Curriculum Vitae

Matthew John O'Dowd

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Education History

- 1996 – 2003: Ph.D. studies in Astronomy and Astrophysics at the Space Telescope Science Institute and the University of Melbourne. Thesis title: "The Host Galaxies of Radio-Loud AGN" Supervisors: Prof. Megan Urry and Prof. Rachel Webster.
- 1995: B.Sc.(Hons) – First Class Honours in Physics at the University of Melbourne.
- 1992 – 1994: B.Sc. at the University of Melbourne, majoring in Physics.

Scholarships Awarded

- 1996 & 1999: Graduate Studentship from the Space Telescope Science Institute
- 1996 MRS mid-year scholarship from the University of Melbourne
- 1996 Australian Postgraduate Award from the University of Melbourne (declined)

Employment Summary

- 2004: Deputy Gemini Scientist and Virtual Observatory Astronomer, University of Melbourne
- 2003 – 2004: Lecturer in Astronomy, University of Melbourne
- 1995 – 2003: Laboratory Demonstrator, University of Melbourne
- 1992 – 1994: Private tutor in physics, mathematics and chemistry

Research Experience

- Observing: Extensive experience observing with world-class telescope facilities, including CFHT, the 2.5m and 1m telescopes at LCO, the 4m Blanco telescope at CTIO, the 4m Anglo-Australian Telescope. Familiarity with CCD imaging, long-slit and multi-object spectroscopy, and adaptive optics. Extensive experience in designing HST imaging programs.
- Data reduction: Experience in reduction of optical and infrared imaging data and optical long-slit, multi-object and integral field unit spectroscopy. Broad experience with data from both ground-based telescopes and HST.
- Data analysis: Broad experience in the development and application of new modelling, fitting and statistical analysis techniques.
- Scientific writing: Several successful observing proposals (including three successful HST proposals, and refereed journal and conference proceedings papers (see attached publication record).

Research Interests

- Galaxies — evolution, dynamics, stellar population spectral synthesis
- AGN — formation and fueling processes, host galaxies, the radio-loudness dichotomy
- Black holes — the link between the AGN phenomenon and the evolution of black hole mass and spin
- Cosmology — modelling the merger history of the universe and using AGN as probes of structure formation

Computing Skills

- Extensive experience in scientific programming with IDL and Fortran
- Extensive experience with IRAF (including IRAF scripting and pipeline development)
- Proficient with UNIX, Linux and Windows
- Proficient with LaTeX and with Microsoft Office (Word, Excel, PowerPoint)
- Very good typing skills.

Science Presentations

- Space Telescope Science Institute AGN Journal Club, 1997, Baltimore. Oral presentation: "Finding Host Galaxies with HST"
- 191st AAS Meeting, 1997, Washington DC. Poster presentation: "Finding AGN Host Galaxies with HST, and the Joint Analysis with Ground Based Images"
- Invited Speaker, Astronomical Society of Victoria Annual General Meeting, 1998, Melbourne, Australia. Oral presentation: "Active Galactic Nuclei"
- Fourth Stromlo AGN Workshop, 1999, Canberra. Oral presentation: "The AGN Power–Host Galaxy Connection"
- Life Cycles of Radio Galaxies, STScI Symposium, 1999, Baltimore. Poster presentation: "Host Galaxies and the Unification of Radio-Loud AGN"
- QSO Hosts and Their Environments workshop, 2000, Granada. Oral presentation: "The Nucleus–Host Galaxy Connection in Radio-Loud AGN"
- 25th meeting of the IAU, 2003, Sydney. Poster presentation: "1517+656: a BL Lac in its Birth Throes"
- ASA Annual Scientific Meeting, 2004, Brisbane. Oral presentation: "Host Galaxy Evolution in Radio Loud AGN"

Other Interests

- Literature, creative writing, film, travel, rockclimbing, outdoor activities, martial arts

Referees

- Prof. Rachel Webster
  School of Physics, University of Melbourne,
  Email: rwebster@physics.unimelb.edu.au
- Prof. Megan Urry
  Department of Physics and Yale Center for Astronomy and Astrophysics,
  Email: meg.urry@yale.edu
- Dr. Daniela Calzetti
  Space Telescope Science Institute,
  Email: calzetti@stsci.edu

