REMOTE ATMOSPHERIC SENSING USING MANDEL'SHTAM-BRILLOUIN SCATTERING OF CO_2 LASER

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ABSTRACT

This paper presents a study of spontaneous Mandel'shtam-Brillouin (M-B) scattering of 10.6 μ CO_2 laser light in the atmosphere. Since the wavelength of this laser light is much longer than the mean free path of the molecules (STP), radiation will not be scattered by individual molecules but rather by larger random density inhomogeneities. These density fluctuations move with the speed of sound and the return signal should therefore exhibit a doppler shift proportional to the sound velocity which in turn is indicative of the temperature of the air. The return signal will furthermore exhibit a broadening inversely proportional to the density of the media. Thus by determining the frequency profile of backscattered CO_2 laser light, it should be possible to determine temperature and density of the air without knowing the total return signal power which has often been required in other remote atmospheric sensing schemes.

The theory for Mandel'shtam-Brillouin scattering is first reviewed and applied to the atmosphere. An experiment to verify the theory using homodyne detection is then presented. The signal to noise ratio for the experiment showed that time integration was required to recover the signal. Various recording, integrating and chopper arrangements were used for this purpose.

About thirty experimental runs were made in the frequency interval of 55 to 80 MHz where the returned signals were expected. An analysis of the data showed a rather weak but always present signal increase around 69-72 MHz and a halfwidth of 4-5 MHz, which correspond approximately to the predicted values. In addition a pronounced signal at 61 MHz with a halfwidth of 3-4 MHz is observed and behaves qualitatively as one would predict for simulated emission. An analysis of the errors involved did not reveal instrumental or other effects that could have caused these features.