THE GAURIBIDANUR ACOUSTO OPTIC SPECTROMETER

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Abstract:

An acousto optic spectrometer (AOS) with 30 MHz bandwidth and 1760 channels used for obtaining the dynamic spectra of solar radio bursts at Gauribidanur is described.

1.Introduction:

The dynamic spectra of solar radio bursts have been used to obtain the characteristics such as drift rate, bandwidth, harmonic structure etc which are related to the physical characteristics of the source. Dynamic spectra of solar radio bursts have been obtained in the last decade using swept frequency spectrographs , Multichannel filter bank receivers and autocorrelation spectrometers. Due to differential drifts and calibration problems the need was felt for wideband system with good long-term stability that could be adjusted to different needs. In recent years acousto-optic spectrometers (AOS) have established themselves as a reliable and versatile tool for the study of radio bursts from the Sun and Jupiter and molecular lines from astronomical objects.. Here we describe the AOS system used for Solar and Jupiter radio bursts observations at Gauribidanur.

2.Principle of AOS:

Aos makes use of the diffraction of light by ultrasonic waves, an effect predicted by Brillouin [1] in 1921 and Raman and Nath [2] in 1935. A parallel beam of light enters at right angles to a beam of sound waves produced by an electrical signal feeding a pizeoelectric transducer. The transducer is attached to one end of a medium with an absorber at the other end to suppress the reflected waves. An interaction occurs between the sound and the light beams. If the sound amplitude is not great enough to cause any significant deviation of the light rays, the sound beam can be considered as a pure phase grating. Since the modulated light has a spatial variation equivalent to the time variation of the signal, parallel processing of the information is possible. The diffraction can be characterised by the parameter

$$Q = 2\frac{\pi\lambda Z}{n\Lambda^2}[3]$$

where λ is the wavelength of the light beam, Z is the width and n is the refractive index of the interacting medium and Λ is the acoustic wavelength. If $Q >> 1$, the diffraction is said to be in the Bragg regime. Most of the practical wide bandwidth applications of acousto-optics depend on the operation in the Bragg regime, and an acoustical device operating in the Bragg regime is called a Bragg cell. In the Bragg cell the result of the acousto optical interaction is the production of the only two significant beams outside the cell, the undiffracted beam and the diffracted beam. The diffraction angle is $\propto$ to the sound frequency and hence the radio frequency. When a band of radio frequencies are present, each deflects the light at its characteristic angle providing a beam of light in the output plane. Light intensity in the band indicates the distribution of energy across the radio spectrum of the incoming signal.

3.The Gauribidanur AOS system:

The Gauribidanur acousto - optic spectrometer is shown in Fig.1.

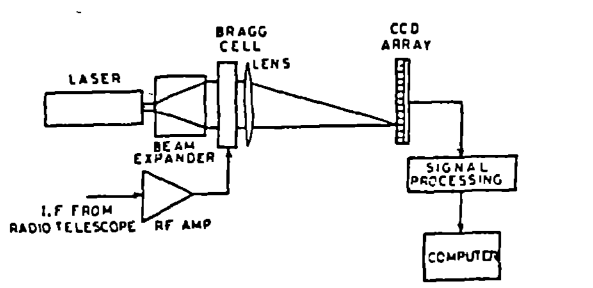

Fig 1 BLOCK DIAGRAM OF AN ACOUSTO OPTICAL SPECTROMETER

The coherent source used is a Helium Neon laser operating at 633 nm with an output power of 2 mw. Using collimation lens and prisms the beam of the laser is expanded in one dimension and the Bragg cell is illuminated. The characteristics of the Bragg cell used are given below.-

Material	TeO_2 - shear (110)
Active aperture	4mmH x 31mmL
Velocity of sound	660 M/s
Input impedance	50 Ohms
Refractive index	2 26

The Bragg cell consists of 1)Pizeo electric transducer,2) Electric impedance matching circuit, 3) Acoustical impedance matching layer, 4) Acousto - optical material and 5) Acoustic absorber.

The time bandwidth product of the Bragg cell is 1760. The diffracted light is passed through a Fourier lens and recorded on a CCD placed at one focal length away from the lens. The CCD consists of 1760 pixels. The output of the CCD is digitized using a 12 bit A/D converter at a conversion speed of 25 microseconds. The output of A/D converter is interfaced to a PC - AT computer. The control and timing signals are derived from the computer clock. The minimum sampling rate is 64 milliseconds. The main characteristics of the Gauribidanur AOS system are given below-

Total bandwidth	30 MHz
Number of channels	1760
Center frequency	45 MHz
Channel spacing	17 KHz
Stabilization time after turn on	6 Hrs
Required temperature stabilization	1 Deg.
Dynamic range	30 Db

4.Observations:

The AOS system is being used along with a broadband array [4] for the study of fine structures in the radio emission of the sun. Fig.2a. shows a typical example of broadband type III radio bursts. Fig.2b shows a typical example of narrowband short duration bursts.

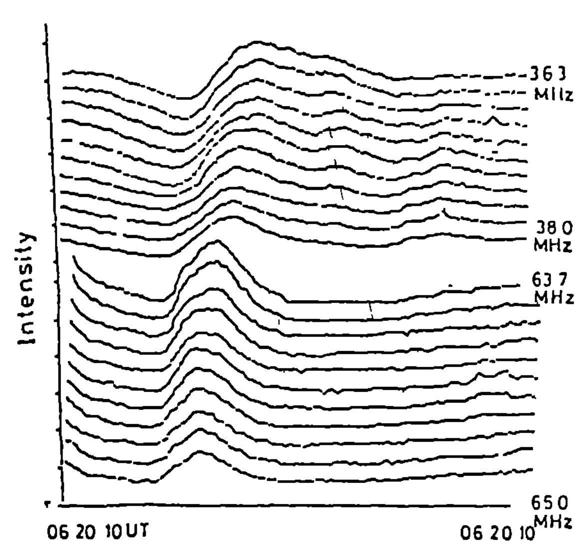

Fig.2a. Typical example of Type III bursts observed with the Gauribidabur AOS system.

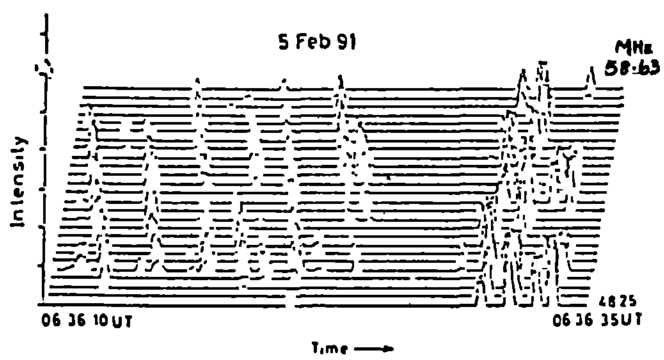

Fig.2b. Typical example of narrowband short duration bursts observed with the Gauribidanur AOS system.

5.Conclusions:

The AOS with capability of parallel processing a large number of channels of a wideband signal has proved to be an effective instrument for obtaining the dynamic spectra of solar radio bursts.

References

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