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Numerical Study on the Effects of the Rupture Process of a Secondary Diaphragm in an Expansion Tube

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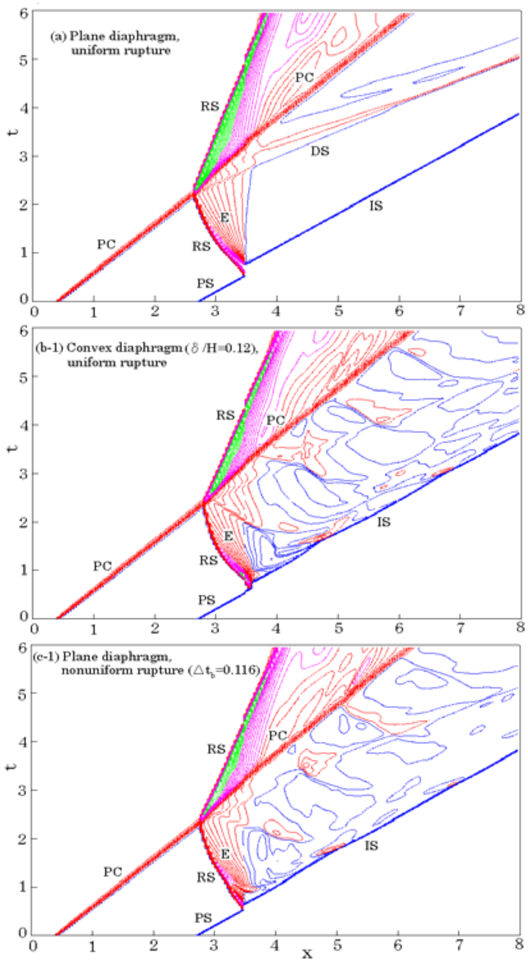
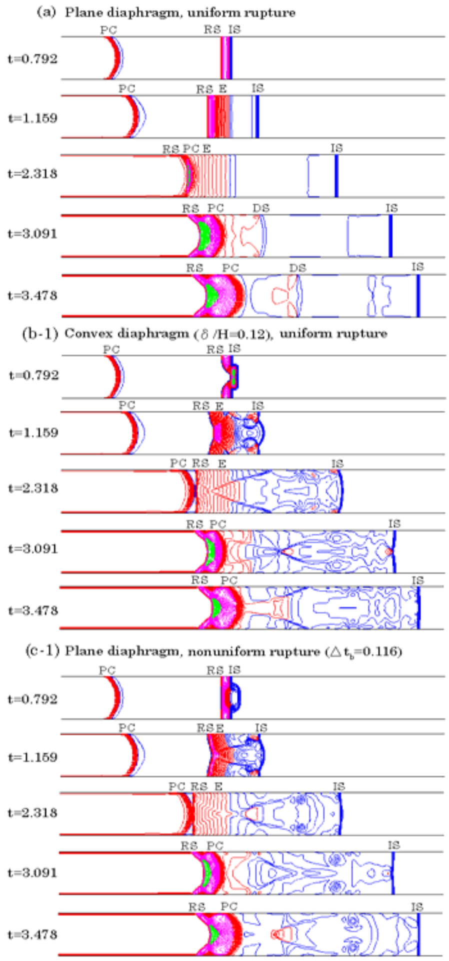


Time-distance plots of the acoustic impedance contours on the axis



Acoustic impedance contours

Nomenclature in frontispiece:

PS: primary shock, PC: primary contact, RS: reflected shock, IS: incident shock, E: expansion, DS: disturbance shock, t: time, x: distance, δ/H: convex of diaphragm, Δt_b: difference in rupture time

These figures show the numerical results of the flow in an expansion tube by time-distance plots of the acoustic impedance and acoustic impedance contours. The disturbance shock produced by the interaction of the reflected shock at a secondary diaphragm with the primary contact is clearly observed. In the cases of the convex diaphragm and non-uniform rupture process, the disturbances are added to the disturbance shock.

