First Name: Aaron
Last Name: Barth & the LAMP2011 collaboration
Title: The Lick AGN Monitoring Project 2011: First Results
Abstract: The Lick AGN Monitoring Project 2011 observing campaign was carried out over the course of 11 weeks in Spring 2011. We targeted a sample of low-redshift Seyfert 1 galaxies, with the goal of measuring new reverberation lags and obtaining velocity-resolved reverberation data in order to constrain the kinematics of gas in the broad-line region. Spectroscopic observations were carried out at the Lick Shane 3-meter telescope, and nightly imaging observations were done using several queue-scheduled and robotic telescopes. In this poster we will present some initial results from our observing campaign.

First Name: Laura
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Affiliation: Harvard-Smithsonian Center for Astrophysics
Title: Connecting SMBH Binaries and Double-peaked Narrow-Line AGN in Galaxy Merger Simulations
Abstract: Supermassive black hole (SMBH) binaries must be common through the history of the Universe, according to the hierarchical-growth paradigm. Nonetheless, evidence for SMBH binaries has been scarce until recently, with only a few resolved pairs known. Recent observations have greatly improved this situation via spectroscopic identification of candidate SMBH binaries, indicating that about 1% of active galactic nuclei (AGN) have double-peaked narrow [OIII] lines, which may arise from SMBH orbital motion on kiloparsec scales. Follow- up imaging already reveals strong evidence that some of these are in fact binary SMBHs. On the theoretical side, however, much work remains to be done in constraining the parameter space of kiloparsec-scale binaries. Simulations of galaxy mergers have not considered the narrow-line (NL) region, and detailed photoionization models have not been applied to the rapidly-varying environment of a late-stage galaxy merger. We make a first attempt to model the dynamics and emission from the NL region in hydrodynamic simulations of galaxy mergers. We use a semianalytic prescription for the narrow H-beta emission based on the gas parameters and ionizing photon flux from the AGN. From this we construct line profiles for arbitrary sight lines at each stage of the merger and determine the fraction of time spent in double-peaked NL phases. We find that double-peaked NLs induced by binary motion are a fairly generic but short-lived feature of major mergers, indicating that most comparable-mass SMBH binaries should pass through this phase, if only briefly. We also demonstrate that double-peaked spectral features owing purely to gas kinematics can arise even when the BHs are widely separated, and we discuss possible means of distinguishing these from the true binaries. Additionally, we explore the dependence of double-peaked NL activity on merging galaxy parameters such as mass ratio and gas content, in the context of determining which mergers are most likely to produce observable double-peaked NLs.

First Name: Todd
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Title: A Large Systematic Search for Recoiling and Close Supermassive Binary Black Holes

Abstract: I report preliminary results from a systematic search for close supermassive black hole binaries among z<0.7 quasars observed spectroscopically in the SDSS. The sample comprises 88 candidates in which the broad H-beta emission line is displaced from the rest-frame of the quasar by more than 1000 km/s. Second epoch, and in some cases, third epoch, spectra have been obtained to search for changes in the line peak that would indicate accelerations consistent with orbital motion. Statistically significant changes are seen in 14 objects within the sample. I will discuss the characteristics of the line profiles of these objects, the nature of the changes in velocity, and the statistical implications of the results for predictions of the density of such objects.

First Name: Francesca
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Affiliation: Harvard Smithsonian Center for Astrophysics
Title : What Happens after Black Holes Merge? Multiwavelength Properties of a Candidate GW Recoiling SMBH
Abstract: We present the peculiar properties of the Chandra-COSMOS AGN CID-42 (z=0.359, Civano et al. 2010ApJ, 717, 209), which combine to support the interpretation as a SMBH kicked from the center of the galaxy by the asymmetric emission of gravitational waves by merging black holes, following a major merger by their hosts.
In CID-42 we observe:
1) Two optical sources in a common envelope are clearly seen in the COSMOS HST image, one central and one offset by about 2.45 kpc (projected). New HST STIS spectra of the two optical nuclei, and results will be presented.
2) New Chandra HRC imaging, with its unprecedented resolution, unambiguously associates the X-ray emission with just one of the two optical sources: the offset active 'nucleus'.
2) A high velocity (1100 km/s) offset, between the broad and narrow components of the H-beta line is measured in independent VLT, Magellan and Keck optical spectra. The velocity offset is too high to be due to a ongoing merger.
3) An unprecedented redshifted, variable energy, X-ray absorption line, plus an emission line forming an inverted P-Cygni profile, are observed in the X- rays at ~6 keV. A high velocity (v~0.02-0.14c) infall of gas at the innermost region (~15Rs) of the accreting SMBH seems to be required. New XMM-Newton spectra are in hand that will define this feature far better.
Our simulations suggest that the SMBH in CID-42 is most likely a gravitation wave recoil objects, caught while still active at a substantial distance from the center of the galaxy, ~10^6 yrs after the kick.

