# THE AERONOMIC PROBLEM OF NEUTRAL HELIUM AND HYDROGEN *

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The vertical distribution of helium-4, helium-3, hydrogen-2 and hydrogen-1 in the thermosphere has been investigated, taking account of the various production rates in the mixing region and different escape rates above the thermopause.

The average escape during an eleven-year period from 1951 to 1961 is about 3.5 $He^3$ atoms $cm^{-2}$ $sec^{-1}$ and $6 \times 10^4$ $He^4$ atoms $cm^{-2}$ $sec^{-1}$, corresponding to the atmospheric production of $He^3$ and to 1 percent of the generation rate of $He^4$ in the earth's crust and mantle. The effect of the solar cycle on the escape rates is such that their ratios reach $10^5$ for $He^4$ and $10^4$ for $He^3$ between 1954 and 1958.

The effusion velocities lead, at 500 km, to life-times of the order of several years for $He^4$ (11 years to 1 year for temperatures between 1700 °K and 2000 °K), of less than 100 days for $He^3$ for temperatures higher than 1700 °K, and of a few hours for $H^1$ (2 hours to 10 hours for temperatures between 2000 °K and 1250 °K). These various lifetimes lead to a normal diffusion-distribution of $He^4$ and $He^3$ in the thermosphere and above the thermopause in almost all circumstances while the vertical distribution of atomic hydrogen and its concentration above the thermopause is subject to variations depending on the temporal variation of the temperature.

The concentration of helium-4 above the thermopause is such that the mean molecular mass at 750 km is less than 16, i.e. less than the mass of atomic oxygen. The helium belt is subject to variations depending on the diffusion level and on the escape flow of atomic hydrogen. Its effective lower boundary reaches lowest altitudes when the thermopause temperature decreases and its upper boundary reaches highest altitudes when the temperature increases.

The diffusion level of $He^4$ may vary according to various atmospheric conditions in the 100–120 km region since the descent of the diffusion level from 115 km to 110 km, and from 110 km to 105 km, requires about 15 days and 30 days, respectively. In any case, diffusion conditions related to the

* The complete paper will be published in Annales de Géophysique.

level of the turbopause shows that the concentration $n(He^4)$ at 120 km should be $(1.25 \pm 0.75) \times 10^7$ atoms $cm^{-3}$ leading to exactly a factor of 10 less at 500 km for thermopause temperatures between 2000 °K and 1000 °K.

The relative concentration of atomic hydrogen in the thermosphere depends on the possible maximum velocity of diffusion in the 100–120 km region which is a few cm $sec^{-1}$. Its vertical distribution approximates a mixing distribution in the lower thermosphere and depends in the upper thermosphere on a scale height gradient limited by an escape flow almost identical to the maximum flow supported by diffusion in the mixing region.

If a concentration $n(H) = 10^7$ $cm^{-3}$ is adopted at 100 km, corresponding to a total content of $10^{12}$ atoms $cm^{-2}$ between 120 km and 200 km, the maximum flow corresponding to the escape rate at 100 km is $2.5 \times 10^7$ atoms $cm^{-2}$ $sec^{-1}$. Under such circumstances, the concentration of atomic hydrogen decreases rapidly above 100 km; it reaches only $10^4$ $cm^{-3}$ at 500 km for a thermopause temperature of the order of 1200 °K and decreases by a factor of 10 when the temperature reaches 2000 °K. Since atomic hydrogen reaches a diffusion equilibrium distribution near 500 km, the concentration decreases slowly with height and is still $2.5 \times 10^3$ $cm^{-3}$ at 3000 km if the thermopause temperature is 1200 °K. Any change in the boundary condition at 100 km, i.e. $n(H) = 10^7$ $cm^{-3}$, will modify by the same factor all parameters dealing with atomic hydrogen.