the eruption velocity greater. Although an additional test should be made, the present data seem to lend adequate support to the proposed model to warrant its temporary adoption.

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Detection of Lyman-β and Helium Resonance Radiation in the Night Sky

Abstract. *A rocket-borne photometer has detected far ultraviolet night glow radiations that are identified as Lyman-β (HI 1026 angstroms), and the helium lines at 304 or 584 angstroms, or at both. At an altitude of 227 kilometers the measured intensity for Lyman-β was about 10 rayleighs. The discrimination characteristics of the broad-band helium radiation filter give helium line intensities, at 227 kilometers, of 4.8 and 12 rayleighs, respectively, pending identification of the wavelength of the radiation as 304 or 584 angstroms. These ultraviolet radiations appear sufficient to maintain the night E and F_1 regions of the ionosphere.*

The existence of an ultraviolet night glow at Lyman-β (HI 1026 Å) and the two helium resonance lines, HeI 584 Å and HeII 304 Å, has been postulated on the basis of resonant scattering theory (*1*). It has been suggested that this radiation may explain the behavior of the nighttime E and F_1 regions of the ionosphere (*2*). In 1960, Byram, Chubb, and Friedman (*3*) flew an open-window, lithium fluoride photocell and set an upper limit of 230 rayleighs for the resonant helium glow.

At 2330 Mountain Standard Time on 10 August 1967, a photometer experiment designed to detect far ultraviolet radiation in the night sky was flown aboard an Aerobee 150 rocket, NC 3.187, launched from the White Sands Missile Range, New Mexico. Two of the photometers that were flown were detectors of the thin film-scintillating phosphor-photomultiplier type described by Lincke and Palumbo (*4*), while the third was an ionization chamber with a lithium fluoride window filled with nitric oxide (*5*). One thin-film filter was an indium window (band pass, 770- to 1080-Å) and was designed for the detection of Lyman-β; the second employed an aluminum window (band pass, 150- to 750-Å) and was utilized for the detection of the combined helium resonance radiations at 304 and 584 Å (*6*). The ionization chamber was used to detect the Lyman-α (HI 1216 Å) airglow.

At 80.5 km on the ascent of the rocket flight, a protective door covering the two thin-film window detectors was released. Upon door ejection, each detector recorded signals that varied as a function of altitude and attitude of the system throughout flight.

Data taken when the two thin-film detectors were looking at a fixed direction in space were first plotted as a function of altitude and were then corrected for signals due to Lyman-α radiation (as measured by the ionization chamber), background noise (determined before ejection of the protective door), and background visible light (detected by an optical star sensor). The corrected signals from each detector increased with increasing altitude, indicating the presence of far ultraviolet radiations that are absorbed high in the earth's atmosphere.

Analysis of the corrected signal from the 770- to 1080-Å detector indicated a radiation that is absorbed principally in the 100-km region of the atmosphere and has an extinction coefficient (*7*) of $\mu \simeq 10^{-6}$ cm^{-1} in this altitude range. Both of these characteristics are exhibited by Lyman-β as it is absorbed by O_2 in the earth's high atmosphere (*8, 9*).

Analysis of the corrected signal from the 150- to 750-Å band-pass detector indicated a radiation that is absorbed mainly in the 140- to 160-km altitude range and has an extinction coefficient that varies from 2.8 to 6.5×10^{-7} cm^{-1} in this region. These characteristics agree quite well with the behavior of HeII 304 Å as it is absorbed by the upper atmosphere (*8*). We cannot, however, eliminate the possibility that a certain percentage of the radiation detected by the 150- to 750-Å detector was the 584-Å line of HeI. Rather than estimate the contribution from each wavelength, we shall give values of intensities and absorption rates, assuming it is either one line or the other.

