Making the Most of the Great Observatories
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ABSTRACTS

(1) Publicizing the Great Observatories through Multiwavelength Views

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While the scientific community discusses its goals for the rest of the Great Observatories' lifetimes, the News Offices of the respective missions are also considering this. Of course, significant scientific breakthroughs have an inherent news value. However, there are also other opportunities for some of the "softer" results to become valuable tools in communicating the exciting science to the public. This poster shows a sample of previously released, successful joint Great Observatories images. It will also suggest ways that the scientific community can help in identifying, obtaining, and ultimately producing as many future successful products for the public as possible.

(2) IRS Spectra of Solar-Type Stars: A Search for Asteroid Belt Analogs

A. Tanner (JPL), C. Beichman, G. Bryden, S. Lawler & MIPS Team

We report the results of a spectroscopic search for debris disks surrounding 41 nearby solar-type stars, including eight planet-bearing stars, using the Infrared Spectrometer (IRS) on the Spitzer Space Telescope. With the accurate relative photometry of the IRS between 7 and 34 microns we are able to look for excesses as small as $\sim$2% of photospheric levels, with particular sensitivity to weak spectral features. For stars with no excess, the 3 σ upper limit in a band at 30-34 microns corresponds to $\sim$75 times the brightness of our zodiacal dust cloud. Comparable limits at 8.5-13 microns correspond to $\sim$1400 times the brightness of our zodiacal l dust cloud. These limits correspond to material located within the $<$1 to $\sim$5 AU region that, in our solar system, originates predominantly from debris associated with the asteroid belt. We find excess emission longward of $\sim$25 microns from five stars, of which four also show excess emission at 70 microns. This emitting dust must be located in a region starting around 5-10 AU. Only two stars of the five show emission shortward of 25 microns, where spectral features reveal the presence of a population of small, hot dust grains emitting in the 7-20 micron band. One of these stars, HD 72905, is quite young (300 Myr), while the other, HD 69830, is older than 2 Gyr. The data presented here strengthen the results of previous studies to show that excesses at 25 microns and shorter are rare: only 1 out of 40 stars older than 1 Gyr or $\sim$2.5% shows an excess.

(3) One Year of Brown Dwarf Observations with Keck Laser Guide Star

Michael C. Liu (IfA/Hawaii), Dagny Looper (IfA/Hawaii), Sandy K. Leggett (UKIRT/JAC), David Golimowski (JHU), Davy Kirkpatrick (IPAC), Adam Burgasser (MIT), Tom Geballe (Gemini), Xiaohui Fan (Arizona), Neill Reid (STScI) & Kelle Cruz (AMNH)

Laser guide star adaptive optics (LGS AO) on large ground-based telescopes provides a powerful new capability for high angular system, the first such system on an 8-10 meter class telescope. Our goals are to assess the binary frequency of ultracool dwarfs; to search for exceptionally cool low-mass objects; to test substellar atmospheric models with these coeval systems; and to find and monitor substellar binaries suitable for dynamical mass determinations. Drawing on a set of 100 observations of different science targets and/or filters, we summarize the current performance of the Keck LGS system and discuss its strengths and weaknesses in relation to Hubble Space Telescope.

(4) Evaporation of Hot-Jupiters. HST Observations and models

Lecavelier des Etangs A. (IAP), Vidal-Madjar A., Ballester G., Desert J.-M., Ehrenreich D., Ferlet R., Hebrard G.

Among the almost two hundreds extra-solar planets known, over 15% orbit closer than 0.1 AU from their parent star. We present HST observations and corresponding models of the evaporation of these objects.

(5) Observing X-ray Binaries with Great Observatories

S.D. Vrtilek (CfA), J. Neilsen, R. Hickox, B.S. Boroson

Binary X-ray sources are strong emitters over a broad range of the electromagnetic spectrum, with each part of the spectrum contributing distinct and often time-variable information. Because the X-ray flux responds sensitively to geometry, UV emission characterizes phenomena in the majority of the accretion disk and the wind, optical emission dominates the outer disk and the companion star, and infrared and radio observations characterize circumsource material and jets, observations in all wavelengths are needed.

