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Commission 28: Galaxies

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Abstract. This report gives a brief overview of some of the activities and developments in extragalactic research over the past three years.

Keywords. Galaxies

1. Major scientific developments 2002–2005

The scientific activities of Commission 28 and its members embrace all aspects of extragalactic research, and are so wide in scope that it is impossible to give more than a brief summary here. This section therefore outlines just a few areas where there have been especially rapid developments over the past three years.

The conference proceedings listed in §2 of this report, together with the review articles listed in §3, give an indication of the scope and level of recent activity in the research areas covered by the Commission. A comprehensive overview of major developments in all areas of astrophysics over the past three years is given in the annual series of papers by Trimble & Ashwanden (2003, 2004, 2005).

1.1. *High–redshift QSOs, the Epoch of Reionization and the first stars*

One of the most exciting early results from the Sloan Digital Sky Survey (SDSS) was the discovery of several QSOs at redshifts $z > 5$ (Fan *et al.* 2001). The observation of a complete Gunn–Peterson absorption trough blueward of the Lyα line in the $z = 6.28$ quasar SDSS $1030 + 0524$ indicated that the photoionization rate at $z \sim 6$ was at least six times lower than that observed at $z \sim 3$ (Fan *et al.* 2002), implying that redshift $z \sim 6$ marks the end of the Epoch of Reionization, during which the first stars formed in the universe and reionized the neutral intergalactic medium. In 2003, the WMAP satellite measured a higher–than–expected value of $\tau_e = 0.17 \pm 0.04$ for the total optical depth to Thompson scattering against the Cosmic Microwave Background (Kogut *et al.* 2003, Spergel *et al.* 2003), implying that reionization may have occurred as early as redshift $z \sim 15$ (Ciardi *et al.* 2003).

These findings have stimulated intense activity from both theorists and observers over the past three years. There are currently no direct observational constraints on how the first stars formed at the end of the cosmic dark ages, but the current standard ΛCDM models predict that the first stars should form in small dark matter halos at redshifts as early as $z \sim 20 - 30$ (e.g. Couchman & Rees 1986). Many aspects of the physics of gas cooling and star formation in ultra–low–metallicity, dust–free gas are not yet well understood, and theoretical predictions for the formation sites of the first stars depend sensitively on the nature and fluctuation spectrum of dark matter in the early universe.

More observational data in the redshift range $z > 6$ are needed to distinguish between different models for early star formation. Several radio experiments are currently being designed to search for the signal of reionization in the redshifted 21 cm line of neutral hydrogen at $z > 6$, either by looking for a redshift 'step' in the global HI profile (Shaver *et al.* 1999, Morales & Hewitt 2004), or by searching for ionization 'holes' in the neutral gas around high-redshift quasars (Wyithe & Loeb 2004). High-redshift gamma-ray bursts may also provide a valuable probe of the earliest epochs of star formation if significant numbers of them arise from supernovae at $z > 5$ (Bromm & Loeb 2002).

This is currently a very active and fast–moving area of research, and an excellent review of recent developments is given by Bromm & Larson (2004).

1.2. *The star–formation history of the Universe*

The star–formation history of the universe, as measuring by the global comoving space density of the star-formation rate (SFR) in galaxies (e.g. Madau *et al.* 1998), has now been extensively mapped out over the redshift $0 < z < 6$, providing a robust constraint on simulations and semianalytic models of galaxy evolution (e.g. Springel & Hernquist 2003). There is now general consistency between the star–formation rates measured from optical, infrared, sub–mm and radio data, and earlier uncertainties related to extinction corrections have been largely resolved (Hopkins 2004).

The most recent data imply that the evolution of the global SFR density is essentially flat over the redshift range $z \sim 1 - 6$, followed by a steep decline in the overall SFR from $z \sim 1$ to the present–day.

