2012 SAO Summer Intern Project Abstracts

Evidence Against Baryons Shaping the Matter Distribution in Cluster Cores

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Despite the growing number of galaxy clusters being discovered which exhibit strong gravitational lensing, the process by which the mass density profile of these clusters becomes centrally concentrated enough to produce high strong lensing cross-sections is not well understood. It has been suggested that the baryonic condensation of the intracluster medium (ICM) due to cooling may drag dark matter to the cores and thus steepen the profile. If this were the case, one would expect to observe signatures of strong ICM cooling (e.g., steep X-ray cores, optical emission line nebulae, star formation) in and around the central brightest cluster galaxy. In this work, we search for such evidence of ICM cooling in the first large, well-defined sample of strong lensing selected galaxy clusters in the redshift range $0.1 < z < 0.6$. Based on the known correlations between cooling rate and both optical emission line luminosity and specific star formation, as traced by [OII]3727 emission and the 4000 angstrom break strength, respectively, we measure the fraction of clusters that have cooling signatures in a new sample of hundreds of strong lensing clusters, and compare this result to that in a control sample of thousands of optically-selected galaxy clusters. Our results argue against the ability of baryonic cooling in the cores of galaxy clusters to strongly modify the underlying dark matter potential, leading to an increase in strong lensing cross-sections. This work is supported in part by the NSF REU and DOD ASSURE programs under NSF grant no. 0754568 and by the Smithsonian Institution.

Piercing The Continuum of WISE Selected Blazars

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Blazars are a particularly interesting subclass of active galactic nuclei (AGN) because they show rapid variability over several decades of energy, strong and variable polarization, and a host of relativistic effects including a Doppler-boosted spectrum and relativistic jets with apparent superluminal motion. Our recent work with WISE archival data has revealed the distinct nature of blazar IR colors, showing that WISE detected blazars lie in a unique region of the [3.4] – [4.6] – [12] micron color-color diagram. This region is even more defined when one considers only gamma ray detected blazars. We investigate the physical mechanisms behind these diagnostics by examining archival spectroscopic data for a selection of WISE detected blazars that have also been observed by Spitzer-IRS. Our analysis focuses on a subsample of 18 blazars that display no prominent line or dust features in the infrared. We present our attempts to accurately model the continuum of these objects. The removal of this continuum reveals the presence of potential silicate or other dust emission features around 10 microns. We comment on the validity of these features and their potential as a diagnostic of host galaxy properties. This work is supported in part by the NSF REU and DOD ASSURE programs under NSF grant no. 0754568 and by the Smithsonian Institution.

New Star Formation Rate Estimates for the Star Formation Reference Survey Using Herschel/ PACS and SPIRE

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We evaluated the potential of new FIR photometry collected by the Herschel Space Observatory to improve star formation rate (SFR) estimates in 87 nearby galaxies that previously only had IRAS photometry. We obtained 70 – 500 micron photometry from Herschel PACS and SPIRE, added it to our existing GALEX/SDSS/2MASS/IRAC/MIPS database, and modeled the resulting spectral energy distributions with MagPhys. The Herschel/PACS 100 micron photometry is systematically lower than the IRAS 100 micron photometry by about 20%, but the IRAS and PACS measurements are otherwise consistent. We calculated the global SFRs, dust masses, dust luminosities, and stellar masses for each Herschel-observed galaxy in our sample. Based on the MagPhys modeling, we found that the total modeled SFRs are significantly lower than previously inferred from IRAS alone and that at least some of the difference is attributable to a portion of the FIR emission being excited by a quiescent stellar population. This work is supported in part by the NSF REU and DOD ASSURE programs under NSF grant no. 0754568 and by the Smithsonian Institution.

