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# CRAF NEWS

Expert Committee on Radio Astronomy Frequencies (CRAF)

## Editorial

This year of 2009 is the year of astronomy. It has come at the right time! In recent years we have become accustomed to the idea that everything in the world is negotiable and merely a matter of social or political convention. Facts are selected to fit the picture; facts that do not fit are ignored. However, a look into the night sky shows us that some facts cannot be ignored: the universe is much, much bigger than our tiny sphere of human influence, and is totally oblivious to our conventions and wishful thinking.

In the Middle Ages, and certainly before that, there was probably no difference between astronomy and astrology in people's minds. Astronomical research was driven by the myth that the constellations, the planets and the stars influence history and our individual lives. To some extent, that is true. The seasons and day and night are, of course, determined by the orbit of our planet, Earth, around the Sun, and its daily rotation relative to the Sun and the stars. It was a small step for our forefathers to extend the evident influence of the celestial position of one star (our Sun) to all other objects in the night sky. The evidence for that extended influence was quite varied. Sometimes the predictions of the astrologers came true, sometimes not. In the first case, it was taken as a clear proof that the 'science' was right. In the second case, the astrologer must have made a mistake in reading the signs. Political decisions were made, wars were fought and lost on the basis of such astrological forecasts, and a multitude of daily decisions were made following a consultation with a local 'stargazer'.

However, that is all in the past; our times have rid us of myths and superstitions – or have they? The newspapers still publish a daily, or more likely a weekly view of what can be seen 'in the stars'; what the future holds for us. Many aspects of our everyday lives are said to be 'for the best' without any real foundation for that assertion. Myths are usually promulgated because it suits a particular person or organisation. Only when a few real facts are 'introduced into the equation' are myths seen for what they are. Similarly, the dogma of 'deregulation' and 'free enterprise' as being the most efficient use of resources has recently been proved wrong with the spectacular failure of the deregulated financial markets at the hands of banking professionals. In spite of such a failure, deregulation and spectrum auctioning are still in vogue in some parts of Europe.

My recent attendance at a meeting on public-sector spectrum management proved to be very instructive. On the one hand it was shown that licences for UMTS had been sold to the highest bidders to the benefit of the tax payer. However, companies who had bid the most and won had financially crippled themselves so badly in the process that it was hard for them to find the funds to actually invest in the development of the new technology required. Nobody wanted a repeat of the experience and another 'free spectrum' auction – a clear enough case that the 'market' *did not* know best.

Another memorable example was shown from the rescue services: a slide showed tumultuous waves and a drowning man being rescued by a helicopter. The caption read: 'And what is his business model?'. Everybody present agreed that the market approach had failed in public-sector spectrum management, but at the same time everybody wanted to carry on with it! As a result of that approach, astronomers in the UK have lost a number of important frequencies for their research. Some of their long-term monitoring programmes of important astronomical sources are now being curtailed. UK astronomers have less spectrum protected by their own national administration than their colleagues across the Channel. Fortunately, international treaty obligations require the UK administration to ensure that radio emissions in the UK do not spill over national boundaries. It should be clear to everyone that many aspects of our lives are determined by factors other than the more or less free negotiation of a price – not everything is a tradable commodity. Pure scientific research, and radio astronomy belongs to that class, should not be tradable. The taxpayer is paying for radio astronomy; *ipso facto* it is in the public interest. After the very successful investment of previous years, it is hard to understand the possible future loss of the returns from that investment other than to assume that it is a dogmatic adherence to a creed.

Living in a dream world of dogmatic make-believe will end only with a rude awakening, as one has seen happen so many times when bubbles burst in deregulated markets. Let the Year of Astronomy inspire us to look at and understand how our world is shaped. Let us concentrate our efforts to ensure that radio astronomy will not be yet another victim of a simplistic ideology.

**Axel Jessner**
CRAF Chairman

# 1. Report from the 48th CRAF meeting

The 48th CRAF meeting was held on 14-15 May 2009 at the Observatoire de Paris, France. The meeting was attended by 24 CRAF members and friends, among whom were two invited representatives: Philippe Tristant from Meteo France, and Ari Sorsaniemi, from the Radio Spectrum Unit, EC. Hayo Hase (as the new CRAF member of the International VLBI Service) and Hans van der Marel (as temporary representative of ASTRON) participated for the first time at a CRAF meeting. Finally, the ESF was represented by Neil Williams, the new ESF-CRAF liaison officer.

