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THE ACOUSTO-OPTIC SPECTROMETER OF THE 2.4 m IAG-USP RADIOTELESCOPE

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RESUMO. Descreve-se um analisador espectral acusto-óptico compacto e seu sistema de aquisição de dados, desenvolvido para observações radioastronômicas com a antena milimétrica de 2,4 m da Universidade de São Paulo.

ABSTRACT. We describe a compact acousto-optic spectrometer and its data acquisition system, developed for radioastronomical observations with the 2.4 m millimetric antena of the University of São Paulo.

Key words: INSTRUMENTS — RADIO TELESCOPES

. INTRODUCTION

Two different spectrum analyzers have been constructed for the observation of olecular lines with the 2.4 meter diameter millimetric radiotelescope of the University of ão Paulo (Lepine and Raffaelli, 1989). One is a filter bank, with 50 channels and 300 kHz esolution. This system is convenient for absolute calibration, but its velocity coverage only 39 kms^{-1} for the CO J=1-0 transition at 115 GHz) is too small for many applications. The econd spectrum analyzer, described in the present paper, is an acousto-optic spectrometer, hich presents the advantage of being compact, easy to adjust, and has a large bandwidth which an be changed by substituting the Bragg cell.

I. THE WORKING PRINCIPLES OF THE INSTRUMENT

The main components of the acousto-optical analyzer are: a coherent source of llumination (He-Ne laser), a Bragg cell, a Fourier lens, prisms and mirrors, a CCD camera and data acquisition interface. The schematic of the instrument is shown on fig. 1.

The working principle of the acousto-optic spectral analyzer is the following:

A radio frequency signal with central frequency of the order of 60 MHz and overall andwidth (at -3 dB) of 40 MHz is injected in the Bragg cell through a electromechanical ransducer ($LiNbO_3$), which is attached to the Paratelurite crystal. The transducer generates coustic waves which propagates through the crystal, carrying the amplitude, frequency and hase information of the original radio signal (Uchida, 1973; Chang, 1976).

The expanded laser light waves incident in the cell, with an angle denoted as ragg angle, interacts with the acoustics waves which characterize the acousto-optic nteraction, diffracting them through an angle that is function of the acoustic frequency. In his condition we can say that the system is operating under the Bragg regime.

The deflected optical beam intensity is proportional to the intensity of the coustic wave that is travelling through the crystal and the deflection angles of the optical

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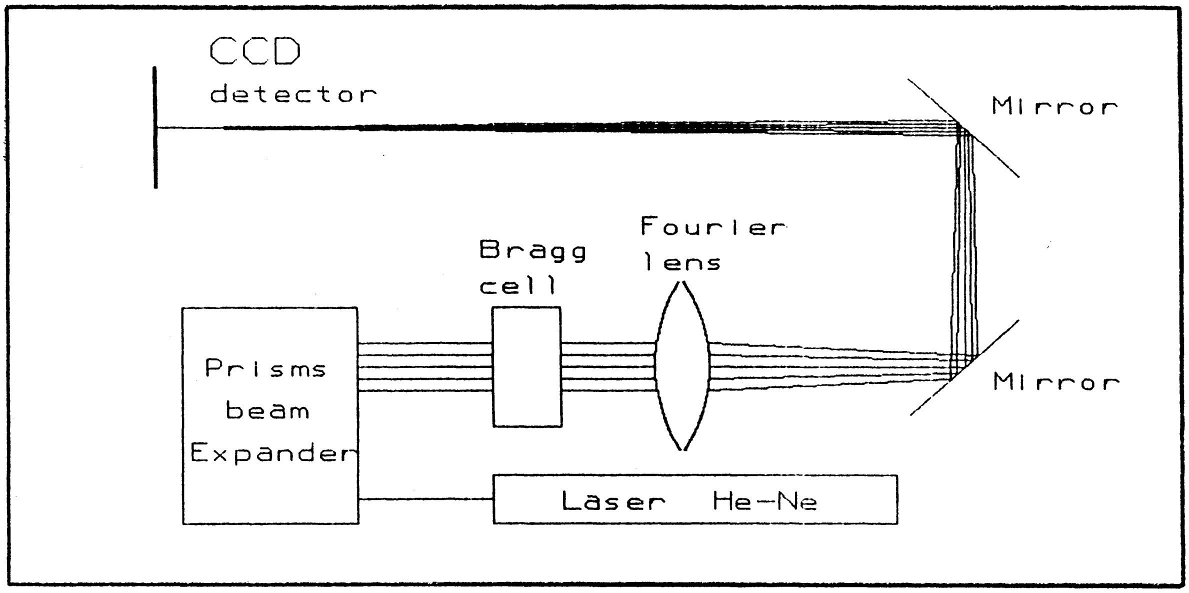

Fig. 1. Schematic of the acousto-optical spectral analyzer.

beam correspond to the interval of radio frequencies that are limited by the transducer. The record of the first order diffracted beam is made after focalization on a linear photodetector array (1728 pixels), through an optical system (Fourier lens). The image obtained on the CCD camera contain the information on frequency and amplitude of the signal being analyzed.

