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DIVISION X RADIO ASTRONOMY

RADIOASTRONOMIE

Division X provides a common theme for astronomers using radio techniques to study a vast range of phenomena in the Universe, from exploring the Earth's ionosphere or making radar measurements in the Solar System, via mapping the distribution of gas and molecules in our own Galaxy and in other galaxies, to study the vast explosive processes in radio galaxies and QSOs and the faint afterglow of the Big Bang itself.

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TRIENNIAL REPORT 2006 - 2009

1. Introduction

We were pleased that the 2006 Nobel Prize in Physics was awarded to John C. Mather and George F. Smoot for their discovery of the black body form and anisotropy of the cosmic microwave background radiation. In addition, the URSI John Howard Dellinger Gold Medal has been awarded to Alan Rogers of MIT Haystack Observatory, and the Balthasar van der Pol Gold Medal to Jack Welch (UC/Berkeley). Moreover, Kavli Prizes in Astrophysics of 2008 were granted to Maarten Schmidt and Donald Lynden-Bell for their contributions to our understanding of the nature of quasars. It is mentioned that

Grote Reber medals were awarded for lifetime achievements in radio astronomy to Bill Erickso (2005), Bernie Mills (2006), Govind Swarup (2007), and Sandy Weinreb (2008).

During the past triennium, radio astronomy witnessed many changes and improvements in the available facilities. We have included links to all major radio astronomical facilities on the web page <www.bao.ac.cn/IAU_COM40/2005/facilities.html>, where the details of the recent instrumental developments can be consulted.

After the consolidation and initiation of the Atacama Large Millimeter Array(ALMA) project highlighted in the previous triennium Divisional report, perhaps international efforts associated with the Square Kilometer Array (SKA) project become the most visible event in the radio astronomical community. The SKA will have a collecting area of up to one million square meters spread over at least 3000 km, providing a sensitivity 50 times higher than existing radio telescopes, and an instantaneous FoV up to at least several tens of square degrees. Over the last few years, several SKA Pathfinder Telescopes (LOFAR, EVLA, MWA, ATA, ASKAP, MeerKAT, FAST, etc.), SKA Design work Studies (SKADS), PrepSKA and TDP have been funded, each of which is developing one or more aspects of the Reference Design technology in depth; see <www.skatelescope.org/>.

The scientific results have continued to flow with great continuity. In the first section of this document we list some of these results that sample the great variety of research being undertaken. By far, this report is not complete and it merely tries to convey the vitality and versatility in this field. Besides the Organizing Committee (OC) members of the Division, we would like to extend our sincere appreciation and gratitude to our colleagues, Michael Kramer, Yu H. Yan, Zhi-Qiang Shen, XueLei Chen, Wayne Orchiston, Kenneth I. Kellermann, and Masatoshi Ohishi, for their valuable contributions to the Division.

Three Divisional Working Groups have renovated their memberships and terms of reference, see <www.bao.ac.cn/IAU_COM40/workgroup.html>.

Three Inter-Division Working Groups are also linked to the Division X webpage: <www.bao.ac.cn/IAU_COM40/workgroupi.htm>.

Sadly, four distinguished astronomers died in the period under consideration.

W. N. 'Chris' Christiansen passed away in April 2007. He developed the innovative cross-type radio telescope known as the Chris Cross. He served as vice-president of the IAU 1964 - 1970, president of the International Union of Radio Science (URSI) 1978 - 1981, and was honored as its Honorary Life President in 1984.

Ronald N. Bracewell passed away in August 2007. He was Stanford University engineering professor, and internationally known for developing magnetic imaging as a tool that evolutionized medicine, and for developing radio astronomy.

As a great pioneer in Solar Radio Astronomy, Paul Wild passed away on 10 May 2008 in Canberra, Australia. He was the second winner of the Hale Prize.

The death of Barry E. Turner on 10 May 2008 was reported in National Radio Astronomy Observatory (NRAO). He pioneered the charting of the astronomical microwave spectrum, thereby establishing astrochemistry as a new field of science.

