactions taking place in the SN 1987A system.

X-Ray Emission from Supernovae as Probes of Stellar Environments

Stefan Immler, NASA/CRESST GSFC

The interaction of outgoing SN shocks with material in their environments can give rise to large amounts of X-rays which are uniquely suited to measure the circumstellar matter (CSM) densities and the mass loss rates of their progenitor stars. Since SN shocks travel at speeds a thousand times larger than the stellar wind velocities, the X-ray observations can be used as a time machine to look back into the histories of the progenitors over periods of tens of thousands of years in the stellar evolution. I discuss the first comprehensive study of the environments of all SNe detected with orbiting X-ray observatories over the past three decades, with emphasis on recent results of SNe 2006bp, 2006jc and 2005kd obtained with Chandra, XMM-Newton, and Swift.

A Deep Chandra Observation of Kepler's Supernova Remnant: An Anomalous Type Ia Supernova

Stephen Reynolds, North Carolina State University

K.J. Borkowski (NC State U), J.M. Blondin (NC State U), C. Badenes (Rutgers), J.P. Hughes (Rutgers), U. Hwang (NASA/GSFC), J.M. Laming (NRL)

We present results from our 750 ks Chandra Large Project observation of the remnant of Kepler's supernova of 1604. This spectacular dataset, containing about 30 million counts, allows detailed spectroscopy on arcsecond scales. We have examined the spectra of over 100 small regions, and find that the vast bulk of emission from Kepler can be identified with iron and silicon-rich ejecta. Very few regions show abundances closer to solar, but those are spatially associated with N-rich optical knots, and show some evidence for N enhancement in X-rays as well. Those regions are also the only locations where O is noticeable in the spectra. A few regions are dominated by synchrotron emission, in the form of knots and diffuse patches as well as thin filaments. There are no O-rich regions. We are forced to conclude that Kepler is the remnant of a thermonuclear supernova, although evidence is also strong that the ambient medium into which the blast wave is expanding is circumstellar material lost from the progenitor. Thus Kepler may be an example of a thermonuclear supernova from a more massive progenitor system, perhaps to be identified with "prompt" Type Ia supernovae required to explain the correlation of Type Ia supernova rates with galaxy star formation rates. However, Kepler's kinematics are also unusual and may require a whole new Ia mechanism, such as the thermonuclear explosion of a single star. The implications of different explosion mechanisms for the cosmological use of SNe Ia are considerable. I shall discuss the significance of our observation for shock-acceleration physics and for the nature of the Type Ia phenomenon.

An X-ray View of the GRB-SN Connection

Alicia Soderberg, Princeton University

Over the past few years, long-duration gamma-ray bursts (GRBs), including the subclass of X-ray flashes (XRFs), have been revealed to be a rare variety of Type Ibc supernova (SN Ibc). While all these events result from the death of massive stars, the electromagnetic luminosities of GRBs and XRFs exceed those of ordinary Type Ibc SNe by many orders of magnitude. The observed diversity of stellar death corresponds to large variations in the energy, velocity, and geometry of the explosion ejecta. Using multi-wavelength (radio, optical, X-ray) observations of the nearest GRBs, XRFs, and SNe Ibc, I show that while GRBs and XRFs couple at least 10^{48} erg to relativistic material, SNe Ibc typically couple less than 10^{48} erg to their fastest (albeit non-relativistic) outflows. Specifically, I find that less than 3 percent of local SNe Ibc show any evidence for relativistic ejecta which may be attributed to an associated GRB or XRF. Recently, a new class of GRBs and XRFs has been revealed which are under-luminous in comparison with the statistical sample of GRBs. Owing to their faint high-energy emission, these sub-energetic bursts are only detectable nearby ($z < 0.1$) and are likely 10 times more common than cosmological GRBs. In comparison with local SNe Ibc and typical GRBs/XRFs,these explosions are intermediate in terms of both volumetric rate and energetics. Yet the essential physical process that causes a dying star to produce a GRB, XRF, or sub-energetic burst, and not just a SN, remains a crucial open question. Progress requires a detailed understanding of ordinary SNe Ibc which will be facilitated with the launch of wide-field optical surveys in the near future.

The late-time light curves of GRB X-ray afterglows with Chandra

Dirk Grupe, Pennsylvania State University

David Burrows (PSU)

For a brief moment in time when they occur, Gamma-Ray Bursts (GRBs) are the most energetic events in the Universe. One of the predictions of the standard fireball model of GRBs is the formation of a jet. The opening angle of this jet is the crucial parameter for the energetics of the burst. This opening angle can be inferred from the 'jet break' when the jet decelerates by interacting with the interstellar gas. Jet breaks are therefore crucial for our understanding of GRBs. We will summarize our late-time detections of GRB X-ray afterglows with Chandra. For the two soft GRBs 070524 and 071221A we were able to follow both X-ray afterglows for more than 3 weeks and found no jet break in 050724 and a jet break 4 days after the burst in GRB 051221A. As for long bursts we had three observations of the extraordinary GRB 060729 with the latest 11 month after the burst - the latest detection of an X-ray afterglow ever. GRB 060729 will still be detectable by Chandra in 2008 and has just been recommended for two Chandra observation next year by the peer review. In all these cases Chandra observations were essential to get late-time detection which are important for the interpretation of the physics involved in GRBs. The detection or non detections of a jet break in GRB X-ray light curves puts tight constraints on the energetics of a GRB. No jet break means that it requires a much larger energy injection and a continuous energy input from the central engine. Only Chandra is able to detect X-ray afterglows at very late times.

Chandra and Spitzer Constraints on the Evolution of G54.1+0.3 and 3C 58

Patrick Slane, Harvard-Smithsonian Center for Astrophysics

The injection of particles and magnetic flux from a rapidly-rotating neutron star into its surroundings produces a synchrotron-emitting bubble known as a pulsar wind nebula (PWN). The particle spectrum injected into the nebula, as well as the density profile of the material into which the nebula expands, strongly constrain its spectral and dynamical evolution. Here I describe recent work using Chandra and Spitzer observations to constrain the spectrum at the innermost regions of 3C 58, for comparison with the broadband spectrum of the entire nebula, and the identification of a shell of emission surrounding G54.1+0.3, presumably corresponding to the previously unseen ambient material into which the PWN is evolving.

Chandra observation of HESSJ1640-465 reveals an x-ray nebula and its putative pulsar

Anne Lemiere, CfA-Harvard

P. Slane , B. Gaensler

During 2004-2006 H.E.S.S. performed a survey of the inner part of the Galaxy where its excellent capability allowed to mark a breakthrough in the field of PWN study: for the first time the morphological structure of many pulsar wind nebulae (PWN) was resolved in the gamma-ray band. We present here a Chandra X-ray observation of one of these sources which fills the center of the SNR G338.3-0.0: HESSJ1640-465. We resolve a point source surrounded by a diffuse emission that fills the centroid of the HESS source, within the shell of the radio supernova remnant. The morphology of the diffuse emission strongly resembles that of a PWN and extends assymetrically in the South East part of the point source that we designate as the putative pulsar. We explore the morphological and spectral characteristics of this object and discuss their implications in term of energies and interaction with the surrounding environment. We finally discuss a scenario in which the gamma-rays originate from this object in term of a time-dependent leptonic model.

X-ray emission properties of old pulsars

Werner Becker, MPE-Garching

C.Y. Hui, H.H. Huang

Young and middle aged neutron stars, which emit strong pulsed non-thermal and/or surface hot-spot plus cooling emission, were studied reasonable well by previous X-ray observatories. In contrast, most old radio pulsars were too faint for a detailed examination of their X-ray emission and are clearly sources which required the sensitivity of Chandra and XMM-Newton to be studied in sufficient detail. In my talk I will review recent results on the X-ray emission properties of old pulsars and report on a study of the diffuse trail like emission components found in some of them.

Target-of-Opportunity Chandra Observations of Anomalous X-ray Pulsars

Victoria Kaspi, McGill University

P. M. Woods (Dynetics), F. P. Gavriil (NASA/GSFC), R. Dib (McGill), C. Tam (McGill)

Since Cycle 4, we have led a Chandra Target-of-Opportunity program to observe Anomalous X-ray Pulsars (AXPs), a small class of isolated neutron stars thought to be magnetars, in outburst. Under this program, we have obtained a total of seven ToO observations of three different AXPs (three of CXOU J164710.2-455216, three of 1E 1048.1-5937 and one of 4U 0142+61), in order to study their rotational, spectral and pulsed fraction evolutions during times of instability. We describe here what we have learned from these observations. In particular we report on a tight, quantitative correlation between flux and pulsed fraction in 1E 1048.1-5937; the first measurement of a period derivative (hence magnetic field) in CXOU J164710.2-455216, thus confirming its AXP nature; as well unique pulse profile evolution, both in the short- and long-terms, in 4U 0142+61. These Chandra observations support the magnetar model for these sources, and put tight constraints on a variety of the outstanding physical questions remaining about magnetars.

Properties of the Accretion Disk Corona in Her X-1

Li Ji, MIT Kavli Institute for Astrophysics & Space Research

N.S. Schulz (MKI), M. Nowak(MKI) & H.L. Marshall(MKI)

We present an analysis of six high-resolution Chandra grating observations of the X-ray binary pulsar Her X-1. With a total exposure of 170 ks, the observations are separated by years and cover three combinations of orbital and super-orbital phases. Our goal is to determine the properties of the photoionized emission and its dependence on phase-dependent variations of the continuum. We find that the continua can be described by a partial covering model which is consistent with the high energy spectra observed with RXTE. Moreover, an additional thermal blackbody component is required to fit the soft band below 12 Å($\sim$ 1 keV). Most of the variability is caused by high absorption columns varying from $(1-3)\times10^{23}$ cm^{-2}. Most spectra show strong line emission stemming from a photoionized accretion disk corona. We model the line emission with generic thermal plasma models as well as with the photoionization code XSTAR and determine changes of the ionization balance with orbital and superorbital phases. Most spectra also show strong and variable fluorescence line emission from near neutral Fe,likely associated with the cooler, outer portions of the disk.

HETG Observations of AC211 in the Globular Cluster M15

Tim Kallman, NASA/GSFC, Laboratory for X-ray Astrophysics

L. Angelini, N. E. White (NASA/GSFC), J. Sepinsky (NWU)

We report on a 60 ksec observation of the low mass X-ray binary AC211/4U2127+119 in the Globular CLuster M15 using the Chandra HETG. The presence of the confusing source ∼3 arc-seconds away necessitates careful observation planning and analysis to disentangle the two spectra. The observation spans approximately one binary orbit, and the HETG spectrum shows emission lines from highly ionized Si, Mg, Ne, and O,and also features which correspond to the K lines of iron. The ratios of the helium-like lines from Mg and Si provide a lower limit on the density or the UV radiation field in the line emitting region. The relative strengths of the H- and He-like lines are consistent with photoionization equilibrium, with a narrow range of allowed ionization parameters. This provides an upper limit on the distance of the line-emitting gas from the source of X-ray continuum. The line emission is crudely consistent with that expected from an accretion disk corona, although there are important differences between this source and other likely ADC sources. One example is the strength of the iron line. We discuss these differences, and interpret them in the context of other information about this source: its orbital parameters and the nature of the companion star.

Cygnus X-3's "Little" Friend

Michael McCollough, SAO

Lynne Valencic (NASA/GSFC)

Cygnus X-3 is a well know microquasar which shows state changes, strong radio emission, hard X-ray-radio correlations, and relativistic jets. The exact nature of compact object associated with this system is still uncertain. In this presentation are shown new results which will further illustrate the complexity and uniqueness of this system. In 2003 extended X-ray emission was discovered associated with Cygnus X-3 using Chandra (Heindl et al. 2003). One of the most likely interpretations of this feature was that of a jet impact region. In 2006 a longer Chandra observation during which Cygnus X-3 was in a brighter X-ray state has revealed a much better look at this emission. We will show that even though this feature is 16" away from Cygnus X-3 it demonstrates remarkable time correlated activity associated with Cygnus X-3. The behavior of this emission and the possible nature of this feature will be discussed in this presentation.

Spectral transition of an ultra-luminous X-ray source, NGC 2403 Source 3

Naoki Isobe, RIKEN

Kazuo Makishima (RIKEN/University of Tokyo), Atsushi Senda (RIKEN), Madoka Kawaharada (RIKEN), Hiromitsu Takahashi (Hiroshima University), Tsunehumi Mizuno (Hiroshima University), Ryohei Miyawaki (University of Tokyo), Tessei Yoshida (Tokyo University of Science), Richard Mushotzky (NASA/GSFC)

We report the study of the spectral variation over 5 years, of an ultra-luminous X-ray source NGC 2403 Source 3, which is located in the arm region of a normal spiral galaxy NGC 2403. We performed a Suzaku observation of NGC 2403 during the Science working group phase on 2006 March 16. All the available archival Chandra and Newton data are also analysed. Except for one Chandra observation, the X-ray spectra of NGC 2403 source 3 are successfully described with a multi-color disk (MCD) model. The innermost disk temperature and bolometric luminosity of the source is found to be rather stable, Tin = 1.04 - 1.18 keV and $L_{\rm bol} = (1.4 - 2.3) \times 10^{39}$ ergs/s, respectively. The innermost disk radius is determined to be 96 - 130 km, indicating that the mass of the source is about 10 - 15 times the solar masses. As a result, the source is inferred to be shining near the Eddington limit. In the remaining Chandra observation, conducted in 2004 November, we have discovered that the source showed a transition to a power-law (PL) spectrum with a photon index of Gamma = 2.37 ± 0.08. In this observation, the luminosity of the source is lower by about 10 /observations. These spectral features are similar to those of Galactic black holes, at high accretion rate near the Eddington limit. Therefore, we will discuss the physical properties of NGC 2403 source 3, in comparison with the Galactic black holes.

Warm Absorbers in Galactic X-ray Binaries

Norbert S. Schulz, MIT Kavli Institute for Astrophysics & Space Research

X-ray binaries, specifically the ones labeled as microquasars, are considered to be the small-scale Galactic counterparts of active galactic nuclei (AGN). Physically they are distinctly different in that they are stellar binaries in which a compact object, in most cases a stellar black hole, accretes matter from a stellar companion. These objects exhibit relativistic jets and outflow patterns reminicent of their of their extragalactic cousins. While their radio and X-ray emission indeed provide many signatures that resemble the ones we ususally see in AGNs, they provide an upclose view of the various accretion phenomena common in these objects. This presentation investigates warm absorbers. Until quite recently, warm absorbers were mostly discussed in the context of AGN, but recent observations with high resolution X-ray spectrometers provided a manifold of different warm absorber activity in X-ray binaries, not all of them are considered to actually be microquasars. This presentation reviews recent results involving microquasars (i.e. GROJ1655-40, Cir X-1) and normal X-ray binaries (i.e. 4U 1624-49, EXO 0748-676) with a wide range ionization parameters and column densities. Only recently have we begun to understand and identify warm absorber features which provide novel clues to understand the accretion process onto compact objects.