Although new estimates of the star–formation rate and galaxy luminosity function at $z \sim 6$ have recently been provided by data from the HST Ultra Deep Field (Bouwens *et al.* 2004, Bunker *et al.* 2004), the total star–formation rate in galaxies at > 3 remains uncertain to within about a factor of two, partly due to the small number of objects in these high–redshift samples. Larger samples of $z > 3$ galaxies, probing to fainter luminosities, are still needed to constrain the shape of the SFR density evolution reliably beyond $z \sim 3$, but 2002–2005 was a period which saw a very rapid growth in observational data for galaxies at redshift $z > 4$. This has come about mainly through studies of Lyman-α emitters (LAEs) and Lyman–break galaxies (LBGs) which are currently being pursued by a number of groups worldwide.

In summary, it appears that the global star–formation history of the Universe is now essentially mapped out over the entire span of cosmic time from the end of the Epoch of Reionization to the present day, though much work is still needed before we can understand the detailed processes of galaxy formation and evolution in different environments.

1.3. *Galaxy evolution as a function of mass*

The variation of the integrated global star–formation rate over cosmic time provides a valuable probe of galaxy formation and evolution, as discussed above. Additional insights can be gained, however, by examining how the star–formation history of galaxies varies with their present–day stellar mass.

Since the total stellar mass in nearby galaxies provides a measure of their integrated past star–formation rate (SFR), the star–formation history of a galaxy can be deduced from the 'fossil record' provided by its total luminosity and optical spectrum. There is excellent consistency between the overall star–formation history of the Universe derived from direct measurements of high-redshift galaxies, and that deduced from the studies of large samples of galaxies in the local universe (e.g. Heavens *et al.* 2004).

The new generation of large, homogeneous galaxy redshift surveys such as the SDSS (York *et al.* 2000) and 2dFGRS (Colless et al. 2001) have now provided high–quality optical spectra for hundreds of thousands of galaxies, allowing new insights into the

physical processes which underlie galaxy evolution. For example, Heavens *et al.* (2004) modelled the spectra of 96,545 SDSS galaxies, and found a strong relationship between the star–formation history of a galaxy and its present–day stellar mass, with lower–mass galaxies forming most of their stars at progressively lower redshifts. Juneau *et al.* (2005) recently extended these techniques to a sample of galaxies in the redshift range $0.8 < z < 2$, and found that the most massive galaxies formed almost all their stars in the first $\sim$ 3Gyr of cosmic time, whereas the main epoch of star formation in intermediate–mass galaxies continued for almost twice as long (~ 5 Gyr) and the lowest–mass galaxies appeared to have formed stars almost continuously.

Over the past few years, therefore, there has been increasing evidence for a "downsizing" of star formation from high–mass to low–mass galaxies over cosmic time, as first suggested by Cowie *et al.* (1996), in contrast to the original hierarchical picture of dark matter assembly (Blumenthal *et al.* 1984), in which the most massive galaxies are assembled last.

1.4. *Hierarchical galaxy formation and stellar halos*

The observation of stellar streams in wide–field surveys of the Galaxy, together with the detection of the remnants of satellite galaxies accompanied by widely–spread tidal debris around the Milky Way and M31, have shown that galaxy formation is still continuing in the Local Group. Since the discovery of the Sagittarius dwarf (Ibata *et al.* 1994), and the accompanying stellar debris encircling the Galactic halo (Ibata *et al.* 2001), other stellar streams, spurs, loops and vestiges of past interactions have been found around M 31 (e.g. Ferguson *et al.* 2002), and new stellites are still being discovered around Local Group galaxies (e.g. Zucker *et al.* 2004).

Numerical simulations of the disruption of satellite galaxies are in good agreement with the observations, and imply that the bulk of stars in the Galactic halo may have been accreted in galaxy interactions (Helmi *et al.* 2003). The detailed interpretation of some of the most relaxed stellar streams could allow a measurement of the shape of the dark matter halo in our Galaxy (Helmi 2004).