Publications

Refereed Publications

- Wayth R.B., O'Dowd M., Webster R.L. *Gemini GMOS IFU Spectroscopy of the Lensed QSO 2237+0305*, submitted for publication
- O'Dowd M. & Urry C.M., 2005, *Host Galaxies Evolution in Radio-Loud AGN*, accepted for publication by ApJ (http://www.ph.unimelb.edu.au/∼modowd/papers/odowdurry2005.pdf)
- O'Dowd M., Urry C.M., Scarpa R., Waythe R.B. & Webster R.L. 2005, *1517+656: The Birth of a BL Lac?*, accepted for publication by ApJ (http://www.ph.unimelb.edu.au/∼modowd/papers/odowdetal2005.pdf)
- O'Dowd M., Urry C.M. & Scarpa R., 2002, *The Host Galaxies of Radio-loud Active Galactic Nuclei: The Black Hole-Galaxy Connection*, ApJ, 580, 960
- Pesce J.E., Urry C.M., O'Dowd M., Scarpa R., Falomo R. & Treves A., 2002, *Hubble Space Telescope Observations of BL Lacertae Environments*, NewAR, 46, 159
- Urry C.M., Scarpa R., O'Dowd M., Giavalisco, M., Falomo R., Pesce J.E. & Treves A., 2002, *Host galaxies and the unification of Radio-Loud AGN*, NewAR, 46, 349
- Scarpa R., Urry C.M., Padovani P., Calzetti D. & O'Dowd M., 2000, *The Hubble Space Telescope Survey of BL Lacertae Objects. IV. Infrared Imaging of Host Galaxies, ApJ, 544, 258*
- Urry C.M., Scarpa R., O'Dowd M., Falomo R., Pesce J.E. & Treves A., 2000, *The Hubble Space Telescope Survey of BL Lacertae Objects. II: Host Galaxies*, ApJ, 532, 816
- Scarpa R., Urry C.M., Falomo R., Pesce J.E., Webster R., O'Dowd M. & Treves A., 1999, *The Hubble Space Telescope Survey of BL Lacertae Objects: Gravitational Lens, Candidates and Other Unusual Sources*, ApJ, 521, 134
- Treves A., Scarpa R., Urry C. M., Falomo R., Giovannini G., Pesce J.E., Webster R. & O'Dowd M., 1999, *Gravitational Lens Candidates in the HST Survey of BL Lac Objects*, Ap&SS, 269, 669

Other Publications

- O'Dowd M., Urry C.M. & Scarpa R. 2003 *1517+656: a BL Lac in its Birth Throes*, IAU, Joint Discussion 18, Sydney, Australia
- Urry C.M., Woo J.-H. & O'Dowd M., 2002, *Black Hole Masses in AGN and Galaxies*, APS, April Meeting, B17.096
- Treves A., Carangelo N., Falomo R., Urry C. M. & O'Dowd M., Scarpa R., 2002, *Host galaxies, BH Masses and Eddington Ratio of Radio-Loud AGN*, in *Issues in Unification of Active Galactic Nuclei*, San Fransisco, USA, ASP Conf. Proc., 258, 303
- Woo J.-H., Urry C.M. & O'Dowd M., 2001, *Black Hole Masses in AGN and Galaxies*, BAAS, 199, 138.09
- O'Dowd M., Urry C.M., Scarpa R., Falomo R., Pesce J.E. & Treves A., 2001, *The Nucleus-Host Galaxy Connection in Radio-Loud AGN*, *QSO hosts and their environments*, Granada, Spain, p376
- Urry C.M., Scarpa R., O'Dowd M., Broadhurst T., Falomo R., Treves A., Webster R., Sillanpaa A., Takalo L. & Heidt H., 1999, *Unusual Morphologies from the HST Snapshot Survey of BL Lac Objects: Three Optical, Jets and A Possible Einstein Ring*, BAAS, 194, 73.08
- Urry C.M., Scarpa R., O'Dowd M., Giavalisco, M., Falomo R., Pesce J.E. & Treves A., 1999, *The Host Galaxies of Radio-Loud AGN*, in *The formation of galactic bulges* , 183U
- Scarpa R., Urry C.M., Padovani P., O'Dowd M. & Calzetti D., 1998, *NICMOS Observations of BL Lacertae Objects*, BAAS, 193, 06.01
- O'Dowd M., Urry C.M., Scarpa R. & Pesce J.E., 1997, *Finding AGN Host Galaxies with HST and the Joint Analysis with Ground Based Images*, BAAS, 191, 103.08
- Pesce J.E., O'Dowd M., Scarpa R., Urry C.M., Falomo R., Kim J. & Paske A., 1996, *The Large-scale Environments of Radio Galaxies and BL Lacertae Objects*, BAAS, 189, 10.01