Resolved jets in quasars and radio galaxies

Yasunobu Uchiyama, ISAS/JAXA

Relativistic jets at hundreds of kiloparsecs from the quasar nucleus generally exhibit strong X-ray emission in excess of that anticipated by a synchrotron-self-Compton model, as revealed by surveys with Chandra. Despite extensive work, the dominant X-ray emission process in quasar jets remains unsettled. Solving this problem will revolutionize our ideas regarding relativistic jets and outflows in the Universe. In this talk, we present results from Spitzer infrared observations of X-ray jets in quasars and radio galaxies, combined with multifrequency imaging data from VLA, Hubble, and Chandra. A particular emphasis is placed on our multifrequency analysis of the kiloparsec-scale jet in the well-known quasar 3C 273, which offers new insights into the controversial origin of the X-ray emission seen in the relativistic jets of quasars and radio galaxies. Our analysis suggests that a population of particles distinct from radio-emitting electrons produces the resolved X-rays in powerful jets through a synchrotron process. We discuss implications for particle acceleration processes operating in relativistic jets. Finally we address effective investigations to be done with current instruments as well as future prospects of this area.

Insights on Jet Physics & High Energy Emission Processes from Optical Polarimetry

Eric Perlman, Florida Institute of Technology

C. A. Padgett, M. Georganopoulos (JCA/UMBC), F. Dulwich, D. M. Worrall, M. Birkinshaw (U. Bristol), W. B. Sparks, J. A. Biretta (STScI), C. P. O'Dea, S. Baum (RIT), A. S. Wilson

Because of their direct tie with the magnetic field in the emitting region, polarimetry can be a powerful tool in disentangling the physics of extragalactic jets. Polarimetry in multiple emission bands can prove particularly helpful, as they can help disentangle cases where emission in multiple bands might originate in physically different regions. A total of nine jets have now been observed polarimetrically with HST, with the results on all but two having been published during the last 18 months. I will discuss the relationship between optical and radio polarization for extragalactic jets, its implications for jet energetic and magnetic field structure, and its importance for understanding the X-ray emission properties seen by Chandra. We are finding that there is not a general pattern in these properties, with each source having somewhat different polarization properties and relationship to X-ray emission. This strongly reinforces the idea that the jets of radio galaxies are not homogeneous flows.

Imaging AGN using gravitational microlensing

George Chartas, Penn State

C. S. Kochanek(OSU), X. Dai(OSU), N. Morgan(OSU), G. Garmire(PSU)

Resolving the emission regions of distant quasars is beyond the current capabilities of present-day telescopes. Until the spacial resolution of telescopes improves to reach the level of tens of nano-arcseconds we will have to rely on indirect methods of mapping the emission regions of quasars. One promising method of imaging AGN accretion disks involves microlensing of the continuum and line emission regions that can occur in lensed AGN. We have initiated a multiwavelength monitoring campaign of several microlensing candidates with the main scientific goal of measuring the structure of AGN in the optical and X-ray bands in order to test disk models. We present constraints on the sizes of AGN accretion disks and their hot coronae. These constraints were obtained by monitoring microlensing events in quasars Q1131-1231 and HE1104-1805. X-ray monitoring observations of these quasars were performed with the Chandra X-ray Observatory and B, R and I band observations were made with the Smarts Consortium 1.2m telescope in Chile. Stacking of the Chandra observations has also provided constraints of the properties of two clusters of galaxies in the vicinity of Q1131-1231.

Chandra and XMM monitoring of NGC 1365: unveiling the structure of the compact circumnuclear absorber

Guido Risaliti, SAO

I present the results of a Chandra monitoring of the Seyfert Galaxy NGC 1365, which revealed an occultation event with a duration of less than two days, implying a distance of the circumnuclear absorber of less than 0.01 pc, and a size of the X-ray emitting region of $\sim 10^{14}$ cm. I will discuss the implication of this result in the context of the unified model, and will present the first results of a long ($\sim$ 5 days) XMM monitoring of this source.

Probing Unification With Chandra and XMM-Newton Imaging and Spectroscopic Observations of NGC 2110

Daniel Evans, Harvard University

Julia Lee (Harvard University), Jane Turner (UMBC/GSFC), Kim Weaver (GSFC), Herman Marshall (MIT)

We present Chandra ACIS-S (50 ks), HETGS (250 ks) and XMM-Newton RGS (60 ks) imaging and spectroscopic observations of NGC 2110, a source classified as a Narrow Emission Line Galaxy, the subclass of Seyferts historically noted for their particularly flat X-ray spectra. Although the nuclear X-ray spectrum of NGC 2110 can be modeled as a power law of photon index $\Gamma \sim 1.4$ absorbed by a column of 3×10^{22} cm^{-2}, the excess absorption we detect at the Si K and Fe K edges implies the need for a more complex spectral model, which we find in the form of a "canonical" $\Gamma \sim 1.7$ AGN spectrum modified by patchy absorption from multiple layers of neutral material. The measured photon index and high intrinsic absorption of the nuclear spectrum of NGC 2110 are consistent with that of a typical Seyfert 2 galaxy, which demonstrates that NELG are typical AGN viewed through slightly more complex absorption, rather than a separate subclass of objects on their own. Based on additional multiwavelength imaging studies, we also find resolved soft X-ray emission 160 pc north of the nucleus, which is spatially coincident with [OIII] emission (HST), but lies just beyond the northern edge of the small-scale radio jet in the source. Taken with the evidence for ionized emission in the HETGS spectra of NGC 2110, we suggest that both photoionization and collisional ionization processes play a role in the circumnuclear environment of the source.

A Deep Chandra Observation of Centaurus A

Ralph Kraft, SAO

R. Kraft (SAO), M. Hardcastle (University of Hertfordshire), A. Jordan (ESO), G. Sivakoff (Ohio State University), D. Evans (Harvard University), J. Croston (University of Hertfordshire), W. Forman (SAO), C. Jones (SAO), P. Nulsen (SAO), S. Murray (SAO), D. Worrall (University of Bristol), M. Birkinshaw (University of Bristol), C. Sarazin (University of Virginia), A. Juett (University of Virginia), S. Raychaudhury (Birmingham University), N. Brassington (SAO), W. Harris (McMaster University), K. Woodley (McMaster University)

We present preliminary results from deep (6×100 ks) Chandra VLP observations of the nearby (d=3.8 Mpc, 1"=18.4 pc) galaxy Centaurus A. Cen A is the nearest early-type galaxy, late stage merger, and radio galaxy; our deep observations probe a wide range of astrophysically interesting phenomena unobservable in any other galaxy. In particular, we will discuss the temperature and abundance profile of the ISM, the GC/LMXB connection, the spectral and temporal properties of the XRB population (including one previously unknown ULX transient, and several others with $L_X < 1E38ergss^{-1}$), the role that the ongoing nuclear outburst plays in heating the ISM and in transporting high abundance material from the galaxy center to the halo, and the spatial and spectral morphology of the X-ray jet. The ISM exhibits a complex temperature and abundance profile, with mixing of gas likely due to both the merger and the radio outburst. We have extensive HST/ACS data on the globular cluster population as well, the proximity of Cen A permits us to measure the structural parameters (i.e. core radii, central densities, etc.) of the GCs to better understand the LMXB/GC link. The energy loss scale for X-ray synchrotron emission in extragalactic jets is only tens of pc. Cen A is the only extragalactic jet for which Chandra's spatial probes this scale.

Modeling the Supermassive Black Hole Driven Shocks in M87

William Forman, SAO

C. Jones (SAO), E. Churazov (MPA, IKI), R. Kraft (SAO), M. Markevitch (SAO), P.Nulsen (SAO), J.Eilek (NMT), F. Owen (NRAO)

We have modeled the shocks detected in the 500ksec Chandra observation of M87 using a hydrodynamic model of the gas surrounding M87. Starting from a description of the unperturbed gas density and gas temperature distributions derived from deprojections, we parameterize the outbursts that produce the observed shocks. For the observed shocks, we derive the outburst energy, the outburst age, and the duration of the outburst. For the outburst that gave rise to the main 13kpc ring, we constrain the duration of the outburst to more than a few million years. Finally, with a simple model for the main outburst, we can estimate the fraction of energy deposited in M87's atmosphere and the fraction that is carried away by the weak shock. We show that the deposited energy is comparable to that radiated by M87's cooling atmosphere.

The unusual X-ray morphology of NGC 4636: cavities, off-center outbursts and shocks revealed by deep Chandra observations

Alessandro Baldi, Harvard-Smithsonian CfA

W. Forman (Harvard-Smithsonian CfA), C. Jones (Harvard-Smithsonian CfA), R. Kraft (Harvard-Smithsonian CfA), P. Nulsen (Harvard-Smithsonian CfA), L. David (Harvard-Smithsonian CfA)

We present the analysis of 200 ksec of Chandra observations of the X-ray luminous elliptical galaxy NGC 4636, located in the outskirts of the Virgo cluster. A soft band (0.5-2 keV) image confirms the presence of a bright core in the center surrounded by an extended X-ray halo and two prominent, quasi-symmetric, 8 kpc long, arm-like features. In addition, faint structures, possibly cavities, are visible outside the core suggesting a more complex history than previous observations. We present surface brightness and temperature profiles of these structures. We show that the edges of at least three of these features are sharp and are characterized by temperature jumps of about 20-25a shock origin. We compare the observed profiles with shock models to derive quantitative parameters including outburst age and power for the shocks that produce the arm-like features that give rise to the unusual X-ray morphology of NGC 4636.

How Luminous Was the Galactic Supermassive Black Hole in the Past?

Frederick Baganoff, MIT Kavli Institute

M. P. Muno (Caltech), W. N. Brandt (Penn State), S. Park (Penn State), and M. R. Morris (UCLA)

Repeated deep Chandra monitoring of Sgr A* over the past few years has revealed rapidly variable Fe fluorescence features within 6' (14 pc) of the supermassive black hole, suggesting that its X-ray luminosity may have been greater than 10^{38} erg/s for at least 2-3 years about 60 years ago, before the first X-ray satellites were launched. These results will be discussed in the context of Chandra observations of Fe fluorescence in Sgr B2 and Sgr C, and arguments will be presented against the alternative hypotheses of irradiation by local X-ray binaries or excitation by low-energy cosmic ray electrons.

X-ray opportunities with GLAST

Julie McEnery, NASA/GSFC

The upcoming GLAST mission represents a major step forward in gamma-ray astronomy, with dramatic improvements in sensitivity, angular resolution and energy range beyond those achieved by the highly-successful EGRET instrument on the Compton Gamma-Ray Observatory. The enormous field of view will cover $\sim 20\%$ of the sky at any instant, and full sky coverage will be obtained every few hours. With these capabilities will come new opportunities for observers across the electromagnetic spectrum. High energy gamma-ray sources are inherently nonthermal, multiwavelength objects, best understood within the context of their behaviour at all wavelengths. In this talk I will describe the GLAST mission and instrument capabilities and discuss the role and importance of joint X-ray and high energy gamma-ray observations for a wide range of astrophysical objects.

Feedback in Clusters of Galaxies

Brian McNamara, University of Waterloo

For more than 25 years, it was thought that dense gas in the cores of clusters cooled at rates of tens to hundreds of solar masses per year, and condensed in a largely unseen form. This perception changed dramatically when X-ray observations of galaxy clusters by the Chandra and XMM-Newton observatories failed to find gas cooling below X-ray temperatures at the expected rates. At about the same time, images from the Chandra observatory revealed giant cavities and shock fronts that provide a direct and reliable means of measuring the energy injected into hot atmospheres by active galactic nuclei (AGN). Average AGN powers are near those required to suppress cooling in isolated giant elliptical galaxies, and in larger systems up to the richest galaxy clusters. This coincidence suggests that heating and cooling are coupled by feedback, which suppresses star formation and the growth of luminous galaxies. I will discuss the broader implication of these results for several fundamental astrophysical problems including the growth of bulges and supermassive black holes, the excess entropy in hot halos, and baryon overcooling in the universe.

X-ray and radio observations of galaxy groups: the history of AGN heating

Jan M. Vrtilek, Center for Astrophysics

S. Giacintucci (CfA and INAF), E. O'Sullivan (CfA), L. David (CfA), S. Raychaudhury (U. Birmingham), T. Ponman (U. Brimingham), W. Forman (CfA), C. Jones (CfA)

The central regions of galaxy groups and clusters are frequently occupied by massive elliptical galaxies with powerful radio sources which strongly interact with the X-ray emitting gas. Recent studies of such interactions have focused mostly on massive clusters, but there is growing interest in extending investigations to groups, which are the locus of most galaxies in the present-day Universe, and which may be more affected by AGN outbursts owing to shallow group potentials and may make radio/ICM interaction more apparent because of the low-pressure group environment. We present observations of about 15 groups, for all of which excellent X-ray data are in hand, and for which we are obtaining low frequency radio data, principally with the GMRT. Radio observations at multiple (especially low) frequencies show the radiative aging of electron populations and can reveal the radio counterparts to X-ray "ghost" cavities that contain old/low-energy electron populations. We present initial results from this observing program that illuminate the mechanisms, distribution, and timescales of energy injection.

Why Do Only Some Galaxy Clusters Have Cool Cores?

Jack Burns, University of Colorado, Boulder

Flux-limited X-ray samples indicate that about half of rich galaxy clusters have cool cores. Why do only some clusters have cool cores while others do not? In this talk, I will present cosmological adaptive mesh N-body + Eulerian hydrodynamic simulations, including radiative cooling and heating, along with Chandra and ROSAT observations to address this question. Our simulations suggest that there are important evolutionary differences between cool core (CC) clusters and their non-cool core (NCC) counterparts. Many of the numerical CC clusters accreted mass more slowly over time and grew enhanced cool cores via hierarchical mergers; when late major mergers occurred, the CC's survived the collisions. By contrast, NCC clusters experienced major mergers early in their evolution that destroyed embryonic cool cores and produced conditions that prevented CC re-formation. As a result, our simulations predict observationally testable distinctions in the properties of CC and NCC beyond the core regions in clusters. In particular, we find differences between CC versus NCC clusters in the shapes of X-ray surface brightness profiles, between the temperature profiles and hardness ratios beyond the cores, and between the distribution of masses. It also appears that CC clusters are no closer to hydrostatic equilibrium than NCC clusters, an issue important for precision cosmology measurements. I will compare these predictions with data from Chandra and ROSAT.