III. DESCRIPTION OF THE SPECTROMETER

In our system the laser beam expansion is produced by a set of prisms. The maximum resolution of a system is obtained when we take the largest possible region of the acousto-optic interaction (Uchida, 1973; Chang, 1976). This is achieved by expanding the optical beam to cover the window of the cell. Two different techniques are commonly used: prisms expanding system (Malkamaki, 1981) and lens expanding system. We decided for the former because it is not so critical to manipulate as the lens system. Using prisms a compact configuration can be achieved, keeping the parallelism of the expanded beam, which is necessary to guarantee the uniform resolution of the system. The lens expanders are difficult to adjust, and for a precise focusing of the lens, i. e., to adjust its focal distance and optical axis, one needs micrometers and the whole process is very time consuming. In fig. 2 we see the geometric disposition of the prisms and the expansion effect obtained.

The Bragg cell uses a Paratelurite crystal (TeO_2) and was constructed by the Matsushita Electronic Components Co., Ltd., Kadoma, Osaka, Japan. In the future we intend to use a $PbMoO_4$ cell.

The camera is a device that has a CCD detector associated to the amplification and control electronics. It utilizes a Thomson TH7803-CD detector (1728 pixels) and was build in Meudon Observatory, France (Raterron, 1985; Teisson, 1985). The optical signal (which is analogic) is accumulated during about 50 ms, for each readout of the 1728 pixels. Longer integration are avoided in order to decrease the dark current contribution and to avoid the saturation of the system. When asked by the data acquisition microcomputer the camera transmits the video output, that corresponds to the optical signals accumulated in each photodiode, to an acquisition and analogic to digital data conversion interface. A clock circuit controls the readout output and send signals to the CCD at time intervals of 30 micro-sec. One complete readout take 51.84 ms.

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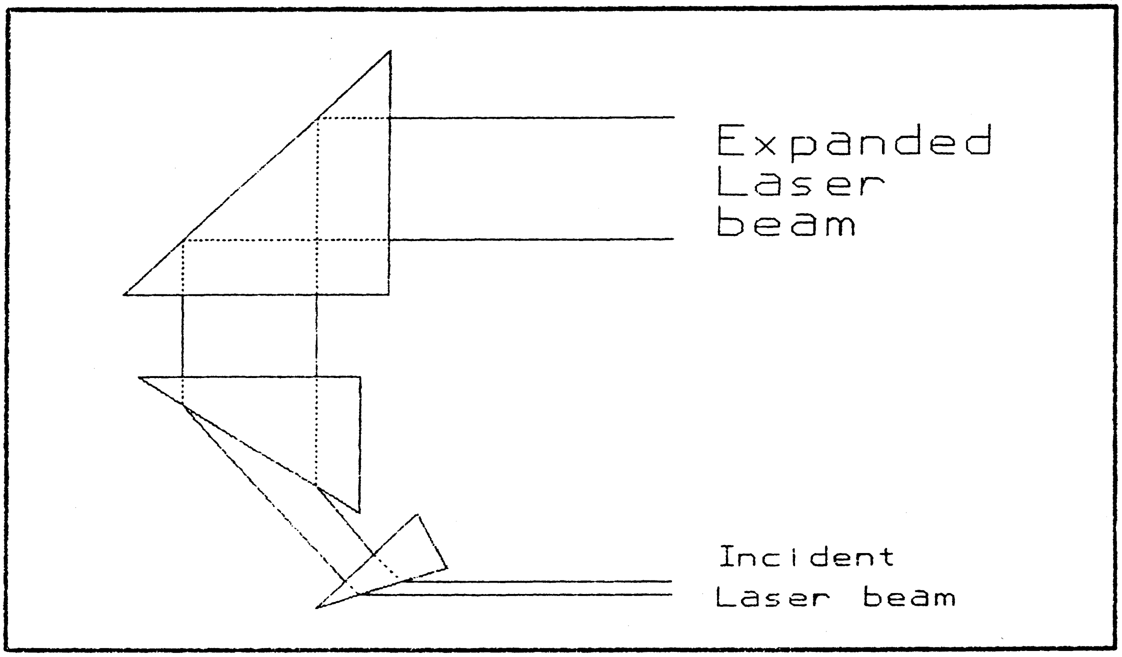

Fig. 2. Prisms beam expander. The light beam of a He-Ne laser is expanded to illuminate uniformly the Bragg cell.