2. Scientific highlights June 2005 - June 2008

2.1. *On molecular observations*

Radio astronomy, in particular at the millimeter and sub-millimeter wavelengths, continues to be a major tool for the study of molecules in an astrophysical context. These studies extend from nearby comets to remote galaxies (e.g., Biver *et al.* 2006; Carilli *et al.* 2007), passing by rotating structures around forming stars in our Galaxy (e.g., Zapata *et al.* 2007). More than 140 molecular species have been detected in space (<www.ph1.uni-koeln.de/vorhersagen/>), with the most recent addition being cyanoformaldehyde (CNCHO) (Remijan *et al.* 2008). Molecular observations are a major part of the programs of existing radio telescopes as well as of the science drivers of projects like ALMA and the Large Millimeter Telescope (LMT). In what follows we briefly summarize major results on this topic obtained over the last two years.

A review on the atomic and molecular content of diffuse interstellar clouds (previously believed to be relatively devoid of molecules) was given in 2006 (Snow & McCall 2006). A complementary review on cold dark clouds, stressing the efforts toward understanding how molecular gas condenses to form stars, was presented in 2007 (Bergin & Tafalla 2007).

Magnetic fields in the Cepheus A region have been determined by Vlemmings *et al.* (2006) using linear and circular polarization observations of the 22.2 GHz H_2O masers (Vlemmings *et al.* 2006). The study of the morphology and kinematics of molecular outflows continues to be an active field of research, as evidenced by the studies in HH 211 and in the OMC 1 South Region (Zapata *et al.* 2006). Patel *et al.* (2005) presented images and kinematical data of a disk of dust and molecular gas around a high-mass protostar. This result has been confirmed by Jiménez-Serra *et al.* (2007). Molecules are also used to study possible protoplanetary disks, envelopes of evolved stars, and planetary nebulae (e.g., Qi *et al.* 2006; Fong *et al.* 2006; Tafoya *et al.* 2007). In our galaxy, an extensive survey of star-formation regions (COMPLETE Survey) has released a phase I database that includes and imaging of these regions. The origin of the large abundance of complex organic molecules in the Galactic Center has been studied, and it was concluded that all of the complex molecules that are observed were probably ejected from grain mantles by shocks (Ridge *et al.* 2006; Requena-Torres *et al.* 2006).

A new ^{12}CO (J=1-0) line survey of the Andromeda Galaxy with the highest resolution to date ($23''$, or 85 pc along the major axis) is reported by Nieten *et al.* (2006), who find radial gradients that suggest that either the atomic and total gas-to-dust ratios increase by a factor of 20 or the dust becomes colder towards larger radii. With increased sensitivity, it has become possible to detect and study molecules in external galaxies. Riechers *et al.* (2006) made ^{12}CO(J=1-0) observations of the high-redshift quasi-stellar objects (QSOs) BR 1202−0725 ($z = 4.69$), PSS J2322+1944 ($z = 4.12$), and APM 08279+5255 ($z = 3.91$) using the NRAO Green Bank Telescope (GBT) and the MPIfR Effelsberg 100 m telescope. They conclude that emission from all CO transitions is described well by a single gas component in which all molecular gas is concentrated in a compact nuclear region. Their observations and models show no indication of a luminous extended, low surface brightness molecular gas component in any of the high-redshift QSOs studied. Weiss *et al.* (2007) argue that the molecular lines and the dust continuum emission observed in the Broad Absorption Line quasar APM 08279+5255 arise from a very compact (dimensions of about 100-300 pc), highly gravitationally magnified region surrounding the central AGN.