Toward cluster cosmology: A review of observational problems, progress and prospects

Marshall Bautz, MIT Kavli Institute for Astrophysics & Space Research

I review the long-understood potential role of galaxy clusters in illuminating the large-scale structure and expansion history of the Universe, and the equally well-appreciated difficulties in realizing this potential. The spectacular progress made in our understanding of clusters since the launch of Chandra has sharpened our appreciation of these difficulties at least as much as it has resolved them. I survey some recent work by others attacking this problem, focussing on contributions by X-ray observers to our understanding of cluster mass and distance measurement, as well as to the scatter of and evolution in relations between cluster structural parameters. I briefly compare cosmological results obtained from cluster studies, on the one hand, with inferences drawn from other cosmological measurements. I try to assess the impact on cluster cosmology of some planned future surveys in the microwave, visible and X-ray bands.

Constraints on dark energy from the observed growth of X-ray luminous galaxy clusters

Adam Mantz, KIPAC/Stanford

Steve Allen (KIPAC), Harald Ebeling (IfA, U. Hawaii), David Rapetti (KIPAC)

I will present cosmological constraints obtained from measurements of the growth of cosmic structure in the most X-ray luminous galaxy clusters in the universe. Our results are consistent with the cosmological constant model and are in good agreement with findings from a variety of independent data, notably the cosmic microwave background (CMB), type Ia supernovae (SNIa), galaxy cluster gas-mass fraction (f_{gas}), cosmic shear, and galaxy redshift surveys. Using the growth of structure data alone, we find the dark energy equation of state $w = -0.97 \pm 0.20$ for a constant-w model; this result is remarkably insensitive to the choice of priors and to systematic uncertainties in the analysis. The combination of growth of structure data with CMB, SNIa and f_{gas} data has the potential to significantly improve constraints on dark energy by breaking a key degeneracy between Ω_m, σ_8 and w.

Scaling Relations from Sunyaev-Zel'dovich Effect and Chandra X-ray measurements of high-redshift galaxy clusters

Max Bonamente, UA - Huntsville

Marshall Joy (MSFC), Samuel LaRoque (U.Chicago), John Carlstrom (U.Chicago), Daisuke Nagai (Caltech), Dan Marrone (U.Chicago)

We present Sunyaev-Zel'dovich Effect (SZE) scaling relations for 38 massive galaxy clusters at redshifts 0.14 <= z <= 0.89, observed with both the Chandra X-ray Observatory and the centimeter-wave SZE imaging system at the BIMA and OVRO interferometric arrays. An isothermal beta-model with central 100 kpc excluded from the X-ray data is used to model the intracluster medium and to measure global cluster properties. For each cluster, we measure the X-ray spectroscopic temperature, SZE gas mass, total mass and integrated Compton-y parameters within r2500. Our measurements are in agreement with the expectations based on a simple self-similar model of cluster formation and evolution. We compare the cluster properties derived from our SZE observations with and without Chandra spatial and spectral information and find them to be in good agreement. We compare our results with cosmological numerical simulations, and find that simulations that include radiative cooling, star formation and feedback match well both the slope and normalization of our SZE scaling relations.

Probing the WHIM through OVII K-alpha Fluctuations

Fabrizio Nicastro, SAO/INAF-OAR

M. Elvis (SAO), J. Drake (SAO), Y. Krongold (UNAM), S. Mathur (OSU), F. Fiore (INAF-OAR), R. Williams (University of Leiden)

According to hydrodynamical simulations the local Universe is permeated of tenuous warm-hot baryonic matter, distributed in filaments throughout the intergalactic space. These filaments imprint extremely weak high-ionization metal absorption in the X-ray spectra of background sources. The strongest of these transitions is the OVII Kalpha resonant, at lambda=21.6 A. Due to the steepness of the number density distribution of OVII WHIM absorbers with an equivalent width larger than a given threshold, however, less than one OVII Kalpha absorber with individually detectable (with current spectrometers) equivalent width ($EW > 10mA$) is expected to be found along a random line of sight up to z=1. Many more numerous of these absorbers, instead, are expected to produce non-resolvable absorption lines, which still, when integrated, give rise to broad and shallow residual opacity. This signature can be searched for in the binned stacked spectra of the brightest blazars in the Chandra archive, up to the minimum common redshift (the redshift of Mkn 421, z=0.03). We have performed this search, and found a 3% signal which we attribute to unresolved WHIM absorption (but note that Chandra-LETG calibrations are also known to a similar accuracy). This signal is in excellent agreement with theoretical expectations: 45 random lines of sight up to z=0.03 extracted from the latest Cen & Ostriker (2006) simulations, show average WHIM opacity of the order of -1.5%, with a 68% standard deviation of up to -3.5%.

Chandra's Close Encounter with the Disintegrating Comets 73P/Schwassmann–Wachmann–3 Fragment B and C1999 S4 Linear

Scott Wolk, Harvard–Smithsonian Center for Astrophysics

C.M. Lisse (Planetary Exploration Group, Space Department, Johns Hopkins University Applied Physics Laboratory), D. Bodewits (KVI atomic physics, University of Groningen), D.J. Christian (Queens University), K. Dennerl (Max-Planck-Institut für extraterrestrische Physik)

On May 23, 2006 we used the ACIS-S instrument on Chandra to study the X-ray emission from the B fragment of into official nomenclature comet 73P/2006 (Schwassmann-Wachmann 3) (SW3–B). In 2006, Comet P/SW-3 had split into at least 43 tracked elements and countless additional pieces, as had passed closer to the Earth in May 2006 than any comet yet detected in X-rays. We obtained a total of 20 ks of observation time of Fragment B, and also obtained contemporaneous ACE and SOHO solar wind physical data. The Chandra data allow us to spatially resolve the detailed structure of the interaction zone between the solar wind and the coma at a resolution of $\sim$ 1,800 km, and to observed the X-ray emission due to multiple comet–like bodies. We fitted both charge exchange and free range spectral models to the whole comet and various regions. We detect a change in the spectral signature with increasing optical depth as predicted by Bodewits etal. (2007). Further, we are able to understand the observed morphology in terms of non-gravitational forces, most notably solar radiation pressure acting on $\sim$1 micron sized particles ejected from the fragment as it disintegrated. We have used the results of the Chandra observations on the highly fragmented SW3B debris field to re-analyze and interpret the mysterious emission seen from comet C/1999 S4 (Linear) on August 1st, 2000, after the comet had completely disrupted. We find the physical situations to be similar in both cases, with extended X-ray emission due to multiple, small out gassing bodies in the field of view. Nevertheless, the two comets interacted with completely different solar winds, resulting in distinctly different spectra.

X-ray Fluorescent Fe Kα Lines from Stars

Jeremy Drake, SAO

Barbara Ercolano (SAO), Douglas Swartz (MSFC)

X-ray spectra from stellar coronae are reprocessed by the underlying photosphere through scattering and photoionization events. While reprocessed X-ray spectra reaching a distant observer are at a flux level of only a few percent of that of the corona itself, characteristic lines formed by inner shell photoionization of some abundant elements can be significantly stronger. The emergent photospheric spectra are sensitive to the distance and location of the fluorescing radiation and can provide diagnostics of coronal geometry and abundance. Here we present Monte Carlo simulations of the photospheric Kα_1, α_2 doublet arising from quasi-neutral Fe irradiated by a coronal X-ray source. Fluorescent line strengths have been computed as a function of the height of the radiation source, the temperature of the ionising X-ray spectrum, and the viewing angle. We also illustrate how the fluorescence efficiencies scale with the photospheric metallicity and the Fe abundance. Based on the results we make three comments: (1) fluorescent Fe lines seen from pre-main sequence stars mostly suggest flared disk geometries and/or super-solar disk Fe abundances; (2) the extreme $\approx$ 1400 mÅ line observed from a flare on V 1486 Ori can be explained entirely by X-ray fluorescence if the flare itself were partially eclipsed by the limb of the star; and (3) the fluorescent Fe line detected by *Swift* during a large flare on II Peg is consistent with X-ray excitation and does not require a collisional ionisation contribution. There is no convincing evidence supporting the energetically challenging explanation of electron impact excitation for observed stellar Fe Kα lines.

The Detectability of X-ray O and Ne Fluorescence Lines on the Sun and the Resolution of the Solar Model Problem

Jeremy Drake, SAO

Barbara Ercolano (SAO), Jay Bookbinder (SAO)

The remarkable agreement between the observed solar oscillation spectrum and that predicted by solar models has been thrown into discord in recent years by evidence suggesting the photospheric C, N, O and Ne content has been overestimated by $\sim 35 - 50$
of the Ne Kα and O Kα lines fluoresced by coronal X-rays and emitted beneath the solar chromosphere have been employed to investigate the use of these features as new abundance diagnostics. While quite weak, we find that both lines should in principle be detectable with a suitably sensitive instrument. The Ne Kα line becomes irretrievably blended with lines of Fe XVIII at plasma temperatures $T > 2 \times 10^6$ K, while that of O is blend-free up to temperatures $T \sim 3 \times 10^6$ K. We briefly describe the instrumental characteristics required to observe the lines and how they can be used to determine the photospheric Ne and O content and discriminate between competing solar abundance recommendations.

X-ray flares, coronae and disks in Orion young stars

Konstantin Getman, Penn State University

E. Feigelson (PSU), P. Broos (PSU), G. Garmire (PSU)

Pre-main sequence (PMS) stars are known to produce powerful X-ray flares which resemble magnetic reconnection solar flares scaled by factors upto 10^4. Several puzzles are present: the stability of implied magnetic loops 10 times the stellar radius; possible magnetic loops extending to the protoplanetary disk; and the origin of slow-rise flares. To investigate these issues in detail, we examine > 200 of the brightest flares from > 160 COUP stars which constitute the largest known homogeneous dataset of PMS flares ever acquired. We use an innovative method to trace the evolution of the flare plasma from an adaptively smoothed X-ray median energy of flare counts, and standard solar flare models to derive sizes of flaring coronal structures. We classify COUP flares into several morphological groups including "typical" rapid-rise-slow-decay and "slow-rise-and/or-top-flat" (SRTF). Rise and decay times range from hours to > 1 day, peak luminosities span $10^{30.5} - 10^{32.9}$ erg/s range, and peak plasma temperatures - $\sim 20- > 100MK$. For 80% of the flares, inferred coronal loop sizes span 0.5-6Rstar while the remainder have even larger loops. Two main results are obtained. First, we find evidence that the coronal extent of PMS stars with inner circumstellar disks does not exceed the Keplerian corotation radius. In contrast, $\sim 30\%$ of stars without inner disks have coronas extending upto two corotation radii. This supports the model of Jardine et al. (2006) for coronal stripping by circumstellar disks. However, there is no relationship found between flare morphology and an inner disk indicative that star-disk field lines produce distinctive flare types. Second, our analyses indicate that the rapidly accreting PMS stars lack long-lasting and morphologically complex flare events such as SRTFs, events which could involve multiple flares from the entire coronal magnetosphere. We speculate that the progression of magnetic reconnection in multipolar magnetospheres ceases when it reaches an accretion hotspot with mass loaded coronal loops.

The Stellar Population And Origin Of The Mysterious High-Latitude Star Forming Cloud CG12

Konstantin Getman, Penn State University

E. Feigelson (PSU), W. Lawso n (UNSW-ADFA), P. Broos (PSU), G. Garmire (PSU)

The mysterious high galactic latitude cometary globule (CG) CG12 has been observed with the ACIS detector on board the Chandra X-ray Observatory. We detect 128 X-ray sources, of which a half are likely young stars formed within the globule's head. This new population of >= 50 T-Tauri stars and one new embedded protostar is far larger than the previously reported few intermediate-mass and two protostellar members of the cloud. Most of the newly discovered stars have masses 0.2-0.7Msun, and 9-15% have K-band excesses from inner protoplanetary disks. X-ray properties provide an independent distance estimate consistent with CG12's unusual location $>= 200pc$ above the Galactic plane. The star formation efficiency in CG12 appears to be 15-35%, far above that seen in other triggered molecular globules. The median photometric age found for the T-Tauri population is ˜4Myr with a large spread of $< 1 - 20Myr$ and ongoing star formation in the molecular cores. The stellar age and spatial distributions are inconsistent with a simple radiation driven implosion (RDI) model, and suggest either that CG12 is an atypically large shocked globule, or it has been subject to several distinct episodes of triggering and ablation. We report a previously unnoticed group of B-type stars northwest of CG12 which may be the remnants of an OB association which produced multiple supernova explosions that could have shocked and ablated the cloud over a 15-30Myr period. HD120958 (B3e), the most luminous member of the group, may be currently driving an RDI shock into the CG12 cloud.

Detection of Short Timescale Variability in Capella

Vinay Kashyap, SAO/CXC

Jennifer Posson-Brown (CXC)

Capella is a bright active binary (G1 III/G8 III) whose coronal luminosity has been remarkably steady over many decades of EUV and X-ray observations, and thus has been a frequent target for calibration observations. Numerous studies have attempted to detect intensity variability on it over various timescales, and have found long term variations of $\sim 10 - 20\%$. Here, we analyze 205 ks of Capella data obtained for calibration purposes with the HRC-I on Chandra. Capella registers at approx 22 ct/s in this configuration, and due to the high data quality, unambiguously we detect variability on Capella at the 2-7% level at timescales of 5-20 ks. This work was supported by NASA Contract NAS8-39073 to the Chandra X-Ray Center.

Characterization of X-ray emission from T Tauri stars

Sonali J. Shukla, Vanderbilt University

David Weintraub (Vanderbilt University), Joel Kastner (Rochester Institute of Technology), David Huenemoerder (MIT), Norbert Schulz (MIT), Paola Testa (MIT)

Although young stellar objects are known to be luminous and variable X-ray sources, the generation mechanism(s) of their X-rays are still unresolved. We have identified a sample of stars in the Chandra archives for which Chandra ACIS-S/HETGS long integration, high spectral resolution data exists. Our sample consists of both classical, weak-lined, and post-T Tauri stars as well as a young main sequence star. We are analyzing this data in a globally-consistent way to determine physical characteristics of the X-ray emitting plasma including temperature, density, and elemental abundances for each star. In addition, we are looking to confirm the results of recent studies that have shown that T Tauri stars have well-correlated H-alpha equivalent widths and f/i line ratios in He-like ions. Line density diagnostics have also shown that low-densities are associated with cool plasmas indicative of accretion shocks. Combining these diagnostic techniques for the variety of stars in our sample will enable us to identify similarities and differences among those stars that are thought to be actively accreting material from their circumstellar regions and those that have little or no accretion signatures in other wavelength regimes. We report on the first phase of our analysis of this sample of stars.

An archive of Chandra observations of regions of star formation (ANCHORS)

Brad Spitzbart, SAO

ANCHORS is an archive of Chandra observations of regions of star formation. It is designed to aid both the X-ray astronomer with a desire to compare X-ray datasets and the star formation astronomer wishing to compare stars across the spectrum. We have completed a Phase 2 reprocessing of all datasets (80+ observations, 50+ distinct fields) to provide improved analysis and greater uniformity. The data consist of X-ray source prop erties including position, net count rates, flux, hardness ratios, lightcurve statistics and plots. Spectra are fit using several models, with final parameters and plots recorded in the archive. Multi-wavelength images and data are cross-linked to other resources such as 2MASS and SIMBAD. We will demonstrate the system, examine scientific pilot studies using the archive, and solicit users' feedback. This project is supported by Chandra archival grant AR5-6002A and NASA contract NAS8-39073.