Among many different topics, the following key items were discussed during the meeting:

- **Revision of the Recommendation ITU-R RA 1513**
  In previous work to study the impact of IRIDIUM unwanted emissions on the radio astronomy band 1610.6-1613.8 MHz, limitations became apparent in defining the data loss acceptable to the RAS. A revision of the ITU-R Recommendation dealing with the percentage of data loss was necessary. A revision was prepared and submitted to the ITU as a multi-country proposal.
- **Segmentation of the 1620 MHz band**
  There is ongoing work to produce a new ECC Decision on the harmonisation of the bands 1610-1626.5 MHz and 2483.5-2500 MHz for use by systems in the Mobile-Satellite Service. In this range there is also a primary allocation (1610.6-1613.8 MHz) for the Radio Astronomy Service.
- **Allocations above 275 GHz**
  There is ongoing work at a CEPT and ITU level in finalising the text for the next WRC-12 Agenda Item 1.6 'to review No. 5.565 of the Radio Regulations in order to update the spectrum use by the passive services between 275 GHz and 3000 GHz'.
- **Preliminary draft new Report ITU-R [Essential Role Observations]**
  This report intends to highlight the importance of the scientific services and their relationships with the current major problem areas of climate change, weather, water, space, and disaster prediction, detection and mitigation.
- **High Altitude Platform Stations (HAPS)**
  This issue will be discussed under the next WRC Agenda Item 1.20 with the task 'to consider the results of ITU-R studies and spectrum identification for gateway links for high altitude platform stations (HAPS) in the range 5850-7075 MHz. A written contribution was submitted to relevant meetings, noting the use in Europe of the band at ~6.7 GHz. CRAF highlighted the importance of this band in Europe for e-MERLIN and the EVN.
- **UWB**
  Devices and applications using UWB technology are not compatible with radio astronomy. CRAF attended meetings where the impact of various applications using UWB was discussed. Examples of such applications are automotive Short Range Radars at 24 and 26 GHz and Level Probing Radar.

Host, Wim van Driel (background) and Chairman, Axel Jessner, at the 48th CRAF meeting.

- **Revision of REC. RA 1237**
  The Recommendation ITU-R RA 1237 'Interference to radio astronomy from unwanted (spurious and out-of-band) emissions resulting from applications of wideband digital modulation' has been revised.
- **Exchange of views and ideas with EU commission: a common policy for spectrum protection for European science services?**
  CRAF and EUMETNET voice the opinion that the European Commission should issue European guidelines for the use and protection of scientific radio frequency bands. That should help to ensure that pressure from national interest groups, or ideology-driven policies do not result in the legalisation of spectrum pollution into passive radio bands. Sorsaniemi outlined the constraints on the EC's powers and asked CRAF for more detailed proposals. Consultations with the EC will continue.
- **Galileo**
  Galileo is reported to operate at 1575 MHz with a BW of 40 MHz and a SPD of -75 dB(W/kHz). In the last few months, CRAF has been contacted by the EC Frequency Regulator for the Galileo system in order to organise a technical meeting to discuss the applicability of the limits defined in ITU-R Resolution 769. They admit that they could have great difficulty achieving the limits for the protection of radio astronomy. During the CRAF meeting, it was decided that IUCAF should be involved in the process leading to a consultation with Galileo staff.

The next CRAF meeting is scheduled to be at Jodrell Bank Observatory (Manchester, UK) on 5-6 November 2009.

**Pietro Bolli**

# 2. Solar radio astronomy, global change and space weather

This note gives a brief overview of the importance of radio astronomy in the monitoring of solar activity and the assessment of its impact on the Earth's environment and human technology.

### Overview

The Sun is a powerful radio source, which has been observed since the very early pioneering years of radio astronomy (see Christiansen (1989) for a historical overview). Nearly 10 years after the first observation attempts, the main typical solar radio events are known and most of the techniques used in modern solar radio astronomy are already in place: flux monitoring, spectrography and imaging.