Numerical conditions are as follows: Mach number of primary shock M_s=4.0, speed of sound ratio across primary contact c_2/c_3=2.0, rupture time of diaphragm t_b=0.193, test gas is argon.

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Quantitative Measurements of Micro- and Macromixing in a Stirred Vessel using Two-color Laser Induced Fluorescence

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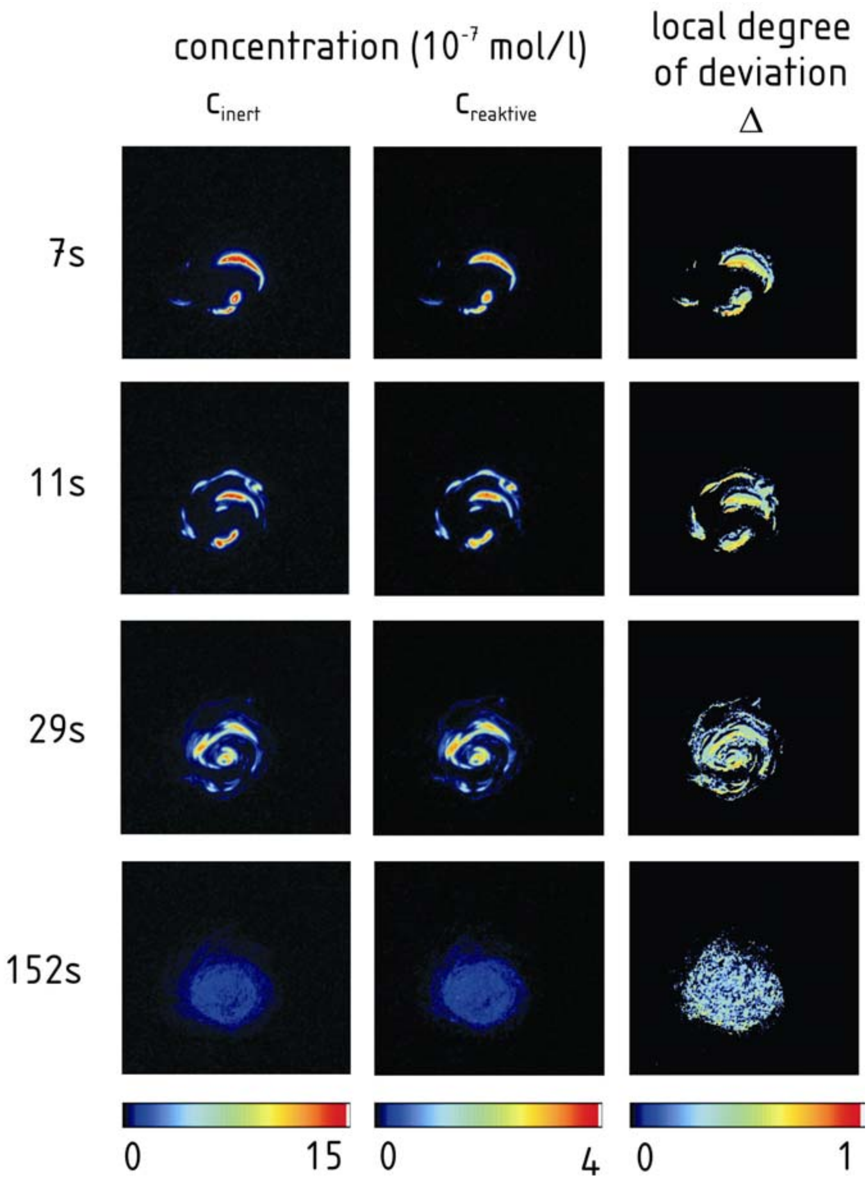

The two-color Laser Induced Fluorescence technique (LIF) gives new insight into the mixing process. A mixture of two fluorescent dyes is injected into the vessel. The inert dye serves as a tracer for the convective transport, i.e. the macromixing. The fluorescent chracteristics of the reacting dye change while undergoing a fast chemical reaction with the vessel content and therefore show the micromixing. The concentration fields of the dyes are measured simultaneously. Low Reynolds number measurements in a mixing vessel equipped with a Rushton turbine clearly show the lamellar structure. Areas of micromixing are detected by calculating the local degree of deviation from the concentration fields. These areas are mainly found in the boundary layer of the lamellas.