The HETGS Orion Legacy Project

Paola Testa, MIT Kavli Institute for Astrophysics and Space Research

Norbert S. Schulz (MIT), David P. Huenemoerder (MIT), Claude R. Canizares (MIT), Joel Kastner (RIT)

The Orion Trapezium Cluster (OTC) at the heart of the Orion Nebula is one of the youngest and closest star forming regions to our Sun. Early Chandra observations resolved a large number of bright X-ray sources in the OTC from very young ($\sim 3 \times 10^5$ yr) stars of masses ranging from substellar to several tens of solar masses. Over the last eight Chandra observing cycles we scanned the OTC with the HETGS to obtain a homogenuous sample of high resolution X-ray spectra from very young stars which are assumed to be coeval in terms of their star formation history, possess similar chemical composition,and span a large mass range. So far we have accumulated over 85% of the anticipated 590 ks of exposure. The set includes good quality spectra of several massive ZAMS stars, and we have identified three processes of X-ray production: standard line driven wind shocks, magnetic confinement of winds, and most recently binary induced magnetic reconnection. The most compelling cases for magnetic activity have been made for Θ^1 Ori C, Θ^1 Ori A and Θ^2-2 Ori A. We also present results from one HAeBe binary (Θ^1 Ori E) and several PMS stars of K/M spectral type (e.g., MT Ori). The results include X-ray emissivities, temperatures, mission radii, plasma densities as well as short- and longterm variability of these sources. We compare the new results with properties previously found in some of these sources as well as other hot and cool stars.

Chandra's X-ray View of Massive Star-forming Regions

Leisa Townsley, Penn State University

Chandra is providing remarkable new views of massive star-forming regions, revealing the effects of massive stars on their surroundings. We will explore the latest data on several such regions, highlighting physical processes that characterize the life of a massive stellar cluster, from deeply-embedded cores too young to have established an HII region to superbubbles so large that they shape our views of galaxies. X-ray observations reveal hundreds of pre-main sequence stars accompanying the massive stars that power these great HII region complexes; this X-ray selected sample of young stars can be used to study disk frequency and evolution in the proximity of massive stars. The most massive stars themselves are often anomalously hard X-ray emitters; this may be a new indicator of close binarity. These complexes are sometimes suffused by diffuse X-ray structures, signatures of multi-million-degree plasmas created by fast O-star winds. In older regions we see the X-ray remains of the deaths of massive stars that stayed close to their birthplaces, exploding as cavity supernovae within the superbubbles that these clusters created.

An X-ray Imaging Study of the Stellar Population in RCW49

Masahiro Tsujimoto, Pennsylvania State University

Feigelson, E. D., Townsley, L. K., Broos, P. B., Getman, K. V., Wang, J. Garmire, G. P. (Penn State), Baba, D. (Nagoya), Nagayama, T. (Kyoto), Tamura, M. (NAOJ), Churchwell, E. B. (Wisconsin)

We present the results of a high-resolution X-ray imaging study of the stellar population in the Galactic massive star-forming region RCW49 and its central OB association Westerlund 2. We obtained a 40 ks X-ray image of a 17'x17' field using the Chandra X-ray Observatory and deep NIR images using the Infrared Survey Facility in a concentric 8'3x8'3 region. We detected 468 X-ray sources and identified optical, NIR, and Spitzer Space Telescope MIR counterparts for 379 of them. The unprecedented spatial resolution and sensitivity of the X-ray image, enhanced by optical and infrared imaging data, yielded the following results: (1) The central OB association Westerlund 2 is resolved for the first time in the X-ray band. X-ray emission is detected from all spectroscopically-identified early-type stars in this region. (2) Most (86%) X-ray sources with optical or infrared identifications are cluster members in comparison with a control field in the Galactic Plane. (3) A loose constraint (2–5 kpc) for the distance to RCW49 is derived from the mean X-ray luminosity of T Tauri stars. (4) The cluster X-ray population consists of low-mass pre–main-sequence and early-type stars as obtained from X-ray and NIR photometry. About 30 new OB star candidates are identified. (5) We estimate a cluster radius of 6'–7' based on the X-ray surface number density profiles. (6) A large fraction (90cluster members are identified individually using complimentary X-ray and MIR excess emission. (7) The brightest five X-ray sources, two Wolf-Rayet stars and three O stars, have hard thermal spectra.

X-Atlas: An Online Archive of Chandra's Stellar HETG Observations

Owen Westbrook, MIT

Nancy Remage Evans, Scott J. Wolk, Vinay L. Kashyap, Joy S. Nichols (SAO), Peter J. Mendygral (University of Minnesota), Jonathan D. Slavin, and Wayne L. Waldron

We have compiled a database of all stellar observations made with Chandra's High Energy Transmission Grating (HETG) to facilitate the rapid comparison, characterization, and analysis of high-resolution stellar X-ray spectra. This database, known as X-Atlas, is accessible through a web interface with extensive searching and interactive plotting capabilities. For each target, X-Atlas also features predictions of the low-resolution ACIS spectra convolved from the HETG data for comparison with stellar sources in archival ACIS images. X-Atlas offers more than 130 observations of over 65 stars and will be updated as additional observations become public. The atlas is currently expanding to non-stellar point sources and eventually will include Low Energy Transmission Grating data as well.

Spectral and Temporal Monitoring of the INS RX J1308.6+2127 with XMM-Newton

Carol Airhart, Dynetics, Inc.

P.M. Woods (Dynetics, Inc., NSSTC), V. Zavlin (NSSTC, Marshall Space Flight Center), M.H. Finger (NSSTC), D.L. Kaplan (MIT), C. Kouveliotou (NSSTC, Marshall Space Flight Center), G.G. Pavlov (Penn State University)

The isolated neutron star (INS) RX J1308.6+2127 has been observed with Chandra and XMM-Newton several times between 2001 and 2007. The six most recent XMM-Newton observations are part of a monitoring campaign we initiated to study the long-term temporal and spectral properties of INSs. The primary goal of this investigation is to better quantify the similarities and differences between INSs and magnetar candidates (i.e. Anomalous X-ray Pulsars and Soft Gamma Repeaters) in terms of their spectral and temporal variability. Here, we present our analysis of the current data set and show that (i) the energy spectrum is well modeled by a blackbody with two absorption lines, (ii) the spectral parameters do not show significant time variability over the last five years, (iii) the pulse profile is strongly energy dependent, but stationary, and (iv) the pulse frequency evolution is consistent with monotonic spin-down. Our spectral and temporal results are in agreement with earlier analyses by Schwope et al. (2007) and Kaplan & van Kerkwijk (2005), respectively. The inclusion of the new monitoring data provides more precise constraints on both spectral and temporal parameters of this INS. For isolated neutron stars whose X-ray emission is not powered by spin-down (INSs, AXPs and SGRs), RX J1308.6+2127 is among the most stable members.

Nonthermal Bremsstrahlung vs. Synchrotron Radiation: Cas A

Glenn Allen, MIT

Stage, M. D. (U. of Mass, Amherst), Houck, J. C. (MIT)

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.

A search for X-ray counterparts of the millisecond pulsars in the globular cluster M28

Werner Becker, MPE-Garching

C.Y. Hui, H.H. Huang, Steve Begin (University of British Columbia)

A recent radio survey of globular clusters has increased the number of millisecond pulsars drastically. M28 is now the globular cluster with the third largest population of known pulsars, after Terzan 5 and 47 Tuc. This prompted us to revisit the archival Chandra data on M28 to evaluate whether the newly discovered millisecond pulsars find a counterpart among the various X-ray sources detected in M28 previously. The radio position of J1824-2452H is found to be in agreement with the position of CXC 182431-245217 while some faint unresolved X-ray emission near to the center of M28 is found to be coincident with the millisecond pulsars PSR J1824-2452G, J1824-2452J, J1824-2452I and J1824-2452E.

Doppler Velocities of Knots and Filaments in the SNR N132D

Tracey DeLaney, MIT Kavli Institute

Dan Dewey (MIT), Claude Canizares (MIT)

The oxygen-rich supernova remnant N132D in the Large Magellanic Cloud was observed with the High Energy Transmission Grating Spectrometer on board the Chandra X-ray Observatory. Individual emission lines of oxygen, neon, magnesium, and silicon are observed and Doppler shifts have been measured. We find Doppler velocities of knots and filaments of only a few hundred km/s supporting previous abundance studies that concluded that the X-ray emission is mostly swept-up ISM and not ejecta.

X-ray Spectroscopic Diagnosis of a Wind-Collimated Blast Wave and Metal-Rich Ejecta from the 2006 Explosion of RS Ophiuchi

Jeremy Drake, SAO

J. Martin Laming (NRL), Jan-Uwe Ness (Arizona State), Sumner Starrfield (Arizona State), Salvatore Orlando (Palermo) and the RS Oph Team

Chandra HETG observations of RS Ophiuchi at day 13.9 of the 2006 outburst reveal a rich spectrum of emission lines from abundant ions formed over a wide temperature range ($\sim 3 - 60 \times 10^6$ K) indicative of shock-heating of the circumstellar medium by the expanding blast wave. Lines are asymmetric and strongly broadened ($v \sim 2400$ km s^{-1} at zero intensity). Using simple analytical model profiles, we show how the lines are shaped by differential absorption in the red giant wind and explosion ejecta, and that shock heating to multi-million degree temperatures appears to have occurred preferentially in the direction perpendicular to the line-of-sight. We conclude that the asymmetric nature of the offset $1/r^2$ density profile and likely equatorial circumstellar density enhancement in which the explosion occurred is responsible for both the shock collimation and broad range in plasma temperature observed. The ejecta mass deduced from X-ray absorption is much more easily reconciled with the expected mass accretion rate for material enhanced in metals by about an order of magnitude.

Spectral Feature at 3.7 keV in the Slowly Rotating Central Compact Object in RCW 103

Gordon Garmire, Penn State University

Audrey Garmire (Penn State)

A series of nineteen monitoring observations of the CCO in RCW 103 were carried out from 2000 to 2005. During these observations a large flare was observed to have occurred sometime before 2000 February 8. The following six years of observation revealed a very slow, but steady decline in the source intensity. About half way through the decline a significant absorption line appeared in the spectrum of the source at an energy of about 3.7 keV. It was observed during four of the nineteen observations. The line appears to be rather narrow, but it could be a proton cyclotron line. Another possibility is that it is from an excited state of ionized Calcium in the surrounding nebula. If it is a cyclotron line, it would imply a magnetic field of greater than 10^{14} Gauss.

Observations of pulsar wind nebulae

C.Y. Hui, MPE, Germany

Werner Becker (MPE, Germany), Hsiu-Hui Huang (MPE, Germany)

In searching for diffuse X-ray emission around a variety of pulsars, we have discovered trail-like nebulae associated with PSRs J2124-3358 and J1509-5850. Examining the diffuse emission, we found that the observed X-rays are non-thermal in nature. Modeling the nebular emission with the one-zone model, we found that the observed X-rays are inline with the emission originating from accelerated particles in the post shock flow. In searching for radio counterparts, we have discovered a radio nebula associated with PSR J1509-5850 which is apparantly longer than its X-ray counterpart. This is consistent with the scenario of sychrotron cooling. The X-ray nebula of PSR J2124-3358 is the first time that extended emission from a solitary millisecond pulsar is detected. In contrast to a typical pulsar wind nebula, the X-ray nebula of PSR J2124-3358 appears to be highly asymmetric and significantly deviated from the direction of the pulsar's velocity.

X-ray observations of the pulsar B1929+10 and its environment

Zdenka Misanovic, Pennstate University

George Pavlov (Pennstate), Gordon Garmire (Pennstate)

We report on two Chandra observations of B1929+10, which reveal a PWN with a torus bent in the direction opposite to the pulsar's proper motion and possibly a small jet in the immediate vicinity of this 3-Myr-old pulsar. There is also a long tail behind the pulsar, extending up to 2' in Chandra images and ∼15' in the XMM-Newton data, with a luminosity of 10e30 ergs/s in the 0.3-8 keV band. However, the PWN morphology does not seem to be entirely consistent with the existing MHD simulations for bow-shock PWNe, suggesting that the intrinsic anisotropy of the pulsar wind must be taken into account when modelling such objects. Contrary to previous results, our spectral analysis suggests that, in addition to the magnetospheric emission, there is a strong thermal component ($\sim 40-50\%$ of the total emission in the 0.3-10 keV band) in the pulsar's spectrum. The combined Chandra and XMM-Newton data suggest that the thermal emission emerges from a polar cap region with an apparent radius of ∼30-40 m and a temperature of about 0.3 keV.

X-ray observations of PSR J1740+1000

Zdenka Misanovic, Pennstate University

George Pavlov (Pennstate), Oleg Kargaltsev (Pennstate)

Extremely long parsec-scale tails associated with pulsars have been detected in recent X-ray and radio observations. We present XMM-Newton and Chandra observations of the middle-aged pulsar J1740+1000, with a tail extending up to 3 pc. The tail has a relatively hard spectrum with a photon index of $\sim$1.4-1.5 and a luminosity of 1-2e30 ergs/s in the 0.3-10 keV band. The pulsar spectrum is best fit by a combination of two black-body models with temperatures of $\sim$0.16 and $\sim$0.08 keV, and a power-law component with a photon index of $\sim$1.4. The X-ray data shows 154-ms sinusoidal-shaped pulsations with the pulsed fraction of $\sim$20-30%. We also discuss the results of the phase-resolved spectroscopy for this pulsar.

The X-ray Spectrum of the Galactic Supernova Remnant RCW 103

Daniel Patnaude, SAO

I present a spectral analysis of archival observations of the Galactic supernova remnant RCW 103. The X-ray spectrum is dominated by thermal X-ray emission and shows little evidence for a nonthermal synchrotron component. Furthermore, the thermal X-ray emission is dominated by shocked ISM and does not appear to have appreciable emission from the ejecta component.

Synchrotron-Dominated X-ray Emission from the Galactic SNR G1.9+0.3

Stephen Reynolds, North Carolina State University

K.J. Borkowski (NC State U), U. Hwang (NASA/GSFC), I. Harrus (NASA/GSFC), R. Petre (NASA/GSFC)

The shell supernova remnant G1.9+0.3 has the smallest angular diameter of any Galactic SNR, at about 1.2 arcmin at radio wavelengths (Green 2004). Our 50 ks Chandra observation of G1.9+0.3 shows a complete shell structure with strong bilateral symmetry. The mean diameter is about 100", though fainter extensions on opposite sides extend about 10" further on each side. The azimuthal brightness variations around the shell are quite different from the single bright maximum in radio. The spectrum is featureless and well-described by the exponentially cut off synchrotron model srcut, with a very high absorbing column of (6.0 +/- 0.3) $\times 10^{22} cm^{-2}$. With the radio flux at 1 GHz fixed at 0.9 Jy, we find a spectral index of 0.65 +/- 0.02 and a rolloff frequency of 1.1 (0.5, 2.5) $\times 10^{18}$ Hz, one of the highest values known. (All errors are 90The high column implies that G1.9+0.3 is at least as far as the Galactic center, and perhaps far across the Galaxy. At 8.5 kpc, the diameter is 4.4 pc, comparable to Kepler's SNR; even at 20 kpc, it would be only half the size of SN 1006. Simple age estimates give values between 200 and 1000 yr. The high rolloff frequency requires shock velocities of several thousand km/s. G1.9+0.3 thus becomes the fourth clear member of the class of Galactic synchrotron-dominated shell supernova remnants.