Past and Current Research Interests

My previous research has focused on the link between the properties of radio-loud Active Galactic Nuclei (AGN), the formation and evolution of their host galaxies, black hole properties, and their ability to generate radio jets. In particular I have:

- demonstrated that BL Lac host galaxies are dynamically similar to quiescent ellipticals
- provided strong evidence against accretion power being a critical determinant of radio-loudness
- detected and characterized BL Lac host galaxies at higher redshifts than previously achieved
- provided strong supporting evidence for the apparent positive luminosity evolution of radio-loud AGN host galaxies
- provided evidence pointing to a scenario in which radio-loud AGN black holes are preferentially formed in a particular cosmic epoch
- provided potential observational evidence that radio-loud AGN are triggered following the transfer of angular momentum in a merger event

The AGN Power-Host Galaxy Connection

While the conditions for the generation of continuum and emission line light in AGN may be somewhat understood in terms of fuel supply, black hole mass, and obscuration, the processes thought to trigger powerful jets are speculative at best. Accretion processes or the properties of the central supermassive black hole (SMBH) may hold the key, however the incidence of a powerful radio jet also seems to be strongly linked to the properties of their galactic environments.

In O'Dowd, Urry & Scarpa (2002), the host galaxies of a redshift-matched sample of radio-loud AGN, spanning a range of 10^4 in intrinsic power, were compared. BL Lacs from our HST snapshot survey (Urry *et al.* 2000) allowed us to extend this study to very low intrinsic AGN power, while still matching the $0.15 < z < 0.5$ redshift range of the HST-imaged radio-loud quasar sample (Bahcall *et al.* 1997; Dunlop *et al.* 2003; Boyce *et al.* 1998; Hooper, Impey & Foltz 1997). It was determined that these host galaxies were all dynamically indistinguishable from quiescent ellipticals, consistent with the low-surface brightness tail of the Kormendy relation. Black hole masses were estimated for the AGN using both the M_{BH}–L_{bulge} and the much tighter M_{BH}–σ relations. For the latter, velocity dispersion was derived using a technique conceived for this study — with surface brightness and effective radius determined through model fitting, σ was determined via the evolution-corrected (Jorgensen, Marijn & Kjaegaard 1995) Fundamental Plane for elliptical galaxies.

It was shown that radio-loud AGN have host galaxies and black holes spanning a small range of masses compared to more than four orders of magnitude in Eddington ratios. This result indicates that it is highly doubtful that accretion power is the sole determinant of radio-loudness.

Host Galaxy Evolution in Radio-Loud AGN

The host galaxies of radio-loud AGN appear to be normal elliptical galaxies in most respects, however at least one striking difference distinguishes them: both radio galaxies and the hosts of radio-loud quasars evolve in luminosity more strongly than brightest cluster galaxies (Lilly & Longair 1982; Aragon-Salamanca *et al.* 1993), other quiescent ellipticals (Stanford *et al.* 1998; Kauffmann *et al.* 1996; Bell *et al.* 2004) or even radio-quiet quasar hosts (Kukula *et al.* 2001; Rix *et al.* 2001; Ridgway *et al.* 2001) The source of this difference is unknown, and may result from a variety of selection biases.

Part of my Ph.D. work was the STIS imaging study of the host galaxies of $z > 0.6$ BL Lac objects to address the question of luminosity evolution in radio-loud hosts. BL Lacs have intrinsically low accretion rates and strongly beamed jets, which means they can be found in large numbers at moderate redshifts, and yet they aren't strongly affected by extended emission line or dust-scattered light like quasars are. Additionally, their observed emission is dominated by the highly angle-dependent Doppler amplification of their jets. As such, any trend between host luminosity and intrinsic nuclear power (e.g. McLeod, Rieke & Storrie-Lombardi 1999; Dunlop *et al.* 2003) cannot result in spurious observations of host galaxy evolution in flux limited samples, as is a danger in studies of other AGN.

The determination of the host galaxy properties was performed using new 2-D fitting techniques that I developed. Host galaxies were detected in five of the nine BL Lacs, three of which are at higher redshift than any BL Lac host galaxy previously discovered.