First Name: Drew
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Title: Probing Intermediate Mass Black Holes with White Dwarf Tidal Disruptions
Abstract: White dwarf tidal disruptions provide an opportunity to investigate the demographics at the low mass end of the massive black hole mass function. Because white dwarfs are only disrupted outside of the event horizons of black holes with masses less than a few times 10^5 solar masses, the luminous flare produced as a result of the tidal disruption serves as a signpost

for moderately massive black holes. To facilitate the identification and analysis of such events, we have carried out a theoretical study of the tidal disruption of white dwarfs on bound and unbound orbits with black holes. In the unbound case we use an analytic model for the dynamical evolution of the stream of unbound debris and synthesize the emission-line spectrum and emission-line profiles produced when the stream is photoionized by the accretion flare. We model the dynamics of the bound case using SPH simulations and find that all of the debris settles into a dense accretion disk around the black hole. Our models suggest that current and proposed optical transient surveys will detect white dwarf tidal disruptions and that white dwarf tidal disruption flares can be distinguished from other bright transients through spectroscopic follow up. However, we find that it will be difficult to extract unambiguous values for the physical properties of the system (e.g., the black hole mass or spin) from these observations.

First Name: Julia
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Title: A Systematic Approach to Identifying Dual Supermassive Black Holes
Abstract: Dual supermassive black holes (SMBHs) with kpc-scale separations are an expected consequence of galaxy mergers, yet surprisingly few dual SMBHs have been observed to date. I will outline new observational techniques for identifying dual SMBHs that utilize a combination of large spectroscopic surveys of galaxies, longslit spectroscopy, and X-ray and radio imaging. I will also present the resultant dual SMBHs that have been discovered with these methods. These systematic searches will enable us, for the first time, to assemble a large observational catalog of dual SMBHs, which will provide observational constraints on the galaxy merger rate, SMBH growth, and SMBH coalescence.

First Name: Robert
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Affiliation: UC Santa Cruz
Title: First Passage Quasars: How common are they and what can they teach us?
Abstract: Theoretical predictions suggest that galaxy interactions may play a key role in triggering quasars. During a merger, there are two clear stages where AGN activity is enhanced: after first passage and during final coalescence. Quasars triggered as the result of the first passage of a galaxy merger can be identified by the presence of a companion galaxy with separations between ~30-80 kpc. Through systematic study of the SDSS, we find an excess of companion galaxies to quasars relative to a background control sample. Comparisons with cosmological simulations and individual galaxy merger simulations allow us to then interpret that excess as a fraction of quasars triggered during first passage. Typically these companion galaxies are not in a quasar phase. Thus, these quasars allow detailed study of both their host galaxies and their companion galaxies to understand why one is undergoing high levels of AGN activity and the other is not.

First Name: Roberto
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Title: Prediction of Observational Signatures

First Name: Colin
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Title: Title: Black Hole Halo Occupation Distribution
Abstract: Using hydrodynamic cosmological simulations that directly follow black hole growth we investigate the halo occupation distribution (HOD) of black holes. Similar to the HOD of galaxies/subhalos, we find that the black hole occupation number can be described by the power law N_BH proportional to 1+(M_Host)^a where a evolves mildly with redshift, indicating that a given mass halo at low redshift tends to host fewer BHs than at high redshift (as expected as a result of galaxy and BH mergers). We further show how to divide the occupation number into contributions from black holes residing in central and satellite galaxies within the halo, finding most BHs within a halo are found in satellite galaxies at high redshift and in the central galaxy at low redshift. The distribution of black holes masses and luminosities within halos tends to consist of a single massive, bright BH (distributed about a peak mass strongly correlated with the host mass), and a collection of relatively low- mass secondary BHs with weaker correlation to host mass. We examine the spatial distribution of black holes within their host halos, and find they typically follow a power-law radial distribution that is much more centrally concentrated than the subhalo distribution. We further show that black hole feedback becomes increasingly important at low redshifts, which can lead to suppression of the central quasar luminosity and increased scatter in the correlation between quasar luminosity and host halo mass. Overall, this HOD formalism provides the most complete tool for characterizing the distribution of black holes within host halos and galaxies, and can be used in semi-analytic and theoretical models and as a framework for interpreting observational black hole measurements.