If the ultraviolet radiations detected were Lyman-β, HeII 304 Å, and/or HeI 584 Å, we find the following intensities and absorption rates. At peak of flight (227 km), the intensity of Lyman-β was 9.6 rayleighs and the absorption rate per unit volume in the 100-km region was about 0.75 photon per cubic centimeter per second. The use of 58 percent (*9*) as the ionization efficiency of Lyman-β when absorbed by O_2 leads to a nighttime production rate of 0.43 O_2^+ ion cm^{-3} sec^{-1} in this altitude range. If all the radiation detected by the 150- to 750-Å band-pass photometer was HeII 304 Å, then its intensity at peak of flight was 4.8 rayleighs, and the absorption rate per unit volume in the 140- to 160-km altitude range was about 0.29 photon cm^{-3} sec^{-1}. If, on the other hand, all the radiation detected by this photometer is to be ascribed to the 584-Å line of HeI, then the above values of intensity and absorption rate per unit volume must be multiplied by a factor of 2.5, the relative efficiency of the aluminum filter at these two wavelengths.

Resonant scattering theory predicts a night glow at those wavelengths measured in our experiment. We shall now examine what conclusions, if any, we can draw on the nature of the scattering medium—whether most of the resonant scattering takes place within the earth's high atmosphere or whether scattering by the gases in interplanetary space makes an appreciable contribution to the measured night glow radiations. In regard to Lyman-β, Meier (*10*) of this laboratory has calculated that the observed intensities can be explained reasonably well by the resonant scattering of solar Lyman-β photons within the earth's hydrogen geocorona. This does not, of course, exclude the possibility that some of the night sky Lyman-β is due to the scattering of solar radiation by atomic hydrogen in the interplanetary medium, but it does not seem necessary to invoke this mechanism in order to explain the bulk of the observational results. The case for the helium resonance radiations is less clear-cut, since exact calculations dealing with the resonant scattering of the solar 584- and 304-Å lines by the neutral and ionized helium within the earth's atmosphere are lacking. Qualitative estimates lead to predicted intensities that are roughly within an order of magnitude of those quoted above for these two wavelengths, but it appears that future experiments are necessary before definitive statements can be made concerning the role of the interplanetary medium in the production of the helium night glow.

For the past several years there has been some controversy concerning the lower ionospheric regions at night—whether they result from undisturbed decay of the daytime ionosphere or whether there is a nighttime production mechanism present. Assuming the existance of a nighttime production mechanism, Ogawa and Tohmatsu (*2*), in a recent theoretical study, employed the ion composition data of Holmes *et al.* (*11*) to compute the radiation intensities required to maintain the E and F_1 regions of the nighttime ionosphere. Our measured intensities agree closely with their findings and thus provide the first experimental basis for the production mechanism theory.

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$$\mu = \left(\frac{d\phi/dh}{\phi} \right) \cdot \cos Z$$

where $d\phi/dh$ denotes the altitude variation of radiative flux at a given altitude; ϕ is the value of the flux at this altitude; and Z, the angle from zenith from which the flux is incident. Notice that μ can be derived from an experimental measurement of ϕ versus altitude. The values of μ given by Hinteregger and Watanabe (*8*) were derived from the measurement of unidirectional solar fluxes, while the values of μ given in this report result from the measurement of radiations from an extended source with detectors that had wide fields of view. While correlation between the sets of values for μ derived from the two experiments will not be exact, we expect better than order-of-magnitude agreement in the regions of maximum absorption. We compare our measured values of μ and the regions of maximum absorption for the radiations detected in our experiment with the rocket monochrometer results given by Hinteregger and Watanabe (*8*) in order to give added plausibility to our wavelength identifications.
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Ceratoscopelus maderensis: Peculiar Sound-Scattering Layer Identified with This Myctophid Fish