Flow Visualization of Streak Lines around a Butterfly, *Sasakia charonda*

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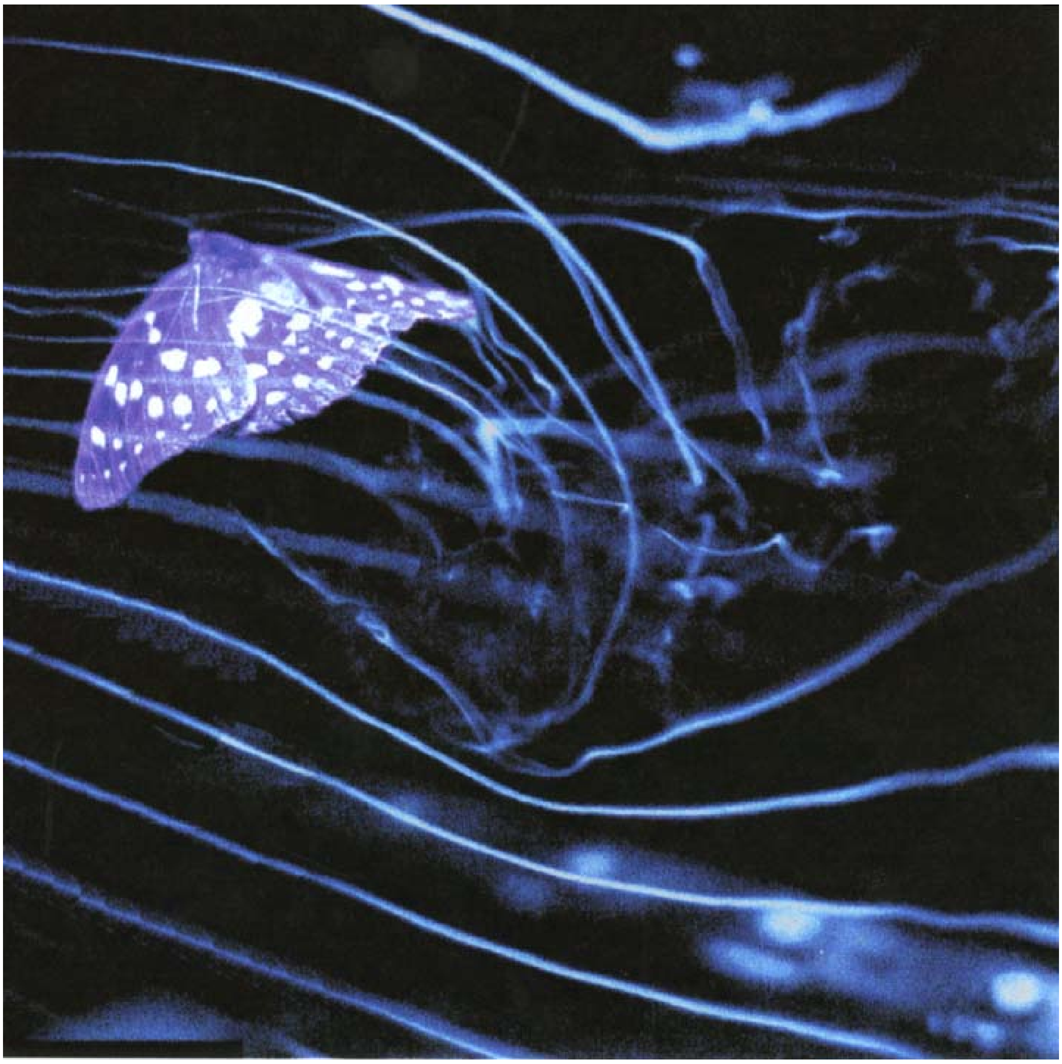