First Name: Andres
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Title: MBHs Evolution in Circumbinary Discs: Gap Formation.
Abstract: The evolution of massive black hole binaries in circumbinarydisks has been so far studied in two limiting case: gas rich(Mdisk >> MBH; Escala et al 2004, 2005; Dotti et al 2006, 2007) and gas poor cases (Mdisk << MBH; Artymowicz and Lubow 1996; Gould and Rix 2000; Cuadraet al 2009). In the first case, an ellipsoidal envelope is formedwhich lags behind the binary and transport angular momentum to largerscales that guarantees short coalescence timescales (Escala et al.2004). On the other hand in the gas poor case, a circumbinary gap isformed and the coalescence timescales are considerably longer such itcan even longer than the Hubble time in many cases (Cuadra et al 2009).Therefore, it is crucial to know under which conditions a gap will be opened in order to determine the final evolution of the binary and possible merging. In thistalk, I will discuss analytical estimates and preliminary numerical resultsfor gap opening criteria.

First Name: Martin
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Affiliation: Universidad de Valparaíso, CHile
Title: "The Nature and Origin of the Black Hole/Bulge M-L and M- sigma Relationships"
Abstract: The structure and kinematics of AGN broad-line regions (BLRs) are now well understood and the BLR can confidently be used to determine black hole masses. This shows that there is a strong decrease in the scatter in the relationship between black hole mass and bulge luminosity with increasing luminosity and that there is very little scatter for the most luminous galaxies. It is argued that this is a natural consequence of the substantial initial dispersion in the ratio of black hole mass to total stellar mass and of subsequent galaxy growth through hierarchical mergers. An important conclusion is that 'fine-tuning' through feedback between black hole growth and bulge growth seems neither necessary nor desirable.

First Name: Jenny
Last Name: Greene
Email :
Affiliation: UT Astronomy Dept
Title: Low-mass black holes in AGN
Abstract:I will discuss our ongoing efforts to use actively accreting black holes to understand black hole demographics at the low-mass end.

First Name: Javiera
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Title: Massive Black Hole Recoil in Galaxy Mergers
Abstract: The ringdown and coalescence of black hole binaries produces a strong gravitational wave signal. Asymmetries in this emission, caused by dissimilar black hole masses or spins, can produce a beamed gravitational wave discharge, which carries away linear momentum. As a consequence, the remnant black hole recoils with a velocity ranging from $10 < v < 4000$ km/s. Large recoil velocities may have significant consequences in the co-evolution of galaxies and their central massive black holes (MBH). In cases where the recoil velocity is lower than the escape speed, the MBH will undergo damped oscillations and eventually return back to the center of the potential. In this talk, I will present the result of simulations aimed at studying the effects and detectability of recoiling MBHs as offset AGN and will review the implications of recoiling MBHs in the context of hierarchical structure formation.

First Name: Kayhan
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Title: Scaling relations and their possible evolution.

First Name: Kimitake
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Affiliation: Department of Astronomy, Kyoto University
Title: "A Road to Supermassive Black Hole Merger"
Abstract: "Hierarchical structure formation hypothesis inevitably leads to the formation of binary massive black holes on a subparsec scale in merged galactic nuclei. However, to date there has been no unambiguous detection of such systems. The talk is divided into three parts: First, the evolution of binary massive black holes is described based on triple disk model, which consists of an accretion disk around each black hole and a circumbinary disk surrounding them. Next, the mass function of binary massive black holes in active galactic nuclei is discussed based on the binary black hole evolution. Finally, characteristic signals from such the binary black-hole system are studied by Smoothed Particle Hydrodynamics simulations. The detectability with Monitor of All-sky X-ray Image and/or Swift/Burst Alert Telescope is also briefly discussed." (References:arXiv:astro-ph/0609144, arXiv:0708.2555, arXiv:0805.3408, arXiv:1001.3612)