Properties of High-Redshift Quasars

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We present results from a study of a sample of 144 SDSS quasars with measured black hole masses. The sample consists of 84 high-redshift ($z > 2.5$) radio-loud quasars with black hole masses derived from CIV line widths, and 60 low-redshift quasars ($1.5 < z < 2.2$) with mass measurements based on the FWHM of both the Balmer and CIV lines. We applied a power law model to the baseline continuum to derive the spectral index and the luminosity at 2500 A. Using a standard accretion disk model, we derived the maximum disk temperature, the mass of the central black hole, the mass accretion rate, the disk luminosity, and the Eddington luminosity ratio. We found that quasars in the high redshift sample had slightly lower black hole masses ($\log(M/M_{\odot}) = 8.3$ to 9.4) compared to the low redshift sample ($\log(M/M_{\odot} = 8.6$ to 9.5). The range of accretion disk temperatures in the high-redshift quasars extended toward higher values than in the low redshift sample (2×10^4 K to 10^5 K versus 2×10^4 K to 7×10^4 K, respectively). The high redshift sample was characterized by a median Eddington luminosity ratio of 0.2 as opposed to 0.1 for the low redshift sample, confirming that quasars were growing more rapidly in the early universe. We found the precision of the black hole mass estimation method based on the standard accretion disk model to be comparable to that relying on the properties of the CIV line. In the future, our mass measurement method could be applied to the photometric data of SDSS quasars that lack spectroscopic information. This work is supported in part by the NSF REU and DOD ASSURE programs under NSF grant no. 0754568, by NASA contract NAS8-39073, and by the Smithsonian Institution.

Discovery of the Ultraluminous Type IIn Supernova PS1-11vo

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We report the discovery by the Panoramic Survey Telescope and Rapid Response System 1 (Pan-STARRS1 or PS1) of PS1-11vo, a Type IIn supernova (SN) at $z = 0.116$ with a peak r-band absolute magnitude of M = –20.4. We also present optical spectroscopic observations from theApache Point Observatory Echelle Spectrograph, the Gemini Multi-Object Spectrograph, and the MMT Blue Channel Spectrograph over a period of roughly one year after detection. PS1-11vo is one of the longest lived, most luminous supernovae (SNe) ever discovered and the highest quality SN IIn documented by Pan-STARRS1. The Pan-STARRS1 photometric observations indicate maximum was reached roughly 50 days after the time of explosion, during which the SN rose by approximately 5 mag. Spectra of PS1-11vo display a prominent hydrogen alpha emission line and P Cygni profile, typical of SNe IIn. We compare the photometric and spectroscopic observations of PS1-11vo to those of other SNe II, including several recent ultraluminous SNe IIn. Finally, we examine its spectral energy distribution to model various parameters of the SN and its host environment at 5 days past maximum, estimating a peak luminosity of $L = 4.5 \times 10^{43}$ ergs s^{-1} and an initial Nickel-56 mass of $4.5 M_{\odot}$. This work is supported in part by the NSF REU and DOD ASSURE programs under NSF grant no. 0754568 and by the Smithsonian Institution.

Exploration of Infrared Variability of Young Disks in Taurus and Chamaeleon

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Variability at mid-infrared wavelengths is known to be a feature of Class II young stellar objects (YSOs). In this study, we characterize the variability of previously identified Class II YSOs in the Taurus and Chamaeleon star forming regions, including new data from the Wide Field Infrared Survey Explorer (WISE) in addition to data gathered by the Spitzer Space Telescope Infrared Array Camera (IRAC), Infrared Spectrometer (IRS), and Multiband Imaging Photometer (MIPS). We compiled data on 161 Class II YSOs in Taurus and 70 Class II YSOs in Chamaeleon. We compared IRAC and MIPS data to WISE data and detected variability in the YSOs in the two study regions. In general, we found a tendency towards disks with gaps and holes displaying different variability than full disks. We link these differences in variability between full and transitional/pre-transitional disks to their distinct disk structures. This work is supported in part by the NSF REU and DOD ASSURE programs under NSF grant no. 0754568 and by the Smithsonian Institution.