1.5. *Supermassive black holes and AGN feedback mechanisms in galaxies*

It is now well–established that a supermassive black hole is present in the nucleus of every bright galaxy, and that the black–hole mass is proportional to the bulge mass of the galaxy. The tightest power–law relation appears to be that between the black hole mass M_{BH}, and the velocity dispersion σ of the bulge, the so–called $M_{BH} - \sigma$ relation (Gebhardt *et al.* 2000).

The growth rate of black holes in galaxies may vary significantly from the bulge growth rate in some particular phases of evolution. For instance, it has been observed that most narrow–line Seyfert 1 galaxies lie below the $M_{BH} - \sigma$ relation, and are characterized by strong accretion onto the black hole at close to the Eddington rate (Mathur & Grupe 2005).

The $M_{BH} - \sigma$ relation has been interpreted in terms of feedback mechanisms, arising from the energetic events related to the black hole, which are eventually able to moderate or halt star formation (Springel *et al.* 2005). The demography of quasars predicted from their black–hole growth, self-regulated through feedback energy from accretion, has been shown to correspond nicely to the statistics observed in the Sloan Digital Sky Survey, as a function of luminosity (Hopkins *et al.* 2005).

AGN feedback has also been observed on larger scales in cooling–flow clusters, where it was recently discovered how violent this feedback can be. X–ray bubbles and Hα filaments and loops are observed in coincidence with radio lobes in the centre of the

Perseus cluster (Fabian *et al.* 2003), and re-heating due to AGN feedback explains why the effective cooling rate in the central regions of galaxy clusters is lower than previously assumed (Nulsen *et al.* 2005).

2. Conferences

2.1. *IAU Symposia*

The following IAU Symposia and Colloquia were in research areas overlapping those covered by Commission 28:

IAU Symposium No. 214 : High Energy Processes and Phenomena in Astrophysics, 5–9 Aug 2002, Suzhou, China. Proceedings ed. X.D. Li, V. Trimble & Z.R. Wang, ASP, ISBN 1-58381-157-5.

IAU Symposium No. 216 : Maps of the Cosmos, 14–17 Jul 2003, Sydney, Australia. Proceedings ed. M. Colless, L. Staveley–Smith & R. Stathakis, ASP, ISBN 1-58381-202-4.

IAU Symposium No. 217: Recycling Intergalactic and Interstellar Matter, 14–17 July 2003, Sydney, Australia. Proceedings ed. P.-A. Duc, J. Braine & E. Brinks, ASP, ISBN 1-58381-166-4.

IAU Symposium No. 220: Dark Matter in Galaxies, 14–17 July 2003, Sydney, Australia. Proceedings ed. S.D. Ryder, D.J. Pisano, M.A. Walker & K.C. Freeman, ASP, ISBN 1-58381-167-2.

IAU Symposium No. 222: The Interplay among Black Holes, Stars and ISM in Galactic Nuclei, 1–5 March 2004, Gramado, Rio Grande do Sul, Brazil. Proceedings ed. Th. Storchi Bergmann, L.C. Ho & H.R. Schmitt, Cambridge Univ. Press, ISBN 0-521-84803-2.

IAU Symposium No. 225 : Impact of Gravitational Lensing on Csomology, 19–23 July 2004, Lausanne, Switzerland. Proceedings: CUP, in press.

IAU Symposium No. 228: From Lithium to Uranium: Elemental Tracers of Early Cosmic Evolution, 23–27 May 2005, Paris, France. Proceedings: CUP, in press.

2.2. *IAU Colloquia*

IAU Colloquium No. 192: Supernovae: 10 years of SN 1993J. 22–26 April 2003, Valencia, Spain. Proceedings ed. J.M. Marcaide & K.W. Weiler, Springer, ISBN 3-540-23039-4. (Book title: "Cosmic Explosions. On the 10th Anniversary of SN 1993J")

IAU Colloquium No. 193: Variable Stars in the Local Group, 6–11 July 2003, Christchurch, New Zealand. Proceedings ed. D.W. Kurtz & K.R. Pollard, ASP, ISBN 1-58381-162-1.

