CASSACA Post-Doc Research Topic Proposal

Digital signal processing development for the next generation single-dish radio telescopes.

Host Professor: Ricardo Finger
Host Institution: Department of Astronomy, Universidad de Chile
Keywords: Astronomical instrumentation, Digital spectroscopy, Pulsar detection.
Duration: 2 or 3 years

General context and previous work

The Millimeter Wave Laboratory (MWL) of the Department of Astronomy (DAS) of the University of Chile (UCh), has been developing digital back-ends for radio astronomy since 2010. As part of the CASPER collaboration we have implemented wideband FPGA-based digital spectrometers as well as new digital signal processing techniques, particularly calibrated digital sideband separation. We have demonstrated beyond state-of-the-art image rejection and two ISI papers [1][2] have been published in this field.

Starting in the second half of 2014, the MWL, has been working on a spectrometer based on a set of specifications proposed by Dr. Ran Duan, Chinese Academy of Sciences. The requirements are motivated from future needs of the FAST telescope, a project lead by Professor Di Li, who recently visited (March 2015) DAS. Equipment needed for this development was procured with the help of Professor Zhong Wang (CCJCA) in 2014. An engineering thesis [3] was carried out to develop a 1.8 GHz, 32K channels digital spectrometer. The spectrometer also achieved a very large dynamic range (~40 dB) by the use of the full 8-bit resolution of the digitizers in the computation of the Fast Fourier Transform (FFT).
A second ongoing project aims to develop a very high spectral resolution (megachannel) spectrometer directly implementing the Cooley-Tukey FFT algorithm in a Field Programmable Gate Array (FPGA) chip. A Chinese researcher (Mr. Chenwei Cai) is currently on internship at the MWL to develop algorithms for this project. First results are expected for mid-2015.

Research Proposal

We propose to develop a new generation of digital back-ends incorporating the latest digital signal processing technology, particularly focused in high spectral resolution, high dynamic range spectrometers; pulsar machines; digital sideband separating spectrometers, digital polarization detection (digital OMTs) and RFI management. We plan to host a joint postdoc to work in China and Chile, first to survey the needs of Chinese telescopes and translate them into technical specifications, and second, to develop algorithms and implement prototypes of such digital processors at the MWL in Chile.

References

[1] A Sideband-separating Receiver with a Calibrated Digital If-Hybrid Spectrometer for the Millimeter Band. R. Rodrguez,F. P. Mena, N. Reyes, E. Michael, R. Finger and L. Bronfman. Publications of the Astronomical Society of the Pacific, Vol. 126, pp. 380-385 (2014)

[2] A calibrated digital sideband separating spectrometer for radio astronomy applications, R. Finger, P. Mena, N. Reyes, R. Rodriguez, L. Bronfman. Publications of the Astronomical Society of the Pacific, Vol. 125, No. 925, pp. 263-269 (2013).

[3] RAÚL IGNACIO SAPUNAR OPAZO., "DISEÑO E IMPLEMENTACIÓN DE UN ESPECTRÓMETRO DE ALTA RESOLUCIÓN BASADO EN FPGA PARA EL ANÁLISIS DE SEÑALES RADIO-ASTRONÓMICAS". MEMORIA PARA OPTAR AL TÍTULO DE INGENIERO CIVIL ELÉCTRICO. FACULTAD DE CIENCIAS FÍSICAS Y MATEMÁTICAS. UNIVERSIDAD DE CHILE. (2015). http://www.das.uchile.cl/lab_mwl/publicaciones/Tesis/memoria_final_rs_cybertesis_final.pdf