Abstract. *A sound-scattering layer, composed of discrete hyperbolic echo-sequences and apparently restricted to the Slope Water region of the western North Atlantic, has been identified from the Deep Submergence Research Vehicle* Alvin *with schools of the myctophid fish* Ceratoscopelus maderensis. *By diving into the layer and using* Alvin's *echo-ranging sonar, we approached and visually identified the sound scatterers. The number of echo sequences observed with the surface echo-sounder (1/23.76 × 10⁵ cubic meters of water) checked roughly with the number of sonar targets observed from the submarine (1/7.45 × 10⁵ cubic meters). The fish schools appeared to be 5 to 10 meters thick, 10 to 100 meters in diameter, and on centers 100 to 200 meters apart. Density within schools was estimated at 10 to 15 fish per cubic meter.*

A peculiar sound-scattering layer, apparently restricted to the Slope Water region off northeastern United States and eastern Canada (*1*) (Fig. 1), differs from typical deep scattering layers of oceanic echo-sounder records in the structure of the echo-sequences. Successive trains of echoes do not form the usual homogeneous band of reverberation such as that which results from the receipt of sound scattered by numerous objects of low target strength. Instead, they form discrete hyperbolic echo-sequences such as those which result from the receipt of sound scattered by a few objects of high target strength. The layer makes a diurnal vertical migration. Midday depth to the shallowest echo sequences on the echo-sounder record is commonly about 330 m. During the evening ascent, the layer has been traced to depths as shallow as 20 m.

The layer has been observed in all parts of the Slope Water, but is irregularly developed. A similar and possibly related sound-scattering feature has been occasionally observed east of Newfoundland. At some times and places, the layer in the Slope Water has been continuously recorded for tens of kilometers; at others, only in small patches or not at all. An examination of the broadband sound-scattering properties of the layer (*2*) during an evening ascent showed that the layer best scatters sound at progressively lower frequencies as the layer shoals. It best scattered sound at about 12 khz when near its midday depth (accounting for the high intensity of the echo-sequences on 12-khz echo-sounder records during daytime); at 30 m the layer best scattered sound at about 3 khz.

The layer was present at 39°48′N, 70°33′W, in a depth of about 1800 m

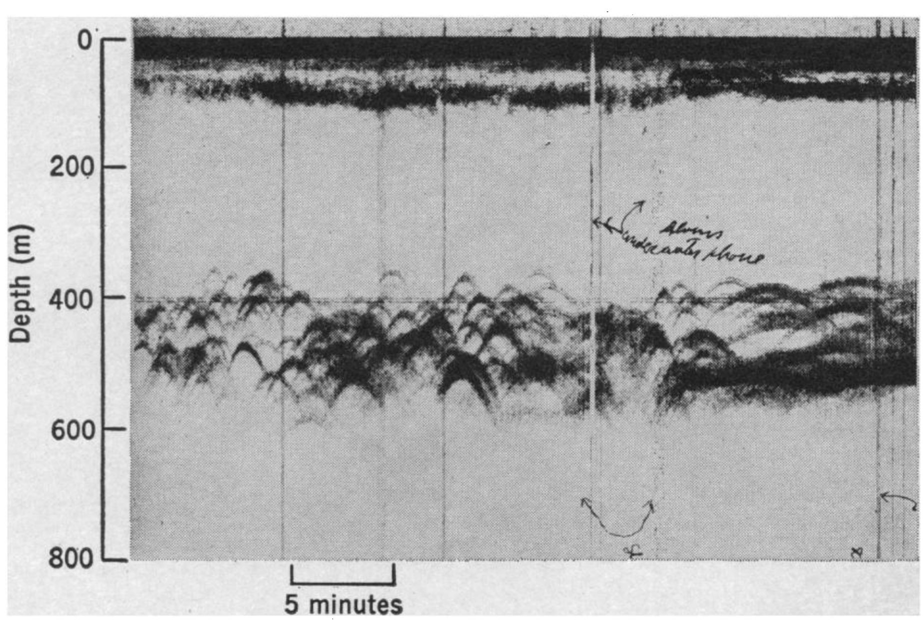

Fig. 1. Portion of 12-khz echo-sounder record made from R.V. *Gosnold* with Litton PDR near 39°48′N, 70°33′W late in the morning of 6 October 1967.