

PRESENTACIÓN ORAL

The antenna DSA 3 and its potential use for Radio Astronomy

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Abstract. The European Space Agency (ESA) will inaugurate its third Deep Space Antenna (DSA 3) by the end of 2012. DSA 3 will be located in Argentina near the city of Malargüe in the Mendoza province. While the instrument will be primarily dedicated to communications with interplanetary missions, the characteristics of its antenna and receivers will also enable standalone leading scientific contributions, with a high scientific-technological return. We outline here scientific proposals for a radio astronomical use of DSA 3.

Resumen. La Agencia Espacial Europea (ESA) inaugurará, a finales de 2012, la tercera antena de espacio profundo (DSA 3), en suelo argentino (Malargüe, Mendoza). El instrumento se dedicará principalmente a comunicaciones con misiones interplanetarias. Dadas las características de la antena y receptores, con la DSA 3 se podrán realizar contribuciones científicas de punta, con un alto retorno científico-tecnológico. Aquí se delinearán propuestas científicas para su uso radioastronómico.

1. Introduction

The purpose of DSA 3 is to provide support to ESA interplanetary missions, like Mars Express, Venus Express, Rosetta, and the upcoming BepiColombo. DSA 3 will have an antenna of 35 m in diameter (D) and will work receiving and sending radio signals in two frequency bands, X and K_a (about 8 and 32 GHz respectively). To make contact with missions typically located at three million kilometers and beyond, the use of low-noise amplifiers cooled to cryogenic temperatures is mandatory, along with highly accurate pointing and calibration. The facility will also have devices for tracking, telemetry modulation and demodulation, telecommand and data, radiometric and meteorological measurements.

ESA already has two of these stations: DSA 1 in New Norcia (Australia) since 2002 and DSA 2 in Cebreros (Spain) since 2005. These antennas, also of $D = 35$ m, are currently the largest ones operated by ESA. DSA 3 will complement ESA deep-space network, ensuring around-the-clock coverage for their interplanetary missions. In return for harboring DSA 3 within its territory, ESA offers Argentina the use of up to 10% of the observing time, which will

represent an outstanding advantage for the local scientific community. Given the unique technical features of the instrument, this fraction of time can be utilized for first-level research in the radio astronomy field and in astrophysics in general.

2. Proposals for scientific use of the Deep Space Antenna 3

The main instrumental parameters of DSA 3 are given in Table 1¹. Scientific proposals would be selected according to their academic excellence by peer reviewers. The host country has researchers formed in Radio Astronomy, that can make an intensive use of DSA 3 and, simultaneously, train new radio astronomers using the facility. **Studies on the sources mapped using DSA 3 will be further deepened with the tremendous imaging resolution (< 1 arcsec) of the forthcoming ALMA dishes at Band 1.** Forefront research lines that can be carried out during the host country observing time are presented below.

Observing bands; band centers (GHz)	X ; 8.45	K_a ; 32.05
Bandwidths (MHz); Angular resolution (arcmin)	100; 4.4	200; 1.1
T_{sys} (K); Expected ($t=1\text{s}$) continuum sensitivity (mK)	18; 1.8	30; 2.0

Table 1. Main parameters of the instrument DSA 3.

Unidentified gamma-ray sources. Last-generation gamma-ray telescopes, such as the FERMI satellite, and the H.E.S.S. I and II arrays (Namibia), continuously monitor the southern sky and are detecting thousands of sources of very high energies (e.g., Fermi-LAT 2nd Source Catalog 2011 and Aharonian et al. 2008, respectively) with angular resolutions comparable to those of the DSA stations. An important part of the detected sources ($\sim 30\%$) cannot be identified as they do not have a counterpart in other energy ranges. The existence of a physical relationship between radio and gamma-ray emission has been known for decades (Ginzburg & Syrovatskii 1965). DSA 3 will be a critical tool to determine the nature of the unidentified sources, and to study the processes that contribute to the radiation. Just to underline the importance of the subject, we remark the amount of resources allocated to instruments looking at high-energy sources, the number of scientists committed to solve the underlying problems and the amount of related articles published on a daily basis.

The radio galaxy Centaurus A. Cen A harbors the closest supermassive black hole. However, its proximity implies a large source angular extension, which prevents us from observing it with radio interferometers at intermediate frequencies (10 - 30 GHz, Israel 1998, Israel et al. 2008, etc). An instrument like DSA 3 can obtain data from all Centaurus A in a few days of observation. For the sake of comparison, the Australia Telescope Compact Array took about

¹Competitive facilities with similar observational capabilities, in Australia, are either oversubscribed -like the Parkes Telescope-, or have very restricted availability (NASA DSS43 & 34, up to 200 h/yr) mostly attached to VLBI programs.

