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TESTING THE BRAGG CELL OF AN ACOUSTO-OPTICAL SPECTROMETER FOR RADIO ASTRONOMY

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In this work we present the test of the relation between the diffraction angle by a Bragg cell (acousto-optical cell), and the position in a linear photo-detector of the focused beam for an Acousto-Optical Spectrometer (AOS). The evaluation was made comparing a synthetic electrical signal spectrum obtained with our AOS against a calibrated spectrum. We discuss the current optical arrangement and propose improvements for the final version of this instrument.

Several studies in radio astronomy have required the development of spectrometers with high spectral resolution and wide bandwidths. At 43 GHz a velocity range of 10^3 km s^{-1} correspond to 143 MHz, while some of the narrowest line widths reported are between 10 to 20 kHz. The goal for this AOS design is objects with narrow line width.

The principle of operation of the AOS is based on the acousto-optic effect, i.e., the diffraction of light by mean of acoustic waves. This effect was predicted and described in 1922, since then, many theoretical and technical developments were made, but this took more importance with the development of the laser in the 60's. At present AOS's has been part of the space projects like SWASS and HERSCHEL (Schieder et al. 2003).

A simplified view of AOS functioning is: The intermediate frequency (IF) is transduced to an ultrasonic wave and injected into a medium (TeO_2 crystal), the changes of pressure into the crystal modify the refractive index (photo-elastic effect), so that a beam of monochromatic light passing through the crystal lattice will be diffracted in different angle as function of frequency of acoustic wave.

It has been estimated that with a cell made of TeO_2 with the optical window of 40 mm, we could reach a spectral resolution $\sim$16 kHz, moreover using a linear photo detector with 3000 pixels the total bandwidth could be $\sim$24 MHz in the theoretical limit (Herrera-Martínez et al. 2009).

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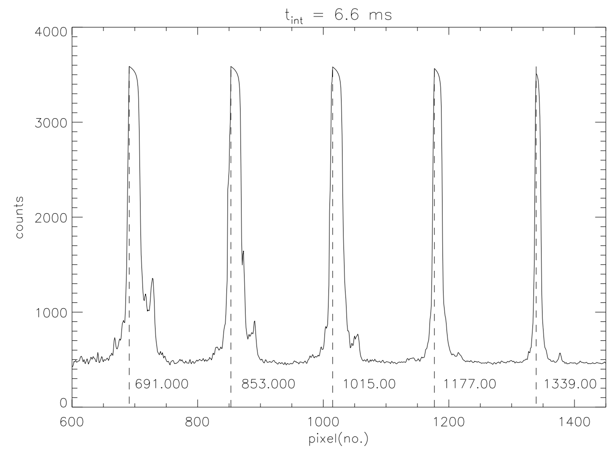

Fig. 1. Spectrum of the tested signal obtained with the acousto-optical cell. The dotted lines indicate the position of diffracted beam maximums on photo detector, the distance between these are equally spaced.

The test signal used in this stage consists of a sweep of different frequencies starting from 50 to 90 MHz with a step of 10 MHz. The spectrum of this signal, obtained with the acousto-optical cell, is shown in Figure 1. The separation between maxima holds a linear relation between frequency and number of pixel in the photo-detector.

An acousto-optical cell for a spectrometer with capabilities for high resolution was tested. The actual performance with this optical array for the spectrometer, gave a frequency resolution about 34 kHz. Currently, improvements on optical design of the focusing system are ongoing. Alternative options for the beam expander (Shcherbakov et al. 2007), and diode laser modules are under implementation. An intermediate stage for coupling the spectrometer to a radio telescope is in construction for future uses in radio astronomy.

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