Monitoring of solar activity, and more generally of space weather conditions, now spans several decades of frequencies from the mm to the km range, allowing a tracking of solar events from the photosphere to the interplanetary medium.

### Solar radio observations and climate change

Deciphering the sources of climate change or its very existence is obviously a very important topic in our society and it goes beyond the scope of this short article. For a recent review of the solar influence on the Earth's atmosphere, the reader is referred to Haigh (2007). While the total solar irradiance is known to be the primary force acting on the Earth's atmosphere, the reality of the effects of solar variability on climate change remains to be debated at the present time. In a review paper, Lean et al. (2005) estimate that solar variability accounts for 4% of the surface temperature variance, compared with 43% for all anthropogenic sources.

In considering the above, an important radio index is the F10.7 index, which is often used as a proxy for the Sun's influence on parameters measured on the Earth such as temperature in a given atmospheric layer. The F10.7 index, which is derived from daily measurements of the radio flux of the Sun at 10.7cm, has been measured in Canada since 1947 (initially in Ottawa and more recently at DRAO, Penticton). In effect, measurement of the 10.7cm flux has probably occurred over a longer period of time than any other solar flux measurement, being superceded in length only by the daily international sunspot index.

### Solar radio observations and space weather

In the field of space weather, the F10.7 index is often used as a proxy for the UV and EUV spectral irradiance, which varies from day to day depending on the number of active regions on the Sun. The effects on the thermosphere of the Earth lead to an increase of the neutral temperature and density at a given altitude, producing atmospheric drag on low Earth orbiting satellites. The F10.7 index therefore plays a significant role in the satellite industry; it is used as input in many operational models of the upper atmosphere and its value is forecast on a daily basis by a number of different Regional Warning Centres of the International Space Environment Service (ISES), including the SIDC in Brussels.

Other aspects of space weather rely on radio observations. Solar events, such as flares or coronal mass ejections, might trigger shock waves that propagate in the solar corona or in the interplanetary medium. These shocks are detected primarily through their specific signatures (known as type II bursts) in radio spectrograms in the metric range (corona) up to the kilometric range (interplanetary medium). With a minimal assumption of the electron density profile along the trajectory of the propagating disturbance, it is possible to estimate its velocity in the corona or in the interplanetary medium. Arrival time at the Earth can then be deduced with reasonable accuracy, leading to an early warning of potential risks to satellite operators, telecommunications etc.

Radio monitoring networks are being developed to provide nearly continuous measurement of the solar flux. The Callisto project, led by the ETH Zürich Institute, is one example of such an effort using spectrographic measurements. The Royal Observatory of Belgium is a partner in this network, with one Callisto receiver in the south of Belgium. It is also involved in a Canadian project led by DRAO and NrCan to extend the time coverage of the F10.7 index.

**Table 1.** Spectral bands and observational methods used in solar radio astronomy.

| Method | Flux measurement | Spectrograph | Imaging |
|---|---|---|---|
| **Frequency range** | 100 MHz – 400 GHz | Few kHz – GHz | 150 MHz – 34 GHz |
| **Usage** | • Irradiance and solar cycle variation (long-term activity indices)<br>• Flare physics | • *In situ* plasma physics, flares, shock signatures | • Solar activity monitoring<br>• Coronal mass ejections |
| **Observatories (examples)** | Penticton, Trieste, CASLEO | ETH Zürich, Izmiran, WIND | Nançay, VLA, Nobeyama |

**Conclusion**

Radio monitoring of solar activity has an important economic potential. However, like other radio astronomy studies, it faces more and more difficulties because of man-made emissions, especially because solar spectral events occur over several decades of frequency: in the metric-decimetric range for example, observations appear to be increasingly affected by the development of digital broadcast systems. An important historical and operational space weather index such as the F10.7 flux relies on observations at an unprotected radio frequency, which might be a problem in the future.