Multiwavelength studies involving one or more Great Observatories have been remarkably effective in increasing our understanding of these systems. A few examples of work by the authors representing a range of X-ray binaries are presented as illustrations. Suggestions for work yet to be done with current instrumentation and some instrumentation needs for the future are listed.

(6) New Views of 30 Doradus

Leisa Townsley (PSU), Bernhard Brandl & You-Hua Chu

We present a composite image of the massive star-forming region 30 Doradus in the LMC, using recent data from Chandra, Spitzer, and the Magellanic Cloud Emission Line Survey.

(7) Chandra/Spitzer Observations of Three Young Stellar Clusters

S. J. Wolk (CfA), T.L. Bourke (CfA), S.T Megeath (University of Toledo), B.D. Spitzbart (CfA) &, E. Winston (CfA)

We review the X-ray aspects of our ongoing Chandra/Spitzer study of regions of star formation. Here we focus on three clusters. NGC281 - one of the most massive clusters within 2.5 kpc, RCW 108 - a more modest O star cluster at a little more than 1 kpc away and NGC 1579 a relatively nearby Be star surrounded by a cluster of lower mass stars. A common thread among these fields is that they are embedded with a minimum of 3 optical magnitudes of extinction.

(8) Great Spectroscopy: The case of Cas A in 3D

D. Dewey (MIT Kavli Institute), T. DeLaney (Harvard University) & J. Lazendic (University of Melbourne)

NASA's trio of Great Observatories each include dispersive, high-resolution spectrometers, with resolving powers above several hundred over much of their wavelength ranges: STIS (Hubble), HETG and LETG (Chandra), and IRS (Spitzer.) These have been used for all types of astronomical objects - probing the details of plasma emission and absorption through individual ions' lines. These spectra also yield line-of-sight velocities through Doppler shifts, adding a third dimension to source modeling.

We present HETG velocity measurements for a set of features in the poster-child source, the supernova remnant Cas A (Lazendic et al. astro-ph/0605078.) These velocities accord with proper-motion results and allow the features to be located in 3D. Using IRS spectra, we have begun to look at "matched knots" seen in the X-ray, Si XIII, and the IR, Ar II. How and why these different temperature plasmas coexist is among the questions we hope to answer.

Since there are other "great" space and ground-based spectrometers (e.g., FUSE, bHROS on Gemini South), astrophysicists will be seeing more of this third dimension and "some will be born spectroscopists, some will achieve spectroscopy, and some will have spectroscopy thrust upon 'em."

(9) The Galactic Super Star Cluster Westerlund 1

M. P. Muno (UCLA), M. R. Morris, J. S. Clark, P. A. Crowther, R. de Grijs, S. M. Dougherty, C. Law, F. Yusef-Zadeh, S. L. W. McMillan, I. Negueruela, D. Pooley, & S. Portegies-Zwart

We present multi-wavelength observations of the massive (50,000 $M_{\odot}$), young (4 Myr) star cluster Westerlund 1. With a supernova rate of one per 10,000 years, the cluster outputs an enormous amount of mechanical energy into the ISM. Using the Chandra X-ray observatory, we have identified one of the remnants of these supernovae, a slow X-ray pulsar. As a member of the star cluster, the progenitor to this neutron star must have had an initial mass of at least 40 Msun. For such a massive star to leave behind a neutron star, as opposed to a black hole, it must have suffered prodigious mass loss as it evolved, or have undergone a particularly violent supernovae. Surprisingly, we find little evidence that this energy is dissipated in the X-ray band, as the diffuse flux from the cluster represents only 10^{-5} of its mechanical luminosity. Spitzer/GLIMPSE images indicate that the material out of which Westerlund 1 was born has been cleared away, so we suggest that the energy escapes our Galaxy relatively unimpeded. These observations, and similar ones of other Galactic star clusters, can serve as the basis for understanding the evolution of larger galactic-scale starbursts.