Streak lines around a butterfly

This figure shows a set of streak lines around a butterfly, *Sasakia charonda* at an instant during the downstroke of the wing in a wind tunnel set up at the University of Shizuoka for Culture and Art. The butterfly was supported on a sting placed in the test section of the wind tunnel. The picture was printed from one of the frames captured by a high-speed video camera (Phantom V5.0) placed at the side of the test section. The streak lines were visualized by ejecting small drops of oil, Fog Juice, from two rows of nozzles arranged in a cross shape. The wind speed was 0.8 m/s and the wing beating frequency of the butterfly was 7.0 Hz. Shed vortices from the mid span of the wing and trailing vortices from the opposite wing tips are clearly visible. A strong downwash is generated in the wake by these vortices.

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Visualization of Shock Wave and Detonation Wave

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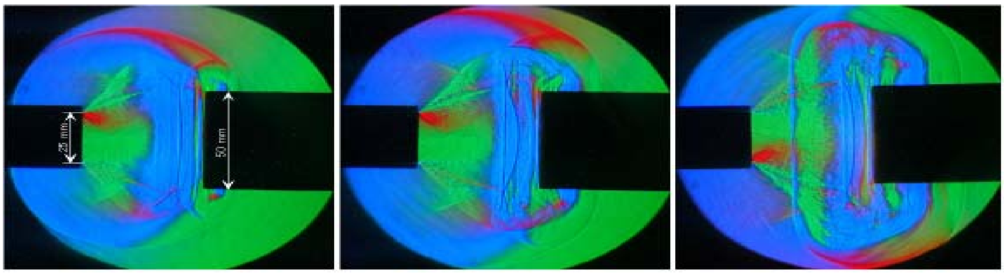

t = 30 μs t = 55 μs t = 75 μs

Fig. 1. Sequential color schlieren photographs showing the diffraction and reflection of a shock wave

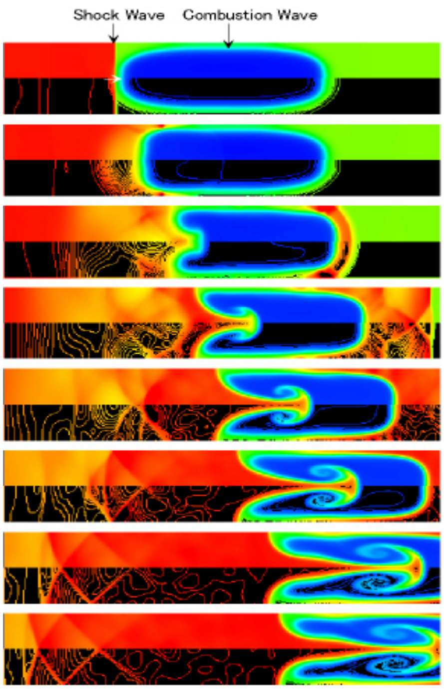

Fig. 2. Numerical simulation of the interaction between a shock wave and a combustion wave

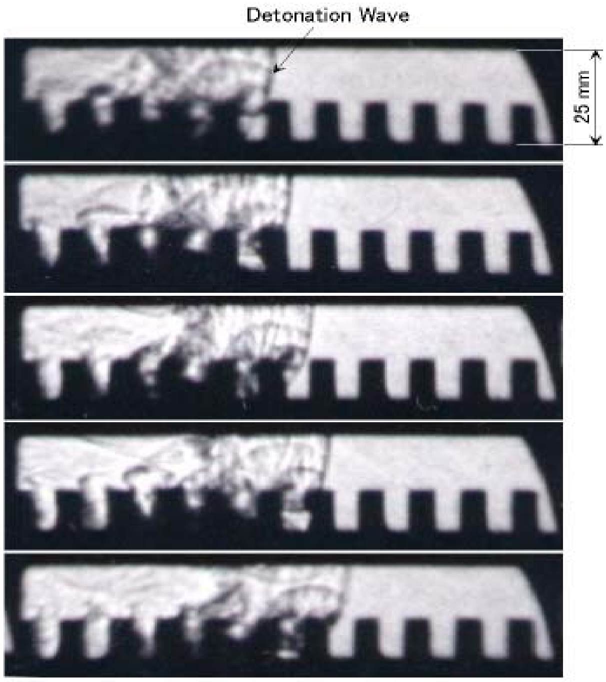

Fig. 3. High-speed schlieren photographs showing the propagation of a detonation wave on an uneven surface