The data acquisition interface converts the analog signal to a digital signal, compatible with the dat bus of an 8 bit PcXT microcomputer. The main steps involved in the data acquisition process are the following:

The microcomputer send a pulse to the CCD camera, that will initialize the internal transfer phase which shifts the contents of all the photodetectors to the analog shift registers. Then, the internal clock (30 micro-sec) of the CCD camera will control the readout output transfer phase of the signal to the interface.

The microprocessor of the microcomputer makes the monitoring of the readout output transfer control signal, identifying when the contents of a photodiode is available at the video output. This control signal is coupled to the internal clock of the CCD camera, which permit identify the pixels and their contents.

After the identification of the instant in which the contents of a pixels is available at the video output, the analog to digital conversion is initiated by a control signal coming from the microcomputer. At the same time the contents of the previus photodetector is read at the output port of the A/D converter and saved in the microcomputer PcXT memory.

When the cycle is completed, the procedure is repeated or the job ended, depending of the operator necessity.

The data obtained in each cycle and that is accumulated in the microcomputer memory can be saved in floppy diskette or hard disk, in a file whose name is choosed at the beginning of the observation.

The radio spectrum feed into the Bragg cell is seen graphically in the high resolution screen of the video monitor. Once identified the areas of greater interest we select part of the spectrum and expand it.

Fig. 3 shows a spectrum obtained on the screen of the video monitor; The signal was produced by a laboratory frequency generator set at 60 MHz. The resolution of the system was obtained by calibrating the frequency scale with the generator. With the TeO_2 Bragg cell, we obtained a resolution of 84 kHz, using the Rayleigh criterion.

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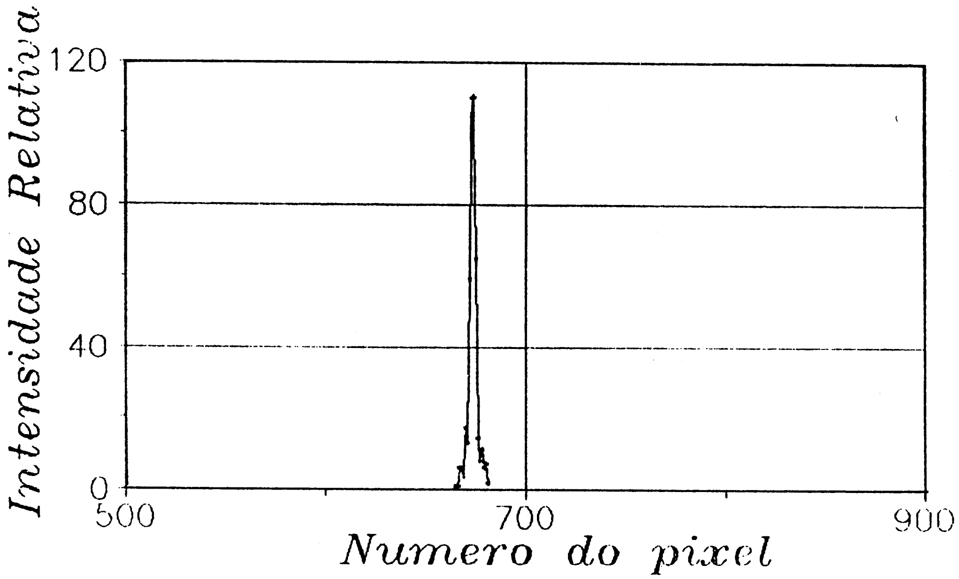

Fig. 3. Spectrum from a laboratory frequency generator set at 60 MHz.

IV. CONCLUSION

We have assembled a compact acousto-optic spectrometer to replace the multi channel system installed in the 2.4 meter diameter CO radio telescope. Preliminary results shows that the new system is properly working and data analysis programs are capable to analyze the line observation. As soon the radio telescope restarts its normal operation we will perform a final test of the system.

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