POSSIBLE PROOFS OF THE LUNAR ATMOSPHERE

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In the period 1955–57 a number of occultations of two radio sources 05·01 Taurus and 06·01 Gemini by the Moon takes place [1]. They will give an excellent opportunity to examine not only the exact position and the shape of these sources but possibly also some traces of the lunar atmosphere [2].

If we adopt as upper limit of density the optical determination by Dollfus [3], who gives 10^{-9} of the terrestrial density at sea level, and if we go still three orders further to 10^{-12}, we meet analogous conditions to those in the terrestrial atmosphere on the top of F region at altitude of some 400 km. There the direct determinations by rockets lead [4] to an electron density of about $N = 10^5$ cm.$^{-3}$. The density of this order can perfectly well be traced by the method based on the radio propagation theory.

In the first approximation we may assume the validity of the Chapman formula, which gives in the uppermost part of the ionized region the relation

$$N = N^* \exp\left(-h/2H\right), \tag{1}$$

where N^* is the electron concentration on the Moon surface, from which we count the altitude h, and H is the scale height (about 10^2 km.).

The total deviation of radio waves of the frequency f will then be

$$\omega = 4{\cdot}03 \,.\, 10^{-5} \frac{N}{f^2} \sqrt{\frac{5460}{H}} = \omega^* \exp\left(-h/2H\right) \tag{2}$$

and their intensity should be multiplied by the factor $1/s$, where

$$s = 1 - \frac{\omega}{R}\left(\frac{1736}{2H} - \frac{1}{\rho}\right) - \frac{1736}{2H\rho}\left(\frac{\omega}{R}\right)^2, \tag{3}$$

which gives the amplification of the intensity due to the convergence of the rays after the refraction in the lunar atmosphere. Here $R = 930''$ is the angular radius of the Moon and ρ is the distance at which the ray seems to

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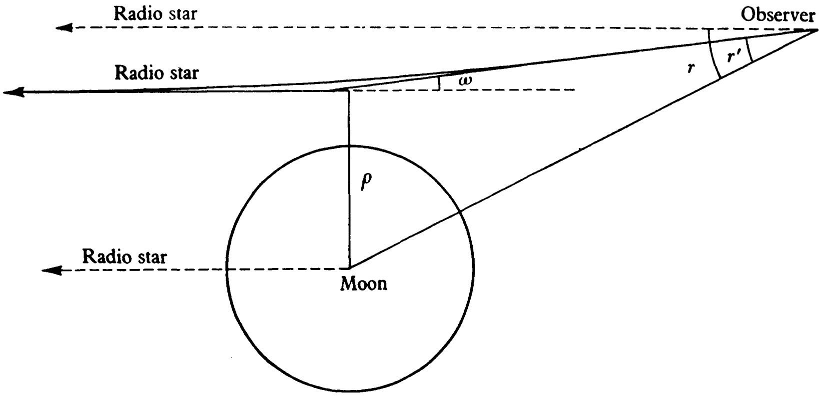

Fig. 1. Refraction by lunar atmosphere.

Table 1. *Total deviation ω and intensity 1/s of the rays at Moon surface*

N (el. cm.$^{-3}$) =	10^5	10^4	10^3	10^2	10^1
H = 1365 km. f = 25 Mhz.		4·6′	27″	2·7″	0·3″
		0·95	0·99	1·00	1·00
50	11·4′	1·1′	6·9″	0·7″	0·1″
	1·08	0·97	1·00	1·00	1·00
100	2·9′	17″	1·7″	0·2″	0·0″
	0·96	0·99	1·00	1·00	1·00
200	23″	2·3″	0·2″	0·0″	0·0″
	0·99	1·00	1·00	1·00	1·00
400	11″	1·1″	0·1″	0·0″	0·0″
	1·00	1·00	1·00	1·00	1·00
H = 341 km. f = 25 Mhz.		9·1′	55″	5·5″	0·6″
		1·02	1·17	1·00	1·00
50		2·3′	14″	1·4″	0·1″
		1·39	1·02	1·00	1·00
100	5·7′	34″	3·4″	0·3″	0·0″
	11·6	1·10	1·01	1·00	1·00
200	1·4′	8·6″	0·9″	0·1″	0·0″
	1·17	1·01	1·00	1·00	1·00
400	21″	2·1″	0·2″	0·0″	0·0″
	1·04	1·00	1·00	1·00	1·00
H = 152 km. f = 25 Mhz.			1·4′	8·2″	0·8″
			1·86	1·04	1·00
50		3·4′	21″	2·1″	0·2″
		3·1	1·12	1·01	1·00
100	8·6′	51″	5·1″	0·5″	0·1″
	0·56	1·27	1·03	1·00	1·00
200	1·8′	10·8″	1·1″	0·1″	0·0″
	2·7	1·05	1·00	1·00	1·00
400	32″	3·2″	0·3″	0·0″	0·0″
	1·15	1·00	1·00	1·00	1·00

pass the Moon's centre, expressed in lunar radii. In Table 1 we have calculated ω and $1/s$ for some reasonable assumptions about N^* and H. The general features of a central occultation are given in the example of Table 2.

Table 2. *Central occultation of a radio point source*

$N = 10^4$ el. cm.$^{-3}$, $f = 50$ Mhz., $H = 341$ km., $\omega^* = 137''$

ρ		$1/s$	r'	r	Δt
1·0	137″	1·39	930″	1067″	4^m 34^s
1·1	106	1·28	1023	1129	6 38
1·2	82	1·20	1116	1198	8 56
1·3	64	1·15	1209	1273	11 26
1·4	50	1·12	1302	1352	14 04
1·5	38	1·09	1395	1433	16 46
1·6	30	1·07	1488	1518	19 36
1·7	23	1·05	1581	1604	29 40
2·0	11	1·02	1860	1872	31 14
3·0	2	1·00	2790	2792	62 04

ρ = Distance of the ray from the Moon's centre in Moon's radii.
r = Geometrical angle between the Moon's centre and the radio source.
r' = Observed angle between the Moon's centre and the radio source.
Δt = Time elapsed since the geometrical occultation ($r = 930''$).

From these results we can see that appreciable effects both in direction and in intensity should be expected, especially on the lower frequencies, if a trace of the lunar atmosphere were present. The deviation of 0·5″ gives in the central case a lengthening of the occultation of about 2^s. Also an augmentation of the intensity of 10 % can be detected.

These relatively simple conditions will be complicated by the diffraction, by the shape of the source, and possibly also by irregularities in the lunar ionosphere. Exact measurements of radio flux on low frequencies are needed before we can undertake a further analysis.

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