A diffracted shock wave (Mach number, Ms = 3.4) from an open-end pipe of 25 mm in diameter is visualized using the color-schlieren technique (Fig. 1). The shock wave is reflected from a reflector of 50 mm in diameter and shows a complicated flow-field interacting with a secondary shock wave and a contact surface. The interaction of a shock wave and a combustion wave is associated with a mechanism to transit a combustion wave to a detonation wave. Figure 2 shows the result of a numerical simulation showing the behavior of a combustion wave interacting with a shock wave of Mach 1.7.

A detonation wave is a combustion wave propagating with supersonic velocity in a combustible mixture. Figure 3 shows high-speed schlieren images of an oxy-hydrogen detonation wave interacting with obstacles and was obtained using an image-converter camera with an inter-frame time of 5 μs.

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Visualization of Lifted Laminar Jet Flame by Rayleigh Scattering, OH PLIF, and CH Chemiluminescence

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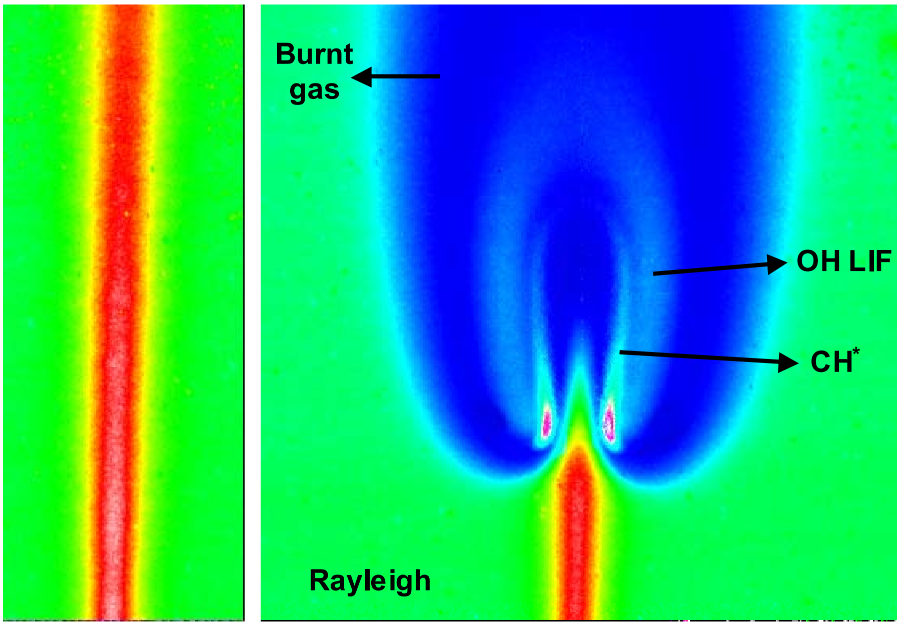

(a) Cold flow **(b) Reacting flow**

A lifted flame in a laminar coflow jet has been visualized, where the jet and coflow velocities were 9.0 and 4.0 cm/s, respectively, for the jet nozzle diameter of 0.25 mm. To visualize the fuel concentration field for both cold (a) and reacting (b) flows, the Rayleigh scattering technique for propane fuel was adopted using an Nd:YAG laser sheet beam of 450 mJ at 532 nm. Two images of Abel-transformed chemiluminescence of CH radical through a narrow band pass filter (430 nm, 10 nm FWHM) and OH PLIF image from $Q_1(6)$ line excitation are superposed on the Rayleigh image (b). The structure of the lifted flame having a tribrachial structure is demonstrated.