First Name: Yanfei
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Title: The Host Galaxies of Low-Mass Black Holes
Abstract: Using HST observations of 147 host galaxies of low-mass black holes (BHs), we systematically study the structures and scaling relations of these active galaxies. Our sample is selected to have central BHs with virial masses ~10^5-10^6 solar mass. Bulges of the host galaxies have I-band magnitudes of -23<M_I<-16. Detailed bulge-disk-bar decompositions with GALFIT show that 93% of the galaxies have extended disks, 39% have bars and 5% have no bulges at all at the limits of our observations. Based on the S'ersic index and bulge-to-total ratio, we conclude that the majority of the galaxies with disks are likely to contain pseudobulges and very few of these low-mass BHs live in classical bulges. Consistent with this conclusion, the galaxies form a new sequence in the fundamental plane, especially in the Faber-Jackson relation where they have smaller velocity dispersions at fixed luminosity. The galaxies without disks are structurally more similar to spheroidals than to classical bulges according to their positions in the Fundamental Plane. Overall, we suggest that BHs with mass < 10^6 solar mass live in galaxies that have evolved secularly over the majority of their history.

First Name: Michael
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Affiliation: University of Maryland, University of Hawaii
Title: The Frequency of Dual AGN (1-30 kpc) in the Low Redshift Universe (z<0.05)
Abstract: If galaxy mergers are the prime way to ignite the central source by sending a large amount of gas into the center region and triggering the AGN, then we expect some fraction of these dual black holes to be actively growing simultaneously as a dual AGN. While optical emission line diagnostics provide the easiest way to identify dual AGN, they suffer from selection effects because of fiber collision limits and a bias against merging AGN, and are best

used in combination with hard X-ray observations. We report on the frequency of multiple accreting nuclei in the low redshift Universe using an ultra hard X-ray selected sample of AGN from Swift and high spatial resolution observations from Chandra.

First Name: Julian
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Affiliation: Johns Hopkins University
Title: Binary Black Holes Embedded in Disks: Torques, Accretion, and Coupled Evolution
Abstract: Most previous accounts of the interaction between binary black holes and surrounding gas have assumed the alpha-model for internal stresses and that the only interaction between the black holes and the gas is gravitational. New MHD simulations of a cold circumbinary disk demonstrate that the former assumption substantially underestimates both the net torque exerted by the binary on circumbinary matter and the accretion rate. These simulations also show that such disks should be strongly asymmetric. If at least one of the black holes accretes at a significant rate, the luminosity generated can substantially alter the structure of the surrounding gas, significantly affecting both the expressed torque and the net gas flows.

First Name: Pablo
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Affiliation: Georgia Tech
Title: General Relativistic Mergers of Supermassive Black Holes in Astrophysical Environments
Abstract: Modeling the late inspiral and merger of supermassive black holes is central to understanding accretion processes and the conditions under which electromagnetic emission accompanies gravitational waves. I will discuss results from fully general relativistic, hydrodynamics simulations to investigate how electromagnetic signatures correlate with black hole spins, mass ratios, and the gaseous environment in this final phase of binary evolution. In all scenarios, the study shows some form of characteristic electromagnetic variability whose pattern depends on the spins and binary mass ratios. Binaries in hot accretion flows exhibit a flare followed by a sudden drop in luminosity associated with the plunge and merger, as well as quasi-periodic oscillations correlated with the gravitational waves during the inspiral. Conversely, circumbinary disk systems are characterized by a low luminosity of variable emission, suggesting challenging prospects for their detection.

First Name: Tod
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Affiliation: NOAO
Title: The High-Mass End of the M-L and M-sigma Relationships

Abstract: Stellar velocity dispersion increases very slowly with increasing galaxy luminosity for the most massive elliptical galaxies, which means that the M-sigma and M-L relationships predict conflicting black hole masses in this domain. Since the most massive galaxies are likely to be created by "dry" mergers, in which sigma does not change over the merger, it is likely that

galaxy luminosity is the better predictor of black hole mass and in BCGs and other bright ellipticals. I will review the status of black hole mass determinations in these systems.