X-ray emission from the young pulsar J1357-6429 and similar objects

Vyacheslav Zavlin, NASA/MSFC/USRA

The first Chandra and XMM-Newton observations of the young and energetic pulsar J1357-6429 provided strong indications of a tail-like pulsar-wind nebula associated with this object, as well as pulsations of its X-ray flux with a pulsed fraction above 50dominating at lower photon energies (below 2 keV). The elongated nebula is very compact in size and may be interpreted as evidence for a pulsar jet. The thermal radiation is most plausibly emitted from the entire neutron star surface of an effective temperature about 1 MK covered with a magnetized hydrogen atmosphere. At higher energies the pulsar's emission is of a nonthermal (magnetospheric) origin, with a power-law spectrum of a photon index of 1.1-1.3. This makes the X-ray properties of PSR J1357-6429 very similar to those of the youngest pulsars J1119-6127, Vela and several others with a detected thermal radiation.

The Entropy-Feedback Connection and Quantifying Cluster Virialization

Kenneth Cavagnolo, Michigan State University

Megan Donahue (Mich. St. Univ.), Mark Voit (Mich. St. Univ.), Ming Sun (Mich. St. Univ.)

Understanding the entropy of intracluster gas is the key to understanding 1) the feedback mechanisms active within clusters and 2) the role of the cluster environment on galaxy formation. Our presented work focuses on examining feedback mechanisms together with the breaking of self-similar relations expected in cluster and galaxy formation models with star formation and AGN. In this poster, we present and describe radial profiles of the entropy distribution in cluster gas. We also examine a metric proposed to quantify the degree of cluster virialization which may in turn reduce scatter in scaling relations, thus increasing clusters utility in cosmological studies. We have assembled a library of entropy profiles for a sample of 100 clusters in the *Chandra* Data Archive (CDA) covering broad mass and morphological ranges, together with the radio and optical properties of the central galaxy. We will discuss the interconnection of central entropy with radio luminosity and Hα emission. We will describe the distribution of central entropy levels in our sample and briefly discuss what can be learned about the range of central heating mechanisms and the timescale of feedback mechanisms from this distribution. We will also present recently completed work for which we explore the band-dependence of the inferred X-ray temperature of the ICM for 179 clusters selected from the *Chandra* archive. We compare the X-ray temperatures inferred for single-temperature fits of global spectra (with the central R=70 kpc excluded and an outer radius of R_{2500}) when the energy range of the fit is 0.7-7.0 keV (full) and when the energy range is 2.0/(1+z)-7.0 keV (hard). We find, on average, the hard-band temperature is significantly higher than the full-band temperature. Upon further exploration, we find the ratio $T_{HFR} = T_{2.0-7.0}/T_{0.7-7.0}$ is enhanced preferentially for clusters which are known merger systems and for clusters which do not have detectable cool cores. Annular regions surrounding cool core clusters tend to have best-fit hard-band temperatures that are statistically consistent with their best-fit full-band temperatures.

X-ray Properties of Clusters with Wide-Angle Tail Radio Sources: Abell 562 and Abell 1446

Edmund Douglass, Boston University

E.L. Blanton (Boston University), T. E. Clarke (NRL, Interferometrics, Inc.), Craig L. Sarazin (University of Virginia)

Named for their characteristic C-shape, wide angle tail (WAT) radio sources are assumed to be formed by the interaction between the radio jets and the intracluster medium in which they are embedded. We present Chandra observations of two clusters that host WAT radio sources, Abell 562 and Abell 1446. While both clusters display isothermal radial temperature profiles and a typically smooth decline in pressure and density with radius, both exhibit evidence for some degree of merger activity and WAT/ICM interaction. We find that the clusters have an excess of emission offset from the cluster core and WAT hosting galaxy. There is significant two-dimensional temperature substructure within the central regions of the clusters as is consistent with infalling clumps or galaxy groups, while the surface brightness distribution of the inner regions of the clusters reflects that of unrelaxed systems. It is possible that this merger activity may be leading to the shaping of the bent radio sources within each cluster. In addition there is evidence that the lobes of both WAT sources have carved out cavities within the intracluster gas.

Constraining the Age of Fossil Groups with Chandra

Renato Dupke, University of Michigan

Claudia Mendes de Oliveira (University of Sao Paulo, Brazil)

Indications that fossil groups are formed at early epochs come not just from the expected high time scale for dynamical friction to merge the core galaxies, but also from recent X-ray observations, including high concentration parameters and featureless X-ray morphologies. However, the lack of cooling cores in fossil groups with short cooling times and the sensitiveness of the dynamical friction time scale on the satellite galaxies impact parameter are also consistent with a more recent formation time. Here, we discuss new constraints on the formation time of fossil groups based on the residual chemical profiles of the intra-group gas as measured by X-ray elemental abundance ratios.

Dynamical Evolution Diagnostics of Compact Galaxy Groups & Isolated Systems

Chris Fuse, TCU

Pamela Marcum (NASA HQ,TCU), Michael Fanelli (TCU)

Compact groups contain galaxies within dense galactic environments, typically with separations less than a few diameters. Due to their short dynamical timescales, these systems are excellent probes of merging and interaction phenomena. Compact groups are the likely precursors to fossil groups and highly isolated elliptical galaxies. The morphology of hot gas is uniquely suited for distinguishing isolated ellipticals with a merged group origin from systems which evolved along alternative paths. As part of a larger study to understand the origin and evolution of isolated early-type galaxies identified in the Sloan Digital Sky Survey, we have analyzed the diffuse x-ray emission of 11 Hickson Compact Groups (HCG) and several isolated early-type systems, using archival data from NASAs Chandra X-ray Observatory. We use the morphology and physical extent of the soft (0.3-2.5 keV) emission, x-ray luminosity, and gas temperature as diagnostics of the dynamical state of these systems. Correlations of x-ray measurements with other group properties provide a tool for assessing dynamical evolution, which can be used to infer the properties of the precursors of isolated ellipticals. A hot intergroup medium is not detected in 5 groups. Most of the members of these spiral-dominated groups exhibit axisymmetric x-ray emission, suggesting that this gas has experienced few external perturbations. The remaining 6 contain an intergroup medium, which extends beyond the optical extent of individual galaxies and shows significant structure. The x-ray luminosity of these groups ranges from 6.8×10^{39} to 8×10^{41} ergs/sec, with gas temperatures ranging from $0.62 \text{ keV} \leq kT \leq 1.1 \text{ keV}$. The HCGs are observed to have sub-solar abundance values. This project is supported by NASAs Astrophysical Data Program, grant #NNG05C53G, and a Texas Space Grant Consortium fellowship.

Intermediate-Redshift Groups in the XBootes Survey

Eric Miller, MIT

Mark Bautz, Catherine Grant (MIT), William Forman, Christine Jones, Stephen Murray, Alexey Vikhlinin (SAO)

Galaxy groups are key tracers of galaxy evolution, cluster evolution, and structure formation, yet they are difficult to study at even moderate redshift. We have undertaken a project to observe a flux-limited sample of intermediate-redshift ($0.15 < z < 0.35$) group candidates identified by the XBootes Chandra survey. By exploiting the unique multiwavelength coverage of the XBootes/NOAO Deep Wide Field Survey (NDWFS) field, we aim to (1) understand the connection between the X-ray and optical properties of groups, and (2) constrain non-gravitational processes that affect the energetics of the intragroup medium. Here we present deep Chandra/ACIS and Suzaku/XIS follow-up observations of the first four targets in this project. All four are confirmed sources of diffuse, thermal emission with derived temperatures between 1 and 5 keV and bolometric X-ray luminosities between 10^{43} and 10^{44} erg/s. We discuss these early results in the context of group and cluster evolution.

An improved pressure profile for fitting Sunyaev-Zel'dovich data from Galaxy Clusters

Tony Mroczkowski, Columbia University

Daisuke Nagai (Caltech), Amber Miller (Columbia), Max Bonamente (MSFC), John E. Carlstrom (U. Chicago), Christopher Greer (U. Chicago), David Hawkins (Caltech-OVRO), Ryan Hennessy (U.Chicago), Marshall Joy (MSFC), James W. Lamb (Caltech-OVRO), Erik M. Leitch (Caltech/JPL), Michael Loh (U.Chicago), Ben Maughan (Bristol, SAO, Chandra Fellow), Stephen Muchovej (Columbia University), Clem Pryke (U.Chicago), Ben Reddall (Caltech-OVRO), Matthew Sharp (U.Chicago), and David Woody (Caltech-OVRO)

We demonstrate the utility of a new model, recently shown to be a robust, self-similar pressure profile, for fitting the current and future generations of Sunyaev-Zel'dovich effect (SZE) observations of galaxy clusters. It has been shown that traditional isothermal β-model cannot describe the cluster gas out to the virial, even when the cluster core is excluded. The gas density profile begins to steepen and isothermality is a poor assumption at large radii. When jointly fitting *Chandra* X-ray and SZ cluster data, the higher signal-to-noise X-ray data drive model shape parameters. For SZE observations of cluster pressure profiles, which are steeper than cluster density profiles due to the decrease in temperature with radius, departures from the isothermal β-model are compounded. The isothermal β-profile systematically overpredicts the integrated SZ decrement, Y_{int}, which scales as SZ flux and is sensitive to the integrated gas pressure, by $\sim 30 - 100\%$ at r_{500} (the radius at which the mean cluster density is 500 times greater than the critical density of the universe at that redshift). Modern SZE imaging instruments, such as the Sunyaev-Zel'dovich Array (SZA), are sensitive to arcminutes scales ($\sim 1 - 6'$), meaning they are capable of probing out to r_{500} for most clusters above redshift $z >\sim 0.2$. The need for a model that can describe a cluster's pressure profile at all observable radii has become crucial to the study of the SZE from clusters. Therefore, a new pressure profile, which is not constrained by the X-ray derived density model shape parameters, has been tested. We find this model provides an unbiased estimate of Y_{int}, and, when combined with X-ray image data through the ideal gas law, yields a reasonably-accurate electron temperature profile without relying on X-ray spectroscopic information. In addition to yielding more accurate relationships between cluster observables and physical cluster properties, this model could prove to be a useful tool in helping to constrain the temperatures of high redshift clusters.

Chandra ACIS Survey of M33 (ChASeM33): The First Look Source Catalog

Paul Plucinsky, SAO

Benjamin Williams (UW), Knox S. Long (STScI), Terrance J. Gaetz (SAO), Manami Sasaki (SAO), Wolfgang Pietsch (MPE), Ralph Tuellmann (SAO), Randall K. Smith (JHU/GSFC), and the ChASeM33 team

We present a source catalog from the Chandra ACIS Survey of M33 (ChASeM33): A Deep Survey of the Nearest Face-on Spiral Galaxy. The 1.4 Ms survey covers the galaxy out to R 18 arcmin (4 kpc). These data provide the most intensive, high spatial resolution assessment of the X-ray source populations available for the confused inner regions of M33. Mosaic images of the ChASeM33 observations show several hundred individual X-ray sources as well as soft diffuse emission from the hot interstellar medium. Bright, extended emission surrounds the nucleus and is also seen from the giant HII regions NGC604 and IC131. Fainter extended emission and numerous individual sources appear to trace the inner spiral structure. The initial source catalog, arising from 2/3 of the expected survey data, includes 394 sources significant at the 3 sigma confidence level or greater, down to a limiting luminosity (absorbed) of 1.6e35 ergs (0.35 – 8.0 keV). The hardness ratios of the sources separate those with soft, thermal spectra such as supernova remnants from those with hard, non-thermal spectra such as X-ray binaries and background active galactic nuclei. Emission extended beyond the Chandra point spread function is evident in 23 of the 394 sources. Cross-correlation of the ChASeM33 sources against previous catalogs of X-ray sources in M33 results in matches for the vast majority of the brighter sources and shows 28 ChASeM33 sources within 10 arcsec of supernova remnants identified by prior optical and radio searches. Support for this work was provided by NASA through Chandra Award Number G06-7073A and contract NAS8-03060

New results from deep Chandra observation of Abell 3667

Alexey Vikhlinin, SAO

I will discuss how a deep Chandra observation of the cold front in the galaxy cluster A3667 provides constraints on the physics of the intracluster medium.

Chandra Observations of NGC 4569: X-Rays from a Large Interacting Spiral Galaxy in the Virgo Cluster

Shanil Virani, Yale University

Jeff Kenney (Yale), Christine Jones (CfA), and Bill Forman (CfA)

We present results from a 30 ks Chandra/ACIS-S observation of NGC 4569, a large spiral galaxy in the Virgo cluster core currently undergoing ram-pressure stripping. We detect X-ray emission on three scales: emission from a central compact core likely from a low luminosity AGN, soft diffuse emission just outside of the core which has a "horseshoe"-like morphology, and emission on 4' scales that is associated with the star-forming disk. The soft diffuse X-ray gas just outside of the core closely traces H-alpha filaments and is likely associated with a nuclear outflow from either an AGN or a starburst. Spectral fits performed on data extracted from the central 2" are best-fit using a power law model with a photon slope of 1.8 +/- 0.2, consistent with the typical indices found for AGNs detected with Chandra and XMM-Newton. Spectral fits performed on data extracted from the central 35" and excluding the central 2", are best-fit using a collionsionally ionized plasma model (MEKAL) with a temperature of 0.63 +/- 0.04 keV. The detection of an AGN in NGC 4569 resolves a long-standing controversy in the literature on whether the X-ray emission from the core is from an AGN or from a compact starburst.

How Were Cold Fronts Formed in Abell 496?

Raymond White, University of Alabama

Renato Dupke (University of Michigan), Joel Bregman (University of Michigan)

Cold fronts, discontinuities in X-ray surface brightness accompanied by continuous gas pressure distributions, are often found in relaxed galaxy clusters. Explaining cold fronts as remnant cores of head-on subcluster mergers does not generally work for such clusters, which has led to competing models invoking gas sloshing. We use a deep Chandra exposure of Abell 496 to test predictions of these sloshing models by analyzing the spatial distributions of density, temperature, metal abundances and abundance ratios. We confirm that the temperature and chemical discontinuities in this cluster are not consistent with being directly identified with a core merger remnant. Nonetheless, we find that these structures could have been caused by sloshing induced by an off-center collision with a dark matter halo. We find a relatively cool "arm" of gas, with different abundance ratios than its surroundings, stretching from the central regions. The spiral shape of this arm emanating from the center is reminiscent of structures induced by off-center encounters with less massive dark matter halos, as found in recent numerical simulations of Ascasibar and Markevitch (2006).