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Numerical Simulations of Unsteady Shock Waves around Complex Bodies

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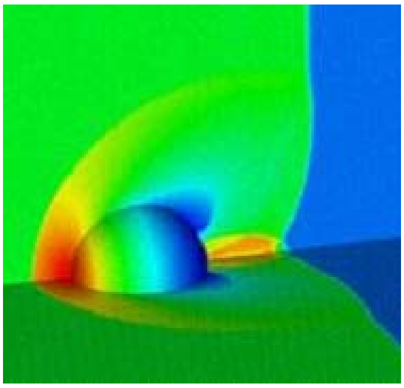

Fig. 1. Density contours around Sphere[1]

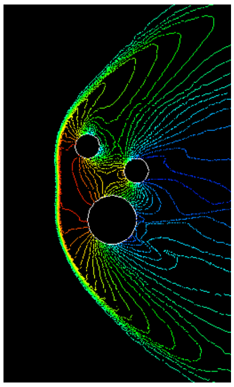

Fig. 2. Density contours around Randomly placed cylinders[2]

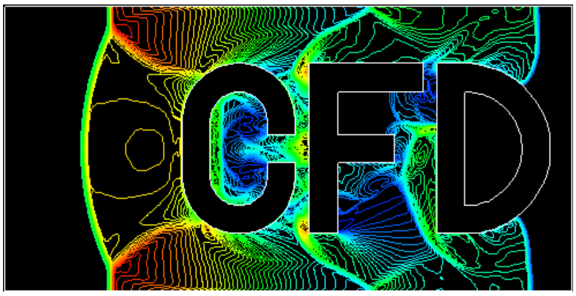

Fig. 3. Density contours around CFD shape[3]

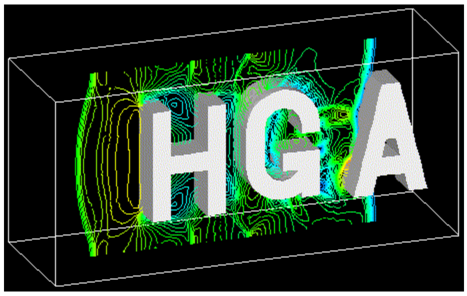

Fig. 4. Density contours around HGA shape

In recent numerical simulations, efficiency of grid generation and efficient use of limited computer resources are demanded. Various solution-algorithms have been proposed. Numerical results of unsteady shock waves in our Laboratory are presented in this paper. Fig. 1 shows density contours around sphere using MPP (Massive Parallel Processors) (M=2.81). Fig. 2 shows density contours of MHD Shock Waves around randomly placed cylinders using AMR (Adaptive Mesh Refinement) Method, which obtains higher resolutions with minimum requirement computer memory by collecting fine grids only in the location where the change of the physical quantity is intense, with Triangular Grid (M=3.00). Fig. 3 shows density contours around CFD shape (M=2.81). Fig.4 shows density contours around HGA shape (M=2.00). Fig. 3 and Fig. 4 are calculated using HGA (Hybrid Grid Adaptation) Method included AMR Method based on Hybrid Grids. In numerical simulation, fully Triangular or Quadrilateral (2D), Tetrahedron or Hexahedron (3D) is usually used. Triangular and Tetrahedron have advantage of shape flexibility. Quadrilateral and Hexahedron can analyze flow problem efficiently. Prism and Pyramid are used as transition grids, too. Therefore, using Hybrid Grids constructed by these cells makes it possible to take a good advantage of both shape flexibility and computational efficiency, and HGA Method takes advantage more both shape flexibility and computational efficiency.

[1] S.Kanou, Graduation thesis, Keio Univ. 1998.
[2] Y.Hara, M.S. thesis, Keio Univ. 2002.
[3] S.Yoshida, M.S. thesis, Keio Univ. 2000.