The Hunt for Recoiling Black Holes: Sifting through COSMOS Data

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With the exception of the Bonning et al. (2008) systematic search in SDSS for recoiling supermassive black holes (SMBHs), which produced a null result, recoiling SMBHs have only been detected and studied on an individual basis. The COSMOS survey, including cornerstone data from the HST's Advanced Camera for Surveys, provides the unique opportunity to perform a comprehensive search for candidate recoiling SMBHs through the identification of their optical signature (a bright point source offset from the galactic center). Using Galfit,we perform a surface brightness decomposition analysis of 4835 galaxies selected with i magnitudes $18.3 \leq i \leq 21.5$, and redshifts $0.2 < z < 0.5$ to isolate candidate recoiling SMBHs. We model the galaxies with a combination of Sersic profiles plus an unresolved component to reproduce the nuclear light, and we measure the separation between the peaks of the different components. We find 14 (0.29%) and 4 (0.08%) sources with separation larger than 3 and 5σ, respectively, with respect to the overall distribution. This work is supported in part by the NSF REU and DOD ASSURE programs under NSF grant no. 0754568 and by the Smithsonian Institution.

Understanding Mass Segregation in Star Forming Regions

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There is currently much debate over whether clusters found in star forming regions are born mass-segregated or if the segregation is a result of dynamic evolution in the first few million years. We examine this question using minimal spanning trees to analyze simulations of molecular clouds forming stars. Mass segregation occurs when the most massive stars are preferentially located near the cluster center. To determine whether mass segregation occurs, we employ minimal spanning trees to establish distances between cluster members and characterize the mass distribution. Our analysis shows that the most massive young stellar objects are near the cluster centers, and investigating this mass segregation over time reveals that the massive stars form near the center rather than migrating there. We demonstrate that mass segregation is primordial because the most massive young stellar object (YSO) remains closer to the cluster center compared to the median mass member. This work is supported in part by the NSF REU and DOD ASSURE programs under NSF grant no. 0754568 and by the Smithsonian Institution.

Blowing Bubbles in the Intracluster Medium: The Growth and Evolution of Radio Lobes from Active Galactic Nuclei

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Observations from Chandra have allowed detailed analyses of cavities created by radio lobes in the X-ray emission of galaxy clusters. These lobes are thought to heat galaxy clusters and provide a solution to the cooling flow problem, but their impacts integrated over time are not known. We provide a simple model for the evolution of a radio lobe in a cluster atmosphere. The motion of a lobe is determined by its pressure and the pressure and density of the surrounding atmosphere. The model assumes the lobe is made up of three components: electrons, a magnetic field, and non-radiating particles. These three components evolve due to inputs from the jet, changing external pressure, and radiative losses. The synchrotron spectrum of the lobe is computed from the electron distribution and magnetic field strength. We chose to model the sources 2A 0335+096, A2052, A2199, A478, and A4059 with data from Birzan et al. (2008). Our simple model is able to match observed radio fluxes at frequencies 327, 1400, 4500, and 8500 MHz. Although the simple model works well, the number of free parameters and the lack of data limits how well we can constrain the properties of these systems. Using lower frequency radio data and a more complete physical model will enable better measurements of the impacts of distant radio galaxies on their cluster hosts in the future. This work is supported in part by the NSF REU and DOD ASSURE programs under NSF grant no. 0754568 and by the Smithsonian Institution.

Variability of Massive Young Stellar Objects in Cygnus-X

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Young stellar objects (YSOs) are stars in the process of formation. Several recent investigations have shown a high rate of photometric variability in YSOs at near- and mid-infrared wavelengths. Theoretical models for the formation of massive stars ($1-10\,M_\odot$) remain highly idealized, and little is known about the mechanisms that produce the variability. An ongoing *Spitzer Space Telescope* program is studying massive star formation in the Cygnus-X region. In conjunction with the *Spitzer* observations, we have conducted a ground-based near-infrared observing program of the Cygnus-X DR21 field using PAIRITEL, the automated infrared telescope at Whipple Observatory. Using the Stetson index for variability, we identified variable objects and a number of variable YSOs in our time-series PAIRITEL data of DR21. We have searched for periodicity among our variable objects using the Lomb-Scargle algorithm, and identified periodic variable objects with an average period of 8.07 days. Characterization of these variable and periodic objects will help constrain models of star formation present. This work is supported in part by the NSF REU and DOD ASSURE programs under NSF grant no. 0754568 and by the Smithsonian Institution.