(10) High Resolution X-ray Absorption Surveys with Chandra and Beyond Observatories

Norbert S. Schulz (MIT), Adrienne Juett & Claude Canizares

X-ray spectroscopy of the interstellar medium (ISM) has been established only recently with the advent of high resolution spectrometers onboard Chandra and XMM-Newton. While it was sufficient for the modeling of low- and medium-resolution spectra to rely on optical constants devoid of atomic substructure, this new generation of spectrometers not only resolve the photoelectric absorption edges and reveal their morphology but also allow to diagnose cool, warm, and hot ISM phases. Distant and bright back-illuminating X-ray sources such as X-ray binaries allow the determination of optical depths of photo-electric absorption edges and the equivalent widths of resonance absorption lines from atoms, ions, and molecules in the ISM. We present results from a survey using Chandra's high resolution transmission grating spectrometer (HETGS). We measure narrow line absorption from $K\alpha$ lines of O I, II, III, Ne II, III, IX, optical depths of O K, Fe L, Ne K edges and determine abundance ratios and ionization fractions for various phases in the ISM. For our interpretations we utilize recent calculations and laboratory measurements of the fine structure of atomic absorption cross-sections. Based on our results so far we lay out strategies for future surveys with Chandra and future observatories.

(11) HST and Spitzer Observations of Extremely Metal-Poor Galaxies

Michael R. Corbin (ASU), David Burstein & Rolf Jansen

We describe ongoing programs of Hubble Space Telescope imaging and Spitzer Space Telescope imaging and spectroscopy of nearby (z ¡ 0.01) extreme ly metal poor (12 + log(O/H) < 7.65) galaxies identified in the Sloan Digital Sky Survey. Our main goal is to determine if these objects represent newly formed (age < 500 Myr) galaxies, or whether they contain a population of evolved stars in addition to their current starbursts. The HST observations are additionally used to determine the objects' morphologies, and the origin of their starbursts, i.e., whether they represent collisions between clumps of stars that are sub-galactic in size and mass. The Spitzer images and spectroscopy are used to establish their dust content as a diagnostic of past star formation, and the form of their mid-IR spectra. We discuss in particular Spitzer and upcoming HST observations of the nearby (∼2 Mpc) extremely metal-poor galaxy CGCG 269-049, as it represents a unique opportunity to study such an object at high spatial resolution, and to directly resolve evolved stars if they are present. Existing observations indicate that all extremely metal-poor galaxies with the possible exception of I Zw 18 contain a significant population of ∼10 Myr old stars, and that their low metallicities derive from the escape of supernova ejecta rather than youth.

(12) A comprehensive study of the SBF method

Cantiello Michele (INAF), Raimondo Gabriella & Brocato Enzo

Recent applications of the SBF have proved that this method is a reliable distance indicator applicable in a wide range of distances, and a promising tool to analyze the stellar content of unresolved stellar systems, in terms of chemical composition, age and - under particular conditions - of the evolutionary status of stars. In this poster we present some theoretical and observational results on both applications of the SBF technique, obtained by the Teramo-Stellar Populations Tools group (Teramo-SPoT). We discuss the results of a study aimed to analyze the relations existing between SBF magnitudes and the properties of stars. The study is carried out by using a stellar populations synthesis code which assumes well defined physical input (stellar tracks, IMF, etc.); similarly, the most reliable scenarios are adopted to properly take into account phenomenon like the mass-loss along Giant Branch stages, the HB morphology, the presence of extremely bright stars experiencing evolutionary characterized by short timescales, etc. Moreover we have developed a pipeline intended to measure SBF magnitudes from CCD images of galaxies. This work has been carried out devoting particular care to the detection of small (<0.2 mag) SBF variations in different regions of the galaxy. The procedure has been applied to ACS images of elliptical galaxies; for all the objects selected we found a clear SBF gradient. Once more these data have been used to perform distance studies of the galaxies selected, or to infer the evolutionary properties of the stellar system present in the galaxy.