X-ray Study of Star Formation in NGC 2403

Mihoko Yukita, UAH

D. Swartz (NASA/MSFC), R. Soria (MSSL)

We present a multi-wavelength analysis of the central 6 kpc region of NGC 2403, where most of the star formation is located in the nearby, face-on, spiral galaxy. From a distance of only 3.2 Mpc, we are able to resolve an individual HII region from most observatories. This allows us to investigate the correlations between soft X-ray diffuse emission and other star-formation tracers, such as H-alpha, GALEX UV, and Spitzer Mid-IR, focusing not only on the galactic scale but also on individual HII regions. The soft X-ray emission in the central region shows internal contributions from young HII regions (< 30 Myrs) and also from extra-diffuse coronal gas, which may be accounted for by older, star-forming activities.

Mid-infrared properties and color-selection for X-ray detected AGN

Carolin Cardamone, Yale University

Maaike Damen (Leiden), Marijn Franx (Leiden), Eric Gawiser (Rutgers), Ivo Labbe (Carnegie), Ezequiel Treister (ESO) , C. Megan Urry (Yale) , P. van Dokkum (Yale), and Shanil N. Virani (Yale)

We present the mid-infrared colors of X-ray-detected AGN and explore mid-infrared selection criteria. Using a statistical matching technique, the likelihood ratio, 921 IRAC counterparts were identified with the 1017 published X-ray sources in the Chandra Deep Field South and Extended Chandra Deep Field South. Although most X-ray selected sources have mid-infrared spectral shapes consistent with power-law slopes, $f_\nu \propto \nu^\alpha$, they display a wide range of colors in the four observed infrared wavelengths $(3.6, 4.5, 5.8, 8\mu m)$. While on average these sources fit to redder (more negative α) power-laws than non-X-ray detected galaxies, more than 50% have flat or blue (positive α) power-law spectral shapes. Because they show these blue galaxy-like colors, we find many infrared color-selection techniques fail to identify the majority of AGN found through their X-ray emission. However, infrared color-selection is successful in finding the subset of AGN displaying broad lines at optical wavelengths. Selection techniques are improved by the addition of 24 micron data because nearly all X-ray selected AGN are red ($\alpha \sim -1$) between 3.6 and $24\mu m$. Roughly a third of the galaxies detected at 24 μm show monotonically red (negative α) power-laws through 24 μm. This could be the subset of our sample whose infrared spectra are dominated by emission from the central AGN region. The majority of the X-ray-selected AGN population displays colors consistent with those of the general galaxy population at observed wavelengths between 3.6 and $8.0\mu m$ making color selection challenging without longer wavelength coverage.

Multiwavelength constraints on the large scale jets of quasars.

Markos Georganopoulos, University of Maryland, Baltimore County and NASA/GSFC

Demosthenes Kazanas (NASA/GSFC), Eric Perlman (Florida Institute of Technology)

We present global and model-specific constraints that the radio to X-ray multiwavelength spectra and morphologies pose on our understanding of quasar large scale jets.

A decade of RXTE Seyfert Observations

Barbara Mattson, UMD/Goddard Space Flight Center/ADNET

Kimberly Weaver (NASA/GSFC), Christopher Reynolds (UMD)

We report results of a systematic X-ray spectral variability study of bright Seyfert galaxies observed by the Rossi X-Ray Timing Explorer (RXTE). The RXTE public archive contains data for 40 Seyfert galaxies spanning timescales from weeks to years. We have developed a data pipeline to automate the data reduction. The pipeline produces a series of time-resolved spectra for each source. The sample consists of ~450 time-resolved spectra from 20 Seyfert 1/1.2 and ~190 spectra from 13 Seyfert 1.9/2.0 galaxies. Each spectrum is fitted to a model with an intrinsic powerlaw X-ray spectrum produced close to the central black hole that is reprocessed and absorbed by material around the black hole. To test the robustness of our results, we performed Monte Carlo simulations of the spectral sample. For the Seyfert 1 galaxies, we find a complex relationship between the iron line equivalent width (EW) and the underlying powerlaw index, which may be driven by dilution of a disk spectrum (which includes the narrow iron line) by a beamed jet component and, hence, could be used as a diagnostic of jet-dominance.

HST observations of PKS 0637-752

Kushal Mehta, University of Maryland, Baltimore County

Markos Georganopoulos (UMBC-NASA/GSFC), Eric Perlman (FIT), Alex Padgett (UMBC-NASA/GSFC), George Chartas (PSU), Demosthenes Kazanas (NASA/GSFC)

We present new NICMOS and ACS HST observations of the jet in PKS 0637-752 that result to the most complete spectral coverage of the jet to date. We also discuss the implications of these observations in the context of models for the jet X-ray emission.

Accretion of low angular momentum material onto black holes: Radiation properties of axisymmetric MHD flows.

Monika Moscibrodzka, UNLV

Daniel Proga (UNLV), Bozena Czerny (N. Copernicus Astronomical Center),Aneta Siemiginowska (CfA)

Numerical simulations of MHD accretion flows in the vicinity of a supermasssive black hole provide useful insights in to the problem of why and how systems – such as the Galactic center – are underluminous and variable. In particular, the simulations indicate that low angular-momentum accretion flow is highly variable both quantitatively and qualitatively. This variability and a relatively low mass-accretion rate are caused by interplay between a rotationally supported torus, its outflow, and a nearly non-rotating inflow. To investigate the applicability of such flows to real objects, we examine the dynamical MHD studies with computations of the time-dependent radiation spectra predicted by the simulations. We calculated the synthetic broadband spectra of accretion flows using Monte Carlo techniques. We applied this method to calculating spectra predicted by the time-dependent model of an axisymmetic MHD flow accreting onto a black hole presented by Proga and Begelman (2003). Our calculations show that variability in an accretion flow is not always reflected in the corresponding spectra, at least not in all wavelengths. We find no one-to-one correspondence between the accretion state and the predicted spectrum. For example, we find that two states with different properties – such as the geometry and accretion rate – could have relatively similar spectra. However, we also find two very different states with very different spectra. The existence of nonthermal radiation may be needed to explain X-ray flaring because thermal bremsstrahlung, dominates X-ray emission, is produced at relatively large radii where the flow changes are small and slow.

Toward a handle on the low-energy end of the electron distribution in kpc-scale jets: The case of PKS 0637-752

Martin Mueller, KIPAC/SLAC

Dan Schwartz (Harvard-CfA)

We re-analyze the Chandra X-ray spectrum of the kpc-scale jet in PKS 0637-752 to investigate the possible low energy cut-off in the relativistic electron spectrum producing the non-thermal radiation in the scenario of inverse Compton emission off the cosmic microwave background. The soft X-ray band is the most promising to detect the effects of this cut-off, as the corresponding radio band at which the synchrotron spectrum starts to show deviations from power law shape is usually too low in frequency to permit observations. PKS 0637-752 was among the first objects targeted by the Chandra Observatory and gives a unique opportunity to study the low energy X-ray emission free of contamination. The power law index of the X-ray spectrum is consistent with that of the synchrotron component, but there is evidence for a broad excess of emission below 1 keV. Under the assumption that this soft excess is unrelated to the electron population responsible for the power law emission, the absence of any low energy turn-over in the X-ray spectrum implies a minimum Lorentz factor of the electron distribution $\gamma_{\rm min}$ of no higher than 75. In addition, the observed optical flux can be used to place a lower limit on $\gamma_{\rm min}$; the constraint is not very strong, but does suggest that $\gamma_{\rm min}$ must be higher than 1 to avoid over-producing the optical emission. An alternative phenomenological description of the soft excess is offered, where the low-energy end of the electron distribution is modified to account for the excess; a possible interpretation is that we are seeing the high-energy tail of the IC/CMB spectrum produced by the mildly relativistic bulk shocked electrons in the jet.

Simulations of relativistic, collisionless shocks: The X-ray hot spots in the M87 jet

Ken-Ichi Nishikawa, NSSTC/UAH

P. Hardee (UA), Y. Mizuno (NASA/NSSTC), G.J. Fishman (NASA/MSFC), D. Hartmann (Clemson Univ.), M. Medvedev (Univ. Kansas).

We studied collisionless shocks and their associated emissions in an effort to model the X-ray hot spots observed in the jet of M87. In collisionless shocks, the Weibel instability is responsible for particle acceleration and magnetic field generation. Particle In Cell (PIC) simulations of relativistic, collisionless shocks show that particle acceleration is provided in situ by the Weibel instability, which produces current filaments and associated magnetic fields. Particles develop a velocity distribution with higher energy a tail due to the acceleration in small-scale, highly non-uniform, amplified magnetic fields. The resulting jitter radiation from electrons in these non-uniform fields can have very different spectral properties than synchrotron radiation. We report recent results of our PIC simulations and relate them to X-ray observations with Chandra.

Confirmation of a correlation between the X-ray luminosity and spectral slope of AGNs in the Chandra Deep Fields.

Cristian Saez, PSU

G. Chartas (PSU), W. N. Brandt (PSU), B. D. Lehmer (PSU), F. E. Bauer (Columbia), X. Dai (OSU), and G. P. Garmire (PSU).

We present results from a statistical analysis of 173 bright radio-quiet AGNs selected from the Chandra Deep Field-North and Chandra Deep Field-South surveys (hereafter, CDFs) in the redshift range of $0.1 < z < 4$. We find that the X-ray power-law photon index of radio-quiet AGNs is correlated with their 2Γ 10 keV rest-frame X-ray luminosity at the $> 99.5\%$ confidence level in two redshift bins, $0.3 < z < 0.96$, and $1.5 < z < 3.3$ and slightly less significant in the redshift bin $0.96 < z < 1.5$. The X-ray spectral slope steepens as the X-ray luminosity increases for AGNs in the luminosity range 10^{42} to 10^{45} erg s^{-1}. Combining our results from the CDFs with those from previous studies in the redshift range $1.5 < z < 3.3$, we find that the Gamma/Lx correlation has a null-hypothesis probability of 1.6×10^{-9}. We investigate the redshift evolution of the correlation between the power-law photon index (Gamma) and the hard X-ray luminosity (LX) and find that the slope and offset of a linear fit to the correlation changes significantly (at the $> 99.9\%$ confidence level) between redshift bins with $0.3 < z < 0.96$ and $1.5 < z < 3.3$. We explore possible physical scenarios explaining the origin of this correlation and its possible evolution with redshift in the context of steady corona models focusing on its dependency on variations of the properties of the hot corona with redshift.

Discovery non-thermal X-ray from radio lobe of Cygnus A

Yuichi Yaji, Department Physics, Saitama University

H. Seta (Saitama University), M. Tashiro (Saitama University), N. Isobe (RIKEN), M. Kino (JAXA), K. Asada (JAXA), H. Nagai (NAOJ), M. Kusunose (Kwansei Gakuin University)

Lobes of radio galaxies are enormous storages of large amount of non-thermal electrons and magnetic fields, both of which are thought to be transferred by jets from active galactic nuclei. Their energies can be comparable to those of thermal energies of intra-cluster medium (ICM), and resultant X-ray "cavities" in ICM are observed from several clusters. Observation of the inverse-Compton (IC) X-ray emission from non-thermal electrons in lobes is crucial to measure the electron and magnetic energy densities. However, it is difficult to precisely measure the IC X-ray from the lobes of radio galaxies located in clusters, because they are often contaminated by the thermal X-rays from ICM. In order to avoid the contamination, spatial resolution is the key. We analysed all the available archival *Chandra* data of the bright FR II radio galaxy Cygnus A (9 pointing in total). After the standard data screening, we obtained 230 ks of good exposure has been obtained. We carefully subtracted the ambient ICM emission, and have succeeded to detect a hard X-ray emission associated with the radio lobes. The *Chandra* spectra of the east and the west lobes are well described by power-law models with energy indices of 0.66 ± 0.05 and 0.70 ± 0.09, respectively. The flux density of the east and west lobes are measured to be 72 ± 3 nJy, 30 ± 2 nJy, respectively. Because the X-ray energy index of the lobes is consistent with the radio synchrotron index ($\alpha_{\rm R} = 0.7$), we regard that the hard X-ray emission from the lobes is produced via IC process by the synchrotron electron in the lobes. Comparison of the determined X-ray flux and radio flux indicates that the electron energy highly dominates that of the magnetic field in the lobes. Comparison of the derived non-thermal pressure with that of ICM will also discussed in the paper.

Yaxx - Automated X-ray Data Processing and Spectral Extraction

Tom Aldcroft, SAO

Yaxx is a software package that can greatly facilitate batch processing of X-ray data. It includes automated spectral extraction, fitting, and report generation. The primary emphasis is on having an easily used tool that can be run without requiring an extensive learning curve. However, for those with the motivation, yaxx is highly configurable and can be customized to support complex analysis. Yaxx has been used extensively with Chandra data and a thread for XMM processing is also available. A modular software design allows for multi-mission support and user customization of the data processing flow. Recent work has focused on thread development, including a comprehensive Chandra analysis thread that starts from ACIS level-1 products and finishes with a flux-calibrated source list. Yaxx is not only intended for X-ray data - it provides a way to easily generate pipelines to automate general data processing tasks, with an infrastructure that provides robust logging, reporting, and error handling.

Chandra ACIS Survey of M33 (ChASeM33): Supernova Remnants

Terrance Gaetz, SAO

K.S. Long (STScI), W.P. Blair (JHU), P. Ghavamian (JHU), J.P. Hughes (Rutgers), P.F. Winkler (Middlebury College), D.J. Helfand (Columbia), R.P. Kirshner (Harvard), T. Pannuti (Morehead State), P.P. Plucinski (SAO), M. Sasaki (SAO), R. Tuellmann (SAO), and the CHASEM33 Team

In our deep Chandra X-ray survey of M33, we have obtained images of seven overlapping fields covering the central regions of M33 using the ACIS-I detector. The survey region includes most of the nearly one hundred supernova remnants (SNRs) which had been previously identified by using a combination of optical and radio imaging and spectroscopy. This survey finds ChASeM33 sources coincident (within 10 arcsec) with 31 of the 100 known supernova remnants in M33. A number of the ChASeM33 sources are spatially resolved, showing X-ray emission clearly extending beyond the size of the PSF. This includes several known SNRs and also some newly identified X-ray SNR candidates. We will report on the most interesting cases, and compare the optical and X-ray data for a number of these. Support for this work was provided by NASA through Chandra Award Number G06-7073A and contract NAS8-03060.