IAU Colloquium No. 195: Outskirts of Galaxy Clusters: Intense Life in the Suburbs, 12–16 March 2004, Torino, Italy. Proceedings ed. A. Diaferio, CUP, ISBN 0-521-84908-X.

IAU Colloquium No. 198: Near–Field Cosmology with Dwarf Elliptical Galaxies, 14–18 March 2005, Les Diablerets, Switzerland. CUP, in press.

IAU Colloquium No. 199: Probing Galaxies through Quasar Absorption Lines, 14–18 March 2005, Shanghai, China. CUP, in press.

2.3. *Other meetings*

The following international meetings all took place in the past three years (July 2002 to June 2005). This is not intended to be a complete list of all conferences in areas related to the activities of Commission 28, but is indicative of the range of topics covered. Much of the information below is taken from the very useful list compiled by Liz Bryson at CFHT (http://cadcwww.dao.nrc.ca/meetings/), which also has links to the full programs and publication details for many of these meetings.

• *The Evolution of Galaxies. III—From Simple Approaches to Self-consistent Models,* 16–20 Jul 2002, Kiel, Germany.

• *Active Galactic Nuclei: from Central Engine to Host Galaxy,* 23–27 Jul 2002, Meudon, France.

• *Chemical Evolution of Dwarf Galaxies—Present Status and Perspectives,* 27 Jul–2 Aug 2002, Ringberg Castle, Tegernsee, Germany.

• *NATO Advanced Study Institute: Accretion Discs, Jets and High Energy Phenomena in Astrophysics,* 29 Jul–23 Aug 2002, Les Houches, France.

• *The IGM/Galaxy Connection: The Baryon Distribution at z=0*, 8–10 Aug 2002, Boulder, Colorado, USA.

• *Chemical and dynamic evolution of stars and galaxies*, 19–24 Aug 2002, Odessa, Ukraine.

• *Extragalactic Globular Cluster Systems*, 27–30 Aug 2002, Garching, Germany.

• *4th International Workshop on the Identification of Dark Matter - IDM2002*, 2–6 Sep 2002, York, UK.

• *Winds, Bubbles and Explosions - a conference to honour John Dyson*, 9–13 Sep 2002, Patzcuaro, Michoacan, Mexico.

• *Galaxies and Chaos. Theory and Observations*, 16–19 Sep 2002, Athens, Greece.

• *Star Formation through Time*, 24–28 Sep 2002, Granada, Spain.

• *The Universe viewed in gamma-rays*, 25–28 Sep 2002, Chiba, Japan.

• *The Emergence of Cosmic Structure*, 7–9 Oct 2002, College Park, Maryland, USA.

• *Outer Edges of dIrr Galaxies: Stars and Gas*, 10–11 Oct 2002, Flagstaff, Arizona, USA.

• *Carnegie Observatories Centennial Symposium I: Coevolution of Black Holes and Galaxies*, 20–25 Oct 2002, Pasadena, California, USA.

• *Structure Evolution and Cosmology: New Synergy between Ground-based Observations, Space Observations and Theory*, 28–31 Oct 2002, Santiago, Chile.

• *Centers of Galaxies*, 11–15 Nov 2002, Ringberg Castle, Tegernsee, Germany.

• *Carnegie Observatories Centennial Symposium II: Measuring and Modeling the Universe*, 17–22 Nov 2002, Pasadena, California, USA.

• *Carnegie Observatories Centennial Symposium III: Clusters of Galaxies: Probes of Cosmological Structure and Galaxy Evolution*, 26–31 Jan 2003, Pasadena, California, USA.