(13) Simulations of SBF signal in elliptical galaxies imaged with ACS

Cantiello Michele (INAF) Brocato Enzo, Blakeslee John & Raimondo Gabriella

In this poster we introduce a procedure developed by the Teramo Stellar Populations Tools group (Teramo-SPoT), specifically optimized to obtain realistic simulations of CCD images of elliptical galaxies. The scope of the tool presented here is to improve our understanding of the Surface Brightness Fluctuation (SBF) signal observed in elliptical galaxies by space and ground/based telescopes. Particular attention is devoted to properly simulate the SBF of the galaxy, the Globular Cluster (GC) system, and the distribution of background galaxies. To reproduce a CCD image of an elliptical galaxy we take into accunt several possible assumptions on the telescope & detector system (field of view, zero point magnitude, exposure time, etc.) but also on the physical properties of the elliptical galaxy simulated as far as on the field objects expected in the frame (galaxy distance and brightness profile, luminosity function of GCs and background galaxies, etc.). As an example here we simulate observations with the Advanced Camera for Surveys in the F814W filter for an elliptical galaxy with distance modulus DM=33.

(14) A Multiwavelength Approach Towards Understanding The Environments of Seyfert Galaxies

Dan Evans (Harvard University), Julia Lee (Harvard University), Maria Kamenetska (MIT Kavli Institute for Astrophysics and Space Research), Sarah Gallagher (UCLA), Ralph Kraft (SAO), Martin Hardcastle (University of Hertfordshire) & Kim Weaver (NASA GSFC)

Multiwavelength observations of the circumnuclear environments of Seyfert galaxies with small-scale radio jets are important diagnostics for understanding the interplay between the ionizing radiation from the nucleus, radio ejecta, and galaxy ISM. We present results from Chandra, HST, and VLA observations of the extended circumnuclear emission in the nearby Seyfert 2 galaxy NGC 2110. We detect resolved soft-band X-ray emission 4" (∼160 pc) north of the nucleus, which is spatially coincident with [OIII] emission, but lies just beyond the northern edge of the radio jet in the source. Through energetics arguments, we find that shock-heating of multi-phase gas clouds can successfully account for this extended emission, although we cannot rule out alternative models, such as the scattering of nuclear radiation by ionized material, or pure photoionization from the nucleus. Our results may suggest that different physical processes could produce the extended circumnuclear environments observed in Seyfert galaxies, and highlight the importance of multiwavelength studies with the Great Observatories.

(15) A Legacy View of Radio AGN: the Low-z 3CRR Sample

Dan Evans (Harvard University), Mark Birkinshaw (University of Bristol), Martin Hardcastle (University of Hertfordshire), Diana Worrall (University of Bristol), Ralph Kraft (SAO) & Julia Lee (Harvard University)

Studies of the 3CRR catalogue have defined the observational properties of radio galaxies and put AGN unification models on a secure foundation. Multiwavelength observations of 3CRR sources with Chandra, Spitzer, and HST have already provided a wealth of new physics on the cores, jets, lobes, and environments of radio-loud AGN. The remaining issues, and new questions that have arisen, can only be answered by studying statistically complete samples, but no fully-observed samples exist. We present examples of AGN science from existing Great Observatories observations of 3CRR objects, and then describe a proposal to complete the Chandra and HST observations of low-redshift ($z < 0.1$) 3CRR sources. We will use the new data, in conjunction with existing Spitzer and VLA data, to investigate the processes occurring in radio-loud AGN. The data obtained in this program will be a widely-used legacy of the Great Observatories.