Combined with the low redshift hosts from our HST snapshot survey, we were able to measure luminosity evolution in these galaxies. I developed a new Monte-Carlo survival analysis method to rigorously account for our non-detections. Comparing with models of stellar population evolution, it was found that these host galaxies evolve strongly, consistent with passive evolution from a relatively low formation redshift of $z_{form} = 1.8^{+1.0}_{-0.5}$, and inconsistent with either a evolution from a high formation redshift ($\gtrsim 5$) or a non-evolving population, even taking evolution of dust and metallicity into account. Together with the increased incidence in merger remnants in the $z > 0.6$ BL Lacs, this strongly supports the idea that active star formation and galaxy interactions are associated with the formation of radio-loud AGN central engines.

The luminosity evolution results indicate that the host galaxies of radio-loud AGN preferentially accrete less material after their formation epoch than brightest cluster galaxies and the hosts of radio-quiet AGN, and that by selecting radio-loud AGN at low redshifts, we are selecting those whose central SMBHs are relatively unaltered since a higher formation redshift. The results point to a scenario in which radio-loud AGN black holes are preferentially produced in a particular cosmic epoch: $0.5 \lesssim z \lesssim 2.5$

A Case Study of a Radio-Loud AGN Possibly in its Birth Phase

This last result was highlighted dramatically by a further program, in which 1517+656 — a $z = 0.702$ BL Lac surrounded by a unusual, ring-like structure — was imaged with HST in multiple bands. Deep STIS imaging revealed the detailed structure of the arcs, allowing us to rule out gravitational lensing as a cause, and so leaving a galaxy interaction as the only possible explanation. WFPC2 imaging in the F555W ($\sim V$) and F814W ($\sim I$) filters allowed us to model the stellar populations in the arcs, using the GISSEL population systhesis code of Bruzual & Charlot (1993), extended to non-solar metallicities (Westera *et al.* 2002). The populations were found to be very young, with the bluest having a maximum age of 0.02 Gyrs. The large mass contained in the arcs, and the high estimated Keplerian velocities

indicate that the ongoing interaction is a violent one. The young ages indicate that this AGN may have been triggered by the observed interaction — a hypothesis supported by the extreme radio-to-X-ray emission properties of the nucleus and by the absence of extended radio emission in VLA observations.

The peculiar circularity of the arcs indicate that the plane of the interaction is within 20° of the plane of the sky. Given that BL Lac jets are believed to be nearly perpendicular to the plane of the sky, this provides a direct link between the observed interaction and the generation of the radio source in this AGN. This may provide the first direct observational evidence that both violent interactions and the transfer of angular momentum in these interactions are critical in the generation of radio jets. O'Dowd *et al.* (2005) details these observations.

Monitoring of Einstein's Cross

The gravitationally lensed quasar 2237+0305, or Einstein's Cross, provides the unique potential to probe the central engine of a quasar (Wyithe *et al.* 2000) on a nanoarcsecond scale. A HST Target of Opportunity (TOO) program has been in place for the past five cycles waiting for this microlensing event to occur. In this time, the source has been monitored with the Apache Point Observatory. My role in this project has been to produce and run the reduction and analysis pipeline for the fortnightly APO data and to determine the trigger event. With typical seeing of $\sim 1''.5$, and lens image separation of $\sim 0''.7$, setting up a fast, reliable pipeline proved challenging. The result, however, was successful, with recovered lightcurves agreeing with those derived from the much higher resolution (although not sufficiently regular) OGLE monitoring.

Other Observing Programs

I also have been closely involved in other HST programs. I worked on the statistical analysis and interpretation of the BL Lac snapshot survey of Urry *et al.* (2000), as well as performing the comparative study with radio-loud quasars, as outlined above. I was closely involved in the design and proposal phases of the NICMOS study of low redshift BL Lacs (Scarpa *et al.* 2000), and prepared the Phase II proposals for this study.

These HST programs have been all supported by ground-based programs. BL Lac objects were imaged with the Las Campanas 1m and 2.5m telescopes, with the CTIO Blanco 4m telescope, and with CFHT, providing tighter upper limits and more confidence in detections for our HST host galaxy results, as well as colours and information on environments for many host galaxies. The PUEO adaptive optics system on CFHT was used in an experimental program to guide off BL Lac point sources, and so gain better resolution for host galaxy measurements. This allowed us to achieve $< 0''.3$ resolution in $\sim 1''$ seeing for sources which did not have nearby, bright guide stars.