• *Carnegie Observatories Centennial Symposium IV: Origin and Evolution of the Elements*, 16–21 Feb 2003, Pasadena, California, USA.

• *The Local Group as an Astrophysical Laboratory*, 5–8 May 2003, Baltimore, Maryland, USA.

• *The Riddle of Cooling Flows in Galaxies and Clusters of Galaxies*, 31 May–4 Jun 2003, Charlottesville, Virginia, USA.

• *Multi-Wavelength Cosmology*, 17–20 Jun 2003, Mykonos, Greece.

• *The Neutral ISM in Starburst Galaxies*, 23–27 Jun 2003, Onsala, Sweden.

• *AGN Physics with the Sloan Digital Sky Survey*, 27–30 Jul 2003, Princeton, New Jersey, USA.

• *Gamma-ray Bursts: 30 Years of Discovery*, 8–12 Sep 2003, Santa Fe, New Mexico, USA

• *Modelling the Intergalactic and Intracluster Media*, 1–4 Oct 2003, Vulcano, Italy.
Stellar Populations, 6–10 Oct 2003, Garching, Germany.

• *Multiwavelength Mapping of Galaxy Evolution*, 13–16 Oct 2003, Venice, Italy

• *Stellar-Mass, Intermediate-Mass, and Supermassive Black Holes*, 28–31 Oct 2003, Kyoto, Japan.

• *Structure And Dynamics In The Local Universe: A Workshop to honor Brent Tully's 60th Birthday*, 24–26 Nov 2003, Sydney, Australia
• *Physics of Active Galactic Nuclei at All Scales*, 3–6 Dec 2003, Santiago, Chile.
• *Multiwavelength AGN Surveys*, 8–12 Dec 2003, Cozumel, Mexico.
• *The Large-scale Distribution of Mass and Light in the Universe*, 19–24 Jan 2004, Aspen, Colorado, USA.
• *The Impact of Active Galaxies on the Universe at Large*, 16–17 Feb 2004, London, UK.
• *Observing Dark Energy*, 18–20 Mar 2004, Tucson, Arizona, USA.
• *Nearby Large-Scale Structures and the Zone of Avoidance*, 28 Mar–2 Apr 2004, Cape Town, South Africa.
• *Beyond Einstein: From the Big Bang to Black Holes*, 10–14 May 2004, Menlo Park, California, USA.
• *Exploring the Cosmic Frontier: Astrophysical Instruments for the 21st Century*, 18–21 May 2004, Berlin, Germany.
• *Planetary Nebulae beyond the Milky Way*, 19–21 May 2004, Garching, Germany.
• *Multiwavelength Observations of the Subaru/XMM-Newton Deep Survey Field*, 3–5 Jun 2004, Kyoto, Japan.
• *Penetrating Bars through Masks of Cosmic Dust: The Hubble Tuning Fork strikes a New Note*, 7–12 Jun 2004, Pilansberg National Park, South Africa.
• *Variability of Active Galactic Nuclei from X-rays to Radio*, 14–17 June 2004, Crimea, Ukraine.
• *1604—2004. Supernovae as Cosmological Lighthouses*, 16–19 Jun 2004, Padova, Italy.
• *Cosmic Abundances as Records of Stellar Evolution and Nucleosynthesis: in honor of Professor David Lambert*, 17–19 Jun 2004, Austin, Texas, USA.
• *Growing black holes: Accretion in a cosmological context*, 21–25 Jun 2004, Garching, Germany.
• *Star Formation in Galaxies*, 28 Jun–18 Jul 2004, Aspen, Colorado, USA.
• *The Quest for a Concordance Cosmology and Beyond*, 5–9 July 2004, Cambridge, UK.
• *Galaxies Viewed with Chandra*, 7–9 July 2004, Cambridge, Massachusetts, USA.
• *Astrophysics of Gaseous Nebulae and Active Galactic Nuclei: A Symposium in honor of Donald E. Osterbrock*, 28–30 July 2004, Santa Cruz, California, USA.
• *Chemical Enrichment of the Early Universe*, 9–13 Aug 2004, Santa Fe, New Mexico, USA.
• *The Environments of Galaxies: from Kiloparsecs to Megaparsecs*, 9–13 Aug 2004, Chania, Crete.
• *Starbursts - From 30 Doradus to Lyman Break Galaxies*, 6–10 Sep 2004, Cambridge, UK.
• *Massive Galaxies over Cosmic Time*, 27–29 Sep 2004, Baltimore, Maryland, USA.
• *Multiband Approach to AGN*, 30 Sep – 2 Oct 2004, Bonn, Germany.
• *The Spectral Energy Distribution of Gas Rich Galaxies: Confronting Models with Data*, 4–8 Oct 2004, Heidelberg, Germany.
• *New Windows on Star Formation in the Cosmos*, 11–13 October 2004, College Park, Maryland, USA.
• *Galaxy–Intergalactic Medium Interactions*, 25–29 Oct 2004, Santa Barbara, California, USA.
• *The Spitzer Space Telescope: New Views of the Cosmos* 9–12 Nov 2004, Pasadena, California, USA.