2 years to map Cen A at 1.4 GHz (Feain et al. 2011). Observations at different frequencies could also provide information on the emission mechanisms. Moreover, the study of the magnetic fields and the relativistic particles involved will be possible by the fully polarimetric information that DSA 3 will supply.

Variability of Active Galactic Nuclei. With DSA 3 it will be possible to perform variability studies of brightness and polarization degree of Active Galactic Nuclei (AGN) emission in a very efficient way. Studies on time scales of hours to years will report on the accretion process on the galaxy's central black hole, still poorly known. Multi-frequency data from a large sample of AGN will allow the study of the physical processes that support the variability of individual objects, and also of the differences between different classes of AGN (e.g., Hovatta et al. 2008, Gliozzi et al. 2009). The advantage of time series analysis is that the information is gathered independently of the AGN type, and that the results complement those found by means of spectroscopic studies.

Supernova remnants and HII regions. The measurement of the fluxes both at the X and K_a bands can be used to discriminate the nature of the source observed; in particular, SNRs and HII regions. Over 50% of the Galactic SNRs are above the limit of detectability offered by the DSA 3, even at 32 GHz. For those of larger angular size, it will be possible to study spatial variations of the spectral index and to measure directly the direction of the magnetic field. Parameters of the HII regions will be obtained from the measured fluxes, such as the mass of ionized gas and the electron density. K_a -band observations will be essential to elucidate, for example, why, although expected, there is no radio continuum emission towards a number of O-type stars, or how significant is the contribution of the surrounding background emission to the measured flux.

Physics and chemistry of proto-planetary clouds. Interstellar dark clouds are the places where stars and planets are formed. The knowledge of their chemical composition is essential to understand how matter in the Universe evolves to planets and life (e.g., Cernicharo et al. 2008). The study of these clouds helps not only to determine chemical abundances, but also their growth (e.g. Ohishi & Kaifu 1998). The instruments used to date, besides having a very high oversubscription, are all in the Northern Hemisphere (NRO Nobeyama-45m, 100-m Effelsberg, Onsala OSO-20m, IRAM-30m dishes), with a declination limit $\sim -25^\circ$. In addition, the observing bands are above 75 GHz for all but NRO while **DSA 3, in comparison, fills a niche covering 8 - 32 GHz bands**. An instrument like DSA 3 will be ideal, and in many cases the only option, to study southern dark clouds, given its great sensitivity, adequate angular resolution and fast coverage.

“Flickering” and the interstellar medium. The interstellar material present in the line of sight towards another galaxy, produces an effect of scintillation or “flickering” of the extragalactic radiation. The study of this phenomenon is an important tool to gain information about the small scale inhomogeneities in the electronic component of the interstellar medium (e.g., Bochkarev & Ryabov 2000). The variability in brightness is produced by the refraction of light that traverses, at high speed, a hot gas permeated by shock waves. Studies of variability -in this case, extrinsic to the object- can be conducted in different time scales (days to years) with DSA 3.

Rotating radio transients. With DSA 3 it will also be possible to search for transient events in radio waves just as with NASA deep space antennas (Buu et al. 2011). The so-called RRATs (Rotating RADio Transients) have been recently discovered (McLoughlin et al. 2006, Lorimer et al. 2007) as sources of very intense pulses that may be of extragalactic origin. The physical description of these rare objects is proving to be a challenge to such an extent that they are considered testers of basic physics and astrophysics.

3. Scientific and technological return

The excellent quality of the state of the art components of DSA 3 guarantees benefits to radio astronomy that are of great importance in leading areas. Since the bulk of the investment is provided by ESA, the use of DSA 3 for radio astronomy ensures a maximum benefit/return to science and technology with a minimum of cost/investment. Furthermore, observing during all the host country time will re-position Argentina as a world class player in the Radio Astronomy arena.

Besides the advancement of the knowledge frontier in the outlined lines of research, some of the additional benefits that can be attained through DSA 3 include:

- Insertion of Argentina in the radio astronomy research mainstream.
- International collaborations with top-level groups.
- Publication of results in international high-impact journals.
- Training of technicians and engineers in the priority area of Information and Communications Technologies (ICTs).
- Training of scientists and engineers at graduate and postgraduate level.
- Technological developments in electronic engineering and software.
- Transfer of technology in communications, instrumentation and control, digital signal processing, frequency and time metrology.

Acknowledgments. The authors are grateful to the ITeDA staff and to Nora Loiseau. P.B. thanks support from PICT 2007-00848, ANPCyT. E.R. and S.C. are supported by UBA and CONICET grants.

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