Optical identifications of Chandra and XMM-Newton sources

Kajal Ghosh, USRA, NASA/MSFC/NSSTC

Carlos M Gutierrez de la Cruz (IAC, Spain), Sergei Fabrika (SAO, Russia),

We have initiated a program to identify the optical counterparts of Chandra and XMM-Newton sources, using the Sloan Digital Sky Survey database and our optical follow-up observations. We have detected Ultra-Luminous X-ray sources, which are brighter than E+41 ergs/s in merging/interacting galaxies at redshifts up to 0.2. In addition, we have detected a varieties of objects: (i) optically faint, X-ray bright sources, (ii) X-ray bright, optically normal galaxies, (iii) different types of Active Galactic Nuclei (lost low luminosity AGNs, radio-loud and radio-quiet, narrow- and broad-line AGNs, Ultrasoft broad-emission-line quasars, X-ray weak AGNs, X-ray luminous BAL-QSOs, highly ionized BAL-QSOs, state transitions of AGNs), (iv) new groups and clusters of galaxies and (v) new gravitational lenses/Einstein Rings. Here we will present these results to demonstrate that exciting science can be carried out using the results of the proposed survey.

X-ray Luminosity Evolution in Normal Elliptical Galaxies with c-COSMOS

Dong-Woo Kim, CfA

G. Fabbiano (cfa), M. Elvis (cfa), T. Aldcroft (cfa), H. Brunner (mpg), M. Brusa (mpg), N. Cappelluti (mpg), F. Civano (bo), A. Comastri (bo), A. Finoguenov (mpg), F. Fiore (inaf), A. Fruscione (cfa), R. Gilli (bo), T. Miyaji (cmu), S. Puccetti (asdc), C. Vignali (inaf), G. Zamorani (inaf), C. M. Carollo (ETH-Zurich), S. Lilly (ETH-Zurich), C. Scarlata (ETH-Zurich), P. Oesch (ETH-Zurich), M. Sargent (ETH-Zurich), R. Feldmann (ETH-Zurich)

We investigate the X-ray luminosity of a well-defined sample of early type galaxies as a function of redshift with Chandra COSMOS data (Elvis et al. 2006). We carefully select high-redshift elliptical galaxies, based on their morphology, optical color, and the Kormendy relation (Scarlata et al. 2007). By stacking X-ray data at the positions of elliptical galaxies after excluding possible AGNs, we find that the average LX / LB increases by a factor of 2 to z=0.4 (or lookback time of ∼5 Gyr), at a 3 sigma confidence level. This increase is slightly steeper than that expected from the previously determined (1+z)2.7, but still consistent within the error. We also discuss the X-ray luminosity and its evolution in S0, E+A, optically (less-) luminous galaxy samples.

Chandra ACIS survey of M33: The Chandra view of NGC604

Ralph Tuellmann, SAO

T. J. Gaetz (SAO), P. P. Plucinsky (SAO), W. P. Blair (JHU), D. Breitschwerdt (Vienna University, Austria), M. A. de Avillez (Un iversity of Evora, Portugal), P. Ghavamian (JHU), K. S. Long (STSCI), T. Pannuti (SSC, Morehead State University)

In the framework of the Chandra ACIS Survey of M33 (ChASeM33, Plucinsky et al. 2008), we present new results of the first detailed X-ray analysis of the giant HII-region NGC604. Our deep (300ks) high resolution (2") ACIS-I X-ray images show highly structured emission covering 70% of the full extent of NGC604. The bubbles and cavities in NGC604 are filled with hot X-ray emitting gas, as evidenced by a morphological comparison of X-ray, FUV, optical, and FIR emission. X-ray spectra, extracted from the images, provide the first reliable constraints on electron densities, filling factors, gas temperatures, and ionized gas masses for the main bubbles and cavities. It is generally believed that NGC604 is a wind blown bubble powered by 200 OB/WR-stars in its center. The observed X-ray luminosity of 1.1x10E36 erg/s is most likely caused by a shocked stellar wind and is consistent with the above assumption. Moreover, the derived X-ray gas mass of 1500 $M_{\odot}$ can be readily explained by heavy mass loss from the central stars. Finally, we investigated the evolution of NGC604 for the case that the first generation of massive stars ended their lifes within a short period of time as SNe. A comparison with current superbubble models implies that NGC604 will be the origin of a superbubble, breaking out into the halo. Currently, M33 does not fulfill the empirical criteria to also form a multiphase gaseous halo. However, the expected energy input should push M33 over the threshold to form such structures which are well known for late-type edge-on spirals with enhanced star formation. This work was supported by NASA Chandra award number GO6-7073A.

Angular Momentum Loss Considerations in Large Scale T Tauri Flares

Alicia Aarnio, Vanderbilt University

Keivan Stassun (Vanderbilt University)

The Chandra Orion Ultradeep Project was able to observe a number of T Tauri stars during highly energetic X-ray flare events. Favata et al. (2005) then applied a uniform cooling loop model effective in modeling solar magnetic field loops to derive loop arc lengths on the order of 100 stellar radii in the most extreme cases. In the context of pre-main sequence evolution, are we to interpret these loops as structures connecting star to disk or, using a solar analogue, do they represent extreme "coronal mass ejections" (CMEs)? We have created Monte Carlo models of the spectral energy distributions of the stars with the largest flaring loops and found that the majority of the sample appears to lack circumstellar disk material. This surprising result is the impetus for detailed analysis of the mass and angular momentum lost via CME events of this magnitude. We present estimates of angular momentum loss via large scale flare events and discuss the implications of this work for stellar angular momentum evolution of young low-mass stars.

Smoothing Algorithm that Preserves Structures of Astronomical X-ray Data

Eli Bressert, Chandra X-ray Center

Kim Kowal Arcand (Chandra X-ray Center), Peter Edmonds (Chandra X-ray Center)

We have processed numerous X-ray data sets using several well-known algorithms such as Gaussian and adaptive smoothing for public related image releases. These algorithms are used to smooth images and retain the overall structure of observed objects. Recently, a new PDE algorithm and program, provided by Dr. David Tschumperle and referred to as GREYCstoration, has been tested and is in the progress of being implemented into the Chandra EPO imaging group. Results of GREYCstoration will be presented and compared to the currently used methods for X-ray images. What demarcates Tschumperle's algorithm from the current algorithms used by the EPO imaging group is its ability to preserve the main structures of an image strongly, while optimizing the image for visual analysis. In addition to smoothing images, GREYCstoration can be used to erase artifacts accumulated during observation and mosaicking stages. GREYCstoration produces results that are comparable and in some cases more preferable than the current smoothing algorithms. From our early stages of testing, the results of the new algorithm will provide insight on the algorithm's capabilities and its potential uses for future applications and images.

Innovations in ACIS Data Analysis

Patrick Broos, Penn State University

Leisa Townsley (Penn State University)

Fields with thousands of X-ray point sources pose significant data analysis challenges to the Chandra/ACIS observer, ranging from source detection to spectral modeling. We describe three innovations we are exploring as part of the ACIS Team's on-going development of the ACIS Extract (AE) analysis package, which has been publicly available since 2002. (1) Point source detection in crowded fields is difficult. We describe a procedure that first proposes sources by identifying peaks in a simple Richardson-Lucy restoration of ACIS image data, and then carefully computes a confidence level for each candidate source using the AE machinery. (2) Accurate local background estimation is critical for effective source detection and for spectral analysis of weak sources. We describe a model-based approach to background estimation, now available in AE, that addresses the crowded field problem. (3) Perhaps the best approach for modeling the low-count spectra produced by the majority of ACIS sources is simultaneous fitting of the raw (not grouped) source and background spectra using the C-statistic. However, the background model employed by XSPEC (when the C-statistic is selected and a background spectrum is supplied) is known to produce biased results. We describe a simple alternative background model that seems to perform well.

Study of HST counterparts to Chandra X-ray sources in the Globular Cluster M71

Hsiu-Hui Huang, MPE, GERMANY

Werner Becker (MPE, Germany), Bau-Ching Hsieh (ASIAA, Taiwan), Ronald Elsner (MSFC, USA), Peter Edmonds (SAO, USA)

We report on the results of the globular cluster M71 (NGC 6838) observed by the Advanced Camera for Surveys and the Wide Field Planetary Camera 2 on board the Hubble Space Telescope. Inside the the half-mass radius of M71, 29 X-ray sources have been detected by the Chandra Observations in the energy range of 0.3 - 8.0 KeV, and 5 of which lie within one core radius from the cluster center. We identify three optical counterparts out of five X-ray sources. Based on the X-ray and optical properties, candidates of cataclysmic variables (CVs), chromospherically active binaries, and background galaxies inside the half-mass radius of M71 are found in our search.

An X-ray Calorimeter on the Spectrum-X Gamma Mission

Randall Smith, JHU & NASA/GSFC

The Russian Spectrum-X-Gamma (SXG) Mission is now under development to carry out the first moderate-resolution, all-sky survey of the x-ray sky since ROSAT. This mission shares the name of the original SXG developed in the 1980s (and not launched due to budget problems) but has been completely redesigned. SXG is a medium-sized satellite ($\sim$ 2200 kg) to be launched in 2011/12 into a 600 km equatorial ($<$ 5 deg) orbit from Kourou or into a ¡30 deg orbit from Baikonur as a fallback option. The payload includes eROSITA (extended ROentgen Survey with an Imaging Telescope Array, MPE, Germany) with 7 Wolter-type telescopes, the wide field X-ray monitor Lobster (LU, UK), the X-ray concentrator based on Kumakhov optics ART or coded-mask X-ray telescopes as a fallback (IKI, Russia) and GRB detector (Russian consortium). The mission will conduct the first all-sky survey with an imaging telescope in the 2-12 keV band to discover the hidden population of several hundred thousand obscured supermassive black holes and the first all-sky imaging x-ray time-variability survey. It will observe the extragalactic sky with high enough sensitivity to detect 50,000-100,000 clusters of galaxies for follow-up pointed observations of selected sources to provide a rich new data set for probing dark matter and dark energy. The survey will also provide valuable data on point sources, populations of unresolved sources that make up galactic diffuse emission along the plane, and diffuse emission from hot gas. SXG will also include an x-ray calorimeter spectrometer developed by NASA/GSFC to provide grating-level spectral resolution, recovering part of the science that was lost from the untimely demise of the Suzaku/XRS. The design will incorporate a 1.6 m f/l x-ray telescope (an copy of one of the eROSITA units) coupled to a spare x-ray calorimeter from the XRS program. Operating in a dewar designed and built in Japan, we expect a resolution of 4 eV (FWHM) at 6 keV. The dewar would be based on flight-heritage cryocoolers and cable of long life without cryogens. With this instrument, the long-standing puzzles of the Galactic x-ray emission would finally be addressed with high spectral resolution and better than 2 arcmin spatial resolution over the entire sky. This would create the best chance ever for disentangling and physically identifying the numerous Galactic components responsible for the diffuse x-ray emission. In addition, the instrument could be used for pointed-mode observations (e.g early in the mission and at the completion of the surveys), thereby creating the possibility of a sampling of scientific topics that were planned for the original Suzaku program.

Probing the 4U 1624-490 Ionized Gas and Dust distribution along the LOS

Jinge Xiang, Harvard University

Julia C. Lee (Harvard University), Michael A. Nowak, Norbert S. Schulz (MIT)

We present results based on our 76 ks Chandra HETGS observation of the "Big Dipper" 4U 1624-490. Specifically, we discuss how the detected Fe line absorption evolves with orbital phase during persistent phases in the context of the geometry of the system as well as changes in plasma conditions over the 4U 1624-490 binary orbit. We show that the evolution of these lines can be modeled using the "XSTAR" photoionized code which places the location of "hot" ($\sim 3 \times 10^6$ K) gas in a region where an Accretion Disk Corona (ADC) is expected to exist an the location of "warm" ($\sim 10^6$ K) gas in a region between the ADC and the disk edge. In addition, we will show how we have used the associated dust scattering halo to derive a geometric distance of 15 kpc to this binary, as well as assess location, uniformity and density of ISM dust grains along the line of sight to this source.

EDGE: Explorer of Diffuse emission and Gamma-ray burst Explosions

Jan-Willem den Herder, SRON

L. Piro (INAF-Rome), T. Ohashi (Tokyo Metropolitan University), C. Kouveliotou (MSFC) on behalf of the EDGE consortium

How structures on various scales formed and evolved from the early Universe up to present time is a fundamental question of astrophysical cosmology. EDGE will trace the cosmic history of the baryons from the early generations of massive star by Gamma-Ray Burst (GRB) explosions, through the period of cluster formation, down to very low redshifts, when between a third and one half of the baryons are expected to reside in cosmic filaments undergoing gravitational collapse by dark matter (Warm Hot Intragalactic Medium: WHIM). In addition EDGE, with its unprecedented observational capabilities, will provide key results on several other topics including: the study of feedback mechanisms into the Interstellar Medium (Supernova Remnants, galaxy/Active Galactic Nuclei outflows), constraints on the Dark Matter and Dark Energy content of the Universe (through clusters and GRBs), equation of state of the densest matter (neutron stars), GRB physics, upper limits on light dark matter particles, accurate measurement of the geometry of space-time by measuring X-ray afterglows of black hole mergers detected through gravitational waves, Active Galactic Nuclei and stellar population surveys, and Solar System physics. The science is feasible with a medium class mission using existing technology combined with innovative instrumental and observational capabilities on a single satellite by: a) observing with fast reaction Gamma-Ray Bursts with a high spectral resolution (R $\sim$ 500). This enables the study of their (star-forming) environment from the Dark to the local Universe and the use of GRB as back light of large scale cosmological structures b) Observing and surveying extended sources (clusters, WHIM) with high sensitivity using two wide field of view X-ray telescopes (one with a high angular resolution and the other with a high spectral resolution). The mission concept includes four main instruments: a Wide-field Spectrometer with excellent energy resolution (3 eV, 1 eV goal), a Wide-Field Imager with high angular resolution (15") constant over the full 1.4 degree field of view, and a Wide Field Monitor with a FOV of 1/4 of the sky, which will trigger the fast repointing. Extension of its energy response up to 1 MeV will be achieved with a GRB detector with no imaging capability. This mission is proposed to ESA as part of the Cosmic Vision call. We will describe the science drivers and the payload of this mission.

Soft and hard X-ray excess emission in Abell 3112 observed with Chandra

Max Bonamente, UA - Huntsville

Jukka Nevalainen (Obs. Helsinki), Richard Lieu (UA - Huntsville)

Chandra ACIS-S observations of the galaxy cluster A3112 feature the presence of an excess of X-ray emission above the contribution from the diffuse hot gas, which can be equally well modeled with an additional non-thermal power-law model or with a low-temperature thermal model of low metal abundance. We show that the excess emission cannot be due to uncertainties in the background subtraction or in the Galactic HI column density. Calibration uncertainties in the ACIS detector that may affect our results are addressed by comparing the Chandra data to XMM MOS and PN spectra. While differences between the three instruments remain, all detect the excess in similar amounts, providing evidence against an instrumental nature of the excess. Given the presence of non-thermal radio emission near the center of A3112, we argue that the excess X-ray emission is of non-thermal nature and distributed throughout the entire X-ray bandpass, from soft to hard X-rays.