(16) The Potential of Chandra Observations of the COSMOS Field

Martin Elvis (CfA) & the C-COSMOS team

The proposed Chandra-COSMOS survey will provide an unprecedented combination of contiguous area, depth and resolution covering the best studied central square degree of the COSMOS field. COSMOS explores the coupled evolution of galaxies, dark matter halos and AGNs (massive black holes) largely free of cosmic variance. COSMOS is a comprehensive survey including: HST, Subaru, VLT, Magellan, VLA, & GALEX, & potentially EVLA & ALMA. Chandra resolution & sensitivity enables: tracing of LSS with AGN; constraints on BH merger history; secure IDs with faint HST galaxies; X-ray evolution studies of starbursts; detailed structure studies of groups/clusters ;'stacking' for many sub-types of normal galaxies & high-z objects.

(17) Probing AGN at Redshifts > 6 - 7 with Large Multi-Band Surveys

Koekemoer, A. M. (STSCI) Alexander, D. M., Brandt, W. N., Chary, R., Conselice, C., Cristiani, S., Daddi, E., Dickinson, M. E., Elbaz, D. & Grogin, N. A.

The advent of deep, wide multi-wavelength surveys with all three Great Observatories provides unprecedented new opportunities to search for very sources that are detected at X-ray and IR wavelengths but completely undetected at optical wavelengths to very deep limits. I will describe recent work on constructing samples of candidate AGN at or beyond redshifts 6 - 7, such as the 'EXO's (extreme X-ray/optical sources), detected at X-ray wavelengths in surveys such as GOODS and other large on-going extragalactic surveys. Combining the optical flux limits with Spitzer detections enables modelling of the spectral energy distributions to help differentiate intermediate-redshift dusty or evolved interlopers from likely high-redshift sources. The resulting constraints on the number of candidate AGN at redshifts > 6 - 7 are used to examine the evolution of the AGN luminosity function at high redshift, with corresponding implications for the co-evolution of galaxies and their central black holes.

(18) Resolving Extragalactic Radio Sources with the Great Observatories

C.C. Cheung (NRAO and Stanford/KIPAC)

Chandra, Hubble, and Spitzer are shedding new light on a number of outstanding problems in the physics of extragalactic radio sources. In combination with ground-based radio interferometers, the broad-band data have given us insight into the source energetics and degree of balance between the energy in particles and magnetic-field, jet speeds and relativistic beaming on large (kpc)-scales, and relativistic shocks and sites of very high-energy particle acceleration. I will present results a number of recent programs where the contribution from the Great Observatories have been crucial to our interpretation of the source physics, and I will highlight some prospects for future direction in the field.

(19) Using the Three Great Observatories to Measure the Baryon Density in the Warm-Hot Intergalactic Medium

Fabrizio Nicastro (CfA), Smita Mathur, David Weinberg, Martin Elvis & Rik Williams

In this contribution, we show how the coordinated use of the three great observatories, Chandra, HST and Spitzer, can be exploited to unambiguously assess the space distribution (dN/dz) and mass density Ω_b of the Warm-Hot Intergalactic Medium (WHIM) in the local Universe. Recently we demonstrated the existence of the WHIM using Chandra-LETG spectra of one blazar (Mkn421) in outburst. With this established result, long WHIM observations are no longer 'high-risk/high-reward' gambles. Moreover, the observations of the flaring blazar Mkn421 (z=0.03) are just not extendable to other, higher redshift, objects: the sky simply does not contain another blazar that flares to such high fluxes, nor for such extended times. The way forward then for Chandra to explore the WHIM, requires long pointings at moderately bright, but higher-z blazars, whose lines of sight are known to be representative of the predicted WHIM distribution. Combined HST and Spitzer relatively shallow observations of the galaxy-field s surrounding these lines of sight can be then used to correlate WHIM filaments with visible structures, so helping tracing Dark-Matter concentrations in the local Universe. Finally, future COS (and hopefully new-STIS) HST observations, of the same targets, will be combined with the X-ray detections to infer absolute metallicities of the WHIM.