2.2. *Pulsars and transients*

The recent years have continued to produce exciting new results in the field of pulsar astrophysics. The double pulsar discovered at Parkes in 2003 has already fulfilled its promise to provide the best tests of General Relativity in strong gravitational fields (Kramer *et al.* 2006). The second most relativistic pulsar, J1906+0746 (Lorimer *et al.* 2006), was discovered as the first of probably many remarkable discoveries of the

Pulsar ALFA Survey(P-ALFA) on-going at the Arecibo Observatory (Cordes *et al.* 2006). Surveys of globular clusters have produced an outstanding number of new discoveries (e.g., Ransom *et al.* 2005), including the discovery of the fastest rotating millisecond pulsar with a spin frequency of 716 Hz (Hessels *et al.* 2006). Further unexpected discoveries include those of several radio transient and intermittent sources, demonstrating that the dynamic radio sky is still largely unexplored. These discoveries include that of a transient source in the Galactic Centre (Hyman *et al.* 2005), the discovery of transient radio bursts from rotating neutron stars named RRATS (McLaughlin *et al.* 2006), and the discovery of an intermittent pulsar PSR 1931+24 which gives unique insight into the workings of pulsar magnetospheres (Kramer *et al.* 2006). Further unexpected radio emission was discovered from magnetars (e.g., Camilo *et al.* 2007) with the remarkable example of the anomalous X-ray pulsar XTE J1810−197, for which single pulses were detected up to 120 GHz (Camilo *et al.* 2006). The link between pulsars and supernovae and the related physics of core collapse was also further studied with the discovery of new pulsar-supernova remnant associations (e.g., Camilo *et al.* 2006) and the velocity of young pulsars (e.g., Chatterjee *et al.* 2005).

2.3. *Radio Sun*

Radio observations cover a wide range from the quiet Sun emissions to flares, CMEs and interplanetary particles. There exist some recent attempts to explore the properties at mm wavelength (e.g., Brajsa *et al.* 2007) and prepare for future ALMA observations (e.g., Wedemeyer-Böhm *et al.* 2007). The Nancay Radio Heliograph (NRH) at dual 17 and 34 GHz has covered one solar cycle, and the scientific outputs are still increasing, such as obtaining the coronal magnetic field distribution (Huang, G., Ji, H., & Wu, G. 2008). The Siberian Solar Radio Telescope (SSRT) interferometer at 5.7 GHz offers the ability to study fast fine structures (Altyntsev *et al.* 2007). High dynamic range snapshot images of the solar corona at 327 MHz were obtained by combining the Giant Metrewave Radio Telescope (GMRT) and the NRH (Mercier *et al.* 2006). Using NRH data, together with other space and ground observations, the CME features, source region of 3He-rich SEP events, electron acceleration and transport, and radio bursts of CME events were studied (e.g., Gopalswamy *et al.* 2006; Pick *et al.* 2006; Trottet *et al.* 2006; Yan *et al.* 2006).

Because of observations with high resolutions by Chinese spectrometers in the 1-7.6 GHz range, data about the detailed spectra of zebra patterns in the microwave range above 3 GHz have appeared (Chernov 2006). Among others, the radio spectrometers from cm, dm to metric wavelengths include ETH, Ondrejev, IZMIRAN, AIP, Athens, etc. An interplanetary Type II like event in 0.1-14 MHz observed by WIND/WAVES is found not to be due to plasma radiation, but instead to incoherent synchrotron radiation from near-relativistic electrons (Bastian 2007). The newly-launched S/WAVES covering the ˜1-16 MHz range can perform 3D localization and tracking of the radio emissions associated with streams of energetic electrons and shock waves associated with CMEs (Bougeret *et al.* 2008). Future major new solar-dedicated observing facilities (specifically FASR and the Chinese Radio Heliograph) will greatly extend the capabilities of achieving high spatial, temporal and spectral resolutions and high sensitivity (Hudson & Vilmer 2007).

2.4. *The Galactic Center*

The past few years have seen a lot of progress in radio observations of the Galactic Center (GC).