• *Arizona/Heidelberg Symposium: The High Redshift Frontier*, 30 Nov–3 Dec 2004, Tucson, Arizona, USA.
• *Cosmology and High Energy Astrophysics (Zeldovich-90)*, 20–24 Dec 2004, Moscow, Russia.
• *Gravitational Lensing, Dark Matter, and Dark Energy*, 5–7 Jan 2005, Columbus, Ohio, USA.
• *Surveying the Universe: Spectroscopic and Imaging Surveys for Cosmology*, 12–19 Feb 2005, Inssbruck, Austria.
• *Galactic Flows: The Galaxy/IGM Ecosystem*, 7–9 Mar 2005, Baltimore, Maryland, USA.
• *Dynamics of Galaxies: Baryons and Dark Matter*, 10–12 Mar 2005, Las Vegas, Nevada, USA.
• *Resolved Stellar Populations*, 18–23 Apr 2005, Cozumel, Mexico.
• *6dF Galaxy Survey - Workshop 2005*, 26–27 Apr 2005, Sydney, Australia.
• *The Origin of the Hubble Sequence*, 6–12 Jun 2005, Vulcano, Italy.
• *Extragalactic Workshop: After the First Stars*, 15–16 Jun 2005, Nottingham, UK.
• *The Fabulous Destiny of Galaxies:Bridging Past and Present*, 20–24 Jun 2005, Marseille, France.
• *The Formation of Disk Galaxies*, 26 Jun–1 Jul 2005, Ascona, Switzerland.
• *Reionizing the Universe: The Epoch of Reionization and the Physics of the IGM*, 27 Jun–1 Jul 2005, Groningen, The Netherlands.

3. Review articles

Sanders, R.H., McGaugh, S.S., *Modified Newtonian Dynamics as an Alternative to Dark Matter*, 2002, ARA&A **40**, 263

Weiler, K,W., Panagia, N., Montes, M.J., Sramek, R,A., *Radio Emission from Supernovae and Gamma-Ray Bursters*, 2002, ARA&A **40**, 387

Freeman, K., Bland-Hawthorn, J., *The New Galaxy: Signatures of Its Formation*, 2002, ARA&A **40**, 487

Rosati, P., Borgani, S., Norman, C., *The Evolution of X-ray Clusters of Galaxies*, 2002, ARA&A **40**, 539

Giavalisco, M., *Lyman–Break Galaxies*, 2002, ARA&A **40**, 579

Carlstrom, J.E., Holder, G.P., Reese, E.D., *Cosmology with the Sunyaev–Zel'dovich Effect*, 2002, ARA&A **40**, 643

Massey, P., *Massive Stars In The Local Group: Implications for Stellar Evolution and Star Formation*, 2003, ARA&A **41**, 15