**Christophe Marqué and Frederic Clette**

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# 3. UK spectrum policy

For approximately 100 years, spectrum in the UK was managed by the public sector and, in general, the spectrum authority decided on both the use of a particular band, and, if the band was not a purely passive band, who was allowed to transmit in the band. The management method has recently been referred to as 'Command & Control' by Ofcom and, as far as radio astronomers were concerned, there was no payment for the use of the spectral bands identified as being for the use of radio astronomy according to the UK Frequency Allocation Tables. The ITU Recommendation, ITU-R 769, lists the bands normally in use for radio astronomy and gives the detrimental levels of interference, urging all administrations to adopt these levels for the protection of radio astronomy, which the UK did for those bands that it had agreed should be for primary radio astronomy use. Having noted that there were many more people who were now interested in using the radio spectrum, the UK Government realised that this could be a source of immense income and commissioned a 'Review of Radio Spectrum Management' in 2001 and – not surprisingly – adopted its findings. (The cynic would say that all government reviews produce results that the government wants!) The new management method was called 'Market Based' or 'Market Forces' and effectively meant that the government initially assumed ownership of all spectrum, which could then be sold for its financial benefit. So, spectrum auctions have come into being, with the highest bidders being given not only licences to use the spectrum, but also the right to trade their 'Rights of Use'.

For radio astronomers without the funding to bid in commercial auctions, a sum of money was provided by the UK Government to the then PPARC (now the Science and Technology Facilities Council, STFC). Initial fees for the use of spectrum shared with commercial organisations were set on a telescope-site basis by Ofcom dependent upon the number of occasions that commercial organisations had been prevented from using the shared spectrum because of previous radio astronomy use. (This will be reviewed in future years.) A not insignificant administrative fee was also set for those bands of little commercial interest, such as purely passive ones. As the money made available did not cover the cost of all the bands that one might wish to use, the result was that radio astronomers applied for Recognised Spectrum Access (RSA) for individual telescope sites for bands in the order of what were considered to be the most important at that time. Once the sum of money available for the payment of spectrum had been used, then RSA could not be obtained for any further bands. Effectively, those bands for which there was no money remaining had to be given up. In fact, funding was provided to pay for the use of spectrum shared with commercial users for our CURRENT telescope configurations as indicated in Ofcom lists. However, this meant that one of our MERLIN telescopes, which currently does not operate at K-Band frequencies, could no longer be protected at those frequencies, and can perhaps now probably never be sensibly upgraded. Commercial organisations can now start to transmit in its vicinity and, once such links are installed, it will probably be impossible to have them removed.

One of the first auctions, at wavelengths of ~11 cm, has highlighted even more the problems for radio astronomy, and what some astronomers believe could be the ultimate destruction of radio astronomy in the UK, and perhaps in the northern hemisphere if the UK Government persuades other European governments to follow their policy. The bands, originally selected very many years ago on scientific grounds for radio astronomy use, occur throughout the radio frequency spectrum. However, this has meant that a spectral range identified for auction is likely to contain a radio astronomy band. If this band or channel, and in particular the adjacent channels, cannot be auctioned, a considerable loss of income would result. In the UK there has been pressure from the licensing authority for radio astronomers to give up their use of the most commercially valuable bands. This was particularly the case for the passive band from 2690 MHz to 2700 MHz, because it has been little used for observations in the UK in recent years. Although the band has still been retained as a passive band, the protection that will in future be afforded to it from 'spill-over' from adjacent channels will not necessarily be at the level defined in ITU-R 769. This means, of course, that should future science once again require the use of the band, as it most certainly could as new discoveries are made, its use will be severely limited for UK astronomers.

More recently, the introduction of digital broadcasting has meant the reorganisation of spectrum in such a manner as to make available another very large amount of spectrum to be sold-off. Not surprisingly, the presence of a radio astronomy band at ~610 MHz ( = channel 38 ) meant that the possibilities for the most profitable commercial sale could not be achieved if the band remained

in use for radio astronomy. Following a number of discussions between Ofcom, STFC and the radio astronomers, the radio astronomers were forced to agree to give up the use of the 610 MHz band in 2012. In fact, more recently, following further considerations by Ofcom, there has been further pressure to give up the use of the band before 2012. One cannot help but ask oneself what frequency will be next.