High-resolution Very Long Baseline Interferometry (VLBI) observations have established that the intrinsic size of Sgr A* is only about 1 AU at 3.5 mm (Shen *et al.* 2005), even though the exact structure of the interstellar scattering needs to be further examined with better longer wavelength radio observations (Bower *et al.* 2006). The size constraint, along with the lower limit to the mass of Sgr A* from the VLBA measurements of its proper motion, strongly supports the supermassive black hole nature of Sgr A*. Recently some testing observations at 1.3 m or shorter have been successfully done.

Many new observations at different radio bands with different instruments have been carried out to investigate the variability of Sgr A*. These include sub-mm observations of Sgr A* with the Caltech Submillimeter Observatory (CSO); the Submillimeter Array (SMA) monitoring observations; the Nobeyama Millimeter Array (NMA) monitoring at 100 and 140 GHz; the Australia Telescope Compact Array (ATCA) observations at 86 GHz; and the Very Large Array (VLA) monitoring at cm wavelengths, etc. As a result, intra-day variability has been detected by the Owens Valley Radio Observatory (OVRO) millimeter interferometer (Mauerhan *et al.* 2005), the NMA, the SMA and the ATCA. The cause of the variability is still in debate. Flaring activity at 43 and 22 GHz with the VLA shows the peak flare emission at 43 GHz leading the 22 GHz one by 20-40 minutes, which can be explained with the plasmon model.

Significant progress has been made in the detection of polarized emission from Sgr A* at mm and sub-mm bands. Linear polarization from Sgr A* was detected with the BIMA at 1.3 mm. Variable polarization in both magnitude and position angle on time scales down to a few hours has been measured with the SMA at 340 GHz (Marrone *et al.* 2007), although its relation to the variation of the total intensity is not clear. The inferred Faraday rotation is very low, and thus a very low accretion rate is needed. The polarized emission is also detected by the VLA at 43 and 22 GHz, which seems to suggest that the rotation measure decreases with decreasing frequency (Yusef-Zadeh *et al.* 2007).

Simultaneous spectra of Sgr A* from 90 cm to 3.8 μm showed a spectral break at 3.6 cm (An *et al.* 2005). At longer cm wavelengths it is consistent with free-free absorption due to the ionized gas. Observations at 74 and 330 MHz reveal the presence of a large-scale diffuse source of non-thermal synchrotron emission with a magnetic field several orders of magnitude below the commonly-assumed 1 mG. Recent radio and sub-mm observations have revealed that magnetic filaments are more widespread than previously thought. Observations at even higher resolution and sensitivity will be required to understand fully the origin, properties and role of the magnetic field at the GC (Lazio & LaRosa 2005).

To understand the emission from Sgr A* and establish the relationship of flaring activity across its spectrum, several campaigns of wide band (including X-ray, infrared and radio) observations towards the GC have been coordinated, with some time delays detected between various wavelengths (e.g., Eckart *et al.* 2006).

There are also many new observations of the GC such as the GBT multi-wavelength survey, the wide-area VLA continuum survey at 6 and 20 cm, the large scale CO 3-2 observations in the GC by the ASTE, Odin observations at 118 GHz, SMA observations of line and continuum emission at 1.3 mm, spectral imaging of the Sgr B2 region in multiple 3 mm molecular lines with the Mopra telescope, VLA observations of OH masers in Sgr A East and the circumnuclear disk. GC appears to be one of the best laboratories for studying the formation of complex organic molecules.

A transient source $2''.7$ south of Sgr A* was detected at 330 MHz (Hyman *et al.* 2005), which was resolved by the VLA into two components (Bower *et al.* 2005). New data with the GMRT at 330 MHz indicate a very steep spectral index. A sensitive 20 cm VLA continuum survey of the GC region has resulted in a catalog of 345 discrete sources. Multi-frequency, multi-configuration VLA observations have been used to investigate the stellar winds and embedded massive star formation in the Quintuplet and Arches stellar cluster. A number of potential ultracompact and hypercompact H II regions in Sgr B2 were studied with the H 52α recombination line, consistent with an ionized outflow from high mass stars. Recently, there was a debate on the possible non-thermal nature of the radio emission arising from the Sgr B complex.

