LETTERS TO THE EDITOR

ASTROPHYSICS

Optical Echoes from the Moon

EXPERIMENTS have been conducted to focus pulsed optical radiation on to the surface of the Moon and to detect the echoes.

A ruby optical maser radiating pulses of approximately 50 joules energy, 0·5-msec. duration, at 6934 Å. was used as the source. The transmitting optical system included a Cassegrainian telescope of 12-in. diameter. The echoes were received on a Cassegrainian telescope of 48-in. diameter, passed through an interference filter of 7 Å. band-width and were detected with a photomultiplier tube of spectral response type *S*-20, cooled to liquid nitrogen temperature. The field of view of the receiving telescope was 0·2 milliradians.

The photoelectron count obtained in a 0·5-msec. interval at the expected time-delay was compared with the counts obtained in 0·5-msec. intervals where no echoes would be expected and where the only relevant contributions to the count were those due to noise, that is, to Earthlight and scattered light (photoelectric dark current was negligible).

Table 1

	1 Eastern standard time	2 Region of the Moon	3 No. of flashes	4 No. of intervals	5 Average noise	6 *S.D.*	7 Average count in expected interval
May 9, 1962	21.56–22.07 hr.	Albategnius 15° S., 8° E.	11	15	1·11	0·28	1·91
May 10, 1962	21.52–22.34 hr.	Copernicus 10° N., 20° W.	23	16	1·39	0·22	1·74
May 11, 1962	21.57–22.50 hr.	Tycho 43° S., 10° W.	30	22	1·42	0·16	1·83
	22.54–23.15 hr.	Longomontanus 50° S., 20° W.	16	17	1·52	0·19	2·32

The experiments, conducted at Lexington, Massachusetts, on May 9, 10 and 11, gave positive results as indicated in Table 1. Column 3 indicates the number of consecutive flashes utilized; column 5 is the average number of photoelectrons due to noise in a 0·5-msec. interval column; 6 is the standard deviation of the noise count; column 7 is the average count in the 0·5-msec. interval where an echo was expected. The expected time delay of the signal was computed from ephemeris data and the position of the illuminated area on the Moon. Column 4 gives the number of range-intervals per trace used to obtain the data in columns 5 and 6.

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Fundamental Band of the Quadrupole Spectrum of the Hydrogen Molecule

THE application of interferometric techniques to astrophysical problems in the near infra-red shows considerable promise. The abundance of hydrogen in planetary atmospheres is probably of major importance.

Herzberg[1] observed the 2–0 and 3–0 bands of the quadrupole spectrum of hydrogen using pressures of 10 atmospheres and optical paths of 10–55 km. atmospheres. In addition, an induced dipole spectrum of hydrogen has been found by Chisholm, MacDonald, Crawford and Welsh[2] by making measurements in the pressure-range of hundreds to thousands of atmospheres.

We have observed the 1–0 band of the quadrupole spectrum of hydrogen. The spectrograph used was of the echelle type described previously[3]. An 8-metre 'White' multiple reflexion absorption tube allowed the optical path to be varied from 32 to several hundred meters. The pressures of hydrogen gas used varied from 1 to 12 atmospheres. The lines observed were $Q(1)$, $S(0)$, $S(1)$ and $S(2)$. The wave numbers of these lines have been measured to a precision of a few thousandths of a wave number. The results are $Q(1) = 4{,}155{\cdot}243$, $S(0) = 4{,}497{\cdot}830$, $S(1) = 4{,}712{\cdot}895$ and $S(2) = 4{,}916{\cdot}990$ all expressed in wave numbers *in vacuo*.

The intensities of the quadrupole lines have been observed to depend only on the mass of gas in the absorbing path (pressure independent). We have been unable to see any pressure shift or appreciable pressure broadening in the pressure-range of 1–12 atmospheres. The quadrupole lines are exquisitely sharp. The breadth of the lines closely approaches the breadth expected from the Doppler effect.

Probably the most surprising feature of the 1–0 quadrupole spectrum is its relatively high intensity. The intensities of the lines is 10–100 times as great as might be expected from the observations of Herzberg[4] on the overtones and the calculations of James and Coolidge[5]. We have been able easily to observe $S(1)$ with atmospheric pressure and an optical path of less than 100 metres.

In addition to the quadrupole spectrum we have also observed the induced dipole spectrum, which consists of extremely broad features underlying the quadrupole spectrum. The intensity of the dipole spectrum has been observed by Hare and Welsh[6] to depend on the square of the pressure. We have been able to verify this last observation. Furthermore, at