Radio astronomers in the UK also share a number of bands with the Ministry of Defence (MoD), who have managed a significant fraction of the entire radio spectrum for many years. Three of these bands are of particular importance for UK radio astronomy. However, the MoD is also going to have to pay commercial rates (and by implication so are the astronomers) for the spectrum that they use and manage. With limited funding for the payment of spectrum access, the MoD will also have to give up as much spectrum as possible, obviously enabling the UK Government to make even more money from its sale. Until now, the radio astronomers and the MoD have helped each other and shared spectrum access to their mutual benefit without any financial accounting and its associated costs. Sadly, it appears that this could end.

**Peter Thomasson**

# 4. Wind turbines

Generating electricity by harvesting wind power is one of the few sustainable ways of power generation with minimal $CO_2$ emissions. CRAF is aware of the grave environmental and energy problems facing humanity on a global scale and welcomes all efforts to find a sustainable solution. As a consequence, CRAF is not opposed to wind power generation per se, but the special requirements of radio observatories may in some cases impose a restriction on the deployment of tall radio-reflecting structures, such as wind turbines, near them. Tall structures, such as wind-power generators within the line of sight of an observatory's antenna, can function as primary or secondary transmitters of interfering radio power. The source in the former category could be the turbine generator electronics, in the latter it could be electronic equipment such as mobile phones, radar, radio links, etc. Simple calculations show that the magnitude of interference from wind turbines several kilometres away from a radio telescope may exceed the recommendations in ITU-RA 769. Adding the path-loss from the wind generator to the telescope to the protection levels given in ITU-RA 769 gives an estimate of the maximum levels of all emissions in the protected radio astronomical bands at the location of the generator. The operators of a wind farm must ensure that the sum of direct and reflected radio power does not exceed these limits. It should be emphasised that there is no absolute limit beyond which a wind turbine does not constitute a disturbing source apart from horizontal distance. For a wind turbine with a height of 100m above the sea, this distance is equivalent to just over 50km for a telescope with height of 20m above sea level. The interference problem is very complex and also very difficult to determine empirically. Test results are often ambiguous, and it would be a fallacy to use the induction principle from single observations in singular circumstances since they may not be at all representative. One may also note that the area which needs to be protected is small and does not significantly influence the energy production of a country.

The above should be a sufficient argument for the precautionary principle to avoid building wind turbines near radio telescopes. The situation is, however, different across Europe: some countries do have coordination zones around their radio telescopes while others have to argue on a case by case basis at great length with the local authorities. Planning permission for tall structures in the vicinity of a radio observatory should be given only if it can be ascertained beyond reasonable doubt that there will be no additional radio interference or other changes to the radio background for the observatory. Impact studies have been made for a number of other services and there is already an extensive literature available on the subject. CRAF would welcome CEPT WG-SE submitting a new work item called, for example, 'Impact of wind turbines on existing radio services' having as its outcome an ECC Report or perhaps even an ECC Decision to simplify the process.

**Michael Lindqvist and Axel Jessner**

# 5. Kick-off of the CRAF Spectrum monitoring

The Radionet Working Package 5 (related to Spectrum Management) has been funded in FP7 with an extra 10K Euro to develop a common RFI monitoring scheme for all the EU observatories. The main purposes of the system are:

- to harmonise the monitoring measurements;
- to coordinate common procedures in reporting interference to national administrations;
- to realise a central repository across Europe.

Therefore, WP5 will conduct a preliminary feasibility study for a common monitoring scheme (hardware and data format) for all European sites. The benefit of such an implementation can be summarised in the sentence: 'no proof of interference, no damage'. Radio astronomers have the right to ask for protection when interference occurs; therefore a network of RFI monitoring systems will certainly help to produce the necessary evidence.

The 48th CRAF meeting was the occasion of the kick-off of CRAF Spectrum monitoring. During the meeting, several monitoring systems already operating at the European observatories were shown. Among them were the Callisto system developed by C. Monstein, and the RFI stations working in Westerbork and in Sardinia.

A new RFI data base exploiting the MySQL engine with a simple Web-interface is now under construction; it will collect RFI information from all the European radio telescopes.

**Pietro Bolli**

**Committee on Radio Astronomy Frequencies (CRAF)**

CRAF is an Expert Committee of the European Science Foundation. Established in 1988, it represents all the major radio astronomical observatories in Europe. Its mission is to coordinate activities to keep the frequency bands used by radio astronomers in Europe free from interference.

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