Crenshaw, D. M., Kraemer, S.B., George, I.M., *Mass Loss from the Nuclei of Active Galaxies*, 2003, ARA&A **41**, 117

Narlikar, J.V., *Action at a Distance and Cosmology: A Historical Perspective*, 2003, ARA&A **41**, 169

Mathews, W.G., Brighenti, F., *Hot Gas in and around Elliptical Galaxies*, 2003, ARA&A **41**, 191

Paerels, F.B.S., Kahn, S.M., *High-Resolution X-Ray Spectroscopy with CHANDRA and XMM-NEWTON*, 2003, ARA&A **41**, 291

Ferland, G.J., *Quantitative Spectroscopy of Photoionized Clouds*, 2003, ARA&A **41**, 517

Balbus, S.A., *Enhanced Angular Momentum Transport in Accretion Disks*, 2003, ARA&A **41**, 555

Refregier, A., *Weak Gravitational Lensing by Large-Scale Structure*, 2003, ARA&A **41**, 645

Bromm, V., Larson, R.B., *The First Stars*, 2004, ARA&A **42**, 79

Elmegreen, B.G., Scalo, J., *Interstellar Turbulence I: Observations and Processes*, 2004, ARA&A **42**, 211

Scalo, J., Elmegreen, B.G., *Interstellar Turbulence II: Implications and Effects*, 2004, ARA&A **42**, 275

Gratton, R., Sneden, C., Carretta, E., *Abundance Variations Within Globular Clusters*, 2004, ARA&A **42**, 385

McCarthy, P.J., *EROs and Faint Red Galaxies*, 2004, ARA&A **42**, 477

Kormendy, J., Kennicutt, R.C., *Secular Evolution and the Formation of Pseudobulges in Disk Galaxies*, 2004, ARA&A, 603

4. Useful websites and electronic resources

The public data release policies adopted by many observatories and research teams means that there is now a wealth of data available to astronomers worldwide through electronic databases. This section lists some websites which may be of particular interest to researchers in extragalactic astronomy.

General databases:	
NASA/IPAC Extragalactic Database	http://nedwww.ipac.caltech.edu/
SkyView Virtual Observatory	http://skyview.gsfc.nasa.gov/
Large–area surveys (optical/infrared):	
SuperCOSMOS sky surveys	http://www-wfau.roe.ac.uk/sss/
Two Micron All Sky Survey (2MASS)	http://www.ipac.caltech.edu/2mass/
Digitized Sky Survey (DSS)	http://stdatu.stsci.edu/cgi-bin/dss_form
Sloan Digital Sky Survey (SDSS)	http://www.sdss.org
2dF Galaxy Redshift Survey	http://www2.aao.gov.au/2dFGRS/
2dF Quasar Survey (2QZ)	http://www.2dfquasar.org
6dF Galaxy Survey (6dFGS)	http://www-wfau.roe.ac.uk/6dFGS/
Large–area surveys (radio):	
NRAO VLA Sky Survey (NVSS)	http://www.cv.nrao.edu/nvss/
VLA FIRST radio survey	http://sundog.stsci.edu/
SUMSS radio survey	http://www.astrop.physics.usyd.edu.au/SUMSS/
HI Parkes All–sky Survey (HIPASS)	http://www.atnf.csiro.au/research/multibeam/

5. IAU Commission 28, past and future

The new IAU Statutes and Bye-Laws passed at the 2003 General Assembly in Sydney state that present and new Commissions will not continue indefinitely but will have a default lifespan of six years, after which their continuation will be reviewed.

Commision 28 was one of the original 32 ‘Standing Commissions’ set up when the International Astronomical Union was formed in 1919. In the early years its membership was small, and the question of its continuation was also raised from time to time.