2.5. *Galactic surveys*

Advances in computing and wide-field interferometric imaging have made possible the execution of large-scale spectroscopic surveys of the Milky Way. Three such surveys are underway. The VLA Galactic Plane Survey (Stil *et al.* 2006) was completed in 2006, and the Canadian Galactic Plane Survey (Taylor *et al.* 2003), and the Southern Galactic Plane Survey (McClure- Griffiths *et al.* 2005) are nearing completion. These surveys provide arcminute-scale resolution imaging of atomic hydrogen emission covering a wide range of longitudes including the three quadrants of the Galaxy (second, first and fourth). These data make available an image of the atomic hydrogen gas in the interstellar medium at comparable angular resolution to data on the molecular gas and dust provided by submillimetre and infrared observations. Planned surveys at submillimetre with the James Clerk Maxwell Telescope (JCMT) and *Herschel*, promise in combination with these H I surveys to provide a complete picture of the Interstellar Medium (ISM) in the plane of the Galaxy at parsec spatial resolution. At this high angular resolution, the cold atomic hydrogen component of the multi-phase ISM is revealed by H I self absorption and continuum absorption to be ubiquitous (Gibson *et al.* 2005, Strasser *et al.* 2007). Complexes of cold H I clouds are detected, that may represent an intermediate temperature and density phase of the ISM linking the diffuse warm ISM to molecular clouds and triggered by passage of spiral arm shocks (Gibson *et al.* 2007).

Radio polarimetry of the Galaxy is enjoying a resurgence as a probe of the magneto-ionic ISM. The dense grid of rotation measure observations towards background radio sources provided by the Canadian Galactic Plane Survey (CGPS) and the Southern Galactic Plane Survey (SGPS) (e.g., Haverkorn *et al.* 2006), along with pulsar rotation measures, are being used to probe the structure of the global magnetic field of the Galaxy and the smaller-scale turbulent field. Recent developments include the discovery of oscillatory RM structures associated with spiral arm structure and the characterization of the reversals of the global field (Brown *et al.* 2007), and the relationship of fields in molecular clouds to the global-scale fields (Han & Zhang 2007).

Broad-band, multi-channel spectropolarimetry offers the possibility of carrying out rotation measure synthesis to deconvolve the three-dimensional structure of the Faraday rotating ISM, the so-called Faraday screen. New Galactic Plane surveys that are soon to be launched, will use new spectrometer systems on Arecibo (GALFACTS) and Parkes and the DRAO 26 m telescope (GMIMS) and will exploit this technique. First observations for both of these surveys will begin in 2008.

Planned surveys at submillimetre with the JCMT and *Herschel*, and new data from *Planck*, promise, in combination with these new low-frequency radio surveys of H I emission and polarimetry, to allow exploration of a more complete picture of the relationship between the phases of the ISM in the plane of the Galaxy at parsec spatial resolution.

2.6. *Active galaxies*

The study of the physics of launching AGN jets is set to make significant progress with the availability of large bodies of pc-scale total intensity, as well as linear and circular polarisation measurements at multiple frequencies and multiple epochs. Sub-milliarcsecond morphology is available for a sample of 250 relativistically-beamed AGN (Kovalev *et al.* 2005), of which proper-motion data were also earlier published for over 100 objects. Multi-frequency VLBI polarimetry with spatial resolution of a few resolution elements transverse to the direction of the jet has also been done for a significant number of AGN, which has enabled the search for and detection of transverse rotation-measure gradients across the pcscale jets (Zavala & Taylor 2005; Mahmud & Gabuzda 2007). Such a gradient has long been suggested as a signature of helical magnetic fields in the jets (Papageorgiou 2006). Homan & Lister (2006) detect significant pc-scale circular polarisation in 15133 AGN at 15 GHz. Gabuzda *et al.* (2008) detect polarisation in another seven AGN which they interpret in the helical magnetic field scenario. With VLBI at 7 mm, rotation measures have been obtained in the high frequency regime, i.e., between 2 cm and 7 mm (Mutel, Denn & Dreier 2005; Gabuzda *et al.* 2006). Measurements of Faraday Rotation can be used to get a handle on the geometry of the ordered component of the magnetic field that is parallel to the line of sight. Using global VLBI polarimetry at 8GHz, Kharb, Shastri, & Gabuzda (2005) have made the first detections of ordered pc-scale magnetic fields in the nuclei of radio-galaxies of the Fanaroff-Riley I type. Gabuzda (2006) has reviewed the various results.