First Name: Youjun
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Affiliation: National Astronomical Observatory of China
Title: Constraints on the QSO lifetime and massive black hole growth from the QSO proximity effect
Abstract: The proximity effect (PE) of QSOs is believed to be useful in constraining the QSO lifetime. In this talk, I will first overview the current status of the observations on the QSO PE, including both the line of sight PE and the transverse PE; then report some new results on using the PE to constrain the QSO lifetime and other QSO properties, i.e., the observations on the QSO PE are consistent with the QSO lifetime of being larger than a few 10^7~yr (comparable to the Salpeter timescale).These results suggest that massive black holes may obtain most of their mass through continuous accretion rather than chaotic episodic accretion occurred on a much shorter timescale.

First Name: Smita
Last Name: Mathur
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Affiliation: The Ohio State University
Title: Title: An alternative track for black hole--galaxy co- evolution
Abstract: The current paradigm of black hole--galaxy co-evolution is driven in part by theoretical models of hierarchical galaxy formation. The observed correlations between BH mass and bulge properties of host galaxies are naturally explained by these merger-driven models. I will discuss recent observational results that question all aspects of the current paradigm. These observations demand that we critically examine the current paradigm of BH--galaxy co-evolution. Were we wrong in interpreting observed correlations as causal relations? We do observe massive, inactive BHs in elliptical galaxies, and they most likely formed through merger-driven hierarchical growth. However, is that the whole story? Is it even a dominant story?Perhaps the most pressing reason to argue for an alternative track of BH formation and growth is the prevalence of pseudo-bulges hosting BHs. I will present our recent work on host galaxies of AGNs and argue for a secular track of BH--galaxy co-evolution.

First Name: Nicholas
Last Name: McConnell
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Title: Environmental dependence of black hole growth and stellar assembly in massive galaxies
Abstract: We present new measurements of black hole masses (M) in brightest cluster galaxies (BCGs), from integral-field observations of stellar kinematics. Whereas non-BCG early-type galaxies exhibit a tight relationship between black hole mass and stellar velocity dispersion, black hole masses in BCGs have high scatter. The "downsizing" of quasars over cosmic time indicates that the 10^9 - 10^10 solar-mass black holes found in present-day BCGs have grown little since z ~ 1. Was an earlier M-sigma correlation erased by stochastic size evolution in

BCGs? Or were the processes that shaped the non-BCG M-sigma relationship suppressed deep within galaxy cluster potentials at early cosmic times?

First Name: Rosalie
Last Name: McGurk
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Affiliation: UC Santa Cruz
Title: Spatially Resolved Spectroscopy of J095+2552: a confirmed Dual AGN
Abstract: When galaxies merge, their central supermassive black holes most likely merge and grow as well. Thus one expects to see the signatures of dual black holes in at least some galaxy mergers. Using spectroscopic surveys such as SDSS, candidates for galaxies containing two active black holes have been identified by the presence of double-peaked narrow [O III] emission lines. With the Keck 2 Laser Guide Star (LGS) Adaptive Optics (AO) system and the NIRC2 camera, we obtained high spatial resolution near-infrared images of spectroscopically-identified candidate galaxies that may contain two supermassive black holes. In our sample of 12 dual-AGN candidates to date, approximately half are in close mergers, have close companion galaxies, and/or show clearly disturbed morphologies. However, spatially resolved spectroscopy is needed to confirm these galaxy pairs as systems with spatially-separated double AGN. With the Keck 2 LGS AO system and the OSIRIS Near-IR Integral Field Spectrograph, we obtained spatially resolved spectra for J0952+2552, a system shown by our imaging to consist of a galaxy and its close (1.0") companion. The main galaxy is a Type 1 AGN with both broad and narrow emission lines in its spectrum, while the companion galaxy is a Type 2 AGN with narrow emission lines only. The two AGN are separated by 4.8 kpc, and their redshifts (0.3381 and 0.3397) correspond to those of the double peaks of the [O III] emission line seen in SDSS (0.3380 and 0.3399). Additional line diagnostics from SDSS indicate that both velocity components come from AGN ionization. We discuss the implications of our observations for the fueling of merging supermassive black holes, as well as for the relationship between AGN activity and major mergers.