In 1938, when Harlow Shapley was President of Commission 28, his triennial report notes that he had written to “all thirty” members of the commission asking for details of their current actvities. Replies were received from “only one-third of the members”,

and Shapley concluded that "there appears to be no immediate problem demanding co-operative activity". He did, however, recommend that Commission 28 should be continued "because of probable future needs".

Time has shown the wisdom of Shapley's recommendation, Almost seventy years later, Commission 28 is the second–largest IAU Commission and has well over 800 members (i.e. almost 10% of the total IAU membership). Although Commission 28 spans a very wide research area, the current trend towards a broad, multi-wavelength approach to extragalactic research suggests that the Commission's scope should not be reduced. It is therefore recommended that Commision 28 should continue in its present form in the near future.

Elaine M. Sadler
President of the Commission

References

Bouwens, R.J. *et al.* 2004, *ApJ* 606, L25
Blumenthal, G.R., Faber, S.M., Primack, J.R., Rees, M.J. 1984, *Nature* 311, 517
Bromm, V., Loeb, A. 2002, *ApJ* 575, 111
Bromm, V., Larson, R.B. 2004, *ARA&A* 42, 79
Bunker, A.J., Stanway, E.R., Ellis, R.S., McMahon, R.G. 2004, *MNRAS* 355, 374
Ciardi, B., Ferrara, A., White, S.D.M. 2003, *MNRAS* 344, L7
Colless *et al.* 2001, *MNRAS* 328, 1039
Cowie, L.L., Songaila, A., Hu, E.M., Cohen J.G. 1996, *AJ* 112, 839
Couchman, H.M.P., Rees, M.J. 1986, *MNRAS* 221, 53
Fabian, A.C. *et al.* 2003, *MNRAS* 344, L43
Fan, X. *et al.* 2001, *AJ* 122, 2833
Fan, X. *et al.* 2002, *AJ* 123, 1247
Ferguson, A.M.N., Irwin, M.J., Ibata, R.A., Lewis, G.F., Tanvir, N. 2002, *AJ* 124, 1452
Gebhardt, K. *et al.* 2000, *ApJ* 539, L13
Heavens, A., Panter, B., Jimenez, R., Dunlop, J. 2004, *Nature* 428, 625
Helmi, A. 2003, *MNRAS* 351, 643
Helmi, A., Navarro, J.F., Meza, A., Steinmetz, M., Eke, V.R. 2004, *ApJ* 592, L25
Hopkins, A. 2004, *ApJ* 615, 209
Hopkins P. *et al.* 2005, *ApJ* 630, 705
Ibata, R., Gilmore, G., Irwin, M. 1994, *Nature* 370, 194
Ibata, R. *et al.* 2001, *ApJ* 551, 294
Juneau, S. *et al.* 2005, *ApJ* 619, L1
Kogut, A. *et al.* 2003, *ApJS* 148, 161
Madau, P., Pozzetti, L., Dickinson, M. 1998, *ApJ* 498, 106
Mathur S., Grupe D. 2005, *A&A* 432, 463
Morales, M.F., Hewitt, J. 2004, *ApJ* 615, 7
Nulsen, P.E.J., McNamara, B.R., Wise, M.W., David, L.P. 2005, *ApJ* 628, 629
Spergel, D.N. *et al.* 2003, *ApJS* 148, 175
Springel, V., Hernquist, L. 2003, *MNRAS* 339, 312
Springel, V., Di Matteo, T., Hernquist, L. 2005, *MNRAS* 361, 776
Trimble, V., Ashwanden, M.J. 2003, *PASP* 115, 514
Trimble, V., Ashwanden, M.J. 20034 *PASP* 116, 187
Trimble, V., Ashwanden, M.J. 2005, *PASP* 117, 311
Wyithe, J.S.B., Loeb, A. 2004, *Nature* 432, 194
York, D. *et al.* 2000, *AJ* 120, 1579
Zucker, D.B. *et al.* 2004, *ApJ* 612, L121