Behind a Wisp of Smoke: Study of the Morphology of Airflow and the Cause of Stripes Formed by Smoke Particles Over a Heat Source of Constant Temperature

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When paraffin is placed on a heat source, a wisp of smoke forms. The project aims to discover some characteristics of this smoke and quantitatively explain them. First of all, the morphology of the airflow can be visualized by the smoke. Experiments show that the airflow generates four different shapes under different heat source temperatures; At a certain height, turbulence and horizontal circulations form. To quantitatively explain why the airflow takes on such morphology, this study derives the partial differential equations of the movement of air. Computer numerical solutions of the equations are consistent with experimental results. Therefore, the observed morphology of airflow is quantitatively explained. In addition, experiments show that smoke particles often form stable dense-and-sparse stripes in the rising airflow. The distances between adjacent stripes are about 10^-3 meters. To explain the formation of stripes, this study takes the particle groups formed by a massive number of particles as basic units of investigation. By making use of mathematical statistics, the fluid-dynamic interactions between individual particles are transferred into equivalent additional pressures between particle groups, and equations for the movement of particle groups are derived. Computer numerical solutions of the equations show that particles do form stripes. The distances between adjacent stripes are about 10^-3 meters. Therefore, the project quantitatively explained the formation of stripes. Moreover, it provided an effective model for studying densely-populated particles in fluids and a possible explanation for the stripes observed in satellite cloud images. It also offered some insights into self-organization phenomena.

Awards Won:
First Award of $5,000