First Name: Brendan
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Affiliation: University of Michigan
Title: The influence of large-scale environment upon BH growth and feedback in early-type galaxiesAbstract: We make use of the AMUSE-Virgo and AMUSE-Field surveys for nuclear X-ray emission in early-type galaxies to compare supermassive black hole activity within cluster and field spheroids. After accounting for the influence of host galaxy stellar mass, we find that field early-type galaxies may have marginally greater nuclear X-ray luminosities, at a given black hole mass, than their cluster counterparts. This tendency is consistent with the field black holes having access to a greater reservoir of fuel, presumably in the form of cold gas located near the nucleus. We are able to rule out with high confidence the alternative of enhanced X-ray activity within cluster spheroids. This suggests that low-level AGN feedback is not generally stronger (intra-host) within clusters than in the field, indicating that for most cluster early-type galaxies direct environmental effects (such as stripping) must play a more relevant role in quenching star formation.

First Name: Edward
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Title: Black Holes at the Centers of Nearby Dwarf Galaxies
Abstract: An accurate census of intermediate-mass black holes in nearby dwarf galaxies is needed to constrain models for the co-evolution of black holes and their host galaxies and to provide insight into the mechanism by which black hole "seeds" formed at earlier epochs. The highlights of an extensive emission-line survey aimed at providing this census will be presented: (1) the ranges of nuclear luminosities and host-galaxy stellar masses of confirmed AGNs; (2) follow-up observations designed to improve completeness of the survey; and (3) a preliminary assessment of the AGN fraction versus host-galaxy luminosity and stellar mass.

First Name: Richard
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Title: Blindly Detecting Orbital modulations of jets from merging Supermassive Black Holes
Abstract: In the last few years before merger, supermassive black hole binaries will rapidly spiral and precess through a magnetic field imposed by a surrounding circumbinary disk. Simulations suggest this relative motion will convert someof the local energy to a Poynting-dominated outflow, some of which may emerge as synchrotron emission at frequencies near 1\,GHz where current and plannedwide-field radio surveys will operate. Though this emission produces a distinctive flare at merger, the shorttimescales of many mergers will limit their detectability with most planned surveys to <1 per year over the whole sky, independent ofthe details of the emission process and flux distribution. However, orbital motion can produce detectable modulations, both on orbital periods and (if black hole spins arenot aligned with the binary's total angular momenta) spin-orbit precession timescales. We suggestthat radio surveys may be able to detect the weaker emission produced by the binary's motion as it is modulated by spin-orbit precession and inspiral well in advance of merger.

First Name: Miguel
Last Name: Preto
Email :
Affiliation:
Title: The Role of Stellar Dynamics in Bringing SMBH Together

First Name: Amy
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Affiliation: NRAO
Title: A Supermassive Black Hole in the Dwarf Starburst Galaxy Henize 2-10
Abstract: Supermassive black holes are now thought to inhabit essentially every modern galaxy with a bulge. However, the birth and growth of the first "seed" black holes, back in the earlier universe, is poorly constrained. Reines et al. (2011) have recently identified a million-solar mass black hole in the vigorously star-forming, bulgeless dwarf galaxy Henize 2-10. This

serendipitous discovery offers the first opportunity to study a growing black hole in a nearby galaxy much like those in the earlier universe, and opens up an entirely new class of host galaxies in which to search for local analogues of primordial black hole growth. Moreover, this finding has important implications for our understanding of the co-evolution of galaxies and their central black holes. In particular, the lack of a discernible bulge in Henize 2-10 indicates that black hole growth can precede the build-up of galaxy spheroids.

First Name: Kevin
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Affiliation: Yale University
Title: "An Observational View of the Relative Growth of BHs and Galaxies"
Abstract: I will discuss some recent observational insights into how galaxies and their central black holes grow together from the Epoch of Reionization to the present-day Universe. The relationship between black holes and galaxies appears to be more complex than previously thought with multiple growth modes of black holes that may, or may not, be connected to the evolution of the host galaxy. Observational studies show that host galaxy morphology is a key ingredient of co-evolution scenarios and that a substantial fraction of cosmic black hole growth may occur in a "secular" or "stochastic" mode in disk-dominated galaxies.

