Kinetic Effects in Spherical Expanding Flows of Binary-Gas Mixtures

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**ABSTRACT**

Diffusion effects in the spherical expanding flows of argon-helium mixtures have been studied using the direct simulation Monte Carlo technique. The similarity analysis was used to study the flow structure. Kinetic effects influence the shock-wave thickness, species temperature, diffusive velocities, and the effectiveness of species separation and ambient gas penetration (see Figs. 1-4). A comparison of the DSMC and Navier-Stokes solutions indicates areas of the continuum-concept applicability for studying diffusive effects in low-density flows.

![Figure 1: Argon Concentration in a Spherical Shock Wave at Different Rarefaction Parameters $K_2$ and $Kn^*$](image1)

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![Figure 2: Stream Velocity and Diffusion Velocities of Argon and Helium in a Spherical Shock Wave at Different Values of Rarefaction Parameter $K_2$](image2)

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It was found that the spherical flow could be separated by the coordinate $r_\ast$, at which the stream parameters are extreme, into two regions with significantly different properties. In the first "internal" region at $r < r_\ast$, the flow is supersonic (this region was studied in Refs. 1-3). In the second "external" region at $r > r_\ast$, there is a transition of supersonic flow into subsonic stream at the infinity (see Figs. 1-4). In the first region, flow parameters depend on two similarity parameters of Knudsen number $Kn_\ast$ and $Kn_+$, based on the critical radius of a spherical source $r_\ast$ and a coordinate $r$. The Knudsen number $Kn_\ast$ based on the length scale parameter at infinity $l = (Qa_0/4\pi p_\infty)^{\frac{1}{2}}$ is the major similarity parameter in the second region. Another important similarity parameter $K_2 = Re(p_\infty/p_0)^{\frac{1}{2}} \approx Re_\infty$ can be used to study the flow structure in this region. Correlations between $Kn_\ast$, $Kn_\infty$, and $Kn_+$, are given in Ref. 2.

**FIGURE 4.** Argon Concentration, Pressure and Density Ratios in Expansion of Argon into Helium ($Kn_\ast = 0.014$, $K_2 = 0.785$) and Helium into Argon ($Kn_\ast = 0.003$, $K_2 = 4.53$).

**REFERENCES**