(20) Characterizing the Sources Responsible for Cosmic Reionization

Johan Richard (Caltech) Richard Ellis Daniel Stark Eiichi Egami Jean-Paul Kneib Graham Smith & Michael Santos

Low luminosity galaxies at z¿6 are thought to produce the bulk of the ionizing photons responsible for ending reionization, yet the number density and properties of such galaxies are largely unknown. We report initial results from a survey combining HST/ACS-NICMOS and Spitzer/IRAC observations to identify and characterize gravitationally-magnified

(21) The Stellar Masses of High Redshift Radio Galaxies across 1<z<3

Nick Seymour (SSC), Daniel Stern (JPL/SSC), Carlos De Breuck (ESO) & SHiZRaG collaboration

We present results of a comprehensive Spitzer survey of 70 radio galaxies across $1 < z < 5.2$. Using IRAC, IRS and MIPS imaging we determine the rest-frame AGN contribution to the stellar emission peak at 1.6um. The stellar luminosities are found to be consistent with that of a giant elliptical with a stellar mass of $10^{11-12}\,M_{\odot}$. The mean stellar mass remains constant at $\sim 10^{1}1.5\,M_{\odot}$up to z=3 indicating that the upper end of the mass function is already in place by this redshift. The mid-IR luminosities imply bolometric IR luminosities that would classify all sources as ULIRGs. Chandra observations of a subset of these radio galaxies imply a stellar/black hole mass relationship slightly below the local relation if these AGN have eddington limited accretion rates. There is a legacy-scale 1.5Ms of HST time devoted to these objects to provide detailed morphological information of the host galaxy of the AGN.

(22) The Hard X-ray Modulation Telescope HXMT

Ti-Pei Li , Department of Physics and Center for Astrophysics, Tsinghua University Institute of High Energy Physics, Chinese Academy of Sciences, Beijing

The Hard X-ray Modulation Telescope (HXMT) is a Chinese high-energy astrophysics mission, which has been selected as a project under the Major State Basic Research Program in China for its Phase-A study since 2000 and planed to launch around 2010. With the direct demodulation technique, the HXMT mission can make full-sky survey in the energy range of 2 - 250 keV with angular resolution ¡ 5' and imaging sensitivity ten times better than Integral/IBIS and Swift/BAT to explore more than one thousand obscured AGNs, and make imaging analysis of diffuse hard X-ray sources and large-scale structure of X-ray and hard X-ray background for the first time. High signal-to-noise ratio pointing observations of scientific hot spot sources with sensitivity $\sim 3 \times 10^{-7}$ ph cm-2 s-1 keV-1 for temporal and spectral studies cab be also performed by this mission.

(23) High-Resolution Spectroscopy: *Really* Making the Most of Great Observatories

Kazunori Ishibashi (MIT)

There is no doubt that high spatial-resolution imaging data from the Great Observatories have advanced our understanding of distant cosmic objects. Nifty, cool pictures of stars and galaxies also have made it easier to promote astronomy education. However, when it comes to formulating and testing a physical description on the behavior of an active astrophysical object, imaging data alone would not be sufficient sometimes.

That is when high energy-resolution spectroscopy rules. Combined with high spatial-resolution imaging, scientists can use high energy-resolution spectroscopic data to obtain a wealth of physical information on temperature, chemical composition and dynamic motions of thermal (the Hubble, the Chandra, the RXTE, etc.) are more useful than imaging datasets.

(24) Mid-Infrared Astronomy at the Gemini 8-meter Telescopes

Adwin Boogert, NOAO Gemini Science Center, La Serena, Chile, S.A.

The twin 8-m telescopes of the International Gemini Observatory in Hawaii and Chile give the US community access to state of the art optical/infrared facilities in both hemispheres. With their single, monolithic, silver-coated primary mirrors, the Gemini telescopes offer unprecedented sensitivity at infrared wavelengths. Mid-infrared (7-26um), diffraction-limited (0.4-0.6 arcsec) imaging and spectroscopy is possible with T-ReCS, Michelle, and TEXES. Although surpassed in sensitivity by satellite missions, the spatial and spectral resolutions of these mid-infrared instruments are at least an order of magnitude better than satellites.