LASER DOPPLER SOUNDING AND RANGING OF DISPERSE SYSTEMS

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When considering the microphysical characteristics of polydisperse systems by laser Doppler spectrometry (LDS) in the absence of external force fields, the autocorrelation function of the scattered light field R(τ) is defined as [1] $R(\tau)=\int g(DK^2)\exp(-DK^2\tau)d(DK^2)$, where $g(DK^2)$ is the normalized distribution of the velocities of the Brownian motion of the particles, $\vec{K}$ is the scattering vector, D is the diffusion coefficient, and τ is the correlation time. The determination of $g(DK^2)$ by calculating the inverse Laplace transform calls for an unrealistically high experimental accuracy.

The combination of methods of layer-by-layer separation of the particles of a polydispersed ensemble in an external field with the LDS method [2] makes it possible to find the mobilities B_s of the singly mobile fractions by analyzing the scattering spectrum of each fraction of the light: $G_s(\omega)=\int R_s(\tau)\exp(i\omega\tau)d\tau$. However, the separation of the harmonic component in the spectrum of the optical field is possible only if the condition $kTK^2<\vec{K}\nabla w$ is satisfied, where k is the Boltzmann constant, T is the absolute temperature, and ∇w is the external-field gradient. Satisfaction of this condition is not always possible for submicron aerosol in real fields, therefore the investigation of the force-governed mobilities of the particles of highly dispersed systems in external fields can proceed in two ways:

1. By stationary shift of the frequency of one of the laser beams of the Doppler anemometer (by formation of a traveling interference Rigghi lattice in the measuring volume).

2. By producing a stationary component of the projection of the reference velocity $\vec{u}$ of the sounded two-phase flux on the scattering vector $\vec{K}$ (formation of a traveling Rigghi interference lattice in a coordinate system connected with the projection of the transport velocity on the scattering vector).

In view of the smallness of the Doppler shifts of the frequency, due to the drift motion of the particles over the external fields, the values of the reference frequency shifts should be of the order of hundreds Hz and have a minimum deviation and spectral width, and this in the former case constitutes a serious technical problem. The use of a reference velocity of the aspiring stream for the formation of the frequency shift by using liquid based aspiring devices makes it possible to realize relatively simply the frequency shift in the beat spectrum of the optical field, and in this case the condition for separating the Doppler component of the signal becomes $DK<B_s|\nabla w|\sin\varphi+u\cos\varphi$, where φ is the angle between $\vec{u}$ and $\vec{K}$, while $\nabla w\perp\vec{u}$.

The experimental setup [3] included aspiration condensers with a device for an isokinetic gathering of the sample of the investigated aerosol and a laser anemometer capable of

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Translated from II Vsesoyuznoe Soveshchanie po Rasprostraneniyu Lazernogo Izlucheniya v Dispersnoi Srede. Tezisy Dokladov (Second All-Union Conference on Propagation of Laser Radiation in a Disperse Medium. Summary of Proceedings), Part II, pp. 15-17, 1982.

0270-2010/84/0502-0181$08.50

operating both in the photomixing regime and in photodetection. The plane of the sounding beams had a rotational degree of freedom relative to the axial axis of the anemometer and this made it possible to establish the necessary angular relation between the drift and transport components of the velocities of the particles relative to the scattering vector. Aspiration condensers constitute plane-parallel channels with optical windows for the entrance and exit of the optical radiation, in which a flat aerosol jet was aspired, blown by pure air, with devices for formation of the external field (electric, thermal, thermal-diffusion). The measurements were performed by plotting the profiles of the velocity in a given section of the stream in the presence and absence of the field.

The experiment was carried out on fogs of ammonium chloride and vaseline oil. In a solenoidal electric field the smallest measured drift velocities of the particles corresponded to a singly charged fraction of the particles, and from the measured profile of the electroconvective ion wind we measured the gradient of the specific space charge along the measurement zone. The limits of the measured electric mobilities were 4×10^{-6} cm^2/V•sec to 5×10^{-4} cm^2/V•sec at flux Reynolds number 1-10. The diffusion-phoresis was investigated in the field of an evaporating drop of constant diameter to determine the regions of aerodynamic and diffusion contribution to the vapor transport at a function of the Reynolds number of the flux. No stratification was revealed by either the shape of the particle drift velocity curve in the region of the diffusion transfer or by the diffusion-phoresis mobilities of the given aerosol systems. Nor was stratification revealed, within the limits of experimental error, by the thermophoresis coefficients for a temperature field with constant shift, up to fields with temperature gradient 25,000 K/m. This is obviously due to the relative monodisperse character of the chosen aerosols. In the temperature field of a filament placed in the stream, the analytic expressions for the temperature field were obtained in the form

$$T = T_0 + \frac{N}{2\pi\varkappa} \exp\left(-\frac{uR}{2\varkappa}\right) K_0\left(\frac{uR}{2\varkappa}\right)$$

$$\left(\frac{\partial T}{\partial R}\right) = \frac{Nu}{2\pi\varkappa^2}\left[K_0^2\left(\frac{uR}{2\varkappa}\right) + K_1^2\left(\frac{uR}{2\varkappa}\right)\right]^{\frac{1}{2}}$$

where T_0 is the temperature of the medium; N, specific power of the Joule heat; $\varkappa$, thermal diffusivity coefficient; R, distance from the filament to the measurement zone; and K_0 and K_1, Macdonald functions of order 1 and 2, respectively. The values of the thermophoresis coefficient for aerosol of vaseline oil lie in the range 0.4-1.2 at a Knudsen number Kn = 0.27.

LITERATURE CITED

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