National Central University
Department of Atmospheric Sciences
Radar Meteorology
Homework II
(2021/10/04 - 2021/10/18)

1. (20 pts.) 在課堂中我們根據公式(2.30)及(2.35)練習了一個電磁波被偏折回地表的例子。現在請用公式(2.28a)再計算一遍。亦即同樣假設在近地表 0.1km 內 dN/dh = -300 km^{-1}，請求出:

(1) 雷達電磁波會發生向下偏折的臨界仰角約為何，且發生向下偏折的地點距雷達多少公里?

(2)若現在雷達的仰角為 0.2°，請問發生向下偏折地點的高度與距離各為何? (請把你的計算結果和圖 2.10 比較) 。

1. Instead of using equation (2.30) and (2.35) in the text book, we now try to use equation (2.28a) in the text book to study again the condition when the radio wave is bended back to the ground. That is, assuming within the lowest 0.1 km, we have dN/dh = -300 km^{-1}. Please compute

(1) what is the critical elevation angle? and the distance between the radar site and the point where the bending takes place?

(2)If the radar's elevation angle is 0.2°, compute the distance and height of the point where the bending phenomenon takes place. Compare your results with those from Figure 2.10.

2. (10 pts.) 假設 dn/dh = -1/(4a)，亦即屬於正常大氣中的垂直分佈情況，請使用公式(2.28a)及(2.30)分別繪出如圖 2.8 的電磁波路徑，並比較其差異。繪的範圍是 Arc Distance (s) < 200 km, 雷達仰角為 0.0, 0.5, 1.0, 3.0 度.

2. Assuming dn/dh = -1/(4a) (which is a normal value), use equations (2.28a) and (2.30) respectively to plot the EM wave propagation path as shown in Figure 2.8. The range for the plot is (a) arc distance < 200 km, and (b) elevation angles are 0.0, 0.5, 1.0, 3.0 degree.

3. (10 pts.) 同上題，假設在近地表 0.1 km 內的 dN/dh = -300 km^{-1}，請使用公式(2.28a)及(2.30)分別繪出如圖 2.10 的電磁波路徑，並比較其差異。繪的範圍是 Arc Distance (s) < 50 km, 雷達仰角為 0.1, 0.2, 0.3 度.

3. Similar to the above question, assuming within the lowest 0.1 km, we have dN/dh = -300 km^{-1}, use equations (2.28a) and (2.30) respectively to plot the EM wave propagation path as shown in Figure 2.10. The range for the plot is (a) arc distance < 50 km, and (b) elevation angles are 0.1, 0.2, 0.3 degree.

4. (15 pts.) 一群高中生欲複製光線在空氣中被偏折的現象,使用的箱子長 1.5 公尺，高 0.3 公尺，箱頂溫度加熱到 60℃，請問：

(1)若想讓光線在箱頂的中間點產生向下偏折的現象，請問光線的初始仰角為多少度？

(2)此時箱內 dN/dh 必須為多少？（令 N 隨高度 h 呈線性變化）

(3)請問箱底的溫度必須為幾度？

(註: 假設乾燥無水氣，且箱內氣壓均勻，保持為 1013.25 hpa)

(4)本實驗之可行性如何?

4. A group of high school students want to do this experiment. Their box is 1.5 m long, 0.3 m high. The temperature at the roof is 60° C.

(1) A light beam sent from the surface at the western side of the box is bended at the center of roof, what will be the initial elevation angle of the light beam?

(2) dN/dh = ? Assuming N changes linearly with height.

(3) Assuming the air is dry, and the pressure is uniform with a value of 1013.25 hpa, what will be the temperature at the bottom of the box?

(4) Is this experiment feasible in a high school laboratory?

5. (10 pts.) 雷達天線發射出電磁波,其功率密度分佈相對於主軸呈對稱結構，可由下式代表:

$$f^2(\theta) = \left\{ \frac{8J_2[(\pi D \sin\theta)/\lambda]}{[(\pi D \sin\theta)/\lambda]^2} \right\}^2$$

其中θ為距主軸的角度，J_2是 Bessel function of second order，D 是天線直徑，λ是電磁波波長,請繪出 f^2 對θ的分佈曲線，θ的範圍在$\pm 3^o$ 內，(令 D=11.89 m, λ=10 cm) 。

5. The above equation shows the distribution of the power density with respect to the main axis of the radar antenna, where θ is the angle from the main axis, J_2 is the Bessel function of second order, D (=11.89 m) is the diameter of the antenna, λ (=10 cm) is the EM wave length, please plot the distribution of f^2 with respect to θ within $\pm 3^o$.