A 28kHz-RESOLUTION ACOUSTO-OPTIC SPECTROMETER

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ABSTRACT. A 28kHz resolution acousto-optic spectrometer has been established. The modulator is a TeO_2 cell with off-axis acoustic slow shear wave. The convolution between the profiles of the modulator and the photodiode array was considered. Its velocity resolution is 0.07 kms^{-1} for 115 GHz CO molecular lines. The test observations were made by association with the 4-m mm-wave telescope in Australia. Some features of the CO lines in dark clouds have been seen more in detail.

Compared with other types of spectrometer, the cost per channel of an acousto-optic spectrometer (AOS hereafter) is relative cheap (Robinson 1980). But its spectral resolution is difficult to surpass 30kHz because of the limitation of crystal in the modulator (Kaifu et al. 1977, and Winnewisser and Vowinkel 1984). Though some AOS with water modulator have achieved a resolution of 20kHz (Cole and Ables 1974, and Malkamäki 1981), the size is large and the diffraction efficiency and bandwidth are limited.

An off-axis slow shear wave TeO_2 modulator which was developed by the Shanghai Institute of Ceramics, Academia Sinica, has been adopted to construct a high-resolution AOS. The acoustic velocity in the crystal now is 650 ms^{-1}. The effective aperture of the modulator is 34mm. And its nominal resolution is 19kHz. The convolution between the modulator's diffraction and the spatial response of the photodiode array has been computed. The convolution broadens the observed spectral lines. Computation shows when the relative number of N (within a half width of a monochromatic line it contains N elements of the photodiode array) is between 1.5 and 2, the compromise between the loss of resolution and the increase of cost-per-channel is appropriate. In this design we take N= 1.8, the line broadening is 1.07 and the peak uncertainty of a CO J=1-0 line is less than 2%. It is satisfactory for the CO observations in dark clouds.

The light source is a 4mW He-Ne laser. The beam expander is composed of four prisms. The diameter of the Fourier transform lens is 90mm. A beam-fold prism makes the whole equipment more compact. The photodiode

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array is composed of 1024 elements. Each element takes 10.52kHz interval and the whole AOS takes 10.8MHz bandwidth.

This AOS was completed in July 1984 at the Division of Radiophysics, CSIRO. The frequency resolution is 28kHz which was tested by a monochromatic signal from a synthesiser. One of the results of test observations is shown in figure 1. The 115.271 GHz CO line from dark cloud DC337.7-4.0 was observed by the 28kHz-resolution AOS associated with the 4-m mm-wave radio telescope at Epping (figure 1.(b)). Compared with figure 1.(a) that was observed by another AOS which has a middle resolution of 240 kHz (0.6 kms^{-1}) associated with the same telescope, the high-resolution observation shows more details than the other. It appears two conponents on the high resolution result. A secondary component is seen overlaped at the limb of the major one. From the middle-resolution result, the major component looked sharp but the secondary can not be distinguished.

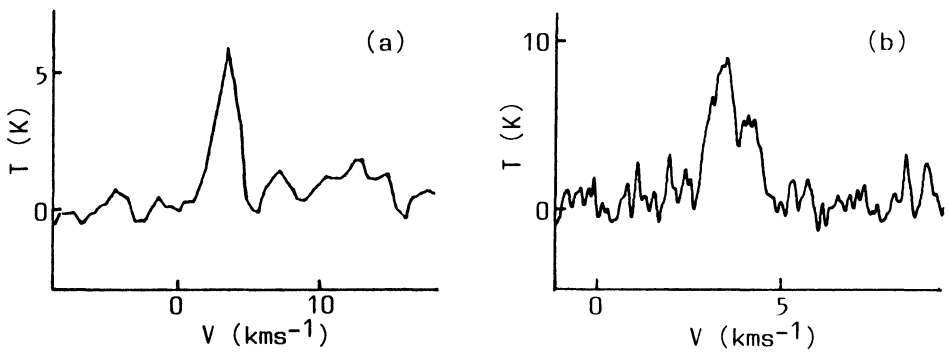

Figure 1. CO line from dark cloud DC337.7-4.0. (a) Observed by a middle-resolution AOS. (b) Observed by the high-resolution AOS.

Evidently, the 28kHz-resolution AOS associated with a mm-wave telescope is a powerful instrument for researches of astrochemistry and astrophysics especially for dark clouds those have very narrow molecular lines.

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