Research Proposal

Linking Galaxy Evolution and the AGN Phenomenon

From HST observations of nearby galaxies, it is now clear that essentially all contain SMBHs (e.g. Joseph *et al.* 2001; Bower *et al.* 2001; Sarzi *et al.* 2001; Barth *et al.* 2001; Gebhardt *et al.* 2003), and that the masses of these SMBHs are closely related to the properties of the galaxies that host them (Kormendy & Richstone 1995; Magorrian *et al.* 1998; Ferrarese & Merritt 2000; Gebhardt *et al.* 2000). Combined with the predictions from hierarchical galaxy formation, this suggests that the formation and evolution of galaxies and SMBHs are closely linked (e.g. Silk & Rees 1998; Kauffmann & Haehnelt 2000; Wang, Biermann & Wandel 2000; di Matteo *et al.* 2003). AGN act as signposts for where SMBHs and galaxies are growing and evolving. Therefore, studies of AGN, their SMBHs, and their host galaxies are critical to tying down structure formation models and understanding galaxy and SMBH evolution.

My recent STIS study of BL Lac host galaxies out to $z \sim 1$ (O'Dowd & Urry 2005) has provided valuable preliminary results. The apparent dependence of galaxy luminosity evolution on the presence of a powerful radio jet indicates that the formation of the black hole conditions necessary to support such a jet (perhaps a high black hole spin) preferentially occurs at a particular cosmic epoch. The evolution of black hole spin, which may be studied through observations of cosmic jets, can provide a powerful probe of structure formation.

Over the course of a postdoctoral appointment I will pursue and expand these lines of investigation. I am leading or centrally involved in several projects that will:

- map and model the broad emission line region of lensed quasars
- determine the demographics of AGN SMBH masses in the local universe
- verify that black hole mass in not a critical determinant of radio-loudness
- determine the dependence of AGN emission processes on merger history
- develop a model of SMBH spin evolution capable of accounting for the luminosity functions of radio-loud AGN
- develop methods for using cosmic radio jets as probes of structure formation

Mapping the Central Regions of Quasars

The outstanding questions regarding AGN emission processes is a potential stumbling block to their use as a probe of structure formation. The nature of the Broad Emission Line Region (BELR) is one such problem. BELR brightness is an important indicator of accretion power, particularly in cases where thermal emission from the accretion disk is superimposed by emission from a jet. Yet we don't even know the kinematics of the BELR, and so such diagnostics are highly speculative.

In a project related to our HST TOO program, we recently obtained Gemini IFU data of 2237+0305 that showed that the flux ratios of the MGII and CIII] lines, although very similar to each other, were markedly different from the continuum. This is firm evidence that some level of microlensing of the BELR is currently taking place, and demonstrates that the MGII and CIII] regions are co-spatial in this quasar. These observations allowed us to derive sizes of 0.1pc and < 0.03pc for the emission regions and continuum respectively (Wayth *et al.* 2005). and hinted at differential microlensing between Fe-α lines and the continuum.

This result demonstrates a powerful new technique for probing the inner regions of AGN, and is applicable to a wide range of lensed quasars. We have a current program to observe two lensed quasars with the Gemini North GMOS IFU (GN-2005A-Q-33; PI: Rachel Webster). This is a trial study and is being extended to 15-20 CASTLES quasars over 2005B and 2006A. The final program will be a statistical study that will measure the sizes of a wide range of broad emission line species, and through modelling constrain the kinematics of the BELR. Coupled with line widths, we will be able to measure the masses of these AGN black holes. My role in this program will be central, from processing and analysis of the IFU data to working on BELR models.

The Demographics of AGN Black Holes

To assess the link between AGN activity and the evolution of SMBHs and galaxies, we need to understand the dependencies of AGN SMBH demographics on both AGN emission properties and the properties of their host galaxies. For this, more extensive reverberation mapping is essential. I am currently involved in a project led by Rachel Webster to perform reverberation mapping of 350 quasars over seven years, currently with the 2dF spectrograph on the Anglo-Australian Telescope and eventually with the AAOmega spectrograph. Trial observations are under way, and we have already detected variation in spectral flux ratios of quasars out to $z = 3$ when compared to 2QZ data.