With the VLA D-array at 5 GHz Gallimore *et al.* (2006) have found that kpc-scale radio-emitting outflows are common in the low-luminosity radio-quiet Seyfert galaxies, and their deviation from the radio-infrared correlation argues for these outflows being driven by the AGN rather than a starburst.

Greenhill (2007) reviews the results on OH and water masers in active galaxies. He argues that while the results argue for OH masers being mostly driven by intense star formation, the water masers are driven by the AGN.

With the Institute for Millimetre Radio Astronomy (IRAM) 30 m telescope, Ocana-Flaquer *et al.* (2008) have searched for the CO(1→0) and CO(2→1) emission lines from a sample of 52 radio-powerful galaxies and detect these lines in 28 objects. They find that the inferred mass of the molecular gas is systematically somewhat lower than that found for FIR-selected radio galaxies by Evans *et al.* (2005) from observations of the CO(1→0) transition with the NRAO 12 m telescope. The modeled value of the dust temperature is warmer than in normal spiral galaxies, pointing to heating of the dust by the AGN. With observations from the IRAM 30 m telescope, Evans *et al.* (2006) confirm that the CO luminosity in the host galaxies of quasars is enhanced relative to the infrared luminosity compared to the infrared-luminous galaxies. This implies either that the star formation is more efficient or that the AGN results in additional dust heating; the measurements of the HCN (1→0) and HCN (2→1) transitions (in the 3 mm and mm bands respectively) support the latter possibility. Evans *et al.* (2006) have the results on molecular gas measurements in low-redshift quasars.

2.7. *Cosmology*

The Cosmic microwave background (CMB) is one of the most important sources of cosmological information. The *WMAP* team released their three year observation data in 2006 (Spergel *et al.* 2007) and five year observation data in 2008 (Komatsu *et al.* 2008). Combined with the Arcminute Cosmology Bolometer Array Receiver (ACBAR) (Reichardt *et al.* 2008), Boomerang (Jones *et al.* 2006) and the Cosmic Background

Imager (CBI) (Readhead *et al.* 2004) data, the first five peaks in the temperature angular power spectrum have been detected. The treatment of the polarization data has been improved, the strong TE correlation at small l observed in the *WMAP* first year data is believed to be due to foreground contamination, and the EE correlation has also been observed. With this update, the epoch of reionization is around $z = 11$, more in line with CDM model prediction. The CMB observations also put strong constraint on the ϕ^4 inflation model. At small l, the power is still too low compared with theoretical prediction, but with better likelihood function it is slightly less severe than the first year data indicates. There is some sign of non-Gaussianity in the data. If confirmed, it will challenge the single field slow roll models of inflation.

Experiments for probing the epoch of re-ionization by red-shifted 21 Centimeter Array (21CMA) line is being pursued by a number of teams, most notably the 21CMA (<21cma.bao.ac.cn>), LOFAR (<www.lofar.org>), and MWA (<www.haystack.mit.edu/ast/arrays/mwa>), which are all dedicated experiments. In addition, the GMRT has also been equipped with new receivers for such searches (Pen *et al.* 2008).

3. Triennial reports of the Working Groups

3.1. *Working Group on Interference Mitigation*

This Working Group, chaired by Tasso Tzioumis (Australia), continues for a third IAU triennium. At the Division X business meeting during the IAU XXVI General Assembly in Prague, 2006, there was very strong support for the continuation of the Working Group. Interference Mitigation is destined to be even more important in the era of new radio astronomical facilities like the SKA and its various path-finders (LOFAR, ATA, ASKAP, MeerKAT, etc.).