First Name: Jeremy
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Title: "Prompt EM emission from BH mergers"

First Name: Anil
Last Name: Seth
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Title: Low-Mass Black Holes in Late-Type and Dwarf Galaxies, Nuclear Star Clusters
Abstract: The lowest mass central black holes are in galaxies with massive nuclear star clusters. I will review and preview results on black hole mass measurements in nearby nuclear star clusters. I will also discuss the implications of these results for scaling relations of both nuclear star clusters and black holes.

First Name: Debora
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Title: Black hole - galaxy co-evolution: a cosmological perspective
Abstract: I will discuss how black hole-galaxy co-evolution proceeds in fully cosmological structure formation simulations. First, I will focus on the formation and evolution of high redshift quasars and show how black hole assembly proceeds in these highly biased regions from redshifts as high as 20 to 6. I will then demonstrate the high degree of interrelation

between black holes and their host galaxies at intermediate redshifts of 3 to 1. Finally, I will show how spins and gravitational recoils influence the relationships between galaxies and their central black holes at high redshifts as well as in low redshift gas-rich galaxies.

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Title: Title: Successive Merger of Multiple Massive Black Holes in a Primordial Galaxy
Abstract: We explore tha evolution of multiple massive black holes (MBHs) in a primordial galaxy by means of highly-accurate N-body simulations. We set ten MBHs with equal mass of 10^7 solar mass in a host galaxy with 10^11 solar mass. Consequently, we found that 4 -- 6 MBHs merge successively in 800 Myr. The key process for the successive merger of MBHs is the dynamical friction by field stars, which enhances three-body interactions of MBHs when they come in the central regions of the galaxy. The heaviest MBH always composes a close binary at the galactic center, which shrinks owing to the angular momentum transfer by sling-shot mechanism, and eventually merges due to angular momentum loss through gravitational wave radiation. After 4 -- 6 MBHs merge, another MBH composes a binary component with the heaviest MBH, leaving a binary of a heavier BH and a less massive BH. The simulations show that a multiple MBH system can produce a heavier MBH at the galactic center purely through N-body process.

First Name: Remco
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Title: Methods of measuring super-massive black hole masses

First Name: Sandor
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Title: The Role of Galaxy Morphology in Black Hole Pairing in High Redshift Galaxy Mergers
Abstract: We study the pairing of supermassive black holes (SMBHs) in high redshift unequal mass galaxy mergers using N-body/SPH simulations. Our simulations include radiative cooling, star formation, BH accretion, and feedback from supernovae and BHs and resolves scales of tens of parsecs. Recent studies have shown that pairing is efficient in high-redshift mergers between relatively gas-rich disk galaxies. A gas-rich secondary galaxy forms a large central baryonic mass during the merger that protects it from tidal disruption and allows it to deposit its SMBH in the center of the primary galaxy. We focus here on the role of the morphology and gas content of the primary galaxy in the successful formation of a SMBH pair. The structure of the primary galaxy will determine when disruption of the secondary occurs through the interaction of their interstellar mediums. We study the efficiency of pairing, the relative accretion of the SMBHs, and the interaction between accretion, feedback, and central star formation and how they vary in our simulations. We also analyze the environment around the SMBHs at the end of our simulations and discuss the prospects for a successful merger.

First Name: Jonelle
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Title: Testing the Consistency of Stellar and Gas Dynamical Black Hole Mass Measurements
Abstract: NGC 3998 is a nearby S0 galaxy with a LINER nucleus. The mass of the black hole in NGC 3998 has been previously measured through gas dynamical modeling of the emission-line disk using HST/STIS observations. The object is also a good target for stellar dynamical modeling, and provides an excellent opportunity to directly compare black hole mass measurements obtained via the stellar and gas dynamical techniques. This necessary consistency check has so far only been attempted on a few galaxies with limited results. We will present laser guide star adaptive optics observations of NGC 3998 that were taken with the integral field spectrograph OSIRIS on the Keck II telescope. From the OSIRIS observations, we measure high-resolution stellar kinematics from the K-band CO bandheads, and are able to resolve the black hole sphere of influence. Additional large-scale observations of the stellar kinematics were acquired at multiple slit positions with LRIS on the Keck I telescope. The OSI RIS and LRIS kinematics are used to constrain orbit-based stellar dynamical models, and we will present results from the modeling and measurements of the black hole mass.

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