The Link between Black Hole Mass and Radio-Loudness

Recent evidence has indicated that, while radio-loud AGN are commonly powered by especially massive SMBHs (e.g. O'Dowd, Urry & Scarpa 2002; Mclure *et al.* 1999), high black hole mass is neither a necessary (Oshlack, Webster & Whiting 2002; Woo & Urry 2002) nor sufficient (Dunlop *et al.* 2003) condition for the generation of a radio jet. To establish that black hole mass is *not* an essential factor in generating a radio jet, I have a current Gemini South program (GS-2005A-Q44) to estimate black hole mass via the coupled Fundamental Plane and M_{BH}–σ relations for a sample of low-luminosity radio-loud quasars that have low virial black hole mass estimates. The accuracy of this method is more than sufficient to determine whether any significant low-mass threshold exists for radio-loud AGN.

Further Investigation of 1517+656

The merger remnants surrounding the BL Lac 1517+656 form a remarkably circular structure, suggesting that the plane of accretion is close to that of the sky — an important observation given the assumed perpendicularity of the BL Lac jet (O'Dowd *et al.* 2005). The apparent link between the angle of the jet and the plane of accretion in this source, along with its extreme radio-to-X-ray emission properties and unresolved radio core, provides evidence that this AGN was triggered by the observed interaction. I am principal investigator of a Gemini IFU program for 2005A (GN-2005A-Q-30) that will accurately determine the stellar populations of the structure and measure line-of-sight velocities to verify its orbital plane.

The Merger History of Radio-Loud AGN

If the merger history of a galaxy dictates its ability to form a powerful radio jet (Hutchings 2001, O'Dowd & Urry 2005), then we expect to see a signature of this dependence in the incidence of merger remnants in radio-loud AGN host galaxies. The striking merger remnants

surrounding the BL Lac 1517+656 suggest that such features may be quite dramatic around young radio sources.

With the advent of adaptive optics and 8m-class telescopes, it is now possible to perform a major study of merger remnants and host galaxy morphological distortions out to moderate redshifts. The optimal instruments for this study — the NIFS near-infrared integral field spectrograph and the NICI coronographic infrared imager on Gemini South — will be commissioned in 2005B, and I am building a collaboration to perform an extensive morphological and near-environment study of a large sample of $z > 0.5$ blazars and radio-loud quasars using these instruments. Having characterized the host galaxy distortions and environments and stellar populations with multi-band imaging, I will compare to the jet, emission line, and continuum properties of the AGN. This study will be extended to the more general quasar population pending the success of the initial study of radio-loud sources.

HST archival studies, with an initial focus on the GOODS data, will be used characterize perturbations in host galaxies at $z < 0.5$ for comparison with the higher redshift results. By determining the evolution of AGN interaction rates we will be able to test some of the implications described in O'Dowd & Urry (2005), and will provide a critical link between the AGN phenomenon and the evolution of galaxies.

Cosmic Radio Jets and the Black Hole Spin Function of the Universe

Given that accretion conditions alone do not seem to dictate radio-loudness (O'Dowd, Urry & Scarpa 2002), black hole spin is likely to be one of the critical properties in generating radio jets (e.g. Rees *et al.* 1982; Meier 2002). The evolution of black hole spin is likely to be dependent on the density, velocity dispersion, and gas content of the cluster environments in which their host galaxies are assembled. Therefore, the evolution of AGN jets should be strongly coupled with galaxy evolution.

Semi-analytic models of galaxy clustering and formation now provide good agreement with galaxy number density and luminosity functions, and even predict reasonable black hole mass functions. This latter has allowed Wyithe & Loeb (2002) to reproduce the optical luminosity function of quasars. The optical luminosity function of radio-loud quasars, taken separately, appears strangely flat, which has important implications for the link between the energetics of the jet and the accretion disk. With Stuart Wyithe and Rachel Webster, I am developing models to account for this. We will extend the black hole growth model of Wyithe & Loeb to model the evolution of black hole angular momentum through mergers and gas accretion. Preliminary work by Volonteri *et al.* (2005) has shown that such an analysis is possible. However, more detailed modelling of the link between black hole spin and accretion disk geometry is needed.

With a model for the evolution and distribution of SMBH spin in hand, combined with the optical luminosity function of radio-loud quasars, we will be able to test models describing the energetics of AGN jets, such as the distribution of jet gamma factors and the dependence of jet luminosity on accretion power. Ultimately, the fine-tuning of these latter models will allow us to use cosmic radio jets as a new tool for constraining structure formation models.

References

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