The charter of the WG was revised in 2008 and the membership was updated. Details are given in <www.bao.ac.cn/IAU_COM40/WG/WgRF.html>. The WG promotes interference mitigation activities and reports at each IAU General Assembly. The group also commissions a technical review of the current state and progress on interference mitigation and this is distributed at each IAU general assembly. Reports from the 2003 and 2006 assemblies are available on the website. A new review has been commissioned and will be presented in the IAU XXVII General Assembly in 2009.

The membership of the WG comprises: Anastasios Tzioumis (chair, Australia), Willem A. Baan (Netherlands), Darrel T. Emerson (USA), Masatoshi Ohishi (Japan), Tomas E. Gergely (USA), J. Richard Fisher (USA), John E. B. Ponsonby (UK), Albert-Jan Boonstra (Netherlands) Wim van Driel (France, IUCAF chair), Haiyan Zhang (China), and Ronald D. Ekers (Australia).

3.2. *Working Group Astrophysical Important Spectral Lines*

This Working Group, chaired by Masatoshi Ohishi (Japan), keeps working actively and continues under its previous status. The WG met during the IAU XXVI General Assembly in Prague, and presented members with a possible list of lines between 1000 and 3000 GHz. The chairman called for further input; however, nothing was submitted. The list was used to support a provisional agenda item at the World Radio Communication Conference in 2011 (WRC-11) of the International Telecommunication Union (ITU) regarding the use of frequencies between 275 and 3000 GHz. The WRC-07 adopted the provisional agenda as an agenda toward WRC-11 with the scope to update a footnote that has identified several frequency bands up to 1000 GHz of interest to the radio astronomical community. The Working Party 7D (radio astronomy) of the ITU agreed to call for further information regarding astrophysically-important spectral lines up to 3000 GHz to support the agenda above. Therefore, an update of the list between 1000 and 3000 GHz and comments on the list are needed; the revised list will be submitted to the IAU XXVII General Assembly in 2009.

4. Conferences and meetings on radio astronomy

Since the 2006 General Assembly in Prague, about sixteen international meetings intimately related to radio astronomy have been held world wide. Regarding the IAU GA and non-GA activities in 2009, we encouraged the members and OC of Division X to submit proposals for Symposia, Joint Discussions, and Special Sessions. One proposed symposium and two Special Sessions are coordinated by Division X, and eight others are supported by Division X. Some representative meetings that show the recent developments that have occurred in radio astronomy are listed below:

- *SKA Science and Engineering Committee Meeting*, (SSEC 1), Perth, Australia, 7-8 April 2008
- *SKA Pathfinder Meeting*, Perth, Australia, 31 March - 1 April 2008
- *VSOP2 Meeting: Astrophysics and Technology*, ISAS, Sagamihara, Kanagawa, Japan, 3-7 December 2007
- *World Radcommunication Conference 2007* (WRC-07), Geneva, Switzerland, 22 October - 16 November 2007
- *Frank N. Bash Symposium 2007: New Horizons in Astronomy*, Austin, TX, USA , 14-16 October 2007
- From Planets to Dark Energy: the Modern Radio Universe, University of Manchester, UK, 1-5 October 2007
- *18th Meeting International SKA Steering Committee*, Manchester, UK, 6-7 October 2007
- *SKA2007 Inter-WG meeting*, Manchester, UK, 27-29 October 2007
- *European Radio Interferometry School*, Bonn, Germany, 10-15 September 2007
- *40 Years of Pulsars, Millisecond Pulsars, Magnetars*, Montreal, Canada, 12-18 August 2007
- *Frontiers of Astrophysics: A Celebration of NRAO's 50th Anniversary*, Charlottesville, VA, USA, 17-21 June 2007
- *LMT Inauguration and Related Radio Astronomy Symposium*, Mexico, 15-17 November 2006

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