Chandra /XMM-Newton cross calibration with clusters of galaxies

Laurence David, SAO

During the IACHEC meeting in May 2007, we analyzed a sample of 8 relaxed clusters of galaxies observed by both Chandra and XMM-Newton. We found that the derived cluster temperatures were consistent between the two observatories for clusters cooler than 4 keV when the data were fit in either the 0.5-7 keV band or a harder band from 2-7 keV. However, when fitting the harder band for hotter clusters, the Chandra derived temperatures are slightly greater than the XMM-Newton derived temperatures. It appears that decreasing the depth of the contaminant on the HRMA mirrors from 22A to 15A produces a better agreement with the XMM-Newton results and also provides better internal Chandra calibration.

Evaluating the Effectiveness of the ACIS Superbias

Joseph DePasquale, Harvard-Smithsonian

Paul Plucinsky (Harvard-Smithsonian), Beverly LaMarr (MIT Kavli Institute)

Prior to executing science observations, the ACIS instrument conducts a bias observation for each active CCD. The biases are later utilized in data reduction to improve the signal to noise by subtracting the amplitude of charge in each pixel in the absence of radiation. The front-illuminated CCDs are particularly vulnerable to cosmic ray events during bias acquisition. These high-energy events deposit large amounts of charge in the CCD substrate which then create "blooms" of charge in the surrounding pixels. On-board bias algorithms are successful at removing most of these events. However, there are occasional events so energetic, the deposited charge lingers for multiple frames of data and is not removed by the algorithm. X-ray events detected in the vicinity of such a bias artifact would be skewed to lower energies after processing. In an effort to mitigate these effects, we investigate the effectiveness of using a superbias, created from a median of many bias observations, in place of the observation-specific bias.

Monte Carlo methods for including correlated systematic calibration uncertainties in astrophysical analysis: Chandra ACIS

Jeremy Drake, CXC

Pete Ratzlaff (CXC), Vinay Kashyap (CXC), Richard Edgar(CXC), Diab Jerius (CXC), Herman Marshall (MIT), Alexey Vikhlinin (CXC)

Abstract not available.

Characterization and Correction of ACIS CTI in the Continuous Clocking Mode

Richard Edgar, SAO

Charge Transfer Inefficiency (CTI) is characterised for the ACIS Continuous Clocking (CC) mode. A method for its correction is discussed and evaluated. Initial results are encouraging, producing results comparable to the TE mode CTI corrector for the flight grades containing about 90% of the events. Background issues will be discussed.

Pileup and the ACIS/HRMA Point Spread Function

Terrance Gaetz, CXC/SAO

Diab Jerius (CXC/SAO)

The ACIS detector is subject to pileup, in which more than one charge cloud can be deposited in the vicinity of a pixel within a single frame. This can result in an incorrect evaluation of the X-ray energy, or even loss of the X-ray event. Because the Chandra on-axis PSF is so narrow, pileup is particularly an issue for point sources. This has implications both for the shape of the PSF, and for extracted spectra. With increasing pileup, the core of the PSF is depressed as a larger fraction of events are changed into events with "bad grades". The reduction in count rate can become significant before the depression of the core becomes visibly obvious. To study the effects of pileup on the Chandra PSF, we performed a series of observations of the isolated pulsar PSRJ0437-4715. The observations used frame times ranging from 0.2s to 10s to provide a range of count rates (counts per frame) to sample different pileup conditions. We report on the status of these studies.

Upgrading the Chandra/HEASARC CalDB Index and Software Interface

Dale Graessle, CXC Data Systems

Ian Evans (CXC Data Systems), Kenny Glotfelty (CXC Data Systems), Helen He (CXC Data Systems), Arnold Rots (CXC Data Systems), Janet DePonte-Evans (CXC Data Systems), Pepi Fabbiano (CXC Data Systems)

The HEASARC Calibration Database (CalDB) standard has been implemented for numerous X-ray missions, including EINSTEIN, EXOSAT, ROSAT, ASCA, Chandra, and SWIFT, among others. As mission configurations have become more complicated, it has become clear that a more flexible index definition and interface would be extremely helpful in adapting the CalDB standard to newer missions. Chandra has by far the most complete and complex calibration data structure of any mission to date. Hence, Chandras need for an upgrade to the index definition and associated interface software is most pronounced. We have reported previously (SPIE Conference 6270, May, 2006) a plan for such an upgrade and herein report progress in implementing that plan. We have finalized a set of requirements for this effort. We have constructed the basic libraries, an index builder, and a preliminary index search tool. We have designed a very flexible index, which may include optional columns for calibration parameters, and have implemented and expandable boundary conditions column. We have also implemented a two-level index querying system, with the goal of limiting the hard-coding of calibration-specific parameters in the analysis tools requesting the calibration data. The ultimate goal is to remove mission-specific calibration information from the CalDB calls, to allow for mission- independent analysis software development.

Correcting for the temperature dependence of ACIS charge transfer inefficiency

Catherine Grant, MIT Kavli Institute

The performance degradation of the charge transfer inefficiency (CTI) on ACIS is substantially improved by a correction algorithm included as part of acis_process_events. The behavior of the charge traps that cause CTI, however, are temperature dependent. At some spacecraft orientations and as the radiator surfaces age, ACIS cooling becomes less efficient and the focal plane temperature can increase by a few degrees. This reduces the effectiveness of the correction algorithm. We are developing a temperature-dependent variant of the CTI correction algorithm currently in use. I will present the temperature dependence of ACIS performance, outline the how temperature dependence is included in the algorithm, and demonstrate the performance improvement.

High Resolution Camera Stowed Background Study

Takashi Isobe, CXC/SAO

Michael Juda (CXC/SAO)

The High Resolution Camera detectors are occasionally active while they are in a stowed position. Data taken during these active intervals can used to study HRC backgrounds. Most "events" that HRC sees during the stowed position are cosmic rays which are missed by the anti-coincidence shield, and hence, we can also use the stowed data to study changes in the anti-coincidence shield efficiency.

Ray-tracing the Chandra PSF: Try this at home!

Diab Jerius, CXC

Terry Gaetz (CXC)

Many analyses of Chandra observations are aided by generating synthetic observations of astronomical objects. Such simulations allow one to more easily examine the effects on an observation of observatory effects, as well as to explore spatial and spectral models of sources. The CXC Optics group along with optical and systems engineers at the Smithsonian Astrophysical Observatory has developed a detailed model of the Chandras optics. Most users are familiar with it through the ChaRT web application. Over the last several years the CXC Optics group has been working on making the underlying simulation software (SAOTrace) publicly available. We report here on the recent release of an unsupported version of the software package, made available for the intrepid user. A fully supported version will eventually be made available by the Chandra Data Systems group.

Updated HRC-I Degapping Correction

Michael Juda, CXC/SAO

Event positions within the HRC detectors are determined using a 3-tap algorithm, centroiding on three signals per axis. Due to the loss of information in using only three signals, a correction to the centroids must be made to eliminate gaps which would otherwise appear in images. This degapping correction is applied in standard processing of the HRC data. We recently completed an analysis of the data from a series of on-orbit observations of Capella that were designed to provide improved degapping corrections for the HRC-I. Capella was observed on-axis for forty 5ks pointings but between each observation the Science Instrument Module (SIM) was translated so that the image was placed on a different location along the HRC-I diagonal. The combination of the SIM translations and the spacecraft dither resulted in nearly complete coverage of all HRC-I detector locations along each axis with X-ray events of "known" location. We have used these data to produce an update to the HRC-I degapping corrections. The new corrections provide a major improvement in the CRSU = 12-13 region and smaller improvements elsewhere.

Incorporating Effective Area Uncertainties into Spectral Fitting

Vinay Kashyap, CXC

Hyunsook Lee (SAO), Jeremy Drake (CXC), Pete Ratzlaff (CXC), David van Dyk (UCI), Rima Izem (Harvard)

We have developed a robust and general method to incorporate effective area calibration uncertainties in model fitting of ACIS low-resolution spectra. Because such uncertainties are ignored during spectral fits, the error bars derived for model parameters are generally underestimated. Incorporating them directly into spectral analysis with existing analysis packages such as Sherpa and XSPEC is not possible without extensive case-specific simulations, but it is possible to do so in a generalized manner in a Markov-Chain Monte Carlo (MCMC) framework. We describe our implementation of this method here. We use the estimates of ACIS effective area uncertainties (Drake et al. 2007, SPIE, v6270, p49) in a MCMC setting to estimate the posterior probability distributions of power-law model parameters that include the effects of such uncertainties. We compare our results with those obtained via Monte Carlo simulations (Drake et al. 2005, Chandra Cal Workshop 2005) and discuss the differences and the improvements.

XMM-Newton: ready for the next decade

Marcus Kirsch, ESA/ESAC

ESA's XMM-Newton X-ray observatory has been operating admirably since December 1999 without major incident, providing the X-ray community with data that has lead to a publication rate of more than 1 paper per XMM-Newton orbit. All instruments are in good shape and ready to (rock n) roll long into the next decade, our only limitation being the hydrazine resources. This talk will give a summary, and prediction into the next decade, of the health status and calibration of XMM-Newton. Additionally cross-calibration with other X-ray observatories is discussed.

ACIS Superbias Creation

Beverly LaMarr, MKI

ACIS biases have artifacts due to cosmic ray traces. Often these features are minor, occasionally they are quite striking. The features can be removed by collecting several telemetered biases and creating a superbias. This poster will describe the process and resulting biases.

Updating the Chandra ACIS Contaminant Model

Herman Marshall, MIT Kavli Institute

The spectral model of the contaminant that is building up on the Chandra ACIS detector was based primarily on one high signal/noise observation of Mk 421. This one observation was obtained late in 2002. The time-dependence was modeled using the data from the ACIS external calibration source (ECS) up to mid-2004. Observations with the LETG/ACIS and the ECS over the past few years show that the contaminant model should be updated in order to continue correcting for its absorption at the 5% level.

The Development and Use of a Background Map for the Chandra Source Catalog

Michael McCollough, CXC/SAO

Arnold Rots (CXC/SAO)

Early in the development of the Chandra Source Catalog (CSC) it was recognized that a background map was necessary to perform critical CSC tasks such as source detection, photometry, and source characterization. We present a discussion of how such maps can be created directly from the Chandra data. The background maps for Chandra ACIS data consist of two components. One is a high spatial frequency component due to read-out streaks and the other is a low spatial frequency component. The discussion of the algorithm used for the high frequency maps has been covered in McCollough & Rots (2005). Here we focus on generating the low spatial frequency maps and on combining them with the high frequency ones to produce the final background maps. We present source detection results with and without use of background maps which illustrates the reduction in false source detections. We also discuss how well the background maps describe the "true" background of the Chandra ACIS data and what future development might be necessary. Finally, we turn to generating similar background maps for Chandra HRC data. These are dominated by the low spatial frequency maps for the HRC since this detector does not suffer from the read-out streak problem found in Chandra ACIS data. This work is supported by NASA contract NAS8-03060 (CXC).

HRC-I Gain Correction

Jennifer Posson-Brown, SAO/CXC

Vinay Kashyap (CXC/SAO)

We study the gain variations in the HRC-I over the duration of the Chandra mission. We analyze calibration observations of AR Lac obtained yearly at the nominal aimpoint and at 20 offset locations on the detector. We show that the gain is declining, and that the time dependence of the gain can be modeled generally as a linear decrease in PHAs. We describe the spatial and temporal characteristics of the gain decline and discuss the creation of time-dependent gain correction maps. These maps are used to convert PHAs to PI channels, thereby removing spatial and temporal dependence, and allowing source pulse-height distributions to be compared directly regardless of observation date or location on the detector.

Testing the graded mode CTI correction

Jennifer Posson-Brown, SAO/CXC

Joseph DePasquale (CXC/SAO), Alexey Vikhlinin (CXC/SAO), Paul Plucinsky (CXC/SAO)

We present results from testing the graded mode CTI correction algorithm developed by Alexey Vikhlinin on External Calibration Source (ECS) and E0102-72.3 data from various epochs and on several of the ACIS chips. We compare fits to data CTI corrected with the new algorithm to those of data CTI corrected with acis_process_events. We find that the new algorithm reproduces the results from acis_process_events very well.

Verifying the HRC-I QE and QE Uniformity

Jennifer Posson-Brown, SAO/CXC

Vinay Kashyap (SAO/CXC)

We verify the HRC-I on-axis QE model by comparing count rates from HRC-I and HRC-S observations of G21.5-0.9 and HZ 43 taken at similar times over the past several years. We also compare ACIS and HRC observations of NGC 2516, 3C 273, and Capella. In addition, we use 40 observations of Capella taken with the HRC-I at different SIM offsets spanning the detector to show that the QE uniformity map is accurate to $\sim 1\%$ at the observation locations.

HETG Observations using ACIS in cc-Mode

Norbert Schulz, MIT

Herman L. Marshall (MIT), Dave P. Huenemoerder (MIT)

Most observations of bright X-ray sources with the HETG are now performed using the ACIS cc-mode configuration. There are currently over 50 such observation in the archive covering a large range of fluxes and source locations on the CCD array. We use specific subsets of these observations in order to characterize the ACIS performance in terms of energy response, charge transfer inefficiency, grade distributions, and quantum efficiency in general, but also with respect to changes with time.

Approximate CTI correction for the ACIS graded mode data

Alexey Vikhlinin, SAO

I will discuss an approximate CTI correction algorithm that can be applied to the ACIS graded mode data.

Improved and Time-Dependent HRC-S Gain Map

Brad Wargelin, SAO

Pete Ratzlaff (SAO)

The first HRC-S gain map was completed in 2000, primarily for use in pulse-height filtering of LETG/HRC-S data. Since that time the detector gain, which was mapped on a 1/2-tap grid, has dropped by roughly 15%, mostly within the first year after launch. We describe the development of a new time-dependent gain map derived from analysis of laboratory and flight data using a 1/3-tap grid. The new gain map(s) will form the basis of an improved pulse-height filter which will provide better background reduction with an even smaller loss of valid X-ray events.

Chandra Telescope Optical Axis and Aimpoint

Ping Zhao, SAO

The telescope Optical Axis and Aimpoint are important parameters of the Chandra X-ray Observatory. Monitoring their positions is one of the on-orbit calibration tasks. Every year, raster scans of off-axis observations of a bright point source (HR1099 or AR Lac) were conducted with both HRC-I and HRC-S detectors. The data are used to calculate the Optical Axis and Aimpoint positions, which have been drifting since the Chandra Launch. I will review the drift of these positions and give the reason for the default ACIS target pointing offsets in different time period.

Notes

Notes

Notes